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Framework and Functionality of the Tracking Subsystem in the Individually Adaptive Learning Management System (IALMS)

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ABSTRACT: This work presents the framework and functionality of the Tracking subsystem in the Individually Adaptive Learning Management System (IALMS). As a result of the current learning management systems analysis, there is revealed a reality of resources offered to the e-learner by the computing machines that have never been mastered. These resources belong to the intelligent computer systems. While the modern e-learning systems utilize the multimedia and communications capabilities of computers, they don't pay adequate attention to the opportunity of a strategically planned conducting of the educational process. The small number of intelligent learning management systems differentiate from IALMS by that the latter represents a project of a generalized learning management system, not having strictly predefined pedagogical categories and structures. IALMS is built on three major units, situated subsequently along the information stream. They are: Tracking subsystem, Individualizing subsystem, and Adaptation subsystem. These units are typical for their programmability and flexibility. The current article examines the framework and functionality of the Tracking subsystem in IALMS.

СТРУКТУРА И ФУНКЦИОНАЛНОСТ НА СЛЕДЯЩА ПОДСИСТЕМА В ИНДИВИДУАЛНО-АДАПТИВНАТА СИСТЕМА ЗА ЕЛЕКТРОННО ОБУЧЕНИЕ (ИАСЕО)

РЕЗЮМЕ: Настоящата публикация представя структурата и функционалността на Следящата подсистема на Индивидуално-адаптивната система за електронно обучение (ИАСЕО). В резултат от анализа на разпространените системи за e-learning, се разкрива една реалност на неусвоени ресурси, които изчислителните машини предлагат на обучавания. Това са ресурсите, принадлежащи към сферата на интелигентните компютърни системи. Ако модерните системи за електронно обучение оползотворяват мултимедийните и комуникационни възможности на компютрите, те не обръщат достатъчно внимание на възможността за стратегически-планирано провеждане на учебния процес. Малкото на брой интелигентни системи за електронно обучение се различават от ИАСЕО по това, че последната представлява проект на обобщена система за e-learning, без строго предефинирани педагогически категории и структури. ИАСЕО е изградена от три основни звена, разположени последователно в информационния поток. Те са: Следяща подсистема, Индивидуализираща подсистема и Адаптираща подсистема. Тези звена се характеризират с програмируемост и гъвкавост. В настоящата статия се разглежда структурата и функционалността на Следящата подсистема на ИАСЕО.

Introduction

Individually adaptive learning management systems are based on the intelligent computer systems and perform adaptation of the educational process towards the learner aiming at an increase of educational results and satisfaction of the learner's needs and interests attainable in the process of learning and suitable with the educational course. This type of organizing a learning management system (LMS) is based on the possibility to store characteristic information about the learner into a database. The LMS user's behavior directly affects the interactive communication between the user and the system. To attain individualization of the educational process and consequential adaptation, this information should be taken into account and stored. Then this information is being analyzed and variations in the LMS's behavior towards the educated are being undertaken, based on this analysis. We call these changes in the LMS's behavior *adaptation* of the LMS towards the educated while the storing of characteristic information about the user – *individualization* as stated in Ivanov (2003). Adaptation and individualization concepts are thoroughly examined and defined by Brusilovsky (1999).

The current trends in individually adaptive e-learning offer versatile learning models suited to different pedagogic paradigms exploited in certain fields of education. Such approaches have been undertaken by Kinshuk et al (2000) and Kinshuk et al (2004).

Kinshuk and Taiyu Lin give a good example. The work presents a formalization scheme of the Exploration Space Control (ESC). Kinshuk defines the process of adaptation in two categories: adaptation of educational content and adaptation of learning paths (links). ESC also defines a number of adaptation control levels. These are certain operations on the adaptation process categories.

The Adaptive subsystem of the individually adaptive learning management system explores learning on generalized bases without predefined pedagogical categories and strategies. This approach proposes a versatile mechanism for formalization of different adaptive learning models. To achieve this task, a formal language for describing the generating structure of the educational material is used as a part of the Adaptation subsystem.

This paper examines the structure of a generalized intelligent e-learning system that separates the process of intelligent learning into stages that are tunable and hence not dependant on predefined pedagogic methods. The LMS presented in this article owns flexibility of defining both the categories of the individual information and the educational material structure. The current project could be looked at as a generalized model of an adaptive e-learning system, allowing the structure of the educational material and the functionality of the tracking, individualizing, and adaptive subsystems to be programmed. The structure of the Individually adaptive learning management system is presented in Ivanov (2004).

Basic Structure

The Individually Adaptive Learning Management System (IALMS) consists of a core of three subsystems:

1. Tracking subsystem

2. Individualizing subsystem
3. Adaptation subsystem

IALMS offers the following functionality. The e-learning system's behavior adapts to the learner's one, with the goal of maximizing the assigned results. The behavior adaptation is performed by the *Adaptive subsystem*. Adaptive subsystem alternates the output to the user taking into account the stored information about learners. This information is organized into individual profiles – one profile for each learner. The process of adaptation is impossible without preliminary individualization. The individualization process is carried out by the *Individualizing subsystem*. It is responsible for the creation of individual profiles of the learners. The individual profile consists of *characteristic information*, which is being collected in the process of interaction between the users and the LMS. To enable the LMS to follow the learner's behavior, it is needed a subsystem for tracking events that carry characteristic information. This system is called *tracking subsystem*. The latter includes the definition and following of a number of events that are called functional events. These carry characteristic information. Finally, to let the user communicate with the system, an auxiliary interface unit is implemented. Thereby arises the structure of an intelligent, adaptive, individualizing, and tracking learning management system - Individually Adaptive Learning Management System. The basic IALMS structure, presenting its philosophy is shown on fig.1. Fig.1 presents the information stream, cyclically passing through the educated and the system.

The information stream in IALMS is developed on one hand between the system and the learner, and on the other – among the different subsystems. Thus the information stream is divided into stages, each one of which is represented with the type of conveyed information.

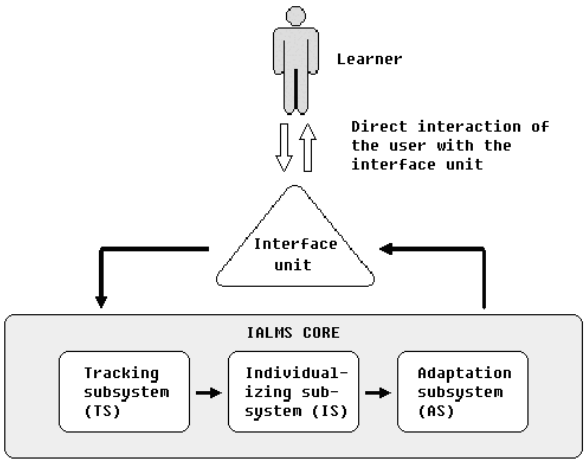

Fig. 1. IALMS basic structure

While the interface unit does not semantically process the information that passes through it, but only the form of its presentation, it does not belong to the IALMS core. The core consists of subsystems for semantic information processing. The information sent to the educated and received back from them, is called *educational material*. In the IALMS project the educational material concept is more general than its standard sense. The educational material consists of *sessions*. The session is composed of educational blocks, being passive or active. As an information stream between the educated and the system, the educational material carries two-way information:

1. Outgoing information: from IALMS to the learner
2. Incoming information: from the learner to IALMS

All blocks forming the sessions of the educational material may convey outgoing information, while only a subset of blocks may convey incoming information. The latter are called active blocks, and the others are called passive blocks.

Educational material definition

As earlier mentioned, educational material is the information stream flowing between the learner and the system. It is a two-way stream carrying incoming and outgoing information. Educational material consists of sessions. The session is the smallest undividable unit of the educational material. The educational content is delivered to the student one session at a time. Working over a part of a session or more than one session is not permitted. The comparison to traditional learning relates a session to a lesson form a textbook or a lecture of an educational course. There is one main difference, though, forming the adaptability features of the system. It is the variation capability of the session and hence of the educational material. Adaptation is the process of alternation of the session content aiming at delivering the most suitable content to the individual learner. Sessions consist of blocks. Generating an individual and adapted instance of a session is performed by selecting a subset of blocks form the generating structure of the educational material. The generating structure of the educational material is an information structure belonging to the Adaptation subsystem of IALMS and is described in Zabunov (2004). Then this subset of blocks is being merged and the newly generated session is being passed to the student. When the latter finishes working over the session they send back the session to the system and thus submit the so valuable incoming information that carries the characteristics of the learner. There are two types of blocks defined: passive and active. Passive blocks carry only outgoing information and they are part of the outgoing informational stream, while active blocks are allowed to carry two way information namely outgoing and incoming. That is why the incoming session consists only of active blocks as opposed to the outgoing session, which contains both of active and passive blocks. This is the educational material flow, beginning from the exit point of IALMS and ending into the entry point of the system. The exit point is the subsystem that generates educational material. This is the Adaptation subsystem (fig.1). The entry point is the Tracking subsystem, subject to this paper.

Tracking subsystem

The IALMS's tracking subsystem appears to be the entry point of the information stream to the IALMS core. Tracking subsystem processes only active blocks of each session. Educational material blocks own certain types defined in IALMS. According to its type, each active block is being processed by a corresponding *interpretation function*. The result from the work of the interpretation functions consists of a set of attribute values. Their meaning is implemented in the attributes forming each user's profile. The value of a given

attribute corresponds to the quantitative measurement of a given learner's characteristic. Block types are defined in the adaptation subsystem, where the educational material content and the generating structure of the educational material are being defined. Attribute types are defined in the individualizing subsystem and interpretation functions are setup in the tracking subsystem.

Tracking subsystem architecture

The tracking subsystem is the entry point of the information stream coming from the user. As described above, only active blocks are reaching the tracking subsystem. Each block has a type that is defined in the adaptation subsystem. According to the block's type a multiplexing procedure is carried out and each block from the information stream is directed to the appropriate interpretation function (see fig. 2). For each active block type an interpretation function is defined in the tracking subsystem. The purpose of the interpretation function is to interpret the result of the educational process involving the current student. The result of this interpretation is extracting the characteristic information about the user. Characteristic information is stored by the individualizing subsystem in the form of attribute values. A certain attribute corresponds to a certain characteristic of the educated. For example, an attribute is the student's logical thinking ability. Student's characteristics are relatively calculated by quantity levels expressed with floating point numbers.

When an active block arrives, it is assumed that it carries information about the defined categories of attributes. The interpretation function calculates the quantitive value of each of the attributes that are carried by the current block. Not all block carry information about all defined attributes. As a result of its execution the interpretation function returns a vector of attribute values. This vector is a subset of all defined attributes. The attributes are later processed by the individualizing subsystem where the personal file of each educated is being maintained. Defining attribute types, interpretation functions, and block types is a process involved in the creation of an educational course. When these elements are programmed the rest of the work for creating the educational course proceeds with entering of educational material into the adaptation subsystem and the individualizing and tracking subsystems remain untouched. Thus the educational course creation process divides into two stages. The first stage encompasses global course definitions. Here falls the configuration of the tracking subsystem. The second stage involves less technically related editing and concerns working on the adaptation subsystem only.

Conclusions and future work

The Individually adaptive learning management system project defines a generalized model of a tracking, individualizing, and adaptive e-learning system that enables the creation of specialized and still intelligent electronic learning environments. IALMS encompasses intelligent computing and modern e-learning strategies aiming to achieve a generalized programmable and flexible electronic educational environment.

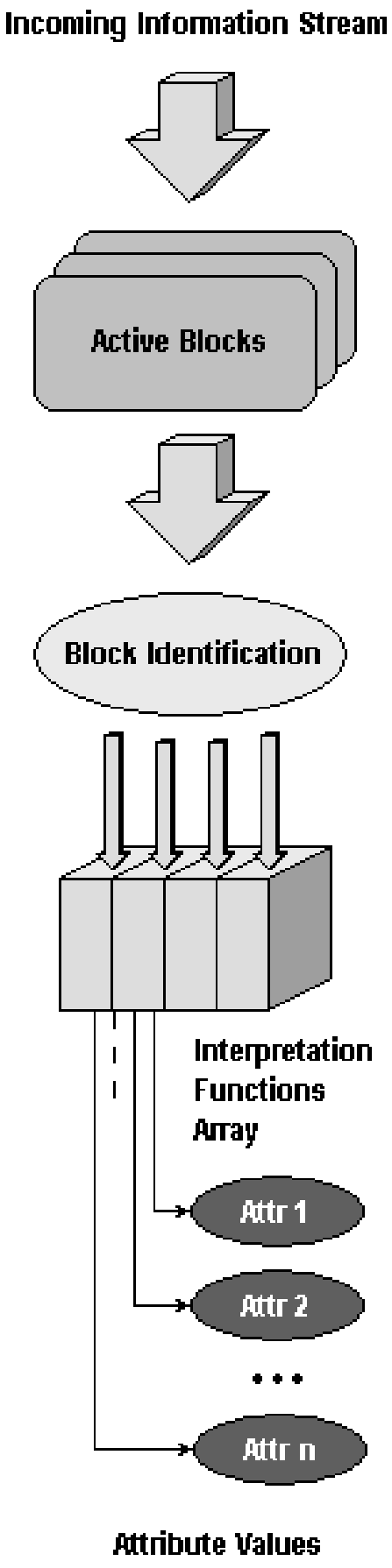

Fig. 2. Tracking subsystem architecture

References

Иванов, К., С. Забунов. 2003. Модел на индивидуално-адаптивна система за електронно обучение. - *Трудове на Научната Сесия РУ'2003*, под печат.

Маждраков, М., Т.Трендафилов и др. 1996. Обучението по ГИС в МГУ "Св. Иван Рилски. - *Международен симпозиум "Приложение на лазерни, GPS и GIS технологии в геодезията", София.*

Brusilovsky, P. 1999. Adaptive and Intelligent Technologies for Web-based Education - *KI - Kunstliche Intelligenz.*

Ivanov, K., S. Zabunov. 2004. Individually Adaptive Learning Management System Project. – *CompSysTech '2004, Rousse*, in printing.

Jianguo, L., Z. Xiaozhen, Q. Yuhui. 2002. Resource Organization and Learning State Control For Adaptive Learning System - *IEEE International Conference on Advanced Learning Technologies (ICALT 2002).*

Kinshuk, A., R. Oppermannn, R. Rashev, H. Simm. 2000. A Cognitive Load Reduction Approach to Exploratory Learning and Its Application to an Interactive Simulation - Based Learning System - *Journal of Educational Multimedia and Hypermedia*, 9 (3), 253-276.

Kinshuk, A., T. Lin. 2004. User Exploration Based Adaptation in Adaptive Learning Systems - *University of Electro-Communications, Tokyo, Japan.*

Ritter, S., J. Anderson, M. Cytrynowicz, O. 1998. Medvedeva. Authoring Content in thePAT Algebra Tutor. - *Journal of Interactive Media in Education,* (9) [www-jime.open.ac.uk/98/9].

Santos, O., E. Gaudioso, C. Barrera, J. Boticario. ALFANET. 2003. An Adaptive E-Learning Platform - *2nd International Conference on Multimedia and ICTs in Education (m-ICTE2003.)*

Tang, T., G. McCalla. 2003. Smart Recommendation for an Evolving E-Learning System – *aied2003 Artificial intelligence education - 11th International Conference on Artificial Intelligence in Education, Sydney Australia.*

Weber, G. 1999. Adaptive Learning Systems in the World Wide Web UM 99 - *7-th International Conference on User Modeling, June 20-24, 1999, Banff Centre, Banff Canada*

Zabunov, S., K. Ivanov. 2003. Methods and Forms of Teaching "Information Systems" and "Computer Networks and Conmmunications" with the Use of the Internet – *50th Annual of University of Mining and Geology "St. Ivan Rilski" – Sofia, Bulgaria.*

Zabunov, S., K. Ivanov. 2004. A Language for Describing the Generating Structure of the Educational Material in the Individually Adaptive Learning Management System – *CompSysTech '2004, Rousse, Bulgaria*, in printing.