

New e-Learning system architecture based on knowledge engineering technology

Yushun Li Zheng CHEN Ronghuai Huang

School of Education Technology
Beijing Normal University
Beijing, China
lyshun@bnu.edu.cn

Xiaochun CHENG

School of Computing Science
Middlesex University
London, UK
Xiaochun.cheng@gmail.com

Abstract—The paper focuses on the field of research on next generational e-Learning facility, in which knowledge-enhanced systems are the most important candidates. In the paper, a reference architecture based on the technologies of knowledge engineering is proposed, which has following three intrinsic characteristics, first, education ontologies are used to facilitate the integration of static learning resource and dynamic learning resource, second, based on semantic-enriched relationships between Learning Objects (LOs), it provides more advanced features for sharing, reusing and repurposing of LOs, third, with the concept of knowledge object, which is extended from LO, an implementing mechanism for knowledge extraction and knowledge evolution in e-Learning facilities is provided. With this reference architecture, a prototype system called FekLoma (Flexible Extensive Knowledge Learning Object Management Architecture) has been realized, and testing on it is carrying out.

Keywords—Ontologies, Learning Object, Knowledge Object, Knowledge engineering

I. BACKGROUND

E-Learning facilities have been evolving three phases. In the first phase, e-Learning facilities mainly be called Content Management System (CMS), which provide functions for managing and delivering learning resource. In the second phase, the functions of early CMS are expanded, and accordingly these enhanced e-Learning facilities are renamed as Learning Management System (LMS), in which the functions for learning management are the keys, such as learner management, course management, record for learner's progress etc.. In the third phase, the functions of early CMS are separated from LMS, and accordingly, a separated e-Learning system, called Learning Content Management System (LCMS), come into being, which make it possible for learning resource sharing and reusing in little granularity. Today, new demands on e-Learning facilities have been presented due to the following reasons: First, new pedagogic approaches have been proposed and applied in practice, such as collaborative learning, knowledge constructive learning etc. Second, new developed technologies in Internet has accelerated the progress in e-Learning facilities, such as technologies of semantic web, web service, web2.0, and social software, etc., which are

inherently related to the field of knowledge engineering, and all these technologies can be used in e-Learning for creating more advanced e-Learning facilities. Third, the technologies of LO have being got great attentions in e-Learning communities, and lots of achievements have been attained in academic research, standardization and practices with LO technologies. Fourth, more distributed e-Learning facilities have been proposed as inter-organization e-Learning infrastructure^[1]. In conclusion, all these factors indicate new possibilities for further development of e-Learning facilities. The paper focuses on the research of new generational e-Learning facilities with knowledge engineering technologies.

The rest of this paper is organized as following, in section 2, the history of evolution process of e-Learning facilities is introduced, especially the latest evolution. In section 3, the factors for new generational e-Learning facilities are analyzed in detail, and based on the analysis, a new e-Learning system's architecture is proposed. In section 4, the efforts of our research are introduced, and a prototype system called FekLoma is presented, which is realized according to the aforementioned e-Learning system architecture. In section 5, conclusion and further research plan is introduced.

II. THE DEMAND FOR NEW GENERATIONAL E-LEARNING SYSTEM

A. The latest revolution of e-Learning facilities

The tools in e-Learning are evolving continually while the architecture of e-Learning facilities has changed only a few times. In early stage, the facilities of e-Learning focus on learning resource, and therefore, CMS come into being. In 1990's, with the tremendous development of Internet, the functions of e-Learning facilities expand to learning management, and accordingly, the systems of LMS develop rapidly. At the begin of 2001, with the maturity of LMS and its application in industry, the issues of e-Learning resource sharing, repurposing, and interoperation between different e-Learning systems have been the focuses, which shape two kinds of e-Learning systems, LMS and LCMS. In these two kinds of e-Learning systems, LMS mainly focus on human (learner, teacher, et al.) management, while LCMS primarily

be used for learning content management. Different to LMS, LCMS provides the following elements: a repository of learning objects, an authoring/assembly tool for creating learning objects, a dynamic delivery engine for delivering personalized learning content to learners. The development of LCMS is a great progress for e-Learning, in which the technology of Learning Object has been widely used. Standard in e-Learning communities, such as SCORM, strengthen these efforts.

B. The new trends in current e-Learning facilities

From the latest revolution of e-Learning facilities (since 2001), information technologies have been progressed remarkably, especially in knowledge engineering technologies related to semantic web, and they accelerate the appearance of new generational e-Learning facility. The following are the key factors that affect the development of new generational e-Learning facility.

- The affections of semantic web technologies on e-Learning Since 1998, the idea of semantic web was proposed by Tim Berners-Lee. Today, a series of technologies in the field has been matured, such as XML, RDF/RDFS and OWL, etc. and they have been used widely in practice. Furthermore, lots of tools for semantic modeling has coming into being, which provide foundation for application of technologies in knowledge engineering field based on semantic web. There have many research effects in this direction. In 2004, Devedzic[2]studied the relationship of education and semantic web. In literature [3], ontology is adopted to improve the efficiency of learning resource search, in the literature [4][5][6], the technologies of learning resource reusing and repurposing based on education ontology were studied, in the literature[7], the technologies of semantic web were used to establish intelligent semantic e-Learning environment.
- Practice and its further development of LO technologies. The technology of LO is developed from the field of object-oriented programming, and it has been developed continually in slow steps for a long time. After great effects on research and practices, the idea of LO has been accepted widely in e-Learning communities, and there have some known international effects, such as [8][9]. The separated e-Learning facilities (such as separation of LMS and LCMS) accelerate the acceptance of LO's notion in e-Learning, and now, it has been the essential element in e-Learning's facilities.

At the same time, the development of LO technologies is combined with technologies of semantic web for creating more advanced e-Learning facilities, and there have research works in this field. In literature [10], education ontologies were used to annotate relations between LOs, and such kind of research work has also been carried systematically by Gasevic^{[11],[12]}. In literature [13], ontology-based query algorithm for semantic-aware learning object was studied. In literature [5], the methods for Ontology-Based Learning Content Repurposing and Reusing

were carried out. In literature [14], the way for Development of Contents Management System Based on Light-Weight Ontology was proposed. In literature [15], the approach of Automatic Aggregation of Learning Knowledge Objects was proposed. To sum up, LO's creating, sharing, and repurposing with semantic technologies has been the key research topics for creating new generational e-Learning facilities.

- The affections of Web2.0 and social interaction on e-Learning facilities. The term "web 2.0" was officially coined in 2004 by Dale Dugherty[16], and key web 2.0 services include blogs, wikis, tagging and social bookmarking, multimedia sharing, audio blogging and podcasting, RSS and syndication, etc. In fact, there are big ideas behind web 2.0, they are individual production and user generated content, harness the power of crowd. Openness web 2.0 has great effects on education systems, for example, knowledge sharing and more constructivist approaches will be more common in web2.0 world. There have some research works of utilizing Web2.0 technologies in e-Learning. For example, in literatures [17][18], the role of web2.0 in the innovation for teaching and learning has been discussed deeply. In literature [19], the idea for constructing new type e-learning system based on web2.0 technology was proposed, and in literature [20], the technologies of web2.0 were used for personal knowledge management in e-Learning.
- The new development requirements from existing LMS LMS is a typical e-Learning facility, and there has continuously evolution in this kind of facility. In the early days of web (from 1993 to 1995), the development of LMS has been accelerated, and till 1997, Blackboard has coming into being, which is the most popular commercial LMS system today. In 2002, the movement of open source has appeared in the domain of LMS, such as Moodle (in 2002), Sakai (in 2004). During this process, the functions of e-Learning facilities has being changed greatly, and the features for collaboration has been the typical characteristic supported by LMS, for example, SAKAI is such a system which aims to provide collaborative environment for teaching and learning. In conclusion, take into account of developing philosophy of web2.0, knowledge management approach will act as more important role in e-Learning facilities.

III. THE NEW GENERATIONAL E-LEARNING SYSTEM: KNOWLEDGE-ENHANCED E-LEARNING SYSTEM

According to the development of new information technologies and new pedagogical approaches, research results in knowledge engineering (such as those from semantic web technologies) will be adopted in new generational e-Learning facilities. With our research, we propose that this process can advanced in two aspects: first, static learning resource should be organized or produced with semantic technologies, within which learning materials will be stored and managed in knowledge structure for querying, sharing, re-using or repurposing. Second, for cooperative knowledge building (as

dynamic learning resources), which has being a promising approach for learning, semantic technologies should also be used to facilitate knowledge creating, knowledge extracting and knowledge sharing, especially in the facilities for large scale learning communities. There have some research efforts in this direction, for example, in literature[21], annotating learning resources with semantic metadata should be the preferential research, which is important for sustainable OER movement; in literature[22], the author propose that knowledge-based fabrics should be provide for learners based on knowledge identification/evaluation, knowledge generation, knowledge representation/organization, knowledge communication, and knowledge use. In literature [23], the author addresses the design issues of e-learning courses that can capture the teacher knowledge. Anyway, enhanced e-Learning facilities support by the results of knowledge engineering has come up, and the requirements for knowledge presentation, knowledge extraction, knowledge deduction, knowledge classification, knowledge retrieving and knowledge reusing has been the most important area of e-Learning facilities. Our viewpoint on e-Learning facilities is explained in figure 1, in which the overview architecture for e-Learning has evolving from CMS, to LMS, to LMS & LCMS, and to enhanced e-Learning system with technologies of knowledge engineering.

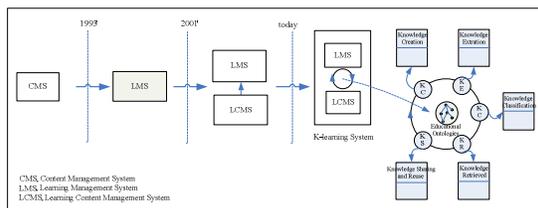


Figure 1 the evolution overview architecture of e-Learning facilities.

IV. CASE STUDY: FECLOMA

Based on the aforementioned research, a reference architecture for e-Learning system with knowledge engineering technologies is proposed, and a prototype system called FekLoma has been realized according to this reference architecture(refer to figure 2).

To realize the philosophy and approach mentioned above, the architecture is composed mainly with four modules, which are Module for Course Ontology Management (MCOM), Module for Knowledge Object Management (MKOM), Module for Cooperative Knowledge Creation (MCKC), and Module for Knowledge Object Delivering (MKOR). Among these four modules, MCOM is the core of the architecture, which is used to guide both the procedure of learning object creation and the process of cooperative knowledge creation. In this architecture, the basic ideas is that: first, the technology of course ontology is used in both of static learning resource creation and dynamic knowledge building, second, with the technology of semantic-enabled learning objects, learning object sharing, reusing, and repurposing can be realized conveniently, third, the concept of learning object can be extended into knowledge object, which is realized through the

integration of static learning resources and dynamic created learning resources.

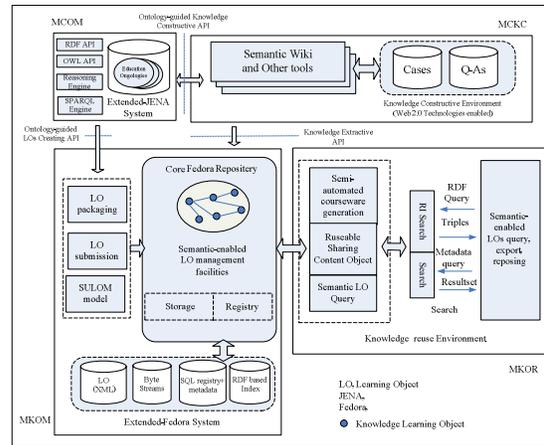


Figure 2 The architecture of FekLoma

The details for these four modules are: First, MCOM is extended from JENA^[24], which is used for creating and storing of course ontologies, and these ontologies are used for semantic relationships annotating between learning objects, and also, it can be used to guide the topics or key features advanced in MCKC. Second, MKOM is extended from Fedora^[25], which is an open source data object management system. MKOM can be used for learning object storing, managing, and sharing, at the same time, all these learning objects are associated each other with the relationships guided by course ontologies, and this approach is proposed as Semantic-Oriented Learning Object Model^{Error! Reference source not found.}. The design philosophy facilitates organizing of learning resource in knowledge engineering approach. Besides, the learning object model extend from data object model of Fedora can be further evolved to knowledge object (refer to demonstration of figure3), which is realized through mechanism that extracted knowledge from cooperative learning process can be gradually integrated into special learning object. Third, MCKC is designed for cooperative knowledge building, which aims to provide various tools for interaction, communication and cooperation. According to the design approach, topics or features happened in these tools are guided by course ontologies, which combined with technologies of web2.0 and automatic knowledge extraction. Therefore, knowledge created from cooperation learning process can be binded into learning object in Fedora, and consequently, these extended learning objects will evolve into knowledge objects. Accordingly, static learning resource can be integrated and optimized with dynamic learning resource from cooperation learning process between learners and tutors. With the design philosophy, the function for knowledge creation, knowledge extraction, and knowledge reusing can be realized. Now, a semantic wiki tool has been realized, in which topics or threaded topics can be driven from the course ontologies in MCOM. Forth, MKOR provide functions for knowledge objects query (with semantic approach), repurposing and re-using. Besides, the optimized learning resource can be exported from MKOM in batch

service mode. Now, the functions for knowledge object query, and supports for optimized learning resource evolution process have been realized in the prototype system

V. CONCLUSION

Knowledge-enhanced facilities are the direction for further development of e-Learning system. The study provides a possible solution for the realization of such kind facility. With this idea, reference architecture has been proposed, with which a prototype system based on knowledge engineering technologies called FekLom has been realized. FekLom is implemented with technologies of course ontology, learning object and the ideas from web2.0, with which advanced learning resource sharing system (query, export, repurposing, etc...) has been realized, especially for the function of integrating static learning resource with dynamic learning resource. The realization of FekLom indicates the feasibility of such kind new generational e-Learning system, and the prototype system will be further validated in practice to strengthen its approach.

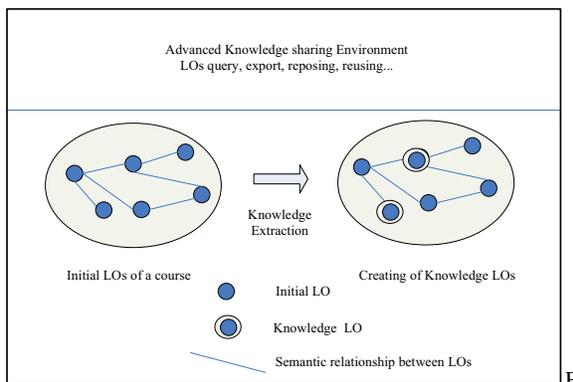


figure 3 "Knowledge" extraction process in FekLom

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