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Remote Online Environmental Monitoring System Based on Cloud Database

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ABSTRACT

In order to study the performance of online environmental monitoring systems, in this research, the effectiveness of remote online environmental monitoring systems based on cloud databases through experimental methods was verified. The overall structure hierarchy of the monitoring system was constructed, including the development of the underlying field device data driver, the development and optimization of the cloud server and database, and the development of the Web user display page. The traditional single-machine structure was optimized for distributed structure data processing, and a scalable interface was developed. After the data acquisition driver, the cloud real-time data interface server was added. After verification and testing, it was found that the remote online environmental protection monitoring system based on a cloud database worked well. Therefore, in this study, a system design and development integrating data collection and communication, database management, data distributed processing and data status monitoring and display was optimized by virtue of the high efficiency, scalability and fault tolerance of cloud platforms.

Keywords: Cloud database; Remote online monitoring; Field data collection; Distributed interface development; Web server

1.0 Introduction

With the rapid development of the economy, environmental protection has received increasing attention from all walks of life. The online environmental monitoring equipment installed and used by enterprises at pollution sources can report the pollutant content index and pollutant discharge information in real time, which is an important means for enterprises to control pollutant discharge and environmental protection departments at all levels to monitor the pollution situation of enterprises. The traditional online monitoring system is limited by the field information technology infrastructure, which results in the waste of resources and low-level asynchronization of monitoring data.

The optimized design and implementation of the remote online monitoring system based on cloud platform can realize the rapid collection, processing and storage of big data, improve the limitations of local single monitoring [1-3], and achieve the integration of the remote monitoring system and the sharing of information.

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Therefore, it is necessary and beneficial to design remote real-time monitoring systems by integrating the application of online monitoring systems and cloud databases. In this research, various functions of the online environmental monitoring system are designed, developed, tested and verified. It includes the acquisition of the underlying data of field equipment, the realization of data remote cross-network transmission, the realization of cloud servers, and the display of Web monitoring pages.

2.0 Methodology

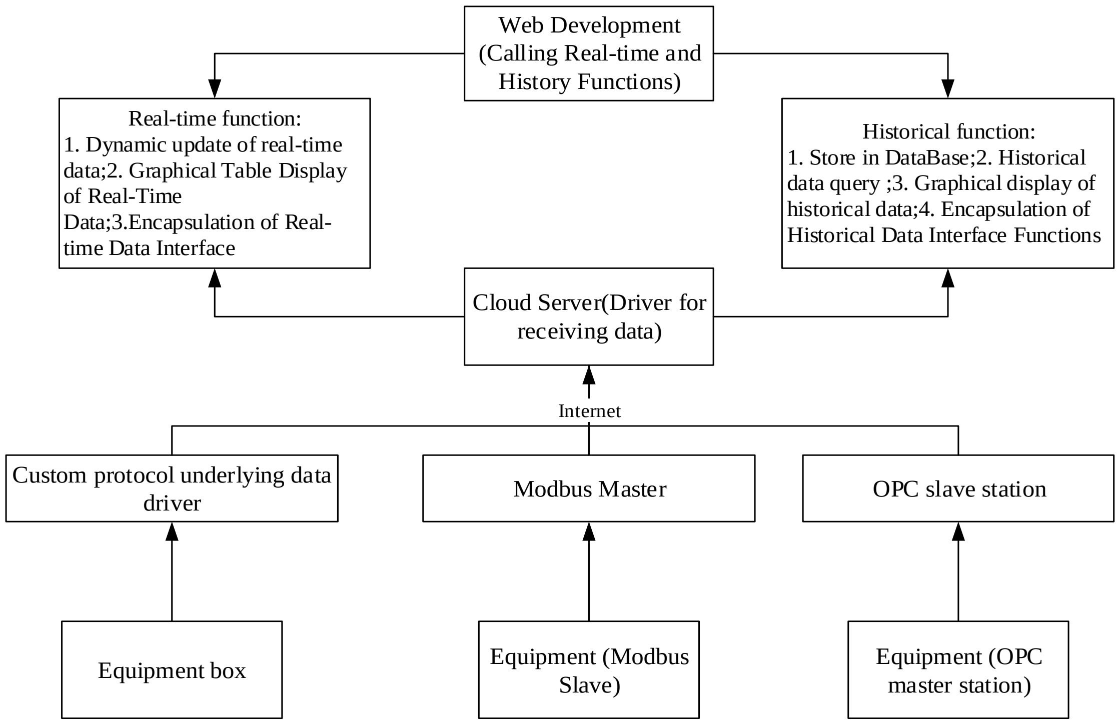
2.1 The overall architecture of the cloud database monitoring system

Cloud databases are databases that are deployed or optimized into a virtual computing environment to achieve on-demand scaling, pay-as-you-go, high availability, low cost, and storage consolidation. Cloud computing divides a task into sub-blocks for execution, which can handle big data with fast data processing speed [4]. Cloud computing does not need to rely on the configuration of hardware facilities like traditional monitoring mode. Cloud data is processed by a network platform, which can make more efficient use of existing resource data and reduce the input of hardware cost. The massive storage capacity and computing capacity of cloud computing can provide data support for millions of users at the same time, and realize data functions that can’t be completed by traditional models [5]. The cloud database can obtain information and services through the terminal at any time and place, and realize the automatic update of information.

Environmental protection materials are basically natural non-toxic, or artificial processing synthetic. Its toxicity is within the scope stipulated by the state, harmless to human health, and will not cause environmental pollution. According to the material, there is a purely natural, non-toxic and pollution-free type, such as wood. There are also synthetic materials, such as fiberboard, which are not harmful to humans in a controlled way. Environmental protection equipment refers to mechanical products, structures and systems manufactured and constructed by production units or construction units for controlling environmental pollution and improving environmental quality [6]. Figure 6 shows the scale of the environmental protection equipment industry in China in recent years.

The remote environmental protection online monitoring system based on cloud databases belongs to the integrated and integrated design and development, which can complete the integrated system design and development such as on-site bottom data collection, network database management, data distributed processing and Web state monitoring [7]. Distribution refers to the development of the system server's top-to-bottom interface to realize the distributed access of the field bottom equipment and the distributed supervision of the upper management users. Compared with the traditional reading and storage data on the local single server, distributed data has the advantage of processing large-scale data and the speed is faster [8]. The data driver of the underlying device side is developed to realize multi-transmission across multiple LANs and the interconnection and interoperability of the network. The design and development of a real-time data server layer makes the data save the time of database storage and reading, so as to improve the real-time data. The scalability characteristics of cloud platforms are more flexible for users. Cloud storage also provides a basis for subsequent data analysis. The overall architecture of the system adopts a hierarchical structure, which mainly includes three layers, including distributed field equipment data transmission layer, cloud server layer and Web user monitoring layer. Figure 1 shows the overall architecture scheme of the system.

Figure 1: Overall Design of the System



2.2 Design and implementation of the level of remote environmental monitoring system

In the online environmental monitoring system, there are a wide variety of field equipment at the bottom with various sensors and different communication protocols. According to different sensor devices, the corresponding protocol access monitoring and measurement system needs to be customized and developed. In this study, Modbus, OPC and custom protocol were introduced for development. For sensors of Modbus protocol type [9], Modbus RTU mode is adopted for data acquisition programs. This protocol is a master-slave mode, in which the master station of Modbus actively queries the slave station and returns the receiving server of local data of Modbus, and directly conducts data analysis to develop the underlying device data transmission driver Modbus Master. The device is used as a slave station. After the creation of the factory object, it extracts and injects Slave input information, creates and initializes Modbus RTU object, creates a keep register Request object, passes parameters from station ID, start bit, and reading length. If the response is abnormal, loop in and parse until the response is normal. For OPC protocol type sensor devices, OPC UA open source clients are developed to receive and parse data locally. The specific process is as follows: an OPC object is initialized and established, a new group and item of OPC are created, and the latter is added to the former. After registering all groups, the corresponding function is called to synchronize data and release data. Remote data transmission uses TCP/IP protocol and Socket [10]. The data of different types of sensors are aggregated according to a custom protocol format, packaged and sent to the cloud server remotely. The data collected by the local area network of the underlying field equipment needs to be transmitted to the cloud platform remotely across the network, and the interconnection of heterogeneous networks can be realized by sending data IP. The distributed field equipment data transmission layer has more advantages of a big data processing system compared with the traditional single version data processing.

The cloud server layer is the remote reception and analysis of the underlying field equipment data. The data is stored in the cloud large database, and the interface of historical data and real-time data query is developed, which facilitates the call of the third party and improves the extensibility of the system connecting with the upstream Web design. It allows access to multiple devices at the bottom. After receiving the remote data, the data acquisition driver performs different parsing according to the three different protocols mentioned above, and encapsulates and opens the corresponding interface for the convenience of later use. The historical data interface uses functions to load the driver of the corresponding database server, create a connection, encapsulate the SOL statement and execute it, and finally process the result to close the connection. The API interface for developing historical data avoids the security problems of open database permissions. Users can call the corresponding historical data API to obtain data information such as device number, variable name, time period, etc. The system has the features of security and expansion.

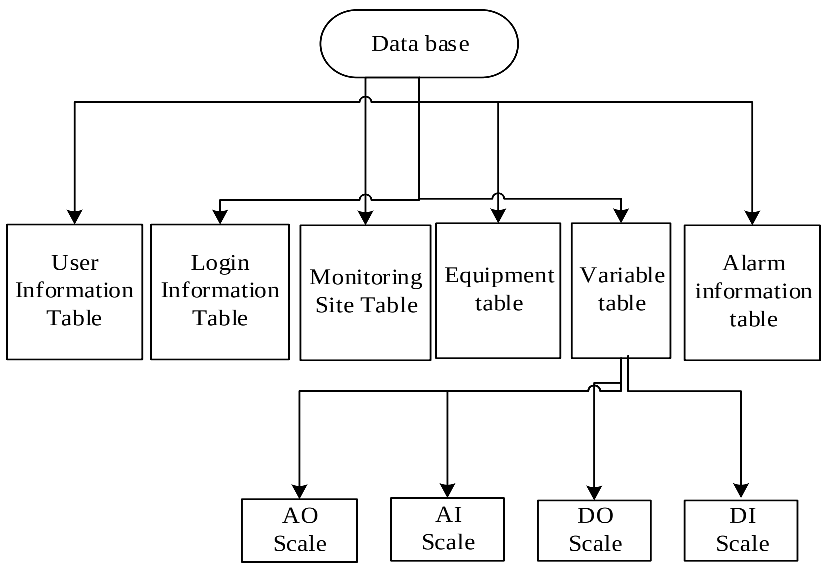
Due to the security problem of opening database permissions, the API interface of historical data is developed. Users can call the corresponding historical data API to get the desired data according to the requirements, such as the device number, variable name, time period, etc., without worrying about the connection with the database or writing SQL statements. This facilitates development and improves the security and scalability of the system. Table 1 shows the function of interface parameters of historical data. After the development of cloud server, it needs to use the Web to publish and display the interface, so as to provide remote calls

Table 1: Historical Data Interface

Function	Parameter explanation	Functional comment
FindByTime (start, end)	Start/end: start time / end time;	Query by time period
FindByGJZ (start, end, gjz)	Giz: keyword	Query by variable keyword
FindBySite (start, end, site)	Site: keyword	Query by device number and time period
FindCynd (start, end)	Start/end: start time / end time;	Query by ozone concentration
FindYqyl (start, end)	Start/end: start time / end time;	Query by oxygen pressure
…	…	…

In order to show the real-time performance of monitoring system data, the cache design is carried out. After the new data received by the cloud server is processed and stored in the database, it will also be stored in the cache area and continuously cover the old data in the cache area, so as to provide users with real-time data response in the cache area. The real-time interface server and the cloud receive data driver are organized by Socket to communicate between processes. The development of a real-time data interface is not to push all the received real-time data to the real-time interface server, but to design the real-time interface server as the Socket client. When it is called, the data acquisition driver in the cloud is actively and regularly carried out. The main thread starts a new thread to fetch and return real-time data that has been overwritten in the cache, so the upper-level interface developer only needs to call the real-time data interface to get real-time data information. The database can provide a post-reading function. The complexity of field monitoring points leads to the huge data acquired by sensors. SQL Azure Database cloud storage service realizes real-time access to every record at every moment of each monitoring point in the field. SQL performs a triple backup, which increases the security and reliability of the database. The access performance of a database is related to the speed and real time of the whole monitoring system. Stored procedures and views are used to increase the read rate of data. Stored procedures are used to read data, which can speed up database servers, reduce network traffic, and enhance sharing. And the view does not use the entire table, which simplifies the operation and enhances the pertinence of the data. The overall table of the database is shown in Figure 2.

Figure 2: The Overall Structure of the Database



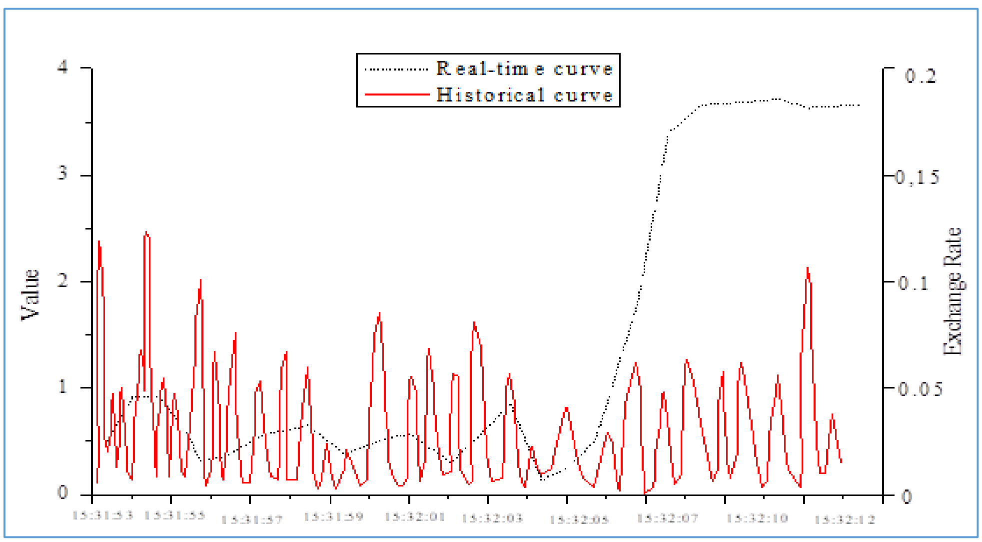
The web monitoring display layer implements distributed supervision of upper-level users. The main functions of the Web interface include two aspects, one is the display of real-time data, the other is the display and query of historical data. Query mode is divided into time periods and keywords. The web responds to requests from the HTTP protocol. If the Web application is to be developed, a logical control of the Servlet container for the front-back interaction process needs to be set on the Wcb server. When setting up the Web server platform, JDK is installed on the cloud platform virtual machine and its environment variables are configured. Then Tomcat is downloaded and installed. After configuring the environment variables, double-click to start the server. When another client sends a request to the local end, the web server responds to the request on the port that handles the interception. At the cloud platform, end point mapping is established to meet the problem of existing port occupation and open a new port browser access. Login account verification is required for the first use of the browser. Log-in logic flow is as follows. After entering the account and password, the system will look up the user name in the database. If the user name exists and the password is correct, then determine whether the user permissions are normal users or system users, and display successful login.

The dynamic display of real-time data adopts the principle of Ajax technology, that is, an intermediate layer is added between the browser and the server to make the interface operation and server response asynchronous and solve the burden of poor response of the server. The server receives the asynchronous request sent by the XmlHttpRequest object from the foreground, calls the real-time data interface mentioned above through the background logic processing, and returns the data to the middle layer to realize the local update situation and prepare to receive the returned response data. In order to intuitively display real-time data monitoring, the page develops the dynamic display of real-time data charts, and the foreground programming language develops and uses Ajax to asynchronously refresh real-time data in the background. The query step of historical data is to create the URL address, open the interface connection and convert it into Http URL, open the input and output switch to set the request information, and then splice the request information to obtain the output stream and send the data to determine whether the request is successful or not. After receiving the returned data, it processes and interacts with the foreground display page display. The dynamic graph of real-time data and historical data is shown in figure 3.

3.0 Results and Discussion

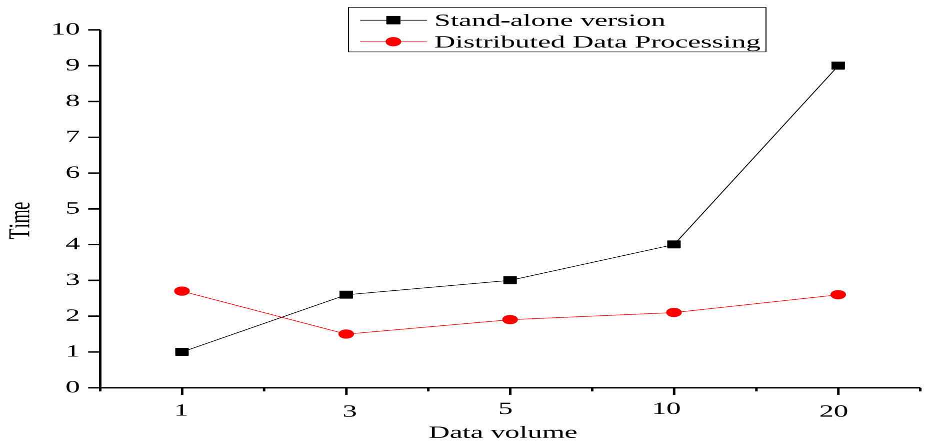
The function of each part of the environmental protection online monitoring system was tested and the system performance was found to be stable.

Figure 3: Real-time Data and Historical Data Dynamic Map



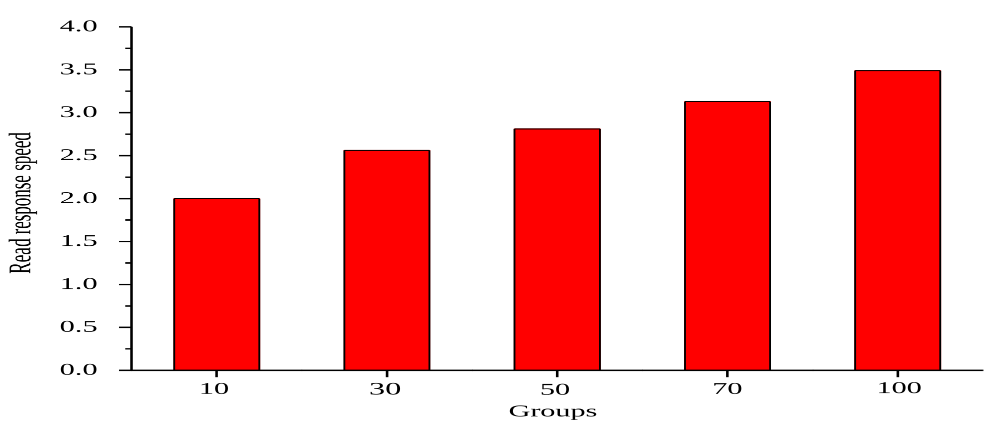
As shown in figure 3, in the real-time changing curve, when the mouse hovered over any part of the curve, the detailed data information of the current time point could be displayed. The historical data change curve was formed by the input keywords and the start and end time click query.

Figure 4: Performance Comparison between Standalone and Distributed Computing



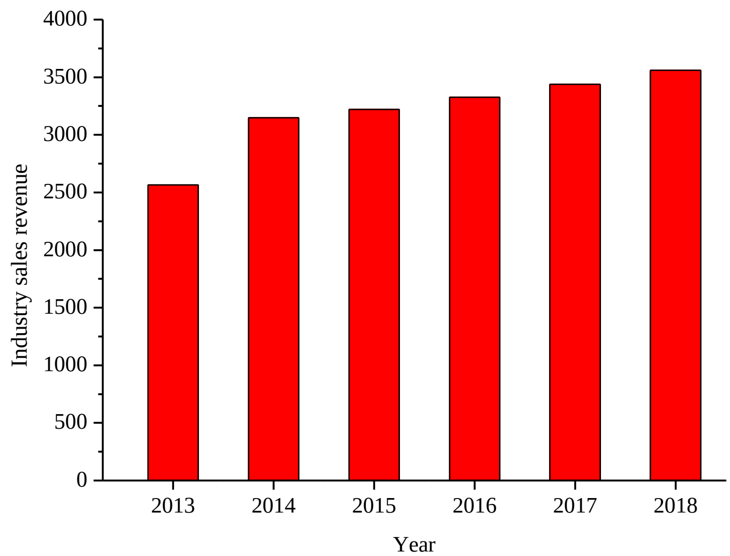
According to Figure 4, when the amount of data text was 20GB, the running time difference between the single version and the distributed version was the largest, and the difference in computing performance was the largest. When the amount of text data was small, the difference between the two was not significant, distributed data processing didn't reflect the advantage, but as the amount of data gradually increased, the advantage of running time was gradually highlighted. Therefore, the proposed distributed data processing had obvious advantages for big data files, which was consistent with the design goal of the data processing application of a remote online monitoring system based on a cloud database.

Figure 5: Test Results of System Performance



The system performance test results showed that the larger the value of the data group, the slower the read response speed and the better system stability, as shown in figure 5. When the number of groups was 10 and 50, the response speed of reading was 2S and 2.8s respectively, and the system run well. When the number of groups was 100, the reading response speed was 3.5s, and the system run with occasional lag. On the whole, the system operation tests were relatively stable, and the response speed of reading was good, which met the requirements of the expected design of the system. The test verified that the system was effective and usable.

Figure 6: Market Size of China's Environmental Protection Equipment Industry (100 million yuan)



As shown in figure 6, in recent years, the market size of China's environmental protection equipment industry has been expanding year by year, and the sales revenue has been growing. In 2018, the industry's sales revenue was about 355.9 billion yuan. The industry has a good operating situation, which indicates that the market scale of environmental protection equipment monitoring in China will become larger and larger.

4.0 Conclusion

In this study, a remote online monitoring system based on cloud data was established, which realized the monitoring requirements of big data with cloud technology and reduced the redundant hardware devices and data drivers. The system was based on a distributed structure and integrated with the online monitoring system by taking advantage of the flexibility and high efficiency of the cloud platform. In terms of field equipment data processing, corresponding data acquisition drivers were developed for Modbus, OPC and custom protocols, and then heterogeneous interconnection was realized through remote cross-network. The cloud server received the parsed remote data, optimized the database, and provided it to the web interface. The dynamic display of historical data and real-time data, the display of curve trend charts, and a series of monitoring functions were realized. Therefore, the whole system runs well and the system performance is more optimized.

Due to the large number of monitoring objects in the online monitoring system, the high requirements on real-time and security of data, and the higher flexibility and extensibility of the system itself, in the later research, more thorough distributed processing method, cloud technology and other technologies need to be further integrated and matched with online monitoring system.

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