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Cloud-Edge Collaborative Scheduling with a Focus on Clean Energy

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Abstract: With the promotion of the national "double carbon" goal, the power system is developing towards the direction of low-carbon transformation. In order to achieve the goal of "striving to peak carbon dioxide emissions by 2030 and striving to achieve carbon neutrality by 2060", we must actively promote the consumption of a high proportion of renewable energy from the grid, which is the most urgent issue to be addressed. In this chapter, access to clean energy will involve multiple aspects such as source, network, load and storage. However, due to the intermittent, random and volatile nature of wind power and photovoltaic power generation, the challenges faced by significant users of the power system are enormous. Traditional energy Internet dispatching adopts centralized dispatching. In this paper, by deploying edge nodes, the autonomous decision-making and autonomous collaboration of power grid nodes at all levels are enhanced, and the collaborative integration level of source, network, load and storage of smart power grid is improved. Aimed at the current power supply and demand imbalance, new energy access problems and energy storage problems. In this paper, a service adaptation algorithm based on dynamic priority is proposed based on the scenario of load storage integration of source network under renewable energy access. Experimental results show that, compared with other algorithms, this algorithm has lower scheduling time and execution time and better performance under the condition of ensuring the highest clean energy consumption rate and first-order load priority response.

Keywords: Clean energy; Cloud-edge; Smart grid; Collaborative scheduling.

1. Introduction

The edge node is the key node for the safe, reliable and fast operation of smart grid. Based on the reasonable allocation of dispatching strategy, through the interaction and real-time analysis of information flow, it can directly absorb the power generation of clean energy. When the power generation of individual clean energy fluctuates, intermittently or uncontrollably, the remaining available energy can be actively and intelligently allocated according to the demands of users at the load end, so as to respond to the multiple demands of users at the load end in the shortest time, conveniently and flexibly. It is critical to match the right source and storage resources for load users to improve service quality and make full use of renewable energy.

In recent years, there have been many researches on the power dispatching strategy of the access source of renewable energy. In order to meet the requirements of renewable energy access to GNLS scenarios, the distribution network needs to improve the utilization rate of clean energy, ensure safe and efficient operation, and realize flexible source-charge interaction. In addition, it also needs to coordinate the export of excess power. It is necessary to adopt new information interaction scenarios between different energy output terminals and loads with different dynamic priorities. It is also necessary to improve the scenario of energy supply and demand negotiation, so as to improve the information blocking caused by centralized allocation. On the premise of ensuring the security and reliability of the multiple deployment network, it meets various service requirements as far as possible, and improves the transmission efficiency and control level of real-time data at the source, storage and load ends.

With the continuous development of the power industry, Multi-Access Edge Computing (MEC) will become a new development direction in the field of smart grid. Edge computing technology can process a large amount of data generated at the edge of the network, bring computing resources closer to the terminal device, shorten the transmission distance of data, and improve the security and privacy of data. The main idea of MEC is to move computing tasks from the central network to the edge network to reduce computing latency and achieve efficient utilization of computing resources. Combined with the progress of communication technology, the combination of smart grid and edge computing technology can reduce the difficulty of device access, improve the ability of protocol conversion, enhance the ability of smart grid to access different kinds, different versions or different structures of data, effectively solve the problem of data isolation, and improve the data processing efficiency of smart grid. While multi-access edge computing has been used in small mobile devices, face recognition, speech recognition and smart healthcare, it has not been widely used in smart grid.

2. Related Work

In recent years, edge computing as an important part of smart grid system has attracted wide attention. The integration of edge computing and power grid can improve efficiency, enhance reliability and reduce operating costs. Next, the research status of edge computing in power grid in recent three years is briefly reviewed, with emphasis on some important contributions in this field. The basic structure is shown in the Figure 1.

With the continuous penetration of renewable and distributed energy sources, the grid is becoming more decentralized and dynamic, posing significant challenges to traditional centralized control and management methods. Several studies have proposed different architectures and frameworks for integrating edge computing into grid operations. For example, Carlos et al. [1] propose a cloud-edge-fog architecture for smart grid systems that uses edge computing for real-time data processing and decision-making, and weather data to predict power consumption. Li et al. proposed an edge cloud architecture for power grid monitoring, using edge devices to collect and process data, and using cloud servers for long-term storage and analysis [2]. Similarly, Chouikhi et al. proposed a layered edge computing framework for distributed energy management in microgrids, which utilizes edge devices for local control and optimization, and cloud servers for global coordination and planning [3].

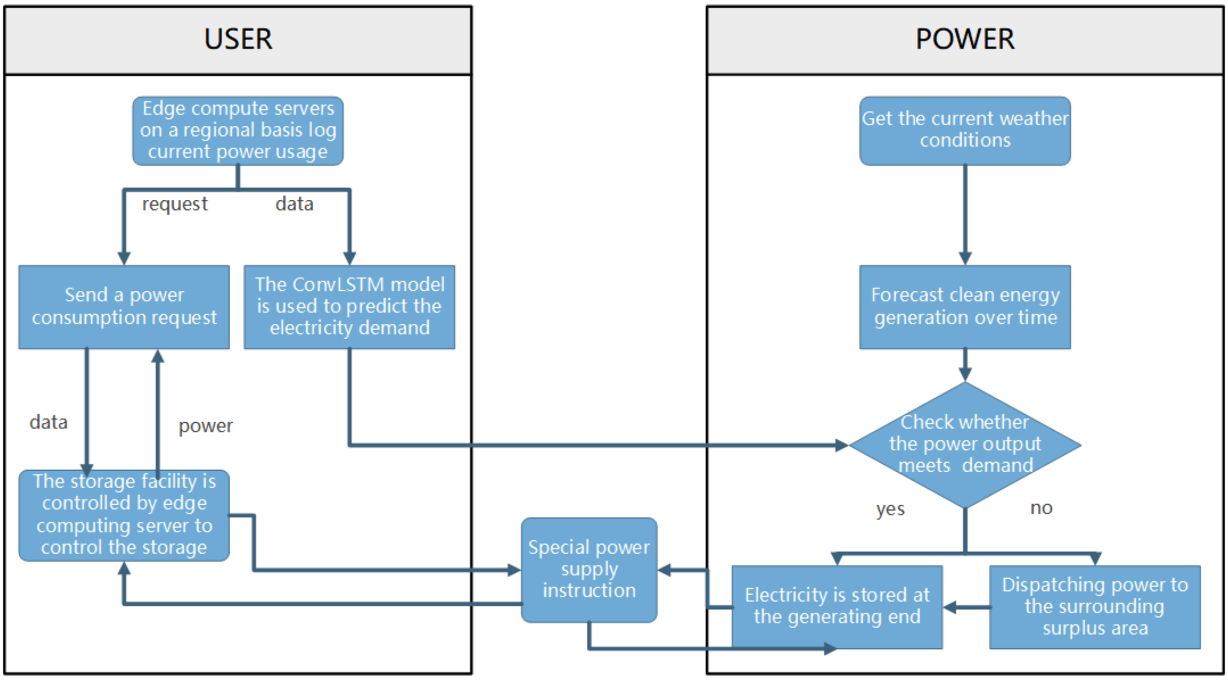

Fig. 1 The basic structure

Edge computing enables multiple applications and use cases in power grid operations, including fault detection and diagnosis, demand response, energy management, and predictive maintenance. For example, Sairam et al. proposed an edge-based power transformer fault detection and diagnosis system that utilizes machine learning techniques to analyze transformer data in real time [4]. Karakolis et al. also proposed an edge-based intelligent building demand response framework, which uses edge devices to detect and respond to changes in energy demand [5]. Dong et al. proposed an edge-based microgrid energy management system, which uses reinforcement learning technology to optimize energy management [6]. Wang et al. proposed an edge-based predictive maintenance system for power equipment, which utilizes machine learning technology for early fault detection and diagnosis [7].

Security and privacy are major concerns in the power grid as the amount of data generated by edge devices increases. For example, Ren et al. proposed a secure and privacy-protecting data sharing framework for microgrid distributed energy management that utilizes blockchain technology [8]. Eskandari et al. proposed an edge-based intrusion detection system for power systems, which uses machine learning technology for real-time threat detection [9]. Gai et al. proposed an edge-based data privacy protection framework for smart grid systems using homomorphic encryption [10].

Energy efficiency is a key consideration in grid operation, and edge computing can improve energy efficiency by reducing cloud surface data transmission and processing. Several studies have investigated the energy efficiency of edge computing in grid operation and suggested different solutions. For example, Li et al. proposed an energy-saving edge computing framework for power grid monitoring that utilizes machine learning techniques to optimize data processing and transmission [11]. Qin et al. proposed an energy-saving edge computing framework for smart grid demand response based on dynamic voltage and frequency scaling [12]. Broring et al. proposed a network aware edge computing framework for power systems, which uses a software-defined network approach for effective network management [13]. Lu et al. proposed an edge-based communication system for distributed renewable energy systems, which utilizes cognitive radio technology for effective spectrum utilization [14].

3. Advantages of deploying edge nodes

Edge Computing is a distributed computing architecture that improves the efficiency and security of data processing by placing data processing and storage resources as close as possible to Internet of Things (IOT) devices, user terminals and service providers to reduce latency and network bandwidth requirements during data transmission. Compared with traditional centralized cloud computing, edge computing pays more attention to real-time computing, data processing and storage on edge devices. The main goal of edge computing is to improve computing efficiency and response speed by distributing computing resources close to the terminal device, reduce the cost of data transmission and network load, and better meet the needs of users for low latency, high bandwidth and security.

With the development of the Internet of Things technology, more and more devices, sensors and systems can be interconnected, thus generating a large number of sensor data, device data, behavioral data, environmental data, etc., featuring diversity, timeliness and real-time. However, in order to be used effectively, these data must be collected, stored, transmitted, processed, analyzed and other links, among which data transmission delay and bandwidth bottleneck is one of the biggest problems. The edge computing framework comes into being to solve these problems. The edge computing framework reduces data transfer and processing latency by distributing computing tasks and data processing to edge devices and nodes closer to the user. Features include high efficiency, real-time performance, low delay, reliability and security. By adopting distributed computing and data processing, edge computing can realize faster processing and analysis of real-time data. In addition, edge computing can improve the efficiency of data processing and reduce the stress and cost of the central server.

The rapid development of electric iot cannot be separated from the support of edge computing technology. By deploying edge nodes, large amounts of data can be preprocessed, which enhances the speed of processing valid data in the cloud center and provides a faster and more accurate understanding of the power demand at the load side. Because it is closer to the user, it can receive feedback from the load user more efficiently, thus improving the quality of service. If edge nodes are properly deployed in GNLS and data preprocessing is completed at the edge, the burden of cloud center can be significantly reduced and the working efficiency of GNLS can be greatly improved. Deploying edge nodes in GNLS enhances the system's responsiveness to load users and improves user experience.

Edge computing reduces latency by processing data closer to the source rather than sending it to a central location for processing; Allow local data processing and storage to enhance privacy and reduce the need to transfer sensitive data to a central location; Allows real-time data analysis, which is useful in applications that require fast decisions or responses; Allow customizable analysis of data based on specific business requirements or use cases; Can reduce the time and resources required for data analysis to improve operational efficiency; By processing data at the edge, less data needs to be sent to the cloud or data center, reducing bandwidth requirements and reducing costs.

4. Conclusion

In order to achieve the goal of "carbon peak by 2030", renewable energy is incorporated into the load-storage integration architecture of the source network. However, it has problems such as intermittency and volatility, which threaten the safe electricity consumption of important users. Therefore, the text generates a dynamic priority based on the constraints of fixed priority, urgency and power consumption at the load end. With the goal of giving priority to the consumption of renewable energy, electricity demand is preferentially processed by the renewable energy generating end, forming a request queue mechanism. This paper presents a dynamic priority scheduling algorithm to optimize demand processing in distributed energy management systems. By adjusting the priority of power demand dynamically, the algorithm realizes the dynamic management of the system, thus improving the energy efficiency of the system and user satisfaction. The results show that the algorithm can effectively reduce the average response time and energy consumption of the system under different loads, and has good performance.

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