A Service-based framework to facilitate the interoperability between personal and institutional learning environments

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***Abstract*—The application of the Information and Communications Technology to teaching and learning processes implies a revolution in the tools employed to carry out learning activities. Especially the learning platforms are one of most relevant tools; they provide services both for teachers and students to facilitate their work. However, such platforms are mostly focused on the course and the institution and no so much in the specific needs of the user. This means that other kind of environments are needed, the personal learning environments. Institutional learning platforms and personal learning environments coexist, so they should interoperate between them. In this work a framework approach is proposed. It uses using web services and interoperability specifications facilitate such integration. The architecture provides the functionalities to make possible that institutional functionalities were exported to personalized environments and the activity that is carried out in them can be tracked from the institutional environment. With this approach it is possible to show that interoperability between this two contexts is possible and it can improve the learning and teaching processes.**

Keywords: Learning Platform, Personal Learning Environment, Interoperability, Web Services

I. INTRODUCTION

The Information and Communications Technology (ICT) application in different contexts is often linked to important progresses in the way in which the processes included in such contexts are carried out. In the area of education also ICT has been applied, with special attention to the Internet application in which is known as eLearning [1].

However, whilst it represents an important advance in many contexts (for example, the rise of mobile 'apps'), it does not always guarantee success in learning processes. This is because several reasons: institutional change resistance, unnecessary use of the technology, the difference between digital natives and immigrants, etc. [2-4].

These problems are shown in the different tools teachers and students use to learn. Teachers use institutional environments to lead eLearning activities, while the students use other kind of tools that are not necessarily link to an institution or a specific period of time. These environments are the Learning Management System (LMS) and the Personal Learning Environment (PLE).

LMSs are the most significant learning tools in the institutional contexts. They provide teachers with tools, which not only support but also extend, the traditional concept of classroom and facilitate managerial tasks. These systems also provide students with spaces in which they may perform their academic activities, supplement their lectures and (to a greater or lesser extent) collaborate with other students and teachers. [5]. However this learning platforms present several problems such as: 1) they are focused on the course and the institution, rather than on the student and their needs [6]; 2) they do not support lifelong learning [7]; 3) they are monolithic and it is quite complex to include new technological trends or tools (such as 2.0 tools, exportation of functionalities and information to non-web based contexts, etc.)[8] and also make them evolve [2].

On the other hand are the PLEs. They are spaces that aim to facilitate students' learning by allowing them to use those tools they want to learn, without a link to an institution or a specific period of time such as an academic course [9]. With PLEs the learners are the responsible of their learning because: they can decide what tools to use, they become a provider of learning and not only a consumer, they can solve their specific problems, etc. [9, 10].

These two environments coexist because they support two different concepts of learning and also because the institutions have invested great quantities in the LMS and have lot of experience using them. This implies that the student and the teacher have to access to two different learning environments and that what happens in the personal environments should be taken into account from the institutional side. Given this situation it is needed that both environments can interoperate, that is, exchange both information and interaction.

In this sense there are several initiatives that can be classified in three strategies posed by Wilson and others:

- Strategy 1. PLEs and LMSs could exist in parallel, as formal and informal environments respectively, without any interaction or integration of the activity that happens in those contexts.
- Strategy 2. LMSs could be opened up through the inclusion of web services and interoperability initiatives. This integration trend includes: *iGoogle* based initiatives [12]; social networks connected with LMS [13]; PLEs with specific communication protocols [14]. The main difficulties for these initiatives are: institutional barriers to the opening of formal environments and the fact that those initiatives are focused on information exportation and not on interaction exchange.
- Strategy 3. External tools could be integrated into the LMS. In these initiatives, the user might not decide which tools she is going to use and they will be limited to institutional decisions. Some initiatives that can be included this group are: LMSs defined for the integration of external tools [15]; *Google Wave* Gadgets integrated into *Moodle* [16]; initiatives based on tool integration driven by learning design activities [17]; etc. These initiatives pose several problems, such as, integration problems between tools, context integration difficulties, inflexibility for customization by the student and so on. The ones that best overcome these problems are those that define a learning platform starting from scratch or from a previous institutional development. This greatly limits the scope of use of the solution, which will be applied to a very specific context.

Taking all these solutions into account, each with its problems it can be concluded that the integration between the LMS and the PLE is still far from being achieved. The use of web services and interoperability specifications facilitates the opening up of LMSs, but they are very difficult to implement.

Given this situation a service-based framework that merges strategies 2 and 3 is proposed. It allow the exportation of functionalities from the LMS to the PLE by using web services and to return the activity of the students in tools included in the PLE by using interoperability specifications.

The present paper is structured as follows. The second section describes the service-based framework. After that (in the third section) the implementation of the framework is shown describing the specific techniques and tools. Finally some conclusions are posed.

II. ARCHITECTURAL FRAMEWORK

The present section describes the proposed framework taking into account firstly the interfaces and components that form it and later the interoperability scenarios that can take place among the LMSs and the PLEs.

A. Interfaces and Components

The proposed service-based framework tries to communicate at least two environments. On the one hand it is the institutional environment that can include one or several learning platforms. On the other it is the personal environment that can include different kind of applications and can be represented in different contexts such as the mobile devices. Both contexts exchange information and interaction through interfaces based on web services and interoperability specifications. In addition the framework can include mediator tools that facilitate the inclusion of other external functionalities or the pre-process of data.

In Fig 1. it can be seen a deployment diagram with the possible components and nodes distribution. In this diagram the institutional environment consists of two different nodes (although more nodes can be included) that include one or several different LMSs. These LMSs implement the support to web services and interoperability specifications in order to allow the communication with the personal environment.

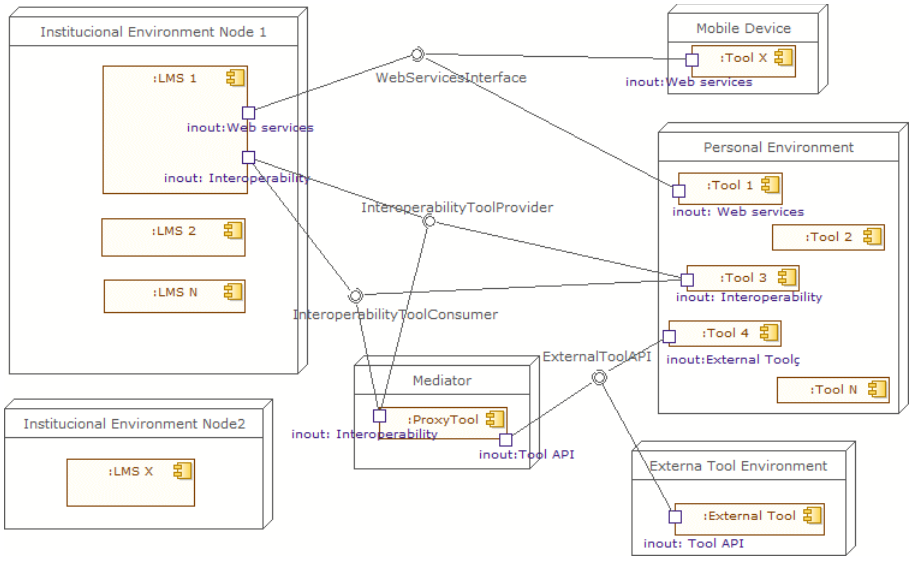

Figure 1. Deployment diagramant fro the framework approach

On the other hand the deployment diagram show a node with a mediator element and an external tool.

Below are described with detail each of the components included in the nodes.

The LMS are the basic tool of the institutional environment. Each node can include one or several and the framework does not define the specific LMS to use or if it is going to be use one or several. However the LMSs should satisfy a minimum set or requirements, they should support web services and interoperability specifications. In Fig 1. is seen that the LMS implements a web service interface (WebServicesInteface) and a interface as the consumer of a interoperability specification (InteroperabilityToolConsumer). In addition it uses the interface implemented by the tools to integrate them, that is the InteroperabilityToolProvider.

Other important elements are the tools included in the PLE. These are the tools that the learner can use to learn in his/her personal environment. There are three types of tools:

- Tools that do not interact with the LMS. These are tools that can be employed in learning activities but in order to take into account what the user does in them, the teacher should leave the LMS, enter into the tool and check the activity carried out. In example the use of Flickr.
- Tools that use the LMS web services. These kind of tools use the web services provided by the learning platforms in order to access to information and functionalities from outside of this environments. Such tools should include a web service consumer that uses the web service interface provided by the LMS.
- Tools that can integrate the students' activity through the use of interoperability specifications. These tools, thanks to the interoperability specifications, can be configured and instantiated as learning activities by the teacher in the LMS. In this way the student can use them in the PLE and it is possible to return the learners' outcomes achieved in such context to the LMS. The teacher does not need to access to other contexts to check what the learner has done.

It should be noted that a tool can consume web service and at the same time act as a Tool provider by using interoperability specifications.

Other kind of components, as commented above, are the mediators, also known as Proxy Tools. These components facilitate the communication among the tools and the learning environments. They have two main aims. The first one is to facilitate the integration of tools that cannot implement a Tool Provider, as could be tools that cannot be accessed to modify the source code. In this case, the mediator also interacts with the tool with the interfaces that they provide (ExternalToolAPI). The other aim of the Mediator is to provide additional functionalities o pre-process data. In example it can be used to provide an interface to evaluate learners' activity in tools that are integrated but were not thought as learning tools.

Last but not least the framework includes a set of interfaces (some of them previously mentioned). These are essential elements that abstract the way in which web services and interoperability specifications are implemented. Specifically the framework includes three main interfaces:

- WebServicesInterface. It is implemented by the LMS and facilitates the access to functionalities and information from the learning platform.
- Interoperability Interfaces (InteroperabilityToolConsumer and InteroperabilityToolProvider). In this framework they are needed to use external tools in learning activities and to return the results of what has happened on them to the LMS. This implies that the LMS and the tools to be integrated should implement this interfaces. They will provide services to facilitate at least the instantiation and set up of an external tool from the LMS.
- Interfaces to access to external tools. They allow the access to the public functionality of the tools in order they can be used from other contexts or other tools such could be the mediators. In example: the Flickr external API.

All these elements configure the service framework but in order to describe the interaction it is necessary to classify it in a set of interoperability scenarios that are presented in the next chapter.

B. Interoperability Scenarios

The components included in the framework interact among them to facilitate the communication between the PLE and the institutional environment. In order to do this there are different possibilities. These are included in a set of interoperability scenarios:

- Scenario 1 - Exportation of institutional functionalities to personalized environments. This scenario aims to export functionalities from a LMS to other environments controlled by the user. In order to export that functionality, the LMS web service layer is used. In that scenario the tool connects with the learning platform by using the web services to access the functionality. This means that the student may use functionality from LMS in the PLE without entering the LMS. The teacher can also follow the student activity as if she was answering from the LMS, so she can be also assessed. Thus, teachers and students use their respective environments while having knowledge about what is happening in the other context. The scenario is open to include other tools and to export the functionality to other contexts different than the PLE such as could be mobile devices.
- Scenario 2 - Taking into account the use of external learning tools from the institutional environment. In this scenario no interoperability between the LMS and the PLE is proposed. It takes into consideration the students' activity into the PLE from the institutional

environment but the teacher should assess such activity by accessing to other contexts that different from LMS. For example, a student accesses an online tool from the PLE, and performs (in agreement with the teacher) a task by using it; then, the teacher should enter into the online tool or the PLE, check her activity and perform her assessment from the LMS. This scenario is quite common in different institutions and it requires a teachers' extra effort.

- Scenario 3 - Use of external online educational tools (with evaluation support) in the PLE, and recover information from LMS. In this scenario the activity is done in the external educational tool but it is integrated in the LMS. To do this interoperability specifications are used and, therefore, a Tool Consumer (TC) in the LMS and a Tool Provider in the external Tool (TP). The TC uses a interface provided by the TP to set up and launch the tool instance and the TP uses a interface implemented by the TC to return the results of the student activity in the application. In this case the teacher set up a launch the activity in the LMS and the student can carry this activity out in the PLE. Once the activity is finished the teacher can gather from the LMS the activity of the students in the external application.
- Scenario 4 - Use of external online tools (not defined as educational and thus without an evaluation interface) in the PLE and recover the information from the LMS. This scenario aims to gather the students' activity in online tools included in the PLE. Those tools are not necessarily educational tools so they are not going to provide an interface to assess the students' outcomes. To address this problem are used interoperability specifications and mediator tools. They provide support for these specifications in tools which code can be modified and also provide the assessment interface to tools not thought with educational aims. As in the previous scenario the activity is carried out by the student in his/her PLE where the tool is represented and the outcomes of this activity is returned to the LMS where the teacher can use it.

Given this components, interfaces and interoperability scenarios the framework is implemented as a proof of concept. This implies to establish some design constrains that are described in the following section.

III. IMPLEMENTATION

This section describes the implementation of the framework. It is divided in two parts, first are presented the design constraints related to the software development and after that the methodology and modelling techniques employed are commented

A. Implementation design constraints

Regarding to the institutional environment although different LMSs could be used, the decision was to use several Moodle 2.1. instances in the proof of concept. There are different reasons for using of Moodle in this context: 1) it is open source; 2) it is very popular and widespread all over the world; 3) it has great success in different institutions [18]; and 4) it includes a web service layer that open it to new technologies and facilitates it to be integrated with service oriented architectures [19].

With regard to the communication channels, web services were used to exchange information and interaction with the LMS and BLTI to integrate the students' activity performed in other environments and to guarantee the portability of the framework to other contexts. The web services will be those provided by the LMS, which can be extended by following the Moodle extension protocol in case of need. However, it is not possible only to use web services because this would mean that the framework should be adapted to the service layer of each platform to use. This is solved by using BLTI, implemented by most of LMS [20]. Nevertheless, it will not be used in the traditional way (to integrate tools into the LMS) because this would limit the student's freedom to choose the tools she wants to use in her learning; instead, it is used to return information to the LMS about what the user has done into the PLE [11].

Relating to the personalized environment it should allow the user to add all kind of tools she uses to learn, including institutional tools. In order to do this a tool container is used; but in this case what matters is not the container but the fact that the applications can be exported and used in other environments and containers. That is why during the proof of concept, standard ways to represent such tools will be used. That is, the use of W3C widgets which can be represented in different web contexts [21], as desktop widgets, on mobile devices and with minor changes on other contexts such as interactive TVs, cars navigation systems, and so on. Regarding to the container Apache Wookie (Incubating), which facilitates the integration of not only that kind of widgets but also others such as Google Gadgets (http://www.google.com/webmasters/gadgets/) or *Open Social* widgets (http://code.google.com/intl/es-ES/apis/opensocial/), will be used.

These design constraints also affect to the interoperability scenarios of the reference approach. Specifically for the Scenario 1 Moodle forum is exported; for the Scenario 2 two online tools (that do not interact with the LMS) are included in the PLE, in this case Flickr and Wordpress are used; for the Scenario 3 an external education tool is defined, specifically a quiz tool; and for the Scenario 4 Google Docs is used as external tool and also a Mediator.

The result of the proof of concept can be seen in Fig 2. This framework has been tested through subjects related to Software Engineering in the University of Salamanca.

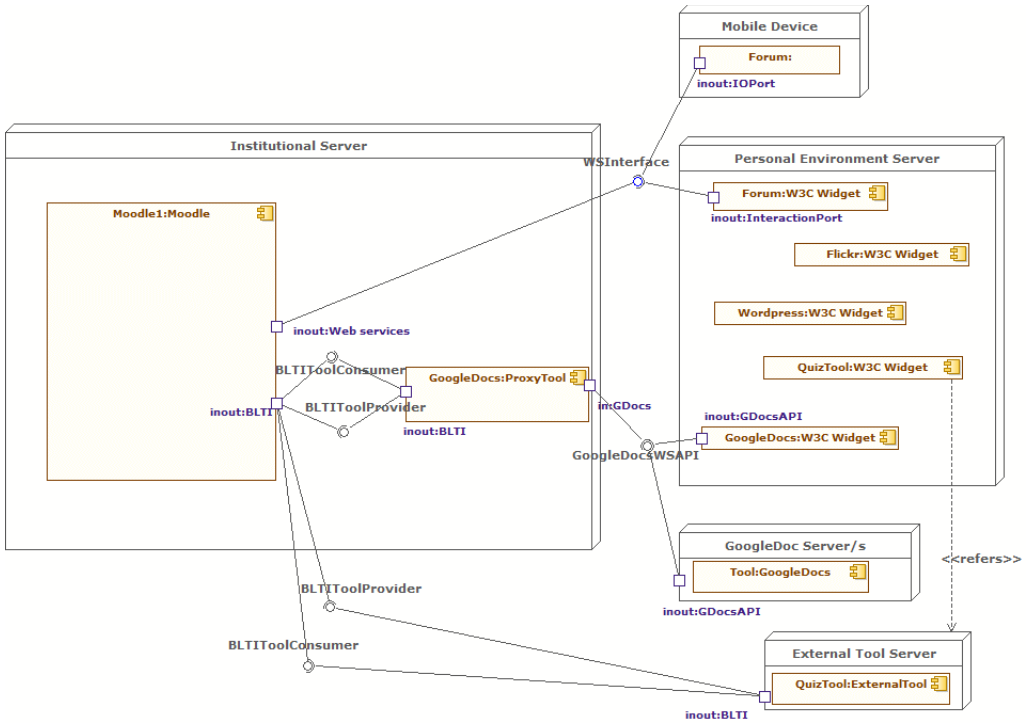

Figure 2. Deployment Architecture for the proof of concept. On the left side the Institutional Server appears with one Moodle instance and the proxy tool for GoogleDocs. On the right side there is a node for the Personal Environment, the Mobile Device and the external tools.

B. Modelling techniques and tools

Regarding to the techniques and tools employed to model the system for the initial description of architecture are used UML 2 (Unified Modelling Language) [22] component and deployment diagrams. The scenarios are described by using BPMN (Business Process Model Notation) [23] which makes easier the process modelling.

With regard to the development the process used is SCRUM [24], because the development team is very small, requirements can change easily, the system is defined in an incremental way and several meetings with the client can be carried out to check the evolution of the project. In total are identified nine tasks that were prioritized. Each of them is divided in smaller elements with which it is possible to work easily and that are implemented in each Sprint (execution cycle of a task). These Sprints are estimated in 21 days and from each of them a new software increment is achieved. For this approach 12 Sprints are carry out so some tasks are divided in more than one Sprint. An example of this process can be seen in Fig 3.

The modelling techniques employed to describe the structure of the system for the proof of concept are as in the initial description deployment and component diagrams that can also be enriched with web-based application conceptual modelling techniques to represent how widgets interface can be defined. In this case OOWS is used [25].

On the other hand to model the services used for the communication in the scenarios SOAml is employed [26]. It is an extension of UML 2.0 that describes the UML profile and the meta-model to design services for Service Oriented Architectures. Specifically it is used to describe the services provided by the LMS and those used by BLTI to implement the interoperability scenarios. These scenarios as in the previous case are described by using BPMN.

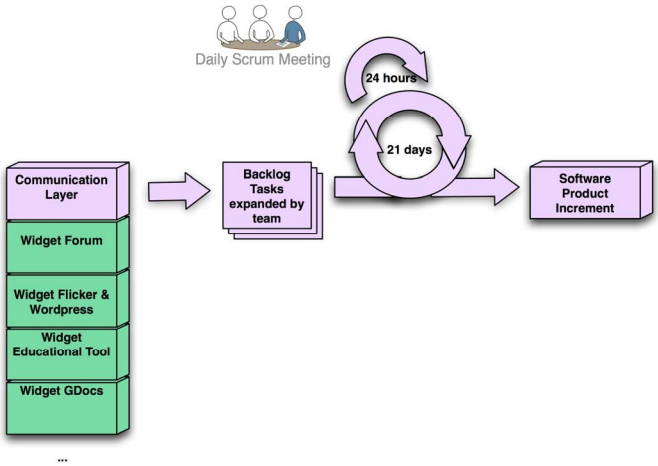

Figure 3. How is used SCRUM to develop this approach

IV. CONCLUSIONS

Along this paper the necessity to integrate the existing learning environments has been presented, those that represent the institutional needs such as the LMS, and those that represent the tools that the learner use to learn along the time, the PLEs. These environments should interoperate between

them and to do so an architectural framework and a set of interoperability scenarios are defined.

This framework facilitates on the one hand the exportation of functionalities from the LMS to external contexts, which means to open the institutional environments. In addition it facilitates the integration of the results of other external tools (included or not in the PLE) into the LMS, so it is enriched and can evolve easily. The teachers have also the possibility to use other tools in their platform and more information about what the students' do outside of the institution. Finally this framework helps the student to access to learning through only one access point and what he/she do in the PLE can be taken into account from the LMS.

It should also be noted that as web services and interoperability specifications have been used, the approach is independent of the underlying implementation and also of the LMS, or the tools used (although they need a slightly adaptation).

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