Designing Adaptive Educational Web Sites: General Framework

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Abstract

This paper proposes a general framework for the development of adaptive web sites by showing its application to a real case study: Conexiones Santander web site. The paper gives a brief introduction to Conexiones model and to other initiatives for the development of academic communities in Colombia, aiming to highlight the relevance of customised learning environments and the pertinence of applying adaptivity techniques to such environments. Additionally, this work illustrates some aspects of the modelling phase of the case study following the MAS-CommonKADS methodology emphasising on agent and expertise models.

1. Introduction

The vertiginous development of information and communication technologies, have made of these, essential elements in the accomplishment of mankind daily activities, among which teaching - learning processes are not the exception. Becoming aware of this reality, in 1993 the initiative Conexiones arose in Colombia as a research project which main objective is to develop a learning environment supported by ICTs (Information and Communication Technologies) aiming to improve the quality and fairness of the education in Colombia.

Taking as starting point the present state, experiences and results of the Conexiones initiative, in this paper a general framework for the development of adaptive educational Web sites is set out and applied to the case study: Conexiones Santander - one of the four nodes that compounds this initiative. This proposal aims to provide a better joint between actors, contents, ICTs and the Conexiones pedagogical model by including adaptivity techniques [11,6,2,4,9,14], customisation [8,3,5], knowledge management [7] and Agent Oriented Software Engineering concepts [1], that help to get a better advantage of the teaching - learning processes in elementary and high school in Colombia.

The following section gives a brief introduction to Conexiones model and to some different initiatives for developing academic communities in Colombia. Section 3 details a general framework for designing adaptive educational web sites: case study Conexiones Santander. Section 4 presents the modelling phase of the system, focussing on agent and expertise MAS-CommonKADS models [1]. Finally, section 5 gathers some concluding remarks.

2. A Look Inside Adaptive Academic Communities in Colombia

Virtual Academic communities in Colombia have emerged in the past years as an answer to the necessity of incorporating ICTs in educational processes. Some Colombian academic virtual communities, focused on elementary and high school education are: The Integrated Network of Educational Participation REDP¹, the Academic Network of Bogota Secretariat of Education² and Conexiones³. These communities, offer services that promote collaborative work and the integration of contents and ICTs, working like networks to distribute and to strength the knowledge construction in several areas of education. These initiatives, play a crucial role in the quality improvement of the Colombian education, nevertheless, the learning rates and interests are different for each individual. This fact reveals the necessity of academic communities that help to take a better advantage of learning and manipulation of individual information, also supporting collaborative learning and providing an evaluation - feedback mechanism. Therefore, in section 3 a general framework to the design of adaptive educational web sites is presented, in order to provide the educational web sites with tools that facilitate the development of customised learning environments and the adaptation of the web site information according the individual interests and personal activities.


The main goal of this work is to present a general framework for the design of adaptive web sites for

¹ http://www.redp.edu.co/
² http://www.redacademica.edu.co/export/REDACADEMICA/
³ http://www.conexiones.eafit.edu.co/
education. Adaptive web sites are sites that automatically improve their organisation and presentation by learning form visitor access patterns [9]. Adaptive web sites have been studied in similar works like [6, 9, 10]. In these works, several techniques and algorithms for the development of adaptive web sites are presented. On the other hand, software agents have been used to the development of adaptive web sites like is presented in [15, 16]. These works describe general characteristics and structure of adaptive agents. Adaptive educational web sites have been studied in several works like in [11, 12, 13, 17]. Such works offer techniques and pedagogical activities based on ICTs for the design of adaptive educational web sites using hypermedia and user models as their strategies.

Designing adaptive educational web sites involves a set of elements that allows the fusion of contents and ICTs inside a collaborative learning environment, where individual capabilities could be exploited to the maximum. In order to provide a mechanism to achieve this goal, in section 3.1 a general framework based on layers to designing adaptive educational web sites is proposed. Additionally, aiming to validate the proposed framework section 3.2 describes its application to the case study Conexiones Santander web site.

3.1. General Framework

Designing the proposed general framework included a previous analysis phase of the activities related to the development of educational web sites as well as a review of elements that allow a better performance of teaching - learning processes. Figure 1 illustrates the proposed general framework.

![Figure 1. General Framework for the Design of Adaptive Educational Web Sites](image)

As shown in Figure 1 the general framework is compounded by five layers: Pedagogical Design Layer, User's Models Layer, Services Layer, Techniques Layer and Technologies Layer.

**Pedagogical Design Layer:** This layer includes three basic activities that help to define goals, what contents will be presented and how to teach these contents using ICTs, so that the goals could be achieved. The activities carried out in this layer are: Definition of educational goals (each educational model has its own goals that could be classified by standards or any other mechanism, these goals allow evaluation and/or measurement of a learning process), Selection of contents (contents to be taught that depend on variables focussed on the knowledge, these variables could be a course, students' ages, social environment, etc.) and the definition of didactic strategies (how to give the contents aiming to catalyse the knowledge).

**User's Models Layer:** Every pedagogical proposal has associated a set of actors inside and/or outside the learning process, for this reason a complete definition of the roles played by each actor must be specified. Depending on the structure of the pedagogical model, there will be actors whose participation could be more active than others, then it is necessary to define what services will be offered and to whom they will be directed.

**Services Layer:** Depending on the user's requirements and his/her access levels, services could be classified as primary and secondary services.

Primary services: Services that are offered to main users (users related to the teaching - learning process), and these services should be focussed on attending needs of knowledge creators.

Secondary services: These services are the base to develop and to enrich other activities of the educational process. The main difference between primary and secondary services, is that secondary services are available to every user of the system, while primary services are exclusive for users that are enrolled in learning activities (courses, collaborative projects, etc.).

**Techniques Layer:** The efficiency and quality of services are based on the techniques and methodologies employed to develop such services, for this reason a good choice of the most suitable technologies to the development of the services is imperative. Because of the abstract conception of this proposal, suggestions about which technologies are better to an specific educational web site are outside of the scope of this framework.

**Technologies Layer:** In addition to efficiency and quality, an adaptive web site must offer some characteristics like permanent availability, information integrity, among others. For this reason the selection of technologies to develop the services is a quite serious and important issue when designing adaptive web sites.

3.2. Applying the General Framework to the Study Case: Conexiones Santander Web Site

The present status of Conexiones Santander web site is characterised by a static structure, where there is not a users classification, so that all visitors of the site could have the same information and that a visitor also spends a lots of time looking for information that is of his/her
interest. By applying general framework proposed in this work to Conexiones Santander web site, an important improvement in the security level and quality of information presented is expected. The result of this process will be a specification that synthesises the most important aspects necessary to transform the actual static site into an adaptive web site, offering a login mechanism to the system for registered users where they could get access to primary and secondary services based on his/her profile. Figure 2 illustrates the extended framework for the case study Conexiones Santander web site.

**Pedagogical Design Layer.** Conexiones model is based on aspects related to a learning environment using ICTs, some aspects are: What to teach?, how the contents must be presented in this kind of educational scheme?, how to use the new technologies to improve the learning process?, among others. These questions are the fundamentals of the pedagogical design of Conexiones and provide the guidelines to articulate the actors and elements of the web site, aiming to improve the quality of the learning process based on ICTs.

Conexiones model proposes three mechanisms which main goal is to organise and to structure the contents and activities involved in a learning process using ICTs. These mechanisms are: Integrated Learning Units (ILU), collaborative projects and courses.

- **ILUs:** An ILU is a set of activities pedagogically organised in order to facilitate an integral learning and to contribute to accomplish the formation process. This mechanism combines the contents of several subjects based on topics of interest to the student and becomes a guide to the contents and activities development inside a course.

- **Collaborative Projects:** This mechanism is based on the development of problem solving tasks using a computer as the main tool, these tasks require a high level of cooperation between the different actors of the learning process.

- **Courses:** This mechanism is the convergent point of the mechanisms described above, offering both teachers and students a mean to organise and to consult contents, activities and learning strategies.

**User's Model Layer.** Conexiones pedagogical proposal involves several individuals where each has different interests and carries out many activities. As a result, transforming the Conexiones Santander web site into an adaptive web site requires an initial phase of user's profiles definition. Users identified in this phase were: Teachers, students, educational agents, researchers, technical support, parents, directors, unregistered users, and the administrator of the web site. This classification is crucial to a suitable definition and assignment of services to be offered by the web site.

**Services Layer:** Primary services into Conexiones Santander are understood like those services that are required by the teaching – learning process, in other words, services that allow the presentation of contents, activities and evaluation-feedback strategies. The primary services identified in the case study were:

- **Course Design:** Provides the tools required to the definition of the course's issues (ILU to use, schedule, collaborative projects, among others).

- **Course Management:** Allows both teachers and students access to the scheduled program contents.

- **Evaluation:** Allows to create, to distribute and to apply regulation and self - regulation methods for the learning process.

On the other hand, Secondary services are those services that are used by primary services to improve their...
development, such services are: E-mail, chat, discussion group, web site guide, blackboard (shows relevant information to the users at the beginning of the session), exposition room (socialisation of the best students' works), creativity space (allows the publication of the students' works) and processes daily (to visualise the process into the courses). Secondary services allow the collaborative work inside a group of students and teachers even from different institutions and nodes.

Techniques Layer: The development of this layer is based on two concepts: adaptivity techniques [9,11] and User's Profile. The inclusion of these techniques arises like a necessity to confront the variety and the large number of system's users. The user profile is compound by a series of characteristics about a user, these characteristics could be preferences, demographic information, behavioural patterns, etc.

- Customisation: User's Model allows the system to have an explicit knowledge about the user. This knowledge will be useful during the application of customisation and adaptivity techniques. Some evaluated techniques to be applied are: Rule based filtering, content based filtering, and collaborative filtering [8,3,5].

- Adaptivity: These techniques will be applied to the development of the primary services identified in the extended framework. The application of adaptivity techniques aims to improve the presentation of the Conexiones Santander web site, by analysing the navigation patterns of all users of the system. Some adaptivity techniques evaluated to be applied are: Web mining [2,4,14], promotion, demotion and linking [9], and reuse of components [6].

Technologies Layer: In this layer the aspects related to the general structure of the web site were identified. This procedure allows a safe usage of the services defined above as well as the complete implementation of the techniques described in the fourth layer of the framework. The development of the system will be reached by following a well known Agent Oriented methodology: MAS-CommonKADS [1] and by using some technologies like J2SE, Oracle and XML to the development of a robust adaptive web site.

A modelling phase of the system was carried out as a complementary task to the application of the general framework to the case study. Although the seven models of the MAS-CommonKADS methodology were applied, due to a lack of space section 4 gives a brief description of just two of them: Agent and Expertise models.

4. Identifying Knowledge Components for Conexiones Santander Adaptive Web Site

The modelling phase of the adaptive web site Conexiones Santander was developed by following the MAS-CommonKADS methodology, this is a general purpose methodology conformed by seven models for the development of multiagent systems.

The inclusion of an explicit model for the identification and representation of knowledge, a complete and independent design model, a specific definition of a life cycle as well as a clear description of the input - output relationships between models are some of the aspects that make MAS-CommonKADS a robust and suitable methodology for the development of systems that involve tasks of knowledge management. MAS-CommonKADS includes six models for analysis phase: Agent Model (AM), Task Model (TM), Organisation Model (OM), Coordination Model (COM), Communication Model (CM) and Expertise Model (EM); and a Design Model (DM).
information sources) and Information-Agents (Agents that carry out tasks related to manipulation, extraction and interpretation of information from both databases and web server logs). Figure 3 shows the inference diagram for Preferences-Automatic-Update, this task requires knowledge to reach the goals which was designed for.

As shown in Figure 3, boxes correspond to sources of information, ovals represent inferences applied on information sources and arcs are flows of information between sources and inferences. Once a user logs in the system, the system must be capable to detect navigation patterns and to adapt its information according to the user's interests, this goal is reached by a matching task between explicit profile, session data and user types information. This information is then matched with the information extracted from web server logs in order to discover and update user's interests.

5. Conclusion

The nature of the learning processes suggests that the design of mechanisms that promote collaborative work and that exploit to the maximum the individual capabilities are required. Designing this kind of environment is a complex task that requires tools to articulate several aspects involved in learning processes. This work presented a general framework aiming to provide a guideline to deal with this problem.

Different rates and methods are the constant in learning processes, the fusion of techniques like customisation (individual preferences) and adaptivity (content adaptation based on individual and collective preferences) could be a good strategy to get a better outcome in a learning process.

The modelling phase presented in this work allows a description of the extended framework with a Bottom Up approach and a complete identification and representation of the knowledge required by the system. These advantages are no present in other similar works like in [11,9].

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