Design and Analysis of Optimized Power Internet of Things System Based on Edge Computing

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ABSTRACT

In the development of China's power Internet construction, in order to better meet the characteristics of network transportation, the key technology to the edge computing framework as the core has been highly valued by the power industry. Nowadays, the professional information systems of China power grid Co., Ltd. have problems such as information cannot be shared and the level of intelligent management and control is low, which requires the power industry to create a smart iot system with existing technical means. On the basis of understanding the current operation status of the power network system, this paper mainly studies the optimized power Internet of Things system architecture and application functions based on edge computing, and then discusses the application effects of relevant technical functions combined with practical cases, so as to prove the application advantages of edge computing framework in the current power Internet of Things system.

Keywords: edge computing; Electricity; Internet of Things; Intelligent interconnection; Multiple perception

1. INTRODUCTION

In 2020, China Power Grid Co., Ltd. proposes to create an international leading energy Internet enterprise with Chinese characteristics, actively integrate, and promote the construction of strong, smart grid and power Internet of things. In this context, the scale of China's power grid infrastructure is getting larger and larger, and the requirements for project management ability are getting higher and higher. Because the power grid construction is mainly based on transmission and transformation projects, the on-site construction has the characteristics of long lines, many points and wide areas, so the relevant management work faces many challenges. Although the rapid development of the new generation of information and communication technologies such as mobile communication, edge technology and cloud computing has provided more innovative means for engineering construction management, which can support the gradual improvement of engineering site management level, there are still many problems that need to be solved from the perspective of practical application. Through the installation of various sensors and edge computer frames in the computer engineering site, the automatic perception and information collection of construction site staff, mechanical equipment, applied materials and other elements can truly realize on-site data analysis and closed-loop processing, and finally form a collaborative interactive system with cloud measurement platform as the core, and create a smart Internet of Things system for power grid infrastructure. Comprehensively improve the on-site management level of power grid projects, and provide abundant power energy for the public.

According to the construction and application of China's power Internet of Things system in recent years, the on-site management elements of power grid infrastructure projects are regarded as the basis, and the actual construction needs of the Internet of Things are divided into the following contents: First, personnel detection management. As the basic condition of power engineering construction management, this element can effectively control the identity, arrival status and operation status of employees by monitoring the identity, real-time location and image information of on-site staff. Second, environmental monitoring and early warning. This element is reflected in all aspects of power engineering management, such as meteorological environment, harmful gases, environmental cleanliness and address status, etc. By collecting relevant data and information, an effective power engineering construction management plan can be formulated as soon as possible; Third, supervision of high-risk links. This element is closely related to the safety of power engineering, including the operating state of the lift, the operating state of the tower crane, the online monitoring

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of the deep foundation pit, the safety of the distribution box and the safety of electricity consumption, etc., through the real-time grasp of the video images during the operation of the power system, the safety and effectiveness of the construction and operation of the project can be fundamentally guaranteed; Finally, the quality inspection monitoring analysis. This element is closely related to the quality of power transmission and transformation projects, including building infrastructure, applied technical materials, etc., and staff can use modern advanced technology for online management. Through the systematic understanding of the development of China's power enterprises in recent years, it can be seen that in the face of increasingly fierce competition in the market environment, how to show the technical advantages of the power Internet of things and the rational use of edge computing framework design innovation are the main issues comprehensively discussed in the power industry. Therefore, after understanding the basic concept of edge computing framework and the current operation status of power system, this paper mainly studies the architecture and application function of optimized power Internet of Things system based on edge computing, and then discusses the application effect and unique value of relevant technical theories combined with practical cases, in order to provide technical support for the innovative development of power industry in the new era.[1-3]

2. METHODS

2.1 Edge Computing

In essence, edge computing is mainly used for real-time, short-term big data analysis, which can effectively support local businesses to achieve intelligent processing goals. Nowadays, when scholars at home and abroad study the key technologies of edge computer, they mainly start from the following aspects: First, how to improve the technical performance. In the face of load requirements in different situations, scholars will put the allocation priority and weight in the first place, and propose the optimal choice based on the allocation strategy. Secondly, how to ensure technical security. In the face of resource and environmental constraints, edge devices should optimize and innovate according to system operation on the basis of ensuring data security, and always pay attention to changes in the network edge environment. Finally, how to show the technology interoperability type. The equipment manufacturer can ensure the interoperability of the system and heterogeneous edge devices by formulating corresponding cooperation protocols and standards.[4-6]

2.2 Intelligent Gateway

From the functional point of view, the smart energy gateway is mainly divided into the following contents: First, in the process of collecting electric energy hamster, the pre-design time interval; Secondly, when transmitting energy, it is not only necessary to change the voltage and Gree appliances, but also to truly realize the controllable energy flow direction. Thirdly, the rational use of edge gateway to process data information can further improve power quality and ensure that the power grid system has a strong self-healing ability; Finally, the information flow will effectively control the energy flow, and the energy flow will have a restrictive effect on the information flow.[7-9]

2.3 System Architecture

In order to fully demonstrate the application value of edge computing technology and build a smart energy gateway that meets the operation requirements of the power system in the new era, after understanding the basic concepts of edge computing, the corresponding system architecture and application are created according to the characteristics of the smart energy gateway, as shown in Figure 1 below. It includes power load metering unit, edge computing server, data remote transmission unit, metadata management platform and login management unit.

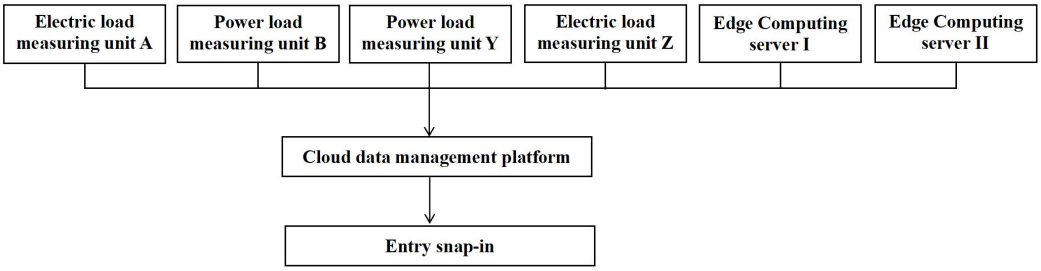

Figure 1. System architecture diagram.

The sensing layer corresponds to sensors, intelligent terminals, monitoring equipment and control equipment, All the technical equipment at this level needs to rely on certain modes of communication, For example, power fiber or wireless

LAN is connected with the edge computing layer and computer layer servers; The hardware layer includes security chips, storage units, master chips, etc., The communication module is divided into two forms: local communication and remote communication; The software layer includes the system kernel and the drivers, Software belongs to the core of the edge-computing framework, Mainly support the effective management of edge nodes, And the edge nodes can provide various functions for the edge computing, For example, it can be computable, interactive, perceptible, etc. The core framework of edge calculation is shown in Figure 2 below:[10-12]

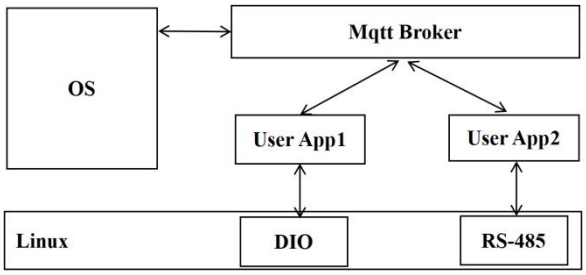

Figure 2. Core frame diagram of edge computing.

3. RESULTS ANALYSIS

3.1 Case analysis

In order to verify the application value of the optimized power Internet of Things system based on edge computing, this paper takes the system operation of a regional power company co., Ltd. as an example to conduct verification analysis, mainly discussing the function, performance, non-functional, application scenarios and other pilot work of the system. When verifying the basic functions of the edge framework, we should start with the device access capability, device management capability, data collection and analysis, App management, data communication capability, etc., as shown in Table 1 below:

Table 1. Functional test analysis content.

Test item	Test point
Device registration and access	After registering devices on the platform function page, devices can access the platform: Batch register all registered devices, and all registered devices can connect to users platform
Object model definition	Object model supports multiple levels; Attributes defined by the model can be added, modified, and deleted: the format of the rows should be standardized Model definition and distribution Object model distribution Model definitions can be issued to edge iot agents: After modification, model definitions should be updated to edge iot agents
Data error retransmission	Support data error retransmission Data distribution State change Data reported by terminal devices can be distributed to different message queues and databases: Valid data can be directly used by upper-layer service applications Data subscription Data can be directly subscribed by business applications Send data command Supports upper-layer applications to send data commands and consume messages through API interfaces Firmware upgrade Firmware upgrade The platform upgrades the firmware of a single or a batch of devices
Manage the APP on and off shelves	APP remote configuration for a single iot agent: APP remote configuration for multiple iot agents is supported Rule engine APP version management Support APP version management, including single device and batch device Rule configuration Add, modify, and delete rules: Enable and stop rules Class SQL syntax and basic semantic operations The rule description supports SQL-like syntax and basic semantic operations Operation and maintenance management Operation and maintenance management View and download the run logs of platform services, edge iot agent devices, and terminal devices: The installation and upgrade of platform services are required to support automated operations

The non-functional test analysis should start from the special application requirements of the power Internet of things, including remote debugging, remote monitoring, reliability and security of the edge framework, etc. From the perspective of practical application, based on the provincial iot management platform, key systems such as edge things and Internet agents are deployed on the site of power enterprises. On the basis of unified edge computing framework and equipment physical model, make full use of local equipment resources to upgrade hardware and software, time color and power system operation data, through the display of real-time analysis, real-time perception, fault analysis and other

basic functions, so that production data and marketing data can be integrated, further improve the efficiency of power system operation. At the same time, the pilot construction work refers to a series of new technologies and theories of power Internet of things, including edge computing, Internet of Things platform, wireless private network, etc., which not only improves the perception ability of the user side of the system, but also truly realizes the lean measurement and management of line loss.[13]

In the process of construction and operation, the minute-level acquisition scheme based on edge computing is reflected in the following points:

First of all, the minute level acquisition task of the meter is set up in the collector, focusing on adding multiple modules such as pre-acquisition, asynchronous response and storage. Secondly, in the collector to concentrator communication channel, the carrier parallel penalty mode is used to improve the utilization efficiency of the channel. Here, the application of edge iot agent overall management system environment, fully demonstrate the application functions of prototype upgrade and online management, reduce the work pressure of the main station computer; Finally, enter the provincial iot management platform to provide equipment management, data acquisition, public perception and other functions to further improve the efficiency and quality of power iot system operation.

3.2 Development Countermeasures

First, provide technical support for the operation of the power grid system. When using edge computing to optimize the design of power Internet of Things system, it is necessary to analyze the data according to the internal and external environmental data changes, look at the technical conditions, propose an executable, quantifiable and decomposing enterprise development strategy system, and quickly formulate evaluation objectives during the implementation of the strategy, so as to provide effective management decisions for the development of power enterprises. At the same time, when creating a data-driven operation analysis system, it can truly realize the continuous sharing of information and data in all links, promote the efficient collaborative operation of cross-professional and cross-department, and further improve the operation efficiency of the power Internet of Things system.

Second, attach importance to the construction and management of network infrastructure. On the basis of fully supporting the access of various intelligent terminals, make full use of various communication resources such as wireless functions to encourage users to provide suitable connection methods, speed up the replacement of old information and communication equipment, orderly complete the internal system upgrade and transformation work, diagnose and solve the security faults within the system as soon as possible, and ensure that the power grid itself has adaptive ability and self-healing ability.

Third, strengthen the security of the power Internet of Things system. In the application of security protection technology in network system, the more common forms are authentication technology, protection mechanism, intrusion detection and encryption technology. As wireless communication is the main factor leading to network security problems, the use of various authentication protocols to fill or detect the loopholes in network security can ensure the safety of system operation, improve the efficiency of system detection, and lay a foundation for the implementation of power industry business.

4. CONCLUSIONS

In summary, in the context of the construction and promotion of power Internet of Things, the reasonable use of edge computing framework to build a suitable power Internet of Things system is an effective countermeasure to guide China's power industry to build a smart Internet of Things system and truly achieve the sustainable development goal. The edge computing technology framework proposed in this study has completed the basic design of edge computing and cloud-edge interaction in an orderly manner, clarified the intelligent ecology and construction objectives of cloud-edge collaboration, and provided technical support for the construction and development of international leading energy Internet enterprises with Chinese characteristics. From the perspective of long-term development of electric power enterprises, the optimized design of electric power Internet of Things system based on edge computing has great economic and social benefits, and should be paid attention to in the future social construction and development.

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