Metadata Management and Sharing in Multimedia Open Learning Environment (MOLE)

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Abstract. This paper presents a framework and an architecture for learning resource management and sharing aiming at facilitating the implementation of such functionality on top of existing Learning Management Systems. It also presents the implementation of this framework and its integration with the MOLE (Multimedia Open Learning Environment – http://www.moleportal.eu/) system. Main components of this architecture are: (a) the LOM Editor, an intuitive web based tool that is able to accommodate different Application Profiles, while getting adapted accordingly; (b) The LOM Repository that stores the metadata generated by the LOM Editor and implements the common repository services (search/expose, submit/store, request/deliver) for the management of metadata records; (c) the user interfaces that exploit those services to expose the metadata management functionality to end-users; and (d) an OAI-PMH interface that allows for harvesting of the repository metadata from large repositories/federations (e.g. ARIADNE, Organic.Edunet etc.) on top of the repository.

Keywords: eLearning infrastructures, metadata management and sharing, LOM Editor, Application Profiles, OAI-PMH

1 Introduction

One of the major challenges for learning organizations today is sharing learning resources by facilitating discovery and retrieval of the learning content they develop and store in their repositories [1]. While learning content repositories already cater for their local users, there are no agreed profiles that address the needs of the learning domain, and no established practices for combining existing specifications into complete solutions [2]. Individual organizations are developing their own ad hoc solutions, following different technical approaches, mechanisms, and metadata models. As a result, the opportunity to establish broader interoperability is limited.

Establishing practices that combine existing specifications into integrated solutions in the form of agreed profiles, in order to address the needs of specific learning communities in terms of learning object sharing, discovery, and exchange, will be beneficial to all stakeholders [2]:

- *Educators* will become more productive by being able to easily discover learning content that addresses the needs of their students, thus maximizing re-use and reducing the cost of reproducing new resources.
- *Students* will gain access to the highest-quality learning resources available, making a significant impact on the quality of their learning experience and their learning outcomes.
- *Content providers* will have the opportunity to advertise their products making them globally discoverable.
- *System vendors* will be able to make their systems compliant with major federations of learning resources, by only supporting a minimum set of specifications, and
- *Federation builders* will secure their investment by developing durable infrastructures based on standard specifications.

A concrete evidence of the significance of this challenge is the fact that the IMS Global Learning Consortium, has established a group on Learning Object Discovery and Exchange (LODE) [2] aiming to facilitate the discovery and retrieval of learning content. The group examines and adapts specifications that are being applied to digital libraries, generic repositories and learning repositories to address the current lack of agreed profiles addressing the needs of the learning domain and practices for combining existing specifications into complete solutions. The project group will study search mechanisms, meta-data harvesting, learning content exchange, content identification as well as collection and service description. It will also define a small number of scenarios for the discovery and exchange of learning resources (e.g., federated searching, harvesting, etc.) with the objective to develop:

- A set of specification profiles to support the scenarios
- Sample implementation(s)
- A conformance domain-profile

The ultimate goal is interoperability among systems involved in those scenarios. Interoperability is achieved when a system (e.g., a LMS) end user is able to discover a compatible learning object hosted on a separate system (e.g., a learning object repository) using a LODE-compliant discovery service. Addressing federated discovery (through either federated search or harvest-driven centralized search) presents the greatest interoperability challenge. Establishing interoperability in terms of LODE requires that the federations should be based on LODE search and LODE registry specifications. However, federation is not a requirement for compliance. The term “federated” is used in a loose sense to refer to a group of distributed, independently managed and potentially heterogeneous repositories, whether or not any agreements, trust relationships etc. exist between them.

In this paper we report on the design and implementation issues related to the support of learning content sharing requirements on top of an existing Learning Management System (LMS). We focus on those aspects that are related with the use of learning metadata standards and their Application Profiles (APs) for the description of learning resources, as well as the implementation of harvesting protocols that will make them available to large repositories/federations, technical issues that should be addressed in eLearning infrastructures.

Our learning infrastructure is based on the MOLE (Multimedia Open Learning Environment – http://www.moleportal.eu/) system. MOLE is a multilingual multimedia information system for managing courses, supporting learning processes and learning communities through the Web. The MOLE multi-tenant architecture supports multiple instances of MOLE using the same core to serve the needs of multiple communities. Each particular community has specific needs for the descriptions of the learning material that are more or less different from the needs of other communities. In this sense, applying the framework described in this paper to MOLE was appropriate in order to support different Application Profiles to suit those community-specific needs and overcome the problems of semantic interoperability.

We have adopted the Learning Object Metadata standard (LOM). Our annotation tool is an intuitive web-based LOM editor that is not strictly bound to a specific AP, as it is the case for most LOM metadata editors. The LOM editor can use multiple APs, thus supporting efficient metadata specifications in any application-specific context. The metadata records are managed by a repository that implements the common repository services (search/expose, submit/store, request/deliver). Appropriate user interfaces have been implemented exploiting those services to expose the metadata management functionality to end-users. Finally, an OAI-PMH interface has been implemented on top of the repository. This interface supports metadata harvesting from large repositories/federations (e.g. ARIADNE, Organic.Edunet etc.). This way, the learning content created by an organization could be made known and exploited by other organizations that are connected to those federations.

The paper focuses on the learning resources metadata management and sharing in MOLE and implements the general architectural framework we propose. Section 2 presents the proposed architectural framework for supporting metadata management and sharing of learning resources on top of a LMS. Section 3 provides details regarding the implementation of this framework in the case of MOLE and considers various technical issues that should be considered for implementing the framework in other Learning Management Systems. Related work is presented in section 4, while section 5 concludes and presents directions of future research and developments.

2 Metadata Management and Sharing Framework and Architecture

A typical LMS can be conceptually represented with the architecture on the left part of Fig. 1. In this architecture, a LMS consists of the following:

- A set of Learning/Collaboration services
- a set of Course Creation/Management Services, and
- a Learning Resources Repository for the storage of the learning resources (physically of by reference) and their metadata.

In this section we present a framework and an architecture for learning resource management and sharing aiming at facilitating the implementation of such functionality on top of existing Learning Management Systems. The main component of this architecture that allows for the extension of an LMS for effective resource management and sharing is called the *Metadata Management and Sharing System*.

The *Metadata Management and Sharing System* allows for the creation of LOM metadata descriptions based on different APs, supporting the needs of different communities in different educational contexts. The technical experts can take advantage of the system, in order to develop an appropriate AP by using the *Application Profile Builder* that the users can later use in order to create the corresponding LOM metadata descriptions through the *LOM editor*. The LOM XML documents that are produced can be searched and edited through appropriate user interfaces. Moreover, the *OAI-PMH Interface* implementing the OAI-PMH protocol on top of the *LOM Metadata Repository* allows for the exposure of the metadata to *Learning Resources Federations/Consumers*.

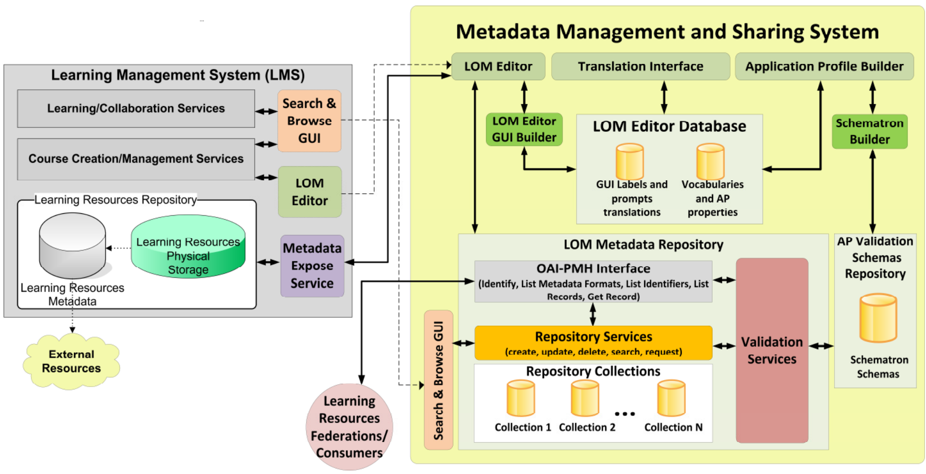

Fig. 1. The Metadata Management and Sharing Architecture

Fig. 1 illustrates in detail the architecture of the *Metadata Management and Sharing System (MMSS)* and its connection points (interfaces) with the LMS. The *MMSS* consists of the following components:

- The *Application Profile Builder* is a web based utility (user interface) that offers a graphical representation of the LOM metadata elements and their structure. Through that utility, the AP expert can navigate through the LOM elements, setting their multiplicity and the vocabularies, taxonomies or ontologies that will be used as value spaces for each of them. Moreover, the expert can state which elements are mandatory, recommended or optional. Furthermore, the expert can create custom vocabularies using list of values, taxonomies or domain ontologies, that can be later used in specific metadata elements. That information is saved in the *LOM Editor Database*.

- The *LOM Editor Database* is responsible for the storage of the system properties, the vocabularies, the translations of the GUI and the help descriptions. It also stores the relevant information that is necessary for the system in order to support the APs.
- The *Translation Interface* is a web based wizard utility that can be used by the experts in order to translate the LOM editor's user interface, labels, prompt messages and help information related to each metadata element into different languages. It takes advantage of the "Google Translate API", suggesting translations to the user simplifying the translation procedure. The information related to translations is also kept in the *LOM Editor Database*.
- The *LOM Editor* is a web application that offers to the users a formal way to create or edit LOM metadata descriptions. The elements that are presented on the editor's user interface are each time adapted to the AP that is being used. The elements associated with vocabularies are supported by auto complete services. For each element a short description (help) is available, explaining the usage of the corresponding element for each AP. The LOM metadata description is finally saved in the *LOM Metadata Repository*.
- The *LOM Editor GUI Builder* utilizes the information that is kept in the *LOM Editor Database* and builds the *LOM Editor's* user interface.
- The *Schematron Builder* is a component invoked by the *Application Profile Builder* as soon as an AP is saved. It is responsible for the creation of schematron schemas [3] according to the corresponding APs. These schemas are stored in the *AP Validation Schemas Repository*" and are used for the validation of the XML documents.
- The *AP Validation Schemas Repository* is the responsible component for the storage of the Application Profile validation schemas (schematron).
- The *LOM Metadata Repository* is responsible for the storage and management of the generated LOM XML descriptions. It consists of the following parts:
    - The *Validation Services* that are used to validate the XML documents that are generated by the *LOM Editor*, utilizing the information that is kept in the *AP Validation Schemas Repository*. The documents that are invalid are also kept in the repository in order to be later completed by the user, but will not be published through the *OAI-PMH interface* until they reach their final state.
    - *Repository Services* is a set of services over the repository collections that conform to the IMS Digital Repositories Interoperability (IMS DRI) Specification [4]. The IMS DRI specification provides recommendations for the interoperation of the most common repository functions enabling diverse components to communicate with one another: search/expose, submit/store, gather/expose and request/deliver.
    - The *OAI-PMH interface* is the responsible part for the exposure of the metadata descriptions. It is an implementation of the OAI-PMH protocol, a widely accepted protocol for the exposure of repositories

information. The LOM XML documents that are exposed by this protocol have been previously validated based on the corresponding Application Profile and the *Validation Services*.

- The *Search & Browse GUI* is a web based graphical user interface that can be used to search and browse the content of the *LOM Metadata Repository*, utilizing the *Repository Services*.

The connection points between the Learning Management System and the Metadata Management and Sharing System are the following, as illustrated in Fig. 1:

- The *Metadata Expose Service* that passes to the *LOM Editor* the learning resource metadata values stored in the LMS that can be mapped to the current LOM AP. This way, the LOM Editor automatically fills in the values of the corresponding elements in the LOM AP metadata description each time a new metadata description for a learning resource is being created.
- The *LOM Editor box* on the side of the LMS corresponds to the integration of the *LOM Editor* in the LMS. This requires no effort, since the LOM editor integration is easily done using technologies like iframes without any changes needed to be done on the side of the LMS. The web interface of the LOM editor can be customized using the *LOM Editor GUI Builder* in order to fit the web interface of the LMS.
- The *Search & Browse GUI box* on the side of the LMS. As in the case of LOM Editor, the Search & Browse GUI can be easily integrated using iframes.

3 Implementation and Usage

The proposed architecture has been successfully implemented on top of MOLE (Multimedia Open Learning Environment – http://www.moleportal.eu/), developed by the Laboratory of Distributed Multimedia Information Systems and Applications (TUC/MUSIC) of the Technical University of Crete. In the following sections we introduce MOLE and its main characteristics and we describe its integration with the metadata management and sharing architecture proposed in this paper.

3.1 Multimedia Open Learning Environment (MOLE)

MOLE is a multilingual multimedia information system for managing courses, supporting learning processes and learning communities through the Web. More specifically, MOLE fosters distance-learning by enabling communication between tutors/trainers and students, cooperation among students and access to coursework information and learning resources. In doing this, MOLE platform also supports the combination of traditional classroom-based lessons and practical sessions, with self-study and e-learning. This, so called, “hybrid” or “blended” approach provides a significant learning opportunity as it combines the immediacy of communication among the instructor and the learners and the irreplaceable practical training in laboratories and the convenience, flexibility and self-regulation of education without the time and space constraints. This hybrid organization aims to exploit the strengths of both approaches (traditional and tele-education).

An important characteristic of MOLE is its multi-tenant architecture (Fig. 2) that can support multiple instances of it using the same core to serve the needs of different projects or communities (Fig. 3).

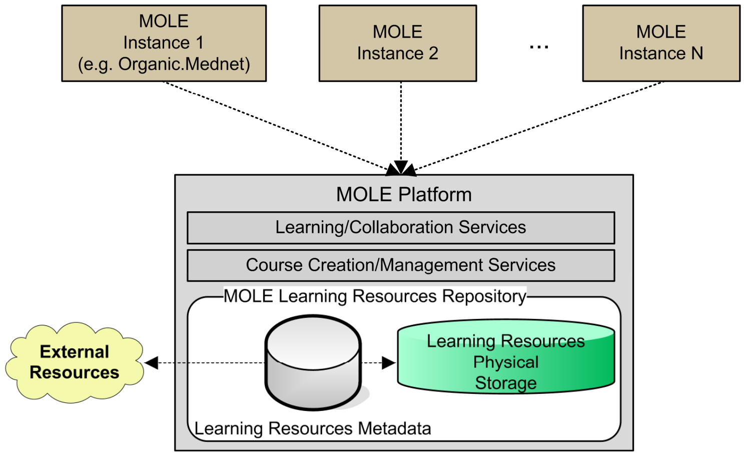

Fig. 2. MOLE has a multi-tenant architecture able to support different communities and projects

MOLE offers a set of services for

- the organization and management of digital educational content (e.g. lectures, notes, exercises, technical lab material, literature, FAQs etc.)
- informing learners (e.g. announcements, mail, calendar, personal rating etc.)
- assisting learning communities (e.g. mailing lists, live chat rooms, forums, personal messaging, instant messaging, annotation tools, video conference etc.)
- supporting educational activities (e.g. registration to courses, formation of lab teams, exercise uploads and deadline management, assessment tests, multimedia presentations etc.)
- monitoring services (course usage statistics, class performance indicators)

Special emphasis in MOLE system is given in the use of multimedia as a powerful learning means and for that reason it is continuously enriched with new multimedia features. In order to support learning applications MOLE meets the following technological requirements:

- Effective support of multimedia and video/audio data streams management.
- Mechanisms for multimedia presentations synchronization
- Support of synchronous and asynchronous learning activities.
- Support of live synchronized multimedia transmission through the system, and access to the recorded multimedia content.
- Support of learners' intervention in live sessions.

- Demonstrations and presentations of software by recording the video presentation and speaker combined with video and slides.
- Educational content creation in two ways
    - Through the Web based interface without the need for specialized software installations
    - Through an autonomous application for the creation of high quality video and editing tools for offline content creation and uploading in the system at different times.
- Communication tools to support educational communities
    - Discussions with video and audio in real time
    - Video Conferencing Services with collaboration tools
    - Asynchronous multimedia communication messages
- Advanced multimedia collaborative annotation tools on educational materials using multimedia

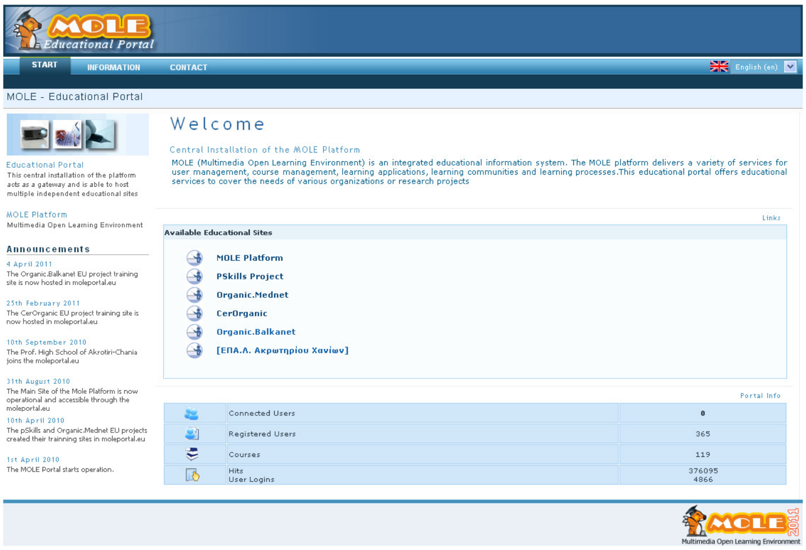

Fig. 3. Communities and projects currently supported by MOLE

3.2 Integration of the proposed architecture with MOLE

The *MMSS* has been integrated with MOLE following the approach presented in Fig.1. The communication between MOLE and the *MMSS* is done over HTTP. Each time a new metadata description is created in the *LOM Editor* for a learning resource residing in LMS, the LOM Editor calls the *Metadata Expose Service* to pass via a POST request the metadata of the learning resource stored in the LMS. This is done according to the mapping between the LMS metadata elements and the LOM AP metadata elements known to the *Metadata Expose Service*. Afterwards, the metadata author can further enrich the learning resource metadata following the rules imposed by the current AP that affect the presentation of the LOM Editor GUI. The information that is passed to the *MMSS* must at least contain the following metadata:

- the *organization identifier* that will be used in order to organize the resources in collections. Each collection represents an instance of the MOLE platform for a specific community.
- the *resource identifier* that will be used in order to identify a resource and the corresponding LOM XML description in the system.
- the *title* of the resource, which will be used as a title of the LOM description.

The richness of the LOM metadata for a learning resource depends a) on the number and type of the metadata elements used in the LMS that are able to be mapped to LOM elements depending on the current AP and b) on the metadata author who may further enrich or not the metadata following the rules expressed in the AP.

In the case of MOLE and using the Organic.Edunet AP [5], the metadata elements of MOLE that are mapped to the elements Organic.Edunet LOM AP (OE LOM AP) are the following (beyond the basic info described above):

- the *description*, that is related to the resource that is kept in the platform (mapped to the General/Description element of the OE LOM AP)
- the *keywords*, relevant to the learning resource being described (mapped to the General/Keyword element of the OE LOM AP)
- the *contributor*, who creates the LOM metadata description (mapped to the Meta-Metadata/Contribute element of the OE LOM AP)
- the *resource location*, which represents the location that the corresponding resource will be accessible (mapped to the Technical/Location element of the OE LOM AP)
- the *resource type* (mapped to the Educational/Learning Resource Type element of the OE LOM AP)
- the *format* of the resource as mime type (mapped to the Technical/Format element of the OE LOM AP), and
- the *file size* representing the size of the resource in bytes (mapped to the Technical/Size element of the OE LOM AP).

The *MMSS* has been developed as a web based application that takes advantages of Java, Java Server Pages and Java Script Markup Language. The core services are implemented in Java and served through the Apache Tomcat servlet container [6]. The *LOM Editor Database* utilizes a MySql database and the services for the management of the information (store/retrieve) are also implemented with Java technologies. The ontologies that are used as value spaces in metadata elements are processed using the Jena OWL API [8] in order to get thereafter presented through an appropriate graphical interface. The communication between the related graphical user interfaces is done through HTTP requests and the exchange of information is done through JSON or XML messages. The *Validation Schemas* that are produced by the Schematron Builder are kept in the local storage. The LOM metadata descriptions in the LOM metadata repository are stored in a native XML database (eXist-db [8]) and the *Services* provided by the LOM metadata repository are also implemented in Java. The *Validation Services* utilize the Xalan Java XSLT processor [9].

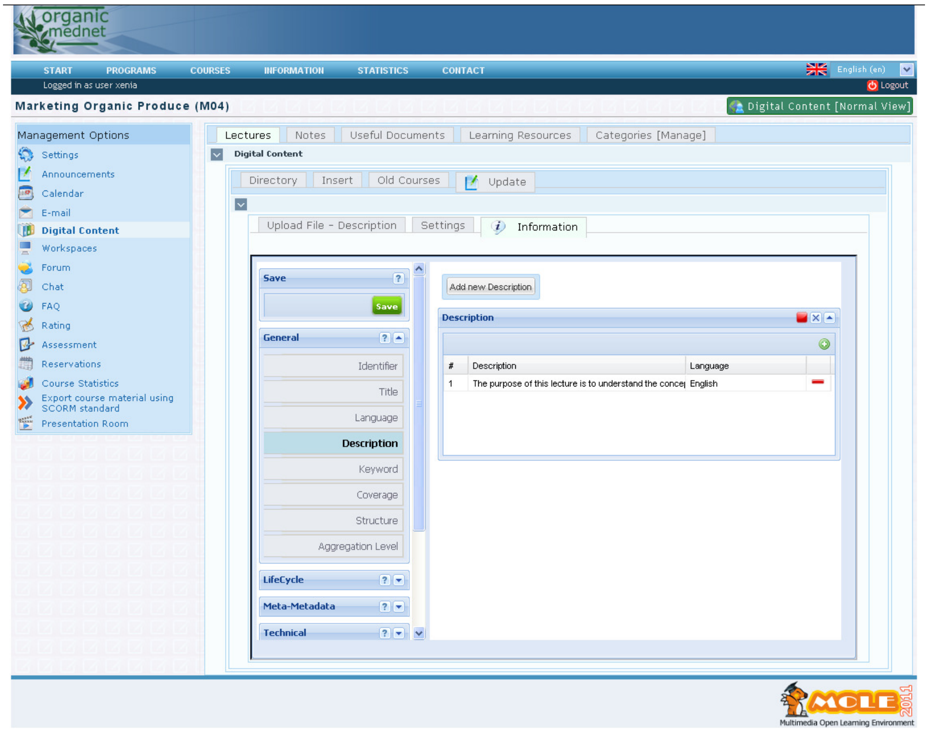

Fig. 4. The LOM Editor integrated in MOLE

As already mentioned, one of the advantages of the web implementation of the *LOM Editor* and the *Search & Browse GUI*, as well as the communication through HTTP requests, is that they can be easily encapsulated in different LMSs by using for example iframes, as in the case of MOLE. Fig. 4 shows the integration of the LOM Editor in MOLE using iframes.

4 Related Work

Different learning communities have different needs to support different educational contexts. Each community has its own needs for the description of the learning material and needs support for semantic interoperability. Those needs can be supported by the use of APs of LOM standard. To support the implementation of APs as well as the creation of metadata descriptions related to a specific AP, different software applications have been implemented. Two of the most known applications are the LomPad [10] and the ASK-LOMAP v1.0 [11].

The LomPad is a meta-tagging tool for learning objects. It is bilingual (French, English) and supports three predefined different applications of the IEEE-LOM standard (LOM strict, SCORM, and CANCORE APs). It is a java desktop application and does not provide facilities neither for metadata management nor for metadata exposure. Moreover, it does not support the creation of different APs.

On the other hand, ASK-LOMAP v1.0 is a web based tool for the creation of LOM APs and metadata authoring tool. Although it supports the creation of LOM APs, it does not support the combination of different vocabularies for the same element. Additionally, it does not support the use of taxonomies or ontologies as an element value space through its interfaces. The metadata authoring tool is not multilingual and it seems that multiplicity of some elements presenting appropriate graphical interfaces is not fully supported, although defined in the corresponding APs. Moreover, no search/browse facilities in the content of the repositories are provided and there is no support for metadata exposure to federations.

Compared to the above mentioned approaches, the advantage of the approach presented in this paper is that it provides a complete framework for metadata management and sharing according to different APs to support different communities that can be easily integrated in an existing eLearning system.

The closest approach to our approach in terms of its objectives is [21], where a Web-based tool is presented that has been developed to facilitate learning object annotation in agricultural learning repositories with IEEE LOM-compliant metadata and its prototype development within Organic.Edunet Project. Learning objects are organized in a portfolio-like user interface in a learning repository, which can be connected with Organic.Edunet federation or external federations as ARIADNE and LRE. The repository back-end is resource-oriented and stores its metadata according to an RDF representation of the Organic.Edunet AP. An interface exposes the repository closest to the internal representation and is based on REST. Several existing tools have been used and adapted: 1) A configurable metadata editor called Annotation Tool, built upon the code-library SHAME (http://shame.sf.net), 2) The electronic portfolio system Confolio (http://www.confolio.org) which allows flexible management of folder-based repository interfaces, and 3) The SCAM (http://scam.sf.net) semantic metadata and resource repository.

5 Conclusions and Future Work

Educational resource sharing is emerging as a viable means to improve the quality of and access to education [1]. Towards this end, the use of learning metadata standards for the description of learning resources, as well as the implementation of harvesting protocols that will make them available to large repositories/federations are technical issues that should be addressed in eLearning infrastructures. The approach discussed in this paper addresses the requirements set by the eLearning community and reflected in the work in progress from the LODE group of the IMS Global Consortium. The solutions proposed here on the design and implementation issues enable an LMS to share and exchange learning content with other systems leveraging the advances in related standards and ensuring the widest possible exploitation of learning content and related investment made by learning organizations today.

Currently, our system supports four European Projects (Organic.Mednet [12][13], CerOrganic [14][15], Organic.Balkanet [16][17], and pSkills [18][19]). Using the infrastructure described in this paper, the first three projects related with organic agriculture describe their learning resources using the Organic.Edunet AP and make them available to the Organic.Edunet federation [20]. Although currently used inside MOLE, the LOM editor and repository design and implementation allows for its use in other applications with minimum effort.

Future developments under consideration include: a) The investigation of mappings between APs, their implementation and use to facilitate exchange and content between learning organizations/communities, and b) Automating as much as possible the creation of LOM metadata by using information stored in the learning object repositories, user profiles as well as forums and other communication facilities provided by LMSs.

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