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A Topic Map based Adaptive Tutoring System

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Abstract: This paper describes an attempt to employ topic map technology in the development of an adaptive WBES. In particular, it explores how topic map standards can be used to represent the knowledge of the system concerning: 1.the educational content, 2. the domain knowledge, and 3. the student's profile, enabling personalized learning as well as reuse and interoperability of educational components. The feasibility and efficiency of the proposed approach is explored in a trial implementation using the subject of microcontrollers as a context.

Key-words: WBES, Adaptive, Semantic web, Topic maps, Reasoning

1. Introduction

Web-based technologies in conjunction with semantic web technologies form a new trend in modelling and development of adaptive web-based educational systems (WBES). Current research trends in the design of web-based educational systems indicate that concept-based systems seem to support adaptation and personalized learning [2,7,8]. Another aspect that should be taken under consideration concerns the facilitation of reuse and interoperability of educational components [2,6].

Towards these directions, research focuses on employing semantic web technologies in order to design an efficient WBES [2,7]. Topic Maps as a semantic-ontological approach seem to offer a feasible solution [2,6].

The aim of this paper is to illustrate the appliance of topic maps to represent knowledge in an adaptive web-based educational system. Consequently, the potential for enhance efficiency of the system and provision of a user-adapted presentation of the learning material, is going to be explored.

2. Semantic Web Technologies and e-learning

A lot of effort has been dedicated to the design and implementation of adaptive and intelligent WBES that can personalise the learning experience. Adaptivity in WBES may be achieved, if the system is capable of demonstrating knowledge-based reasoning, in providing an adjusted representation of educational material to student performance and preferences[2,6]. Another important issue in the design of such a system is to provide means that allow achieving reusability, shareability and interoperability among WBES [1,7].

Semantic Web seems to provide a promising solution as it offers new technologies enabling a more sophisticated management of information [1,6]. Semantic Web technologies have a great deal of potential in organizing domain knowledge and building student models in WBES [7,8]. Concepts, and Semantic Web standards i.e. XML, RDF, XTM, OWL are expected to provide semantically richer modelling in order to achieve improved adaptation in an e-learning system, as well as reusability, interoperability and advanced reasoning support [9].

Topic Maps offer a semantic ontological approach and their supporting infrastructure seem to be suitable for the development of well-structured concept-based WBES [3,12]. TM describe what an information set is about by formally declaring topics, by establishing typed relationships among topics, and by linking the relevant parts of the information set to the appropriate topics [13,16]. The basic concepts of Topic maps (TM) are Topics, Associations, and Occurrences — the TAO of topic maps, and the additional concepts of Identity, Facets and Scope — the IFS of topic maps [16].

TM provide a more abstract layer of data modelling, storage and querying. A main advantage of this model is the clear separation between the description of the information structure and the physical information resources [13,17]. Furthermore TM structure enables intelligent retrieval of information through the use of inference-based queries. TOLOG language can query topic maps for topics of specific types, which participate in certain combinations of associations, and also supports inference rules [11].

In the context of this paper a research attempt is presented, aimed at employing TM technology in the implementation of an adaptive WBES. The potential of this approach is going to be explored in the teaching and training area of microcontrollers.

3 Description of TM-TUTOR system

The proposed adaptive web based educational system (TM_TUTOR) implies a 3-tier architecture. The system is Java-based, as Java technology provides a reliable solution for highly interactive Web-based adaptive intelligent tutoring systems [4,18].

Figure 1 depicts the system's architecture, composed of the Domain module, Pedagogical module, Student module, Adaptation Engine and a GUI.

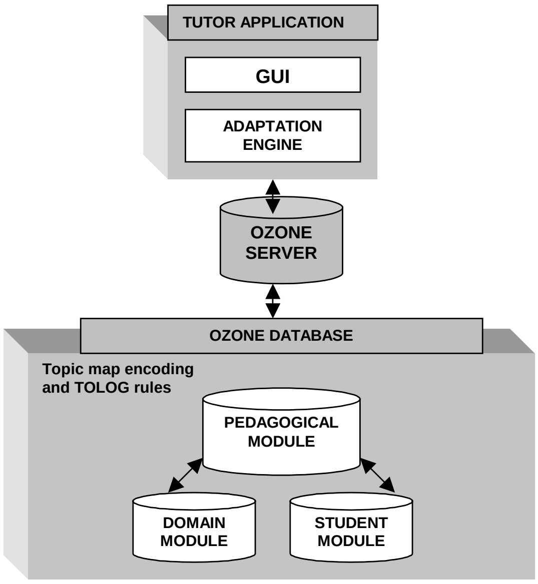

Fig. 1: System architecture of TM-TUTOR

Management and maintenance of the system relies on the server side. The components of the knowledge base should be able to dynamically assembled and adapted as the student's situation evolves. Ozone (OODBMS)[15] controls the communication of the whole system. Is a fully featured, object-oriented database management system completely implemented in Java language and distributed under an open source license. Ozone is based on central activation architecture and client applications control their objects in the database via proxy objects. In the client side, a windows application (TUTOR) offers the desired functionality to every user. The system provides an adjusted representation of educational material to student performance, i.e. degree of obtained knowledge, suitable detail level and evaluation of the student. The system monitors the performance of the student and updates student's characteristics.

4 Knowledge base design and implementation

Topic maps were applied to manage metadata describing educational components and to represent Domain and Student modules. Ontologies and TM standards represent the knowledge about the student and store explicit metadata for the educational content of the system. The use of TM enables interoperability and reusability providing a unified framework for the representation of knowledge. The pedagogical module is represented by TOLOG rules enabling the construction of a powerful adaptation mechanism tailored to the student's educational needs Topic maps were developed using Atop [10], a software application tool for TM editing, manipulation, navigation that also supports rules and querying using TOLOG language [11].

4.1 Domain module

Domain module contains the knowledge about the teaching domain. This is decomposed into a set of basic concepts concerning the actual educational material i.e. html documents representing lessons and test items. The system has a clear separation between knowledge concepts and resource repository (Figure 2)

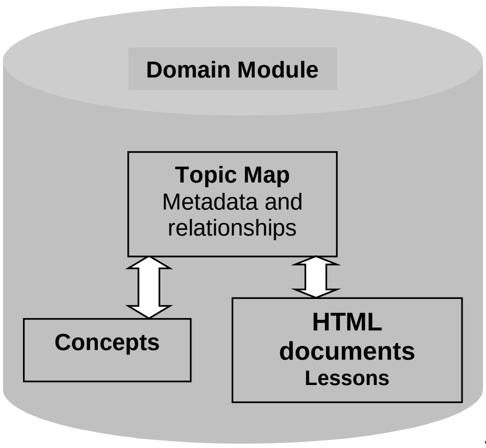

Fig. 2: Structure of Domain Module

The system uses a knowledge base, which consists of knowledge concepts. The role of concept structures is to describe the content at the level of abstract concepts, but it is also a way to deal with the resource-concept separation. Knowledge concepts are represented in TUTOR_TM as topics of the topic map.

The educational resource repository of the system is formed by a set of HTML files, which contain lessons and test items. Each resource is enriched with metadata, which are represented as occurrences in the topic map. These metadata are related to: the necessary information which the application need to know about each learning component and the amount of information needed for reuse and exchange of learning material.

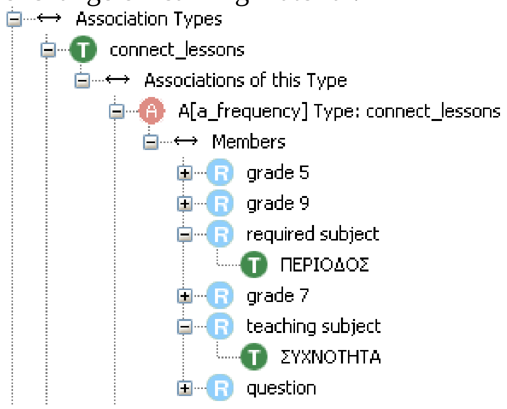

Fig.3: An association in Domain Module

Metadata concerning other properties of each document could equally well be used, as the system treats them without attaching any semantic knowledge. Keeping the metadata separate from the documents, TM-TUTOR allows the same documents to be used in multiple courses.

The next step was to link resources and knowledge concepts. Each resource is assigned to one or more concepts. The system depicts learning dependencies based on prerequisite relation between concepts and the difficulty level of each lesson. In TUTOR-TM system, linking is established via associations. An example is shown in Figure 3.

4.2 Student module

Student Module represents the knowledge that a WBES must have, taking into account the profile of each individual student. This knowledge will be used at run time to decide which goals and preferences must be covered by the educative content that the system provides. Such a student model is also object to changes over time because of the student's activities. The student model was also encoded and implemented as a topic map. General characteristics of the student model were defined as "occurrences". An example is illustrated at Figure 4.

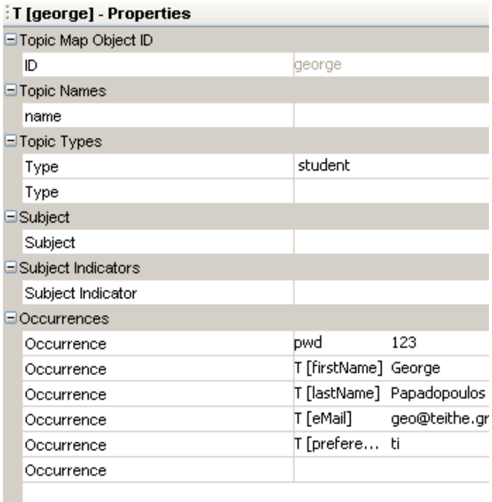

Fig.4: Main properties for a student profile

The main properties that characterize the student's profile, the functional property that indicates the student's cognitive style of learning and his target teaching goal, are represented as "occurrences" according to the topic map model. The student's knowledge in each topic and the grades that have received in evaluation tests are represented by an "association" pointing to the topics in which the student has knowledge and the level of that knowledge .

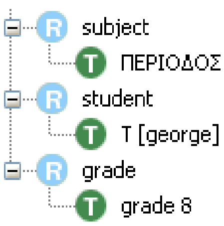

Fig.5: Association representing student's knowledge on a topic

4.3 Pedagogical module

The pedagogical module provides the knowledge infrastructure necessary to tailor the presentation of the teaching material according to the student model. The pedagogical module uses TOLOG rules and acts as a rule-based inference engine. The Pedagogical Module in TUTOR-TM system, uses information stored in the Student Module and in the Domain Module in order to deliver personalised learning to every student. Rules in the pedagogical module give the necessary information for making decisions about particular adaptive decisions. These rules are represented via TOLOG language, providing the knowledge infrastructure, necessary to tailor the presentation of the educational content according to every student needs and preferences. For example in rules that represented in Figure 6, the prerequisite relation between resources and concepts, states which lesson need to be learned before a certain lesson can be studied.

```
required_1($tSubject,$tRequired) :-
  connect_lessons($tSubject:teach_subject,$tRequired:required_subject).
is_root($tSubject) :-
  instance-of($tSubject,subject)
  ,not
  (    instance-of($tSuperSubject,subject)
     ,required_1($tSuperSubject,$tSubject)   ).
required($tSubject,$tRequired) :-
{  required_1($tSubject,$tRequired)
  |required_1($tSubject,$t),required($t,$tRequired)}.
has_requirements($tSubject) :-
  required($tSubject,$tRequired).
```

Fig.6: TOLOG Rules in Pedagogical Module

5 TUTOR Application

TUTOR is a software application tool that enables student to enter and explore the proposed web based educational system. It is a Java-based application that can be used in standalone mode and has been implemented as a module under NetBeans 3.6, due to portability advantages that ensure the platform independence of the developed application [14].

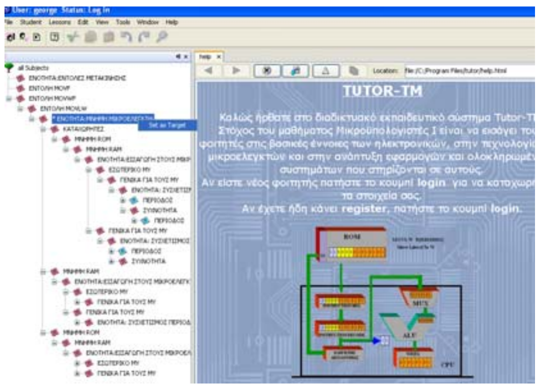

Fig.7: TUTOR application

The publication 3.6 has been selected due to its advanced features for creating and managing windowing systems. Thus, the developed application provides a facile graphical user interfaces (GUI), enriched with a lot of enhanced operations (Figure 7). Concepts that form domain knowledge

of the system are represented in a dependency tree-like graph in the left frame of TUTOR application window.
Student may choose a topic as his learning goal. The system can reason over learner's performance, and process requests for tutorials tailored on learner's learning situation in order to achieve his learning goal.

5. 1 Adaptation engine

Adaptation Engine is part of TUTOR application. Adaptation Engine uses TOLOG queries and manages rules contained in Pedagogical Module for making decisions, evaluating the student and deciding the next step in order to provide adjusted representation of educational material to student performance.

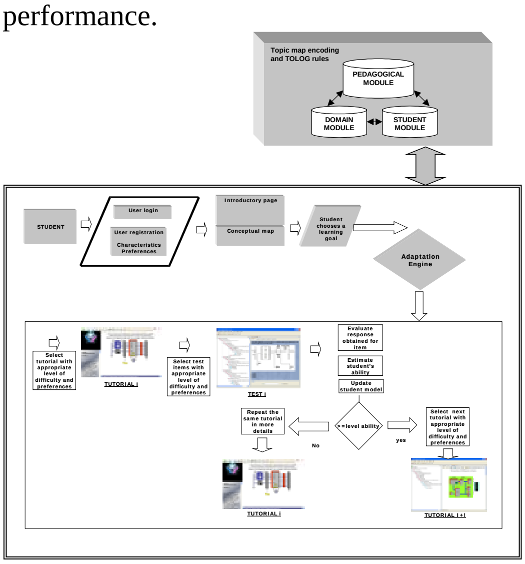

Fig.8: Flow chart of system's functionality

Figure 8 depicts the flow chart of system functionality. Adaptation engine selects the educational contents to be presented tailored to every student and determines the presentation style based on the knowledge available about each student and incorporating the rules that represent pedagogical module. Adaptation engine also continuously updates the Student Module according to the student's activities. Rules and queries allow automated harvesting of information from structured documents into the knowledge base by using the structure and the relationships between the structural components. This way reasoning support is enabled in order to implement an efficient adaptation mechanism.

6 Conclusions

The aim of this approach was to implement a web-based adaptive educational environment based on topic maps technology. It has been illustrated how this technology was applied to represent knowledge base of a WBES, in order to achieve improved adaptation and flexibility, as well as reusability, interoperability and advanced reasoning support. Topic Map model, as a semantic-ontological approach seems to achieve the level of knowledge management needed for the development of well-structured concept-based educational systems.
Topic maps were applied to manage metadata describing learning objects and to represent Domain and Student modules. The use of TM enables interoperability and reusability at the syntactic level on the Web. The Pedagogical module is represented by TOLOG rules enabling to construct a powerful adaptation mechanism tailored to the student's educational needs Topic maps were developed using ATop, a software application tool for TM editing, manipulation, navigation that also support rules and querying using TOLOG language.
Furthermore the system offers a friendly and easy –to-use user interface to the student. *The Adaptation Engine* uses TOLOG queries and manages rules contained in the Pedagogical Module. Thus it becomes easier to make decisions and calculate the next step aiming to provide adjusted representation of educational material according to student educational needs and preferences.
Future scopes of this attempt include: a) efforts to provide suitable templates for Topic Maps authors in order to create TM-based educational system b) the employment of more enhanced topic maps and rules and queries in knowledge base, in order to improve the adaptation of WBES and the reasoning support.

References

1. Aroyo, L. & Dicheva, D., AIMS: Learning and teaching support for WWW-based education, IJCEELL, 11 (1/2), 2001, 152–164.
2. Aroyo, L. & Dicheva, D.(2002): Concept and ontologies in WBES, Proc. ICCE Workshop on Concepts & Ontologies in Web-based Educational Systems, Auckland, New Zealand, 2002,pp 3–4.
3. Biezunsky, M., Bryan, M., Newcomb, S., (1999). ISO/IEC FCD 13250:1999 – Topic Maps, www.ornl.gov.
4. Brusilovski, P., Adaptive and Intelligent Technologies for Web-based Education, In C. Rollinger and C. Peylo (eds) Special Issue on Intelligent Systems and Teleteaching, Kunstliche Intelligenz, 1999, Vol. 4, pp 19-25
5. de Kereki, I. F. (2003): “Use of Ontologies in a Learning Environment Model”. Proceedings of the IASTED International Conference. Rhodes, Greece, Jun 2003, pp. 550-555
6. Dichev, C., Dicheva, D. and Aroyo, L. Using topic maps for Web-Based education Advanced Technology for Learning, 2004, Vol. 1, No. 1
7. Devedzic, V. (2001). The semantic web: Implications for teaching and learning, Proc. ICCE'2001, Seoul, Korea, pp 29_30.
8. Devedzic, V. (2002). What does current Web-based education lack. Proceedings of the IASTED International Conference APPLIED INFORMATICS. Innsbruck, Austria, Feb 2002.
9. Devedzic, V. (2003). Next-generation Web-based Education. International Journal for Continuing Engineering Education and Life-long Learning, 11 (1/2), pp 232-247.
10. Hatzigaidas, A., Papastergiou, A. & Tryfon, G. (2005). ATop: A Software Tool for Topic Map Technology , Proceedings of 4th WSEAS International Conference ,Telecommunications and Informatics (TELE-INFO 05), Prague, Czech Republic, March 13-15, 2005, pp 197-203, ISBN:960-8457-11-4
11. Garshol, Lars Marius, (2001) TOLOG, a topic map query language, http://www.ontopia.net/
12. ISO 13250, (2000). International Organization for Standardization, ISO/IEC 13250, Information technology — SGML Applications — Topic Maps (ISO, Geneva 2000)
13. Moore G. (2000). Topic Map technology - the state of the art. Proc. of XML Europe, Paris http://www.infoloom.com/gcaconfs/WEB/paris2000/S22-04.HTM, June 2000
14. Netbeans IDE Organisation, http:www.netbeans.org
15. Ozone database homepage www.ozone-db.org/
16. Pepper, S. (2000). The TAO of Topic Maps. Proc. of XML Europe, Paris
17. Rath, H.H. (1999). Technical Issues on Topic Maps, in: Proc. of Metastructures 99 Conference, GCA, Alexandria, VA
18. Sun Microsystems, Inc. Java programming language. An interpreted language, http://java.sun.com/