Interdisciplinary Journal of Knowledge and Learning Objects Volume 3, 2007

Meta-Data Application in Development, Exchange and Delivery of Digital Reusable Learning Content

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Abstract

Using a survey, conducted among students at Sofia University "St. K. Ohridski" (the biggest University in Bulgaria), a general need for more adaptive and flexible learning content was identified. Meta-data and their standardisation are seen as a promising technology for achieving this goal. On the base of analysis of existing standards, a model for meta-data application in reusable learning resources delivery is proposed. It is further shown how the model can be applied in existing Learning Content Management Systems (LCMS) in order to achieve more adaptive learning content delivery. This will allow future research in the filed of meta-data use in delivery of learning materials via mobile technologies and for satisfying special needs of people with disabilities.

Keywords: meta-data, XML, IEEE LTCS LOM, LOM, RLOs, ontology, meta-data editors, extended learner profile, Protégé

Introduction

Problems in advanced e-learning are related to development of searchable and indexed learning content. In the paper advanced methods for learning resource description and flexible assembling of content according to learners' needs are discussed. Meta-data description of learning resources is crucial when we aim to create adaptive to the students' requirements learning materials. Meta-data allow important characteristics of learning resources to be described, so they can be further indexed, searched and discovered. There are many problems related to the development of meta-data and finding the most appropriate description of the learning resources. Some of them are related to standards in the field discussed by Friesen (2005). In the paper two standards are presented – XML (XML, 2006) and IEEE LOM (LOM, 2002), and their capabilities for learning resources description are analyzed. The main problem addressed in this paper is: how to describe learning objects with meta-data, so the meta-data can be further used in order to generate the unique individualized learning path, corresponding to specific learners' preferences. An analysis of tools for creation of meta-data descriptions of existing learning resources was conducted, and most appropriate one for the needs identified at Sofia University was chosen and used.

Editor: Keith Harman

Educational Needs of the Information Society

Effective education, aiming to achieve the needed knowledge and skills, is critical for the individual and organizational success. For this reason, many innovations, tools and methods for learning and knowledge management have been developed and implemented. All learners (both individual and from companies) with their common needs for competences, skills, and knowledge (but with specific requirements for the process of education and knowledge exchange and delivery) may be considered as some kind of specific virtual community. In order to explore the learning needs of the students at University of Sofia, a survey was conducted involving students both at MSc and BSc levels. Results of the survey are presented in Figure 1.

About 20% of the students state that the level of adaptability and flexibility of proposed learning materials is very low, and only 6% of the students evaluate them as very appropriate for their education.

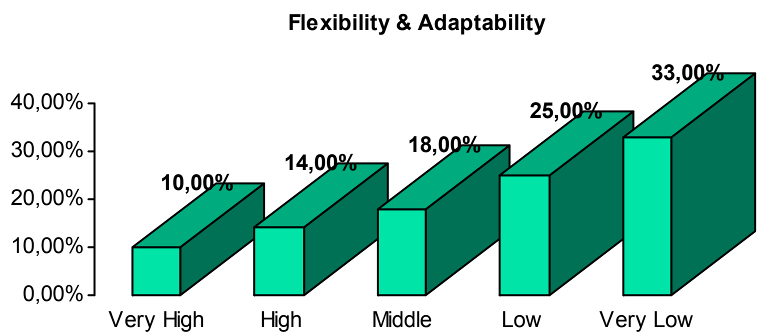

Figure 1: Survey results of adaptability and flexibility of proposed education

Metadata Importance and Capabilities

One very promising approach for improving the flexibility and adaptability of learning resources is through the use of meta-data - data that are used to describe other data. Usually meta-data is used to index important information about learning resources and is stored in a database. This makes it possible to search, find, and deliver the needed learning resources to the learners, using only the meta-data. Usually meta-data descriptions of learning resources include the name of the author of the resource, the most suitable keywords, the language and other characteristics.

Flexibility and adaptability of the learning content is a critical feature for successful and effective education. Meta-data allows learning content to be developed independently of the way it is used and visualized. This way learning resources can be combined in different learning contexts and they can be visualized in user-friendly and appropriate means for the learner mode. Meta-data in e-learning allow learning materials to be well described and easily searched, assembled in desired learning context, and delivered according to the learners' preferences and needs of education. As a result, users have access to the learning content most appropriate for them, and receive only the necessary and needed information, instead of being overloaded with learning materials that they already know or are not related and appropriate to their expertise, professional background and educational needs.

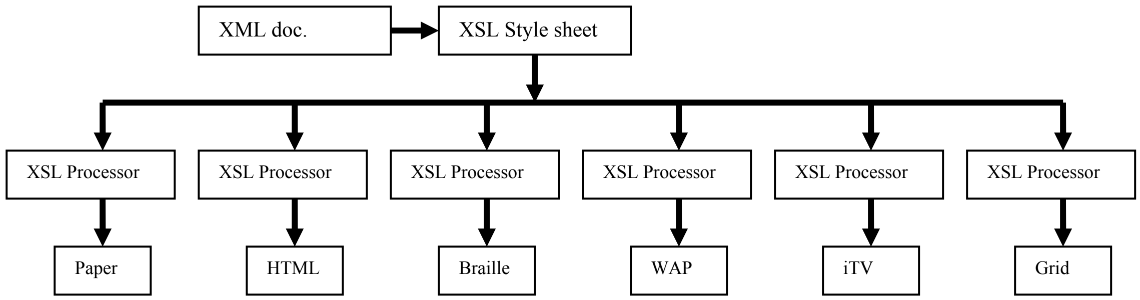

Figure 2: Capabilities of XML for knowledge representation in different contexts (adapted by McGrath, 1998)

Metadata Standards Overview

The most popular and commonly used meta-data standards are XML and IEEE LOM.

IEEE LTSC LOM (Learning Object Metadata) is based on meta-data models developed by IMS (IMS, 2001) and ARIADNE (ARIADNE, 2004) and uses a tree-like structure of namespaces to describe the data content and structure. It is better suited to be laid into an XML structure.

RDF (RDF/XML, 2004) is a foundation engaged in the development of the architecture of web services. RDF is a meta-data structure that has application without discipline specific meaning. This is a special form of XML with language specific semantics defining predicate logic structures. The model describes a "triple" of Predicate, Object and Statement, designed to annotate the context of knowledge. The RDF structure is not designed for human readability, so its usage is backed by tools, which package and decompose the metadata, and the meaning is presented in the shelter of the application space.

XML is most commonly used standard for meta-data development. The learning object meta-data is expected to be encoded in XML, according to the schema provided by IEEE, and contained in a single file. This file may then be attached to the learning object or made available as a standalone file for the purpose of locating and retrieving learning objects. Groups of learning objects may be grouped together; in a "package" described using the IMS content packaging specification.

LOs, Meta-Data, Ontologies, and Extended Learner Profile

The main goal of meta-data usage in learning is to allow different pieces of information like LOs (Leaning Objects) or UoLs (Units of Learning) to be described and stored in digital stores, so they can be reused in different contents, and to be shared among users and learning systems. Each separate unit of information should be described by meta-data file that defines its title, language, description, keyword, format, learning resource type, interactivity level, difficulty, etc. When the learning resource is searched and found, its characteristics are compared with learners' preferences, so the most appropriate learning content to be delivered to the learner in flexible and adaptive manner. Buzzeto-More and Phiney (2006) propose well-structured guidelines for LOs development.

LOs and Ontologies Capabilities

The technical specifications should address the interoperability of LOs, and the physical structure aiming to facilitate easy manipulation of the building elements. The ability to execute the LOs in different operating systems and delivery media is the main factor for the success of the standard.

The choice of the language for describing LOs meta-data is crucial for achieving the interoperability. XML is ideal for achieving this goal since it is being endorsed as the standard for all future applications. Additionally, separation of structure, content and presentation, which is the fundamental logic of XML, will allow the flexibility required for LOs management. In this respect we can talk about Reusable Learning Objects (RLOs). Snae and Brueckner (2006) present an example for use of ontologies, LOs, and meta-data in e-learning delivery.

Ontologies are used for sharing of knowledge in some domain. They are intended to serve as consensual rallying points to exchange and interpret information. Ontologies contain both the syntax and the semantics of the objects being modelled. This requires formal compatibility on syntactic levels as well as semantic levels. A simplified vision for exchange of data and meta-data is presented in Figure 3.

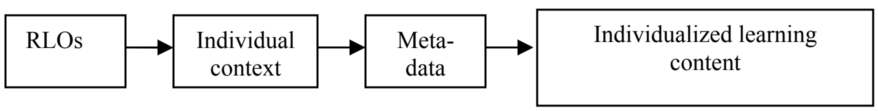

Figure 3 Delivery of individualized learning content (Adapted by Nonaka, Konno, & Toyama, 2001)

Learner Profile Description

One of the most important problems of advanced e-learning is how to organize the education process in the most effective and high quality way. One possible approach is to use the extended learner profile, which stores learners' preferences, the preferred learning style, and other individual learner characteristics that describe her competencies, previous experience and skills. Using this information, the learning system will deliver the most appropriate learning content generated dynamically in an adaptive manner.

The analysis of the learner is done on the base of various characteristic types - cognitive (learning cognitive styles, general or specific prior knowledge and levels of language, or intellectual capacity), physical, affective (interests and motivation, their attitude toward subject matter) and social (social, economical, racial and ethnic background depending on the countries and individual). All such characteristics and their levels can be obtained by asking the learner to fill in a questionnaire. The most important part of the learner analysis is devoted to the exploration of the learner's cognitive styles preferences (Todorova, 2006), and on the basis of educational background and life experience to decide what is the most appropriate learning content to be provided.

Model for Meta-Data Integration in Adaptive Learning Content

A model for meta-data integration in delivery of flexible and adaptive learning content was developed (Figure 4). It is based on the appropriate meta-data descriptions of LOs as defined by their learning approach, content and used delivery media. The meta-data characteristics have to allow searching by users depending on their features and users' needs, like extended learner profile. Reusable LOs are organized by following the ontology hierarchy and relations and delivered to users from database repository so they could be used many times in different learning contents.

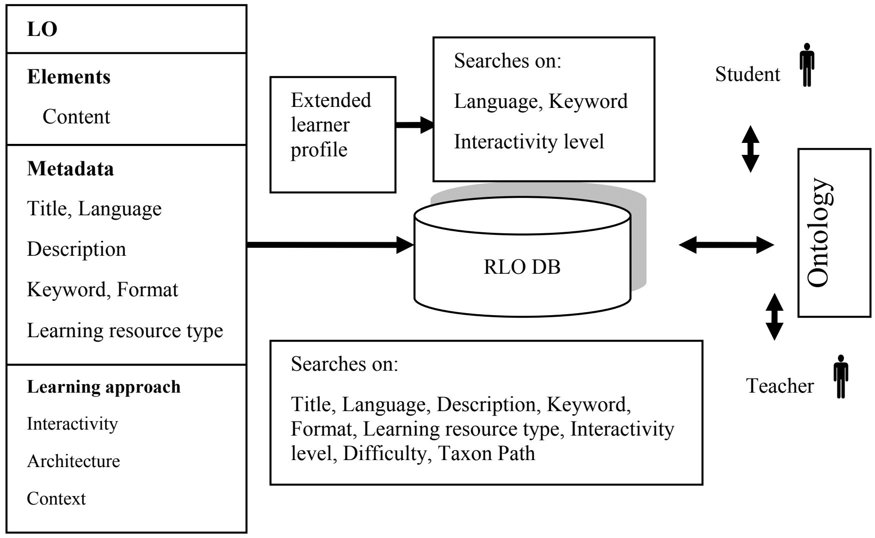

Figure 4: Detailed description of model for meta-data integration in RLOs sharing (Adapted by Barritt & Alderman, 2004)

The model is described by UML Sequence diagram (UML, 1997) that defines basic relations among learners and different system components (Figure 5).

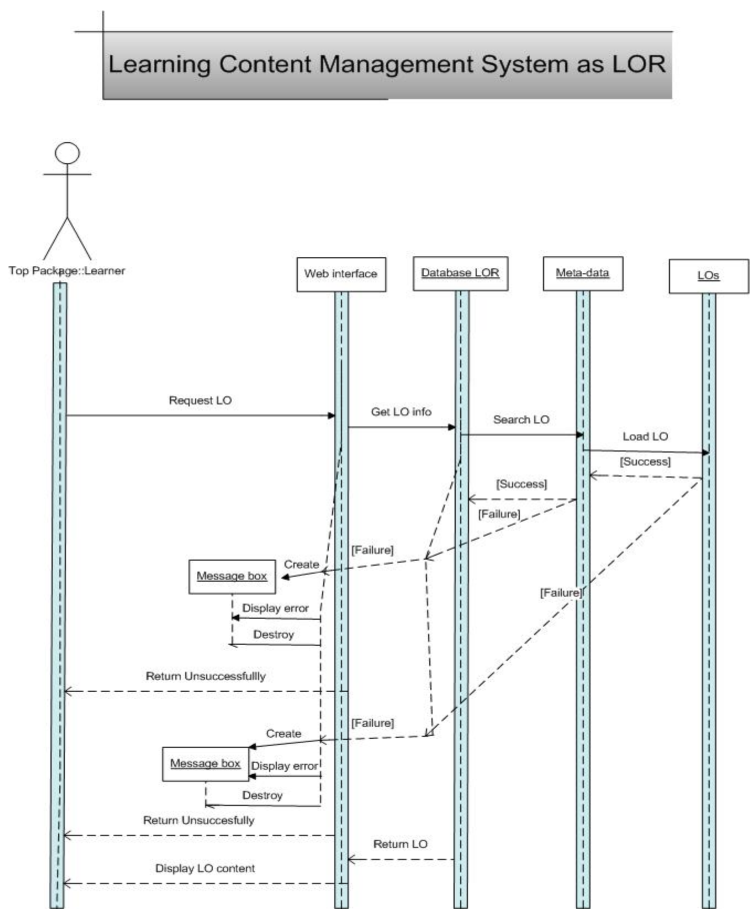

Figure 5: UML Sequence diagrams of learner interaction with system components

The learner requests a LO according to his/her education needs and learning preferences. For this purpose the learner interacts with the web interface of the LCMS, designed as Learning Objects Repository (LOR). Requested LO is searched in the database of LOR, and the success is depending on the LOs' meta-data coincidence with the searched criteria. When the appropriate LO is found depending on the suitable match encountered between its meta-data characteristics and learner's preferences, this LO is loaded from the LOR to the LCMS, and its content is delivered to the learner. Possible application of LOR in e-learning and online courses is presented by S. Nash (2005).

Meta-data Editors Analysis and Meta-Data Development

Parsers, document editors, formatting tools, browsers, delivery tools, application environments and development tools constitute the main basic types of meta-data tools available. The IEEE Learning Object Metadata (LOM) standard uses several groups of meta-data proposed by Barritt and Alderman (2004): General (title, language, description, keyword), Technical, Educational (learning resource type, interactivity level, difficulty), Classification. They are presented in Table1.

Table 1 IEEE LOM meta-data groups selection

	EEE Learning Object Meta-data (LOM) categories and element	Selected elements for the project
General	• Title • Language • Description • Keyword	• Title • Language • Description • Keyword
Life Cycle	• Version • Status	
Technical	• Format • Size • Location • Duration	• Format
Educational	• Interactive type • Learning resource type • Interactivity level • Difficulty	• Learning resource type • Interactivity level • Difficulty
Rights	• Cost • Copyrights	
Relation	• Kind • Resource	
Annotation	• Entity • Date	
Classification	• Purpose • Taxon Path • Description • Keyword	• Taxon Path

We choose several of them for the implementation of meta-data in the project. We conduct analysis of the five most popular tools: Protégé (Protégé, 2007), XML Spy (XML Spy, 2007), XMetaL (XMetaL, 2006), and XML Pro (XML Pro, 1997).

XML Spy has as a main component a validating XML editor that provides four advanced views on the documents, like an enhanced Grid view for structured editing, database/table view that shows repeated elements in a tabular fashion, text view with syntax-colouring for low-level work, and integrated browser view that supports both CSS and XSL style-sheets.

XmetaL allows learning content to be created and reused. This tool offers a flexible XML authoring control, a web-based XML reviewing solution, a XMetaL developer configuration kit, and a XMetaL asset manager. Turbo XML v2.0 is a professional solution for developing and managing XML assets. It allows creating, validating, converting, and managing of XML schemas, XML files and DTDs, and it has capabilities of a centralized Web accessible repository for XML infrastructure assets. XML Pro V2.0 is a data-centric (vs. document-centric) view of what XML is about. The XML Pro GUI puts a hierarchical tree view of the document in the primary workspace and has a full-time view of attributes and attribute values.

Protégé is a free, open source ontology editor and knowledge-base framework, allowing different formats like RDF(S), OWL (OWL, 2004), and XML Schema (XML Schema, 2004) to be used.

On the basis of a conducted survey, Protégé editor was chosen for meta-data development because of its better integration with developed ontology and capabilities for connecting the concept with respected learning material and meta-data description (Figure 6).

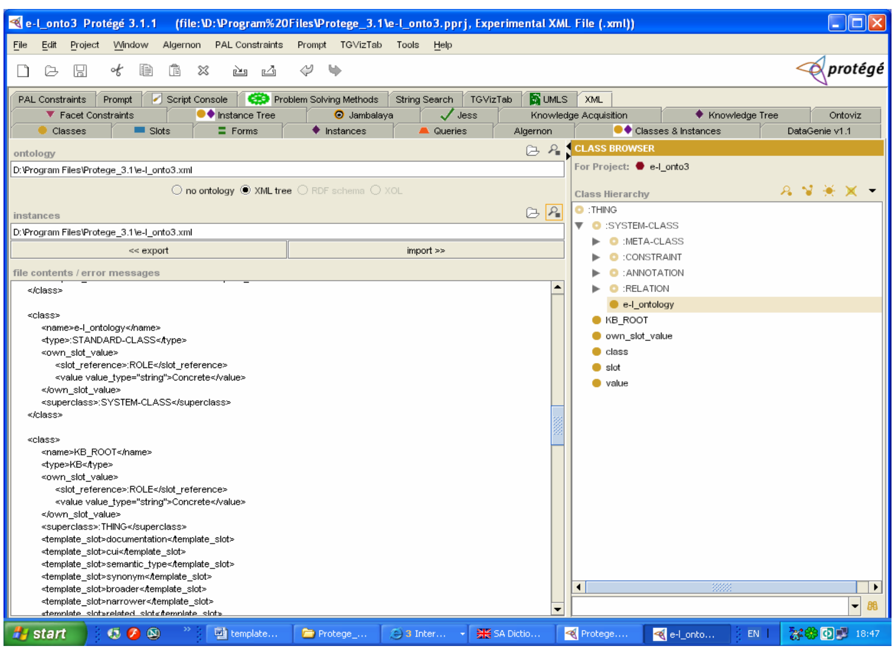

Figure 6. Protégé editor capabilities for meta-data creation

Meta-description of the most important LO characteristics:

```
<class>
  <name>e-l_ontology</name>
  <type>:STANDARD-CLASS</type>
    <own_slot_value>
       <slot_reference>:ROLE</slot_reference>
       <value
         value_type="string">Concrete
       </value>
   </own_slot_value>
   <superclass>:SYSTEM-CLASS
  </superclass>
</class>
```

Conclusion

Application of meta-data for description of learning materials was discussed in the paper. Problems related to the use of learning content in different contexts and in different formats most appropriate for an individual learner were presented, and possible solutions to problems described, based on the use of XML as a language for meta-data creation were presented.

Standardization in the field of meta-data will help the developers of learning content to create adaptive learning resources which could be exchanged and shared among different learning systems that are compatible with the meta-data standards.

We stressed on the importance of the meta-data and the capabilities which they provide for learning resources description, as well as for facilitating learning materials sharing and exchange. Standards and tools for meta-data development were overviewed and analyzed.

Future work is related to editing and creation of metadata for representation of existing learning content in new formats based on advanced ICT technologies like iTV, semantic Web and Grid, mobile technologies, support and exploration of meta-data tools and standards, capabilities for more flexible and adaptive assembling of leaning resources in different contexts of education.

Another topic for future research is related to research of XML capabilities in definition and application of accessibility preferences for learners with disabilities.

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Biography

Korneliya Yordanova is a PhD student at Sofia University <www.uni-sofia.bg/>. Her current research interest includes e-learning, learning systems design and development, creation of reusable multimedia learning content, m-learning, advanced technologies like iTV, Semantic web, Grid and advanced forms of education – CSCL, mobile Collaborative learning .