Individually Adaptive Learning Management System Project

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Abstract: *This article presents a project of a generalized and intelligent learning management system. The whole project is organized upon the circular information flow between the system and the learner. The main feature of the system is its adaptability to the individual learner with the goal to maximize learning process results. This aim defines three major units of the system: Tracking subsystem, Individualizing subsystem, and Adaptation subsystem. They are situated sequentially along the information stream. The result of the work is the definition of a complete Individually adaptive learning management system (IALMS).*

Key words: *E-Learning, Individually Adaptive Learning Management System, Adaptive Learning Systems, Intelligent Learning.*

INTRODUCTION

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. This type of organizing a learning management system (LMS) is based on the possibility to store characteristic information about the learner into a database on the computer. 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.

Later, this information is being analyzed and changes 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* [3].

The current e-learning systems and theoretical works on adaptive electronic education define models of learning management systems that implement strictly predefined categories and structures of the individual information about the learner and the educational material. [4], [5], [6].

This article examines the structure of a generalized intelligent e-learning system that divides the process of intelligent learning into stages that are highly programmable and hence not dependant on certain predefined pedagogic categories and paradigms. The LMS presented in this work 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 [1].

BASIC STRUCTURE

Intelligent learning management systems accommodate the following functionality. The LMS behavior adapts to the learner's behavior, with the goal of maximizing the assigned results. The behavior adaptation is performed by the *Adaptive subsystem* (AS). AS alternates the LMS's 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 LMS individualization is performed by the *Individualizing subsystem* (IS). IS is responsible for the creation of the individual profiles of 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 LMS to follow the learner's behavior, it is needed a system for tracking events that carries characteristic information. This system is called *tracking subsystem* (TS). TS includes the definition and following of a number of events

(functional events) that carry characteristic information. Finally, to let the user communicate with the system, an auxiliary interface unit is required. Thereby, the structure of an intelligent, adaptive, individualizing, and tracking system arises. It is called the *Individually Adaptive Learning Management System (IALMS)*. The basic structure, representing the IALMS philosophy is shown on fig.1. Except that, 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 system units. Thus the information stream is divided into stages. Each stage is represented with the type of conveyed information.

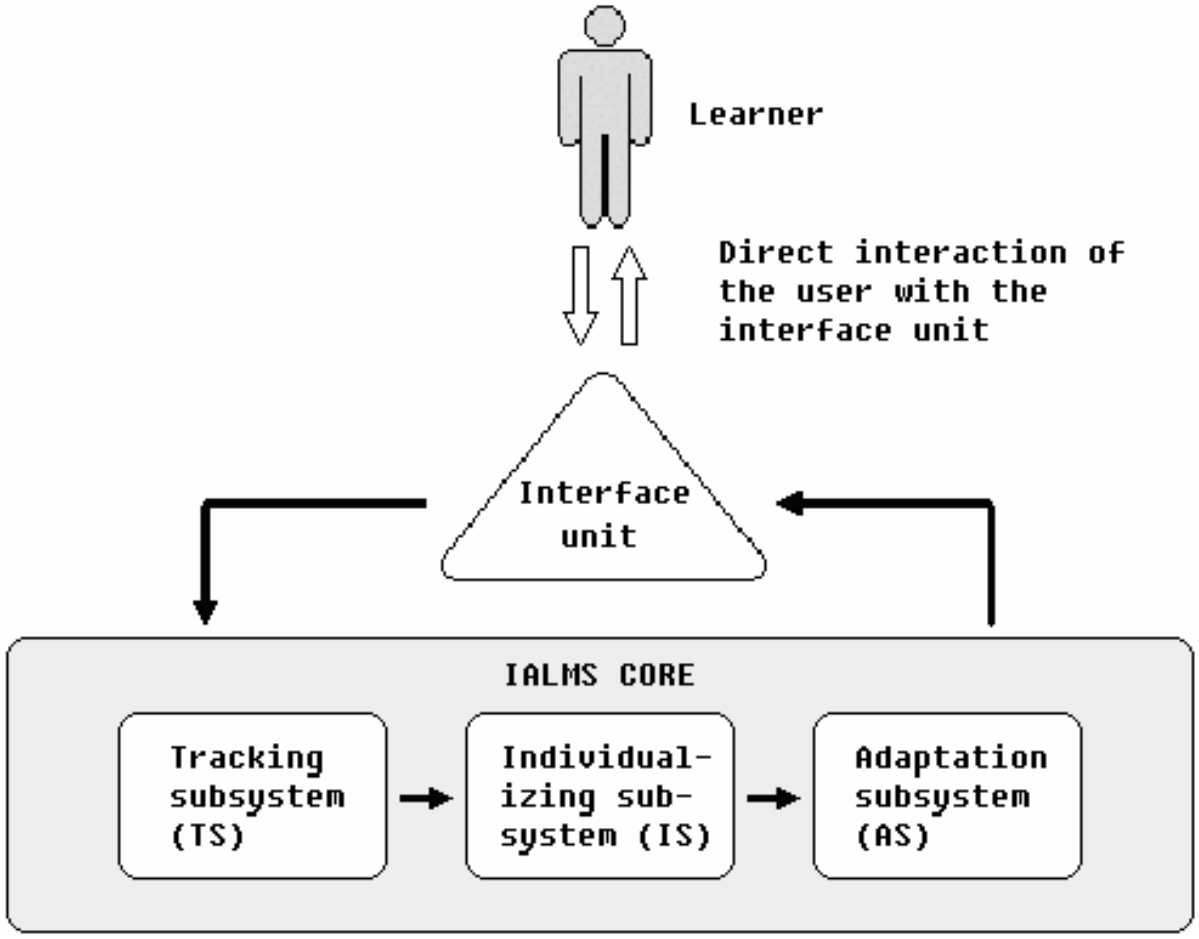

Figure 1. *IALMS basic structure.*

The interface unit does not semantically process the information that passes through it, but only the form of its presentation. Hence, it does not belong to the IALMS core, consisting of subsystems for semantic information processing. The information sent to the educated and received back from him/her, is called *educational material*. In this case, this concept is more general than its standard sense. The educational material consists of *sessions*. The session is composed of educational blocks. Blocks are passive and active. Being an information stream between the educated and the system, the educational material should carry two-way information:

1. From IALMS to the learner (outgoing information)
2. From the learner to IALMS (incoming information)

All blocks may convey outgoing information, but only a part of them may convey incoming information. The latter are called active blocks, and all the rest – passive blocks.

TRACKING SUBSYSTEM

The IALMS's tracking subsystem appears to be the entry unit 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.

INDIVIDUALIZING SUBSYSTEM

The individualizing subsystem deals with the storage of characteristic information about each learner into a database. The return values of the interpretation functions are used as a resource of characteristic information. These functions are defined in the tracking subsystem. The characteristic information is organized in profiles – there is a profile created for each learner. At the beginning this profile is empty. The profile consists of attributes. Their definition is done in the Individualizing subsystem. To calculate the new value of a given attribute, its old value is taken into account along with the value delivered by the current interpretation function. The new value is calculated by an *accumulating function.* The accumulating functions are defined in the Individualizing subsystem, as for each attribute an accumulating function is defined. The information cycle from the user to the Individualizing subsystem runs along the following scheme:

1. The user finishes work on a given session.
2. The Interface unit encodes the result into an incoming session, consisting of active blocks.
3. Session reaches the Tracking subsystem. TS processes the incoming session, as for each active block it determines the interpretation function corresponding to its type.
4. TS executes the interpretation function and receives as a result a set of attribute values. These attribute values are then passed to the Individualizing subsystem.
5. IS processes each attribute value from the set by transferring it to the accumulation function defined for the given attribute.
6. The accumulation function performs actualization of the attribute value in the user's profile.

ADAPTATION SUBSYSTEM

The goal of the Adaptation subsystem (AS) is the generation of educational material. After the educational material has been generated, it is handed to the user through the Interface unit. The educational material is structurally composed of sessions. Each session corresponds to a lesson from a classic textbook. The main distinction is the session's alternating content aiming at adaptation to the qualities and knowledge of the learner, compared to lessons that have permanent content. The educational material frame of a lesson specifies the degree of session's content variation. The certain degree of alternation is determined at the definition of the *Educational material content (EMC)*. Educational material content along with the *Generating structure of the educational material (GSEM)* are the major informational units of the Adaptation subsystem. EMC is

fully programmable. It is defined for each session of the educational course. On the other hand, GSEM is defined only once for the whole course and it is constant for all sessions.

Each educational course that is input into the IALMS presumes that the generating structure of the educational material and the educational material content are defined. When the user starts working with the system or finishes work on a certain session and needs to continue his or her education, IALMS generates a new session on three stages:

1. Choosing a new working session
2. Choosing the working session content
3. Generation of the working session content

The first two stages are carried out by GSEM, while the third is accomplished by EMC.

Educational material content (EMC) consists of two types of components: generators and evaluators. These are functions. To each type of block in GSEM corresponds a pair of functions – one generator and one evaluator. The generator is a function that generates educational material for a given block of a given session. It has one parameter: the identifier of the session, which the current block belongs to. As a result the educational content of the given block of the given session is returned. Evaluator function takes one argument as well: the identifier of the session, which the current block belongs to. As a result a relative value for the importance of the given block of the given session is returned.

Generating structure of the educational material (GSEM) has the structure of a reversed tree. To each leaf there is defined a corresponding type-block. GSEM determines the structure of all sessions of the educational course. The type-block is an informational structure that conforms to a certain type of block from the educational material. As it was mentioned, educational content consists of sessions, while the sessions are composed of blocks. Blocks are the smallest indivisible compounds of the educational material. To the type-block is assigned a generator and an evaluator. Both of them belong to EMC.

At the first stage of educational content generation (Choosing a new working session) the significance of each session of the educational course is evaluated. The one with highest importance is chosen. The evaluators in the GSEM leave determine values of importance for each block from each session. The intermediate nodes in the GSEM tree represent relational functions with several arguments and one return value (fig.2). To estimate the need for assimilation of a given session, the results from the evaluators gradually flow up to the top of the tree, passing through the relational nodes until reaching the GSEM tree root. On this stage relational functions execute the operation "addition" to their input arguments. The sum is returned as a result and is used for an entry to the next relational function. The value reaching the GSEM root is the searched value for the need of learning of the given session.

During the second stage of the session generation (Choosing the working session content) the Adaptation subsystem has already determined the session that is to be handed to the learner. The current goal is to determine its content. This problem is reduced to specifying the subset of type-blocks that should be included in the current session variant. Again, the GSEM is used for this purpose. Each type-block importance value is calculated using the evaluators in the GSEM leaves. These values come to the root of the tree, passing through the relational functions. At this point, relational functions perform their real purpose. There are two types of relational functions: OR-type and XOR-type. When passing through a relational node of type OR, all type-blocks whose leaves have generated evaluation values greater than or equal to the required value are being combined and passed through. This threshold value is stored in the relational node. When passing through a relational node of type XOR, the type-block whose leaf has generated the greatest evaluation value is determined and if its evaluation value is greater or equal to

the required value, the type-block is let to pass through the relational node. Again, the threshold value is stored in the relational node. Eventually, there is a subset of all leaves (type-blocks of the session) reaching the GSEM's root. This subset represents all type-blocks that should be included in the current variant of the session.

At the third stage (Generation of the working session content) generator functions are used to generate each block's content from the subset of type-blocks corresponding to the current session variant. Every generator is executed. The result is then merged and represents the educational material for the current session. It is then handed to the learner.

On fig.2 there is a sample scheme of a GSEM. There are several type-blocks defined. They are of two types: active and passive, as the active ones have dark background.

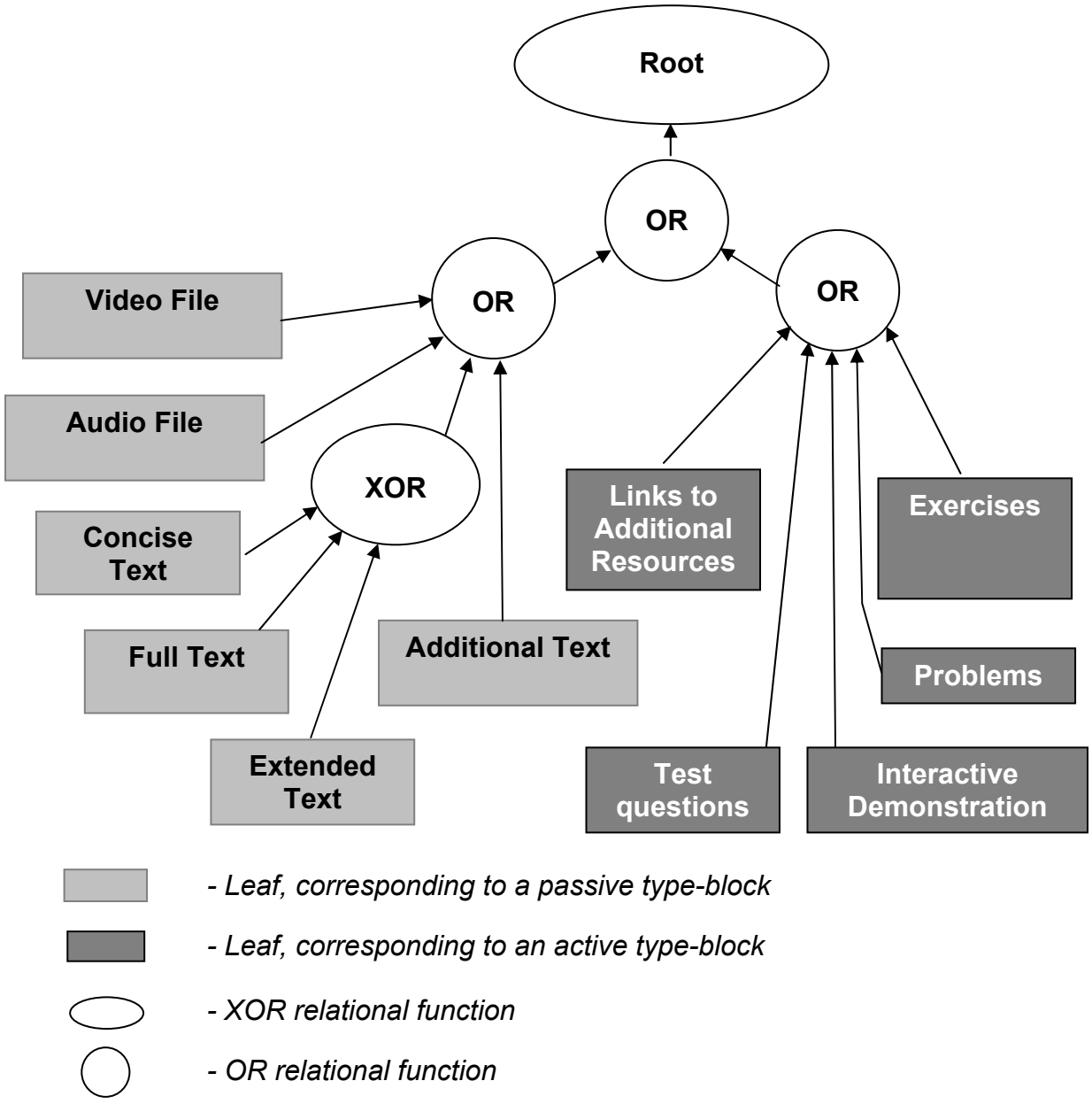

Figure. 2. *A sample structure of GSEM of a given educational course - one for all sessions.*

Mutually excluding type-blocks are combined with XOR-relational functions, while concurrent type-blocks are joined using OR-relational nodes.

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 to achieve a generalized programmable and flexible educational environment.

REFERENCES

[1] Иванов, К., С. Забунов - Модел на индивидуално-адаптивна система за електронно обучение, Трудове на Научната Сесия РУ'2003, 2003.

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

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

[4] Jianguo, L., Z. Xiaozhen, Q. Yuhui. Resource Organization and Learning State Control For Adaptive Learning System - Faculty of Information and Computer Science, Southwest China Normal University.

[5] Ritter, S., J. Anderson, M. Cytrynowicz, O. Medvedeva. Authoring Content in thePAT Algebra Tutor. - Journal of Interactive Media in Education, 1998, (9) [www-jime.open.ac.uk/98/9] Published, 8 Oct. 1998.

[6] Santos, O., E. Gaudioso, C. Barrera, J. Boticario. ALFANET: An Adaptive E-Learning Platform - aDeNu Research Group, Artificial Intelligence Department, Computer Science School, UNED, c/Juan del Rosal,16, 28040 Madrid, SPAIN. E-mail: {ocsantos, elena}@dia.uned.es; cbarrera@invi.uned.es; jgb@dia.uned.es

[7] Tang, T., G. McCalla. Smart Recommendation for an Evolving E-Learning System - Dept. of Computer Science, University of Saskatchewan 57 Campus Drive, Saskatoon, SK S7N 5A9, CANADA, yat751@mail.usask.ca, mccalla@cs.usask.ca.

[8] Weber, G. Adaptive Learning Systems in the World Wide Web - Department of Psychology, University of Education Freiburg, Germany.

[9] Zabunov, S., K. Ivanov. Methods and Forms of Teaching "Information Systems" and "Computer Networks and Conmmunications" with the Use of the Internet. Annual of University of Mining and Geology "St. Ivan Rilski" - Sofia, 2003.

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