A Multi-Model Approach for Supporting the Personalization of Ubiquitous Learning Applications

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Abstract

An additional platform for supporting learning in the same physical space in which it takes place, is now available owing to the continuous advancement of wireless and mobile technologies. However, new challenges arise for the development of ubiquitous computing learning applications capable to provide appropriate content and services according to the individual needs of each learner. In this paper, we describe the implementation of a centralized system with a multi-model based approach to support the personalization of such applications. These models contain information about the application, the user's characteristics, the usage behavior and the situational environment.

1. Introduction

The evolution of computer supported learning environments has been accelerated by the continuous technological improvements, and with those newly available technologies an individual learning environment can now be embedded in daily real life [11]. Mobile devices have become broadly available, opening an additional platform for supporting learning. More specifically, wireless mobile learning devices offer stunning technical capabilities for the development of new systems, because of their portability and low cost [14].

Certainly, these new paradigms of computer assisted learning represent a great deal of opportunities for research and development in the field of mobile user modeling for ubiquitous computing and ubiquitous information scenarios [12]. The necessity to create environments that are capable of keeping their learners interested and promote their participation, leads to the development of personalized interfaces, which provide service to as many learners as possible, while considering each learner as an individual. Thus, research in the user modeling field has come up with many techniques for adapting and personalizing applications to the individual learner's needs according to their preferences, goals and intentions. However, those user modeling techniques were only restricted to desktop systems, where the learner physical context was not important, since the access to the system was registered only in a virtual way. Nowadays, a further representation of the external context in which the learner is involved has become a necessity; hence environment modeling has gained a lot of importance as stated by several authors [4, 8].

Another concern is the variety of mobile devices and the lack of standardization in software, platform and communication capabilities, which complicate the task of providing user modeling services to distributed ubiquitous applications that would benefit from sharing these services [10]. A partial model created from the information retrieved by one application could be combined with those of other applications, obtaining a more accurate and complete model.

2. Modularity in user modeling services

User modeling systems explicitly tailored for one application have the disadvantage of low reusability, and this derived in the research and development of generic user modeling servers to provide the basic capabilities of user modeling grouped in one system, keeping all the information centralized and making it accessible for several applications [12]. Nevertheless, the requirements of each application differ depending on its domain, and to satisfy these changing requirements these generic servers must add more and more capabilities, which can lead to a waste of resources. Most of the time, applications will only make use of part of the information contained in the entire model, and considering that for each application the model of several users has to be retrieved processed and updated continuously, the amount of information to be managed becomes an important issue to regard while designing and implementing reliable systems.

A modular approach helps not only to reduce the amount of information that the server has to process at a given time, by allowing the applications to work with all the model or only with a restricted part of it, but also to increase the reusability of the model itself. Notice for example the case of APeLS (Adaptive Personalized eLearning System) form Dagger et al. [7], whose adaptive engine is fed by several separated models, such as content model, learner model, narrative model, terminal model and service model, to separate their logics and to open the possibility of having more models added ad required. Through this approach models are regarded as individual pieces that can be attached or detached from a compounded model.

In the next section we further describe our approach for a generic user modeling system composed of four models. Among them, applications choose those that find useful for their own particular purposes. Even more models can be easily added because of the architecture of the system, which keeps all the models integrated yet not as an intrinsic part of its structure.

3. Architecture of the models

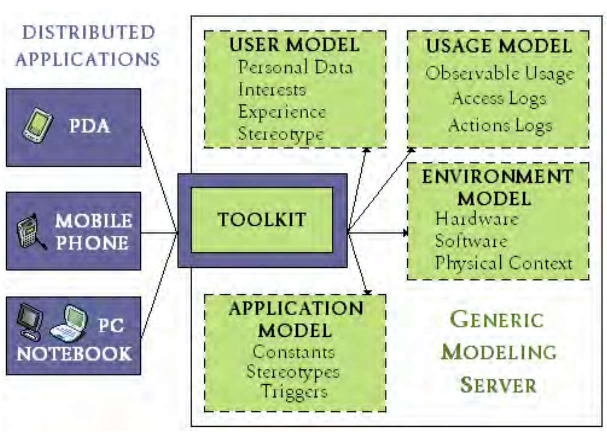

Figure 1: Architecture of the models

The architecture of the proposed system is separated basically in four models (Figure 1), which consist of information about the application, the user's characteristics, the usage behavior, and the situational environment. An additional component was developed as an entrance point for establishing communication with the applications, and it was called toolkit because it comprises the tools for the manipulation of the models. Furthermore, this component contributes to keep the models integrated and to the overall flexibility of the system, by keeping the changes to the minimum when adding or removing components of this multi-model approach.

Relying on the premise that the lack of standardization in relation to platform, software and communication techniques available in mobile or wireless devices is inherent to the variety and rapid evolvement of new technologies, we aimed to design a system that could be as accessible as possible, even for applications programmed in different languages or running over different platforms. Thus, the information is delivered to the applications using XML (Extensible Markup Language), because is a flexible text format that has been widely accepted as a standard for the exchange of data [2] (Figure 2). Another example of XML applied in user modeling is the ubiquitous computing simulation environment UBI's World [10], which has an XML-based exchange language which they denominated UserML (User Modeling Markup Language).

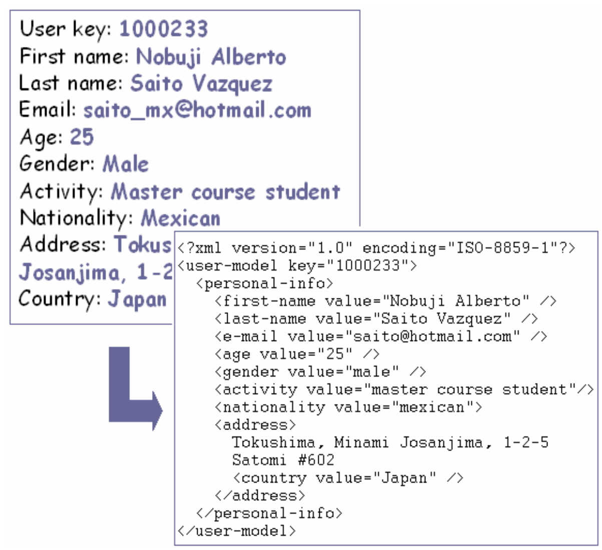

Figure 2: XML view of the personal information component inside the user model

In addition, this architecture uses SOAP (Simple Object Access Protocol) as communication protocol, since it is founded upon XML technologies and intended for data exchange over several underlying protocols, independently of the programming model and other specific semantics [9]. The use of this protocol is related only to the toolkit component and separated from the business logic of the rest of the components.

3.1 Application model

The application model is compounded by the particular modeling knowledge of the applications, and is divided as follows:

- Access information, to verify and regulate the permissions granted to the applications to register themselves for using the services of the system, and it will be required by the toolkit for establishing communication. By doing this, we are trying to assure the consistency and privacy of the application's information.
- Constants, the values predefined by the application for the thresholds that will be used for evaluating the beliefs maintained in the models. The application can modify these values at anytime, to further regulate the behavior of its models.
- Stereotypes, the classification of the identified homogenous characteristics among subgroups of users. This may be used later for assigning a standard model to new users, which is composed of common information retrieved from the models of other users in the same category that have previously interacted with the system. As the application begins interacting with the new users, more accurate assumptions can be made, and their models will be gradually modified [6, 13].
- Triggers, changes to be made to the model when it reaches a state that satisfies the predefined conditions. Repetitive changes that the application may want to perform to the models should be included here. For example, if a user has the commitment to attend to a meeting, and the las time that the user logged in the system was registered during the scheduled time, then the location of the user could be set to the same location where the meeting is taking place.

3.2 User model

The user model is considered to be a set of beliefs that the system has about a specific user, and we have represented it through probabilistic values assigned to those beliefs. The probabilistic values are calculated using the mathematical approach proposed by Ayala & Paredes [1]. The following elements are regarded as relevant for this model:

- Personal information to identify the user, such as name, e-mail address, age, gender, nationality, address, etc.
- Experience information about his/her capacities and abilities, spoken languages and educational background.
- Interests and intentions, including his/her commitments to others.
- Stereotype assigned according to the characteristics defined for the classification established in the application model.

The information in this model is either provided directly by the user, or inferred through the interaction with the system, and for the first case the information must be sent by the application, either complete or by parts, through the toolkit interface. Several applications that contribute in the generation or maintenance of a group of models should be careful when making any modification, and remember that their requests are attended in the same order in which are received.

3.3 Usage model

The usage model is a representation of the behavior history of the user interaction [12], and we have separated it in two different logs:

- Access logs, used to obtain information about the usage frequency and regularities, such as: How many times? When was the last time? When does s/he usually access?
- Action logs. We take in consideration three kinds of actions, selective (such as following a link on a web page, linking a resource or printing a file), confirmatory (book marking a page, saving or downloading a document), and disconfirmatory (deleting a file, erasing a page from his/her bookmarks). Other actions that fall into these categories may be aggregated by the applications when considered valuable information as well.

3.4 Environment model

The environment model comprises data about the situational context in which the user is engaged. According to Roschelle [14], in the same physical space in which learning is taking place there is an overlaid network of wireless devices, and in order to relate the learner and his/her surrounding environment we have to represent the characteristics of both. In our representation, the environment model consists of 3 elements:

- Hardware information, such as processing speed, accessible input and display devices. Basically, promotes the terminal personalization for the user's device. For example, if the display of the device is small, the application could redirect the user to a smaller interface, or restrict the use of complex functionalities that consume more resources.

- Software information, including version, platform or available plug-ins. Before running a program or displaying a file, applications could verify if the device's installed software is capable of executing the action, otherwise prompting the user to install it.
- Location information, about the physical place, the objects at hand and other users located in the same area. This will contribute with a better insight of people and objects located around the user that could establish an interaction with him/her. One example of this could be an application whose users are supposed to do a cooperative work, and the best matches for the teams are decided by searching people in a nearby spatial location.

3.4 Toolkit

The toolkit is the component that interacts directly with the models, and provides an entrance point to the applications. We decided to have an extra component to give mobility and flexibility to the system. For its implementation we used Java programming language and followed the J2EE (Java 2 Platform, Enterprise Edition) specification, which supports the development of reusable components as well as the integrated data interchange using XML-based open standards and protocols. The toolkit has two interfaces, acting as:

- A remote endpoint that can be accessed through RMI (Remote Method Invocation) by applications programmed in Java.
- A web service endpoint that can be accessed through the SOAP protocol by applications developed using other programming languages.

4. Configuring and using the system

Since there is no direct interaction between this system and the users, the information to fill in the models is obtained from the application itself. At the development time, the application configures the application model using the assigned configuration interface (Figure 3). At running time, while interacting with the user the application submits the user registered actions and data which the server will process to update the models. These modified models are sent back to the application that will use them to support the personalization of its content, structure or presentation, in order to make it relevant to the actual situation of the learner.

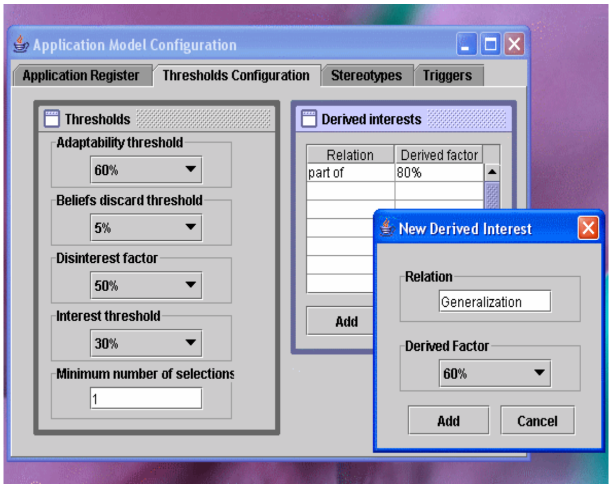

Figure 3: Configuration interface for the application model

5. Conclusions

This paper focused on the design and implementation of a centralized system with a multi-model based approach to support the personalization of ubiquitous computing learning applications. The main characteristics of ubiquitous learning [2, 5] are advocated by:

- Continuously recording the characteristics and behavior of the learner, to identify the learning processes. These records contribute to the permanency of the information.
- Using standard formats and protocols (such as XML, SOAP) for enhancing the accessibility of the information.
- Making information available immediately. Several requests can be processed at the same time, and the modularity of the system allows each module to be running in different host machines to improve the processing speed.
- Finding the best matches for peer interaction, and discussion groups based on the interests, capabilities and location of the learners.
- Keeping track of the actual situation of the learner, the environment characteristics and objects or people s/he can interact with. This information relates him/her with the surrounding environment and the application can designate appropriate instructional activities.

5. Future work

Until now we have finished the implementation of the proposed system, and based on its modeling services provided a learner model to support the personalization of the BSUL (Basic Support for Ubiquitous Learning) project. The evaluation of the performance of the system and the behavior of the models will take place in coordination with the testing of BSUL in two courses at the University of Tokushima. Depending on the results of that evaluation, we would like to continue improving the system and extend its services to other ubiquitous learning applications that are being developed at the same university.

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