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An Ontology-Based E-Learning Authoring System

Hyunjong Choe
Department of Computer Education, Seowon University, 231 Mochung-dong,
Cheongju Chungbuk, 361-742, South Korea

Abstract: This study proposes an e-learning authoring system architecture model based on the ontology, which can help to search and package learning objects in accordance with the knowledge of a subject matter. To support an instructional designer with guiding next stepped or related useful learning object, this prototype system adapted the knowledge presentation layer, i.e., the ontology of the semantic web, into the e-learning system which consisted of 3-tier layered architecture. In the middle layer of architecture, the learning design in this study can guide contents designers to search and package learning objects in accordance with contents and structure of a target subject matter. The domain knowledge of ontology is 'computer hardware' in this study. After building computer hardware ontology and its prototype system, some instructional designer in e-learning system participated in the case study acknowledged its usefulness, comfort in designing learning content in this prototype system.

Key words: An ontology-based authoring tool, computer hardware ontology, learning object

INTRODUCTION

Recently, an effort to support efficient e-learning systems is learning objects and its packaging. So lots of e-learning researchers and institutes are underway aiming at developing the technologies that would enable efficient e-learning; technologies based on learning objects and their description methods, i.e., metadata, as well as on the processes for their management and structuring into educational entities. However, despite its potential of the advancement of the e-learning technology, its contribution to the educational process still lags behind. Learning objects are reusable learning materials so that object-oriented paradigm can make them reusable objects like LEGO blocks (Wiley, n.d.). This paradigm may solve the problem of costly reproduction of learning materials in e-learning systems. The problem arising here is related to the size and extent of complexity (granularity) as well as the way to achieve the intelligent composition of learning objects in order to (automatically or not) generate courses with pedagogic efficiency and value[1]. The most important point of these problems is the appropriate composition of learning objects. We try to concentrate our attention on this subject.

The composition of learning objects is the concern of learning design, i.e., instructional design, in pedagogical aspect. Some learning theory or teaching strategy can help design the structure of learning objects in the pedagogical aspect. For example, cognitive psychology suggests that a mental model consists of two major components: *knowledge structures* and *process* for using this knowledge. Thus, a major concern of instructional design is the representation and organization of subject contents to facilitate learning (Merrill, n.d.). Several studies have been made on the pedagogical background of e-learning systems over the past few years, but it is insufficient to give guidelines to e-learning designers. The primary purpose of this study is to model the subject contents structure, i.e., structural knowledge in a mental model, for the intelligent e-learning authoring system because we have an opinion that the structure of subject matter's knowledge can guide an instructional designer or e-learning contents designer to design and implement a sequence of learning contents. In order to illustrate the context of our work the study starts with a brief introduction to related works.

Related works and adaptation: There are many efforts to select and combine learning objects in the e-learning system that has led to several standardization projects. Some projects have focus on determining the standard architecture and format for learning environments, such as IEEE Learning Technology Systems Architecture (LTSC), Instructional Management Systems (IMS) and Sharable Content Object Reference Model (SCORM). IMS and SCORM define and deliver XML-based interoperable specifications to exchange and sequence learning contents, i.e., learning objects, among many e-learning systems. They mainly focus on the standardization of the modeling of how the systems manage interoperating educational data relevant to the educational process (Adelsberger, n.d.). Especially, IMS and SCORM have

announced their content packaging model and sequencing model respectively. The key technologies of these models are the content package, the activity tree, learning activities, sequencing rules and the navigation model. Their sequencing models define a method for representing the intended behavior of an authored learning experience and navigation models describe how the learner- and the system-initiated navigation events can be triggered and processed.

The IMS and SCORM models describe well the educational activity and implemented system aspect, but are insufficient in describing educational contents knowledge in the educational activity. Juan Quemada's and F. P. Rokou's models tried to add more pedagogical background by emphasizing educational contents and sequence using the taxonomy of learning resources and the stereotypes of teaching model[1,2]. But the educational contents and their packaging in these models were

Fig. 3: The snapshot of a prototype implementation to search and package learning objects with an ontology-based e-learning authoring system prototype.

dependent on the system and lacked standardization and reusability. Thus, I believe that if the educational contents frame of learning resources is introduced into an e-learning authoring system such as ontology-based properties and hierarchical semantic associations among them, this e-learning authoring tool has capabilities for providing adaptable and intelligent learning context to instructional designers.

The hierarchical contents structure is able to show the entire educational contents, the available sequence of learning activity and the structure of educational concepts such as related super- or sub- concepts in the learning contents. Further, some of semantic relationships among educational contents such as 'equivalent', 'inverse', 'similar', 'aggregate' and 'classified', can give important and useful information to instructional designer, or teacher, in the e-learning authoring tool.

For this purpose, the ontology is introduced in my model. It can play a crucial role in enabling the representing, processing, sharing and reusing of subject matter's knowledge among many e-learning authoring tool systems because it specifies the conceptualization of a specific domain in terms of key concepts, attributes and relationships in the subject matter. Moreover, the number of recent ontology-centered researches has dramatically increased because popular ontological languages are based on the Web technology standards such as XML and RDF(S) so as to share and reuse it in any Web-based knowledge system[3,4]. Thus, I devised an authoring model providing the contents structure using the ontology to represent a subject matter's contents.

Design an ontology: An ontology defines the common words and concepts used to describe and represent an area of knowledge[5]. Ontologies are used by people, databases and applications that need to share domain information; a domain is just a specific subject area or area of knowledge. Ontologies include computer-usable definitions of basic concepts in the domain and relationships among them. They encode knowledge in a domain and also knowledge that spans a domain. So, they make that knowledge reusable. If a e-learning authoring tool has a good modeled ontology about specific domain, it will become a useful authoring tool to design and package learning objects. Because it will be an intelligent authoring tool to provide the basic concepts and their relationships among them in the process of designing a learning unit consisted of packaged learning objects.

Ontology typically contains a hierarchy of concepts within a domain and describes each concept's crucial properties through an attribute-value mechanism. Further defining relations between concepts might be described through additional logical sentences. Many formal languages to specify Ontology have been proposed such as RDF, XOL, OML, SHOE, OIL, DAML+OIL and OWL. Especially, Tim Berners-Lee also proposed a new term as a Semantic Web which gives semantic relations among web resources with ontology languages[6]. And World Wide Web Consortium, charged by Tim Berners-Lee, has announced a web ontology language as OWL, which has potential power to share and reuse ontology knowledge in the semantic web. Figure 1 shows the snapshot of ontology for representing the computer hardware knowledge in the Protégé 2000 ontology editor.

In this study, we present an example of the adaptive design of content management and learning activity on a subject. The specific domain in this paper is the computer hardware for middle school students. The general educational goal is the comprehension of a memory unit in computer. An ontology of the computer hardware must contain some useful property information of a memory such as its 'Volatilize', 'read and write' and so on.

Developing an prototype: The e-learning authoring architecture generally consisted of a user interface layer, logic layer and data layer, just like 3-tier layered web application. Figure 2 shows three layers of the architecture.

Data layer can hold lots of learning objects which managed by local learning object designers. The function of this layer is to give learning objects from local storages to logic layer. Logic layer holds computer hardware ontology which is created by a teacher and provides the knowledge of computer hardware to a user interface layer after analyzing user's keyword. For example, one user wants to design a learning activity to teach his students the meaning of RAM. If he typed 'RAM' in this user interface, this interface shows its super concept is 'main memory', its sibling concept is 'ROM' and its related properties like 'read and write', 'volatilization' and 'is related with virtual memory and disk cache'. I adapted a Web Browser as a user interface layer. Figure 3 shows the snapshot of a prototype implementation to search and package learning objects with an ontology-based e-learning authoring system prototype.

CONCLUSION

This study proposes ontology based e-learning authoring system to search and package learning objects using ontology. Ontology is the key concept of our research to use share domain information, i.e., the knowledge of a subject matter. If e-learning authoring system has a good modeled ontology about specific domain, it will become a useful and powerful module to search and package learning object form many distributed learning resources storages and also, this authoring system will be an efficient e-learning module to provide valuable information, not meaningless information, for both a skilled instructional designer and a novice.

We conclude that there are two primary advantages of the ontology-based e-learning authoring model in this study. One is that the proposed model containing a hierarchical contents structure and semantic relationships between concepts can give related useful information for searching and packaging learning resources in e-learning systems. The other is that it gives the opportunity to a developer or an instructor to combine the learning sequence plan after having comprehended the why and how of the learning process designed by the instructor.

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