2003 International Symposium on Advanced Intelligent Systems
September 25-28, 2003, Jeju, Korea

e-Learning Environments for Digital Circuit Experiments

Hideki MURAKOSHI
Department of Electronic Systems Engineering
Tokyo Metropolitan Institute of Technology
6-6 Asahigaoka, Hino, Tokyo 191-0065, Japan
hm@tmit.ac.jp

Abstract - This paper proposes e-Learning environments for digital circuit experiments. The e-Learning environments are implemented as a WBT system that includes the circuits monitoring system and the students management system. In the WBT client-server system, the instructor represents the server and students represent clients. The client computers are equipped with a digital circuit training board and connected to the server on the World Wide Web. The training board consists of a Programmable Logic Device (PLD) and measuring instruments. The instructor can reconfigure the PLD with various circuit designs from the server so that students can investigate signals from the training board. The instructor can monitor the progress of the students using Joint Test Action Group (JTAG) technology. We implement the WBT system and a courseware of digital circuits and evaluation the environments.

I. INTRODUCTION

A lot of Web-Based Training (WBT) systems are proposed and developed on World Wide Web (WWW) [1]. Most of those WBT systems are one-way lecture type. It is similar to TV program. Experiments are very important for students in technology and science course. But there are a few WBT systems for experiments and training. WBT systems for experiments of the digital circuit are proposed in [2] [3]. Since the server system has hardware for experiments and measuring instruments, students can not investigate signals from physical circuits. It is same as the simulation. In hardware experiment, it is very important that students can operate measuring instruments and observe signals from physical circuits.

In this paper, we propose e-Learning environments for digital circuit experiments [4]. The e-Learning environments are implemented as a WBT system, which includes the circuits monitoring system and the students management system. The WBT system is client-server system, the instructor represents the server and students represent clients. The client computer with the hardware training board is connected to the server on WWW. The training board consists of PLD and measuring instruments such as oscilloscope. The instructor provides contents and circuits data by reconfiguring the PLD [4]. As the training board is implemented by JTAG device, the instructor can monitor the progress of the students using JTAG technology from the server (JTAG is the IEEE standard, IEEE1149.1, for debugging circuits). Thus, the instructor can instruct accurately to the student.

We implement the WBT system and a courseware for digital circuits. 15 students learned digital circuits by the WBT system, and they filled out a questionnaire. We confirm that the WBT system is useful for learning digital circuits by the result of the questionnaire.

In the remainder of this paper, the WBT system is described in Section2. In Section3, implementation of the system and some examples of contents are shown, and we evaluate the WBT system. Section 4 is the conclusion part of this paper.

II. WBT SYSTEM FOR DIGITAL CIRCUITS

A. Overview of the WBT system

The overview of the WBT system for digital circuit experiments is shown in Fig.1. The WBT system is client-server system, the instructor represents server and students represent client. The client computer with the hardware training board is connected to the server on WWW. Students use the training board for experiments or training. The training board consists of PLD and measuring instruments such as oscilloscope. Students can measure signals of PLD using the measuring instrument. The training board has a workspace for students to wire signal lines of PLD. Thus, students can connect digital circuit modules that are reconfigured in PLD, and complete a digital circuit on the workspace.

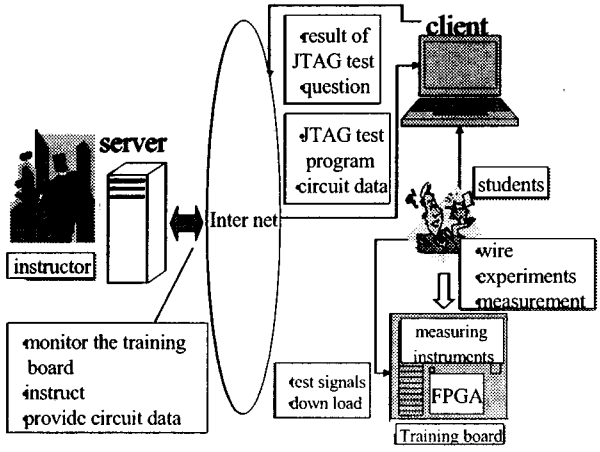

Fig.1 The WBT system for digital circuit experiments

The server provides contents and circuit designs by reconfiguring the PLD on the training board. The instructor can monitor the behavior of students by using of JTAG technology. Thus, the instructor can give timely advices to the student.

B. The circuits monitoring system

For monitoring the progress of students, JTAG Test is implemented in the training board (Fig.2). JTAG is the IEEE standard, IEEE1149.1, for debugging circuit. In JTAG Test (or Boundary-Scan Test), Boundary-Scan Register is arranged to each Input/Output signal line of each IC chip, and the value latched in the BSR are investigated by JTAG Controller. BSR plays the role of the probe attached to a measuring instrument. Thus, the status of the circuit (wirings, signals, etc.) is observed by investigating BSR. In circuit design of the PLD on the training board, BSR is attached to each Input/Output signals for all primitive logic modules (AND, OR, NOT, etc.). Then, all wirings and signals are possible to be observed. The instructor can monitor the status of the digital circuits on the training board, by observing the result of the JTAG Test through the Internet. The BSR is also arranged in the probe of measuring instrument on the training board. The instructor can monitor the probe position which the student investigates the signal on the training board.

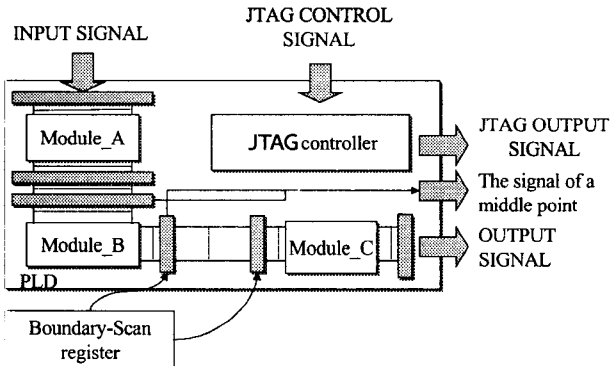

Fig.2 An example of circuit design for PLD on the training board

C. The students management system

The students management system, as shown in Fig.3, is also implemented on the server, and has the courseware, the FAQ database and the learning log database. The courseware has some sections, such as Boolean algebra, full adder, flip-flop, etc. Each section has an examination, and the score of the examinations are stored in the learning log database. The learning log database also has learning time, access log and reference log of the FAQ database. The learning log database classifies the students by the examinations. The FAQ database has three answers for one question. The answer depends on the student's progress. And the FAQ database selects an appropriate answer for a student by asking for student's progress to the learning log database.

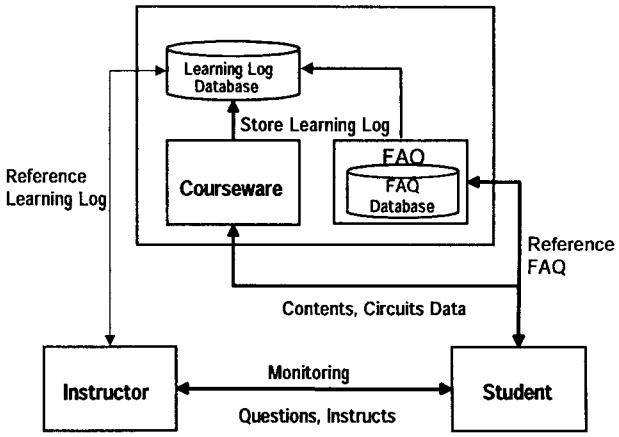

Fig.3 The students management system

III. IMPLEMENTATION AND EVALUATION

We implement the WBT system for digital circuit experiments and a courseware. The contents of the courseware are beginner's class for digital circuit, and they are implemented by HTML and Java Applet. The student receives a class for digital circuits and guidance of the experiments by using browser, and the student downloads the circuit design for experiments. When the student has a question, it is possible to ask a question the instructor via chat window.

A. The circuits monitoring system

The prototype of the training board, as shown in Fig.4, consists of the PLD board (Lattice PLD 2k100 corresponded to JTAG is mounted), the workspace for wiring and the JTAG controller JT3710. The PLD board is also mounted the 7-segmented LED's for output and switches for input. The PLD board is connected to the workspace and the JTAG controller. The workspace has the space for wiring and the probe for measurement. The JTAG controller is connected to student's PC. Thus, students test and debug the circuit by using the training board.

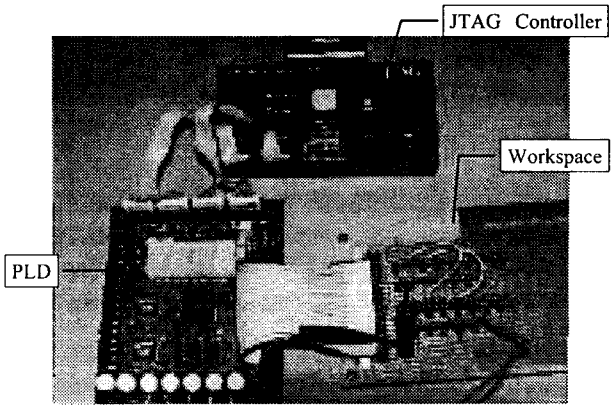

Fig.4 The prototype of the training board

The monitoring tool of instructor side is shown in Fig.5. It consists of the monitor section for monitoring the progress of the student and the chat section for guidance. Both sections are developed by the Java. The information of wiring on the workspace, the information of signals and the position of the probe are expressed in the monitor section.

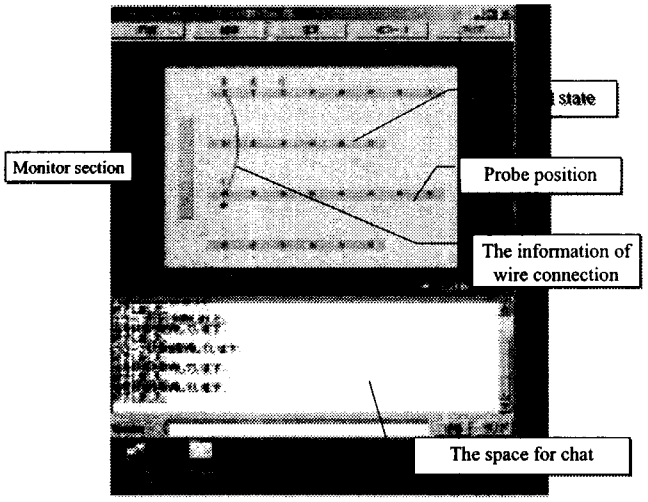

Fig.5 The student monitor

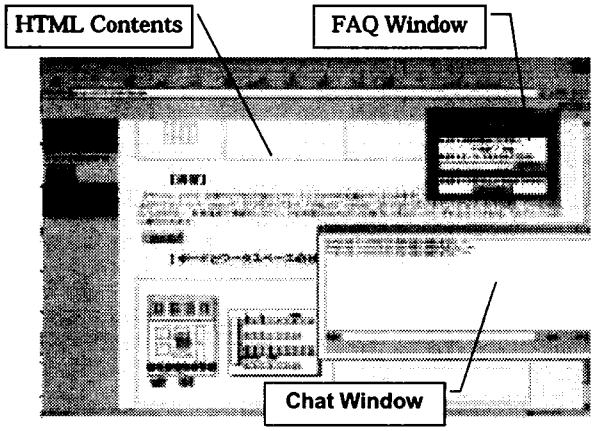

Fig.6 An example of the student's display

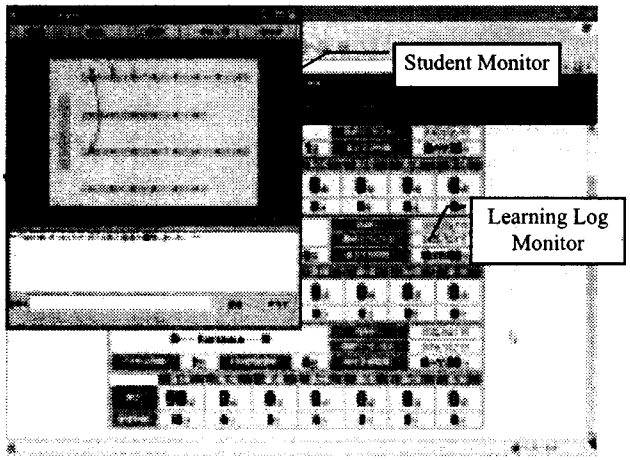

Fig.7 An example of the instructor's display

B. The students management system and the courseware

The courseware is implemented by HTML. The content includes explanations of the subjects, practices and experiments. The sample content is illustrated in Fig. 6. The student can open the courseware, the chat window and the FAQ window simultaneously. When the student has a question, the student asks by using the chat window at any time.

Fig. 7 shows the instructor's display. It has the student monitor and the learning log monitor. The learning monitor indicates the student's progress such as learning time, access log and reference log of the FAQ database and the score of the examinations. The instructor is able to advice to the student appropriately by consulting with the student's progress.

C. Experimental results

15 students learned digital circuits by the e-Learning environments. They are graduate students and have enough experience in learning digital circuits and they filled out a questionnaire. The questionnaire has following 10 questions and free comments space.

1) Do you understand the sample contents of digital circuit?
2) Do you feel that the e-Learning experiments are the same as experiments?
3) Can you make the same circuit as the e-Learning experiments?
4) Does the instructor give you appropriate advices?
5) How do you feel the explanations of contents?
6) How do you feel the layout on the display?
7) Can you understand the use of the training board?
8) Does the FAQ system answer appropriately?
9) How do you feel the FAQ system?
10) How do you feel the e-Learning environments?

Students answered the each question by the value from 1 to 5 (1:very bad, 2:bad, 3:fair, 4:good, 5:excellent).

Table.1 The result of the questionnaire

Question No.	Ave. of results		Question No.	Ave. of results
1)	4.8		6)	4.1
2)	4.3		7)	4.1
3)	3.9		8)	4.2
4)	4.3		9)	4.3
5)	4.3		10)	4.1

The result of the questionnaire is shown in Table 1. Table 1 shows the average of the answer of 15 students. We could get the good result from the questionnaire. We consider that this good result is caused by being able to give timely advices to students, because it takes 1-2.5 seconds to monitor wiring information, signals and probe position. Furthermore, students write positive

opinions in free comments space (for example: Experiments using the WBT system is more interested than ordinary style of experiments, etc.). As the result of the questionnaire, we confirm that the WBT system is useful for e-Learning of digital circuit experiments.

IV. CONCLUSIONS

The WBT system for digital circuit experiments is proposed. In this WBT client-server system, client computer has the hardware training board. The training board consists of PLD, measuring instruments and workspace. The instructor can reconfigure the PLD with various circuit designs. Students carry out the experiment in digital circuit using the training board. The instructor monitors the progress of the student by using of JTAG technology. Thus, the instructor gives appropriate advice to the student.

The WBT system for digital circuit experiment and some contents are implemented for evaluation. 15 students learned digital circuits by the WBT system, and they filled out a questionnaire. We confirm that the WBT system is useful for digital circuit experiments by the result of the questionnaire.

The next challenges of our study are to improve and enrich the contents, and to develop the automatic reply system in the server.

REFERENCES

[1] Y. Okazaki, H. Kondo: n ITS (Intelligent Tutoring System) on the WWW(World Wide Web), IEICE Trans. Information and Systems, No.5, pp.1304-1307 1997.

[2] N. L. V. Calazans, F. G. Moraes: Integrating the Teaching of Computer Organization and Architecture with Digital Hardware Design Early in Undergraduate Courses, IEEE Trans. on Education, Vol.44, No.2, pp.109-119, 2001

[3] C. C. Ko, B. M. Chen, S. H. Chen, V. Ramakrishnan, R. Chen, S. Y. Hu, Y. Zhuang: A Large Scale Web-based Virtual Oscilloscope Laboratory Experiment, IEE Engineering Science and Education Journal, Vol.9, No.2, pp69-76, 2000

[4] IEEE Standard Test Access Port Boundary-Scan Architecture, IEEE Std 1149.1-1990

[5] H. Izumi, H. Murakoshi, et al: Proposal of the Web-based Training System for the Experiment of the Digital Circuit, Proc. IECON'01, pp.1766-1770 2001

[6] H. Murakoshi, H. Izumi, S. Ishijima : Investigation of the web-based training system for the construction and experiment of the digital circuit, Japan Distance Learning Association Journal, Vol.3, pp33-37 2001