

Ontology-based Content Management and Access Framework for Supporting E-Learning Systems

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Abstract

E-Learning is a fast, just-in-time, and non-linear learning process, which is now widely applied in distributed and dynamic environments such as on the World Wide Web. However, it also poses three challenges to the systems that support e-learning. This paper present our on-going effort to develop an ontology-based framework for e-learning systems, which allows teachers to organize learning materials in a dynamic and flexible manner, and provides multiple ways for students to access the materials either by navigation, search or recommendation. A module that helps to classify the learning materials according to the schema of the ontology is also presented in the proposed framework.

1. Introduction

With the advancement of computer, multimedia and network technologies, students are given alternative choices beyond traditional classroom learning that were not available before. E-learning, where students learn course related or other types of materials via online computer systems, has proved to be an effective way of delivering materials to previous unreachable students under previously impossible circumstances with previous unavailable access and presentation methods. The success stories of e-learning conferences and e-learning community speak for the glory.

However, there are several challenges in supporting students' learning activities in e-learning systems. First, the collection of an e-learning system constantly changes with course materials being added, edited, or removed by teachers. Since collaborative activities are encouraged in learning process, the collection in e-learning systems often contain materials authored, commented, and submitted by students too. Therefore, the collection management side of e-learning system should be flexible in content representation, friendly in content management and straightforward and intuitive in user interface.

Second, how to access and interact with teaching materials have traditionally been dictated by teachers. In e-learning systems, students get chances to decide their own strategies and means to do so. The requirements, therefore, to e-learning systems are that various access and interaction methods should be provided to suit different preferences and needs of students. Some of these means include browsing or searching materials by course delivering sequences, by relevance to a specific topic, by course modules, or any other ways that students want.

Third, along with the advantage of allowing students to access the learning system at any time, any place, the presence of lecturers during the learning process, which is an important component in face-to-face education, could be missing. Therefore, how to retain the knowledge provided by lecturers in an e-learning environment and present them in straightforward and intuitive way is another challenge that e-learning systems need support.

Currently, there are many academic e-learning systems, but most influential ones are developed commercially, such as Blackboard¹. Although Blackboard provide certain methods of content management and access, the basic metaphor still resemble file cabinets and static web page collection, where materials are organized in unalterable collections with a static structure. It is difficult for both teachers and students to manage the materials. In addition, it lacks of diverse, powerful and intuitive access tools.

In this paper, we will talk about one approach we developed to meet the three challenges in designing web-based learning support systems. The approach relies on an ontology-based digital library framework to 1) support dynamic classification of the learning materials based on the content. 2) allow teachers to organize and visualize the materials in a dynamic and flexible manner because students have diverse backgrounds and learning preferences. 3) offer students multiple ways (i.e., by browsing, by search or by recommendation) to access

¹ <http://www.blackboard.com>

materials from any place and at any time. Overall, the goal of our platform is to support students' learning by improve the quality of their experience with the web-based e-learning system.

In remaining of this paper, first we analyze the characteristics of an ontology and its role in teaching and learning. Then, we give an overview of the proposed framework, followed by an explanation of the mechanism of each module in the framework. Finally, we will review some related work and give the closing conclusions.

2. The role of ontology in e-learning

In Berners-Lee's famous Semantic Web architecture¹, ontology plays a critical role for sharing information and achieving the semantic interoperability on the Web. With the characteristic that ontology is a shared vocabulary and conceptualization of a domain [12], we believe that ontological technologies can help in building a better e-learning system. In e-learning domain, though standard schemas like IEEE LOM² and Dublin Core³ have been applied to describe learning objects, these standards only focus on the minimal set of attributes. Such a simple structure cannot help students learn complex knowledge and relationships among topics. From the student point of view, to complete a learning task not only requires a comprehensive understanding of what the learning materials talk about, but also needs to know semantic connections/relations between these materials. In such situation, ontologies can be applied as a new approach to integrate the content, context and structure of the learning materials. For instance, ontologies allow teachers to organize and visualize major topics of the course through hierarchical and association relationship [1, 6]. Ontologies provide students new opportunities to interact with Web-based courses and other educational systems in personalized ways [4]. Ontology also support semantic information access to materials relevant to certain topics [8, 9], and allow future integration with other courses in the same or related domain [7].

3. The ontology-based content management and access framework for e-learning systems

Figure 1 is an overview of the proposed ontology-based framework for e-learning systems, in which domain ontology interacts with three modules, i.e., Material

Classification Module, Content Organization Module, and Semantic Information Access Module.

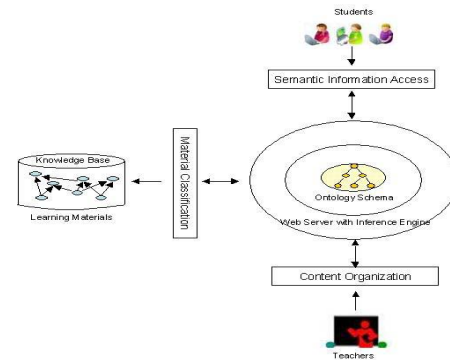


Figure 1 Overview of proposed ontology-based framework for e-learning systems

3.1 Material Classification Module

The Material Classification Module aims at automatically classifying learning materials to one or more concepts in the ontology. To associate learning materials with the ontology, all learning materials are indexed using a generic search engine such as Indri⁴. Then, a query is generated based on the linguistic information (i.e., name, label, and description) of each concept and sent to the search engine, which returns a ranked list of learning material. In the result set, learning materials that have a ranking value greater than a minimum threshold will be assigned to the queried concept. Multiple assignments are allowed. To guarantee the correct classification, user adjustment is allowed at the end. Finally all learning materials will be stored in the knowledge base as instances and associated with each other according to the schema of the ontology. The overview of the Material Classification Module is shown in Figure 2.

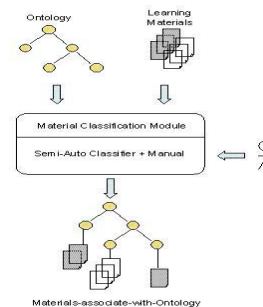


Figure 2 Material Classification Module

¹ <http://www.w3.org/DesignIssues/RDFnot.html>

² <http://ieeeltsc.org/wg12LOM/>

³ <http://dublincore.org/>

⁴ <http://www.lemurproject.org/indri>

3.2 Content Organization Module

The Content Organization Module is for teachers to create courses. Assume all needed learning materials have been stored in the knowledge base. Though the teacher is not required to prepare any specific materials any more, s/he needs to provide a course description file to identify which concepts are needed in her/his course. Having the course description file, the Content Organization Module will automatically “grab” the materials from the knowledge base, and then organize and visualize them in a hierarchical structural. Afterwards, students can access the course either by browsing, search or recommendation, which will be described in next section. Figure 3 is an example of a course description file, in which the first two units of a course named “Digital Library” are presented. The first unit, “introduction”, contains five concepts and the second unit, “architecture”, contains seven concepts.

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- <course>
  <name>Digital Library</name>
  - <unit id="1">
    <name>Introduction</name>
    <concept>What_is_digital_library</concept>
    <concept>core_attributes_of_DL</concept>
    <concept>digital_library_faith</concept>
    <concept>goal_of_digital_library</concept>
    <concept>digital_libraries_and_traditional_libraries</concept>
  </unit>
  - <unit id="2">
    <name>architecture</name>
    <concept>three_dimensions_of_DL</concept>
    <concept>5s_layers_of_DL</concept>
    <concept>four_dimensions_of_DL</concept>
    <concept>building_blocks_of_DL</concept>
    <concept>digital_objects</concept>
    <concept>client_server_architecture</concept>
    <concept>DL_interoperability</concept>
    <concept>FEDORA_architecture</concept>
    <concept>Open_archival_initiative</concept>
  </unit>

```

Figure 3 An example of a course description file

3.3 Semantic Information Access Module

With all learning materials classified into the concept of the ontology and semantically linked by relationships, the ontology can further enable students to access learning materials through different ways, i.e., navigation, search and recommendation.

As stated in [6], students are often unaware of the complete context of a learning task, and need help in getting oriented in the conceptual structure of the subject domain. With the characteristic that an ontology can structure domain concepts and relations in a taxonomic way, it allows students to navigate the course topics through the hierarchical structure and explore internal semantic relationships among course topics simultaneously. Figure 4 illustrates an ontology-based navigation in the DiLight system [8, 9].

Search is another big problem that students face in an e-learning system. Simple keyword searches has the limitation that it may return false relevant documents containing homonyms, and miss truly relevant documents that have only synonyms or abbreviations. However an ontology-based search can overcome term mismatch

problems with the ability of specialization, inference and scope elaboration. For example, when students browse the concept hierarchy in the ontology, it is very likely that students do not know the exact name of a topic given by the teacher because they have different viewpoints and knowledge levels of learning materials. In this scenario, the domain ontology allows students to start a search from high level and find its specializations based on the hierarchical relation in the ontology.

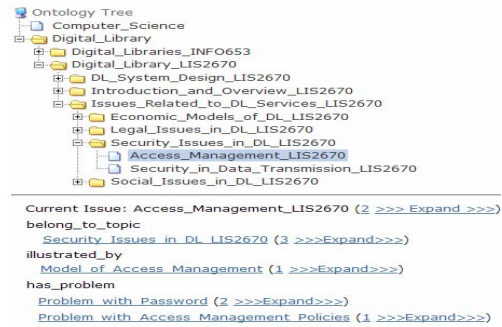


Figure 4 Ontology-based navigation in DiLight system

Another example of ontology-based search is utilizing its inference ability to achieve more accurate or comprehensive results. For instance, our collection contains three documents concerning data encryption. Document A is about MD5 (Message-Digest Algorithm 5), B is about RSA (a public-key encryption technology), and C is about DES (Data Encryption Standard). A is assigned to concept “Algorithm in Data Transmission”. B and C are assigned to concept “Technique and Standard in Data Transmission”, which is related to “Algorithm in Data Transmission”. A normal keyword search on “RSA” would only return B. However, our ontology-based search can also return A and C with the help of the inference that the concepts of A and C are related to that of B, even though neither A nor C contains keyword “RSA”. Furthermore, if the student knows “RSA” is a security issue in DL, s/he can explicitly identify the search scope as within topic “Security Issues in DL” instead of searching the whole data repository of DiLight to eliminate the ambiguity of the word and thus increase the accuracy.

Ontology-based navigation enables access to materials via links between parent and child nodes, whereas ontology-based search provides a set of access points over the whole ontology. However, both of them are limited at providing navigation beyond the immediately linked topics. However, sometimes it is important for students to build up understanding about related topics over long distance (e.g., taught in different classes or under different circumstances). In this situation, with a comprehensive understanding of internal connections between different topics, the teacher can utilize the “relate to topic” relationship in the ontology to explicitly markup the connection. Thus, an associated recommendation is

provided when students access either of the topics. With such relationship, learning materials in both topics are linked together across the ontology.

4. Related work

Though the application of ontologies in e-learning environments is still at an early stage, recent researches imply that it will be a promising direction in the future. One of the earliest researches on employing ontology in e-learning is Ontology-based Intelligent Authoring Tool [2], in which four ontologies were used to construct learning model and teaching strategy model. Another widely cited work about e-learning on the Semantic Web can be found in [10], where the main roles of ontology in their work are the providing of and the accessing to the learning materials. The use of ontologies in e-learning is also discussed in [11], in which domain specific ontologies are used to provide semantics-based classification, navigation and query for learning repositories. Other related researches using ontologies to support e-learning include the collaborative courseware authoring support in [5] and the object-oriented collaborative course authoring environment in [3].

5. Conclusion

In this paper we have proposed a generic ontology-based framework for supporting content management and access in e-learning systems. The usages of ontology have been exploited in three ways: 1) help classifying the learning materials according to the schema of the ontology, 2) organize and visualize major topics of a course, 3) provide effective methods to support students' access to relevant materials in a semantic way. We are in the stage of implementing the system and conducting user experiments to test the effectiveness of the approach.

6. References

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