A Dynamic Conceptual Network Mechanism for Personalized Study Plan Generation

Elvis Wai Chung Leung and Qing Li

City University of Hong Kong, {iteleung,itqli}@cityu.edu.hk

Abstract. In a web-based learning environment, *student-centered* study plan become critical since the target users who have the *self-learning expectation* and *individual academic background* are very different from those of a traditional classroom. In fact, designing individual study plan is very *complicated* and *time consuming* as the target users normally are very diversified. To the best knowledge of our understanding, most of existing course enrollment facilities are quite primitive. In this paper, we introduce a conceptual framework for setting up individual *student-centered study plan* through 1) a dynamic conceptual network mechanism for capturing the relationships among courses to facilitate the dynamic generation of a study plan, and 2) intelligent knowledge base facilities, such as personal profiles, to help understand students' behavior so as to provide student-centered results to different learning groups.

1 Introduction

To face up to the increasing trend of continued learning demand, most universities are taking advantages of technology for their Web-based education [8, 9]. One characteristic in Web-based education is that the learning initiative is driven by the students. Thus, there is an increasing need to explore a mechanism for helping learner design a personalized study plan.

In fact, the design of individual study plan is very *complicated* and *time consuming*. The target users are generally in a very wide range and of different background. In the traditional classroom learning, the design of a program is usually targeted to a student group rather than individual students. It may seem to be possible that personal mappings of the student's background to the study program can be done manually, the procedures and resources involved however are tremendous. The program designer has to consider individual user's academic study background as well as the vocational study background before admitting a student into a program. Apart from the study background, other issues like the prerequisites of each course (if applicable) the proper duration of the program to the student, and the student's progression will also need to be considered. It inevitably creates the problem of duplicating the efforts and wasting time and resources.

Meanwhile we have to realize the fact that users carry different knowledge and different goals. So *"One program with pre-defined courses for all"* approach is insufficient for today's Web-based education. The focus of online education is to understand individual student's background knowledge and learning needs in order to provide proper courses in the program for their study anytime anywhere. Currently the course

W. Zhou et al. (Eds.): ICWL 2003, LNCS 2783, pp. 69–80, 2003.

choices provided in a program are quite limited and the duration and progression of the program are also pre-defined. There is little room to allow students to switch from one to the other or to proceed faster in their study route based on their own progress. One of the advantages of e-Learning is the ability to provide a bulk of courses in a particular period because it needs not take into account the issues of teaching manpower, classroom, student schedule, and so on. However, most of existing web-based education systems are quite unsatisfactory in providing sufficient flexibilities for the selection of courses, progression of study, and duration of study. Thus, there is a need for such systems to re-organize the courses contained in the program based on individual needs by using proper Web-based education system in an effective and efficient manner.

1.1 Paper Objective and Organization

To facilitate the Web-based individual study plan generation, we introduce in this paper an innovative mechanism that utilizes *user profile* and *dynamic conceptual network* to provide the *personalized study plan*. The proposed mechanism makes use of the user profile to determine the characteristics of the study group, including background knowledge and learning goals. The dynamic conceptual network is a *hierarchy tree* in association with *courses*. Each course is stored in a *node* of dynamic conceptual network. Apart from the course contents, each node also contains some *attributes* for construction of relationship among each node and self-description of each node. This paper aims at advocating the idea of *treating different students differently* in the generation of personalized study plan based on the hybrid use of user-profiles, XML, and Java technologies. Our proposed web-based mechanism is thus able to establish, in particular, the relations among the program and courses, and also adapt to users having very different backgrounds and learning goals.

Through designing the conceptual framework and algorithms for dynamic concept network, we aim to address the following main topic in this paper: *How to effectively serve individual student in preparing the personalized study plan?* The rest of this paper is organized as follows: Section 2 reviews the current e-Learning systems and discuss their pros and cons. The specific features of the proposed conceptual framework and algorithms are detailed in sections 3. The final section concludes this paper and makes suggestions for further research.

2 Related Work

For the past few years, some researchers have focused on the areas of agent-based, multimedia, and adaptive approaches for e-Learning system. Before we introduce our dynamic study plan generation approach, some related research projects are discussed as below.

For the agent-based research work, *Andes* [6] a collaborative project started since 1995 between the University of Pittsburgh and the US Naval Academy, has took a modular architecture, and is implemented in Allegro Common Lisp and MS Visual C++. The main agents of *Andes* contain a problem author, a problem solver, an action interpreter and a help desk. These agents function in the sequence of creating problem definition, generating the problem solution graph model, and referring to the student model to make decisions upon receiving appropriate feedback and assistance. *LANCA* [7] adopts an intelligent agent's approach to distance learning in a distributed environment by using a constructive approach instead of user profiles to assist students in difficulty by building a common and useful databank. Unlike *Andes* and *LANCA*, *DT Tutor* [12] uses decision-theoretic methods for coached problem solving to select tutorial actions that are optimal given the tutor's beliefs and objectives. It employs a model of learning to predict the possible outcomes of each action, weighs the utility of each outcome by the tutor's belief that will occur, and select the action with the highest expected utility.

Among the multimedia-based projects, *Classroom 2000* [14] is designed to automate the authoring of multimedia documents from live events. The researchers have outfitted classrooms at Georgia Institute of Technology with electronic whiteboards, cameras, and other data collection devices that collect data during the lecture and combined it to create a multimedia document to document the class activities. *Cornell Lecture Browser* from Cornell University [10] captures a structured environment (a university lecture). It automatically produces document that contains synchronized and edited audio, video, images and text, so as to synchronize the video footage in the live classroom with the pre-recorded slides used in the class. Last but not the least, *MANIC,* from University of Massachusetts [9], discusses the ways of effectively utilized WWW-based, stored materials and presentation paradigms. In particular, *MANIC* proposes that students be given the opportunity to browse the materials at their own pace, stopping and starting the audio at their will.

For the adaptive approaches for online course materials, *WebCT* [11] has been widely used in education sectors to produce online courses or to act as a tool for publishing supplementary materials for existing courses. A *WebCT* course is mainly created by using a series of linked HTML pages which are defined as paths or "road map", and all these interactions take place through a web browser. *InterBook* [15] is based on a specific concept-based approach to develop an adaptive Web-based LISP textbook while *NetCoach* [16], an authoring system, allows the users to create adaptive and individual course modules without programming knowledge. The concepts used in *InterBook* are basically elementary pieces of knowledge for the given domain, with a more advanced form of the domain model being a network. Each page has a set of outcome concepts and a set of prerequisite concepts associated with it to support adaptive navigation and hyperlink annotation. Unlike *WebCT* and *InterBook, NetCoach* implements two adaptive navigation techniques: curriculum sequencing and adaptive annotation of links. In *NetCoach*, the knowledge base of a course consists of concepts that are internal representations of the pages to be presented to the learner at the front-end.

However, individual or tailored instruction based on learners' needs and background has not been achieved yet. Therefore, the integration of multiple agents [4,5], user profile [13], and multimedia technologies into a collaborative learning environment remains a very challenging problem.

3 Conceptual Framework and Algorithms

In this section, we describe a conceptual framework of the dynamic conceptual network and study plan generation algorithms. In order to provide an overall picture of the implied structure, the conceptual framework for the dynamic conceptual network will be explained first.

3.1 Relationship for Program, Course, and Credit Units

With the existing online education systems, one of the most important limitations for study plan generation is that the relationships among the courses of a specific program are not well defined. Thus, preparing an individual study plan is very complicated and timing consuming. In order to provide a better solution, we need to identify the structure for courses of a particular program.

As an example, figure 1 shows the main structure of a particular program (Master of Business Administration) as an illustration. Due to the wide variety of target users in online education, a *credit unit system* for online learning is introduced in our model in order to serve the individual student needs. Normally, a *program* includes *core courses, elective courses*, and *minimum required credit units*. A student is required to complete the core courses as the fundamental training. Subsequently, he/ she also needs to determine the major study by choosing the elective courses. Both the core and elective course are assigned with a number of credit units. Upon completion of the courses, the credit units will be recorded in the individual user profile. Finally, an academic designation will be awarded if the minimum credit units of the program are reached.

In order to define the dynamic conceptual network, we need to identify the relationships among program and courses. As shown in figure 1, some *natural relationships* are implied and to be discussed as follows.

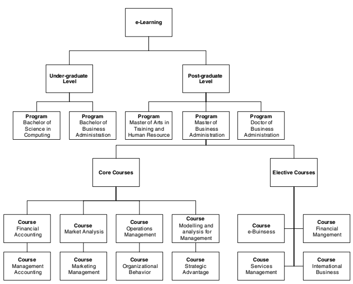

Fig. 1. Structure of an example program (Master of Business Administration)

- *Relationship among program and program.* A program is designed for under- and post-graduate level. Normally, a student is required to complete the under-graduate program first, and then the post-graduate program is provided for the advanced study consideration. To ensure the student with sufficient knowledge to learn the post-graduate program, usually the prerequisite (admission requirements) checking is used. The student is only allowed to enroll the program if the prerequisites are fulfilled.

- *Relationship among program and course.* A program includes a set of courses whose syllabus is designed based on the program nature such as science, business, philosophy, and so on. To meet the individual learning goals and study background, a student is allowed to choose from the set of courses those that can meet the individual program requirements for receiving an academic award.
- *Relationship among course and course.* A Course is a unit to contain concepts and knowledge for student's studying. Normally, a student is required to complete the foundation courses first, and then the advanced courses will be provided for further study. To ensure the student with sufficient knowledge to learn a particular course, usually the prerequisite checking is also used. The student is only allowed to take a course if its prerequisites are fulfilled.

3.2 Conceptual Framework for Dynamic Conceptual Network

In order to build up the relationship among the program and courses, we introduce a *dynamic conceptual network* for personalized study plan generation.

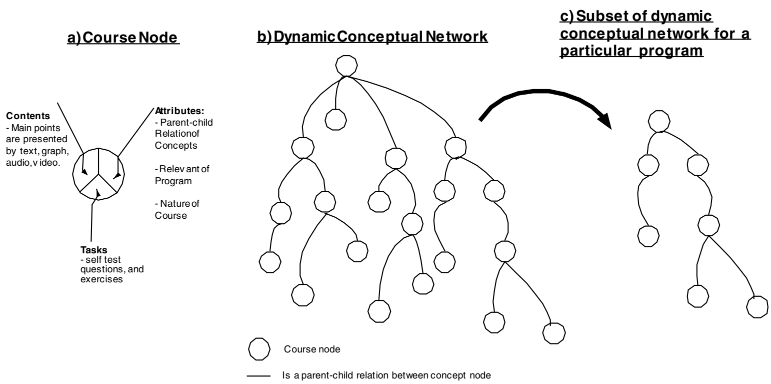

Fig. 2. Dynamic conceptual network

Definition: A dynamic conceptual network (figure 2b) is a *hierarchical tree* for developing the *inter-relationships* among *courses*. Each course is stored in a *course node* (figure 2a) of the dynamic conceptual network.

The dynamic conceptual network is composed of course nodes. Each course node has a unique identity for easy reference. As shown, the course node in figure 3a includes contents, tasks, and attributes. The contents are presented by text, graph, audio, and video. Tasks include self-test questions and exercises. In order to provide facilities for building up relations among the course nodes, three attributes are defined in each course node, i.e., Parent-child relation of concepts, relevance of learning objectives, and level of difficulty. The semantics of each attribute is explained below.

- <u>Parent-child Relations</u>. These inter-concept links are for building up the dynamic conceptual network. Each relation contains a *parent link* and *child link,* which refer to the identities of some other course nodes.

- Relevance of Program. This is the information for identifying the relevant course for a particular program and the program admission requirements.
- Nature of Course. As a means to serve the concept of personalization, this is a parameter to determine whether the course is core or elective for the targeted group.

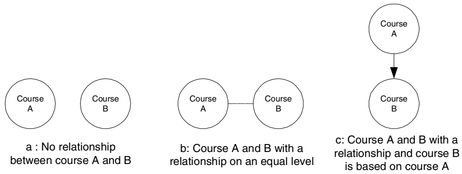

Fig. 3. Course nodes relationships

Based on the above attributes, figure 3 shows three possible scenarios among the course nodes, i.e., no relationship between course, courses A and B with a relationship on an equal level (level of difficulty), and courses A and B with a relationship and concept B is based on course A. A rule-based mechanism [4] is employed for the concept node's mapping using the following rules.

- **Rule A:** // Figure 3a shows no relation between courses A and B.
  IF <no equal of parent-child attributes for the course nodes A and B>
  THEN <No relation between A and B>
- **Rule B:** // Figure 3b shows that courses A and B are of a relationship on an equal level.
  IF <the parent links of course A and B in their parent-child attributes are of the same object reference>
  THEN <A and B are of the relation on an equal level>
- **Rule C:** // Figure 3c shows that courses A and B are of relationship and course B is based on course A.
  IF <the parent link of course node B is of the same object reference as that of course node A's child link >
  THEN <A and B are of the parent-child relation; course node A is the parent and
  course node B is the child>

3.3 Personalization of Course Materials for Target Study Group[1]

According to the above rules and mechanisms, we now show for a particular program how a subset of dynamic conceptual network is used to generate a set of personalized study plan for a target study group. The overall processes are divided into two stages: ***extraction*** of relevant courses from the program and ***filtering*** the most suitable course(s) for the target group based on the result set. For illustration, we assume that student A graduated with Bachelor of Computer Science and student B graduated

[1] We assume that the program requirements for those students who have similar user profiles are much the same. Thus, we can serve a target group of students based on their alike user profiles.

with Bachelor of Engineering. Now both two students want to take a Master of Business Administration program in order to strengthen his management skills.

Extraction of relevant courses for the program. Although the relations are only built on the course nodes, we can still extract the relevant course(s) for the particular program due to the attributes of each course node. Based on the attributes, a *multi-layer retrieval mechanism* is devised to retrieve the relevant information based on attributes' value and reconstruct the hierarchy based on the parent-child relations, as captured by the algorithm in figure 4. As an example, for the given program "*Master of business administration"* of figure 1, relevant course nodes within the program will be compared based on the pre-defined rules (cf section 3.2) so as to identify the relations among the course nodes for reconstruction of the hierarchy tree. Following the algorithm in figure 4, we obtain a preliminary subset of dynamic conceptual network (as shown in figure 5) in which the courses include *financial accounting, market analysis, operations management, modeling and analysis for management, management accounting, marketing management, organizational behavior strategic advantage, e-business, financial management services management* and *international business*.

```
DCN = Dynamic conceptual network
SRP = Student Required Program
RelevantSubset(DCN, SRP)
Empty(SubsetofDynamicConceptualNetwork)
While not Empty (DCN.CoursetNodes) do
 If DCN.CoursetNode.RelevantofProgram = SRP then
  /* Checking the relationship among course nodes based on the above rules */
 /* The comparison is below the DCN.CourseNode to nodes of the result set
    (subset of  dynamic conceptual network) */
 /* If the rules B,C are true, the relationship link will be added to the result set */
     While do
         If Rule C  is true then
           Mapping the relation to the result set
           Exit do
         Else Rule B  is true then
            If  DCN.CoursetNode.NatureofCourse= core then
                Add a new dimension to the result set in core course root
            Else
                Add a new dimension to the result set in elective course root
            Endif
           Exit do
         Endif
     Until  Empty(SubsetofDynamicConceptualNetwork)
   Else
     Disregard
Endif
 Enddo
 Return (SubsetofDynamicConceptualNetwork)
```

Fig. 4. Extraction of relevant courses for the given program

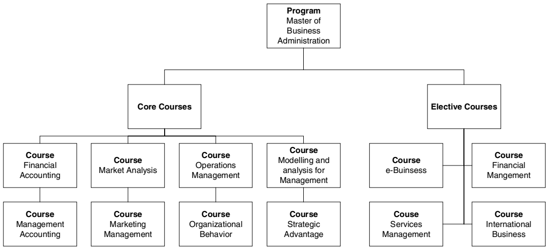

Fig. 5. A preliminary subset of dynamic conceptual network

Filtering the courses for the target group. In order to provide a personalized study plan for Web-based education, student profiles can be utilized [2,3]. In particular, a student is only required to identify the interested program, and then based on the student profiles available, the proposed mechanism will generate the relevant program structured for his/ her consideration. The information contained in a user profile includes student study history, preference and so on. To show the function of personalization, assume we have two individual user profiles: 1) Student **S1** who has studied the operations management; and 2) Student **S2** who has studied the financial accounting. The algorithm in figure 6 assumes that if the parent node is irrelevant to the target group, then the child node is also irrelevant. First, the user profile will be compared with the result set in order to identify the irrelevant course nodes based on the study history of the study group. The irrelevant course nodes will be marked "irrelevant" in the child link so as to ignore them in the dynamic concept network. The result of this filtering process is shown in figure 7 where **S1** is provided with such courses as financial accounting, market analysis, modeling and analysis for management, management accounting, marketing management, organizational behavior strategic advantage, e-business, financial management services management and international business. In contrast, **S2** is provided with the courses of market analysis, operations management, modeling and analysis for management, management accounting, marketing management, organizational behavior strategic advantage, e-business, financial management services management and international business.

3.4 Multi-layer Model for Study Plan Generation on the Internet

We now introduce a *Multi-layer Model* for Web-based study plan generation. Among others, it leverages various mechanisms of the framework's programming model, so as to produce efficient applications that are also maintainable.

Figure 9 shows the Multi-layer Model that facilitates the development of the study plan generation; it consists of ***User View Layer*** (UV), ***Processing Layer*** (PL), and ***Knowledge Repository Layer*** (KR). All layers have their own functions that can handle different tasks on behalf of the model. The UV layer, as the information collector, is located at the first to receive queries from the requesters. When a student submits a request, UV starts to function and passes the information to the second layer, PL that cooperates with KR for designing personalized study plan. The KR layer includes *XML-based study program and course information* and *User Profiles*. At the final stage, UV is requested by PL for the result sets' presentation.

```
h = study history of the target group
r = RelevantSubset(DCN, SRP)
t = true
ProcessFiltering(r, h)
While not is Empty (r) do
   t = true
   While not is Empty (h) do
      If h.course  = r.CoursetNode then
         Assign "Irrelevant" to the r.CourseNode.Child.Link
          t = false
       Endif
   Enddo
If t = true then
    If  the child link of parent node for the r.CourseNode marked with "Irrelevant"
then
            Assign "Irrelevant" to the r.CourseNode.Child.Link
        Endif
   Endif
Enddo
```

Fig. 6. Identifying the relevant learning courses for the target study group

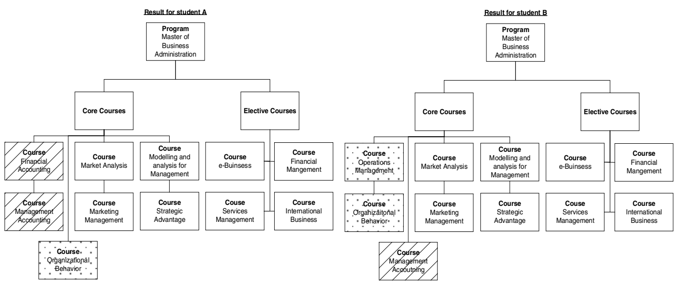

Fig. 7. Result of personalized course materials for students **S1** and **S2**

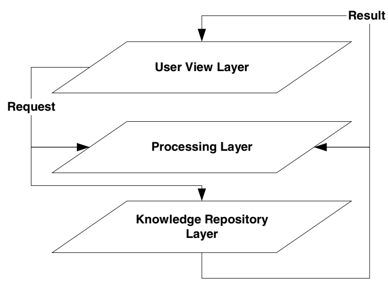

Fig. 8. Multi-layer Model

As a comparison on delivering study plan to students, UV depends on the student's user profile to determine the presentation layout as a frame for study plan delivery. In contrary, PL and KR are based on each individual request to generate the required results. Under this proposed model, each layer works independently in terms of its own tasks. Thus, no matter how any combination of courses for a program or how the user view is changed, the possible negative chain effects and cost of modification can be minimal. Eventually, the efficiency and effectiveness of development, implement and maintenance can be enhanced.

3.4.1 Implementation Aspects

To implement the proposed framework, the following techniques and tools are adopted for the elements in each layer:

User View Layer

- **Java server pages (JSPs)** – JSPs expect the servlet to provide data in the request context that is after formatting ready to be inserted into an HTML page. In general, the role of the JSP page is to make the final decision about the format and content of the response to an end user request

Processing Layer

- **Servlets** – Servlets provide the coordination between the programming and content elements of an application.
- **Java Architecture for XML Binding (JAXB)** – JAXB provides an API and tools that automate the mapping between XML documents and Java objects.
- **Command beans** – Command beans are beans that implement a basic business logic step. Their roles are to abstract and regularize the computations supported by the business logic of the application.

Knowledge Repository Layer

- **XML** – All course materials are stored in XML format. As an XML document is typically structured in a tree/hierarchical way, the relationships inside are mainly parent-to-child, which facilitate easier addition or removal of the nodes or documents. Relational databases do not deal well with highly flexible data relationships. XML-native data is treated more like a document, which is good for two key purposes: document-resident data is subject to changes, and documents need to be passed around intact to a number of people.

Based on the above, the servlets in PL can process HTTP requests and coordinate the rest of the application elements (such as Java Bean and JAXB) for study plan generation. As mentioned, the KR layer is to serve the PL in providing relevant source of the course and user profiles for the study plan generation. The responsibility for generating the user interface is assigned to JSPs in UV. For the study plan delivery, the JSPs take data provided by the servlet, format it and insert it into a HTML data stream to be sent to the client. Such a multi-layer decomposition provides a basis for rapid customization of dynamic pages and thus supporting the customization model of development.

4 Conclusions and Future Work

In this paper, we have presented a dynamic conceptual network mechanism for personalized study plan generation through the hybrid use of dynamic conceptual network, user-profiles, XML and Java technologies. Among the many desirable features offered by the proposed mechanism, the following ones are worth particular mentioning:

- **Dynamic conceptual network**. It provides a hierarchical tree for developing the inter-relations among individual courses. Each course is stored in a course node of a dynamic conceptual network, through which a student is supplied with the relevant study background information for a particular program.
- **Personalization of study plan for target study group.** The suggested study plan is generated based on individual learning group's expectation and learning goals, which supports the ideas of personalization and interactive learning [1] effectively. A win-win solution can be delivered in that the teacher has the relevant study plans for further advisory, and the student also has a personalized study plan for reference.

Currently, the presented study plan mechanism is being incorporated, together with a cooperative tutoring mechanism [3], into our agent-based e-Learning system [2]. In our subsequent research, we plan to design a *personalized scheduler* to help student arrange the online learning timetable for any given period.

References

[1] Jonassen, D.H., Supporting Communities of Learners with Technology: A Vision for Integrating Technology with Learning in Schools. *Educational Technology*, 35(2). 60–63, 1995

[2] Leung E., and Li Q., Agent-Based Approach to e-Learning: An Architectural Framework, in Kim, W., Ling, T.W., Lee, Y.J. and Park, S.S., *The Human Society and the Internet*, LNCS 2105, pp.341–353, 2001.

[3] Leung, E. and Li, Q., Architecture and Algorithms of CPS – an Agent-based Tutoring System for Coached Problem Solving on the Web. *Proceedings of the First International Conference on Web-based Learning (ICWL2002)*, World Scientific Pub., pp.59–79, Hong Kong, 2002

[4] Riley, G., *CLIPS, A Tool for Building Expert Systems.* http://www.ghg.net/clips/CLIPS.html.

[5] Lesser, V. R., *Cooperative Multiagent Systems: A Personal View of the State of the Art,* IEEE Transactions on Knowledge and Data Engineering, vol. 11, no.11, Jan –Feb 1999

[6] Gertner, A. S. and VanLehn, K., Andes: A Coached Problem Solving Environment for Physics in Gauthier G., Frasson C. and VanLehn K., *Intelligent Tutoring Systems*, pp. 133–142, 2000

[7] Frasson, C., Martin, L., Gouarderes, G. and Aimeur, E., LANCA: A Distance Learning Architecture Based on Networked Cognitive Agents, in Goettl B., Halff H., Redfield C.

[8] Pimentel M. G.C. and Abowd G.D., Ishiguro Y., Linking by Interacting: a Paradigm for Authoring Hypertext, *Proceedings of ACM Hypertext*, May 2000

[9] Stern M., Steinberg J., Lee H. I., Padhye J. and Kurose J.F., MANIC: Multimedia Asynchronous Networked Individualized Courseware, *Proceedings of Educational Multimedia and Hypermedia*, 1997

[10] Mukhopadhyay S., Smith B., Passive Capture and Structuring of Lectures, *Proceedings of ACM Multimedia*, October 1999.

[11] WebCT: http://www.webct.com/Murray, R. C. and VanLehn, J., DT Tutor: A Decision-Theoretic, Dynamic Approach for Optimal Selection of Tutorial Acitons, in Gauthier G., Frasson C. and VanLehn K., *Intelligent Tutoring Systems*, pp. 153–162, 2000

[12] Bradley K., Rafter R. and Smyth B., Case-Based User Profiling for Content Personalisation, in Brusilovsky P., Stock O. and Strapparava C., *Adaptive Hypermedia and Adaptive Web-Based Systems*, pp.63–72, 2000

[13] Pimentel M. G.C., Abowd G.D., Ishiguro Y., Linking by Interacting: a Paradigm for Authoring Hypertext, *Proceedings of ACM Hypertext*, May 2000

[14] Brusilovsky, P., Eklund, J., and Schwarz, E. web-based education for all: A tool for developing adaptive courseware. Computer Networks and ISDN Systems, Proceedings of Seventh International World Wide Web Conference (1998) 291–300

[15] Weber, G., Kuhl, H-C, Weibelizahl, S. Developing adaptive internet based courses with the authoring system NetCoach. Proceedings of the third workshop on adaptive hypertext and hypermedia, UM2001, TU/e Computing Science Report 01/11. (2001)