ISA Transactions 53 (2014) 1377–1382

Contents lists available at ScienceDirect

ISA Transactions

journal homepage: www.elsevier.com/locate/isatrans

Design and implementation of an internet-based electrical engineering laboratory

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ARTICLE INFO

Article history:
Received 23 July 2013
Received in revised form
23 December 2013
Accepted 25 December 2013
Available online 24 January 2014
This paper recommended for publication by A.B. Rad

Keywords:
Combination of virtual and physical experiments
IEE-Lab
XML
Modelica language

ABSTRACT

This paper describes an internet-based electrical engineering laboratory (IEE-Lab) with virtual and physical experiments at Zhejiang University. In order to synthesize the advantages of both experiment styles, the IEE-Lab is come up with Client/Server/Application framework and combines the virtual and physical experiments. The design and workflow of IEE-Lab are introduced. The analog electronic experiment is taken as an example to show Flex plug-in design, data communication based on XML (Extensible Markup Language), experiment simulation modeled by Modelica and control terminals' design.

1. Introduction

Electrical and electronic technology is widely applied in various fields and has become a required basic course for students in related majors. Electrical and electronic engineering is also a physical profession [1], which specially emphasizes the combination of theory and practice. Therefore, the experiment teaching is important for students to grasp the basic knowledge, experimental methods and practice skills. However, as an increasing number of students participate in the adult education and distance education, traditional experiment resources fail to meet the demand of experimental teaching [2]. Problems such as outdated equipments and teaching methods in experiment education are also highly hindering the fostering of engineers who are skilled in practice and innovation. With the rapid development of information technology, some experiment systems based on internet [3,4] have been developed all over the world. As a result, internet-based laboratory, which began in the 1990s, is an emerging information transmission experimental system. Compared with traditional laboratory which is constrained by experimental place, equipments and schedule, internet-based laboratory has advantages such as no geographical restrictions, no time limit, and high utilization of experimental equipments [5]. Internet-based laboratory provides a distant experiment platform for the students from different regions [6], and become an attractive economical solution for the increasing number of students [7].

So far there are two kinds of internet-based laboratories: one is based on physical experiments [8,9], which means the experiment results are collected from physical equipments [10]; and the other is based on virtual simulation, which namely means the experiment results are based on virtual modeling and computer simulation [11]. For example, the VC-Lab in [12] employs merely simulations to illustrate practical situations. In [13] a simulation environment for e-learning in digital electronics is introduced, which guides students' activities through specialized browsers. Besides, [14] describes a remote web laboratory using Pspice to simulate the circuit and using Matlab to analyze the control and feedback issues. In [15] the application of physical experiments in electrical engineering education is introduced. The computer tool in [16] uses only simulation and presents a detailed vision of the network to users. In fact, in a variety of fields, such as digital process control [17], PID control [18] and embedded communication systems [19], remote physical experiments are available in nowadays. Compared with the internet-based physical experiment laboratory, the virtual experiment laboratory which is mainly based on software is quite suitable to handle concurrent situations and easy to update [5]. Remote physical laboratory can lead to intuitive results in an experiment, however, the equipments are easy to be damaged; although virtual lab can do experiments by making models and can save lots of time, they are ideal models after all which may influence the experimental effect. In conclusion, internet-based physical and virtual experiments both have their own advantages and disadvantages.

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0019-0578/$ - see front matter
http://dx.doi.org/10.1016/j.isatra.2013.12.035

Different categories of internet-based laboratory have different performances, and an efficient and excellent one must meet the following requirements [20]:

- Can be accessed through the Internet anytime and anywhere.
- System can be easily and quickly developed.
- Experiments can be customized by users.
- Experiment scene shows good performance and fidelity.
- The software of the system has great expandability and reusability.

In order to offer an efficient and convenient experiment platform for students, Zhejiang University has developed a comprehensive internet-based laboratory which combines the virtual and physical experiments. The laboratory with the function of experimental guidance and teaching management covers five major electrical engineering courses such as circuits, microprocessors, power electronics, control engineering and electrical motors with 25 groups of experiments. In the IEE-Lab at Zhejiang University, students could choose either the simulation experiment or the practical part, and get a deeper understanding of experiment principle through the comparison of them [5].

The rest of this paper is organized as follows: Section 2 introduces the system structure and workflow of the laboratory. Section 3 shows the design and the implementation of the combined laboratory. Section 4 gives an experiment demonstration and introduces the application of remote education at Zhejiang University. Finally, in Section 5, conclusions are drawn and future work is discussed.

2. System structure and workflow

2.1. System structure

As shown in Fig. 1, IEE-Lab is based on Client/Server/Application framework and includes three main parts: client, server and application. Each part interacts with the others and is responsible for a specific function. Users only need to interact with the client browser interface to conduct physical or virtual experiments.

2.1.1. Client

The client is mainly composed of a series of user nodes, each of which represents an experimental request. The web portal module is responsible for user login, where users can login IEE-Lab through two different ways: client software or browser. The MFC client software which has fast system response is suitable for frequent users. Browser is suitable for common users to download experiment plug-ins from IEE-Lab automatically, and experiment plug-in module provides a platform for experimental scene.

2.1.2. Server

Server-side consists of four servers: video server, web server, database server and application server. The authenticity of the video server AXIS-2400 used in physical experiments is responsible for forwarding the online video content to show the real experiment scenes which enhances the reduction of scenario. Open-source server Tomcat is adopted as IEE-Lab's web server, and provides services such as user authentication and download of experiment scene plug-ins. The My-SQL database server provides the storage service of user information and experimental information. As the core of server, application server is divided into two parts: virtual experiment module and physical experiment module. Its function is always listening to experimental request from the users, and assigning experimental scene to virtual computing cluster or to physical experiment devices, and returning results to the client.

2.1.3. Application

Application-side, including physical side and simulated virtual nodes, is responsible for different experiment tasks separately. The virtual experiment part consists of monitoring module and simulation module. When receives a virtual experiment scene simulation task from load balancing module in application server, the monitoring module would start a series of simulation modules to compute, wait to forward the results, and finally close the calculation process to free up system resources. Physical experiment side contains five parts: experiment boards, testing equipments, data acquisition cards, industrial computers and cameras.

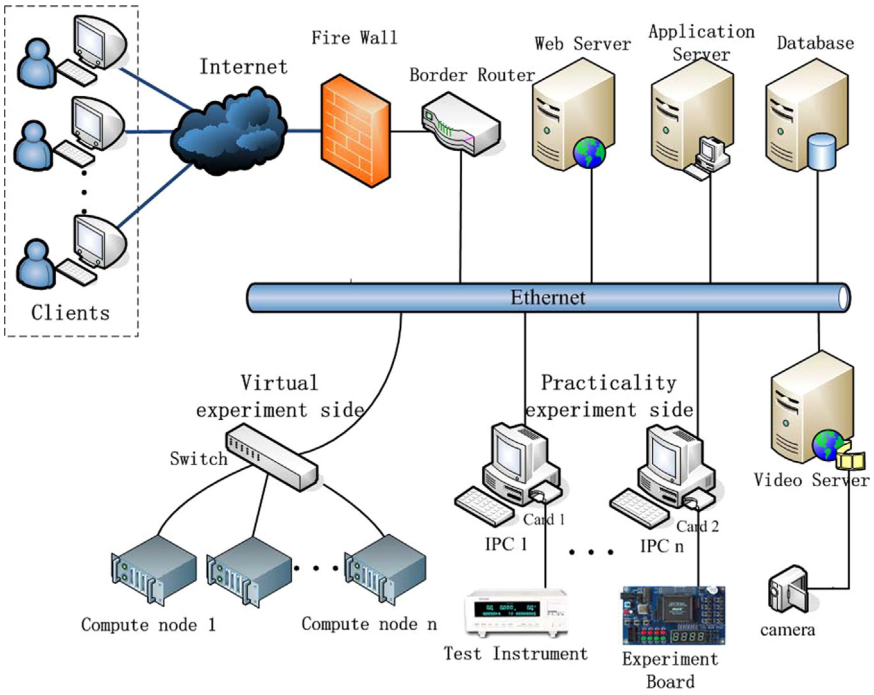

Fig. 1. System structure.