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Research on Intelligent Distribution Network Architecture based on End-Edge-Cloud Collaborative Computing

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Abstract

The existing cloud computing-based distribution network architecture can analyze new applications, services, and intelligent collaboration with large amounts of data, but it is still limited by factors such as network flexibility, bandwidth limitations, and delay time. It is used in high-speed, low-latency, and real-time applications. The availability is greatly reduced. Based on the distribution network system of the traditional cloud computing framework, this paper proposes a distributed smart distribution network architecture based on end-edge-cloud collaborative computing, which has strong application value in the process of smart grid construction.

Keywords

Edge Computing; Cloud Computing; Collaboration; Smart Distribution Network.

1. Introduction

As a key link in power transmission, the distribution network is directly connected to users, and the intelligent and reliable operation of the distribution network directly affects the safety and stability of the power supply system [1]. With the advent of the 5G era, new technologies such as the Internet of Things, artificial intelligence, and big data are developing vigorously, and the intelligent distribution network must pursue a higher degree of intelligence and sensitivity [2]. In recent years, the technical characteristics and operation patterns of my country's distribution network have also undergone major changes.

In the past few decades, cloud computing, as the dominant computing paradigm [3], is widely used in distribution network systems, which can provide considerable computing power to process user data, and can provide users with flexible services through the wide area network. With the advent of the Internet of Things era, the exponential growth of smart mobile devices and data traffic has increased the burden on the Internet, and cloud computing has been unable to meet the latency-sensitive service requirements of Internet of Things applications [4]. Edge computing is a new type of distributed computing paradigm [5]. Edge computing extends cloud services to the edge of the network, and uses small-scale edge servers with limited computing resources to provide timely services to users on the edge of the network. The edge server can be an edge node, an advanced router, an edge gateway, and so on. Deploying edge servers in power distribution network substations can provide real-time services for delay-sensitive applications [6] in the Internet of Things environment.

Based on the distribution network architecture based on cloud computing, this paper proposes a smart distribution network architecture based on end-edge-cloud collaborative computing. It consists of large-scale cloud servers, a large number of edge computing servers deployed in substations, and humidity sensors, It is composed of temperature sensor, current leakage sensor, smart video sensor and other data collection equipment. The new architecture system

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has high data security, strong reliability, and strong decision-making capabilities, opening up broad prospects for intelligent dispatching and intelligent decision-making in the distribution network.

2. Traditional distribution network architecture based on cloud computing

2.1. Introduction to Architecture

The traditional distribution network system [7] relies on the two-level architecture of the cloud, which is mainly composed of two parts: data acquisition equipment and servers. The acquisition end mainly includes current transformers, voltage transformers, digital signal processors, and GPRS wireless transmission modules. The equipment performs digital collection and submits the collection results to the cloud computing center for processing. The traditional distribution network architecture based on cloud computing can be subdivided into three layers, namely the data acquisition layer, the network transmission layer and the application control layer. As shown in Fig. 1.

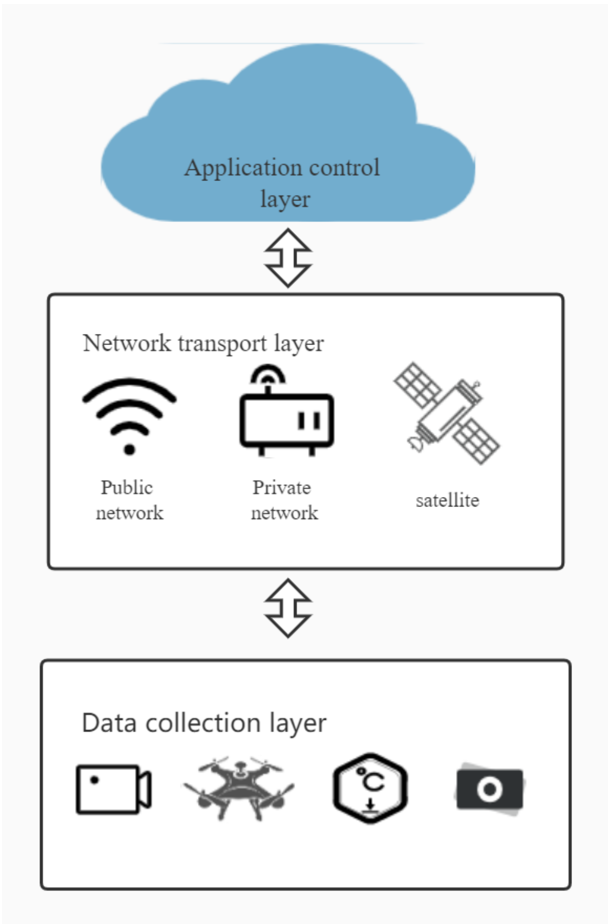

Fig. 1 Traditional distribution network architecture based on cloud computing

2.1.1. Data collection layer

This layer achieves the goal of using various collection devices to monitor and collect information in the distribution network system. It is composed of various data collection devices, such as various sensors, cameras, etc., in order to collect data. At the same time, it also has a communication module that connects the Internet of Things devices with the network layer.

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2.1.2. Network transport layer

The network layer is composed of a converged network formed by various telecommunication networks and the Internet. The network layer is widely accepted due to its mature technology. Its function is to map the information collected by IoT devices in the perception layer to a telecommunication protocol. Subsequently, it sends the mapped data to the application control layer through the relevant telecommunication network. The core network (the Internet) is responsible for routing, information transmission and control. The access network will be based on other telecommunication networks. The Internet of Things management and information center also belong to the network layer. The network layer can rely on public and industry-specific communication networks.

2.1.3. Application control layer

The application layer is the integration of cloud computing technology and industry expertise to implement various applications and systems. Its function is to process the information received from the network layer, and based on this information, it can monitor the distribution network equipment and environment in real time and perform troubleshooting and other tasks. The key elements provided by the application control layer are information sharing and security.

2.2. Related problems and shortcomings

a) High cost. Cloud computing needs to be equipped with a large data center. Faced with the ever-increasing amount of data, cloud computing also has high requirements for its own bandwidth speed. The maintenance costs of cloud equipment are very expensive.

b) High latency. Traditional cloud computing architecture requires high-speed processing and large-scale data storage capabilities, and cannot provide effective real-time services.

c) Low sensitivity. When power transmission lines, power distribution centers, etc. fail, it is difficult for cloud data centers to process and analyze massive amounts of data effectively and in real time. Affect the stability of the distribution network system.

d) Low data validity. Many insignificant data (such as redundancy, noise, temporary data, etc.) are all transmitted to the cloud, wasting cloud resources. In addition, some data to be consumed locally does not need to be sent to the cloud. Data filtering capabilities have not received enough attention.

e) Strong network dependence. Although data stored in the cloud can be accessed from anywhere at any time, users rely heavily on the availability of internet connections and servers. When the network is unavailable and data cannot be accessed due to the characteristics of the power system, the cloud will no longer have a greater advantage.

3. Intelligent distribution network architecture based on end-edge-cloud collaborative computing

The distribution network mainly includes overhead or cable distribution lines, distribution stations, pole transformers, distribution switchgear, distribution boxes, etc. [8]. Usually refers to the network that distributes power to users directly or after step-down on the low-voltage side of the secondary step-down transformer in the power system [9].

In order to expand the intelligent distribution network architecture under the cloud computing environment, improve the low-latency and high-flexibility performance of the intelligent distribution network. A smart distribution network architecture based on end-edge-cloud computing is proposed. As shown in Fig.2, the tasks of the distribution network system can be divided into delay-sensitive tasks and computationally intensive tasks according to the amount of calculation and response time [10]. Among them, the data collection layer is responsible for

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data collection and monitoring, interaction and control, the control and interaction layer is responsible for information integration and task response, and the service collaboration layer is responsible for the processing of computationally intensive tasks and the storage of big data.

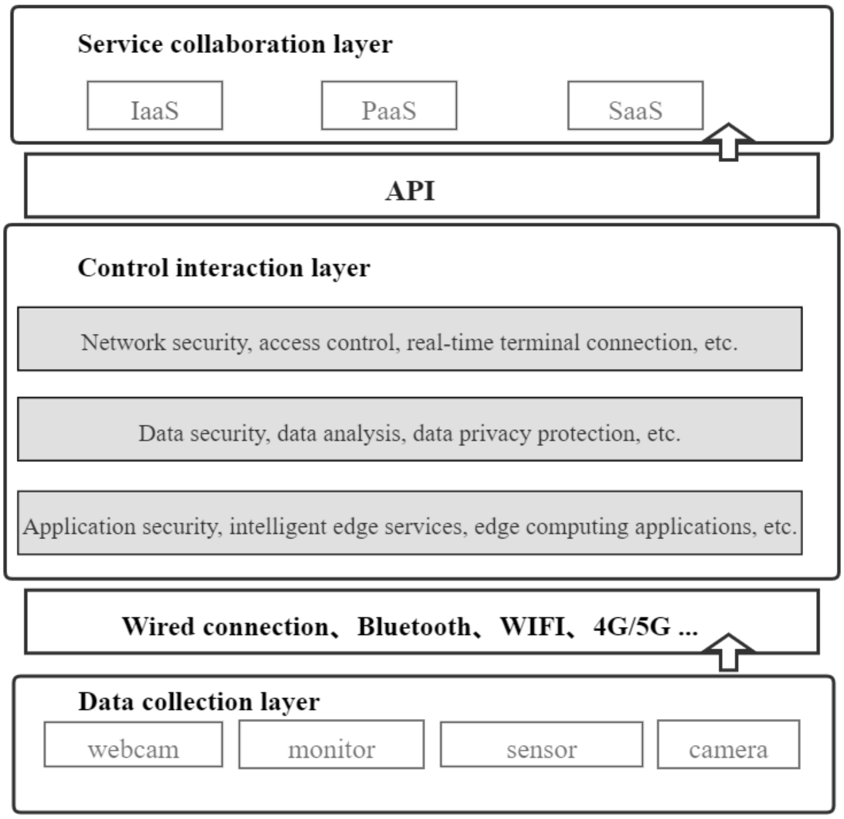

Fig. 2 Intelligent distribution network architecture based on end-edge-cloud collaborative computing

3.1. Data collection layer based on end device

The data collection layer supports the access of various field devices and can be connected to the control interaction layer upwards. Mainly responsible for the intelligent monitoring of substation equipment, cable tower poles, power distribution equipment, station environment and inspection and inspection devices in power transmission and transformation. In addition, it can also monitor environmental factors such as temperature, humidity, and pressure. Wait. In order to keep abreast of changes in the equipment of each link, a large number of various sensing devices (such as various smart sensors, radio frequency identification, drone inspections, etc.) are configured. These resources work closely with each other to provide a guarantee for safety perception.

3.2. Control interaction layer based on edge computing

The control interaction layer is mainly an edge resource pool composed of interconnected computing nodes. As shown in Fig.3, there are corresponding gateways and resource management nodes in the resource pool, as well as multi-clock edge computing nodes (such as routers, network switches, local servers, etc.) deployed in the substation. The resource management nodes can perceive other computing nodes to perform Resource scheduling and resource allocation in the edge environment. The edge computing node is mainly responsible for filtering, compressing, and storing collected data, and processing service requests at the same time. It can also perform noise processing on the collected data, clean abnormal data, and

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perform data compression when necessary. Edge devices also have certain data storage capabilities, which can store real-time status data and information such as alarms and faults. For the collected real-time data, the edge computing device can perform simple data processing and analysis. For example, through data analysis of various sensors, edge computing can determine whether the status of cables and transformers is normal and what operations are being performed. In addition, after simple data processing and analysis, automatic feedback control of the manufacturing equipment running according to predetermined rules can be realized. The feedback control on the edge side is sufficient to ensure real-time performance.

Each edge computing node is connected to the cloud data center through a resource management node, and the gateway is mainly responsible for receiving and processing data from the data collection layer. When the computing node receives the task request assigned by the management node, it can execute the task locally or send data to other nodes for calculation. The management node is responsible for coordinating and distributing task requests and computing resources in the edge environment, and transmits part of the data of the edge computing layer to the cloud computing layer to drive corresponding services. Under the unified management of the management node, the edge layer realizes the inter-node The mutual cooperation and close cooperation with the cloud. The control interaction layer based on edge computing can effectively reduce the bandwidth of data transmission to the cloud computing layer. At the same time, it can reduce the processing delay for delay-sensitive tasks.

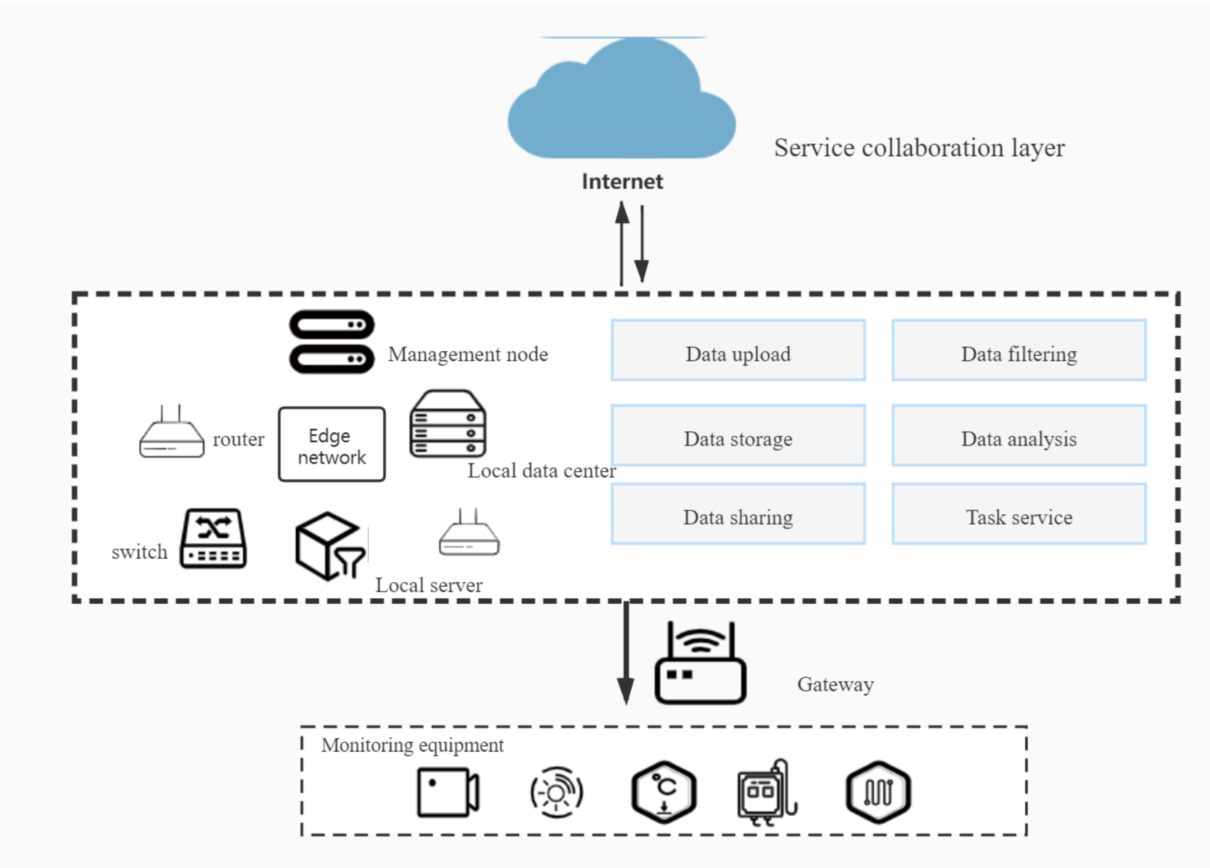

Fig. 3 Control interaction layer based on edge computing

3.3. Service collaboration layer based on cloud computing

As shown in Fig.4.The cloud computing layer has powerful computing and storage capabilities. The cloud computing layer is responsible for the analysis and storage of big data. During the operation of the distribution network, a large amount of data will be generated. The cloud

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center can receive and process the massive amount of data uploaded by the edge management node from the edge layer. data. In order to extract additional value from the data, a data processing model was established, and the large complexity, low latency sensitivity and massive data were analyzed, and the results were displayed. Taking equipment fault diagnosis as an example, a diagnosis model based on equipment data is established. The larger the amount of equipment data, the easier it is to form an accurate and reliable diagnosis model. This requires more computing resources and higher computing power, and is more suitable for cloud Established and updated. After the diagnosis model is established, the model is downloaded to the edge layer to realize real-time and reliable diagnosis of the equipment. Perform big data analysis and mining in the cloud layer to form a model. The control interaction layer downloads the model to analyze the real-time status in real time. During the operation of the device, new data will be generated and uploaded to the cloud again. The cloud layer model will be updated based on historical big data and new data.

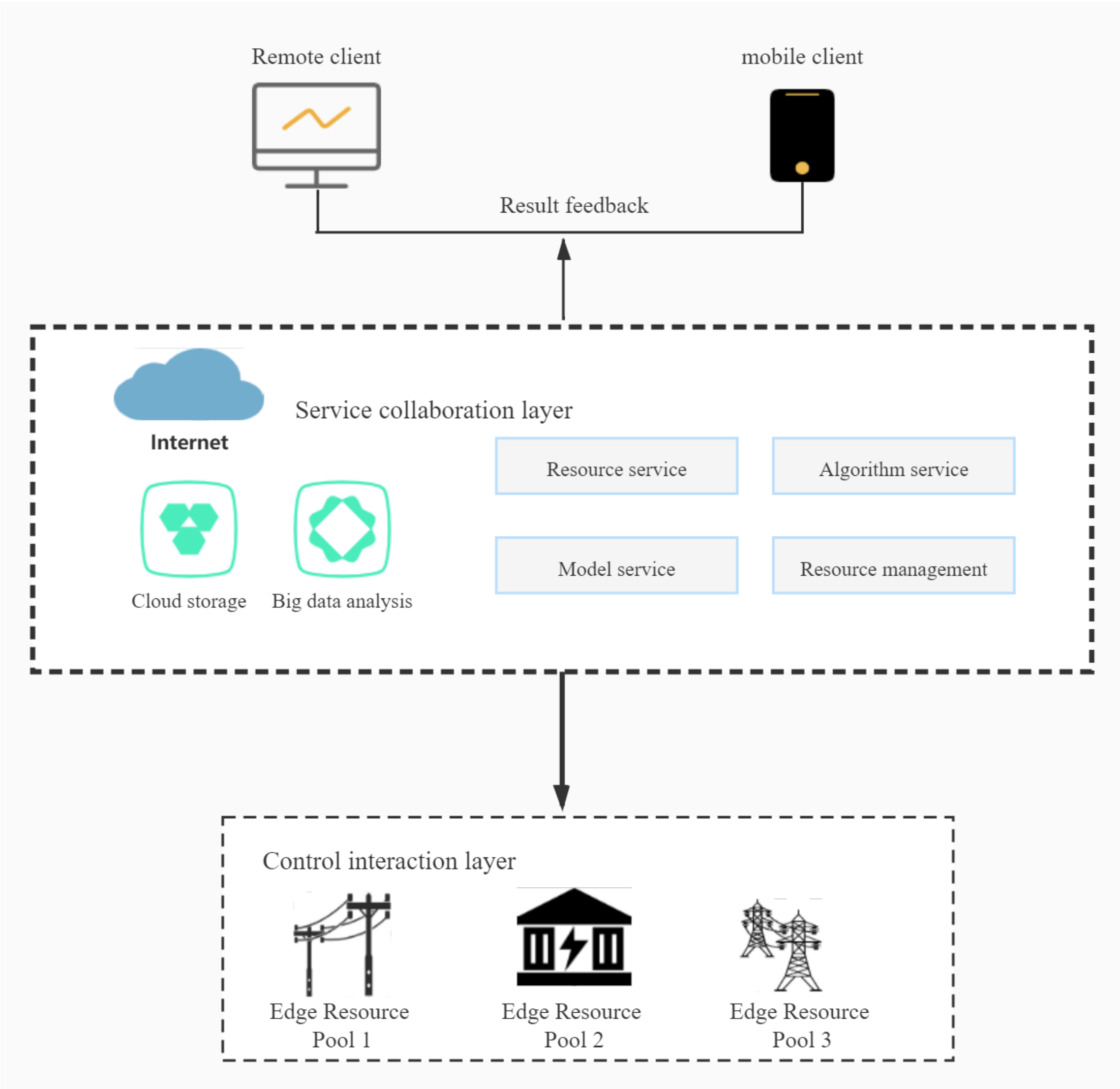

Fig. 4 Cloud computing-based service collaboration layer

4. Summary

This paper introduces the traditional distribution network architecture based on cloud computing, and proposes a smart distribution network architecture based on end-to-end cloud computing. The distribution network environment is divided into a data collection layer, a

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control interaction layer, and a service collaboration layer. In the distribution network environment, whether it is real-time response or services based on edge computing and cloud computing, it fully reflects its advantages over traditional cloud computing power systems. The collaborative scheduling and intelligent scheduling of end-edge-cloud will be further research.

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