ADAPTIVE HIPERMEDIA SYSTEMS IN E-LEARNING

DAŠIĆ PREDRAG 1, NEDEFF VALENTIN 2, ŠEHOVIĆ SEFEDIN 3

1 High Technical Mechanical School, R. Krstića 19, 37280 Trstenik, Serbia, dasicp@yahoo.com and dasicp@ptt.yu
2 University of Bacău, Faculty of Mechanical Engineering, Str. Calea Mărășești, nr. 157, 600115 Bacău, Romania, vnedeff@ub.ro
3 University of Belgrade, Teachers Faculty, Belgrade, Section in Novi Pazar, Serbia, ubfgonp@yahoo.com

Abstract: E-Learning is application of modern informational technologies (IT), as such: Internet and Web technologies, software for modern education, Hi-tech and mobile classrooms, video projectors, digital tables etc. in process of learning. Adaptive Hypermedia Systems (AHS) are almost always based on some Artificial Intelligence (AI) technologies. In paper is given an explanation of e-learning and adaptive hypermedia systems (AHS).

Keywords: IT (Information Technology), E-Learning, AHS (Adaptive Hypermedia Systems),

1. INTRODUCTION

There are many factors that influence learning. On one side is a student’s motivation and style for learning, while on the other learning environment. Learning environment include educators pedagogy and educational materials as well as different requirements and characteristics of learning. There are a large number of factors that can influence the extent of learning and some of these can be viewed in figure 1 [9]. Learning style can be defined as “the attitudes and behaviors which determine an individual’s preferred way of learning.

![Figure 1: Factors that influence learning](image_url)
2. E-LEARNING

E-Learning (Electronic Learning) is application of modern informational technologies (IT), such as: Internet and Web technologies, software for modern education, Hi-tech and mobile classrooms, video projectors, digital tables etc. in process of learning.

Term of E-Learning is being bound to the beginning of computer application in education, usual names were [9, 12, 18, 26]:
- CAI (Computer-Assisted Instruction),
- CAL (Computer-Aided Learning and Computer-Assisted Learning) or CBL (Computer Based Learning),
- CBLA (Computer Based Learning & Assessment);
- CALL (Computer-Assisted Language Learning),
- CBT (Computer-Based Training),
- CMI (Computer Managed Instruction),
- CML (Computer Managed Learning),
- ICALL (Intelligent Computer-Assisted Language Learning) and etc.

In the beginning e-learning was conducted by using floppy and CD with educational content, LAN networks and at last Intranet and Internet networks for distribution of educational content. Application of Internet technologies in phase of e-learning gains a name:
- On-line learning,
- DL (Distance Learning),
- ODL (Open and Distance Learning),
- Tele-learning
- WBT (Web Based Training) or IBT (Internet Based Training)
- WBL (Web-Based Learning) and etc.

E-Learning has a multi-disciplinary nature that provides its greatest challenge and opportunity. Technology enhanced learning is an inter-disciplinary research area that includes: artificial intelligence, other areas of computer science, cognitive science, education, learning sciences, educational technology, psychology, philosophy, sociology, anthropology, linguistics, and the many domain-specific areas for which technology enhanced systems have been designed and built (figure 2). It is this multi-disciplinary nature that provides the opportunity to make considerable breakthroughs and to discover new models, theories and paradigms that combine the best of different disciplines.

![Inter-disciplinary nature of e-Learning](image)

E-Learning has started its development in 1980’s, and since then it passed four phases. Those phases have been displayed in table 1.

E-learning gives many new educational methods where besides text and speech other like pictures, data, graph, audio and video data are also transmitted. For this purpose modern classrooms are used with multimedia devices and suitable software for example: MobiLAN system from HP Corp., which consists of 30 HP xE3 notebook computers, with 802.11b wireless LAN card each, with NetSchool Orion
software which supports up to 8 teachers and 120 students. In e-Learning application and MWTPC (*Mobile and Wireless Tablet PC Classroom*), WMC (*Wireless Mobile Classroom*) and other mobile classroom.

**Table 1:** Shows the brief history of E-Learning technologies

<table>
<thead>
<tr>
<th>Time frame</th>
<th>Era</th>
<th>Characteristics</th>
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| Before 1983| Instructor-Led Training Era | • Computers were not widely available.  
• Instructor-led training (ILT) was the primary training method.  
• ILT allowed students to get away from the office to focus on their studies and to interact with their instructor and classmates.  
• However, ILT usually meant high costs and downtime during office hours. |
| 1984 – 1993| Multimedia Era              | • Windows 3.1, Macintosh, CD-ROMS, and PowerPoint were the technological advancements of this era.  
• Computer-based training (CBT) courses were delivered via CD-ROM to make training more transportable and visually engaging.  
• The anytime, anywhere availability of CD-ROMs also provided time and cost savings that ILT could not.  
• Anyway, CD-ROM courses lacked instructor interaction and dynamic presentations – making the experience slower and less engaging for students. |
| 1994 – 1999| First Wave of E-Learning    | • As the Internet evolved, its potential to improve training was explored.  
• The advent of email, Web browsers, HTML, media players, low fidelity streamed audio / video, and simple JAVA began to change the face of multimedia training.  
• Basic mentoring via email, intranet CBT with text and simple graphics, and Web-based training with low-quality intermittent delivery Web casts emerged. |
| 2000 - 2005| Second Wave of E-Learning   | • Advanced web site design, rich streaming media, high-bandwidth access and JAVA/IP network applications revolutionized the training industry.  
• Live instructor-led training via the Web can be combined with real-time mentoring, improved learner services, and up-to-date, engaging, “born on the Web” content to create a highly-effective, multi-dimensional learning environment.  
• These sophisticated training solutions provide even greater cost savings, higher quality learning experiences, and are setting the standard for the next wave of e-learning. |

E-learning is a term covering a wide set of applications and processes, such as Web-based learning, computer-based learning, virtual classrooms, and digital collaboration. It includes the delivery of content via Internet, intranet/extranet (LAN/WAN), audio- and videotape, satellite broadcast, interactive TV, CD-ROM, and more. E-learning can be realized by computer network which is used for information delivery, interaction and improvement of learning process. With that various computer networks can be used:

- LAN (*Local Area Network*),  
- WLAN (*Wireless Local Area Network*),  
- MAN (*Metropolitan Area Network*),  
- WMAN (*Wireless Metropolitan Area Network*),  
- RAN (*Regional Area Network*),  
- WAN (*Wide Area Network*),  
- Intranet and Extranet,  
- Wi-Fi (*Wireless Fidelity*),  
- WSN (*Wireless Sensor Network*),  
- WSN (*Wireless and Satellite Networks*),  
- Internet and etc.
And according to prognoses in few years in this purpose other kinds of communicational networks will be used:
- GSM (Global System for Mobile Communications),
- GPRS (General Packet Radio Service),
- HSCSD (High-Speed Circuit-Switched Data),
- EDGE (Enhanced Data-Rates for GSM or Global Evolution),
- CDMA-2000 (Code Division Multiple Access 2000),
- UMTS (Universal Mobile Telecommunications System or Service),
- FOMA (Freedom of Mobile Multimedia Access),
- TD-SCDMA (Time Division Synchronous Code Division Multiple Access),
- W-CDMA (Wideband Code Division Multiple Access),
- HSPA (High-Speed Packet Access),
- HSDPA (High-Speed Downlink Packet Access),
- HSUPA (High-Speed Uplink Packet Access),
- LTE (Long Term Evolution),
- HSOPA (High Speed OFDM Packet Access),
- WiMAX (Worldwide Interoperability for Microwave Access) and etc.

For e-learning some Microsoft software initiative are used: Educative Community, Innovative Teacher, Microsoft Learning Gateway, as their complete software solution: Microsoft Class Server, Macromedia-Presidia Express, based on Flash and in combination with Microsoft program for presentation PowerPoint gives all elements needed for e-learning.

For e-learning some of new technologies and systems are listed below [2-5, 7, 9, 12, 14-15, 18-19, 26, 31, 35-37, 39-41, 45-46, 49-50]:
- AEHS (Adaptive Educational Hypermedia Systems),
- AHS (Adaptive Hypermedia Systems),
- AIES (Adaptive and Intelligent Web-Based Educational Systems),
- AML (Adaptive Mobile Learning),
- ATS (Adaptive Tutoring Systems),
- AWBES (Adaptive Web-Based Educational Systems),
- CMS (Course Management System),
- EHS (Educational Hypermedia Systems),
- IES (Intelligent Educational Systems),
- ILS (Integrated Learning Systems),
- ILE (Intelligent Learning Environments),
- iLMS (Intelligent Learning Management Systems),
- ITS (Intelligent Tutoring Systems),
- IWT (Intelligent Web Tutor),
- LCMS (Learning Content Management Systems),
- LMS (Learning Management System),
- VLE (Virtual Learning Environments),
- WBES (Web-Based Educational Systems),
- WIES (Web-Based Intelligent Educational Systems) and etc.

LMS (Learning Management System) and IWT (Intelligent Web Tutor) includes a repository for On-line learning materials and learner tracking functionality. IWT includes access to an ITS (Intelligent Tutoring Systems) and LIA (Learner Intelligent Agent) that selects modules for learners based on their preferences and progress to date, and a KRT (Knowledge Representation Tool), which allows tutors to create/import/export courses and modules.

3. ADAPTIVE HIPERMEDIA SYSTEMS

AH (Adaptive Hypermedia) [3-5] is utilized in several domains, such as e-Learning and professional training, where there is a growing movement towards the use of cognitively richer and more ‘active’
approaches to user engagement. Research in the area of AH has focused on the adaptive selection, at runtime, of multimedia content in tandem with the personalized sequencing and presentation of that content. AH is a relatively new direction of research on the crossroads of hypermedia and user modeling. Adaptive hypermedia systems build a model of the goals, preferences and knowledge of each individual user, and use this model throughout the interaction with the user, in order to adapt to the needs of that user.

AHS (Adaptive Hypermedia Systems) [3-5] are almost always based on some AI (Artificial Intelligence) technologies. However, the spectrum of AI technologies being used is quite limited, and includes mainly early AI technologies such as concept networks and frames, concept graphs, machine learning, statistical models and adaptive natural language generation and understanding. AHS focus on providing two main adaptive behaviors, the adaptive selection and sequencing of content (adaptive navigation) and the adaptive presentation of resources to the user. Traditionally, the goal of AHS is to present the user with appropriate material from a much larger hyperarc while maintaining the associated benefits of adaptive presentation of resources to the user. Two groups that look especially promising including the following: NLG (Natural Language Generation) techniques and non-symbolic AI technologies.

As a complex issue for AEH, these models are studied in CSCL (Computer Supported Collaborative Learning) and CSCW (Computer Supported Collaborative Work).

Examples of existing AHS systems and current work in progress in this area include [1, 6-13, 15-38,42-50]:

- 3DE (Design, Development and Delivery Electronic Environment Educational Multimedia), available on Web site: http://www.3deproject.com/;
- AES-CS (Adaptive Educational System Base on Cognitive Styles);
- AHAM (Adaptive Hypermedia Application Model);
- AHM (Adaptive HyperMan), available on Web site: http://ic.arc.nasa.gov/projects/aim/edp/ahm.html;
- AMLE (Adaptive Multimedia Learning Environment);
- APeLS (Adaptive Personalised e-Learning Service), available on Web site: http://wundt.uni-graz.at/demos/apels/;
- ASCIL (Adaptive Support for Collaborative and Individual Learning);
- CAMELEON (Computer Aided Medium for Learning on Networks);
- CLAROLINE (ClassRoom On-Line), available on Web site: http://www.claroline.net/;
- GEAHS (Generic Educational Adaptive Hypermedia System);
- ILASH (Incorporating Learning Strategies in Hypermedia);
- INSPIRE (Intelligent System for Personalized Instruction in a Remote Environment);
- iTeach (Interactive Teach);
- iWeaver (Interactive or Individualised Weaver), available on Web site: http://iweaver.sourceforge.net/ and http://www.adaptive-learning.net/media/html/iWeaver.htm;
- KBS-Hyperbook (Knowledge-Based System HyperBook), available on Web site: http://www.kbs.uni-hannover.de/hyperbook/;
- KN-AHS (Konstanz Adaptive Hypertext System);
- LAOS (Layered WWW AHS Authoring Model with its Corresponding Algebraic Operators or short Layered AHS Authoring-Model and Operators);
- PEGASUS (Presentation Modeling Environment for Generic Adaptive Hypermedia Support Systems);
- RATH (Relational Adaptive Tutoring Hypertext), available on Web site: http://wundt.kfunigraz.ac.at/rath/;
SKILL (Scalable Internet-Based Teaching and Learning System), available on Web site: http://nestroy.wi-inf.uni-essen.de/;
TANGOW (Task-Based Adaptive Learner Guidance on the Web);
WHURLE (Web-Based Hierarchical Universal Reactive Learning Environment), available on Web site: http://whurle.sourceforge.net/; and etc.

Modern AHS systems building are applied open source technology, such as Java (JSP and JESS), Java Servlet, HTML, XHTML, XML and MySQL and etc.

**AHA!** *(Adaptive Hypermedia Architecture)* [20-22, 33, 42] is an open source general-purpose adaptive hypermedia system (AHS) for electronic learning (e-Learning), which has been studied and experimented on different research groups in different countries. It represents adaptive architecture of open source code, which enables similar author tools, as: Concept Editor, Graph Author, Form Editor, Test Editor etc. It is written in Java programming language, and it is built by using technologies of open source as: Java (JSP and JESS), Java Servlet, XML and MySQL. In courses contents are HTML and XHTML and internal format for storage is XML and MySQL. In AHA! concepts can have many attributes (access, visited, knowledge, suitability, stability, etc.) that SCORM *(Sharable Content Object Reference Model)* hasn’t; these we create with default values. AHA! has more types of concept relationships (knowledge update relations, etc.) than SCORM has. Therefore, only SCORM rules for sequencing can be converted to AHA! prerequisite relations (with adaptive link annotation). AHA! also has conditional inclusion of fragments that SCORM hasn't and it also provides a layout model to determine the desired look and feel of a course. This system architecture is shown on figure 3.

It is developed in 2000 year from side Paul De Bra, Ad Aerts, David Smits, Natalia Stash, Bart Berden and etc., with TUE *(Technische Universiteit Eindhoven)* from Eindhoven (Nederland). AHA is available on Web site: http://aha.win.tue.nl/.

**AHAM** *(Adaptive Hypermedia Application Model)* [23, 49] is a generic adaptive hyper-media system (AHS) based on well-known Dexter referent model. It describes hyper-media application as content layers, which are concentrated on layer for storage, who contains Domain Model (DM), User Model (UM) and Adaptation Model (AM). The first serious attempt at describing the architecture and functionality of adaptive hypermedia systems in a (semi-)formal way was published in. It was developed in 1999 year by Paul De Bra, L. Calvi, G.-J. Houben, H. Wu etc., with TUE *(Technische Universiteit Eindhoven)* from Eindhoven (Nederland).
APeLS (Adaptive Personalised e-Learning Service) [12, 13] is a variant of adaptive hypermedia system (AHS) for electronic learning. It is a variant of hyper-medial system (AHS) for electronic learning e-learning, which is used as a part of student courses and has applicable outer positive back leash in course use. It is built by using technologies of open source, as Java (JSP and JESS), Java Servlet, XML and MySQL. This system architecture is shown on figure 4. APeLS applies VARK (Visual, Auditory, Read/Write and Kinesthetic) learning styles and Kolb's model for selecting content for the learner. It is developed in 2003 year by L. Clarke-a, with Trinity College Dublin (Ireland). APeLS is available on Web site: http://wundt.uni-graz.at/demos/apels/.

ASCIL (Adaptive Support for Collaborative and Individual Learning) [1] is a software environment for cooperative and individual learning. It represents integration of AHA! and CLAROLINE system. It was developed in 2004 year by Carlos Arteaga, Ramon Fabregat, Jorge Eyzaguirre and David Merida, with UdG (Universitat de Girona) university from Girona (Spain).

CAMELEON (Computer Aided Medium for Learning on Networks) [32] is a variant of adaptive hypermedia system (AHS) which is executed over Internet and Intranet. It allows the teacher to introduce courses and lectures for studies (courses and evaluation presentation etc.) over adaptive interface. It was developed in 1998 year by M. Laroussi and M. Benahmed.

Figure 4: Architecture of ApeLS system [12, 13]

iWeaver (Interactive or Individualised Weaver) [48] is an interactive Web based adaptive environment for addressing certain learning styles. It is written in HTML marker language and in Java programming language, using JSP technology and JavaBeans. iWeaver software environment is executed on Tomcat Web storage and uses MySQL as database for storage of permanent data. For synchronization of audio recording with correspondence of PowerPoint slides and click by teachers on key words uses SMIL programming language. The diagram flow on figure 5 illustrates the schematic system architecture of the iWeaver learning environment.

It is built on Dunn & Dunn model learning style, which R. Dunn and K Dunn suggested in 1978, year and uses BES as software tool for estimation. It was developed in 2002 year by Christian Wolf, from RMIT University from Melbourne (Australia). iWeaver is available on Web site: http://iweaver.sourceforge.net/ and http://www.adaptive-learning.net/media/html/iWeaver.htm.

KBS-Hyperbook (Knowledge-Based System HyperBook) [30] is a software tool for building framework for designing and maintenance of open adaptive hypermedia system (AHS) on Internet. It uses explicit conceptual models and meta-data for structure and connection of extem data. It is completely implemented in Java programming language.
Developed in 1999 year by Hadhami Dhraief, Wolfgang Nejdl, Boris Wolf and Martin Wolpers, from Hannover university (Germany).

KBS-Hyperbook is available on Web site: [http://www.kbs.uni-hannover.de/hyperbook/](http://www.kbs.uni-hannover.de/hyperbook/).

LAOS (Layered WWW AHS Authoring Model with its Corresponding Algebraic Operators or short Layered AHS Authoring-Model and Operators) [17] is a general model for native adaptive hypermedia. It is based on AHAM model, which is extended on Dexter referent model for specific area of adaptive hypermedia.

It is composed of five components: (figure 6):

- **Domain Model (DM),**
- **Goal and Constraints Model (GM),**
- **User Model (UM),**
- **Adaptation Model (AM) and**
- **Presentation Model (PM).**

Developed in 2003 year by Alexandra I. Cristea and Arnout de Mooij, from TUE (Technische Universiteit Eindhoven) from Eindhoven (Nederland).

MOT (My On-Line Teacher) [16] is a generic authorized adaptive hypermedia system (AHS) which is capable of supplying adaptive specifications for courses. Material created in MOT system is transformed into SCORM specification. Construction of MOT system is based on LAOS and LAG framework and MyET system. It was written in Perl programming language, and its data structures storage into MySQL query language.

It was developed in 2003 year by Alexandra I. Cristea and Arnout de Mooij, from TUE (Technology University Eindhoven) university from Eindhoven (Nederland).

4. CONCLUSION

The goal of this paper is to present the state of the art in adaptive hypermedia at the eve of the year 2000, and to highlight some prospects for the future. Goal of AHS is to present the user with appropriate material from a much larger hyperspace while maintaining the associated benefits of hypermedia. AH is a relatively new direction of research on the crossroads of hypermedia and user modeling. AHA! has more types of concept relationships knowledge update relations.

A list of AHS systems and current work in progress is listed: 3DE, AES-CS, AHA!, AHAM, AHM, AMLE, APeLS, ASCIL, AVANTI, CAMELEON, CLAROLINE, ELM-ART, GEAHS, ILASH, INSPIRE, iTeach, iWeaver, KBS-Hyperbook, KN-AHS, LAOS, MOT, PEGASUS, RATH, SKILL, TANGOW, WHURLE.

REFERENCES


