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# A REVIEW OF THE APPLICATION OF EDGE COMPUTING IN SMART GRIDS

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**Abstract:** In recent years, with the rapid development of Internet of Things technology, edge computing has received more and more attention and has been used in many application fields. Certain research results have been achieved. The development of the Internet of Things has promoted the development of smart grids, and the surge in data volume in smart grids has given rise to edge computing. applied research in computing. The relationship between edge computing and smart grid is analyzed, the supporting technology after edge computing is introduced into smart grid is discussed, and the development This paper expounds the typical applications of edge computing in smart grids from four aspects: electricity, power transmission and transformation, power distribution and power consumption. Finally, it puts forward the current application of edge computing in smart grids. pressing issues facing the energy grid.
**Keywords:** Internet of Things; Edge computing; Smart grid; Artificial intelligence; 5G

## 1. INTRODUCTION

The rapid popularity of IoT devices has brought edge computing, a lightweight, low-latency data processing technology, into people's attention. edge meter Computing is different from cloud computing, which sinks computing resources to the edge, where data is generated, and performs part or all of the data processing at the edge. management to improve system performance, ensure data security and reduce costs. because of The characteristics are consistent with the Internet of Things, and edge computing has become the development trend of the Internet of Things. One of the important supporting technologies for development [1]. Out [2]. 2016 Year 5 In September, Professor Shi Weisong from Wayne State University in the United States A formal definition of edge computing is given, namely: "Edge computing refers to the A new computing model that performs computing at the edge of the network, edge computing operations The objects include downstream data from cloud services and data from the Internet of Everything upstream data from connected services, while the edge of edge computing refers to the data from the data source Any computing and network resources on the path to the cloud computing center are a continuum [3]. " 2018 In 2017, China Edge Computing Industry Alliance launched It is mentioned in the published white paper that edge computing has the following basic characteristics and attributes: Characteristics: connectivity, first entrance to data, constraint, distribution and integration. It also emphasizes the collaborative development of edge computing and cloud computing. development, edge computing and cloud computing are not antagonistic, but complementary. Edge-cloud collaboration will amplify the application value of edge computing and cloud computing and provide important support for the development of the Internet of Things [4].

according to IDC predict, arrive 2022 years, more than 50% of the data will be in the data It is generated outside the data center and cloud and processed externally [5]. 2025 years, there will be more than 55% of the data consists of IoT Equipment is provided and there will be 416 billions of IoT devices generated 79.4ZB of data [6]. The Internet of Everything has become an inevitable trend, followed by the intelligence of life and the advancement of industry. Automation, of which the most representative one is "everything in the smart grid" interconnected".

## 2. THE RELATIONSHIP BETWEEN EDGE COMPUTING AND SMART GRID

Smart grids use widely deployed distributed intelligence and broadband communications to and the inheritance of automatic control systems to ensure real-time market transactions and seamless connections and real-time actions between members on the power grid [7]. "

Smart grid is the integration of new technologies such as information technology into traditional power grids, making the power grid easier to manage while improving the economics of the power grid benefit. The surge in data volume is part of the transformation from traditional power grids to smart grids. This is an important feature. The current power grid data shows the following characteristics [8] :

1) There is a lot of data collection, and the sampling scales of different collection points are different. Depending on the section, each collection point collects relatively fixed categories of data, and Distributed in various voltage levels;

2) The data is incomplete, and there are errors and missed transmissions in data collection;

3) Data is distributed in different application systems.

While the amount of data is surging, the transformation of traditional power grids is also subject to some The influence of other factors, such as power generation method, electricity consumption method, etc. [9]. For electricity To solve the above-mentioned data problems existing in the Internet, cloud computing has been introduced in recent years. perform data processing, but cloud computing has its disadvantages, such as high transmission costs, Poor timeliness, etc. To solve these problems, edge computing is introduced into the smart grid. It has become an inevitable trend to apply edge computing to smart electronics. The network has the following 3 an advantage [10].

1) Improve performance. With edge computing, it is possible to analyze data in milliseconds Analyze and process data collected at the edge. For example, in a wind farm, if the wind If the speed and wind direction change, edge computing software can analyze these changes in real time. data and adjust the turbines to optimize overall wind farm production, and Only the fused data will be sent to the cloud, which greatly Reduced communication bandwidth and data transfer time. In addition, the turbine The machine will generate terabytes of data during its working cycle, and these data It is technically feasible to send it to the cloud for analysis, but its daily Operating costs are too high. With edge computing, users can finally get everything from turbines to Machines capture streaming data and process it in real time to prevent unplanned downtime and extended device life while reducing data sets to more manageable sizes Small for transmission to the cloud.
2) Ensure data security and privacy. Edge computing moves computing closer to the device and avoid uploading data to the cloud, which allows This greatly reduces the possibility of private data being leaked or damaged during transmission.
3) Reduce operating costs. Cloud computing connectivity, data migration, Bandwidth and latency characteristics make cloud computing very expensive to use, and Edge computing can significantly reduce operational costs by reducing bandwidth requirements and latency time cost.
Edge computing is the best way to solve the problem of data explosion in the power grid. One of the best methods, and smart grid is also considered to be the best for edge computing One of the landing scenes. Already done globally After more than ten years of smart grid construction, with the continuous application of new technologies, smart The connotation of the power grid is also constantly developing. In our country, 2019 Year, State Electric Network Co., Ltd. proposed to comprehensively accelerate the construction of ubiquitous power Internet of Things Strategic deployment [11]. 2021 In 2018, State Grid Corporation of China released its action plan, which called for promoting the power grid to move toward the Energy Internet and striving to create a clean Clean energy optimization allocation platform [12]. Along with a series of national strategic ministries With the implementation of power deployment, the establishment of ubiquitous power Internet of Things has become an inevitable trend. potential, and edge computing is its important carrier.

## 3. SUPPORTING TECHNOLOGIES FOR EDGE COMPUTING

Applying edge computing to smart grids must consider its practical application feasibility. The vigorous development of edge computing is inseparable from its two supporting technologies. technology, one is the chip technology that provides it with powerful computing power, and the other It is a communication technology that provides short-distance, low-latency information transmission.

### 3.1 Chip Technology

Deploying computing power on edge nodes has two basic requirements for its processor: Require:
1) Strong enough computing power. The edge server must have certain computing power It can support the fusion of heterogeneous data and basic data processing. management, or can be equipped with a trained artificial intelligence model. Update it A deeper requirement is to be able to deploy neural networks for real-time training and feedback.
2) Low enough power consumption. The capabilities of edge nodes and edge servers The battery capacity is generally limited, and the cost of reactivating it after the battery is exhausted is relatively high, so it is low Power consumption is a necessary requirement. Table 1 For some of the more advanced embedded chips at home and abroad in recent years data comparison. With the widespread application of edge computing, many chips Manufacturers have begun to design dedicated chips for edge computing, among which Intel Britain Terr designed a device called " Movidius" ” Neural Compute Stick with Raspberry Pi 3 Model Used together to analyze live images and videos Objects in the computer, this computing stick can perform model training directly on the end, and has It has the embedded characteristics of low power consumption [13]. To implement deep learning algorithms in IoT Applications in Devices, NVIDIA The company launched NVIDIA Jetson TX 2 and DRIVE PX2 development kit, this kit enables implementation based on low Power consumption and real-time deep learning for multi-object visual tracking.

**Table 1** Embedded chip comparison

| model | company | Main frequency | Number of cores | B |
|---|---|---|---|---|
| Maxwell | NVIDIA | 921 MHz | 128 | 0.5TFLOPS |
| Movidius™ Myriad™ X | Intel® | 700 MHz | - | 4+ TOPS |
| Kirin 9000 | Huawei | 3. 1 GHz | twenty four | Mali-G78,Kirin Gaming+ 3.0 |
| T3 | Quanzhi | 1.2 GHz | 4 | Mali400MP2 Architecture |

Our country has also conducted a series of research on edge computing hardware development. Research, among which China Southern Power Grid launched the country’s first power-specific main control chip “Fuxi” based on domestic command architecture and domestic core. "And will achieve mass production in the near future," Fuxi The successful research and development and mass production of " are of great significance to the independent control of science and technology in the fields of national power, energy, information security, and industrial control. Tencent has launched its product "Visual Seed" through which developers can easily call face detection at the edge, recognition, registration, pose, attribute and other algorithms.

### 3.2 Communication Technology

Cloud computing has high requirements on network and communication, and edge computing Computing also has higher requirements for communication, but it is lower than cloud computing and more similar to cloud computing. in Wireless Sensor Networks (WSN). The main object served by edge computing is uplink data from Internet of Everything services. Produced by sensors and requires a high-speed, low-latency communication method Uploaded to edge servers, thus a communication suitable for edge computing Technology is crucial.
The application scenarios of edge computing have the following characteristics:
1) The edge server is physically located close to the edge node;
2) Edge nodes have multiple access methods, and mostly wireless Enter, such as 4G, WiFi wait;
3) Edge nodes have limited energy;
4) The number of edge nodes is huge.
It can be found by comparing 5G Ten application scenarios with edge computing points of agreement. 5G The system is a variety of wireless access technologies that can satisfy sensor Multiple access methods; 5G There are macro sites responsible for basic coverage, and there are also Low-power micro-stations that undertake hotspot coverage are physically topologically connected to edge Similar to edge computing, the significant increase in the number of base stations can meet the coverage of large-scale edge nodes; 5G Technology with self-organizing network, through self-organizing network Organization, clustering, cluster head election and other methods can reduce edge node energy consumption and delay Long service life [14].
against 5G The integration with edge computing has already achieved certain results at this stage. Results. literature[15] discusses the role of MEC (Mobile Edge Computing) in the network deployment and its 5G the possibility of fusion, whereby a fusion is proposed MEC The future 5G mobile communication network architecture is expected to meet the Video services and new services bring high backhaul bandwidth and low latency requirements.

## 4. TYPICAL APPLICATIONS OF EDGE COMPUTING IN SMART GRIDS

Edge computing technology has developed a closer relationship with smart grids. Combining smart power generation, smart power transmission and transformation, smart power distribution and smart power consumption In other aspects, we have begun to gradually build a basic framework and implement simple application. Among them, the main application of edge computing in the fields of power generation, transmission and distribution is system control and monitoring. In the field of electricity consumption, edge computing mainly It should serve comprehensive energy services and power market transactions [16]. edge meter The main applications of computing in smart grids are as Table 2 shown.

**Table 2** Typical applications of edge computing in smart grids

| field | research direction | main application |
|---|---|---|
| generate electricity | System control and monitoring | Power generation forecast |
| Power transmission and transformation | | Intelligent operation and maintenance |
| power distribution | | Optimize scheduling |
| electricity consumption | Integrated energy services Electricity market trading | Collection of electricity consumption information and demand side management energy trading |

### 4.1 Smart Power Generation

Smart power generation is an important part of the smart grid, which aims to By configuring a large number of sensors to monitor the status of the generator, and will Electrical data is aggregated on edge servers, and the aggregated data is analyzed To provide support for subsequent power grid services [17]. Intelligent power generation at this stage The focus of field research has two aspects: on the one hand, it is to strengthen the understanding of the generator status status monitoring, fault diagnosis and fault prediction; on the other hand, virtual Research on virtual power plants, by constructing virtual power plants to gather distributed energy resources, Intelligent dispatch and power generation prediction are performed through the processing of edge data.
Fault diagnosis and fault prediction based on edge computing is the first application use form. In recent years, domestic and foreign scientists have carried out state monitoring of power generation equipment. conducted a series of studies. literature[18] In response to the increasingly common wind The power generation system designed a deep learning model based on cluster IoT for fault diagnosis and fault prediction. obtained by the sensor Real-time device data is input into the deep learning model for training, and the trained Good models are loaded onto edge servers for fault prediction and passed State feedback fault-tolerant control system to perform disturbance-free switching of faulty systems Change. literature[19] Based on weighted AAKR Algorithms establish the power generation equipment The state estimation model realizes the application requirements of offline modeling and online monitoring through the edge deployment of the model. Literature[20] designed a hydropower Dam safety monitoring system, using IaaS The model of cloud platform will be different The heterogeneous data of hydropower stations are integrated at the edge to provide intelligent big data Dam safety group control service.
Distributed energy applications based on edge computing are the second application form Mode. At present, distributed energy energy resources, DER) [21] has become a trend, in which distributed power generation systems have Entering into practical application as a supplement to traditional centralized single power supply system stage. Distributed generation aims to deploy smaller generation units closer to the site of electricity consumption The units are designed to cope with

short-term power peaks and meet the needs of specific users. With the increase of distributed devices, remote aggregation management and automatic Optimizing scheduling issues have become the focus of attention, and methods to deal with these issues One of them is virtual power plant (VPP) [22]. The concept of virtual power plant is to manage energy through information, control, communication and other technologies. Small-scale distributed energy resource aggregation controlled by management system machines A type of integrated power plant formed by 2 shown. All this The concept is similar to the concept of aggregation nodes in edge computing. In recent years, domestic Foreign scholars have conducted a lot of research on virtual power plants based on edge computing. and achieved a series of results. Literature [23] designed a multi-level collaborative virtual power plant reactive power optimization clearing model. This model uses edge computing to To evaluate and improve the reactive power service capabilities of distributed power generators in the form of By aggregating bank information and calculating the comprehensive reactive power quotation of the virtual power plant area, you can participate in the reactive power service market accordingly. Literature [24] uses the distributed model predictive control method to realize a distributed wind-solar hybrid power generation system. model, the proposed distributed model predictive controller can be trained according to To allocate the output power of each subsystem according to the power allocation principle, the Predictive controllers deployed into edge servers can achieve real-time power generation predictions. According to the literature[25] GA-BP Neural networks build photovoltaic power generation Power prediction virtual model and obtain sensor information in real time Updated to the database and achieved photovoltaic power generation through twin data Very short-term forecasts. Edge computing solutions for power generation mainly focus on virtual The construction of virtual power plant model and real-time analysis of equipment monitoring data, the construction of virtual power plant model effectively improves the power plant management level and effectively integrates With distributed energy, computing power is deployed in front-line power generation equipment and matched with actual The operating system can detect and process abnormal data in a timely manner and conduct risk management Warning and processing greatly reduce production risks.

### 4.2 Intelligent Power Transmission and Transformation

Power substation is an important part of the operation of the power grid. Substations serve as connecting power grids. The intermediate bridge in the network transmission and distribution link has special characteristics and ensures the safety of the substation. Stable operation has become a necessary condition to ensure high-quality power supply [26]. Edge computing also has broad scope for use in this field. Current edge count The main applications of computing in the field of power transmission and transformation are focused on power transmission and transformation equipment. Intelligent operation and maintenance [16]. For transmission lines, smart grid requirements guarantee the grid Overall monitoring of transmission line status and safety maintenance management of line safety Control [17]; for substation equipment, it should be based on cloud-edge architecture and use machine vision and image processing technology to monitor the entire substation in real time. Measurement, including power equipment status, personnel movement trajectory and production safety status State and so on [27].

Intelligent robots and drone inspections are the key applications of edge computing in the field of power transmission and transformation. The first type of typical application in the domain. For the field of power transmission, traditional transmission lines Inspection and maintenance of roads and substations rely on manpower, and with the development of technology, Using inspection robots and drones to conduct intelligent inspections has become a mainstream choice, but due to the data processing capabilities of current equipment, it is often Use an a priori approach to channel selection and path planning for inspection equipment. planning, and perform fault diagnosis through offline detection. With edge computing With the rapid development of the Internet, applying it to inspections can achieve the goal of online inspections. After potential hidden dangers are discovered, they can be processed in real time. By introducing Edge computing can significantly save time and cost and improve inspection efficiency. arts [28] proposed a channel based on reinforcement learning and Lipunov optimization. Select algorithms to achieve highly reliable and low-latency transmission of data through the edge Computing technology applies algorithms to inspection robots to realize online channels selection, this method can maximize the effectiveness of the inspection robot. arts presented[29] a two-layer heuristic algorithm based on edge computing, which improved the traditional The ant colony algorithm uses deviation to guide pheromone update and introduces The annealing algorithm is used to speed up the convergence speed and optimize the selection of inspection paths. Efficient substation monitoring system is the key to edge computing in the field of power transmission and transformation The second type of typical applications. In the field of power transformation, my country's power grid is widely distributed There are a large number of substations, so an efficient and economical substation monitoring solution is needed. Literature [30] designed a two-layer edge computing framework and resource scheduling method for substation drone inspection. According to the characteristics of drone inspection, Established a data model and inspection flow oriented to tasks and equipment to be inspected process; application Stackelberg multi-layer game algorithm uses calculation amount as resource allocation degree of pricing basis, integrating the IoT terminal's own data resources and computing resources as constraints for allocating resources, and verified through simulation that no The intersection point of the optimal price curves of human -computer and data analysis servers is the Nash equilibrium point of resource scheduling. Literature [31] designed a real-time monitoring system for substation equipment, which consists of two subsystems: infrared thermal imaging monitoring subsystem system and substation environmental monitoring subsystem, put these two subsystems into Edge servers can be effectively used to manage changes in large industrial organizations. power station. Cable joints are one of the most widely used components in power transmission and transformation in power plants. First, real-time monitoring of its status is crucial. Literature [32] designed a An edge computing-based detection unit using an adaptive fuzzy system (ANFIS) fuses the electric field and temperature field information of the cable head The combination realizes real-time intelligent sensing and monitoring of the operating status of cable joints.

At this stage, the main applications of edge computing in power transmission and transformation are focused on Equipment monitoring and maintenance, where computing power is applied to real-world applications through edge computing Time-based inspection is a hot topic of research, and online inspection can be realized through edge computing. Fault detection, real-time path planning, etc.

### 4.3 Intelligent Power Distribution

The power distribution field is the part of the power system connected to the user side. Smart grid requires optimal dispatch in the power distribution field, including equipment Monitoring, fault location and asset management of equipment and its operating status [17].

The status detection of power distribution equipment is an application of edge computing in the field of power distribution. The first type of application. One of the key points in establishing the ubiquitous power Internet of Things is the high To effectively utilize power distribution information, how to collect, transmit and analyze power distribution data and ensure the privacy of power distribution links are issues that must be considered. Literature [33] proposed a set of low-voltage smart station application design based on edge computing. Through the intelligent distribution transformer terminal, all electrical quantities and quantities in the low-voltage station area can be effectively monitored. Environmental data and realize local topology calculation and identification, branch line loss analysis Analysis and other functions, and this solution has been applied in multiple pilots and achieved good results. Literature [34] proposes an intelligent sensing terminal applied to distribution transformers to perform online inter-turn short circuit monitoring through edge computing. detection, cable latent fault detection and transformer loss monitoring, this method can Solve the blind zone problem of information perception on the high-voltage side of small-capacity distribution transformers. Literature [35] conducted a partial discharge edge measurement based on mean drift. Research on computational methods, using multiple partial discharge ultra-high frequency sensors to detect interference Joint positioning of interference signals can identify pulse-type interference signals, and the identification accuracy is 81.4%. Literature[36] proposed a new type of inspection network plan, passed The combined networking method of LoRa, power integrated data network, 4G/5G and edge part information processing are used to conduct in-depth evaluation of inspection equipment, which is beneficial to improving the efficiency of inspection of power distribution equipment.

Demand-side analysis is the second category of edge computing applications in power distribution. application. The demand side of the power grid is also where a large amount of data is generated, which can These data are processed through edge computing and collaborated through edge cloud way to support the distributed task processing needs of different users. literature [37] discussed various feasible routes to build the information system of smart grid. system, among which wireless sensor networks have proven to be the most suitable for future power grid development. network mode. Literature [38] evaluates three node selection methods, namely random selection, shortest estimated delay first and shortest estimated buffer first, Designed an edge node reconfiguration considering storage and computing resource constraints. Setting method, allocate services to designated edge nodes, improving the hit rate of nodes. Literature [39] designed a network-based method based on resource sharing. The betweenness size, computing performance and communication delay of nodes are used to find the cluster connections. Key fog nodes greatly improve service reliability. Literature[40] analyzed Edge computing task allocation and deployment method with minimized energy loss. arts [41] focused on business reliability and proposed an edge cloud Deployment method. Literature [42] introduces a northbound communication protocol based on The functional design and system design plan of the edge computing gateway are discussed and designed. And it was tested in an actual power distribution Internet of Things project, and the results reached expected.

Distribution network dispatching is also one of the key applications of edge computing, which is directly related to the operating efficiency of the power grid. Literature [43] uses a distributed state-aware source-grid-load-storage cooperative scheduling to more accurately control power distribution. network for scheduling and reducing scheduling losses. This collaborative scheduling method facilitates Taking advantage of edge computing, the scheduler is moved down to the network of edge nodes. In Guanzhong, the gateway of the edge node is geographically located in the center of the cloud computing data. The center should be closer to the power transmission and transformation equipment, thus effectively reducing data Transmission delay improves real-time performance, thereby reducing the power transmission and transformation process Power loss.

### 4.4 Smart Electricity Use

The main application areas of smart grid on the power consumption side can be divided into two parts: Branch: Integrated energy services and power market transactions. Among them, the comprehensive energy field Applications in the field mainly include low-voltage meter reading, electricity safety, and factory intelligent applications. electricity, smart home, smart charging, smart buildings, etc. [17]. The main applications of electricity market transactions include resource optimization allocation, active/reactive power market clearing, Ancillary service market mechanism, etc. [44].

The primary application of edge computing in the field of electricity consumption is comprehensive energy services. service. Comprehensive energy services for power consumption measurement, in order to avoid large amounts of data transmission The transmission causes the communication channel to be blocked, which satisfies the power Internet of Things' requirements for rapid response, Due to the special requirements of accurate execution, edge computing is generally introduced into the power Internet of Things. In the terminal equipment of the network. Literature [45] proposes an edge computing collaborative architecture for user-side intelligent power systems, which mainly introduces home appliance priority. The idea of ordering is to control the switch of home appliances according to priority to avoid Load power overload problem. Literature [46] designed an intelligent power management and control system based on edge computing, including a complete system architecture layer The design of secondary database and edge server was actually applied to the existing student apartment power management and control system, achieving good results. arts [47] proposed a terminal architecture for edge computing of the power Internet of Things. It has two major mechanisms: container start and stop, and computing resource allocation and recycling. It also proposes corresponding business timing logic and computing load model for terminal services. type, which strengthens the dispatching capabilities of smart grids at the power consumption end. Literature [48] designed a model based on the Model View Controller (MVC) programming model. Terminal service module for diversified load management, and then through Docker Come and match Set up edge servers to realize edge data processing of edge devices and Used in concentrator data interaction, it significantly improves the low-voltage meter reading system. work efficiency. Literature [49] proposed a hybrid solution to make Process data with cloud and edge computing. in close proximity to embedded devices and processing and prediction at the edge of the home versus putting all processing in the cloud Compared with medium, it can save latency and storage space.

Electricity market trading is another major application of edge computing on the power consumption side. field. By analyzing large amounts of electricity consumption data, resource allocation can be optimized for Provide data support for active/reactive power clearing. Literature [50] based on household microelectronics The network proposed a time-of-use electricity price and demand response strategy, by using edge As the core of "cloud, pipe, edge, terminal "Four-layer architecture to collect and process household electricity data and establish load models to achieve demand response and provide time-sharing Electricity pricing strategy.

## 5 THE URGENCY FACING EDGE COMPUTING IN SMART GRIDS QUESTION

At this stage, cloud computing has been widely used in all walks of life. Exploratory research on edge computing is also gradually unfolding, but edge computing as There are still some problems with this new computing model, such as the lack of unified A unique programming model, dynamic scheduling method, security standard, etc. [1]. At the same time, edge The application of edge computing is still in the initial stage of exploration, and edge computing is mainly As an adjunct to enhance existing programs. At present, edge computing has It has received full attention in the power grid field and has many application trials. tried, but also faced some problems during the exploration process. According to edge meter The integration characteristics of computing and smart grid are as follows: 3 question in the next few years Urgent needs to be solved in 2020: cloud-edge collaboration, data security, multiple heterogeneous data Fusion.

### 5.1 Cloud-Edge Collaboration

The combination of edge computing and cloud computing is the future development trend. situation, how to coordinate the two well and achieve optimal scheduling? has always been the focus of research.

Subject to the current research progress of edge computing, edge-cloud collaboration has not yet There are mature solutions, but domestic and foreign researchers have achieved certain Progress. Literature [51] proposed 6 A kind of cloud-edge collaboration technology, including resource collaboration, data collaboration, intelligent collaboration, business orchestration collaboration, application management collaboration and service collaboration, etc., and for this 6 A comparative analysis of the technologies. Literature [52] SDN The network is an effective solution to the problem of cloud-edge collaboration. It provides solutions to the challenges faced by cloud-edge collaboration. SDN solution decision slightly, but at this stage SDN There is still a single point of failure in the specific implementation of the network. efficiency, network scalability, API Many challenges and difficulties in interface standards and other aspects. Literature [53] constructs an optimization problem that minimizes the weight sum of all user task execution delays and energy consumption, and proposes an optimization problem based on this problem. A deep reinforcement learning algorithm for asynchronous cloud-edge collaboration, through deep learning To train a cloud-edge collaborative computing migration mechanism. This mechanism can Maximize the use of cloud and edge computing capabilities to achieve approximate greedy calculations optimal performance. Literature[54] has begun to explore the distributed third 6 Next-generation mobile communication system (6G) cloud-edge collaborative computing architecture, and mathematical modeling is given.

There is currently a lot of exploratory research on cloud-edge collaborative applications. There are many, but edge computing technology is far from mature, so cloud-edge collaboration is often in theoretical research stage. At the same time, most edge-cloud collaboration technologies are still unilateral. oriented research to achieve all-round collaboration of resources, data, application management, etc. This is the direction that needs to be addressed urgently.

### 5.2 Data Security

Edge Computing Security and Wireless Sensor Network (WSN) Security The research is closely related and can be divided into physical security and information security of nodes. Data security, in the field of edge computing security research, the physical properties of the node itself Security and communication security between multiple sensors are often not considered as a priority consider scope.

Research on edge computing security for smart grids is still in the In the preliminary stage, certain results have been achieved but a complete research body has not yet been formed. Tie. Literature [55] proposed a risk assessment model for the security of edge computing applications in the State Grid and gave its element hierarchy, and used AWVS, AppScan Waiting for tools Web Application security assessment. literature [56] proposed a security risk assessment method based on fuzzy level analysis. method, from the device layer, data layer, network layer, application layer and management layer 5 Aspects to conduct security assessment of grid edge computing. Literature [57] designed a complete set of combined weighting models and used an improved analytic hierarchy process to Determine the subjective weight, use the entropy value method to determine the objective weight, and construct Established a security assessment model for the power grid. Literature [58] compared popular one-time passwords (OTP) and analyzed identities suitable for smart grids. Authentication technology. Literature [59] introduced a blockchain-based mutual authentication and key agreement protocol to meet the security requirements of smart grids, which can effectively support Conditional anonymity and key management for grid edge computing.

Future research on grid edge computing security may focus on the following aspects: Aspects: Implement lightweight distributed data security protection system, explore Multi-entity identity authentication issues prevalent in edge computing, edge node Point of physical security protection and dynamic data security maintenance.

### 5.3 Multivariate Heterogeneous Data Fusion

A large number of sensors are deployed in smart grids to collect information and For target detection, due to the huge number of nodes, the data of each node needs to be transmitted transmitted to the convergence node, and a large amount of redundant information will be generated during the transmission process. information, resulting in a waste of communication bandwidth. To address this problem, logarithms are needed Conduct in-depth research based on fusion technology.

The traditional single data fusion method has certain limitations. In the face of In the case of multiple sensors, multiple data fusion algorithms must be used for optimization. Integrate potential to cope with. Data fusion can be divided into 3 information level, data Level fusion, feature level fusion, decision-level fusion, the mainstream fusion at this stage The technology is still data-level fusion, through genetic algorithm and fuzzy neural network The network can achieve feature-level fusion, and for edge computing, which is a direct aspect Device-oriented technology requires more decision-level integration, which is also an urgent need One of the issues to be solved.

## 6 CONCLUSION

This article introduces and summarizes the application of edge computing technology in smart grids. Using the current situation, the possibility of edge computing being applied in smart grids is analyzed. From power generation, transmission and transformation, distribution and consumption 4 An in-depth and comprehensive introduction to all aspects The application of edge computing in the power grid. Finally, some edges are listed Urgent issues facing computing in smart grids. Edge computing is the Internet of Things The product of network development, if you want to realize the Internet of Everything, you cannot do without edge computing. Therefore, if you want to build a complete ubiquitous power Internet of Things system, you must introduce edge computing. Generally speaking, the current application of edge computing in the power grid is The application is still in its preliminary stage, mainly focusing on the design of theoretical framework and Simple edge applications have not yet formed a complete architecture, and as technology With the rapid development of technology research, edge computing will be implemented more and more in the power grid. important role.

## COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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