Casany, M. J., Alier, M., Conde, M. Á., & García-Peñalvo, F. J. (2009). SOA initiatives for eLearning. A Moodle case 23rd International Conference on Advanced Information Networking and Applications, AINA 2009, Workshops Proceedings. The International Symposium on Mining and Web (MAW 2009) (pp. 750-755). Los Alamitos, California, USA: IEEE Computer Society. doi:10.1109/waina.2009.196

SOA initiatives for eLearning. A Moodle case

María José Casany Guerrero, Marc Alier Forment
Universitat Politècnica de Catalunya
Barcelona, España
{mjcasany,malier}@lsi.upc.edu

Miguel Ángel Conde González, Francisco José García-Peñalvo
Universidad de Salamanca
Salamanca, España
{mconde,fgarcia}@usal.es

***Abstract*— Mobile learning applications introduce a new degree of ubiquitousness in the learning process. There is a new generation of ICT-powered mobile learning experiences that exist in isolated contexts: experiences limited to small learning communities. These rising mobile learning experiences appear while web-based learning, specially Learning Management Systems (LMS), are consolidated and widely adopted by learning institutions, teachers and learners. The innovation techniques breeding in the experimental world of mobile learning need to be translated into the mainstream echosystems. Mobile learning is not intended to replace e-learning or web based learning, but to extend it. So, mobile learning applications need to be integrated somehow in the web-based LMS. To do so is needed to address interoperability issues on both ends: the LMS and the mobile application.**

Web Services and Service Oriented Architecture offer a standarized and effective way to achieve interoperability between systems. This paper presents an architecture that allows a two-way interoperability between LMS and Mobile Applications: access LMS contents from the mobile device, and to be able to embed part of the mobile applications inside the LMS framework. This architecture incorporates elements from famous interoperability standards (IMS LTI and OKI) and has been validated with two projects related to the Open Source LMS Moodle.

Keywords: Interoperability, SOA, Moodle, OKI, IMS-LTI, mLearning.

I. INTRODUCTION

The delivery of knowledge and the education process has evolved during the last century and its evolution is bound to the technological revolution. There are several forms of delivery such as distance learning, computer based training (CBT), the interactive CD-ROM, the Learning Management Systems etc. All these practices have transformed the methodological approach to education, defining the new trends in e-learning.

In the year 2000 e-learning was the state of the art for distance training [10]. But as the technology changes rapidly, the learning process evolves to new scenarios such as m-learning. M-learning can be seen as an evolution of e-learning that allows students take advantage of mobile devices as a tool support the learning process [7].

During the last years, m-learning has provided very innovative tools and applications to enhance the learning process. But, current m-learning applications must be integrated with the pre-existing e-learning applications and platforms to enhance the learning process, because e-learning platforms have also an important role in the learning process. As both technologies (e-learning platforms and m-learning applications) have positive aspects to enhance the learning process, it is important to take advantage of both sides.

One interesting research field is the adaptation of LMS and its contents to the mobile scenario. The adaptation of learning platforms and its contents to the mobile scenario must consider several issues such as what has to be adapted, what are the characteristics of the mobile terminal etc. Nonetheless, the adaptation of any learning platform to the mobile world must keep track of the inscriptions, users and course enrollments. The adaptation must also take advantage of the capabilities of the mobile device to communicate the users involved in the learning process and generate activities that can be developed on the mobile device [10].

Some of the initiatives that try to adapt LMS to the mobile world include:

A study conducted by the Athabasca University, into some of the technical and organizational implications of implementing Moodle on mobile devices [5].

Moodle for Mobiles. A module developed by Jamie Pratt to do Moodle tests using mobile devices.

Mobile Moodle. A simplified Moodle version for mobile devices developed in Japan. The simplified version includes tests, feedback, authentication, multilingual support etc. Due to technological issues this project can only be used in Japan [8].

Moodle Offline from the Open University provides an offline mobile Moodle client for Ultra Mobile Personal Computers that can be used to work offline and synchronize with the Moodle server. [12].

This paper is organized as follows: section 2, introduces the service oriented architecture (SOA) and current e-learning standards based on SOA. Secion 3 describes two currently m-learning applications of the SOA developed by the authors.

Section 4, presents an architecture based on SOA to allow 1) the extension of LMS to the mobile scenario, and 2) the integration of activities from external applications into the LMS. In the extension of LMS to the mobile scenario, a proof-of-concept application to extend one of the most widely adopted LMS, (Moodle) to the mobile world is presented. This application is the fusion of the two previous m-learning applications described in section 3. Although the proof-of-concept application extends only the Moodle system to the mobile world, the proposed architecture can be used to adapt any LMS. Finally section 5 presents the conclusion of this work.

II. The SOA approach and learning interoperability specifications

The problem of delivering educational contents through the web and its integration with LMS has been widely studied. But education is not only about contents, as the last educational models make explicit (connectivism and social constructionism) [4],[1]. Nowadays learning applications can offer a wide range of services and functions. To take advantage of these new services there is a new approach for integration and interoperability. This approach, which works in the direction of creating interoperable software, is the Service Oriented Architecture (SOA). The SOA provides a separation between the interface of a service and its underlying implementation, so that consumers (applications) can interoperate across the widest set of service providers, and providers can easily be swapped on-the-fly without modification to the application code. The Open Knowledge Initiative and the IMS organizations are developing standards for interoperability based on the SOA.

There are some SOA proposals to extend LMS to mobile devices [13]. This proposal extends the main capabilities of a LMS, the assessment, to mobile devices. This is a first step to extend LMS to mobile devices. But, there is also the need to integrate external applications into the LMS.

A. *The Open Knowledge Initiative OSIDs*

The Open Knowledge Initiative (OKI) was born in 2003 with the purpose of creating a standard architecture of common services that learning software systems need to share, such as authentication, authorization, logging etc. The OKI project has developed and published a suite of interfaces known as Open Service Interface Definitions (OSIDs), whose design has been informed by a broad architectural view. The OSIDs specifications provide interoperability among applications across a varied base of underlying and changing technologies. The OSIDs define important components of a SOA as they provide general software contracts between service consumers and service providers. The OSIDs enable end-user tools to be installed in different LMS using a plug-in architecture. The OSIDs are compatible with most other technologies and specifications, such a SOAP or WSDL. They can be used with existing technology, open source or vended solutions.

Each OSID describes a logical service. They separate program logic from underlying technology using software interfaces. These interfaces represent a contract between a software consumer and a software provider. The separation between the software consumer and provider are done at the application level to separate consumers from specific protocols. This enables applications to be constructed independently of any particular environment, and also eases integration [11].

For example, services such as authentication are common functions required by many systems. Usually each application has built this specific function. As a result the authentication function is implemented in many ways and this results in information being maintained in different places and being unable to easily reuse. OKI would separate the authentication function from the rest of the systems and provide a central authentication service for all the applications in the system.

Thus using the OKI OSIDs has some advantages such as: 1) the ease to develop software. The organization only has to concentrate in the part of the problem where they can add value. There is no need to redo common functions among most of the systems; 2) Common service factoring. OKI provides a general service factory so that services can be reused; 3) Reduce integration cost. The current cost of integration is so high that prevents new solutions from being easily adopted. OSIDs are neutral open interfaces that provide well understood integration points. This way there is no need to build a dependency on a particular vendor; 4) Software usable across a wider range of environments, because OKI is a SOA architecture.

B. *IMS-LTI*

The OSIDs tells us how to exchange information between the LMS and an external learning application, but how will the teacher and the student reach the application form the LMS? OKI describes a complete set of services between the LMS (service consumer) and the application (service provider). But, the LMS users students and, specially teachers, need to perceive the external application like a service native to their LMS. Otherwise the adoption of a new kind of application will introduce big deal of confusion among students and teachers, by the lack of consistence on the interface. The goal should be to be able to deliver the OKI-enabled applications with consistence with the LMS interface and standard workflows (See Fig. 1).

The IMS Global Learning Consortium is anther organization working in standards towards interoperability and integration of learning services and systems. One of these standards is the IMS Technologies for Interoperability (IMS TI). IMS TI (and the new revision IMS Learning Technologies for Interoperability (IMS LTI)) focuses on the process on how a remote service is installed on a web based learning system [9].

The IMS LTI 2.0 specification resolves the way an external application can be integrated inside a LMS. IMS LTI 2.0 describes the specific Web Services calls necessary to conduct between service provider and consumer, so the consumer (LMS) can deliver the providers application to its user in a consistent way.

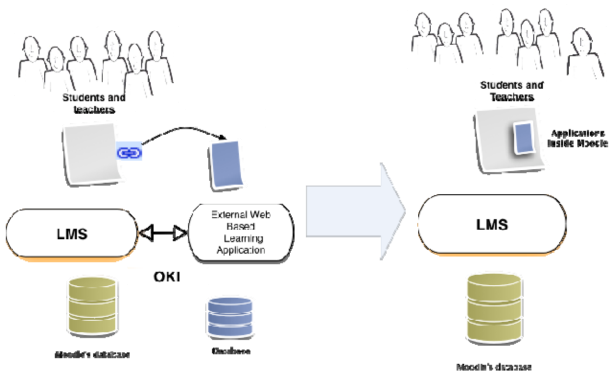

Figure 1. Delivery of OKI applications with consistence with the LMS.

In this line of work, in the 2008 Google Summer Of Code program, the UPC student Jordi Piguillem mentored by the IMS advisor Charles Severance and Marc Alier, has successfully developed a reference implementation for a IMS LTI simplified consumer (http://potato.lsi.upc.edu) for Moodle. This Moodle plug-in allows the integration of non Moodle applications as if they where native Moodle applications, by just implementing a simple set of Web Services. The estimate workload to adapt a learning application using this standard is less than two weeks.

III. INTREGRATION OF LMS AND M-LEARNING APPLICATIONS

This section describes the general features of two m-learning projects developed by the authors which are based on a SOA approach. The fusion of these projects is used in section 4 as part of the proposed architecture.

A. Moodbile: the Moodle Mobile Client

The customization of LMS to be accessible from web browser on mobile devices has been an interesting research problem. Researchers and web developers have come up with possible solutions to this problem with different degrees of success. But, what happens if a student wants to read the latest forum posts while she/he is traveling on the underground without wireless access? Does the student need to pay for the wireless access every time she/he wants to access to contents of the virtual campus from the cell phone? And what if she/he prefers to use her wifi access in the cell phone to get all the data for free while she has free connection and review these data afterwards?

The point is that the students might want to access the data from the LMS when they are offline and synchronize whenever they want. And this is not possible in a web based scenario which requires to be online to work (regardless of other issues such as security).

For the previous reasons, the UPC DFWikiteam started a research project which leads to the development of a specific mobile client to access the Free Open Source LMS Moodle: the Moodbile project. The Moodbile project constitutes an extension of this LMS to the mobile scenario.

Moodbile is the test drive application developed by the authors and their team in the UPC that implements this kind of mobile client for Moodle 1.9 [3];[2]. The general architecture of Moodbile consists of the following elements:

- The Moodle LMS that runs on the server: Moodle (but other systems such as Sakai could be adapted).
- The Moodle interoperability extension (Moodle-DFWS) an API to access the services of the Moodle core system, with independence of its implementation. This part runs on the same server as Moodle does. Using Web Services as transport implementing both the XML-RPC and SOAP standards. However the mobile client will use only the XML-RPC protocol because -theoretically - will be more efficient in this kind of scenario. The analysis of this issue is material for another eventual research.
- The Moodbile Client. Through the interoperability layer (Moodle-DFWS) the Moodbile client syncs the data with the Moodle server. The mobile user can work offline using the mobile device with the same data he can get through the web interface. The user can even contribute to the Moodle course while offline. All the modifications are stored in the local database on the mobile device and sent to the server in the next sync.

The Moodbile client can work online as well as offline. When working online the Moodbile client uses the interoperability extension to access the new information originated in the Moodle server. This new information is sent to the mobile client and stored persistently for further or offline access. When working offline the mobile user will be able to access the information stored on the mobile device in the last synchronization. The mobile user will also be able to do some updates from the mobile device. When the user updates an activity, the changes are stored locally on the mobile device database and sent to the Moodle server database when the user decides to synchronize.

Considering that the user will use the mobile device to access very specific information about recent events in short connections or extend the learning process on the move, we selected the following activities to be access from the user's mobile device: 1) forums, 2) wiki contents, 3) glossary entries, 4) internal mail messages and 5) calendar from the virtual classroom. The selected activities are the Moodle core activities.

In summary, we did not want to develop a full Moodle client able to perform all the tasks performed from the web interface, because we considered that mobile devices are only suitable for specific tasks of the learning process. Instead, we considered that the mobile device could be useful to do short connections to the Moodle system to access specific information and to do limited updates that do not require large amounts of data entries from the mobile device.

B. *CLAYMobile – System for content adaptation*

At the research GRoup in InterAcción and eLearning research group from the University of Salamanca (GRIAL) and with the collaboration of the Research Department of Clay Formación Internacional, the authors have developed CLAYMobile. The start point of this research is a mobility system based on the learning platform ClayNet 2.0 [6] which has been implemented by Alberto Velasco Florines at the University of Salamanca [15].

The previous system allows users access and interaction with the learning resources of the learning platform (ClayNet) using mobile devices. The main goal of the project is to provide a series of Web Services that different mobile clients use to access the contents of the ClayNet platform. The Web Services implements the necessary methods to control the connection and authentication from the mobile device, as well as the access to the resources. The resources of the learning platform are adapted to the specific characteristics of the mobile device.

Several resource adaptation packages are used to adapt the contents to the specific characteristics of the mobile device used to access the learning platform. These adaptations also take into consideration the resource type (PDF file, Web page etc.).

All the actions performed by the mobile client are designed to operate as efficiently as possible, using the lowest transfer rate, reducing the size of the resource and using the connection to the learning system only when necessary.

The authors have currently developed a mobile adaptation system for Moodle 1.8.X and 1.9.X and also a client to access to those adapted contents.

Some features of Moodle must have been considered to define this new system due to Moodle's resource distribution and its hierarchical user structure. In particular, must be considered:

- Where are the resources? What resources are allowed? How Moodle distribute resources, etc.
- How much different kind of users can interact with the LMS? What permissions have the different users over resources?
- How are courses distributed? How an existing role or a new one could view course or category contents?

Having clarified those concepts the adaptation system was redefined in the following parts

- Authentication service. This service receives a log-in request from the client application which includes the username and password introduced by the user and one object which includes the technical features of the device. It allows connection with Moodle and determines which role has the user in the system.
- Content service. This service contains methods for accessing resources and other methods for navigating through the courses structure. The last ones, which do not involve any adaptation at all, obtain a list of elements which are enclosed in a higher level element.
- Content adaptation. The first step for all the types of adaptation is checking if the device supports the file type of the original resource. If not, a new copy will be generated, if it is possible, in another file type which the device does support. Then, the adapted resource will be then send to the client.
- Client application. The invocations of the remote methods of the web service are executed in separated threads so as to prevent a connection error from blocking the entire application. In addition, since mobile connections are usually quite slow, a wait screen for informing that the connection is being established is shown. The graphical user interface (Fig. 2) will allow the user to navigate through the courses structure and menu options easily. There will be a multimedia player (Fig. 2) for playing audio and video files, an image viewer and a text viewer. A high level of optimization of screen rendering will be achieved thanks to content adaptation.

Now are being developed clients for iPhone and android-based devices.

IV. An Architecture for LMS and Mobile Applications Integration

In this paper the authors propose a software architecture that 1) enables mobile client applications access to the LMS contents and activities, as well as 2) enables the integration of external educational applications (mobile or not) with the LMS consistently with the LMS interface and workflow. To develop this architecture the IMLS LTI 2.0 and the OKI OSIDs v.3.0 are used as the basic standard transport mechanisms.

The architecture proposed by the authors is based on services (SOA) and tries to integrate existing external educational applications with existing LMS as well as to extend the LMS resources and activities to mobile devices. As shown in Fig 3. - point 1, every LMS implements a set of basic services (such as authentication, authorization or course enrollment). These services are used by external applications using a Web service (WS) layer. This Web Service layer is based on the OKI OSIDs.

Figure 2. Graphical user interface and video player.

On one hand, this set of Web Services has allowed the authors develop an advanced mobile application (offline advanced mobile client) that accesses the LMS resources and activities. This Web Service layer is used to extend the LMS to the mobile scenario, a further step than traditional mobile web browsers which are highly limited.

The previous mobile client application is a fusion between the Moodbile and the CLAYMobile applications. This fusion creates an advanced mobile client application that accesses the resources and activities on the LMS. This mobile application uses the bandwidth efficiently, can work online and offline and adapt the LMS contents to the specific characteristics of the mobile device. From time to time the mobile client application syncs its data with the LMS to get the last updates. The mobile database stores these updates for further access. The mobile client application is able to do some updates of the LMS activities (see Fig. 3 - point 2).

On the other hand, the proposed architecture takes advantage of the IMS LTI 2.0 features to integrate external educational applications with the LMS. For example, assume we have a mobile application to create collaborative digital videos and want to integrate this application with a specific LMS. In this scenario, the users would use their mobile phones to shoot the story and take pictures. As the media is being captures with the mobile phone this media is transferred via MMS to the editors at the computer via the server-side mobile application (Fig. 3 - point 3). Finally this applications is integrated in the LMS (Fig. 3 - point 4). The proposed architecture allows the integration of these external applications with the LMS expanding the possibilities of the educational activities.

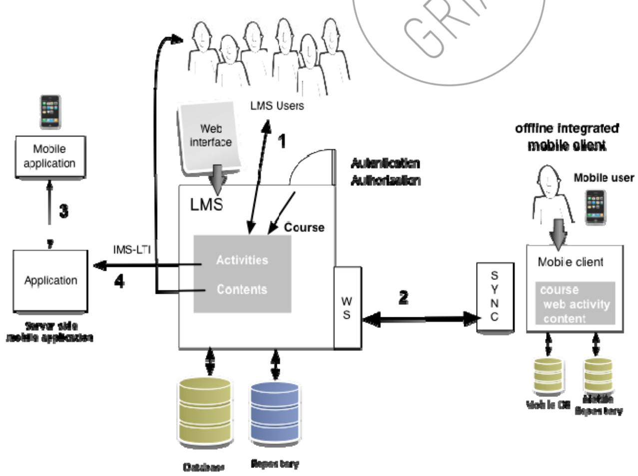

Figure 3. Architecture to integrate LMS with external mobile applications.

The proposed architecture presents important advantages such as 1) LMS independence. The Web Service layer defines the necessary services to access contents and activities in any LMS. The only thing to do is the implementation of this WS layer on a specific LMS. 2) mobile device independence. Any kind of mobile device can be used as a client application (i.e, cell phones, tablet PC, One Laptop per Child). It is possible to have different implementations en different clients. 3) external application independence. The architecture is independent from the external applications that need to be integrated with the LMS. 4) The possibility of offline work on the mobile client application

V. CONCLUSIONS

The evolution of the educational process and the delivery of knowledge is bound to the technological revolution. The existence of a current solution that matches the current requirements is not enough, because these requirements may change in the near future, especially if we consider that we live a rapidly-changing world. For this reasons it is necessary to create new strategies to surpass the new pedagogical challenges. Mobile technology represents an opportunity in this direction. The SOA architecture expands LMS services to many scenarios and allows the integration of different system, overcoming an inherent problem of many current e-learning standards based on data exchange [14].

The architecture based on services we propose, provides an infrastructure that can be used to improve the learning process. It also tries to unify several current approaches such as the integration of external learning tools with LMS, and the distribution of LMS services to the mobile scenario.

This architecture could be the starting point of new integration tendencies that were able to solved problems related not only with technological evolution but also other learning process changes like integration between LMS and backoffice tools, new LMS access contexts, actors progress (digital natives vs. immigrant natives) and so on.

REFERENCES

[1] Alier, M. "A social constructionist approach to learning communities: Moodle". In Militiadis D. Lytras (Ed.), Open Source for Knowledge Management: strategies beyond tools. Hersley: Idea Group Publishing, pp. 369-381. 2007.

[2] Alier, M. et al. "A Mobile extension to a web based Moodle virtual classroom". Proceedins of E-challenges International Conference. The Hague, Netherlands, Vol. 4, pp. 1169-1176. 2007

[3] Alier, M., & Casany, M. "Moodbile: Extending Moodle to the Mobile on/offline Scenario". Proceedings of IADIS International Conference Mobile Learning. Algarve, Portugal, pp.11-18. , 2008.

[4] Arina, T. "Learning Zeitgeist: The Future of Education is Just-in-Time, Multidisciplinary, Experimental". In Masternewmedia. Retreived July, 20, 2008 from http://www.masternewmedia.org/news/2008/02/13/learning_zeitgeist_the_future_of.htm

[5] Cheung, B. Stewart, B. McGreal, R. "Going Mobile with MOODLE: First steps". Mobile Learning 2006. IADIS.

[6] Conde, M. Á., Carabias, J., Martín, R. Mª, González, I., García, F. J. "Portlet-based ARCHITECTURE FOR A LMS: CLAYNET 2.0". En

F. J. García Peñalvo, J. Lozano Galera, F. Lamamie de Clairac Palarea (Eds.).Virtual Campus 2006 Post-proceedings. Selected and Extended Papers. CEUR Workshop Proceedings. http://ceur-ws.org/ ISSN 1613-0073. En prensa.

[7] Conde González, M.Á. & García Peñalvo, F.J. "mLearning, de camino hacia el uLearning", en Avances en Informática y Automática. Salamanca. 19-12-2007. ISBN:978-84-612-1283-5. pags 11-20.

[8] Hinckelman D. “Moodle for Mobiles”. Reviewed February 2008 from http://docs.moodle.org/en/Moodle_for_Mobiles

[9] IMS Global Learning Consortium. IMS Tools Interoperability Guidelines. (2006). Retrieved June 10, 2008 from http://www.imsglobal.org/ti/index.html

[10] Keegan. D. “Mobile Learning: The Next Generation of Learning Distance Education International”. 2005. Retrieved October 2008 from http://learning.ericsson.net/mlearning2/files/workpackage5/book.doc

[11] Merriman, J. “Redefining interoprability. The Open Knowledge Initiative (OKI)" 2008. Retrieved May 5, 2008, from http://www.okiproject.org/view/html/node/2916

[12] Offline Moodle. 2007. Retrieved February 2008 from http://hawk.aos.ecu.edu/mobilemoodle/

[13] Riad, A. El-Ghareeb, H. 2008. “A service oriented architecture to integrate mobile assessment in learning management systems”. Turkish Online Journal of Distance Education-TOJDE April 2008 ISSN 1302-6488 Volume: 9 Number: 2 Article 12

[14] Vossen, G and Westerkamp, P. (2008). “Why service-orientation could make e-learning standards obsolete”. In Int. J. Technology Enhanced Learning, Vol. 1, Nos. 1/2, pp.85-97.

[15] Velasco, A. Carabias, J. Conde, M. Á. and García, F. J. “CLAYNET: Content Adaptation in M-learning”. In Proceedings of IADIS International Conference Mobile Learning 2007, part of the IADIS Multi Conference on Computer Science and Information Systems 2007 - MCCSIS (July 5-7, 2007, Lisbon, Portugal). I. Arnedillo Sánchez (Ed.). Pages 269-272. IADIS Press. ISBN MCCSIS 2007978-9728924-37-9. ISBN ML Volumen 978-972-8924-36-2. 2007.