The Use of a Dynamic Background Library within the Scope of adaptive e-Learning

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Abstract: The concept of a Dynamic Background Library (DBL) is well-known in literature and applied for several application areas. As it is planned to use a DBL within the scope of the research project *AdeLE*, a first prototype named EHELP was developed and evaluated already. Nevertheless, we never analysed the DBL in terms of the applicability for educational usage, in particular for e-learning and adaptive e-learning. After a short review of critical aspects of adaptive e-learning, the conceptual design and the implementation of the EHELP system are outlined. Further, concrete educational scenarios for the application of a DBL are described and linked to aspects of the *AdeLE* project. Finally, first experiences derived by an evaluation of EHELP and the next steps of our future work are given.

1 Introduction

Based on the idea of a *Dynamic Background Library* (DBL), as e.g. depicted in (Dietinger et al., 1998) a first prototype described in (García-Barrios et al., 2001) was developed. Its successor, named EHELP (EnHanced E-Learning Repository), was partially evaluated, as shown in (García-Barrios et al., 2004a). Further, (Mödritscher et al., 2004a) highlights the plan to integrate EHELP in an adaptive e-learning environment within the *AdeLE* (Adaptive e-Learning with Eye-Tracking) research project.

The applicability and usage of such a DBL for the e-learning situation is presented and discussed in this paper. Firstly, problematic aspects of e-learning and adaptive e-learning are pointed out in order to identify some intervention options for the DBL as a possible solution tool. Thereafter, the basic concept and the planned realisation of the extended EHELP system are shown by means of an architectural design. Finally, concrete advantages of a DBL are examined by describing specific application scenarios. After summing up this paper, we denote the next steps of our future work.

2 Critical aspects of adaptive e-learning

As stated in (Jain et al., 2002), e-learning consists of two main processes, the learning and the teaching process. With respect to the learning process, factors such as attention, relevance, confidence and satisfaction (see Keller & Suzuki, 1988) have to be considered. Though, this section focuses also on relevant critical issues concerning the teaching process. On that account, critical aspects of adaptive e-learning are treated in this section by means of the following topics: (a) pedagogical and didactical aspects, (b) adaptation-based systems, and (c) enhancement of learning processes.

2.1 Pedagogical and didactical aspects

In agreement with (Park & Lee, 2003), we are of the opinion that important pedagogical aspects comprising motivation, emotions, prior knowledge, cognitive and effective abilities, preferences, interests and so forth can be mapped to learning types and *learning styles*. These learner-specific characteristics and traits are mostly managed by means of user profiles, or more specifically, learner models. Using such models about learners can be helpful to analyse the target group of any course and plan all further didactical activities. Hence, this approach termed as aptitude-treatment interaction (ATI) is being researched for nearly a half century (see Cronbach, 1957).

Considering didactical aspects, (IDS, 2002) highlights the *necessity to determine and assess learning objectives*. In that sense, there is a need for a description of activities for planning a course as well as for methods to deliver the content, to create tests and to graduate students within the classroom and the distance learning situation. Further, providing content by pure e-learning leads to a *limitation of teaching processes* in terms of several aspects, e.g. in diversifying teaching styles and methods (see Mödritscher & Sindler, 2005). If a teacher wants to adapt an instruction to the learner's behaviour, for instance by giving another explanation model for a concept, tutoring support within an exercise or helpful feedback at an exam, she/he always has to predefine the content, which is not practicable, or use ITS technology within specific domain contents (see Park & Lee, 2003).

Both, the pedagogical and didactical aspects have to be considered in the classroom as well as in the e-learning situation. In traditional education, the adaptation of such aspects is dependent on the *didactical skills of the teacher*, which can be seen as relatively easy and feasible, because teacher and learners can interact immediately at any time during the lesson. In contrast, *technology-based education*, such as e-learning and distance learning, faces a lot of problematic aspects that are already been examined, as e.g. in (Dietinger, 2003). Therefore, different approaches like blended learning or adaptive e-learning are researched with the aim to find remedies for the disadvantages of e-learning. In particular adaptive e-learning, which is the main focus of the *AdeLE* research project, can be useful to improve different factors of technology-based learning.

2.2 Adaptation-based systems

Adaptive e-learning comprises a research and development stream treating with educational systems which adapt the learning content as well as the user interface with respect to pedagogical and didactical aspects (see Shute & Towle, 2003). Technological realisations of this main stream are for instance intelligent tutoring systems (ITS) as well as adaptive hypermedia systems (AHS), both described e.g. in (Brusilovsky, 1998). As highlighted in (Park & Lee, 2003), the basic concepts like macro- and micro-adaptive instructional design or the ATI approach can be tracked to the beginning of the 20th century, while the development of technology-based systems start in the 1960s and 1970s. (Mödritscher et al., 2004a) describes a model of adaptive e-learning based on four historically documented mainstreams and justifying two important aspects of the *AdeLE* research project.

On the one side, *designing the courseware* depends firstly on the macro-adaptive theory, where didactical decisions like levels of detail, the paths through a course, pre- and post-conditions for instructions etc. are adapted, secondly on the ATI approach, which represents the basis for personalisation on the level of content aggregating and sequencing the instructions, and thirdly on the constructivistic-collaborative approach considering new learning paradigms, motivational aspects, collaborative tasks etc. In the context of the *AdeLE* project, (Mödritscher et al., 2004b) defines a set of pedagogical requirements for the learning content.

On the other side, the *adaptation process* can be best realised with respect to the micro-adaptive approach, which is about two main components, a diagnostic process assessing the learner's states and the learning progress as well as a prescriptive process adapting content and control elements in terms of didactical objectives and the observed learning behaviour. The *AdeLE* prototype is expected to be an AHS combined with ITS functionality realised on the basis of the Openwings framework (see Gütl et al., 2004).

2.3 Enhancement of learning processes

Adaptive e-learning can improve the learning process in the e-learning situation, which is proofed for several approaches by means of field studies, as summarised e.g. in (Park & Lee, 2003). Nevertheless, several problems can be identified in this research area. To conclude this section, let us give a short overview over some of these problems, as follows:

First of all, *observing the learners' behaviour* is unreliable if only using default input devices of a computer as sensors of the adaptive system. That is why eye-tracking technology is used within the scope of *AdeLE* in order to

scrutinise the applicability and the impact of usage of some other 'uncommon' devices (see García-Barrios et al., 2004b).

Second, *creating adaptive courseware* takes too much effort, if all defined requirements concerning the learning content have to be considered. This aspect is particularly critical, because the main advantage of the ATI approach has not been proven yet.

Third, most e-learning environments focus on a *single learning context* (i.e. a specific learning situation or scenario) by means of one of the three basic learning theories: behaviourism, cognitivism and constructivism. In practice, an e-learning platform realises typical school situations providing a behaviouristic environment, some kind of tutoring support in terms of cognitivism or a content management system for self-driven learning with respect to constructivism. Only few systems such as INCENSE (see Akhras & Self, 2000) offer the ability of identifying and analysing different learning situations and, if necessary, automatically switching among them.

Finally, let us state as a problematic issue our assumption regarding the 'rather impossible' task to *simulate a teacher by technology* through the fusion of an expert (in a certain research field) and a pedagogue in one person.

3 Basic concept and realisation of EHELP

Due to the problems depicted in the previous section, we suggest to provide a more general courseware, which is structured by means of the most important high-level concepts within the adaptive e-learning environment. Further, we recommend the usage of a background library for the retrieval and delivery of (internal and external) materials, which are relevant to reach the learning objectives and, at the same time, fit the learning context.

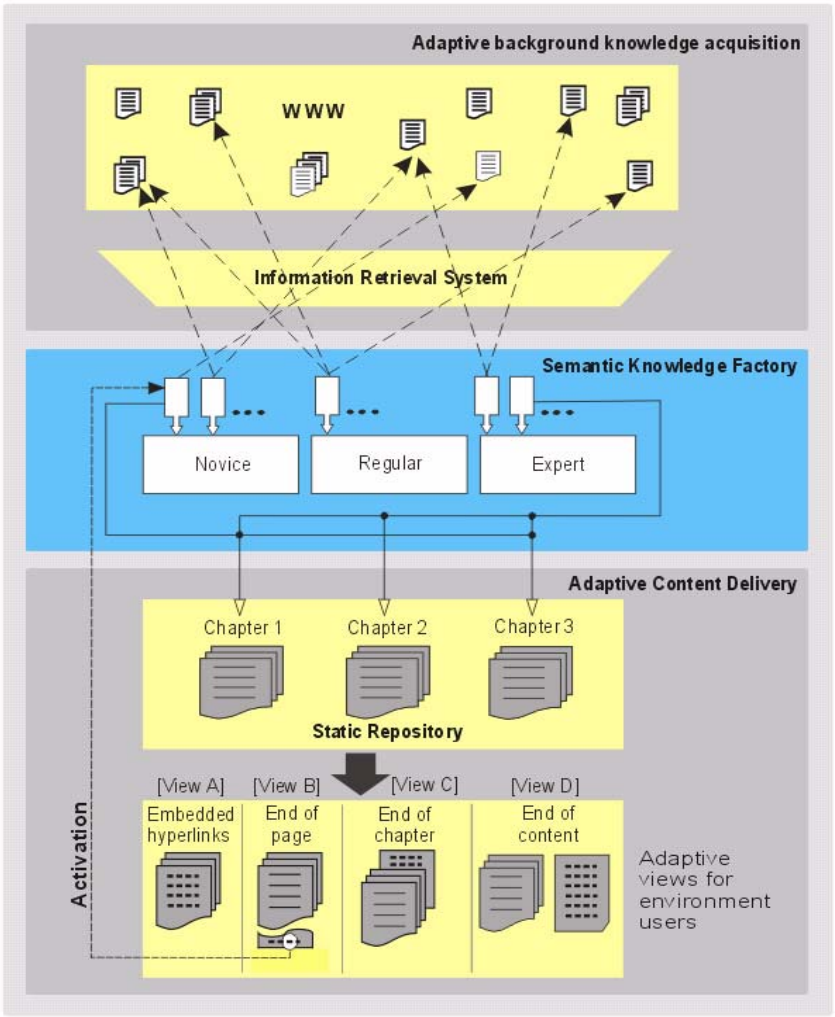

Figure 1: Basic functionality scheme of EHELP

In contrary to our proposal, other architectural models or realised systems just solve partially the problems: they provide either fully structured learning content, e.g. with adaptive links as described by (De Bra & Ruiter, 2001), or a totally unstructured course materials, such as the Knowledge Sea portal by (Brusilovsky, 2004), where the teacher just specifies the range of learning materials or activities and the system organises the content in a matrix-based knowledge map. Though, we prefer the solution in the middle of these two opposite approaches and focus on small and compact adaptive courseware, for which low-level learning objectives can be reached e.g. through the additional usage of a dynamic background library that interacts with different search engines. Such a setup can also be used to realise high-level learning objectives and support other factors, such as learner's curiosity and intrinsic motivation. Hence, a running prototype named the Enhanced E-Learning Repository Manager (EHELP) was developed at the Institute for Information Systems and Computer Media (IICM), Faculty of Computer Science at Graz University of Technology (see García-Barrios et al., 2004a). The basic functionality scheme of EHELP, as shown in Figure 1, depicts the different interaction layers and their interdependencies through the knowledge transfer process.

Beginning with the layer at the top of Figure 1, the 'adaptive background knowledge acquisition' describes the process of retrieving, for a pre-defined concept, background knowledge resources from a certain repository by using a certain Information Retrieval System (IRS). Therefore, the course creator can define specific concepts and assign to each of them a query for a particular search engine, e.g. for one concept the teacher might want to use Google to provide up-to-date information from the internet, or to use the online Oxford Advanced Learner's Dictionary to provide explanations of terms, or to use the LEO English/German Dictionary to provide translations of words. The layer in the middle of the figure comprises the 'semantic knowledge factory', a component storing the concepts which have to be pre-defined by means of an abstract name and a meta-query transformable for each used search engine, assigned to the relevant expertise level group and linked to the course content or to parts of it.

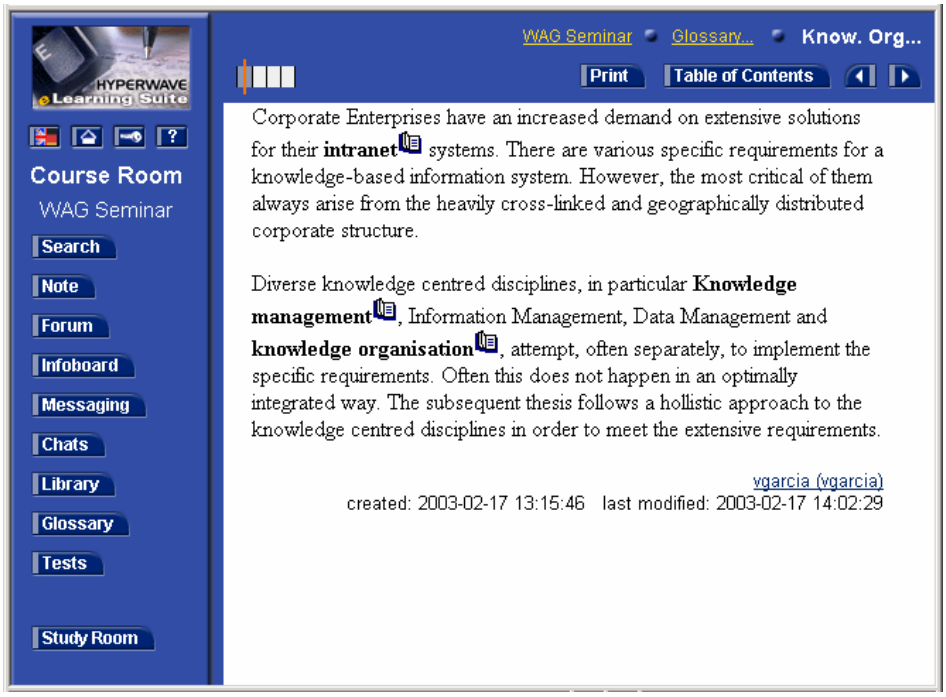

Figure 2: EHELP viewing mode "Embedded hyperlinks"

The layer at the bottom of Figure 1 describes how the adaptive content delivery is realised. The lessons and instructions of a course can be interpreted as static content. If an assigned concept is found within one instructional unit, its correspondent background knowledge may be accessed through hyperlinks, which are dynamically added to the courseware and delivered by means of the four following different view modes:

- *Embedded hyperlink*: The content of the requested page is parsed and modified dynamically depending on the current settings, as depicted in Figure 2 (see also bottom-left side in Figure 1, View A). Each match is highlighted and hyperlinked to a context chooser and further to the IRS, which processes the corresponding search query requests that are passed through the hyperlinked 'book'-icon.

- *End of page*: A list of the matching items is appended 'at the end' of the current page (see bottom part in Figure 1, View B).
- *End of chapter*: Single pages are not modified. At the end of each chapter a dynamically generated HTML page is provided and contains an alphabetical list of the chapter- and level-specific EHELP items as illustrated in Figure 1, View C.
- *End of course content*: a dynamically generated HTML page with a list of all level specific items is attached at the end of the course (see Figure 1, View D).

As stated in (García-Barrios et al., 2001) and (García-Barrios et al., 2004a), the prototype of EHELP, which was restricted to manage only one IRS (Google or xFIND), is realised as an extension of Hyperwave's eLearning Suite (see eLS, 2004) and fully written in server-side Javascript following an object-oriented approach. At the present, EHELP is being ported to Java as an enhanced independent system, which manages concept sets for free-definable information spaces. The aim of this new system is to provide enhanced EHELP-features for the *AdeLE* prototype within the service-oriented approach (see Gütl et al., 2004). How useful such a system could be in the scope of the *AdeLE* research project is shown in the following section by pointing out a set of possible application scenarios.

4 Application scenarios for a dynamic background library in the scope of *AdeLE*

Based on a literature research, we could identify several possible scenarios for the application of a dynamic background library in the field of technology-based learning or any educational activity in general. Six of these scenarios are listed and explained as follows:

- First of all, (Campbell et al., 2004) reports about students from abroad having problems with *understanding the language*, in particular certain vocabularies. In this context, a DBL such as EHELP could offer useful translations applying some kind of dictionary service. With respect to the research project *AdeLE*, we see a fabulous chance for the eye-tracking device to detect if a learner from a foreign country – in terms of not speaking fluently the course language – has problems reading or comprehending a word or a term. By exploiting the eye-tracker characteristic of being also a gaze-tracker, some of the features gained from the system and that could be combined in order to identify linguistic problems, are e.g. scanning path, high frequency of returns to specific fixation places and reading velocity.
- Similar to the previously illustrated scenario, a learner in general could have problems *understanding a passage* due to a lack of knowledge about a certain concept (word or phrase), unclear and contradicting formulations or, again, completely unknown terms. Using EHELP to retrieve relevant and context-specific sources for the problematic passage, for instance by querying a digital repository as described in (IMS, 2003), could improve the learning process by offering the student another explanation models or some missing definitions. Let us also state at this point that in order to prevent an unmanageable overload of information the teacher has to pre-define some kind of criteria for the relevance of the material.
- Another aspect which is treated in (Dreher et al., 2004) regards to *thematic-driven learning*, comprising the idea that each student specialises on one chosen topic and then reflects other topics by performing certain tasks such as peer reviewing or peer assessment. Thus, EHELP would be a great tool to manage and provide the topics as well as different materials for the students to study in a more focused way. Again, a repository for learning objects, as one of the IRSs in the background, would be of high relevance.
- Referring to constructivistic theory – e.g. researched by (Bruner, 1966) –, new paradigms in the e-learning situation are of importance nowadays. *Context-driven learning* can be supported by EHELP through the usage of different IRSs to retrieve the background knowledge. One context is e.g. reflected by the already mentioned scenario, where the classical learning process of a student takes place and EHELP offers background knowledge, such as definitions or another explanation models. Another context could comprise a researcher scanning the learning content - provided by EHELP - for new developments through applying a specialised IRS on the internet in order to gather accurate and up-to-date information. A more neutral context could be the evaluation of content through a teacher, where no certain background knowledge needs to be retrieved.
- *Adaptability and* even *adaptivity* as outlined e.g. in (Oppermann, 1994) may be realised by defining different concepts for different types of learners or for learner groups, based on user information such as pre-knowledge in the domain, preferred search engines, or interests. Furthermore, it is also imaginable to ignore the course structure and pre-defined sequencing at all, and allow the learner to explore the course

freely and at his own pace. Therefore, a DBL could provide important didactical anchors using the concepts defined by the teacher. It is planned to realise this approach within the *AdeLE* research project.

- Quite often, learning content needs to be updated continuously. In matters of this need, EHELP may be also applicable for teachers in order to gather new information about defined concepts as well as linking instructions to external sources or other courses. Therefore, a DBL could be used to support the *evaluation of accuracy and topicality of course content* by linking concepts to new information via internet. Thus, we would have to extend the EHELP system in order to interact with a learning content management system (LCMS). Again, the service-based approach of the *AdeLE* prototype seems to be very advantageous.

As highlighted in this section, a DBL has beneficial applicability for the learning process as well as for the maintenance of the learning content. Based on an ongoing evaluation of EHELP, partially completed and published in (García-Barrios et al., 2004a), we can derive the following experiences from the test users and their comments after absolving a course enhanced by the dynamic background library (using Google as background IRS):

- Some test users requested for language-restricted results gathered by the IRS to avoid Russian or Chinese search results, which happens quite often by Google.
- Other test users wanted to get results from other search engines for different reasons, such as getting definitions from Wikipedia, translations from the LEO online-service, or simply disliking the results from Google, because they were partially not relevant or too global.
- Further, the majority of subjects claimed that they had to adjust the pre-defined query to find appropriate material, which justifies the idea of adapting the behaviour of the background library with respect to the context. Thus, it is absolutely necessary to use the right IRS for a given context and a personalised query in order to enable the student to fulfil the postulated task. For instance, several test persons, mainly researchers or students writing on a thesis, asked for build-in links to cited literature resources.
- In addition, some test users wanted the EHELP system to embed cross references within the course and to other courses. Thus, some learners want to go through the learning content at their own pace and in their own way, which is proven by many studies within the field of the macro-adaptive instructional design (see Mödritscher et al., 2004a).

The few experiences depicted in this section are just restricted to the view of the learners. We, as active lectures applying distance teaching methods, would appreciate a tool allowing us to evaluate and update our course materials. Thus, EHELP is also being redesigned and extended in terms of context-dependent adaptation of the system's behaviour, such as using different IRSs as well as features to evaluate and manage learning resources.

5 Conclusion and future work

Summarising this paper, we have to point out that a dynamic background library may be of great value for the learning as well as for the teaching process. One the one side, the EHELP system can be applied to adapt with respect to pedagogical aspects such as learning styles, pre-knowledge, preferences, and so forth. On the other side, it could be also interesting from the didactical point of view, if it supports the teacher in planning, organising, carrying out and evaluating a course. Yet, our first prototype has some restrictions in the applicability. In particular, we face now the problem that we can only define one information retrieval system to gather background knowledge resources. This problem forces us to get stuck with respect to one single learning situation. Regarding the first experiences of EHELP's ongoing evaluation, we have to commit that we used Google to cover a broad range of contexts. Therefore, the test users criticised the quality of the retrieved background knowledge, which in turn means that learners advocate the usage of more context-specific information retrieval systems.

For future work we plan to redesign the prototype of EHELP according to the experiences gained from our evaluations. First of all, the system is being ported to a service-based Java framework. Second, we want to introduce some ontological approach in order to semantically manage and enhance the pre-defined concepts. And finally, it should be possible to define different information retrieval systems to adapt in terms of the context in which the system is used. Furthermore, it is planned to apply the new version of the dynamic background library in order to support the adaptive e-learning environment within the research project *AdeLE* and to evaluate this system with respect to the insights of this paper.

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