A Systematic Framework of Virtual Laboratories Using Mobile Agent and Design Pattern Technologies

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ABSTRACT

Innovations in network and information technology have transformed traditional classroom lectures into new approaches that have given universities the opportunity to create a virtual laboratory. However, there is no systematic framework in existing approaches for the development of virtual laboratories. Further, developing a virtual laboratory from scratch is time consuming and costly. This article proposes a systematic framework to classify the activities between learners and instructors in the laboratory and to design the mobile agent-based virtual laboratory by wrapping the existing CAI tools without knowing the source code. Using the existing CAI tools can reduce the time and cost in constructing a virtual laboratory. The framework consists of three parts: mobile agent execution environment, mobile agent and learning platform. Moreover, various mobile agent design patterns are provided for users to design and implement virtual laboratories. This framework of patterns could make mobile agent based virtual laboratories easier to design and understand. The authors’ framework has the following merits: adaptability, cost-effectiveness and collaboration. Their framework has demonstrated its feasibility in several applications, including digital circuit, language learning and digital signal processing laboratories. [Article copies are available for purchase from InfoSci-on-Demand.com]

Keywords: Design Pattern; Learning Technology; Mobile Agent; Virtual Laboratory; Wrapper

INTRODUCTION

Virtual laboratories, virtual course-rooms, virtual collaboration rooms, virtual libraries and virtual private offices are categorized as part of the distance learning framework (Bennmohamed et al., 2005; Jiang et al., 2001). In general, a traditional laboratory is composed of a number
of physical instruments and a set of software applications. It is usually very expensive to construct a laboratory with physical instruments. Thus, virtual instruments and simulation tools can be used to construct a virtual laboratory. Currently, various virtual tools such as CAI/CAD systems are available in the market, but most of them are standalone tools. In order to include these standalone applications in a virtual laboratory and use them via networks, the source code for these systems must be modified to enable networking capability. Usually, to get the source code of these standalone applications is difficult. Therefore, reusing standalone applications in constructing a virtual laboratory without knowing the source codes is a great challenge.

The mobile agent (Perdikeas et al., 1999) is an emerging technology that has potential for use as a convenient structuring technique in distributed and Internet-enabled applications. In order to assist students in the virtual laboratory, the mobile agents should have sufficient knowledge to solve problems and guide students to absorb the knowledge during the learning process. The mobile agent technique has been used to design and implement in several virtual laboratories (Dow et al., 2002; Pantie et al., 2005). However, these virtual laboratories and most of their system functions were implemented using an on-demand approach. Under these system environments, agents need to be redesigned and redeveloped for constructing a new virtual laboratory. Thus, it is necessary to provide design patterns to help designers in developing mobile agent-based virtual laboratory applications.

This work proposes a framework to solve the above problems. The proposed framework provides various design patterns and features for virtual laboratory developers and end-users. In our framework, wrappers (Dow et al., 2002; Dow et al.; 2006) are used as the middleware in virtual laboratories. Various agents are designed to provide collaboration between instructor and learner or between learner and learner in a virtual laboratory. Furthermore, ten activities for virtual laboratory were classified in the proposed system. Various existing CAI tools or on-line web sites can be incorporated into a virtual laboratory with the proposed framework. Thus, a framework that uses existing CAI tools and design patterns to develop virtual laboratories for saving time and resources is presented in this work.

The rest of this article is structured as follows. Section 2 briefly describes the background materials and related work. Section 3 describes the wrapping concepts and models for the proposed system architecture. The agents and design patterns for virtual laboratories are presented in Sections 4 and 5, respectively. The implementation of the virtual laboratories with the proposed method and experimental results are presented in Sections 6 and 7. Conclusions are described in Section 8.

RELATED WORK

There are many research areas related to our work, such as virtual laboratory, e-learning, mobile agents, wrappers and software patterns. With the growth of network technology and the increasing popularity of new learning methods, more and more researches focus on the virtual laboratory and e-learning (Benmohamed et al., 2005; Bermejo, 2005; Chang et al., 2000; Dow et al., 2002; Dow et al., 2006; Gomez et al., 2000; Jiang et al., 2001; Jou, 2005; Muzak et al., 2000; Tzeng et al., 2000). The virtual laboratory proposed by Muzak et al. (2000) focuses on digital computers and is based on the client/server computing paradigm. A virtual laboratory changes the traditional lecture hall into a network enabled lecturing environment. Moreover, it focuses on the lecturing only and lacks some important activities such as an assessment system. Another virtual laboratory proposed by Tzeng & Tien (2000) for teaching electric machinery has realistic, interactive and flexible characteristics based on the client/server computing paradigm. Aside from the client/server based virtual laboratories, several researches have established virtual laboratories based on the World Wide Web, such as the virtual
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