A MODEL TO REPRESENT THE FACETS OF LEARNING OBJECTS

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Abstract

This paper presents a model to describe Learning Objects (LO). The main objective of this model is to consider all the aspects of the LO for which a description will ease the LO re-use. The LO description we promote respects the current standards of e-learning and includes the following: metadata, scenarios the objects are used in, and the objects they are composed of. We enrich this multi-facet representation by taking into account the semantics of learning object contents. Another contribution of our work is that this multi-facet representation relies on ontologies, allowing a semantic representation that facilitates communication between machines and users.

Keywords: e-learning, reuse of learning objects, standards for e-learning, ontologies, semantic representation.

Introduction

E-learning relies on the provision of electronic documents called learning objects organized in teaching scenarios.

Many digital pedagogical resources can be found on the web but they are often on-line presentations of existing documents, and thus not designed to be included in e-learning platforms. (Psyché, 2005) notes that more pedagogical approaches and learning designs should be proposed to improve the use of resources in e-learning systems. In addition, learning objects should be reusable in different teaching scenario. E-learning technologies and standardization efforts offer a partial solution to these issues. SCORM (SCORM, 2004), (Fage, 2005) and LOM (LOM, 2002) contribute to the homogenization of learning object representations and facilitate their interworking, while IMS-LD (IMSLD, 2003) considers the pedagogy of training and its progress. However, the meta data associated to objects is limited and do not focus on content. It is then difficult for a designer to know if a resource (image, chunk of text, exercise, concept definition, etc.) already existing in a document can be re-use. As a result reusability is low.

Our contribution in this paper is related to the enrichment of e-learning standards with the representation of complementary knowledge that would be helpful for a user to know the content of a learning object ; this knowledge is represented in the form of ontologies (Mizoguchi, 2004). This additional knowledge corresponds in one hand to the theme studied that is to say the topic of the course and on the other hand to the pedagogical theories.

In this paper, we present first the main e-learning systems' characteristics and standards. Then we describe the conceptual model we promote to represent learning objects and their usages. Next, we explain the implementation and finally, we give a short example of an instance based on our model.

State of the Art

E-learning Systems: Learning Objects and Standards

E-learning is a teaching-learning activity which aims at knowledge acquisition while reducing the time and space constraints between learners and teachers, thanks to new communication and information technologies (E-TUD) (Boutemedjet, 2004).

An e-learning system must allow:

- access to the relevant learning objects thanks to a relevant indexing of the resources (Gasevic and Hatala, 2005), (Psyche, 2005), (Lenne et al., 2005), (Abel et al., 2003),
- browsing techniques improving learner / teacher / system interactions according to an adequate pedagogy (Psyché, 2005),
- reutilisability of learning objects and learning design (Knight et al., 2005),
- design and update of the contents of courses by teachers (Lenne et al., 2005), (Abel et al., 2003),
- an individualized monitoring of learners (IMSLD, 2003).

A learning object has been defined by the IEEE-LTSC working group (Learning Technology Committee Standards) as: "Any entity, digital or non-digital, that can be used, reused or referenced during technology supported learning".

Various standards have been defined to help the development of training systems. (Friesen, 2005) presents an overview of e-learning standards which goal is to ensure interoperability, portability and reusability. These systems handle learning objects, their representation, and their relationship. The use of these standards, which are considered as common description languages of digital educational resources (Vidal et al., 2004), guarantees not only the interworking but also the quality of systems to facilitate the usage of the learning objects no matter the platform or the technological environment used.

The standards are mainly used to ensure:

- Interoperability: towards the content exchanged and handled by different systems and the interaction between learning management systems.
- Re-use: not only towards the rapid assembly of contents and codes but also the assembly and objects use in new contexts.

- Adaptability: the system can be configured to have extended functionality for new goals.
- Durability : ability to use learning objects in any educational contexts change in the run-time environment and for lasting use of these resources.

Among e-learning standards, LOM, SCORM and IMS-LD are the most important. LOM focuses on describing resources (objects), SCORM on the structure of objects, and IMS-LD on teaching scenario.

LOM

LOM (LOM, 2002) (Learning Object Metadata) is a standard for learning object annotation with metadata. It specifies the syntax and semantics of the metadata describing educational digital or non-digital resources, and defines the attributes necessary for a complete description of the educational resources. Metadata are classified in nine categories as follow:

1. General: independent characteristics from the context as the identifier, the title, the language of the resource …
2. Lifecycle: groups the features related to the history (Version) and current state (Draft, Final, Revised, Unavailable) of this learning object and those who have affected this learning object during its evolution.
3. Meta-metadata: characteristics of the description as Identifier, Contribution (persons having participated in the elaboration of the metadata), Catalog, language …
4. Technical: technical requirements and technical characteristics as the format (of the necessary software to reach the resource), size of the learning object etc…
5. Educational*:* groups the educational and pedagogic characteristics of the learning object
6. Rights*:* the intellectual property rights and conditions of use for the learning object; Costs, copyrights, description
7. Relation*:* it defines the relationship between a learning object and other related ones.
8. Annotation*:* provides comments on the educational use of the learning object and provides also information on the author and the date in which comments were created.
9. Classification*:* describes the learning object in relation to a particular classification system such purpose, reference classification, path etc…

LOM standardizes indexation of learning objects in the e-learning systems by giving specific information on the object.

Nevertheless, most of the actors of the standardization make some criticisms about LOM (Bourda, 01) (DeLa Passardière and Jarraud, 04):

- Some inconsistency between the generic definition of learning objects as proposed by IEEE and the elements to describe them, due to the consideration of non digital entities.
- The fact that the unit of indexation is a file, which represents a technical unit but not an educational one;
- The fact that a complete lesson is indexed in the same way as a unique exercise or an image;
- The fact that terms meaning and metadata definition is not completely solved;
- The ambiguities in the model make difficult its usage.

To solve these problems, they propose to use LOM application profiles. In an application profile, the mandatory elements provide a minimum of information for a given resource while the optional ones simplify the indexation. An application profile is an instance of a model, as LOM, in a particular context; it is composed of a metadata subset adapted to the needs of the groups or of a particular application, while remaining interoperable with the original LOM schema.

To achieve this, the syntax and the semantics of the LOM metadata are interpreted, refined, spread, and simplified.

LOM standard and application profiles are useful to assure access to pedagogical resources. However, it does not specify the semantic content of resources. For this reason, we complete a LOM indexation with a content representation based on theme ontology.

SCORM

SCORM (Sharable Content Object Reference Model) (SCORM, 2004) of Advanced Distributed Learning (ADL) is a suite of technical standards that enable web-based learning systems to find, import, share, reuse and export learning content in a standardized way.

SCORM treats the following elements:

- Packaging: It has for objective the transmission of contents between platforms. It is also interested in the structuring of the educational objects.
  A package SCORM is a ZIP file which contains :
    - Elements under varied formats (HTML, JPEG, Flash Animations, Word, PPT…)
    - A Manifest (XML file) containing :
        - a metadata section which describes the packages,
        - a section of resources which lists elements in the archives and the available resources via an URL on Web,
        - a section of organization which describes the structure of the resources.
- Metadata: they came from LOM and have for objective to share the standard information which describes the nature and the objective of the contents. This information can be used either for helping object searching or for managing the users' rights and for technical needs.
- Communication or environment of execution: determine the communication with a Web environment. The notion of environment is also present in IMS-LD.
- Sequence and browsing: defines a method of representation of browsing the learning objects. Specifically, it describes connections and streams of learning activities in terms of trees of activity.
- Content Aggregation: it distinguishes three levels of resources:
    - The elementary digital resource *(Assets)* establishes the basic elements of learning resource; it can involve a simple document (JPEG image or GIF, WAV sound or MP3, web page) but also any set of information which can be released towards a Web client (Flash document, Javascript code, etc.).
    - A Shareable Content Object *(SCO)* is a coherent set of Assets. Respecting the SCORM protocol of execution, it represents the lowest level of resource granularity which can be followed-up in a platform of on-line learning (Learning Management System).
    - A *Content Aggregation* is a set of educational resources structured in a coherent way within an entity of higher level, such as a lesson, a chapter, a module, etc.

The structure of the contents of the course modules according to the SCORM model allows them to be reused in others modules for various training formations or systems. Furthermore, it improves the dialogue between the learning objects and the system on one hand, and between the actors and the system on the other hand.

SCORM defines what are the mandatory characteristics of learning objects :

- Reusability: the contents are independent from the context of learning and can be used by several learners.
- Accessibility: the contents can be identified and located at any time.
- Interoperability: the contents can be read and used in any environments (Hardware and software)
- Durability: the contents do not require modification further to a change or an update of the operating system.

In addition, the learner's progress is supervised and reported back. In our model, SCORM is used to represent learning resource structure and to insure interoperability.

IMS-LD

A Learning Design is a description of a method allowing to a learner to reach some objectives by the realization of some ordered educational activities, in a learning environment. (IMS-LD, 2003).As a supplement to SCORM, IMS-LD (Instructional Management System Learning Design) is a standard which aims at bringing elements of pedagogy in an e-learning system. It is a language to model learning process. Based on the work of Koper (Koper & al., 01), it is designed to define learning scenarios and interaction for content creators. It helps the designers to model the teaching scenario organization like: “who makes what, when and with which resources and which services to realize objectives of learning”.

IMS-LD standard aims at helping to design any teaching-learning process in a formal way. It structures learning units through “**play”**, “**act”**, and “**role-part”** elements. The “**play”** element (that is often unique) contains several “act” elements. These acts are run in sequence; each one being triggered by the end of the preceding one. The play is complete when the last act is finished. The transitions between acts thus form a set of synchronization points for all the participating “roles” (teacher, learner…).

In order to facilitate the production and its implementation, LD has been divided into three levels:

- Level-A: contains all the basic structures including: Activities, Environment, Components, Proceedings, Roles, Services,
- Level-B: adds Properties and Conditions to A. This allows more advanced customization, sequencing and interaction based on the profile of each learner,
- Level-C: adds the notifications to level B. A notification is triggered by the completion of a result and makes an activity available and executable for a given Role. Each level is represented by separated XML files.

In the proposed model, IMS-LD is used to define interaction between learners and computers during the phase of execution and use of the learning objects.

These standards solve several problems such as interoperability and use in pedagogical scenarios but for (Varlamis and Apostolakis, 2006), to achieve better co-operation between e-learning components it is important to define standards which cover all the e-learning process. Nevertheless, reuse and access (how to find the most relevant resources) are not solved. Another problem is how to assign the same meaning to given metadata. Finally, the links and relations such as the content, sequencing, and dependence of prerequisites between every learning object must be mentioned to allow the system to effect treatment or automatic tasks on these objects.

Before describing the model, we present related works that try to enrich learning object representation using ontologies.

Ontology-based e-learning system

Using metadata as recommended by e-learning standards is not sufficient to solve the problems of object reusability and accessibility (Zarraonandía, 2004). Indeed, these problems will be solved only if a common meaning for metadata values is used by the system and the actors. On the other hand, bonds and relations such as content, sequencing, and dependence of pre-knowledge between learning objects must be included to make it possible, not only to carry out automatic treatment or tasks on these objects but also to produce new knowledge from what already exists. The use of ontologies in the model of an e-learning system is an interesting solution. An ontology gathers the concepts which represent the knowledge of a field in an explicit and formal specification (Studer et al., 1998). (Snae and Brueckner, 2007) presents an ontology for the e-learning process : from the construction of e-learning objects to the administration tasks. They propose ontologies to describe the semantics of the process, but also the activities, the communication and the context of e-learning. MEMORAE "MEMoire ORganisationnelle Appliquée à l'e-learning" (Organisational Memory Applied to e-learning) (Lenne et al., 2005) (Abel et al., 2003) is an e-learning tool which allows resource indexation. This tool provides learners with educational resources, either within a local resource repository, or on the web. Compared to MEMORAE which presents courses structured according to the relations of inclusion, usage, reference and prerequisite between the concepts to be learnt, (Gasevic and Hatala, 2005) allow the users to formulate queries. Moreover, they respect the LOM standard. These two studies represent the system knowledge through ontologies. An ontology describing the concepts such as the people (students, tutors, secretaries…), the documents (books, presentation slides, web pages…) is called ontology of the training field for (Lenne et al., 2005) and target ontology for (Gasevic and Hatala, 2005). (Mitrovic and Devedzic, 2002) also uses an ontology to represent the domain of each tutor. Another ontology is used to represent the concepts to be learnt (ontology of application for (Lenne et al., 2005) and source ontology for (Gasevic and Hatala, 2005). In order to ensure reusability, (Hernandez, 2005) advises separating task (learning context, documents…) and theme (concepts to learn) while maintaining bound the concepts of both ontologies.

(Psyché et al., 2005) and (Knight et al., 2005) integrate the notion of teaching scenarios thanks to an ontology based on the standard IMS-LD. (Psyché et al., 2005) only take into account the educational theories. As in (Lenne et al., 2005) and (Hernandez, 2005), (Renaud et al., 2006), (Bouzeghoub et al., 2005) use an "ontology of theme" which represents all the concepts describing the domain knowledge to semantically index resources. However (Bouzeghoub et al., 2005) is characterized by the use of two types of metadata: one for describing the pedagogical aspects and the other for the semantic aspects of the resources.

In the studies (Gasevic and Hatala, 2005), (Psyché et al., 2005), (Lenne et al., 2005), the context of learning object use is not taken into account. In order to increase the reusability of scenarios and learning objects, (Knight et al., 2005) introduce an "ontology of context".

To obtain all the qualities required for an e-learning tool like reusability, accessibility, interoperability and durability (SCORM, 2004) (Fage, 2005), we take into account learning theories as well as the contexts of training and uses of learning objects. Our approach is based on ontologies as well as on the e-learning standards. This paper focuses on the aspects corresponding to the representation of learning objects and their uses.

Semantic Representation Model and Use of Learning Objects

Multi-facet Representation and Usage of Learning Objects

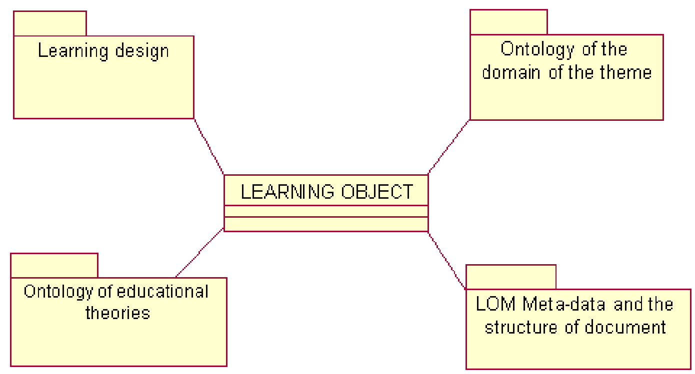

Figure 1: Useful knowledge to represent a learning object and its use.

The model we promote takes into account the various aspects of learning objects. Our model includes technical description, pedagogical description but also related uses of the learning objects. This model allows building a system that relies on an appropriated pedagogical approach. It also enables the reuse of learning objects and learning design.

To represent a learning object we consider various items of knowledge :

- Knowledge about the structure (standard SCORM), and about the resource itself (standard LOM),
- Knowledge about the theme : notions to learn,
- Knowledge about educational theories,
- Knowledge about learning design (IMS-LD standard).

Figure 1 represents the 4 different facets used in our representation of a learning object. These aspects of a learning object are described in the following sections.

SCORM and LOM description

A learning object is a semantic unit of an educational resource. It can be an exercise, an examination question, a definition, examples, or a lesson, etc… Each learning object can gather elementary components (as an image) named Component (called “Assets” in SCORM standard) which can be in different digital (.DOC, .PDF, .JPG etc) or physical formats.

The description of the metadata associated with a pedagogical document corresponds to LOM description. As in (Duval et al., 2002), we propose the use of a *Profile of application* in order to indicates what is mandatory and optional as metadata for an object. In our proposal, a LOM description is attached to each learning object (elementary or composed object). The useful metadata for a given application is filtered via the application profile.

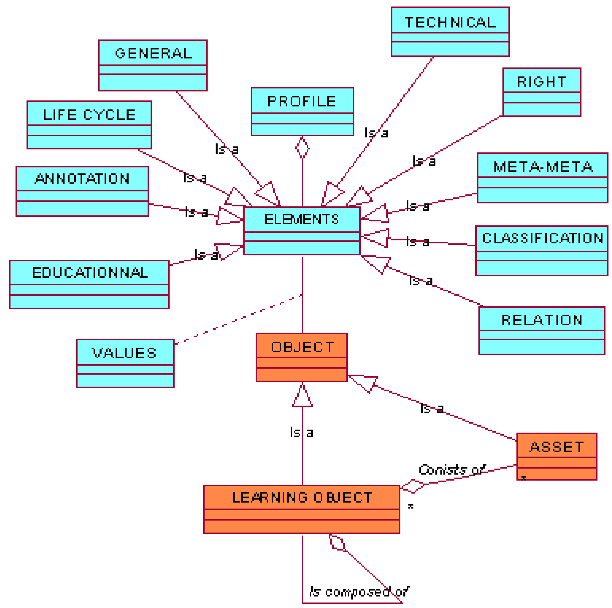

Figure 2: SCORM and LOM descriptions

The metadata we consider for representing a learning object are presented in figure 2. A **Learning Object** can be composed of other **Learning Objects**. A learning object is a LOM **Object** and consists of SCORM **Assets**. As proposed in LOM, the object is annotated with different **Elements** or metadata such as the **Right** associated to the object, **Technical** which are technical requirements and technical characteristics of the object, **Educational** which are the educational and pedagogic characteristics of the learning object, etc… (see the section on LOM for more details). All metadata can be filtered according to a **Profile**.

When an object is used in a given course, some values of metadata associated with the course itself are automatically filled in for the associated learning objects.

Modeling this information does not require the use of an ontology. Hence, this description is not based on an ontology but rather on simple metadata associated to objects.

However, as indicated above, the semantic representation of object contents proposed in current e-learning standards is not sufficient to allow their complete or partial reuse in other applications or other systems. We therefore supplement it by a thematic representation of contents.

Thematic description

Learning objects are also represented according to the themes or concepts they deal with. Learning objects are indexed with concepts of a theme ontology describing the notions associated to the considered domain. As presented in figure 3, a theme ontology relies on a specific model. This model enables to represent for a **Formation**, the different **Modules** that will be given, and for each Module the **Notions** that will have to be taught to the learners. For example, in a computer science formation, a module will be given on data bases. Examples of notions to taught are "*relational data base*", *which is conceptualized* by an "*Entity-Relationship model*". These notions, theme and knowledge to be learnt are gathered in an ontology.

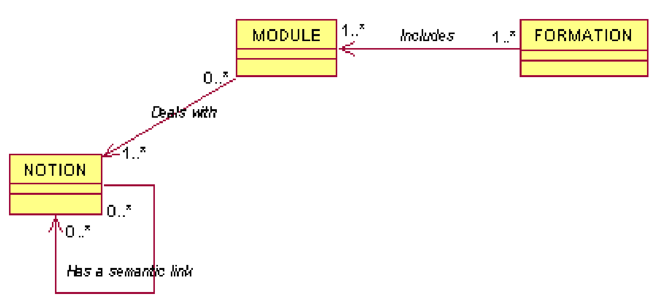

Figure 3: Thematic description

To represent the semantics of learning object contents, concepts from the theme ontology are associated with them. In other words, for a given module, the concepts to be learnt are specified in a theme ontology and learning objects related to this domain are indexed using these concepts.

This approach has various advantages for teachers as well as for learners. Indeed, when a teacher wishes to create a lesson, he can have access to the set of learning objects which were indexed by a specific concept. A teacher can then reuse these retrieved objects or decide to design new ones if they are not appropriate.

Educational theory description

According to educational theories, each pedagogy belongs to a specific approach (Empiricist, Rationalist, Interactionnist) (Lebrun, 2002) and consists of several distinct *stages* to follow. A given pedagogy will give place to several teaching scenarios (*Methods)*.

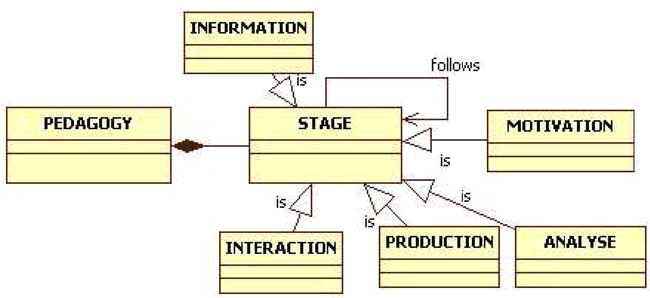

Figure 4: Educational theory description

A **Stage** indicates the theoretical structure of a given teaching approach, as illustrated in figure 4. It can be a phase of information, motivation, interaction, production, analysis, etc… **Pedagogy** describes the set of educational theories which can be used for carrying out trainings successfully.

Knowledge associated with teaching theories is represented through an ontology. This representation is justified by the fact that we wish to be able to associate reasoning. More specifically, it would then be possible to guide the construction of a scenario starting from a learning object, and using knowledge from educational theory. This representation is inspired from EML-OUNL (Koper, 2001).

Learning design description

IMS-LD proposes to model the sequencing of activities allotted to each role to attain the goal of the course, while following a well defined pedagogy. Knowledge that must be taken into account is of various type as follows:

- Knowledge about actors involved in the course (learner, teacher …). It is represented by the **Role**. Each role has some activities.
- Knowledge about scenarios in which learning objects are used. It is called **Method**, it can be composed of **plays**. A play is composed of **acts** which are composed of **role-parts**. A role-part associates a role with an activity.
- Knowledge about the activities in which a learning object is used. In our model, **Activity** describes the tasks a learner performs (exercise, lecture…).
- Knowledge about the context in which a learning design is used. A learning object may be used differently in different activities. The context makes it possible to describe the use of a given learning object in an activity.

All this knowledge is represented thanks to an ontology, as shown in figure 5.

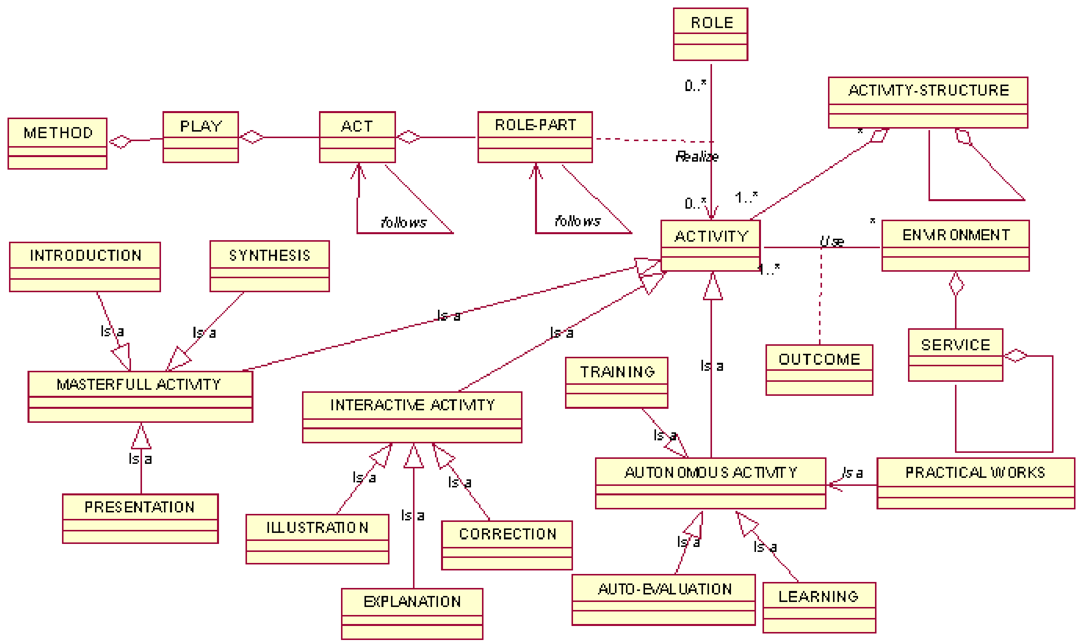

Figure 5: Description of a teaching scenario (Learning design).

The global model

The different facets we detail in the previous section are integrated in a single model as described in figure 6. Concept interlinks are introduced. The various activities of the lessons and their organization as well as the learning objects used are represented thanks to the link between **Activity** and **Learning object** classes. The use of an **object** in various **activities** is specified in the **Context** class. The prerequisites for activities are considered through the pre-necessary notions (concepts from the theme ontology) and pre-necessary competences. This corresponds to a relationship between **Activity** and **Notion**. The concept **Pedagogy** of the educational theories ontology is linked to the concept **Method** of the learning design ontology. So, according to the chosen educational theory, a teacher can be helped while constructing a resource. The concept **Notion** of the theme ontology is linked to the concept of **Activity** because learning a notion can be carried out in different activities. The same object can be used for several **Notions** and in several **Activities**.

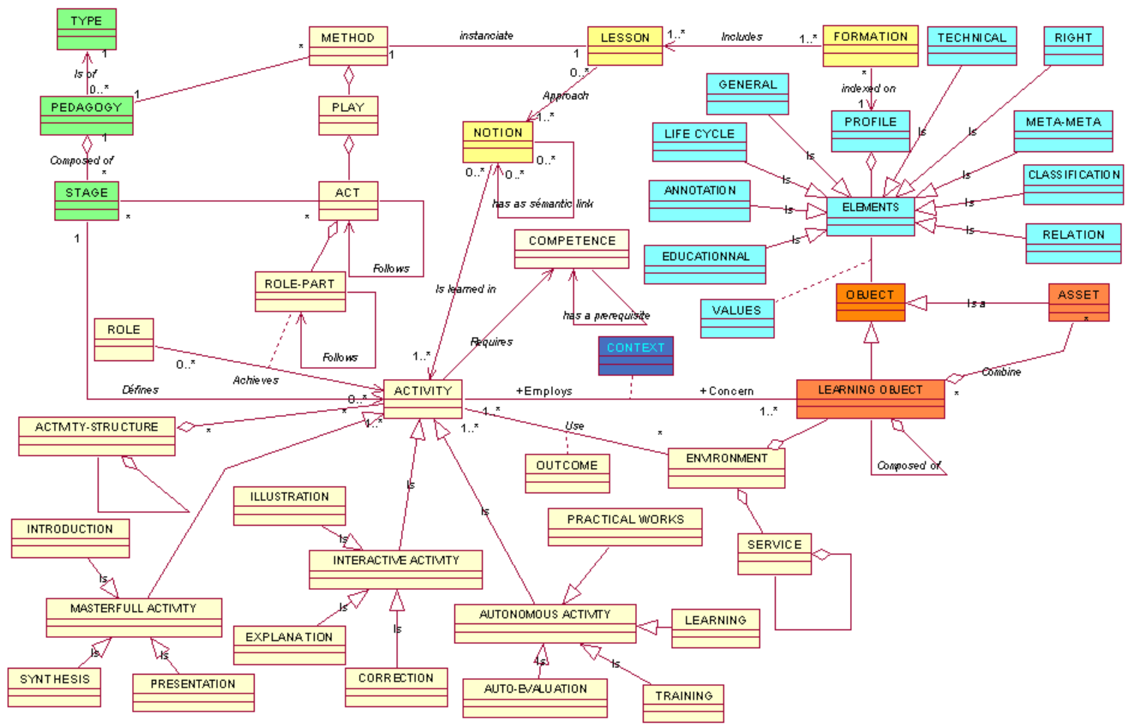

Figure 6: Complete model integrating the various aspects of representation of a learning object in its context of use.

By using these four facets (as summarized in figure 1) the suggested model improves reusability of an object. Its description by metadata and especially on its contents (the concepts it treats of) as well as the definition of its structure make it possible to implement mechanisms for accessing and searching learning objects and elementary components. Object use in scenarios of training also can help a designer to understand better a learning object and help him to consider it as a component of a new course. Lastly, the interoperability and durability are ensured thanks to the conformity of the model with the standards.

Implementation

We implement the ideas that are presented through the model using the Reload CP Editor; we also used the Protégé software. We based this first stage of validation on courses from the e-training e-MIAGE (Méthodes Informatiques Appliquées à la Gestion des Entreprises) from the Université Paul Sabatier (Toulouse III). Some of the elements we present here are extracts from the classes on relational databases in L3 level. Then, from these learning objects, we consider how to implement our model to make it usable.

Ontologies

Ontologies are implemented using OWL (Web Ontology Language) (W3C, 2004) using the Protégé resource (Stanford Medical Informatics). Regarding the domain ontologies, they are manually built (meaning that we choose the concepts to include). However, we have also developed a method that helps a designer to build ontologies, based on texts on the domain (Aussenac et al., 2000), (Mothe and Hernandez, 2007).

LOM and Application Profile

Parameters from Reload CP Editor have been set in order to take into account the application profile. For doing this, we modify two files: the profile file and vocabulary file.

The application profile we defined is composed of the LOM metadata enriched by the vocabulary associated to the « *Learning object type* » metadata considering the pedagogical functions. This metadata implements the link between the ontology of the educational theories and learning objects.

The metadata we added is the « *Notion* » which takes its values in the domain ontology. Thus, this metadata implements the link between the domain ontology and learning objects.

Both the « *Learning object type* » and the « Notion » are defined as mandatory in the application profile. Figure 7 is an extract of the application profile vocabulary description.

```
<!-- RELOAD Metadata Profile -->
<!-- This is the default Profile - do not edit or delete! -->
<profile vocabfile="EMIAGE_Vocab.xml" schemahelperfile="EMIAGE Helper-
.xml">

<group name="General">
<element name="Identifier" path="lom/general/identifier"/>
<element name="Title" path="lom/general/title/langstring"/>
      <group name="Catalog Entry">
      <element name="Catalog"
path="lom/general/catalogentry/catalog"/>
      <element name="Entry" path="lom/general/catalogentry/entry/lang-
string"/>
</group>
<element name="Language" path="lom/general/language"/>
<element name="Description"
path="lom/general/description/langstring"/>
<element name="Keyword" path="lom/general/keyword/langstring"/>
<element name="Coverage" path="lom/general/coverage/langstring"/>
<element name="Structure" path="lom/general/structure/value/lang-
string"/>
<element name="Aggregation Level"
path="lom/general/aggregationlevel/value/langstring"/>
</group>

<group name="Life Cycle">
<element name="Version" path="lom/lifecycle/version/langstring"/>
<element name="Status" path="lom/lifecycle/status/value/langstring"/>
<group name="Contribution">
<element name="Role" path="lom/lifecycle/contribute/role/value/lang-
string"/>
     <element name="VCard"
path="lom/lifecycle/contribute/centity/vcard"/>
     <element name="Date" path="lom/lifecycle/contribute/date/date-
time"/>
</group>
</group>
```

Figure 7: Extract of file profile EMIAGEProfile.xml

Thematic description of learning object

With regard to the thematic description of learning objects, in addition to ontologies, we need a process to make the link between the domain ontology and the learning objects. This link is made by automatically indexing the learning objects by the concepts of the domain ontology. To implement this, we will reuse the modules developed in our team in (Hernandez, 2005). This work proposes methods for automatically extracting from document contents the concepts of a domain represented by an OWL ontologie. This work can be used to index the learning objects as documents. According to this approach, the semantic indexing is composed of two stages: identification of the concepts in the objects and weighting these concepts in order to determine their representativeness of the objects. To automatically extract the terms from the contents, we use a syntactic text parser, in our case Syntex (Bourigault and Fabre, 2000), itself based on TreeTagger POS. Syntex extracts the text units from each document and makes them as noun phrases, verbs, etc... Note that in our case, we consider noun phrases only as they correspond to the nature of the labels of the concepts in a domain ontology. In order to capture the lexical variations of the phrases, those are extracted in their lemmatized form (Syntex and TreeTagger do this for us). Finally, the lexicon of a document is defined by the set of the extracted and lemmatized noun phrases. The phase of identification of the concepts referred in a document consists in finding, among the extracted phrases composing the document lexicon, the labels of the ontology as well as the corresponding concepts. The following stage consists in weighting the extracted concepts. The concept weighting aims at determining the degree per which this concept is representative of a given document, but also reflects its capacity to distinguish the relevant documents from those which are non-relevant when this concept is considered as a query concept. This degree is called statistical representativeness of the concept. We use a concept weighting which takes into account at the same time the statistical representativeness and the semantic representativeness of the concept. The statistical representativeness is calculated by the adaptation of the tf.idf measure (Robertson, 1976) used in information retrieval. Applied to the learning objects, this work would make it possible to index the contents automatically. The indexing by other ontologies or representations is considered as manual. Thus, the teacher or designer who created a new learning object will have to fill out the various elements associated with this object within the framework of the scenario that it carries out.

Scenario

Reload Learning Design Editor has also been used to implement and handle units of learning, associated with the IMS-LD standard. These units can be interpreted by the LD Players.

Illustration within the framework of a course

In this section, we illustrate our model using a simple example (case study) on a course on computer science (database lesson). We consider a learning object which is an *exercise* on data file indexation. The object is composed of three elementary objects: *two images* of B-trees in jpg and an *examination statement*.

We illustrate in the following subsections how our model allows the learning object to be reused according to various pedagogical purposes.

Learning objects reuse according to LOM Metadata

The learning object *exercise* and each of its elementary elements are indexed using LOM metadata according to the model presented in figure 2. These metadata help the learning system users reuse the different elements easily.

For example, the metadata **right** of the two *images* is defined as public, so any teacher or learner may reach it and use it. On the other hand, for the *Examination statement*, the metadata **right** is defined as private to the people following the course. This implies that the *examination statement* as well as the learning object *exercise* can be reused only by teachers of the course and be consulted by learners registered on this course. Teachers can thus reuse the *exercise* in other lessons, while students can only reuse the B-trees *images* for making revision notes for example.

The metadata **pedagogy-level** related to *the exercise* is set at initiation. This indicates that the *exercise* is addressed to students who have not studied file indexing methods. The *exercise* can be used by teachers for designing any module addressed to a public having this level.

Learning objects reuse according to their content

Learning objects are also represented by the concepts that they are dealing with. An extract of the ontology of the theme of data processing is presented in figure 8.

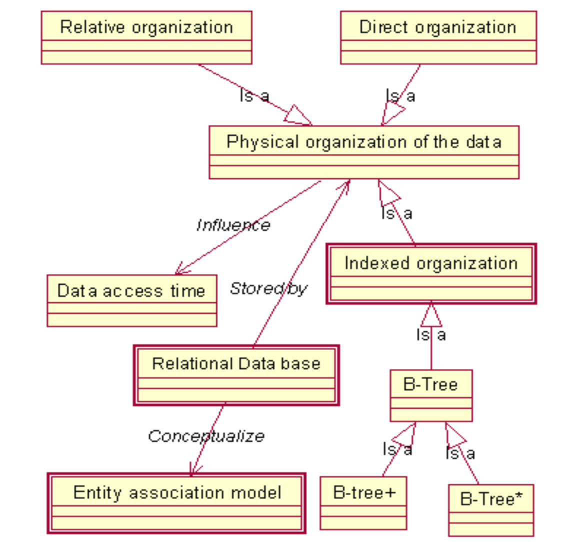

Figure 8: Extract of the theme ontology of the data processing.

This extract corresponds to the ontology related to the database domain. The concepts are represented by rectangles containing the various labels or terms, the captioned arrows represent the semantic relations between concepts. In the extract presented here, the doubly-framed concepts represent the concepts to be studied within the framework of the module “Relational Data Base”.

One of the *images* represents a “B-tree +”, and the other a “B-tree *”. In our model, the two *images* are thus represented by these two concepts of the ontology of data processing. The *exercise* approaches the concepts of “indexed organization” of the data, starting from “B-trees” while insisting on the “access time” to the base. These three concepts of the ontology are thus used to index it. The advantage of specifying these concepts is that a teacher will be able to reuse this exercise when s/he wants to work on the concepts previously quoted. Moreover, as the notions are represented within an ontology, different teachers can interpret the same meaning associated to the notions by visualizing the different concepts and relations stated in the ontology.

Learning design

Learning scenarios are also considered in our model. Learning objects are represented according the acts and plays in which they have already been used. Let us consider the following scenario composed of different acts.

Act 1: The teacher presents the notions to be studied by students by providing a written document.
Act 2: The students read the corresponding resource and require explanations from the teacher.
Act 3: The teacher gives explanations, using examples, and waits for a new reaction of the students. Possibly s/he gives additional explanations if the students request some.
Act 4: When the time limit is reached, the teacher gives the exercises which the students must do.
Act 5: The teacher corrects the exercises while providing precise explanations on each point which is not mastered by the student, by e-mail, by on-line dialogue or on forum. In order to en-

sure the comprehension and memorization of the concepts to be learnt, self-assessment and some exercises to evaluate the students are provided to them.
Act 6: Finally, the teacher gives a summary of the most important points on the studied notions.
When this scenario is chosen, the system will be able to propose our learning object “exercise” and its elementary elements for different acts. The exercise can be used in both the acts 4 and 5. When preparing these two acts, the teacher will have access to all the exercises that have been indexed with the notions considered and that have already been used in such kind of acts. The *images* of the B-tree + and B-tree * can be proposed during act 1 to help the teacher design the written document, in act 3 to help the teacher give examples and in act 4 and 5 to prepare exercises. Representing learning objects with our model enables the reuse the objects according to how they have previously been integrated in a scenario.

Conclusions

The proposed model can be applied to any electronic document which has an educational objective. It can be integrated into any model of learning (synchronous or asynchronous distance learning…). It also presents the possible use and adaptation on any type of course because it was not conceived within the framework of a specific training.

The model is based on a multi-facet representation of documents by using three ontologies: ontology of theme, ontology of the tasks, ontology of the educational theories and a LOM/SCORM description. The proposed ontologies are represented in OWL (Web Ontology Language) (W3C, 2004) and based on the syntax RDF / XML. It makes it possible to explicitly represent the significance of the terms of vocabularies and the relations between the associated concepts.

One of the key points of the model is that the ontologies enable all the life cycle of a learning object to be covered: from its conception by the teacher to the search for pieces of information on a given notion by learners. It makes it possible to develop a system including the users’ assistance from the conception of the resources. The different actors of the system (teachers, learners) and their various tasks are considered. The model supplies the flexibility of a semantic representation and search for relevant learning objects by the use of the LOM application profiles. Respect the standards of on-line courses guarantees interoperability with other systems.

To further our study, we intend to set up a system allowing on the one hand automatic indexing of learning objects and on the other hand searching for learning objects matching a need (expressed by a learner or a teacher). The mechanisms will be based on the theme ontology. The first aspect will be based on the work of (Hernandez, 2005) which proposed this type of mechanism in another context (scientific documents). Another aspect relates to the automated construction of theme ontologies which must be produced for each domain of teaching. Work of the IRIT laboratory in this field (Aussenac et al., 2000) could be reinvested here.

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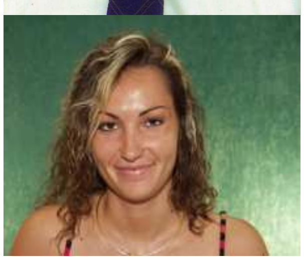
Biography

Nathalie Hernandez



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