China 5G Vertical Industry Progress and Research Requirements Quarterly Report

September 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/
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2. Key Messages & Suggestions

- ✧ China 5G Vertical Industry in this quarter report includes Multimedia (updated based on May report), Smart Grid (updated based on May report), Smart Port (New), and 5G Slicing E2E Standard Progress & Research Requirements (New).
- ✧ Smart Grid is already commercial. Multimedia is pre-commercial. Much more POCs have been deployed in China.
- ✧ 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. Detail Information

3.1 5G Multimedia (updated based on May report)

A) Top Use Cases - Smart Stadium (Continued)

China Sports Media (CSM), China Mobile and telecom vendors have jointly built a 5G smart stadium solution at the Jinan in Shandong Province.

The project is divided into two phases. The 1st stage is "editing & communication", mainly used for sports competitions and commercial show for CSM. The 2nd stage is now pre-commercial, to cooperate with stadium operators to digitize stadiums and enable

"Internet + sports" and "Internet + stadiums". The May quarterly report explained the first phase. This quarterly report illustrates the progress of the second phase.

CSM, Shandong Mobile, Migu, Shandong Luneng Taishan Football Club, and telecom vendors worked together to achieve the first MEC-based 5G smart stadium show at Jinan Luneng Training Base on June 4, 2020.

➢ The pre-commercial solution is mature

- Multi-camera live broadcast with ultra-low latency

In the actual event, the 4 camera signals from different positions are encoded (single-channel uplink coding rate is 15Mbps), and they are respectively transmitted to the MEC through uplink of the 5G network. Transcoding is performed by the MEC (single-channel transcoding rate is 10Mbps), and distributed to 5G terminals through the 5G network. Mobile users can independently select multi-camera signals, switching to watch the content of the event. The end-to-end delay of all multi-camera signals is required to be less than 1s. Synchronous transmission among multi-cameras is maintained. The live broadcast signal and multi-camera switching require smooth and no frame freezing, and the visual quality was evaluated by subjective evaluation to achieve excellent on-site experience.

- 180°VR / 360°VR

In the actual event, the multi-camera signals of the two specifications of 180° and 360° VR are encoded (180° single-camera uplink coding rate 15Mbps, 360° single-lens uplink coding rate 5Mbps), respectively uplink to MEC through the 5G network. The 180°VR signal is processed by the MEC for distortion correction, virtual background fusion and transcoding (single channel transcoding rate 10Mbps), and is distributed to 5G terminals through the 5G network downlink. The 360°VR have 4 lens, and each lens signal is independently transmitted through uplink to the MEC. The MEC performs synchronous alignment, multi-lens splicing, FOV (Field of View) optimization and transcoding (single channel transcoding rate 10Mbps), then distribute to 5G terminals through the 5G network. The mobile user can independently select the multi-camera signals to switch the viewing angle. The VR live signal requires no visible defects in splicing quality, no visible distortion of the 180° foreground signal, and smooth signal without frame freezing.

- Wonderful short video

In the actual event, the multi-camera signals are transmitted to the remote production center for short video editing and production, and packaged as a video clip with video title and description information. The encoding standards include H.264, mp4, 4M code rate encoding. The remote production center uploads short videos to MEC through the public network, and the MEC distributes them to 5G terminals through the 5G network. The short video playback delay requires that it

can be watched on the terminals within 2 minutes after the event occurs. The quality is evaluated by subjective evaluation, and the video has no visible flaws and frame freezing. The short video title and description information can be normal present in the corresponding position.

- Real-time event data

Real-time event data is provided by the platform of Yingdong Power Event Data (GDM), and CSM Remote Big Data Center provides real-time data analysis and production. 5G terminals at the game site accesses the game platform interface through the app, and presents real-time game data in the form of automatic data capture. The terminals experience requires that the data presentation delay is less than 10s. The app obtains the dynamic information of the event data at a refresh rate of 1s. The presentation of the event data is consistent with the actual game content, and the event information is displayed in an accurate chronological order.

Picture 1 - Real-Time Super Audience Experience

	Number of Cam	Number of View	Camera	Video specifications	Estimated Upstream Bandwidth	Actual Downlink Bandwidth	Estimated downstream bandwidth	Actual downstream bandwidth
Multi-cabinet plane live broadcast (fixed slot)	4	4	Broadcast TV SDI HD Camera Output 1080p	1080P 25FPS	15M*4	10M*4	10Mbps	10Mbps
Ultra-wide-angle 180° VR live broadcast	1	1	4K stream output of the ultra wide-angle fisheye lens	4K 25FPS	30M	15M	15Mbps	15Mbps
360° VR live broadcast	1	4	4-channel 4K output of a 4-camera 360-degree VR camera	4K 25FPS	15M*4	3M*4	15Mbps	15Mbps
Total	6	9			150Mbps	67Mbps	10Mbps~15Mbps	10Mbps~15Mbps
About 120 minutes of broadcast					135GB	60.3GB	9GB~13.5GB	9GB~13.5GB

Table1 - E2E traffic measurement

Picture 2 - Test on the switch delay of multiple cameras: ~290ms

- **The value chain of the pre-commercial solution is clear**

The 5G smart stadium solution realizes the key capabilities of MEC's multi-stream real-time splicing, high-definition low-code and precise streaming, and can provide live users with a real-time super live viewing experience of less than 1 second (multi-camera viewing, VR viewing, Wonderful short videos and real-time event big data), to provide event organizers with agile production and broadcasting service capabilities that replace broadcast trucks, and enable intelligent services in stadiums. The 5G smart stadium solution can save event organizers more than 40% of operating costs such as OB (Outside broadcasting) vans and stadium wiring, and the revenue per event is expected to increase 20%. The 5G network operators can lease 5G super uplink dedicated lines and 5G edge computing services, which bring more than extra 30% revenue.

5G smart stadium applications have been widely disseminated in stadium live broadcasting related industries, and aroused positive responses. CSM has successively received feedback and cooperation requirements from customers in various industries. In addition to sports event organizers and sports industry bases, there are also other industries such as Beijing International Service Trade Fair and Taihe Music in the field of digital music. Now, the solution still needs further exploration and innovation in the product offering, and the clarification of the responsibility interfaces among CSM, the 5G network operators, and industry customers.

B) Top Use Cases - Smart AR Advertisement Screen （NEW）

Outdoor advertising, which introduces 5G and AR technology and connects with consumers' paths, has once again attracted the attention and favor of advertisers.

According to the analysis of iResearch, the compound annual growth rate of the outdoor advertising market in the past four years was 18.2%, reaching 6.5 billion US dollars. With the commercialization of 5G, outdoor AR is bound to further accelerate the industrial upgrading of traditional advertising, and it is expected to bring at least $500 million in space for 5G connection services each year.

In December 2019, telecom vendors, China Mobile Guangdong Shenzhen Branch and Blaz Information demonstrated the “5G+AR” education, cultural and travel application for the first time at Shenzhen Airport. The cooperation lasts till today.

At present, most outdoor advertising screens are SD/HD TV screens, and 2D advertisements are transmitted unidirectionally, and the communication efficiency and advertising conversion rate are not high. Its deployment and operation are mostly carried out through manual on-site operations, and a small amount of wired broadband or Wi-Fi access is used for cloud transformation. It faces challenges such as complicated wiring, long cycles, unstable Wi-Fi connections, and a long cloud-based AR interaction delay. In contrast, the smart AR advertising screen based on 5G connection fully embodies the new industrial development trend, merging advertising, education/culture/tourism, and entertainment together. It not only has richer content and more accurate delivery, but also effectively improves the efficiency of operation and maintenance.

The low latency of the 5G network (less than 20ms) ensures the user experience of AR applications. The precise positioning capability of 5G networks enables AR applications to be accurately delivered according to the users’ location. 5G networks make it possible for outdoor advertising screens to transform from the traditional offline mode of all-in-one machines to the online mode of "Agile deployment and operation based on MEC". This solution is expected to be applied first in airports, shopping malls, tourist attractions and hotels.

Mr. Zhu Wenzhen, founder and chairman of Blaz Information, said that the 5G MEC solution provides AR applications with large bandwidth, low latency, flexible deployment of connection and computing services, which greatly reduces the deployment threshold of AR terminals and AR experiences are guaranteed. According to authoritative reports, the complete rate of users watching advertisements through AR/VR reaches more than 80%, which greatly improves the interactive effect of advertisements and can help increase 30% revenue of the outdoor advertisements.

Picture 3 - Smart AR Advertisement Screen

3.2 5G Smart Factory (No update. Please check the May Report)
3.3 5G Mobile Health (No update. Please check the May Report)

3.4 5G Smart Grid (updated based on May report)

A) Top Use Cases - China Southern Power Grid （Continued）

- Technical PoC Update

In August 2020, the miniature 5G timing CPE developed by China Southern Power Grid, China Mobile, and telecom vendors was put into commercial use on the live network in Shenzhen. Joint commissioning with the distribution network differential protection device was successful. The timing precision, channel delay, and line differential current met expectations. The CPE supports the 5G network timing function and has built-in power security chips developed by China Southern Power Grid. It is the industry's first 5G timing CPE that complies with security standards in the electric power industry, marking a solid step in the maturity of the “5G + smart grid” industry ecosystem, breakpoints in the 5G power industry are being quickly filled.

- Business Model Update

China Southern Power Grid is conducting group-level business model negotiation with the three major carriers. It is expected to sign a mid- and long-term unified framework contract in Q4 2020.

B) Top Use Cases – SGCC Qingdao Supply Company（NEW）

Since August 2019, as the member of the 5GDNA (5G Deterministic Network Industry Alliance), China Telecom, State Grid Shandong Power Company Qingdao Power Supply Company, and telecom vendors have worked with upstream and downstream partners of the industry chain, relying on the three-party joint innovation lab, China's largest 5G smart grid experiment network with diverse scenarios and a complete ecosystem has been successfully built in Qingdao. The following achievements have been made.

- The largest scale in China

  Since October 2019, the first phase of the project has deployed the largest 5G smart grid experiment network with 29 5G sites and 2 MECs, in four demonstration areas, including Qingdao Ancient Town Entrance, Jinjialing, International Sailing Centre, and Qingdao Power Supply Company Dispatch Building.

- The first commercial contract in China

At the end of June 2020, Qingdao Telecom and State Grid Qingdao Power Company successfully signed the industry's first “5G + smart grid” commercial contract, marking the official transition from application demonstration to commercial implementation. The entire business contract is based on the 5G Network as a Service (NaaS) model. Operators provide a package solution of 5G VPN for the grid of the electric power industry. .

✧ Abundant use-cases deployment

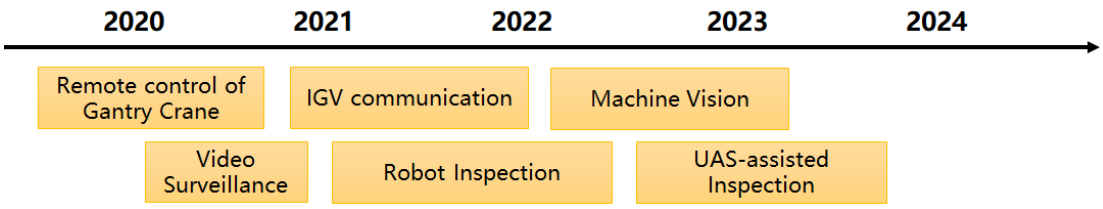
Phase 1 focuses on five application scenarios: intelligent distributed feeder automation, 5G distributed differential protection, distribution network situational awareness, 5G 4K UHD security surveillance for transmission lines, and intelligent peak clipping and filling. More scenarios will be launched in the future.

✧ Comprehensive ecosystem

Based on the 5G applications joint innovation lab and external lab network, the project team continuously promotes breakpoints in the 5G terminal devices of the electrical power industry. Currently, telecom vendors have successfully incubated three types of 5G power industry terminals (5G industrial routers, 5G intelligent integrated terminals, and 5G power security surveillance cameras) with built-in 5G chips, and is cooperating with Dajiang on 5G power inspection drones.

3.5 5G Smart Port （NEW）

A) General Plan



Picture 4 – 5G Smart Port General Plan

Ports are hubs for transporting cargo between container ships and vehicles. Seaborne trade contributes to two thirds of all global trade. There are more than 800 seaports in the world, among which 7 of top 10 ports are in China, ranking No. 1 in the world. It is estimated that by 2025, the 5G communications service space in global ports will reach US$2.4 billion annually. It could be US$700 million in China.

Picture 5 – Smart Port

The transformation of remote control of gantry cranes at ports is urgently needed. As a key service of port operation, the remote control has strict requirements on communication and control networks. Industry-oriented, dedicated, differentiated, and user-defined 5G networks open up new choices for ports.

1. Workers remotely control gantry cranes based on multiple-channel video images backhauled to the control center. The networks are required to provide high uplink bandwidth (35 Mbit/s for a single Rubber Tyred Gantry - RTG crane) and stable low latency.
2. Gantry crane operation data is the key for ports. Network isolation and data local procession is basic requirement.
3. The port communication and control network currently has problems such as slow commissioning and provisioning and an untraceable network running status. A DIY network is required to respond to rapidly changing service requirements and make network monitoring more convenient.

To sum up, the primary scenario for 5G applications in smart port is remote control. Other scenarios include IGV (Intelligent Guided Vehicle) communication, video surveillance, and robot / UAS (Unmanned Aerial System) -assisted inspection. Operators need to use new deployment and service architectures when deploying networks to meet port owners' strict requirements. The Cloud Native-based 5G mobile networks are deployed for the dedicated resources allocation and control signals with customized SLAs. MEC is also deployed by operators at the network edge to fit PLC stability requirements of control signal latency. These deployments will make remote control of RTG cranes ready for commercialization and help the owners of ports process data locally.

B) Top Use Cases – Ningbo Port

China Mobile, ZPMC (Shanghai Zhenhua Heavy Industries Company), Ningbo Port and telecom vendors, reconstructed the communication network of gantry cranes using 5G SA Network Slicing and MEC at the Meishan Island international container terminal in

Ningbo Port. 5G-based remote control of gantry cranes is realized at Ningbo Port with guaranteed SLAs.

This is the first “5G + smart port” project empowered by 5G SA Network Slicing and MEC technologies.

Ningbo Port is one of the world's largest port with an annual cargo throughput of over 1 billion tons for 10 consecutive years. It has more than 550 gantry cranes responsible for transshipping 70% of goods in the port. Work conditions for the workers driving gantry cranes are poor. Port enterprises urgently need to transform traditional ports that rely heavily on manual operations to automatic ports to improve workplace conditions and efficiency.

Zhejiang Mobile, together with telecom vendors and other partners, builds the “5G + smart port” solution using the 5G SA Network Slicing and MEC. This solution overcomes technical difficulties, such as ultra-low latency and highly reliable data transmission, and has successfully completed the reconstruction of gantry cranes in Ningbo Port. For 5G remote control of RTG cranes, the MEC deployment reduced the average control signal latency from 28 ms to 10 ms.

Telecom vendors has applied the solution to the overseas market and verified the feasibility of “5G + MEC-based” remote control of RTG cranes at the Laem Chabang Port in Thailand

After the reconstruction into automation, one worker can remotely monitor multiple RTG cranes at the same time. This greatly improves the working environment for employees, reduces the labor cost, and resolves recruitment difficulties. ZPMC once tried to use Wi-Fi and 4G to build port communications infrastructure. However, these solutions could not meet the requirements of large bandwidth, low latency, wide coverage, and mobility. 5G networks satisfy all the requirements.

C) Research Requirements

The 5G technology should be used to reconstruct the port information systems, including horizontal transportation, vertical transportation, and ship entry and exit system, to achieve smart transformation.

The next step research scenarios include multi-channel onsite video backhaul, automatic port tally, and self-driving of container trucks in closed areas.

3.6 5G Slicing E2E Standard Progress & Research Requirements (NEW)

Internationally, 5G RAN and CN network slicing standards are mainly researched in 3GPP, and transmission slicing standards are mainly researched in IETF. In China, the CCSA has established a special project team to solve the problem of independent

deployment of each sub-domain and cross-domain interconnection manually. The progress of each standard organization is as follows.

- 3GPP

  - SA2 (Architecture)

R15, the basic slice architecture functions are formulated, including architecture, identification and selection of a Network Slice, network slicing session management, network slicing for roaming, network slicing and Interworking with EPS, etc.

R16, the network slicing functions are enhanced, including interworking with EPS, network slice-specific authentication and authorization, slice-level SLA assurance, etc. R16 has been frozen in September 2019.

R17, the enhancements study of Network Slicing Phase 2 are proposed. The objective of this study is to identify the gaps in the current 5G system procedures defined in SA WG2 to support GST slicing parameters, and to study potential solutions that may address these gaps.

  - SA5 (Telecom Management)

R15 released at the end of 2018, including basic concepts, roles, management requirements of network slicing, lifecycle management of network slicing, hierarchical and service-oriented architecture, resource model, configuration management, fault management and performance management, etc.

R16, network slicing management were enhanced, including service discovery of cross-vendor management, support tenant concept, slicing management capability exposure and E2E key performance indicator enhancement for network slicing. In addition, charge of network slicing (2B) was defined.

Now, R17 research has been initiated. This research focuses on how to provide consistent and assured communication services across operators, define operators' network resource models and ensure slice SLAs for industry network slicing.

  - SA3 (Security)

3GPP SA3 mainly researches standards related to mobile network security. In 3GPP R16, the major research contents of network slicing include: (1) network Slice-Specific Authentication and Authorization, re-authentication and re-authorization, authorization revocation. (2) Privacy of a network slicing, including privacy protection of a network slicing at air interface and protection solutions for network slice privacy not known by third-party slice authentication and authorization servers. (3) Privacy of user IDs used for network slice authentication and authorization; (4) Network slicing

management security. Now, R16 has been released. SA3 begins to discuss whether to initiate a research on slicing security enhancement in R17.

- IETF

IETF mainly focus on research on transport network slicing standardization. The standardization research mainly includes: (1) Research on the transport network slicing architecture, including the VPN+ architecture, transport network slicing definition, upper-layer architecture and cross-domain transport network slicing mapping. (2) Research the network slicing management plane, focusing on the transport network slicing northbound interface model. (3) Research on the control plane of transport network slicing, focusing on the extension of control plane protocols of transport network slicing. (4) Research on the data plane of transport network slicing.

Currently, the architecture is gradually stable. The other projects are still being defined. But the detailed work plan has not been determined. The key industry members hope that the data plane standardization of slicing can be clarified by the end of 2020 and the control plane protocol extension can be basically completed by 2021.

- CCSA

In order to resolve cross domain network slicing specifications, CCSA established a special project team in December 2019. At the first meeting of the project team, some standards were proposed, including the generic requirements of 5G E2E Network Slicing, E2E Network Slicing Interworking Requirements based on SPN / IP transport network. Now the first series of standards are relatively stable. In July 2020, the second series of standards were proposed, including TN-NSSMF (Network Slice Subnet Management Function) Functional and Interface Requirements. These new series of standards will further study the transport network slicing standardization.

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