A DOMAIN-INDEPENDENT OTOLOGY-BASED APPROACH TO REPRESENTATION OF COURSEWARE KNOWLEDGE

Eleonora Stoyanova, Polina Valkova, Irina Zheliazkova

Abstract: This paper proposes an ontology-based approach to representation of courseware knowledge in different domains. The focus is on a three-level semantic graph, modeling respectively the course as a whole, its structure, and domain contents itself. The authors plan to use this representation for flexibie e- learning and generation of different study plans for the learners.

Keywords: domain-independent, ontology-based approach, semantic graph, courseware, knowledge representation

ACM Classification Keywords: Computer Uses in Education, Knowledge Representation Formalisms and Methods

Introduction

The term “ontology” has been put in use in knowledge engineering (KE) since the beginning of the 90’s in order to stress on the need and benefits of an explicit conceptual structuring of domain knowledge [Kellett & Marshall, 1990], [Decker et al., 1999]. In its simplest form this key idea was proposed earlier by [Dovgialo & Visotcki, 1983] for the needs of Computer-Aided Learning (CAL). The authors suggested a top-down strategy for development and implementation of courseware including mainly background material, structuring in topics with corresponding pretests and posttests. According to the semantic networks formalism the type of the relationships between topics, e.g. on the level of course is "a-part-of". At the same time and independently [Sato & Chimura, 1984] proposed to represent the structure of the taught course by means of a binary matrix, corresponding to a directed graph whose nodes stand for the topics and arcs for their input/output relationships. The idea of structuring the domain knowledge on two levels respectively course (global) and topic (local) belongs to [Peachey & MacCalla, 1983]. They proposed to represent the input ("preconditions") and output ("expected results") relationships of the topics by means of AND/OR/NOT operators.

The ontology-based approach was transferred from CAL systems to Knowledge Management CAL (KMCAL) systems where it was extended using mainly different kinds of networks (feature, semantic, augmented, and so on). The term KMCAL was used for the first time by [Webb, 1988] as a result of a comparative analysis of the frame-oriented CAL systems and Intelligent Tutoring Systems (ITS). He introduced the feature networks (FN’s) for knowledge representation on the topic level. Webb is a co-developer of the KMCAL system ECCLES based on this intelligent formalism and aimed to enhance English language learning. He pointed out seven teaching modes (interrogative, test, declarative, immediate, constructive, reference, and mixed) derived from the FN’s representation. The author also pointed out the restrictions of the FN’s structure making this formalism not so appropriate on the course level. More recently a domain-independent KMCAL system MICROKURS had been developed for teaching/learning declarative knowledge in different domains. On the local level this system is based on priority semantic networks [Marinov & Zheliazkova, 2005] and on the global level - on a set of input/output relationships between the course topics.

The ontology-based approach to modern domain-oriented design environments (DODEs) follows the contributions in cognitive and pedagogy sciences. The researchers in this area are interested in methods for solving practical tasks and in specialized tools facilitating the capturing, structuring, sharing and reusing of domain knowledge. This complex problem has been partly solved by development of knowledge repositories called ontological servers (*Ontolingva, Ontobroker, KA2* and other projects) with the static domain knowledge for reuse [Decker et al., 1999]. The efficiency of this kind of servers is more perceptible in case of theoretical courses with complex learning objects such as algorithms, context-free grammars, neural networks, final state-machines, and so on. DODEs are seen by [Fisher & Schvarff, 1998] as environments for support of self-directed learning. Gamelan, Educational Object Economy, and Agent Sheets Behaviour Exchange are three web-based DODEs supporting the learning needs of a community of software developers. Short analyses of the tools for support of the domain ontology can be found in [Stefanov, 2003], where the computing education ontology for the needs of the project DIOGENE is also described. This ontology consists of one class (computing education field), a lot of instances (terms from the computing domain) and a predefined set of relations, called respectively "*has-part*", "*requires*", and "*suggested-order*".

Nowadays the course author has to work as a knowledge analyst and engineer making visible the course curriculum and conceptual structure of the taught domain. For the needs of representation and delivering the curriculum contents through INTERNET a hybrid approach has been proposed by [Fung, 2002]. Although it is demonstrated on the basis of an introductory course in Mathematical Statistics the approach is domain-independent. It is based on a combination of standard directed graphs and modified state-charts. Except the hierarchical relationships, e.g. type "a-part-of" and "type-of", two other types can be used, called respectively "*contained-in*" and "*applied-to*". The author focuses on the opportunity for generating different study plans with depth-first, top-down, bottom-up, and breath-first strategy to suit the different students and delivering the appropriate teaching multimedia material.

In task-oriented environments (TODEs) the ontology-based approach using a visual language facilitates and enhances both adaptive individualized planning and flexible self-directed learning. Once a course is represented in such a way different study plans can be generated to suit the different learning styles and flexible learning can be ensured that suits the learner's interests, needs and preferences. Additionally in TODEs the ontology design is also used as a procedure for precise assessment and diagnostics of the learner's knowledge relatively to the author's one [Zheliazkova, 2005].

In this paper a domain-independent three-level semantic graph is proposed to model courseware knowledge. This model is close to the multi-hierarchical directed graph model described by [Otzuki, 1990] for the needs of KE and to the discrete Markov chain model of [Jelev, 2004] for the e-learning assessment in higher education. Each level of the proposed model is commented and demonstrated with elements of an example courseware in a separate section. The courseware specially created for research purposes by means of MACROMEDIA FLASH 5.0 is in the domain of Programming Environments (PEs) and the working language is Bulgarian. The Conclusion outlines the authors' contributions and future intentions.

First Level Semantic Graph Model

The first level of the semantic graph model concerns the courseware as a whole (fig.1).

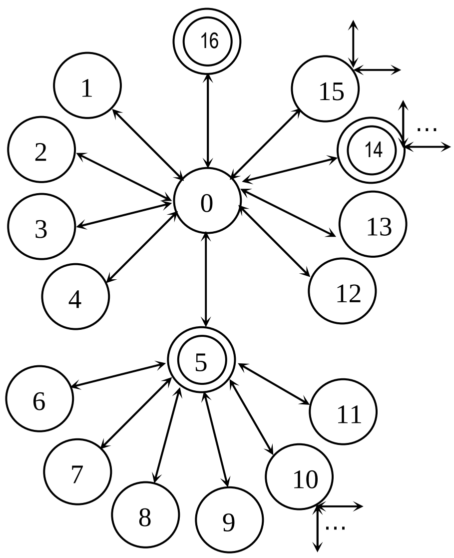


Fig. 1. First level semantic graph model

Index	Dialog state
0	Courseware home page
1	Institution home page
2	Department home page
3	Author's home page
4	Teacher's home page
5	Initial course page
6	Curriculum timetable
7	Curriculum annotation
8	Curriculum contents
9	Technology of teaching
10	References
11	Discussion forum
12	Search machine
13	Frequently asked questions
14	Dictionary
15	Courseware map
16	Home pages of similar courses

Table 1. Decoding the node

The model has the form of two connected stars, where all arcs are type ‘a-navigation-link” and the node indexes are decoded in table 1. The frequently used links are to/from the pages of: the members of the authors’ team, elements of the curriculum, standard tools for human INTERNET communication, similar courses, and so on. Node 10 (References) has a set of external links from/to some nodes on the third level of the model representing the domain knowledge itself. Node 15 (Courseware map) has links to/from nodes belonging to the three levels as well as opportunities for downloading the background material, pretests, and exercises (fig. 2). Double-circle nodes (5, 14,16) stand for subgraphs. The need of a terminological dictionary (node 14) can be motivated by the different meanings one and the same word may have in different domains. For example, the word “frame” in Psychology means a kind of spirit, in Mechanics skeleton of construction, in CAL screen content, in Artificial Intelligence an information structure for knowledge representation, and so on. Although English has become the main official language all over the world it’s better for non-native speaking English learners to use their native language as working one. That’s why the dictionary has to be multilingual.

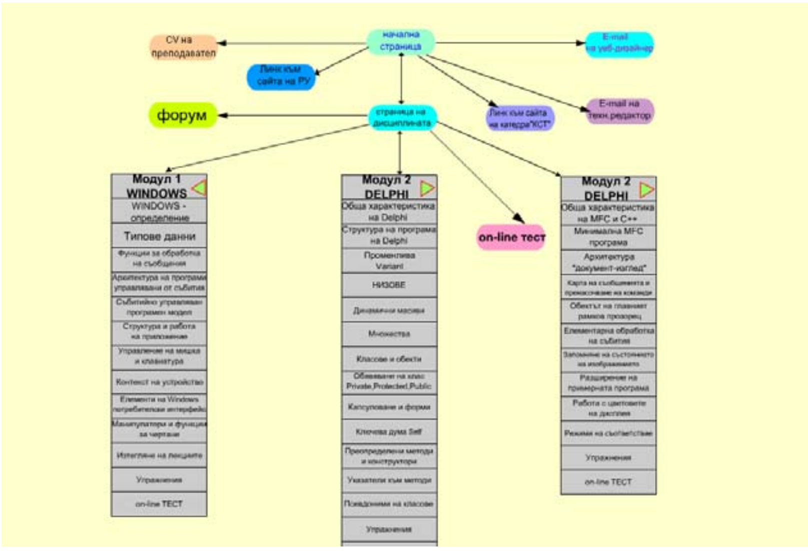


Fig. 2. PEs courseware map together with modules and topics

Second Level Semantic Graph Model

A detailed analysis of the standard curriculum for engineering education at the University of Rousse has shown that besides explicit hierarchical links of type “topic-subtopic” such a curriculum can contain several types of implicit links, such as: “topic-test”, “topic-exercise”, “test-test”, and “exercise-exercise”. In the most common case the cardinality of these types of relationships is 1:N. That means more than one taught topic can be tested with one test or applied to one exercise. Also more than one exercise (test) can serve as subexercise (subtest) in another exercise (test). The above-listed types of links can be found on fig. 3, presenting the subgraph node 5 from fig. 1. Here the following graphical primitives are used in addition: an ellipse for a subtopic, a triangle for a test, and a square for an exercise. Fig. 4 presents a part of the PEs hierarchical structure viewed in Notepad as a standard text file.

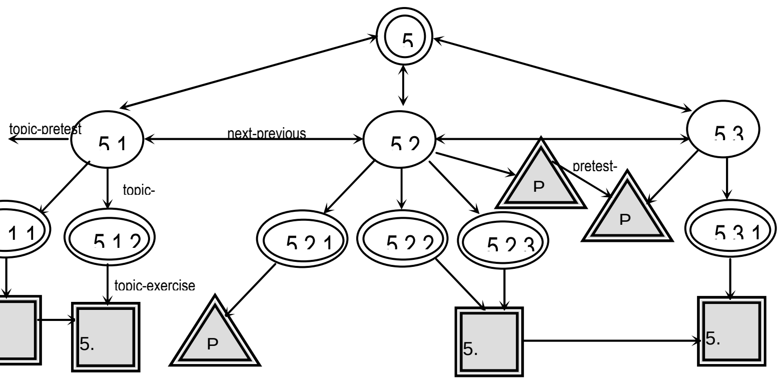
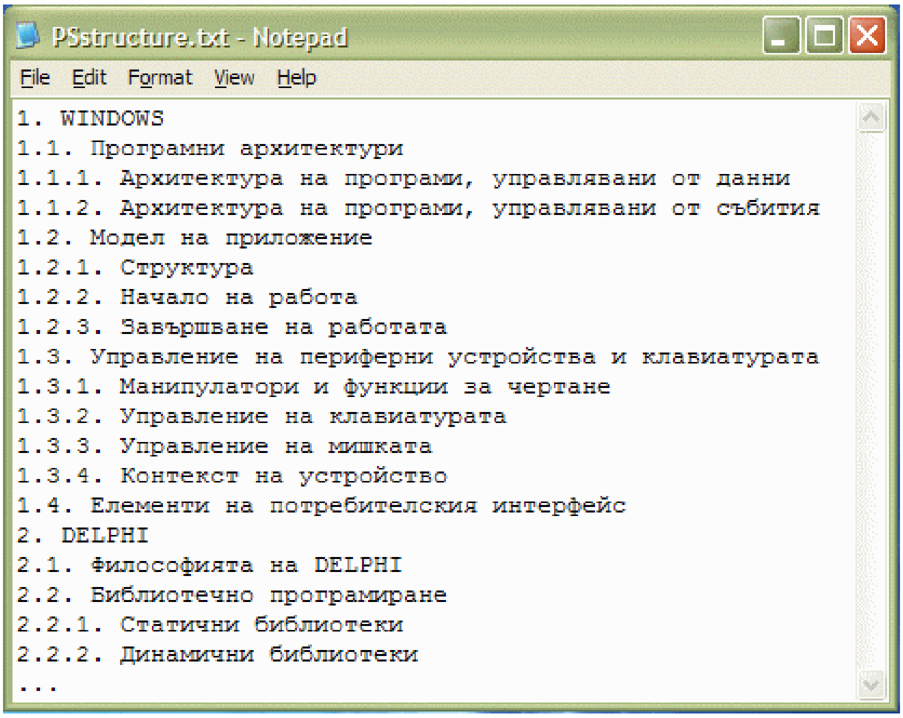


Fig.3. Second level semantic graph model



1. WINDOWS
1.1. Програмни архитектури
1.1.1. Архитектура на програми, управлявани от данни
1.1.2. Архитектура на програми, управлявани от събития
1.2. Модел на приложение
1.2.1. Структура
1.2.2. Начало на работа
1.2.3. Завършване на работата
1.3. Управление на периферни устройства и клавиатурата
1.3.1. Манипулатори и функции за чертане
1.3.2. Управление на клавиатурата
1.3.3. Управление на мишката
1.3.4. Контекст на устройство
1.4. Елементи на потребителския интерфейс
2. DELPHI
2.1. Философията на DELPHI
2.2. Библиотечно програмиране
2.2.1. Статични библиотеки
2.2.2. Динамични библиотеки
...

Fig. 4. A part of the PEs hierarchical structure viewed in Notepad

Third Level Semantic Graph Model

On the third level the semantic graph model represents the domain contents itself. Actually, three disconnected semantic graphs respectively for a topic (lecture, lesson), test, and exercise serve as formalism for this purpose.

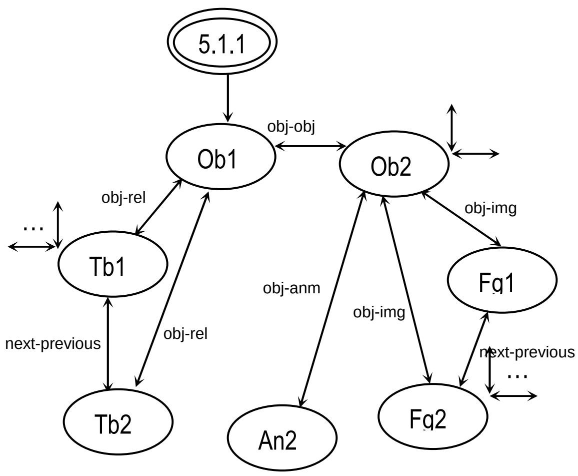


Fig. 5. An example semantic graph of a topic

On fig. 5 an example semantic graph corresponding to the ellipse terminal node 5.1.1 from fig. 3 is shown. Here nodes Ob1 and Ob2 stand for the text description of two learning objects, nodes Fg1 and Fg2 for two different images of Ob2, node An1 for an animation of the same object, and nodes Tb1 and Tb2 for two different relations of Ob1. A text description page from a topic from the PEs lecture is shown on fig. 6 together with links to several nodes on the third and first levels.

Fig.6. A text description page with links to 3 nodes on third level and 8 nodes on first level

The semantic graph on fig. 7 corresponds to the triangle subgraph node P1 from fig. 3. Note, that the goal of the test is not only to assess the learner's understanding of the background knowledge, but also to fill in the missing knowledge and correct wrong one, e.g. the test plays a teaching function too.

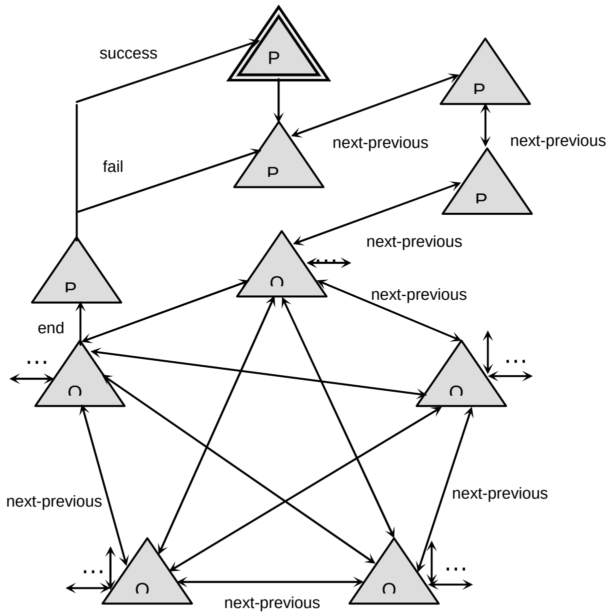


Fig. 7. The semantic graph model of an on-line test

Here the node AP represents the administrative information about the test as a whole, e. g. organization, department, author, goal; DP - key directives for the teacher's intervention; CP - criteria for the learner's assessment; Qi (i =1,…,N) - questions. The bi-directional links between nodes-questions of type "next-previous" signify that the learner has free access from the current question to all other questions. External links from/to each question correspond to the related pages with the topic material accessible by means of the key teacher's directive "Help". A fragment of an on-line test covering the module WINDOWS of the PEs courseware is given on fig. 8.

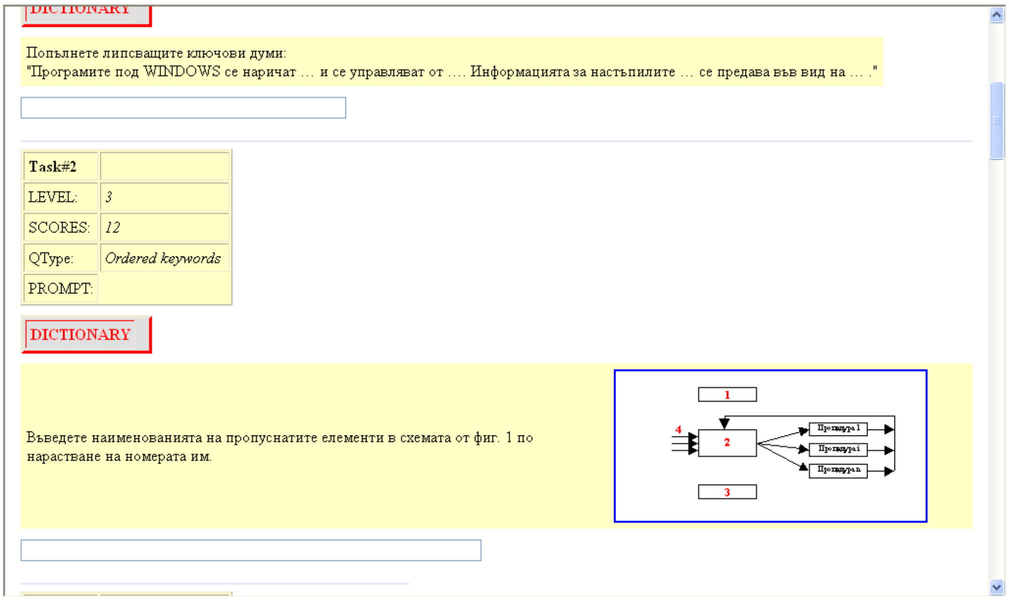


Fig. 8. A fragment of the on-line test covering the module WINDOWS

When the learner's test result is lower than a given threshold he/she has to perform the test again (the feedback "fail"). Otherwise the learner is allowed to start the related practical exercise (the feedback "success").

The semantic graph model corresponding to the square subgraph E1 from fig. 3 is presented on fig. 9. Fig. 10 presents a fragment of downloaded WORD document with exercise instructions. In on-line mode the learner can read the exercise information about: administrative data (EA), directives for the teacher's intervention (ED), and the assessment criteria (EC). Node TFi corresponds to the i-th task formulation, and the next several nodes TSj (j=1,M*)* for skills for solving the task, extracted step by step. Links "next-previous" between nodes stand for the suggested order of the corresponding pages, and the external links mean the learner has access to the related pages with the topic material.

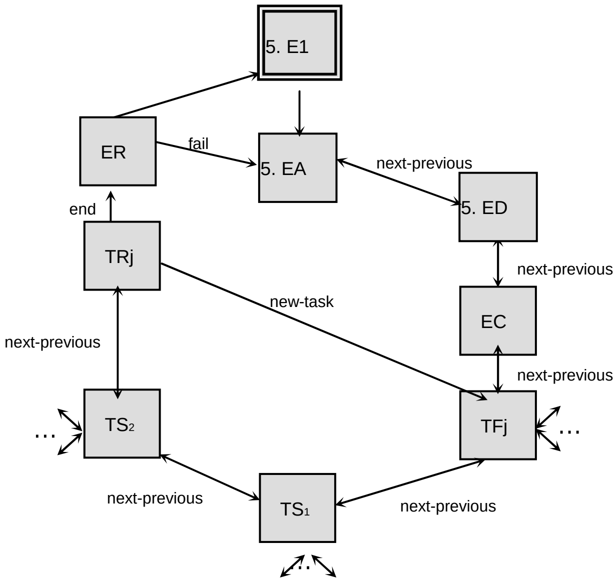


Fig. 9. The semantic graph model of an on-line exercise

A report with a final mark about the learner's task performance is generated (node RTi). The feedback to TFi corresponds to the learner's moving on to the next task. An exercise report (node ER) is received. If the learner's mark is lower then a given threshold (link "success') he/she has to perform the exercise again (the feedback "fail"). Otherwise he/she is allowed to continue with the next topic.

Visual C++ практическо упражнение 1 стр.1 от

Практическо упражнение 1
Общи сведения за средата Visual C++
Работа с менюта и ленти с инструменти

Цел на упражнението

- Запознаване с организацията на работата със средата Visual C++ - основни прозорци, ленти с инструменти на средата, видове файлове.
- Усвояване на начините за добавяне на менюта и ленти с инструменти към потребителски програми

Основни сведения за средата Visual C++

При започване на работа с Visual C++ трябва да се отвори или създаде нова *работна среда (workspace)*. В една работна среда може да има един или повече *проекти (projects)*. Във всеки проект може да има много файлове. И в най-елементарната програма има поне файл(ове) с изходен код (*source, .CPP*), с ресурси (*resource, .RC*) и хедери (*headers, .H*). Ресурсните файлове съдържат стандартни елементи на потребителския интерфейс – диалози (включващи бутони, edits, checkboxes, comboboxes и т.н.), икони, менюта. Те се създават удобно в диалог с програмиста. На етапа на свързващото редактиране (linking) те се вмъкват в изходния EXE файл. Форматът на EXE-тата за Windows е доста различен от този за ДОС. Една от разликите е именно възможността освен код, те да съдържат и ресурси.

Fig. 10. A fragment of a downloaded WORD document with exercise instructions

Conclusion

A domain-independent ontology-based approach to courseware knowledge representing has been proposed. The three levels of the semantic graph model correspond to the course as a whole, structure and domain knowledge itself. There are three disconnected semantic graphs respectively for a topic, test, and exercise on the third level. The practical usefulness of the approach has been demonstrated on a courseware from the field of software engineering education. The future authors' efforts will be focused on implementation an on-line environment for courseware generation based on the described semantic graph model.

Bibliography

[Chimura & Sato, 1984] Chimura H., Sato T., Computer-Assisted Analysis and Determination of Instructional Sequences, *IEEE Trans.*, Vol. 3, 1984, pp.136-144.

[Decker et al., 1999] Decker S., Erdmann M., Fensel D., Studer R. ONTOBROKER: Ontology Based Access to Distributed and Semi-structured Information, *Proceedings of Eighth Working Conference on Database Semantics, Semantic Issues in Multimedia Systems,* Meersman R., Tari Z., Stevens S., (Eds.), Kluwer Academic Publishers, Boston, 1999.

[Dovgyalo & Visotski, 1983] Dovgyalo A. M. & Visotski I. I. A Top-Down Methodology for Development and Implementation of Courseware. Journal of Cybernetics, 1983, pp. 103-108 (in Russian)

[Fisher & Scharff, 1998] Fisher G., Scharff E. Learning Technologies in Support Self-Directed Learning, *Journal of Interactive Media in Education*, Vol. 98, No. 4, October, 1998, www-jime.open.ac.uk/98/4.

[Fung, 2002] Fung I. P. A Hybrid Approach to Represent and Deliver Curriculum Contents, http://www10.org/cdrom/papers/207/node3.html

[Jelev, 2004] Jelev G. A. Strategy for E-learning in the Faculty of Computer Systems and Control in TU-Sofia. Proceedings of the International Conference on Computer Science, 7 December, Sofia, Bulgaria, pp. 263-267.

[Kellett & Marshall, 1990] Kellett J. M., Marshall G. Knowledge Engineering: Tools and Techniques. Artificial Intelligence in Engineering. Ed. G. Winstanley. John Wiley & Sons, England, 1990, pp.119-149.

[Marinov & Zheliazkova, 1992] Marinov M. T., Zheliazkova I. I. An Interactive Tool Based on Priority Semantic Networks, *Int. J. of Knowledge-Based Systems,* No.18, 2005, pp.71-77.

[Osuga & Saeki, 1990] Osuga S., Saeki I. Knowledge Acquisition, (Eds.), Moscow, Mir, 1990 (in Russian).

[Stefanov, 2003] Stefanov K. Computing Ontology Creation. Proceedings of the International Conference on Computer Systems and Technologies. Sofia, Bulgaria, 14-16 June 2003.

[Peachey & McCalla, 1986] Peachey D. R., and McCalla G. I. Using Planning Techniques in Intelligent Tutoring Systems. *Int. J. Man-Machine Studies*, Vol.24, 1986, pp.77-98.

[Webb, 1988] Webb G. I. A Knowledge-Based Approach to Computer-Aided Learning, *Int. L. Man-Machine Studies*, Vol. 29, 1988, pp. 257-285.

[Zheliazkova, 2005] Zheliazkova I. I. From ITSs Through VLEs Towards DODEs and TODEs, Proceedings of the *National Conference on E-learning in Higher Education,* 3rd –5th June, Kitten, Bulgaria, 2004, pp. 21-25.

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MODELS, TECHNIQUES AND APPLICATIONS OF E-LEARNING PERSONALIZATION

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Abstract: In recent years Web has become mainstream medium for communication and information dissemination. This paper presents approaches and methods for adaptive learning implementation, which are used in some contemporary web-interfaced Learning Management Systems (LMSs). The problem is not how to create electronic learning materials, but how to locate and utilize the available information in personalized way. Different attitudes to personalization are briefly described in section 1. The real personalization requires a user profile containing information about preferences, aims, and educational history to be stored and used by the system. These issues are considered in section 2. A method for development and design of adaptive learning content in terms of learning strategy system support is represented in section 3. Section 4 includes a set of innovative personalization services that are suggested by several very important research projects (SeLeNe project, ELENA project, etc.) dated from the last few years. This section also describes a model for role- and competency-based learning customization that uses Web Services approach. The last part presents how personalization techniques are implemented in Learning Grid-driven applications.

Keywords: Adaptive Learning Content, Customized learning, Grid technologies, Learning Management Systems, Personalization, Simple Sequencing, Web Services.

ACM Classification Keywords: H.3.7 Digital Libraries- User issues, H.3.4 Systems and Software- User profiles and alert services, H.3.5 Online Information Services- Web-based services, K.3.1 Computer Uses in Education – Distance learning.

Introduction

Personalised learning presupposes high quality teaching that is adaptive to the different ways students achieve their knowledge and skills. Therefore, the teaching courses, curricula, and school organisations have to be designed in a way to reach as many students as possible with diverse needs and experiences for as much of the time as possible. Personalised courses actively engage the learners by providing teaching strategies and materials that appeal to the learners' knowledge and preferences etc. Since it would be costly and unfeasible for teachers to produce personalised courses that meet all of these requirements, the LMSs are of prime importance for education. Such systems allow for delivering information outside the traditional bound of a classroom situation, where learners are taught by a static one-fits-all approach. An educational system that responds to individual needs by creating a personal learning path enables individual students to experience excellence in his or her learning. Analytical study of key functional LMSs requirements such as adaptability, personalization, modality, possibility for record-keeping on student's performance, and usage statistics for the system as a whole has been done in [Pavlov et al.'04].

The personalization includes how to find and filter the learning information that fits the user's preferences and needs, how to represent it and how to give the user tools to reconfiguration the systems, in consequence, reconfiguration system could be part of personalized environment in some systems. The user modelling is the process of constructing (often computer-based) users models, background knowledge and users behaviour