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Research on the Application of 5G Edge Computing Technology in the Power Internet of Things

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***Abstract*—The basic guarantee factor for the construction of power Internet of Things is the comprehensive perception and interconnection of information. In the case of ensuring the normal operation of the power system, the efficiency and stability of the system should be improved as much as possible. With the digital transformation of the power grid, a large amount of data is generated by power terminals, which puts forward higher requirements on computing, storage, and network performance. Therefore, edge computing technology is introduced into the power Internet of Things. The edge computing framework proposed in this paper is based on the business needs of the power grid, and this paper describes the application of edge computing in typical scenarios such as transmission, substation, and distribution. edge computing has lower latency, higher efficiency, security protection and other performance. Therefore, the application of edge computing in the power Internet of Things is of great significance.**

Keywords— edge computing; power Internet of Things; condition monitoring; fault inspection;

I. INTRODUCTION

Power Internet of Things is the product of the integration of smart grid and Internet of Things[1]. Power Internet of Things provides effective support for the operation of power grid basic business[2]. Sensors, charging piles, intelligent substations, intelligent meters and other terminals in the power system in each link have achieved interconnection, which promote the intelligent and integrated construction of the power grid. In order to improve the intelligent level of the power grid and the operating efficiency of the power system, strict requirements are put forward in the aspects of positioning, identification, detection, monitoring and patrol inspection.

With the development of the Internet of Things and the access of a large number of intelligent terminals[3], power Internet of Things terminals generate massive amounts of data, which are all transmitted to the cloud server for processing, but the cloud server cannot carry the communication pressure brought by massive data and the demand for computing resources of power business. The main existing problems are as follows:

(1) The storage demand of massive data: there are many data types and large amount of data, and the storage pressure of cloud platform is great;

(2) Real-time: delay-sensitive services cannot be well supported;

(3) Bandwidth demand: alleviate network congestion caused by massive uploads to the cloud;

(4) Security: communication security, physical security, etc.

Edge computing, as a key technology of 5G, provides an effective solution for it. Edge node, as the "cerebellum" of the Internet of Things, is the server with independent access and computing capacity. The role of edge computing in the power Internet of Things depends on the wide deployment of edge nodes, and edge side devices are part of the "last kilometer" of the power Internet of Things service users. Edge computing is a distributed computing mode[4]. Edge computing provides real-time computing and communication services to terminals by deploying edge servers close to the terminals. Edge computing and cloud computing is a complementary relationship, edge computing by deployed near the edge of the data source server computing and storage resources [5], edge computing expands the cloud computing resources of the power communication network center to the edge of the network, so that they can better support power information system of real-time data processing, in order to meet the different needs of the business of power systems, and to cooperate to complete the business assigned by the power grid.

This paper describes in detail the application of 5G edge computing technology in the power Internet of Things, in generation, transmission, distribution and consumption of four links, the data processing and applications run down by the network center to the edge nodes, a large number of business on the edge of network end, which reduce the burden of core network and reduce the bandwidth resource utilization, making the edge data

more secure.

II. Power Internet of Things based on Edge Computing

A. Overview of Edge Computing Technology

The Edge Computing Consortium (ECC) explicitly states the concept of edge computing: The network edge side nodes close to the data source are used to process and analyze the data. The network edge side can be any functional entity between the data source and the cloud computing center, which carries the edge computing platform that integrates the core capabilities of network, computing, storage and application. The edge computing platform architecture is shown in Figure 1.

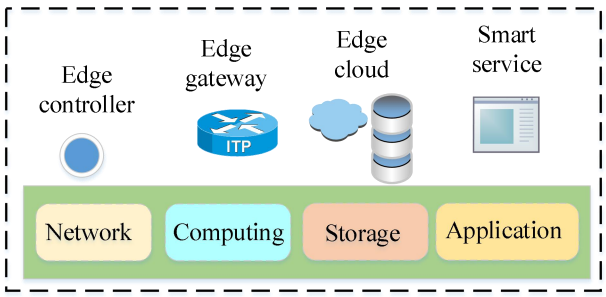

Fig. 1. The edge computing platform architecture.

Edge controller: through the integration of network, computing, storage and other ICT capabilities, with autonomous and collaborative capabilities.

Edge gateway: through network connectivity and protocol conversion functions connecting the physical and digital worlds, providing lightweight connection management, real-time data analysis, and application management functions.

Edge cloud: an intelligent system is constituted based on the collaboration of multiple distributed intelligent gateways or servers, providing elastic expansion of network, computing and storage capabilities.

Intelligent service: based on the unified service framework driven by model, it provides the development service framework and deployment operation service framework for system operation and maintenance personnel, business decision makers, application developers and other various aspects.

The key technologies of edge computing include: first, virtualization technology; Second, distributed storage and management. Edge computing is applied in the scenarios with low delay, high bandwidth, high reliability, massive connection, security protection and other characteristics [6], such as intelligent transportation, smart city and smart home industries or other fields. Advantages of edge computing : (1) Real-time performance. Data processing is closer to the data source, reducing transmission delays. (2) Less network traffic. (3) Lower costs. (4) Higher operating efficiency. (5) Higher safe.

Edge computing processes data in two main parts: one is the downlink cloud service, and the other is the uplink Internet of Everything service. Cloud computing is centralized computing[7], while edge computing is distributed computing. It is a new architecture developed in response to the explosion of modern data volume, which is closer to the edge of network. Edge computing is a supplement of cloud computing and optimization, edge computing expand the cloud computing network computing model[8], edge computing is based on cloud computing, with huge amounts of intelligent terminals for the front perception end, by means of optimizing the allocation of resources, to achieve more efficient intelligent computation, storage, transport and other services[9]. Further meet the industry digitization in real-time business, data optimization, application intelligence, security and privacy protection needs.

B. Overview of Power Internet of Things

Power Internet of Things is the application of Internet of Things technology in smart grid. It is an important measure to realize future energy internet convergence to build a widely interconnected power Internet of Things and deeply integrate it with strong smart grid. Power Internet of Things can realize the comprehensive perception of state information of various power equipment, and sharing of information and data, thus effectively improving the efficiency of power grid operation and the level of user experience.

Power system involves various links of generation, transmission, substation, distribution, electricity consumption and dispatching, which can be roughly divided into three categories: the first is the data of power grid operation and equipment detection or monitoring; The second is the marketing data of electric enterprises. The third is the power enterprise management data. The application of Internet of Things technology can improve the level of equipment condition monitoring, intelligent management, distribution network scheduling and emergency repairing, scheduling and operation management, etc., so as to realize real-time monitoring, management information and lean of power grid.

The business of power Internet of Things has the following categories : (1) Patrol inspection business. Patrol inspection is the inspection of power lines and equipment by the inspection personnel. Failure should be reported in time, and the remote dispatching command center will issue the maintenance plan, and the maintenance personnel will carry out the maintenance according to the steps. This process requires lower communication delay and higher reliability. (2) Unmanned aerial vehicles(UAVs) patrol inspection business. UAVs carry images and other recording equipment, which are widely used in the inspection business of transmission lines, poles and towers. UAVs carry ultraviolet equipment to detect the discharge

conditions of transmission lines, which improves the quality and efficiency of line inspection. Especially in difficult environments, it can greatly reduce the labor intensity of manual labor. (3) Video surveillance business. To avoid missing critical information and improve staff efficiency. (4) Internet of Things sensor services. Most of the substations are unmanned, and the environment and equipment data inside the substation are collected in real time through sensors.

C. Power Internet of Things Architecture based on

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recognition system, the automatic collection of transmission line the abnormal information identification is realized. Using the edge computing technology, the transmission of sensory data through gathering node to the Internet of Things, the operation and maintenance personnel can clearly identify the defects of transmission lines, helping the operation and maintenance personnel to complete the large-scale rapid survey of transmission lines, guiding the precise operation and maintenance, and so that improve the inspection efficiency of transmission lines. Transmission line inspection based on edge computing can effectively reduce the consumption of resources and time. The typical application scenario architecture of transmission based on edge computing is shown in Fig. 3.

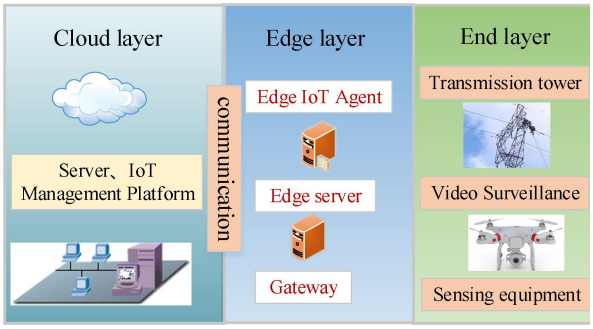

Fig. 3. Architecture of typical transmission application scenarios based on edge computing.

B. Substation Application Scenarios

Edge Internet of Things agent equipment is deployed in the substation, all kinds of sensing devices are installed, and patrol inspection robots are configured to realize a comprehensive perception of the running state of equipment. The warning of abnormal equipment is realized through edge computing, and the upper application such as multi-form intelligent fault warning and decision-making is supported. The analysis of demands for substation business in edge computing are shown in Table 2.

TABLE II. ANALYSIS OF SUBSTATION BUSINESSES

Business demands	State perception and comprehensive monitoring of substation equipment
	Intelligent inspection of substation
	Active early warning of equipment defects and intelligent fault decision-making

Take substation fault inspection as an example. In recent years, robots inspection has been applied in substation inspection. However, with the construction of power Internet of Things, it is urgent to integrate edge computing technology to improve the efficiency and intelligence level of inspection operation. Using the edge computing model, image and video monitoring data are connected to the edge Internet of Things agent and transmitted to the Internet of Things management platform through wired or wireless networks to realize the functions of substation equipment status perception, data fusion analysis, intelligent risk prevention and control, etc. The visual monitoring data of the device should be uploaded to the video monitoring host, then connected to the unified video platform, and the analyzed effective data should be uploaded to the Internet of Things management platform, so as to carry out intelligent decision-making analysis on the edge agent node and reduce the communication between the edge agent and the central node. The typical application scenario architecture of substation based on edge computing is shown in Fig. 4.

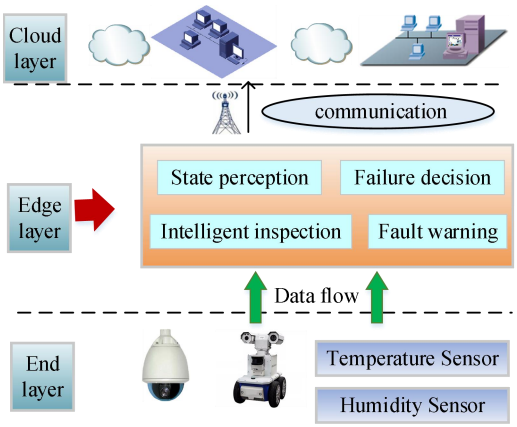

Fig. 4. Architecture of typical substation application scenarios based on edge computing.

C. Distribution Application Scenarios

The distribution room is the part connected between the whole power system and users. All kinds of sensor equipment are installed in the distribution room. By collecting the operation information of power equipment and environmental information in the distribution station, an autonomous and controllable power distribution Internet of Things is formed. Through the local analysis and processing of edge computing, the Internet of Things can deploy the edge Internet of Things agent teminals in the distribution pad, so that comprehensively perceive and monitor low-voltage distribution transformers, intelligent switches and other equipment. The precise fault location and remote intelligent operation and maintenance management of distribution station are realized by edge computing. The analysis of demands for distribution business requirements in edge computing are shown in Table 3.

TABLE III. ANALYSIS OF DISTRIBUTION BUSINESS

Business demands	Automatic recognition of low-voltage topology in station area
	Power quality analysis
	Proactive reporting and diagnosis of power outage information
	Accurate fault location

Taking low-voltage fault precise positioning scenario as an example, the core of intelligent distribution station is

edge computing node, which will dock with various sensor devices in the station and collect real-time operation data and fault information data of terminal devices. Combined with the edge computing technology, the edge computing function is used to make preliminary analysis and judgment of the data, and the warning information can be pushed to the mobile terminal of the operation and maintenance personnel in real time, and the remote real-time shooting can be started in time, so as to realize accurate fault positioning, active order dispatch and accurate emergency repair. The typical application scenario architecture of distribution based on edge computing is shown in Fig. 5.

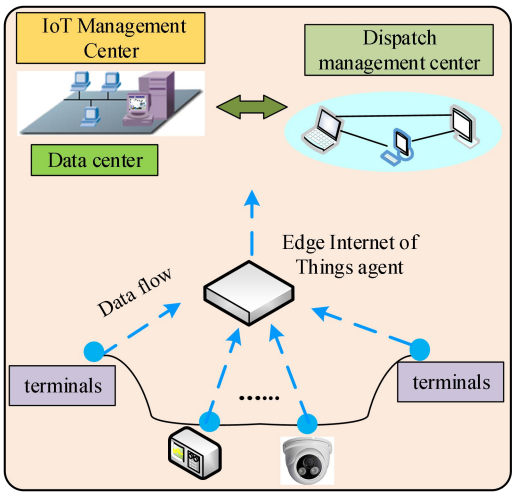

Fig. 5. Architecture of typical distribution application scenarios based on edge computing.

D. Grid Condition Monitoring

Grid status monitoring mainly uses sensor equipment to obtain equipment status and environmental weather related data during the operation of the grid. Edge computing is used in power grid status monitoring, real-time sensing of cable operating parameters, and converged to edge Internet of Things agents through wired or wireless methods. The edge Internet of Things agent performs edge computing on the aggregated information and then performs data interaction with the Internet of Things management platform. By processing the data on the edge side, sharing the computing tasks of the cloud platform, so as to realize the evaluation, diagnosis and prediction of the power equipment status, and fully, timely and accurately understand the operation status of the power grid. The typical application scenario architecture of grid condition monitoring based on edge computing is shown in Fig. 6.

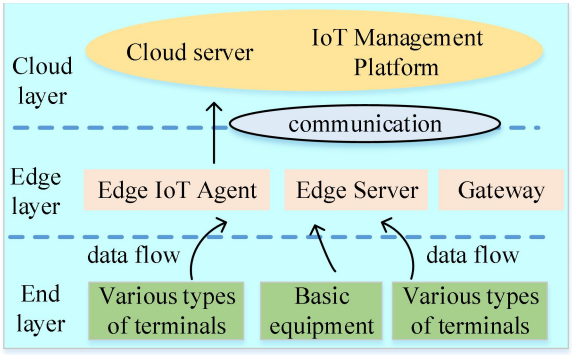

Fig. 6. Architecture of typical grid condition monitoring application scenarios based on edge computing.

IV. Conclusions

Edge computing presents a strong market demand in the Internet of Things and other fields. Edge computing, as a key technology of 5G, plays an important role in the development of the power industry. Edge computing plays an important role in the comprehensive perception of terminal state information and efficient information processing. This paper designs a power Internet of Things platform architecture based on edge computing. Edge computing is widely used in typical business scenarios of power grid. Edge computing can not only improve work efficiency and relieve the pressure on the core network, but also data is only exchanged between the source device and the edge device, which is more secure. It effectively solves the contradiction between limited cloud computing resources and high communication demand, and can meet the key demands of power grid in accurate perception, unified Internet of Things, edge intelligence and other aspects. Edge computing plays an important role in the development of the power Internet of Things.

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