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Edge computing Helps the Development of Smart Grid

Sen Yang, Ruijuan Zheng

Henan University of Science and Technology, Luoyang 471000, China

Abstract: With the rapid development of smart grids, the number of terminals connected to them has sharply increased. Using these terminals, the smart grid management system can monitor real-time information such as power consumption and power quality in the power grid to ensure safe and stable operation of the power grid. However, the access of a large number of terminals has also increased the amount of data that needs to be processed in the power grid. The traditional centralized cloud computing model can no longer meet the needs of rapid data processing, and a new model is urgently needed to solve the problem. As an emerging distributed computing model, edge computing is an ideal solution to realize large-scale distributed management of smart terminals in the future smart grid by providing computing and storage capabilities at the network edge near device terminals and user sides, reducing data transmission delay, improving data reliability, protecting user privacy, and reducing the computing and storage pressure of cloud data centers.

Keywords: Edge computing; Smart grid; Cloud computing.

1. Introduction

With the rapid development of new energy technology, the Internet of Things technology, and the promotion of intelligent electricity business, more and more power terminals are connected to the smart grid [1]. According to statistics, by 2021, there will be 2.617 million charging poles in China's energy Internet serving nearly 8 million new energy vehicles, and 480 million smart meter serving users. With the help of these sensing devices and complex communication networks, the smart grid has become a multidimensional heterogeneous network with real-time and dynamic sensing capabilities [2]. The rapid increase in the number of power terminals and users in the smart grid has greatly affected the processing of user data and information, leading to a significant increase in the demand for computing and storage in the smart grid [3]. Fig 1. shows the number of public charging stations in China from 2018 to 2025.

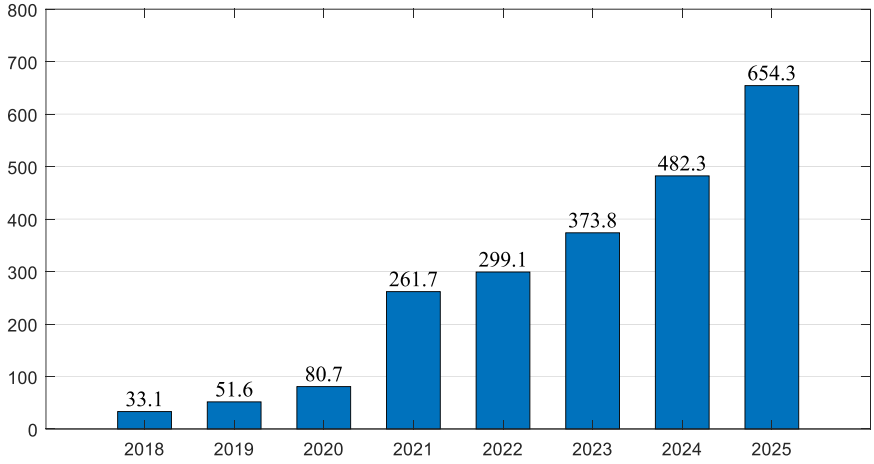

Fig. 1 The number of public charging stations in China from 2018 to 2025

The traditional cloud computing model belongs to a centralized computing model, where all data is uploaded to a remote data center for unified processing [4]. However, with the sharp increase in the amount of data collected by terminal devices and the rapid development of the Internet of Things, data presents characteristics of large scale and strong heterogeneity [5]. In this context, the linear growth of computing power in cloud computing cannot meet such needs. At the same time, the contradictions and alliances between heterogeneous data, as well as the requirements for real-time processing, have brought huge obstacles to cloud computing that cannot be solved [6]. In addition, for users at the edge of the network, the delay and privacy issues brought by long-distance transmission cannot be ignored, and more reasonable and reliable computing models are needed to compensate for the shortcomings of cloud computing [7].

As an emerging distributed computing model, edge computing provides computing and storage capabilities at the network edge close to the device terminal and user side, reduces data transmission delay, improves data reliability, protects user privacy, and reduces the computing and storage pressure of the cloud data center [8]. It is an ideal solution to achieve large-scale intelligent terminal distributed management in the future.

2. Advantages and Architecture of edge computing

Edge computing is a new type of distributed computing model. By computing and storing at the network edge near the device terminal and user side, it can reduce the pressure on the cloud data center, reduce data transmission delay, and

improve data reliability [9]. It is an ideal solution to realize distributed management of large-scale intelligent terminals in the future. Compared with cloud computing, edge computing has the following advantages: 1) low latency. Processing data near the data production location eliminates the need for communication with cloud computing centers through the network, greatly reducing system latency; 2) Relieve network bandwidth pressure. The large amount of data generated at the edge is processed at the edge and no longer uploaded entirely to the cloud, greatly reducing the pressure on network bandwidth and data centers; 3) Safe and reliable. Edge computing no longer uploads user data, but stores it on the network Edge device, reducing the risk of network data leakage and protecting user data security and privacy. These advantages make edge computing very suitable for real-time, short cycle data analysis and processing, local decision-making and other scenarios [10].

Edge computing processes data at the terminal node as much as possible, so that data and applications can get rapid response and processing. The hierarchical architecture of edge computing can be divided into three layers: terminal layer, edge node layer, and cloud data center [11]. The architecture is shown in Figure 2.

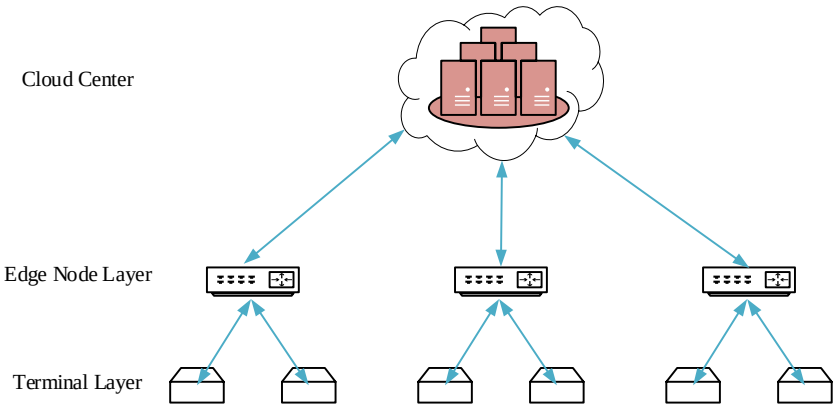

Fig. 2 The architecture of edge computing

Terminal layer: consists of various IoT equipment terminals (such as smart meter, sensors, cameras, etc.), which mainly collect original data and transmit it to the edge node layer.

Edge node layer: the node layer is composed of reasonably deployed edge computing nodes to provide users with computing and storage capabilities at the edge of the network and achieve rapid response to services.

Cloud Data Center: For tasks with higher dimensions and more complex calculations, edge nodes upload them to the cloud computing center for execution. At the same time, the cloud computing center has global information of the system, which can dynamically adjust and allocate resources to the edge node layer.

3. Application of edge computing in Smart Grid

The increasing number of access terminals in the smart grid has also made the logical topology structure of the smart grid communication system very complex. For example, the distributed energy generation, energy storage, and state information between users in the smart grid are dynamic and constantly changing, requiring appropriate methods to manage these power terminals and information. Edge computing is an ideal way, and its distributed characteristics are very suitable for building smart grid communication systems. Figure 3 shows an edge computing smart grid model with a three-tier architecture [12]. The smart grid layer is composed of terminal devices and power users from different communities. Such as user's smart home, smart meter, etc. This layer is responsible for communication between power terminal devices. The edge node layer is composed of edge nodes and electronic devices that interact with them, enabling data storage, analysis, transmission, and management. Compared to cloud centers, edge nodes have limited computing and storage capabilities. Therefore, in order to ensure that data in the smart grid can be processed, the top level is set as a cloud server, which can further process, analyze, and store the data selected and sent by edge nodes.

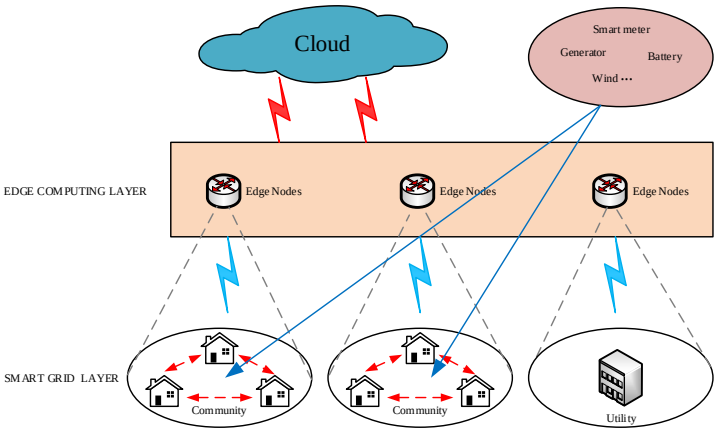

Fig. 3 The edge computing smart grid model [12]

For users and grid managers, the communication and information processing of the power grid need sufficient

security, so the secure communication of smart grid based on edge computing is also very important. Blockchain, as a decentralized technology, has been widely used in data encryption. Figure 4 shows a blockchain based smart grid communication encryption framework [13]. In this framework, blockchain plays a role in encrypting data communication through transactions and smart contracts.

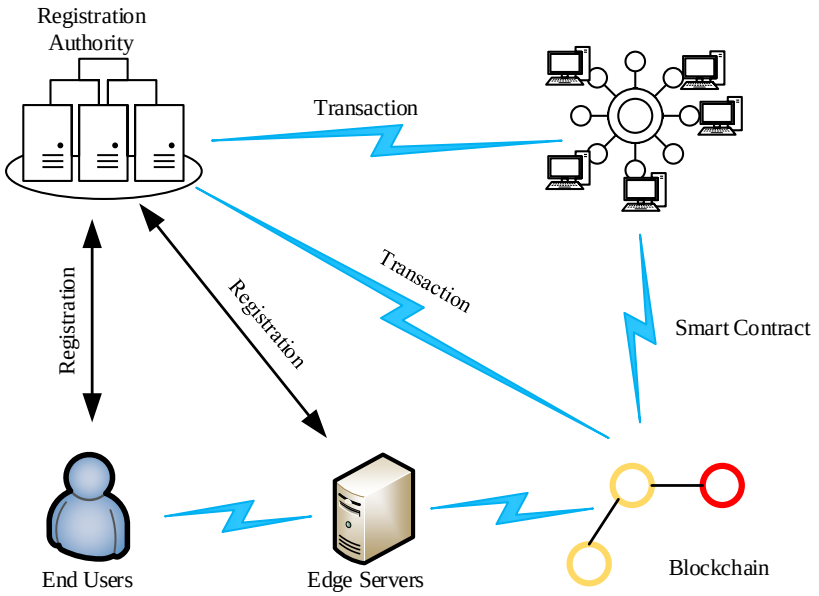

Fig. 4 The blockchain based smart grid communication encryption framework [13]

4. Summary

The rapid increase in the number of terminals connected to the smart grid has led to an increase in the amount of data that needs to be processed in the grid, and the logical topology of the power grid communication system has also become very complex. The traditional centralized cloud computing model can no longer meet the needs of rapid data processing. As a promising computing paradigm, edge computing can reduce data transmission delay, improve data reliability, protect user privacy, and contribute to the safe and efficient operation of the smart grid by providing computing and storage capabilities at the network edge near the device terminal and user side.

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