Metadata Models for Technology Enhanced Learning in SINUS Project*

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***Abstract* – This paper presents the basic idea, functionalities and information structures of Technology Enhanced Learning Environment of the SINUS Project. The emphasis is put on the decisions taken to form the suitable metadata constructions supporting the processes of search, extraction and annotation of the used multimedia objects.**

***Keywords* – Technology Enhanced Learning, Metadata, Ontologies**

I. Introduction

Current approaches to Technology Enhanced Learning (TEL) are fundamentally based on providing a learner with appropriate learning content. In the current Learning Management Systems the allocation of learning resources is done predominantly at design-time and there are not many capabilities to reuse existing blocks of information objects. Authoring of adaptive content, realized partially in the so-called Learning Content Management Systems, is one of the most important and labor-intensive activities in the modern TEL practice. Traditionally authoring of adaptive content relies on the design of a fine-grained domain model and careful indexing of various Learning Objects (LO) with multiple domain concepts targeting re-usability and re-purposing of information object in different learning situations or learning environments.

SINUS Project is a 3-years long research project of the National Science Fund of Bulgaria, which mission is to demonstrate how the learning process could be supported and facilitated by the modern technologies of Semantic Web Services (SWS). The major approach of the SINUS Project is based on analyzing and exploiting the advantages of SWS technology in the automation of Learning Objects discovery, selection and composition within one distributed service architecture seamlessly integrated through ontologies [1]. The project architecture defines number of information objects stored into set of repositories that are accessed via http protocols as XML Web services. The information objects have additional semantic annotation that enables development of the system in order to compose learning environment personalized in some aspects.

The paper is organized as follows: The next section presents SINUS Project giving short overview of project goals, description of Use-Case scenarios, terminology and some architectural views. The third section presents the abstract annotation levels and metadata models in SINUS Project; each level is described in respect to decisions taken about metadata organization and its connection to some standards taken into account. The last section is a short conclusion.

II. Technology Enhanced Learning Environment of the SINUS Project

A. Basic Idea

SINUS project follows the idea to increase the effectiveness of preparation and use of adaptable learning content and to change the data and metadata-based paradigm to a dynamic service-oriented approach. The learner is provided with a dynamic supply of appropriate functionalities, in order to enable a dynamic adaptation to the learning context at runtime of a learning process, including dynamic access to different multimedia sources. The learning content creators are supported during the creation of learning materials and procedures giving assistance to learners. In SINUS Project Learning Objects are based on multimedia objects. The needed metadata to organize the work of SWS and access to Learning Objects is based on international metadata standards and domain ontologies. SINUS Project goes further with the lessons learnt from two IST FP-6 European research projects: INFRAWEBS and LOGOS, and the ambition of the team is to be developed more mass-user-centered and user-friendly approach and tools.

B. Use-Cases

The learning domain chosen for demonstrations of SINUS platform functionalities is Bulgarian Iconography. It presents a fruitful field to demonstrate how the digital photos of iconographic works (icons, wall-paintings, etc.) could be used during the learning process. The multimedia resources of SINUS Use-Cases are digital photos. The Multimedia Digital Library "Virtual Encyclopedia of East-Christian Art" [2] is the source of multimedia content for learning scenarios.

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The learning domain of Bulgarian Iconography is potential field of interest for people with wide range of learning demands: from formal and specialized professional education to self-training or personal cultural investigations. The SINUS Use-Cases are directed primary to formally organized students of Art disciplines, History, Theology. There are two general user roles round which the Use Cases are build: The Educationalist and the Learner.

The Educationalist prepares learning tasks for her/his students by means of the environment. The Educationalist creates sets if instructions associated to each particular learning task and prepares or recommends the multimedia resources to be used in "solving" the learning task. Usually the learning task contains two tightly connected parts: 1) to be gathered a collection of multimedia resources (digital pictures of iconographic works) and 2) the collection to be analyzed or commented in some specific aspects, which concern the learning (art specifics, historical aspects, theological aspects, etc.). The solution of such a learning task is a multimedia document containing the digital images of prepared collection and text, comments of the author-learner. The created multimedia document is called project in SINUS platform terminology.

The Lerner receives a particular learning task and some instructions. S/he is expected to collect appropriate multimedia resources and to prepare analyses in multimedia document: project. At each single step from the receiving of the learning task, through the access to different multimedia sources of information and visual resources, to the preparation of the project the Learner is supported by the functionalities of SINUS platform.

C. Overview of Conceptual Architecture of SINUS Platform

The conceptual architecture of SINUS platform consists of two main elements: Design-time Environment and Run-time Environment.

The Design-time Environment proposes:

- Information structures for storing and retrieving semantic and non-semantic data:
  - Semantic Web Service Repository enables efficient storage and retrieval of all elements of the Semantic Web: goals, ontologies and Semantic Web Services.
  - Learning Metadata Repository contains annotated metadata about Learning Objects, used for grounding of SWS.
  - Information Indexer and Retriever contain a special representation of both Semantic Objects and Learning Objects.
- Tools for creation and maintenance of resources, metadata and supporting ontologies:
  - Semantic Web Service Creator aims at designing Semantic Web Services by reusing already existing semantic and non-semantic descriptions stored in the Semantic and Learning Metadata Repositories.
  - Ontology Creator aims at creating ontologies in a user-friendly manner.
  - Semantic Goal Creator provides means for creation of SWS-based reusable goals for designing TEL applications.
  - Learning Content Description Tool aims at creating metadata annotations and consists of Digital Objects Annotation Package, Semantic Annotations Package and Learning Objects Annotation Package (see Fig. 1 below). Multimedia and Learning Objects are annotated according to certain TEL standards and some formal ontologies.
- Methods used for creating and maintaining Semantic and Learning Objects:
  - Combination of TEL-specific and logic-based methods for object discovery
  - TEL-specific decision-support methods for dynamic service composition
  - Several methods for calculating similarity and object retrieval – structural, linguistic, statistical, fuzzy, etc.

The Run-time Environment is responsible for discovery, dynamic composition, execution and monitoring of SWS. The Run-time Environment consists of the SWS Discoverer, SWS Composer and SWS Executor components.

SINUS conceptual architecture is an adaptation of the INFRAWEBS SWS-architecture towards Technology Enhanced Learning applications and presents a novel approach for creating and maintaining Semantic Web services and SWS applications. It is based on tight integration of similarity-based and logic-based reasoning. Similarity-based reasoning is used for fast finding of approximate solutions, which are further concretized by the logic-based reasoning.

One of the objectives of SINUS Project is the development of new methods and tools for creation and semantic annotation of Learning Objects compatible with Semantic Web Services methodology. The investigation aims at design of activity scheme and information models for dynamic creation and adaptation of learning objects (multimedia objects, annotated with content- and context-oriented metadata), facilitating their reusability and addressing active authoring as learning activity. The research addresses the limitations of standard LO metadata through the usage of ontologies to represent the knowledge encoded in the metadata in machine readable forms. The information models and methods for learning content organization are based on pragmatic restrictions and modifications of the project LOGOS information models (see III.B below). This is a step to orienting the information models and tools to mass authors of learning materials without need of specific knowledge and skills concerning information models and basics of ontology engineering.

III. METADATA MODELS OF MULTIMEDIA OBJECTS WHITHIN SINUS

SINUS environment provides its users with effective methods to operate with different multimedia objects during the working process. Presented above Use-Case of working within the area of Bulgarian Iconography illustrates the processes of search, extraction and annotation of multimedia objects. The architecture aims the following annotation levels

(see Fig. 1): Digital Libraries level, Semantic Objects level and Learning Objects level. Each one of the levels has three major elements:

- Repository – The repository works as storage space for different types of objects. A repository is accessible via http protocol and presents the functionality as web services.
- Specific annotation package – The annotation package is a set of software tools for managing descriptions specific for the level and according to particular standard.
- User role (annotators) – a group of users dedicated to work with the objects on each level. The groups of annotators are defined on the basis of functional requirements for given set of logically related operations on the objects [3]. These sets of operations specify the annotation levels that have the similar professional qualification requirements from the user roles that perform them.

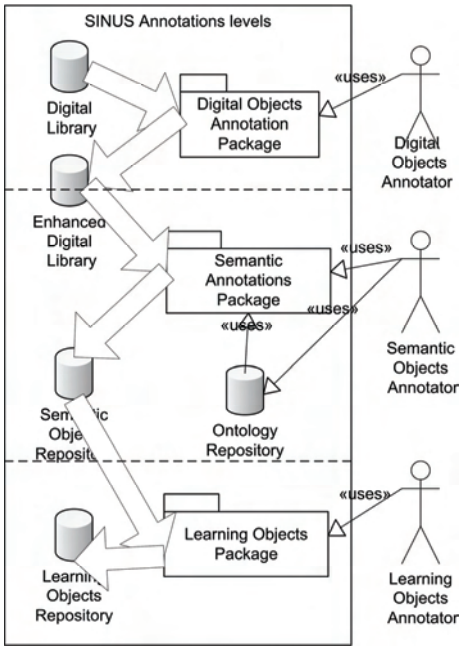

Fig. 1 Annotation levels

A. Level of Digital Libraries

The digital libraries level is dedicated for storage, management and editing of digital objects. The objects of digital library are not intended to have any educational purposes. The digital library is pre-existing feature with specific formats and architecture. The only requirement for the library is to expose its objects as well known XML Web Services. The role of digital object annotator on the Fig. 1 is to insert additional metadata in the cases when descriptions provided by the library are not sufficient. Annotations are stored into extended digital library. The digital object annotation package has to be able to insert annotation at least according to Dublin Core Standard [4]. The approach of inserting an annotation according only to Dublin Core Standard has limited capacity of description of video clips. For sustainable and yet flexible description of digital objects it is reasonable the usage of public standard for metadata description like Moving Picture Experts Group (MPEG 7). According to [5] the MPEG standard allows different operations on images and video like describing objects' movement, camera motion, relations between objects, returning a list of videos with similar or dissimilar temporal and spatial elations, describing actions of given video content and preparing a list of videos where similar actions happen.

Concerning the metadata model for described Use-Case in SINUS Project we intend to use the fields of Dublin Core Standard at this level.

B. Level of Semantic Objects

Semantic Objects' level is the essential layer in SINUS metadata architecture. It gives flexibility in defining possible usage and re-use of multimedia objects, which could be described in different contexts according to different ontologies. Currently ontologies are the constructions which represent the semantics of human realm in form usable for software programs. The definition given in [6] is widely accepted and says that ontologies are "formal specifications of a shared conceptualization of a certain domain". This understanding is the ground of the rapidly growing interest to implemented ontologies. Creating new ontology starts from knowledge elicitation from domain experts, this is knowledge level; then working on symbol level the knowledge engineers formalize this knowledge; then at the implementation level the ontological construction is implemented in particular formalism or language (Frame Logics, Conceptual Graphs, OIL, OWL, etc.).

With the increasing number of applications using ontologies the problem with ontologies interoperability arises. It is in fact a problem of knowledge exchange among different *worlds*, which are introduces by different ontologies. In [7] four different general types of ontologies are defined. A *Top-level Ontology* describes very general concepts like space, time, event, which are independent of a particular problem or domain. A *Domain Ontology* describes the vocabulary related to a generic domain by specializing the concepts introduced in the *Top-level Ontology*. A *Task Ontology* describes the vocabulary related to a generic task or activity by specializing the *Top-level Ontologies*. Concepts in an *Application Ontology* often correspond to roles played by domain actors while performing a certain activity. Usually all the four types of ontologies are involved in real complicated tasks and platforms like in support of Technology Enhanced Learning proposed in SINUS Project.

Here we are concentrated only on Domain Ontology and metadata constructions supported by it at the level of Sematic Objects in SINUS platform. Semantic metadata of multimedia object in terms of SINUS Use-Case is tightly connected to the learning domain. Terminology of the learning domain Bulgarian Iconography is accessible trough the ontology "Bulgarian Iconographical Objects" [8], OBIO for short. OBIO is first created under the project LOGOS **"**Knowledge-on-Demand for Ubiquitous Learning" [11] and now enhanced.

In all its variations OBIO could be asserted to be a specialization and uses as Top-Level Ontology the CIDOC Conceptual Reference Model [9], which is an ICO standard since 2005 for organizing documentation of libraries preserving art collections and artifacts of world historical heritage. For the purposes of SINUS Project the ontology is implemented in OWL, it consists of 48 classes with 39 different properties. Semantic metadata of Use-Case multimedia objects in SINUS platform is expressed by ontological constructs of OBIO.

There are two cases with semantic metadata when the user of SINUS platform is searching for appropriate multimedia object. The first case is all the semantic features of the object to be supported by the Digital Library where this object is looked for. The second case is when the user needs to access some features of the multimedia object, which are not operating features of objects for the searching machine of the Digital Library. In the first case the record of semantic metadata of multimedia object is completely fulfilled with information received by SWS from the Enhanced Digital Library. In the second case the SINUS platform supports additional metadata of user interest in the Semantic Object Repository. In fact, for the user is not recognizable how the metadata of particular multimedia object is accessed and stored, the user works on the level of SINUS platform and uses all the functionalities there: access to the Digital Library, Semantic Annotations Package, access to the Domain Ontology, etc.

C. Level of Learning Objects

The learning objects layer is dedicated to handle the educational aspects of previously created semantic object. Educational aspects of semantic objects are made by enrichment of the semantic objects with Learning Object Metadata (LOM) according to [10] standard. The LOM enable search, educational annotation, and classification of semantic objects different by seize, purpose and granularity. The standard is widely used and accepted. The learning objects annotator is an Educationalist. This is user role in SINUS platform which is responsible to manage educational usage of the objects. The learning objects package has to be able to reference an object on the semantic level and to support the educational annotations with LOM. The educational annotations according to LOM standard are stored into the Learning Objects Repository.

IV. CONCLUSION

SINUS Project and TEL in general provide opportunity for ambitious and interesting research, especially concerning metadata models, which support annotations of multimedia and Learning Objects. In this paper were presented the decisions in organizing multilevel architecture for effective operating with metadata in SINUS Project. Further challenges in front of the team are grounding Semantic Web Services, interoperability of different ontologies, problems concerning annotation, access and extraction of multimedia objects.

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