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## Introduction

UNED with the partners where the facilities will be deployed (PSUT, JUST MUTAH and HU) will develop services for the connection of the remote labs, delivery and implementation.

The remote labs need several components in order to fulfill its objective. It is possible to identify a set of common components in any remote laboratory (see Figure 1):

1. The **experiment itself**: a microscope, a telescope, a magnetic levitation system, engine, etc.
2. The **devices and equipment**, called actuators, that allows control of the experiment and the acquisition instrumentation of the experimental results, called sensors. This equipment could be based on standard equipment or use custom designed interfaces.
3. A **lab server** to ensure the control and monitoring of the experiment, through control instrumentation devices and equipment.
4. A **server** that ensures the link among remote users and the laboratory server, typically over the Internet. The solution for this server varies widely, from dedicated applications deployed on web servers (usually presenting a simple description of the experiment and containing additional learning materials) to the delegation to an LMS more complex control operations

users and allocation of time for the use of experiments. In that sense, this component can be decomposed into a set of web (or layers) servers with specific functions: the presentation of related materials (information experiment, theoretical background, and so on), user authentication, book experiment timeslot, management of the learning process, and so on. Not surprisingly, the functions referred to can be accessed through a web portal, as a major customer for experiments or by an institution established by an interagency consortium, providing access to a set of remote experiments.

5. **Server-based video and audio** that can be used by the remote user to get a visual and audio information of the state of the experiment; this functionality could also be included in the aforementioned web server, but it is common to rely on a dedicated hardware external to the software platform to achieve this goal.

6. **Collaboration tools** allowing audio communications, video and chat among users.

7. **Client workstations** ensuring remote users to connect to the experiment and their associated resources. Importantly, some remote laboratories are based on a simple web browser, while others have to have specific plugins or download client programs in order to get proper access to the experiment (this is the case when using LabVIEW-based platforms servers).

It is important to note that a student does not need all of the above components to establish a remote laboratory with a strong impact on the learning process. However, it is also necessary to emphasize that when a lecturer wants to switch from a remote laboratory based on a single experiment to a remote laboratory provides several experiments to a large number of users, several complex issues need to be addressed, from the stage development and integration of many different topics, such as how to handle the problems of security, scalability, multiple access and other accessibility issues, maintenance, etc..

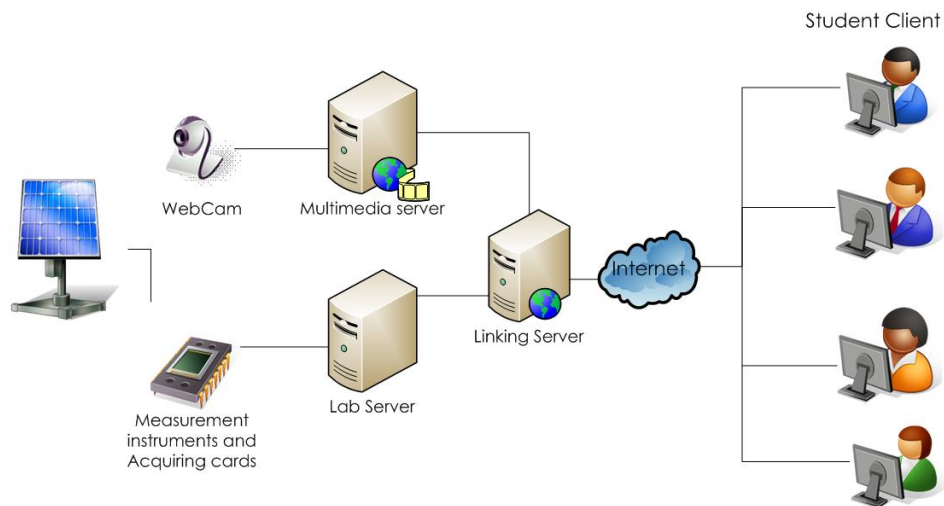


Figure 1. Different components of a remote laboratory.

This task is focused at the detection and development of those needed components and services for the federation of the four remote laboratories in the project.

### Current Status

During the meeting of the 21 June of 2013, several of the UNED remote labs have been presented during a session. In particular, a prototype of remote laboratory intended to eolic

energy production that has been development for the project as a proof of concept of the real remote laboratories capabilities. The basic phases of development of the prototype have been explained. Partners also have exchanged opinions and questions about the development of the prototype, the network bandwidth impact, security regarding the users and the possibilities of its integration inside a course. This was the first step in order to determinate the services of the further integration of the remote laboratories.

On 10 June of 2014, after the deployment of the first remote laboratory at PSUT, the partners have been attended to a meeting in order to coordinate efforts in this task. UNED has lead the meeting and present a roadmap for the developing of the adaptation services. UNED got in touch with the laboratories providers in order to integrate the remote labs into Moodle.

Laboratories provider is going to send us a list of the parameters (see Annex I) that the system is reading or writing so UNED can detect which ones are needed in the integration process. Laboratory providers also sent a description of the laboratories services (see Annex II) to help in the integration process. In addition, PSUT have granted UNED to the already deployed remote laboratory at <http://remotelab.psut.edu.jo/>. As a consequence, the following additional services must be provided so the remote laboratories can be federated:

- User creation and authentication, provided directly by means of the Moodle platform.
- Booking system that must be built for the remote laboratories.
- Concurrent access that must be built for the remote laboratories.
- Authorization, provided directly by means of the VLE Moodle.
- Video streaming server, that is solve by means of Webcam IPs installed in conjunction with the physical laboratory.
- User monitor provided by means of the Moodle platform and the laboratories services.

So, UNED focused its attention towards concurrent access and a booking system options. Institutions can desire to share their laboratories by means of the courses designed at the VLE, avoiding the need to reproduce the same deployment in each institution. The sharing of laboratories, not only cost, but also allows students to have a wider offer of laboratories. This way, instead of isolated remote laboratories, there are remote laboratory repositories managed by *Remote Laboratory Management System (RLMS)* middleware such as WebLab Deusto, LabShare Sahara, Related or LiLa. This software can provide the lacking services for remote laboratories. Most of RLMS offers capabilities for concurrent access and scheduling schemas.

UNED have analyzed the existing RLMS options nowadays. The result of this research is represented at 1.

	<b>Labshare (Sahara)</b>	<b>Ilab</b>	<b>WebLab Deusto</b>	<b>RELATE D</b>	<b>Lila</b>	<b>UNED labs (EJSapp)</b>
<b>Platform</b>	Windows, Linux	Windows Server	Windows, Linux	Windows, Linux		Moodle
<b>Authentication</b>	Username and Password, Federate Australian universities	Username and password	Username and password, LDAP, OpenID, Oauth 2.0.	Username and Password	Shibboleth	Using Moodle Services

<b>User creation</b>	Directly at the Database			By an email.		Using Moodle services
<b>Authorization</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Booking system</b>	Calendar and Queue	Calendar an queue	Queue	Queue	Calendar	Calendar
<b>Online Experiments or Activity</b>	Batch and interactive (directly controlled and not directly controlled)	Batch and interactive	Batch and interactive	Interactive		Interactive
<b>Federation</b>	Yes	Yes	Yes			
<b>Monitoring user</b>	Yes	Yes	Yes	Yes		
<b>Documentation</b>	Poorly Documented		Yes (current version no)		Yes	Yes
<b>Developed by</b>	UTS (Sydney, Australia)	MIT (Boston, USA)	Deusto University (Spain)	R. Pastor (SCC, UNED, Spain)	University Library Stuttgart	UNED (DIA, UNED, Spain)

*Table 1: Comparison of remote laboratory management systems.*

Among these options the UNED prototype has been integrated into RELATED platform and EJSapp as a proof of concept.

On 26 November 2014, partners have a meeting at PSUT to discuss technical aspects of remote labs installation. The discussion led to a roadmap to continue with the pending activities. UNED is still waiting for more information about the deployed laboratory from PSUT and providers so they can tackle this task.

UNED held a workshop at its premises in the period 18-25 January 2015 in order to demonstrate the methodology of remote laboratories integration into a RLMS such as RELATED so that partners are able install their own RLMS at their universities and integrate their remote laboratories into the federation network of the project. The participants of the workshop from Jordanian partner universities were:

1. Bashar Hammad, Haneen Hizaji, Anas Sameer, HU, Jordan
2. Mamour Dmour, JU, Jordan
3. Jarir Al-Nsour, Wasim Faous, Mahmoud Fares, Mohammad Ashshi, PSUT, Jordan
4. Eyad Rewashed, JUST, Jordan
5. Imad Halasa, MU, Jordan

The team from UNED which supervised the workshop were led by Professor Manuel Castro with participation from Dr Salvador Ros, Dr. Rafael Pastor Vargas, Dr. Llanos Tobarra and Belen Moríñigo.