What can we adapt in a Mobile Learning Systems?

Rim Drira[2], Ichraf Tirellil[1/2], Mona Laroussi[1/3], Alain Derycke[1], Henda Benghezala[2]
1 TRIGONE
2 RIADI
3 INSAT

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Abstract:

Adaptativity in mobile learning confronts a set of challenges. First, how to make use of technology without losing pedagogical aspect of learning. Second, how to specify adaptation dimensions, adaptation kinds and different relations between them -what to adapt, how we adapt and what to take into account to adapting-. In order to response to these questions, we begin by reviewing the literature to determine adaptivity dimensions and kinds introduced by the mobility. And then we introduce a proposed framework of adaptive mobile learning that treat the issue of how considering adaptivity dimension not only from a technological point of view but also from a pedagogical point of view. This framework is considered in our researches that are interested in developing mobile learning environments based on an adaptive content and adaptive learning activities. Finally, we detail how we exploit this framework to adapt Web services and SCORM (Shareable Content Object Reference Model).

1. Introduction

Advances in computer technology, intelligent user interfaces, context modelling applications and recent developments in the field of wireless communications, have created a wide array of new possibilities for technology users. When these technologies started to be used in education, a new learning paradigm, mobile learning, emerged. Thus, many new issues emerge and need to be explored. In this paper we are interested, in particular, on adaptation in mLearning. First, it's our research field. Second, while adaptation in elearning systems has attracted much attention, mobile learning is still struggling with basic technological and pedagogical problems. In fact, learning in mobile settings introduces certainly new dimensions of adaptation. So, the relevant questions which need to be answered are:
Did dimensions of adaptation in e-learning remain relevant in m-learning?
What are the differences between adaptation in e-learning and m-learning systems?
What to adapt in m-learning systems and how?
Many issues regarding adaptive mobile learning systems have not exhaustively been covered. Therefore, we are interested in our researches to adaptive mobile learning. Dealing with adaptation requires fixing initially adaptation dimensions. So, we begin with reviewing the

literature in order to conclude most relevant dimensions in m-learning -those inherited from e-learning and those introduced by mobility-.
Then, we suggest a general framework that presents how to deal with dimensions in adaptive m-learning systems.
The framework assembles different adaptation dimensions (user's model, user's context, devices and connectivity) and kinds (content, navigation, interaction, collaboration and presentation) in mobile learning and shows relationships between them with respect to the pedagogical aspect.
This framework is considered in our researches that are interested in developing mobile learning environments based on an adaptive content and adaptive learning activities.
Until now, an adaptive hypermedia system based on user's learning styles is already developed [Laroussi, 2001]. At present, our researches treat adaptive learning content and adaptive learning activities in m-learning.

The first theme aims to adapt SCORM[1] (Shareable Content Object Reference Model) [HREF2] so that it supports adaptive and mobile content. Indeed, in the actual version of the standard, SCORM 2004, there are some aspects towards learner-centred adaptivity missing [Mödritscher, 2004]. In addition, SCORM does not support mobility [Chan, 2003].

The second theme focuses on adapting learning activities using adaptive Web services[2]. To adapt SCORM or web services we choose a set of dimensions listed in the proposed framework and we use its adaptation's principle. More details will be given in the section V.
The remainder of this paper is organized as follows. Section II is the description of the adaptation in e- and m-learning systems. The general framework is introduced in Section III. The application of the framework in our research fields will be detailed in the section IV. Finally conclusion and future work is given in Section V.

2. Adaptive learning Systems: from e to m

In the glossary of elearningeuropa.inf, e-Learning is defined as: the use of new multimedia technologies and the Internet to improve the quality of learning by facilitating access to resources and services as well as remote exchanges and collaboration.
An e-learning environment is considered adaptive if it is capable of: monitoring the activities of its users; interpreting these on the basis of domain-specific models; inferring user requirements and preferences out of the interpreted activities, appropriately representing these in associated models; and, finally, acting upon the available knowledge on its users and the subject matter at hand, to dynamically facilitate the learning process. [Paramythis, 2004]
Accordingly, adaptive e-learning systems carry out adaptation in accordance with a user model [Laroussi, 2001] which constitutes the main dimension of adaptation in adaptive e-learning systems.

[1] SCORM is a collection of a set of interrelated specifications adapted from multiple sources to provide a comprehensive suite of e-learning capabilities that enable interoperability, accessibility and reusability of web-based learning content.

[2] A Web service is defined by the World Wide Web Consortium (W3C) as a software application identified by a uniform resource identifier (URI), its interfaces and binding are capable of being defined, described, and discovered by XML artifacts. This application supports direct interactions with other software applications using XML based messages via Internet-based protocols.

The User Model is a representation of relevant features of the user such as knowledge state, goals, preferences, interests, background, expertise, competence, learning styles, cognitive traits and other features that enable the system to distinguish different users.

2.1. What to adapt in e-learning?

According to [Paramythis, 2004], during an e-learning session we can adapt: interaction, course delivery, content discovery and assembly, and, finally, collaboration support.
- *Adaptive Interaction* refers to adaptations that take place at the system's interface and are intended to facilitate or support the user's interaction with the system
- *Adaptive Course Delivery* refers to adaptations that are intended to tailor a course (or, in some cases, a series of courses) to the individual learner. The intention is to optimise the "fit" between course contents and user characteristics / requirements,
- *Content Discovery and Assembly* refers to the application of adaptive techniques in the discovery and assembly of learning material / "content" from potentially distributed sources / repositories.
- *Adaptive Collaboration Support*, is intended to capture adaptive support in learning processes that involve communication between multiple persons (and, therefore, social interaction), and, potentially, collaboration towards common objectives.
The availability of high bandwidth wireless channels - such as 3G-telecommunication infrastructure, wireless LAN- and the popularity of handheld devices, has opened up new accessible opportunities for education. The true potential of e-learning as 'anytime, anywhere' has finally started to be realised with the advent of mobile learning (m-learning).
Mobile learning can be defined as "... any service or facility that supplies a learner with general electronic information and educational content that aids in acquisition of knowledge regardless of location and time ..." [Lehner, 2002].

2.2. What to adapt in m-learning

Mobile learning can be considered from two viewpoints:
The first one is a technical oriented perspective. It points out that e-learning simply becomes m-learning by creating an additional channel of access for mobile users with mobile devices -such as hand phones, PDAs or pocket PCs-. The content suitable for e-learning needs to be used and then available in mobile environment.
The second one is a pedagogical oriented perspective. It points out that m-learning supports a new dimension in the educational process. Development of new skills and approaches will be required to ensure the pedagogical effectiveness of mobile learning.
We are interested in both viewpoints in order to fix dimensions of adaptation in m-learning. We consider transmitted dimensions from e-learning and those raised up by learning in mobile settings.
With greater restrictions posed on mobile learners due to time, space and varied technical solutions available in different circumstances, adaptivity is expected to play even a greater role [Kinshuk, 2003b]. In fact, interesting possibilities arise with adaptive mobile learning

environments and additional issues that do not usually apply in e-learning environments become relevant.

The user model dimension of adaptation in e-learning is still relevant in m-learning [Bull, 2003]. However, supplemental features gain importance. In fact, the user model is extended with user's contextual information.

Also, new dimensions of adaptativity, provoked by the mobility will appear. These are mainly: device dimension and connectivity dimension. [Trifonova, 2004] [Goh, 2002]

- The user model dimension

Location and general context are new features to be considered. Indeed, some environments take the user's location or some aspect of the general context into account, in order to present information or provide an interaction relevant to the learner's situation. An illustration is [Zancanaro, 2003] a museum guide which uses infrared sensors in order to present multimedia information related to the fresco painting in front of which the user is standing. However, this kind of application does not necessarily adapt to the individual. All users in the same location may receive exactly the same information. [Jameson, 2001] argues for combining research in the fields of context awareness and user modelling. An example of such an approach is the LISTEN system [Zimmerman, 2003], which provides audio presentations according to the location and also the profile of a visitor to an art exhibition. These kinds of approach unite the fields of context awareness and user modelling in applications can be highly adaptive not only to relevant contextual information, but also to the needs or interests of an individual user.

The features of learner context are mainly: location, level of noise, temperature, light, objects in proximity of the learner, motivation, level of concentration and so on.

- The device dimension

It's crucial to consider capabilities of user's devise for the mobile learning adaptation due to the fact that they have a big impact on what content is possible and meaningful to be delivered. Mobile adaptation to devise should consider device's hardware attributes and device's software attributes.

Hardware attributes include: size and resolution of screen, Multilanguage capability, input possibilities (keypad, keyboard or pointer device), memory capability, processing power, cookies, supported media types and capabilities in presenting multimedia content, and so on.

Software attributes include: operating system, compatible applications and so on.

- The connectivity dimension

It's one of the main differences if we compare a mobile device with the PC (the usual medium for delivering e-learning). Nowadays mobile devices might be connected to 'The Net' via many technologies –WAP, GPRS, UMTS, Bluetooth, WiFi, etc. Mobile devices often have periods of disconnection, either intentionally (when the connection is too expensive) or not (when no infrastructure is provided). [Trifonova, 2004]

[Goh, 2002] consider that under this dimension, there are four operating sub-dimensions. The user can operate in a real-time online sub-dimension mode. In this aspect, the operating connecting speed and throughput determine some of the adaptation capability such a multimedia representation or text-based representation. Another sub-dimension is the pre-fetching capability of the application. While static pages can be pre-fetched easily, interactive applications need further consideration such as the depth of pre-fetching. Here device

capability and network reliability and connecting type are the main consideration for adaptation. The third sub-dimension is the off-line synchronization sub-dimension. Here the attributes of depth and encrypted cookies need to consider providing seamless adaptation especially for highly interactive application where parameters regarding users' actions need to be returned to the server. The last sub-dimension is the channel sub-dimension. This sub-dimension represents the actual mode of connection between the users and the server. For example in a satellite connection the user can experience a longer delay than a cable connection and a hot spot Bluetooth connection might not be suitable to support rich multimedia.
Mobile adaptation must take this dimension into consideration.

3. A general framework for m-learning adaptation

The term adaptive is associated with a quite range of diverse system characteristics and capabilities in the m-Learning industry, thus it is necessary to qualify the qualities one attributes to a system when using the term.
Adaptation in learning systems is two-fold: on the one hand, there is the question of what can be adapted in such environments and on the other hand, there should be a given answer to the question of how the presented dimensions influence the adaptation process.
According to section 2 there are many dimensions of adaptation in m-learning systems essentially: user model, user context, devices and connectivity.
The following figure shows the proposed framework. This framework assembles different adaptation dimensions (user's model, user's context, devices and connectivity) and kinds (content, navigation, interaction, collaboration and presentation) in mobile learning and shows relationships between them with respect to the pedagogical aspect.

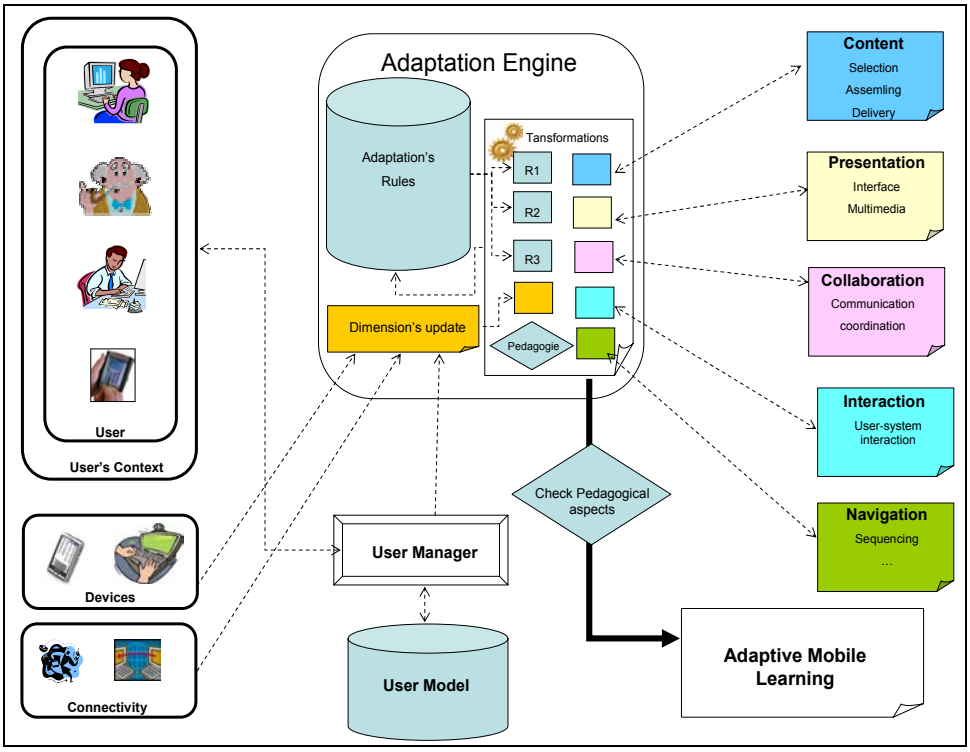

Figure 2: General framework to mobile learning adaptation

According to the user's model, user's context, mobile devices and connectivity we attempt to obtain an adaptive mobile learning system. For each adaptation dimension, many features should be considered (see sections 2), so it is difficult to adapt content, presentation, collaboration, interaction and navigation according to all features in the same time. Thus, it is recommended to specify which features carry out adaptation. In addition, we should fix what to adapt according to features chosen.

To adapt content we can adapt the elementary content fragment or learning object, the selection of adequate learning object or their assembly.

For adaptive presentation, it seems obvious to provide users who are visually strong or having high preferment interface, for example, with images, or graphs to common text. The visualization and animation of content, combination of text, sound, video and images is heavily influenced by the kind of users' learning modalities.

Adaptive navigation in learning systems is strongly effected by learning sequences [Rumetshofer, 2003], which describe the order and organization of learning activities.

Collaboration is adapting using a set of services such us mailing list, chat rooms, forums… Learning systems should therefore be competent enough to enable or disable access to these services according to individual requirements. Further services to support individual learning strategies may also be adapted with respect to student's cognitive styles. [Rumetshofer, 2003]

According to the adaptation's features, the adaptation engine determines what can be adapted using a set of adaptation rules. These will be used, later, in the suitable transformations to obtain the adaptive mobile learning with the respect to pedagogical aspects. Adaptation features can be modified using an updated process.

The suggested framework clarifies the adequate use of adaptation features. Since we can't consider all features at the same time, we begin, in our research, to treat a set of them.
Actually, we have proposed to adapt some interaction and collaboration aspects using adaptive web services [Tirellil, 2006b]. In deed, learning activities are modelled by Web services, then a Web services' orchestration algorithm treats some features of collaboration and interaction [Tirellil, 2006a]. We are concentrated now to adapt presentation using adaptive Web services. For the test a platform of adaptive mobile learning is in progress [Tirellil, 2005]
For SCORM adaptation issue, the next step will be to specify features of adaptation. Then, we intend to propose an extension of SCORM to support adaptive and mobile learning according to the features chosen.

4. How we exploit the framework in our research fields

4.1. Adapting Web services in learning systems

A *Web service* is essentially a stand-alone software component that has a unique URI (the Uniform Resource Identifier is a unique address), and that operates over the Internet and especially the Web.
In an e-learning system, a variety of aspects, features, and components can be perceived and realized as a Web service, including content authoring, content configuration into classes or courses, learning objects management, content updating, learner registration and management, content adaptation, learner profiling and tracking, testing of acquired knowledge, tutoring, virtual classroom setups, organization of chat rooms and the search for and presentation of content itself. Thus, we imagine that the entire functionality of a learning system is decomposed into individual activities which can be modelled as processes and provided as services, in such a way that the originally functionality can be reconstructed through suitable service compositions. [Gottfried, 2003]
So, to adapt learning system we suggest to adapt web services which compose it. According to the framework described in this paper, the adaptation engine adapt content, presentation, collaboration, interaction and navigation of a software component according to user profile, context and a set of adaptation rules.
For the web services, one feature of navigation concerns the question: how do we compose web services to satisfy user's profile and user's context? Which composition way is more adaptive?
To response to this question we are actually thinking about a dynamic composition. We define a dynamic composition as a composition on run time or on fly.
The collaboration for web services concerns web services negotiation to compose and to offer the adaptive results to the user.
We are interesting in our research essentially on tow facets of web service adaptation: the first is to adapt web services by adapting its description or profile and by adapting the selection of elementary web services, the second is to adapt web services composition dynamically [Tirellil, 2006a] [Tirellil, 2006b].

4.2. Adapting SCORM in learning systems

In this part, we introduce how we use the framework to adapt SCORM. According to the framework, it is complex to adapt all kinds of adaptation to all dimensions. So, we start by fixing, the content as kind of adaptation and the user and his devise as dimensions of adaptation.

Indeed, SCORM does not support user devise [Boyer, 2005] and many aspects towards user adaptativity are missing [Mödritscher, 2004] such as learning style, cognitive traits. Thus, the content adaptation in SCORM is based on limited information about the user interaction with content such as the result of an assessment or learning objects already visited. In addition, that information does not persist from session to session because SCORM does not support user profiling. So we propose to use the framework to adapt SCORM to support devise and user centred adaptation of content. We propose to:

- Add to connexion (API[3]) between the LMS and SCO (Shareable Content Object) new data elements allowing the exchange of devise and user characteristics.
- Propose a user model and devise detector as a plugin to add to the LMS (Learning Management System) so that we ensure interoperability.
- Extend the description of SCORM learning object with elements describing user characteristics and devise.
- Design and implement an adaptive engine –as described in the framework-. It will be activated, at run time, when receiving the user and devise information.

Technical description of our proposal will be detailed in a paper to appear.

5. Conclusions

In this paper, we presented dimensions of adaptation in m-learning. We proposed, then a general framework to support adaptation in mobile learning systems. This framework assembles different adaptation dimensions (user's model, user's context, devices and connectivity) and kinds (content, navigation, interaction, collaboration and presentation) in mobile learning and shows relationships between them with respect to the pedagogical aspect. Future work includes more study on adaptation process, in particular for learning objects and learning activities to meet new requirements of mobile learning. The relationship between the adaptation dimensions and the adaptation kinds still need to be carefully investigated. In addition, we will concentrate further on how to implement the pedagogical check in adaptive m-learning systems.

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Author(s):

Rim Drira[2], Ichraf Tirellil[1/2], Mona Laroussi[1/3], Alain Derycke[1], Henda Benghezala[2]
1 Laboratoire Trigone - CUEEP - Bât B6 Université des Sciences et Technologies de Lille
59655 Villeneuve d'Ascq cedex – France
http://noce.univ-lille1.fr/cms/index.php
Mona.laroussi@univ-lille1.fr;
Alain.derycke@univ-lille1.fr;
Henda.bg@cck.rnu.tn
2 RIADI ENSI campus de la Manouba 2010 Tunisia
Rim.drira@riadi.rnu.tn
Ichraf.tirellil@riadi.rnu.tn
3 INSAT Centre Urbain Tunis Nord BP 676 CEDEX 1080 Tunis TUNISIA