HANDHELDs FOR DIGITAL LIBRARIES

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ABSTRACT

The present chapter introduces digital library services’ utilization through handheld devices, such as PDAs and smartphones. It argues that handheld devices proliferation justifies the term digital library in terms of anywhere-anytime access, retrieval and management of information. Furthermore these devices constitute powerful information harvesting tools that help users enhance their interaction with information spaces, both of physical and digital form. The chapter presents the services that can be accessed by means of portable devices and analyzes the main socio-technical issues that arise and influence user interaction. Factors that affect acceptance of these devices are discussed, and future trends are presented to outline the research landscape for the forthcoming years.

INTRODUCTION

During the last years, computer technology has been evolving from the mainframe and personal computing era to the third one, that of Ubiquitous Computing. Wireless communication networks and Mobile Computing were similarly affected by the evolution in computing devices. As a result, people can choose among dozens of portable devices, capable of establishing radio connections, to join a computing network, such as the Internet, realizing the vision of ubiquitous information access and delivery services. On the other hand, the web lacks authority and quality control, is inadequately indexed and the search interfaces are ineffective and simplistic. These reasons along with the need for anytime access to information and the need to retrieve relevant and accurate information from anyplace lead to the creation of Digital Libraries (DLs).

In this article we present the reasons why handhelds, like Personal Digital Assistants (PDAs), smartphones, TabletPCs and the most recent Ultra Mobile PCs (UMPCs) can be used as tools to access DL content. The approach of this article is user-centered and focuses on the services that can be supported by these handhelds, the interaction for use in DLs and the acceptance of such devices.

BACKGROUND

The term PDA was coined in 1992 by John Sculley for a handheld device that offered work organizing tools, like calendar, scheduler, address book, memos, clock and a calculator. The potential they introduced in information delivery was quickly recognized and soon these devices were utilized, mainly, by Health Sciences Libraries (Jones, et al. 2000; Smith, 2002; Rios, 2004). Meanwhile, bigger screens were made available and able to depict colorful graphics. Computing power, memory and storage capabilities increased, and data input methods, like handwriting and virtual keyboards, were implemented. Audio playback was made available and both size and weight reached the ideal measures. Wireless networks also evolved making anywhere information delivery a reality. Moreover smartphones appeared providing telephony and other communication services like e-mail, 3-way communications (conferencing) and Internet access.
Apart from the physical libraries, DL organizations also found the wireless connectivity features quite attractive. Handhelds could be used to access multimedia content on a 24/7 basis. They could also keep notes and other information for reference, or even be used as communication tools. During the last years many researchers have been studying issues that arise by the usage of such devices for information retrieval tasks. In early 00s several prototypes were implemented in various settings, such as James Madison University, USA (McCabe, 2004), Oulu University, Finland (Aittola, et al., 2003) and Cornell University, USA (Jones, et al., 2000). Students from an informatics class in J.M. University used a PDA to view and edit patient records whereas students in the Oulu and Cornell Universities used the PDAs to help them navigate in the university's library, access the OPAC, locate books of their interest, communicate with other persons on the network, including library personnel, take some notes, scan or photograph topics from the books retrieved and transfer data on a personal storage area. Participants in the studies expressed enthusiasm for the ability to combine mobile information access with other activities such as writing or organizing materials. Map guidance to locate a book was preferred over traditional shelf classification. Even though the service was considered easier to use from a desktop terminal, the usage of a portable device in larger libraries was appreciated. However, as Jones et al. note (2000, p. 98) “their enthusiasm declined significantly when either technology purchase or student fees where suggested”.

SERVICES ACCESSSED WITH HANDHELDs

Among the advantages of DLs over physical libraries, two are of great importance: anytime and anywhere access to the library’s content. Even though the existence of DLs goes back at the late 80s, the term “anywhere” was strongly associated with indoor places, like a home or company office where a wireline connection to the Internet or some other Data Base system was available. Only recently, with the rapid growth of wireless communications and mobile computing, the term “anywhere” really reflects outdoor connections. Handhelds are used to fill this spatial gap among access points, by enabling connections to remote information providers from any point, giving a new perspective and potential to fields, like education and life-long learning, business, logistics, e-commerce, health and entertainment.

There are three well-known and established information retrieval methods, namely searching, browsing and asking (Rosenfeld & Morville, 2002). Nowadays, handhelds can support their users in information seeking tasks by delivering valuable services. Powerful searching tools like search engines, on-line catalogs, bibliographic databases, citation tools, search zones, lexicons, thesauri and controlled vocabularies are accessible via the web, properly formed for the small screen devices (Mobile Google, mOPACs, i-mode) and can be delivered to a user, whether she is in an airport lobby, in a train or sitting in a park.

In cases where the user’s information needs are vague, the browsing method can help the user to start her research. Handhelds can provide access to categorized content, i.e. taxonomies and hierarchies, where the user can progressively narrow down the seeking procedure until she finds what she is looking for. Navigation aid is also considered a valuable service. Navigation can be site-wide, to help users understand where they are and where they can go from there, or it can be local to let them know where they are and what resources are available nearby. Also, additional navigation aids like site-map trees and Tables of Contents offer to the user a condensed overview of the information landscape and links to major content areas let the user choose the level of
abstraction she desires, with a single tap on the screen. Map guidance can also be used when looking for a physical object, e.g. a book, in the physical library (Aittola, et al. 2003) or the nearest open gas station in town. Nowadays many handlods integrate Global Positioning System (GPS) modules and Geographic Information Systems (GIS) software to support their users in navigating in the physical space. Since the handheld user is no longer restricted in a small area, location dependend services (LDS) are now becoming available, aiming at delivering the information or service that best fits the user’s location. Apart from navigation aids, other valuable tools like metadata indexes, guides, wizards and contextual linking systems can be delivered right to the user’s palm, whenever and wherever she needs them.

In more complex information seeking tasks, searching and browsing methods are often integrated and used in an iterative fashion. When the information needs are not well defined, the user starts browsing the content and eventually performs a fine search within a subcategory. However, when this technique does not yield the desired information, asking an expert might be the solution. Thanks to their communicating features, handhelds can support Live Referencing by means of e-mail, web-forms, instant messaging or chatting and even phone calls. The lack of nearby resources for advice, like books and encyclopedias while being outdoors, makes stronger the need for remote assistance and especially when the need arises beyond office hours. Live referencing services are suitable for 24/7 access and therefore strongly match the DL profile. Many academic institutions worldwide expand their referencing services, like the Library of Congress, the Pennsylvania State University and the National State Libraries of Australasia. However, most of the referencing services currently available are oriented to users sitting in front of a desktop terminal. One of the few pioneers in supporting mobile users is the Library of Curtin University of Technology, where users can ask the library’s experts by submitting an SMS query. The lack of a keyboard makes the procedure of text input somewhat cumbersome and therefore it becomes difficult for the mobile user to describe to an expert the kind of information she needs. On the other hand, the capabilities of the new handheld devices enable the user to contact an expert via telephony, and allow him to send all the necessary information, e.g. short texts, summaries and URLs, to her terminal. A similar example is the situation where a police officer asks from the Operations Centre detailed information for a car by submitting the plate’s number via police radio and gets the detailed data on a mobile data terminal (MDT) placed in the car.

Apart from Live Referencing, handhelds are also very popular in applications of static referencing, i.e. the user can download information content into the device while being at home or office and look up to it whenever a need arises. Address books, dictionaries and tables are some well known examples, but as the screens of handhelds become bigger and capable of depicting high resolution graphics it is expected that diagrams, images and e-books will be widely used. Marshall and Ruotolo (2002) made a study for reading on handhelds and found that reading on screen is strongly preferred when the user wants to locate and focus on short segments of a longer text, e.g. abstracts, summaries, definitions, etc, and navigate through an extensive set of familiar materials. For example, an engineer can always carry a handbook or manual, a software developer can carry a reference guide and a medical doctor can always have along the medical records of her patients.

Besides publishers, other sources of electronic information can be digitization projects of
textbooks and manuscripts that go back at the early 70s with Project Gutenberg¹ and Perseus² project at Tufts University, and continue until today with large-scale digitization projects, like the ones funded by Google³ and libraries in the US and UK, such as the libraries of Harvard, Stanford, the University of Michigan, and Oxford University, as well as the New York Public Library (NYPL), aiming for the on-line accessibility of more than 30 million full-text volumes. At the early 90s, with the evolution of electronic publishing, many textbooks were originally created in electronic form and soon the first e-books appeared. Many e-book vendors provide rich collections that can be accessed, displayed and read with the appropriate software on the handheld, while specialized loaning software permits libraries to apply policies on electronic content. Also, the storage capacity of the handheds, allows the user to carry hundreds or thousands of e-books on a single device.

Content management tools for annotation, storage, organization, transfer and sharing, can also help the mobile user to exploit the retrieved information in the most efficient way. For example a student may use her device during a lecture to keep some notes, to record the lecture, to classify it as “course notes”, to e-mail her notes to a friend and finally to migrate the whole session to her desktop computer for post-processing.

Since handheds are designed to extend our workplace outdoors and not completely substitute our desktop computers, we need to have most of our information in both places, indoors and outdoors. For example, a new e-mail downloaded on the handheld must also be transferred to the PC, if the user wishes so, and vice versa. The handheld and the PC can be connected by means of a cable or a cradle, or even by establishing a wireless link, e.g. Bluetooth, Infrared (Heisey & Paolillo, s.d.) or WiFi. Upon connection the synchronization software compares the files and information between the two devices and copies the most current versions of the files to both devices. That way, the user always has a backup copy of her data, which can be a lifesaver if the handheld is broken or stolen. When synchronization is finished, the user can continue working on the desktop computer, e.g. extending her research based on the results or URLs returned from some OPAC queries, where a keyboard and a bigger display are available. User requirements studies have shown that the idea of beaming stations where one can exchange information between the devices is highly appreciated (Carney, Koufogiannakis & Ryan, 2004).

**INTERACTION ISSUES**

Many challenging questions arise when one attempts to combine the two evolving technologies of DLs and mobile computing. Current broadband wireless connectivity is available for short-range coverage, forming hot-spots and dead-zones. As an alternative, mobile telephony networks offer almost everywhere-coverage, but for low-speed and expensive connections, as in the case of the services provided by mobile phone operators in North America, Europe and Japan.

Apart from wireless connectivity, another issue emerging when providing DL services to mobile users involves modifying the nature of the services to accommodate the constraints placed by the mobile context. Specifically, mobile users need services specially designed for a constantly changing context of use. Users might be changing location, carrying objects, destructed, etc.

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¹ http://www.gutenberg.org/wiki/
² http://www.perseus.tufts.edu/
³ http://www.google.com/press/pressrel/print_library.html
What is more, many handheld devices have small screen size, small or even no keyboard, and they are usually used in noisy environments with poor lighting conditions and many interruptions. Therefore instead of extending the desktop paradigm, these services must meet the users’ needs for brief, targeted sessions (Roussos, 2005). Today, handhelds support graphical user interfaces (GUIs) and WIMP (Windows, Icons, Menus and a Pointing device) systems. Due to the small screen size of handhelds, usually only one application window appears at a time and therefore the devices are not considered to be multitasking. However, as Peterson (2004, p.53) notes, “bedside is not the place to conduct a literature search on a database or to read full-text journal articles”. Due to context constraints, mobile users’ information search and delivery must be short, focused and quick, which is sometimes called “information snacking”, i.e. short on-line visits to get specific answers.

Upon full-text presentation on demand, as in the case of e-books, information must be presented progressively, in a successive disclosure fashion. A popular way is to use a text-based representation (Buyukkokten, et al. 2001), where a tree hierarchy scheme is used to represent the information-layout structure. The first branches (nodes) of the tree represent the information headers, the second-order nodes represent the sub-headers and so on, revealing more information bits as the user moves on to deeper levels (Buchanan, et al. 2003). A similar approach is Scatter/Gather, which proposes that similar documents are automatically clustered and key term summaries can be displayed for each cluster (Jones, et al. 2002).

Besides deciding upon the content to present to the handheld user, the issue of information presentation and management is of critical value. Crestani et al. (2006) suggest that fonts must be customizable to the user's needs, especially for those with poor vision. Moreover, the user must be provided with full-text search tools, annotation modules and screen capturing for saving image files. Furthermore, navigation tools, like subject trees, headers, bookmarks and indicators have proved useful, i.e. informing the user of how much of the text has been read. Another issue regarding content presentation in small screens concerns images. When someone is looking for textual information he should be given the option of not downloading accompanying images.

Regarding the layout presentation, the small screen-size is almost always inadequate to display the document retrieved in its original form. Therefore, in many cases the user is given the option to have the document reformed. This procedure can be prompted by the user at the time she stores some files in the handheld, e.g. when moving pdf files from a desktop PC to the handheld, or the procedure can start in real-time, from mediators that provide the information content, such as AvantGo and OpenWave, when pushing web content to their subscribers. For example, the web page of a newspaper that has a multi-column front page, is reformed so that columns are placed beneath each other, instead of next to each other, and pictures are presented as thumbnails.

While the latter case makes the text easier to read by changing the font size and properly rearranging the structure of the text, it lacks the insight offered by the layout context, i.e. topics arrangement, font size and face, etc. As an alternative, the image-based approach delivers to the user a scaled-down version of the pages of the document retrieved (Microsoft’s Deepfish, n.d.). This approach is very common when the information to be delivered is not generated upon request but it is usually retrieved in the form it had when published, like a digitized manuscript. However, the topic retrieved doesn’t necessarily have to include static information; it can contain
dynamic information and hyperlinks to other topics of information, much like the World Wide Web documents.

Lately, text-to-speech software is used to automatically convert e-books to spoken books. MATCH, is a prototype supporting multimodal interaction with a handheld device, used as a city guide (Johnston et al., 2002). Vadas et al. (2006) made a study to assess performance of comprehending text while mobile, i.e. situations where the user is walking or sitting. They compared a head-down visual display to a speech audio display. They found that users’ comprehension scores for the audio-walking condition were comparable to the scores for the visual-walking condition. Furthermore, they recorded improvements in the users’ ability to navigate the environment when using the audio display.

Apart from the content presentation to a handheld user, there's also the reverse problem of giving an input to a handheld device. Predefined input, like commands, must be quickly recognized and in many cases they can be issued by code detectors or other peripheral devices, connected to the handhelds through expansion slots, such as barcode and RFID readers or cameras that scan QR-Codes. As an alternative, a touch screen and a pointing device such as a pen allow for easy selection of graphical objects among menu commands, icons, buttons or drop-down lists. For free form text input, the user can use the small keyboard available or a virtual keyboard if provided. External keyboards can also be used, ranging from laptop size to laser pocket-keyboards. In addition, some sophisticated devices can recognize the user's handwriting and use lexicons that predict the word written, to increase writing speed.

ASSESSING ACCEPTANCE OF HANDHELDs FOR DIGITAL LIBRARIES

Device acceptance strongly depends on several issues, such as usefulness, usability, cost, social interactions, compatibility, reliability and security. Meta-analysis studies (Lu, et al. 2005) based on the Technology Acceptance Model (TAM) have identified motives and barriers of PDA usage. TAM (Davis, 1989) is an approach to modeling people intentions to use a new technology tool, taking into account two latent variables; perceived usefulness (PU) and perceived ease of use (PEoU). Their values can not be directly measured and therefore are inferred from other sets of variables, which are visible and measurable. For instance, a big number of errors recorded when the user tries to enter a query, would indicate a strong usability issue which reflects upon PeoU. The most common motives include mobility, time saving and accuracy of information which all affect PU. On the other hand, technical features (size, weight), small screen design, energy consumption, reliability and input methods are shown to affect PEoU (Dearnley, et al. 2004; Shipman & Morton, 2001). In addition, personal factors, like age, subjective technical confidence, training etc., are expected to affect both PU and PEoU. In the specific domain of DLs it is of outmost importance that handhelds should be integrated in user’s workflow and should satisfy user’s work and information tasks in an integrated way.

In order to assess acceptance, formative evaluation methods are encouraged during the implementation of DL services in order to trace user requirements and needs, adjusted to specific IT skills profile. Pilot installations have used triangulation of methods to collect data. This multiple research strategy includes interviews, focus groups, user observation, think-aloud protocols and questionnaire surveys. Since the context of mobile users differentiates strongly the user interaction, evaluation should be conducted in realistic conditions, where environmental
factors affecting users’ behavior, e.g. frequent interruptions, can be identified, recorded and studied (Ryan, et al. 2005). However, as subjects are moving it is not easy to observe their interaction with the device by having an operator with a camera to look over their shoulder. In most cases this method is rather obtrusive to the procedure, alters the behavior of the subjects and biases the study results. As an alternative, a software program installed on the mobile device can record the whole interaction session and transfer it in real-time to the computer of a remote observer. This strategy is well-known and widely used for the evaluation of usability tests regarding Human-Computer Interaction with desktop computers. Once data are collected from diverse sources, e.g. voice and video recordings, field notes and interview transcripts, qualitative research software helps the researchers to manage the data, shape it and make sense of the unstructured information, so that they can explore issues, understand phenomena, validate their assumptions and answer questions.

FUTURE TRENDS

Broadband wireless technologies, such as WiMax networks, are evolving, providing connectivity within the ranges of a city and thus making information exchange available almost anywhere. As a result handhelds will integrate connectivity capabilities, providing multimedia access and advanced modes of information delivery.

Interfaces should adapt to the new requirements of the mobile users. Sound or voice features will enable multimodal dialectics, enhancing thus user interaction. Speech synthesis could be used to have the retrieved textual information read to the user and therefore she will not need to look at the display. The small display problem might be solved thanks to Virtual Retinal Display (VRD) technology (Kleweno et al., 2001) which projects information right into the user's eye (retina), resulting in an image similar to that of a conventional monitor. Semantic processing is expected to strongly enhance information retrieval and content presentation. Instead of presenting to the user the full retrieved information, e.g. long texts, she will be given extracted summaries or descriptions. However, the user will still have access to the full content retrieved if she wishes so.

Services are expected to be personalized and deliver the right information, at the right time, in the right place, in the right way, to the right person. DLs will be providing location depended information and services, like nearby points of interest, activities or exhibitions and navigation assistance to help users find their way, either in physical or in digital domains.

Nowadays, many of the conventional libraries keep digital or digitized collections. We believe that in the near future we will see physical libraries merging with digital ones, to form a Hybrid Library, where electronic and paper-based information sources are used alongside each other, delivering valuable information either inside or outside the building. The goal is to encourage end-user resource discovery and information use in a variety of formats and from a number of local and remote sources, in a seamlessly integrated way. We expect that mobile computing and distributed wireless networks will play a major role towards the vision of Hybrid Libraries.

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TERMS AND DEFINITIONS

Human computer interaction: is the study of interaction between computers and their users. This interaction occurs at the user interface, which includes both software and hardware, e.g. general purpose computer peripherals (disk drives, CD players, etc) and large-scale mechanical systems, such as aircraft and power plants.
Mobile Computing is a term to describe a user's ability to use technology from a non-fixed location, using battery powered, portable computing and communication devices, such as laptops, notebooks, palmtops, smartphones and PDAs. Computing activity can take place locally, i.e. the user can use her device to retrieve some information stored in it, or it can be connected wirelessly to another information/computing system with wireless LAN or wireless WAN technologies.

Personal digital assistants (PDAs): are handhelds that facilitate tools like calendar, clock, calculator, address book, memos and alarms. Newer models support multimedia playback, voice recording, e-book readers, e-mail and web access. There are also models that integrate Global Positioning System (GSM) and Global System for Mobile communications (GSM) modules for navigation and telephony respectively.

Smartphone: (also known as hybrid) is any electronic handheld device that integrates the functionality of a mobile phone, personal digital assistant (PDA) or other information appliance. This is often achieved by putting “smart” capabilities, such as PDA functions, into a mobile phone. “Smart” functionality includes any additional interface including a QWERTY board, a touch screen, or even just secure access to company mail.

Ubiquitous Computing: is the idea of embedding computation into the environment by using everyday objects that enable people to interact with information-processing devices more naturally and casually than they currently do. The term was coined by Mark Weiser, chief scientist of Xerox PARC. Other terms include pervasive computing and calm technology.

Usability: ISO 9241-11 defines usability as “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use”. Usability of hypertext/Web is commonly measured using established usability dimensions covering these categories of usability defects such as screen design, terminology and system information, system capabilities and user control, navigation, and completing tasks. Perceived usability expresses people's belief to the extent that a system is not too hard to use, and the performance benefits are not outweighed by the effort of using it.

Usefulness: This is debatable. Some make the distinction between usability and usefulness. Although it is impossible to quantify the usefulness of a system, attempts have been made to measure its attainment in reference to system specifications and the extent of coverage of end users’ tasks supported by the system, but not on end user performance testing. Perceived usefulness expresses people's intention to use (or not) a new technology to the extent that they believe it will help them perform their job better.

Wireless networks: the term refers to communication networks, whose interconnections between nodes are implemented without the use of wires, such as a computer network. Wireless communication networks are generally implemented with some type of remote information transmission system, consisting of base stations and client terminals that use radio waves.