AUTHORS SUPPORT IN THE TM4L ENVIRONMENT

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Abstract: The TM4L environment enables the development and use of ontology-aware courseware based on the Semantic Web technology Topic Maps. In this paper we discuss its features in the light of authoring support, giving illustrative examples to highlight its use.

Keywords: Ontologies, digital libraries, courseware, Topic Maps.

ACM Classification Keywords: H.5.4 [Information Interfaces and Presentation]: Hypertext/Hypermedia – navigation.

Introduction

Current Web-based educational practices indicate that courseware authors' ability to gather and generate information exceeds their ability to organize, manage, and effectively use it. Ontologies are a key technology emerging to facilitate Web information processing by supporting semantic structuring, annotation, indexing, and search. Ontologies allow organization of learning material around components of semantically annotated topics. This enables ontology-based educational systems to do efficient semantic querying combined with structured intuitive navigation and access to the learning resources. However ontology development process is costly, which should be compensated by reusing the work. We have developed an authoring tool, the TM4L Editor [1], which enables the development of ontology-aware courseware based on the emerging technology Topic Maps [2]. To our knowledge TM4L is the only general educational Topic Maps Editor presently available. It is free software available at http://compsci.wssu.edu/iis/nsdl/ download.html (for the period May 2005 - February 2006 it had 3,259 downloads.)

In the Topic Map (TM) paradigm an ontology is an accurate description of the essential entities and relations which are found in the modeled subject area, and can be represented as a set of *topics* linked by *associations*. Therefore the Topic Maps technology is well suited for structuring learning material around subject ontologies.

As part of the TM4L Editor evaluation we conducted a study to find out what are the major difficulties that authors of educational topic maps face. In this paper we propose strategies for overcoming some of the problems in educational topic maps authoring and discuss their use for re-designing TM4L.

Support for Ontological Classifications

It is tempting to think that the classification schemes utilized by the libraries can be adapted in a simple way for use in e-learning systems. However, the neutral and objective classification used in the libraries might be in conflict with the user centric considerations in an e-learning environment. In such an environment the classification structure should account for multiple perspectives depending on the context in which the information is being sought. For a conceptual structure to be interoperable and resources to be sharable between different groups of learners, this contextual information must be explicit. An implied goal in re-designing TM4L was to produce an authoring environment enabling the representation of different *perspectives* of a domain instead of just capturing and representing an objective reality.

An important requirement was derived from the observation that a *practically useful* educational topic map cannot solely rely on a single standardized classification. A shareable conceptual structure of an educational topic map normally can not be derived from a particular textbook or a course syllabus. Besides the fact that textbooks and courses (modules) are changed frequently, their structures are often founded on a subjective categorization. The resulting topical structure needs also to conceptualize the instructor's view of the learning collection and the knowledge level of learners for which the classification is designed and constructed. To insure better support for educational TM authors, TM4L allows them to incorporate domain structures and course structures. Since the act of classification is inherently contextual, TM4L supports incorporating *perspectives* in classification construction.

On the other hand a shared objective classification scheme can function as a means for communication within and among domains by standardizing a vocabulary and meanings in the domains. A classification is objective when the criteria used for classifying are not subject to the whim of the person doing it. The lack of a shared understanding and consistency in using concepts on a textbook and course level might be compensated by using objective domain conceptual structures (domain ontologies). The purpose of ontologies is not to replace the contextual viewpoints but to coexist with them complementing and enhancing the informational support. Intuitively ontological classification enables us to organize a set of entities into groups, based on their ultimate nature and existing relations. From this viewpoint we conceive domain ontologies as a *conceptual reference system*, with a collection of concepts, relations between concepts and classification hierarchies. The resulting conceptual schema could serve as an aid for integrating related concepts (terms) from different repositories.

TM4L provides support for authors that want to create ontological, objective classification: they can create light-weight domain ontologies represented as topic maps. Differently from typical ontology editors, our model includes three basic concept hierarchies: “superclass-subclass”, “whole-part” and “class-instance”. In this way authors are able to create more easily expressive conceptual structures that include various classifications of certain concepts. Authors can create typed concepts (with variant names) and an arbitrary number of resources linked to them. They can add any number of relations including transitive and symmetric relations in conjunction with the predefined classification hierarchies. By limiting the predefined relations and meta-level concepts we wanted to avoid unintended deviation between the learner's expectations and the produced output. The degree of formality of ontology is not necessarily a measure of quality in an e-learning environment: the focus should be on capturing the intended use of the ontology.

However, there are some challenges involved in the domain ontology development process: it is difficult and costly. Arriving at a representation of a domain requires deep knowledge of that domain and involves identifying its boundaries, selecting which concepts to define and at what level of detail and deciding how these concepts should be related. For example, programming languages are often classified between being interpreted or compiled. However these parameters do not reveal the essence of programming languages; neither semantics nor syntax depends significantly on whether code is compiled or interpreted.

Further on, concepts should account for multiple perspectives depending on the context in which the ontology is being used. All these assume support of a sufficient range of operations in the ontology development process, such as ontology design, implementation and browsing, merging of ontologies, searching for resources, multiple perspectives, etc.

3. Reusing Ontologies

One way to minimize the cost of creating ontologies is to make them reusable. The domain ontology component of a TM whose development is costly is *more stable* and therefore *reusable*. It is stable because classification based on a domain ontology is objective. The fact that the Procedural Languages are subclass of the Imperative Languages and that C is an instance of the Procedural languages is independent of human judgment or interpretations. Our framework supports reuse not only of learning resources but also of domain knowledge and instructional knowledge.

Figure 1. The Java Portal: exploring the Java ontology.

Figure 2. The Java Portal: exploring the Java course handouts.

We can view the domain ontology conceptual structures as independent information resources in their own right. An existing conceptual structure can then be overlaid on different information pools (using the TM4L editing functionality), or merged with other topic maps (using its merge functionality) capturing different viewpoints on the same collection. An existing structure can be a source for new perspectives or used for interchange.

TM4L supports ontology reuse which is essential for effective information integration. In addition to promoting common understanding of concepts and avoiding redefinition of terms it allows adding new meaning to preexisting course structures as it is illustrated below.

TM4L supports the extension of conceptual strictures through merging. For example, an existing conceptual stricture (ontology) implemented as a topic map can be integrated with a course representing topic map by merging them with additional mapping when necessary. We used this approach to create the topic map, driving the Java Portal (see Fig. 1 and 2): by merging the separately created Java ontology and a particular course structure (developed for the CSC 1311 Programming 1; using Tony Gaddis' book 'Starting Out with Java').

4. "One Ontology-Many Courses" Model

The conceptual representation of the domain is a key factor in our framework, which is built on the assumption that a rational structure will facilitate a correct representation of a collection of learning resources as well as the process of seeking them. The intuition supporting this assumption is that a conceptual representation can facilitate prediction and thus the chances of success of a specific navigational strategy.

We argue that a single standard classification of learning materials in a subject area is a weak strategy from a practical perspective. In general, a classification is simply one particular rationalization of the relationships in a given domain that satisfies a group of individuals at a certain point in time. Any classification, no matter how it is constructed, represents one possible view on a domain and thus one potential way to organize a learning collection. Any field of knowledge may be classified from different viewpoints or contexts resulting into different classifications. For each particular task the authors choose to represent one particular view of the domain, therefore, a classification of a knowledge area is aimed to support a given viewpoint at the expense of other views.

We can think of two basic perspectives on a course Topic Map in a particular subject domain: a *structure of concepts* describing the subject area and a *collection of text units* (chapters, subchapters, sections, segments) storing the corresponding information in a specific format. A common mistake is to confuse the container for the concept(s) contained. Figure 3 illustrates these two viewpoints on the Prolog domain. The first one is a conceptual classification; the second one represents Prolog from a course structure perspective. The suffix LN attached to each term stands for Lecture Notes.

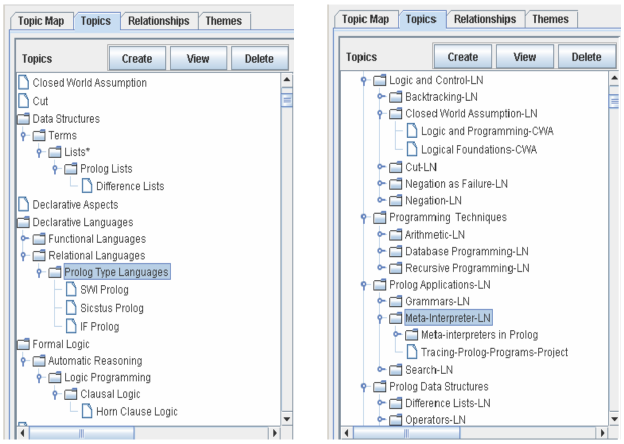

Figure 3. Two perspectives on Prolog learning resources.

It would be difficult to argue that only one of these classifications is an accurate representation of the domain and the other is not. The selection of categories in a classification depends on the viewpoint/context of the community of individuals in which the classification is created and used: in our case instructors and learners. In this case a classification based on a modules/lessons structure is not less significant than its conceptual counterpart.

The second classification supports learners that like to explore resources clarifying particular fragments from the studied material (lecture), the first one supports learners that like to explore resources related to individual concepts in the domain of their study. Therefore we found it beneficial to incorporate both of these classifications in the educational Topic Maps that we are developing, to serve as bases of different views.

This approach however posed a new problem. By extending the domain ontology conceptual structure with the specific course structure the resulting topic map turned to be course specific. This of course is highly undesirable with regard to the topic map reusability in a different course in the same subject area, for example, a course using a different textbook or instructor's handouts, etc. Hence we choose to create two independent topic maps – an *ontology topic map* and a *course structure topic map*. This separation of the content structure into “public” and “private” along with an efficient support for merge is the basis of our proposed model of educational topic maps.

To create a practical information support for users one needs to know the community’s vocabulary since the classification must reflect and respond to this particular community. This consideration shifted the focus of our work on enhancing TM4L from the system’s issues and techniques to the domains and contexts in which classifications function.

5. Building TM-driven Course Portals

Topic maps provide a suitable model for building portals and other forms of Web-based information delivery. The function of portals to provide a single point of access to a broad array of resources and a rich navigational structure are a fundamental characteristic of topic maps. Topic map-driven Web portals create dynamically the frame structures and content from the underlying topic map.

For displaying/using our developed educational topic maps it was feasible and convenient to relate the portal interface to the course structure components. However, the short life-cycle of course structures is quite common in the learning domain. In addition, we wanted to reuse the portal interface for a number of courses. Therefore the conventional methods for portal constructions were not suitable.

To overcome these problems, in TM4L we devised a generic topic map-driven portal and a tool for *automatic generation of portals* from it. The generic portal provides the interface, the topic filtering functionality, and the topic map-directed browsing functionality. The latter supports two different patterns of browsing based on the structure of the underlying topic map. By providing a specific description of the desired presentation categories (indexes) and a specific topic map (an XTM file) to the tool, the author may generate a specific portal from the generic model. Different portal versions may be generated by specifying different categories that should be explicated by the portal, such as course units, glossary, examples, tests, online resources, etc. The specified categories must be resource or topic types in the corresponding topic map. Figures 1 and 2 are screenshots of such a portal – the Java Portal (P4J), available at http://iiscs.wssu.edu/p4j/.

The resources in P4J are linked to course topics that are organized in a hierarchy, and there is an “uplink” to the much richer conceptual level. Therefore the learning resources can be viewed in the context of the related topics along with the relevant conceptual components of the learning collection. In a similar manner topics can be inspected in a drill down fashion. This means that the learner always sees the concepts to which the inspected resource is linked to and can always switch back and forth between the resource and concept domains. The P4J portal navigation is context-driven and view-driven. The learner can inspect the learning collection from a selected perspective (domain, course structure, etc.) or choose to examine a contextually related topic (e.g. to switch from “Lists” to the related topic “Recursion”). This kind of contextual visualization gives the learner a feeling of being in a “relational space”.

6. Conclusion

In an ideal world there would be a single conceptual structure for describing each subject area and a single standard for structuring course resources. However the reality of e-learning combined with the legacy of traditional learning is a mixture of different conceptualizations, viewpoints and subjective logic. Rather than preaching how to reach the absolute consistency, we address the reality by providing means to divide the learning resource structure into “public” and “private”, that is, into durable and unstable. While many works have reported on particular conceptual frameworks and implementations, the impact and practical implications of various aspects of the traditional learning support on e-learning tools have not been discussed in great detail. In this paper we outline the evolution of the TM4L Environment based on some practical observations. The focus is on the difficulties authors face when creating ontology-based courseware with TM4L, on the lessons learned and on the proposed strategies for overcoming some of the problems. Many of our findings may pertain to other ontology-based editing environments.

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AN ONTOLOGY-BASED APPROACH TO STUDENT SKILLS IN MULTIAGENT E-LEARNING SYSTEMS

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Abstract: The main idea of our approach is that the domain ontology is not only the instrument of learning but an object of examining student skills. We propose for students to build the domain ontology of examine discipline and then compare it with etalon one. Analysis of student mistakes allows to propose them personalized recommendations and to improve the course materials in general. For knowledge interoperability we apply Semantic Web technologies. Application of agent-based technologies in e-learning provides the personification of students and tutors and saved all users from the routine operations.

Keywords: e-learning, ontology, software agents, multiagent systems, Semantic Web technologies

ACM Classification Keywords: I.2.11 Distributed Artificial Intelligence: Multiagent systems

Introduction

The growth of the information society provides a way for fast data access and information exchange all over the world. Now, a lot of materials that used for education process exist in electronic form. In many domains the results of work are plain test materials. However, human readable data resources (like student control works, reports etc.) have serious problems for achieving machine analyses.

Computer technologies have been significantly changing the content and practice of education. The consequent applications of multimedia, simulation, computer-mediated communication and communities, and internet-based support for individual and distance learning all have the potential for revolutionary improvements in education [1, 2].

Online learning (e-learning) offers new possibilities in learning: a student can et immediate feedback on solutions to problems, learning paths can be individualized, etc. Online learning is a growing business: the number of organizations working on online learning and the number of courses available on the Internet is growing rapidly. Now a lot of e-learning tools with varying functionality and purpose exist [3,4].

E-learning is a contrary concept to the traditional human tutoring system. The course tutor in a software tutoring system controls learners relatively weaker than in the traditional tutoring where it is the tutor who is charge the contents and sequence of instructions. Therefore, in order to obtain better tutoring outcomes, a software tutoring system should emphasize engaging students in the learning process and be adaptive to each individual learner.

The goal of the early software tutoring systems was to build user interfaces that provide the efficient access to knowledge for the individual learners. Recent and emerging work focuses on the learner control over the learning process such as learner exploring, designing, constructing, and using adaptive systems as tools [5].