TAKING RICH CONTEXT AND SITUATION IN ACCOUNT FOR IMPROVING AN ADAPTIVE E-LEARNING SYSTEM

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Abstract: Although there are several approaches for adaptive e-learning systems, they focus mainly on technological and/or networking aspects without taking into account other contextual aspects, such as cultural and pedagogical context. This paper presents a context-aware situation-dependent personalization approach designed for an adaptive e-learning system called AdaptWeb®, based on a rich context model as an extension to student modeling.

1 INTRODUCTION

A Web-based e-learning system (ELS) is normally used by a wide variety of students. Adaptive ELS adjust the content, presentation and navigation to a student's model. Personalization (or adaptation) is the process of adapting a computer application to the needs of specific user and takes advantage of the acquired knowledge about him/her. ISO defines usability as evaluated by the effectiveness, efficiency and satisfaction which users achieve specified goals in a particular context of use (ISO 9241, 1998). Specifically in an e-learning environment: i) an user is typically someone playing a student or a teacher role; ii) goals are related to activities of learning process, by acquiring new knowledge, behaviors, skills, preferences or values, and may involve synthesizing different types of information; and iii) differently from human-to-human interactions, in human-to-computer interactions, the context of use is usually described by a set of (cultural, technological, pedagogical, etc.) characteristics that are necessary to support the learning process and its goals.

Since ELS are normally used by a wide variety of students with different skills, background, preferences, and learning styles, an ELS must provide improved usability being adaptive and personalized. Traditionally, the most widely used components of student profiles have been considered (Brusilovsky and Míllan, 2007): knowledge, individual traits such as learning or cognitive styles, experiences and background (Souto, 2002), goals or tasks, as hierarchical task network planning presented in Ullrich (2008). However, there are other relevant criteria to reach personalization, such as motivation, working memory capacity, personality traits, behavior, culture, etc. (BROWN et al. 2009). At the same time, ELSs may be dynamically adjusted not only according to the student's model but also depending on a richer notion of context. A contextualized ELS provides the student with the material he needs, and appropriate to his knowledge level and which makes sense in a special learning situation, called a *scenario* (Eyharabide et al., 2009), (Gasparini 2010).

The aim of our research is to investigate approaches putting the users' profile and contextual information into practice in the development process of the ELSs AdaptWeb® (Freitas et al. 2002), whose goal is to adapt content, presentation and navigation in an educational web course according to the student model. AdaptWeb® is an open source environment, available in SourceForge .

This paper is organized as follows. Section 1 presents an overview of our research and objectives. Section 2 explains some related works. Section 3 discusses our approach to modeling context and

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culture. Section 4 introduces our extended architecture. Section 5 illustrates some examples of utilization. Finally, in section 6 we expose our conclusions.

2 RELATED WORK

Research in adaptive educational hypermedia has demonstrated that considering context leads to a better understanding and personalization (Brusilovsky and Míllan, 2007). Context is vital to improve personalization in ELSs. Recent works aim to provide the capacity for identifying the right contents, right services in the right place at the right time and in the right form based on the current student´s situation. There is an interesting theory of learning for a mobile society (Sharples et al., 2007) but our work is closely related to others like (Barbosa et al., 2006), (Yang et al. 2006), (MOBIlearn, 2003) and (Bouzeghoub, and Do Ngoc, 2008). The interesting propositions of GlobalEdu (Barbosa et al., 2006) in terms of architecture, for instance, have distributed and central alternatives with different models (student, context and environment).

An infrastructure to ubiquitous learning is presented in Tetchueng et al. (2007) where an environment to provide collaborative learning is proposed, based on three systems: a peer-to-peer content access and adaptation system; a personalized annotation management system and a multimedia real-time group discussion system.

Particularly about cultural aspects, Blanchard and Mizoguchi (2008) describe an upper ontology of culture, by working at the meta-level of culture. They aim to identifying major constituents to be considered when dealing with any kind of cultural issue without having to endorse a particular culture's representational framework. They use this approach to deal with many CATS (Culturally-Aware Tutoring Systems) related issues by providing objective formalism for cultural representation. Chandramouli et al. (2008) presented the notion of the CAE-L Ontology for modeling stereotype cultural artifacts in adaptive education and used a Cultural Artifacts in Education (CAE) questionnaire to gather the information required to determine if there is a significant cultural bias within online education, specifically Adaptive Educational Hypermedia.

Motz et al. (2005) introduce an architecture in the e-learning EduCa Project, based in a strong use of ontologies for the retrieval, management and clustered of electronic educational resources according to user's cultural aspects, like degree of impatience, attitude, treatment, language, learning styles and activities. These cultural aspects are specified in a MultiCultural Aspects Ontology, which follows the standard Learning Object Metadata (LOM) and uses OWL (Web Ontology Language). Sieg et al. (2007) presented a framework that integrates critical elements that make up the user context, namely the user's short-term behavior, semantic knowledge from ontologies that provide explicit representations of the domain of interest, and long-term user profiles revealing interests and trends. They present a novel approach for building ontological user profiles by assigning interest scores to existing concepts in a domain ontology.

Reinecke et al., (2007) present a Cultural User Model Ontology (CUMO) that contains information such as different places of residence, the parents' nationality, languages spoken, and religion. Furthermore, CUMO contains information about Hofstede's (Hofstede, 1991) national cultural dimensions.

Our research has a different point of view of these works as we integrate cultural, technological, pedagogical and personal aspects as part of a rich context model (Eyharabide et al., 2009) that makes sense in a special situation, in a given time. An improvement in the user's contextual information leads to a better understanding of users' behavior in order to adapt (i) the content, (ii) the interface, and (iii) the assistance offered to users. A contextualized ELS provides the student with exactly the material he needs, and appropriate to his knowledge level and that makes sense in a special learning situation. However, while learning is a process intensively related to the notion of situation, in most of ELSs situation is only implicitly mentioned and not explicitly modeled. In order to support situation-aware adaptation, it is necessary to model and specify both context and situation. More accurately, there is a complex intermeshing and continuous transformation of situations in combination with fluctuating contexts, where meaning changes according to context and through preferences of different participants. In this sense, e-learning personalization is situation-dependent and cannot be managed in an independent form.

3 APPROACH TO MODELING CONTEXT AND CULTURE

In this section, our approach to model context and culture in e-learning is described. Specially, we improved the models used in the AdaptWeb® environment in order to incorporate the notion of context and situation. We add a rich notion of context to existing student profiles in order to provide a rich personalization process. To be effective, learning process must be adapted not only to the student's profile but to the learner's context as well, creating some kind of matching between context and profile to provide for example the appropriate content, navigation, and recommendations. Learning processes have to provide extremely contextualized content that is highly coupled with context information, limiting their reuse in some other context. If the context information is represented independently from content information, the possibilities for reuse increase.

In a broader sense, *context* describes the circumstances under which something occurs as well as the interrelationships of those circumstances. Such interrelationships provide a semantic perspective that restricts and narrows the meaning of "something" (Abarca et al., 2006). A context-aware ELS is an application that adapts its behavior according to the students' context. Context-aware applications not only use context information to react to a user's request, but also take the initiative as a result of context reasoning activities (Dockhorn Costa et al., 2007). We have developed a model based on upper-level ontology. In this model, a student might be involved in several overlapping contexts, and consequently, his/her educational activity might be influenced by the interactions between these contexts. Overlapping contexts contribute to and influence the interactions and experiences that people have when performing certain activities (Bouzeghoub and Do Ngoc, 2008), (Yang et al., 2006), (Eyharabide and Amandi, 2008). Our model has three levels: meta-model, model (ontologies), and object (Eyharabide et al. 2009). The meta-model level is represented by an upper ontology; the model level with several ontologies to describe the elements that populate the context and, in the lower level, we find the instantiations of the context ontologies. In other words, the ontology concepts of one level are the instantiations of its immediate superior level.

We personalize an ELS for each user based on the information stored in a student model. In our work, the typical characteristics of students are extended to include the context dimensions having personal, technological, pedagogical and cultural aspects.

Personal context is widely considered in ELS, usually gathered in user profiles. It considers the student's personal information (such as name or address) and also the student's personal preferences (like interaction preferences, colors or layouts). In our environment, typical characteristics of user profiles include age, scholarship, background, gender, interests, knowledge, experiences, goals, behavior, and navigational preferences.

Technological context is related to many different technological constraints (e.g., device processing power, display ability, network bandwidth, connectivity options, location and time). It includes concepts such as browser type and version, operating system, IP address, devices, processing power, display ability, network bandwidth or connectivity options.

Pedagogical context consists of multifaceted knowledge due to many distinct viewpoints of pedagogical information needed to personalize e-learning. In practice, many adaptive systems take advantage of users' knowledge of the subject being taught or the domain represented in the hyperspace, and the knowledge is frequently the only user feature being modeled (Brusilovsky and Míllan, 2007). Recently, various researches started using different characteristics described in other related fields, such as personality model OCEAN (Goldberg, 1993), cognitive (Ford and Chen, 2000) and learning styles (for example, from Felder's model (Felder and Brent, 2005).

3.1 Cultural Context

Cultural context is referred to different languages, values, norms, gender, social or ethnic aspects or even ideological, political and religious aspects. It describes cultural characteristics on different levels, such as national, organizational or individual characteristics. In turn, culture can be analyzed in some levels: national and regional aspects, organizational aspects, professional aspects and fields, and individual aspects. There are different cultural dimensions proposed in the literature, but the most accepted for national point of view are the five dimensions proposed by Hofstede (1991), based on value orientations and shared across cultures. According to Bossard (2008) there are two categories of topics that are affected in human computer interaction localization, (i) presentation of information (e.g. time, date and color format) and language (e.g. font, writing direction, etc.); and (ii) dialog design (e.g. menu structure and complexity, layout, positions) and interaction design (e.g. navigation concept, interaction path, interaction speed, system structure, etc.). Despite some HCI works now focusing on cross-cultural aspects in HCI, the research of culturaldependent aspects of HCI, is still embrionary (Zaharias, 2008).

Cultural aspects are preferences and ways of behavior determined by the person's culture. Cultural context includes cultural background of a student and may have a great impact on their ability and efficiency to learn a given set of content (Chandramouli et al., 2008). A Culture Profile cannot be defined as a fixed or prescribed specification. The specification should be extended and dynamically improved based on the user´s context. As described in Reinecke and Bernstein, (2007), research conducted on the effect and usability of culturally adapted web sites and interfaces has shown enormous improvements in working efficiency.

Cultural-aware in this paper deals in identify navigations paths and user´s behavior in an ELS to support adapting content and navigation. It is not our goal to treat sociological aspects.

3.2 Modeling Context and Culture

The meta-model, presented in Figure 1, is an upper-level ontology describing abstract concepts like user, application, user profile, situation or date. The model depicts the different contextual dimensions. Each contextual dimension is represented by a different ontology such as a cultural ontology (with concepts like nationality and values, language, etc.), education ontology (course, learning style, discipline, etc.), personal ontology (name, gender, preferences as navigational mode and interface colors, birthday, action focus in this moment, etc.) or technological ontology (operating system, browser, network bandwidth, etc.). Finally, the object model will comprise instances describing the context of a particular user like a concrete name (John Smith), a course (Human Computer Interaction) or a particular language (English).

The situation could be completely changed if the contexts of student change. Among all the possible information gathered in the student model, we are especially interested in modeling scenarios because they change according to context. Scenarios may depend on the situation the student is now in and on external factors. The concreteness of scenarios helps students and teachers to develop a shared understanding of the proposed contextual information, and allows assimilating and representing complex idiosyncrasies of that they would otherwise misunderstand.

We define a scenario as a tuple containing an entity that the student prefers in a given situation, a relevance denoting the student's preference for that

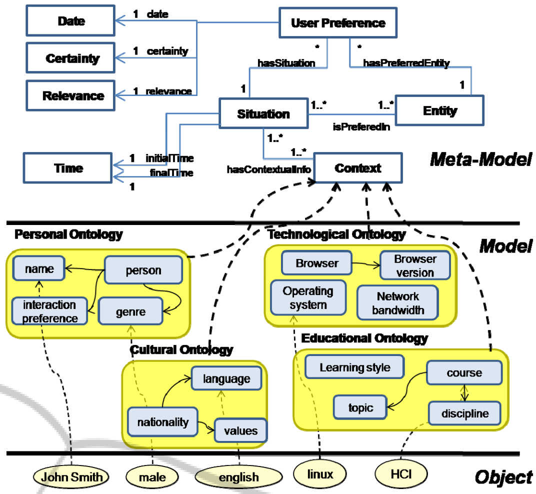

Figure 1: Example of a scenario-oriented situation.

entity, a certainty representing how sure we are about the student having that preference and a date to indicate when that preference is stored:

Scenario = {entity, situation, relevance, certainty, date}

Situations are the key to include temporal aspects of context in a comprehensive ontology for context modeling, since they can be related to suitable notions of time (Dockhorn Costa et al., 2006). As context varies during certain time intervals, it is vital to consider it within the concept of Situation. Examples of situations could be "John was at home using his notebook to read lesson number 3 of the Human Computer Interaction course" or "A Japanese Professor, who speaks English, is adding new exercises to the course Introduction to Java using a high speed connection while she travels by train". Therefore, we define situation as a set of contextual information in a particular period of time:

Situation = {Context, initial time, final time}

An example of contextual information would be: "The student named John is reading lesson number 7". This is a description relating an entity (the student John) to another entity (the lesson number 7) via a property (is reading). We represent this contextual information as (Student.john, isReading, Lesson.lesson#7). We define the context as a set of triples composed by concepts, instances and relations between them. It is important to emphasize that the concepts and instances might belong to the same ontology or different context ontologies:

Context = {(Ca1.Ia1, R1, Cb1.Ib1), ..., (CaN.IaN, RN, CbN.IbN)}; (C: concept, I: instance and R: relation)

To clarify these ideas, let us consider again John example. John prefers reading visual learning material in a situation when he is at home using his notebook to read lesson number 3 of the Human Computer Interaction course. Hence, the corresponding context1 will be:

Context1={ (Person.John, locatedIn, Location.home), (Person.John, uses, Device.notebook), (Person.john, reads, Lesson.lesson#3), (Lesson.lesson#3, belongsTo, Course.HCI)}
Situation1={ Context1, 4:00PM, 7:00PM}
Scenario1={User, Situation1, relevance.high, certainty.95%, date.05-02-2010}

4 ARCHITECTURE FOR CONTEXT-AWARE ELS

The extended AdaptWeb® architecture is presented in the Figure 2, where the boxes represent the new modules inserted in the already functioning architecture of AdaptWeb®. Beyond the new modules, is showed in the figure the three servers which were proposed to store and model the context data.

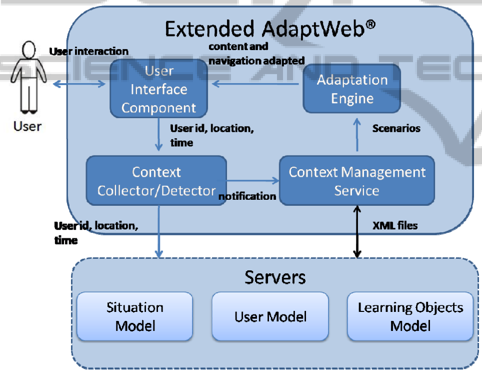

Figure 2: Extended architecture.

Starting with the modules, the User Interface Component is responsible to both obtain the user data, and present the adaptations processed by the environment. Actually, the AdaptWeb® environment already stores all the information related with the login, the chosen discipline and the author notifications to the students. So, it is possible to aggregate user context data to be obtained via interface, like the learning object actually in use and the path made by the student while using AdaptWeb®. Knowing this path, we can discover the occurrence of learning events that are important to starts an adaptation. These events are detected by the Context Collector/Detector and, depending on the event, notified to the Context Management Service.

The extended architecture is based on three servers that operate together to provide and manage contextualized data according to the student's scenarios. Each server manages specific data related to the user context, being respectively responsible for the storage and adaptation of (i) environmental context (information related to the user environment, tasks, activities, time interval, devices, location), (ii) information about students (personal data, preferences, objectives, knowledge background, behavior, learning styles, cultural context, etc.), and (iii) learning object's information (documents provided by the educational environment to its users for their learning).

The Context Management Service is responsible for analyzing the context managed by the servers, generating different scenarios that can be experienced by the students in a specific period. These scenarios are used to guide the adaptation (in the Adaptation Engine), and materialized in the interface rendered to the user. The main goals of the architecture are: (i) easily reuse of educational resources, since they will be adapted to the user scenario while the stored content remains the same, (ii) integration into the existing architecture, since the new architecture is supposed to take advantage of the existing functionalities and (iii) extensibility to other educational systems, using standard technologies. The personalization is possible with the combination of contextual data related to whom and where the user is, what he/she is doing and what does he/she needs to achieve his/her educational targets. More details can be found in (PERNAS et al., 2010).

5 ADOPTING CONTEXT MODELING

In this section, we describe some improvements of the personalization's capabilities of AdaptWeb® in order to provide support to this contextual modeling approach. We start by describing different learning situations to explain the contextual adaptations developed in AdaptWeb®, and then we detail how those situations trigger the corresponding contextual adaptation. We show some examples of possible contexts in a Database System course.

We show some examples in a Database Systems course context where the teacher provided a set of links learning objects with diverse content about database system, for example: History and motivation for database systems, Components, DBMS functions, Database architecture and data independence, etc. A learning object (LO) is defined as any entity, digital or non-digital, that may be used for learning, education or training (IEEE, 2002). For a simplification purpose, we have a few variables over student´s model: student's knowledge, subject, network connection, learning style, Language, LanguageLevel and Country.

In *Context1*, Mike is a student who lives in Brazil, his mother tongue is Portuguese, and he has a low level knowledge in English. He is trying to learn about the subject XML databases, which is explained in English. He is doing exercises about that subject, but unfortunately he is not obtaining satisfactory results. In addition, he has a high network connection and according to Felder's model (Felder and Brent, 2005) he is active.

The user model checks his number of mistakes and identifies if he needs help resolving the exercises. In the meantime, the situation model detects via teacher's agenda that a chat with the students was previously scheduled by the teacher to happen in 15 minutes. These events will start a service of notification in the Context Management Service, informing that a change of the current scenarios related with these events may change. After a new orchestration by the Context Management Service, the User Interface sends a message to the student, notifying him of this possibility to solve his doubts and shows the "chat" link in a different and highlighted color.

In another scenario, *Context2*, Marie, a French speaking PhD student of Engineering from France, has very good skills in three different foreign languages (English, Portuguese and Spanish). She is also learning the subject XML databases and not having good results. She has a low network connection and her Felder's learning style is reflective. In consequence, AdaptWeb® sends a message by email to her teacher advising to contact the student and changes the order of the links, putting links related to video material with low quality resolution in the end and disabling links related to video material with high quality resolution (those who are heavy and difficult to see). Furthermore, AdaptWeb® detects some important links for learning material written in English and Spanish and shows this in the top of the list.

These contexts are formalized as following:

Context1 = {
(Student.*Mike*, **isLearning**, Subject. *XML databases*),
(Subject. *XML databases*, **isExplainedIn**, Language.*english*),
(Student. *Mike*, **hasUserKnowledge**, UserKnowledge.*bad*),
(Student. *Mike*, **hasConnection**, NetworkConnection.*high*),
(Student. *Mike*, **hasStyle**, LearningStyle.*active*),
(Student. *Mike*, **hasMotherTongue**, Language.*portuguese*),
(Student. *Mike*, **hasLanguageSkill**, Language.*english*),
(Student. *Mike*, **hasEnglishLanguageLevel**, LanguageLevel.*low*),
(Student. *Mike*, **isCitizenOf**, Country.*Brazil*)}
Context2 = {
(Student.*Marie*, **isLearning**, Subject. XML *databases*),
(Student. *Marie*, **hasUserKnowledge**, UserKnowledge.*bad*),
(Student. *Marie*, **hasConnection**, NetworkConnection.*low*),
(Student. *Marie*, **hasStyle**, LearningStyle.*reflective*),
(Student. *Marie*, **hasMotherTongue**, Language.*french*),
(Student. *Marie*, **hasLanguageSkill**, Language.*english*),
(Student. *Marie*, **hasEnglishLanguageLevel**, LanguageLevel.*high*),
(Student. *Marie*, **hasLanguageSkill**, Language.*portuguese*),
(Student. *Marie*, **hasPortugueseLanguageLevel**, LanguageLevel.*high*),
(Student. *Marie*, **hasLanguageSkill**, Language.*spanish*),
(Student. *Marie*, **hasSpanishLanguageLevel**, LanguageLevel.*high*),
(Student. *Marie*, **isCitizenOf**, Country.*France*)}

In summary, the adaptation mechanisms in AdaptWeb® can be for example the following actions/recommendations:

Context1 → *"send notification to student only in Portuguese" + "show highlighted links"+ recommend LO and content about the same subject (same concept in the domain ontology) in Portuguese with a low level of difficulties;* An example of this adaptation is presented in figure 3, where the set of LO is especially adapted to him.

Context2 → *"order links" + "hide or disable links" + "show highlighted links" + "recommend LO and content about the same subject written in French, English, Spanish or Portuguese".* An example of this adaptation is presented in figure 4.

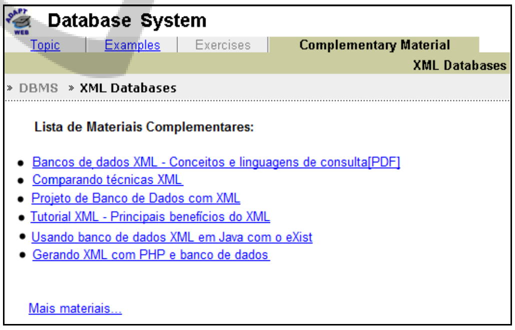

Figure 3: LO adapted to Mike´s situation.

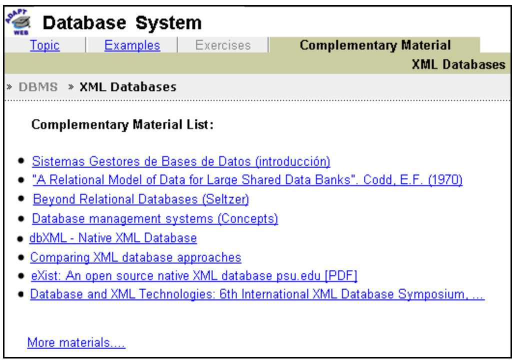

Figure 4: LO adapted to Marie´s situation.

These contexts are used by the context management service within logical rules in order to predict future recommendations.

Currently, this model is being under evaluation with real students and actual courses in AdaptWeb® environment.

6 CONCLUSIONS

The constant evolution of ELSs and the way people communicates demands the development of new efficient solutions to offer faster and better information, aiming to improve their utilization and, more ambitiously, the learning process. One meaningful example is the need to deal with context modeling and its relation with user modeling. In fact, context modeling extends traditional user modeling techniques, by explicitly dealing with aspects we suppose to have a significant influence on the learning process assisted by an ELS.

In this paper, we proposed to improve an ELS taking into account a richer notion of context, guided by scenarios, and showing how this context data can be related in a daily application.

In this work, we look to increase even more the capabilities of the actual systems personalization, making use of ontologies to model the student's context in different scenarios, adapting the systems content, navigation and presentation. To show a materialization of this proposition, we extend an existent ELS environment architecture and explain its new operation.

Research in education has shown that environments, instructional design and learning methodologies cannot be always displayed in the same way, and cannot be universally applied because their effect can vary from one culture to another, i.e. some tactics may be effective in a cultural group, but not in another. As well as other software applications, ELSs are usually restricted to one personalization strategy per country. However, a predefined localized personalization cannot be assigned to all people of a nation, as some might have many cultural influences and are, therefore, culturally ambiguous (Reinecke and Bernstein, 2008). In this way, researchers are focusing on cultural aspects to produce learning technologies, and to understand the dimension of a cultural background has on the choice of underlying teaching methodologies. In our approach, we consider culture as another contextual dimension. Our future work includes increasing cultural dimensions (national, social and personal) as part of cultural context and for this improvement to use different aspects as values, norms, social or ethnic aspects in the cultural context model.

We expect to have a more understanding of users and a better communication with LO provided by teacher, meaning effective learning for students in AdaptWeb® environment. We plan to carry out more experimental tests, with our partners in France and Argentine, to develop a course with the same content to a wide variety of students, belonging to different cultures.

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