Adaptive model for user knowledge in the e-learning system

Todorka Glushkova

Abstract: The paper presents a conceptual model and some ideas for realization of the e-learning system in the secondary school that is adaptive to the user knowledge. We propose the algorithm for evaluation of student’s cognitions at three levels – as general mark, as level of subject domain knowledge and as mark of each concept. According to this valuation and the stereotype information, the LMS starts and manages an appropriate training process.

Key words: e-Learning, adaptive, adaptable, user model, stereotype model, overlay model, DeLC.

INTRODUCTION

The adaptation to user’s peculiarities is one of main characteristics of every e-learning system. The main goal of this report is to present a model of adaptation to students’ knowledge in DeLC-based system for distance and electronic teaching [7], [3], [9]. We will look at the adaptation, as a property of the learning system to be self-tuned and to determine its behaviors according to the user’s background knowledge; manner of access to training resources; preferences; user’s habits and behaviors during the learning process etc. There are different aspects of adaptation according to level of user’s cognitions, skills, goals and plans; his preferences and habits; the specifics of subject domains etc.

1. Some definitions

There are two similar concepts [11], [1], [6] that can be used– adaptive and adaptable. They present two different adaptive levels – static and dynamic. The static adaptation level corresponds with mechanisms for accommodation of the system to characteristics of the concrete user. The adaptable system allows dynamic interaction between user and LMS as synchronize the learning process to learner’s knowledge, aims and behaviors in the real time. We will define some concepts, which will be use in the model.

User profile is an aggregate of facts for the concrete user that permits his integration to preliminarily specified user group of learners with similar aims, behaviors, preferences and rights for access to learning services and information resources in the system.

The stereotype presents formally in the system a group of learners with homogeneous characteristics that must be able clearly to be monitored and measured. The set of main stereotype characteristics are called triggers. We will use stereotypes for grouping consumers with similar characteristics. When the entered by the user information or the conclusions of the system, based of user’s behavior sets values of the triggers, the system made guess with high degree of security that the user pertains to this stereotype. If the information is activating from the trigger, it is being transferred to the user profile from the stereotype. The common stereotype information is not always accurate on the concrete consumer, but it is a background for the future specification of information. It changes so and advances the individual consumer model. The stereotypes can present as hierarchy structure. For example, the stereotype “secondary school student” is daughterly on the stereotype “Student” that on the other hand inherits the stereotype “Learner” etc. After initial starting of the system, the triggers of the most general stereotypes into the hierarchy receive default values. As result from communication with the user, his answers and behaviors, the system activate the triggers of some sub-stereotype with more specific and appropriate values for this user.

The cluster is dynamic changed user group that is specifying dynamically from user’s behaviors in the run time learning session. The system uninterruptedly gathers information

1 LMS-Learning Management System
of the different consumers as well and searches the most appropriate criterion for grouping them into separate classes.
The clusters and the stereotypes are similar, but there are some differences between them. While the stereotypes are inactive, the process of cluster defining is active. We dispose with initial information at the stereotypes, while in clustering such information misses or is insufficient for specification clearly of the user group. At the realization of the e-Learning system, the stereotypes will use as part of the static user model, and clustering – at part of the dynamic.

2. A model of adaptation to user knowledge

The adaptation in this aspect is fundamental for each learning environment. It is connected with determination of the sphere of him knowledge that is part of the given domain ontology. Our goal is to determine the level of knowledge for every of learned concepts and to separate a set of unknown or incorrect learned concepts from the concrete school subject. We can use some standard diagnostic technologies as:

- Analysis of the often used user requests (such as tutorial systems);
- Saving and analysis of communication between the user and the system (for example, if the system is gave to the student information for some concept, it mark this concept as known);
- Generalization by rules based on the concrete domain structure (for example if the student understand the concept „orthogonal triangle”, then he understand the summary concept „triangle”);
- Generalization by rules based on user’s profile information (if the student is in VI-th grade, he knows the concepts from domain “Mathematics of the V-th grade”);
- Create and use of reference library with mistakes that the students make often.

There are different approaches for realizations of this adaptation aspect. We based our investigations on stereotype, overlay and combined approaches.

The stereotype approach classifies the learner to some in advance determinate community by crediting the general group characteristics for him. In such a way, he has an opportunity to use the common learning services and resources. The stereotypes are present as hierarchy structure and they can extend these that are over them (alike on following classes in the programming languages). The stereotype models are sufficient, when serving for modeling the interface or at option to the type of the education, but they are disappointing, when the individual adaptation requests more minute description of the user or providing specific aid. We will use this approach in the next aspects:

- Formalization of the customer groups and definition of their eventual common characteristics. We will regard as base stereotypes the groups of the students, the educators, the authors of instructional content, the administrators etc.
- Specification of the main characteristics of user groups and determination of the differences between them as structuring of stereotype hierarchy (Fig.1.);

![Fig.1. Stereotype hierarchy and association of the users](image-url)

- Categorization of the concrete user to one or more communities and active association to other group, when the user changes his role and position during the work with the
system. For example, one as well same consumer can be an author of e-learning content; teacher who use in the classroom the accessible training resources and services; long life learner, who wants to complete his knowledge etc. In such a way, the user can change his role and joins to different stereotype groups into the hierarchy (Fig.1.). It is needed to develop a mechanism for observation, control and management of this process.

The overlay models allow the user’s knowledge to be present as subset of system knowledge. All knowledge of the learning system can specify by the science of the subject domain, the science of the expert or the hoped knowledge of the student, according to Bulgarian Educational Requirements\(^2\) [12]. The overlay model is among the most dominant type of user models, normally introduced as a hierarchical or semantic net of nodes associated directly with the concepts, from the school subject area. We could use numerical values for evaluation of the student’s cognition. The ways of determining these values are frequently contested in the advanced literature. According to a lot of authors [2], the overlay models price independently the science of the consumer in the different subject-domains and this make the system a lot of flexible and adaptive. We will take this attitude and develop an evaluation system of base student’s cognitions in each school subject domain. Bulgarian government educational requirements are on legal grounds for the creation of school subject domain ontologies with the main learned concepts, and dependences between them. We will associate numeral worth (in percent) that shows the degree knowing of this concept for each concrete student.

When we want to determine background knowledge of a new student we will use opening test, including sciences of the different instructional disciplines for the respective class. The results of the test we will evaluate at three levels: as general result for the student; as complex estimate on the separate instructional school subjects from the examination; as level of knowing of each separate concept. The evaluation from the first level will be a base for specifying the main stereotype group of this student, the estimate from the second level starts determining of the sub-sterotype of the student of his education by the concrete school subject, and the results from the third level will use for realization of the overlay model with the concepts from the relevant domain. The next table (Tab.1) presents an example for application of this approach.

| Tab.1. A model of evaluation of the concepts in domain “Math for 5th class” |
|----------------------|----------------|
| Hierarchy of concepts | Evaluation |
| | The level of student’s knowledge | Estimate of the degree on the cognition in % |
| 1. | Polygon | Know (>= 50%) | 62 (average from 1 to 3) |
| 1. | Unspecified | Know | 80 |
| 2. | Triangle | Know | 52 (average from 2.1. to 2.6.) |
| 2.1. | Orthogonal | Don’t know | 40 |
| 2.2. | Obtuse-angled | Don’t know | 20 |
| 2.3. | Acute-angled | Know | 70 |
| 2.4. | Scalene | Know | 60 |
| 2.5. | Isosceles | Know | 50 |
| 2.6. | Equilateral | Know | 70 |
| 3. | Tetragon | Know | 53 (average from 3.1 to 3.3) |
| 3.1. | ... | ... | ... |

If the student is familiar for the system, it has saved information (as numerical values) on his past learning sessions and the results of the tests in each learning domains. These values are formatted by the system in the moment of user identification and use in the future instructional cycle. On base of stored in the system information for student’s knowledge in this sub-domain the system loads values, associated with these concepts.

\(^2\) Government Educational Requirements for Bulgarian secondary schools
We accept that the pupil knows one concept if the system evaluates his knowledge at a level over 50 percent. At the made hierarchical structure, the mark of the concept is an average estimate from each daughterly concepts. This model has a multitude of advantages, associated largely with his simplicity, and the small resources requirements, but we can fix unknown concepts for the concrete user with difficulty, if the domain is showed as network ontological structure. We consider that if use this model for each concrete student, this will hamper the system and will decrease its efficiency. To raise the effect of the opportunities that the top two models provide and to understate its negatives we consider making combination between them.

The **combined approach** is based on the stereotype and overlay models. The algorithm includes the next stages:

- The users affiliate to certain stereotype group of the hierarchy, according to their user profiles.
- The system asks initial value -50% of all concepts from all ocular subject areas, studied at the previous class. The Bulgarian Government Educational Requirements for secondary school determine the minimum level of obligated knowledge for each school subject by termination of each grades. We evaluate this minimum level as 50%.
- After settling the opening test, the system evaluates knowledge of the student in three levels:
  a) General assessment of the test that is needed for affiliation of student to some of the sub-stereotypes for the various form of education (regular, independent…) and the relevant grade- as “beginner” (to 60 %t), “intermediate” level (between 60% and 80%) and “excellent” level(over 80 %),
  b) The estimation of the complex sciences in each school subject domain (history, geography, chemistry, Math…). This mark will be used for choosing of appropriate lesson from this subject domain for the concrete student. We develop three kinds of lessons for every topic in the relevant domain – lesson that guarantees “minimum” level of knowledge, lesson for “good” level, and lesson for “advanced” students.
  c) The third level is connected with evaluation of the knowledge on the separate concepts of relevant domain. These values are used for choosing of the lessons, advanced resources or services with information that is necessary for enriching of the knowledge in the relevant theme.
- If the user is known for the system, it is saved the information for his knowledge and results from the tests in the previous instructional sessions. The concepts level of knowing are initialized with these values.
- In the learning process the values from the top three levels change dynamically for the each student

**3. User modeling of the system**

The personalization is the main characteristic of each e-learning system, because it should ensure an individual training process for every student, according to him individual goals, tasks, plans, background knowledge, preferences, etc. [2], [4]. We will focus our investigations largely to learners. The information about the students we will separate from the rest information in the system and will process at two levels - statically and dynamically. The static information includes the personal data for the concrete user as name, grade, form of teaching, birthday, email, personal goals, preferences etc. At this level we will describe the stereotype hierarchy, where users with similar characteristics will be incorporated.

The dynamic level includes a set of information that is user-specific in the process of working with learning environment. This information is connected with evaluation of the current training process in the present learning session. That determines the connection of the User model with adaptation to the cognitions of the students and necessity from application of the combined approach, that connects stereotype and overlay models.
The adaptation process we will look at from three aspects, according to collecting of information for the student; processing on this information for formatting and updating of the user model; finding and adapted representation of an instructional material, that is appropriate for this learner. The modeling procedure calls using techniques for collecting and processing of the incoming information for the users and mechanisms that supports the next functions: to give assistance to students during the learning process; to offer personalized help information; to give up an adapted user interface etc.

The user model describes the notion of the system for student’s knowledge, his goals and intentions. The model must be updated uninterruptedly according to the active changes of the level of user's knowledge. The algorithm includes the following steps:

**Step 1:** Completing the static profile information. According to the form of education and grade, the student affiliates to some stereotype in the stereotype hierarchy. The initial values of the parameters are completed in dialog with the user or the system puts the default values. We use stereotype approach for transferring of the more general information about the group to supposition for the separate user.

**Step 2:** According to the user stereotype, the system offers initial complex test, including knowledge from all school subjects in the relevant class. We use the results from the test for specifying the individual user learning profile. The marks are grouped in three levels: as general mark, that determines the student to some sub-stereotype groups ("beginner", "intermediate" and “excellent" student); as mark for level of knowledge in each separate school subject domain – “minimum”, “good” and “advanced”); as mark for each separate concept from the relevant domain.

**Step 3:** In dialog with the student, the system determines the desired school subject, the topic, the individual didactic aims and plans. After that LMS starts the most appropriate lesson according to the stereotype of the student (“beginner”, "intermediate" and “excellent”) and the level of his knowledge in this subject domain.

**Step 4:** Implementing of individual training process;

**Step 5:** The system stored the actual values for student’s knowledge of the three levels –as general mark; as domain mark and as value for each concept.

**Step 6:** Updating of profile individual information about the knowledge and likely didactic aims of the student.

We can describe the information from the next two aspects: as domain – specific and domain – independent. The domain-specific information is closely connected with the dynamic level of user modeling. It includes the evaluation of the student, his background knowledge, stores of his acts and behaviors during the training process etc. The domain-independent information is connected with individual general aims of the student, his cognitive accomplishments, motivation, preferences, personal data as name, age, etc. The presented algorithm ensures actualization of the domain-independent and domain-specific information. The model is being restored uninterruptedly, to show correctly the user in the system. The information that is independent from the domain supports adaptation for representation of the instructional content, based on the student’s manner of learning, cognitive characteristics, an emotional activity etc. The information that is domain specific supports as navigational adaptation, so as well adaptation of the instructional content and additional resources, according to specifics of the relevant domain.

**CONCLUSIONS AND FUTURE WORK**

This paper presents a conceptual model and some ideas for realization of the adaptive user modeling [30]. We develop the static adaptive user model from two aspects: as part of development authoring tool for creation of learning resources and in the run-time environment of the learning system. The dynamic level interacts with LMS in the learning environment. The presented user model is connected with the other basic e-learning models. The background knowledge of the learner interacts with the pedagogical and
domain models by means of the overlay model. The domain model interacts with the service model, as according to the specificity on the relevant instructional discipline, proposing suitable services. The pedagogic model is associated with the Goal and Tasks model, which is being formatted from the user profile and after the determination of the individual plan starts appropriate scenario for its realization.

The initial version of the model is implemented in the SCORM-based e-learning portal of the secondary school – Brezovo [13]. Our future plans are connected with formalization of the adaptive model by UML, ITL and policies [5]. We intend to use personal agents for realization of the interaction between students and LMS [10].

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ABOUT THE AUTHOR
Todorka Glushkova, University of Plovdiv, Department of computer systems, Bulgaria, Phone: +359 0878212950, E-mail: todorka.glushkova@gmail.com