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AulaNetM: Extension of the AulaNet Environment to PDAs

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Abstract. The widespread use of mobile equipment and wireless networks offers a huge potential for educational applications, since these technologies enhance traditional applications and bring about new ones. Interactive multimedia portable devices can be regarded as a powerful learning tool, even though there are restrictions such as small screen sizes, limited memory, unstable connectivity and difficulties imposed by mobility. In this paper, we present the AulaNetM, an extension of the AulaNet teaching-learning environment for PDA users, explaining how context information is important in order to enrich the learning activities carried out and, at the same time, select the content and the activities presented to the learner.

Keywords: context, m-learning, mobility, mobile computing.

Resumo. A difusão do uso de dispositivos móveis e de redes sem fio oferece um grande potencial de aplicações na área da educação, aumentando o potencial de uso dos serviços tradicionais já existentes e abrindo espaço para uma nova gama de serviços. Equipamentos portáteis, multimídia e interativos configuram-se como uma ferramenta de estudo poderosa, embora estes possuam restrições como tamanhos de tela reduzidos, pouca memória, conectividade instável e dificuldades impostas pela mobilidade. Neste trabalho será apresentado o AulaNetM, uma extensão do ambiente de ensino-aprendizagem AulaNet para usuários de PDAs. Também será mostrado como as informações de contexto são relevantes para enriquecer as atividades de aprendizagem realizadas e, ao mesmo tempo, selecionar o conteúdo e as atividades apresentadas ao aprendiz.

Palavras-chave: contexto, m-learning, mobilidade, computação móvel.

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1 Introduction

The use of mobile equipment coupled with wireless network technologies is growing quickly, increasing the potential use of already existing traditional services such as web browsing and e-mail and opening up space for a new range of services, such as those that make use of information about the user's physical location. The essence of what is being sought through the adoption of these new technologies is the possibility of having access to information, communication and services in any place at any time and in a more authoritative fashion than that which is provided by traditional computer networks. In view of this situation, education increasingly must include solutions that make use of these resources. It is to be expected that mobile equipment will be merged into learners' and mediators' day-to-day lives, both inside and outside the classroom, and that a number of innovative new features supporting teaching and learning will be added to software. Thus, the concept of mobile learning (m-learning) is emerging from the possibility of offering users more mobility.

In order to incorporate the benefits of these new technologies into the AulaNet learning environment, an extension of this environment is being developed that makes it possible to make use of mobility resources as well as adjusting it to the requirements of mobile equipment users. Context information has presented itself during the first phase of the development of this project as being a resource that enables users to better understand their study objectives and to decide about their next actions. One of the important factors guiding the development of this AulaNet extension, called AulaNetM, is the mapping of context information that is important to this learning environment.

The AulaNet environment is described in Section 2. Aspects about m-learning and mobile technology, respectively, are presented in Sections 3 and 4. Section 5 presents the extension of the Conferences service of the AulaNet for PDA users and the importance of context for the AulaNetM extension. Section 6 concludes this paper.

2 The AulaNet and the Information Technology Applied to Education Course

The AulaNet is a teaching-learning environment on the Web that has been under development by the Software Engineering Laboratory of PUC-Rio since June 1997. It is used by a number of different companies, both within and outside of Brazil, in Portuguese, English and Spanish versions. It is distributed for free through the Eduweb company (www.eduweb.com.br).

The AulaNet uses a groupware approach; that is, its architecture is based on the 3C collaborative model 3C [Ellis, Gibbs and Rein 1991] whose schematic is shown in Figure 1a. The classification of services that are available on the AulaNet environment, following the communication, coordination and cooperative elements of this model [Fuks, Gerosa and Lucena 2002], is shown in Figure 1b. These services allow teachers to create their courses and teach them entirely at a distance or in support of live classes. Of these services, the Conferences service was chosen as the starting point to expand the AulaNet interface to mobile devices.

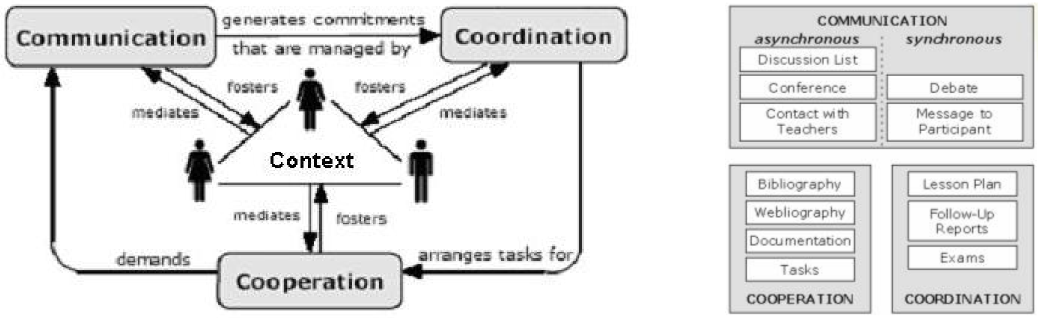

Figure 1 - (a) 3C Collaboration Model (b) Classification of the AulaNet services

The AulaNet development team also runs the TIAE (Information Technology Applied to Education) course [Fuks, Gerosa and Lucena 2002] that has been a regular offering of the PUC-Rio Information Technology Department since the second semester of 1998. This course is taught entirely at a distance through the AulaNet environment. The course's objective is to make learners collaborate using information technologies, turning them into web-based educators. Learning activities are conducted in two stages: in the first stage, learners participate in one conference and one debate about each one of eight program subjects; in the second stage, they are responsible for preparing a project (site) that makes use of interactive and multimedia resources.

3 m-learning

Given that it is a recent field of study, a number of different m-learning definitions have been adopted: some refer to equipment; others assume the users' point of view. A wider definition is the one that states that m-learning is any type of learning that takes place when the learner takes advantage of the learning opportunities offered by mobile technologies [O'Malley et al. 2003].

InkPen [1998] emphasizes that besides the mobile aspect, the advantage of m-learning is that it provides a greater opportunity for collaborative study. In m-learning, teachers and students can take advantage of the technology resources in places where it previously was not possible. The use of computers for studying is no longer restricted to the places typically set aside for this purpose and now take place in any one of the learner's natural environments. Instead of the student going to a desktop computer, he or she is accompanied by a small, customized, multimedia, interactive device that is able to connect to the Internet in different places. Information such as text, audio, images and video that are stored on mobile devices such as a PDA, coupled with the possibility of conducting Internet searches and being able to communicate with other people, offer students a powerful and portable study tool.

The advantages of adopting mobile technology are not restricted only to the expansion of connectivity and the introduction of mobility. Mobility turns location, whether it is absolute or relative, into context information that is significantly relevant and useful. One wants to know not only where one is but also where other people and locations of interest (buildings, geographical accidents, and different objects) are located. More than this, one wants to know how far away one is from a person or an object in the environment. Localization services will encourage meetings between learners and the sources of learning surrounding them, whether these are a person, a group, a building or a geographical accident, and they also will enrich the learning process through new activities. This is in line with theories of learning that emphasize how important it is for content that is learned be put into the context of the learners' environment [O'Malley et al. 2003].

4 Characteristics of a Mobile Environment

The mobile computing technology upon which m-learning is based has a series of limitations that must be dealt with. These limitations stem from three factors: the restricted resources of the mobile equipment, such as a small screen and limited memory; the poorer quality of the wireless transmission networks; and the difficulties imposed by mobility. In the latter case, a user may leave the coverage area and available services may vary from one location to another.

In view of these problems, a series of adaptations on different levels are proposed [Pitoura and Samaras 1998]. From the point of view of architectural layers, the adaptations can be made at the hardware level, at the operating system and network protocol levels and at the middleware level. In the latter level, context information such as location, the device's signal, battery charge and CPU occupation percentage are used to choose the most appropriate adaptation options. Especially, location information obtained through middleware is used to make it possible to offer services based upon localization (LBS).

Adaptations also can be introduced into the application level itself, such as by restricting the transmission of certain types of data and features offered by the service. Some advantages in this case are that at the application level there is a more precise understanding about the importance and the priority of a given task and the level of fidelity that users want to specify to their data. The application layer also is the most appropriate one for interacting with users when choosing the type of adaptation; that is, it can directly supply the context information that makes a better adaptation possible at any given moment.

Furthermore, application level context information is important in terms of helping save resources. The more restricted configuration of mobile equipment, especially regarding screen size, and the constant possibility of becoming disconnected do not permit resources to be used indiscriminately. In practice, this means that user requests must be resolved quickly through concise, precise and focused responses. One of the ways to achieve these objectives is to make use of context information that filters the content to be sent, keeping users from losing time selecting content, thus letting them carry out other activities in parallel [Lonsdale et al. 2003].

5 The extension of the AulaNet Conferences Service to PDA Users

Designed to initiate the investigation into the use of the AulaNet environment coupled with mobility aspects, an extension of the Conferences service was implemented that to verify the feasibility of an online mode of this service using a PDA browser. In a typical scenario, learners could use their PDAs to follow a course conference within the coverage area of a wireless network on a university campus.

One basic requirement of the system developed from this extension was that the system interface had to have fewer resources in order to be adapted to the smaller screens. The adoption of an interface with fewer elements also was advantageous in making it possible to reduce the volume of data to be processed, stored and transferred. Another factor considered was the option to use only basic elements of the HTML language that could be reproduced on the different PDA browsers.

In order to meet these objectives, it was decided to reconstruct the service's interface with the minimum amount of information and features required. The main consequence was the changing of the browsing mechanism used for reading messages and the exclusion of most context information. In this first stage, the feasibility and acceptance of PDA users in using their devices to participate in a conference with a high volume of messages was tested. It was also possible to observe what the most preeminent needs that users identified were in this new scenario.

The extension of the Conferences Service used the JAVA and SQL languages and servlet and JSP technologies. The PDAs included the Palm Tungsten C and the HP iPAQ 5555, both with color screens and Wi Fi interfaces.

5.1 Extension of the AulaNet Conferences Service to PDAs

The tree structure that presents the list of messages in a conference (Figure 2) was the target for the main change in the interface. Messages are read based upon this message list. A message is selected and, once read, the user returns to the message list. The advantages of a two-screen interface--one displaying the message and one the message list--are not available in the case of small screens. This occurs because the meta-information associated with each message--category, title, author and date--is presented on a single line. Furthermore, the indentation of this line depends upon the relationship of the message to the others. In the case of PDAs, the size of the message meta-data and the indentation cause the lines to break or for part of the information to run off the visible area of the screen. Regarding display, a message is contextualized with the meta-information of all of the messages that preceded it, which also leads to a considerable volume of text in terms of a PDA screen.

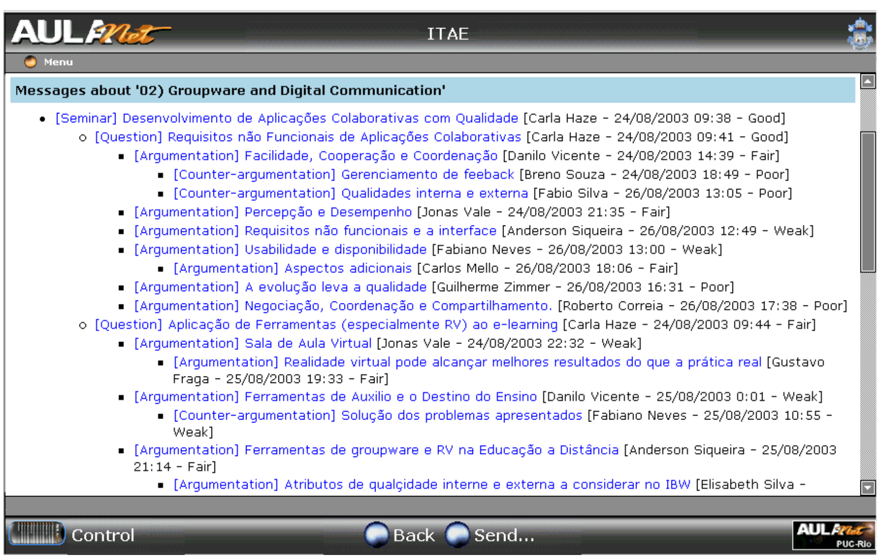

Figure 2 - Message List Screen in an AulaNet Conference

In the second form of browsing, it was decided to add more data to the message display screen in order to provide more message context information and to reduce the number of screens. In this option, every message screen is displayed with the following structure: the meta-information of the father-message, the message itself, and the list of the meta-information of the offspring messages. In order to view the other messages on the same level, users have to return to the father-message presentation screen, avoiding possible difficulties regarding the path that was taken.

To get around these problems and, nevertheless, maintain the structuring information, two browsing options were considered. In the first, the messages would be presented with “back” and “next” options. The previous message is the father; that is, it is the message that is being answered. In this case, there always is just a single previous message that can be immediately displayed on the screen. The “next” option would correspond to the answers to the message (offspring messages). Since there might be a number of responses to a single message, the choice of the next option does not lead to the text of an answer but, rather, to a list of answers (a list of the meta-information of the answers). Based upon this list, the users will select the response whose content they want to read. Browsing in order to delve deeper — that is, to read the answers to the answers — is accomplished by toggling between the message screen and the list screen. In the opposite direction, returning from higher message levels, the father-message is always unique and its contents can be displayed immediately. In this case, the number of screens that must be browsed is cut in half. One negative point is that the two directions present different browsing speeds. Another one is that, given that many requests are made to the server and the connection quality varies a lot, there is an increase in failure probability and also an increase in the response time.

The second browsing option showed itself to be more advantageous because each time a message appears on the screen it is contextualized with information from the father-message and the offspring messages. Furthermore, compared to the first option, a savings of one of every two screens was achieved. This has a positive impact in the case of mobile environments where the quality of the connection varies and where a fewer number of steps means a greater probability that the user will arrived at the desired information. Figure 3 illustrates some system screens.

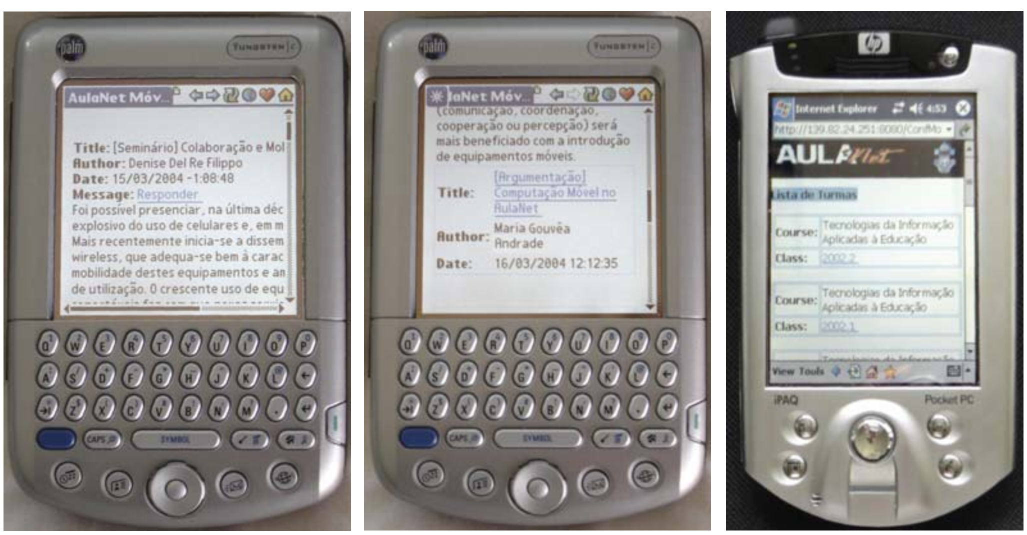

Figure 3 - AulaNet for PDAs: (a) Message presentation (b) End of a message’s text followed by the meta-information of an answer (c) A learner’s class list

5.2 Coordinating AulaNet Conferences through PDAs

The need identified by some students and mediators to present this conference structure in the form of a tree was mainly due to the importance of the information that it carries. From the point of view of a conference participant, the structure contextualizes the message within the conference: at a glance, it is possible to know where the message is within the conference hierarchy, which is the father-message, how many sister and daughter messages there are and how the discussion developed after a message was posted (Figure 4). Having this context information about the conference may lead to an increase in the level of interaction among the users, since it facilitates and organizes the discussion and supplies instruments to reduce information overload on people [Gerosa, Fuks and Lucena 2001].

More subtle context information also can be obtained from the conference tree structure. Depending upon characteristics of this tree, the mediators can appraise whether a quality discussion is taking place or not: if the tree has more depth than width, it means the answers are following up on previously posted messages. If a tree is wide and not very deep, the discussion is lacking quality since participants are limiting themselves to directly answering just a few messages without entering into a dialogue with the other participants who answer the same message. Gerosa et al. [2004] propose that this and other statistical information, such as the depth of the tree, the percentage of leaves and the size of the message be displayed visually to the mediators. Even without having to read the conference messages, mediators can intervene and guarantee that learners will participate in an adequate manner, since the information supplies warnings regarding problematical situations and an overall notion about how the conference is going.

Figure 4 - A conference and possible abstraction trees for coordination purpose

This tool for coordinating the conference is quite adequate for being used in PDAs for two reasons. The first is the visual aspect of the context information that is presented. Maps, charts, images and videos are preferable to text on the small mobile device screens. Another reason refers to the situations in which this information can be sought. In a typical scenario, mediators do not need to get to a desktop computer just to check how the conference is going. Only if they want to intervene and do not want to do it on a PDA would mediators need to have access through a desktop computer.

Besides the tool for coordinating the conference, another extension of this service consists of using context information from the course calendar to present pressing information to the users. Depending upon the activity to date, the opening of a conference could display different information. For example, in the ITAE course, if the learner accesses the service during the conference period, it appears immediately, and it is not necessary to select the course and then the course conference. If there is a conference underway, the most recent messages can be displayed.

5.3 Scenarios Based on Localization

The previous sections dealt with how the conferences could be used in an m-learning scenario and how context information could enrich the content presented to the user. Other AulaNet environment services also can be extended to be used by mobile devices, such as downloading teaching plans and the sending of alerts through SMS messages. However, these activities essentially are the same that already are available through a conventional Internet access environment. It is in the possibility of locating the learners and the learning objects they will relate to where m-learning could bring innovative activities into education. Some scenarios of activities based upon localization through the AulaNet environment follow.

A first scenario explores physical proximity of static objects. For example, learners are requested to pass through a given area of their city as a task. They participate in a game, earning points as they complete certain activities along the route. When learners intentionally or casually draw near to objects related to their fields of study, this proximity is detected and the content and activities being studied are presented to them. Information about buildings, monuments, streets, trees, mountains and rivers could be presented as the learners pass by them. The same object could present different content in different areas: for example, being near Sugar Loaf, one of Rio de Janeiro's picture postcard views, could trigger geological and environmental information, maps and statistics, aspects relating to civil engineering or even exercises proposing the calculation of the average speed of the cable car. A panoramic over flight could be simulated or events related to the location, such as the founding of the city, could be displayed. A student could even become a character in a fight game that makes use of historic figures and settings from the battles between the Portuguese, the French and the Indians. It should be noted that in the above scenario, the localization information introduces a difference from the current Web. The point here is that there is no search for information by the students: presentation of the content is set in motion by their location and selected by context information.

A learner could collect data, take pictures, record impressions and exchange them with other colleagues or mediators. The most relevant AulaNet service to be adapted for this activity is the Message to Participants, through which a learner can communicate online with other learners who are connected at that moment to the environment. An environment with this capacity follows the trend of the WWW service proposed by Spohrer [1997] in his WorldBoard: a spatial hypertext of worldwide scope, containing information anchored on locations and physical objects.

The location-based content to be presented would be selected according to different context information, such as the subject the learners are taking, the stage of the course, the need for greater study of a given area, the interest in the subject, the absence of tests and tasks to be delivered, the fact that it is not a holiday, the occurrence of special events and reputation among other mediators and learners regarding the content or activity.

Physical proximity of other people can be explored in a second scenario. An alert to the fact that a learner is near a mediator or colleagues could favor the holding of a live meeting where doubts could be resolved or decisions taken. The meeting-favoring aspect also could be extended to people who don't know each other but have interests in common. Location data coupled with a user's context information could generate an exchange of virtual business cards and meetings through the AulaNetM or a live encounter. Collaboration in observation activities also could be explored: for example, learners could exchange observations about a single location from different points of view if they were aware of the presence of some of the others in the region.

The selection of potential interlocutors in the situations presented above could be accomplished through different context information. Factors that could bring people together are such things as attending the same class, having participated in the same course but at different times, having the same interests, having a similar (or different) level of knowledge of a given subject or being a member of the same work group. Furthermore, a learner might want to meet the mediators only when the conferences are in session or only encounter work group colleagues when a task is being carried out. It also would be possible to refuse meetings on weekends, based upon the context information relating to the learner's availability.

In a third scenario, physical proximity of objects and people can be used to enhance learning activities. Games such as gymkhanas or treasure hunts are collaborative activities that are enriched by mobile equipment and features based on location. The learners go out into the real world to find objects scattered around a region. At these locations, the learners can find real objects, such as a book or a magazine about a given subject, and can carry out tasks, such as observing an animal or visiting a construction site, taking photographs, collecting plants, taking measurements, resolving problems and sending a message, among other possibilities. They could also run up against virtual objects--information, exercises, tasks, mediators and colleagues--alerted to them by their mobile devices at the moment in which they are getting close to the stipulated location. The information found is used to prepare a paper or as knowledge necessary for solving a problem or a project. It also serves as a supplement to or source of comparison with information deriving from other groups.

Context information should be used to filter the content that is presented to a learner. It can depend upon the group to which he or she belongs, the number of participants of the group who are collaborating on-line at a given moment, the tasks that must be carried out, the stages previously concluded and the number of points earned, among other possibilities. It is interesting to note that in such a scenario as this one, context information is strongly linked to the content and current status of the tasks, having to be especially created for the activity.

6 Conclusion

The system developed in this work presented a sub-set of features essential to the AulaNet Conferences service. Although adding other features and services is pertinent, one important line of investigation for proceeding further with this work is the creation of services that exploit all of the potential for use of mobile equipment on wireless networks. These services will introduce a wide range of resources and innovative ways to teach and to learn at a distance.

It was necessary to make adaptations to the original system, mainly to reduce the volume of text per screen in order to adjust it to the reduced space on a PDA. As a result, the browsing characteristics of the AulaNet Conferences service for desktop computers could not be used and the interface had to be revamped. Although an attempt was made to reduce the quantity of text per screen to its minimum, it was seen that the increase of non-essential but contextualized information about a message significantly reduced the number of screens that needed to be displayed. Besides offering more information regarding the context of a message, this solution also speeded up browsing because the server receives fewer requests.

Based upon the experiences and the scenarios presented in this paper, it was seen that context within the AulaNetM appears in a number of situations and different levels, with different functions: as a content filter, as meta-information for coordination, as support for the decision-making process and a link to the real world and subsequent association of objects of study to the world around learners.

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