Invited Paper - The iLab-Europe Initiative: Exploiting Possibilities Created by a Network of Shared Online Laboratories

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Introduction

The availability of high bandwidth internet connections world-wide and other derivative capabilities in the areas of real-time communication, control, teleconferencing, video streaming and others have made multi-site collaborative work, utilizing state-of-the art equipment in remote laboratories across the globe a current reality.
Active learning or working by means of online laboratories is especially valuable for distance working and education. Users in the workplace can access remote laboratories without having to travel. This flexibility is important for teleworking, education and lifelong learning. However, the implementation and maintenance of online labs is expensive and partially associated with high administrative efforts. These are reasons, why sharing online lab resources via different universities worldwide is a current necessity and can offer several advantages, such as providing access to potential expensive laboratory hardware to students from universities with scarce financial resources by means of a cooperative network of remote systems. Furthermore, online controlled systems can be very useful when applied to situations involving the often substantial costs of transporting people or equipment. Different institutes and schools could share experiments and knowledge in a collaborative manner that parallels real-life working conditions. Importantly, online labs can be also used in workplace settings where there is a pressing need to apply these systems to continually provide learning opportunities for workers who must adapt to rapidly changing conditions.

Online laboratories is a subfield of the interdisciplinary field of Online Engineering. Online can be defined as an i utilizing the areas of engineering, computing and telematics, where specific engineering activities like programming, design, control, observation, measuring, sensing, and maintenance are provided to both remote and local users in a live interactive setting over a distributed, physically-dispersed network.

Learning situations in laboratories can be highly complex, although they have the advantage of usually being well structured. How the particular experiments and learning strategies of specific practices provided in laboratories must be tailored to the knowledge students possess in the theoretical realm and in function of the abilities and competences that are explicitly stated in educational objectives of each individual practice. Although self-directed learning is the most common learning strategy used, a mix of self-directed and collaborative learning is also very common. It is important to mention that this mix in learning strategies is important as it favors both field independent and field dependent learning styles respectively.

The iLab-Europe Initiative

The iLab Europe started as an initiative of several partners who agreed to share their online experiments within this network. It is, in this context, a step towards a broader usage and dissemination of online laboratories and helped to raise the issues that must be addressed for the implementation of a more efficient model to govern the practice of sharing labs in a cross institution basis.
The software architecture used to maintain the lab sessions as well as scheduling service and experiment data storage is the iLab Shared Architecture (ISA) described in the previous

section. ISA has an important characteristic namely its distributed topology what made it the ideal solution for the implementation.
ISA has already built in mechanisms that allow to setup trusted connections between its autonomous network nodes (service brokers) so that online laboratories can be seamlessly shared between them. This means that the institutions are free to manage their own online laboratories and their own user accounts and deliver these labs via their own server. In this way, access for their users to their own labs does not depend on the status of other service broker. In the other hand in order to be able to use labs from other universities a user has to authenticate himself in the main service broker as depicted in Figure 2. Each institution member of the network is expected to setup one service broker and deliver at least one experiment via this server. This means that from a pool of labs available at one institution it is up to them to decide which labs will be available to the other members of the network.

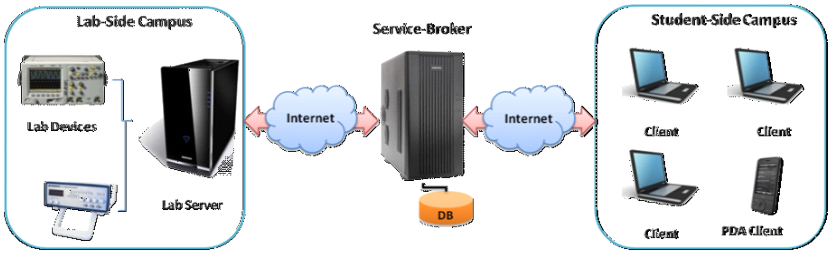

Figure 01. The iLab Shared Architecture

Sharing Online Laboratories

In spite of all the efforts and the technology available, the idea of sharing remote or online laboratories has still to mature. If in one hand it is very appealing, on the other it might be complicated to setup all the policies to share online resources.

These constraints are not related to the technical aspects associated to the practice of sharing labs. There are well known RLMS (Remote Laboratories Management Systems) that provide mechanisms and services for lab session scheduling, user management and data storage targeted specifically in online laboratories.
In fact, most of the constraints lie in the lack of an economy of online laboratories and a business model to govern the practice of a cross institution sharing of labs considering implementation and equipment maintenance costs.
Some of these RLMS are: Weblab Deusto, Labshare Sahara, Lila and iLab Shared Architecture.
As the iLab Shared Architecture (ISA) is the software framework chosen to be implemented for the iLab Europe network we will focus on this architecture.
ISA is a software architecture developed at the MIT (Massachusetts Institute of Technology) that facilitates a cross institution sharing and management of online labs. ISA provides a framework for the maintenance of a lab session, lab users management and experiment data storage. It establishes clear rules governing the communication between clients and their respective online lab servers by means of an API (Application programming Interface) based on Web services SOAP calls.
ISA proposes a classification for online experiments. On one side there are the batched experiments and on the other the interactive experiments. Batched experiments are those in which all parameters necessary to run it are specified before execution. On interactive experiments, the course of the execution can be changed at any time by the user.

In this architecture the communication between clients and laboratory is mediated by a middleware server (Service Broker), a Web application that manages users' accounts, data storage and can provide different clients with access to several different lab servers in a "many to several" mode and delegates to experiment server only the experiment execution. The interface that provides the communication between clients with service broker and service broker with lab servers is implemented with Web services, and is therefore platform independent. That means that clients and lab servers can be developed in any platform supporting Web services.

Related Efforts to promote sharing of online laboratories and other resources

The Global Online Laboratory Consortium (GOLC) is an initiative from several universities in USA, Europe, Africa and Australia. Its aims are promoting the development and sharing of, and research into remotely accessible laboratories for educational use.
GOLC's activities are based in two main pillars: the development of an interoperability API that allows different RLMS to communicate and possibly share experiments in a seamless way and the development of a standard description language for online laboratories and related resources.
The the motivation behind the initiative to create a common metadata schema is due to the fact that currently, available online laboratories are often hidden from the public. The most significant reason for this problem is the current lack of information about online laboratories that provide potentially interested parties the ability to search for adequate laboratories. This problem affects nearly any role in the online lab community such as students, administrators as well as professors even if this influence them in a different manner. The fundament of this problem is the lack of information which describes the resources. This is not a specific problem of online laboratories but rather a general problem of the current Web and concerns many content types of special interested communities.

The ultimate aims of this description language are:

- to allow systems (RLMS, Lab repositories, etc) to share these information
- provide mechanisms for discovery of labs
- structure data in laboratories and RLMs databases
- provide requirements for plugging/sharing labs with third party systems (e.g. Go-Lab Portal) and for the execution of labs
- and allows advanced search mechanisms
- support dissemination of labs

GOLC defines an ontology and specify a metadata set for annotating the different resources. The metadata set is intended to cover a broad range of the online laboratories domain, but the systems making use of it might be interested in a smaller subset only and that should typically be the case. The GOLC metadata set defines profiles or subsets of metadata covering different application fields.
The online lab ontology is organized in classes and RDF (Resource Description Framework) is used as the standard to define the expressions between different resources as a so called RDF triple. However, the concept of a class is not defined by RDF.
The online lab ontology defined is based also on existing standards like DC terms, FOAF and LOM. GOLC ontology defines the OLM (Online Lab Metadata) namespace and a set of classes and properties defined inside this namespace.

Conclusion

In traditional laboratories most of the equipment is not efficiently used because of the fact that the labs are used for other experiments or very specific equipment are only used for a very short time period of the year. Online laboratories are a suitable instrument to solve these problems by sharing the labs. Since some years a number of different initiatives to share labs and related technologies that allow this practice have emerged.
Beyond the technical aspects, sharing experiments can offer several advantages, such as providing access to potential expensive laboratory hardware to students from universities with scarce financial resources by means of a cooperative network of remote systems. Furthermore, online controlled systems can be very useful when applied to situations involving the often substantial costs of transporting people or equipment. Different institutes and schools could share experiments and knowledge in a collaborative manner that parallels real-life working conditions. Importantly, online labs can be also used in workplace settings where there is a pressing need to apply these systems to continually provide learning opportunities for workers who must adapt to rapidly changing conditions.

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