A General Architecture to Support Mobility in Learning

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Abstract

A rather new tendency in distance learning is the usage of mobile and wireless technologies to support learners and educators. In this paper we present an architecture, where the functionalities of e-learning platform are presented as web services and on top of it a mobile Learning Management System is taking the responsibilities of adapting those services for the mobile users and for providing additional mobile specific services. Such a system should have three main functionalities – "Context Discovery", "Mobile Content Management and Adaptation" and "Packaging and Synchronization".

1. Introduction

Online courses, web-based education, computer supported training and even virtual university are already wide used terms. All of them represent e-learning which is growing very fast both in educational end corporate environment. The rapid development of wireless infrastructure and the advent of mobile devices in everyday life of people push the research to combine those two domains, which results in the emerging of mobile learning [6]. Considering the functionalities of e-learning system in this paper we analyze the possibilities to extend it to provide services for mobile devices. This includes distribution of didactic material, user identification and authorization, gathering of data relative to the user-system interaction, provisioning of mobile services etc. We find suitable an architecture that provides interoperability between eLMS and mLMS (LMS stands for Learning Management System).

In Section 2 we give a description of what e-learning is and the services generally offered by e-learning platforms; then we discuss the problems in the transition from e- to m-learning (3). Section 4 is dedicated to the proposed architecture. Related work (5), conclusion (6) and references follow.

2. E-learning

E-learning has two main facets: the first is relative to using technology to support distance learning, the second is concerned with enhancing the learning experience with the help of information technology. In the first case the learners and the instructors can be physically separated (they never or rarely meet for face-to-face lectures, discussions, etc.) and thus all the learning process is technology-mediated. In the second scenario the traditional learning approaches can be supported with complementary services, like online delivery of the learning materials, support for collaborative work, virtual communities etc. In many cases both aspects are simultaneously present. The goals of e-learning systems and the functionalities they offer can differ: the needs and goals of know-how transfer in an industrial company are quite different from the educational needs of a university. The functionalities can be broadly grouped in four categories: access to resources (data), specific e-learning services, common services and presentation. We intend to first list the main services and then discuss how these services must be modified with the introduction of small ubiquitous devices.

a) *Resources*

- Support of learning objects (LO) – any digital material, link to other resources, active element (like simulations etc.). Breaking the educational content into small pieces allows modularity and reusability of the content. These chunks of digital resources can be rearranged in modules, like lectures and courses. To facilitate this process they are usually described by additional metadata (as prescribed by the LOM standard).
- Support for Learning Metadata – Repositories for metadata can help to catalog learning objects, and facilitate search and reuse.

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- Quizzes and questions: lecturers can create a pool of questions and answers to be used both for automatic formal examination (summative assessment) or self-assessment of the students.

b) *E-learning specific services*

- Content management services – In general any e-learning system has the notion of Course and Lecture. A course can be composed by collection of resources: syllabus, one or many lectures, a structure for describing lecture sequence, forum, board, etc. A lecture is usually composed by many resources: presentation, exercise, additional material. All these components should be organized and accessed through a proper engine. There could be searchable directories of courses, programs, etc.
- Assessment - one of the main advantages of computer-supported learning is the automation of some important processes. The self-assessment is one example. The pool of questions/answers and a suitable engine allow automatic generation of different versions of tests and quizzes and also automatic checking of the results, evaluation of performance and comparison with others' results.
- Knowledge management (KM) – today most e-learning systems do not really support knowledge management services. KM in general aims at extraction, summarization and organization of explicit or tacit knowledge from data sources (e.g. Web, e-mails, chats, etc.). Application of KM to e-learning can be of vital importance in companies, while in university context (where most of the knowledge to be acquired by the students is explicit and formalized) it can be a useful but less relevant addition.
- Tools to support learners and tutors in managing their learning resources - some systems allow different users to have their own workspace and to upload personal resources (links, documents, notes, etc.), or to markup learning material.

c) *Common services*

- Support of different actors (students, teachers, tutors, administrator and guests), and integration with the company (university) information system. Different users typically have different levels of permissions. Unregistered users (guests) can have some (typically very limited) level of access to the platform.
- Collaboration tools: synchronous (chat rooms, shared applications, whiteboards, web-cast, audio- or video-conference, role games, simulations) and asynchronous (FAQ, forums, wikis, blogs, message/news boards, e-mail, mailing lists). Usually few different services are offered for communication between users of the system (learners, lecturers, tutors, mentors). Some of these tools are mainly meant to support cooperative work, while others aim at sharing and accessing important or topical information.

3. M-learning

In the general case mobile learning can be viewed as any form of teaching or studying that happens when the user is interacting through a mobile device. Nevertheless here we try to transfer the services provided by an e-learning platform (enumerated previously) into the mobile context. We can easily see that there are services that need to be adapted to fulfill the limitations of certain devices, there are other services that are infeasible to transfer, but also new services appear, provoked by the mobility.

The connectivity is 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. Although it is predictable that in the future the 'always on' will be wide spread still it is not the case. Mobile devices often have periods of disconnection, either intentionally (when the connection is too expensive) or not (when no infrastructure is provided).

Devices' hardware and software characteristics have a big impact on what content is possible and meaningful to be delivered. Usually the web content is designed for desktop PCs, thus unpleasant and even rarely useful from a small-screened device. Nowadays mobile phones became more powerful with amazing speed (both from hardware and software point of view) however their screens will remain comparatively small. Often also the navigation is hard. Equipped with a small phone-style keyboard or a touch-screen (for the PDAs) the users might loose more time in searching where on the page the information they need is than in reading it. We can imagine alternative ways of navigation, for example voice commands. The memory available on a mobile device is also relatively small. It is possible to use extension packs on some devices like PDAs, which reduces some of the restrictions.

Location is a new thing to be considered. Although up to now we are talking only about limitations, confronting m-learning and e-learning there are also advantages. The small size of the device and the wireless connections make them available anytime and anywhere. The mobility opens variety of new scenarios. Services involving location-discovery are for example receiving directions how to get to a certain room or alerts for seminars/lectures that can be triggered while taking into consideration the current place and the time to get to the needed destination, location-aware printing of the learning content, etc.

4. The Architecture

In Section 2 we presented the functionalities offered generally by Learning Information Systems (LIS). The services approach (exposing web service interface to access these functionalities) allows flexibility, interoperability and possibility for extension. In this section we are presenting an architecture that will provide access to learning materials and other services to users equipped with mobile devices. Our goal is to have an architecture which is:

a) General – to be able to provide all possible services offered to the e-learning users from the corresponding eLMS, but also to support services that are new in the mobile context.

b) Generic – to support different mobile devices (digital pones, smart phones, PDAs, tablet PCs and etc.) with different characteristics and be easily extensible for the new generation devices.

To achieve this goal we believe that a "mobile adapter" should sit on top of the traditional e-learning system and provide adaptation of the existing e-services, like user identification, authorization, distribution of didactic material, gathering of data related to user-system interaction etc. In addition it should take care of mobile specific service.

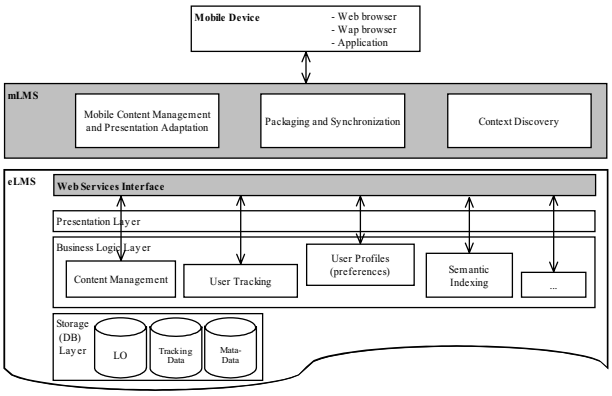

Figure 1: General M-Learning Architecture

The mobile adapter (in the following m-LMS) is a broker: on one side it has the mobile device, request access to it from a web browser, WAP browser or specific application.

On the other side we have the eLMS which exposes an interface to the services it provides. Only some possible services are shown on Figure 1. In the business logic layer these services might not be so clearly separated.

We identify three main modules in an m-LMS. They are:

- Discovery of context
- Content management and specific adaptations
- Support for disconnected operation

Let's see the interaction between different modules by giving a simple example. We can imagine a scenario in which a user requests an interaction with learning system from her PDA. The system shows to the user the services which it can provide and the user selects to requests more data about a seminar. The system provides to the user the information about the subject, speaker and location of the seminar, and if the user is interested also creates a reminder, which is triggered by the system depending on what time the user needs to get to the seminar room. Later the systems gives to the user direction how to get to the room and during the seminar lets the user watch the slideshow of the presentation also on the PDA display.

First the user request is captured and in order to proceed the system need to know who is the user and what is the device used. This is done automatically by the "Context Discovery" module, which (based on the first request or additional interaction) already hold the information about the user and the capabilities and limitations of the device (both software and hardware). Based on this data the system checks the user role (student, teacher, guest, etc.) and access rights in the eLMS, decides what services can be offered at this time and proposes a list to the user. After the next interaction with the user the m-learning system requests information about the seminar from the eLMS and triggers the "Mobile Content Management and Presentation Adaptation" module. Knowing the capabilities of the device (from the "Context Discovery" module) the data is redesigned and returned to the user. Afterwards the user requests the reminder to be set up for her. The system needs additional context information, namely the user location, in order to calculate the needed time to get to the seminar room. Once again the "Context Discovery" module is triggered to track the user current position. Meanwhile, as the system 'knows' that the network is not accessible in the seminar room, it triggers the "Packaging and Synchronization" module. The eLMS might contain big amount of materials concerning the seminar – the presentation itself, including explanations from the lecturer; related links; additional papers and examples; etc. As the system already knows the limitations of the device the "Packaging" module selects (with certain confidence) what part will be more useful and important during the seminar (for example only the presentation). In order to fit the device memory the system also 'asks' the "Presentation Adaptation" module to resize the images used. In the end the presentation is seamlessly uploaded to the user's PDA and is accessible when needed.

4.1. "Context Discovery"

This module adds an abstraction that can hide the details about the different physical methods of context

discovery. By context we mean identity, temporal information, spatial information (i.e. physical location), environmental information (i.e. noise level), availability of resources (i.e. battery, display, network, and bandwidth), and etc. For example for finding location different positioning systems can be used – outdoors a GPS system can be used while e inside a building the strength of WiFi signal from more antennas will be used. A possible solution is the introduction of a semantic server, which translates data from the format used by the device (GPS, WLAN, etc.) into a proper format for the service that requests the context information. It is not necessary that the system detects all possible context data at the first user request for service. Some context data might be detected and provided when needed (on demand).

4.2. "Mobile Content Management and Presentation Adaptations"

An important service provided by e-learning systems is content delivery. The presentation of learning materials is an important issue and should be carefully designed. If, for example, the content will be accessed through a standard web-browser on the PDA then it should not contain incompatible elements, like scripts. Adapting e-learning material for a mobile scenario might imply something more than a simple reshaping of material or translating from one presentation language into another. It should be more precise and could involve different presentation logic than in e-learning - "Mobile Content Management". The presentation adaptation can include adaptation of the structure, of the media format, quality or even type, etc. This module should be also used to adapt the presentation for auxiliary services, not only presentation of content.

4.3. "Packaging and Synchronization"

For allowing offline usage we require a mechanism for selecting what the user needs and also for taking care of content's coherence and synchronization with the system. During offline usage user activities should be tracked and the gathered data should be fed back to the LMS when the connection is re-established. This module should be able to predict which 'learning path' the user is most likely to follow and assign weights to the learning objects depending on how important they are for the next user session. The objects with higher weights should be uploaded to the device first; afterwards the materials with smaller weights should be uploaded until the device's available cache is filled. The module should be able to analyze how successfully the previous uploads were done and improve further prediction.

5. Related Work

A work closely related to ours is [2]. The authors discuss the possible m-learning scenarios in respect of e-learning platforms and the functionalities an m-learning platform is best suitable for. Also the characteristics of the mobile devices are discussed and their impact on foreseeable learning scenarios. What differs drastically in this work is that the mobile platform functionalities are direct mapping of the functionalities of an e-learning platform and only those that are impossible to deliver are excluded. In our opinion is also important to foresee the support of new services that are proper only in the mobile case, like location-dependent services.

In [4] context awareness architecture for mobile learning is presented. Similar to our "Context Discovery" module their "Context Engine" is responsible for gathering the context data. A very good description of context is given in a hierarchical structure with the notion of context states and substates, dynamics and historic dependencies of processes. The main difference from our "Context Discovery" is that authors suppose that all the context information is collected on the mobile device (including data obtained from sensors). In our vision some context data can be extracted directly from the infrastructure (i.e. location) and does not require adding additional load on the device. Also in our opinion we should support the presumption that the context data might be needed in different formats by diverse applications and services, thus there should be a way to 'translate' it properly. Still this work proves the viability also of our ideas. The authors also see the web services as a most appropriate way for integrating their context-aware (sub)system with a mobile learning system.

In [5] architecture for m-learning based on web services is discussed. The analyses here show that this technology is proper for supporting mobile equipped users in learning scenarios. The authors find one of the biggest challenges in the ability of such system to convert in satisfactory time the data (LO) from one format into another. They find the solution in preliminary (before request) creation of different versions. A major miss that we find in this work is that the only way the system would support the offline usage of material is on manual request of the user ("students could easily access and download the entire course content anytime anywhere on their mobile device").

A lot of work has been done in the area of content adaptation for mobile devices and of device independent representation of web content. In this context different

approaches are proposed for describing device capabilities; different architectural approaches are developed for using this information for adapting the content accordingly. A comprehensive review of the current device-independence technologies and activities can be found in [1] and http://www.w3.org/2001/di/. Transcoding servers or proxies are often used for adaptation of content (see e.g. [3]), which is retrieved by the server together with the client preferences and constraints. A negotiation is then done between the client and the server about the needed adaptations. Finally the converted content is delivered. Different transcoding techniques can be used for translating from one presentation language to another (e.g. WAP-HTML-WAP), for reducing the contents size, for satisfying bandwidth or screen capabilities, for adapting the structure of the content etc. What is missing here is that generally only online access to the content is considered. Only some of the transcoding proxies take care also for caching web pages for offline usage (e.g. AvantGo). Another point to consider is that in the learning scenario the content that is to be delivered could be sometimes quite large. We think that delivering content for offline usage is an important issue as still mobile devices are often disconnected because of the lack of access in certain places but also because of the high prices, thus our intention is to support both online and offline access to data.

The off-line access to data is treated in the offline browsing of web content. The typical pre-fetching solutions offered by offline browser utilities cannot be cast to the mobile domain without taking into account the (severe) memory limitations of such devices.

6. Conclusion

This paper presents a general architecture to support mobility in the learning scenario. We discussed the services provided by eLMS, how they have to be changed (adapted) for accessing them through mobile devices and what additional services should be supported. We identify three main functionalities for a mLMS, which sits on top of the usual eLMS - "Context Discovery", "Mobile Content Management and Adaptation" and "Packaging and Synchronization". Interaction between these modules will allow the automatic selection of services, properly constructed for devices' capabilities, user preferences and needs and will permit the usage both online and offline.

7. Acknowledgement

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