

## The design of an open laboratory information management system based upon a browser/server (B/S) architecture

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**ABSTRACT:** In order to improve the efficiency of laboratory management, an intelligent information management system based on a browser/server (B/S) architecture is proposed. First, the features of the traditional management systems are analysed; then, the structure of management systems is introduced; finally, the implementation of a ground and power control module, and a network information management module are described in detail. The system is a distributed network for laboratory management, and can carry out the functions of users' login, attendance management, schedule querying and experiment booking, among others. It can not only mobilise the initiative of students to practise and innovate, but also reduces the labour intensity of laboratory management.

### INTRODUCTION

With the development of science and technology, society has a higher demand for talent and innovation. Many colleges and universities have carried out teaching reform using open laboratories, which mainly include basic skills developed by open experiments, comprehensive design exercises, students' research projects, and so on. This has broken the traditional mode of organised classroom teaching, hence, giving students more autonomy by moving from passive to active learning [1][2]. It provides a broad space for students to achieve their potential by using experiments requiring creative thinking by students.

Students can arrange experiments according to their own learning, interests and time, which results in the most efficient use of experimental equipment. It also plays an important role by promoting good engineering practice and innovation by students. However, because of the complexity of arranging open experiments, laboratory management and administration is more difficult and has new requirements, covering student information management and other aspects of the experiments [3]. To address these problems, a design methodology for an information management system is proposed in this article. It can not only mobilise students to innovate, but also can reduce the labour intensity of laboratory management.

The rest of this article is organised as follows. The second section presents the problems with traditional management. The third section describes the design principles of the proposed management system. The specific design methodology is introduced in the fourth section. In the fifth section, some conclusions are presented.

### PROBLEMS WITH TRADITIONAL LABORATORY MANAGEMENT

The open laboratory for higher education is itself a project. But its lack of regularity and dispersion leads to operational problems, which affect the teaching and training of the open laboratory [4][5]. The main aspects are as follows:

1. Students do not know how to apply for open experiments. The open experiments are designed by teachers and then published on-line, free for students to apply for. The project announcement only provides the names of the projects and teachers. Students generally do not know the details of the experiment. Some students register and participate in several experiments, only to find that the experiments were not the same as originally thought, and so quickly exit the programme. In this regard, the university project authorities could make project descriptions more comprehensive to enable students to better understand the information, so they can relate it to their own situation and interests, and make a reasonable choice.
2. The management of laboratories is backward. Currently, the basic condition of a university laboratory network is stable, and the laboratory equipment can meet the basic needs of current teaching. However, laboratory

management tools are relatively backward and mainly rely on manual management by teachers and students, whose status in the good use of the equipment is not clear. For example, students cannot keep abreast of the information regarding content and experimental time; students have to go to the laboratory for the appointment; the registration is completed by the laboratory teacher, etc. So the work is cumbersome, inefficient and has other defects.

3. Innovation in experimental teaching is lacking. At present, the school has a lack of experimental teachers, coupled with a lack of enrolment, resulting in a lack of students in the experimental process. Students cannot complete the transition from basic to comprehensive and innovative experiments, so that students lack practical and innovative skills. In addition to this, students turned in a huge amount of experimental work; teachers were overwhelmed and had not enough time to study and reform experimental teaching methods. Teaching quality needs to improve.

Therefore, the traditional laboratory management cannot satisfy the requirements of the open laboratory. With the rapid development of computer and network technology, the establishment of an open network laboratory information management system will be important. On the one hand, one can arrange laboratory hours and laboratory resources to effectively stimulate and motivate students' learning. On the other hand, it also improves the efficiency of management personnel to ensure the efficient and orderly operation of the open laboratory.

## DESIGN PRINCIPLES OF THE SYSTEM

In the open laboratory information management system, the users are mainly laboratory management administrators, experimental teachers and students [6]. Their responsibilities are as follows:

1. The laboratory administrator is responsible for the co-ordination of laboratory activities and management of the equipment. He or she can assign user permissions, add/delete users, perform data backups and maintenance.
2. The experimental teachers are responsible for the experimental setup of projects, opening hours, student appointment confirmation, students' submissions of work, attendance, assessment, etc.
3. Depending on student numbers, students can log in to the system and check laboratory equipment, staffing, etc. They can also query laboratory access information, details of selected pilot projects and experimental appointment times before the appointment is approved. They can make and modify appointment information and can query the approved projects and times.
4. The department manager is responsible for the arrangement of laboratory activities according to experimental plans and co-ordinates the use of other laboratory equipment.

The open laboratory teachers arrange the experiments according to teaching plans published through the Web. Students do the experiment and attend their appointment. The experiment is done in a time approved by the experimental teacher. Students' attendance should be according to the campus schedule and the experiment commenced after determining the correct bench. Students need to submit test records to the experimental teacher after the experiment.

## SYSTEM COMPONENTS

### Attendance and Power Control System

In order to confirm the attendance of course staff, an attendance and power control microcontroller system is installed in the laboratory, which mainly consists of a microcontroller, serial bus, LCD, buzzer, keypad, card reader, clock modules and other components. The laboratory attendance and power management system can identify entrants by reading the campus card information. A student should use his or her card before conducting an experiment.

For legitimate users, the system will automatically assign users to the start test-bed for the experimental equipment, and records time and other relevant information. Meanwhile, the single chip microcomputer controller receives commands from the computer to control the power on/off to the test-bed. The flow chart is shown in Figure 1.

### Information Management System

According to the requirements of system design, Web B/S (browser/server) software is in three layers; namely, the user layer, the functional logic layer and data layer. This is shown in Figure 2.

This structural design allows users to query comprehensive laboratory management information using a normal Web browser at any time, any place and without installing any client software. The users interact with the system through the user interface layer and the data are sent to the browser for display. The business logic layer is located between the user layer and the data layer, and provides the business logic for the realisation of the system specifications.

This level provides the link between the customer applications and data services, and its main function is the implementation and packaging of the applications. The data layer is used to define, maintain, access and update data, and to satisfy the data requests of the service management.

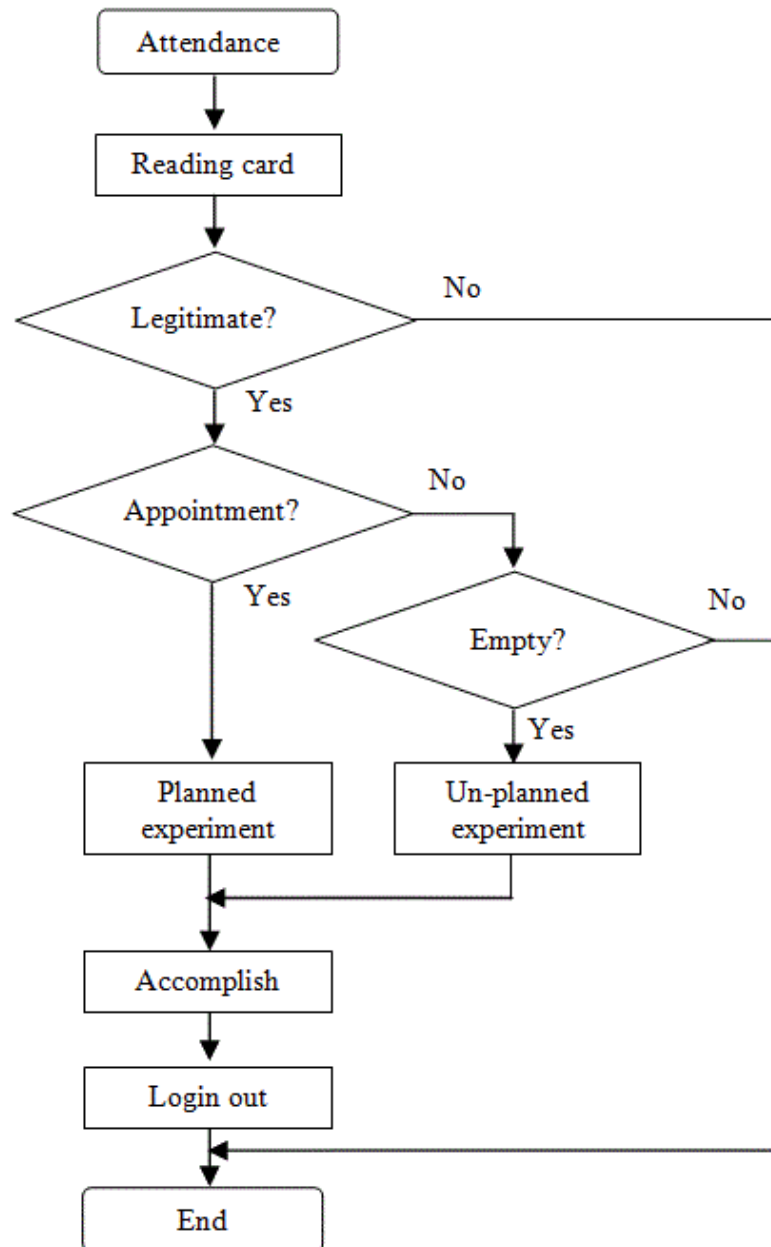


Figure 1: The flow chart of students' attendance.

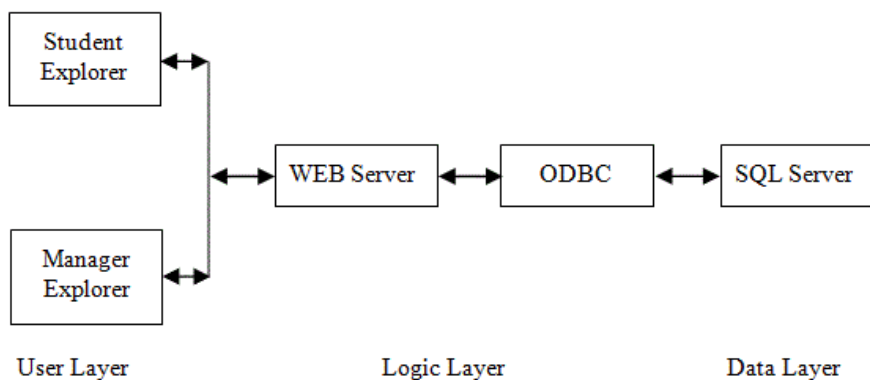


Figure 2: The system structure based on B/S mode.

Based on the above structure, the functional modules of the system include: laboratory equipment management module; test appointment management module; experimental teaching module; database management module; reporting module for innovative pilot projects; integrated query module; on-line communication module; and system help module. The main modules are shown in Figure 3.

Through the open laboratory management information system, a teaching manager can organise the teaching and coordinate equipment usage for an open laboratory. The experimental test arrangements and management of teachers' operations are completed in a network environment. Students can perform on-line bookings, reporting and make alternative experiment choices from within the school or from outside:

1. Experimental appointment management. Students query arrangements for experiments under their own ID and password, choose times and experimental projects, and form an appointments record. After approval, the system automatically assigns a laboratory bench.
2. Experimental teaching management. According to plans, teachers login to the network to complete the curriculum content setup and set experimental details. This mainly includes test name, test equipment requirements, test content, timing, etc.
3. Laboratory equipment management module. This mainly provides equipment updates and information management, including laboratory equipment availability, classification, serial number, performance parameters, names and status information.
4. Database management module. This is responsible for authority distribution and data maintenance of student information, teacher information and laboratory information; it satisfies query and maintenance requests for experimental projects, laboratory reports, test results, equipment, files and other information.
5. System help. This mainly helps teachers and students to solve common problems, such as system registry, course selection, information and tips, and helps them to quickly master the use of the information management system.
6. Integrated query module. Students can query: the normal semester teaching plan for the laboratory; the use of the equipment and apparatus; the working principles; experimental evaluation of the content, requirements, scoring, and so on.
7. On-line communication module. This provides an on-line venue for students and teachers to exchange information and raise issues. Common problems will be collated and published in the *Frequently Asked Questions* module.
8. Innovative experimental project declaration. In order to make full use of laboratory resources and stimulate student innovation, the system provides an innovative project declaration. Students can design an experiment project with content according to their interests. If approved, the experiment can be included in the open laboratory.

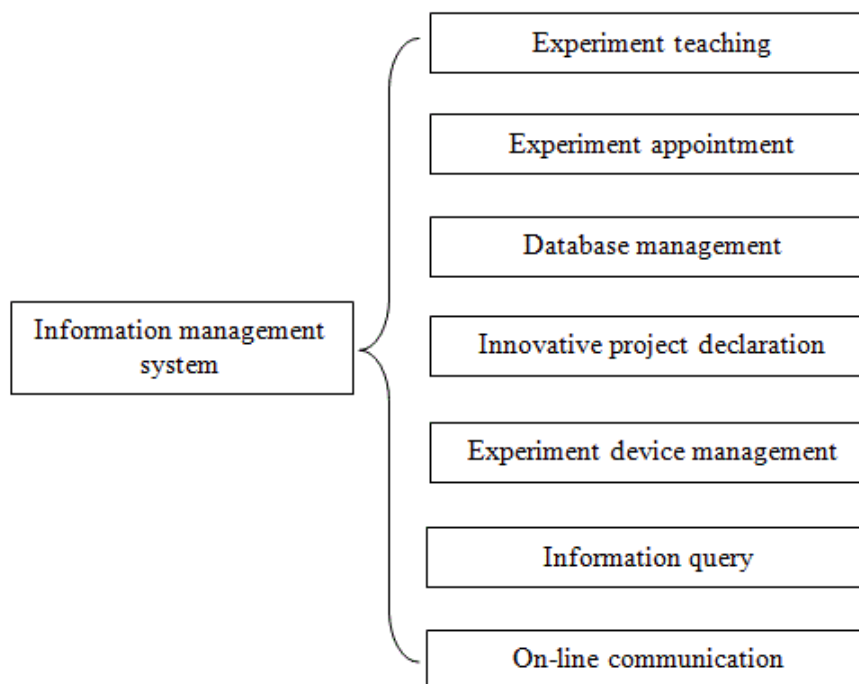


Figure 3: Application modules of the information management system.

## CONCLUSIONS

An open laboratory information management system was designed based on a B/S (browser/server) architecture. It can provide for the overall management of the student experimental information. On the one hand, it can maximise the utilisation of laboratory resources, and fully mobilise the initiative of students to practise and innovate. On the other hand, it can help the management staff to improve efficiency and reduce work. It can solve the difficulties of open laboratory teaching management and promote the professional engineering education reform process of open laboratories. The open laboratory information management system provides a good way to improve the level of engineering practice and the ability of students.

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