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Design & Development of a Dynamic Hypermedia Educational System

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Abstract

The adaptation of hypermedia educational systems to the specific needs of each of the students' increases their functionality and their capabilities, in general. This paper presents issues related to the design and development of an adaptive hypermedia educational system for training adult employees via the Internet. More specifically, we present the structure of the system, i.e. the abstract machine, the trainer's subsystem (interactive user interface), the student's subsystem (adaptive hypermedia user interface, student's model and profile, pedagogical module, evaluation module) and the navigation, storage and management module (knowledge base and hypermedia database).

Keywords: Adaptive Hypermedia Educational Systems, Hypermedia Databases, User Model, Pedagogical Models, Distance Learning, Graphical User Interface, Knowledge Base.

Introduction

Through the use of continuously evolving Information and Communication Technologies, Networked Learning (NL) has set the scene for an effective and low cost Open and Distance Learning (ODL) scheme. Many course providers (Educational institutions and Businesses) worldwide offer courses on various topics through the use of the Internet and the World Wide Web. The current technology allows: course material to be electronically distributed, communication between learners and instructors as well as between learners themselves to be established (Sherry, 1995; Lawhead *et al.*, 1997), on-line digital libraries and other educational resources, to be accessed (Marchionini & Maurer, 1995), etc.

Networked Learning is a flexible form of education (over the time and the place when education takes place), which functions alternatively to other education forms. Its main advantage is that its effectiveness is much higher than other traditional educational settings and its cost is comparatively lower (Rumble, 2001).

Networked Learning as an educational method, at first sight, seems to be putting people apart, to be isolating them in their own place. However the pedagogical method followed in many

cases is based on collaborative learning (Stacy, 1999; Thomas & Carswell, 2000). According to this method groups of learners are established which work in common assignments, developing interaction among them. Each group of learners is evaluated by his group project work, based on the related criteria such us the originality and the innovative of ideas, the quality of the electronic presentation e.t.c. and by the contribution to the other groups' project work, by making critical comments. All of the above generate a lot of interaction among learners and trainers, so that an electronic community of learners is established.

The use of multimedia and virtual reality technology in the educational sector has created the appropriate conditions for the implementation of interactive systems (extremely friendly for the user/learner) that offer the students the ability to extend their knowledge without any help from the trainer.

Furthermore, hypermedia systems increase the capabilities of multimedia by adding the potential of free navigation. When it comes to "adaptive" hypermedia systems, the capability of these systems to be adapted to the students' preferences extends hypermedia functionality by offering customized learning.

Adaptive Hypermedia Educational Systems

Adaptive hypermedia systems can incorporate Artificial Intelligence methods in order to produce systems oriented to the specific preferences of each student. These systems embed hypermedia data into a platform that manages it "smartly" and presents it to the end user. They also offer the ability of monitoring the performance and progress of the student and intervening for guidance to the student when it is necessary. Additionally, in such systems, the nature of a student's error or misapprehension of a topic, defines the type of help to be offered.

Adaptive Hypermedia Systems (AHS) extend the functionality of hypermedia systems by offering every user the ability to navigate "smartly" in hyperspace (extended and decentralized information and knowledge network). They combine hypermedia and intelligent instructional systems theories, and they belong to that class of adaptive systems that have the end user as their primary focus (user-oriented).

AHSs' objective is to adapt the content, user interface and navigational type to each individual user. Adaptation of the content of training means that the content of a hypermedia page is composed of partial sections corresponding to the student's level. In the adaptation of links, the student is supported during his/her navigation in hyperspace, and the visible links are adapted according to his/her particular needs. Thus, the hypermedia system is adapted according to the user's knowledge, his/her intentions, preferences, knowledge background, experience and learning speed (Brusilovsky, 96; Henze, 00).

AHSs can be used in every application field that is used by users with different needs, intentions and knowledge. They can also be used when the hyperspace of the system is fairly large and there is the "lost in hyperspace" danger. Users with different needs may be interested in different information sections presented by a hypermedia user interface and may wish to use different navigational tools such as overview maps, interaction histories, guided tours, etc.

The biggest application field of adaptive hypermedia systems is *educational hypermedia systems*. In these systems, every user or student has a specific educational objective that is either the learning of a whole topic, or of a part of it. Of special interest is the case of a student who doesn't follow an academic educational program, but training – instructional program directly related to his/her professional career. Such programs have a relatively small hyperspace that represents a series of courses on a specific subject.

In order for the hypermedia system to be able to be adapted to the different needs or preferences of each student, it needs to incorporate a student model that will keep all of his/her particular characteristics. This information is collected by the system during its interaction with the student. First, the system collects this information and embeds it to the student's model and, then, it keeps updating this model with new information.

In the next section of the paper, we will present the structure of an Adaptive Hypermedia Educational System for teaching via the Internet.

Structure of an open Adaptive Hypermedia Educational System

Primary goal of the Adaptive Hypermedia Educational System is the dynamic creation of educational units for training adult employees, which will correspond to the level of knowledge, needs and preferences of each employee student. In Figure 1 the structure of a typical educational unit is presented.

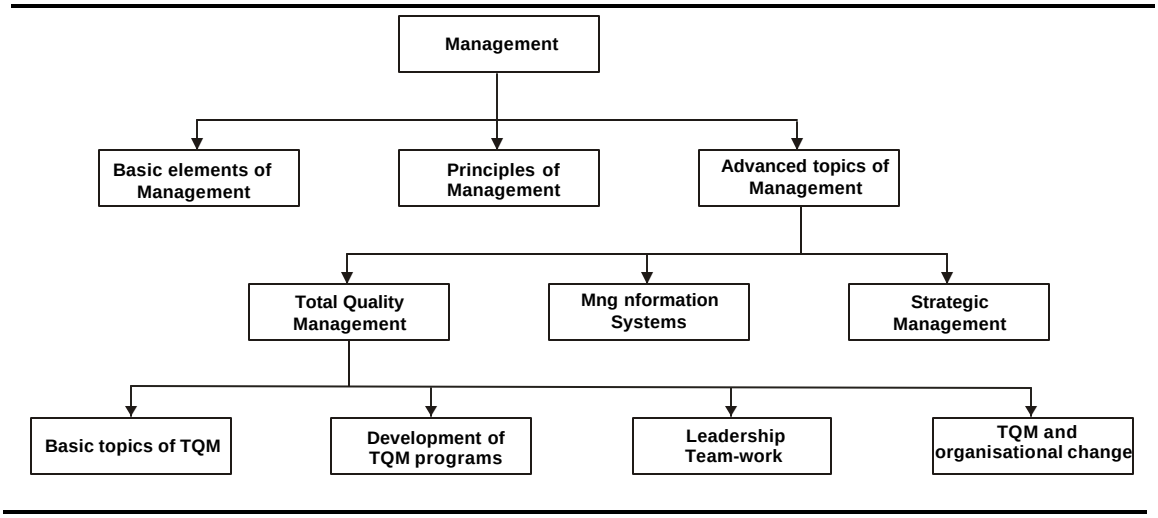

Figure 1: The contents of the unit «Management»

The application field of the system is distance training via the Internet. In this form of training, the population of a class is usually heterogeneous, referring both to the level of knowledge as well as to the degree of familiarization with the new technologies. In addition, the students study alone in place and time of their own will, thus undertaking the prime responsibility of learning.

The proposed system monitors the student's actions and responses during time of studying, assesses them and readapts the provided educational material of the courses. In the beginning, it aims at limiting the field of knowledge presented to the student (in his/her first steps) while gradually enriching it following his/her progress.

For a typical subject matter, e.g. "Management" the users are evaluated according to their profile in three different levels of knowledge. In level A there is the basic knowledge corresponding to first level managers, in level B there is good theoretical knowledge corresponding to junior managers and in level C there is high level theoretical knowledge corresponding to senior managers. Each user, regardless of the level he/she is being evaluated, "sees" all the contents of the educational program (Figure 1). From these contents he/she will be taught those topics in which he/she has problems, based on the evaluation of the prerequisite knowledge defined by his/her profile. In every level, the content of knowledge is differentiated (e.g. in the first level basic concepts and in the third level advanced topics), as well as the user interface environment with the use of more advanced search, navigation and interaction techniques.

Our system consists of five sections, the subsystem of the trainer, the subsystem of the student and the navigation, storage and management module, as in Figure 2.

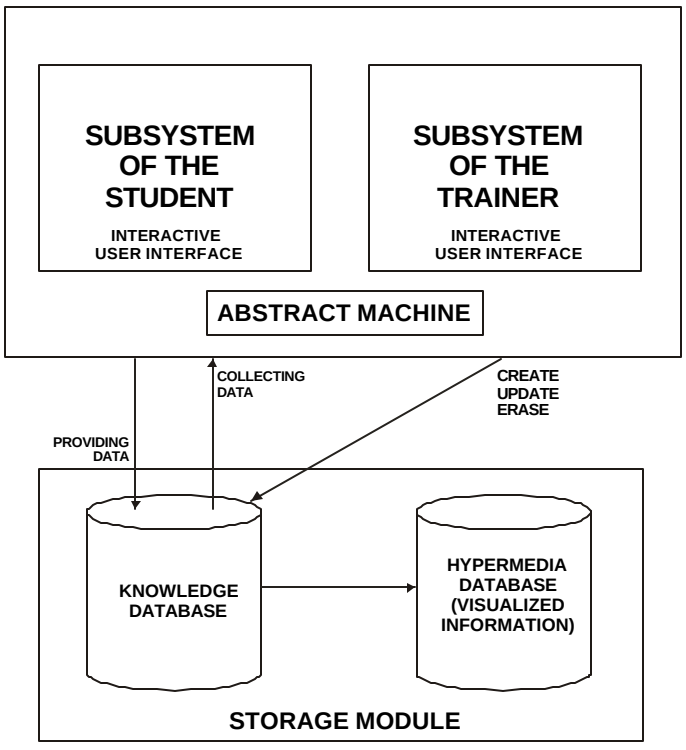

Figure 2: System's structure

The Abstract Machine is placed between the database level and the user interface level. At this level the nodes and links are defined and their interrelation and management is maintained. The abstract machine "knows" the form of the nodes and links and what features are related to each one of the nodes and links.

The trainer's subsystem (Figure 3) offers the trainer the ability to communicate with the abstract machine and the storage module through a graphical user interface, in order to:

- create, through the abstract machine, an educational strategy (scenarios, applications, case studies, explanations, evaluation tests) for every section, by defining the knowledge content in a tree form (nodes with suitable linking between them) as in Figure 1, and, on the other hand, by developing the corresponding visualized (hypermedia) material which is stored in the storage module (knowledge base & hypermedia database), in respect to the level of knowledge of the student (degree of difficulty).

  As it was mentioned earlier, we consider that knowledge of every user is represented with 3 states: A (perfect knowledge of the subject), B (good), and C (minimal). So, for example, the trainer creates a network in the form of Figure 1 (knowledge base) and connects every state (level of knowledge) and the corresponding visualized material (which must exist in the hypermedia database), to every node.

- select one or more educational strategies from the already existing in the storage module (knowledgebase and hypermedia database) which will correspond to the student's needs.

- modify each one of them, according to the student profile, in order to improve his/her level of knowledge.

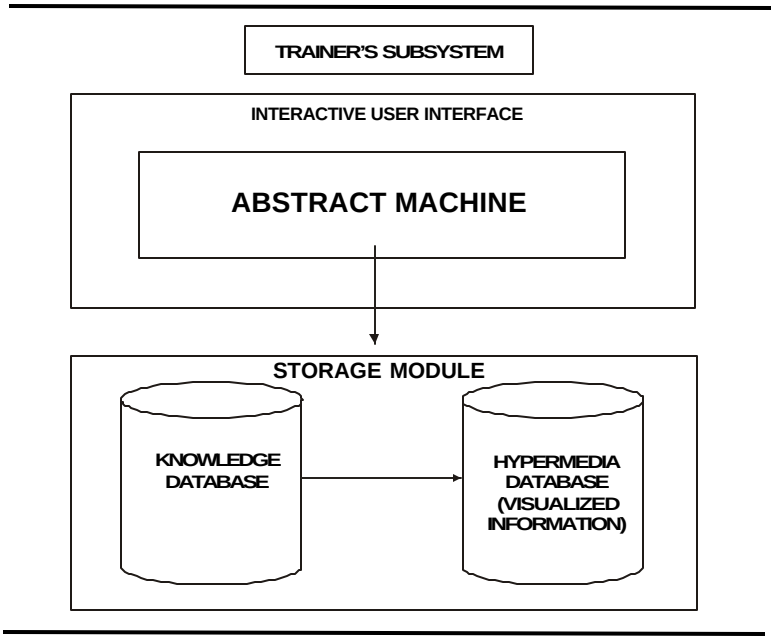

Figure 3: Trainer's subsystem

The student's subsystem (Figure 6) consists of the adaptive hypermedia user interface (self-instruction & practicing), the pedagogical module, the student's characteristics logging module (student profile), the student model and the evaluation module.

- The adaptive hypermedia user interface of the student is adapted according to the user's knowledge, his/her intentions, preferences, knowledge background, experience and learning speed (Brusilovsky, 96), (Henze, 00). It contains the self-instruction and practice modules, through which the student's interest is stimulated with the help of the visualized (hypermedia) learning material. The student is presented with the appropriate for each user, educational material, in the form of knowledge sections – educational strategies (scenarios, applications, case studies, explanations, evaluation tests).

  In the self-instructional module, the hypermedia user interface environment (figure 4) provides the student a series of tools for synchronous and asynchronous communications, which allow the frequent interactive communication between the students and the teacher. The environment has been designed in such a way that the student can realize how navigation takes place (with the use of graphics, buttons and icons), by just looking at a basic screen. Furthermore, in this module special emphasis has been put to the design of the system having as a primary objective the best possible communication between the student and the system (Sullivan & Tyler, 91), (Shneidernman, 92), (Buford, 94). The students can communicate each other, accept guidance and advice from the trainer and be encouraged to participate in teamwork. Next we will cover with full detail the tools of the system, which help in the fulfillment of the objectives mentioned above.

  The 'contact' selection provides the student the facility of sending e-mail messages, as well as information such as phone and fax numbers for a different way of communicating with the trainer.

  For an easier search of the particular section of the subject that interests him/her, the student can access the system database using the 'search' selection.

  A modern form of communication between students and the trainer is the 'chat' selection through which a 'discussion' with the use of written messages in real time, takes place. The aim is for the students to inform each other and to receive information on issues and possible questions they may have regarding the course.

  The 'Forum' selection is used for asynchronous communication where the students can send messages related to possible questions or problems regarding the course. The student can read these messages either one after the other or selectively, guided by an index. By looking at the contents he/she can locate subjects that are of his/her interest, answer whatever messages he/she wishes, while his/her messages will be 'published' at the same place and remain there so that other students and the trainer can see them.

  In the 'News' unit, announcements regarding the course (examination dates, submission of homework dates, meeting dates between trainer – student dates, etc.) are issued.

Finally, with the 'Site Map' selection, an alternative way of navigation and search of a particular chapter is provided through the use of a tree diagram displaying the chapters of the course as they are structured in the web.

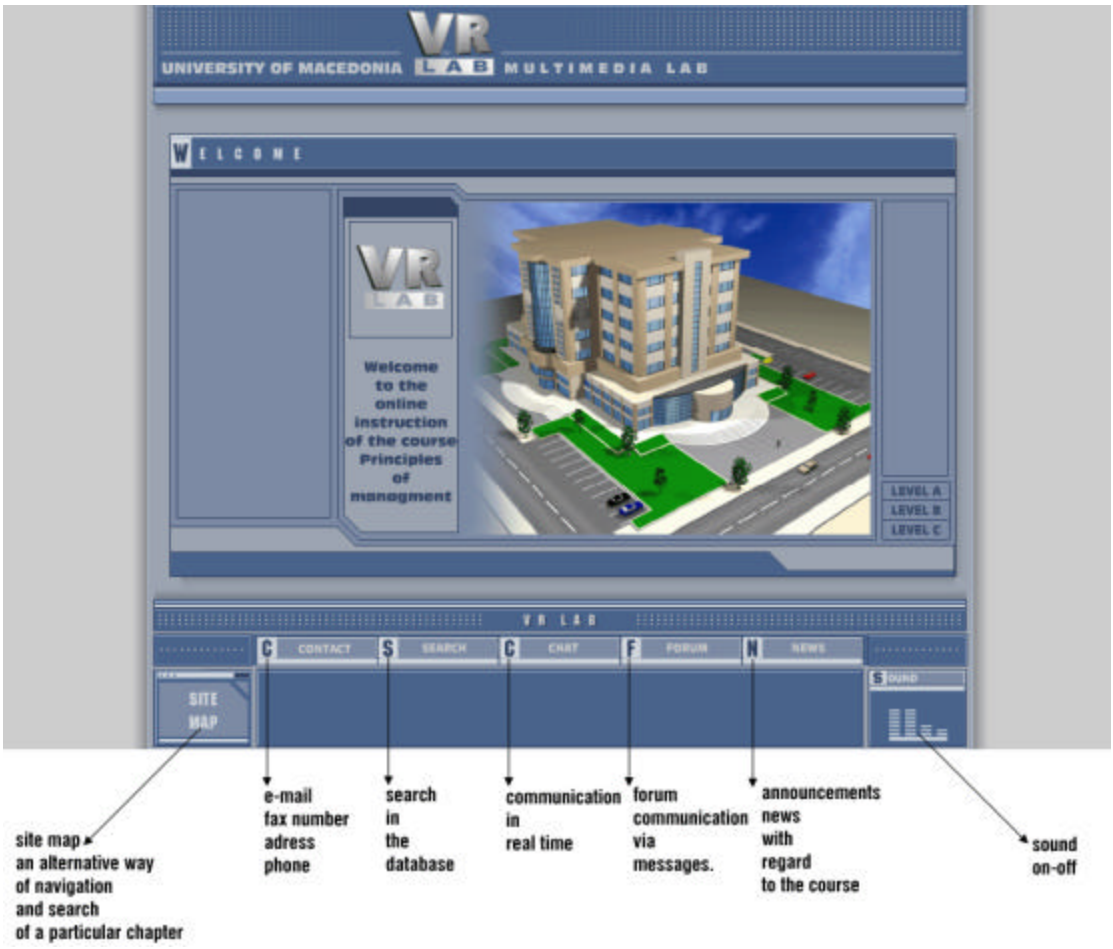

Figure 4: Screen displaying the environment of the user interface of the introduction to the educational object

- The student characteristics logging module (profile) logs all necessary information concerning each student, as well as with his/her performance grades from the evaluation module. This information is sent when requested to the student module. The student model is an inference machine which accepts as input the user's characteristics (profile) and produces as an output the appropriate topics and problems to be studied by the student. In other words, it suggests to the user which states of nodes are more preferable to be taught.

The student model checks both his/her level of knowledge and if he knows all prerequisite pieces of knowledge for comprehending a topic. For example, in Figure 1 the model checks the level of knowledge of the user on the subject «Management» and classifies him/her in one of the pre-mentioned levels. If the student doesn't know any prerequisite theoretical pieces of knowledge in any level, then the system recommends their study (Brusilovsky, 96). In Figure 5, a screen of a typical educational chapter is displayed. At the end of the course the student is considered to have been taught all the material corresponding to his/her level of knowledge. With this method the student can realize one navigational step from the links proposed by the student model. In this case, the model takes into consideration the student's characteristics, too.

Figure 5: Screen of a typical educational chapter

- The *pedagogical* module selects the best pedagogical method to be followed, of course, taking into consideration the conclusions drawn by the student model.

- The *evaluation subsystem* evaluates and examines the performance of the student related to the "training" (self-instruction & practice) he/she received, which is encoded – visualized in the storage module (knowledge base and hypermedia database) of the system, along with the actions that have to take place as a response to the choices of the

student. Finally, the performance and grades of the student are logged in the logging module, and the trainer is informed (through his/her subsystem) of any modifications of the educational strategy in order to improve the level of knowledge (level of difficulty).

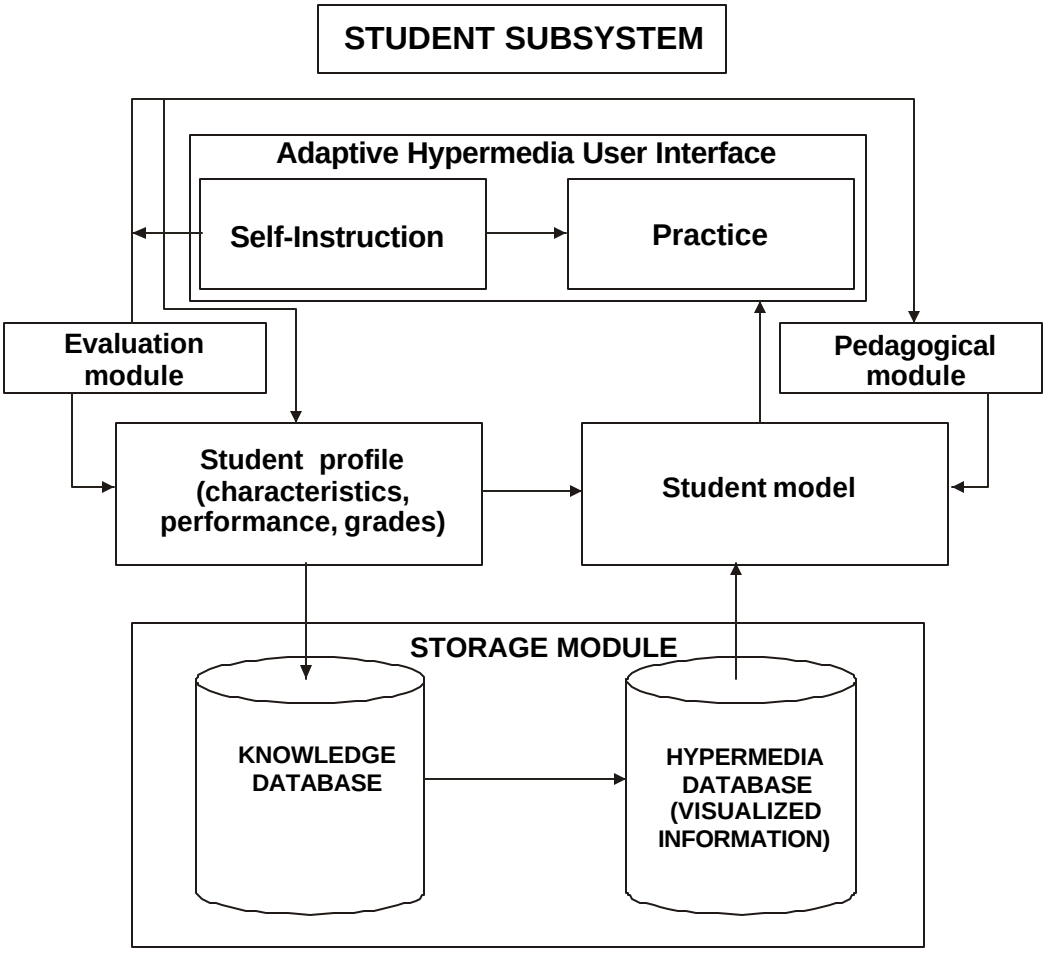

Figure 6: Student's subsystem

The management and navigation module controls the system's files (trainer's, student's), the hypermedia data, the navigation and the direct help, so that the system will be continuously giving the student the feel that he/she has the control of the system.

The storage Module consists of the knowledge base, which will contain the structure of the course, and the hypermedia database in which the various hypermedia data (educational material) will be stored. We separated the two bases in the storage module, in order for the user model to be able to manage the knowledge of the base for inferencing, more easily, without having to worry about the hypermedia data, which usually take up a lot of storage space.

Some of the information that has to be provided by the *knowledge base* is:

1. Data on how the course is structured, i.e. it contains the nodes and the links between the nodes.

2. The connection of every knowledge node with the hypermedia data required by the hypermedia database.

3. The list of the prerequisite knowledge for every new node the user intends to visit or it is recommended for visit by the student model.

4. The initial data of every student, such as the name, age, knowledge background (what the student knows for the specific subject any possible prior knowledge), intentions, experience with other hypermedia systems and the student's speed of learning. This data is collected in the form of a questionnaire answered by every student.

5. The state of knowledge of each student for each one of the subjects he was taught.

The *hypermedia database* contains all the hypermedia elements, i.e. text, hypertext, pictures, animations, video, sound and is created by the author-trainer. Those items matching the student's level will be retrieved from the knowledge base (as in Figure 2).

Discussion – Conclusions

There is an increasing demand for education from companies and individuals due to the evolution of new technologies and the new economy's characteristics. The demand must be met in a just in time basis and in a rational cost without interrupting or disturbing the normal work life. Companies and individuals operate more and more in an electronic environment. Networked Open Learning in the near future will be a very important alternative to provide educational programs to companies and individuals.

Training for adults addressed to employees in their business environment is a complex process. Traditional education and training techniques are in most cases incapable of handling this complexity. In addition, traditional education can be very expensive and time consuming. Networked Open Learning is able to provide the necessary flexibility both for the context and the way the course reaches this kind of target groups. This paper discussed the advantages of developing and delivering Networked Open Learning courses in a distributed manner. The flexibility of designing new courses in interdisciplinary domains at an international level and the active participation of the trainees are among them.

The success of educational programs offered via the WWW requires a detailed design of all the components of the program and especially those concerning the characteristics of the new media.

An educational system must respond consistently to the demands and preferences of each student in order to be continuously adapted during interaction with him/her (Brusilovsky, 96).

This paper presented the architecture of an adaptive hypermedia educational system designed to be used for training within the context of a company (adult employees training). The primary objective is on the effort to select the best sequence of steps a student must follow, in order to comprehend the curriculum the best possible way.

The system is being implemented in the Multimedia Lab of the Applied Informatics Department of the University of Macedonia. The application field of the system is networked training of adult employees in subjects derived by the needs of the company/organization (e.g. training of new employees in issues and processes of business administration), which can be dealt with this form of training.

A hierarchical representation of the learning material is adopted in the system, where every chapter is further divided into topics and subtopics. Every chapter, topic, or subtopic is represented in the form of a node. Every node for every state (A, B, and C) is connected to the appropriate hypermedia elements of the hypermedia database.

A critical point of the system is the student model, where decisions on what material and in what form will be presented to the student, are made.

The student model, initially, suggests some topics and the student, according to his/her level, either studies theory or answers questions, or solves problems. In parallel, the system collects data on how many questions (problems) were answered correctly, the number of tries made by the student to answer these questions (problems) correctly, the time spent on these tries, what major concepts the student has learned, what is the possibility of success in learning the topics. The student model that suggests the new topic and the state (A, B and C) that must be studied by the student, manages all this information. In other words, the model suggests the content to be presented, what links must be visible, what is the degree of difficulty of the theory, the questions and the problems.

This suggestion is passed to the pedagogical module, which determines what pedagogical method will be followed in order for the specific topic to be presented to the student.

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