Case Study: Ontology for Metadata in e-Learning

Ana María Fermoso García[1], Salvador Sánchez Alonso[2],
Encarnación Beato Gutierrez[1] and Roberto Berjón Gallinas[1]
[1]Computer Sciences Faculty, Pontifical University of Salamanca, Compañía 5, Salamanca, Spain
[2]Information Engineering Research Unit, University of Alcala, Alcalá de Henares, Spain

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Abstract: Learning objects are a fundamental concept in new educational paradigms based on e-learning. These resources are not only content but also include metadata descriptions organized into categories, often in the form of an application profile of the IEEE LOM standard. These metadata descriptions facilitate the design, search, exchange and reuse of educational contents reachable through learning object repositories. The aim of this paper is to present the case of the Organic.Edunet portal, where the semantic search capabilities implemented made necessary to design an OWL mapping for the IEEE LOM standard. We called this effort LOM2OWL. LOM2OWL is in fact an ontology aimed at improving the search, reuse and use of learning objects stored in the Organic.Edunet Web portal and repository.

1 INTRODUCTION

Organic.Edunet is a learning portal that provides access to digital learning resources on Organic agriculture and agroecology and aims to facilitate access, usage and exploitation of such content. The result of the European project Organic.Edunet, it makes use of IEEE LOM metadata standard for the educational annotation of resources and the aim is enhancing its semantic capabilities. Given that Organic.Edunet provides different mechanisms for finding resources based on computational semantics, it was necessary to define a mapping from the human-oriented IEEE LOM metadata records that content contributors provided to a semantic version we received To attain this aim, we suggested to adapt IEEE LOM to a semantic language to describe learning object metadata records in OWL.

This paper reports on this effort and provides as the most interesting result a series of tables showing how the mapping was made and the way we approached to map the different categories in the standard.

In the semantic Web model the ontologies are the main tool to present and structure the knowledge. The most extended language of ontologies is OWL (Ontology Web Language) (W3C-OWL, 2011). We think that a LOM to OWL mapping would facilitate the creation and management of learning objects metadata by automated engines making use of Seemantic Web capabilities, easing at the same time their storage in semantic repositories such as Ont-Space (http://code.google.com/p/ont-space/), a Java-based software framework providing the services of a semantic metadata repository.

2 IEEE LOM

IEEE LOM is a metadata standard for learning objects developed by IEEE for the description of educational resources in digital format through metadata records. These metadata capture the essential characteristics of the resource and organize them according to a number of previously agreed and established categories.

IEEE LOM establishes a conceptual data schema that defines the structure of a metadata record for a learning object. Thus, the first step to an OWL mapping was to understand these characteristics, those which are grouped into 9 categories in IEEE LOM. Each category has subcategories. For example *General* category has the following subcategories: Identifier, Title, Language, Description, Keyword, Coverage, Structure and Aggregation level.

A brief description of the categories in the standard would be the following:

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1. General: includes general information that describes the learning object as a whole.
2. Lifecycle: it describes the history and current state of a learning object, as well as and those entities that have affected the learning object during its evolution.
3. Meta-Metadata: it describes the metadata record itself, rather than the learning object that a given metadata record describes.
4. Technical: it groups the technical requirements and characteristics of the learning object.
5. Educational use: it groups educational and pedagogical characteristics of the object.
6. Rights: describes the intellectual property rights and conditions of use of the object.
7. Relationship: defines the relation between a learning object and other learning objects to which it is related.
8. Annotation: comments on the educational use of the learning object and information on when and by whom these comments were created.
9. Classification: it describes where the learning object falls with a particular classification system (taxonomy).

Besides these categories, LOM also defines the following data types: *LangString* for strings, *DateTime* for dates, *Duration* for time periods and *Vocabulary* for enumerated types.

Using this schema allows the authors of learning objects to specify what elements make up a body of metadata, to facilitate search, evaluation, acquisition and use of learning objects by students, instructors or automated systems. In addition it also facilitates sharing them, allowing the development of catalogues and repositories.

The inclusion of instances of metadata with the learning object provides standard information on the contexts of use, thus increasing their reusability. Usually this metadata structure is implemented in XML format. Our effort targeted to map this structure to an ontology format in OWL.

3 LOM2OWL

As we have seen in the preceding section, learning objects are characterized by metadata records, each composed by a set of properties. We thought that these properties could be used to describe instances of the learning object from an ontological point of view. To create an instance of an object implies first, to define an identifier for the object in order to identify it, and then to associate values to each property of the object.

In IEEE LOM conformant metadata records, an object is described by using nine categories, *1. General, 2. Life cycle*, etc. Each category is formed by a set of related properties called subcategories. For example the *General* category has the subcategories *1.1. Identifier, 1.2. Title, 1.3. Description*, and so on. Some of these categories have recursively new subcategories, such as for instance the subcategory *1.1. Identification*, that is described using characteristics *1.1.1. Catalogue* and *1.1.2. Entry.* This hierarchical structure of categories and properties to define an object made easier its translation to an ontological schema.

In the following sections we will present the classes defined in the LOM2OWL ontology which correspond to the knowledge in IEEE LOM metadata elements. These classes will be used not only to represent the LOM data types, but also to describe any LOM record.

3.1 Mapping IEEE LOM Data Types to LOM2OWL

To represent the LOM data types in OWL we have defined one class per data type. Table 1 shows the correspondences.

Table 1: Correspondence between LOM data types and classes of LOM2OWL.

LOM Datatype	OWL Class
DateTime	`dateTime` has the subclass `lomDateTime` which has two properties: `textDescriptor` and `timeItem`
LangString	`langString` specifies the language of a string. It is composed by various instantes of the `simpleLangString` class
Duration	`lomDuration` has two properties, one to define the duration and other for its description, similat to IEEE LOM *duration*

As it is clear in the table, every data type groups some characteristics called properties of the data type. For example the data type *LangString* has two characteristics associated: the language of the string and the string of characters itself.

Another important data type in IEEE LOM is the data type *Vocabulary,* which does not have an equivalent type in OWL. When a property is of this type, we suggest using a data property of *string* type restricted to take values from a fixed list of values including of course those terms permitted in each specific vocabulary.

There are several properties of this type. For example in the *5. Educational* category, the *5.5.*

Intended End User Role subcategory means the principal user(s) with this learning object was designed to. This feature is encoded in LOM2OWL using the `isIntendedForUserRole` property of the `learningObject`. The value space of this property, which would form its vocabulary are: `teacher`, `author`, `learner` and `manager`.

3.2 Mapping LOM Categories

In order to define a metadata record of an IEEE LOM learning object in OWL, it is first necessary to define the basic classes which will show the categories schema of LOM. The main class of the OWL ontology is `learningObject` which represents, obviously, the concept of learning object. Apart from this basic one, we created one class for each IEEE LOM category. These categories are described in turn by several subcategories with grouped elementS. Table 2 shows a summary of the main classes of our LOM2OWL ontology and the equivalent categories and subcategories in IEEE LOM. At the same time, Figure 1 shows the hierarchical organization of these classes.

Each class in the ontology has one or more properties, one for each of its features. These properties are usually named by using the convention `has<property_name>`. As usual in all ontologies, all properties are defined by a domain (objects to apply it) and a range (values which the property can take). Properties can either be of type objectProperty or *dataType*.

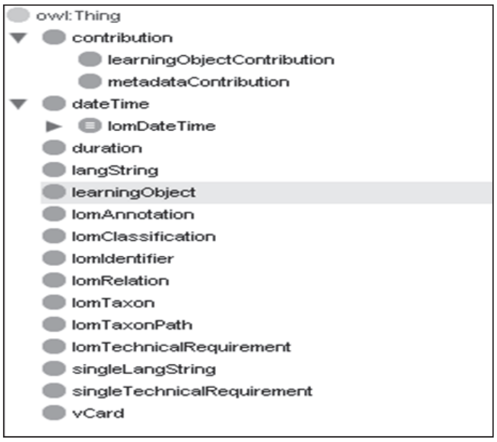

Figure 1: Classes hierarchy in the LOM2OWL ontology.

Table 2 shows some of the LOM2OWL classes only, because a full detail of all of them would take not display very well in the format of this paper. In any case, we will define in detail the implementation of one category, for example the *Description* of the *1.4.General. Description* category because other classes follow a similar pattern and can thus be deducted from this example.

This category is aimed at including a textual description of the content of the learning object. In LOM2OWL this feature will be implemented using the property `hasDescription` of the `learningObject` class. Its domain will be the `learningObject` class. Its range will be of `langString` data type. This data type allows more than one description of the learning object where each `singleLangString` would provide a description in a particular language.

4 CONCLUSIONS

IEEE LOM is a model to describe learning object based on a structure schema hierarchically organized. This organization make easier to adapt this model to an ontology with classes and properties, that in our case we have used to enhance and promote semantic capabilities in the Organic.Edunet web portal.

This ontology is currently undergoing a process of evolution, refinement and polishing as part of the tasks and activities of the Organic.Lingua project.

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Table 2: Correspondence between LOM2OWL classes and properties of IEEE LOM categories

LOM2OWL class	Equivalent LOM category	Properties of LOM2OWL class
contribution learningObjectContribution metadataContribution	"contribution" appears in two LOM categories defining a subclass for each one; .LearningObjectContribution → 2.3. Lyfe Cycle. Contribute .MetadataContribution → 3.2. Metadata.Contribute	entityContribution, dateTimeContribution
lomAnnotation	8. Annotation	annotationDescription, annotationEntity, date_that_this_annotation_was_created
lomClasification	9. Classification	clasificationPurpose clasificationTaxonPath, taxonDescription
lomTaxonPath	9.2. Clasification. Taxon Path	clasificationSource, clasificationTaxon
lomTaxon	9.2.2. Classification.Taxon Path.Taxon	taxonEntry, taxonId
lomIdentifier	1.1. General.Identifier 3.1. Metadata.Identifier 7.3. Relation.Identifier	inCatalog, isEntry
lomRelation	7. Relation	createdSource, relationKind
lomThecnicalRequirement	4. Technical	
singleTechnicalRequirement	4.4. Technical. Requirement	hasType, maxVersion, minVersion, requirementName
Vcard		hasEmail, hasName, hasOrganization
learningObject	Learning object: This is the main class of the ontology. All the categories describe some property of the learning object.	It has a lot of properties, one for each category and subcategory of the object. This table only enumerates some of them together with the corresponding IEEE LOM category: .hasAgregationLevel – 1.8. General. Aggregation Level .hasCopyRightRestrictions – 6.2. Right. Right and other restrictions . hasCost – 6.1. Right.Cost . hasDifficulty – 5.8. Educational. Difficulty. . hasDuration – 4.7. Technical.Duration .hasInstallationRemark – 4.5 Technical. Installation remarks .hasInteractivityLevel – 5.3. Educational. Interactivity level .hasInteractivityType – 5.1. Educational. Interactivity type .hasOtherPlatformsRequirement – 4.6. Technical. Other platform requirements . hasSemanticDensity – 5.4. Educational. Semantic Density . hasSize – 4.2. Technical.Size . hasStatus – 2.2. Life Cicle. Status . hasStructure – 1.7. General. Structure . hasTitle – 1.2. General. Title .hasTypicalLearningTime – 5.9. Educational. Typical learning time . hasVersion – 2.1. Life cicle.Version .hasMetadataLanguage – 3.4. Metadata. Language