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Retraction

Retracted: The Laboratory Intelligent Management System Using NB-IoT and Artificial Intelligence Technology

Mathematical Problems in Engineering

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] F. Zhang, J. Wu, and F. Wu, "The Laboratory Intelligent Management System Using NB-IoT and Artificial Intelligence Technology," *Mathematical Problems in Engineering*, vol. 2022, Article ID 6574042, 10 pages, 2022.

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Research Article

The Laboratory Intelligent Management System Using NB-IoT and Artificial Intelligence Technology

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For the traditional laboratory manual management, there is a need for laboratory managers. The managers cannot keep abreast of the laboratory conditions, and forget to shut down and close the windows, causing waste of electricity and equipment damage. Based on NB-IoT and artificial intelligence, a laser intelligent management system is developed using technologies such as network communication, intranet, automatic control, artificial intelligence, and software. Through this system, administrators can grasp the situation of the laboratory in real time, realize the intelligent management of the laboratory, improve the scientific management of the laboratory, improve the work efficiency of laboratory technicians, and better play the laboratory as an important platform for scientific research training in colleges and universities. This paper aims to develop an intelligent laboratory management system based on NB-IoT and AI technology. Through this system, the manager can grasp the situation of the laboratory in real time, realize the intelligent management of the laboratory, and better play the role of the laboratory as an important platform for scientific research and talent training.

1. Introduction

At present, laboratory managers in China are constrained by the traditional desktop to work more efficiently, the management of labor organizations and teaching work is huge and affairs are increasing, the primitive laboratory management means can no longer meet the development and construction requirements of today's university laboratories, therefore, a well-run laboratory management system is urgently needed to provide an efficient and convenient environment for the teaching and daily work of universities and platforms [1, 2]. With the development of global economic integration, information technology has undergone great changes. However, AI and NB-IoT technologies are still not widely used in laboratory management, and there are still many management vulnerabilities that lead to excessive security risks and are detrimental to the safety of the laboratory environment [3, 4]. Although laboratory management systems have been partially implemented, their level of security control is clearly inadequate and still dominated by manual control [5].

With the development and widespread application of AI technology and NB-IoT technology, the wisdom management of comprehensive use of various technologies and computer software is used [6–9]. As an important teaching and research platform in universities, laboratory is the basis for guaranteeing the normal teaching and research social services, and in the traditional laboratory management, the corresponding laboratory management positions are mainly set up and dedicated to laboratory management, but with the expansion of universities, the laboratories and laboratory equipment in universities are increasing, due to the limitation of the number of laboratory positions, resulting in laboratory management personnel [10].

However, with the expansion of colleges and universities, the number of labs and lab equipment in colleges and universities is increasing, and due to the limitation of the number of lab positions, the lab managers are unable to manage the labs accurately, and the lab managers cannot grasp the situation of the labs in time, and forget to turn off the electricity and windows, resulting in power waste and equipment damage, which causes the loss of school property and cannot guarantee the normal teaching and research social services of the school and affects the development of the school [11, 12]. Based on NB-IoT and AI technology, this paper aims to develop an intelligent laboratory management system. Through this system, the manager can grasp the situation of the laboratory in real time, realize the intelligent laboratory management and better play the role of the laboratory as an important platform for scientific research and personnel training.

2. Related Work

The LIMS technology first appeared in the late 1960s and has been developed for nearly 50 years since then [13]. From the initial small-scale construction, the main emphasis was on the management of data, and in the later stages of development, more emphasis was placed on the realization of the overall management of the laboratory, thus continuing the data management of the computer to the application management and making the whole laboratory work intelligent, automated and paperless operation, and implementation of management [14].

In terms of global usage, LIMS is widely used in laboratories in developed countries in Europe, America, Japan, and Australia, with tens of thousands of foreign laboratories installing LIMS and dozens of foreign professional companies specializing in LIMS products [15]. Many developed countries have established industry codes and king industry standards for LIMS-related products, such as ISO9000, ISO/IEC17025-1999, GLP, and GMP. LIMS products in Europe and the United States must comply with the relevant industry standards established before they are allowed to be marketed [16]. However, LIMS standards are difficult to localize because of their wide coverage and complex index rules, and require developers to learn LIMS standards exclusively for localization and development, and are prone to unstable operation [17].

NB-IoT is a narrowband communication technology that supports three deployment methods: stand-alone, guard-band, and inband. The current NB-IoT rates are estimated to be less than 250 kbps downstream and 250 kbps upstream (in multi-tone mode) or 20 kbps (in single-tone mode) [18]. In the same bandwidth band, the coverage area of the NB-IoT network is expanded by 100 times, and the battery life of a single terminal can reach more than 10 years if it runs in a typical low-rate service model, with long standby and good power control, and its latency is in the order of seconds [19]. As of May 2019, eight operators in 48 countries have deployed NB-IoT.

Table 1compares the four wireless transmission methods, NB-IoT is better than others in terms of transmission distance, deployment method, and cost. Although Zigbee also has many advantages, its network requires additional gateway equipment and the multi-hop data transmission form is not applicable to the mode of direct communication between terminal and server, so this system adopts the NB-IoT communication mode [20].

The application of AI in laboratory management is very promising. At present, facial recognition is one of the magic weapons of AI technology, so automatic registration of laboratory personnel in and out can be carried out with the help of AI technology [21]. Through electronic monitoring equipment for automatic facial recognition, automatically record each student, teacher, and laboratory management personnel entering and leaving the laboratory and saving the information to the database to achieve paperless records [22, 23].

AI technology can be used to achieve intelligent laboratory safety supervision, specifically in the following areas: firstly, the intelligent control of laboratory temperature is realized through artificial intelligence technology. The laboratory is generally equipped with large-scale instruments and has high environmental requirements. However, under the traditional manual control, the temperature and humidity are often adjusted by the feeling of laboratory personnel, which cannot effectively control the temperature and humidity [24]. Therefore, AI technology can be used to achieve intelligent laboratory temperature and humidity control, using advanced AI algorithms such as [25, 26], the use of microcomputers to adjust the temperature and humidity of each laboratory, thereby extending the life of laboratory experimental instruments and equipment. Secondly, with AI technology to achieve automatic warning of laboratory fire. Thirdly, to achieve intelligent power distribution in laboratories with AI [27]. NB-IoT is defined as a major change in cellular IoT wireless access technology, originally intended to address indoor coverage enhancement, large-scale low-rate device access, low latency sensitivity, low device cost, low-power consumption, and network structure optimization.

3. Laboratory Intelligent Management System Based on NB-IoT and AI Cloud Platform Technology

3.1. Analysis of System Functional Requirements. The purpose of designing this system is to simplify the management process and improve the efficiency. For this reason, the system should be designed with a good investigation of the actual requirements, especially for the reliability, ease of use, and scalability of the system. Through extensive research and study, the laboratory management information system needs to provide four user roles: system administrator, laboratory administrator, teacher, and student. Considering the scalability and maintainability at a later stage, Auth-based permission authentication is used in the backend. The system administrator can flexibly assign different permissions to user groups by judging the value of various attributes of the user groups.

(1) Functions of the system background are shown in Table 2

(2) The system client role table is shown in Table 3.

TABLE 1: Comparison of wireless transmission methods.

Name	Bluetooth	Wi-Fi	ZigBee	NB-IoT
Transmission speed	1 Mbps	11–54 Mbps	20–250 Kbps	20–250 Kbps
Transmission distance	≤10 m	≤100 m	≤200 m	≤10 km
Number of nodes	≤7	≤32	256–65000	≤200000
Deployment mode	Node	Node + gateway	Node + gateway	Node
Peak current	≤30 mA	10–50 mA	≤40 mA	≤50 mA
Overhead	Larger	Big	Small	Small
Cost	Low	Middle	Low	Low

TABLE 2: Main functions of the backend.

Basic information management	Laboratory management	Permission management	System settings
College	Announcement management	User management	Log off and exit the system
Class	Booking management	Rule management	Change password
Teacher	Maintenance management	User group management	

TABLE 3: Role table.

Laboratory administrator	Teacher user	Student user	Common modules between roles
Essential information	Teacher registration	Student registration	System bulletin
Maintenance management	Essential information	Essential information	Message module
Booking management	Teacher roll call	Student sign in	Login account
Announcement management	Roll call list	Check in list	Exit the system
	Experimental items	Experimental items	Password modification
	Equipment repair	Equipment repair	Forgot password
	Experiment appointment	Experiment appointment	
	Student achievement list	View results	

3.2. Overall System Design. Narrow band Internet of Things (NB-IoT) has become an important branch of the Internet of Everything network. Built on cellular networks, NB-IoT consumes only about 180 kHz of bandwidth and can be deployed directly on GSM networks, UMTS networks, or LTE networks to reduce deployment costs and enable smooth upgrades.

NB-IoT is an emerging technology in IoT that supports cellular data connectivity for low-power devices over wide area networks, also called low-power wide area networks (LPWAN). NB-IoT supports efficient connectivity for devices with long standby times and high network connectivity requirements. It is said that the battery life of NB-IoT devices can be improved by at least 10 years, while also providing very comprehensive indoor cellular data connectivity coverage.

The laboratory management system using NB-IoT and AI cloud platform technology consists of four parts to realize remote monitoring and intelligent regulation of the scale intensive laboratory environment as shown in Figure 1.

The sensing layer includes the environmental data acquisition module and the video monitoring module. It uses the microprocessor STM32 as the core to read, examine, and store the environmental information collected by the sensors to send to the NB-IoT communication module: the video monitoring module is a camera to collect the internal picture information of the laboratory and transmit it to the platform layer via the WiFi network.

The network layer uses NB-IoT communication technology, base stations, and core network. The base stations are provided and maintained by the operator, and the core network supplies the cloud and terminal service transmission channels, and the overall architecture of network transmission is shown in Figure 2.

On the basis of LTE, the NB-IoT network transport layer is optimized and enhanced through IoT service functions. Interact with HSS through the S6a interface to realize the user authentication function; SGW is responsible for routing and forwarding user data packets; PGW is responsible for the upstream and downstream charging of the communication between UE and other network interfaces: SCEF supports non-IP transmission of data types on the control plane. The user plane transmission path is UE-eNodeB-SGW-PGW, and the control plane transmission path is UE-eNodeB-MME-SCEF and UE-eNodeB-MME-SGW-PGW. In this paper, NB-IoT is selected, and data are uploaded through the CoAP communication protocol using the Telecom Internet of Things SIM card.

Platform layer includes the server and the database, according to the design requirements and the IoT platform on the server to configure NB-IoT parameters, profiles and decoding plug-ins and other deployments are developed. Realize the server and telecom IoT interaction data, the network layer uploads the terminal data information to the server, which is analyzed and processed by the server and stored in the database.

Application layer includes mobile and PC monitoring interface. Managers can view environmental data, lab video screen, historical data, and alarm notification in real time through the PC web interface or WeChat applet.

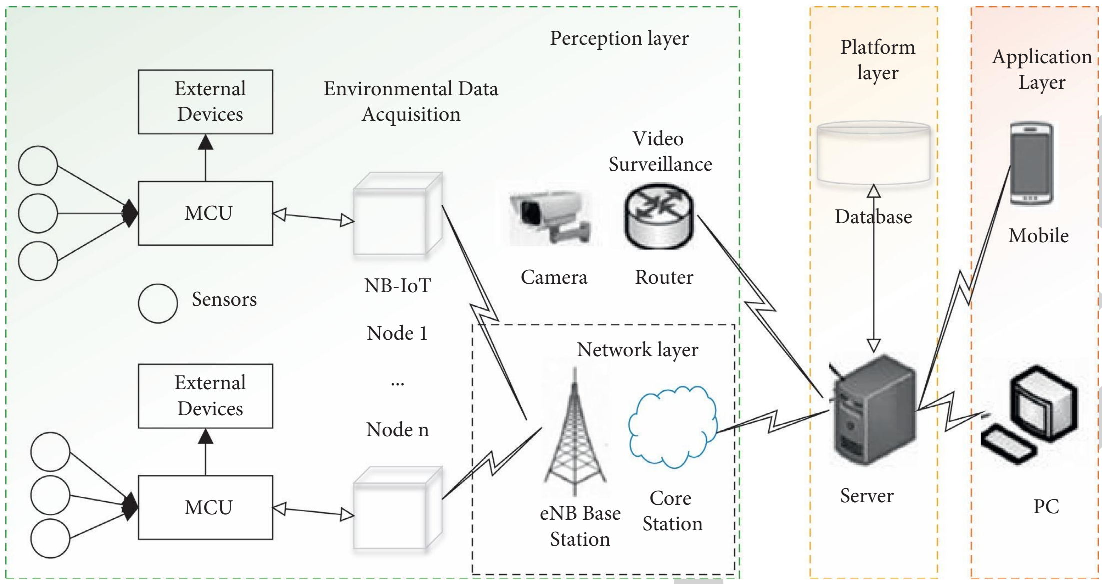

Figure 1: Overall structure of the system.

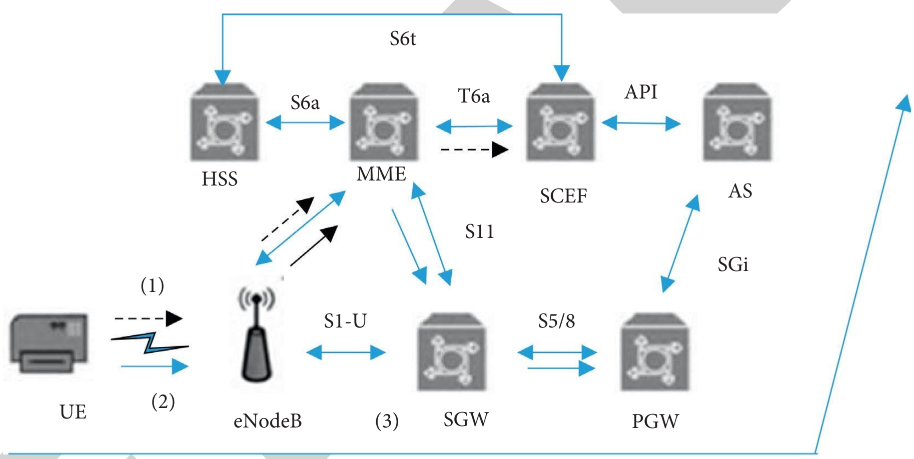

Figure 2: Overall architecture of network transmission.

3.3. System Implementation Functions. The system functions are shown in Figure 3, which mainly include three modules: lab security and monitoring, network layer big data analysis and statistics, and cell phone application. Students and managers can generate data information and access data information through the cell phone application; students can book labs for experiments anytime and anywhere on the application; there is no need for staff on duty in the labs, students can enter the labs after successful booking by swiping their cards; the power supply of the labs is ready to use, students can turn on the power supply and start experiments by swiping their cards on the corresponding lab tables after entering the labs; during the experiments, students can report problems with the experimental instruments through the mobile phone application. When an emergency occurs, the alarm will be sounded to remind the administrator to deal with it; teachers can open the laboratory and view students' experiment records through the cell phone application.

3.4. System Use Case Analysis

3.4.1. System Administrator Module. The system requires the system administrator to have super privileges, and the system administrator needs to add, delete, modify, and view the user information in the system, and the system administrator needs to be responsible for the assignment of user privileges and the management of system maintenance modules. The corresponding use case diagram is shown in Figure 4.

3.4.2. Laboratory Administrator Module. Lab administrators are required to manage the system announcement, appointment management, and maintenance management modules to make announcements about the lab, with two ways to select when faculty users and student users make appointments for lab response (agree or disagree), and two ways to select when faculty users and student users request maintenance response (in maintenance or normal). Also, lab

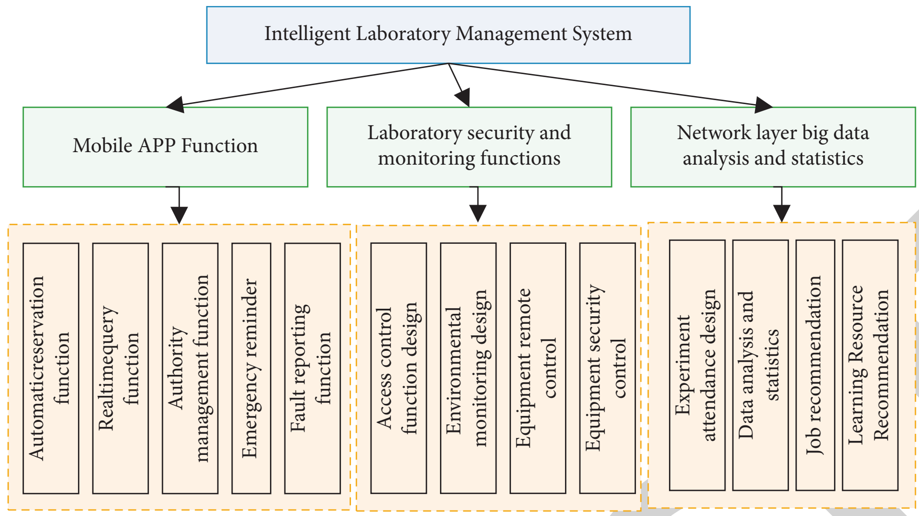

Figure 3: Main functions of intelligent laboratory management system.

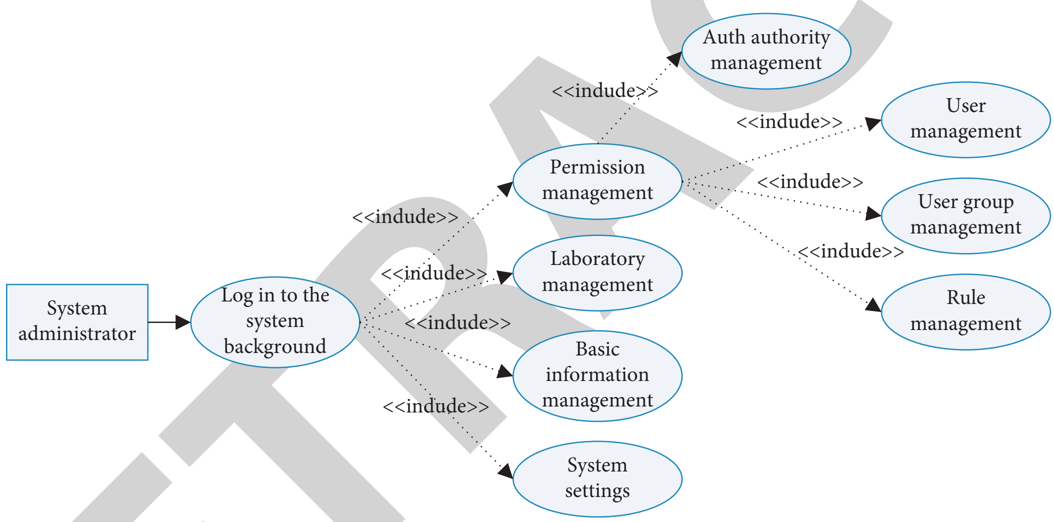

Figure 4: Lab administrator user use case diagram.

administrators are required to assist faculty in maintaining basic information about faculty, classes, labs, instruments, etc. The corresponding use case diagram is shown in Figure 5.

3.4.3. Teacher User Module. Teacher users need to register for the first time, and after logging into the application, they can maintain basic information of teachers, publish experimental projects, report repairs, make appointments and other module functions, and receive announcements about the lab, as shown in Figure 6.

3.4.4. Student User Module. Student users need to register for the first time, maintain their basic information after logging into the application, analyze the functions of modules such as check-in, view experimental items, report repair equipment, and book experiments and receive announcements about the lab, whose corresponding use case diagram is shown in Figure 7.

3.5. System Hardware Design. The core of the system hardware design is "acquisition + control", including terminal video monitoring and environmental monitoring of two parts, the user through the client to the camera and environmental control equipment for remote operation.

3.5.1. Video Surveillance Hardware Design. Video surveillance consists of a camera and a wireless router. The IPC2A5L-IR cartridge camera of Uvision Technology is selected to develop its own SDK library with the camera head through ActiveX control to achieve remote interactive communication, so that managers can remotely control the

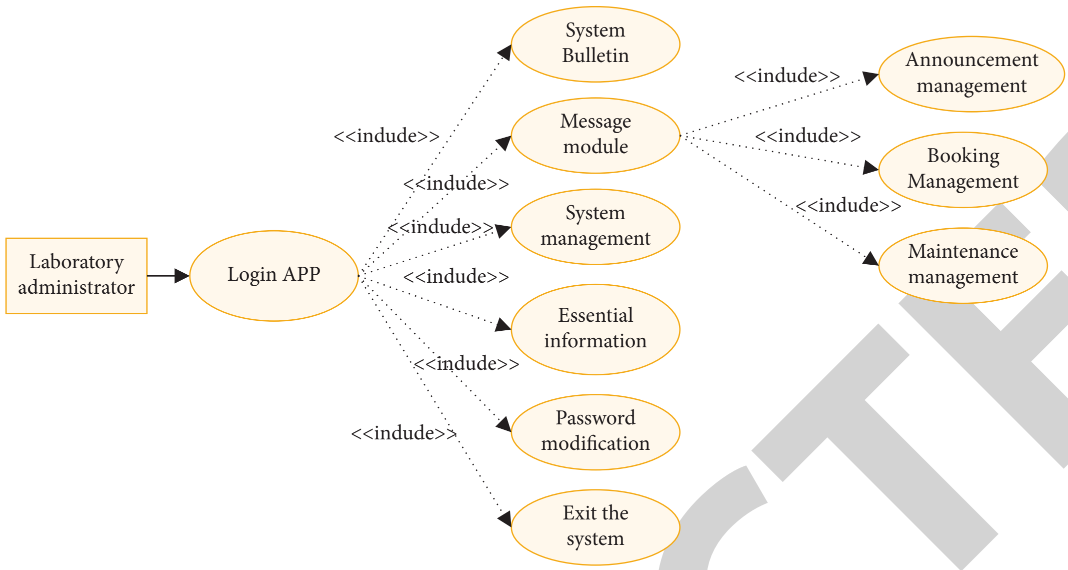

Figure 5: Lab administrator user use case diagram.

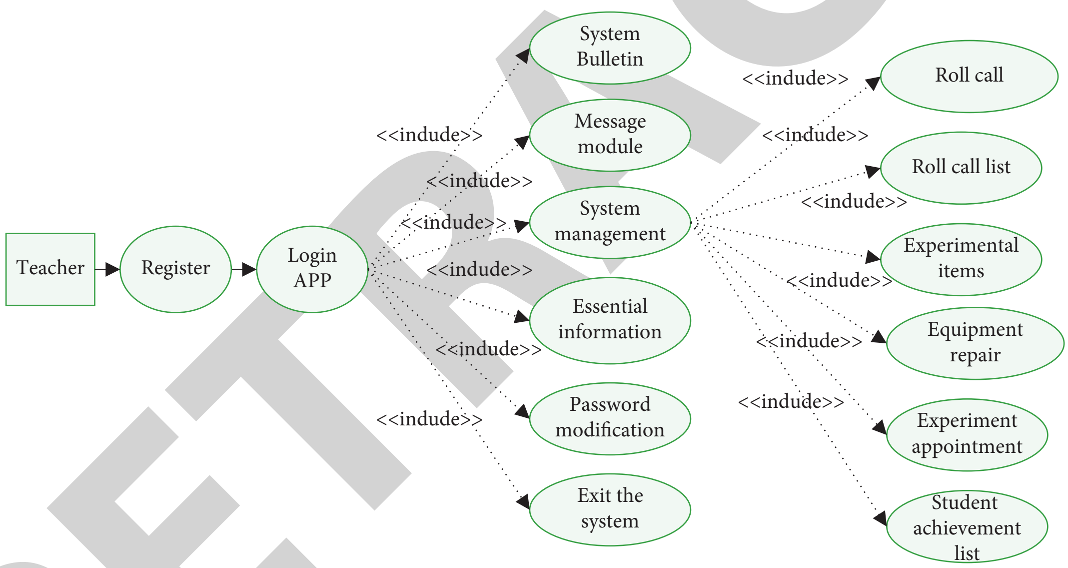

Figure 6: Teacher user use case diagram.

camera angle, orientation, focal length, shooting, and storage functions through PC or mobile terminal anytime and anywhere to view the actual situation and historical records of the laboratory site.

3.5.2. Environmental Monitoring Hardware Design. Environmental monitoring hardware design includes the design of microprocessor, sensor, external device, and NB-IoT communication module, the overall hardware framework is shown in Figure 8.

The microprocessor is STM32F103ZET6 with ARM Cortex-M3 core, which has excellent operation speed and processing performance and can respond to the processing of laboratory environment data information in real time, large 512 kb flash storage capacity, and more than a dozen interfaces on board, which can meet the needs of the laboratory management system to deploy peripheral resources.

The sensor module is composed of CLE-1012-401 NH_3 concentration detection, CLE-0112-402 H_2S concentration detection, PMS7003 CO_2 concentration detection, S8-0053 PMl0 detection, where the NH_3 and H_2S sensors are electrochemical gas sensors. It needs to be conditioned by the LMP91000 chip signal before the data can be read by the ADC channel of STM32. STM32 reads temperature and humidity, light intensity data through single bus and IIC interface, and PM and CO_2 data through UART interface, respectively. The external devices include fans, roller blinds, wet blinds, heating, spraying, ventilation, and make-up light. They are connected to the STM32 through relays, and an optocoupler isolation circuit is added to the driving circuit of the relays to prevent electromagnetic interference.

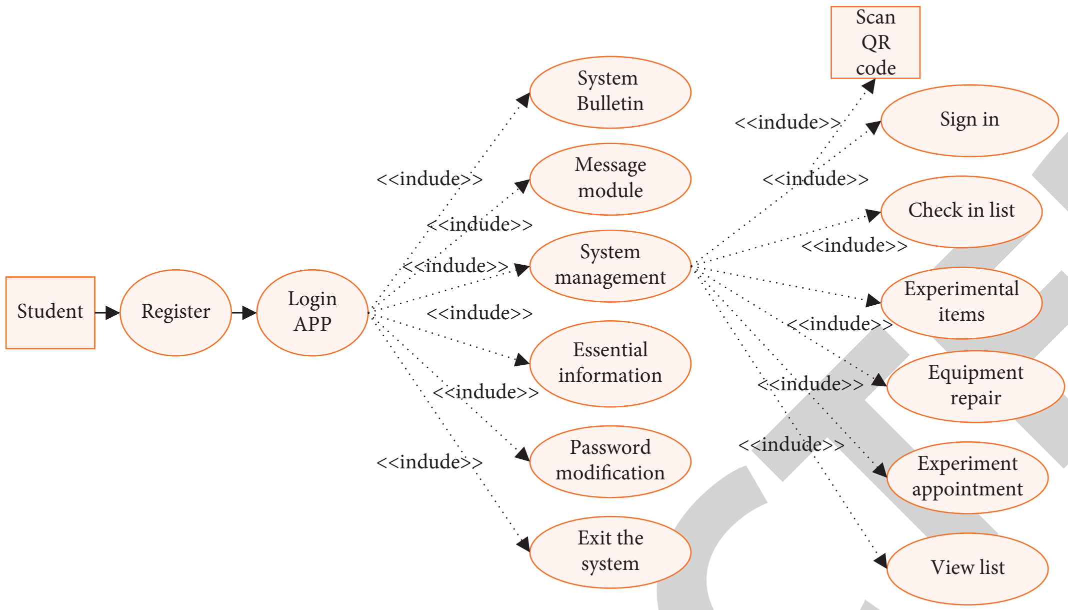

Figure 7: Student user use case diagram.

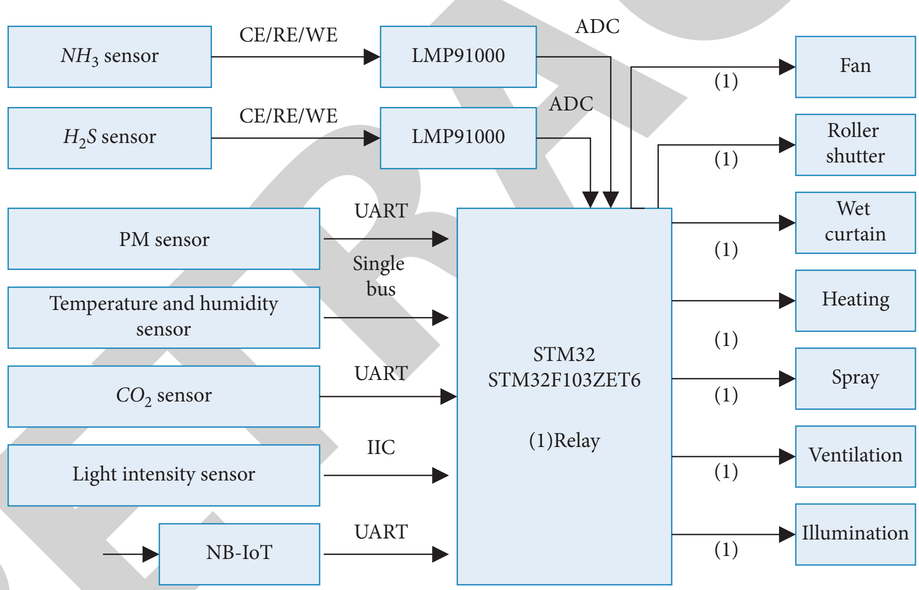

Figure 8: Hardware block diagram of environment acquisition terminal.

According to the IoT cards of different operators, the corresponding transmission mode is selected to communicate with the cloud platform through UART serial port and STM32 interactive communication. The microprocessor STM32 reads data and uploads it to the cloud platform through WH-NB73 and telecom IoT SIM card via the CoAP mode to access the NB-IoT network, and when the environmental threshold value is exceeded, the cloud platform sends control commands to adjust the switch of the corresponding external device relay.

4. System Testing

In this paper, the system is applied to a university laboratory to test the feasibility and stability of the system. 6 NB-IoT wireless collection nodes are deployed in the laboratory to conduct field tests on the communication performance and overall functions of the wireless sensing network, including the communication stability of NB-IoT modules, accuracy of data collection in the laboratory environment and remote regulation performance tests.

4.1. System Communication Test. Due to network blockage, equipment failure, and other problems, packet loss occurs when the NB-IoT wireless communication module transmits environmental data to the cloud server, and packet loss is inevitable. To verify the stability and reliability of the system signal in the transmission process, the data collected by the NB-IoT wireless sensor network is transmitted to the cloud server every 10 minutes. The 6-day data from July 10, 2020, to July 15, 2020, are used as test samples. Each node should

Table 4: Communication packet loss rate results.

Node	Receivable packets/pieces	Received data package/piece	Packet loss rate/(%)
1	864	857	0.82
2	864	851	1.52
3	864	859	0.57
4	864	856	0.92
5	864	854	1.15
6	864	860	0.45
Average value	864	856	0.90

Table 5: Data for field equipment collection in piggery.

Time	Temperature/(°C)	Relative humidity/(%)	Illuminance/(Lx)	PM10 concentration/($ug \cdot m^{-3}$)	CO_2 concentration/($\times 10^{-6}$)	H_2S concentration/($\times 10^{-6}$)	NH_3 concentration/($\times 10^{-6}$)
7:00	24.7	70.3	85	245	348	1.5	4.4
8:00	25	69.8	74	262	355	0.9	3.8
9:00	25.1	70	82	225	376	1.2	4.5
10:00	25.5	69.5	81	218	364	0.8	3.2
11:00	25.9	68.1	78	238	350	1.5	1.5
12:00	26.2	68	76	182	327	1	3.6
13:00	25.5	68.4	83	244	335	1.5	3.8
14:00	26.2	68.8	85	168	343	1.4	2.9
15:00	25.8	69.2	83	237	352	0.8	3.4
16:00	25.2	68.6	78	199	345	1.2	3
17:00	25.2	68.9	77	215	354	1.5	3.5
18:00	24.9	68.7	85	223	338	1.4	4.1

Table 6: Data collected by the NB-IoT wireless sensor network.

Time	Temperature/(°C)	Relative humidity/(%)	Illuminance/(Lx)	PM10 concentration/($ug \cdot m^{-3}$)	CO_2 concentration/($\times 10^{-6}$)	H_2S concentration/($\times 10^{-6}$)	NH_3 concentration/($\times 10^{-6}$)
7:00	24.9	70.2	89	242	349	1.3	4.4
8:00	24.5	70	79	263	358	0.8	3.5
9:00	25.3	70.3	80	228	376	0.5	4.1
10:00	25.3	69.8	81	213	362	1.2	3.5
11:00	26.2	68.2	78	244	353	1.5	4.2
12:00	25.9	68.5	81	183	331	0.6	3.5
13:00	25.5	67.8	85	242	341	1.5	3.8
14:00	26.8	68.8	80	271	340	1.1	3.0
15:00	25.9	69	82	234	348	0.2	3.2
16:00	25.2	69.5	81	199	345	1.3	3.1
17:00	24.8	69.2	80	220	347	1.5	3.5
18:00	24.8	68.2	85	224	342	1.7	3.8

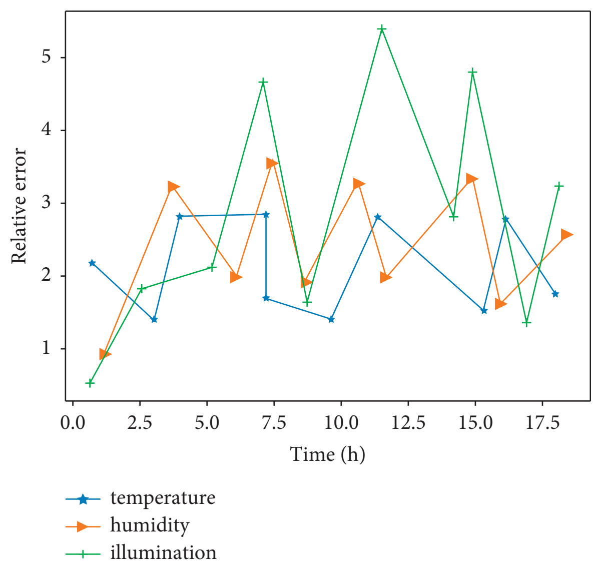

FIGURE 9: Relative errors of three measurement results.

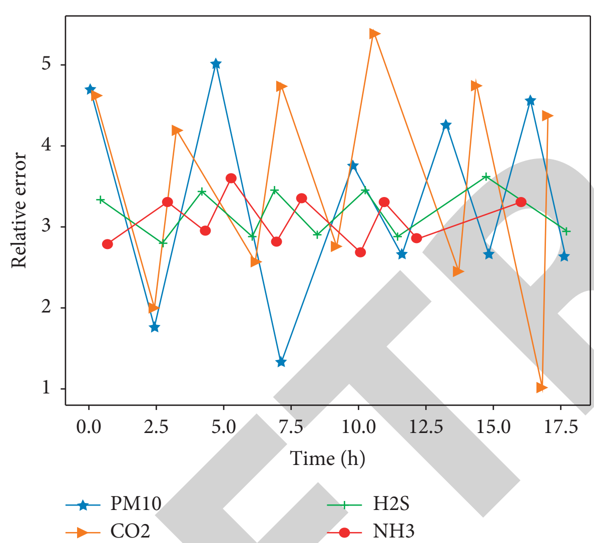

FIGURE 10: Relative errors of four measurement results.

upload 864 data packets and extract the data stored in 6 terminal nodes for analysis, and the results of the communication packet loss rate are shown in Table 4.

The test results show that the system has good communication stability, and the average number of packets received by each node in the selected 6 days is 856. The average packet loss rate is 0.91%, and the communication success rate is above 99%.

4.2. System Testing and Analysis. To verify the accuracy of the collected environmental information between 7 am and 6 pm, we will release the relevant information to the public at 6:30 pm. See Table 5 for the data collected by laboratory equipment on-site from 3:00 pm. to 6:00 pm. and Table 6 for the data collected by the NB-IoT radio sensor network. Figure 9shows the relative error of the two measurement results.

From Tables 5 and 6 and Figures 9 and 10, the relative errors of temperature, humidity, H_2S, and NH_3 for the two measurements are about ±0.5, while the relative errors of light, PMIO, and CO_2 are about ±5, while the average relative measurement errors of temperature, humidity, light, PMIO, CO_2, H_2S, and NH_3 are ±0.233°C, ±0.291%, ±2.75 Lx, ±2.58 ug/m^3, $\pm 2.25\times10^{-6}$, $\pm 0.216\times10^{-6}$, and $\pm 0.175\times10^{-6}$, which are all within a reasonable range, indicating the high accuracy of the data collected by the NB-IoT wireless sensing network.

5. Conclusion

With the current development of information engineering, the traditional manual management methods of laboratories can no longer meet the requirements of the times. Therefore, it is necessary to develop an effective laboratory management system. The laboratory intelligent management system is developed and realized by network communication, network and software based on NB-IoT, and artificial intelligence technology. At the same time, it can effectively reduce the development cost of the laboratory intelligent control system and facilitate the subsequent system upgrade. The intelligent management of the laboratory is realized through various functions of the system, which provides intelligent management support for better utilization of the laboratory as an important platform for scientific research and talent cultivation in universities.

Data Availability

Data are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding this work.

Acknowledgments

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