Revealing semantic relations in learning object structure

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Abstract: - In the framework of the EU-funded SLOOP Project, Sharing Learning Objects in an Open perspective, we have developed FreeLOms, a Learning Object Management System aimed at managing learning objects according to the new OpenLO model. In this work we present our proposal for extracting semantic relations from the structure of existing SCORM-compliant learning resources using the semantic web technologies. Semantic web technologies encourage a multiplicity of analyses and dynamic organizations of resources through reasoning about the related concepts and relations. The benefits of this kind of functionalities offered by the FreeLOms platform are reflected mainly in the reusability of the learning objects.

Key-Words: - learning object, semantic web, ontology, learning object management system

1 Introduction

Over the last few years we have witnessed a rapid evolution of ICT-based solutions in education. In this scenario, specific issues concerning the production and sharing of learning resources and, more in general knowledge management, have been extensively analyzed.
The proposal to structure learning contents according to the model of the Learning Object (LO) has evolved out of this context. The characteristics of durability, interoperability and reusability and the related standardization process needed to achieve these goals, have played an important role in the diffusion of the Learning Object model. In particular the standardization process has focused on two main aspects: the description of LOs to provide efficient search and retrieve mechanisms; the model of LO to guarantee the reusability and interoperability of educational resources in the hundreds of learning platforms and learning systems available worldwide.
Amongst others, the IEEE Learning Object Metadata (IEEE LOM) [1] and the Shareable Content Object Resource Model (SCORM) standard [2] are rapidly being adopted by Learning Management System (LMS) constructors as well as by digital content developers.
The LOM standard facilitates description, search, evaluation, acquisition and use of LOs, while the SCORM provides the technical specifications in order to guarantee learning content interoperability and reusability.
At the same time it is necessary to consider the doubts, raised by different authors, about the lack of pedagogical aspects in the description of LOs; for example there are no references to the educational context or to the didactic process in which the learning objects can be used. Moreover, the use of technical standards complicates the task of developing learning objects for the teacher.
But it is particularly due to its shortcomings as far as the reusability issue is concerned that the LO model has failed to live up to expectations.
One reason for this is that Learning Objects are often compared to Lego building blocks [3]which can be combined to create new Lego objects; similarly learning objects could be aggregated to create new lessons or new courses; this vision is one of the aspects of the learning object model which has come under most criticism, , as mentioned in [4], since it has been proved that the combination only works in a few cases.
Different studies, [5][6][7] amongst others, suggest that the introduction of a semantic layer can improve the management of learning resources and allow users to search, assemble and reuse learning resources in a semantically valid way.
The idea of semantic information is strictly connected to the concept of ontologies. An ontology is a specification of a conceptualization[8]. It describes the concepts and relationships of some phenomenon in the world. By using well-defined ontologies it is possible for computer agents to process data semantically since there is a common

knowledge base, made up of terms and the relationships between these terms.
In [5] authors analyze the relations of LOs and the Semantic Web, identifying several kinds of ontologies related to LOs: domain ontologies, e-learning ontologies, teaching and learning strategy ontologies, and learning object structure ontologies.
Other authors argue that these ontologies are not sufficient to guarantee an effective reusability of learning objects; some authors suggest adding a context ontology[9] in order to describe the educational context where a learning object has been used; others propose the addition of an ontology related to the student, thus guaranteeing a personal content customization depending on a student's previous knowledge[7].
In our opinion, just using a semantic level to describe the resources does not allow the evolution of the existing contents and does not guarantee a real reusability of learning objects.
Actually, the application of semiautomatic procedures to reorganize closed contents (contents that cannot be modified) generates hybrid objects that may exhibit coherence at a semantic level, but in practice are difficult for teachers to reuse easily.
For this reason we maintain [10][11] that, in order to guarantee effective pedagogical reusability of the educational materials in a constructivist approach [12][13], it is necessary to provide content authors with mechanisms to enter the learning object at an appropriate level; in such a way, the author can modify and evolve the content according to his real pedagogical needs.
To overcome this problem, we need to rethink the current model of LOs, moving to a new model that we call Open Learning Object (OpenLO)[10].
Only through this new model can users edit LOs created by different authors, and customize the LOs according to their own pedagogical needs.
Nevertheless, our experience in the context of a European funded project called SLOOP (Sharing Learning Object in an Open Perspective)[14], and in particular in using a Learning Object Management System developed within the framework of the project and called FreeLOms, proves that the organizations of contents is still an unresolved problem.
We consider that the model of OpenLO is essential for achieving our goal of reusability; moreover the possibility to semantically annotate the resources stored in a repository could provide users with effective knowledge organization procedures and search mechanisms.
The application of a semantic level to educational resources developed according to the OpenLO model represents an extremely important opportunity to activate semantic-based LO aggregation procedures and, at the same time, to modify the newly created resource. In such a way, it is possible to guarantee effective reusability of the educational resources.
After describing the learning technology standards strictly related to or influencing the semantic web concept, we present our proposal for extracting semantic relations from the structure of existing SCORM-compliant learning resources.

2 Learning Object Metadata and the semantic web

The efficient retrieval of learning resources is a well-known problem. For this reason it was immediately decided that an efficient system was needed for classifying LOs.
For example, IEEE LOM and Dublin Core (DC) [15] are two initiatives specifying a standardized set of metadata that facilitates retrieval of learning resources.
Unlike the DC model which describes the essential references of any Web resource, the IEEE LOM aims to communicate, in addition, a whole set of information which will identify the resource for educational purposes.
The IEEE LOM uses a common pre-defined vocabulary to describe the content of LOs. There are nine categories in the model including General, Lifecycle, Meta-metadata, Technical, Educational, Rights, Relation, Annotation and Classification.
The description of Learning Objects through metadata [5] facilitates the creation of cataloguing and classification mechanisms for learning resources. This is extremely important for improving search procedures, especially considering the large number of learning objects available on-line that makes the traditional search procedures difficult.
For IEEE LOM as well for DC an XML binding is defined; the XML structure of LO metadata facilitate the indexing process; in fact it is possible to use the search mechanism of XML information systems such as XPath and XQuery to retrieve annotated learning resources.
However, the challenge is to overcome the limitations of text based research mechanisms.
From this point of view the XML metadata are not sufficient; XML allows users to define the structure of objects without saying what these structures mean.
To represent the semantic relations between LOs and

the related concepts we need a powerful language such as the Resource Description Framework (RDF) [16]; RDF can formalize knowledge through subject-predicate-object expressions; terms and constraints to compose these expression can be defined in RDF-Schema documents. RDF is the basis for the so-called semantic web.

The IEEE Learning Object Metadata RDF binding[17] provides an RDF representation of the IEEE LOM standard. The idea is to provide a mechanism which allows the RDF language to be used to describe the LOMs so they can then be integrated into a more complete ontological system. This means that a didactic resource can be linked to a domain ontology which represents the semantic relations of the concepts connected to the field of study.

Although RDF is a powerful language for representing knowledge, on its own it has no way of making inferences or deductions. It is necessary to go to a higher level where concepts can be associated with logical usage rules by means of specific software: this is represented by the ontologies.

As in the case of XML and RDF, the W3C has defined a standard for ontologies: ontology web language (OWL)[18]. The use of ontologies makes it possible to establish correspondences and relations between different dominions of information.

The creation of an indexing and search system would mean using an inferential engine to find the resources which meet the needs of the user.

3 SCORM and the semantic web

As far as interoperability is concerned, the adoption of standards like SCORM allows teachers to create learning materials that can be used in different Learning Management Systems. In particular, SCORM is a set of standards that defines a model to create, share, and re-use learning resources.

First of all the SCORM defines the content model, that is the set of components that are used in a learning experience, like:

- Asset, the most basic form of learning resource; it can be a single media, or a text, an assessment object.
- Sharable Content Object (SCO), the smallest unit that can be used as a self-contained LO, in fact it represents the lowest level of granularity of a learning resource that can communicate with an LMS using the SCORM Run-Time Environment; moreover, it can be a collection of one or more Assets.
- Content Organization; it provides a complete learning experience, introducing Activities as structured units of instruction; the Activities represented in a Content Organization may consist of other activities. (There is no set limit to the number of levels of nesting for Activities).

SCORM defines also how such elements must be organized to obtain the intended behaviors of the learning experience. Figure 1 shows an intuitive representation of a Content Organization.

SCORM uses the IMS Content Packaging Specification to provide a standardized way to exchange learning content between different systems or tools. The Content Package also provides a place for describing the organization and the intended behaviour of a collection of learning contents.

A Content Package contains two major components: the manifest file and the physical resource files that are parts of the content package. (Figure 1 shows the components of a Content Package).

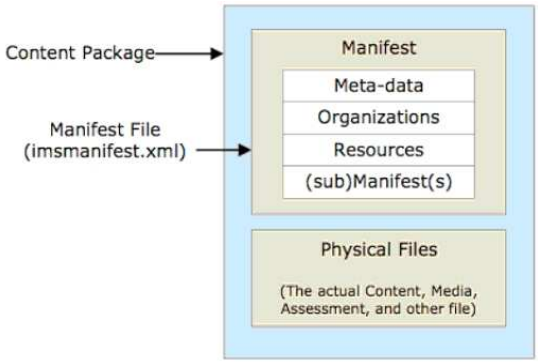

Figure 1. Content package conceptual diagram

In particular the manifest file is an XML document that describes the content structure and the associated resources of the package. The standard requires that a manifest must be present at the root of the content package. The manifest is composed of four major sections:

- Meta-data: data describing the content package as a whole.
- Organizations: used to describe how the content is organized in the content package. The content organization should not be confused with the physical structure of the content package, or with the structure of the manifest itself. For example, the files in a content package are often organized in a hierarchy of folders, but that structure in itself cannot tell the user of a content package how to use the content of the package.
- Resources: defines the learning resources bundled in the content package, which are assumed to be physically located in the package.

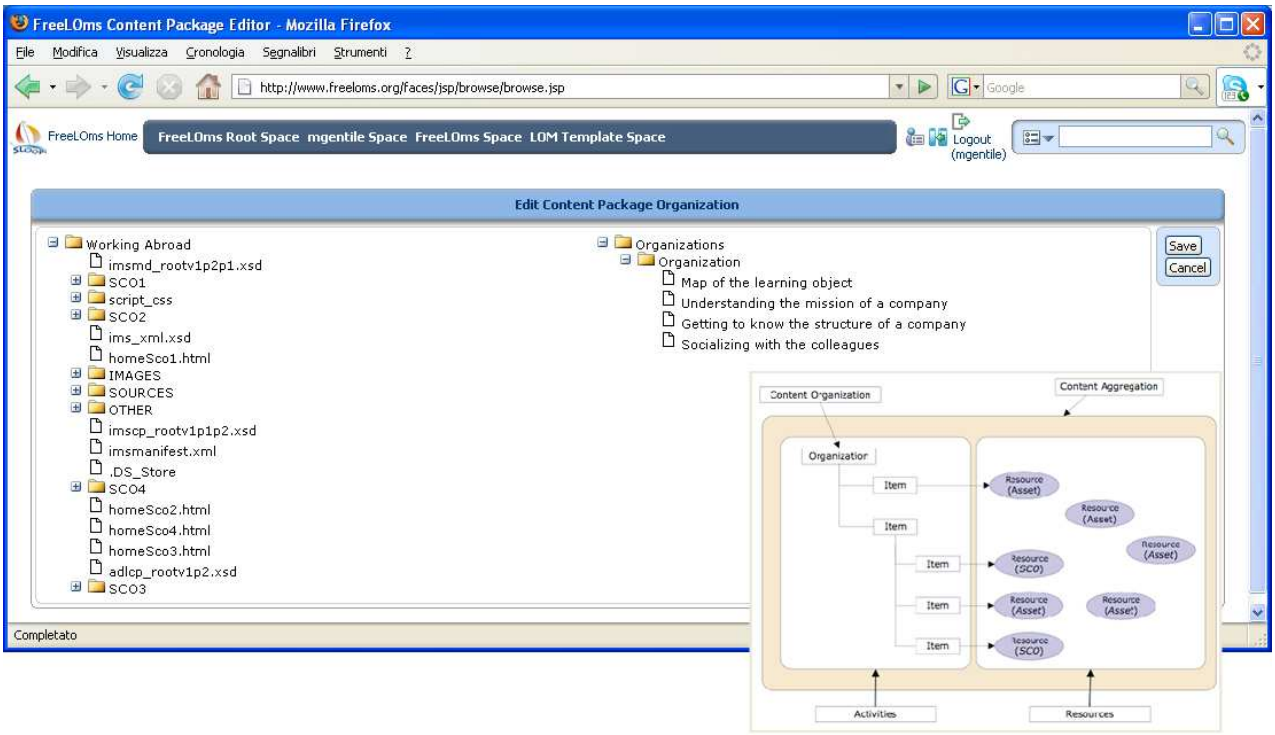

Figure 2: A screenshot of FreeLOms content package editor

– (sub)Manifest(s): describes any logically nested units of instruction (which can be treated as stand-alone units).

The organization of resources specifies in which order the resources must be shown to students accessing the LO through an LMS. Moreover, the organization specifies the relationships between activities and the resources. In particular, the organization represents a tree structure where each node is called an item; each item can be related to a resource or it can contain other items in a nested structure

Sequencing information is external to the learning resources associated with those learning activities. In fact the LMS is responsible for launching learning resources associated with these activities. This is important both at a conceptual and a practical level, because the reuse of learning resources is limited if a learning resource has embedded sequencing information that is context-specific to a specific learning experience.

According to [9] the SCORM standard, documents contain relevant information, beyond metadata, that allow a semantic description of LO.

In the next paragraph we explain our experience in extracting this kind of information from SCORM LO and express them in RDF language using the IEEE LOM and SCORM ontology defined by [9]

4 Extracting semantic relations in learning objects: the FreeLOms case study

The rapid evolution of ICT-based solutions in education has required teachers to acquire new digital skills in order to cope with e-learning oriented technologies such as LMSs and technical standards on which learning platforms are based.

This phenomenon has led to the diffusion of a huge number of tools to manage digital contents in the learning objects paradigm.

In order to support teachers in designing and developing their LOs, we should not require them to learn too many technological terms and sophisticated programs.

According to the overview provided by [20], the tools available to manage the elaboration of LOs can be divided into: authoring tools, tools to implement learning technology standards, learning object repositories, learning management systems, collaborative environments for sharing LOs. These tools are used respectively in the phases of production, description in conformity to standards, searching, fruition and sharing of LOs.

The diffusion of on-line Learning Object Repositories (LOR) [21][22] facilitates the storing and retrieval of learning resources; accordingly,

teachers and learning communities have the opportunity to access large collections of freely available learning resources. Recent developments of LOR, e.g. the FreeLOms [11], also include tools to re-elaborate learning resources in a collaborative way, thus increasing the potential for developing new LOs.

In [11] we introduce the concept of Learning Object Management Systems (LOMS), integrated solutions that can support a community of practice in cooperatively managing sets of digital educational resources; through a LOMS, not only can users share LOs as in traditional Learning Object Repositories (LORs), but they can also modify the LOs at different levels and download them into an LMS.

In the framework of the EU-funded SLOOP Project, Sharing Learning Objects in an Open perspective, we have developed FreeLOms [11], a Learning Object Management System aimed at managing learning objects according to the OpenLO model presented in [10].

The main objective of FreeLOms is to provide a community of teachers with an on-line platform to share and collaboratively produce learning resources: new learning objects can be developed as the evolution of LOs already stored in the platform. FreeLOms is inspired by the philosophy behind the Open and Free Source Movement, and implements the idea that not only can the software be freely developed by a community of practice, but the educational digital contents could also be developed by a community of teachers and educational experts.

Based on the results of the SLOOP projects, we have observed that more and more LOs are being produced according to the SCORM standard in order to guarantee interoperability.

In the FreeLOms platform we have designed a GRDDL-aware agent to analyze LOs, created using the SCORM standard.

Using techniques such as those adopted for GRDDL[23], we can extract semantic information and represent them through an ontology, using a language like RDFS [7].

A GRDDL-aware agent is a software module that computes GRDDL results of information resources to automate the transformation tasks.

Starting from the organization section we can extract relations like: is-part-of, has-part, requires, is-based-on, previous, next. In [24] these relations are used to define the logical structure of learning materials, through a so called structure ontology.

For the purpose of our work we have chosen to use Dublin Core Metadata Terms[25] to capture these relationships and express them in RDF.

The approach proposed in this paper could be complemented by extracting information from the metadata associated with the learning objects; in particular, the section "Relation" in the IEEE LOM standard could be exploited in order to gather further relations amongst LOs.

However, the metadata are not mandatory, and authors often find it tedious to fill them in; on the contrary, the organization is always necessary to deliver a SCORM learning object, even if some authoring tools create it automatically, so the mechanism is not apparent to the author.

This represents an important advantage of the approach proposed in this paper. Nevertheless, we expect to include the analysis of metadata in order to enrich the structural description of the resources with specific properties.

The benefits of the application of this kind of method are related to the search mechanisms offered by the FreeLOms platform, this is reflected also in the reusability of the learning object, in fact, a teacher can understand not only if a learning object concerns a specific topic but also the contexts in which that learning object has been used.

5 Conclusion

Starting from the FreeLOms platform we have designed a GRDDL-aware agent to extract from the organization structure of LOs described by SCORM the standard semantic relations of a structure ontology. The structured data extracted in RDF populates an RDF storage system and will be accessed through appropriate query language for RDF such as SPARQL.

For this to happen we use the GRDDDL mechanism, that was designed with the aim of gleaning data structured in RDF from generic XML documents.

The GRDDL transformations are based on the use of XML Transformation languages such as XSLT.

In conclusion, we think that the addition of semantic descriptions of the learning objects to the OpenLO model can significantly improve the reusability of learning resources.

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