INTEGRATION OF ONTOLOGY IN DISTANCE LEARNING SYSTEMS
Models, Methods and Applications

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Abstract: Semantic web technologies, including domain ontologies, can enhance possibilities and functionality of traditional Web systems. The problem is that these technologies are not fully adopted yet to bring benefits to final users. We analyse the oppurtunities to integrate domain ontologies into typical learning management systems in order to gain some automation or support from the system in frequent and time consuming jobs, which are performed by students and academic staff in ourdays systems. The main aim of our research is to propose a methodology for the development of the distance learning course domain ontology and its integration into the distance learning systems. In this paper, we present our research directions and proposed solutions. Furthermore, we pay here more attention to learning scenarios, which we design considering the proposed methodology and the particular learning manamement system – MOODLE – in mind.

1 INTRODUCTION

Semantic web technologies, including domain ontologies, can enhance possibilities and functionality of traditional Web. For example, Davis (2007) characterises the business value of semantic technologies in five critical areas:

- Development – automation in different development steps;
- Infrastructure – enablement and orchestration of core resources;
- Information – semantic interoperability of information and applications in real context;
- Knowledge – knowledge work automation and supporting knowledge workers;
- Behaviour – systems knows what they are doing.

Obviously, the technology itself provides only with increased possibilities. Therefore, methods, frameworks and tools are necessary for realising practically all mentioned aims. The problem is that there are no enough results in using these technologies, which brings benefits to final users.

Semantic web technologies are usefull in any knowledge intensive area. We restrict ourselves with e-learning domain, where Semantic web technologies – ontologies, agents, web services – are also employed and intensive researches are carried in this field (Alsultanny, 2006; Stojanovic *et al.*, 2001).

The topics of ontology engineering are comprehensively described in (Devedzic, 2002; Corcho *et al.*, 2007), including methods and methodologies for the development of ontologies, ontology development process and lifecycle, ontology tools and languages.

Several authors analyse and develop domain ontologies for specific topics in e-Learning (Sosnovsky & Gavrilova, 2006; Angelova *et al.*, 2004). Other papers deal with domain frameworks or recommendations for ontology development (Gavrilova *et al.*, 2005; Boyce & Pahl, 2007). After the analysis of scientific literature, we separate two types of approaches to the use of ontology in e-Learning system:

1) Ontology is used at development time. Automation and reuse are in the main focus (Ateveh & Lockemann, 2006; Karampiperis & Sampson, 2005; Valkeapää *et al.*, 2007). Here as *development* we consider the development of particular study courses or their elements. Also it would be very advantageous to actually use ontologies while designing and developing e-Learning systems, and later seeking for their interoperability. Such development process is called an ontology-driven development of information system, as in (Guarino,

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1998). But we have not found any comprehensive research results in this field.

2) Ontology is used at run time. Users' support is in the main focus and ontology is understood mainly as shared knowledge source and the mean for achieving personalisation (see, for example, Angelova *et al.*, 2004).

In this paper, we present our research directions and proposed solutions for the development of the distance learning course domain ontology and scenarios for ontology application in the distance learning system.

2 RESEARCH PROBLEM

We have practical experience in designing and delivering distance study courses (DSC) for more than 6 years. Also one of our functions is to support academic staff in these processes. So the problems, which are formulated here, arise not only from scientific analysis but also from our social experience. Here we clearly state and analyse some problems, which we are seeking at least partially to solve. The purposes, which we are striving to achieve, are:

- ***Increasing effectiveness of workload.*** Not only the efficiency of the system, but also the efficiency of activities of its user, both lecturer and student is actually important. Students need different kinds of support: technical, administrative, subject oriented, motivational. In order to achieve good learning results, a significant amount of workload time of instructors is necessary. The ontology-based description of required knowledge is a prerequisite while seeking to shift a part of the student-instructor collaboration processes into the student-study material level. Therefore, some functions can be detached from an instructor and attached to a computer system. It is important to pick for transfer time-intensive, frequently repeated, maybe not complicated functions. In this way, efficiency will be increased on the organisational level, too. There is a misleading opinion that self-supporting studies usually happen effectively. For this type of studies people with very strong motivation are necessary. Despite of very large amount of information, it is difficult to find, what is useful. Therefore ontologies and software components, for example agents, allow us to present study material in a convenient way for a learner, avoiding information overload, adapting study material to the learning style of learner, readiness of a learner. In practice, learning scenarios can be generated and thus personalised learning implemented. This fact resounds modern ideas of individualised learning.
- ***Increasing of satisfaction***. Achievements of students depend on their satisfaction during gaining learning experience, too. Students meet modern web technologies in daily life; therefore, they also expect them in delivering modern curriculum.
- ***Adaptivity in dynamic context***. Adaptive systems are concerned as systems, which offer dynamically built and automatically performed personalisation. Learning materials perform changes in time. New learning objects come; some resources replace the other, some supplement. The cost of preparing DSC is conditional big in relation with DSC delivery. Therefore, we need DSC, which can be reused in different context.

Relevant problems are analysed in (Dignum & Dignum, 2003) and the objectives of knowledge management technologies, considering ontology modelling is one of them, are stated as follows:

- Assist people to generate and apply "just in time" and "just enough" knowledge, prevent information overload and stimulate sharing of relevant knowledge in a dynamic, collaborative environment.
- Preserve individual autonomy and contribute to the creation of an atmosphere of trust between participants.

Summarising, we can state that the same problems exist in different subject domains, not only in e-Learning, where users' work intensively with big amount of information. Therefore, supposed business value of spreading semantic web technologies, including ontologies, concerns better support for user in information-intensive environments, such as e-Learning systems.

Our selected problem domain is e-Learning, which, strictly speaking, covers participants and their performed activities. Our solution domain concerns ontology modelling/engineering and application. The goal, expressed abstractly, is to achieve better performance. Therefore, we begin our analysis from two directions:

1) Analysis of the problems in modern e-Learning environments, concerning data/information/knowledge resources used and processes, in which knowledge management appear.

The purpose of this part is extraction of possibilities for qualitative or quantitative change.

2) Analysis of technologies, tools, and methodologies, concerning ontology modelling/engineering; design of framework for change; design of scenarios for innovative use in e-Learning setting.

Our research object is integration of domain ontology into the e-Learning system. The objectives of our research are the following:

- to analyse and compare known approaches to ontology modelling/engineering related to the development and improvement of virtual learning environments (VLE);
- to analyse the ontology quality criteria and the ontology evaluation methods;
- to propose a methodology for the development of the distance learning course domain ontology and its integration into the distance learning systems;
- to propose an ontology quality evaluation model for the distance learning domain;
- to develop an experimental domain ontology for the distance learning course using the proposed methodology;
- to integrate the domain ontology into the existing VLE;
- to propose learning scenarios based on the developed ontology;
- to evaluate the quality of the developed domain ontology and its use.

Research hypothesis: we expect that extending LMS with domain ontology will increase tool functionality, provide more capabilities for effective learning and self-learning, and allow for rapid prototyping of DSC.

3 PROPOSED SOLUTIONS AND RESEARCH DIRECTIONS

3.1 What Have Been Done

3.1.1 Multi-layered Architecture of e-Learning System Proposed

The multi-layered architecture of the distance learning system, introduced by us in (Dzemydiene *et al.*, 2006), integrates components from the common LMS and extends it with intelligent components by the means of two architectural layers: 1) Intelligent layer – intelligent decision support components, which must act as a mediator between the core LMS elements and different types of user interfaces; 2) Deeper knowledge layer – domain, users', learning designs' ontologies, which can act as foundation for adaptive educational sequencing. Further, we restrict ourselves with domain ontology as a tool for reuse on the subject knowledge and a mean for automating some tasks. And differently from solutions, where semantically enriched systems are developed from scratch, as, for example, in our experiment (Tankeleviciene & Sakalauskas, 2008), we tend to use a great functionality of modern LMS.

3.1.2 Development of Domain Ontology Analysed

Development of domain ontology was analysed in (Dzemydiene & Tankeleviciene, 2008a). As ontology is "a conceptual specification that describes knowledge about a domain in a manner that is independent of epistemic states and state of affairs" (Guizzardi, 2007), it can be treated as a universal model of domain. Therefore, in the context of e-Learning, we can distinguish: 1) ***Domain level***, which concerns the domain knowledge. 2) ***Course level***, which concerns the practical implementation of e-Learning. The course consists of a set of learning resources, including both teaching/learning materials and activities. 3) ***Technological level***, which deals with learning objects (LO) and information objects. Such framework allows us also to distinguish between domain engineering and course engineering. Therefore reuse can be employed on a higher level.

In our approach we argue for:

1) Manual ontology development. Despite of the fact, that there are still much heuristics in the development of domain ontology manually, it remains still the best approach to the development of ontology of high quality. In the near future we have plans to experiment with semi-automatic methods for ontology (or its base - taxonomy) development, because this task is very time consuming.

2) Real schema-based ontology. The differences between schema-based ontology and topic-based ontology are explained in (Kiryakov, 2006). The author accentuates the possibility to formalise the domain while using a set-theoretical model and set theoretical operations. We choose schema-ontology for capturing subject domain knowledge, because: a) It better corresponds with our understanding of the concept of ontology; b) It deals with formal or semiformal representation, and it represents a top-down systematic approach; c) It better fits in our instructor-led e-Learning context.

3.1.3 Reasoning Over Ontology Elements Analysed

As ontologies are static knowledge resources, we need active components for performing the tasks. The concept, possibilities, types and implementations of reasoning over ontology were analysed in (Dzemydiene & Tankeleviciene, 2008b). Also in this paper the framework for conceptual linking of educational resources, based on reasoning over domain ontology elements, was proposed.

In our approach we argue for:

1) Query-based reasoning, because it is simpler and more efficient than logic-based reasoning. We choose hybrid information systems, where current web technologies and ontology engineering are combined.

2) The necessity to implement simpler reasoning mechanisms over domain ontology in order to support learner in simple tasks. We strive to achieve better trade-off between control and self-responsibility; therefore, conceptual linking of educational resources and displaying different ways of reaching the learning goal correspond to our pedagogical viewpoint.

3.2 Ways for Extending MOODLE with New Functionality

For our practical experiments MOODLE (http://www.moodle.org/) was chosen. MOODLE is a free Learning Management System (LMS) for offering DSC. The main part of DSC is usually composed from topics (see Fig. 1 in the middle). For each topic instructor can define resources and activities. In our MOODLE version (1.9.2+, last build 2008.09.17) there are the following types of resources: a) Label; b) Text page; c) Web page; d) Link to a file or a web site; e) Directory display; f) IMS content package.

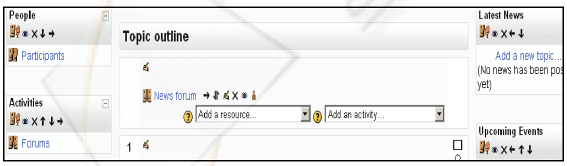

Figure 1: A part of MOODLE environment in the editing mode.

The same version by default offers the following activity types: a) Assignments; b) Chat; c) Choice; d) Database; e) Forum; f) Glossary; g) Lesson; h) Quiz; i) SCORM/AICC; j) Survey; k) Wiki.

The right and left hand sides of the DSC page (see Fig. 1) include blocks that display various information. Instructor can choose what blocks to display; some of the most popular blocks are: Latest News, Upcoming Events, Calendar, Participants.

All these elements – resources, activities and blocks – provide students with 1) transferring of knowledge in different forms and in different ways; 2) active participation in learning activities. The constructivist viewpoint towards learning especially emphasizes the importance of active participation in ones own development. For this purpose a great level of interactivity must be implemented. Here *interaction* means primarily the communication between the user and the system. Interactivity is one of the criteria or indicators showing quality of distance studies (Karoulis & Pombortsis, 2003). These authors emphasize interactivity with the instructional material, which is described as navigational fidelity, multimedia components, multiple kinds of exercises, facilitation of the active interaction, support for collaborative work and group dynamics. Students' support is formulated as other indicator and it concerns guidance and encouragement of the student both from the instructional material and from the communication channels, accessibility to the tutor, instructional organisation.

Since MOODLE is an open sourced system, there are quite many possibilities to extend its functionality. We can use third party plug-ins or develop them ourselves; also we can modify existing elements of a system. Basically modifiable elements are:

- Modules. They define new learning activities.
- Blocks. Usually they provide extra information or support for students.
- Inner elements of some module. For example, question types in Quiz module.

We have found very few efforts to integrate MOODLE and Semantic web technologies (Lukichev *et al.*, 2007; Diaconescu *et al.*, 2008).

3.3 Outline of Experiments

After analysis of semantic web technologies and particular LMS architecture, we have decided to proceed with experiments in the following areas:

1) ***Visualisation of domain structure***. A tag cloud as user interface design pattern is planned to be used. Protégé has plug-in ***Cloud Views*** (http://protegewiki.stanford.edu/index.php/Cloud_Views), which allows to visualise ontology as a tag cloud, but this plug-in don't support yet the export

of prepared tag cloud. Also we could use some tag clouds generator, but in this way visualisation of the domain will be pre-delivered as the DSC starts. Our idea is to support dynamical linking between domain ontology and its visual representation. We think ***Classes by usage*** is the best way to accentuate more important concepts (also we can calculate siblings, descendants, etc.).

2) ***Navigational support***. The scenario for providing navigational support is provided by us in (Dzemydiene & Tankeleviciene, 2008b). Briefly it consist from several steps: 1) Requested resource is displayed; 2) The position of the requested resource in the predefined by lecturer course structure is displayed; 3) Reasoning over domain ontology and mappings between ontology concepts and resources is conducted; 4) Links to resources of possible interest are generated and displayed. The problem in implementing this algorithm is related with the definition of current state, i.e., the position of the particular resource in overall course structure. The other problem concerns universality of semantical linking. We can't know in advance the possible intensions of such linking. Therefore, we restrict ourselves with main linking patterns: 1) Finding all child concepts; 2) Finding all siblings; 3) Finding all instances; etc.

For these first two scenarios, the standard MOODLE HTML block is planned to override. HTML block provides an HTML editor for formatting text. Also we can integrate images and other elements, for example, Flash moves. The differences in functionality is that the content of visualisation block is generated once, when student logs into DSC, and the content of navigational support block must be generated on every change of resource (*resource view* record in log file).

3) ***Semi-automatic generation of test questions and their answers***. The possibility to append new question type in Quiz module is foreseen. This module provides templates for editing questions and their answers. We are seeking to implement the support in development of questions by the means of suggesting ontology components, for example, labels of classes, and names of instances or relations. We plan to use the following question types: 1) Multiple choice – where one or more true answers are must be chosen; 2) Short answer – where people must type a word; 3) Matching – where relations between elements in two column must be found.

4 CONCLUSIONS AND FUTURE WORK

Semantic web technologies are rapidly evolutioning, therefore, it is a great demand for analysis of the latest achievements and striving to use them in existing solutions – information systems from different fields.

The approach to using domain ontology in the development and delivery of educational resources enables automating these processes, increasing adaptivity and personalisation. Scenarios for those tasks are foreseen. The first two scenarios for ontology usage are more oriented towards learner satisfaction and higher learning effectiveness, because they introduce learners to domain space and provide more possibilities for personal navigation. The third scenario is oriented towards automation of workload of academic staff. The main shortcoming of this approach is that it requires large efforts of humans at initial stage, and we will benefit from this approach only after its repeatable reuse, but, on the other hand, this problem concerns distance studies and e-Learning in general, too.

In order to evaluate the proposed methodology and designed learning scenarios, we shall implement and test these scenarios in a particular LMS.

Our future research work also will focus on the analysis and formulation of the detailed list of the semantical linking patterns, derivation of possible patterns of test questions from semantical linking patterns, and implementation of experimental tools for realisation of these patterns.

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