Development of Adaptive e-Learning System Based on Learning Objects

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Abstract: This paper discusses Adaptive Educational Hypermedia (AEH), which is at present a hot topic of research and an important aim for e-Learning systems. The presented approach is knowledge-based. The domain ontology and the learning objects play a central role as resources structuring the learning content and supporting flexible adaptive strategies for navigation through this content.

Keywords: adaptation, Adaptive Educational Hypermedia (AEH), e-Learning, Learning objects, Ontology

1. Introduction

E-learning was identified as one of the emerging areas in the last few years. Personalized support for learners becomes even more important, when e-Learning takes place in open and dynamic learning and information networks.

At present there are two main views of how to use the advanced media in education:

- One possible application is to consider Internet as an *enlargement of the standard classroom* where the teacher communicates with a growing number of students via virtual blackboards, virtual bulletins and so on. Current advances in this area concern issues like how to transfer the lecture to the student, how to keep students' attention, how to provide the communication between the student and the teacher (most of the papers in e.g. [3] consider different aspects of these problems).

- Another possible application of Internet in education is to use *Intelligent Tutoring Systems* (ITS) because they are designed to play the role of the teacher. The recent view is that – in order to be advanced - the Web-based ITS systems should be *adaptiv*e, since they are developed to satisfy the needs of many different students. However, during the last ten years it turned out that adaptivity is a desired feature, which is difficult to achieve.

The present paper is organized as follows: Section 2 discusses different aspects of adaptivity, section 3 presents architecture of adaptive e-Learning system and section 4 contains conclusion and further work.

2. Adaptive Educational Hypermedia

According to [2], research in AEH field can be grouped in four directions:

(i) Evaluation of *how much* and *why* an adaptive system supports the Educational process;

(ii) Investigation of student features that are suitable as a basis for adaptation;

(iii) Investigation of system features that may be changed and maintained by adaptation;

(iv) Research of different "adaptive goals", methods and techniques for achieving them and evaluation of the gains and failures in different approaches.

Adaptation may be supported according to different user characteristics, including to his/her preferences of browsing hyperlinks.

The overview [2] identifies five main features used for maintaining adaptivity: *(i)* student goals, *(ii)* student knowledge and familiarity with the domain, *(iii)* student qualification (how quickly he or she acquires knowledge), *(iv)* experience in the hyperspace and *(v)* personal preferences. Below we will consider in more detail student knowledge, which is considered to be the most important student characteristic in the majority of the current adaptive systems.

Most of the adaptive systems, which use knowledge representation and domain models, consider the student knowledge as a means for providing adaptivity. Student knowledge is a variable for every particular student. This means that these adaptive systems should evaluate or test the student knowledge, recognize the changes in its status and change the user model accordingly.

3. Architecture

Adaptive e-Learning systems usually contain the following modules (fig. 1):

- User interface - for chanelling computer-user interactions
- User model - list of facts describing the history of user interaction and his performance in every step. Student knowledge in the topic is often represented by a covering model, which is grounded on the domain knowledge base.
- Pedagogical module – navigates user thru the learning process
- Expert module - the domain knowledge base provides the structural description of the subject area, represented as learning objects, concepts and relations between them represented as domain ontology. Learning objects (LO) (fig. 2) are chunks of elementary knowledge in the domain.

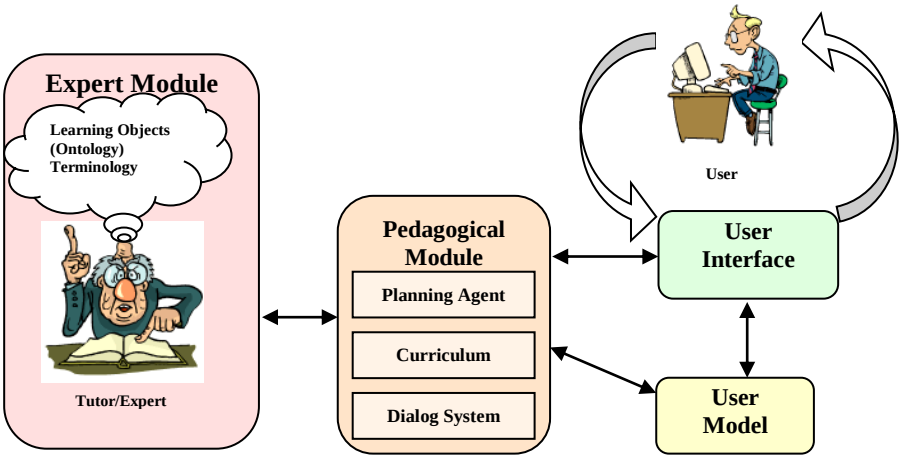

Fig. 1 Adaptive e-Learning System Architecture

In Expert Module knowledge-base contains repository of LOs.

List of TestedAspects of LO is empty for “reading ”LO and list of triples for an “exercise ”LO:[Aspect,Proposition Id,Weight], where:

- Aspect represents major types of aspects:(i)b_def :basic definition,(ii) a_fact :additional fact,(iii)rel :encodes possible relations i.e.object, agent, attribute, characteristic, instrument and etc.

- PropositionId is a Id-number of an ontology statement and
- Weight is a predefined number between 1 and 100, which reflects the importance of the tested information regarding domain understanding while teaching course material.

Sometimes there are more than one aspects of a concept that can be tested for an exercise entry which are encoded in separate triples.

Comparing content and objectives of LOs we can generate: LOs with same objectives but with different content or LOs with same content and different objectives and all possible relations between them in order to present information from different points of view. This approach allows more flexible and deep maintenance of information. Thus LOs will be adaptive and reusable. If every lesson is defined as a set of objectives (aims and knowledge) then using LOs we can automatically compose Learning materials (fig. 3) and Lessons. This approach allows us to develop adaptive e-Learning courses based on LOs and on personal user knowledge according to user model.

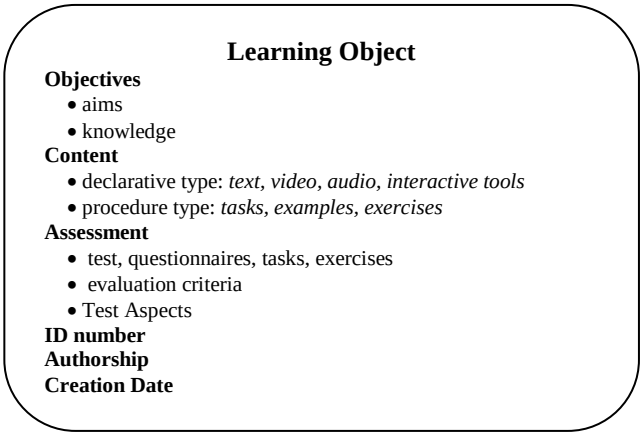

Figure 2 Learning Object

User model contains information about user's assessment for LOs and Pedagogical Module on this base can choose appropriate learning material in order to increase user knowledge in the domain and to achieve course objectives.

The User model keeps clauses to describe learners 'familiarity with the terminology which is closely related to domain knowledge.:

- know - the learner knows a term; the clause is inserted for correct answers;
- not know - the learner doesn't know a term; the clause is inserted for wrong answers;
- self not know - inserted when the learner chooses the "don 't know "answer to certain LO, if such answer exists; and
- –know wrongly - the learner's knowledge is considered wrong (eventually, might need corrections); the clause is inserted for partially correct answer to a certain LO.

Each of the learner model clauses has seven arguments:

- user name, logging identifier of a user;
- ontology concept, the tag ConceptLabels from the LO annotation;
- tested facts ,the tag List of TestedAspects from the LO annotation;
- exercise identifier (an unique Id corresponding to the tags course identifier, topic identifier and unit identifier from the LO annotation);
- counter how many times the user passes trough the tested learning object;
- indication of conceptual mistakes and
- unique index for tracking the whole dialog history

The pedagogical agent has two main strategies for active sequencing: local and global. The local strategy plans the movement between drills testing different characteristics of one concept. Its main goal is to create a complete view about learner's knowledge concerning this concept. This strategy chooses exercises with increasing complexity when the learner answers correctly and it gives again previously completed drills if the learner has performed poorly. For instance, if astudent does not know some fact related to the tested concept (term), which is encoded in the exercise annotation with low weight, the pedagogical agent will suggest a reading. The global strategy plans the movement between exercises testing different concepts, according to their place in the ontology. For instance, if the student does not know the basic deffinition of a concept and its major additional facts, the pedagogical agent will choose to test first whether the student

knows at all the super-concepts and only afterwards to suggest basic readings for the unknown concept.

The pedagogical agent chooses the next learner's movement depending on:

- the annotations of available learning objects,
- the position of the tested concept in the type hierarchy, and
- the current LM user's status: history and quality of learner's performance.

4. E-learning Course Model

One of the major goals is to provide a methodology and tools to structure learning objects in a way that allows for both reusability and adaptive delivery.

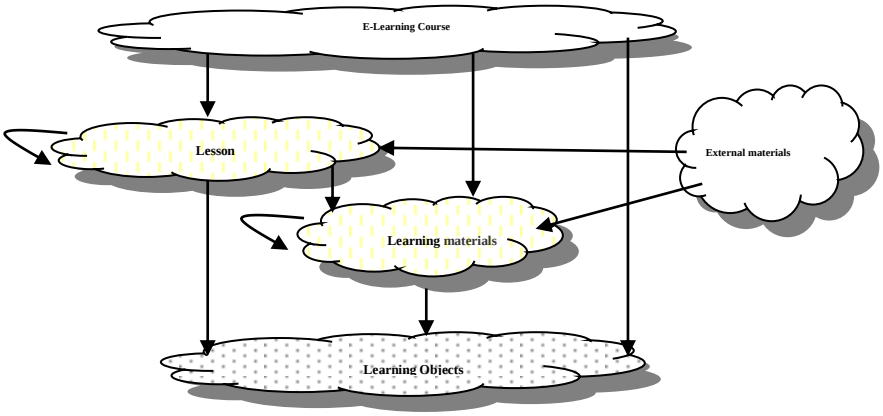

Figure 3 e-Learning Courses based on Learning objects

Content Model sum up four distinct structural levels where each higher level may contain instances of all lower levels. These levels from bottom to top are:

1. Learning Object
2. Learning Materials
3. Lesson
4. Courses

The lowest level of granularity is formed by *Learning object* which represent the smallest indivisible element in a course.

They shall contain material that illustrates a certain aspect in one thematic area and thus refers to actual learning content. Several related Learning Objects are typically assembled into the Learning Material, which is the logical representation of a distinct, thematically coherent unit and are further grouped into larger structural units, so-called *Lesson*. Lesson may also be used to build an arbitrarily deep nested structure by including other Lessons. At the highest structural level are contained in an *E-learning course* (see Figure 3). To foster maximum reuse, all structural elements are supposed to be self-contained and (ideally) context free.

Knowledge types
Receptive knowledge items can be categorized using a didactical ontology defined in [4]:

- ***Orientation knowledge*** helps a learner to find her way through a topic without being able to act in a topic-specific manner ("know what").
- ***Action knowledge*** helps a learner to acquire topic related methods, techniques, or strategies ("skills", "know how").
- ***Explanation knowledge*** provides a learner with arguments that explain why something is the way it is ("know why").
- ***Reference knowledge*** teaches a learner where to find additional information on a specific topic ("know where").

These four basic types are further sub-divided into a fine grained ontology shown in Figure 4.

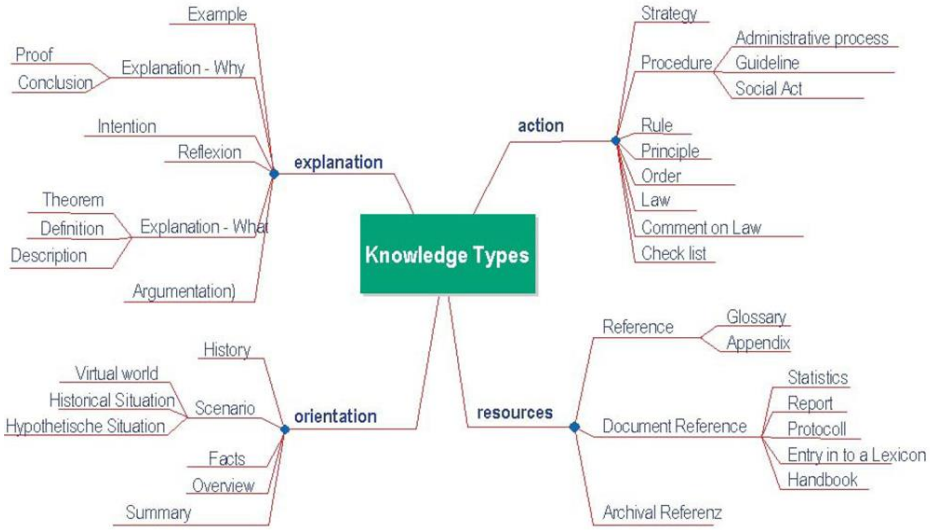

Fig. 4 Ontology

5. Conclusion and Further work

The attractive field of adaptive educational hypermedia is a hot research field at present. Nearly no fully adaptive systems are available at the market. Fine-tuning to complex user models in available at present in research prototypes with complex domain models and correspondingly deep user models. We can expect that in the near future the interest in AEH will grow and more systems with practical importance will appear.

The discussed Adaptive Educational Hypermedia (AEH) is an important aim for e-Learning systems. The further work includes possibility to implement the adaptive test for learner evaluation and congruence between pool of learning objects and pool of relevant test questions for the adaptive tests.

6. References

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