Analyzing Moodle/LMS Logs to Measure Mobile Access

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***Abstract*—Most Educational Institutions worldwide have deployed web based Learning Management Systems (LMS) as a means to provide support for their presence-based lectures and offer online-exclusive learning. These LMSs were designed and developed for users accessing the system through web browsers on desktop computers or laptops. However, over the last years, an increasing percentage of the registered accesses to various LMS platforms have been from mobile devices such as smartphones. While tackling the problems arising through the design of a mobile client for the Open Source LMS Moodle called Moodbile, the question of how to decide which services of Moodle could be accessed from smartphones became very relevant. This paper presents a data analysis study conducted on the Moodle server logs of the Universitat Politècnica de Catalunya - Barcelona Tech (UPC) virtual campus, Atenea, and the insight gained regarding the particular characteristics of the accesses from mobile devices. The main achievement of this study is that it provides insight of the use of the university LMS from mobile devices.**

Keywors-M-Learning; LMS; Moodle; Web analysis; Activity Logs.

I. INTRODUCTION

With the vast majority of learning institutions around the world embracing e-learning as a valid avenue for knowledge dissemination, there is an ongoing struggle of a number of Learning Management Systems (LMS) for a piece of the market. Moodle is one of the largest open source LMSs with a registered user base of more than 57 million people and more than 66,600 registered and verified sites as of December 2011 [1].

Universitat Politècnica de Catalunya UPC – Barcelona Tech is one of the institutions that opted to move to Moodle from a proprietary LMS. The migration to this new Moodle-based platform named Atenea, was carried out in stages, starting in 2004 and completing in 2007. Since then, there has been a dramatic rise in the usage of the services provided by UPC's virtual campus both on-site and off-site and currently Atenea gives service to more than 30.000 students.

Parallel to the establishment of Atenea and the surge of activity in this new platform the smartphone market emerged from its shy beginnings to become an important part of the mobile device market [2], [3]. This soar in the number of users owning a smartphone over the past few years has inevitably been noticed in the general usage statistics of Atenea, where we detect that a small but not negligible percentage of all user accesses is done from smartphones.

This observation poses a series of interesting questions as to the nature of these smartphone accesses, their success rate and any special requirements they impose upon the LMS compared to traditional desktop usage. The predominant concern is whether Moodle in general, and Atenea in particular, are ready to cater effectively to the needs of smartphone users. This concern arises not only from a software development perspective, but also from the learning design of the activities.

Tackling the issue of the emergence of mobile users in the Open Source LMS Moodle, the Moodbile project proposes a Service Oriented Architecture (SOA) in order to provide mobile learning applications with a set of Web Services that give access to a set of Moodle functionalities, while keeping these services as abstract and decoupled as possible, so that they could easily be ported to other LMSs if necessary [4]. Once the project started, the question of how to prioritize the services of Moodle became very relevant.

To study this question, this paper presents a data analysis study conducted on the server logs of Atenea. This study tries to answer several research questions: What tasks do mobile and desktop users perform on Atenea? Are there any significant differences between the tasks performed by mobile users and desktop users? Are short access time tasks the best ones for mobile users? And, what tasks are more suitable to be adapted for mobile access?. One of the results of this study shows that mobile sessions are shorter than desktop sessions. In fact mobile users usually access the Atenea/Moodle server to do only one task. This and other results are discussed in this paper.

The organization of the paper is the next: since our general goal is to integrate m-learning applications with Moodle, the related work regarding this integration is summarized in section two. After that, to decide which services of the LMS may be adequate for mobile devices, the data analysis of the Atenea server logs is presented and organized in two sections; section three presents the research questions and method to analyze the data and section four presents the results we found. Section five presents a

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discussion of the most relevant issues and finally section six presents the conclusions and further work.

II. RELATED WORK

The integration between m-learning applications and LMS is not an easy task, because LMS do not usually include interoperability standards to communicate with external applications; they are usually designed as monolithic or layered systems [5]. This section analyses some of the previous projects that have extended the LMS to the mobile scenario.

This extension is based on the creation of m-learning applications that extend the scope of the LMS. Such mobile applications usually follow one of two different approaches. The first approach focuses on engagement with mobile devices and mobile native applications. The benefits of this approach include access to engaging design, free use of hardware features and fast and lightweight technology. However, the main limitation is that applications are device specific, which usually requires high development costs. The second approach focuses on the interaction with a browser, so the technology is ubiquitous and device-independent. However, it may also be slower and it may be harder to access for some smart phones.

Usability and online/offline work are important issues when extending LMS to the mobile world. Specific restriction on mobile devices to display information and to interact with the user must be taking into account, and properly adapted. Some m-learning applications allow offline work when network coverage is not available or expensive. Offline work also implies that mobile applications must, at some point, synchronize the data stored locally on the device with the data stored on the LMS [6].

Lehner and Nosekabel [7] did one of the first studies about mobile devices that interact with virtual campuses. In this study, m-learning complements traditional learning. The *Welcome* system was developed to offer access to certain contents and services (such as calendars or events) of the virtual campus of the *Regensburg University* using mobile devices. The communication between the virtual campus and the mobile device is done mainly using SMS messages.

A classification of the services and functionalities of a LMS are presented in [6] and [8]. LMS functionalities are separated in four groups: data resources, e-learning specific services, common services (such as authentication, authorization or event management) and presentation of contents. They also identify the main issues of a LMS's architecture that may be resolved to offer these services to a mobile device. These architectural issues are: 1) context discovery (the system must check automatically the mobile device features and decide which services may be provided), 2) adaptation of contents and 3) synchronization between the mobile device and the LMS. They present a custom-made LMS developed in the University of Trento that follows this architecture in order to support mobility.

Hinkelman [9] developed, in Japan, a module of Moodle 1.6 to do testing using mobile devices. This version mainly offered testing services and feedback to students. Due to technological issues, this project was developed to work with Japanese mobile phones (because the tool is based on CHTML and 98% of the Japanese mobile phones supported this language). Afterwards, a study to adapt Moodle to mobile devices centered in the adaptation of contents is presented in [10].

The *Open University* has been working on Moodle extensions to mobile devices for quite long time. At 2009 they presented Mobile VLE for Moodle, a m-learning application to access Moodle from mobile devices. This application provides a subset of Moodle functionalities to be accessed by means a mobile device. This selection was done by popular polls to students. Students rated very high the following LMS functionalities as candidates to be the mobile services: assessment scores, messages (read course messages and unread forum posts), tasks, planning (see current week and its tasks, also the following weeks and the whole course) and resources (read resources from mobile devices and download if it is supported by the mobile phone) [11].

Momo [12] (*Mobile Moodle*) and MLE [13] (*Mobile Learning Engine*) projects developed m-learning applications to access some Moodle 1.9 functions. The Momo m-learning application is based on J2ME (Java 2 micro edition, a java version for mobile devices) while the MLE project developed a J2ME client application and an additional web version to access Moodle courses from mobile browsers. Some of the Moodle modules/activities supported by this project are the following: lesson, quiz, task, resource, forum, survey, choice, wiki (read only), database (search and query) and message.

Project MPage [14] develops a Moodle 1.9 client for iPhone. Some of the Moodle modules/activities supported by this project are the following: view course categories, access MyMoodle, edit events, access to resources in different formats, chat, choice, forum and Quiz.

Moviltest [15] is a J2ME application to download Moodle 1.9 tests and execute them in the mobile phone. After finishing the test, the results can be sent back to the Moodle server.

Moodle.org [16] has published a list of functionalities for an iPhone client for Moodle. The main functionalities they want to offer are the following: 1) To upload video, audio and other file formats to the user's private space in the Moodle server. 2) To view courses where the user is enrolled as well as to view other users enrolled in the same courses. 3) To view activities and content of a course and to download these contents to the mobile client. 4) To view user grades for students. 5) To receive notifications from the Moodle server, as well as to create and send new internal email messages. 6) To view forums, discussions and create and reply posts. 7) To view calendar events and assignments deadlines.

The current version of the prototype designed by *Moodle.org* only allows uploading files to the user's private space in the Moodle server, viewing course participants and view the list activities and contents of a course.

The related work is summarized in Table I. The table contains the studies that extend LMSs to the mobile scenario. The respective functions of the LMS involved in the study are listed.

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TABLE I. SUMMARY TABLE OF THE DIFFERENT STUDIES INVOLVING EXTENDING THE LMS TO THE MOBILE WORLD.

LMS Functionalities from Related Work	
Source	***LMS functionality***
[8]	Upcoming Calendar events
[7][9]	Create an LMS adapted to info mobility from the scratch
[10]	Quiz
[12]	Resource, assessment, assignment, messages, posts
[13][14]	Quiz, lesson, assignment, resource, forum, survey, choice, message, wiki
[15]	Course activities, myMoodle, event, resource, chat, choice, forum, quiz
[16]	Quiz
[17]	View course participants, upload files, list course activities

III. RESEARCH AND DESIGN METHOD

A. Research questions

This work tries to analyze the characteristics of mobile users who access the LMS (Moodle) trough mobile web browsers and has been focused in answering the following research questions:

1. Which are the tasks performed by users from mobile browsers and from desktop or laptop browsers (referred to as desktops for the remainder of the paper for brevity)?
2. Is there any significant difference between the tasks performed from mobile devices and the tasks performed from desktops?
3. Are short access time tasks the best-suited ones for mobile devices?

Which tasks are more suitable to be adapted for mobile devices?

B. Related work

Several sources can be used to identify the basic patterns of mobile users accessing the LMS and which activities are more used from such small devices. The most popular approach is to make a survey for students and teachers [11], [19].

However, recently, new less intrusive and less subjective approaches are being adopted to gather data or requirements [20], [21]. These approaches include data analysis from different sources such as web server logs or LMS logs. Web server logs are vast collections of data about accesses to specific web pages. The main limitation of analyzing web server logs is that they contain only low-level data. LMS log files are perhaps the most promising source of automatic gathered online learning data. Since students typically login on such systems, the LMS logs keep track of users and sessions. These logs also gather a range of relatively high-level student data such as grades, posts in a forum etc. These data are more focused on student activity than web server logs. In [22], there is a summary of several alternative approaches to automatically analyze e-learning data as well as the different data sources used for the analysis.

Nevertheless, in the above approaches, only one data source was used. The challenge with respect to data gathering is the interrogation of several data sources. If the LMS data were correlated with additional information gathered from other systems, a richer picture of student learning process could be generated [23]. In our study, the data from the LMS and web server has been merged in order to gather information about the client operating system. Another limitation of the previous approaches is that none of them are specifically designed to analyze mobility and LMS.

C. Data sources and analysis

This study was conducted using Moodle/Atenea logs and web server logs of the first academic semester of 2011. More than 15 million entries/registers were analyzed. We have addressed the analytical process in the following three phases, shown in Fig. 1.

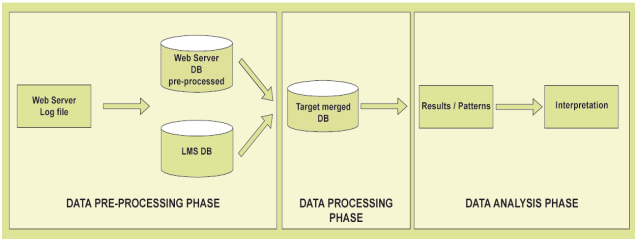

Figure 1. Data analysis phases.

1. Data Pre-Processing: that includes selection and capture of data. During this step, data is cleaned from empty or useless web server log entries. Some derived information is calculated or aggregated from web server log entries (see Table II). All this information is stored in a relational DB and merged with the entries provided by the LMS log. The merging criteria take into consideration data and time, IP-address and Moodle module accessed or type of action performed (view, add, update, etc.).

TABLE II. EXAMPLE OF PRIMARY AND DERIVED VARIABLES FORM WEB SERVER AND LMS LOG.

Variable name	Description	Type (Primary/Derived)
Course	Moodle course id	Primary
Module	Moodle module accessed	Primary
Action	Moodle action performed	Primary
Operation System	Type of operating system	Derived
Year period	Exams or lectures	Derived
Day slot	Morning, midday, afternoon, evening, night	Derived

2. Data Processing. In this phase, data of the database is processed and aggregated accordingly to facilitate the generation of partial reports to support the analysis and to answer our research questions.
3. Data Analysis**.** In this phase, data is analyzed based on the previously generated reports and conclusions of the analysis are presented.

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IV. RESULTS AND FINDINGS

The analysis of the data retrieved from both sources points out that most of the accesses to the LMS (96,21%) are performed from desktop or laptop computers, while only 3,48% are from mobile devices and 0.28% from tablets. Three distinct types of accesses to the LMS have been identified: queries, updates and logins/logouts. Fig. 2 shows the relative percentages of the three types of accesses for desktops and mobile devices.

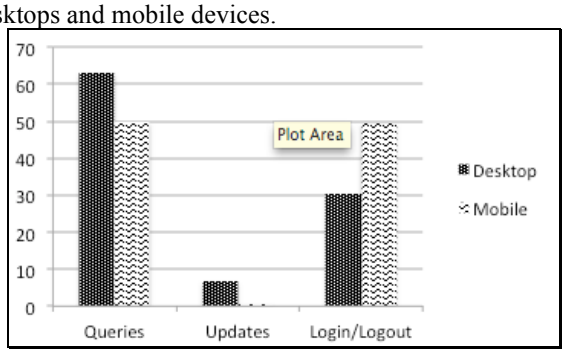

Figure 2. Relative percentages of the three types of accesses for desktops and mobile devices.

Regarding mobile Operating Systems, more than half (58.49%) of the registered accesses were from an iOS device followed by Android devices (18,67%) and Blackberry OS (12%). Fig. 3 presents a detailed breakdown of the various OS percentages.

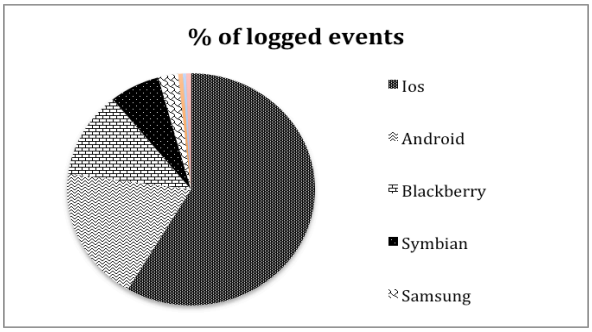

Figure 3. Breakdown of logged events by mobile OS.

The number of logins from mobile devices is very high compared to the total number of mobile operations. Therefore, we have isolated the average % of mobile logins and we detected that the mobile sessions are very short, almost atomic: 45,15% of the average events recorded from mobile devices are logins, while only 23,74% of the logged events from desktop computers are logins. This situation is similar in almost all the mobile operating systems (except from Windows CE and Android mobiles where the average % is a little lower). Therefore, we can state that many times the mobile users try to login to the LMS without success and when they do succeed; they only do one action (the average number of actions per session from mobile devices is 1,12 compared to 3,21 in desktop). In this sense, we hypothesize that Mobile users usually access the LMS from a link to do one single action. Additionally, logs state that the usual entrance point to the LMS is not the main course page, because only 20% of the logged events correspond to the "course view" action.

Finally, we have analyzed which actions mobile users and desktop users perform in the LMS. In general, the most frequently used LMS activity modules are quiz, assignment, forum, course, resource and the access to the user profile, as it is shown in Fig. 4. Among update actions the most attempted action from mobile devices are "answer the quiz" followed by "post in a forum".

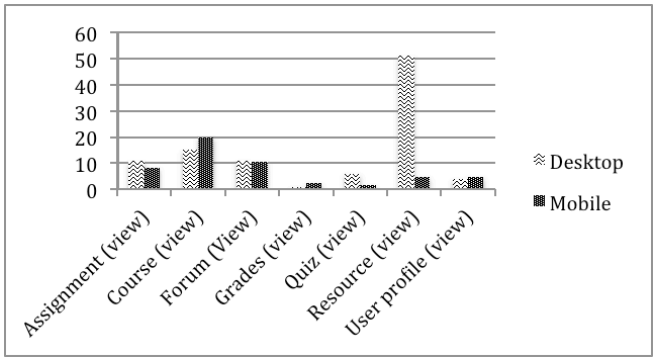

Figure 4. Percentages of query actions carried out.

To analyze the actions with a higher percentage of mobile users, actions have been divided in two groups: updates and queries. Action-updates with a higher percentage for mobile users compared to desktop ones are quiz attempts with 86,85% from mobile devices compared to 67,12% from desktop users, followed by forum accesses for discussion/post creation with 10,51% vs. 5,27%. Action-queries with a higher percentage include course view with 20% vs. 15 user profile view 4,87% vs. 3,96% and finally, consulting grades with 2,44% vs. 0,96%. Another observation is that "view resources", which is the second most queried activity, has a similar percentage across both platforms (50,5% for mobile compared to 51% for desktop).

Furthermore, we have analyzed and compared the data retrieved during spring lecture season (February - May) of 2011 and of the exams season of autumn semester (January 2011) of 2010 and the spring semester (June) of 2011. 61,86% of the total registered accesses were during the spring lecture season and the 38,14% were during the two exam periods. Table III shows the relative percentages of the accesses during these two periods. We have also included activity from tablets for completion purposes.

TABLE III. BREAKDOWN OF ACCESSES REGISTERED DURING LECTURE AND EXAM PERIODS.

	Exams (E)	**Lectures (L)**
Desktop	95,34%	96,75%
Mobile	4,29%	2,98%
Tablet	0,32%	0,25%

From the table data, we observe that although the activity from desktops remains almost unchanged during the two periods, there is a roughly 50% increase in activity from mobile devices.

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Figs. 5 and 6 present the variations in activity for mobile devices and desktops across these two periods.

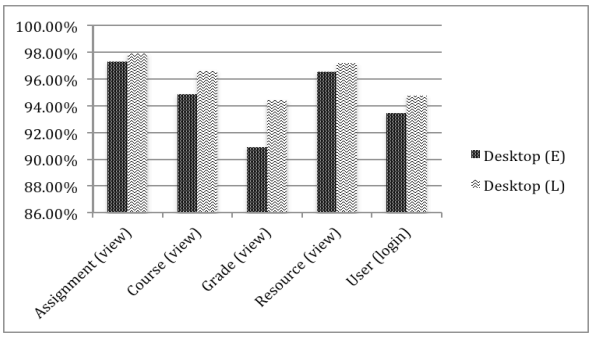

Figure 5. Desktop activity during exams (refered as E) and lectures (refered as L).

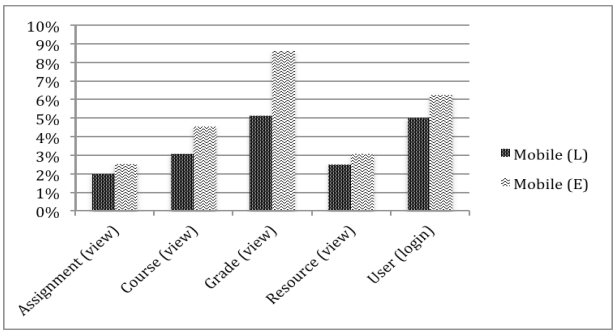

Figure 6. Mobile activity during exams (E) and lectures (L).

From Fig. 6, we see that during the exams period, mobile users mainly consult grades followed by course view and resource view.

Finally, we divided the day into 5 time periods:

- Early morning (0:00 – 7:00)
- Morning (7:00 – 13:00)
- Midday (13:00 – 16:00)
- Afternoon (16:00 – 20:00)
- Night (20:00 – 24:00)

In general, we notice that activity is higher during the afternoon (34,47%) followed by morning (28,58%), midday (18,28%), night (13,33%) and finally, early morning (5,33%). Fig. 7 shows a rise in mobile activity during the night hours while desktop activity drops during the same hours.

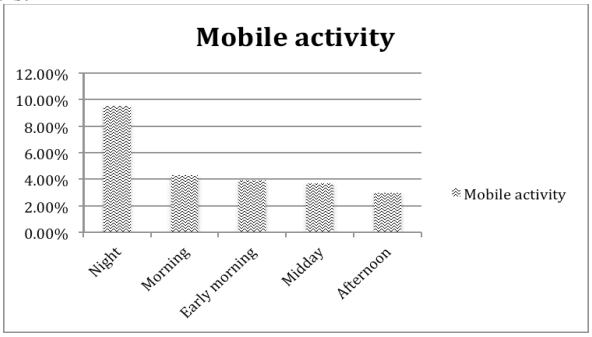

Figure 7. Breakdown of mobile activity during the different time periods.

Analyzing the mobile activity in more detail, we notice that queries and updates increase considerably during night hours (7,15% of the updates and 9,07% of the queries), followed by morning activity (0,49% of the updates and 3,45% of the queries).

During night hours the most accessed activities are: view grades, view course, view wiki, view user profile, view choice, enroll into course, add posts or discussions in a forum, and view task.

V. DISCUSSION

The first interesting observation is that most of the Atenea modules that are accessed using computers seem to be used as well from mobile devices. One explanation could be that the Atenea has been modified by UPCnet to improve accessibility and usability. These improvements include adding caption fields to tables, links and figures, adding explanations to popup menus, etc. [24].

Another issue is the high percentage of login activity from some mobile devices. The login activity represents approximately 45% of the mobile activity. From this we deduce that many times the mobile user cannot log in to Atenea. Fig. 8, shows the percentage of mobile activity dedicated to login attempts.

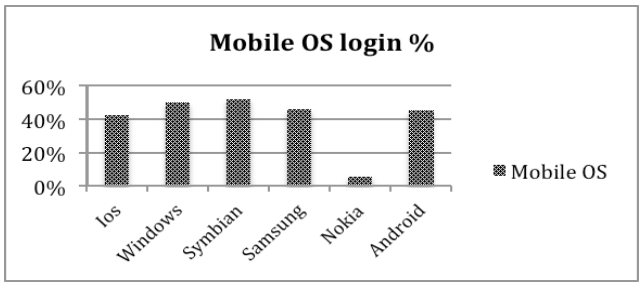

Figure 8. Percentage of mobile login activity.

From the related work and the Atenea log analysis, we have found that the following Moodle features are the most accessed from mobile devices.

TABLE IV. MOODLE FEATURES TO BE USED FROM MOBILE DEVICES.

	From Related Projects	From Atenea/Moodle log Analysis
Internal Message	x	
Forum posts and discussions	x	x
Task /assignment	x	x
Resource (view)	x	x
Choice and quiz	x	x (quiz only)
Course activities (view)	x	x
Course participants (view)	x	
Grade (view)	x	

So, we have considered the following Moodle features as necessary to be includes in the Moodbile project development pipeline: view course activities, view course

participants, view student's grades, view resources, view and upload tasks, access forums and discussions, read and reply posts, do quizzes, view upcoming calendar events and view user profiles.

VI. CONCLUSIONS

In the analysis of the logs of Atenea, only 3,48% of accesses came from mobile devices; but in spite of this, it is fair to assume that this percentage is going to grow significantly. Relative large screens (4,3 inches and above) that replace the cheap feature phones are starting to show up on the smartphone market. Some market studies show how tablets (with screens from 7 to 10 inches) are cannibalizing the market of cheap netbooks that students used to buy during the last four years [25].

From the results of the study, we find especially relevant our hypothesis that mobile users usually access the LMS from a link to do one single action. This hypothesis is based on the fact that mobile sessions are very short (about 1.2 logged actions per session) and that from the logs we know that students do succeed in doing this action. From this we conclude that the navigation design of the LMS needs to be tailored for this quick usage pattern.

Another issue is the fact that almost half of the actions performed from mobile are to log in and out. Mobile LMS front-ends should automatically login the student/teacher, cache the contents of the LMS, and make it available offline when connection is unavailable, slow or expensive.

Finally, teachers need to be aware that students access their online courses through mobile devices, and make their online courses more mobile friendly. Learning design has to take this issue into deep consideration.

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