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# Architecture of a System for Context-based Adaptation in M-Learning

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## Abstract

*In this paper, the architecture of a system that supports context-based adaptation for m-learning is presented. This system manages data about users and activities so that the most suitable activities to be accomplished at each time are proposed to each user. This decision is not only based on the user's personal features, preferences or previous actions but also on information about the specific user's context, including the spare time, location and available devices.*

## 1. Motivation

The number of users that access to Web-based applications daily with learning purposes is increasing continuously. The fact that different learners may have distinct needs, interests, preferences or personal features has been considered with adaptation purposes. With the aim of guiding each individual during the learning process, adaptation techniques have been used to customize the information space, the organization of information in this hyperspace, the navigational possibilities and the contents to be presented to each user in the corresponding web pages.

The rapid development of mobile and wireless technologies has given rise to a widespread use of different devices such as PDAs, mobile phones, laptops or tablet PCs, among others. These devices, along with those technologies, constitute a new and attracting opportunity for learning through the Internet.

Many applications have been developed with the aim of supporting information access from different types of devices. In this respect, adaptation techniques have been used in some cases for the customization of the contents to be showed through different devices.

Nowadays time is one of the most valuable goods. It is a fact that people tend to be too busy, to study or work in the university, at home or at any place when

possible (to get more free time), and spend quite a lot time travelling. Therefore, there is a need of supporting learning activities at any time, from any place and through different devices. Furthermore, the learning situations can be completely different in each case, and the suitability of certain learning activities for users in specific contexts may vary depending on the user and his/her particular situation. This suggested us the convenience of using adaptation techniques to support the management of mobile learning environments so that, given a specific user accessing to the system in a particular context, the system is able to suggest him/her the most suitable activities to be accomplished in that specific situation.

In this paper we present the architecture of such a system, which supports context-based adaptation for mobile-learning (m-learning). In section 2 the state of the art is presented. The architecture of the system, along with an example, is explained in section 3. Finally, section 4 contains the conclusions of this work.

## 2. State of the art

The main goal of *Adaptive Hypermedia (AH)* is to adapt the information presented to the users to their personal features, needs, preferences, goals, interests, and so on. In order to provide individual adaptation, it is necessary to store information about the users in what is called the user model [1]. From AH origins to nowadays, many adaptive educational hypermedia systems have been developed [2] [3].

Individual learning can be enriched by means of collaborative activities [4]. Learners can not only learn but also develop other personal skills [5]. Nowadays, there are some adaptive-collaborative systems such as EPSILON [6] and TANGOW [7].

In the last years, the use of mobile devices has been increasing continuously. Many people connect to learning systems using their personal mobile devices.

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This aspect, together with the technological advances in communications, has motivated new learning methods that support learning independently of the place, time and devices used by the users. This is how the area of *m-learning* appears, which is defined as e-learning through mobile and handheld devices using wireless transmission [8].

Currently there are many researches exploring the potential of mobile and wireless devices to support learning. One of their challenges is to adapt the learning resources to users' context, considering it along with their individual features [9]. For example, JAPELAS [10] provides the most suitable Japanese polite expressions depending on the learner's localization and his/her personal features and Ketamo presents a geometry learning game for handheld devices that is adapted to the user's behaviour [11].

### 3. Architecture of the system

The system presented in this paper supports the management of users and activities in mobile environments in which the users can accomplish activities either individually or collaboratively. It has its origins in the U-CAT project, whose main goal concerns the development of an integrated environment

that facilitates the realization of learning activities in arbitrary places by using different physical devices (personal computers, laptops, mobile phones and PDAs) in different contexts.

In this system adaptation techniques are used in order to suggest, to each individual when connected to the system, a set of activities suitable of being accomplished by that specific user at that time and in his/her particular situation. This is what has been called context-based adaptation, since decisions are taken not only by considering the users' personal features, preferences or previous actions, but also information about their specific situation at each time, such as the spare time, location or available devices.

The architecture of the system presented here corresponds to the adaptation layer of U-CAT. This layer takes information from the users and their context, and selects the set of activities for each individual. The architecture of the adaptation layer is represented in figure 1.

The actors of the system are the person(s) in charge of the activity design and the users interacting with each others and executing activities. The adaptation layer needs information about each user and the activities to be accomplished. This information is stored in the corresponding databases.

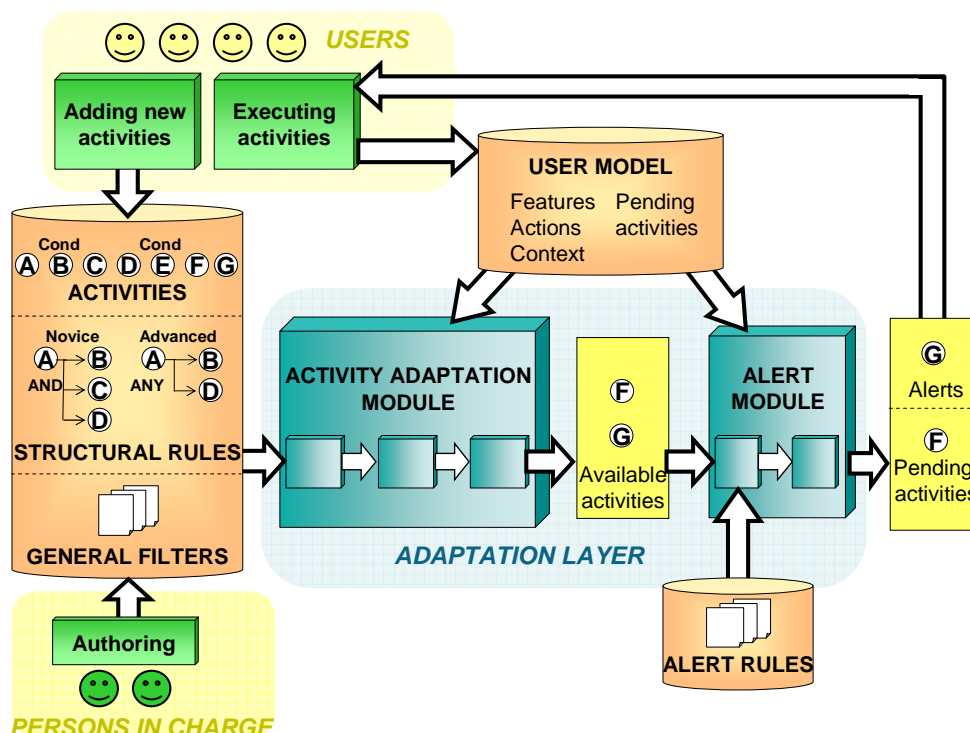


Figure 1. General architecture

All the information about the activities to perform (type, atomicity, relationships between them, etc.) is included in the system mainly by the persons in charge through an authoring process. Each activity can include conditions about its availability depending on the information stored in the user model. This information is related to the users' personal features (i.e. knowledge, learning style), their actions (i.e. activities performed, results of these activities), and their context when interacting with the system (i.e. spare time, location, available devices). It also contains information about the pending activities for each user.

Furthermore, the users of the system can create new activities such as messages to be read by their partners or tutoring requests.

The adaptation layer is composed by two modules:

- *Activity Adaptation Module*: It's the responsible of deciding which the available activities are, taking into account the characteristics and the current context of the user (more details in section 3.1).

- *Alert Module*: It receives the list of available activities from the previous module. For each activity, it decides if the user must be informed of its availability in an intrusive way or, otherwise, if it must be stored in the "pending activities" list, so that the user is not interrupted at that time (see section 3.2).

When a user finishes an activity, information about its accomplishment is stored in the corresponding part of the user model to be used from then on with adaptation purposes.

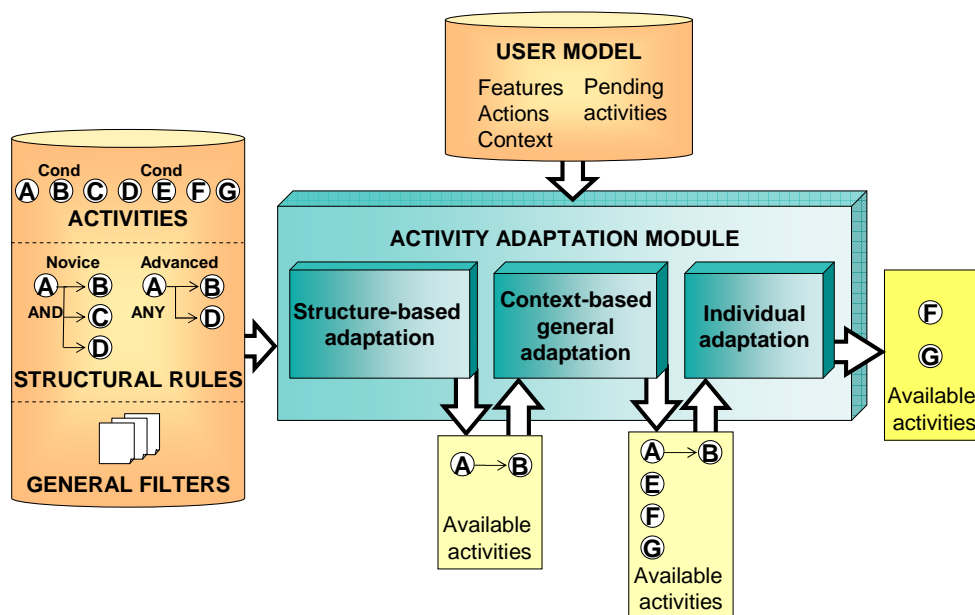
### 3.1. Activity adaptation module

This module is the responsible of deciding about the availability of activities and of generating the list of available activities to be sent to the *alert module*. It is structured in three submodules: *structure-based adaptation*, *context-based general adaptation* and *individual adaptation* (see figure 2).

For a better understanding of the functioning of each module, the following example will be used:

Several activities have been included in the database: A is a practical work to be done collaboratively. In order to do A, novice students must perform B (a first meeting between the group members), C (collaborative elaboration of a solution) and D (writing a report), in this strict order. Advanced students should perform only C and D, but in any order. These two possibilities for decomposing the same activity in different ways are specified by means of structural rules, as drawn in figure 2 (from now on, they will be named as rule 1 and rule 2 in the text, corresponding to the rules represented in the left-hand side of the database and in the right-hand side, respectively). Finally, E is an individual exercise, F is a review activity and G is a message sent by a user for a partner of the same work group.

The user connected to the system in this example is Alice, who is travelling from the university home. She has 45 minutes available. She has no previous knowledge (is novice) and her learning style is active. The system will decide what activities are more suitable for her to accomplish during her trip home.



**Figure 2. Activity adaptation module**

**3.1.1. Structure-based adaptation**

This module processes the structural rules, which establish, for each type of user accessing the system, the relationship between activities, as well as the order in which they must be performed, if any. Its main aim is to generate a list of activities to be suggested to the user. Initially, this list is empty. The first step is to select the activities according to the most appropriate rules for a certain user. For the same activity, the list of subactivities can be different depending on certain conditions related with the user’s personal features, preferences, as well as his/her current situation, including the context (spare time, location, available devices), pending activities and actions during his/her interaction. Therefore, the rule activation conditions are checked and the corresponding rules are triggered.

As Alice is novice, the condition of rule 1 is satisfied. Therefore, as the rule indicates that the activities B, C and D must be performed in this order, only B is added to the list of available activities.

**3.1.2. Context-based general adaptation**

This module consists of a filter that processes a set of general rules to choose the type of activities that are more suitable of being accomplished depending on the user context. Therefore, this module adds/removes activities depending on their type (review, individual exercises, collaborative activities or messages, among others). This filter affects to all the activities to be performed. The person in charge is the responsible of defining this type of rules (general filters in figure 2).

In the example, one of these rules indicates that if the user has an active learning style, is outside the university and has more than 30 minutes left, then review activities, as well as individual exercises are suitable of being done, and messages can also be received. Therefore, E, F and G activities are added to the list of available activities, since E is an individual exercise, F is a review activity and G is a message.

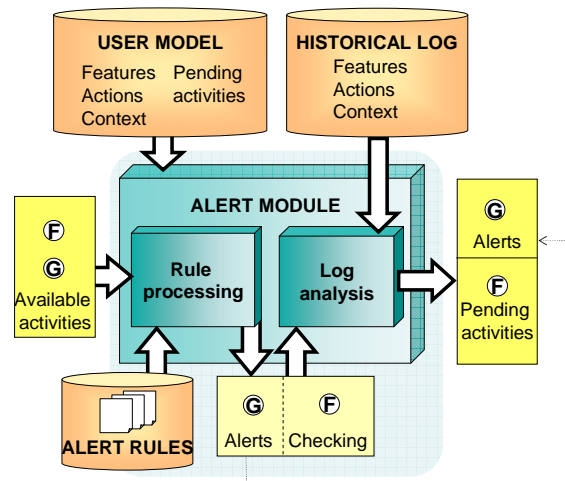
**3.1.3. Individual adaptation**

Finally, the third submodule checks the conditions of atomic activities, if any. These conditions can be related with any user feature or action stored in the user model. In the example shown in figure 2, B and E have activation conditions. On the one hand, B ones are related to the availability of the members of the group. On the other hand, E will be performed by novice students only if they have more than 60 minutes

available, while it would be proposed to advanced students in the case they have more than 30 minutes left. Therefore, the individual adaptation filter deletes B and E activities from the list because Alice, novice student, has not enough time for performing this activity and her partners are not connected. Consequently, the final list of activities to be proposed to Alice contains the activities F and G.

**3.2. Alert module**

The *Alert module* receives the list of available activities and decides if the user must be informed at that time about the availability of each activity intrusively or, otherwise, if the activities remain in the list of pending activities. This module consists of two submodules: *Rule Processing* and *Logs Analysis*.



**Figure 3. The alert module**

**3.2.1. Rule processing**

This submodule is the responsible of processing a set of rules that indicate in which cases the situation of the user is appropriate for alerting him/her about the availability of an activity, interrupting him/her. These rules may have conditions related either to information stored in the user model (i.e., location) or to the specific activities (i.e., priority). The result of this module is a subset of activities, along with information about the convenience of alerting the user or not about each one. For each activity, if the rules give information about the convenience of alerting him/her about it, the activity is added to the list of alerts or directly sent to the list of pending activities. In other

case, this decision can be taken by the *Logs Analysis* submodule.

In the example, this module receives F and G in the list of available activities. One alert rule indicates that messages must be directly sent to the users. Therefore, G is included in the list of alerts. Given that no information is provided for F (review activity), the next submodule can take charge of the final decision.

### 3.2.2. Log analysis

This submodule analyses the previous actions of the users to decide whether, in a specific situation, it uses to be appropriate to alert the user about the availability of certain activities. In order to do so, it considers the current situation of the user; it checks what the user did in similar previous situations when he/she was alerted about the availability of a similar activity; and, based on this information, it decides whether the user must be alerted. In the case that no much information about previous interactions of the user is available, the analysis is done with respect to what similar users did in these cases. The similarity between users is based on features of their user models.

In our example, no decision has been taken concerning the activity F. Therefore, this activity is processed. Let us suppose that the result of the statistical study is that more than the 50% of similar users in similar situations did not make any action concerning this type of activity when they were alerted about its availability. Thus, the decision consists on not interrupting the user but adding the activity in the list of pending activities.

## 4. Conclusions

In this paper the architecture of a system that supports context-based adaptation for m-learning has been presented.

The current situation of learners, which think of time as a valuable good and tend to profit from any spare time to do their tasks, makes it necessary to move from traditional web-based courses to mobile environments in which different types of activities can be accomplished in different contexts (different time, locations, situations and devices).

Therefore, this suggests the need of supporting different types of learners accomplishing distinct activities in diverse contexts. With this aim, rule-based adaptation techniques are used in the system presented in this paper, which is currently being developed. The modularization of the adaptation layer makes it

possible the specification of adaptation capabilities in different levels of abstraction. Rules can be supplied by the persons in charge of the learning environment. This makes it possible to describe the activities to be accomplished, as well as the adaptation capabilities of the system (that is, the situations in which they should be proposed to each student), in a flexible and configurable way.

## 6. References

- [1] A. Kobsa, "A generic User Modeling Systems", *UMUAI, Vol. 11*, Kluwer Academic Publishers, Netherlands, 2001, pp. 49-63.
- [2] Brusilovsky, P. (2001) Adaptive hypermedia. User Modeling and User Adapted Interaction, Ten Year Anniversary Issue (Alfred Kobsa, ed.) 11 (1/2), 87-110
- [3] R. M. Carro, A. Ortigosa, E. Martin, and J. Schlichter, "Dynamic Generation of Adaptive Web-based Collaborative Courses", *LNCS, Vol. 2806*, Springer-Verlag, Berlin, Heidelberg, 2003, pp. 191-198.
- [4] D. W. Johnson, R. T. Johnson, and E. J. Holubec, *Cooperation in the Classroom*, Edina, MN: Interaction Book Company, 1984.
- [5] R.E. Slavin, "Cooperative learning", *Review of Educational Research, Vol. 50*, 1980, pp. 315-342.
- [6] A. Soller, "Supporting Social Interaction in an Intelligent Collaborative Learning System", *International Journal of Artificial Intelligence in Education, Vol. 12-1*, 2001, pp. 40-62.
- [7] R. M. Carro, E. Pulido, and P. Rodríguez, "Developing and accessing adaptive Internet-based courses", *Virtual Environments for Teaching and Learning*, World Scientific Publishing Company, 2002, pp. 111-149.
- [8] D. Ktoridou, and N. Eteokleous, "Adaptive m-learning: technological and pedagogical aspects to be considered in Cyprus tertiary education", *Recent Research Developments in Learning Technologies*, Formatex, Badajoz, Spain, 2005, pp. 676-683.
- [9] A. Zimmermann, M. Spetch, and A. Lorenz, "Personalization and Context Management", *UMUAI, Vol. 15, 3-4*, Kluwer Academic Publisher, USA, 2005, pp. 275-302.
- [10] H. Ogata, Y. Yano, "Context-aware support for computer-supported ubiquitous learning", *IEEE International Workshop on Wireless and Mobile Technologies in Education*, IEEE Computer Society, Taiwan, 2004, pp. 27-34.
- [11] H. Ketamo, "mLearning for kindergarten's mathematics teaching", *Wireless and Mobile Technologies in Education*, Sweden, 2002.