Exploration of the Computer Hardware Experiment Teaching Method Based on the Cloud Platform

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***Abstract*-This paper presents a new method for Computer Hardware Experiment teaching. Previous hardware experiments of computer is built on a computer connected to a hardware equipment locally, and then student operate the hardware devices on the switches, buttons, etc. to carry out experiments and verify the developed hardware code is correct. Such experimental methods have lots of significant limitations. To solve the problems, we have developed a cloud-based real hardware experiment system platform. Students can use the experiment board anywhere internet available at any time. They can land at any place where they can access the cloud platform server, that will help them to get a hardware device, and then they can operate, and get results the same as local. We set up a cloud, and many sub-clouds in different cities. Each sub-clouds have a certain number of the special hardware experiment devices. The hardware device is assigned automatically, especially it can solve the problem of insufficient experiment hardware within a university. The platform has been set up with an experimental database, to analysis what is the difficult points for students and make a big data to help for improving computer hardware experiment educational methods. It provided a good experimental support for the online hardware experiment teaching content of MOOC.**

Keywords—MOOC ； Hardware ；Experiment; Cloud

I. INTRODUCTION

In the knowledge content of computer science, it can be divided into two major categories of software and hardware [1]. As important as software courses, hardware courses are the important component in the course of computer science curriculum [2]. Through the study of the hardware courses, students can understand the working mechanism of the computer, and then design and develop a new hardware, which plays an important role in the development of computer science. At present, most of the computer hardware series courses in colleges and universities have been set up, including Digital Logic, Computer Component Principle, Computer System Architecture, etc.

Theoretical teaching focuses on the knowledge points, and the experimental teaching focuses on the application of knowledge points. Through the study of computer hardware experiment, we can train students' practical ability, engineering practice ability and the ability of development and innovation [3]. Hardware experiment teaching is an important part of computer hardware course. Computer hardware is real equipment, virtual and other technical means cannot fully realize the real hardware experimental environment. Online education develops rapidly, and online courses should be set up to meet the teaching mode of the combination of theory and experiment, which improve the quality of teaching. Computer software experiments have been carried out online, including online compilation, results feedback and score, and have abundant experimental content and reasonable experimental system [4].

Internationally, MIT has achieved the remote experiment system iLab, students can have access to and control the laboratory equipment through the network. In domestic universities, some teachers have used virtual computer hardware experimental software to meet the computer hardware needs of online experiments, and applied in Digital Circuit course experiment [5].

CS2013 raises: Appreciation of the interplay between theory and practice [6]. Undergraduate students of computer science and technology should have strong practical ability, and they should understand the interplay between theory and links .In China, the Ministry of Education selected a number of national experimental center [7]. The centers are to promote and strengthen the practice teaching in the overall teaching status, and Computer Science subject is one of them.

II. TEACHING METHOD

Hardware courses mainly include Digital Logic, Computer Composition Principle, Computer System Architecture, interface and so on [8,9,10]. These hardware courses have an important feature, which is based on the specific hardware, so these courses are very practical. Experimental teaching is one important part of the curriculum, which is an indispensable mean to cultivate students' practical ability, engineering practice ability and innovation ability. Therefore, each university sets the experimental teaching in the important position in the process of the hardware course.

In the practice teaching of computer hardware, the authenticity and the systematism are two important characteristics. The computer hardware experimental teaching should not be the same as usual, which was only to complete the introduction and verification of some specific knowledge points.

The current large-scale open online course like MOOC is in full swing, which has become an important area of future education and branch. Many colleges and universities have tried some computer science courses on the MOOC teaching, and has

achieved some good teaching effect. However, these courses are mainly based on the theory of curriculum, which is lack of corresponding experimental teaching content.

First, the way of carrying out online experiments. As the online learners rely on the Internet, they do not have the conditions to carry out experiments in the laboratory. So the experimental teaching must also be completed online. For computer software experiments, the situation is better, which only needs to have the appropriate software environment, for example, they can be connected to the server through the experimental system. But the hardware experiment needs some specific equipment, and it is difficult to carry out experiments without the experimental equipment.

Secondly, it is the problem of large-scale experiments. Different from the traditional experiments, the online experiments will be carried out in large scale, which is difficult to be solved. Certainly, it will not work using the traditional manual method. It can only work through the experimental test and the automatic test of the computer automatically to ensure the smooth development of the experiment, and improve the efficiency of the inspection.

Based on the above considerations, we have developed a remote hardware platform named as the Cloud Experiment Platform. The system can complete hardware experiments and complete the experiment of automatic verification. We explore a set of computer hardware practical teaching methods and systems. Therefore, students can do hardware experiments on the network. Each experiment board has an ARM Embedded System, running the Linux operating System.

A. The concept of Cloud Experiment

To train the core ability of the hardware design of computer subject students, we must firstly lead them to understand the working mechanism of CPU; then secondly, to practice the ability of designing CPU. For experimental platform of computer hardware, the hardware design and debugging features are needed. With the popularization of large-scale online education, especially massive open online courses, supporting for the larger scale students online learning, which makes the computer hardware experiment is no longer limited by laboratory opening time, is no longer limited by the number of experimental equipment.

The Cloud Experiment Platform is based on all special experiment equipment in universities, which have been established. The management servers of the platform schedule and manage all special experiment equipment that provide students hardware experimental service. Every special experiment equipment in the university forms a cloud. Based on all these clouds, the dynamic monitoring and distribution server of national special experimental equipment is set up. According to the use of the special equipment in the cloud, the students are allocated to the experimental equipment. Then they have access to a hardware experimental equipment transparently.

The present question is that we cannot provide so many hardware devices to support the students around the world to do such a hardware experiment; it needs more hardware equipment and scattered servers. If more schools join the program, it will benefit more students. On this platform, you can do what you want to do about hardware experiment.

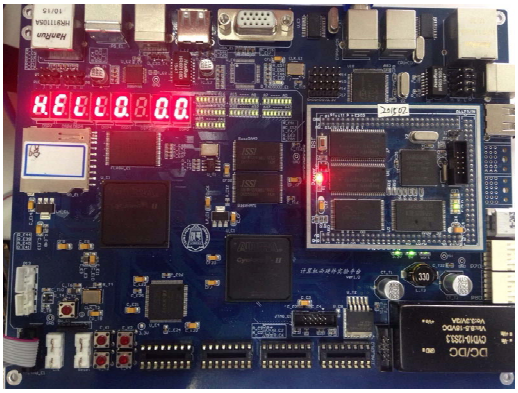

Fig. 1. Single special hardware

The special experiment equipment in university consists of special experiment board which can be assigned to students, single special hardware shown in Fig.1, dozens of such boards can be connected via internet make up a hardware box, as shown in Fig 2.

Fig. 2. A remote hardware box

B. The overall frame of Cloud Experiment Platform

The cloud experimental platform includes three parts (as shown in Fig. 3). The first part is the students use the general browser or the client software to access the cloud platform; the second part is the cloud management platform; the third part is every cloud with dozens of special experimental equipment.

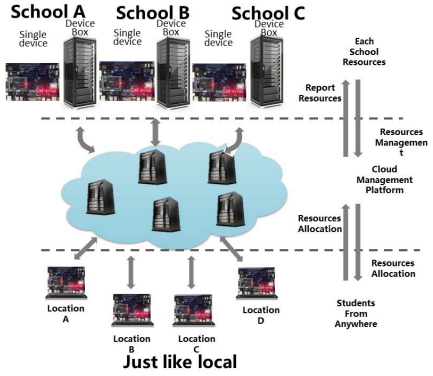

Fig. 3.The overall frame of the Cloud Experiment Platform

Through the browser or using dedicated client software, students can access the cloud management platform, and then get a set of special experimental equipment. The cloud management platform is responsible for obtaining equipment information directly from every experimental equipment cloud provided by the university, coordinating all the cloud equipment, courses, students and experimental conditions. The overall frame of the Cloud Experiment Platform in school is as shown in fig.4.

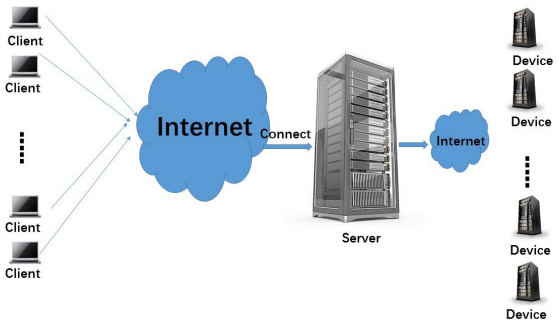

Fig. 4.The overall frame of the Cloud Experiment Platform in school

When students do hardware experiments through the web browser or client software, the local server will inquiry resources from the cloud platform, and the appropriate resources will be allocated to the student. If the local resource is not enough, then the cloud platform will request the nearest cloud for idle equipment, which is calculated and constantly updated. All resources usage period and network conditions are calculated periodically. The process is transparent to the student.

III. TECHNICAL FEATURES

The Cloud management platform is divided into two level: the management server and sub-cloud management server in every university.

A. The allocation of resources

We need to implement adaptive resource allocation function. According to the students' experiment Internet IP address, request priority, and resource requirements, the appropriate allocation of resources will be selected by Cloud management server for students.

According to the priority level of the request, and the students' IP address, it will search the nearest available resource to meet the requirements of the principle of sub-cloud platform for resource allocation.

B. Resource management

Sub-cloud management is faced with the problem of school resources. Sub-cloud platform should monitor the real-time status of resources. It needs to allocate resources to students and update real-time status, then feed back the state to cloud management server.

The allocation of resources is based on the IP address, which is the measurement of the distance to the resources. When students and the special hardware are all in the same university, and if the resources are enough for students to use, the cloud management server will set all students request in the same sub-cloud. If the resource is not enough, the sub-cloud may serve the nearest students from other schools. It will trace all students' experiments and record it. The cloud management server can easily get the records. When students do experiments and studies, it is not required to considerate about the overall load balancing. But it should comply with the following points:

a) According to the specific class needs of each school itself, sub-cloud can reserve some resources in specific time period.

b) Sub-cloud server reports resources to the cloud management platform, and updates in real time.

c) The cloud management center server statistics for each experiment, experiment data, the situation of the students completed the experiment.

d) The software automatically detects the version of each server, and automatically update without affecting the normal experimental activities.

Resource management and scheduling module

In each sub-cloud, the college or university server has a resource management reservation table. This reservation table is based on the curriculum of the university, student's number, free experiments and other information.

For sharing resources, the resource scheduling policy is established. It can be used between universities, when the college select payment mood; it will have different priority with its' rental level. Certainly, the university can buy a set of special equipment with the government funds support so as to have the highest priority, and these are mutual way of sharing resources.

Resources statistics module

In order to coordinate the various sub-cloud servers, remote special hardware experimental system and improve cloud platform, there are a subset of the data cloud server resource statistics process.

Each sub-cloud will have a server resource statistics module, to report statistical data to the cloud servers. Statistics include the completion status of student experiments, the various experimental choice, the usage states and time statistics and others.

IV. THE APPLICATION OF THE CLOUD EXPERIMENT PLATFORM

The platform aims at digital logic courses, computer composition principle courses and computer system architecture course. According to the relationship between the courses, it has been designed from components to the system of multi-level experiment, and supported large-scale online experiment content. The basic experiments almost cover the core hardware curriculum experiment. For the core basic course of computer science, there are many basic experiments supported. Abundant of experimental sample is designed, for example: four bits' adder

experiment, a decimal adder experiment (as shown in Fig.5), Multiple selector experiment, counter experiment (as shown in Fig.6), etc.

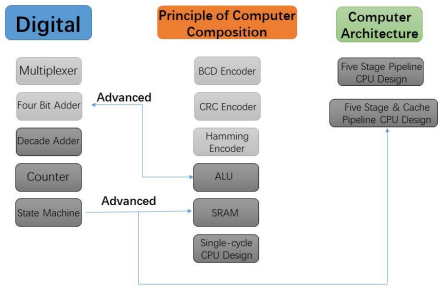

Fig. 5.Supported experimental course and contents

Operating results of the platform as shown in Fig.6

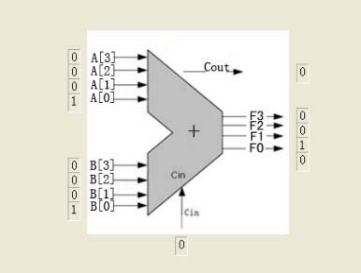

Fig. 6.A decimal adder experiment

Fig. 7.Operating results of the platform

In order to meet the needs of different levels of talent and innovative personnel training, the system supports open CPU experimental design. According to the different requirements, it designs and implements different experiments.

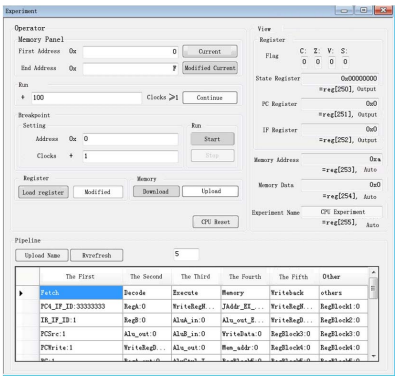

Fig. 8.CPU experiment online debug window

V. FEEDBACK AND CONCLUSION

In the process of experiment teaching, the problem of large scale online hardware experiment can be solved by using the cloud platform. Because it is based on the real hardware of the experimental system, students can reproduce the experiment in real time, combined with online and laboratory experiments. It makes students more intuitive understanding of the theoretical knowledge, and it strengthens their practical ability. Moreover, students feed back that this experiment teaching mode has many advantages in experiments, and helps them to improve their hardware design ability. We chose the digital logic course of the computer department of Tsinghua University as the source of statistical data. The students' hardware experiment test average score by clouds VS go to lab shown as Fig.9.

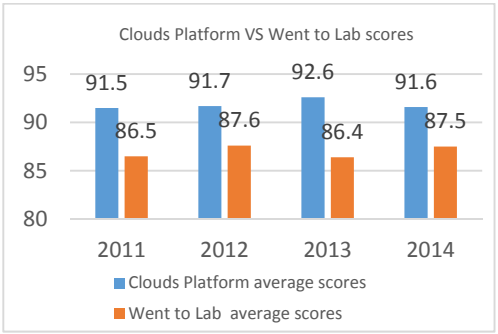

Fig. 9.hardware experiment test score by clouds VS go to lab

The number of students who chose cloud platform to complete the hardware experiments were on the increase. From their courses test scores (shown as Fig 9), we can see that the students' design capability is getting better and better. Formerly, the students can design 8 bit CPU, and now can design 16 or even 32 bit CPU.

Computer hardware experiment teaching method is based on the cloud platform teaching system, so learners can use it anywhere in the world. By MOOC online education system, apply to join the online teaching of computer hardware, you can online apply to a computer hardware experiment equipment, design their own from digital logic to the CPU of computer hardware, and online debugging, accept the results back, compared to their design, call the online remote logic analyzer, modify their hardware design and, ultimately, the correct results of hardware design. This method provides a solution to the computer hardware course, which requires hardware equipment in the laboratory, the need to occupy a lot of space, occupied many hardware devices, and can support 24 hours online, at any time can do the design of computer hardware. This hardware course is free on MOOC.

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