

Semantic Knowledge Factory: A New Way of Cognition Improvement for the Knowledge Management Process

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Abstract: The goal of the novel tool HERMA (enHanced E-learning Repository MAnager) is to improve the efficiency of the knowledge transfer process in web-based learning environments. The mechanism enables users to improve adaptive courseware enlargement and it supports the dynamic retrieval of the content, its presentation and navigation. Based on self-defined semantic parameters, which describe course and user specific factors, it generates dynamically context dependent, user relevant and always automatically updated background knowledge that relies outside the static repository by applying a smart search framework. HERMA places this dynamically generated background knowledge at the disposal of learners across distinct viewing modes while navigating through the courseware. In addition, HERMA may improve the process of course generation and maintenance. In our first application, HERMA is integrated in the Hyperwave eLearning Suite and interacts with the smart search framework xFIND.

Motivation

At the IICM we had long-term experiences in the fields of web based learning systems, for example (Dietinger et al. 1998b), hypermedia management systems like (Hyperwave 2001), dynamic background libraries, as stated in (Dietinger et al. 1998a), and knowledge discovery, as with (xFIND 2001). The praxis showed that within the learning process the sole application of a static course repository is not sufficient. This led us to propose that one of the key issues of modern web based learning systems is to reach a dynamically enhanced knowledge transfer.

The knowledge transfer process could be interpreted as a holistic phenomenon composed of two, mostly overlapping but essentially different, main streams: a) the teaching process, which concerns knowledge generation and delivery, and b) the learning process, which concerns knowledge acquisition. A wide range of problems caused by a huge and an increasing amount of information as well as by rapid changing knowledge are faced within both processes. A selection of those problems is discussed as follows.

Knowledge in virtually any subject is a dynamic entity itself. According to (Lymann et al. 2001) each year a dramatic amount of 1.5 EByte of unique information is produced worldwide. Course authors and learners have to keep up with permanently increasing and changing knowledge. Thus, a mechanism should be given to support trainers in gathering new knowledge and tracking the modifications. Learners should get informed dynamically of this up-to-date background knowledge during their learning process.

Another problem is that nested hyperlinks in static documents often lead to no longer reachable resources. A survey of hyperlink sources in research papers has shown, that some 20-30% become invalid links within one year (Lawrence et al. 2001). Thus, the delivery of content with embedded linkages should happen in a semantic and adaptive way. The system should provide an adaptive extension of the static repository for example by defining an itemized semantic-based background library. Furthermore, the system should ensure relevance, actuality and reliability of this background knowledge. This can be achieved by collaborating with a smart search framework, like xFIND.

The learning process is a not always predictable user dependent entity. Current systems provide distinct “adaptive” features to deliver user-tailored content. We propose that adaptive and goal-oriented knowledge generation and delivery should be supported in web based training systems in order to define semantic topic maps and to assign user expertise levels. This enhances the responsiveness of the system in order to reach a wider target audience. Our former experiences in user behavior within the learning process, as stated in (Pivec 2000), have endorsed that learners hold distinct learning methods. Some prefer to get informed of background knowledge directly within the content of the course, for example through embedded hyperlinks. Others prefer information at the end of each chapter, and so on. Thus, a mechanism to provide adaptive presentation alternatives for the dynamic background library should be enabled.

Furthermore, trainers should have the possibility to specify grouped topics that describe different background knowledge resources in accordance to the skills of learners. In addition, learners should get the freedom to define their own expertise level, to personalize their view of the dynamic background library and add their own sources of information.

Based on the motivations, facts and problems stated above we have set up a prototype implementation called ‘HERMA’. The enHanced E-learning Repository MANager HERMA may be seen as a smart dynamic background library that transparently monitors all the features to solve the problems described above. Thus, it improves most of the needs of trainers and learners within web based training systems. An optimized adaptability is reached due to its gradable features and its permanent presence through the entire knowledge transfer process.

State of the art

As Peter Brusilovsky stated in (Brusilovsky 1998), we advocate the criteria of assessing adaptability within web based training systems on dependence of the provided or absent adaptation technologies. A survey in the field of pre-existing learning environments as well as present research work led us to emphasize that current systems do not meet the needs of trainers and learners for adaptive technologies. Annotations, chat rooms, asynchronous messaging, dynamic navigation, personalized study spaces, courseware delivery platforms, curricula sequencing, progress tracking, static library and glossary, internal search functionality, virtual references, adaptive collaboration, meta descriptors, topic maps, metadata servers as well as self-assessment features represent only some of the existing modules interacting in current on-line learning environments. Nevertheless, problems arise after trainers have already published their courseware. At this point they have determined their strategy to reach a specific didactical goal. In order to reach different target audiences with various levels of expertise, they should have to enlarge the courseware physically on the system storage.

A similar problem could emerge during the course attendance, for example if enrolled learners are not able to manage the delivered knowledge in the expected time or manner. Because of that, we propose that courseware as well as additional background information (background library) have to be provided according to learners’ needs. HERMA solves these problems by exploiting novel features that allow constant reconfiguration and personalization of courseware and dynamic background library.

The static knowledge repository is the basic element of on-line learning systems. Apart of representing a static collection of ready-to-use digital materials, it should integrate an adaptive complement for assisting trainers and courseware authors while developing, presenting and maintaining the courseware according to the needs of learners and to the dynamically changing knowledge. This should happen all the time, during the whole teaching and learning process.

HERMA enhances the goal-oriented knowledge transfer process by enabling the development of a dynamically indexed background library of subject-relevant resources relying outside the static repository. Trainers may determine, after creating its static courseware, a set of topics referring to accurately described resources on the Internet. Relevance, actuality and access of this background knowledge are maintained

with the collaboration of the smart search framework xFIND.

The Basic Idea

The basic functionality schema of HERMA, as shown in (Fig. 1), depicts the different interaction layers and its dependencies through the knowledge transfer process. Background knowledge relying on the Web is dynamically accessed via the smart search service xFIND (exploiting Quality Metadata) according to the predefined items in the Semantic Knowledge Factory 'HERMA'. These items are essentially defined within expertise level groups and assigned to one or more course chapters. Thus, depending on the selected viewing, the requested page is dynamically generated and contains a list of valid items. Clicking on a delivered item, in (Fig.1) symbolized by the arrow 'Activation', will lead to a search call of xFIND using the pre-stored item specific query term. The final result is a set of accurate, relevant, up-to-date documents.

From the point of view of the trainers, HERMA essentially provides an option for determining a set of topic specific items, which refer to a dynamically generated set of resources provided by xFIND. Each item belongs to a specific level of expertise, may be grouped with other items to a specific 'subject' collection, may have synonyms - which should be referenced in the same way as the topic itself -, and has a scope of validity within the courseware. From the point of view of the learners, HERMA provides the possibility of choosing its own level of expertise and one of four different viewing modes for displaying the currently valid elements while navigating through the courseware.

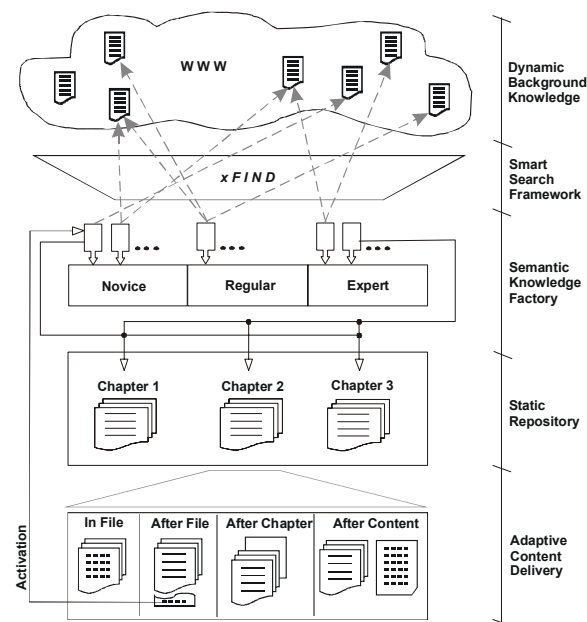


Figure 1. Basic Functionality Schema of HERMA

Prototype Implementation

The implementation of HERMA runs fully integrated in the Hyperwave eLearning Suite system, works hand-in-hand with its data base objects (courseware and users stored on the Hyperwave Information Server), and accesses background knowledge from the Internet intercommunicating with xFIND. When learners demand a page of the static repository, HERMA dynamically parses it applying a smart pattern matching mechanism. It remembers each valid occurrence of the predefined items and delivers the content according to the personalized learner settings. An item within HERMA is defined as a combination of: a) descriptive information about a topic, which is stored as an xFIND specific query term, and b) metadata about the meaning and validity scope of the topic definition within the training system.

Trainers assign each item a user-specific expertise level. The name of the item is simultaneously the name of the Topic, for example 'Internet'. Some Topics may also be collected in self-defined super-ordinate sets called Subjects, for example 'Information Technologies'. After determining via (xFIND 2001) a satisfying list of accurate information from the Web, the xFIND specific query terms are stored within HERMA. These terms represent the semantic retrieval of background knowledge and ensure always up-to-date information from the Internet. Trainers define also the scope of validity for each Topic (one or a set of course chapters for which the topic is valid). A set of Synonyms corresponding to the Topic may also be defined, for example "Intranet". Thus, the presentation of the semantically itemized background knowledge depends on the intention of the trainers and on the personalized learner configuration.

Learners may not only choose an expertise level but also one of the four provided Viewing Modes that are shown in (Fig. 2) and explained as follows: a) Embedded hyperlinks: the content of the demanded page is parsed and modified dynamically depending on the current settings. Each match is highlighted and hyperlinked to a proper xFIND-specific search request. This is shown in (Fig. 2) by the word INTERNET and its Synonym INTRANET (identical hyperlink information stands behind the icons beside those terms). b) End of page: A list of the matching items is appended 'at the end' of the page. In the example of (Fig. 2) both, the topic Internet and its Synonym Intranet, were found. Therefore, the corresponding Topic name is contained in the List of items immediately after the content. c) End of chapter: single pages are not modified. At the end of each chapter a dynamically generated HTML page that contains an alphabetical list of the chapter and level-specific items is provided. d) 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.

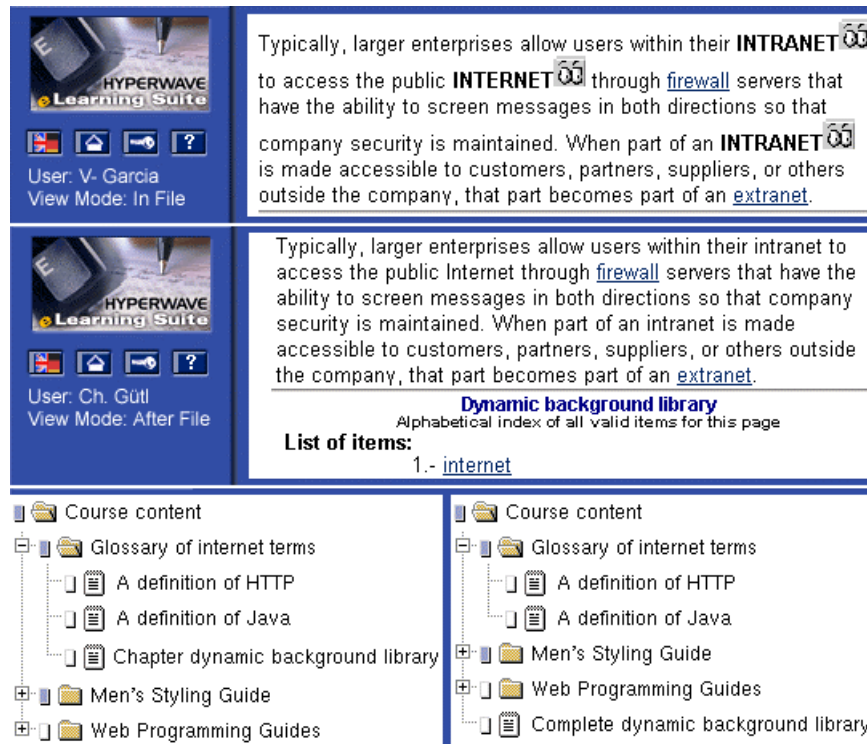


Figure 2. Adaptive Presentation and Content Delivery with HERMA [Top: Embedded hyperlinks - Middle: End of page - Bottom Left: End of Chapter - Bottom Right: End of Course Content]

Conclusion

As shown through the paper, HERMA enhances dynamically the functionality of static repositories by providing smart features that improve accuracy, actuality and goal orientation of static courseware. The prototype implementation of HERMA has been successfully tested for the course

'Knowledge Management' at IICM, Graz University of Technology. Further research and development work will update HERMA's functionality. Thus, a learner may not only use one global Semantic Knowledge Factory, but develop a personal one or share a self-defined one within a group of course participants. It is also planned to integrate HERMA in large distributed systems, where users of different environments, like universities, may mutually manage a multi-server Semantic Knowledge Factory.

A semantic-based dynamic mechanism with various interactions, as implemented with HERMA, assists trainers, publishers and learners along the whole knowledge transfer process: it assists actors during knowledge creation, structuring, delivery, maintenance, personalization, reconfiguration and acquisition. Knowledge delivery is adaptable to users' needs without overloading system capacities. The separate treatment of delivery and storage of knowledge makes the system flexible, reusable and cost effective.

The smart reconfiguration feature of HERMA makes it possible to gradually conduct the activities of learners during the whole knowledge transfer process. This enhances the teaching process by means of an improved guided learning.

As stated in this paper, HERMA applies a smart pattern matching mechanism to each topic definition - and to its corresponding synonyms - during the content delivery process. This simple idea enables a single HERMA environment to manage also systems that support multilingual content delivery, by associating topic definitions with synonyms in different languages.

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