WWW/Newton: Mobile Computing for the Internet

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Abstract: In this paper, we motivate the importance of mobile access to global information systems and present WWW/Newton, a WWW frontend for Apple's Personal Digital Assistant (PDA), the Newton. An emphasis is put on impacts of the PDA technology and limited network bandwidth on the software architecture of WWW/Newton. On the other hand, we will discuss resulting requirements for next-generation WWW protocols and servers which can be easily generalized to other global information systems. The work presented was carried out in the context of a larger project which investigates the mutual impacts of mobile computing technology and distributed applications. WWW/Newton software has been successfully presented on several international exhibitions and has received vital interest from the network community.

1 Introduction

Terms and definitions: we use the term personal digital assistant (PDA) to denote a palmtop-size handheld computer which is purely pen-operated, i.e. lacks a keyboard. In accordance with the definition given by John Sculley in 1992, a PDA combines functions of an organizer (notepad, addressbook, calendar) with communication abilities (fax, modem, e-mail, beam) and an integrated intelligent assistant and built-in OCR software to analyze the user's handwriting.

Motivation for using PDAs: the current first-generation PDAs, such as the Apple Newton we use, have been received with too much enthusiasm first and with too much deception in the sequel. Too thick to fit into a pocket, too small for serious handwritten note-taking, still too unreliable as to its handwriting recognition, still too underpowered, and with much too little connectivity, the actual PDAs can only be seen as pathfinders towards a new technology. This new technology, however, can safely be considered to carry a technological revolution at least as important as that of the PC. For example, (improved) PDAs are ideally suited for Mark Weiser's [Weiser, 1993] vision of ubiquitous computing. In order to approach this technological revolution, the PDA has to overcome the deficiencies cited and, maybe even more important, has to shift its focus from delivering local standalone applications to being a very intelligent communication front-end, a kind of handy (portable cellular phone) which contains programmable logic and memory and which provides access to both instantaneous (synchronous) and delayed (asynchronous) communication with both humans and machines (General Magic uses the term PIC - personal integrated communicator - to denote the communication focus). In our project, the PDA has been used to explore this shift in focus.

Motivation for combining mobile computing and global information systems (GIS): the combination of mobile computing and on-line multimedia GIS seems to be the marriage of a mouse and an elephant: mobile devices with their limited capabilities (wrt. storage, power, and particularly UIs) and communication bandwidth seem to fit badly with multimedia GIS which require high bandwidth for multimedia transfer as well as powerful UI and display capabilities. Using PDAs, this mismatch seems to be put to the extreme since the lack of a keyboard seems to match badly with the predominant task of formulating queries known from traditional information systems, and screen size and available communication devices are possibly the worst in the range of existing mobile computers. The reason for which we chose this strange combination of PDAs and a multimedia GIS lies in the prospects of communication-enhanced PDAs as described above which we will illustrate a bit further. For example, in his book "Hitchhiker's Guide to Galaxy" Douglas Adams provides Ford Perfect, one of his main

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characters, with a special electronic travel guide produced by the Ursa minor publishing company. Whenever Ford Perfect needs some information he just types in a keyword and gets all the desired data. Sometimes even more. We consider the combination of a PDA and of a multimedia GIS as an important step towards (and in some areas beyond) this vision.

GIS such as WWW [CERN, 1994] support the user with a wide variety of individual databases, allow computer aided learning and publishing with text, pictures, sound and short movie sequences and include on-line documentation. WWW services, in particular, may serve students (campus wide information systems), scientists (literature search, access to newest information), but also all kind of people who need on-line information. Further applications include virtual malls, weather forecast, medical databases, virtual libraries, virtual exhibitions, and on-line dictionaries, to cite just a few. Two examples will be used to illustrate the gains obtained with the move from conventional services to GIS services, and with the move from static to mobile (PDA-based) access to such GIS services.

- *Virtual library:* Imagine someone who wants to perform an article research using a conventional library. He has to go to the library where he might browse several databases and in a first step get some hits. In a second step he might take that list to the archive and try to find the articles in the magazines. In case of a miss he might have to place an order which may take several weeks.
  Using WWW, the user can do the search and download the documents from the same place, and there is a choice of several libraries. At a first glance, using a mobile device (here: a PDA) seems to increase the comfort for the user only a little. Looking at the working style of students, however, one gets aware of the impact of mobile access: students may want to do such work at many different places (in the dormitory, at a leisure place, at the parent's home, in the bus, during lunch or class) which are not equipped with WWW clients, and they may want to take the results along with them in electronic form. (for WWW users, we include a sample reference to a comparable WWW service, cf. URL: http://glimpse.cs.arizona.edu:1994/bib/)
- *Travel guide:* as the wide-spread example of GIS-based campus information shows, electronic travel guides can be much more up-to-date, are feasible even for small numbers of highly distributed readers who in addition need access only to a small fraction of the information, and can be edited in a "distributed authoring" style. But obviously, travel guides are most needed when users *move* into *a foreign* place. Since they move, mobile communication is a must, and since the place is foreign, the users will most likely not have easy access to on-site terminals. Since a mobile device can provide access to the on-site travel guide as well as back home or to third-party services, a user can for instance take a look at his flight schedule, change or book flights, and exchange messages with the office or family while traveling. (again, cf. dictionary: http://calamity.rz-berlin.-mpg.de/eg.html, or travel guide: http://www.willamette.edu/pgg/).

According to this vision of using GIS services 'everywhere at any time', this article focuses on the usability of a combination of existing PDAs (the Apple Newton) with the World Wide Web (WWW) as an on-line global multimedia information network. Due to the lacking availability of more advanced mobile WAN communication hardware, connectivity was restricted to ordinary phone lines (via modem). With the upcoming high speed ISDN networks and wireless modems, some of the corresponding restrictions will be overcome. On the other hand, the telephone network represents a good and inexpensive approximation of ubiquitous network access.

2 The WWW browser

In the attempt to explore tools for ubiquitous computing, key software design decisions for PDA-GIS solutions were identified. This chapter will discuss design alternatives and motivate our decisions.

2.1 Distribution

PDA Client: At a first glance, one may think of implementing the standard WWW client functionality on the PDA. This solution, however, has the disadvantage that the user has to fully account for the power and bandwidth restrictions of the PDA. Help from the WWW client is actually not to be expected because special consideration of restricted resources in clients is not reflected in the current version of WWW's communication protocol (HTTP) and document description language (HTML). Finally, this version is currently not even feasible because WWW servers do not provide phone access by now.

PDA Terminal: another possibility is to use the PDA as dumb client (terminal), just sending requests to a workstation which acts as a WWW client and interfaces to the PDA, converting between PDA compatible I/O and the WWW compliant formats (see lower part of Figure 1). While such an architecture may be fast, the PDA client depends on the same workstation for all interrelated sessions and does not allow disconnected operations.

Reliability, mobility (in the sense of disconnected operations), and cost-effectiveness (cf. long-distance connections) would be low.

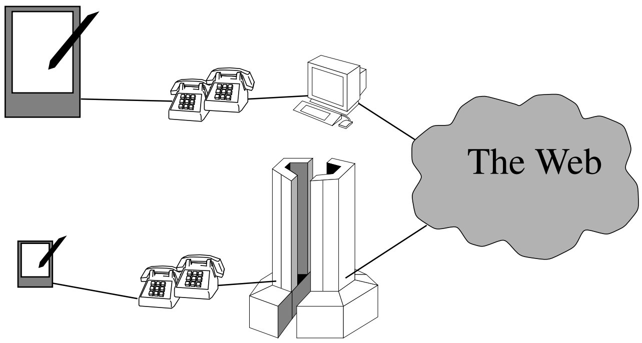

Figure 1. Possible architectures of the PDA-WWW browser: terminal vs workstation

Distributed Client: for a more ubiquitous version, the client can be distributed between PDA and workstation. If the workstation is mainly used to operate the connection to the server and to do state-independent preprocessing, the PDA part of the client does not need to be connected to the same workstation all the time (see top of Figure 1). A WWW-PDA daemon can be realized, similar to the finger-daemon, to be installed on as many workstations as possible. The PDA can then connect to any such host in order to access WWW.

The WWW/Newton system presented here follows this third approach (see Figure 2). Preprocessing in the workstation part of the client compensates mainly for the limited display, and storage capabilities of current PDAs and for some missing features in the HTTP-protocol (cf. next chapter). Since a distributed client represents the most sophisticated architecture, a stand-alone WWW client can be easily built if upcoming generations of PDAs make it desirable and as soon as the planned HTTP features become available

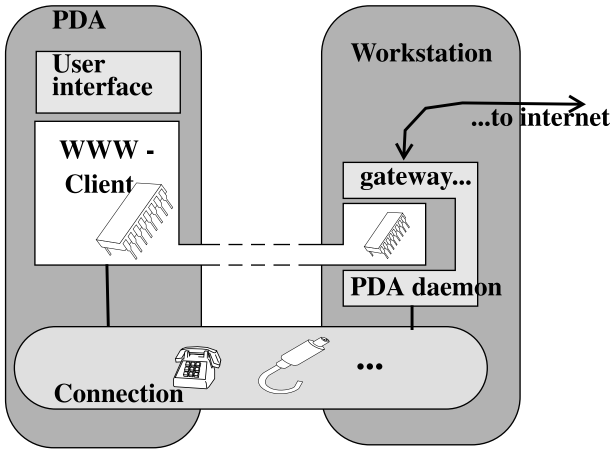

Figure 2. Distributed WWW- client

In our implementation, the workstation part of the client performs the communication with the Web, caches received documents, transforms images into a PDA usable form and manages the fragmentation of large text documents into small parts which are sent to the PDA piece by piece. The PDA part of the client performs most of the client functionality. It manages the whole interaction with the user, sends its requests to the UNIX-server, receives texts and images, and prints the documents on its screen. In particular, the complete interpretation of HTML is done on the PDA.

Users are able to build up a hotlist as well as all kind of user preferences dealing with the display style. The user interface is designed to have the same look and feel as the well known Mosaic client. Figure 3 and Figure 4 show screenshots from our WWW-client. To follow links in our browser, the user just taps on underlined words with the Newton pen.

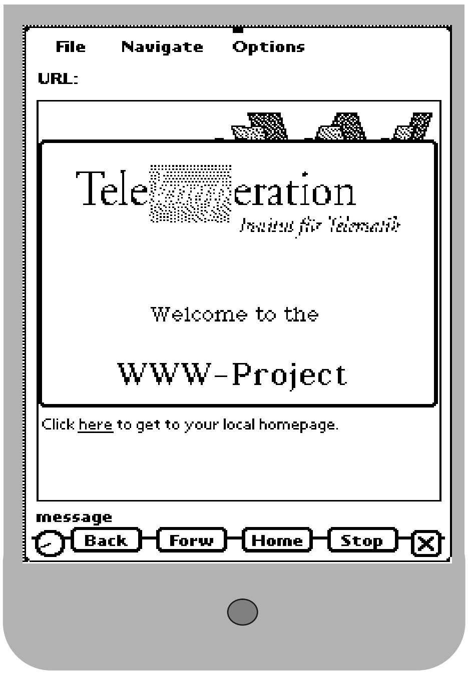

Figure 3. The PDA WWW browser

2.2 Connection

Current versions of the Newton offer either telephone or serial connection to workstations, both at a bandwidth of 9600 kbit/s. WWW/Newton supports serial connections in-house and WAN access via phone, according to the standard Newton philosophy. Support for wireless networks is planned, the corresponding hardware is only about to be available, however. Due to the flexible design as a distributed client, bandwidth considerations of the alternative connection types can be included in WWW/Newton as soon as the alternatives lead to considerable bandwidth differences. In addition to the printing facility, we also support PDA specific communications like faxing and beaming.

2.3 Supported datatypes

Due to the serious resource restrictions on the PDA, the actual version of WWW/Newton supports only text and image data. Regarding the special size and capabilities of the display we had to solve different problems.

Text: The LCD-Display is small compared to a conventional computer screen. Scrolling is much more likely and it might be more difficult to get an overview of the text. WWW browsers depend heavily on the ability of producing 80 column text which is not possible with a PDA. We had two possibilities: Four-way-scrolling to present the reader an 80 column text: an evaluation proved very soon that this solution is very uncomfortable for typical WWW texts; two-way-scrolling (only up and down) and only 50 column text. This requires new clipping of the text which sometimes leads to less beautiful results but is much easier to read than possibility one (see Figure 4); this solution was chosen.

In addition, we tried to 'fix' strange clipping by transforming all kind of nested lists into lists of depth one. Titles can appear clipped and using more then one line. The PDA does not support fixed pitch so we could not support it in our browser. Text which should be rendered in a teletype font is printed with a proportional font. This rare but unsatisfying situation requires an extension to the PDA font family to be solved. Long text documents are splitted into small parts by our separate UNIX server and sent to the PDA piece by piece on demand.We support HTML or plain text. External viewers for postscript files or other document types are not yet available.

Images: The image loading is delayed as default. Only when a user really wants to see an image and taps on its icon a request for its data is sent. We only have a B/W display so all incoming pictures have to be transformed into 1-bit depth, B/W images by the host. Pictures larger than the display are reduced in size. With further versions of HTTP it should be possible to receive PDA suitable images [see chapter 4].

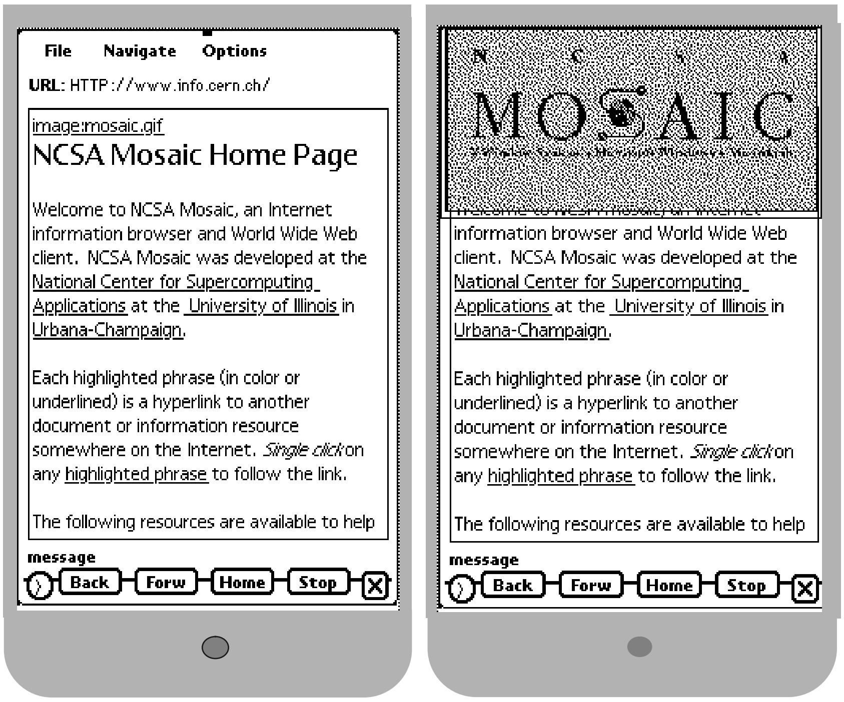

Figure 4. The NCSA homepage (delayed and requested image)

2.4 Present state

The current version of WWW/Newton can be considered stable and intuitive in use. The most annoying resource restriction is the network bandwidth. At the moment it takes about 10 seconds to transfer a document from the workstation to the PDA and display it. The upcoming network extensions to the Newton will significantly reduce this problem. We support the most common structures of HTML and HTML+ and images. Since wireless modems were not yet available, we could only approach the scenario which we call “no matter where you are - you have access to all the information”. The results were still impressing and leveraged plans for new versions of WWW/Newton and for new applications.

3 General experiences with PDA-GIS architectures

Connected to a multimedia GIS, the limited text-input capabilities of PDAs are not much of a problem: most hypermedia information retrieval in current multimedia GIS is based on hypertext navigation; such navigation can be controlled very ergonomically with the PDA pen. It can be anticipated that more serious, mission-critical use of multimedia GIS will be based less on link navigation than on graphical queries which combine hypertext structure information and content (e.g., “search all nodes of type annotation authored by Alan_Kay and pointing to a node authored by John_Sculley”). The current generation of PDAs is not very well suited for this kind of sophisticated graph-based query interface. By the time graph-based query interface will leave the academic and research state, however, it can be expected that the handwriting/drawing recognition of PDAs will have improved; if so, the PDA will even have an ideal interface paradigm for multimedia GIS.Even for the current version of WWW/Newton, the evaluation has shown that pen-based UIs to GIS are preferred over mouse-based ones by the users.

Display size and communication bandwidth have been identified above as the most scarce resources in the PDA-GIS marriage. A major revision of the PDA technology will be needed to resolve the display size problem. The bandwidth problem seems to be much more short-living. ISDN PCMCIA cards for PDAs are about to be available, and fast radio LAN access can also be accepted soon. By that time, transfer of more resource intensive media like postscript documents can be considered. Even digital audio or even video can then be imagined, provided the output capabilities of future PDAs support the respective media. As to the GIS side, extensions to HTTP and HTML are desirable, see below. Apart from that, WWW servers should be extended to allow direct connectivity from mobile devices, first via phone, then via ISDN and radio LANs and WANs.

4 Experiences with the WWW protocol and language

HTML is the markup language used to structure WWW hypertext documents [Berners-Lee, 1993]. E.g., HTML defines the identifiers and usage of tags for indicating paragraphs, headings, links, highlighting, lists etc. HTTP is the protocol used between server and client [Berners-Lee & Conello, 1993]. The core protocol is very simple: the client establishes a connection with the server, sends a request containing the URL (a unique resource identifier) of the desired document, and receives the corresponding document from the server in response. The following problems with HTTP and HTML and resulting requirements for new versions were identified:

- As we mentioned before, HTML assumes 80 column wide displays. PDAs are currently restricted to half that size. Reformatting text for 40 columns usually yields fairly acceptable results; titles may run over serial lines, which is usually acceptable, too; tables or nested lists however may become unreadable. In summary, the present version of HTML is acceptable for PDAs as WWW browsers. Along with the HTTP extensions proposed below, HTML should be extended to allow, e.g., particular HTTP-compliant flags to be included.
- As to HTTP, one problem is the fact that documents can only be received as a whole once a request is issued to the server. Due to the small storage capabilities of PDAs it is not possible to download long documents into its memory. Therefore, HTTP should be augmented by a QoS negotiation protocol at connection establishment time, including, e.g., the maximum number of bytes the client is willing to receive per download.
- Another problem is the fact that format conversions are supposed to be done at the client side. Thus, e.g., color or greyscale images are transferred although the PDA can only display bitmaps. This consumes a magnitude of bandwidth more than necessary and renders PDA-only clients impossible for the moment. HTTP should be augmented so that server-side conversion of images may be required. This feature is planned for future HTTP versions and is very desirable.
- During our work, we found it very desirable to obtain attribute information about resources before downloading the document, such as size and the usefulness of the content. Images for instance, often contain special bullets to be put in front of lists or small “ghosts” to be put behind vertical lines. With a ‘PDA-usable’ flag associated with images the browser could distinguish the pictures containing necessary information from fancy artwork to avoid unnecessary down-loading of such images. Other information could be used to support the user in his decision process about whether he wants to download an image or document (e.g., size could be transformed by the PDA client into an estimation for the download time). An extended version of HTTP, the HTTP2 protocol, includes a certain level of support for attribute information; the above mentioned flags or priority schemes, however, are not yet planned up to now.

5 Summary and Outlook

Our first version of WWW/Newton yielded promising results. We use a “distributed client” approach, connecting the PDA to a workstation which includes part of the client functionality and manages the connection to the server. The workstation part of the client is rather memory-less and generic; thus, subsequent WWW/Newton sessions can involve different workstations, an important feature from the point of view of mobility and reliability. With minor extensions to HTTP, a minor increase in the storage capabilities of PDAs, and mobile network support at the server side (phone, ISDN, or radio networks), a PDA-only version of a client could be built. But even for this case, it might be desirable to stick to the “distributed client” approach to make use of the resources available on workstations.

Further versions of WWW/Newton will include support for faster networks and more document types such as postscript. Follow-on projects will investigate other GIS, based, e.g., on Gopher, ftp, network news and Wais. If not today, than at least with versions to come up soon, PDA-GIS architectures represent an important step towards the networked mobile technology which will drive a major revolution in the information society.

6 Major References

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