Research on The Wireless Communication Scheme of Substation Full Coverage

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Abstract. In order to meet the mobility and Broadband communication requirements of smart substation, this paper proposes a wireless communication scheme based on Wireless-Fidelity network for substation all-domain coverage, and makes an in-depth analysis of network performance. In this way, a communication scheme suitable for specific electric power application scenarios can be created, which can effectively improve the basic support capacity of information communication.

1. Introduction
Information and communication infrastructure is the key to realize two-way flow of information in smart grid. The traditional communication mode of substation relies on wired communication and power line carrier to realize the service carrying for the measurement and control devices of substation and the primary equipment state information monitoring, etc. This communication network is difficult to deploy and construct, and has high management and maintenance cost [1]. With the development of smart substation, mobile and broadband requirements are generated, such as mobile inspection, equipment state information monitoring, power infrastructure video, emergency communication, which puts forward higher requirements for communication network coverage [2]. Combined with the transmission wired network, wireless full-coverage network should be set up in the substation, it will satisfy the access of large bandwidth service, large connection service and mobility service through heterogeneous communication mode. Finally, a smart substation with ubiquitous access, efficient transmission, massive heterogeneous information processing, safe control and intelligent control of equipment is constructed.

2. Performance Comparison of Wireless Communication
The scenario of Substation power Internet, including various types of connection communication requirements, which is mainly about indoor perception and monitoring services, and the delay is required in seconds. There is a big difference in bandwidth requirements. The high-bandwidth business needs such as robot mobile inspection, while the equipment and environment-aware business have low bandwidth requirements. Some of the Dynamic environment sensing devices are battery-powered and sensitive to power consumption. The communication bandwidth and power consumption requirements of different business terminals in the substation vary greatly, and different wireless connection technologies are needed to provide a perfect overall solution. Therefore, the wireless coverage scheme of the substation needs to be supported by multi-standard communication means [3]. The parameters of mainstream short distance wireless communication technology are shown in Table 1.
Table 1. Comparison of mainstream short-range wireless communication technologies

| Wireless technology | Frequency                      | Data rate       | Power consumption/mA | Communication distance/m | Number of connected devices |
|---------------------|-------------------------------|-----------------|-----------------------|--------------------------|-----------------------------|
| WiFi                | 2.4GHz, 5GHz                  | 11-54Mbps       | 10-50                 | 50                       | 255                         |
| ZigBee              | 2.4GHz                        | 100Kbps         | 5                     | 5-300                    | 216-264                     |
| IrDA                | Near-infrared band            | 16Mbps          | 8                     | 0.1-1                    | 2                           |
| Bluetooth           | 2.4GHz                        | 1,2,1.3Mbps     | 20                    | 10                       | 7                           |
| UWB                 | 3.1GHz, 10.6GHz               | 53-480Mbps      | 10-50                 | 0.2-40                   | 7                           |

3. Principle of Scheme Design

Substation wireless network design should meet the following principles:

- **Principle of Safety**: In order to ensure the security of information transmission, authentication access and encryption transmission technology should be adopted to prevent attacks.
- **Principle of reliability**: To ensure the signal quality of the network and avoid single point of failure, redundant backup is adopted in management, data and authentication. In case of network failure and authentication failure, corresponding backup strategy and escape strategy are adopted[4].
- **Principle of easy maintenance**: The equipment should be convenient for management, centralized authentication, unified system configuration, unified monitoring of equipment parameters, data flow, system performance, and can be remote management and fault diagnosis[5].
- **Principle of extensible**: The network should be extensible to meet the needs of the foreseeable future, such as the expansion of the bandwidth and equipment, mobile place extension.

4. Principle of Scheme Design

Combined with the performance advantages of wireless Wireless-Fidelity network, the auxiliary communication network within the scope of the substation is constructed to provide channel support for substation operation and maintenance. The whole area of the substation adopts wireless AP deployment to achieve full coverage of the substation and provides real-time uploading of equipment detection and patrol data. At the same time, it provides information transmission channel for remote expert guidance and remote fault diagnosis.

4.1. The overall architecture

The wireless communication network with full coverage of substation can be divided into three layers, namely, wireless access layer, secure access layer and network service layer. The specific network structure is shown in Fig.1.
The first layer is wireless access layer, by the deployment of a certain number of wireless access points, hereinafter referred to as the AP, which connect user terminal data to the wireless network. Then AP upload the data to the aggregation device through wireless channels, and the wireless aggregation devices transmit the data to the data aggregation switch through network wires or optical fibers, so that the data aggregation of all users can be processed together.

The second layer is the security access layer. Due to the high security requirements for wireless service access, network security equipment, such as network gate or firewall, can be set up between wireless access layer and the network business layer, which to isolate and filter the data entered by the wireless access layer to meet higher security requirements.

The third layer is the network service layer, where the data connected to the lower layer are processed centrally, such as data bandwidth limitation, packet security detection. Devices include Wireless-Fidelity voice service server, video monitoring server, data service gateway.

Wireless network deployment using wireless access controller and wireless wireless access points, the core switches using two devices, virtualized into a device by stacking logic. The core switch is equipped with wireless controller, wireless management and access server to meet the wireless network management requirements and users' security access requirements. The power over Ethernet switch is connected with the core switch by dual links with 10MB optical fiber. The power over Ethernet switch provides power for wireless access points through Ethernet ports and realizes data transmission.

4.2. Protocol selection
The substation covers the Wireless-Fidelity network in the whole domain and adopts the 802.11AX protocol, which is significantly improved compared with the previous Wireless-Fidelity network performance. The performance pairs of several generations of Wireless-Fidelity protocols are shown in

Figure.1 Network structure diagram
Table 1. Through a series of new technologies and optimization means, such as high modulation order (1024 Quadrature Amplitude Modulation), upstream and downstream Orthogonal Frequency Division Multiple Access technology, upstream and downstream Multiuser Multiple Input Multiple Output technology, space multiplexing technology, Wireless-Fidelity 6 improves the wireless network in terms of speed, access density and coverage distance.

| Protocol          | WiFi 4   | WiFi 5   | WiFi 6   |
|-------------------|----------|----------|----------|
| Spectrum          | 2.4GHz   | 5GHz     | 2.4GHz   |
| The maximum bandwidth | 40MHz   | 80MHz    | 160MHz   |
| The highest modulation | 64QAM  | 256QAM   | 1024QAM  |
| Single current bandwidth | 150Mbps | 433Mbps  | 1200Mbps |
| The largest bandwidth | 600Mbps | 3466Mbps | 6933Mbps |
| Maximum spatial flow | 4x4     | 8x8      | 8x8      |
| Multiuser Multiple Input Multiple Output | N/A     | N/A     | Upside, downside |
| Quadrature Amplitude Modulation | N/A     | N/A     | N/A     |

5. Scheme Performance Analysis

5.1. Secure access spacing
   (1) Secure identity authentication mechanism
   The identity authentication mechanism based on SM2 algorithm supports CRL/OCSP to query the status of certificates, effectively preventing security risks such as identity fraud.
   (2) Session secret key update mechanism
   The session secret key adopts one secret at a time, and the key update strategy can be set according to needs, supporting the renegotiation of the shortest time interval of 1 minute.

5.2. Reliability management
   (1) Terminal access service mechanism
   Wireless management access server can carry out unified control and real-time monitoring on the equipment, and timely identify new terminals and find abnormal endpoints through a series of mechanisms such as active detection, deep scanning and risk handling by scanning endpoints in each area at a specified time or periodically.
   (2) Intelligent platform management mechanism
   The access server for wireless management can carry out integrated and centralized management of wireless equipment and wired equipment such as AC, FAT AP, FIT AP and mobile terminals in the network, and carry out alarm and monitoring of various performance indicators for the whole network equipment, so as to realize intelligent management of equipment through the integrated platform.

6. Conclusion
Based on Internet of Substation, this paper proposes a global coverage of the wireless communication scheme based on Wireless Fidelity - network for Substation, which meets the requirements of large bandwidth, low power consumption and other business terminal access. At the same time, this paper makes an in-depth analysis of the network performance, creates a communication scheme suitable for specific electric power application scenarios, and improves the basic support capacity of information communication, which has great research value.
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