On the integration of remote laboratories in collaborative social media platforms

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Abstract—Considering the wide-spread use of social platforms, and the need to use real equipment in education in order to obtain scientific skills (e.g. critical thinking, hypothesis formulation), the integration of remote laboratories and social platforms is of real interest for the teaching community. This paper describes our work on how the integration of real scientific laboratories in social media platforms based on OpenSocial has been performed.

Index Terms—remote lab, integration, OpenSocial.

I. INTRODUCTION

The use of real scientific laboratories is a very important asset when trying to embed scientific skills (e.g. critical thinking, hypothesis formulation) in primary or secondary students and to gain them to become scientists when they reach adulthood. But the use of such real laboratories is very difficult because of many different issues – among others, the limited budgets of primary or secondary schools, or the need for highly specialized staff to maintain such laboratories. To tackle these issues, the use of remote laboratories [1] (e.g. laboratories that can be used remotely, and even shared by different institutions through the Internet) may become a solution to this problem.

In a previous contribution [2], a Python-based middleware called *gateway4labs* was presented which allows the integration of different Content Management Systems (CMSs) or Learning Management Systems (LMSs), such as Moodle or Joomla, through IMS Learning Tools Interoperability (LTI) [3], so that they share laboratories managed by a Remote Laboratory Management System (RLMS), such as Weblab-

Deusto [4][1], Labshare Sahara [5][2], or MIT iLabs [6][3]. So, gateway4labs can be seen as an hourglass that interconnects a variety of CMS/LMS and RLMSs by means of IMS LTI. This way, teaching institutions can share scientific laboratories for educational purposes. Not supporting this integration forces remote laboratory systems to duplicate certain structures (e.g., authorization) already available in the CMS/LMS. Thanks to this middleware, the user experience can be improved since the remote laboratories are treated as yet another educational resource in the LMS.

In the social network field, OpenSocial [7][4] is a set of Application Programming Interfaces (APIs) for web-based social network applications. In order to host OpenSocial applications, a container must be put in place, being the most common and widely used Apache Shindig [5]. Thanks to OpenSocial and Shindig, collaborative social media platforms (such as [8], which provides knowledge management and enables collaboration among students) can be created.

In this paper, the gateway4labs is extended to integrate social platforms based on OpenSocial with the aim of allowing institutions using them the access to remote laboratories. Thanks to this integration, teachers from different institutions can create Personal Learning Environments (PLEs) based on OpenSocial in order to run customized experiments using the aforementioned real scientific equipment. This work presents

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[1]https://www.weblab.deusto.es/web/
[2]http://sourceforge.net/projects/labshare-sahara/
[3]https://wikis.mit.edu/confluence/display/ILAB2/Home
[4]http://opensocial.org/
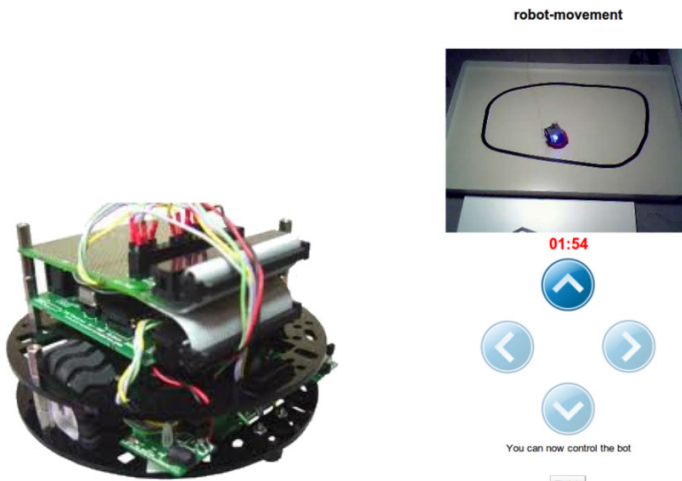[5]http://shindig.apache.org

Fig. 1. A robot laboratory and its user interface [9].

the extensions for the gateway4labs in order to provide the integration between the remote laboratories and OpenSocial-based LMS/CMS. For the developments presented in this paper, the OpenSocial-based Graasp [8] tool is used.

The paper is structured as follows: Section II introduces the concepts of remote laboratory, remote laboratory management systems, and remote laboratory federation. Then, Section III presents a literature review of integration of remote laboratories in CMS/LMSs. Section IV explains the proposed solution to integrate real scientific laboratories in social media platforms based on OpenSocial. Finally, Section V describes our conclusions and future work.

II. REMOTE LABORATORY CONCEPTS

This section introduces the concepts of remote laboratories, Remote Laboratory Management Systems (RLMSs) and remote laboratory federations.

A. Remote laboratories

A remote laboratory is a software and hardware tool that allows students to remotely access real equipment located in an institution. Users access this equipment as if they were in a traditional hands-on-lab session, but through the Internet. To show a clear example, Figure 1 shows a mobile low cost robot laboratory described in [9]. Students learn to program a Microchip PIC microcontroller, and they write the code at home, compile it with the proper tools and, then, submit the binary file to a real robot through the Internet. Then, students can see how the robot performs with their program through the Internet (e.g., if it follows the black line according to the submitted program, etc.) in a real environment.

In this line, there are many examples and classifications in the literature [10], [11]. Indeed, remote laboratories were born nearly two decades ago [12], [13], [14], and since then they have been adopted in multiple scientific fields: chemistry [15], [16], physics [17], [18], electronics [19], [20], robotics [21], [22] and even, nuclear, reactor [23].

B. Remote Laboratory Management Systems (RLMSs)

Every remote laboratory should manages a subset of the following features: authentication, authorization, scheduling users to ensure exclusive accesses (typically through a queue or calendar-based booking), user tracking and administration tools. These features are common to most remote laboratories, and are actually independent of the particular remote laboratory settings. For example, an authentication and queuing system is valid both for an electronics laboratory and for a chemistry laboratory.

For this reason, Remote Laboratory Management Systems (RLMSs) arose. These systems (e.g., MIT iLabs [6], WebLab-Deusto [4], or Labshare Sahara [5]) provide development toolkits to create new remote laboratories, as well as management tools and common services (authentication, authorization, scheduling mechanisms). The main idea is that by adding a new feature to one of them (e.g., supporting LDAP, or LMSs), all the laboratories which are developed on top of them will support this feature automatically.

C. Federating remote laboratories

One of the features that RLMSs started supporting was federating their remote laboratories. For example, if two universities (*University A* and *University B*) install a particular RLMS, they support federation protocols so *University A* shares a laboratory with students of *University B* without knowing these students. The key here is that the provider university does not need to register particular students, but rather groups or simply universities. It is the consumer system who defines that a set of local users can access a particular laboratory of the provider system.

Therefore, the relationship between two federated entities is the following:

- The consumer system manages the authentication and authorization of its students.
- The provider system manages the scheduling and the access to the laboratories, keeping track of users.
- The consumer system will later ask for results to the provider system.
- The provider system does not need to know any information regarding any particular user.

D. Importance of sharing laboratories

Remote laboratories have been considered as part of the *Five Major Shifts in 100 years of Engineering Education* in the Special Centennial Issue of the Proceedings of the IEEE [24], with respect to the influence of Information Communications and Computational Technologies.

In particular, the interest on federation of remote laboratories is growing. The Labshare project survey [25], made on all 34 Australian universities offering undergraduate engineering programs, reflects that the interviewed executives were more interested in getting involved for the pedagogic merits of the remote laboratories, and were more inclined on initially being laboratory consumers than providers.

Indeed, the European Union Commission is investing 60 million euros in research actions, projects and network of excellencies in Technology-Enhanced Learning (TEL), under the objective ICT-2011.8.1 of the call FP7-ICT-2011-8. One of the target outcomes is precisely "Supporting European wide federation and use of remote laboratories and virtual experimentation for learning and teaching purposes" [26]. Indeed, the IP project Go-Lab [27], funded by this call with 10 million euros, aims to support a wide federation of remote and virtual laboratories. Parallel and related efforts have been placed on systems that index remote laboratories located at different institutions such as lab2go [28] or even grant access to laboratories as LiLa [29], [30], [31].

III. EXISTING INTEGRATION OF LABORATORIES IN LEARNING TOOLS

The relevance of this field is that, as detailed in [32], there are several services duplicated between remote laboratories and learning tools. The administration and user experience would increase if they were merged. Both systems usually support user authentication, authorization, group management, administrative tools, user tracking, and even scheduling. Some integration approaches suggest to delegate all these services to the learning tool, but some of these services will still be at least shared, such as scheduling (especially when federation systems arise) or user tracking (since some interactions with the remote laboratory might occur outside the scope of the web browser).

There are two types of solutions in the literature for using remote laboratories in CMS/LMSs: ad-hoc solutions or based on federation protocols. In this section we review some of the most relevant proposals found in literature, both for the integration of social-based tools and traditional learning tools (e.g. C/LMSs).

A. Ad-hoc solutions

In this work, the term ad-hoc describes proposals that have been developed for a clear and specific technology, which cannot be extended or generalized to work with other different technologies. In order to integrate remote laboratories and LMSs, [10] discusses the usage of Sharable Content Object Reference Model (SCORM) and [30] implements an architecture around it. This technology is designed to be supported by different LMSs and indeed multiple LMSs have implemented different versions. However, since it is a client-side technology and therefore it cannot contain any server code, it does not support a secure way to exchange credentials, ensure reservations or return results to the LMS.

Another approach is to develop an ad-hoc plug-in to include a particular remote laboratory on a C/LMS, applying the required changes in the remote laboratory [33]. This approach is common in the literature, and sometimes it is implemented by just copying or exchanging the users among both systems. Within the field of integrating remote laboratories on electronic tools appears the integration of remote laboratories on CMSs. In [34], the remote laboratory relies on Joomla to perform all the administrative tasks. This approach is interesting since it does not duplicates all the tasks refered in [32]. However, it is an example of an ad-hoc integration, which does not support the integration of other remote laboratories neither the integration on other CMS/LMSs.

In the specific context of social tools, a number of examples of ad-hoc integrations can be found in literature. Among others, [35] and [36] integrate Facebook and the RLMSs Weblab-Deusto and FCEIA-UNR respectively, so that users could run experiments in Facebook by means of a Facebook application.

In [37], authors extend the LMS Moodle with a plug-in enabling OpenSocial apps to run within Moodle. This extension provides flexibility in managing tools used by people for their learning goals and aggregation of external resources from the Internet. Furthermore, the work presented in [8] shows the integration of a remote experimentation device within the Opensocial-based Graasp platform [8], which provides knowledge management and enables collaboration among students. In this work, the original Java applet that controlled the laboratory was replaced by a set of light-weight widgets.

Finally, several works investigate the integration between virtual worlds, LMSs and external hardware instrumentation in order to create highly structured, experiential based learning experiences for students, among others we can find [38], [39], [40], [41].

All these works only allow the ad-hoc integration between the social tool and the remote laboratory, which requires a high effort for the integration of new social tools or RLMSs.

B. Federated solutions

In [42], it was proposed other approach to integrate remote laboratories in CMS/LMSs, relying on the existing federation protocols already existing in certain RLMSs. The advantage of this approach is that indeed, federation protocols have the same targets as the integration protocols of remote laboratories in CMS/LMSs, where the consumer system is the CMS/LMS. Indeed, if in the description of federations presented in Section II-C, the term consumer system was replaced by CMS/LMS, the following description would be presented, which applies very well to the definition of integration of remote laboratories in CMS/LMSs:

- The CMS/LMS manages the authentication and authorization of its students.
- The provider system manages the scheduling and the access to the laboratories, storing what the users did.
- The CMS/LMS will later ask for results to the provider system.
- In every moment, the provider system does not need to know anything related to the particular students.

So as to demonstrate this, [42] presented two use cases, both using the WebLab-Deusto RLMS and using plug-ins which consumed the federation protocol for two CMS/LMSs: Joomla and Moodle. In both cases, the development was dependent on the federation protocol of WebLab-Deusto, and two CMS/LMS plugins which required some administration

tasks (for managing the authentication and authorization) were required. The use of federation for integrating different tools has also been addressed in the literature [43].

IV. SUPPORTING COLLABORATIVE SOCIAL MEDIA PLATFORMS

As it was already presented in [42], it is possible to use federation protocols to integrate remote laboratories in CMS/LMSs. However, the solution presented in that contribution was only suitable for those particular systems (WebLab-Deusto, Joomla, Moodle). However, RLMSs need to support multiple CMS/LMSs, since they are installed in multiple universities which may use different CMS/LMSs. So, if 7 CMS/LMSs were aimed (e.g. Moodle, Sakai, dotLRN, Joomla, ...), and 4 RLMSs were attempted to be supported (e.g. Weblab-Deusto, Sahara, iLabs, ...), then 28 integrations (and testing) would be required – this requires a significant amount of time and effort.

With this regard, [2] presented a Python-based middleware called *gateway4labs* which allows the integration of different CMS/LMS through IMS LTI [6], so that they share laboratories managed by a RLMS. So, gateway4labs can be seen as an hourglass that interconnects a variety of LMS/CMS and RLMSs by means of IMS LTI. This way, teaching institutions can share scientific laboratories for educational purposes, without the need to create specific plugins for each CMS/LMS and RLMS used. In the example above, with 7 CMS/LMSs and 4 RLMSs, 11 plugins should be implemented in the gateway4labs – thus reducing the amount of time and effort required for this integration.

Social applications have achieved growing popularity in the recent years, and a number of social platforms have been developed in many different topics, including leisure (such as Facebook[7] [44] or Twitter[8] [45]), or professional (such as ResearchGate[9] [46] or LinkedIn[10] [47]), among others. In this context, OpenSocial [7] is a set of Application Programming Interfaces (APIs) for web-based social network applications. In order to host OpenSocial applications, a container must be put in place, being the most common and widely used Apache Shindig. Thanks to OpenSocial and Shindig, collaborative social media platforms (such as [8]) can be created.

In order to integrate a network of remote laboratories into an OpenSocial-based CMS/LMS tool, such as [8], the architecture of gateway4labs has been extended as shown in shade in Figure 2. This architecture connects two different types of components: the left side represents the consumer systems (including LMSs such as Moodle or Sakai, and OpenSocial-based learning tools which are the topic of this work), and the right side represents the RLMS connector. Every RLMS connector installed on the right side will be supported by all the consumer systems (including the OpenSocial-based

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[6]www.imsglobal.org/toolsinteroperability2.cfm
[7]http://www.facebook.com/
[8]https://twitter.com/
[9]https://www.researchgate.net/
[10]https://www.linkedin.com/

learning tools). This way, a modular architecture which allows easy addition of new components has been developed.

Apache Shindig, the OpenSocial container supporting the social CMS/LMS tool, provides a secure mechanism based on tokens for enabling third party services to access information about the current user, app and space. Gateway4labs uses this feature to identify the user (as long as the user is signed in). In most scenarios, the user identification itself is not used since students are not logged in; however, it still provides statistical information regarding the context from which the laboratory is consumed.

The most basic interaction has been developed and will be used as the basis for the development of future remote labs requirements. The most interesting features are enumerated next:

- It supports multiple RLMS. It provides an API that can be used by the rest of the legacy RLMSs to be supported.
- Authentication: internally, this system connects to the RLMS with a particular username and password (always the same), but reported the system that it was being used by a foreign user, providing the user identifier at the ILS (Inquiry Learning Space).
- Scheduling: The user interface has to be loaded in different apps, but the desired behavior was that all of them were using the same reservation. So as to do this, gateway4labs applies a master/slave concept, where all of the apps display a "Reserve" button. When the user clicks on the button, that app is chosen as master, and the remaining labs as slaves. In this moment, a reservation is requested, and that reservation identifier is shared with the rest of the apps in the same web browser. This is represented in Figure 3.
- It supports multiple different labs per space (as presented in Figure 3), and it manages that the different apps of one lab do not communicate with the different apps of other lab.
- It supports both an anonymised model, where students use the system from the Opensocial-based CMS/LMS with the RLMS unaware of the particular schools and users, but it also supports an authorized model where teachers register their schools in the tools and certain labs are only available to certain schools.

Gateway4labs also provides the automatic creation of widgets for the RLMSs based on a widget template, so that the Opensocial-based C/LMS platform can access RLMS services easily – provided that the appropriate permissions have been configured for that C/LMS and laboratory in the Gateway4labs. For this, a new application must be added in the Opensocial-based C/LMS, this application pointing to an URL, for example *http://weblab.ieec.uned.es/golab/labmanagers/agustin/opensocial/widgets/school2/robot/widget_camera1.xml*. This URL includes the Gateway4labs instance (*http://weblab.ieec.uned.es/golab/labmanagers/agustin/*), the name of the institution (*school2*), the name of the laboratory
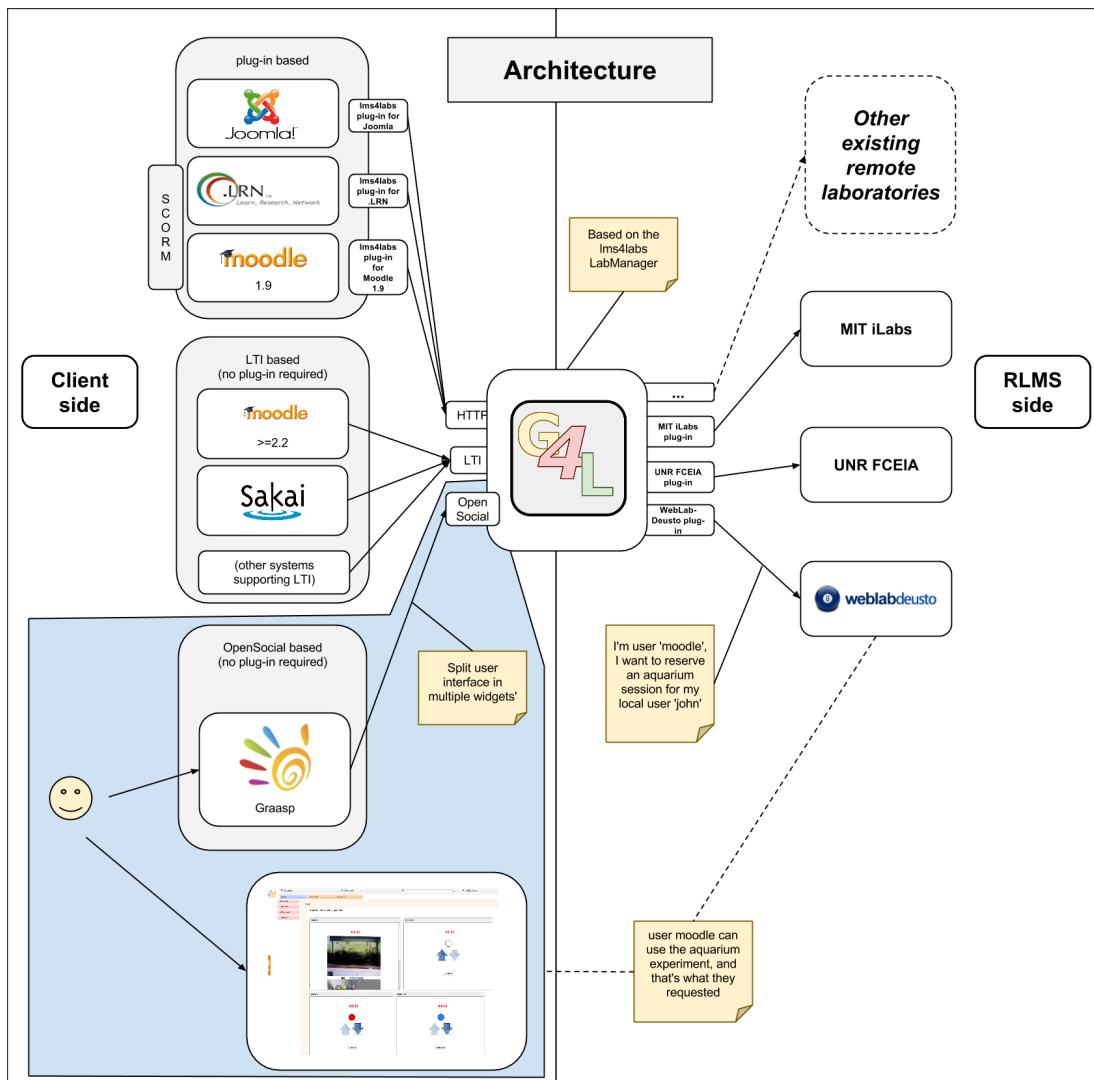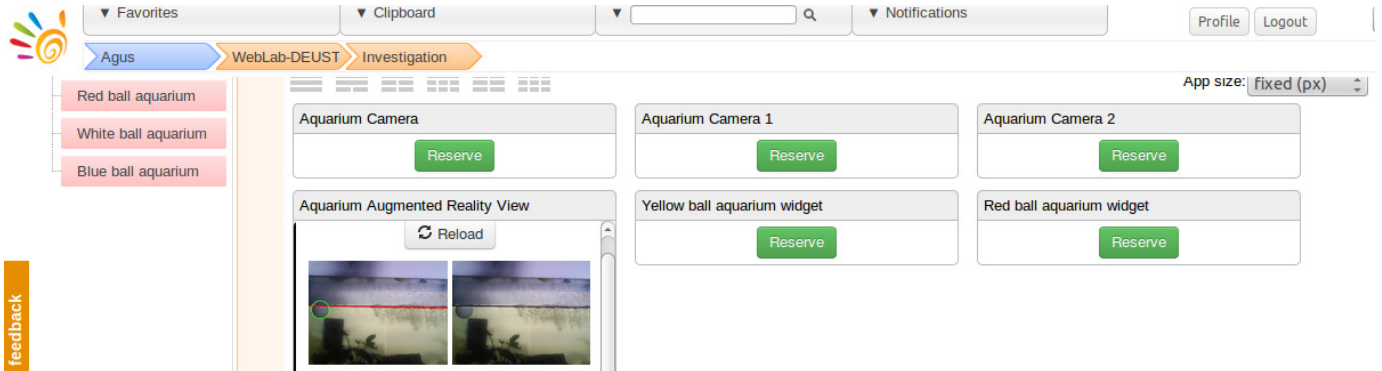
Fig. 2.   Architecture of gateway4labs.

Fig. 3.   A number of apps presented in an space of an Opensocial-based tool [8].

(*robot*), and the name of the service (*widget_camera.xml*). Based on this URL, the Gateway4labs uses a widget template to create the widget for this institution and laboratory, that will be presented in the Opensocial-based C/LMS space and which will be used by its users to deal with the laboratory. As an example, Figure 3 shows 6 widgets in the Opensocial-based

Graasp [8] platform.

V. Conclusions and future work

In order to enhance the scientific skills of young people and increase their willingness to become scientists when they reach adulthood, the use of real scientific equipment is of real interest. Due to technical and economical difficulties, the use of this type of equipment is limited to the use of remote laboratories.

In order to shorten the gap between schools and remote laboratories, a Python-based middleware called *gateway4labs* was presented [2]. Gateway4labs can be seen as an hourglass that interconnects a variety of CMS/LMSs and RLMSs by means of IMS LTI. Thanks to this middleware, the user experience can be improved since the remote laboratories are treated as yet another educational resource in the LMS.

Due to the growing popularity of social platforms, which exist in a wide variety of fields including education, the integration of remote labs in social platforms is of real interest for the educational community. In this paper, the gateway4labs is extended to integrate social C/LMSs based on OpenSocial [7]. This integration allows teachers and students of institutions employing such platforms for the use of remote laboratories. Details on this integration have been presented in this work.

As for future work, evaluations from the system and from the users' points of view are planned to be conducted.

Acknowledgment

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