

Using Handhelds to Search in Physical and Digital Information Spaces

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Abstract

In recent years a wealth of information is becoming available thanks to computer and networking technology. Modern libraries incorporate in their collections information content in both physical and digital form. Meanwhile, mobile computing enables the library patrons to access that content anytime, anywhere. In this paper we present the design procedure of a new library service that supports users in seeking information in hybrid collections while being in the stacks, thus enabling content retrieval from a unified information space. Moreover an evaluation model and methodology and the results of an experimental procedure are presented aiming to assess the user satisfaction for the new service.

1. Introduction and motivation

Nowadays, libraries enrich their print collections with supervised digital sources, held either locally or in remote information organizations, such as digital libraries. Computer terminals in the library premises offer access to the library OPAC (On-line Public Access Catalog) and other electronic services and collections. Most of them are available in electronic form and therefore can be accessed anyplace/anytime. This allows for ad-hoc access to content, to inform research or business decisions, whether in office or at home.

However, inside a library the two collections (physical and digital) are kept separately; as a result, users can seek for information either by searching in the electronic catalogs from a PC or by walking to and browsing through the stacks. To avoid moving between the two spaces and overcome the discontinuity of searching in two different areas these spaces need to be brought close. The recent advancements in handheld computing devices like PDAs (Personal Digital Assistant) enable them with high resolution colorful graphic displays and wireless communication features.

For instance, a PDA/smartphone can wirelessly connect to a local computer network and the library's electronic services, and thanks to the device's inherent mobility the user can walk into the physical information space with an open window to the digital space, right on his palm. This allows for a uniform seeking procedure that integrates physical and electronic information collections into one, namely a hybrid information space.

In this work we present the design procedure of creating a new library service that supports library patrons in seeking information in hybrid spaces using handheld devices, such as PDAs and smartphones. We also describe a methodology to evaluate the user satisfaction for that new service and present the derived results. Section 2 discusses related work in mobile computing for information services. The design procedure and service functionalities supported are presented in Section 3. The evaluation method is described in Section 4 and the results are presented in Section 5. Section 6 concludes this paper with a discussion on the findings and limitations and a brief description of future work.

2. Background

The potential raised by mobile devices in providing anywhere, anytime access to reference material and storing information locally, was quickly acknowledged by field practitioners, especially in healthcare environments [1]. In the early 00s Libraries at Virginia Commonwealth Universities (VCU) were among the first to explore the PDA supporting services for medical doctors and paramedic personnel [2], [3]. These mostly involved PDAs used to access reference content stored locally, such as the ePocrates clinical drug database and medical records, dictionaries and textbooks as well as writing and beaming prescribing aids.

Buchanan, Jones and Marsden [4] present an

evaluation study on the usage of PDAs to access a remote Greenstone-based Digital Library. Their study focuses mainly on the presentation issues raised when searching and delivering content in small screen devices. However, no focus has been given to the usage of the PDAs in conventional libraries.

As soon as the mobile computing devices were enabled with wireless communication features new opportunities and applications appeared. SmartLibrary [5] was a PDA-driven project started at Oulu University, Finland, where handheld devices were used to enable map-based guidance for book finding. A small search interface was used to submit a query to the library's OPAC and get a list of books that matched the searching criteria. Upon selection of a record from the list, the user could see its metadata and a small image of the library's floorplan, indicating the position of the book. However, searching in electronic resources was not supported.

A closer approach to the usage of mobile computing devices to enrich information from the physical space with information stored in a digital space is MoTag system [6], which uses PDAs to access G-Portal. G-Portal is a digital library of geospatial and georeferenced resources that holds also social tags concerning the accessibility of public buildings and other similar structures. During their visit in a certain place, PDA users can search the G-Portal for any tags left by previous visitors, submit a photo of a location, create new tags and also add comments and time-stamps. Similar examples come from the tourist industry and the museums. Many studies have investigated the use of PDAs in the context of city and museum guides [7] for navigation and brief personalized information presentation [8], [9]. In these systems handhelds are used to display a floor plan of the current area. The map indicates nearby objects or exhibits and the user can interact with it to retrieve short descriptions about the objects and navigate in the area.

Most of the current research efforts focus on the development of applications that either facilitate mobile searching in the digital space or use the handhelds to provide navigation instructions in the physical space. Even though many libraries keep a wealth of recorded knowledge in both physical and digital form, to the authors knowledge no studies have been made to assess the impact of a new mobile service that supports library patrons to seek information in hybrid collections.

This work presents the design, implementation and evaluation of such a service. The initial stage was the

determination of the functionalities of the new service. For this purpose a focus group was conducted, to gain some insight into the users' information seeking strategies, determine which services can be supported by the handhelds, and create usage scenarios for a library setting to use them in an evaluation study. The next stage was the design and implementation of the new service by extending the current infrastructure at the Library of Panteion University (Athens, Greece) to support wireless communication with the mobile terminals and build interfaces suitable for the small screen devices. The third phase of this work was on the evaluation of the new service, which was divided in the following steps: (a) determine the evaluation criteria and scales to assess the impact of the service on the library patrons, (b) construct an evaluation model to describe the relationships between the criteria, (c) choose a data collection method and create the necessary tools, (d) run an experiment to collect the data from the users and (e) proceed to the data analysis and draw conclusions.

3. The Prototype System

3.1. Defining the user needs

To find out which were the main functionalities of such a service in an academic library and how they could be ported on a mobile computing device, we conducted a focus group. The group consisted of 1 moderator, 2 observers, 5 librarian experts and 4 experts from computer science. Prior to the discussion, the participants were informed on its topics, procedure, as well as its audio and video recording.

The participants received a list of scenarios expressing the functionalities of the proposed mobile service. These scenarios were derived from the literature and the participants were asked to provide their viewpoints for similar applications in a library. During the meeting they were encouraged into an in-depth discussion that revealed the regular information seeking behaviors of library patrons as well as technical issues encountered when implementing tools and services for mobile devices. In addition, at the end of the discussion participants were asked to fill a short questionnaire, expressing their attitude on a 5-point Likert scale towards adopting (or not) the information seeking aids discussed.

To select the functionalities to be implemented for the new service we set an acceptance threshold, proposed by Nielsen [9], based on the emphasis given during the discussion; for a functionality to be selected it should (a) have an average score over 4, (b) at least 7 participants (80%) should have given it the top rates (4

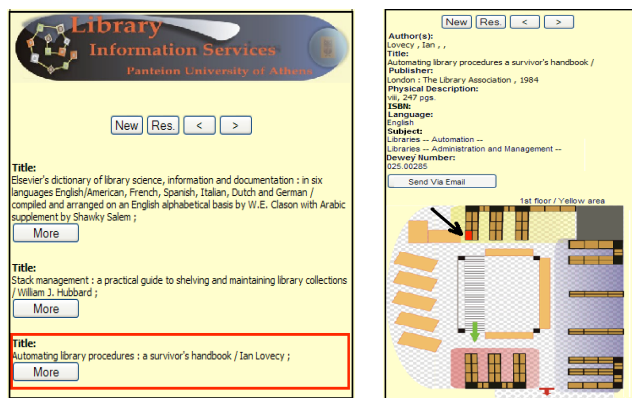


Figure 1. A results list of a query submitted to the OPAC and a snapshot of a book's metadata

or 5) and (c) no more than 1 participant (10%) should have given it the lowest rate (1). The functionalities that survived the selection criteria were (a) the wireless access to the OPAC and the e-resources of the library, (b) the use of a map indicating a book's position in the stacks, (c) the ability to communicate with the mobile device directly with other on-line users or send a short message/email to be received later, (d) the ability to download/save/disseminate electronic files retrieved, such as journal articles and lecture notes, and (e) the ability of taking some quick notes either written or verbal. If available, snapshot taking with a camera-enabled device was also considered useful.

3.2. Design and Implementation

To implement a prototype system we first had to create a mobile version of search interface for the library's sources, suitable for small-screen devices (<http://library.panteion.gr/mobile/opac.php?sid=&lang=en>). That interface accepts the searching term(s), the searching field (author or title) and the searching collection (either OPAC or the electronic resources). Upon a query submission a results list is send back to the handheld and the user can tap on the record of interest to see its metadata (Figure 1). Each record from the physical collection is associated with a map indicating the corresponding item's location. In case the retrieved record belongs to the e-resources of the library, the user has the option of sending its metadata to an email account. Users are also allowed to download any available full-text material on the mobile devices. In addition, the instant messaging (IM) tool allows for short dialogs with other on-line users and library staff.

In a typical scenario a student uses the device to submit a query to the mobile OPAC. From the results list she sees the desired book and other related print

works. Using the stylus she taps on the desired book to retrieve its metadata and she sees that there are a few copies available on the shelf and a map indicating the location of the book in the stacks. While walking to the stacks to locate the book she activates her MSN account. Having found the book, she takes a quick note on the other related books of the author and sends a short question to the on-line librarian asking to inform her on due dates for previously borrowed books. Without needing to head for the computer room, she now searches the library's electronic resources for relevant entries. The results list shows a couple of records that seem relevant. She decides to download an article and send an email with its metadata, including a download link, to a colleague.

4. Evaluation

4.1. Evaluation model and criteria used

To evaluate the usage of mobile computing devices in hybrid information spaces, like libraries, an evaluation study was conducted to: (a) examine if mobility provides valuable help to the users when seeking information in hybrid spaces, and (b) identify which factors mostly affect the user-device interaction and how do they reflect on user satisfaction of a new service that uses mobile devices for information access.

Several researchers agree that usefulness and usability are the most significant concepts for the user-centered evaluation of information services [10], [11]. Therefore, in a user-centered model that evaluates the impact of the new service to its users we need to examine the users' Satisfaction (S), Usefulness (U) and Ease of Use (EoU) towards that service and the effects between them.

To assess usefulness the criteria of relevance, time saving, completeness and utilitarian value were taken into account. The later criterion refers to the value the new service has in helping its users in fulfilling their goals [12]. The other criteria refer to aspects of retrieving valid and relevant information from hybrid collections [13], [14]. Time saving and utilitarian value were addressed -through different questions- towards specific actions that were described in the scenario of section 3.2., such as information searching, storage, communication, etc. On the other side, ease of use is assessed by taking into account several interface attributes [12], [15], such as easiness to learn, easiness of transition between tasks, organization of information, ease of task execution, clearness, help and support. Users of different background, e.g. different level of computing experience, may perceive

differently the ease of use of the new service. In addition, many usability studies have shown that user interfaces have a strong impact on Ease of Use. Table 1 summarizes the criteria referred in the bibliography and adopted by the present research.

Table 1. Evaluation Criteria

Categories	Criteria
Ease of Use	a) Easy to learn, b) Task transition, c) Information organization, d) Ease of task execution*, e) Clarity, f) Help, g) Support
Usefulness	a) Utilitarian value**, b) Time saving*, c) Relevance, d) Completeness

* Set of six questions, ** Set of five questions

4.2. Experimental setup

The next stage was to setup an experiment to collect data from users. The methods chosen for that purpose were observations, interviews and questionnaires. A software application installed in the PDAs recorded the user-device interaction sessions in a video file which was sent in real-time to a remote PC.

Post-graduate students from 3 departments at Ionian and Panteion Universities (Greece) were invited to participate in the experiment. They were encouraged to use the new service to collect bibliography for their semester projects. Prior to the experiment, participants were invited into a 30-minute briefing session where they were informed about the goal and the procedure of the experiment and also had a hands-on experience with the PDAs.

According to the procedure, each student would borrow the PDA from the library's help-desk and would also be given the usage scenario described in Section 3.2. They were allowed to change the order of tasks described in the scenario, but they had to complete all the tasks. Two observers were also present to watch in a remote PC the users' interaction and provide any help needed. Upon completion of the tasks students either participated in an in-person interview or were asked to fill a questionnaire.

In total, 77 students participated in the current study. Ten of them were randomly chosen to be interviewed and 67 filled the questionnaire (dlib.ionio.gr/hls/ev1/qst/), which was divided into two sections; the first to create the participant's profile and the second to describe her experience with the device.

5. Results

5.1. Collecting and analyzing qualitative data

Semi-structured interviews were conducted based on both open-ended and closed questions to compensate

for the drawbacks of each form. Each interview lasted nearly of 20 minutes and was recorded on a video file. The interviewees' opinions on the usefulness, usability and satisfaction for the new service were assessed using a 5-point Likert scale, (1=strongly disagree, 5=strongly agree). All data collected from these sources were analyzed with ActivityLens [16], a tool which supports ethnographic research and facilitates the analysis of data in different format (audio, video, image and text). ActivityLens supports hierarchical task analysis and therefore the recorded interaction of each user was classified in 3 levels of abstraction. At the lowest level the events for a task completion were annotated, according to a set of typologies; for instance an event could be annotated as "successful search to OPAC", "unsuccessful copy of metadata to the notepad", etc. In the middle level the events of a user were grouped into tasks, according to the scenario, e.g. searching, typing, chatting, emailing, etc., with new typologies used to annotate the successful completeness (or not) of a task. Finally, at the third level tasks were outlined as goals (seeking, communicating, etc.), while new typologies denote if the user achieved a goal.

Regarding the users' profile it was found that more than half of the interviewees were visiting the library frequently and were familiar with its physical space. In addition, 9 of them also use its e-resources and 6 use daily web search engines. However, only 3 had previously used a mobile device, such as a PDA for an extended period of time.

The interviews revealed that users were very enthusiastic for the option of quickly searching in both information spaces from anyplace within the library, right when the need arises. This finding indicates the usefulness of the new service, which is also verified by the interviewees' Likert rates.

With most usability scores for the service interfaces above 4 (in 1 to 5 Likert scales), we conclude that the users found it easy to interact with the device. This was due to design resemblance of the mobile interfaces to their desktop counterparts. The most useful feature was the capability of emailing the retrieved information (M=4.44), followed by information storage in mobile disks, such as a memory card (M=4.33). Similarly the average usefulness of searching in the OPAC using the device was 4.33, while it was found very convenient and easy to use it anytime/anywhere (M=4.67), in contrast to the library's terminals. The usefulness of searching e-resources through a handheld was mostly affected by the "relevance" of the retrieved information (M=4.11). This task received a high usability score

(M=4.33). In addition, the participants would like to have the option of simultaneously choosing both collections (OPAC and e-resources) as searching targets. Concerning the ability of taking quick notes, only three of the interviewees found it useful (M=3.56) and reported that it was easy to copy/paste metadata (M=4.22).

The video recordings revealed difficulties in text input using the virtual keyboard, which was a totally new experience for seven of the participants and gathered 45% of the complaints regarding the user-device interaction. The small screen size and stylus followed at 14% each and the remaining 23% regarded navigation instructions, presentation style, device dimensions and interfaces. However participants stated that after some training period, these difficulties would not be strong enough to obscure the usefulness of the new service.

Some tasks gathered negative comments regarding their utilitarian value. At the bottom of the rank participants placed the use of the navigation map into the physical area (M=2.33). Moreover the usability of this functionality was characterized indifferent (M=3.0) and that was partly due to its reduced usefulness. Participants considered the service useful for new visitors, like freshmen, and for larger buildings. Furthermore they would prefer more vivid identification patterns, such as the existence of an indicator of the user's position in real-time. For similar reasons participants rated low the usefulness of the synchronous communication with the reference librarian (M=3.22). Concerning the information completeness, they would like to have an indication of the number of hits in the search results as well as a relevance indicator next to each record.

Overall, the majority of the participants (nine out of ten) declared satisfied with the new service and they described it as innovative, interesting and interactive. Anywhere/anytime access to the library's content and services is time saving and enables the users to easily swap the searching space in an iterative fashion until they are satisfied with the resulting list. Regarding the interaction with the mobile devices, users do not find the device's constraining resources (screen-size, lack of keyboard, low memory, etc.) to be a good reason to reject the new service. All of the interviewees intended to reuse the new service and recommend it to a friend.

5.2. Quantitative Results

The majority of the 67 participants that took part in the questionnaire survey were female (71.6%, $n=48$), while the rest (26.8%, $n=18$) were male (one missing).

Most of the participants were active information searchers through the Internet channels and e-resources (73.1%, $n=49$) reporting increased daily usage and 12 reporting frequent weekly information searching. The majority holds a bachelor degree (79.1%, $n=53$), while 9 (13.4%) hold an MSc, with the rest 5 (7.5%) having either a PhD or completed a post-doctoral course.

Stepwise regression analysis was performed twice, using the criteria presented in TABLE I as independent variables and *Ease of Use* and *Usefulness* as predicted outcomes. This analysis reveals which set of predictors is most important in explaining the variance in the predicted outcome, thus paying particular attention to them in development stages.

In the category of *Usefulness* two independent variables were able to predict usefulness, namely *Time saving* ($t(57)5.190$, $p<.001$) and *Utilitarian Value of Anywhere Access to E-Resources* ($t(57)2.267$, $p<.05$). These criteria were found to account for 53% of variance in usefulness ($R^2=.532$, $F=32.346$, $p<.05$) and highlighted the fact that the participants to the current study perceive the usefulness as the efficient access to resources from anywhere in a ubiquitous fashion. As in the qualitative study, the participants did not consider as important factors the implementation of several innovative functionalities, such as the navigation map aid and the assistance for locating books, probably due to their familiarity with the library environment.

In the category of *Ease of Use* five variables were accounted for 59% of its variance ($R^2=.596$, $F=12.385$, $p<.001$): *Information Organization* ($t(42) 2.826$, $p<.01$), *Clarity* ($t(42) 2.763$, $p<.01$), *Easiness to Execute Communication Tasks* ($t(42)3.216$, $p<.01$), *Easiness to Execute Moving/Storage Tasks* ($t(42) -2.518$, $p<.05$) and *Help* ($t(42) 2.756$, $p=.01$). The results of this analysis demonstrate the importance of interface characteristics and help functionalities in the perceived EoU, as well as the easiness of executing crucial tasks that handhelds support.

Stepwise regression was performed to define which criteria from both categories are significant predictors of *Satisfaction*. In general the Ease of Use criteria account for 50.4% ($R^2=.504$, $F=15.221$, $p=.01$), while the Usefulness criteria account for 48% ($R^2=.483$, $F=26.679$, $p=.01$) in Satisfaction variance. Three criteria were found to account for 57% in Satisfaction variance ($R^2=.572$, $F=19.178$, $p=.01$). These are *Time Saving (TS)* for E-Resources Searching ($t(43) 3.979$, $p<.001$), *Completeness (C)* of the retrieved content ($t(43) 2.514$, $p<.05$) and *Easiness of Learning (L)* how to operate the mobile device ($t(43) 2.696$, $p<.01$).

with the standardized beta coefficients being .439, .267 and .313 respectively. The model equation is $S = 0.352 + 5.077TS + 5.652L + 0.198C$. These three factors reveal why participants are willing to use mobile computing devices in the library; it helps them in retrieving information content from multiple and diverse sources in a way that is quick and easy to learn.

6. Discussion and conclusions

The qualitative and quantitative findings provide valuable information, such as the fact that users envisage the proliferation of digital libraries by means of mobile devices in order to raise space barriers. Furthermore users believe that the unified search for physical and electronic resources is an important feature, which was in agreement with the recommendation of experts. However our findings indicate that the implementation of several innovative and interesting features should be examined in regard to the profile of the served community. Also interface design should follow the principles of understandable organization and clarity.

This three-stage work (focus-group, qualitative and quantitative analysis) allowed the extraction of firm conclusions regarding the design of the application and the service in general. Design recommendations were based on user requirements found in formative evaluation stages, while summative evaluation stages assessed the incorporation of the whole service in a realistic and active environment. Based on these results future work includes the extension of the prototype features in order to perform searches in more sources, the resolution of interface problems that impede interaction, and the conduction of a test-control study to locate differences in users' efficiency.

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