An Architecture for Online Laboratory E-Learning System

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ABSTRACT

Internet-based learning systems, or e-learning, are widely available in institutes, universities, and industrial companies, hosting regular or continuous education programs. The dream of teaching and learning from anywhere and at anytime becomes a reality due to the construction of e-learning infrastructure. Traditional teaching materials and methods are shifting to the new paradigm. In higher education, laboratory work is playing an important role in the area of training students and helping students to absorb more knowledge. With the goal of bringing e-learning to the traditional laboratory experiment, in this article, we present an architecture for an online laboratory e-learning system to facilitate the design and deployment of lab-based courses for e-education. The article provides an overall view of the system design and implementation so the Internet-based laboratory can be easily integrated with the e-learning infrastructure.

Keywords: e-learning; learning management system; online laboratory; reusable learning objects; SOAP; UML; XML-based messaging

INTRODUCTION

The Internet and Web-related technologies are affecting more and more person’s lives and work around the world in many positive ways. They are also bringing many changes to the education domain. A major change in this area is the way educational materials are designed, developed, and delivered to the student. Internet-based learning, so-called e-learning, is widely available in institutes, universities, and industrial companies as regular or continuous education program, such as Blackboard (Blackboard Inc., n.d.), Swift Author (Gemini Inc., n.d.), Macromedia Authorware (Macromedia Inc., n.d.), and TopClass Publisher (WBT Systems, n.d.). Most of e-learning systems provide the services of searching, downloading, and delivering learning content, which includes text, audio, animation, applets, flash, or video clips to their users in order to enhance learning experiences.

Internet-based laboratory (i.e., online laboratory) is a rapidly growing research in
universities. In some cases, it also is called virtual lab, remote lab, Internet lab, or Web lab. In existing e-learning systems, the hardware equipment is not supported by the e-learning infrastructure, although IMS Learning Design Best Practice and Implementation Guide (IMS, ver 1.0, 2003) presented some use cases of a virtual laboratory. These use cases have been chosen to validate the conceptual model of a learning system. However, it does not provide the details of design and implementation of such a lab-based learning platform in a systematic way.

In this article, we have presented the architecture and modules of an online laboratory system, or OnlineLab for short. The main objective is to combine OnlineLab researches and e-learning infrastructure in order to achieve the goal of increasing and enhancing learning opportunities and experience for students. We first briefly present an overview of the e-learning system followed by a research review on Internet-based laboratories. Next, we provide details of the proposed architecture for OnlineLab, which is based on the current Shareable Content Object Reference Model (ADL, SCROM) learning model. Finally, we demonstrate sample implementations based on the proposed model followed by concluding remarks.

OVERVIEW OF E-LEARNING SYSTEMS

The following equation represents a typical e-learning system (Maish Nichani, 2001):

\[
\text{LCMS} = \text{LMS} + \text{CMS} \ [\text{RLOs}]
\]

In this equation:

- A Learning Content Management System (LCMS) is a “multi-user environment where learning developers create, store, reuse, manage, personalize, and deliver digital learning content from a central object repository” (elearningpost, n.d.).
- The main purpose of a Learning Management System (LMS) is to manage students and learning events and to collate data on learner progress.
- The objective of a Content Management System (CMS) is to simplify the creation and administration of online content (articles, reports, pictures, etc.) used in publications.

In a CMS, complete learning courses are assembled from several self-contained chunks called content components. These content components, when used in the learning domain, are called Learning Objects (LOs). One important benefit of the LO approach is reusability. Learning objects could be combined to form a hierarchy of lesson, module, course, or curriculum in order to provide a rich learning environment and to reduce the time, instructor skill, or cost associated with development. In this case, it is Reusable Learning Objects (RLOs). With the LCMS, learners not only receive the instructions when they desire (just-in-time learning) but also receive only the portion of the instruction that they desire (granular learning, or just-enough learning).

Many organizations are working in one or more phases of the process in order to develop industrywide standards that ensure interoperability of learning solutions. Some are as follows:

- Aviation Industry CBT Committee (AICC) was formed out of a need for hardware standardization of CBT delivery platforms in 1988. It has published a variety of recommendations, including hardware and software configuration. Their computer-managed instruction (CMI) guidelines have had the greatest impact.
- Advanced Distributed Learning (ADL) is an initiative launched in 1997 by the U.S. Department of Defense and the White House Office of Science and Technology Policy. Their recently released Shareable Courseware Object Reference Model (SCORM) provides one of the best and most recent examples of the application and integration of these learning standards.
- IMS Global Learning Consortium (IMS). Headquartered in Burlington, Massachusetts, it focuses on the development of XML-based specifications. These specifications
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