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PubMed on Tap: Discovering Design Principles for Online Information Delivery to Handheld Computers

Susan E. Hauser, Dina Demner-Fushman, Glenn Ford, George R. Thoma

Communications Engineering Branch, Lister Hill National Center for Biomedical Communications, National Library of Medicine, National Institutes of Health, Department of Health and Human Services, Bethesda, Maryland, USA

Abstract

Online access to biomedical information from handheld computers will be a valuable adjunct to other popular medical applications if information delivery systems are designed with handheld computers in mind. The goal of this project is to discover design principles to facilitate practitioners' access to online medical information at the point-of-care. A prototype system was developed to serve as a testbed for this research. Using the testbed, an initial evaluation has yielded several user interface design principles. Continued research is expected to discover additional user interface design principles as well as guidelines for results organization and system performance.

Keywords:

Handheld Computer; Computer-Assisted Decision Making.

Introduction

The practice of evidence based medicine (EBM) has grown dramatically since the term was introduced in the early 1990's [1]. EBM involves integrating individual clinical expertise with the best available evidence from systematic research [2]. One reason for the growing interest in EBM is the creation of information systems that permit the near real-time delivery of clinically relevant information [3].

During the same time period, handheld computers, or personal digital assistants (PDAs), were introduced and have become increasingly popular for a variety of medical applications [4]. Given the desire for access to current, high-quality information at the point of care and the convenience of PDAs, it is not surprising that mobile health care providers see PDAs as a valuable tool for "providing information nuggets in a just-in-time manner" [5].

Prevailing sources of best evidence are electronic, with access via an internet connection and a web browser [6]. However, web pages designed for display on a desktop computer screen seldom render well on the small screen of a PDA [7]. Providing the same power and flexibility to PDAs as to desktop-based clients will require system designers to look beyond the now-traditional model for desk-top computer, browser-based information access. The goal of the PubMed on Tap[1] project is to discover design principles to facilitate practitioners' access to medical information at the point-of-care, namely those related to user interface design, results organization and system performance.

Testbed Design

A prototype testbed system, PubMed on Tap, was built and tested to explore user interface design, results organization, and system performance. The system is based on MEDLINE®, the National Library of Medicine's (NLM's) premier database of indexed citations from biomedical journals and on PubMed, NLM's interface to the database. A system requirement was the need to use PubMed's search and retrieval capabilities, while at the same time controlling the interface to PubMed as seen by the PubMed on Tap user. This is accomplished through PubMed's Entrez Programming Utilities (Esearch, Efetch and Elink). These tools provide access to Entrez data outside of the regular web query interface and support search and retrieval from other environments. Other system design goals include: (a) timely transmission of information to numerous concurrent users; (b) performance monitoring; (c) utilization of aggregate usage statistics to improve performance; (d) the ability to facilitate precision through support of user-specific preferences (input) and through clustering and/or ranking of citations (output).

Three designs were considered that would permit using the Utilities for search and retrieval, while managing the user interface at the handheld computer. Briefly, they are: (a) develop client software for the PDA to access PubMed directly; (b) develop a proxy server as an intermediate website for PDAs, using templates to format html pages for small screens; (c) develop client software for the PDA to communicate with a proxy server that, in turn, communicates with PubMed via the Utilities. Table 1 lists some of the advantages and disadvantages of each design.

The client plus proxy server was selected as the best overall design for the testbed. The client program permits control of the user interface while the processing power of the proxy server supports experimenting with methods to facilitate precision and improve response. Together these allow for flexibility in those aspects of information delivery that are being researched. An overview of the system is shown in Figure 1.

The client in this design is not platform independent; it was designed for PDAs running the Palm operating system, since the literature reports these to be the most popular among physicians who own PDAs [8].

1. The PubMed on Tap application is available at http://archive.nlm.nih.gov/proj/pmot/pmot.php.

Table 1: Pros and Cons of three prototype designs

Design	Pros	Cons
Client Only	Control of user interface Able to store user-specific data locally	Not platform independent User must install new version when client changes Client must do all data processing No opportunity to monitor performance or gather aggregate usage statistics
Proxy Web Server	Platform independent Changes for new versions implemented at the server only Can perform data processing at server Can monitor performance and gather aggregate usage statistics Can store queries, results, citations at server to improve performance	Little control of user interface Must store user-specific data at server, requiring user identification Html file ~4 times the size of equivalent XML data
Client plus Proxy Server	Control of user interface Able to store user-specific data locally Can perform data processing at server Can monitor performance and gather aggregate usage statistics Can store queries, results, citations at server to improve performance Only need to transmit data to be displayed (XML data)	Not platform independent User must install new version when client changes

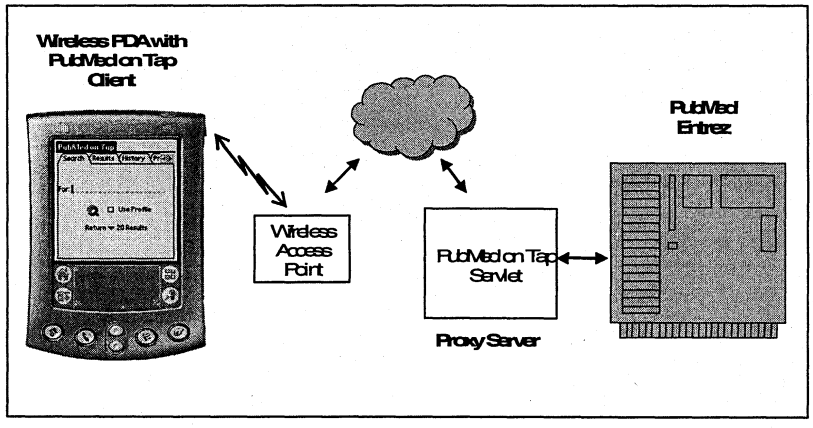

Figure 1 - PubMed on Tap system components

The client program is written in C/C++ using the Code Warrior development environment. It uses the PDA's wireless communication interface and the http protocol to communicate via the internet with a servlet on the proxy server. The servlet, written in Java, runs in a Tomcat servlet container on an Apache http server in a UNIX environment.

To present a familiar-looking interface to new users, the design of the client user interface is modeled in part on ePocrates, the drug database reported to be the most popular application for PDAs among healthcare professionals [9]. Following this model, functions are organized by tabs and drop down lists are used where possible to save space. Although space is at a premium on the small screen, readability trumps space utilization, so whitespace is used to separate distinct items on the screen. For navigation, small icons are used in place of larger, text-identified buttons. Search limits are easily selected from the Profiles tab and are stored locally. Previous queries are also stored locally and are available for reuse. Figures 2 through 5 show four of the PubMed on Tap screens.

Evaluation

In July 2003, the prototype system was tested in the National Cancer Institute's Usability Lab with nine volunteers from a variety of backgrounds. Details of this study are reported in Alexander [10]. Insights into a few design principles are noted here:

(a) *Retain the icon functions of the target application.* The desktop PubMed environment uses various icons of pages to indicate "No Abstract", "Abstract", "Free Full Text Article" and "Article in PubMedCentral". PubMed on Tap used a blank page icon as a link from the article citation to "Related Articles." Our volunteers, who were familiar with PubMed, found this confusing.

(b) *Use visual prompts.* Users need a visual clue that tapping at some location will yield results. Even though our volunteers "knew" that tapping the abbreviated summary text would display the abstract, they tended to forget that because there was no visual prompt. Likewise, because of the widespread familiarity with WWW conventions, users expected there to be a visual clue that a given abstract has already been "visited" once it had been viewed.

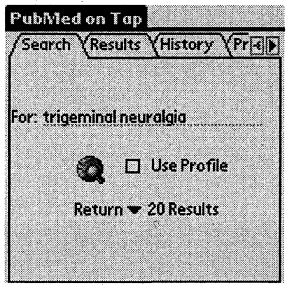

Figure 2 - The Search lab

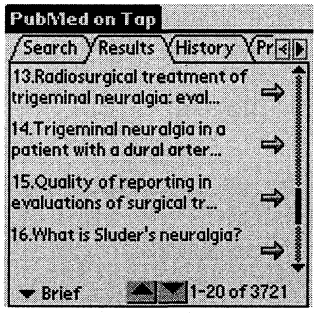

Figure 3 - The Results tab

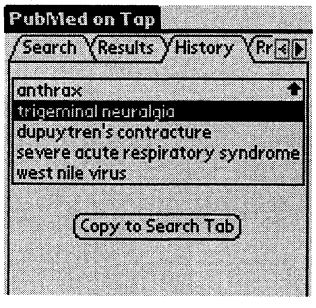

Figure 4 - The History tab

(c) *Focus text entry.* When text is to be entered, users may benefit by having the text field automatically focused with a blinking cursor. PubMed on Tap includes a separate screen to select journal titles to which searches can be limited. There is a "Find" text field at the bottom of the screen in which users can enter the first few characters of the journal name to quickly jump to it. Although our volunteers understood how to use that feature once they saw it, several failed to notice that the field was present without being prompted.

(d) *Avoid complexity* [11]. The results screen supports two navigational paths for obtaining "more information" for an article of potential interest: one leading to MeSH terms and journal Subject Headings, and one leading to the abstract. Our volunteers were accustomed to going from the title to the abstract. Having an additional choice was confusing rather than helpful.

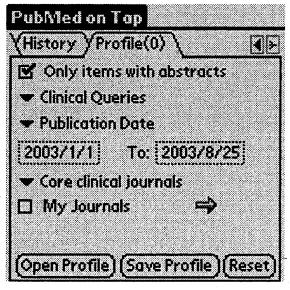

Figure 5 – The Profile tab

Following the test session, each volunteer completed an on-line evaluation form consisting of 29 multiple choice questions. Overall, the reactions to PubMed on Tap were favorable. Most participants found it fast, easy to use, easy to read, and said they would probably use it at work if they could. Features found to be "very useful" were the ability to limit the search to citations with abstracts, and to limit the search by date of publication. Opinion was divided about the ability to display results in "Brief" mode; most participants thought it was "slightly" or "moderately" useful, but two thought it was "extremely" useful. Regarding additional features, all but one participant said that the ability to save selected citations would be "extremely" useful. Many also thought that clustering citations by MeSH terms or other criteria would be "very useful".

Ongoing research

Based upon these observations, the next version of PubMed on Tap is being developed to incorporate changes that would yield the greatest improvement for modest effort. 80 individuals have registered at the PubMed on Tap website to use and evaluate the software. When the new version of the application is developed and tested, it will be sent to these users along with a request to complete a structured evaluation. We also plan to exhibit the system at conventions of health care practitioners to elicit feedback directly from our target users.

Initial research has been largely focused on user interface design. Future research will place additional emphasis on results organization and system performance.

Results organization: This research explores ways to organize the search results by summarizing, clustering and ranking the resulting citations. Initial work involves categorizing citations returned in response to a query, creating multi-document summaries for clusters of highly related documents, and single-document descriptions containing features specific only to a given document in the cluster [12]. The research includes developing an appropriate user interface for display and selection of results categories.

System performance: A system design goal is to enable simultaneous use by hundreds of users with no reduction in reliability or speed. Therefore, research in this area is focused toward discovering design factors that ensure the speed and reliability of the hardware and software required for accurate and timely retrieval of data. Areas of investigation include choice of parsers, efficient use of a database to store recent queries and citations, and load testing.

In the longer term, other issues will be addressed: e.g., achieving platform independence or alternatively, developing multiple versions of the client; retrieving and displaying full text articles; exploiting Hotsync to support additional capabilities such as automatically updating the client software with a new version; linking to an Electronic Medical Record to use patient data to inform the search.

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Address for correspondence

Susan E. Hauser, Ph.D., P.E.,
Lister Hill National Center for Biomedical Communications,
National Library of Medicine, Bethesda, Maryland 20894, USA.
E-mail: hauser@nlm.nih.gov