Design of smart laboratory management system based on cloud computing and internet of things technology

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Abstract. In view of the backward and low efficiency problems of laboratory instruments and equipment management and laboratory environmental monitoring in Colleges and universities, by analyzing the traditional management mode and method of the laboratory, based on cloud computing platform of Sichuan University of Science & Engineering and radio frequency identification, wireless sensor network, Internet and other technologies, the construction scheme of the laboratory instrument and equipment management platform was designed. The system architecture, system topology, software functions have been designed. The system is applied to the management of scientific research and teaching laboratories in Colleges and universities, improving the efficiency of supervision and utilization of equipment, and precisely maintaining the life cycle of equipment.

1. Introduction
At present, the monitoring, teaching and scientific research equipment storage and maintenance of university laboratory environment are still in the inspection, manual registration and maintenance of experimental staff. The traditional laboratory management mode is inefficient, the workload is large, the utilization rate of laboratory equipment is low, and the laboratory environment and instrument equipment cannot be monitored in real time. Aiming at the current status of laboratory management in colleges and universities, an intelligent laboratory management system based on cloud computing and Internet of things technology is constructed, which can effectively monitor the laboratory environment and instruments and equipment in real time and dynamically manage and maintain them [1-4].

2. Key technology
2.1. Cloud computing
Cloud computing is a new kind of mode of information service, which is based on the calculation of the Internet, in cloud computing, resources, software and information provided in the form of a kind of to each according to his need, the user can get the needed information resources through the network, and according to the actual usage fee, need not care about resources position[5]. User can through the network resource sharing cloud platform provides hardware and software resources, cloud computing...
services provided by the way there are three main types: IaaS (infrastructure as a service), PaaS (platform as a service), SaaS (software as a service) [6]. Software service mode (SaaS) is one of the modes with a large number of cloud computing users. Users do not need to buy software, only need to rent software from the provider and use it through the Internet, which is the development trend of future management software. It has advantages such as long benefit cycle of one-time investment, on-demand service, flexible use and wide application range [7].

2.2. ZigBee and RFID technology
ZigBee is a low-power LAN protocol based on IEEE802.15.4 standard. It realizes communication, data collection, monitoring and control of multiple sensors through self-organizing network functions. ZigBee technology is mostly used for short-distance wireless communication, and has the advantages of power saving, simplicity and low cost [8].

Radio Frequency Identification (RFID) is a technology that uses radio frequency communication to realize non-contact automatic Identification. A complete RFID system consists of three parts: electronic tag, reader and application system. RFID readers first transmit radio frequency signals to electronic tags through antennas, and then electronic tags receive radio frequency signals and transmit signals. RFID readers read and decode the information inside electronic tags, and finally transmit the decoded information to the application system for further processing [9-10]. RFID reader structure block diagram, as shown in figure 1.

![RFID reader structure block diagram](image)

Fig. 1 RFID reader structure block diagram

3. Design of system

3.1. Overall architecture of the system
The architecture of the intelligent laboratory management system is shown in figure 2, which mainly consists of three parts: data collection and transmission, data communication, application service and management.
Fig. 2 System architecture diagram

(1) Data acquisition and transmission. This part mainly collects the information of the laboratory equipment, laboratory staff, scientific research teachers, etc. by means of RFID readers, and collects the environmental information of the laboratory through temperature and humidity sensors, smoke sensors and infrared sensors. The safety information of the equipment and the laboratory environment is collected by the surveillance camera. The collected data information is transmitted to the upper layer by using the sensor middleware technology and the ZigBee technology.

(2) Data communication. This part mainly uses the Internet with wide coverage and high stability as the data transmission carrier, completing information docking between the field server and the data acquisition system through 4G mobile network, and stores and manages the collected data.

(3) Application services and management. This part mainly uses cloud computing and high performance computing technology through cloud service management platform to classify and manage the data and information of the laboratory acquired by the network layer. The server is convenient for managers to monitor and manage the laboratory equipment and laboratory environment security information remotely. Such as remote monitoring and management, but also convenient for users to query the status of the equipment.

3.2. System topology diagram
The topology structure of the wisdom laboratory management system is shown in figure 3. The platform is designed with a three-layer structure, namely, the perception layer, the network layer and the application layer.

(1) The sensing layer collects data information mainly by RFID tags, RFID readers, smoke, infrared, temperature and humidity sensors, and camera alarm devices. RFID tags can be used to mark instruments and devices that cannot speak, users, teachers and students who enter or leave the entrance guards use RFID identification cards to enter or leave the lab. Personnel and equipment enter or leave the lab and are read by the reader from the RFID tags or identification cards. The laboratory environment information is detected to sensors in real time. When the laboratory environment is abnormal, the management personnel are notified in time through the alarm device, and then the information is uploaded and stored to the server through the network transmission device.

(2) The network layer realizes the transmission of data information. It is composed of ethernet, wired local area network and 4G mobile communication network. It mainly collects data information of laboratory sensors and RFID reader, and transmits the collected information to cloud platform server.
The application layer has user management and service functions. The cloud platform manages data servers, Web servers and management servers through virtualization. The application layer implements the management of instrument and equipment, laboratory personnel information, asset inventory and maintenance information, laboratory environmental monitoring information, and classifies statistics and analysis of the collected information. This layer adopts B/S mode design, which can provide information query and management services to asset management departments, experimental and scientific research teachers, students and so on.

3.3. Design of software function

3.3.1. Design of cloud platform function. Through network access, cloud platform can provide on-demand allocation of shared resources, as well as efficient distributed computing and data storage. There are three types of application categories for cloud computing: stream computing, batch processing, and ad hoc queries. Stream computing refers to the low-latency calculation of data before entering the database in order to save storage space. After the calculation result is obtained, it is used for data filtering and is suitable for data pre-processing in laboratory environment monitoring. Batch processing refers to the use of data in the database for mining calculation and analysis, which is suitable...
for computing tasks with huge workload and low real-time requirements, and is suitable for model modification in the Internet of things system, etc. [11]. AD hoc query is applied to the search function with a large amount of data. MapReduce provides a technical implementation for quickly finding the data information of a certain device [12]. Cloud computing deployment is shown in Figure 4.

Fig. 4 Cloud computing deployment structure diagram

3.3.2. Design of RFID Reader Management Function. The RFID reader directly collects data information of laboratory equipment, experiments and scientific research personnel. The reader in the intelligent laboratory management system consists of access control reader and handheld reader. The software function design of access control reader includes asset management, experimental equipment use management, personnel management, etc. Handheld reader is light and convenient, and it is suitable for inventory and management of bulk instruments and equipment. The functional structure is shown in Figure 5.

Fig. 5 RFID reader functional structure diagram

3.3.3. Design of RFID Reader Management Function. The ZigBee environmental monitoring module collects and transmits information such as temperature, humidity, smoke, abnormal intrusion and so on. The embedded software realizes the functions of network formation and data transmission. The workflow of ZigBee software is shown in Figure 6.
Fig. 6 ZigBee work flow chart

4. Analysis of System Application Performance
The intelligent laboratory management system can effectively realize the centralized classification management of instruments and equipment, register once, intelligently count, collect information and management, improve the efficiency of management, and realize real-time monitoring of laboratory environmental safety.

(1) Intelligent planning and management improves work efficiency
The basic information is registered when the instrument is stored in the warehouse. The system allocates the appropriate laboratory according to the function of the device and its subject area, and issues an RFID tag as the identification tag of the instrument. The RFID reader can quickly complete the maintenance, use, borrowing, inventory of the device. The way of working reduces the cumbersome process of manual statistics of managers, and improves the accuracy and efficiency of information statistics.

(2) Real-time monitoring improves the safety of the experimental environment
The access control reader ensures the safety of the personnel entering the laboratory. Those who do not have permission are not allowed to enter, and the attendance registration of the experimental personnel is also performed. The multi-sensor simultaneously monitors the experimental environment information in real time, once, an unexpected situation occurs, the system promptly issues an alarm and notifies the administrator through the mobile network to minimize losses and ensure asset security.

(3) Sharing instruments and equipment improves the utilization rate of resources
Users can access the cloud-based smart laboratory management system at any time to understand the use of the instrument and the basic state of the device, which devices are in the maintenance state, which are in normal use, etc., understanding in advance and reasonable planning arrangement can reduce the idle and waste of resources and improve the utilization rate of instruments and equipment.
5. Conclusion
In the era of information and intellectualization, advanced cloud computing technology and Internet of Things technology are applied to the management of laboratories, which effectively carries out unified planning, classification and centralized management of laboratories, improves the efficiency of laboratory managers, and monitors and manages the environmental safety and instruments and equipment of laboratories in real time. To record and analyze the maintenance, inventory, use and laboratory environment of the instrument and equipment. The system is developed based on SaaS mode of cloud computing, which not only saves the cost of development and maintenance, but also greatly improves the security and stability of the system. At the same time, with the development of cloud storage and large data processing technology, the refined and precise management of experimental equipment is the focus of future research.

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