

Research and Practice of IoT Technology based on Smart Campus

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Abstract: This paper designs and implements an Internet of Things (IoT) student arrival management system based on smart campus, and uses big data technology to solve the problems of information lag and inaccuracy in traditional management mode. The system uses IoT technologies such as RFID and NFC to realize real-time monitoring and recording of students' arrival at school. By deploying sensor equipment and developing user interface, the system collects, processes and analyzes students' arrival information in real time, and provides convenient services for teachers, students and parents. This paper introduces the design and implementation process of the system in detail, including key technical points, system architecture, functional modules, implementation and testing. The practical application shows that the system significantly improves the efficiency of campus management and promotes the communication and cooperation between home and school. The challenges encountered in the implementation of the system are analyzed, and the corresponding countermeasures are put forward. This study highlights the unique advantages and broad application prospects of student arrival IoT management system integrating big data under the background of smart campus.

Keywords: Smart Campus; IoT; School Management; RFID; Big Data.

1. Introduction

With the expansion of education scale and the increasing demand for high-quality educational resources, the challenges faced by the traditional campus management model are increasingly prominent. As an important part of campus daily operation, the management of students' arrival at school is directly related to students' safety, the stability of teaching order and parents' trust in the school [1]. Traditional school management methods, such as manual registration and paper leave, are difficult to meet the needs of modern campus management [2]. Especially in case of emergency, the limitations of traditional methods are more prominent, and it is impossible to realize fast and accurate information transmission and personnel tracking [3]. Students and parents hope that the school can provide more intelligent services, such as real-time understanding of children's school situation, convenient access to campus notices, and participation in online learning [4]. These demands urge schools to speed up the pace of information construction and improve their management level by means of modern science and technology.

The construction of smart campus provides a new solution for students' school management. Through IoT technology, schools can realize comprehensive perception and intelligent monitoring of people, things and environment on campus. For example, using RFID tags or NFC technology, students' arrival at school can be tracked in real time to ensure the accuracy and timeliness of data; Through the intelligent access control system, access to the campus can be strictly controlled and campus security can be improved; Combined with big data analysis, students' school habits and behavior patterns can be deeply explored, which provides strong support for teaching management. At the same time, the construction of smart campus also promotes the integration of students' school management with other campus management

systems [5]. Through the unified campus information platform, students' arrival data can be seamlessly connected with many systems such as student status management, curriculum arrangement, dormitory management and book borrowing, forming a complete student information management chain [6].

The purpose of this study is to explore the application of IoT technology, using big data to manage students' arrival at school under the background of smart campus. Through in-depth analysis of the background and needs of smart campus, the characteristics of IoT technology and the potential of big data to enhance decision-making, an efficient and intelligent student management system is designed and implemented. The system not only accurately records the students' arrival at school in real time, but also provides comprehensive data insight and strong support for teaching management by using big data analysis. Through the implementation and testing of the system, the feasibility and effectiveness of integrating IoT technology and big data in the construction of smart campus are verified, which provides valuable insights for similar initiatives of other educational institutions.

The significance of the research lies in many aspects. First of all, by using IoT technology and big data, the efficiency and accuracy of students' school management can be significantly improved. Secondly, the construction of smart campus supported by these advanced technologies has promoted the overall upgrading of school information infrastructure and improved the management level of the school. Finally, this research aims to promote the progress and development of smart campus plan, and highlight the transformation potential of IoT technology and big data in modern educational environment.

2. System Overview

2.1. System Design Concept and Core Components

The core idea of system design is to ensure the superiority of user experience, data-driven decision support, flexibility of modular design and highly integrated system architecture [7]. As the core of Internet of Things technology, sensor network is responsible for collecting key data of students' arrival at school, and then using these data for big data analysis. An efficient identification system is formed through the RFID chip installed in the student ID card issued by the school and the RFID antenna installed at the school gate. When a student enters the campus with a student ID card, the antenna will detect and read the number of the RFID chip. This information is immediately sent by the front-end system of the Internet of Things to the intelligent management system of the cloud campus through the Internet of Things card, where it is integrated into the big data platform for further analysis. The flow of IoT data management and control in smart campus is shown in Figure 1.

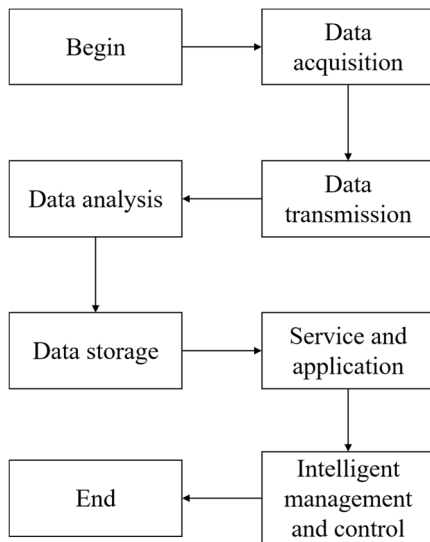


Figure 1. Data management and control

The data processing center receives the data from the sensor network for cleaning, integration and analysis. With the help of advanced algorithms, such as machine learning model, the data processing center can identify the students' arrival mode and predict the future arrival trend. User interface is the window for the system to interact with users. These interfaces provide a wealth of functional options, and it is necessary to pay attention to the optimization of user experience, such as adopting responsive design and providing personalized recommendations [8]. The notification and early warning system is responsible for conveying important information to users in time. This information includes the reminder of students' arrival/departure, the examination and approval result of leave application, campus security alarm, etc. Adopt advanced encryption technology to protect the security of data transmission and storage, and ensure that only authorized users can access sensitive data. In addition, the system is regularly scanned for vulnerabilities to find and fix potential security problems in time.

2.2. System Cooperation and Realization of Goals

All components of the system work together efficiently to achieve the goal of smart campus students' management. When a student enters the campus with a student ID card with a built-in RFID chip, the RFID antenna will capture the information of the chip and send it to the data processing center [9]. After receiving the information, the data processing center will quickly compare and analyze it, confirm the identity of the students and record their arrival time. At the same time, the notification and early warning system will send school reminders or abnormal alarms to relevant users according to preset rules. In the whole process, the security and privacy protection system always ensure the security and privacy of user data.

Through this design, the student arrival IoT management system based on smart campus realizes real-time and accurate arrival records and provides rich data analysis functions. The modular design and high integration of the system make it easy to adapt to the specific needs of different schools and provide a comprehensive perspective for campus management. It is expected that through the implementation and optimization of the system, a safer, more convenient and more comfortable campus environment can be created and better conditions can be created for students' growth.

3. Key Technical Points

3.1. Data Acquisition and Transmission

Sensors such as RFID card reader, NFC terminal and smart camera are selected and strategically deployed in key areas of campus. The types and main functions of sensors are shown in Table 1. These sensors can capture students' arrival information in real time, and ensure the stable transmission of data through wireless transmission technologies such as Wi-Fi and LoRa. In order to further improve transmission efficiency and ensure data security, data compression and encryption technology are adopted.

Table 1. Sensor Types and Their Main Functions

Sensor Type	Main Function	Deployment Locations
RFID Reader	Identifies student identity and records arrival time	Campus entrances, classrooms
NFC Terminal	Enables close-range data exchange for tasks like book borrowing, door access	Libraries, dormitories
Smart Camera	Monitors campus security, aids in data collection	Various locations across the campus

3.2. Data Processing and Analysis

Firstly, the collected original data is cleaned and integrated to remove invalid and erroneous data, and then it is integrated into the unified database. Then, using machine learning algorithm and data mining technology, the data of students' arrival at school are analyzed, and the students' arrival mode, abnormal behavior and potential safety hazards are identified. Table 2 shows the data analysis algorithms and application scenarios in practical applications.

Table 2. Data Analysis Algorithms and Their Application Scenarios

Algorithm Type	Application Scenario	Main Function
Clustering Algorithm	Student Arrival Pattern Recognition	Identifies patterns in student arrival times
Anomaly Detection Algorithm	Abnormal Behavior Identification	Detects and addresses anomalies in student arrival data
Prediction Algorithm	Arrival Trend Forecasting	Predicts future student arrival trends based on historical data

3.3. User Interface Design

User interface is the window for the system to interact with users. We pay attention to the responsive design of the user interface to ensure that users can get a good browsing experience on different devices and screen sizes. At the same time, personalized recommendation service is provided to recommend relevant information and functions according to users' preferences and historical behaviors. In addition, it also pays attention to the interactive design of user interface, and improves the use efficiency through simple and clear interface layout and friendly prompt information.

3.4. Security and Privacy Protection

Security and privacy protection is an indispensable part of system design. Advanced data encryption technologies, such as AES and RSA, are adopted to ensure the security of data transmission and storage. Fine-grained access control of data is achieved by means of user authentication, authority management and audit log. In addition, regular security audits and vulnerability scans are conducted on the system to find and repair potential security problems in time.

4. System Implementation and Testing

4.1. System Implementation

According to the campus environment and demand, sensor devices such as RFID card reader, NFC terminal and smart camera are installed. On the data center server, the data processing center software is installed and the necessary configuration is made, including database connection and algorithm parameter setting. In order to ensure the smooth operation of the system, the original student information, school attendance records and other data were migrated to the new system. After the implementation of the system, provide training and support for teachers, students and parents to help them get familiar with the functions and operations of the system.

4.2. System Test

System testing is an important link to ensure the quality and stability of the system. Functional testing, performance testing, safety testing and other aspects of testing, and recorded the test results, as shown in Table 3.

Through the implementation and testing of the system, it is ensured that the student arrival IoT management system based on smart campus can run stably in the actual environment. Future work will continue to pay attention to user needs and technical development, and constantly improve the system.

Table 3. System Testing Results

Test Type	Test Content	Test Result
Functional Test	Student Arrival Recording Function	Passed
	Leave Application Function	Passed
	Notification Push Function	Passed
Performance Test	High Concurrency Access Test	Response Time < 2s, Processing Capacity Meets Demand
Security Test	Security Vulnerability Scan	No High-Risk Vulnerabilities Found
	Penetration Test	No Exploitable Vulnerabilities Found

5. Challenges and Countermeasures

Technology integration is the primary problem, especially in the diversified technology environment of smart campus. Different devices, platforms and systems have different communication protocols, data formats and interface standards, which makes integration difficult. In order to meet this challenge, two strategies have been adopted: one is to work closely with suppliers and development teams to jointly formulate unified technical standards; The second is to introduce middleware technology, such as message queue and API gateway, to simplify data exchange and communication between systems.

With the rapid increase in the amount of data processed by the system, data security and privacy protection have become the core issues. In order to ensure the security of sensitive data such as student information and school attendance records, strict data encryption and access control mechanisms have been implemented, and a strict access authority system has been established. At the same time, conduct regular security audits and vulnerability scanning to find and repair potential risks in time.

User acceptance is the key to the successful application of the system. Facing the huge user groups with different technical levels, a simple and easy-to-use user interface is designed to reduce the learning cost and provide diversified training. In addition, establish a user feedback mechanism to respond to user needs in time and improve user experience.

The system needs to deal with a large number of data and requests, and its stability and reliability are very important. In order to cope with the performance pressure in high concurrency environment, system performance optimization and load balancing are carried out to improve the processing capacity of the system. At the same time, establish a fault recovery and data backup mechanism to ensure rapid recovery in case of system failure or data loss.

6. Conclusion

With the rapid development of IoT technology and the arrival of big data, the construction of smart campus has become an important direction of educational informatization. By integrating IoT technology, the system designed in this study can not only realize real-time monitoring and accurate recording of students' arrival at school, but also enhance its functions by using big data. The system processes a large amount of data to provide insights and patterns, enrich its functions, and provide a more convenient operation interface to meet the different needs of teachers, students and parents.

In the process of system implementation, major challenges such as technology integration, data security, user acceptance and system stability have been successfully overcome. The future work aims to further deepen the application of IoT technology and big data analysis in the construction of smart campus. This includes exploring innovative management modes and service methods, such as expanding system functions, comprehensively monitoring and analyzing students' behavior, learning status and other aspects.

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