Architecture design of wireless access system in power grid application scenario based on 5th Generation Mobile Communication Technology small base station

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Abstract. The use of digital radio station and GPRS public network is affected by false data, which leads to the small coverage radius of access network and the throughput is inconsistent with the ideal situation. In order to solve these problems, the architecture design of wireless access system in the application scenario of power grid based on 5G small base station is proposed. FPGA channel encoding and decoding is adopted to design base band processing unit, which is helpful to deploy the platform with other network virtualization functions. Using switch, we can get useful information through monitoring module, scheduling module and information description module. The abnormal data are detected by using RF processing unit. In view of the situation of the data produced by the switch having state mutation, the reliability factor is introduced to monitor the false data in real time. The operation status of open architecture wireless access network is analyzed, and the application scenario of power grid is determined. Thus, the non-interference wireless access network is deployed. The experimental results show that the coverage radius of the architecture is 15cm, the static scene throughput range is 26-33KB, and the dynamic scene throughput range is 45-59KB, which has good access effect.

1. Introduction
The active small base station has the advantages of low power consumption, convenient deployment and low delay. It can also assume the central function of smart home / office in the 5G era. It can not only coordinate with the macro base station to remove the coverage blind area, but also realize the digital 5G indoor coverage to meet the diversified needs of services [1]. In the 5G era, more and more business scenarios give birth to more and more application types, and with the increasing proportion of indoor traffic, the new generation network construction puts forward higher requirements for indoor coverage network indicators [2]. At present, many telecom equipment manufacturers have released 5G indoor coverage solutions for base stations. The network is divided into two parts: the master station and the slave station. The master station is responsible for querying the data of the meters in the coverage area, and the slave station sends the data back to the master station [3]. The advantage of this networking mode is that the network structure and network design are very simple, but the efficiency of data collection is not high. In order to solve the problems such as the small coverage radius of the
access network, the small throughput, and the inability of the data transmission station to actively report services. Therefore, a wireless access system architecture design for power grid application scenarios based on 5G small base stations is proposed. This paper designs a wireless access system architecture for power grid application scenarios based on 5G small base stations.

2. System hardware structure design
The base station configuration of 5G extended small base station includes baseband processing unit, switch and RF processing unit, as shown in Figure 1.

As can be seen from Figure 1, the switch connects the baseband processing unit and the RF processing unit. For the downlink, it broadcasts data to all RF processing units. For the uplink, it combines all uplink data from the RF processing unit according to the cell set [4]. The baseband processing unit is connected with the switch and the switch is connected with the RF processing unit through the forward interface.

2.1. Baseband processing unit
For 5G extended small base station, baseband processing unit realizes baseband processing. It includes the realization of protocol stack function, synchronization and forward transmission of wireless access network layer 1 / layer 2 / layer 3. Considering the development process of hardware implementation from general-purpose to special-purpose, the protocol stack can be implemented in three ways: full general-purpose processor / general-purpose processor + accelerator card / baseband special chip [5]. At present, the most common way is to use FPGA, FPGA (field programmable gate array) / ASIC to realize the real-time channel codec and forward transmission [6]. Based on the baseband processing of general server, the software and hardware decoupling is introduced to make the hardware more general, realize more efficient resource management scheme and more flexible network architecture, and help operators to provide flexible and fast business applications [7].

2.2. Switch
The baseband processing unit of 5G extended small base station is responsible for data distribution and merging. The switch can be implemented based on FPGA / ASIC, and its functions can include signal monitoring, scheduling and information description. According to the requirements of wireless access switch based on 5G small base station, its modules are divided into monitoring module, scheduling module and information description module.
(1) Monitoring module. The wireless access switch based on 5G small base station mainly includes the non blocking switching port and the monitoring port. The non blocking switching port can monitor the switching data, and the monitoring port can quickly transmit the data to the analysis and recording unit to monitor whether the switch can operate normally. There are two monitoring modes set on this port, one is monitoring the monitoring port, the other is monitoring the message. (2) Scheduling module. When there are less than two data sources in the monitoring port of the switch, monitoring scheduling is needed to monitor the data processing of all ports. Generally, there are two monitoring scheduling methods, one is priority, the other is no priority. (3) Information description module. The information description module is mainly divided into three parts: switch name, IP address and usage time. It can add, change and delete the information of the switch, and update the real-time data. According to the use time of the switch, monitor the IP address and location, and query.

2.3. RF processing unit
RF processing unit is the core of the system positioning and the whole identification system. Radio frequency processing unit is a non-contact intelligent radio frequency identification technology, which can obtain relevant abnormal data by detecting radio frequency signals, and has the advantages of high security and fast transmission speed. The unit is mainly composed of RF processing reader, electronic tag and reader. The electronic tag can bear the relevant information, while the reader can receive the RF signal, and the RF processing reader is responsible for reading, writing and data transmission of the relevant data. The hardware design of RFID module for RF processing is shown in Figure 2.

As can be seen from Figure 2, in the hardware structure of the whole identification module, the master read-write module and the slave read-write module are composed of RF chip, clock module, Transceiver RF antenna and peripheral impedance circuit, and the general structure is similar.

3. System software design

3.1. Data monitoring of power grid wireless access based on 5G small base station
In view of the situation of the data mutation in the switch, the reliability factor is introduced to improve the real-time monitoring technology, which solves the problem that the monitoring results may be changed due to false data.
Set $a$ as the data generated by the switch; $\gamma_1(a)$ is the normal reliability of the data generated by the switch; $\gamma_2(a)$ is the credibility of the switch when it generates abnormal data; $S(a)$ is the credibility of abnormal data and $\gamma_2(a)$ virtual conversion coefficient. The formula is as follows:

$$S(a) = \frac{N(a)}{M(a)}$$ (1)

In formula (1): $N(a)$ is the number of alarms that data $a$ affects monitoring; $M(a)$ is the total number of data $a$ impact monitoring.

### 3.2. Implementation of wireless access environment in power grid application scenarios

Based on the monitoring results of 5G small base station power grid wireless access data, the open architecture wireless access network is defined. Using programmable software protocol stack, access network data can be extracted according to business requirements, and access network capacity can be opened. In addition, it is necessary to realize the dynamic handover between indoor small base station and outdoor macro base station, so as to achieve the best balance between user coverage and capacity, so as to maximize the spectrum efficiency of operators, support higher level data use, and meet the growing expectations of customers for high-quality experience.

### 4. Experiment and analysis

In order to verify the rationality of wireless access system architecture design in power grid application scenario based on 5G small base station, the experimental verification analysis is carried out.

#### 4.1. Testing environment

Select 2 test stations in Guangzhou intensive urban area, respectively represented by site A and site B. The distance between station A and station B is 2.1 km, and the station information is shown in Table 1.

| Tab 1 Information of two test sites | Base station | Station A | Station B |
|------------------------------------|--------------|-----------|-----------|
| Antenna height /m                  | 100          | 50        |
| Antenna azimuth °                  | 360          | 360       |
| Antenna inclination °              | 5            | 5         |
| Working frequency /MHz             | 1785-1790    | 1785-1790 |
| Feeder length /m                   | 60           | 75        |
| Working condition                  | Normal       | Normal    |

#### 4.2. Experimental results and analysis

**4.2.1. Coverage test**

Considering that the power grid works in 1800 MHz band, COST231-Hata propagation model can be used to calculate its coverage. COST231-Hata model path loss formula:
In formula (2), $L$ is the median value of basic propagation loss in urban area; $f$ is the working frequency; $h_b$ and $h_m$ are the effective height of base station and mobile station antenna respectively; $a$ is the antenna height correction factor of mobile station; $d$ is the propagation distance; $\gamma$ is the long-distance propagation correction factor; $C$ is 0 in medium-sized cities and suburbs and 3 in dense urban areas. According to this formula, the coverage radius of power grid with omni-directional antenna in dense urban area is obtained through comparative analysis using data transmission radio, GPRS public network and wireless access system based on 5G small base station. The comparison results are shown in Figure 3.

As can be seen from Figure 3, the horizontal coverage radius of the digital radio is 14.5cm, and the vertical coverage radius is 9.6cm; the coverage radius of GPRS public network is 7cm in horizontal direction and 6.5cm in vertical direction; the coverage radius of the wireless access system based on 5G small base station is 15cm in horizontal direction and 15cm in vertical direction, which is larger than the coverage radius of data transmission station and GPRS public network. Therefore, the coverage radius of the system is larger.

4.2.2. Capacity test

The system capacity test is mainly from the perspective of throughput, using data transmission radio, GPRS public network and wireless access system based on 5G small base station respectively. The throughput of power grid with omni-directional antenna in dense urban area is obtained through comparative analysis, and the comparison results are shown in Figure 4.
As can be seen from Figure 4, with the data radio access mode, the throughput is in the range of 19-40KB in the static scenario and 36-54KB in the dynamic scenario; using GPRS public network access mode, the throughput is in the range of 22-36KB in static scenario and 38-54KB in dynamic scenario; using 5G small base station wireless access system, the throughput of static scenario is in the range of 26-33KB, and that of dynamic scenario is in the range of 45-59KB. Therefore, the system is stable and consistent with the ideal situation.

5. Conclusion
In 5G deployment scenario, the active small base station for indoor coverage becomes one of the important technical solutions. Among them, 5G extended small base station can be used as a breakthrough to open the access network. At the same time, the introduction of 5G small base station can also provide the foundation for more open, intelligent and customized wireless access network. The architecture design of wireless access system in power grid application scenario based on 5G small base station can effectively provide open access network capability, and contribute to the collaborative development of future network and application by enriching local applications. This article summarizes and looks forward to the current architecture and deployment scenarios of 5G small base stations based on general-purpose servers. In the aspect of virtual facility management, the existing management methods are temporarily used, and the actual needs are not analyzed. This aspect needs further exploration.

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