ESEIG Mobile:
an m-Learning approach in a Superior School

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Abstract. In recent years, mobile learning has emerged as an educational approach to decrease the limitation of learning location and adapt the teaching-learning process to all type of students. However, the large number and variety of Web-enabled devices poses challenges for Web content creators who want to automatic get the delivery context and adapt the content to mobile devices. In this paper we study several approaches to adapt the learning content to mobile phones. We present an architecture for deliver uniform m-Learning content to students in a higher School. The system development is organized in two phases: firstly enabling the educational content to mobile devices and then adapting it to all the heterogeneous mobile platforms. With this approach, Web authors will not need to create specialized pages for each kind of device, since the content is automatically transformed to adapt to any mobile device capabilities from WAP to XHTML MP-compliant devices.

Keywords: SOA, interoperability, services, e-learning.

1 Introduction

In our University we use a Learning Management System (LMS) to provide access to the learning resources and activities. In a recent survey (see section 3) we verify that a large number of students use mobile devices. They are already experienced with mobile technology, and are eager to use their devices in e-Learning scenarios. Another argument for the usage of mobile devices results from the students' profile since most of them is already employed while studying part-time. This situation decreases the chance to attend virtual events synchronously. Moreover, we also noticed that the students present different mobile devices with different characteristics that difficult the user experience regarding the access to mobile content. Based on these facts, we argue the need to automatically deliver uniform educational content on particular devices, normally referred as content adaptation.

In this paper we explore the use of open source technologies to provide a better design experience regarding mobile learning (m-Learning) content adaptation and promoting the "write once run anywhere" concept.

The remainder of this paper is organized as follows: Section 2 defines context delivery and enumerates several initiatives working on this subject. In the following section we present a survey made in our School regarding mobile devices. Then, we introduce the architecture of ESEIG Mobile and the design of its internal components. Finally, we conclude with a summary of the main contributions of this work and a perspective of future research.

2 State of Art

The concept of Content Adaptation is commonly related to mobile devices. Due to the variety of types and technologies supported they require special handling through a series of content transformations, in the deliver process, made by the content provider (server) [1]. Instead of authors having to create specialised pages for each kind of device, content adaptation automatically transforms an author's content to match the device characteristics. Some examples of such features are related with their limited computational power, small screen size, constrained keyboard functionality and media content type supported. The W3C Device Independence Working Group described many of the issues [2] that authors must face in an environment in which there is an increasingly diverse set of devices used to access Web sites.

One approach is to use the common capabilities of the mobile devices and ignore the rest. Finding the Lowest Common Denominator (LCD) of the capabilities of target devices, will allow to you design a site that will work reasonably well in all devices. In order to allow content providers to share a consistent view of a default mobile experience the Best Practice WG has defined the Default Delivery Context (DDC) as a universal LCD [3]. This purpose is commonly adopt, however it limits the devices with better capabilities than LCD and decreases the use of a wider and heterogeneous mobile audience.

There are different adaptation points in the delivery of content to the device: server-side, in-network and client-side. The former needs to negotiate which version of a document should be delivered to a user in order to define the delivery context. One of the most widely used delivery context information is through the HTTP accept headers. These headers can be used to obtain the capabilities of a requesting device, such as, MIME types, character sets, preferred reply encoding and natural languages. In addition to the accept headers, the User-Agent header includes not standard information about the device and the browser being used. This lack of standardisation increases the difficult to interpret and extend this data [4].

To overcome these difficulties emerged in recent years the device profiling concept - a repository of device capabilities, where a user agent (client) can supply the profile to the content provider (server), which can then adapt the content to suit the client device capabilities. The definition of the structure of the profile data is being covered by several standards, such as [5], [6] and [7].

Recently, to overcome the UAProf issues, the W3C MWI (Mobile Web Initiative) have outlined specifications for a Device Description Repository. These specifications include a formal vocabulary of core device properties and an API [8]. The consortium also published a working draft for a new independent language specification named

W3C's DIAL (Device Independent Authoring Language). This specification is a language profile based on XHTML 2 and XForms, and uses the DISelect vocabulary to overcome the authoring for multiple delivery contexts. One known implementation is the XDIME language. Targeting e-Learning, several extensions appears in recent years to expose the LMS (e.g. Moodle) in mobile devices. One such case is the Mobile Moodle (MOMO).

In recent years others specifications arises regarding this subject. It's the case of WNG [9] and WURFL. The Wireless Abstraction Library New Generation (WNG) is a Java tag-library that supports the use of universal mark-up for wireless devices. WNG allows the developer to write a web application once and have optimized content delivered to a variety of devices.

WURFL is a repository of wireless device capabilities describing the capabilities of common wireless devices worldwide and providing an API to programmatically query the capability repository.

3 Mobile Experience Survey

An exploratory study concerning mobile devices usage was made at our Institution. The aim of this study was characterizing the mobile devices usage, namely the diversity of mobile technologies and services used by students and professors, and analyzing future expectations concerning the usage of m-Learning platforms.

3.1 Research methodology

The survey was made using a questionnaire, sent to the Institution community, which includes almost a thousand and two hundred students, and eighty teachers. The questionnaire was sent by e-mail to all teachers, and the students were invited to answer the questionnaire through the Moodle e-Learning platform. The questionnaire was accomplished with a brief description of the study and their objectives, and it was structured in three main sections:

- Inquired profile: student or teacher;
- Services and technological characteristics: it comprises the identification of the main mobile services used and technological issues concerned with mobile devices;
- Educational mobile contents: it comprises the expectations about the usage of m-Learning platforms, the main services that they would like to use and the m-Learning constraints.

3.2 Results and discussion

We received one hundred and fifty valid questionnaires answers. From these ones, thirty two were from teachers and one hundred and eighteen were from students. Only two students answered that they haven't mobile devices. Regarding those who have

mobile devices, we analyze that the majority of them owns a mobile device with Internet connection as shown in Figure 1.

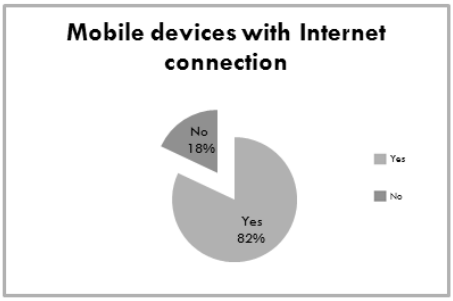

Fig. 1. Internet connectivity.

In fact, according to the survey results, eighty two percent of inquired persons have mobile devices with internet connectivity; from these ones, eighty six percent use internet connectivity based on GPRS (General Packed Radio Service) or WAP (Wireless Application protocol) technology, and only twelve percent of mobile devices support WiFi (Wireless LAN) technology.

One question addressed in the survey was about the main mobile services generally used by inquired persons. Figure 2 summarizes the achieved results.

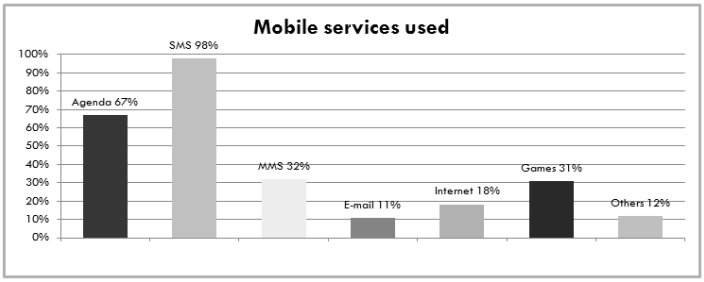

Fig. 2. Mobile services used.

Another issue addressed in the study was the potential role and expectations about educational mobile contents and services. Figure 3 summarizes the most relevant educational mobile services, according the survey answers.

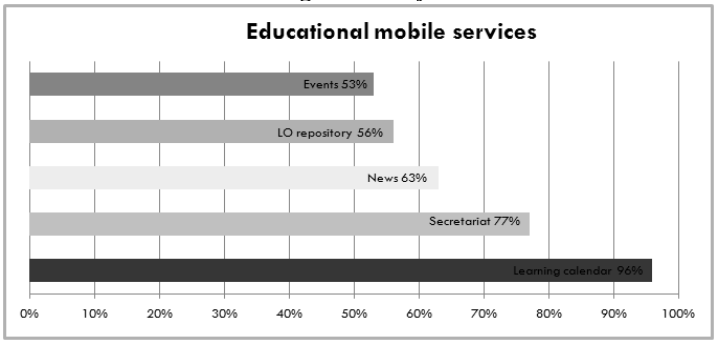

Fig. 3. Educational mobile services desired.

On the other hand, Figure 4 presents the main m-Learning constraints identified through the survey. The cost of the Internet provider, the screen dimensions and resolution are some of the students' complaints regarding the use of mobile devices.

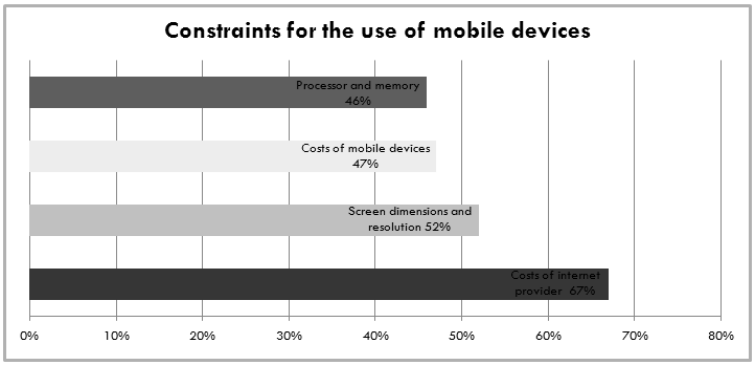

Fig. 4. Main constrains for the use of mobile devices.

The survey also includes two questions to analyse the expectations about the value added that m-Learning can bring to the students learning process. These questions are based on a likert scale of five degrees [10], from nothing important (level one) to very important (level five).

One of them if about the potential role of m-Learning in the learning student's process: eighty six percent on inquired persons answered from important to very important, like shows Table 1.

Table 1. Role of m-Learning in the learning students process.

Likert scale	Answers (%)
Nothing important	3%
Some significance	13%
Important	39%
Significant	34%
Very important	13%

Another question is about the potential role of m-Learning in the distribution/access to learning contents: eighty five percent answered that m-Learning could perform an important or very important role in this field as shown in Table 2.

Table 2. Role of m-Learning in the distribution/access to learning contents.

Likert scale	Answers (%)
Nothing important	4%
Some significance	11%
Important	38%
Significant	42%
Very important	5%

According the survey results it is possible to present some considerations:

- Almost all students and teachers use mobile devices with internet connectivity, however these devices present different characteristics and support different technologies;
- There are a set of educational mobile contents and services, identified by inquired persons, that they would like to use in a m-Learning platform;
- A large percentage of students and teachers recognize the potential contribute of m-Learning in supporting educational contents and services, bringing added value to the learning students' process.

4 Overall Architecture

Based on the previous survey, we decided to design an open system, called ESEIG-Mobile, to uniform the delivery of e-learning content to mobile devices. The ESEIG-Mobile system comprises two components – the **Core** and the **Repository** – that can be integrated in any e-Learning system. Figure 5 shows the inclusion of these two components in a typical e-Learning system. The Core component receives HTTP requests, performs the respective transformations in the requested resource and delivers an adapted content based on the capabilities of the requester device, stored in a special repository. This repository stores information about capabilities and features of many mobile devices. The repository is based on WURFL, an XML configuration file.

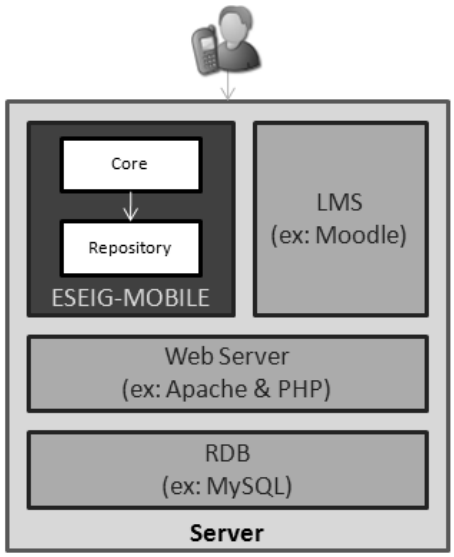

Fig. 5. Overall architecture.

4.1 The ESEIG-Mobile architecture

The architecture of the ESEIG-Mobile system is described by the UML component diagram shown in Figure 6.

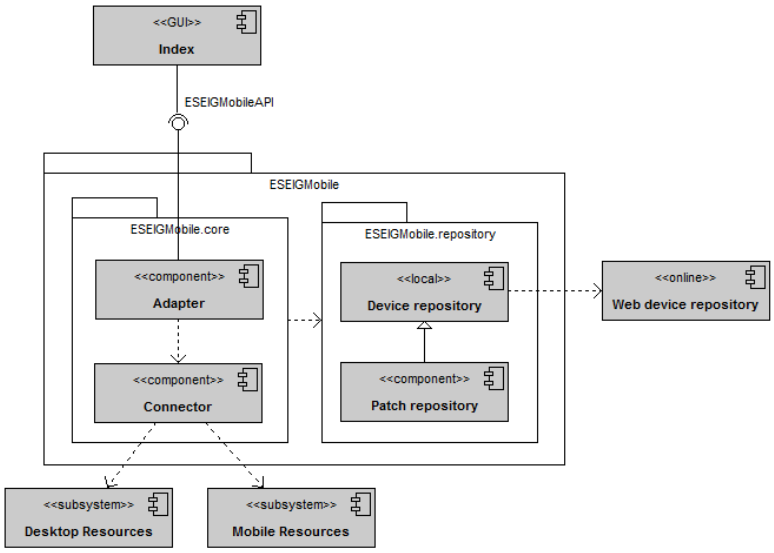

Fig. 6. Component diagram of the ESEIG-Mobile system.

The component diagram includes two main packages:

- The **core** package: receives HTTP requests and adapts content based on the capabilities of the device stored in a special database formatted as an XML configuration file;
- The **repository** package: includes a repository with device capabilities and a patch to handle new updates.

The **core** package includes two main components: the Adapter and the Connector component. The former is responsible for adapt the contents requested by the client device. This adaptation will be ensured, in a near future, by the use of WNG [10]. WNG is a JSP tag library that abstracts the mark-up differences in all known wireless devices and allows the page creation similar to HTML, while delivering WML, C-HTML and XHTML Mobile Profile to the client device. Device capabilities are queried dynamically using the WURFL API. The connector component deals with the information querying and merging from the specific resources. The connector component handles the connection with web resources.

The **repository** package contains a file with a large list of device features based on WURFL. The WURFL is an open source database (XML file) of wireless device capabilities. The WURFL repository can synchronize with a public repository of the WURFL DB where the developer community can make new additions to the WURFL DB. The **Patch repository** is a small XML file called *wurfl_patch.xml* that can enrich WURFL data dynamically. This file stores modified/enhanced groups and capability

lists for new or existing WURFL devices. When the WURFL is parsed, the patch file is also imported to build a modified version of the device database.

In Figure 7 we present the schema file of the WURFL repository.

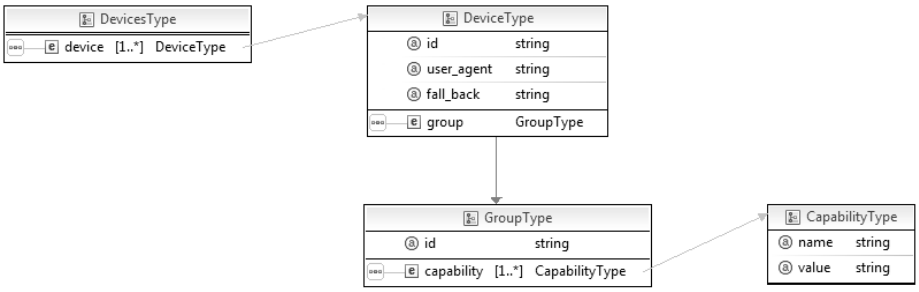

Fig. 7. The WURFL schema.

The WURFL is based on the concept of family of devices. All devices are descendent of a generic device, but they may also descend of more specialized families. This mechanism, called *'fall_back'*, lets programmers derive the capabilities of a given phone by looking at the capabilities of its family, unless a certain feature is specifically different for that phone.

For instance, Nokia phones support tables because *fall_back* is defined as generic (WURFL default) as described in the following piece of code:

```
<device user_agent="Nokia" fall_back="generic"
id="nokia_generic">
 <group id="ui">
  <capability
      name="break_list_of_links_with_br_element_recommended"
      value="false" />
 </group>
</device>
```

4.2 Evaluation

In this moment ESEIG-Mobile is in early development as we are only detecting if the HTTP request is made from a mobile device. We use the WURFL API to query the repository based on the *User Agent* header of the request and present a resource suitable to the respective device capabilities. The following snippet of code demonstrates how the detection is performed and how we can query a particular device capability:

```
  …
  require_once('./wurfl_config.php');
  require_once(WURFL_CLASS_FILE);
  $userAgent = $_SERVER['HTTP_USER_AGENT'];
  $wObj = new wurfl_class();
  $wObj->GetDeviceCapabilitiesFromAgent($userAgent);
  $max_colors = $wObj->getDeviceCapability('colors');
  …
```

The result is the adaptation of a suitable web resource according with the requester device capabilities as shown in Figure 7.

Fig. 7. An ESEIG-Mobile resource.

5 Conclusion

In this paper, we presented several approaches for defining delivery context and also a survey targeted to ESEIG students and teachers that base our work. The survey demonstrated the real perspectives and expectations of students and teachers' community, in this field of educational mobile contents.

We presented also the design of an open system for the delivery of suitable e-Learning content to the mobile devices of our students. The mobile devices advent could enable a more useful proximity between students and teachers, facilitating and promoting the learning process.

Our work is in progress, but we expect some challenges in the prototype implementation process regarding, for instance, the transformation of the Web resources in the WNG format. For this task we are considering using XSLT to formally describe the transformations.

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