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A USE CASE SCENARIO FOR TECHNOLOGY-ENHANCED LEARNING THROUGH SEMANTIC WEB SERVICES

Lilia Pavlova-Draganova, Desislava Paneva-Marinova, Lubomil Draganov

***Abstract**: A use case scenario dealing with the formal presentation of semantic Web services for technology-enhanced learning has been developed in the frames of the SINUS project "Semantic Technologies for Web Services and Technology Enhanced Learning"[1]. The main functionality and design of the SINUS platform, as well as its usage, are demonstrated on the basis of this scenario.*

***Keywords**: Use Case Scenario, Technology-enhanced Learning, Semantic Web Services, Multimedia Digital Libraries.*

***ACM Classification Keywords**: H.3.5 Online Information Services – Web-based services, K.3.1 Computer Uses in Education – Distance learning, H.3.7 Digital Libraries – Collection, Dissemination, System issues.*

Semantic Web Services in a Technology-Enhanced Learning Environment Presented Formally by Use Case Scenario

The project "Integration of Semantic Technologies for Service-Oriented Computing and Technology Enhanced Learning" (SINUS) is an interdisciplinary research project aiming at advancing two of the fastest evolving information technologies – Service Oriented Computing and Technology-Enhanced Learning by applying the Semantic Web Service (SWS)[2] methodology. The main project vision [Dochev and Pavlov, 2009] [Agre and Dochev, 2008] is to provide a dynamic adaptation of learning content to the context and the learner's needs during the learning process through:

- Developing new application-oriented methods and end-user oriented tools for Semantic Web services description, discovery and dynamic composition;
- Developing a new Semantic service-oriented architecture-based framework oriented to eLearning applications facilitating reusability and repurposing of learning objects.
- Developing new methods oriented to Technology-Enhanced Learning for Semantic Web services dynamic composition.
- Developing new methods and tools for creation and semantic annotation of learning objects compatible with SWS methodology.

[1] Research project No № Д-002-189 with the National Science Foundation of the Ministry of Education and Science. Project executors: consortium of two science organizations – the Institute of information Technologies at the Bulgarian Academy of Sciences and the Institute of Mathematics and Informatics at the Bulgarian Academy of Sciences – and one high technology software company –"Active solutions" Ltd.

[2] Web services, which are self-contained, self-describing, semantically marked-up software resources that can be published, discovered, composed and executed across the Web in task driven way [Arroyo, 2006].

During the search for technologically executable decisions for implementation of technology-enhanced learning in the project a use case scenario has been developed. This scenario covers the development of learning and semantic resources for presenting Bulgarian iconographical art with the potential to satisfy learning needs in various disciplines. The scenario aims at covering a broad set of possible learning situations. It formally presents a large spectrum of activities and functionalities required by the user to be implemented through Semantic Web services. The scenario illustrates the description, discovery and dynamic composition of these services (for this research aspect of SWS technology no general solutions have been found yet). The research on SWS description is directed to the graphical and ontology-based approach of SWS design. The research on discovery and dynamic composition of SWS is based on the data-driven SMS composition approach [Agre and Dochev, 2008].

The use case scenario also describes methods oriented to facilitate the reusability of learning objects and new options in the automation of learning objects discovery, selection and composition within a distributed services architecture seamlessly integrated through ontologies. Along these lines the research is for developing new semantic schemas for SMS, oriented to technology-enhanced learning application, that is based on further development and refinement of the INFRAWEBS Framework[1] (project INFRAWEBS, [Agre and Dochev, 2008]).

The scenario outlines the framework of the activity schema and the supporting information models for dynamic creation and adaptation of learning object (multimedia objects, annotated with content and context-oriented metadata), facilitating their reusability. This aims at developing methods and tools for creation and semantic annotation of learning objects compatible with SWS methodology. A wide range of activities expected by the authors and learners is included. The scenario emphasizes on the active authoring as a major learning activity, *i.e.* on supporting advanced learners in their work to find, collect, integrate and create digital objects with learning purposes. The information models and learning methods content organization described in the scenario are oriented to the mass authors of learning materials without need of specific knowledge and skills concerning information models and basics of ontology engineering. This permits the implementation of a user-centered learning content description tool for creating and editing descriptive, content- and context-oriented metadata. The learning description tool has to take into consideration the end-user profiles adaptable to characteristics, preferences and requirements of different user groups.

The project methodology aims at adapting and developing at larger scale the original methods and software components, developed by project member under the 6FP project INFRAWEBS (www.infrawebs.eu) and LOGOS (www.logosproject.com, [LADL 2007], [Arapi et al., 2007]).

Stages of the Use Case Scenario Development

"The learning scenarios in system design describe typical or important way of use of the system. They are designed to give all the partners in the project (both technical partners and content providers) a shared understanding on the purpose of the system and the ways it will be of use in practice." [LOGOS Deliverable D3, 2007].

The development of the present scenario went through the following stages [Paneva-Marinova et al., 2009]:

Stage 1 Determining the needed functionality of the use case scenario and all ontological and gnoseological assumptions, the methodological approach, basic requirements, detailisation phases of development, etc.

[1] A framework for semantic services engineering that covers the whole SWS life-cycle and allows creation of complex semantically-enable applications [Agre et al., 2008].

Stage 2: Description of a real learning situation in which the SINUS platform would be used according to the present knowledge resources (media objects, descriptions, glossaries) of the chosen knowledge repositories (Multimedia Digital library "Virtual Encyclopaedia of the East-Christian Art" [Pavlova-Draganova et al., 2007a] [Pavlov and Paneva, 2007]), learning resources needed to be developed, learning situations and context of use. Special attention is paid to the learning content in the areas of cultural heritage and in particular in the area of Bulgarian iconographic culture and art. The chosen learning domains have the potential to satisfy various learning needs in disciplines such as humanitarian studies, arts, history, social anthropology, cultural studies, theology, etc. The scenario aims at covering a wide range of possible learning situations – from the processes of development of learning content to the implementation of various types of learning (formal learning, professional qualification, self-training etc.) according to the needs of the target groups of users [Paneva-Marinova et al., 2008] [Paneva-Marinova et al., 2009].

Stage 3: Presentation of the general formulation of the scenario with clear definition of the objectives, basic type of resources, user groups, activities, requirements, preferences, motivation, needed and/or required information services along the learning process according to the various users, other required functionalities and information processes to be achieved.

Stage 4: Formalization of the scenario and presentation of the functionality required by the users via a combination of activities that can be carried out by the SINUS platform. For each activity the following information is defined: input and output data, user group performing the activity, steps leading to the accomplishment of the activity, information structures and tools needed for the development, and maintenance of resources supporting the activity.

Stage 5: Development of the scenario and definition of a minimal and an extended variant.

Stage 6: Determining of the basic requirements to the multimedia, semantic and learning resources supporting the use case scenario.

General formulation of the use case scenario of the SINUS platform and its versions

Overall objective of the scenario

The overall objective of this scenario is to describe the basic ways of exploitation (called *activities*) of the platform for technology-enhanced learning by the various types of users. For each activity the following components are defined: input and output data, users, the steps needed to accomplish the activity, the activity's information structures and tools.

Basic resources

The basic types of resources managed or provided by the SINUS platform are:

- Primary annotated digital resources – informational content and multimedia objects of the target learning domain. A main source of these resources is the *Virtual Encyclopedia of East-Christian Art*. For each resource a primary annotation is made in a specially developed scheme in XML format that includes Dublin Core descriptors and an indicator for the position of the media file in the digital library repository.
- Semantically annotated digital resources – primary annotated digital resources with additional semantic annotation according to the domain ontology of the selected learning area. They are kept in a repository for digital resources.
- Learning resources – combinations of indicators for one or more semantic digital resources accompanied by text commentaries and annotation according to the LOM standard. According to the

level of elaboration of the learning resources the author defines the corresponding appropriate user types. These resources are kept in a repository for learning resources.

- Semantic resources (ontologies) – domain ontologies developed in the frames of the project that describe the learning domain, the users and the learning methods used.
- Profiles of users – these are semantic metadata describing the knowledge about every user of learner type and thus building his profile. These metadata are determined by the domain ontology of user profiles. The profiles are kept in the repository for user profiles.

Users

The main user groups of the SINUS platform are the developers of various resources by means of the SINUS platform and the consumers of those learning resources.

Developers of various resources by means of the SINUS platform:

- Authors of semantic resources – develop and maintain the domain ontologies in the frames of the project: learning domain ontology[1], user profile ontology [2], ontology of the learning methods[3]. They are experts in the domains covered by the corresponding ontologies. The authors formally present the semantic resources by means of the ontological language of the project using a tool for creating ontologies provided by the SINUS platform. These users define a knowledge level[4], a symbol level[5] and an execution level[6] [Schreiber et al., 2000] of the ontologies created.
- Authors of semantic digital resources (annotators) – annotate and semantically index the primary annotated digital resources of the target learning domain by means of specific tool in the SINUS platform so as to make *semantic digital resources*. The procedure is the following: the annotators find a primary digital resource to be semantically annotated in the multimedia digital library *Virtual Encyclopedia of the East-Christian culture and art*; they select an appropriate domain ontology, annotate and keep the annotations in a specific *semantic annotation repository* for digital resources (repository of semantic digital resources). The annotators use a specific software tool for creating semantic annotations.
- *Authors of learning resources* – create reusable learning resources by means of specific tool in the SINUS platform. Each learning resource is presented as a combination of indicators for one or more semantic digital resources accompanied by text commentaries and annotation according to the LOM

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[1] *The learning domain ontology* is a domain ontology used for annotation and semantic indexing of digital resources. These resources are being taken from the multimedia digital library "Virtual encyclopedia of the East-Christian art" [Pavlova-Draganova et al., 2007b] [Staykova et al., 2007].

[2] *The user profile ontology* is utilized to create semantic metadata describing the level of knowledge and developing the personal profile of each user of the type *consumer of resources* [Paneva, 2006].

[3] *The ontology of the learning methods* is a domain ontology used to define the learning methods utilized in the process of technology enhanced learning in the frames of the project.

[4] *The knowledge level* determines the goal, range, use, level of formalization of the ontology and collection of data using different methods of extraction.

[5] *The symbol level* corresponds to the specification of categories, characteristics, rules, restrictions, individuals and their synonyms and facts in the ontology. The possible integrations with other ontologies could be examined on this level.

[6] *The execution level* – on this level the ontology is formally implemented on an ontological level and one could estimate its completeness, level of harmonization and rudimentarity.

standard. According to the level of elaboration of the learning resources the author defines the corresponding user types. These resources are kept in a repository for learning resources.

Consumers of learning resources in the SINUS platform:

- Academic users: students of various courses in the target learning domain – these users should be normally of medium or high level of knowledge in the target learning domain or should plan to use the SINUS platform to reach a high level in this domain. They actively search and use the learning resources being found to accomplish their learning goals – development of thematic projects, term projects, graduation works, preparation of analysis and analytic searches of various problems in the area, performing formal TEL education etc.
- Researchers in the target learning domain – the SINUS platform enable these users to search informational materials on specific themes related to their scientific work.
- Non-academic users – these users are not professionally involved in the target learning domain but have interest in it and want to introduce some basic parts of it. They have basic knowledge on search of resources specific for the Internet based environments and can use the SINUS platform to enrich their knowledge in the domain.

Motivation of the users

The basic motivation for the use of SINUS consists in:

- Achievement of the following main learning demands, summarized as follows:
- The academic users need additional specialized learning content with appropriate visual presentation. This content could be thematically organized or not, directly or indirectly related to the university subjects.
- The academic users need access to repositories with learning resources of high quality, which they could use in their projects, analysis, thematic discussions etc.
- The academic users need possibilities to make multicriteria search learning objects from the target learning domain, search with grouping of the results according to various values of the chosen criteria for search; consecutive filtering of the results etc.
- The researchers in the field need new resources of information materials and systematized results from serious studies, made by a specialist in the field.
- All the users need an environment providing them qualitative, well structured and adapted learning content according to their profile.
- The users want to have information about the actual state in the domain, to examine domain resources that cannot be reached in the standard way.
- The users want to be part of a community of interests and to communicate with each other.

Needed/wanted information services in the learning process according to the different user groups

When using the SINUS platform the users – developers of several types of resources are expecting the following:

- Authors of semantic resources: the SINUS platform to provide a software tool/editor for creation of ontologies. This tool should ensure the needed functionality for specification of the categories,

characteristics, rules, restrictions, individuals and facts in the ontology; development of annotation patterns for the different types of informational resources, such as: iconographical objects, object presenting an iconographic technique, object presenting an iconographic school and object presenting an author. To facilitate the exploitation of the software editor a self instructor or a usage manual should be provided.

- Authors of semantic resources (annotators): the SINUS platform to provide software tool/editor for creation of semantic annotations which should ensure:
  - Access to the library with the primary digital resources so that the annotators could find and choose an appropriate resource for annotation;
  - Access to available domain ontologies, possibility to select and preview the content of the selected ontology, its categories, characteristics, rules, facts and annotation patterns for the different types of objects, as well as the possibility to choose an appropriate annotation pattern;
  - Annotation and semantic indexing of the selected resource using an appropriate annotation pattern from the chosen ontology;
  - Possibility to save the created annotation in a semantic annotation repository;
  - Possibility for multiple reusability of the existing semantic annotations – description of similar objects preserved in the semantic annotation repository;
  - To facilitate the exploitation of the software editor a self instructor or a usage manual should be provided.
- Authors of learning resources: the SINUS platform to provide software tool/editor for creation of learning resources which should ensure:
  - Access to the semantic annotation repository and the possibility to search appropriate resources so as to be grouped for the creation of learning resources;
  - Possibility for arrangement of the selected digital resources and inclusion of explanatory text commentaries (notes – introductory, intermediate, concluding; analysis, etc.);
  - Possibility to indicate which descriptors of each digital resource in the platform should be visualized, e.g. author, technique used, present location of the artifact;
  - Possibility to indicate the level of appropriateness of a digital resource for the different types of users according to the degree of detail of the digital resource description;
  - Annotation according to the LOM standard of the resource created;
  - Possibility for multiple use of the existing LOM annotations – description of similar resources preserved in the learning resource repository;
  - Testing of the visualization feature in a real-use mode;
  - Possibility to choose a visualization pattern for the learning resource created;
  - Possibility to edit a selected visualization pattern;
  - Publishing of the selected learning resource in the learning resource repository;
  - Possibility to edit a selected learning resource, its content and LOM annotations;
  - Search and preview of the existing learning resources;
  - Identification of the status of the learning resource – finalized or in edit mode.

The users of learning resources expect:

- The SINUS platform to enable their interaction with the learning content: semantic search of web resources, preview and selection of learning resources, creation of collections of learning resources chosen by the user himself; inclusion of commentaries and notes to selected learning resources, sharing of selected learning resources with other users, etc.

Other requested functionalities – information processes to be achieved:

- Registration and profiling of the users
- Administration of the users, rights, etc;
- Attractive visualization of the resources;
- Navigation of the resources;
- Communication between the users, etc.;

A Real Situation to Demonstrate the Scenario for Exploitation

Title of the learning situation: Development of the project The Iconography of Christ in the Historical territories of Bulgaria.

Learning domain: East-Christian culture and art

Primary source of digital objects for the learning domain: the multimedia digital library "Virtual Encyclopedia of the East-Christian art" '

Users: developers of various resources by means of the SINUS platform and users of the learning resources.

General scenario situation: Professor Ivanov is a lecturer at the National Art School. He is delivering a course on Iconography for students of different classes of the Wall painting and art history departments and students of the Faculty of theology of Sofia University. To all his course members he has given the task to prepare a project on the *Iconography of Christ in the Historical territories of Bulgaria.* The learners are expected to make:

- analysis of the theological meaning of the Iconography of Christ;
- art critic analysis of the development of Christ's image in the different iconographical schools in Bulgaria;
- study of the main iconographic techniques used in the historical territories of Bulgaria
- depiction of an icon of Christ or of part of wall painting of one of the Lord's feasts.

This project supposes division of the students in several teams according to their interests:

- theological team
- art critic's team
- art technique's team
- artistic team

Preliminary preparation: Professor Ivanov and his team should prepare and provide to all of his students access to some additional learning resources of the East-Christian art domain for the implementation of this project. To enable a complex semantic-based search of these objects the team of professor Ivanov should provide their semantic descriptions according to the specifics of the approved domain terminology.

Version 1 of the learning situation:

Users: Developers of various resources by means of the SINUS platform and users of the learning resources

Use case 1: Creation of learning resources

Users: Authors of semantic digital resources, authors of learning resources

Description of use case 1: The team of Prof. Ivanov has access to the *Virtual Encyclopedia of East-Christian Art* through the semantic services of the SINUS platform that provides a wide range of primary annotated digital resources – digital copies of icons, iconographic objects of various iconographic schools, authors, periods of creation, iconographic technique etc. The selection of multimedia objects (images, text etc.) is made by means of the search tools of the digital library. The next step of the developers team is the semantic description of the selected objects by means of the domain ontology developed (*Ontology of the East-Christian art*) and its annotation patterns. The semantic annotations of the digital resources are kept in a specific repository for semantic annotations. The authors of learning objects have access to this repository and use the services for searching, visualization, adding, deleting and editing of the digital objects. The authors of learning resources are annotating each selected digital object according to the LOM standard, describing the learning content and the learning situation in the context of the SINUS project.

Use case 2: Creation of semantic resources

Users: Authors of semantic resources

Description of use case 2: The semantic resource to be developed by Prof. Ivanov and his team by means of the SINUS platform is the domain ontology – *Ontology of the East-Christian Art*. Prof. Ivanov's team is responsible only for its formal description in ontological language. The conceptual level of the ontology is developed by a wide team of domain specialists.

Use case 3: Finding of appropriate learning resources

Users: Users of learning resources

Description of use case 3: In the frames of the proposed project Prof. Ivanov sets to the different workgroups the following concrete tasks:

1. to make an analysis of the theological meaning of the iconography of Christ (the theological team);
2. to make an art critic's analysis of the chronological development of the iconography of the iconography of Christ in the different iconographic schools in Bulgaria (art critic's team);
3. to examine the main iconographic techniques used in the best Bulgarian examples of iconography of Christ (the art technique team);
4. to make an icon of Christ or a part of a mural painting depicting one of the Christ's feasts (art team);

The members of the different teams are expected to make a number of semantic based searches in order to prepare their own analysis. For example:

- *General task:* Find all the iconographic artifacts in the SINUS platform containing the image of Christ.

  Main goals:

  - Studying the main iconographic scenes containing the image of Christ, so that it is needed its theological meaning to be analyzed and/or
  - Studying the theological meaning of the various symbols and signs in the different iconographic scenes.

- *General task:* Find iconographical artifacts, containing the image of Christ, from different periods.

  Main goal:

  - Defining the specific periodization in the depiction of the image of Christ (having in mind that it is independent and does not coincide with the periodization by centuries)
  - This goal may be achieved by repeated search and selection of objects.

    Step 1: One should start with *search* and *preview* of objects by/from century/centuries;

    Step 2: *Search* and *grouping* according to the iconographic schools should be made in the resulting set;

    Step 3: Search and grouping of the objects according to *part of century* they belong to, follows; Afterwards one should select iconographic objects similar in style.

    Step 4: Presentation of the search results and grouping of the objects according to the new periodization.

- *General task:* Find all the iconographic artifacts in the SINUS platform containing the image of Christ and compare their specifics from technological point of view.

  Main goals:

  - Comparison of different iconographic techniques, study on the periods of prevalent use of the different techniques, estimation of the performance quality, etc.

    This goal may be achieved by the finding of artifacts made using a single technique, others – with combined techniques. One should then perform searching and grouping in the resulting sets of objects according to the time frame and the iconographic school. One could also group the objects according to the different technological characteristics, such as: base, couch, varnish.

Version 2 of the learning situation:

Users: developers of various resources by means of the SINUS platform and the consumers of those learning resources

Version 2 of the learning situation includes *Use case 1* and *Use case 3* of Version 1. The following extension is added to *Use case* 2:

Use case 2.1.: Creating a semantic resource for profiling of the learning resources consumer

Users: authors of semantic resources

Description of use case 2.1: Professor Ivanov and his team develop an ontology describing learners' educational level in order to enable the automatic setting of tasks to the learners according to their educational level, experience and interests.

Use case 2.2.: Determination and integration in the platform of rules for automatic comparison of certain concrete tasks for comparative analysis of learning resources consumers with a certain profile.

Users: authors of learning resources

Description of use case 2.2: Professor Ivanov and his team include in the platform rules for comparison of concrete tasks with a relative user profile. These rules and concrete tasks are determined on the bases of the

team's professional experience in the learning domain and more specifically in the work with students with different capacity, knowledge, learning goals, etc.

Use case 2.3.: Selection and inclusion in the platform of concrete tasks in the frames of the project *the Iconography of Christ in the Historical territories of Bulgaria.*

Users: authors of learning resources

Description of use case 2.3: Professor Ivanov and his team include in the platform a number of concrete tasks in the frames of the proposed project (see the examples in Use case 3 of Version 1 of the learning situation)

Use case 2.4.: Profiling of learning resources users and providing concrete tasks in the frames of the project *the Iconography of Christ in the Historical territories of Bulgaria*

Users: users of learning resources

Description of use case 2.4: The users register themselves in the platform and fill up a questionnaire, so that their profile to be specified according to the *User profiles ontology*. Each user receives as a result a concrete task from the platform corresponding to a greater extent to his profile

Version 3 of the learning situation

Users: developers of various resources by means of the SINUS platform and the consumers of learning resources

Version 3 of the learning situation includes *Use case 1* and *Use case 2* of Version 1

Use case 3: Learning course development

Users: authors and users of learning resources

Description of use case 3: The analysis prepared by the theological, art critic's and art technique teams should be provided to the artistic team as instructions for the examination of the final task in the project - depiction of an icon of Christ or of a part of wall painting of one of the Lord's feast. The students, helped by professor Ivanov and his team, prepare a complete learning module consisting mainly of the thematic teams' analysis developed within the platform.

Conclusion

The appearing new generation of information technologies is gradually alienated from the software as a basic term and starts to consider all the information resources as services in service-oriented architectures. What is meaningful for the user in the world of informational services is the service itself and not the software and hardware components behind it. The development of a use case scenario an determination of the specific requirements for the different components of the SINUS platform are supporting considerably the design of such a service-oriented architecture, as well as the determination of the functional specifications of the services provided by the platform, the needed informational services, methods and operations on the different levels of exploitation, the users and their activities, etc. One could plan on the basis of the use case scenario the testing and the evaluation of the platform and its components, as well as the functionality and the multiple reusability of the selected project approach.

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