REALIZING THE PERSONALIZED LEARNING PATHS IN A LMS

Funda Dağ, Kadir Erkan
Kocaeli University, Turkey
fundadag@kou.edu.tr, erkan@kou.edu.tr

ABSTRACT

In this work is proposed that an adaptation tool that is for the automatic generation and personalization of courses of a general-purpose LCMS that is named A Tutor. A Tutor is a Learning Content Management System. The architecture of the adaptation tool that allows a personalized sequencing of LOs in A Tutor for the learner's learning goals, learning styles and cognitive state is presented.

Keywords: Learning Management System, Web-Based Adaptive and Intelligent Tutoring System, Curriculum Sequencing, Semantic Network, Concept Map.

INTRODUCTION

Intelligent LMS or LCMS (iLMS) is an application area of AI-Education researches. It is composed of Intelligent Tutoring Systems(ITS), Adaptive Hypermedia Systems(AHS) and Learning Management Systems(LMS). Basic goal of an iLMS is to improve the learning experiences by personalizing and adapting instruction that is formed Learning Objects(LOs), based on what the system knows about the learner. iLMS practices instructional planning for presentation of LOs by using course sequencing technique of ITS and adaptation techniques of AHS. The heart of LMS is Learning Objects. LOs are web-deliverable digital sources that are used in LMS or LCMS, which provide a Web-Based platform for their delivery to learners. Standardization is the most important subject to develop a LO based learning environment. Applications of LMS or iLMS must be organized according to e-learning standards. As a result that, iLMS presents a new direction for AI-Education research.

To examine iLMS, this work provides an in-depth investigation and analysis of the knowledge requirements, knowledge modelling architecture of an intelligent learning environment and functioning of an instructional planner that uses LOs to interact with learners in a LMS.

RESEARCH DESIGN

The architecture of the system is investigated according to three perspectives. These perspectives are instructional design, architecture of AHS and software development. The system is composed of three models. These are Domain Model, User Model and Pedagogical (or Adaptation) Model. The models of the system are referenced by AHAM reference model that is an application-independent model for AHS (De Bra et. al, 1999). Domain Model of the system which is ontology-based, is organized to support e-learning based on LOs (Kanellopoulos et. al, 2006). Ontology allows representing the most important domain concepts and relations among them (Mohan et. al, 2003). There are different knowledge bases for each model of the system. The domain model knowledge base has a three layer that are Learning Objectives, Domain Concepts and Learning Objects (Papanikolaou et. al, 2003). User Model of the system is constructed by overlay model. It can measure independently the user's knowledge of different topics (Brusilovsky, 1996). User model knowledge base of the system contains knowledge sets for each user's learning goals, learning styles and knowledge level about the domain knowledge. Pedagogical Model is composed of a pedagogic knowledge base that is based on an instructional design theory and an instructional planner. Software architecture of the system is component-based.

In second section of the paper that is named as Instructional Planning, we provide an overview of instructional planning in traditional ITS and next generation ITS named as intelligent e-learning system. In third section of the paper that is named as Knowledge Modelling and Ontology, we discuss the need for ontologies to define the structure of LOs that is key component of the e-learning system, are used by instructional planner and the need for pedagogic knowledge is related to the idea of e learning design. In forth section that is named as Proposed Architecture, we discuss the architecture of the proposed system. Also, we purpose the knowledge representation framework for the instructional planner of A Tutor. In the last section, we summarize the results presented in the paper and mention some further extensions currently being researched.

INSTRUCTIONAL PLANNING

Planning of an instruction is a teaching-learning process that takes place in a unit of learning (a course, a lesson, a learning module, etc.) The key principle in instructional planning is that it represents the learning activities and the support activities that are performed by different persons (learners and teachers) in context of a unit of learning.

Instructional planning is a research subject in Intelligent Computer Aided Instruction (ICAI). It was used in early ITSs such as Pepe (Vassileva and Wasson, 1996), DCG (Vassileva, 1997) and in Adaptive Learning Systems such as Elm-Art (Brusilovsky et. al, 1996), INSPIRE (Papanikolaou et. al, 2003). The main idea of instructional planning approach is applying AI techniques to determine the content of instruction and this is firstly proposed by Peachey and McCalla (1986) (Vassileva, 1997).

Instructional planning requires pedagogical decision making. This decision is concerned with both the *content* (what goals to focus on) and the *delivery* (how to achieve the goals) of instruction (Vassileva and Wasson, 1996). Instructional planning is named automatic course sequencing in Adaptive Learning Systems. In ALS, two main approaches have identified for automatic course sequencing (Brusilovsky and Vassileva, 2003). These are *adaptive course sequencing* that is similar to the delivery planning of ITS and *dynamic course generation* that is similar to the content planning of ITS. In adaptive course sequencing, the goal is to generate an individualized course according to the specific learning goals and the initial level of the learner's knowledge and then content sequencing keep existing situation going, instead of generating a course incrementally. In dynamic course generation, the system observes the progress of the learner during his/her interaction with the course and dynamically adapts the course according to preferences, knowledge level and also learning styles of the learner (Vassileva, 1997).

Both approaches these are mentioned above can be used filtering of LOs and generate adaptive sequencing of LOs in the e-learning system. There are some researches about this approach (Karampiperis and Sampson, 2004; Mohan et. al, 2003; Capuano et. al, 2003). Applying of instructional planning in e-learning system is similar to ITS or ALS. So that, personalized content of the context of the e-learning system or generate pools of learning objects satisfying certain learning objectives, an instructional planner should be used. This instructional planner can be usable for different knowledge domain because of the nature of the e-learning system (Mohan et, al, 2003). Firstly, it needs to have knowledge on the concepts to be learned in the domain and relationships between these concepts. This is generally referred to as the *domain model*. Secondly, generation of the instruction to individual needs of the learners, various kinds of information (such as systems' beliefs about the knowledge level of the learner for the domain, learning styles and preferences of the learner, etc.) should be stored in a *user model*. In addition, to generate internally consistent and coherent interactions with the learner, the system's interactions with the learner should be recorded in *a learner history knowledge base* that can be a part of the user model. Finally, to make pedagogic decision for effective instruction should be used *a pedagogical model* that is named the adaptation model in the ALS. Pedagogical model of the system should be based on an Instructional Design Theory.

Key component of the instructional planner is the domain model. To implement the domain model can be used a kind of semantic network structure. This network consists of nodes representing concepts in the domain and semantic relationships between concepts in the domain structure (Papanikolaou et. al, 2003; Karampiperis and Sampson, 2004; Capuano et. al, 2003). LOs are especially reusable learning material. They can be created elsewhere and used any e-learning system. And also, an e-learning system can be used different courses in other words different domains. So, the nature of the e-learning system based on LOs, in domain model, which concepts are specified and linked to LOs for arbitrarily defined domain models and their LOs is a much difficult problem (Mohan et. al, 2003). To overcome this problem, ontology based learning domains could be used (Mohan and Greer, 2003).

KNOWLEDGE MODELLıNG AND ONTOLOGY

The use of ontologies can significantly simplify the task of knowledge structuring by providing a standard based way for knowledge representation of the domain model. Ontology is a semantic web technology that is specifications of the conceptualization and corresponding vocabulary used to describe a domain (Karampiperis and Sampson, 2004). Ontologies typically consist of definitions of domain concepts, their relations and axioms (rules) about these concepts and relationships. Ontology based e-learning system approach is the result of standardization requirements of e-learning systems. As a result of these standardization efforts some standard learning ontologies is generated by learning organizations. For instance, IEEE LOM (for metadata specifications of LOs), ADL SCORM, IMS Learning Design specifications. The proposed system has been structured ontology based.

The other important point of instructional planner is pedagogic knowledge. Pedagogic knowledge guides the instructional planner into making principled decisions when choosing learning goals for a learner and when choosing and restructuring sequencing of LOs to achieve the learning goals.

Instructional planning process is in common field of Artificial Intelligence and Education. Generally pedagogic knowledge that controls the action of the instructional planner is expressed as rules. Because of e-learning systems can be used different domains, should be used domain independent rules for the instructional planners being used for e-learning, since they allows the same instructional planner to handle content from many different domains (Karampiperis and Sampson, 2004).

THE PROPOSED ARCHITECTURE

The proposed system is constructed by three models. These are Domain Model, User Model and Pedagogical (or Adaptation) Model. The models of the system are referenced by AHAM reference model that is an application-independent model for AHS (De Bra et. al, 1999).

In the proposed system, the domain model has a three layer that are Learning Objectives Layer, Concept Layer and Learning Materials (LOs) layer these are like INSPIRE (Papanikolaou et. al, 2003). User Model of the system is constructed by overlay model. Overlay model is powerful and flexible for user model, it can measure independently the user's knowledge of different topics (Vassileva and Wasson, 1996). Pedagogical Model is composed of a pedagogic knowledge base and an instructional planner that is based on an instructional design theory. The components of the pedagogical model are structured by referencing Merrill's (1996) Instructional Transactions Theory. In Figure 1, the proposed system has been showed.

The Domain Model

Domain model is the core component of the system. This model is different from domain models that are often used in ITS. Domain Model of the system is organized to support e-learning based on LOs and ontology-based. Ontologies allow representing the most important domain concepts and relations among them.

A domain concept (DC) is a concept belonging to the described didactic domain and can be possibly explained by one or more LOs. In the proposed system, the common thesaurus represent the domain concepts in the didactic domain is characterized by CE-2004 Curriculum Reference Guide (CE-2004). The typical relationships among DCs are structured by relation category of IEEE LOM.

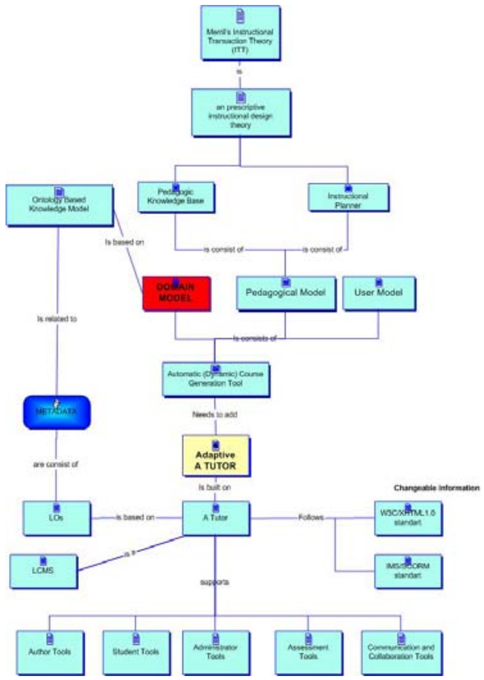

Figure 1: The architecture of the system.

To construct an example of the domain model; firstly, an application module was selected from CE-2004 ontology. That module is CE-CSG4 Frequency Response which is in the body of knowledge of CE-CSG Circuits and Signals. Then, according to the application module learning objectives was established. And so, DCs, LOs and their relationships were planned. In all layer of domain model, relationships were referenced by categories of IEEE LOM.

According to Figure 2, domain model of the system is a DAG (Directed Acyclic Graph). The domain knowledge representation of the domain model was realized by Concept Map Software (Coffey et. al, 2002), developed at the IHMC was used to lay out ideas and concepts pictorially and show how they are related.

There are three concept types in the model that are composite concept (is showed by an ellipse), atomic concept (is showed by a rectangular) and LO metadata (is not showed in this sample). A composite concept has a sequence of sub concepts that are either all composite concepts or all atomic concepts. An atomic concept has not any sub concept. It can be used to recognize the relations between levels. Such as, only atomic concepts are linked between learning goals level and domain concepts level or between domain concepts level and learning materials level (LOs) by means of the relation reference or explained by.

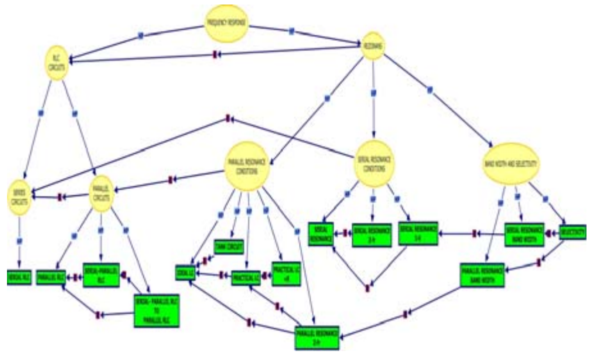

Figure 2: An example of the knowledge representation of the domain model.

The relations among concepts are represented by four relation types. These are;

HP(has part): HP(c, $a_1,a_2,...,a_n$) means that the concept c is composed of the concepts $a_1,a_2,...,a_n$. *R(requires):* R(c_1,c_2) means that to learn c_1 to have already learnt c_2.

REF(references): REF(a,c) means that an atomic concept such as a private learning goal in the learning goals level is related to an atomic or composite concept in the concept level

EB(Explained by): EB(a, LO_x) means that an atomic concept in the concept level can be explained by means of the LO_x in the learning materials level.

The result of the merging of three levels of the domain model, the DAG gives information about which concepts explained in the LOs. LOM metadata fields are used for representing of all concept types and relation types of the domain model. Also, some system functions and a set of rules are defined for conjunction of metadata fields of the domain concepts, cognitive state modeling of the user and automatic curriculum sequencing.

The User Model

The user model of the system has two main information types that are stable and changeable information. The stable information is similar to user database knowledge of A Tutor such as, user ID, preferences and experiences of the user about the system. The changeable information is cognitive state of the user about the domain knowledge. Cognitive state of a student is represented by a knowledge set. This knowledge set will be used to pose "the system knowledge on about each student knowledge". During the learning process; values of the knowledge set is evaluated by the result of post and pre tests that are fulfilled by the user. The representation of cognitive information will be inserted the user database knowledge of A Tutor. Afterward, user learning styles will be integrated to the user model.

The Pedagogical Model

The pedagogical model of the proposed system is composed of a pedagogic knowledge base and an instructional planner. The pedagogic knowledge base consists of knowledge from DM and UM. These are knowledge about domain concepts that are linked to learning objectives, knowledge about content structures used for delivery of content and knowledge about the user in UM. This pedagogic knowledge guides the instructional planner into making principled decisions when choosing learning goals for a user and re-structuring LOs to achieve these learning goals.

Instructional planner of the system is based on Merrill's (1996) Instructional Transactions Theory (ITT). This is a prescriptive instructional design theory. Prescriptive theory consists of IF/THEN prescriptions. That is, if the learner is to acquire a particular kind of knowledge or skill then the instruction must employ the instructional strategy that is appropriate for promoting the acquisition of that kind of knowledge (Merrill et. al, 1996).

ITT is based on knowledge objects, their interrelationships and transaction shells that are consist of rules for selecting and sequencing knowledge objects. A knowledge object can be an entity, an activity or a process. An instructional transaction shell is a computer algorithm that encapsulates the conditions for teaching a given type of knowledge. In ITT , there are 13 different transaction modes that are needed depending on the kind of knowledge or skill required.

An optimum learning path can be realized by using of the sequencing rules of the transaction that are conditional on the knowledge about the user model of a student.

Using of domain independent rules to control the behavior of the instructional planner is clearly the better approach for instructional planner. According to this approach, ITT is the most suitable instructional design theory for realizing of the domain independent intelligent e-learning systems.

In our work, we will use only component transactions of ITT. Component instructional transactions enable the learner to acquire knowledge of the components which comprise a single knowledge object that is like a LO in our work. There are three classes of component transactions: identify, execute and interpret. These transactions could be used by a method of the domain concept classes.

CONCLUSIONS AND FUTURE RESEARCH

In this paper is brought together technologies of ITS and AHS and general purpose LMS. So, an iLMS is proposed. It is a LMS that have adaptive behaviour, can assist in the management of LOs using AI techniques, and can learn from student's performance and sequence the delivery of learning content according to individual learning needs of the student. This novel way of managing content improves the reusability of LOs and effectiveness of LMS.

We described models of the system generally. We proposed a domain model and a pedagogical model for the automatic course generation of the A Tutor.
Realization of the system is still continued. In our feature work, we will focus on to make better adaptation features of the system, such as adaptive presentation and adaptive navigation. And also, we will integrate learning style on the system.

REFERENCES

Brusilovsky, P. (1996). Adaptive hypermedia, an attempt to analyze and generalize. *In P. Brusilovsky, P. Kommers, & N. Streitz (Eds.), Multimedia, Hypermedia, and Virtual Reality (Lecture Notes in Computer Science, Vol. 1077).* Berlin: Springer-Verlag, 288-304.

Brusilovsky, P., Schawarz, E., Weber, G., (1996). ELM-ART: An ITS on WWW. In Frasson, Gauthier,C.&Lesgold,A(Ed.), Intelligent Tutoring Systems, Lecture Notes in Computer Science, Vol.1086, 261-269, Berlin, Germany.

Brusilovsky, P. Vassileva J. (2003) Course Sequencing Techniques for Large Scale Web-based Education, International Journal of Continuing Engineering Education and Life-long Learning, 13, (1/2), 75-94.

Capuano, N., Gaeta, M., Micarelli, A., Sangineto, E. (2003). An Intelligent Web Tutoring System for Learning Personalization and Semantic Web Compatibility. *Proceedings of the 11th International PEG Conference "Pawerful ICT for Teaching and Learning" June 28 – July 1 2003,* St. Petersburg, Russia.

CE 2004 - Curriculum Guidelines for Undergraduate Degree Programs in Computer Engineering, *Retrieved January 24 2007 from http://www1.acm.org/education/curricula.html#CE2004*.

Coffey, J.W., Hofmann, R., Canas, A.J. and Ford,K.M. (2002). A Concept Map-based Knowledge Modelling Approach to Expert Knowledge Sharing. *Proceedings of the IASTED International Conference on Information and Knowledge Sharing*, Virgin Islands.

De Bra,P., Houben,G.J., Wu,H. (1999). AHAM:A "Dexter based Referance Model for Adaptive Hypermedia." *Proceedings of ACM Hypertext'99*. Darmstadt, 145-156.

Kanellopoulos, D., Kotsiantis, S., Pintelas, P. (2006). Ontology-Based Learning Applications: A Development Methodology. *Proceedings of the 24th IASTED International Multi-Conference Software Engineering, February 14-16*. Innsbruck, Austria.

Karampiperis, P. & Sampson, D. (2004). Adaptive Instructional Planning using Ontologies. *Proceedings of the IEEE International Conference on Advanced Learning Technologies (ICALT'2004)*, 0-7695-2181-9/04.

Merrill, M.D. & ID2 Research Team (1996). Instructional Transaction Theory: Instructional Design based on Knowledge Objects. *Educational Technology*, 36(3), 30-37.

Mohan, P., Greer, J., McCalla, G. (2003). Instructional Planning with Learning Objects. *18. International Joint Conference on AI Workshop on Knowledge Representation and Automated Reasoning for E-Learning System (KRR-5), Sunday, August 10*. Acapulco.

Mohan, P. & Greer, J. (2003). E-learning specifications in the context of instructional planning. *In Hoppe, U., Verdejo, F., Kay, J., eds.: AI in Education, AIED-2003,* IOS Press (2003), 307–314

Papanikolaou, K.A., Grigoriadou, M., Kornilakis, H., And Magoulas, G.D. (2003). Personalising the Interaction in a Web-based Educational Hypermedia System: the case of INSPIRE. *User-Modeling and User-Adapted Interaction*, 13 (3), 213-267.

Vassileva, J., (1997). Dynamic course generation on the WWW. *In: B.D.Boulay and R. Mizoguchi (eds.): Artificial Intelligence in Education: Knowledge and Media in Learning Systems. IOS Press, Amsterdam, pp. 498-505.*

Vassileva J. & B. Wasson (1996). Instructional Planning Approaches: from Tutoring towards Free Learning. *Proceedings of Euro-AIED'96, 30.9.-2.10.1996.* Lisbon, Portugal, 1-8.