

E-learning System with a Real System and Graphical Simulator for Embedded System

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Abstract: This paper describes an e-learning system with a real system and simulator for studying embedded system. Proposed e-learning system provides learners with three items for studying embedded system. First one is on-line textbook. Second one is a graphical simulator, and third one is a real system. The simulator consists of microprocessor and its peripheral circuit. The real system consists of same composition as a simulator and is connected to the internet, namely it is a remote experimental embedded system. The simulator is used for the verifying the programming and for understanding the theory of embedded system operation, namely it is used for exercise. The real system is used for the experiment to check the real reaction of the system, namely it is used for experiment. Therefore the learner can study embedded system regardless of location and time. Moreover they can learn even if they do not have a real system. Thus they do not have to prepare any equipment needed for developing embedded system.

1. INTRODUCTION

E-learning offers potentially universal access to "best-in-class" content, regardless of location, and it can transform education and training from a passive consumption experience to a more flexible and student-centered experience[1]-[5]. Many computer- or web-based training program are available nowadays. Even in traditional face-to-face classes, several web-based homepages support student's study preparation, review and discussion off- or on-campus.

Let us consider studying embedded system. Embedded system is now very important subject. Because there is a great demand for engineers who can develop the embedded system with microprocessor by being intelligence in many products. Learners have to master general theories such as computer architecture, electric circuit theories, logic calculation, programming techniques and so on. Then, they confirm those theories by exercise or computer based simulations. Finally, applying those theories to real systems, they feel the validity. Fig.1 shows relationship of learning process. These phases are very important on student's learning. We developed an e-learning system with a real system which is connected to the internet and graphical simulator for studying embedded system, so that off-

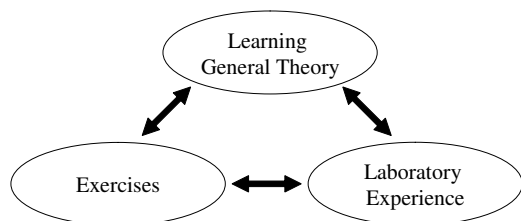


Fig. 1. Learning Process

campus learners are able to learn and experience concerning "Exercises" and "Laboratory experience" parts in Fig. 1.

This paper describes an e-learning system for an embedded system via the Internet. Proposed e-learning system has three services. First one is a on-line textbook. Second one is a graphical simulator, and third one is a real system. The simulator consists of microprocessor and its peripheral circuit. It is used for the verifying the programming and for understanding the theory of embedded system operation, namely the simulator is used for "Exercises". The real system consists of same composition as a simulator and is connected to the Internet, therefore it is used for the "Laboratory experience". Learners can run the experiment and studying general theories just by accessing the web page. The structure of the system is schematically presented in Fig.2.

2. DEVELOPING PROCESS OF THE EMBEDDED SYSTEM

Figure4 shows the general developing procedure of making software of embedded system. This procedure has following 5 steps.

- (1) The learners write the program code, and then compile the program code by using compiler in the PC. Then the Hex file is generated.
- (2) The Hex file is written into the microchip by using program writer which is connected to the PC.
- (3) The microchip is implemented into the target circuit.
- (4) The execution is done.
- (5) The learners confirm the reaction of the execution, and verify and debug the program code.

Above procedure is a developing loop. The learners repeat this loop until their program code works well. Therefore the target circuit and developing environment is indispens-

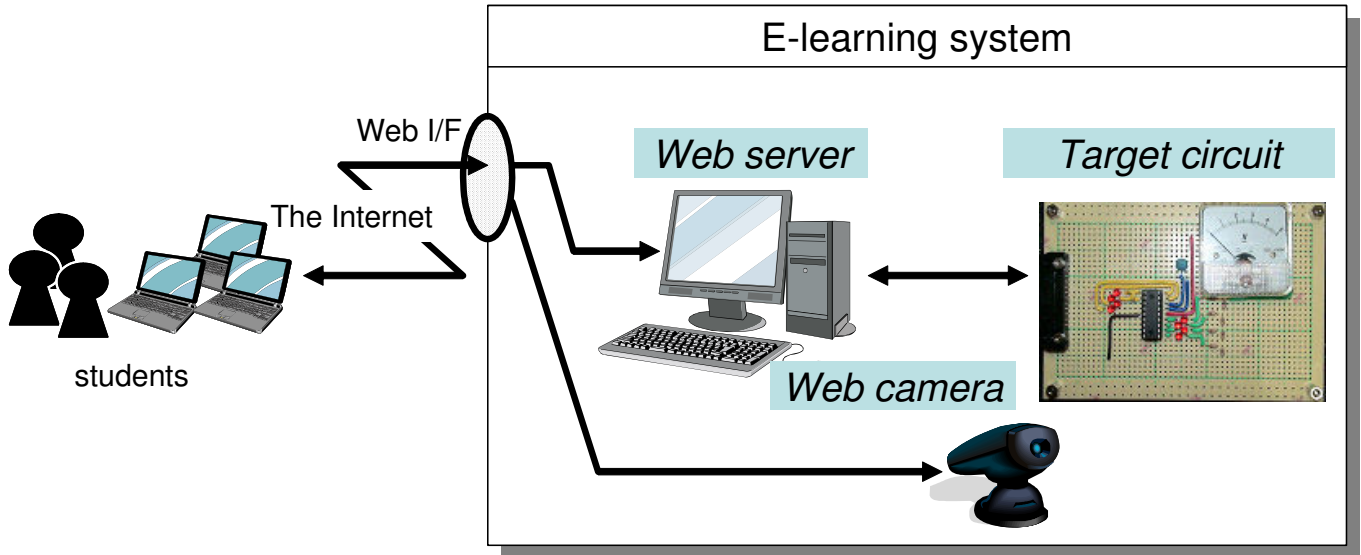


Fig. 3. The e-learning system for embedded system

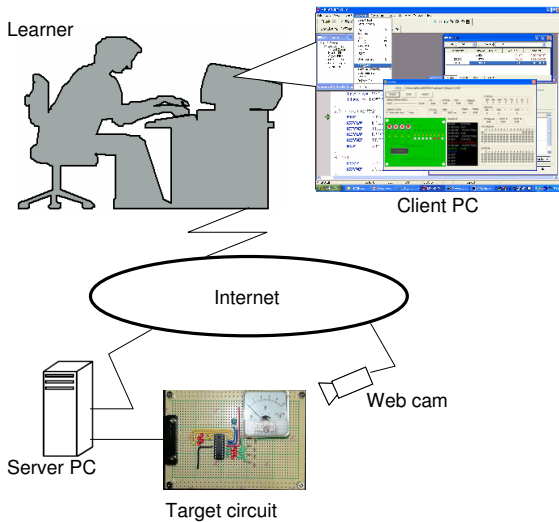


Fig. 2. E-learning system
 able for making the software of embedded system. Thus the real system is very important.

3. E-LEARNING SYSTEM

It is desirable for learners to confirm their program by using target circuit (such as Fig. 4) by themselves, namely the learners should have own target circuit and developing environment. However it is difficult to prepare the target circuit and developing environment for beginners.

Therefore, we develop the e-learning system for embedded system(Fig. 2). Learners can study the topics concerning embedded system by just accessing the web pages, because all equipments are connected to the internet. Therefore learners do not have to prepare real target circuit and developing environment.

3.1 Target user and pedagogical strategy

The assumed target learner is a beginner of microprocessor. Therefore, first, the learners have to know the

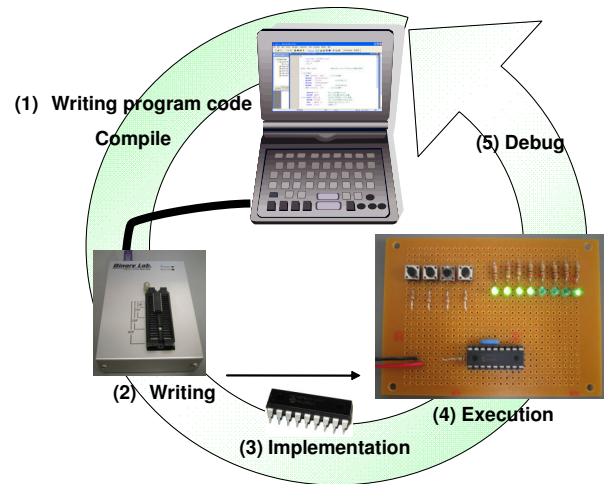


Fig. 4. Developing procedure

computer architecture, electric circuit theories, logic calculation, programming techniques and so on(Learning general theory). Next they study how to write the program code(Exercises). The preferable study sequence is following(Laboratory Experience).

- (1) The learners study general theories.
- (2) They make program code by using graphical simulator (try and error).
- (3) They confirm their program code by using remote target circuit (final check).

In order to realize this pedagogical strategy, the configuration the e-learning system is as follows.

3.2 Hardware configuration

The e-learning system (Fig. 2) consists of two components (target circuit, and web server) from the view point of hardware aspects. These two components are as follows:

- The target circuit is connected to the Web server. It consists of Microchip (PIC), switches, LEDs, voltmeter and analog input.

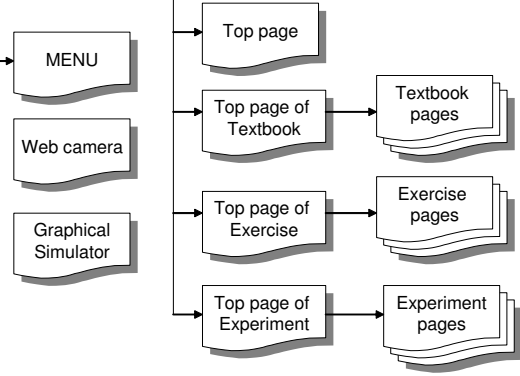
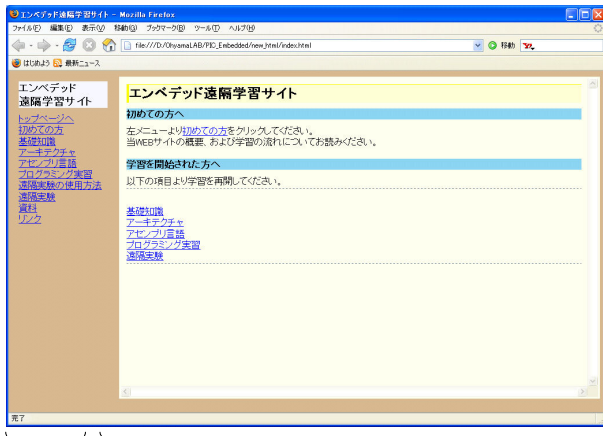


Fig. 5. Configuration of Web pages

- The web server provides three services. The first one is online-text book. The second one is to provide graphical simulator. The third one is online experimental system(Remote target circuit).

Web server The interface of this e-learning system is the web page, namely web page is the gateway to this system. The learners access the web page in order to study embedded system or download the simulator or execute the experiment. Fig. 5 presents the configuration of the pages. The web page is mainly composed of textbook page, exercise page and experiment page. In textbook page, computer architecture, electric circuit theories, logic calculation, programming techniques are explained precisely. In exercise page, learners check the configuration of the microprocessor by using short test. Moreover learners download the graphical simulator to confirm and promote their understanding. In this step, they brush up their program by try and error. In the experiment page, learners confirm their program by using real system as a final check of the program. Fig. 6 shows the snapshot of the experiment page. In the left frame, learners upload their program, and confirm the reaction of the real target circuit by using picture from web cam. The right frame is the interface of the real circuit, learners change the state of the switches. This interface is connected to the real system. Therefore learners are able to confirm the reaction of the real system.

3.3 Three services

The web server provides three services which are on-line textbook, exercise software (Graphical simulator) and

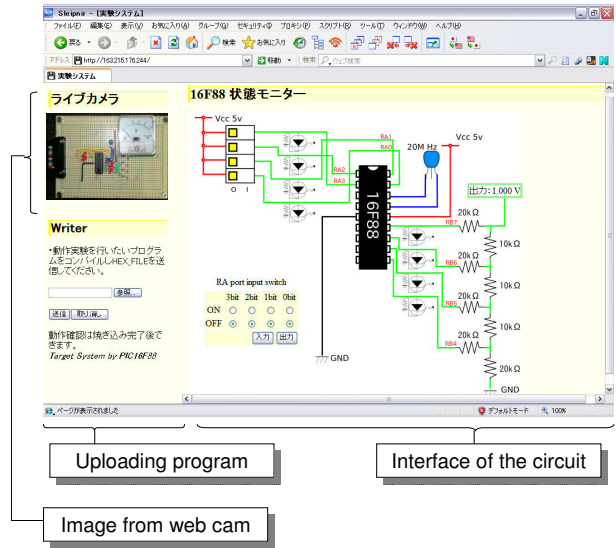


Fig. 6. The screenshot of the experiment

experimental environment(Remote target circuit) through the web-page.

On-line textbook Therefore, first, we design the web contents for the on-line textbook. The textbook is designed by referring the university's lecture course. The chapters are as follows.

1. Introduction to the embedded system
 Outline of the embedded system and microchip
2. Logic circuit
 Binary, hexadecimal, logic circuit
3. Microchip architecture
 PIC microcontroller
4. Assemble language
 Description of assemble language
5. I/O
 Outline of I/O circuit
6. Timer
 Configuration and interrupt
7. A/D D/A
 Circuit and algorithms

In the chapter 1~3, the learner can study by using only on-line textbook. However after chapter 4, learners have to write program code and verify the reaction of their program by using target circuit. Therefore we have to design exercise software and experimental system.

Graphical simulator There have been some softwares which simulates the reaction of the microchip. However, most of them represent the internal memory map by using numerical value, and don't have graphical user interface. It is difficult to understand the reaction of the microchip by using memory map for beginners. The graphical user interface is preferable for understanding intuitively. Therefore we developed the graphical simulator.

This software simulate the steps which are (2) writing, (3) implementation and (4) execution in the Fig. 4, namely Fig. 4 is replaced with Fig. 7 by the proposed simulator. Therefore the learners can execute and confirm their program without target circuit and developing environment.

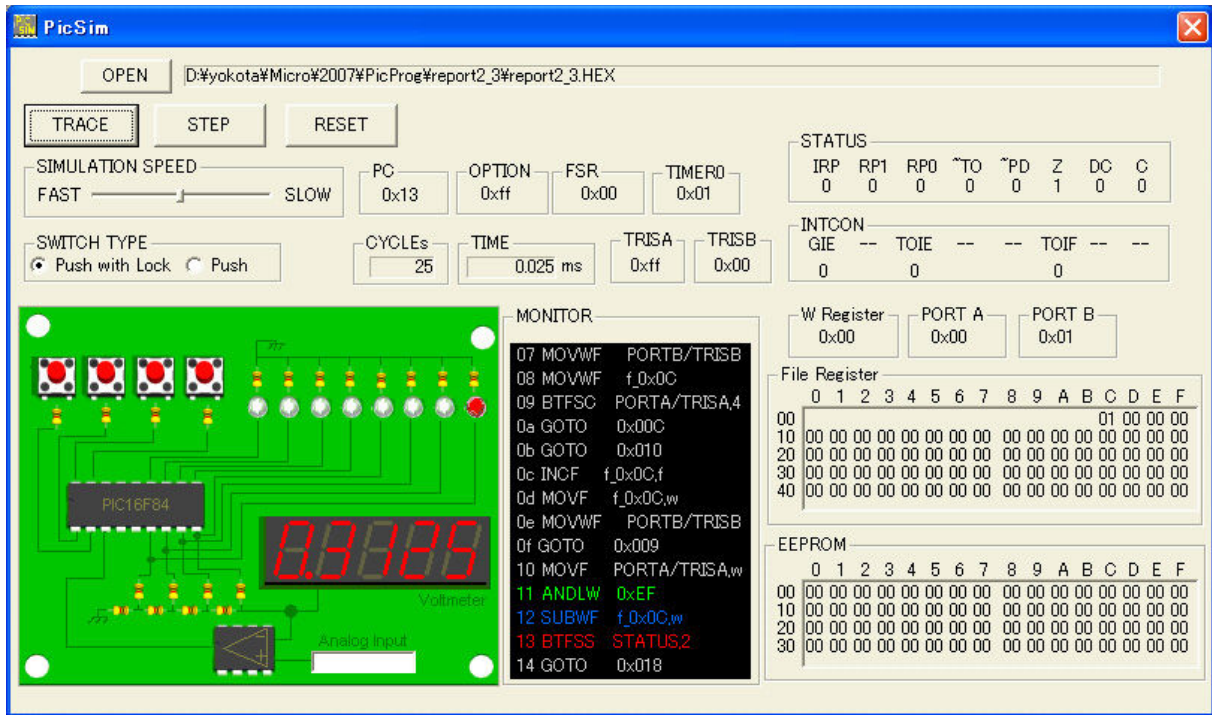


Fig. 8. Screenshot of the graphical simulator "PicSim"

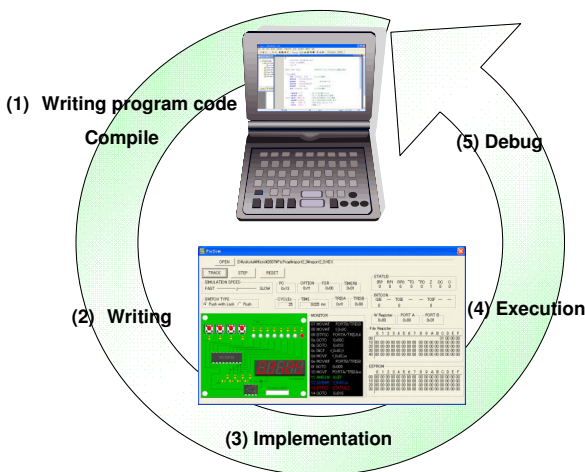


Fig. 7. The role of proposed simulator

This simulator has both digital IO and analog IO functions. Digital IO is realized by some switches and LEDs. Analog IO is realized by ladder circuit. Fig. 8 shows the snapshot of the proposed simulator named PicSim. The left part of the window is the graphical interface, which is consisted of Microchip (PIC), switches, LEDs, voltmeter and analog input. By clicking the switches, states of switches are changed and LEDs are lighted. The learners can intuitively understand the reaction of the microchip by observing the states of LEDs, switches and voltmeter.

Loaded program code is shown in the center of the window. The right part of the window shows the internal memory map. As the graphical interface, program code and memory map are presented at same time, it is able to be easily understand the relationship between these three elements.

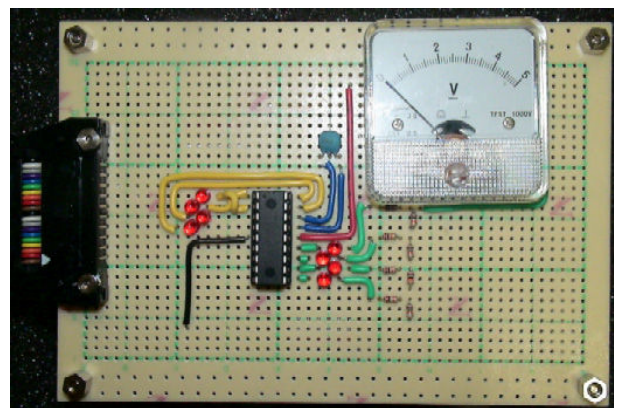


Fig. 9. The Target circuit

Remote target circuit Usually, the learners proceed their studies by using on-line textbook and graphical simulator. The learners improve their program code by repeating developing loop (Fig.7). If the program code works completely well, then the learners verify their program by using real target circuit as the final check.

Fig. 9 is the real target circuit. The real target circuit consists of same composition as a simulator.

The target circuit is connected to the Internet through the web server (Fig. 2).

First, the learners compile their final source file to the hex file in their PC. Then they upload their hex file to the web server, and then the server writes the program code into the real target circuit. In this writing step, the server detects writing errors by monitoring a writing sequence. The server has functions of writing, verifying, erasing, and reset. If some errors occur, the server detects and notifies that to the learner in the web interface. Then the learners

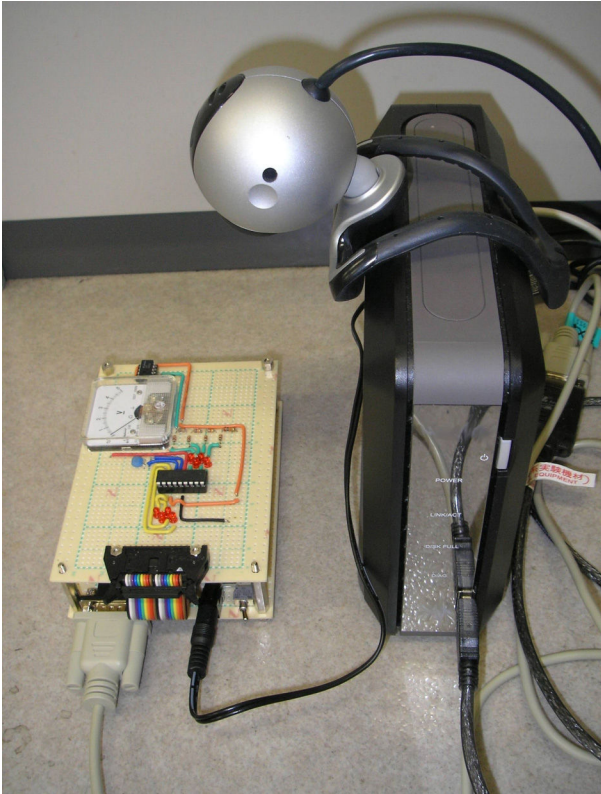


Fig. 10. The overview of the system

are able to execute and confirm the reaction of the real system by using the web cam. Fig .10 shows the overview of the system.

There might be a means that web server has a compiler and the learners only need a web browser. However the assumed target user of this system is beginner. Therefore They does not have experience to make embedd system or program code for microcontoller. For beginners, it is important to study in developing procedure in the condition similar to actual development environments such as how to use compiler or to create hex file. Thus this system requires the learners to compile and to create hex file by own PC. This procedure is same as the case of actual development environment.

4. SOME RESULTS

In order to confirm the function of the proposed system, we did two experiments which are DA conversion and AD conversion. The experiment procedure of DA conversion is as follow.

- (1) The learner writes the program code.
- (2) The program code is complied by certain software such as MPLAB.
- (3) The learner access the "experiment system" page via web contents of this system.
- (4) The hex file is uploaded to the target system from "experiment system" page
- (5) When the uploading is completed, the learner can add the voltage to desired pins by selecting the buttons on the "experiment system" page.

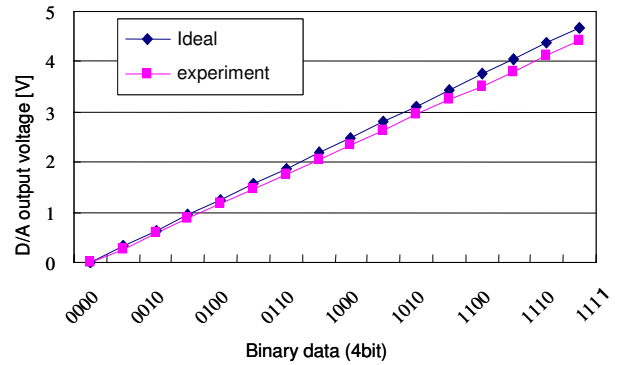


Fig. 11. Experimental result

- (6) Then the learner can confirm the reaction the program or difference between theory and practice by using web camera.

The result is shown in Fig. 11. The experiment page could indicate the input status to the target circuit, and could capture the analog voltage of the target circuit. The target circuit could generate the analog voltage by using the input status. In Fig. 11, there are errors between ideal data and experimental data. The reason is considered as follows; The DA converter on the target circuit was realized by using ladder resistor circuit. Therefore the learner can confirm the reaction of their program and the difference between the theory and real system, namely the learner can observe the real reaction which simulator never has.

5. CONCLUSION

An e-learning system for embed system via the internet has been described in this paper. Proposed e-learning system provides three services. First one is on-line textbook. Second one is a graphical simulator, and third one is a real system connected to the internet. The simulator is used for the verifying the programming and for understanding the theory of embedded system operation. The real system consists of same composition as a simulator and is connected to the internet, namely it is a remote embedded system. The preferable usage of this system is following sequence. First, the learners study general theories by using on-line textbook. Second, they make program code by using graphical simulator (try and error). Third, they confirm their program code by using remote target circuit (final check). For these steps, learners are able to study embedded system regardless of location and time. Moreover they can learn even if they do not have a real system. Thus they do not have to prepare any equipment needed for developing embedded system.

Feature works: We have a plan to test this system for a large scale class, in order to confirm the effects on student's understanding and improving their general skills.

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