Adaptive Open Corpus E-Learning and Authoring, Using Collaborative Ontology Learning

Tatyana Ivanova*
* Technical University of Sofia, College of Energy and Electronics, Botevgrad,
tiv72@abv.bg

***Abstract*—Adaptive e-learning systems are better for achieving many learning goals, but adaptive content development is more difficult and expencive. The open-corpus model enable use and reuse of many external resources to facilitate development process and ensure well-organized actual and personalized learning content. The main idea of this paper is controlled extension of previously developed by professionals learning course in the learning process by learners. We propose conceptual model and evaluation example of adaptive e-learning system, including easy-to-use tools, allowing users to find needed in the learning process external content and adding them as semantically described new learning resources in the system. The added content may be then checked and changed by other users – learners or teachers. The system propose tools not only for finding, manipulation, annotation and organization of the new content, but it ensure the enrichment of it described schema (ontology) by using interactive ontology learning.**

I. INTRODUCTION

IMS Learning Design (IMS LD) specification has recognized as leading standard in e-learning. A large number of systems and tools for creation, publication and usage of units of learning have been developed (Moodle, Sakai, LAMS etc.). These tools facilitate student's access to learning content and activities, using Educational Modeling Languages (EML) to describe *from a pedagogic point of view* the learning design of courses. Standartization, description of learning content by usage of structured metadata, professional development of learning content and severe guidance of the learning process by professional pedagogs are in the basis of IMS – based E-learning. Despite of all this enormous and well-done work, they are not universally used, there are many learning courses, that don't use them, and many research projects, searching better solutions. Main drawbacks of standard IMS – based learning systems are:

- insufficient expressiveness of underlined XML-Schema- based metadata model;
- IMS systems are directed to the average student. Personalization capabilities are limited and rarely used;
- current pedagogical practice is still teacher-centric. The process of education is primarily institution-centric, rather than learner centric;
- the LMS is not open to activities occurring outside its realm. No support of using resources or contacts outside the system, time and labor – consuming updating of internal learning content;
- in the IMS systems supporting collaboration and communication is limited.

There are two main approaches to improve the quality of e-learning systems: by enrichment of LMS – based systems (by adding additional metadata and intelligence in structure and processing) [3], [6] and by using new open and learner – centric educational model [2]. Many projects have been developed in the last years to overcome the IMS – based system limitations by adding intelligent and semantic web technologies[1], [5], [6]. The results show some improvement, but shortcomes in communication and collaboration are still persistent. Using semantic technologies is usually domain and language specific and requires doing much specific knowledge – representation tack before achieving quality improvement. To investigate the open, Web – based educational model, several PLE (Personal Learning Environment) systems have been developed and tested [4]. Results show that they present successful solving of communication and collaboration problems, but new problems, related to quality of learning and interface usage problems have been arisen.

We believe that flexible combination of these two approaches according to learning specifics and goals are needed for development of good e-learning system. In this paper we propose conceptual model and run testing example of adaptive e-learning system, including easy-to-use tools, allowing users to find needed in the learning process external content and adding them as semantically described new learning resources in the system. The added content may be then checked and changed by other users – learners or teachers. The system propose tools not only for finding, manipulation, annotation and organization of the new content, but it ensure the enrichment of it described schema (ontology) by using interactive ontology learning.

II. E-LEARNING AND AUTHORING SYSTEM ARCHITECTURE

Our system architecture includes loosely-coupled tools for learning, teaching and authoring, proposed as

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services. It may be used in personal learning environment to ensure the arrangement of different personalized views for different users. They are intended to facilitate learning and authoring, as well as working with semantically-organized resource metadata. The system architecture is open (internet communications for finding external resources are assumed), and layered. It include four layers: User interface layer, providing interfaces for learners or teachers, Service layer, including all proposed services, Metadata and knowledge layer, and e-learning resources layer (Figure 1). The main resource development strategy assumes professionals first develop the most important learning resources for the course (Base e-learning resources layer), it semantic structure and semantic tools, and then learners are expected to use these tools to enhance learning course according ti his specific educational needs.

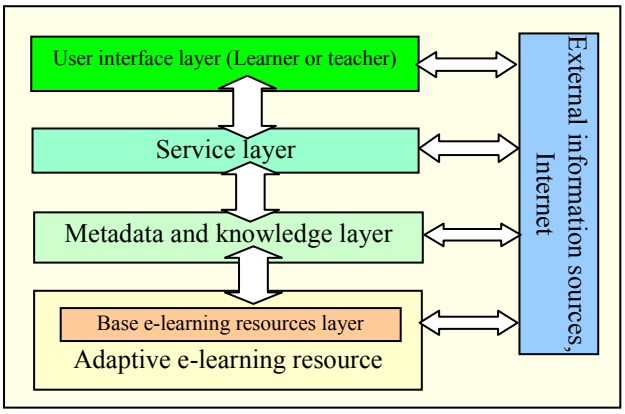

Figure 1. Adaptive e-learning and authoring system architecture

A. *User Interface Layer*

It provides interfaces to ensure easily usage of learning, teaching, e-learning resource authoring and metadata and ontology management by non-professionals (learners or teachers). This includes personalized resource recommender, ontology visualization tool, query disambiguation tool, tool, helping in interactive formal specification of the concept semantic (for supporting ontology learning process). As user may wish to use only some of the proposed tools, and different users may prefer different tools, the system should propose a also a tool for arrangement of chosen interface elements in personal working area of every user (similar to the PLE).

B. *Service layer*

The service layer includes implementation of all valuable software components, implementing the min system functionality. The system requires registration and authorized login to control the quality of the developed resources. That is why User profiles management tool is required. In case of any change in learning resources, information about this (who, and when this ss made) is stored for future analysis. Resource development is carried out by a specialized tool for this purpose (Figure 2). It sends queries outside the system (usually in the internet) for necessary resources, then calls the tools for analysis of returned results metadata, or analysis of the resources themselves (based ontologies, thezauruses, or templates, available in the system), call the ontology learning or mapping tools when needed. Currently, our system can analyze only HTML and plain text resources. Annotation tool analyze the document, determine it structure and components, using document structure ontology, may break them in smaller parts, supply parts with the required metadata and propose them to the E-learning resource development as potential further learning resources.

When new resource has been added to the system, it may be related to the concept or property, not currently presented in the domain ontology, but being in potential interest for students. In order to guarantee opportunities for expanding and deepening the larner's knowledge and support qualified semantic description of educational materials, sometimes extension of course domain ontology, in the process of training is needed. This is performed by ontology learning tool. This tool may interact to the learner, asking him about the semantic of the consept, for which he/she search learning materials(if this consept not previously included in domain ontology), and use the answers to detetermine properties and relationships of the new consept to ensure ading them in ontology. Domain thesauruses, other ontologies, or linguistic analysis of learning resources also may be used in the ontology learning process.

The Tool for developing learning resources reseive user queries, describing it needs from new learning resources, choose development strategy and query other servises for performing semantic search lexical, syntactic and semantic analysis of textual resources, classification, annotation, breaking into smaller parts, mapping or enrichment of domain ontologies (Figure 2).

All these tools are provided as a service. For the

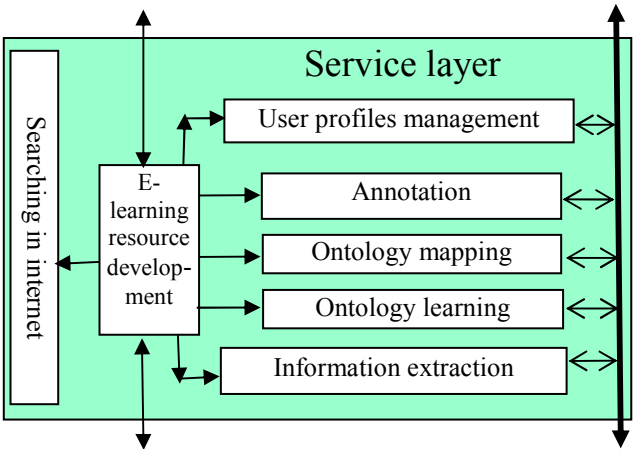

Figure 2. Main components of the service layer

overall organization of the system service-oriented architecture is used. This ensures communication compatibility and modularity at the level of communication with other systems.

C. Knowledge and metadata layer

The metadata (knowledge) level contains both semantic metadata to ensure the process of developing resources and implemented methods and algorithms for their use. Ontological representation of metadata guarantee both storing the semantic of metadata and computational reasoning on this base. To describe various characteristics of the learning materials and learning process, several ontologies are used (Figure 3): Learning content ontology, Upper domain ontology, Document structure ontology, Learner profile ontology, Learning goals ontology.

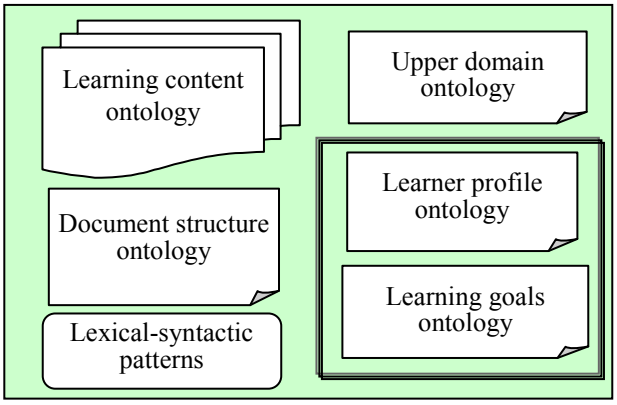

Figure 3. Knowledge and metadata layer

Learning content ontology is previously developed for each course. Therefore the system can include several such ontologies. Each of them represents essential cource domain terms and it relationships in needed granularity. In these ontologies parts of definitions and properties of learned concepts are explicitly represented in machine processable way. Every found online resource should be evaluated on the basis of those ontologies in two aspects: whether it include connections between the concepts presented in the ontology and if it contains links between some concepts that might enrich the ontology. The existence of concepts and links in the resource presented in the Learning content ontology is a criterion for thematic proximity of the resource to the course content and the presence of some new concepts and relationships offer the potential to broaden and deepen learner's knowledge. When new resources are added dynamically during learning process, they may contain consepts or relations, not included in the domain ontology. In this case, ontology learning tool analyze relations of these entities to the entities in domain ontolgy, using pattern – based text analycis and existing system ontologies and tezauruses and propose to the user through graphical interface some presumptions about possible relations. If user confirm some of them, they are added to the domain ontology. In such a way, interactive ontology learning process is performed.

Document structure ontology is used for classification of resources according to what media (text, video, audio) they contain, what accompanying metadata include (for example, information about the author, layout, use of documents (for detailed study, to define in practice .. .) or according to their style (popular science). Depending on the type of resource it could be used as part of a training sequence in a specific place for a particular purpose or user.

Upper domain ontology is useful in many cases for identifying closely-related domains, and making rapid conclusions if returned material may be in potential interest, or not. It also is used when for finding interdomain relationships, and in some other cases.

Pedagogically-rich ontologies as Learner profile ontology or Learning goals ontology include knowledge about the learner, or pedagogy, needed for optimal organization of the learning and teaching process, or supporting development of the high quality learning resources. Learner profile ontology may contain classifications of learning styles, learning problems of the groups of learners, that can be used for annotation of resources according to the learner type, for which they are designed

Lexical - syntactic patterns are important in the machine analysis of natural language text to automation of the processes of learning resource development. They can be used in conjunction with semantic knowledge represented in ontologies in the process of identification and categorization of text resources.

D. Learning resource layer

The level of educational resources include developed resources repository. The main resource development strategy assumes professionals first develop the most important learning resources for the course (Base e-learning resources layer), and then learners are expected to enrich learning course materials in the learning process according to his specific educational needs. The main goal is to achieve the maximum possible degree of automation using metadata and semantic web technologies. The main source of materials for resource development is internet, and search engines are used to find needed web resources.

III. TESTING EXAMPLE – DEVELOPMENT AND EXTENSION OF E-LEARNING COURSE IN PROGRAMMING ENVIRONMENTS

Motivation of this work comes primarily from practice. We first have developed a small system for to assist students in lerrning programming environments, then increase it functionality and flexibility, adding semantic representation of metadata, and semantic tools. Finally we develop an above model to explain it architecture from more abstract point of view, make general conclussions and discuss possibilities for use this architecture in other domain or other learning scenarios. For initial resource development we use HTML and JavaScript. Then we divide large resources intended to support learning MFC programming to smaller parts and present new course organization, using terminology

classification by developing OWL ontology. Initial version of this ontology is shown on Fig. 4.

Writing effective working programs, using MFC require excellent knowledge and programming skills in basic C programming and object – oriented programming. Our students are studying these courses, but some of them proved to have significant gaps that need to fill, seeking materials from various sources, which takes a long time. To cope with this problem, we use Java servlets and Tomcat to add some assistence in

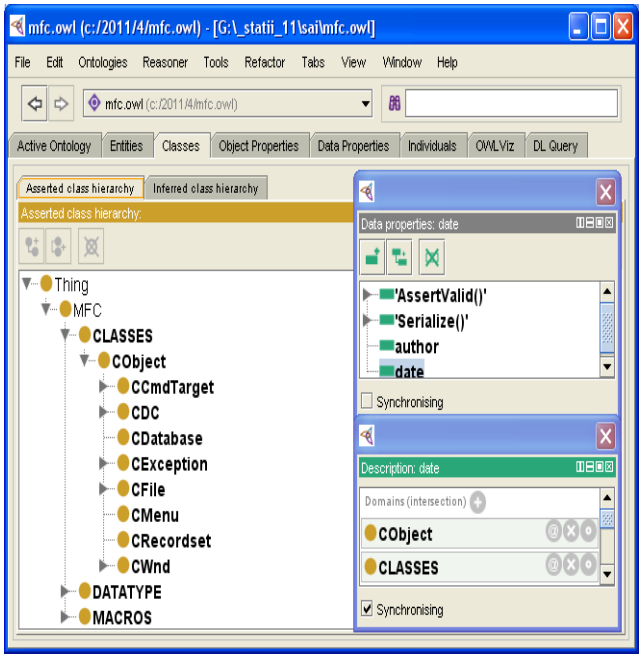

Figure 4. Initial version of domain ontology

writing clear and unambiguous queries for effective web search, Java and WordNet libraries for development of tools, making lexico-synthactic text analysis, Jena and Protégé API for development of ontology – based annotation tool, omtology mapping and ontology learning tool. Really, this take a lot of time, but not so much, because we have found a lot of free source code, writing in Java, and it modification comes sgnificantly easy, than writing all code from scrach. We write only initial working versions of these tools and run them on our small example. On the future, they may be optimized, if better performanse or precision are required. Despite of fact, that programs are written and used in the domain of programming environment, the main part of softwere is domain – independent, and after after minor changes may be used in learning systems for other domains. Only initial version of MFC ontology must be completely replaced by the semantic description of the terminology of the other learning domain.

In the interactive ontology learning process to facilitate domain ontology enrichment we use Web information sources: Glossary of Programming Terms Used in C++ (http://www.steveheller.com/ glossary.htm) and http://www.abbreviations.com/. To extract needed relationships ftom the first resource, we use lexico-synthactic patterns. The second resource is useful in determining the possible meaning of abbreviations, sa they are frequently used in the programming and computer science domain.

IV. RESULTS AND STUDENT'S OPINION

We evaluate our system by proposing it to the students, write all them activity and analyze it after finishing the course of programming environment and examination. On fig. 5 the screenshot of the domain ontology at the end of the course, opened in protégé is shown.

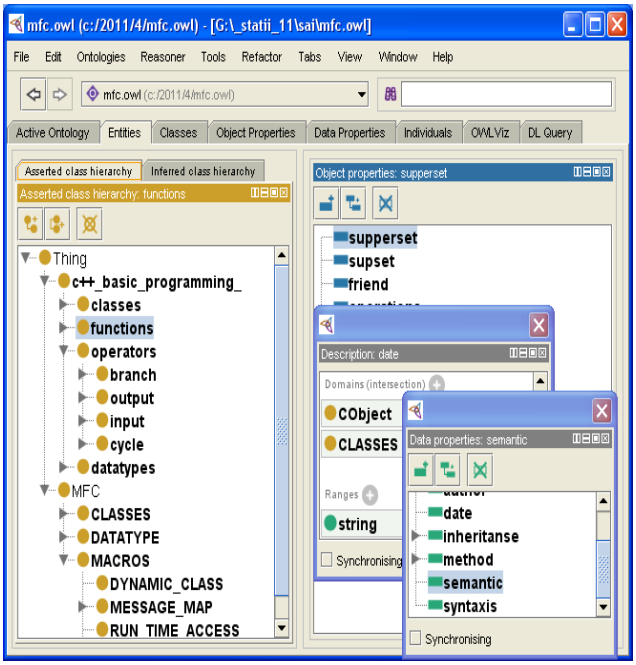

Figure 5. Domain ontology at the end of course

29 of all our 41 students (71%) are participated in adaptive resource development or ussage of developed by other student resource process. Individual participation of every of these students is illustrated on Fig. 6, where are sorted by final examination results. 19 students (46%) participate in interactive semiautomatic ontology

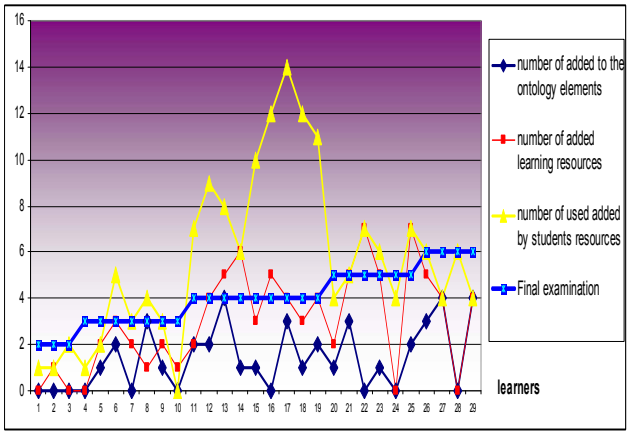

Figure 6. Student's results, resource development and usage

development, adding 41 entities. 87 new adaptive

learning resources are added, mainly to support revision of studied before material.

As may be seen on fig. 6, the most frequent usage of adaptive resources is in group of students, achieving good results. This can be explained by the fact, that they are hardworking, but have some gaps in previous training. For teaching this group, such adaptive e-learning system is the most useful, because excelent students have lower need in searching remembering resources, and weak students doesn't work very hard (may be). Excellent students use at average 5 adaptive resources each. At about a half of these materials discuss knowledge, out of range of previously attended courses.

To obtain student opinion about the system and its features, we present a non-mandatory questionnaire at the end of the course. 37 of our 41 students filled in the questionnaire. 98.% of them were active users. Overall results are illustrated in Figure 7. 96% of the students agree that adaptive resources are useful in learning. 12 % agree that ontologies are useful in learning, but 70% find difficult ontology development. Having in mind the fact, that we present an interactive ontology development interface, maximally hiding the details of knowledge representation, we conclude, that courses on working with knowledge and representing data at semantic level (using semantic web technologies and machine reasoning are needed to be included in the university education to make these modern and perspective technologies more understandable for educated peoples.

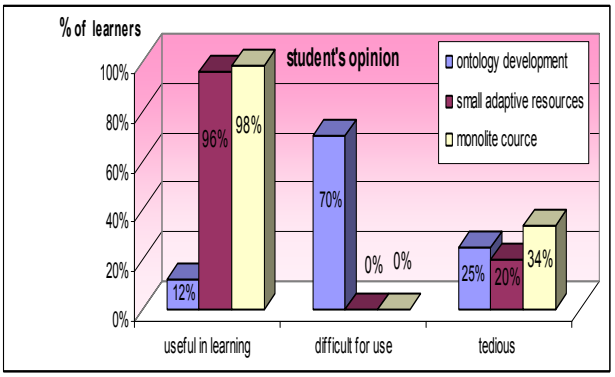

Figure 7. Student's opinion

V. CONCLUSION

In this paper we present an adaptive e-learning resource parallel usage and enrichment approach, based on semantic technologies. Our approach successfully combines professional e-learning resource development and collaborative personalized enrichment at the stage of it usage. Adding of new resources to the e-learning course in general leads to usage of extra concepts or relations that are not included in the domain ontology, describing the course semantic. That is who if we give to the students the opportunity to add new teaching materials in the course, we should provide tools to automatize their semantic description (semantic annotation) and to extend the course schemma (adding new concepts in the domain ontology). Our test case in the domain of programming environments, using MFC show that combining some natural language analysis and ontology learning techniques may facilitate interactive ontology enrichment and make possible some semiautomatic extension of e-learning course, adding personalized and adaptive content. The quality of developed in such a way resources should be controlled by professionals, but they certainly are useful in three aspects: helping professionals better understanding learner needs, saving time and efforts in searching and analyzing external materials, and promoting active participation of learners in the process of learning and resource development.

VI. REFERENCES

[1] R. Amorim, et al, "A Learning Design Ontology based on the IMS Specification". IEEE Journal of Educational Technology Society, volume 9, number 1, 2006, pp. 38-57.

[2] S. Downes, "The Future of Online Learning and Personal Learning Environments", From http://www.slideshare.net/Downes/the-future-of-online-learning-and-personal-learning-environments, 2007

[3] "IMS LIP. IMS learner information package specification". Available at: http://www.imsglobal.org/profiles/lipinfo01.html., Accessed on April 20, 2011

[4] T. Martindale, M. Dowdy. "Personal Learning Environments". In Veletsianos, G. (Ed.), Emerging technologies in distance education, 2010, 177-193.

[5] D. Milosevic, C., Sukic, R., Sendelj. "Ontology-based Learner Modeling in Intelligent Tu-toring Systemsby". Technics Technologies Education Management Ttem, Volume: 5, Issue: 2, 2010

[6] J C. Vidal, et al,. "OPENET LD: An Ontology-Based Petri Net Engine to Execute IMS LD Units of Learning". Ninth IEEE International Conference on Advanced Learning Technologies, 2009