

Development and Interaction of Web Labs and LMS

E. San cristóbal¹, S. Martín¹, R. Gil¹, G. Díaz¹, M. Castro¹, J. Peire¹

¹Electrical and Computer Engineering Department (DIEEC) – Spanish University for Distance Education (UNED) – c\ Juan del Rosal, 12 – Ciudad Universitaria – 28040 Madrid, Spain

{elio, smartin, rgil, gdiaz, mcastro, jpeire}@ieec.uned.es

Abstract – Nowadays there are a great number of universities and organizations working in e-learning solutions. One of most well-known is the learning management system or LMS that allow displaying theoretical content in an organized and controlled way. In some jobs and studies it is necessary that the student get a practical knowledge as well as a theoretical knowledge. To obtain this practical knowledge, the universities and organizations are developing virtual labs and Web labs.

At these moments the LMS and Web labs are working independently. We are studying a new architecture allowing the integration of the LMS with different Web labs. This architecture must allow the student, teachers and administrators to use the services of LMS and specifications of web as if he was working with the same software.

Index Terms – e-learning, knowledge, Learning Management System (LMS), on-line learning, Virtual Labs and Web Labs.

INTRODUCTION

The improvement in the communication networks (bandwidth, transfer rate, etc.) and the emergence of Internet have induced important changes in the conception of learning. E-learning has given an opportunity to study those people who cannot attend the traditional courses due to geographical problems (living far away from the educational institutions) or schedule problems [1].

Actually a lot of organizations are working in solutions to manage and display theoretical content for its workers or students. This content is displayed in an organized and controlled way (content packets, modules, user profiles) usually under a learning management system being implemented under solutions that have third-party developed, as they are WebCT, Blackboard, Moodle, .LRN, etc. In some cases, the theoretical knowledge is not enough and it is needed a practical knowledge.

Virtual labs have been developed so that the students can obtain this practical knowledge without having to go to the real laboratory or in some cases to reduce the time devoted to do real practices and to get the same handful capabilities.

LEARNING MANAGEMENT SYSTEM (LMS)

A LMS is a software program that allows displaying theoretical content in an organized and controlled way.

Besides, it must offer a set of features and services, some of them are:

- Administration. It must be able to manage user registrations, roles, assign tutors, user payments, etc.
- Content packing. It organizes the content in a hierarchical structure and sets up a mechanism to swap content between different learning management systems. To do it, it's usually used the specification IMS content packaging or the specification SCORM (Shareable Courseware Object Reference Model).
- Communication. It must allow collaborative work. So that they can share information, opinions and experiences. There are two types of communications:
- Asynchronous communication tools: e-mail, distribution list, bulletin board.
- Synchronous communication tools: chats, etc.
- Knowledge evaluation. The tutors and teachers must be able to evaluate the student's progress. Also the students can do test where they can see their progress. To do it, it's possible to use the specification IMS QTI (Question and Test Interoperability).

A great number of organizations and universities have implemented some e-learning solution or Learning Management Systems, as WebCT, Blackboard, Moodle, .LRN, etc. In some cases, (for example .LRN and Moodle), it's allowed the organizations and universities to add new services that they have created. These services can be used, with a few changes, by other organizations. So they allow the code reusing. We are working with these kinds of LMS where we can create a middleware that allow interconnecting different remote web lab with a LMS without having to make many changes.

I. Specifications or standards used in a LMS

There are a lot of specifications and standards developed. These allow exchanging content (information, test, courseware, etc.) among different learning management systems. Some of the most important are:

- IMS content packing Administration. It's developed by global learning consortium and it promotes the reuse of e-learning content. To get it, it's defined a structure to pack the theoretical contents [1].
- ADL SCORM. It's a collection of standards and specifications adapted from multiple sources (for example IMS content packing) to provide a comprehensive suite of e-learning capabilities that

enable interoperability, accessibility and reusability of Web-based learning content [2].

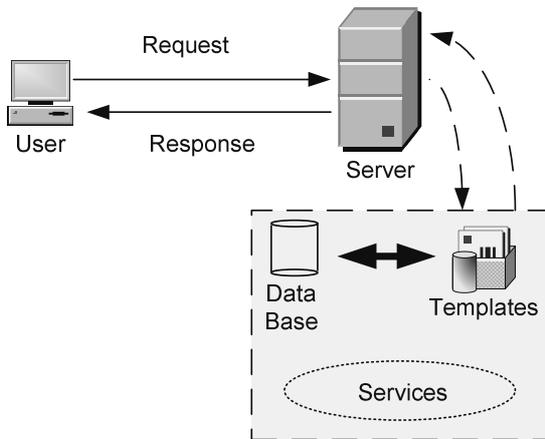


FIGURE 1
BASIC ARCHITECTURE OF A LEARNING MANAGEMENT SYSTEM.

- IMS QTI. It's developed by global learning consortium and describes a data model for the representation of question (assessmentItem) and test (assessmentTest) data and their corresponding results reports.

It's very important that our LMS used this specifications and standards.

VIRTUAL LABS

A virtual lab is a program that allows to a student to carry out his experiments from a PC at any time and anywhere without going out from home or from his study place. There are different types of virtual labs, some summarized in [3]-[8]:

- Software labs.
- Virtual Web labs.
- Remote Web labs.

In some cases and scenarios these labs can have mixed functionalities. For example, a teacher want that a student could carries out operations that could damage the instrument being in these cases a good solution to use simulation programs besides a remote lab [10]-[14].

I. software Labs

They are based on software programs that are being executing in the student's computer. The student's computer must have the hardware and software requirements and it is not required an Internet connection. The advantages and disadvantages are further detailed.

Advantages:

- The students could carry out their experiments at any time from their house. He has only to switch on his computer.

Disadvantages:

- The teacher can't have information about the student's progress (problems that student has founded, time he has spent, etc.)
- Version problems. The software programs are used to be stored in a CD or DVD. In many cases is necessary to update them in further distribution media.
- They didn't include collaborative tools.
- The students don't work with real instruments else they work with simulation programs.

II. Virtual Web labs

They are programs that use web resources. The student's computer must have an Internet connection with a wide bandwidth connection. The advantages and disadvantages are further detailed.

Advantages:

- The students could carry out their experiments at any time from their house. He has only to switch on his computer and has available an Internet network connection.
- In contrast to the software labs a Web lab allows the student to download the updates of the programs from Internet.
- The web server allows the student to work with collaborative tools.

Disadvantages:

- The students don't work with real instruments else he works with simulation programs.
- The students must have a good Internet connection.

III. Remote Web labs

A remote lab allows the student to carry out his experiments with real instruments. It is necessary a driver to manage the instrument. The advantages and disadvantages are further detailed.

Advantages:

- The students can carry out their experiments with real instruments. So that it allows the students to work from their houses although the physical instruments are in a real laboratory whose door is closed.
- The teacher can have information about the student's progress (problems that the student has found, time that he has spent, etc.).
- The web server allows the student to work with collaborative tools.

Disadvantages:

- Every educational organization develops its own solution so it is very difficult to reuse programming code.
- It is necessary to use a good Internet connection, because data, audio and video are usually going to be transmitted.

STRUCTURE OF REMOTE WEB LABS

It was mentioned what a Remote lab is in the above paragraphs. In this section we are going to explain a possible structure of a Remote lab being formed by [3]-[6]:

- Client or user interface.
- Web server.
- Audio and video server.
- Database server.
- Controller.

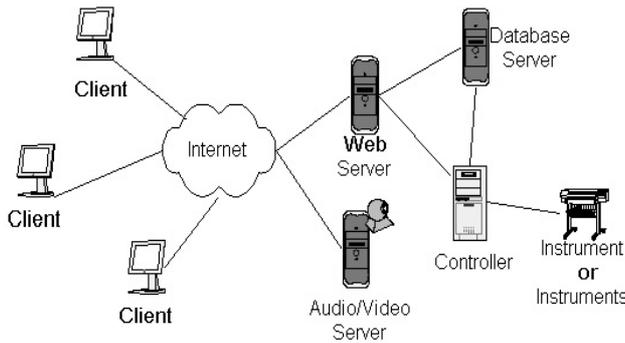


FIGURE 2
BASIC ARCHITECTURE OF A LEARNING MANAGEMENT SYSTEM.

I. Client or user Interface

The user interface is what the user or student is going to see in the screen of his PC. The user or the student must perceive as if he was in the physical laboratory. It is very important do not overload neither the interface nor the Internet connection with unnecessary information [4]. The user must be able to decide what he want to watch or do, of course, within some limits.

In order to create a user interface it is possible to use programming or mark up languages, for example JAVA, JavaScript, VRML, HTML, XML, etc. [7]-[9]

II. Web server

The web server contains web pages with the experiments that the students must carry out with the laboratory instruments. Also it must send commands to the controller and receive the results of the operation from the controller or from database server.

Normally the web server must attend only an user laboratory request at a certain moment, but it can and must attend another types of request while a user laboratory request is been served. Before the students can use the laboratory they must be authenticated.

III. Audio and video server

The audio and video servers send video and audio data to the user interface. The client could manipulate the web cams, of course within some limits, to see and do not lose any detail of the experiments.

The user's Internet connection must be good enough to receive the audio and video data in a quick and simple way. For example, if the video data is displayed really slowly the user could leave the experiment after boring.

IV. Database server

This server will store all the information of the student's experiments so the web server can write user data in a table of the database, for example (the hour in what the student accesses to the instrument, his name, etc.).

V. Controller

The controller is going to send commands to instruments and receive the results of the executed commands. Normally the Controller is communicated with the instrument using a GPIB or an USB or Firewire bus, a hardware data acquisition or a digital signal processor. When the controller receives the results of the executed commands then they are sent to the web server or to the database server.

INTEGRATION OF A REMOTE WEB LABS AND A LMS

Nowadays the LMS and remote web labs are working independently. We are working in the creation of a middleware that allow different remote web labs to use the LMS services as user registration, security options, communications tools, etc.

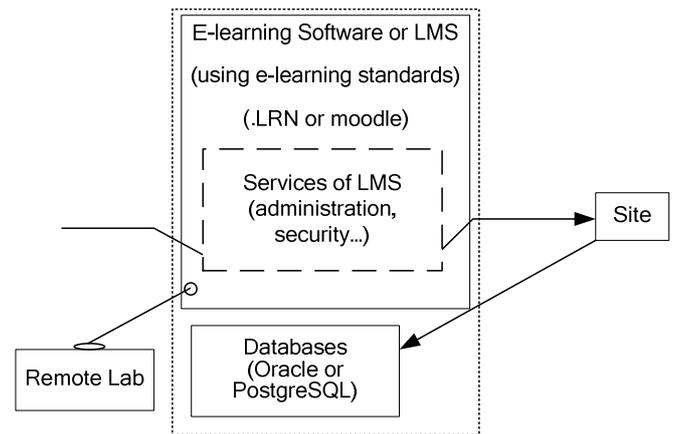


FIGURE 3
LOGICAL ARCHITECTURE OF A LMS AND A REMOTE LAB.

Remote lab must be an integrated module or service to be used from e-learning solution. This module must manage the laboratory instruments and the results that the students obtain to do their practices, in the above section has been explained the physical architecture of a remote lab. This module can be designed and developed with simulation software allowing the students to carry out operations that could damage the physical instruments.

Some of the problems that we have to resolve are:

- Remote lab interface.
- LMS and remote lab data base.
- Communication between LMS services and remote lab.

I. Remote lab interface

When the user wants to do a practical exercise with the remote lab, he should access through the LMS. Once he has accessed the LMS display the interface of remote Lab. This interface is divided in a set of portlets. Some of them are:

- A Portlet with documentation to carry out the experiment.

- A portlet that receive the video and audio from audio and video server and displays these to the user.
- A set of portlets that allow the user to write commands and to receive the result of them.
- A portlet that contains link to the different communications tool from LMS.

It is very important do not overload neither the interface nor the Internet connection with unnecessary information. Also this interface should keep the same graphic design that the LMS interface.

II. LMS and remote lab database

The main idea is that the remote lab used a lot of the tables of LMS data base. However the remote lab will also use its own tables.

It's necessary to create storage proceeds to get and put information from LMS and remote lab tables. We are using postgres because .LRN is a LMS that works with postgres or Oracle.

III. Communication between LMS services and remote lab

As we can notice, it's necessary to create a middleware between the e-learning software and the remote lab. This middleware should integrate the remote lab module in the e-learning solution and manage the communication between them, independently of the remote lab used.

The remote lab will use some of the services LMS so it isn't necessary to create again. Some of the LMS services that remote lab uses:

- User administration (roles, user registration, etc.).
- Synchronous and asynchronous communication tools. The remote lab must allow the students can communicate with another partners to exchange information about his experiences to carry out the experiment. So we needn't create new communications tools else the remote lab can use the LMS's communications tools (chats, bulleting board, email, etc.).
- Knowledge evaluation. We have to create documents that the students read to carry out his experiments and also we have to create test to evaluate to the students. The idea using LMS's knowledge evaluation services and the e-learning standards.

Now, we are going to show an example of this. When a student wants to access to remote lab:

1. The student is displayed the LMS access page.
2. The student writes his username and password. LMS checks the username and the password and display so that the remote lab uses LMS service of administration users.

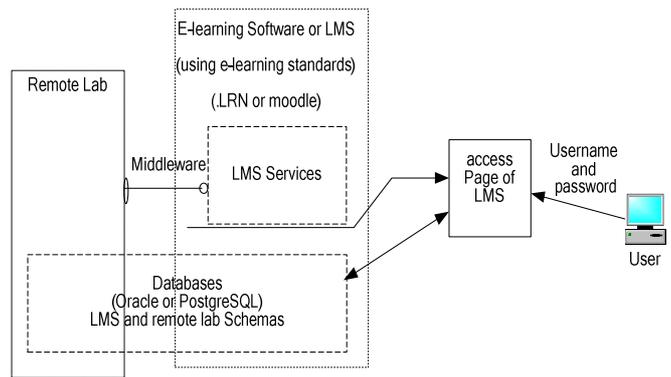


FIGURE 4
The user access to LMS.

3. LMS displays a new web page where there is a portlet with a link to the remote lab.
4. The user click on the link. LMS calls to the remote lab service (middleware) where the user will be carry out his experiments. This call must contain some optional and necessary parameters for the remote lab runs correctly.

The remote lab and the LMS must communicate each other through middleware. So the remote lab uses the LMS services and vice versa.

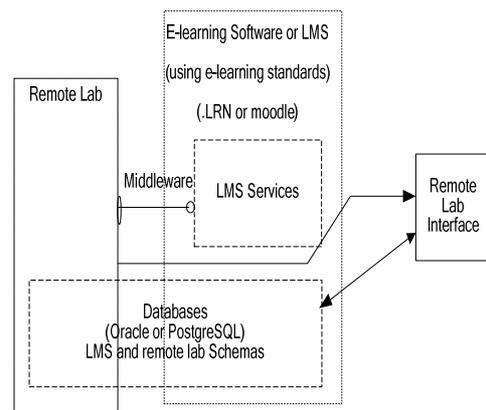


FIGURE 5
The LMS call to the remote lab (using the middleware).

It's very important that the remote lab uses standards as SCORM, IMS QTI, etc. so that, although we change the oldest instruments from remote lab by new instruments. The remote lab could continue using the information and test without having to create again. Also we can reuse the content in another LMS that uses e-learning standards.

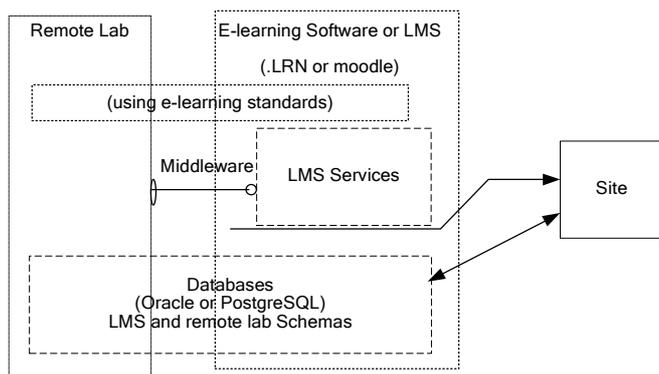


FIGURE 6

The remote lab must use e-learning standards.

.LRN is an open code e-learning solution that allows the organizations and universities to add new services that they have created. These services can be used, with a few changes, by other organizations. So they allow the code reusing. Having in mind those advantages we are developing this middleware on .LRN and later we will implement in Moodle.

CONCLUSION

This paper describes the idea of designing a project e-learning where different virtual labs can use the advantages of a learning management system (user administration, content packing, etc.) and vice versa. The LMS and the virtual labs must carry out with the e-learning standards like SCORM, IMS or QTI. Besides it is necessary to build a middleware that allow interconnecting different remote web lab with a LMS without having to make many changes.

ACKNOWLEDGMENT

The authors would like to acknowledge to the Spanish Science and Education Ministry and the Spanish National Plan I+D+I 2004-2007 the support for this paper as the project TSI2005-08225-C07-03 "mosaicLearning: Aprendizaje electrónico móvil, de código abierto, basado en estándares, seguro, contextual, personalizado y colaborativo".

REFERENCES

- [1] <http://www.adlnet.gov/scorm/index.cfm> Last visit: April 2007.
- [2] <http://www.imsglobal.org/question/> Last visit: April 2007.
- [3] Ko, C.C., Chen, B.M., Chen J.: *Creating Web-based Laboratories*. Ed. Springer, 2004
- [4] García, A., Rodríguez, S., Rosales, F., Pedraza, J.L.: Automatic Management of Laboratory Work in Mass Computer Engineering Courses. *IEEE Transactions on Education*. IEEE Vol. 48, Nº 1, January 2005
- [5] Lang, J., Nungent, G.C., Samal, A., Soh, L.-K.: Implementing CS1 with Embedded Instructional Research Design in Laboratories. *IEEE Transactions on Education*, IEEE Vol. 49, Num. 1. January 2006

- [6] Domínguez, M., Reguera, P., Fuertes, J.J.: Laboratorio Remoto para la Enseñanza de la Automática en la Universidad de León (España). *RIAI*, Vol. 2, Num. 2, April 2005
- [7] Castro, M.: Laboratorios Virtuales para Enseñanza en Internet – Situación y Desarrollo. I Jornadas Tendencias sobre eLearning (TEL 2005). Madrid, 2005
- [8] Candelas, F.A.: Propuesta de Portal de la Red de Laboratorios Virtuales y Remotos de CEA. Documento elaborado para la Red Temática DocenWeb. 2003
- [9] García Zubía, J.: Laboratorios Virtuales para Enseñanza por Internet. I Jornadas Tendencias sobre eLearning (TEL 2005). Madrid 2005
- [10] Candelas, F.: Laboratorio Virtual Remoto para Robótica y Evaluación de su Impacto en la Docencia. *Revista Iberoamericana de Automática e Informática Industrial*, Vol. 1, Num. 2, July 2004
- [11] Yang, A.: Design of a Distributed Computer Security Lab. Consortium for Computing Sciences in Colleges. 2004
- [12] National Instruments, 2005. Last visit: May 2006. <http://www.ni.com/>
- [13] Wikipedia, 2007. <http://es.wikipedia.org/> Last visit: April 2007.
- [14] Revista Iberoamericana de Automática e Informática Industrial. <http://riai.isa.upv.es/> Last visit: April 2007.