An Ontological Approach for Enriching Metadata of Learning Objects to Support Effective e-Learning

Kalla. Madhu Sudhana[†], V. Cyril Raj[††] and R.M. Suresh[†††]

[†]Ph.D Scholar, Dept of Computer Science, St. Peter's University, Chennai, India
[††]Head, Dept of Computer Science, Dr M.G.R University, Chennai, India
[†††]Principal, Jerusalem College of Engineering, Chennai, India

Summary
The metadata elements in e-learning domain provide some meaning about the metadata content. But the current existing metadata standards are not providing fully educative support information and also they are not completely suitable enough to integrate Semantic Web technologies into e-learning domain. In this paper, we discuss the issues surrounding the existing learning object's metadata standards and the need of ontological approach to enrich existing standards. Along with this we investigate the existing standards and possible approaches to strengthen e-learning metadata.

Key words:
Metadata standards, ontological approach, strengthen the metadata standards, Educational Specific

1. Introduction

The major challenge in e-learning system is to find appropriate learning objects from the distributed content repositories according to the needs and interests of the learner. For this, the educational objects must be annotated with standardized, semantic-based educational metadata.

As we discuss in section-3 there are many metadata standards developed by different organizations. But almost all of them are developed for management purposes of learning objects, so they are not able to provide full-fledged support to the new generation of e-learning system, such as educational semantic web and intelligent e-learning system.

For the recent development in semantic-web technology and the pedagogical requirements of e-learner there is a need to enrich the existing metadata standards to make them suitable for current requirements.

Here, we investigate various existing Learning Objects Metadata (LOM) standards and the need of LOM enrichment. Finally, we come out with proposing some educative support metadata elements along with their ontological representation.

2. Related Research

The literature review presents the ontological extensions of metadata standards especially concerned to educational-domain, which are developed by various organizations and researchers.

OntoEdue project [1] emphasized the need of ontology for adaptability and personalization techniques in e-learning domain.

ALOCoM ontology [2]: is designed to generalize the content models and to provide an ontology-based platform to integrate different content models by explicitly defining their structure of LOs. The revised ALOCoM ontology [3] divided into two different parts:

ALOCoM Content Structure ontology is to enabling a formal representation of LOs.

ALOCoM Content Type ontology is to definine the educational role of LOs and their components.

CoAKTinG project [4] developed ontology for distributed e-Science through the application of advanced knowledge technologies.

Mohan & Brooks [5] proposed three different types of ontologies related to Learning Objects such as domain ontologies to cover subject area, ontologies that covers learning and teaching strategies and ontologies for structuring of learning objects.

The EUME Onto [6] is an educational ontology that mainly contains concepts related to learning resources, learning design and learning contents.

The SCORM specification provides a limited number of fields for context-related information. But the efforts such as Reusable Learning Objects (RLOs) have not had widespread uptake [7].

3. Current Metadata Standards

Electronic Learning, in particular in the form of Blended Learning, is applied by a rapidly increasing number of universities and companies realizing the concept of learning objects [8]. The self-contained and reusable learning entities offer a new conceptualization of the learning process.

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These learning objects must have an external structure of information called learning objects metadata to facilitate their identification, storage and retrieval. Usually most of the metadata standards are encoded in XML format.
Several metadata standards for educational Learning Objects (LO) have been proposed by various research organizations, but most popular metadata standard in educational domain is IEEE Learning Object Metadata (LOM).
These metadata standards are designed especially for describing the characteristics of educational resources. According to Al-Khalifa and Davis [9], an important feature of LOM is that, it is simple to use and has an inherent extension capability. This extensibility allows for the easy incorporation of new elements and enables LOM to meet the specific needs of applications.

In educational domain the well-known metadata standards are:

- IEEE LOM- IEEE Learning Object Metadata
- IMS -Instructional Management Systems
- SCORM- Sharable Content Object Reference Model
- DCMI - Dublin Core Metadata Initiative
- ARIADNE - Alliance of Remote Instructional Authoring and Distribution Networks for Europe
- ADL - Advanced Distributed Learning
- DSpace
- DC-Ed
- CanCore

Few organizations are using their own metadata for learning content description some of them are as shown below:

- TArgeted Reuse
- GEneration of TEAching Materials (TargeTeam)
- Tutorial Markup Language (TML)
- Procedural Markup Language (PML)

4. Problem Definition

The current e-learning standards are conceived especially for learning management purposes, and not for integration with various Semantic Web applications.
Most of the implementers and researchers still remain with XML based technology for meta-data even though there are many potential benefits with semantic web technology.
The semantic based standardization of important base technologies for e-learning applications is growing to become a significant force.
Recently the popular standard IEEE LOM is expressed in Resource Description Framework (RDF) [10] format and the semantic information is included in the document model on the top of the IEEE LOM e-learning standard.
As shown in Fig.1 the educational metadata must have elements to support content, structural, semantic and contextual descriptions of educational domain. But the current metadata elements are generic terms which are not specifically designed and developed for educational domain so that, they are just useful for the purposes of content management and structural description of learning material but not much support for semantic or contextual description of learning material.

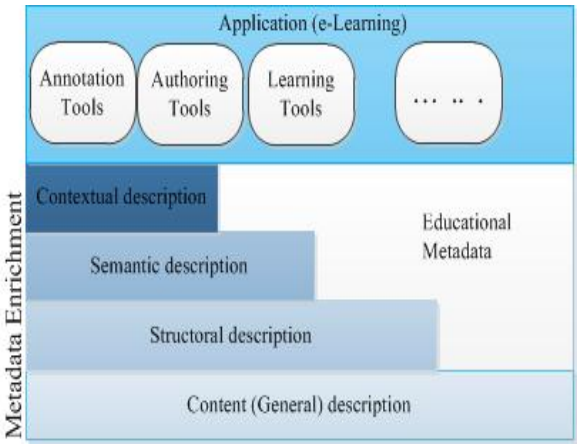

Fig.1 Stack of Metadata enrichment stages

To get full-fledged educative support metadata, the existing metadata must be enriched so as to support all the four layers that are shown in Fig. 1. These four layers can be described as:
Content: What the learning material is about, that is basic information about learning object, such as title, identifier, format etc.
Structure: How the group of learning materials can be managed and organized with proper structural relations among the learning material.
Semantic: The semantic description consists of different types of interrelations among learning objects in the context of educational settings.
Context: Where and in which case the material is useful and in what form and how the learning material is presented.

5. Drawbacks in Existing Approaches (Standards)

From the educational domain perspective here, we believe that there are mainly four types of drawbacks with existing metadata approaches such as Ambiguity with direct use of some of the elements, Need of more specific elements, Lack of Relational-metadata and Lack of educative-support information.

(i) Ambiguity with direct use of some of the metadata elements:
Each metadata type provides specific meaning about the learning object in computer based applications, but the problem arises when the same metadata element is used in many contexts, and a computer application is not able to make the difference, unless we provide it with some supplementary information.
For example consider the "title" element in Dublin Core and IEEE LOM metadata standards.

<dc:title>: it says that content under this tag is title of resource but, it won't say meaning of title.

If we consider e-learning domain "Title" may be concept title, domain title, subject title, sub-topic title, sub title or some other else.
The solution for such type of problems is the correlation of certain metadata with a certain ontology construct.

(ii) Need of more specific elements:
If we consider the most popular IEEE LOM standard, it defines 80 fields within 9 categories as follows: 1-General, 2-Lifecycle, 3-Meta-Metadata, 4-Technical, 5-Educational, 6-Rights, 7-Relation, 8-Annotation and 9-Classification. The elements in these categories are not sufficient enough to meet learner requirement.

For example, in educational domain the Relational-metadata and Educative-support Information plays an important role to represent the interrelation among different categories of learning material.

(iii) Lack of Relational-metadata:
The Relational-metadata- elements such as Predecessor, Successor, Related topic, similar topic etc., are some of such type of elements required for e-learning domain, but these types of elements are not available in existing metadata standards. Table 1 shows an example of relational metadata for the subject "Data-structures" in computer science domain.

Table 1: Relational metadata

Category	Type	Example
Relational and Structural information	Domain	Computer science
	Subject	Data structure
	Topic	Trees
	Sub-topics	Tree traversal
	Similar-topic	Binary Trees
	Related-topics	Graph traversal

(iv) Lack of Educative-support Information:
Educative-support Information-is an important requirement to be incorporated in educational metadata standards that helps learner to understand well about the topic or concept through referring different supportive materials such as examples, references and application scenarios. Some of the Educative-support elements are as shown in Table 2

Table 2: Educative support Information

Purpose	Educative support elements
To improve understanding level	Example, Illustration, Application-areas, Case study etc.
For further reading	Prerequisite, References, Bibliography, Related topics etc.

6. Possible Approaches to strengthen current metadata standards

Here, we mentioned three possible approaches to strengthen the metadata standards so as to make it suitable for educational domain with educative and semantic support information.

(i) Incorporating additional elements:
As per the Dublin Core metadata standard specifications, it is possible to incorporate additional qualifiers or elements through a "new" element or property within the Dublin Core element, with more specific meaning based on domain requirements and more specialized than its parent element.
IEEE-LOM also enables to add new elements as per the domain requirements, so that IEEE-LOM can be used for developing application profiles.

(ii) Semantic information through paired tags:
The University of Hull Centre for Internet Computing [11] followed an approach to describe the context and semantics of domain through structuring the semantic information in the form of paired tags as <predicate/object> pair. It means that the metadata tags can be included along with required semantics like-
<isa, university-website>, <has, academia>

(iii) Through ontological approach:
Ontology technology is considered to be a highly suitable means of supporting educational-technology systems [12] and ontologies provide more semantics to learning resources description model.
The usage of one or more types of relations between concepts and using the classical semantic relations such as "is-a" and "part-of" relations between concepts will improve the precision of modeling [13].
So, we believe ontological approach is the suitable means to enrich existing metadata standards and to overcome differences in terminology.

7. Towards Ontological approach

The goal of using ontologies in educational domain is to model the learner, domain and educative support information at the semantic level.

The ontological framework presented here may be useful to strengthen metadata of learning resources and makes e-learning domain to cope-up with Educational Semantic-web Vision.

Here, we believe that three different categories of ontologies are required to strengthen existing e-learning system and to facilitate the reusability of learning designs and learning objects.

As shown in Fig. 2 these three ontologies consists of Domain-related information, Educational specific information and Learner preferences.

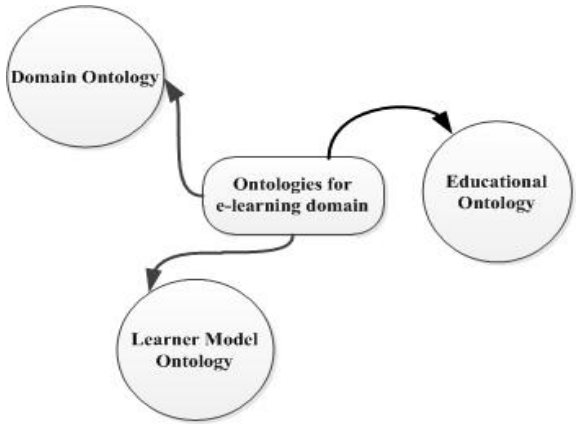

Fig .2 Required ontologies in e-learning domain

Concerned to these three ontologies, in Table 3 we provided some key metadata elements for supporting an extensible environment to learning domain.

Table 3: Key metadata elements

Domain	Educational	Learner
Creator	Difficulty-level	Learning orientation
Date	Application	Learner preferences
Identifier	Examples	Execution environment
Description	References	Time schedule
Document type	Bibliography	Learning area
Title	Case-study	Qualification
Language	Illustration	Learning approach
Domain	Course	Learning media
Subject	Standard	Location
Concept	Scope	Role
Sub-concept		
Objective		

(i) Domain Ontology:

The domain ontology contains information about the domain knowledge of learning content and describes the content structure.

The semantic based representation of learning contents has various representation approaches, but for personalized or adaptive learning environments the ontological representation of learning contents is much suitable.

Fig. 3" shows that, the partial representation of domain ontology consists of classes (terms) and inter relations (axioms) among domain concepts.

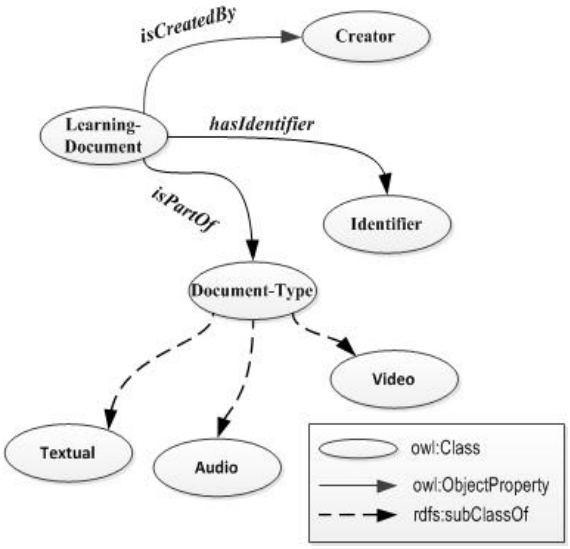

Fig.3 Partial representation of domain ontology

The partial OWL program for domain ontology is as shown in Table 4. In this program we considered only three elements that are:

Subject- Learning-Document
Object-Identifier
Relation- hasIdentifier

Table 4: Partial OWL Program

```
<rdf:RDF
xmlns:owl ="http://www.w3.org/2002/07/owl#"
xmlns:rdf ="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
xmlns:xsd ="http://www.w3.org/2001/XLMSchema#">

<owl:Ontology rdf:about="">
<rdfs:comment>Domain OWL ontology</rdfs:comment>
</owl:Ontology>
<owl:Class rdf:ID="Identifier">
      <rdfs:subClassOf rdf:resource="#Learning-Document"/>
</owl:Class>

<owl:ObjectProperty rdf:ID="hasIdentifier">
      <rdfs:domain rdf:resource="#Learning-Document"/>
      <rdfs:range rdf:resource="#Identifier"/>
      <rdf:type
rdf:resource="http://www.w3.org/.../owl#FunctionalProperty"/>
</owl:ObjectProperty>
-------
</rdf:RDF>
```

Many organizations have developed their own ontologies for various needs, so there is a need of proper tools to make them suitable for educational semantic web vision.

(ii) Educational Specific Ontology:
The Ontologies for educational specific contents allows learners to acquire knowledge about a learning subject and to improve understanding level of learner. It is also useful for structuring and grouping the learning material as per the course and curriculum requirements of institution.
Educative support information allows the learning material to be adapted based on the learner's knowledge level, course and standard. It also enables the learner to select suitable material as per his educational requirements such as scope, activities, standard etc.

(iii) Learner Model Ontology
The learner-ontology consists of learner specific information such as learner personal details, preferences, time-schedules, learner-skills, subject-domain, execution-environments etc. Fig. 4 shows the partial learner ontology developed in "Protégé 4.2 (Onto Graf Plug-in)" which is the most popular ontology development environment.

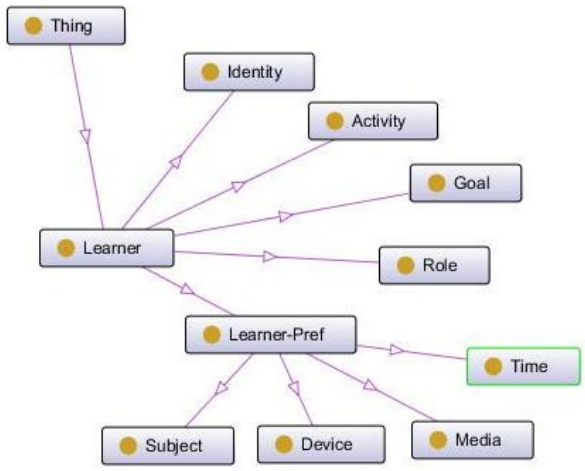

Fig.4 Partial learner model ontology

The proposed Ontologies adopt Web Ontology Language (OWL) as the representation language to enable expressive content, context and structural descriptions and data interoperability with third-party services and applications.
The recent development in Semantic Web technologies such as XML, RDF and OWL (for ontologies) has enabled the possibility to promote the existing e-learning services and applications to cope-up for the semantic, contextual and pedagogical requirements of e-learner.

8. Need of Ontological Approach

In the knowledge representation domain, the term "ontology" refers to the formal and explicit description of domain concepts, which consists of: set of entities, relations, instances, functions, and axioms.
The general goal of using ontologies in e-learning domain is to increase the accessibility and the reusability of the e-learning material. Following are some of the requirements for using ontological approach in e-learning systems.

(i) To get common understanding:
There is heterogeneous metadata standards developed by different organizations, these metadata cannot work with each other. Hence, ontology based common understanding among various standards is required. This helps learners to search learning objects that are being annotated by various metadata standards.

(ii) To promote content-based applications:
Ontology helps to promote the existing content-based learning applications to semantic-aware, context-aware and personalized learning applications.

(iii) As intermediate layer:
By means of representing the learning material characteristics in an ontological format, it can act as intermediate layer between personalized learning agents and learning object repositories.

(iv) For personalization:
Adaptivity is an important characteristic in e-learning domain for course-based or personalized learning environments, where learning material is to be customized for learner needs.

9. Conclusion

Here, we believe that the existing metadata must be represented in ontological format to support Educational Semantic-web Vision and new set of metadata elements is to be incorporated into existing set of standards so as to support semantic, contextual and pedagogical needs of e-learning domain.
In this paper, we discussed the issues and drawbacks surrounding the existing learning object metadata standards and the need of ontological approach. Here we proposed the required ontologies in e-learning domain along with key metadata elements.
Finally, our proposal is to create supplementary metadata set along with existing standards and also there is need to incorporate semantic dimensions in e-learning metadata.

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Dr. V. Cyril Raj received Bachelor degree in Electronics and Communication, Master degree in Computer Science and Engineering and PhD from Jadavpur University. He is currently Head of the Department of Computer Science and Engineering, Dr. MGR University, Chennai, India. He has published number of papers in national and international conferences, seminars and journals and author of many text books. At present many members are doing research work under his guidance in different areas. His research interests include Bioinformatics, Semantic-Web, Computer Networks and Data Mining.

Dr. R.M.Suresh received Master degree and PhD in Computer Science and Engineering. He is currently working as a principal in Jerusalem College of Engineering, Chennai, India. He received young scientist award from government of Tamil Nadu, India. He published number of papers in national and international conferences and journals. At present many researchers are doing their research work under his guidance in different areas. His research interests are AI, Soft Computing, and Data Mining.

Kalla.Madhu Sudhana received Bachelor degree in Computer Science and Engineering from Visvesvaraya Technological University, Bangalore and Master degree in Computer Science and Engineering from Dr. MGR University, Chennai. Currently he is a research scholar in Department of Computer Science and Engineering, St. Peter's University, Chennai, India. His research interests are Ontology, Semantic-Web and E-learning.