REV2012 - Remote Engineering & Virtual Instrumentation

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REV 2012 is the ninth in a series of annual events concerning the area of remote engineering and virtual instrumentation. The REV conferences are the annual conferences of the International Association of Online Engineering (IAOE) (**www.online-engineering.org**). REV2012 will be held at the University of Deusto, in Bilbao, Spain. The general objective of this conference is to demonstrate and discuss fundamentals, applications and experiences in the field of remote engineering and virtual instrumentation. With the globalization of education the interest in and need of teleworking, remote services and collaborative working environments now increases rapidly. Another objective of the symposium is to discuss guidelines for education in university level courses for these topics. REV 2012 offers an exciting technical program as well as academic networking opportunities during the social events.






Scope of the conference

Remote Engineering and Virtual Instrumentation are very future trends in engineering and science. Due to:

- the growing complexity of engineering tasks,
- more and more specialized and expensive equipmentas well as software tools and simulators,
- the necessary use of expensive equipment and software tools/simulators in short time projects,
- the application of high tech equipment also in SME's,
- the need of high qualified staff to control recent equipment,
- the demands of globalization and division of labour,

it is increasingly necessary to allow and organize a shared use of equipment, but also specialized software as for example simulators. Organizers especially encourage people from industry to present their experience and applications of remote engineering and virtual instruments.

The general objective of this conference is to discuss fundamentals, applications and experiences in the field of remote engineering and virtual instrumentation.
The use of virtual and remote laboratories is one of the future directionsfor advanced teleworking, remote service and e-working environments.
Another objective of the symposium is to discuss guidelines for educationin university level courses for this topic.

This conference will be organized in Bilbao by the University of Deusto and Deusto Institute of Technology - DeustoTech:

Links to earlier conferences

Topics of interest include (but are not limited to)

- Virtual and remote laboratories
- Remote process visualization and virtual instrumentation
- Remote control and measurement technologies
- Online engineering
- Networking and grid technologies
- Mixed-reality environments for education and training
- Education and operation interfaces, usability, reusability, accessibility
- Demands in education and training, e-learning, blended learning, m-learning, and ODL
- Open educational resources (OER)
- Teleservice and telediagnosis
- Telerobotics and telepresence
- Support of collaborative work in virtual engineering environments
- Teleworking environments
- Telecommunities and their social impacts
- Present and future trends, including social and educational aspects
- Human computer interfaces, usability, reusability, accessibility
- Innovative organizational and educational concepts for remote engineering
- Standards and standardization proposals
- Products
- Military wireless applications
- Information security
- Telemedicine
- Renewable energy
- Applications and experiences.

Types of sessions

- **Full Paper sessions** (peer reviewed)
- **Interactive demonstrations** (online demonstrations or lectures from a remote location are also welcome)
- **Poster sessions**
- **Discussion panels**
- **Tutorials**
- **Keynote talks**

Other opportunities to participate

Thematic workshops / tutorials / technical sessions, as well as interactive demonstrations and exhibitions, may also be proposed. Prospective organisers of other REV2012 events are encouraged to contact the Conference Chair.

Conference language

English.

Proceedings

The proceedings will be published on CD by the International Association of Online Engineering (IAOE), and they will be indexed by IEEE Xplore.

Interesting papers may be published in the International Journal of Online Engineering (iJOE), **www.online-journals.org/i-joe/** .

Authors will find instructions right **here** .

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One Step Ahead in the Future of Labs: Widgets, Ubiquity and Mobility

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***Abstract*— Traditional laboratories have yield to online Labs. These are actually web applications, used in blended and distance learning, which allow students to carry out online experiments at anytime and anyplace. Online Labs are in constant evolution due to the advance in programming languages, communication and data networks, and hardware. This article shows this evolution in the e-learning landscape, the current and future initiatives, and the challenges that the developers of online Labs have to face.**

***Index Terms*—online labs, online experiments, E-learning standards, higher education.**

I. Introduction

Until several decades ago, traditional laboratories were the only possibility that allowed students to carry out experiments and get the needed skills for their future jobs, but, this fact has changed thanks to the improvement in communication networks and programming languages [1]. So, currently, it is possible to find a vast number of high schools and universities that design, create, and install hardware and software which allow student to acquire skills from home. All these applications can be in one of the next categories:

1) Virtual Labs are software simulation programs which allow students to carry out experiment from their computer. They can be divided into software laboratories and virtual web laboratories.
   i. Software virtual Labs are stand-alone computer-based programs that must be installed. They do not run over Internet.
   ii. Virtual web labs are applications installed in a web server and accessed over Internet. Therefore, the students are able to access to them through a web browser from some PC with an Internet connection.
2) Remote laboratories are systems which allow students to utilize real instruments [2-3]. Their division is similar to virtual labs, therefore it is possible to find:
   i. Software remote labs are stand-alone computer base programs that must install. The PC which has installed this software must be connected to computer. It works in stand-alone without Internet connection.
   ii. Remote Web labs are applications which allow student to manipulate hardware through a Web browser over Internet.

It is important to remark that although these applications are in different categories. Teachers can work with virtual and remote Labs in a same e-learning scenario. For instance, teachers could use a virtual Lab to acquaint students with several instruments, once it is done, students could start to work with a remote labs that allow them to hand those instruments.

In this paper the readers will see several examples of these applications in several institution and universities, both virtual and remote labs [4-5]. Also, it will be shown that until several years ago, these applications were ad-hoc solutions which were not able to be used by other universities. And therefore, the necessity of the creation of software architectures and the use of e-learning standards for reusing of Labs was focused on some universities, such as:

1) LabShare is led by the University of Technology, Sydney, and is a joint initiative of the Australian Technology Network: Curtin University of Technology, Queensland University of Technology, RMIT University, University of South Australia, and the University of Technology, Sydney [6]. This project aims to create a national network of shared remotely accessible Laboratories. This mean a greater number of high-quality laboratory-based educational experiments are available to university and high school students from anywhere in Australia and around the world.
2) The WebLab-Deusto project is an open source project providing a web-based, experiment-agnostic, scalable software infrastructure, which permits the University of Deusto to offer several laboratories to its students through the Internet [7].
3) The iLab Shared Architecture (ISA) implemented by the MIT to facilitate the rapid development of new web laboratories and to provide a mechanism for students from one university to use the experiments and the hardware instruments of another university [8].
4) OCELOT (Open and Collaborative Environment for the Leverage of Online insTrumentation) is an open source and collaborative Online Laboratory framework and middleware. It is based on mixed reality and interactive multimedia. One of its core features is the multimodality of the W3C Widgets-based Graphic User Interface delivered to the learner. It is currently being implemented by Télécom Saint-Etienne (France) under LGPL [9].
5) LiLa (stands for Library of Labs), a European eContentPlus project that promotes a portal of

Online labs resources and fosters exchanges on experiments among institutions [10].

6) Lab2go project has created a generic model ontology consisting of various properties to add laboratories such as remote laboratories, virtual laboratories, experiments, access URL, status, cost, release date, languages, description, administrator, etc. Likewise, the ontology consists of properties to add experiments such as description, scientific field, documentation duration, etc [11].

These software architectures such as LabShare, WebLab-Deusto and iLab allow universities to reuse remote labs. But, virtual and remote laboratories need be included in a learning environment where students can carry out experiments and other activities such as assessments, chats, etc. On the one hand, this can be done, creating new e-learning tools for that laboratory [12]. On the other hand, the laboratory can be integrated in a LMS, and therefore, it can be used along with e-Learning activities which LMS offers [13-14].

OCELOT, LILA and Lab2go have focused on working with e-learning standards to describe and reuse virtual and remote Labs, but in some case as LILA the use e-learning called SCORM is not enough for the new technologies trend. Due to this, new e-learning standards are emerging, such as IMS-CC & LTI [14], SCORM next generation [15], and WIDGETS. These new e-learning standards are paying attention to the reusing of content and rich application in the Cloud and considering new ways to display e-learning scenarios and applications in mobile phones and tablets.

So, Virtual and remote Labs are also being reused and integrated within mobile platforms to be utilized in anyplace and moment. On-line labs must face several challenges to really get implemented on these devices [16]. The first one is related to the programming language used. Flash-based Labs does not work on iOS devices, such as iPhone and iPad. Also, some of the Labs are not suitable for mobile visualization, such as those that require submitting a programming file to the lab, e.g., microprocessor Lab, because such programming environment currently are not available for mobile devices yet. In some cases, labs are being used in mobile devices through mobile-adapted Web sites, apps in the AppStore or Android Market, or integrated within ebooks. All these new communication channels will foster and complement current online labs-based learning.

Also, the evaluation is an integral part of the experience of teaching and learning and is considered one of the crucial stages of instructional design in distance education. Moreover, the evaluation is one of the critical points of distance education programs; because it rests on the social credibility of the certification of e-learning programs and also the efficiency of assessment processes deployed in e-learning programs.

On the other hand, the main objective of Biometrics is to identify a user against a group or database, i.e. identifying or verifying the claimed identity. So far, the ultimate application of Biometrics has been the control of physical access to buildings, but for the emergence of new options in the network, including in higher education, it makes sense to apply biometrics for network control and for higher education to give strength and viability to development of a distance course [17] fully with virtual and remote labs experiences.

II. Online Labs

In the last few decades, the advance in communication and computer networks, the design and creation of new programming languages, and hardware have made easier the development of new e-learning tools such as online labs.

Online labs, normally, are virtual or remote laboratories which are available through Internet, and allow students to acquire the necessary practical knowledge and skills at anytime and anywhere. These online labs cover a wide range of fields, such as chemistry, electronic, physic and electricity. Before describing some of them, it is important to mention several empiric recommendations to weigh up:

1) Virtualizing expensive equipment: when instruments are very expensive to purchase and maintain, a Virtual Laboratory may be financially more interesting. One must keep in mind that software development is also costly and also requires a minimum of maintenance over years as the environment evolves (changes of operating system versions, changes of instrument models to stay up to date, etc.).
2) Securing fragile instruments: when students have to learn how to use damageable instruments, a Virtual Laboratory can be preferred to a Remote Laboratory, at least for first trainings. As soon as learners show enough competencies, they then are switched to a remote access on real instruments.
3) Offering realism: when students carry out experiments in a Remote or Virtual Laboratory, they should have the sensation of working with real instruments. With Remote Laboratories, video and audio feedbacks are essential but require a larger bandwidth. With Virtual Laboratories, this realism must be rendered thru realistic 2D or 3D graphics.

   Although these sensations can become very close to the reality, Virtual and Remote labs are not able to support senses such as smell, touch taste.
4) Both Remote and Virtual Laboratories are learning resources. They should be integrated into a learning process and made reusable for any institution as for any other classical learning resource [13],[18] .

These general ideas and other particular issues associated to organization, such as technical and educational personal, money, and time, are crucial in the design, development and implementation of Virtual and Remote labs.

The next subsections will show some example of Virtual and Remote labs in Internet.

A. *Virtual web Labs*

As it has been mentioned, Virtual web Labs are simulation applications which allow students to carry out online experiment through Web. Therefore, these can be developed in a wide range of web programming languages [1], such as Java Applets, Adobe Acrobat, AJAX or LabView. Further, it is enumerated a set of free Virtual web Labs for different educational fields:

1) Chemistry.
   i. The Iowa State University provides a set of Virtual web Labs in Flash where students can carry out experiments about electrochemistry, gas laws, stoichiometry, and acid-base equilibria [19].
   ii. The department of chemistry from University of Oxford provides several Virtual web Labs, developed in Flash [20].
   iii. The IrYdium Project's Virtual Lab started in 2000. Their goals are to support a community of instructors interested in improving chemistry education through interactive and engaging online activities [21].
2) Physic.
   i. The department of physic from University of Oregon provides a set of Java applets which allow student to carry out experiment about astrophysics, thermodynamics, mechanics, and energy [22].
   ii. The website called virtual labs and simulator (http://websites.kahoks.org/Richert_Gary/sciweb/applets.html) displays a set of java applets to teach physic concepts about thermodynamics, mechanics, waves, etc.
3) Anatomy.
   i. The Stanford University provides a set of online interactive media to teach human biology. This website, http://virtuallabs.stanford.edu/, provides virtual labs, games, etc.
   ii. The Indiana University provide a virtual labs based on a set of graphics and test to learn anatomy [23].
4) Math.
   i. In this URL, http://www.math.uah.edu/stat/applets/, is possible to find a set of applets to teach math. For instance, there are experiment about Bernoulli trials and finite sampling models. The vast majority of them are developed in html5 and JavaScript.
   ii. The University of Colorado at Boulder provides a set of simulations about math. Some of them are: equation grapher, vector addition, and calculus grapher.
5) Electronic and Control.
   i. The Department of Electrical and Computer Engineering of UNED have developed several Virtual Labs. For instance the digital electronic lab which allow students to carry out experiments with logic gates (OR, AND, NOR; NAND, EXOR), and many combinational and sequential circuits (coders, decoders, multiplexors, comparators, synchronous and asynchronous flip-flops, chronograms, synchronous and asynchronous counters, and shift registries) [31].
   ii. The website Educypedia stores a great number of applets for electronic and control [24]. One of these applets, is programmed in Flash, allows students to control a water tank for increasing or decreasing water flow rate (http://educypedia.karadimov.info/library/feedback.swf).

These Virtual web Labs are free, but also other great number of them are only available by students of the institution that developed it.

B. *Remote web Labs*

In contrast to Virtual web Labs, Remote web Labs allow students to work with real instrument from one institution. Therefore, issues such authentication, authorization and scheduling are needed. Now, it will be described some Remote web Labs.

1) Electronic Remote web Labs allow students to work with real hardware, such as dual channel oscilloscope, function generators, DMM, and a number of components such as resistors, IC circuits etc. Some of them are:
   i. Visir project developed by Blekinge Institute of Technology (BTH) in Sweden that has created a lab workbench equipped with a unique remote control interface, enabling students to perform physical experiments at home or elsewhere [26][27].
   ii. The ELVIS Lab is based on the National Instruments Educational Laboratory Virtual Instrumentation Suite (NI ELVIS) hardware platform and is used to perform measurements on a variety of electronic devices and circuits. At this moment, this labs is implemented in several institutions, such as MIT and UNED [28][29].
2) Control Remote web Labs allow students to measure the output performance of the device being controlled and those measurements can be used to give feedback to the input actuators that can make corrections toward desired performance. Some of them are:
   i. Magnetic levitation experiment is a steel ball, is levitated using the force generated by an electromagnet. This is provided by the Mechanical, Aerospace, and Manufacturing Engineering Department at Polytechnic University, Brooklyn, NY [30].
   ii. Fluids Remote Lab is provide by The Department of Electrical and Computer Engineering of UNED. This Lab allows students to configure and monitor the acquired data from working with a hydraulic plan [31].
3) Physic Remote Web Labs allow students to understand physic concepts. Some examples are:
   i. Force On a Dipole Experiment from MIT. This Remote Lab consists of a small magnet suspended vertically by a spring in the center of two horizontally mounted coils. A video camera set is used in a position to observe the oscillation of the magnet [32].
   ii. Radioactivity Remote web Lab from University of Queensland, Australia. This is the measurement of the activity of radioactive sources over various distances and durations [33].

4) Telecommunications Remote web Labs. Among them are:

i. This lab is being developed by University of Technology, Sydney, and allows students to familiarize with the use signal generators and oscilloscopes. Signals can be outputted from a signal generator (Arbitrary waveform generator) and are observed/visualised and measured on an oscilloscope [6].

ii. The Makerere University, Uganda, has developed several Labs to teach telecommunication, such as: Nyquist Sampling Theorem, Pulse Code Modulation, and Line Coding Schemes.

As it has been mentioned, these Remote web Labs allow handling real instrument from anywhere. Therefore it is needed to control issues, such as authentication, authorization and scheduling (in many cases the hardware don´t support concurrency).

III. Virtual and Remote web Labs in E-learning Arena

As it has been shown in section II, There are a great number the virtual and remote labs on Web. The vast majority of them are ad-hoc solutions for a specific university or organizations. Each of them is implemented following a different architecture and the reuse of them by other universities is difficult.

For this reason several initiatives and projects have been developed with the main goal of providing shareable online experiments. Some of the most meaningful are:

A. Architectures to Reuse Virtual and Remote web Labs

Some initiatives have defined and implemented a shareable architecture that provide a set of services web which allow Virtual and Remote web Labs, independently of programming language, to reuse services such as authentication, authorization and scheduling.

1) LabShare is led by the University of Technology, Sydney [6]. The main goal of this project is to provide a network of remote laboratory that could be used by all Australian Universities. To do this, software architecture was developed and called SAHARA (Fig. 1).

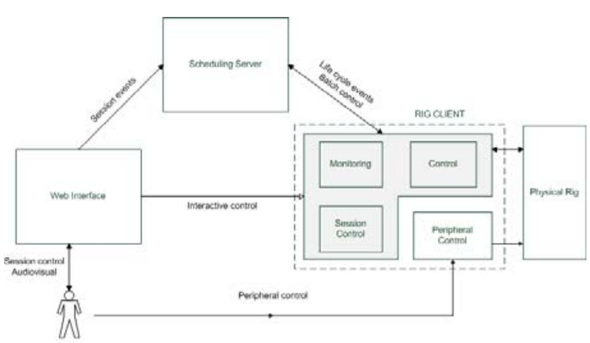

Figure 1. Sahara architecture [34].

2) The WebLab-Deusto project is an open source project providing a web-based, experiment-agnostic, scalable software infrastructure, which permits the University of Deusto to offer several laboratories to its students through the Internet [7]. To do this, software architecture has been developed (Fig. 2). Nowadays they are implementing federation.

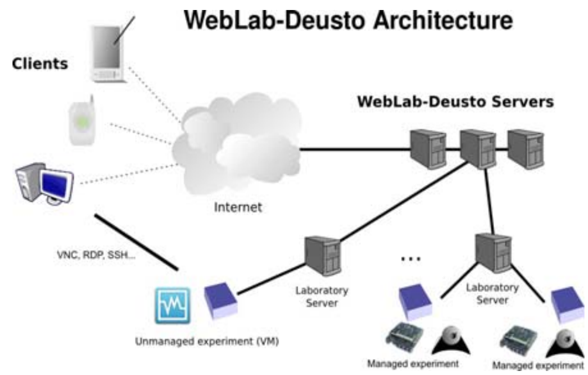

Figure 2. Weblab-Deusto FPGA experiments [35].

3) The MIT have developed the iLab Shared Architecture (ISA) to facilitate the rapid development of new Web Labs and to provide a mechanism for students from one university to use the experiments and the hardware instruments of another university [36]. This architecture support three types the experiments:

i. Batched experiments are those in which the entire course of the experiment can be specified before the experiment begins. These are supported by the architecture shown in the figure 3

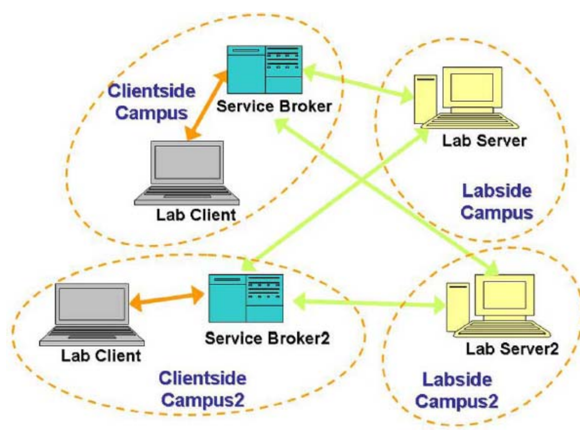

Figure 3. iLab architecture for batched experiments [36].

ii. Interactive experiments are those in which the user monitors and controls one or more aspects of the experiment during its execution.

iii. Sensor experiments are those in which users monitor or analyze real-time data streams without influencing the phenomena being measured. Both these experiments and interactive experiments can be supported by architecture shown in figure 4.

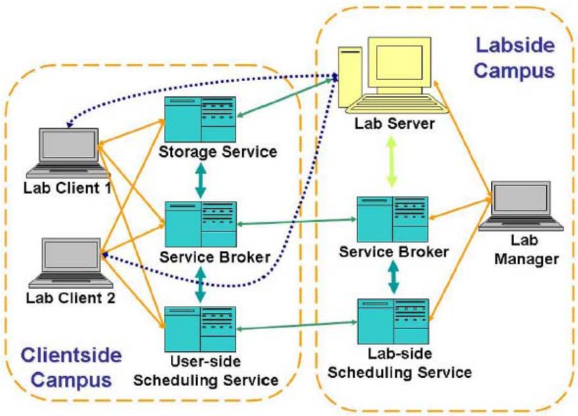

Figure 4. iLab architecture for interactive experiments [36].

B. Using e-learning standards to Share Virtual and Remote web Labs

At present, there are a wide range of e-learning standards. These are grouped in different categories, such as:

1) E-learning standards to describe electronic resources. These describe a metadata schema which allows describing e-learning resources and make easy their search by Internet. Some of them are: IEEE-LOM [37] and Dublin Core [38].
2) E-learning to pack electronic resources in a learning object. Some of the most well known are: IMS-CP [39] and SCORM [40].
3) E-learning standard to reuse questions and assessments such as multiple choice, fill in the blank, and true/false choice. The most known is IMS-QTI [41].
4) E-learning standards to describe the development of a framework that supports different teaching strategies (pedagogical approaches) and educational goals. The most known is IMS-LD [42].

Virtual and Remote web Labs are e-learning resources, therefore, they can be described with metadata and packed in learning objects. These ideas can be represented by the next initiatives:

1) Lab2go project has created a generic model ontology consisting of various properties to add laboratories such as remote laboratories, virtual laboratories, experiments, access URL, status, cost, release date, languages, description, administrator, etc [11]. To do this the lab2go project adopts basic terminology and data types from Dublin Core [38].
2) LiLa architecture consists of a web server running the LiLa portal and a database for keeping the experiments, and a second database for the booking and reservation time slots and the corresponding booking and reservation codes. Experiments are, as already described earlier, represented by SCORM packages.

These initiatives or projects, as LILA, can be used in learning management systems or LMS. The section IV will describe some disadvantages of using the current e-learning standards.

IV. Virtual and Remote web Labs in E-learning Arena

Both Virtual as Remote web Labs are applications focus on providing students with online experiments. These allow students to acquire the skills and practical knowledge to develop their future jobs. Therefore, these must be complemented with other e-learning tools which allow students to acquire other knowledge as theoretical knowledge, and abilities, such as communication and collaborative.

Therefore, it is normal to find that the most of the Virtual and Remote Labs are implemented with manuals in HTML, assessments, even chats or forums (Fig.5). To avoid this, several initiatives can be considered:

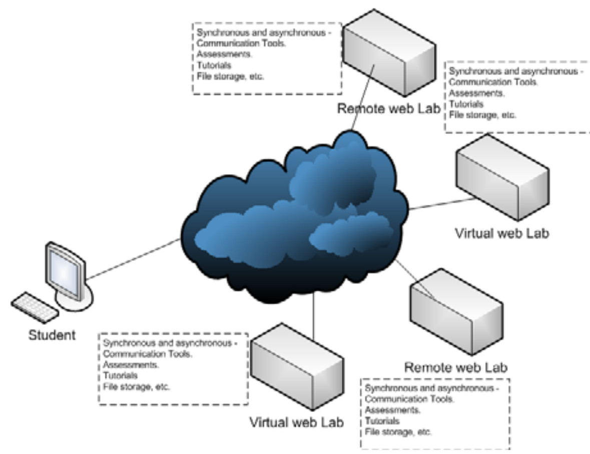

Figure 5. Not Reusing e-learning services.

1) The DIECC of UNED has worked in creating a web architecture which allows using the e-learning services of LMS (Fig 6). Apart from reusing these services in Labs, also it is possible to reuse assessments (IMS-QTI) and content (SCORM or IMS-CP).

   This architecture requires the creation of an activity for Moodle, Sakai, DotLRN, etc. Once this activity is created in a LMS, this can be installed in some instance of that LMS

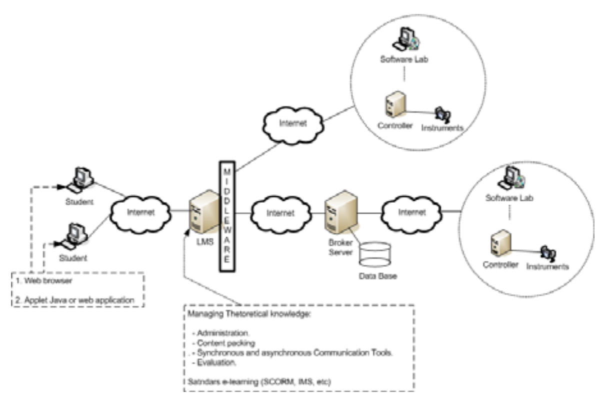

Figure 6. Reusing e-learning services of a LMS[13][43] .

2) LILA. This project is based on SCORM and allows packing Labs and content in SCORM. The main problem is that the data to exchange between LMS

and SCORM package are constrained by SCORM API.

3) OCELOT is an open source and collaborative Online Laboratory framework and middleware. It is based on mixed reality and interactive multimedia. One of its core features is the multimodality of the W3C Widgets-based Graphic User Interface delivered to the learner.

These initiatives are their advantages and disadvantages, depending on the university or institution can be chosen one or other.

V. Mobile Lab

The emergence of mobile and ubiquitous technologies as important tools to complement formal learning has been accompanied by a growing interest in their educational benefits and applications. Mobile devices can be used to promote learning anywhere and anytime, to foster social learning and knowledge sharing, or to visualize augmented reality applications for learning purposes.

Mobile learning is slowly changing the way people learn and teach. Virtual and remote Labs are also being reused and integrated within mobile platforms to be used in anyplace and moment. This new methodology is penetrating education using different technologies, such as native apps, mobile webs, e-books, mobile learning management systems, or mobile social and collaborative tools.

However, mobile learning has some unique attributes that can enhance education beyond simply providing “anywhere, anytime” learning. Mobile devices reach places that traditional learning cannot [44-47]. Also mobile device-based learning works best as part of a blend of approaches [44-46]. Acording to Atewell, mobile devices make the learning process faster, easier, more attractive and more acceptable to disenfranchised learners [44].

However, there are experiments that can simply not work on a mobile device or it does not make sense to use it in a mobile device. For example, a microprocessors remote lab does not make sense to work on a mobile device because usually the student has to create a program using assembler or other programming language and submit it to the lab. This task is usually not supported by current, mobile devices. Some Universities, such as Carinthian University, have solved this problem allowing the student to access directly to the remote machine with the software installed. Thus, a student can efficiently use the IDE software without having to install it, from anywhere in the Internet. This approach could be applied to the scenarios related to mobile devices, where the student might be able use a mobile device to interact through a remote desktop with the required IDE. However, even if this approach could be applied, it might be difficult to use since the IDE GUIs are designed for desktop machines.

Also, a smartphone screen is too small for suitable visualization of some labs. Tablets may solve this problem providing wider screens. Other challenge that mobile labs must face is related to the programming language used. Flash-based Labs does not work on iOS devices, such as iPhone and iPad.

In some cases, labs are being used in mobile devices through mobile-adapted Web sites, apps in the AppStore or Android Market, or integrated within ebooks. All these new communication channels will foster and complement current online labs-based learning. In general, there are two main approaches for porting an application to mobile devices: adapting a web version to the constraints of mobile devices, and building a native implementation in each supported mobile phone.

Nowadays, most mobile devices provide development frameworks on top of which third-party developers can build applications. The added value of this is clear: the functionality of the mobile device becomes flexible, since new applications can be built using the capabilities of the mobile device. The advantage of using a native technology is that it can use all resources that the mobile device provides through the used SDK. If the mobile device supports it, the application may use 3D graphics, retrieve the user's position, access the accelerometers, the camera, use bluetooth, interact with files and handle disk storage, access the mobile calendar or contacts, or even play music and videos, while mobile web browsers usually do not provide these features to web applications. However, most of these features usually are not needed to be used by a Remote Laboratory [48].

Support for web applications in mobile devices has increased during the last years. Nowadays, mobile devices count with different modern web browsers. However, web applications usually need to be adapted for mobile devices. This adaption requires three changes [49]:

1) Provide a proper layout. Developers should think what is actually going to be used from a mobile device, and how may the user see it in a small screen. For instance, newspapers tend to provide a vertical panel where each news item is represented in a row with a single sentence, so the user can quickly see what news item is more interesting and click on it. Each row acts as a button, so it becomes easy to click it with a touch screen.
2) Provide the required contents. Developers should think what contents are going to be migrated to the mobile version. Users might look at the mobile version as a complement to the desktop version, so it becomes normal that some features are not present.
3) Avoid plug-ins. Many web applications provide features that are based on plug-ins such as Java applets, Adobe Flash or Microsoft Silverlight. These plug-ins are not available in most devices, and it is difficult that they become available there, due to the resources required for the plug-in developer to port the plug-in to the wide range of mobile platforms.

The decision of implementing a native version or not depends mostly on if it is affordable. In general, the web approach requires adapting it once to mobile screens and then it will work on most modern mobile devices. Depending on the technologies and on the design used for developing the Remote Laboratory client, providing this web version does not require much effort. However, if it was built on top of a plug-in such as Java Applets, Adobe Flash or LabVIEW, it might require to be completely rewritten [48].

On the other side, providing a version of the application for each mobile platform is expensive to build and expensive to maintain. Every time there is a new feature, all the versions should be updated [48].

Therefore, the decision of implementing the native version or the web version will rely on if the requirements of the experiment are so important that they justify the amount of work required for implementing it for the most common mobile platforms that are used by the students. This decision must be made for each experiment [48].

VI. Biometric in Lab Exams

The application that was developed in this research aims to combine traditional authentication systems, i.e. user name and password with the fingerprint, so the comparison is 1 to 1, this means verification.

In a LMS, a course can be designed through specific requirements of a university or institution; even can include practical activities, such Labs. The biometric control was integrated in Moodle, an open source LMS.

As we said above, the comparison 1to 1 means some changes in the login to Moodle, these are: a biometric sample stored in Moodle database, this must be stored at the time of enrolment in Moodle Web site and it must be used every time when user access to the Web.

Thus, the *login/* folder must be modified, introducing new elements: the fingerprint application and a new field in the table of the Moodle database that manages user information, *mdl_user*.

Although the folder *login/* is composed of a series of files, we focus only on two sets of files to be modified:

a. *signup.php* and *signup_form.php* – Enroll as a new user.

b. *index.php* and *index_form.html* – Access with an account.

Also, other files in different folders need to be modified, which are related to these two sets of files. If we use fingerprint verification, we will need a template previously stored in a database in order to compare the new sample of a fingerprint. This database is not external to Moodle, in our case we choose to add a new field in the table *mdl_user* of Moodle database that is used to access or enroll on the Moodle site.

It was developed in PHP with Javascript what makes possible to introduce lines of code in the original files of Moodle. Fig. 6 shows the home page (*index.php*) with the new field introduced in *index_form.html*. A new fingerprint will be captured every time that someone wants to access and the new sample will be compared with the already stored in the field "FPText" in the table *mdl_user* for that user, who has a username and password unique.

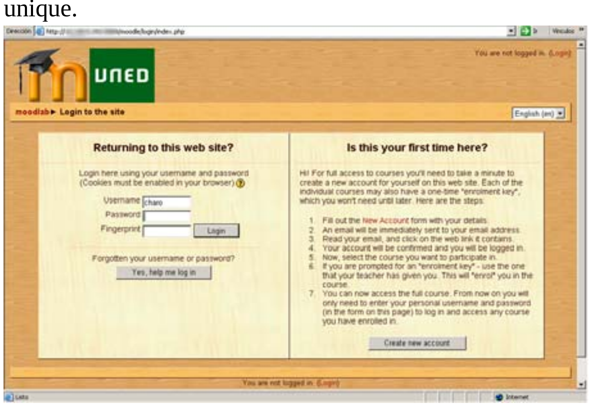

Figure 6. Registration form with fingerprint login.

After the development, a control test was necessary to assure the success of the application and the satisfaction or receptivity of the users who face to a new tool of login. During June 2010, the fingerprint system was used for accessing real labs through Moodle by students and it worked without errors. Students were asked for their participation to assess the use of fingerprint control as a method of verification in Web tests. The results of completed questionnaires by students are shown below.

A. Characteristics of the sample

The group of students, who took the fingerprint verification during their laboratory practices, was a total of 23 students. Most of them are in the segment from 26 to 35 years old, matching the profile of the majority of engineering students from UNED. They have a college degree; students at Higher Technical Engineering School mostly come from the Engineer School. Almost all are men. The sample is very close to the profile of students of Industrial Engineering at UNED.

B. Descriptive results

The aim of the survey focused on analyzing the students' attitudes to a new medium of access control in the e-learning activities. Table 1 shows the most important results:

TABLE I. Most Important Question/Rate in the Survey about E-learning Activities

Questions	Rate
How do you consider the register via fingerprint to access to the courses in Moodle?	47,8% students consider it is convenient or very convenient
If you had to choose one biometric technology to access Moodle courses, which one you would choose?	52,2% Fingerprint
Do you consider that it was easy to access the course in Moodle using fingerprint verification?	78,3% easy or very easy
How would you consider your knowledge of biometrics?	60,9% without knowledge level
Have you ever used the biometric access control?	73,9 % Never

The results show a positive trend of students towards the use of fingerprint as a way of access to e-learning activities, because they consider it is safer, easier and faster than any other mean of access. The fingerprint is the most popular access control, the best-known by the public and it is present in personal devices, for example, laptops. Students found that it is easy to manage the interface that was developed during this research. Many of them have scarce knowledge about biometrics and have never used them before.

This application shows another way to combine Lab and technology emergent. If we think in exams by Internet we must add a control module automatically; but if we want to use practical activities with real instrumentation in Internet, there is a possibility of damaging material, thus, we have to integrate along with the real lab a biometric system to assure identity of user for his own benefit and for the institution's.

VII. CHALLEGES: INTERNET OF THINGS AND NEW E-LEARNING STANDARDS

During these sections, the readers have been able to see that:

1) There are a great number of Virtual and Remote web Lab on Web.
2) There are reusable architectures which allow sharing these Labs among different universities.
3) There are several ways to use Virtual and Remote web Labs in e-learning environments (reusing services and contents).

But, a long road must still be walked. New challenges must be faced and solved. The next subsection will present some of them.

A. *Creating a Global Network of Virtual and Remote web Labs*

It has been mentioned that there are a set of shareable architectures, such as ISA, SAHARA and WebLab-Deusto. These architectures allow connecting Labs from different institutions and therefore teachers and students from these universities can work with them.

But, this implies that a Lab in ISA is not available in SAHARA or WebLab-Deusto. Unless the programmers of Lab implement the calls and services that communicate the Lab with the other architectures.

The Global Online Laboratory Consortium (GOLC) [50] has the mission of the creation of sharable, online experimental environments which increase the educational and scientific value of learning which may not be accessible, scalable or efficient through traditional methods". This means especially:

1) To encourage and support the creation of new online labs and associated curricular materials;
2) To sponsor the design of an efficient mechanism for sharing, exchanging and trading access to online labs by creation of a global network of shareable experiments;
3) To support communities of scholars created around online laboratories; and
4) To lead the evolution of an architecture that enables the sharing of online labs by unified standards.

In this consortium are involved a great number of universities such as:

- University of Technology, Sydney
- Massachusetts Institute of Technology
- University of Deusto
- University of Stuttgart
- Carinthia University of Applied Sciences
- Universidad Nacional de Educación a Distancia
- Makerere University
- Technische Universität Graz
- The University of Queensland
- TU Dortmund University
- School of Engineering - Polytechnic of Porto
- Universidad EAFIT
- College of the North Atlantic Qatar
- Obafemi Awolowo University
- Nanyang Technological University
- RMIT
- Bleckinge Institut of Technology

B. *Internet of Things*

"New" Ideas to consider Internet and their elements are emerging. According Thompson [50], one question is asked "Could it be we are wasting a lot of time accommodating our devices while they should be accommodating us?" To answer this question has appeared two concepts:

1) The Internet of Things which envisions the connection of all existing objects for the universality of communication processes, for the integration of any kind of digital data and content, for the unique identification of real or virtual objects and for architectures that provide the communicative glue among these components [51]. The Internet of Things naturally evolved toward the Web of Things which relies on well-accepted and understood web standards [54][55].
2) The Smart device paradigm [52-53]. Physically, the considered smart device is made of the adjunction of a controlling computer connected to a physical equipment on one the server side and connected to the Internet on the other side. A smart device has enough intelligence to communicate and adapt to any clients and it is also capable of adaptation to its surrounding.

Several initiatives are working in this idea, in concepts such as smart devices and e-learning standards such as Widgets.

C. *New e-learning standards*

E-learning standards such IMS-CP or SCORM are being redefined, due to the advance technological. The fact of packing the content in a Zip file is an "old" way to use e-learning resources.

Learning resources are enabled on the web and should be used as e-learning services. For this reason several initiatives are working in it.

1) Common Cartridge & Learning Tools Interoperability Alliance (http://www.imsglobal.org/cc/alliance.html). They are two initiatives from IMS Global Learning Consortium which work in the definition of a new package interchange format for learning content, called cartridge [56] and the access to rich, web-based applications or tools embedded into cartridges [57].
2) SCORM next generation. This initiative is focused on the access to individualized and relevant learning material that is provided where it is needed and delivered on a learning platform that best suits the learner's needs. This will require greater communication between and among systems and content types [58].

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