Research on the Application of 5G Network Slicing in Smart Grid

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Abstract: With the continuous construction and development of domestic power grids, the state has put forward many effective strategies to achieve the effectiveness and durability of energy supply, in order to ensure the stable operation of the power grid and the construction of smart grids. One of the most important components of the smart grid is various communication technologies. 5G network slicing is a typical application of the smart grid, because the wide-area distributed grid has greater requirements for low latency, high reliability and security. And 5G network slicing has the ability to meet its requirements. This paper analyzes the principle of 5G network slicing, analyzes the end-to-end isolation scheme of network slicing and the current smart grid slicing business model and existing problems, and proposes an effective solution for building a smart 5G slicing network.

1. Introduction
With the in-depth integration and development of smart grids and the Internet of Things, the business characteristics of large capacity, low latency, high speed, and mass access, as well as the carrying and transmission of diversified and integrated information, have become advanced requirements for the intelligent upgrade of the power grid. The arrival brings the possibility to achieve the above requirements. The high rate of 5G can provide strong support for the transmission of massive data, and the low-latency technology can achieve millisecond-level precise control of power services. In the 5G era, power and information will be better interconnected, and the feasibility of 5G networks to carry power diversified services will also be further expanded. The application of the 5G network slicing process to the smart grid will facilitate the smooth development of multiple processes such as power generation, power consumption, and delivery points, and will drive the development of the power system, creating a more convenient and efficient power environment for the masses.

2. The basic concepts and composition of smart grid and network slicing

2.1 Smart grid concept and basic components
The smart grid uses computer information technology and communication technology to manage the running system, and has the characteristics of high reliability compared with the traditional power grid. Isolate or self-heal the components in the power grid with less or less human intervention, reduce the
risk of power outages for users, and analyze the local network in time when the power grid fails to identify, respond, restore and maintain higher safety standards. Smart grid has high safety standards, adopts emergency mode, and adjusts in time, regardless of whether the software and hardware systems are subject to external attacks. Even if the business is interrupted, the entire system can quickly resume operation. An integrated interactive system can integrate subsystems such as monitoring, control, management, operation, resource planning, and interact with user equipment and power terminals during a specific operation period to achieve more complete grid dispatch.

The concept of 2.5G network slicing and the needs of smart grids

Smart grid network slicing is a typical case of 5G network slicing in the vertical field. The 5G network slicing process has a profound effect on the smart grid. By using the form of network virtualization technology, a 5G communication physical network is logically divided into multiple virtual end-to-end networks, under the influence of wireless networks and transmission networks. Each network is independent of each other, and each virtual network will not interfere with other networks when it fails. 5G borrows slicing technology, so it can realize the fission of multiple networks. In theory, the development of 5G technology will greatly increase the difficulty of operation and maintenance, so automation should facilitate 5G networks. Based on the rapidly changing 5G perspective analysis, the realization of full automation and one-off becomes extremely difficult. 5G network slicing technology will manage and arrange network resources according to changes in market application requirements, realize tailoring of network functions, and provide customers with exclusive virtual network service support.

Among them, the access network, transmission network, and core network can all use network slicing technology to achieve new breakthroughs. Among them, the core network sub-slices are mainly based on SDN/NFV (Software Defined Network/Network Function Virtualization) technology, which untie network functions from physical network elements to form service-oriented components. The transport bearer network is a support Multi-service network requires very high isolation between sub-slices. It is generally implemented through hard segmentation based on time division multiplexing mechanism and soft segmentation based on frequency division multiplexing mechanism, so as to finally produce different bearers. A series of physically isolated independent sub-channels and multiple independent logical channels of the slicing service of the wireless network; according to the business scenario, the wireless network sub-slices can be flexibly divided and deployed CU (Centralized Unit, centralized unit) / DU (Distribute Unit, distributed Unit), SDN/NFV and other technologies, and adopt a static and dynamic allocation method to divide the wireless resources in the air as the only specific identification parameter of the network slice, which can be used for the terminal to accurately identify different slice types. For example, for edge single-link sites to carry out related business scenarios, formulate a 5G public network backup switch plan, apply core key technologies, and jointly carry out business switch test verification with public network operators. Test the switching delay of service switching to verify the technical indicators of power service switching. It is expected to purchase 4 industrial-grade CPEs and develop 4 intelligent switching devices. The number of power business terminals used in each demonstration scenario is estimated as shown in the following table:

Table 1 Statistics on the number of power terminals in the demonstration scenario

| Demonstration scene name | Industrial gradeCPE | Smart switching device |
|---------------------------|---------------------|------------------------|
| Emergency Application of Communication Channel in Substation | 4 | 4 |

3. Application of 5G network slicing in the field of smart grid

The 5G network and service system is an optimized high-distribution network that has the advantages of flexibility, reliability, low latency, high data transmission rate and high bandwidth, and can meet all the main communication conditions of the smart grid. The overall slicing architecture of the smart grid
Among them, CSMF (communication service management function) is the entrance to the slice, completes the demand order of power business, and passes it to NSMF (network slice management function) for slice design.

NSMF is responsible for end-to-end slice management and design, selects the appropriate slice according to the power business requirements received from CSMF, decomposes the SLA requirements of the slice into the SLA requirements of the slice subnet, and delivers the network slice to the NSSMF (Network Subslice Management Function) Subnet deployment request.

NSSMF is responsible for sub-slice management, including radio access network sub-slice management function (AN-NSSMF), bearer network sub-slice management function (TN-NSSMF), and core network sub-slice management function (CN-NSSMF). 5G network slicing completes the deployment of end-to-end slicing networks through the collaboration of CSMF, NSMF and NSSMF [4].

1. Application of intelligent distributed power distribution system

Smart power distribution is an extremely critical process. After smart power distribution, the masses can directly use electricity, and smart power distribution will have a direct impact on the daily lives of the masses, so there is a higher demand for the quality of smart power distribution. The advantages of intelligent slicing applications based on 5G networks are as follows:

(1) 5G network slicing can control distributed power distribution. When the power distribution capacity of distributed power is low, 5G network slicing can control distributed power and improve its power supply capability.

(2) 5G network slicing can repair the process of power distribution. If a problem occurs during the power supply process, the 5G network slicing process can not only quickly solve the power distribution problem, but also improve the ability of remote power supply and strengthen the configuration of the power supply structure. Because 5G network slicing is used in smart power distribution, it constitutes a power distribution network that can be independently managed and controlled. The distributed feeder automation device is independent from the collective fault prompt system, which can quickly respond to the breakpoint, perform topology analysis, and quickly solve the
problem. Up to now, distributed wire-feeding automation devices have to be built with optical fiber cabling. Because 5G can provide 9 milliseconds of network buffering and gigabit data transmission. The research of network slicing technology will analyze the design requirements and the entire process of operation and maintenance in the system. For example, in the equipment management of the smart grid power terminal, if you want to improve the management ability of the power terminal equipment group, the static team members must follow the power management system. The control plane of the network, the information generation data changes, and the data resources are transmitted to the UPF module to ensure the effective supervision of various information [5].

2.5G network slicing for smart power transmission applications

In the work of smart power transmission, the 5G network slicing process has a very critical impact. The key is to monitor and protect the entire power transmission line through sensors to ensure that the power can be smoothly delivered to the designated location. The functions that can be completed are:

1. Install the sensor equipment with 5G network technology intelligence in the transmission line. The sensor equipment can monitor the problems that occur in the transmission process and the line damage and other aspects, and report the problems to the general control center in time, and then timely repair the existing problems in the transmission process, reduce the loss in the process, and effectively protect the normal operation of the transmission circuit.

2. The application of drone devices is also an extremely effective and reasonable monitoring measure. The addition of 5G network slicing technology to drones can not only take more high-definition photos and videos of the actual circuit, but also quickly determine the location of the transmission circuit failure, effectively improve the efficiency of solving circuit problems.

3.5G network for smart grid power generation

Smart grid is the most critical component of the power system. Most of the energy it uses is clean energy, so it can realize the effective application of resources and save resources. At this stage, it seems that the use of solar energy and wind energy to generate electricity is extremely common. The core content of smart power generation is solar energy. The current solar power generation situation is unstable, and the amount of energy generated is subject to adverse effects such as weather changes. Therefore, solar power generation. The situation is not optimistic, and 5G network slicing is needed to help. 5G network slicing can connect each network slice to solar power stations in different regions, and use sensors to measure the solar power supply status of each region, and then implement remote control of all power stations to reduce the instability of solar power supply. In addition, the core control point of the 5G network can be used to regulate the power generation in all solar power stations, which can not only meet the people's demand for low-latency and large-capacity power, but also realize the effective application of clean energy.

After 5G network slicing and smart grid integration, after the intelligent distributed FA slicing has been created, information checking can be carried out in accordance with the operation of the electricity system. Just like the smart grid can build the online status and resource application information query system of the power terminal, so as to fully ensure the openness of the slice management system, improve the slice status of power users and the terminal information management and monitoring, and also design the smart grid. Provide support for the development of power companies.

4.5G network is used for unmanned inspection power grid

Real-time supervision and control of video images. Real-time video image supervision and control are generally used in security control systems and supervisory control systems. Under the action of the video supervision and control system, the power system operation sites and the operation status of important nodes in the distribution network are supervised and controlled. The video supervision control points are general. It will be arranged in a remote power distribution room or a relatively hidden public place. The video signal transmission is a centralized business mode and requires a more advanced power distribution system. The existing optical fiber-covered wired network cannot meet the requirements of flexible supervision and control of the system. UAVs can provide relevant alternatives to inspections with high operating costs and higher risks. Using UAVs to inspect the transmission line
network can prevent the existence of potential risks and improve the efficiency of inspections.

4. Conclusion
Smart grid is an inevitable development of power grid technology in the new era. Compared with traditional grid operation, smart grid has a higher level of informatization and automated management capabilities, shows strong flexibility in power transmission and distribution, and can effectively improve the power grid. The operating efficiency of the power grid enhances the safety and reliability of grid operation. Distributed management is the core in the operation of the intelligent network system. Under the action of distributed management, 5G network slicing can be effectively integrated into the smart grid, and user information can be collected in time to help users observe, supervise and control in time The actual operation of the power grid.

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