A Development Tool for E-learning Applications

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Abstract

Task information support on the Web is not always an easy and straightforward process. Much of the information is inaccurate, biased, out-of-date, or just not thorough enough. The Internet has emerged as an active resource for the average student. It has also provided a universal, yet independent, platform for educators for over a decade now. Conversely, many useful and exciting educational tools have evolved from the Internet's promising example. Hypertext and hypermedia offer students a visual and hands on experience that class lecture and the traditional textbook may not be able to offer. In this paper we discuss the effectiveness of context-based hypertext and hypermedia to enhance student learning in computer science courses. Computer science students (group 1 – freshman and sophomores, group 2 – juniors and seniors) that used hypertext and hypermedia in the prerequisite course, programming CSI, had higher performance in academic activities (test and/or quizzes) than those who had the option to use hypertext and hypermedia in the advance course, Software Engineering.

1 Introduction

E-learning can be defined as training or instruction that is delivered electronically. It embraces learning of all types including academic and professional training. Typically it uses the Internet to bridge distances and enables people to learn no matter where they are. The successful and effective implementation of an e-learning strategy depends on more than just providing the technology, training and equipment. A crucial issue in e-learning is how to organize and classify the learning content so that learners and instructors can find what they need when they really need it. The success of e-learning applications depends on the amount of effort that is involved in developing teaching and learning material by authors and in retrieving relevant learning resources by learners. Thus accessibility, findability, and usability are critical issues in e-learning. A solution to these problems involves providing a suitable model, coupled with an environment that supports rapid development of e-learning applications.

Task information support on the Web is not always an easy and straightforward process. Much of the information is inaccurate, biased, out-of-date, or just not thorough enough. One major challenge for students is to filter out irrelevant documents from the search engine results. For example if we try Google with the keywords "Prolog", "lists" it responds with about 300, 000 hits. Moreover, a large part of the references provided in the first few pages are introductory notes on Prolog lists. Many of the listed pages are simply different versions or different parts of the same overall site. There are high quality teaching resources on Prolog Lists but they are buried somewhere in the pile of 300, 000 web pages. We need technology, which allow learners to find information about particular subject rather than retrieving documents, which satisfy a given query. For example, a learner may be interested in courses dealing with object-oriented programming rather than in the courses where the term "Java" or "C++" is stated.

To address the above critical issues we propose a (prototype) courseware development tool based on the ISO 13250 XTM standard - XML Topic Maps [1, 9, 10]. Topic Maps (TMs) are emerging technology, used as a means to organize and retrieve information in e-learning repositories in a more efficient and meaningful way. The expressive power of Topic Maps, commonly perceived as a method for indexing of information resources, places the standard very close to artificial intelligence and knowledge modeling. Topic Maps resemble semantic networks and conceptual graphs, but offer more - a unique, standards-based way of

encoding and exchanging of knowledge. Topic maps provide an external meta-structure (a knowledge navigation layer or ontology) in form of a dynamic, semantically based hypertext. As a result, TM-based courseware offers the following benefits:

- *For learners:* easy finding of relevant content; ”help system” (orientation) through the knowledge layer (represented by interrelations or associations between topics and their occurrences); “browsing” in a subject field (knowledge domain) that supports exploratory learning; learner-centric learning process adapted to learner’s own interests.
- *For instructors:* structuring and presenting the content as a semantic web; distributed courseware development and ongoing further development; support in the selection of relevant content by providing a semantic structure.

We have proposed a general framework for developing Topic Maps-based e-learning applications and have used it to implement an authoring environment for creating Topic Maps-based e-learning materials – TM4L-Editor (Topic Maps for e-Learning). The tool can be downloaded from http://compsci.wssu.edu/iis/nsdl/download.html.

2 General Framework for TM-Based Environments

A key feature of our approach to developing e-learning materials is to use a network of concepts as both a medium of *domain knowledge representation* and a *navigable structure*. From one side, this would allow authors to create views of a specific domain in terms of domain concepts that suggest the semantics of the resources relevant to that domain - the view of interrelated resources is more than the sum of their parts. From another side, information retrieval would benefit from conceptual support based on *domain ontologies* since their predefined set of concepts, relationships, and inference rules constrain the possible interpretations. In order to be reusable and interoperable, learning objects must comply with *technological standardization*, in addition to *knowledge standardization* (consensus on the meaning of educational content). This implies that they should be represented using standard formalisms, including educational standards, such as LOM [5] and XML-based languages.

The proposed general framework of concept-based digital course libraries is based on building a conceptual structure that represents a subject domain ontology and using it for structuring and classification of the library content [2, 3, 4]. The classification involves linking learning objects (content) to the relevant ontology terms (concepts), i.e. using the ontological structure to *index* the library content. This will allow applications and users to understand the relationships between the library resources and thus will insure efficient topical access to them. The use of subject ontologies that provide shared agreement on the subjects meaning will also allow for ontology-based merging of digital repositories.

The main components of the proposed framework are the information repository, the information-authoring module, and the information retrieval module. An architecture built within this framework utilizes the advantages of concept-based and standards-based content organization, which will benefit both learners and authors. For learners it will support efficient contextual retrieval of information relevant to their needs and for authors - the reusability, shareability, and interoperability of created instructional units.

We have proposed a layered information structure of the library repository consisting of three layers, each of which captures a different aspect of the information space - conceptual, resource-related, and contextual. Thus the developed authoring tool supports: semantic layer (ontology) authoring, resource authoring, and context authoring.

3 The TM4L Editor

Based on the proposed general framework, we have implemented a prototype of an authoring environment, TM4L-Editor, which enables the creation of ontology-aware courseware. The main design requirements to the environment include:

- The environment should have a scalable and expandable architecture.
- The environment should use XML-based schema language to create shareable, platform independent repositories.
- The environment should promote interoperability. It should have the capability to import/export structures from/to other XML-based repositories.

The above requirements were used as guiding principles for the selection of the development tools. We have chosen to use the ISO 13250 XTM standard - XML Topic Maps to implement the environment. A screenshot from the TM4L Editor interface is shown on Fig. 1.

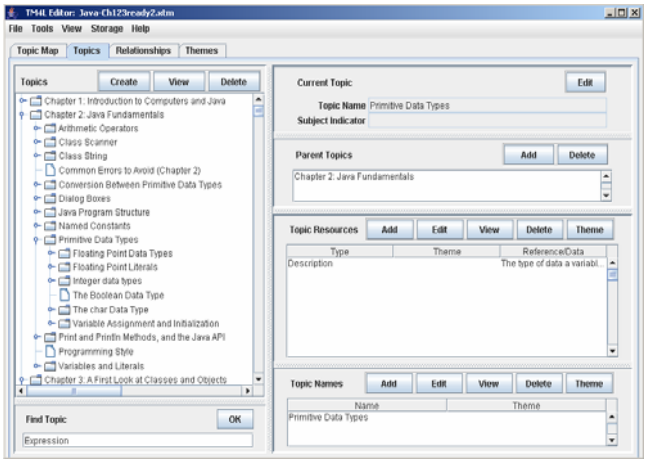

Figure 1. TM4L interface

3.1 Topic Maps

Topic Maps is an emerging technology that attempts to solve the knowledge representation, management and information retrieval challenges on the Web. They help establish an associative network between resources, which represent concepts, by relating them to topics, and associating those topics, in a structured way, thus organizing resources into a new information/knowledge space. In effect, Topic Maps are a new ISO standard providing a paradigm for organizing and retrieving online information and for interchanging semantic information on the Web [1, 7, 8].

Topic maps have their roots in traditional finding aids such as back-of-book indexes, glossaries, and thesauri. It is no surprise, therefore, that this paradigm accommodates easily the representation and finding-aids associated with digital collections. Topic maps can be viewed as a standard, interchangeable hypertext navigation layer above diverse electronic information sources that supports topical finding of various kinds of resources, such as documents, graphics, images, database records, audio/video clips, etc [6, 7, 8]. Thus they seem extremely appropriate for representing the proposed layered structure of digital course libraries.

The advantage of using the topic maps technology for developing digital learning objects is twofold: from one side it provides convenient and intuitive presentation and manipulation of interrelated concepts embedded in information resources (learning objects), and from another, the learning material is in a standard format, which makes it interchangeable i.e. it can be used in other TM-based courseware systems. In addition, the topic maps standards define the way in which two or more topic maps may be combined or *merged*. Topic maps merging is a fundamental and highly useful TM characteristic as it allows a modular approach to the creation of topic maps and provides a means for different users to share and combine their topic maps in a controlled manner. All these promote topic maps reusability, shareability, and interoperability.

While topic maps offer a powerful and promising technology for intelligent organization and access of information in general, creating topic maps for e-learning is not a clear and simple task at present [2, 3]. Therefore, specialized education-oriented TM tools are needed that facilitate the creation, maintenance, search, and visualization of topic maps-based learning resources. This was our motivation for designing and implementing the TM4L-Editor.

We are exploring a number of research questions related to using Topic Maps for educational purposes and specifically for representing educational resources, such as, how to transform the standard TM knowledge representation-oriented terminology into a domain-specific user-oriented terminology, etc. In our previous work we have identified some problems that users often encounter in creating conceptual structures. We also conducted a survey (of more than 50 students) in the Computer Science Department at WSSU allowing a preliminary needs analysis related to conceptual support of information retrieval.

3.2 Design Principles

The TM4L Editor is designed as a tool, in which authors externalize their subject knowledge in cognitive schemes represented as topic maps. The basic steps in building a topic map assume that the user has a conceptual specification of the learning content in terms of its topic set, association set, occurrence set, and their interconnections. However, creating such a conceptual specification is a difficult task and unfortunately there are no cookbooks on building topic maps. There are several topic maps building tools currently available but they have not yet matured into integrated development environments such as the environments available in other software practices. Most of the existing topic maps editing tools offer only limited functionality and user support due to their generality. Therefore, specialized tools for supporting end users have to be developed in different areas, incorporating the specifics of the area to help users in defining topic maps in that area. According to our knowledge there are no specialized TM editors for the area of education developed so far. Thus our focus was on creating a specialized editor that improves and strengthens users' ability to efficiently create teaching and learning content based on topic maps.

The TM4L editor offers enhanced, specialized support for creating digital learning repositories. It benefits of the topic maps' basic feature to support easy and effective merge of existing information resources while maintaining their

meaningful structure. This allows for flexibility and expediency in re-using and extending existing repositories.

The learning content created by the editor is compliant with the XML Topic Maps standard and thus could be viewed by any standard topic maps browsing tool. In addition, in order to achieve interoperability, the editor will be able to import and export TM-based learning objects in XML format.

Following the general requirements, the design of the TM4L Editor satisfies the following more specific criteria:

- Provide intuitive interface that:
    - reduces authors' cognitive overload when creating and editing concept-based learning content,
    - is easily learnable,
    - allows merging topic maps from different repositories.
- Provide extensive support to authors in developing topic maps, including:
    - Support for editing and modifying existing TM-based learning objects.
    - Easy comparison and merge of independently built learning objects (e.g. from different repositories).
    - Checking for inconsistencies in the learning content.
    - Easy access and manipulation of TM constructs (i.e. specific topics, associations, and resources) using a custom (e-learning domain) language.
    - Support for finding and adding external information resources, e.g. through accessing key educational repositories, such as standardized vocabularies, encyclopedias, ontologies, etc. and educational portals.

TM4L Editor's functionality includes the following capabilities:

- Maintaining concepts: adding concepts, deleting concepts, linking concepts to other concepts.
- Creating learning objects: defining learning object types, adding learning objects, deleting learning objects, modifying learning objects, merging learning objects.
- Creating contexts (organizing learning objects): linking learning objects conceptually, organizing learning objects hierarchically, and defining different views.
- Importing/exporting topic maps, i.e. 'transporting' topic maps from one application (repository or system) to another.

3.3 TM4L Implementation

The TM4L Editor is an authoring environment that supports the overall, cyclic learning repository engineering process including adding/updating repository entities and related metadata as well as browsing and codifying them. The TM4L Editor is topic maps-based, thus the main objects it manipulates are topics (representing domain ontology concepts), relationships between them (corresponding to the TM associations), resources, and views (implementing the TM scoping feature). A screenshot of the TM4L Editor interface is shown on Fig. 2 It illustrates the tree based representation of the topic maps, along with additional features for manipulating parent topics, topic names resources, association and themes. This screenshot also illustrates the process of adding new topic.

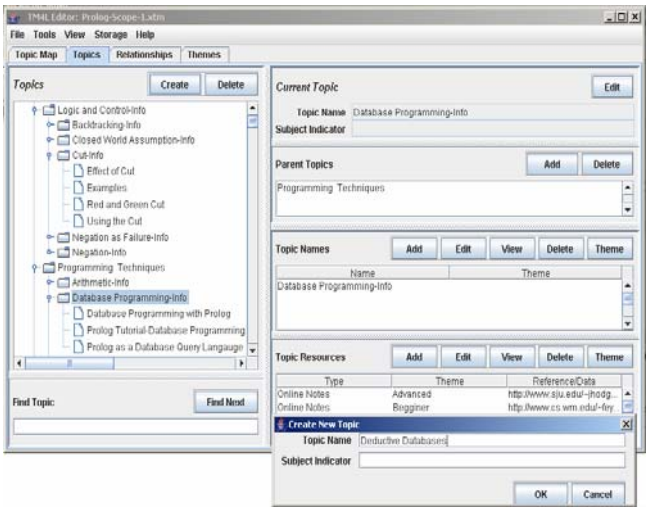

Figure 2. Adding new topics to the 'Prolog" Topic Map

The Editor GUI includes four different sections: *Topic Map*, *Topics*, *Relationships*, and *Views*, with the *Topics* section shown. On the left side, the topics ontology is represented in the form of "browser tree" that allows navigation through the topics. Using the 'Find Topic' option the user can also search for topics by their names. When a topic is selected, all information related to that topic, including topic's subject indicator, type (parent topic), names and resources, can be viewed in the right-side panels: 'Parent Topics', 'Topic Resources' and 'Topic Names' and their popping-up windows.

The TM4L Editor is implemented as a client-server application developed in Java and using the TM4J Topic

Map Engine [12], which is a an open source providing a comprehensive API that allows creating and modifying topic map structures either stored in-memory or persistently stored in a database.

4 Conclusion

This work is aimed at contributing to the development and use of efficiently searchable, reusable, and interchangeable discipline-specific repositories of learning objects on the Web. We proposed an authoring environment supporting the development of ontology-aware courseware. The next step in our agenda is the design and development of a browser for Topic Maps-based learning materials. It will support learners to efficiently navigate educational Topic Maps and search for useful resources. The latter is crucial in project-based and self-directed learning where the learners are actively engaged in retrieval of relevant information.

Our work is motivated by problems related to the efficiency of both courseware authoring and retrieval of learning resources. It is based on the idea of integrating concept-based digital libraries with subject ontologies that matches closely with the topic maps paradigm. We discuss a framework defining a novel architecture of topic maps-based digital course libraries, which is aimed at supporting efficient retrieval as well as reuse, exchange, sharing, and interoperability of digital learning materials.

A secondary motivation behind this work is to evaluate the advantages of using the emerging topic maps technology for management of digital learning content in general and concept-based learning support systems in particular. Concept-based learning support systems represent a field of research and development that is highly regarded today and this work addresses an issue of the underlying dimensions that a concept-based approach can deal with in a rational and pragmatic manner. The proposed concept-based architecture of digital course libraries provides ground for efficient context-based retrieval of library information relevant to learners' current goals as well as for deeper understanding of the ontological structure of the specific subject domain. The proposed topic maps-based implementation of the architecture provides a unifying framework for standards-based knowledge representation and management, which promotes reusability, shareability, and interoperability of the learning content.

The present work can be continued in several directions. One possible direction is to study how to represent and use instructional knowledge in topic maps and how to model the learner (user) and use this knowledge for 'library adaptation', etc.

Another possible direction of future work is related to the information support necessary for the proposed 'opening' of a digital course library to the Web. The idea is to provide the learner with contextual support for external searches on the Web, when the available library resources are not satisfactory for his or her goals. Some of the questions, related to this problem, include: What kind of (educational) context can be used to constrain the Web search and improve its quality and precision? What kind of a search tool to provide to the users to assist them in their search for learning materials on the Web? Should we leave the learners in control of their search strategy or use a meta-search-like automatic modification of their search queries?

A third direction of future work is to create a substantial topic maps-based digital library collection in Computer Science based on the courses taught in the Computer Science Department at Winston Salem State University. A subject for future work is also to evaluate further the proposed environment based on a broader and longer-term experience of its use and to compare the results with other similar environments

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