# Enabling mobile access to digital libraries in digital divide contexts

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*Abstract* — **Digital libraries (DL) have had a tremendous impact on improving the accessibility of scientific and academic publications. In developing countries, they seem to be the great hope, due to the serious existing problems with the traditional publishing and distribution mechanisms and to the potential they have on enabling access to a great panoply of publications. Moreover, accessing digital libraries over mobile devices has the potential of reaching a broader community of users and on helping to bridge the digital divide, since there are very reduced computer and Internet penetration rates in these countries, along with a higher mobile phone usage. For developed countries, accessing digital libraries on the go might also bring important added value. This paper features an analysis of the major issues related to making digital libraries accessible over mobile devices. A specific study on the possibility of using mobile digital libraries in a developing country context is also presented along with a proposal for making DSpace based digital libraries accessible over mobile phones.**

***Keywords-Digital library; digital divide; developing countries; Cape Verde, mobile phones; mobile digital libraries; DSpace***

## I. INTRODUCTION

A profound revolution on the distribution of scientific and academic publications, started taking place with the birth and development of digital libraries. A vast panoply of resources are now accessible theoretically at anytime and from anywhere, as far as, for instance, a computer with Internet access is available. For developing countries, digital libraries are seen as a great hope. These countries traditionally face serious problems in accessing printed publications, and there are evidences that print-based library services have failed on their mission of providing relevant and timely information [1]. Printed publications are very expensive for the buying power of the developing countries. In Africa, where more than 50% of poorest countries in the World are located, the printed academic books are too expensive for the majority of students [2]. The traditional distribution mechanisms tragically failed the developing world [3]. Thus, digital libraries are a good alternative. However, developing countries face several problems in building and using such libraries: low computer and Internet penetration rates, poor ICT infrastructures, low level of digital literacy, lack of financial resources, etc. [4].

A possible alternative is making digital libraries available over mobile phones. If computer access in developing countries is a real challenge, mobile phones are available to a broader percentage of the population. In many regions where the wires are difficult to reach, mobile devices Internet access seem to be particularly important. Therefore, these devices can be used for accessing the resources available in digital libraries. Thus, making digital libraries accessible on mobile phones and understanding the way they are perceived and accepted in this context, seem to be very important.

In the developed world, the massification of mobile phones usage, with an average penetration rate around 118%[1], the proliferation of smartphones, the increasing global data traffic over mobile networks which has bypassed the voice traffic, along with several other reasons, make mobile devices also an important alternative way of accessing scholarly publications. In fact, estimations indicate that within a few years, more users will access the Internet from mobile devices than from desktop computers [5]. This shift to mobile Internet access has been experiencing interesting growth since 2007 with larger multitouch smartphones, and with multitouch tablet computers since 2010.

Making services available over mobile phones, requires however a good level of understanding about users needs and requirements as well as overcoming several issues that are traditionally related to using mobile phones for online activities, such as small screen size, input constraints, etc. The following sections present some of the major specificities on making digital libraries available via mobile phones, introduce a user study on the usage of mobile devices in a digital divide context, and propose a design for making a popular open source digital library system (DSpace), available via mobile phones.

## II. MOBILE ACCESS TO DIGITAL LIBRARIES

If mobile phone accessible digital libraries are a possible alternative for developing countries that traditionally face serious problems in accessing printed publications and ICT resources, these libraries can also bring important added value to the developed world as an additional access mechanism. In the process of making these digital libraries available for such devices, the existing challenges and best practices are worth taking into account.

### *A. Challenges*

Using mobile devices for Internet access and therefore for accessing online digital libraries, is replete with challenges that

[1] http://www.itu.int/ITU-D/ict/statistics/at_glance/KeyTelecom.html, February 20th 2012

should be carefully addressed when making such services available. Among these challenges, there are some that are particularly relevant to be highlighted:

- Reduced screen space - studies, have revealed that users of the small screen devices are 50% less effective in completing tasks than the large screen users [6]. Thus, it is necessary to work on the way users interact with the digital library, as well as on the way the system is presented to the them in such a small screen.
- Content adequacy - Web contents are usually prepared for desktop computers. Accessing these contents on mobile devices requires them to be adjusted to the small screen size.
- Input constraints - input on mobile devices are often difficult compared to desktop computers with a keyboard. They usually have very limited keypad, with small keys and no pointing device.
- Device limitations - since mobile phones browsers don't often support scripting or plug-ins, the range of content that can be supported is very limited. Moreover, some devices also have very limited processing power, as well as working and storage memory.

### *B. Best Practices*

Despite the challenges in accessing digital libraries on small screen devices, there are several examples of making digital objects available on mobile phones. Thus, before venturing into making a digital library available on these devices, it is important to consider some relevant questions: what are the lessons previously learned from these experiences? What could be done in a better way? Reference [7] identify some key learning from these experiences:

- The project should be kept as simple as possible;
- A mobile framework that has already been tested in multiple platform should be used;
- A specific web service should be created to provide data to the application instead of bundling images and metadata with the application;
- There should be a clear focus on mobile interface development and less on platform specific applications.

In order to make a digital library accessible via mobile devices, there are two major alternatives: developing a mobile Web interface or developing a mobile application. No matter which alternative is used, there are some important guidelines that should not be neglected. Reference [8] indicates several guidelines that should be taken into consideration when developing a mobile Web site or application. Among these guidelines, there are some that might be considered particularly relevant for a digital library project:

- It is imperative to understand the potential users beforehand, and therefore to know who they are, what their needs are, what functionalities they want, which mobile devices they have, etc.
- Since there might be several types of users with different kinds of mobile devices, the mobile site should have distinguished interfaces, for feature phones, smartphones and touchscreen phones.
- The full desktop site should not necessarily be made available to mobile users. Typically only a subset of functionalities is made available according to the user's needs. However, the response they get from the mobile site or application should not be incomplete when compared to the desktop version.
- When offline access is an important prerequisite or some mobile specific features are needed (such as camera, user location, etc.), building a mobile application is recommended instead of a mobile Web site.
- Considering the specificities of mobile environments and equipments, a special attention should be given to the usability and interaction design.

## III. BUILDING A MOBILE INTERFACE FOR DSPACE BASED DIGITAL LIBRARIES

When building digital libraries in developing countries, the usage of open source software is a must [3]. There are several open source digital library systems that are widely used even in these countries: DSPace, Fedora, EPrints, Greenstone, etc. Thus, in order to make digital libraries widely accessible over mobile devices, the usage of open source systems seem to be an effective mechanism. By building a mobile interface for a popular open source DL system, library resources might potentially reach a broader range of people. The remaining part of this paper presents the design of a mobile application for accessing DSpace digital libraries, with a particular emphasis on the specificities of a digital divide context.

DSpace is a popular free and open source DL system with more than 1.160 installations in tens of countries. It is an OAI-PMH complaint system and its interface is translated into more than 20 languages. Making this library system properly accessible over mobile phones, certainly contributes to facilitating access to library resources.

### *A. User expectation and usage of mobile device*

As mentioned before, for enabling user access to a web site through a mobile device or for developing a mobile application, it is crucial to know the users, to understand what their needs are, which devices they use, etc. [8] Given the objective of making DSpace based digital libraries available over mobile phones, especially in a digital divide context, a user study was conducted in a developing country scenario, characterized by difficulties in accessing printed publications as well as low Internet and computer penetration rates. This study was conducted at the University Jean Piaget in Cape Verde, and aimed at finding the responses to the above

mentioned questions on the process of developing a mobile interface to DSpace based digital libraries.

Cape Verde is a 10 islands archipelago with 491.875 inhabitants, 17,2% analphabetism rate[2] and a US$3.737 GDP per capita. 30% of the Cape Verdean population have regular Internet access and 76% own a mobile phone. However, computers are only available at 11% of the homes. The country faces serious problems in accessing printed publications, and there is no national network for book trade. Even accessing the national publications, especially the scientific ones, are often a real challenge. In this scenario, building and using digital libraries seem to be a good alternative. The first existing digital library in the country was built at the University Jean Piaget of Cape Verde in 2008, using DSpace DL system.

For collecting information on user requirements, devices and needs in a developing country context, a survey was conducted among the potential users at the University Jean Piaget of Cape Verde, where there was already a DSpace based digital library available with the members of the University academic community as the main target public.

The survey took place between January 24th and February 2nd 2012, and involved 312 potential users among the University's 2.100 students and 200 lecturers. People from all areas responded to the questionnaire that was divided into four main parts: (1) ICT access; (2) usage of mobile devices; (3) accessing online academic materials; (4) expectations. The survey results are presented and analyzed bellow.

*1) ICT access*

The survey revealed a level of ICT access far above the Cape Verdean average: 86,5% of those who responded to the survey, had a computer at home, and laptop was owned by 71%. Therefore, at about 15%, had both, a desktop and a laptop computer at home! Apart from that, 11% intend to acquire a laptop within the next 6 months! Regarding the Internet access, 69,7% revealed that they had an easy Internet access, while in the entire country, the Internet penetration rate is around 30%!

Thus, despite the low level of computer and Internet penetration rates in the country, the members of the University's academic community revealed that in general, they do have access to such ICT resources.

*2) Usage of mobile devices*

According to the survey, mobile phones are owned by 97,4% of the students and lecturers of the University and 16% of them, own iPhones. If we consider iPhones and other modern devices (namely iPod Touch, iPad, Blackberry, Android, and Windows Mobile), this percentage raises up to 43%. Moreover, 26% of the respondents have plans to acquire one of these devices within the next 6 months.

Therefore, within the next 6 months about 69% of the potential users at the University will have a smartphone, iPod Touch or tablet, that might be used for accessing an eventual DSpace based digital library.

However, only 29% of the potential users have subscription to Internet access services on mobile phones. Those who do not have such subscription explain that the main reasons for not doing so are low quality of service, high cost, and the fact that they don't really need it. Even those who have subscribed the service explain that they usually don't use it when an Internet connected computer is available.

*3) Accessing online academic materials*

The potential users of the mobile digital library usually don't read academic materials online using their mobile devices. Only 22% have this habit. Approximately the same percentage of users download these materials using their mobile devices, for further offline readings. They usually read such materials in PDF format and as regular Web sites.

Among the major strong barriers on using mobile phones for accessing academic materials, users consider: WiFi/mobile network unavailability (39.4%), speed (35,9%), application unavailability (27.2%) and small screen size (21,7%).

*4) Expectations*

When inquired if they would consider the availability of digital libraries over mobile devices as something that they would use, 73,7% responded positively. There are mainly three functionalities they would like to see available on a mobile phone accessible digital library: content downloading (59%), reading materials online (56%) and searching (49%). Their preference in file formats are PDF (52,4%), simple text (26,9%) and HTML (20,5%).

After conducting this survey, the key findings can be summarized on the following items:

- Users do have computer, Internet and mobile phone access. iPhone is the most popular smartphone among them.
- The majority of users do not have a smartphone, but within 6 months time, it is probably that about 69% of them will have a Smartphone, iPod or tablet.
- The majority of the users don't have the habit of reading academic materials on their mobile phones due mainly to unavailability of WiFi/mobile network, slow connection speed, application unavailability and small screen size.
- Users would use a digital library available over mobile devices and would like the materials to be available in PDF, text, and HTML formats, with the possibility of reading the content offline.

*B. Designing a mobile solution*

After conducting the survey and analyzing the results, the system for accessing DSpace based digital libraries started being designed. As part of this process, personas were built using the collected information, as well as prior user studies on the usage of the DSpace based digital library at the University Jean Piaget of Cape Verde [9]. Additional updated data were also used, including Google analytics statistics on the digital library. Taking all these information into consideration, four main personas were built: (1) a university student with no Internet access at home; (2) a university lecturer and researcher; (3) a university student with Internet access at

[2] http://www.ine.cv, January 30 2011 - 2010 national census

home; (4) a foreign student. (1) and (2) are primary personas, and (3) and (4) are secondary personas.

Despite the positive Internet access indicators among the potential users at the University, the system is also intended to be used in other places, eventually with more limited Internet access possibilities. Thus, instead of simply designing a DSpace Web theme for mobile devices, two different complementary approaches were chosen.

The first one is developing a mobile application that would enable the usage of DSpace based digital libraries over mobile phones, for searching and reading materials, as well as for receiving reading suggestions according the user's profile. The mobile application would also enable users to read materials even when no Internet connection is available. Therefore, they would be able to download resources and store them locally for further readings. When online, this mobile application would enable federate search on several DSpace instances, and present the results do the users. In order to accomplish this goal, there should be a back-end service installed on the DSpace server side that would perform the major operations (searching, providing reading suggestions, federate search, etc.) and send the results to the mobile application. The federate search on DSpace libraries should be accomplished using either the DSpace REST API or Perl DEiXToBot scripts. Figure 1 presents the architecture of the proposed system. On the back-end service, a process should run during idle times to convert the available resources into adequate text based format for proper reading on mobile devices. Reading suggestions and better-formatted documents will only be available for the DSpace instances that have the proposed back-end service installed. Figure 2 shows a concept map describing the key functionalities of the mobile application, according to the primary personas (red and green) and secondary personas requirements (blue and brown).

The second approach focuses on building a DSpace theme for mobile phones. Therefore, a specific DSpace mobile Web interface will also be built. In order to accomplish this goal the idea is using DSpace Manakin, a web-based user interface for DSpace digital library systems. Thus, XSL, XHTM and CSS, will be used for developing the mobile phone theme. This theme would function with any DSpace Manakin installation and would have to be installed on the server.

Considering the existing multiplicity of mobile devices among potential users, both, mobile application and mobile Web interface will be developed. Three types of devices will be supported: iPhones, Android and feature phones.

A user centric design approach is being used and a prototype is being built. The proposed system is still at the design phase. In this process, formative usability tests for collecting users feedbacks will take place.

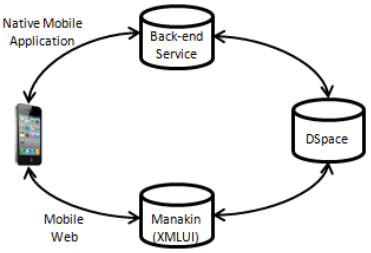


Figure 1. System Architecture

## IV. Conclusion

This paper has introduced the challenges developing countries face in their struggle to access library resources and has pointed mobile phone accessible digital libraries as a potential alternative for minimizing such problems. Developing both mobile application and mobile Web interface for DSpace, a popular digital library system, might bring an important value added in this process.

After the system is fully developed, a user study should be conducted in order to understand the usage and acceptance of a mobile phone accessible digital library among the potential users, especially in a developing country context.

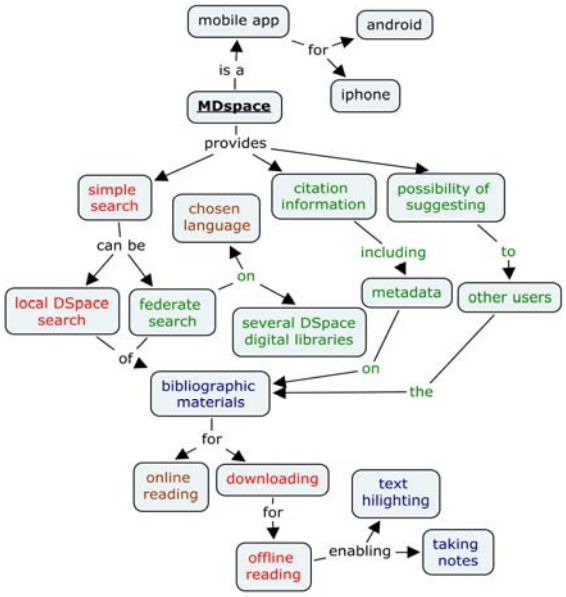


Figure 2. Concept map of mobile Application Functionalities

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