Design of Learning Activities to Access Web-based Thematic Dynamic Resources

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ABSTRACT
In this paper we present a proposal of designing learning activities to dynamically provide thematic web resources enriched with linked data from a semantic repository. The approach has been implemented as a tool for Learning Activity Management System (LAMS) that provides an interface to automatically select the related resources that are to be delivered to students running a learning activity. It also enables teachers to share a variable set of learning resources and applications related to a given subject and postpone the resource delivery to the deployment or enactment of the course.

General Terms
Integration Architectures, Learning Systems.

Keywords
Learning design, LMS integration, LAMS, Linked-data

1. INTRODUCTION
The life-cycle of a learning activity in a course consists of a number of steps that includes authoring (i.e. the creation, packaging and distribution of learning resources), deployment (i.e. allocating the course elements such as users, resources, activities, applications or services to the learning activity, according to the actual members, roles and structure of the course) and enactment (i.e. starting the interaction with the actually available resources and services as designed) [1]. In a web-based learning environment, perhaps the simplest kind of learning activity that can be designed is to share the URLs of a set of web-based resources and/or applications, which teachers want to make available to their students. Authoring, deployment and enactment phases of even the simplest activity design are usually coupled, meaning that if the teacher wants to share a given resource in the course, he or she must explicitly know and include its URL as part of the authoring stage and prepare its deployment to a set or subset of the learners before expecting it to be enacted in the actual run of the course.

The goal of this work is to present a dynamic approach to the provision of thematic resources in learning activities design which enables teachers to share a variable set of learning resources and applications about a subject, and postpone the delivery of actual resources either to deployment of enactment time. The advantage of this approach is that learning contents can be constantly updated without needing to re-author and deliver the course. The approach has been built on top of a learning systems' integration architecture that uses semantic and linked data technologies to decouple learning resources and services from the Virtual Learning Environment (VLE) or Learning Management System (LMS) that actually manages the course activities. A new kind of learning activity tool has been designed for the Learning Activity Management System (LAMS) [2] to test and validate the thematic resource sharing.

2. LEARNING SYSTEMS' INTEGRATION ARCHITECTURES
LMSs are used to store, manage and track web-based learning courses and events. A 2009 survey [3] yields the following functional features as the most valuable in an LMS: reporting (52%), tracking (46%), assessment (45%), content management (29%), course catalogue (28%), authoring (19%), analytics (17%) and collaboration tool integration (15%). 37% of respondents identified content integration as the biggest challenge to implement an LMS. LMSs usually have to store and manage the web contents and applications as a part of their responsibilities. More modern virtual environments aim at decoupling the management of resource contents and web applications from the LMS. In such systems, web-based learning resources, applications and services have to be integrated with the LMS, which must keep the functions of managing and tracking the learning process [4]. Web-based resources, applications and services must be externally provided, managed and integrated with the learning system.

2.1 LMS and resource integration
Learning resource integration was firstly approached by defining how contents are packaged and delivered in order to make them shareable as an open format (e.g SCORM), which properly tagged with metadata (e.g. LOM) allows to describe the educational contents they hold [5]. Resources and metadata are usually kept in educational repositories, from which they can be then imported into any learning environments or LMS [6]. In a second stage, Educational Modeling Languages (EML) has been used to extend the content-based learning course model with formal descriptions of the activities that the course contains [7]. Some LMS have been extended with software engines that enable running EML descriptions of the learning activities based on the IMS Learning Design (LD) specification [8], such as *CopperCore* [9] and *Grail* [1]. Other learning environments, such as LAMS [2], have proposed their own playable model of learning activity sequences along with its associated users, activities and resources, among other items.

All these systems manage and deploy activities, web resources and applications based on an asymmetric relationship between their users. In other words, instructors usually prepare the educational contents to be consumed on a single direction, i.e. from instructors to students. However, in practical terms of a learning process, to give the student not only the role of consumer of resources, but also to share their own with other students, creates an added value to all the participants. To enable a more symmetric way of interaction, current trends persist on changing traditional e-learning platforms to support the integration of external collaborative applications and services based on open standards [10]. This trend is addressed as a new design of the LMS, known as Personal Learning Environments (PLE) [11], which are more concerned about students' active practices that can facilitate the implementation of symmetrical relationships among learners and instructors.

From the needs of next generation LMS and PLE, software architectures of integration have to be defined, focused in platforms and software applications that implement service-based learning environments [12], or either evolve to web service-based architectures and protocols [1][13]. Indeed, new versions of most widespread LMSs such as Moodle are integrated with external applications through service-based extensions [14].

2.2 Learning system resource integration

We have defined a web-based learning system integration architecture that aims at decoupling LMS responsibilities from external learning resources and application, such as Content Management Systems (CMS), social networks and so forth, using the two-level, service-based integration approach depicted in Fig. 1 [15]. The integration architecture is generic enough to be applied not only to traditional LMSs, but also to personalized, mashed-up environments made of W3C widgets that can be exploited in usual e-learning scenarios [16].

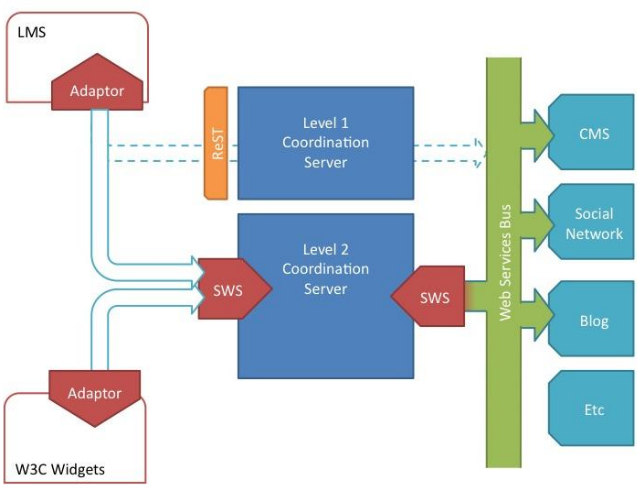

Fig 1: Two-level system architecture for integration of learning resources and services in the LMS: First integration level uses a ReST-based protocol to access external resources and services. Second integration level introduces a semantic web services layer to further decouple the LMS from resources and services.

The first level of integration deals with the protocol required to interact with the external learning resources. At this level, the allowed interactions between activities and resources must be done by providing the activity descriptions with special-purpose user interfaces that can manage and access the learning resources. This simple approach can still be useful to decouple users and resources, since the LMS that manages users can also manage the user-activity mapping independently of activity-resource mappings. A ReST-based architectural style has been used to achieve the raw protocol-based integration of resources into the LMS [13]. ReST provides an explicit, resource-based representation of the operational model of the external resource that are to be shared with the LMS activities. The LMS is free to use this model for their implementation, but also to map it to an appropriate internal model that can be exploited from the user interface of the activity.

The second level of integration aims at decoupling further the LMS and the learning resources through a semantic web services layer. The LMS and learning resources model share a common ontology that describes the resources of the repository. The integration process is done in several steps: first, the resources to be consumed by LMS activities are described based on the integration ontology; second, the resources must be semantically described; and third, the semantic layer maps required resources to actual resources.

3. SHARE THEMATIC RESOURCE TOOL INTEGRATION

To deliver a set of thematic web resources to students of a course, perhaps the simplest way is to ask students do a google search for a number of terms. Then they get millions of web resources. To focus on the search results, the next step is to perform the search on a learning resource repository for a given subject, according to a set of metadata that must be specified in the query. Our approach is based on the latter through the extension of resources with semantic information that describes the subject or theme. To design such kind of activities we have extended the LAMS *Share Resources* tool (see Fig. 2), which enables a teacher to share a predefined list of URLs to the students that will execute the activity.

3.1 Share thematic resource tool design

A new type of LMS activity has been designed on top of LAMS using the learning systems' integration architecture described above. An extension to the LAMS Share Resources tool, called *Share Thematic Resource* (STR) tool, has been developed using the LAMS tool contract API. By this API, LAMS can communicate its core services (i.e. admin, author, learner, monitor, etc.) with any external applications.

The STR tool allows easily selecting the resources that are to be presented to the students. Unlike the Share Resource original tool, a hyperbolic interface allows to navigate through a set of thematic concepts and relationships, according to a given ontology. After selecting the desired concept, the tool automatically selects the related web resources that are to be delivered to the students.

In order to provide the tool with the required semantic capabilities, an endpoint configuration for SPARQL (RDF query language) was provided, using the STR tool *Add Resource* option. Thus, the tool can query any semantic repository that exposes its data via an SPARQL endpoint that gives access to the thematic ontology, making the tool independent from the selected ontology that models the subjects or themes.

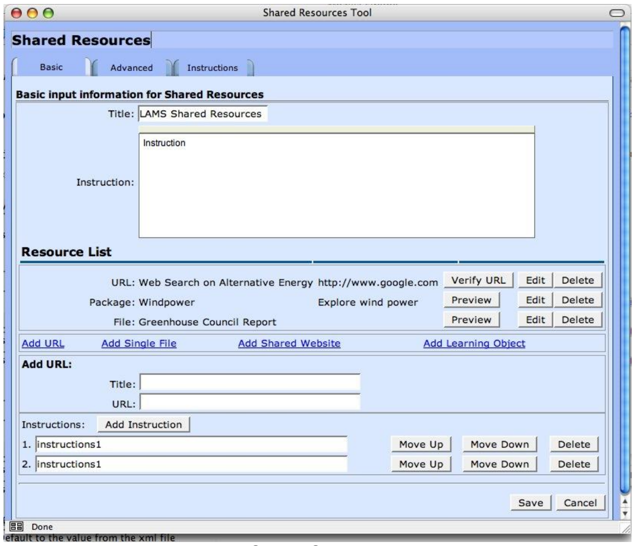

Fig 2: Authoring interface of the original Share Resource Tool used in LAMS during the authoring phase, which prepares the delivery of a set of URLs to all the students that eventually execute the activity.

A navigable interface (see Fig. 3) using the JavaScript InfoVis Toolkit is provided. This framework enables to create interactive data visualizations of the theme information. Whenever the instructor selects a concept, a query against the endpoint is generated and the tool manages the response. The communication with the server is handled by JQuery framework, which offers a suite of tools for RDF processing and JSON parsing. From the obtained response, the tool will automatically deliver a set of web resources to be shared among students.

3.2 Web Resource Generation Strategies

When it comes to generating the actual resources to be delivered to the student, we can pose the following questions: What knowledge sources can be extracted from the thematic ontology? How can we extract interesting resources to students from a given concept of the ontology? Here, we identified several strategies to extract actual learning resources:

Underlying ontological knowledge: The set of axioms and assertions stored in an ontology represents an important source of knowledge. However, the definition of ontologies is not intended for human consumption. Thus, we might consider as a learning resource the representation of the ontology in a friendly format (e.g. a visual graph). In our case, it can be done over the subset of the ontology that results from mapping those elements that are related to the selected concepts.

Annotation properties: Another approach can be using the *rdfs:seeAlso* and *rdfs:isDefinedBy* properties in the ontology items. These are present in all resources of the ontology and provide additional information about them. However, there is no standard agreement in the use of these properties, making it complicated as an effective and general exploitation method.

Explicitly linked resources: Ontologies allow you to define relationships between concepts in multiple ways. For example, in the Music Ontology (MO), property *mo:wikipedia* is used to link a musical genre, for instance, to its corresponding wikipedia page. In the Friend-of-a-Friend (FOAF) ontology, the property *foaf:homepage* relates something to a homepage about it. These object properties provide direct access to web resources that describe these concepts. However, this is an important issue, since accessing such resources depends on the specific ontology. Therefore, it is not known what properties defined in the ontology are likely to publish their assertions as learning resources.

Automatic discovery of resources: From a given concept, we may automatically collect all the web resources available from it. With this aim, all the resources available through the axioms of *xsd:anyURI* datatype properties and the axioms of object properties can be collected. This alternative presents a major problem. Since it involves an exhaustive search, it is possible to obtain URIs of scarce interest for learners or URIs that return content that is not suitable for human consumption.

All this strategies present some pros and cons. We have chosen to use a mixed strategy between automatic discovery of resources and explicitly linked resources, as we explain next.

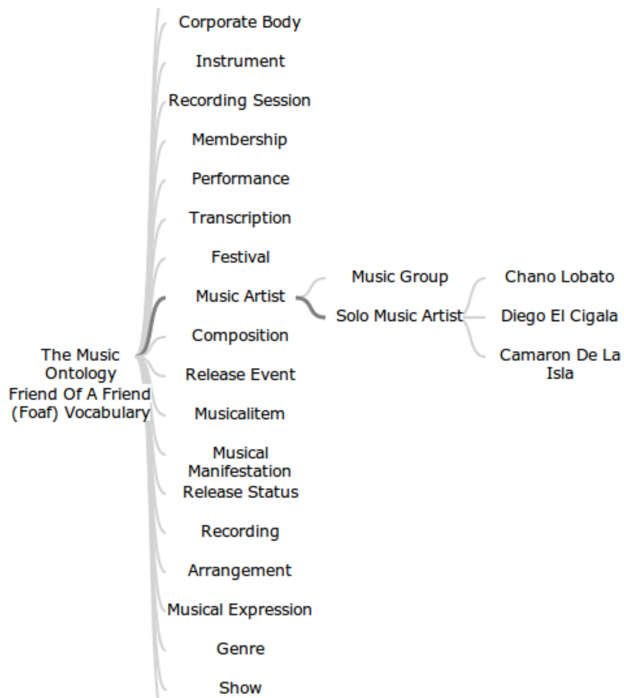

Fig 3: Interactive hyperbolic navigation through the concepts of the ontology. The figure only depicts items from the Music Ontology and FOAF vocabulary, but any other ontology can be managed.

3.3 Generating Dynamic Resources

The STR tool is based on the automatic discovery of resources. After the user selects the concept that he/she wants to present to students, the system automatically collects the interesting URIs. Subsequently, the system will present to the activity author a window with the types of relationships supported by the selected concept. Additionally, the system will display some of the URIs associated with the concept for each type of relationship (see Fig. 4), in a query-by-example fashion.

Fig 4: Visual interface to configure how thematic resources must be generated and delivered to the students.

In the window of Fig. 4, the user can observe the retrieved URIs. Then the user can select the types of relationships that he/she is interested in and obtain related learning resources. After selecting the desired types of relationships, the system offers the possibility of choosing the HTTP content type that is interested in, according to standard MIME types (e.g. text/html, application/pdf, application/rdf+xml, etc.) Thus, the system can gather the preferences of the author of the activity: thematic concepts to deal with, possible relationships and the content types to publish.

After the activity has been designed and built into any LAMS learning activity sequence, it will be ready for deployment and enactment to learners. When a student executes the activity, the system launches a query to the SPARQL endpoint. This query will discover all the URIs associated with the concept selected by the instructor, taking into account the preferences indicated in the design phase of the activity.

3.4 Tool integration with a semantic repository

The STR tool has been connected to the semantic content repository of the eCultura platform (www.ecultura.org). This platform hosts producer or consumer web applications, built around a linked-metadata RDF-based core repository. This repository is currently filled with the MO and CIDOC CRM ontologies.

STR is built onto an LAMS instance, which can act as a consumer application in the eCultura platform. This way, thematic resources related to musical and cultural concepts can be automatically generated. These resources have been created through other linked-data producer applications, such as LinkedWiki and LinkedBlog [17] that feed the resource repository.

4. CONCLUSIONS

In this paper we have addressed some alternatives that semantic integration technologies provide to decouple learning resources and services from the VLE or LMS that actually manages activities of a course. We also discussed some integration strategies used to retrieve resources from a semantic metadata repository by managing and consuming linked data. A tool has been defined independently of the underlying concepts of the ontology, which enables to share dynamic linked-data resources as part of a LAMS course. We have used concepts from a semantic repository that use thematic ontologies on the cultural domain, such as the CIDOC CRM, Music Ontology and FOAF. The set of ontologies can be easily extended to other domains that are suitable to the educational purpose of the learning community.

The initiative of the proposal arises from the project "Access to Semantic Services and Educational Contents through Learning Technologies" (ASCETA). The implantation of this project lasts until 2012. Future works include the achievement of feedback from educators and how would outperform education competencies, educational behaviors or skill indicators extracted from a didactic experience in the context of this project. Moreover, we have planned to extend the integration architecture to other LMSs to access external web contents as well as applications and services.

5. ACKNOWLEDGMENTS

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