Case Study

5G MEC
Edge to Cloud
Intel® FlexRAN Reference Architecture
Intel® Smart Edge

Integrating 5G and Edge Computing to Accelerate the Intelligent Transformation of the Power Sector

Intel helps China's State Grid Information & Telecommunication Group (SGIT) build a 5G MEC solution for the power sector private 5G network spanning edge to cloud.

SGIT 国网信通产业集团 STATE GRID INFO & TELECOM GROUP

"Private 5G dedicated to the power sector has allowed related business data to be transferred from the public network to a more independent and secure private one, enabling high-performance and low-latency data processing, while better ensuring information security. In addition to efficient edge data processing and flexible wireless access, the introduction of cutting-edge Intel® products and technologies, such as 2nd Gen Intel® Xeon® Scalable processors, Intel® FlexRAN reference architecture, and Intel® Smart Edge, has also significantly improved the efficiency of edge application development and deployment, as well as edge-to-cloud collaboration, making intelligent power sector applications in various scenarios now a reality."

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Senior expert
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The State Grid Information & Telecommunication Group (SGIT) is a subsidiary of the State Grid Corporation of China (SGCC). In response to China's "New Infrastructure" strategy and to address the needs of massive data transmission and processing required by automated and intelligent devices, SGIT is building a private 5G network based on a 5G Mobile Edge Computing (MEC) solution, planning to migrate its data from public to private network for transmission and processing, so that data will be better secured; the high bandwidth, low latency, and massive connection of 5G can be fully leveraged; and jobs can be offloaded to the edge near where business takes place, thus processed with higher performance. These will add up to an improved capability to orchestrate across cloud and edge, all contributing to higher business efficiency.

To effectively roll out the solution, SGIT has collaborated with Intel, introducing a series of Intel software and hardware, including 2nd Gen Intel® Xeon® Scalable processors, Intel® FlexRAN reference architecture, and Intel® Smart Edge. This has greatly empowered the 5G white-box integrated small cell design, unified edge application management, and high-performance computing and processing in the new solution.

The private 5G based on the new solution has already been deployed and used in several real-world scenarios, receiving positive front-line feedback. Soon, it will become the new engine for the intelligent transformation of the entire power sector.

Benefits of the 5G MEC Solution to the Power Sector Private 5G Network:

- The network architecture of private 5G for the power sector based on the new 5G MEC solution can fully leverage the high bandwidth, low latency, and massive connection features of 5G to support high-performance power sector application scenarios and enhance information security.
- By introducing the Intel® FlexRAN reference architecture, the 5G MEC solution easily enables a software-defined virtual network access solution, supports flexible accesses of multiple terminals, and lays a solid foundation for low-latency services of power sector applications.
- Intel® Smart Edge reduces network complexity through abstraction and accelerates the development and deployment of edge applications. The platform is implemented based on the micro-service architecture, which facilitates integrated management and supports fast application updates and upgrades.
- The 2nd Gen Intel® Xeon® Scalable processor is integrated with Intel® Speed Select Technology - Base Frequency (SST-BF). It can power up the operating frequency of a particular processor core when massive user plane data needs to be forwarded in the 5G MEC scenario, thus improving the work efficiency and reducing overall power consumption.

Over the years, increasing demands for data transmission and processing have emerged across business scenarios throughout the power sector, from power generation and transmission, to voltage conversion and power distribution, until it finally reaches end users. A large number of devices, electric power pipelines, and monitoring systems are generating, exchanging, and processing massive amounts of data across all links, including line inspection, resource scheduling, construction, operation and maintenance, and safe production. As intelligent applications are increasingly being introduced to the power sector, the demand for data processing has surged exponentially.

Traditionally, the power sector has used 4G, WiFi, Ethernet, serial ports, or carrier waves to exchange or transmit data. However, these communication approaches are more or less plagued by high latency, compromised data security, lack of flexibility in deployment and access, insufficient reliability, and limited bandwidth. Take the inspection robot as an example. Due to limited bandwidth and terminal processing capacity, oftentimes the robot can only be equipped with a single camera, which limits its inspection range. In addition, the results are subject to further human analysis, making it prone to errors. Worse still, when the network condition is suboptimal, high latency might lead to a delay in the robot's response, causing safety risks. Moreover, more critical business data transmitting through the public network also brings data security risks.

In light of this, SGCC has turned to 5G technologies to accelerate the digital transformation of the power sector. 5G is a natural result of network and artificial intelligence (AI) integration from bottom-up. Based on the technological innovations in enhanced Mobile Broadband (eMBB), massive Machine Type Communication (mMTC), and ultra-high Reliable and Low Latency (uRLLC) scenarios, and backed by key technologies such as MEC and network slicing, 5G can support customized network services for the power sector, and provide bandwidth, latency performance, and connection scale on-demand, thereby improving the efficiency of resource utilization and saving infrastructure investment.

As a specialized subsidiary under SGCC, SGIT has collaborated with Intel to address a series of needs in real-world business scenarios in the power sector. Together, they have created a private 5G network dedicated to the power sector by combining the advantages of network transmission and edge computing provided by 5G and MEC, and adopting new products such as the "5G in box" to enable a brand-new 5G MEC solution. A host of Intel software and hardware, such as 2nd Gen Intel Xeon Scalable processors, Intel FlexRAN reference architecture, and Intel Smart Edge have been used in this new solution to provide strong computing power, architecture, and software solutions.

Providing Strong Private Network Support and Edge-to-Cloud Collaboration Capabilities for the Power Sector

Business scenarios in the power sector usually feature long business process, wide coverage, and complex and diverse requirements, and demand rigorous data security. Therefore, SGIT has prioritized the following two considerations when designing the private 5G:

- **Complementing the public 5G network:** This aims to leverage the advantages of both public and private 5G. The wider coverage of the public 5G network helps solve the "last mile" communication access problem for the power grid, and the transmission path will also be optimized, with core business data separated from the public network and migrated to the private network to cope with communication latency and data security issues.

- **Forming high-efficiency MEC computing and processing nodes:** Edge nodes are expected to be upgraded with data computing and processing capabilities. 5G core virtualization, user plane and control plane separation, and new features that can be flexibly deployed will be used together with MEC to realize service offloading to the nearby nodes and on-demand distribution. Moreover, these edge nodes will also provide strong and solid computing power support for AI applications in edge scenarios.

Based on these demands, SGIT has partnered with Intel to build a brand new private 5G network dedicated to the power sector with multiple products and technologies based on Intel architecture, using the stand-alone Non-Public Network (NPN). Figure 1 shows the new x86 server-based architecture of the private network. Network Functions Virtualization (NFV) is used to flexibly carry the Base Band Unit (BBU), User Plane Function (UPF), and other edge applications. In the meantime, control plane and user plane separation in the network core in this architecture has helped eliminate the performance bottleneck in the high-speed network.

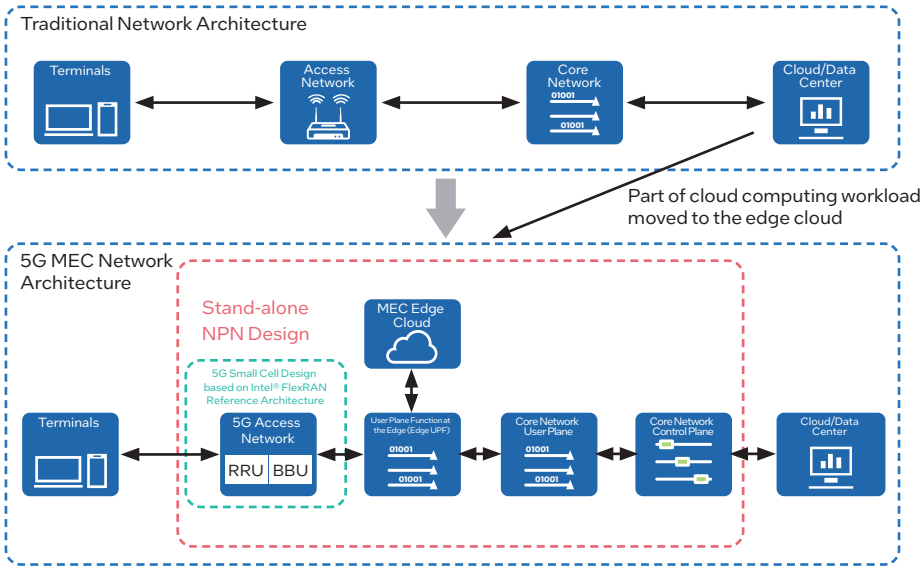

Figure 1. Network Architecture of SGIT's Power Sector Private 5G

As shown in the red dashed box in Figure 1, the stand-alone NPN design enables all access network elements, core network elements, and edge platform servers in the architecture to be deployed locally on the same platform, and the general-purpose computing platform supports on-demand software deployments. These have enabled the decoupling of software and hardware. With this architecture, power companies can deploy and enjoy exclusive network resources or a dedicated network slice while customizing the scale of deployment according to their business characteristics, achieving more flexible scalability. Users can also set a higher security level for their core data. For the design of the radio access network, SGIT has adopted the 5G small cell design based on Intel FlexRAN reference architecture to improve transmission performance and access flexibility. When wider wireless coverage is needed, users can deploy additional radio access nodes in the architecture.

The private 5G network for the power sector based on the new architecture can be deployed in enclosed areas such as power stations, substations, and converter stations, etc., to directly serve related AI applications. For example, in the automated transmission and distribution (T&D) line inspection solution, the 5G networked drones would constantly capture high-definition (HD) videos and upload the data to the back-end cloud, after which inferencing could be done with AI algorithm models for fault analysis and risk warning. The strategy obtained from inferencing results would in turn be sent back to the drones for their subsequent works. There is a potential problem in this process: If all tasks related to data cleansing and model inferencing are done by the remote cloud platform, network transmission would face tremendous pressure, resulting in obvious delay in response, which may be catastrophic in many latency-sensitive scenarios.

To reduce latency, SGIT has introduced Intel technologies and products, such as Intel Smart Edge and 2nd Gen Intel Xeon Scalable processors, to the new architecture to build on the edge side an MEC edge cloud platform with powerful computing capabilities. By moving the massive complex computation and AI processing tasks to edge platforms where business terminals are closer, the optimization of the transmission path helps related business data to be transferred from the public to the private network. This allows for faster response and higher security, effectively addressing the real-time and security demands in power sector application scenarios, such as intelligent prevention and control, accident alerts, and equipment monitoring.

To enable more power companies to deploy this 5G MEC solution with ease, SGIT has been collaborating with Intel and other partners to launch the "5G in box" product, designed following the principles of "simplicity, flexibility, multi-functionality, and high efficiency" based on the differentiation between power sector applications and public network applications. The hardware design of "5G in box" (see Figure 2) combines the MEC platform, BBU and RRU, integrating data communication, storage, computing and application into a single cabinet, which facilitates the deployment and usage for power companies. On top of the hardware, the MEC data computing platform and business application platform are built into the "5G in box", which provide sufficient computing power for multiple smart applications on the upper layer, allowing businesses to choose from different AI application systems based on their different needs in corresponding scenarios.

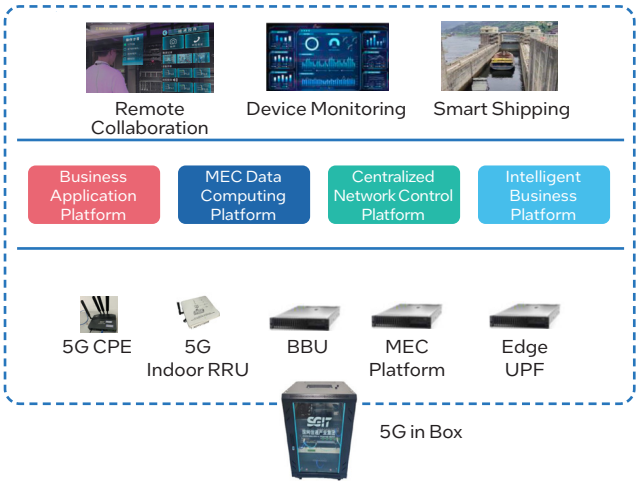

Figure 2. 5G in box in the 5G MEC solution

Deployment of this new solution in the real-world power sector provides the following advantages:

- **Support for communication of multiple terminals, networks, and business data:** The 5G white-box integrated small cell design based on Intel FlexRAN reference architecture is compatible with the existing equipment, communication, and business systems.
- **Compact deployment of BBU, MEC, and edge UPF in a single device:** The solution incurs lower network construction cost and equipment footprint, enabling flexible network deployment that can be easily used on a general-purpose computing platform, on which the data transmission path is optimized so that services can be offloaded to the nearby nodes and distribution accomplished on demand.
- **AI capabilities at the edge:** By integrating the MEC platform, the solution supports the selection of different AI application systems for integrative analysis and smart identification with data from multiple sources.
- **Configuration on demand for communication management and control + MEC edge computing + AI application platform:** The solution can be deployed at the edge, in the cloud, or in a hybrid manner based on business needs to satisfy the differentiated needs of different users.

Notably, the introduction of open architecture designs including Intel Smart Edge and Intel FlexRAN reference architecture has brought about favorable software and hardware compatibility and industrial ecosystems, allowing the edge-to-cloud collaboration capability developed by SGIT in this 5G MEC solution to extend beyond the power sector, providing additional capabilities to related industries by coordinating with the public 5G. This not only improves resource utilization, but also makes the power sector private 5G an integral part of the overall 5G network.

Intel's Hardware and Software Portfolio Empowers the 5G MEC Solution

As a leader of innovation in the field of information and communication technologies, Intel is committed to driving 5G and MEC by introducing its rich portfolio of hardware and software. As shown in Figure 3, in the case of SGIT's 5G MEC solution, Intel has contributed to the 5G white-box integrated small cell design, unified edge application management, and high-performance computing.

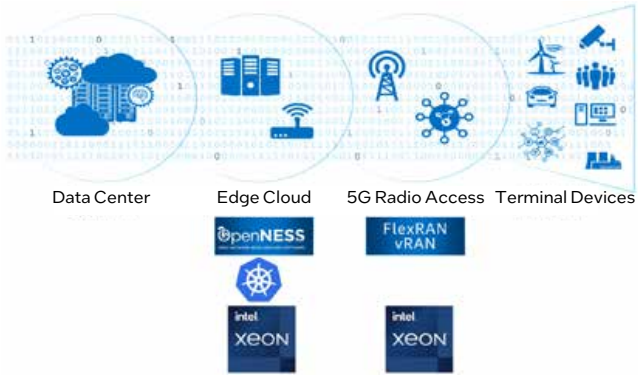

Figure 3. Intel products and technologies contributing to the 5G MEC solution

In the 5G scenario, smart terminal devices are characterized by portability and mobility, leading us to an increasingly wireless future with regard to network access environment. To deliver powerful cloud (cloud computing) and network (5G) capabilities and make processing possible at the edge, Intel has provided Intel FlexRAN reference architecture to this 5G MEC solution. This architecture features 2nd Gen Intel Xeon Scalable processors and Intel® Field Programmable Gate Array (FPGA) as the computation processing core. It also integrates the Data Plane Development Kit (DPDK) and other technologies to enable full virtualization of the radio access network and optimized implementation of network slicing. Based on this flexible and open reference architecture, the 5G MEC solution can achieve on a general-purpose x86 server platform the same BBU performance as on the traditional radio access network, providing high-throughput and low-latency 5G wireless connections to different application scenarios across the power sector.

What's more, the power sector private 5G achieves higher efficiency by moving computing resources and business applications to the edge. However, due to the architectural differences between the edge and the core, many software applications cannot be directly migrated, adding to the difficulty of development and deployment. To obtain a unified application development and hosting environment in the heterogeneous public and private networks, Intel has offered the Intel Smart Edge software to the 5G MEC solution, which allows for easier smart application migration and deployment at the edge. This platform works in collaboration with Kubernetes to support edge service orchestration and boost application performance by pre-provisioning resources for the edge platform. In addition, the platform provides easy access to obtain application and terminal data with identity authentication. The Intel Smart Edge platform has enabled power companies to effectively avoid the negative impact from heterogeneous underlying architectures of different networks, allowing them to develop and deploy intelligent edge applications with higher efficiency, which significantly enhances the accessibility of this solution.

In the construction of the fundamental hardware facilities, the 2nd Gen Intel Xeon Scalable processors and Intel FPGA have been adopted to provide sufficient computing power. Specifically, the solution has adopted Intel® Xeon® Gold 6252N processor integrated with Intel® Speed Select Technology - Base Frequency (SST-BF), which allows user to power up the frequency of a particular core without increasing the overall power consumption of the processor. This feature effectively addresses the massive demands of user plane data forwarding under the 5G MEC scenario. When a certain core is used for high-speed user plane data forwarding, Intel SST-BF would power up its frequency to achieve higher processing capability. Such flexible adjustment improves the processing efficiency of key workloads in the solution, while reducing the overall power consumption.

The 5G MEC Solution Use Case: Enabling Smart Shipping for a Hydropower Station

Dams with a hydropower station built nearby usually have to factor in both shipping and power generation needs. Acquiring shipping information in the watercourse to manage and control the situation is indispensable for ensuring production safety and improving efficiency. Traditionally, the hydropower station would use cameras to collect images on site for monitoring. The video data would then be sent back to the remote control center where dispatchers receive the information and conduct management and control accordingly.

In the past, with 4G, the video image quality and transmission latency were highly susceptible to the physical distance and network conditions, resulting in poor user experience. Moreover, transmitting business data over the public network can compromise information security, while large video files are often subject to traffic restrictions and are also expensive to transfer. To solve these problems, SGIT has helped the subsidiary of SGCC that owns the hydropower station to build its first-ever power sector local private 5G, using the 5G MEC network that covers the entire shipping hub to realize smart shipping capabilities for the hydropower station.

As shown in Figure 4, the front end of the 5G network is deployed with portable 5G dome cameras, which support wireless access and can be quickly installed at video image collection points without cabling. The cameras send back high-quality video signals via the MEC platform, while the 5G core network devices deployed in the enterprise data center enable users to implement authenticated control and secured data processing. Dispatchers from the hydropower station can use the software application on their mobile phone or on a computer terminal to monitor the vessels, field personnel, floodgates, and water level changes, etc., to implement operational control.

Figure 4. Front end access and back end monitoring platform interface of the 5G MEC solution for hydropower station

With the power sector private 5G, data doesn't even leave the enterprise premises. It guarantees that business data and control signaling don't interact with external networks, better ensuring data security and saving traffic costs. Moreover, wireless access also saves the company from the cabling headache when deploying a network. Combined with the large bandwidth, low latency, and massive connections of the 5G, the quality of network transmission is significantly improved, enabling the real-time uploading of high-definition videos, and helping dispatchers efficiently monitor shipping conditions and respond to emergencies in a timely manner.

According to the internal test data from this hydropower station, under the private 5G architecture, downlink bandwidth has reached up to 800 MB to 1 GB, and uplink bandwidth can be customized to better support multi-channel HD video streaming. In addition, the

private network can be accessed by hundreds of smart 5G terminals[1] to support multiple application scenarios concurrently and cover a wider monitoring range, providing strong support for efficient management of the hydropower station.

Looking Ahead

The integration and application of 5G and edge computing technologies have incubated and given birth to an increasing number of innovations in various scenarios in the power sector. It has also helped major power companies such as SGCC to overcome difficulties and break new ground in renewables. Backed by the software, hardware and technologies based on Intel architecture, the private 5G network using the 5G MEC solution has provided a more efficient and reliable technical foundation for the intelligent transformation of the entire power sector.

In the future, SGIT will continue its in-depth cooperation with Intel to bring forward more innovations in 5G and MEC, such as investments in the R&D of Time-Sensitive Networking (TSN). The two parties will also work together to promote private 5G in other industries, so that it not only contributes to the digitalization and intelligent transformation of the power sector, but also yields a synergistic effect to speed up the adoption of smart applications across industries in wider and more diverse scenarios.

[1]Data from feedback of SGIT's clients. For more details, please consult SGIT at http://www.sgit.sgcc.com.cn/