Analysis of e-learning repository systems and frameworks with prepositions for improvements

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Abstract. *Systems manipulating large number of courses and students are called learning management systems (LMS). LMS have excellent performances implemented through advanced Web technologies but often poor or rarely used repository for storing institution's educational data. There still remains a problem of how to allow users of LMS to easily modify and integrate content form federated e-learning repositories into their courses. In this article we present analysis of present repository frameworks and projects. Also, we present possibilities of using FEDORA (Flexible Extensible Digital Repository Object Architecture) framework as a repository solution. A pilot application has been created for demonstration of interaction between LMS and repository.*

Keywords. e-learning repositories, repository framework, learning objects, learning managements systems.

1. Introduction

One globally accepted way to implement LMS as all-in-one system for online education, which covers registration, administering, monitoring of users and content. LMS also provides other tools such as assessment tools, discussion forum, grading tools etc. Therefore, it has become irreplaceable for modern universities and other educational institutions. Blackboard [1] is the leading commercial provider of LMS solutions, and Moodle is a widely accepted open source solution [1]. Generally, LMS supports exporting of learning content to another system but collaboration with external e-learning repositories is not standardized. On the other hand, solutions for e-learning repositories are advancing, offering federated sophisticated searches of learning objects through a network of repositories. The term "learning object" (LO) is not intended to be restrictive but refers to any digital asset which can be used to enable teaching or learning.

Many projects tried to define integration between LMS and federated repositories but none has provided a widely accepted solution.

The rest of the paper is organized as follows. Section 2 covers analysis of present LO repositories and actual projects in the field. Section 3 explains a proposed alternative by introducing FEDORA [2] repository framework based on data-service oriented architecture. Section 4. covers communication of LMS and LO repository (LOR). In Section 5 we present an example for storing, defining, dissemination and integrating of LO compositions into a LMS. Section 6 describes the usage of our application for creating e-learning content (lesson) from LO stored in repository. Section 7 explains possibilities for future work in this filed and the conclusion is given in Section 8.

2. LO repositories and actual projects in the field

MERLOT, LORNET , EDNA, ARIADNE LOR [3] are some of the prominent LO repositories. Many of them are using different metadata to describe the content stored in repository. Therefore, Application Program Interface (API) was established for querying through Simple Query Interface search (SQI) GLOBE [4] with special focus on issues related to a common metadata schema and to a common query language [5]. SQI Registry is basically an UDDI [12] registry, which maintains a list of SQI targets that can be queried using SQI .

Main SCORM (Sharable Content Object Reference Model) [6] attempt aimed to provide such shareable LO environment is called CORDRA (Content Object Repository Discovery and Registration Architecture) [6]. CORDRA is a highly complex system that is still being developed and has not yet been adopted by any of the educational institutions.

EduSource Communication Layer (ECL) [7] is a middleware framework that enables building of bridges to other protocols and networks, such as OAI, SRW/SRU (Resource Discovery

Network) in UK, EdNA (Australia), SMETE (USA), SQI (Ariadne), and LionShare (gnutella based P2P network) [7].

ECL connector is one of the first implementations of the IMS Digital Repositories Interoperability (IMS DRI) [7] specification, it will allow repositories to share search results, gather records, alter each other to new materials and submit new materials in other repositories.

Repository solutions and frameworks mentioned here are mainly focused on interoperability among different repositories. A problem that remains is how to build different semantic web applications that would allow better interactions among LMS, LOR and users. Also, which ontology to accept while doing so. In the next chapter we mention some of the projects in the field that are dealing with that issue.

2.1 Frameworks for decomposition and reusability of LO

A lot of repositories have stored complex and large amounts of data as LO. In these environments, LO are losing their original meaning. A number of projects were started in order to achieve an effective ontology-based decomposition and integration of LO but also to achieve a higher level of interactions and reusability as mentioned in previous section. In this section we discuss three main projects in that area.

RAMLET (Resource Aggregation Model for Learning, Education and Training) [8] is a project focused on retrieving, interpreting, disaggregating, aggregating and deploying content from different types of structural elements from specialized repositories.

RAMLET's ontology has aggregating purposes and it's not concerned with the relationships between sections and chapters or with the interactive properties of different media types [8].

ALOCOM provides a generic content model that defines a framework for LOs and their components. The ontology defines concepts representing different LO component types and their structure. Plug-ins are available for MS Word and MS PowerPoint allowing users to search for text, graphs, pictures and other elements in repository of decomposed MS Word and MS PowerPoint documents in ARIADNE repository [8].

ALOCOM is not part of ARIADNE core tools and just a couple of ALOCOM component repositories exist [8] with a possibility to define LO relationship through ontology.

There is another institution that is doing a lot of research in the similar field of library archives - Open Archives Initiative has started Object Reuse and Exchange (OAI-ORE) [9] which defines standards for the description and exchange of aggregations of Web resources.

The goal of these standards is to expose aggregations of rich content to applications that support authoring, deposit, exchange, visualization, reuse, and preservation [9].

The OAI already produced a protocol very similar to SQI - Protocol for Metadata Harvesting (OAI-PMH) [9], as a mechanism for repository interoperability. It consists of Data Providers, - repositories that expose structured metadata via OAI-PMH, and Service Providers which make OAI-PMH service requests to harvest that metadata. OPI-PMH is widely used, highly valued and continually developed, which cannot be said for network of LORs based on SQI used by academic community.

LO reuse through LORs is not currently in mainstream use among teachers [10]. While most LORs have been in operation for several years (MERLOT: 7 years, SMETE: 5 years, ARIADNE: 7 years), the amount of learning objects indexed in any one of them is small and it is comparable in number with the amount of learning objects stored in a single medium-sized LMS [10].

So it seems likely that the RAMLET project would complement the work being undertaken within and around the OAI-ORE. The problem at hand is obvious - without a common nomenclature and conceptual model to provide the interpretation of these formats and specifications, it is difficult to create applications that can interoperate [19].

2.2 LMS-LOR integration - LUISA project

The best solution would be if user's needs could be met right in the environment native for users and that were their own institutional LMS. The main effort in this field is undertaken by LUISA [11] project under the European Commission.

The goal was to create a rich flexible infrastructure supporting development and reuse of learning materials for both learners and educators, and also integration with a LMS-LCMS (Learning Content Management System) in order to get the best of these two worlds.

Therefore, the whole project is built on Moodle and plug-in for Moodle is available that allows search of LUISA LOR, based on ontology (RDF), which is a core of the LUISA project.

LUISA calls semantic web services that can apply user profile, topics and competencies to resolve the wanted set of LO. Web services also enable users to annotate and define metadata description based on their role in LMS of LO and to compose lessons out of different LO and to store them into local LOR.

LUISA's architecture explains how systems collaborate with federated repositories allowing users to annotate content and to save it in local repository.

Although it offers integration to other Web applications which could interact with LUISA, those applications are still not being developed. A set of tools should be developed to prove that LUISA could be integrated into any LMS environment which has until now been achieved only for Moodle.

LUISA does not allow additional LO annotations of users which can be seen by other users of the repository. Users can only combine different LO into a single one, but they cannot modify or integrate any LO in whatever way and whatever context they choose.

Still LUISA is an excellent beginning of truly emergent, ontology based, semantically enriched, modular LMS-LOR and it is our opinion that in near future a lot of projects may emerge that would try to cover the remaining problems in the field. Considering previously stated, we shall try to draw a picture of a system that can be built upon all the projects mentioned here.

LUISA is a good basis for LMS-LOR integration but its ontology should be improved with other projects in the field. Parsing, categorizing and annotation of LO could be complemented with OAI-ORE decomposition in combination with ALOCOM ontology principles.

Most of the quality content resides on LMS. SAmgI (Simple Automatic Metadata Generation Interface) [10] project shows that many valuable metadata fields can be extracted from LMS.

RAMLET could be used for composition of LO from different repositories. SAmgI would be a good tool to refine results of the searches but ECL protocol could be the best solution to achieve interoperability across different federated networks of repositories. RAMLET decomposition complemented with OAI-ORE with stronger semantic web services integration points could allow development to a number of distributed applications for rich user-content and user-user interaction.

The key point in this moment is not technology but the agreement on usage of a different ontology, metadata schemas and semantics in applications and repository implementations.

3. Architecture of data-service oriented digital repository

Here we explain how FEDORA platform could be used as a web service oriented platform which can be integrated with existing solution or used as a LMS internal or external LOR. FEDORA is project based on OAI-PMH. FEDORA has a powerful digital model for storing objects, which supports different ways of manipulation, editing and relations over and among objects. That model is the core advantage because it is completely focused on objects it stores.

FEDORA is actually designed for archiving bibliography records but our goal is to show how such a powerful platform can be used in e-learning environment. Architecture of FEDORA repository is shown in Figure 1. Users can access LO repository via web browser, client application or third party application through frontend web services. In that way, different functionalities can be achieved like searching, modifying, and adding digital objects, linking objects, retrieving metadata or whole objects etc.

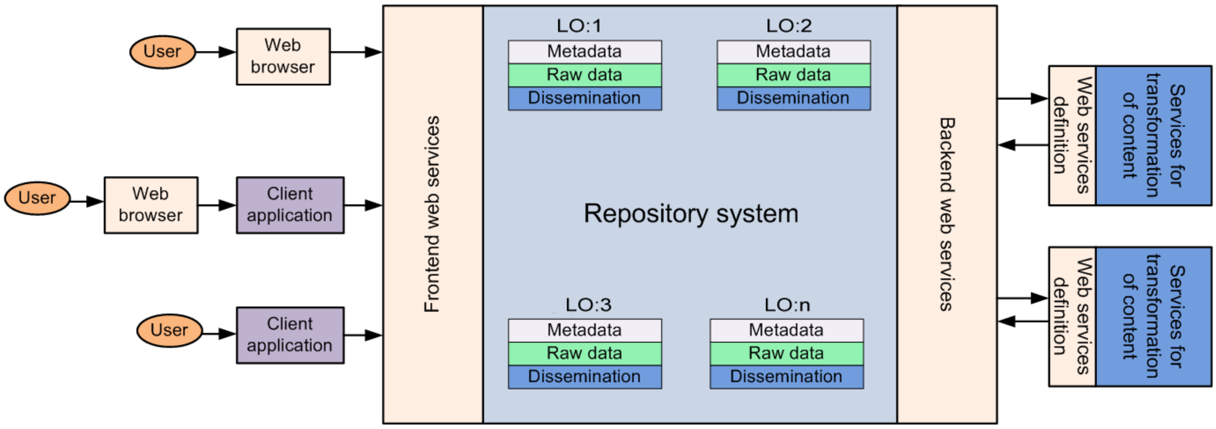

Figure 1. Architecture of system for digital objects storage

A digital object consists of three main groups of data:

1. Metadata:

• Description metadata: used for correct description of a LO. Metadata define the purpose, type, and possible educational usage of the object. Any metadata scheme can be used in FEDORA.

• Relational metadata: definition of relations between objects, relations between object and external content and definition of parameters needed for application manipulation.

2. Raw data: all stored data supported by LO repository. Raw data is the term used for all MIME (Multipurpose Internet Mail Extensions) data or data without metadata attached to it.

3. Dissemination data: used for calling of remote or local application for management of objects stored in LO repository. Examples of applications that require dissemination are: application for picture manipulation and for automatic transformation of certain types of content into PDF format. Applications used by repository are web applications, dissemination data has to contain source or URL of the source and format definition of the data that needs to be transformed, and also location and parameters needed for calling the web service over REST [12] method and SOAP [12] protocol.

This is the most powerful feature allowing LO to be a standalone object which can seamlessly interact with other LO and applications in local or remote repository.

Web services are frontend of the system for communication with other systems, services and applications. They are not used only for dissemination of objects but for interaction with other repositories, maintaining and indexing of objects, calling other web services, applications etc. These are the backend web services, shown in Figure 1.

Any ontology, semantics and application can be built on FEDORA. Semantic value of the LO can grow over time because it can store information from every LMS, repository, system that has accessed or modify it. FEDORA has a versioning system that allows saving different versions of the same LO. LO in FEDORA can be referred to while residing in FEDORA repository, which means that they can be directly embedded or manipulated by an internal or external application without user awareness where object really resides. In our example we shall demonstrate how FEDORA LO can be referred to, modified and combined with other LO without being saved in local LMS LOR. We can call our simple embedding application from Webct wrapper like external link resource and internal FEDORA web applications for content manipulation to compose simple HTML page made out of three LO from FEDORA repository.

From the given information it is obvious that LOs inside FEDORA are totally platform independent units. Any information needed for LO to be manipulated and retrieved, is stored in LO itself. LO in FEDORA is not only a semantically enriched content building block but it can be seen like one from technical perspective too because its stores all the information needed for communication over network, which is usually stored in repository.

4. Communication between LMS and the FEDORA repository

FEDORA can interact with any LMS. Figure 2. shows how two widely used LMSs, Moodle and WebCT, can interact with the same FEDORA LO repository.

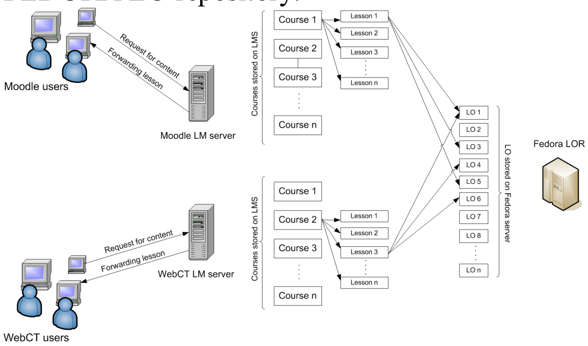

Figure 2. Example of communication between LMS and digital repository

In the place where FEDORA LOR is in Figure 2. we can put the FEDORA LOR network of repositories which can exchange metadata. SQI federated repositories can also exchange data with FEDORA over FEDORA backend services. ECL protocol supports integration of OAI-PMH based frameworks so that interoperability with other repositories is achieved.

5. Storing, defining, dissemination and integrating of LO compositions into LMS

The process of automatically describing LMS LO with metadata can be realized through projects similar to SAmgI, mentioned before. Because of the way that FEDORA digital object is defined, LMS objects can stay inside LMS repository and be manipulated through FEDORA. Figure 3. Shows administrators backend and one LO stored with its LOM (Learning Object Metadata) [6] metadata and content items. JPEG content item is shown as one of parts of LO. Figure 4. shows the definition of dissemination. Method definitions are automatically available according to the type of the content item, in this case a JPEG picture. According to the chosen method definitions (web service arguments), different mechanisms (web services) can be used for different manipulations. Respective URL is then available for calling the defined web service. This is not an end-user application but an administration backend for definition of web service handlers for manipulation with LO.

6. Creating lesson from LO

The application for creating lessons is shown in Figure 5.

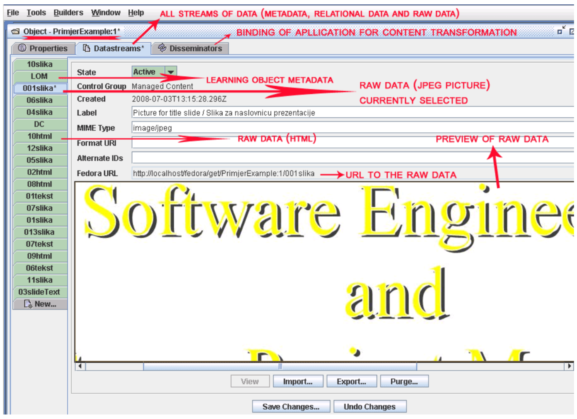

Figure 3. Example:1 LO

The figure shows how the application, residing on another web server, can be easily integrated as a tool inside any LMS. User of WebCT LMS starts the application via URL. User can define title of the lesson and URL of each content item inside any LO. Figure 5. shows how a lesson can be build out of three stored content items in Example:1 LO. Second content item is transformed by web service. Original content item picture is transformed by user input (600 pixels) and by calling disseminator defined in Figure 4.

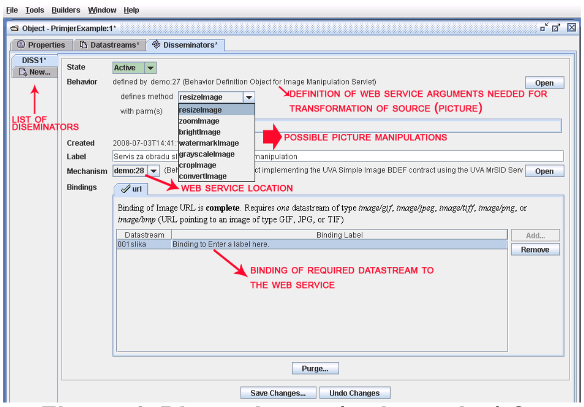

Figure 4. Disseminator (web service) for picture manipulation

Changes on each LO in repository can reflect on the lesson which is created out of any number of LO from repository. Calling of application is identical for any other LMS. The presented application is still under development and the first version of the application will be tested on the E-business elective course at the Zagreb School of Economics and Management in the following semester.

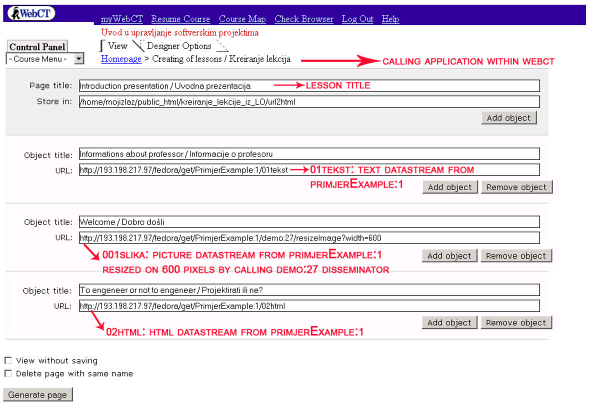

Figure 5. Application for creating lessons called within WebCT

7. Future work

The proposed application is not yet suitable for end users. Plans for development include:

- A control panel for deployment of internal and external web services on multiply LO in repository.
- User friendly interface for LMS users for manipulating, changing, composing and annotation of LO.
- Integration of present solutions for collecting metadata from LMS.
- Integration of present solutions for decomposing and storing of LO in repository.
- Definition of user roles and permissions
- Integration of present web applications for user collaboration.

8. Conclusion

LMS are still a closed environment even if they are functioning on open platforms like Moodle. Copyright issues are not the primary reason why collaboration among users is on such a low level. LMS are an environment built to reach only students and it leaves hardly any space for collaboration of different departments in the same university let alone they are able to connect scientists across the world. Higher integration of LMS and LORs are a prerequisite if we wish to see LORs grow in size and interaction level, because core user/content community resides on LMSes.

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