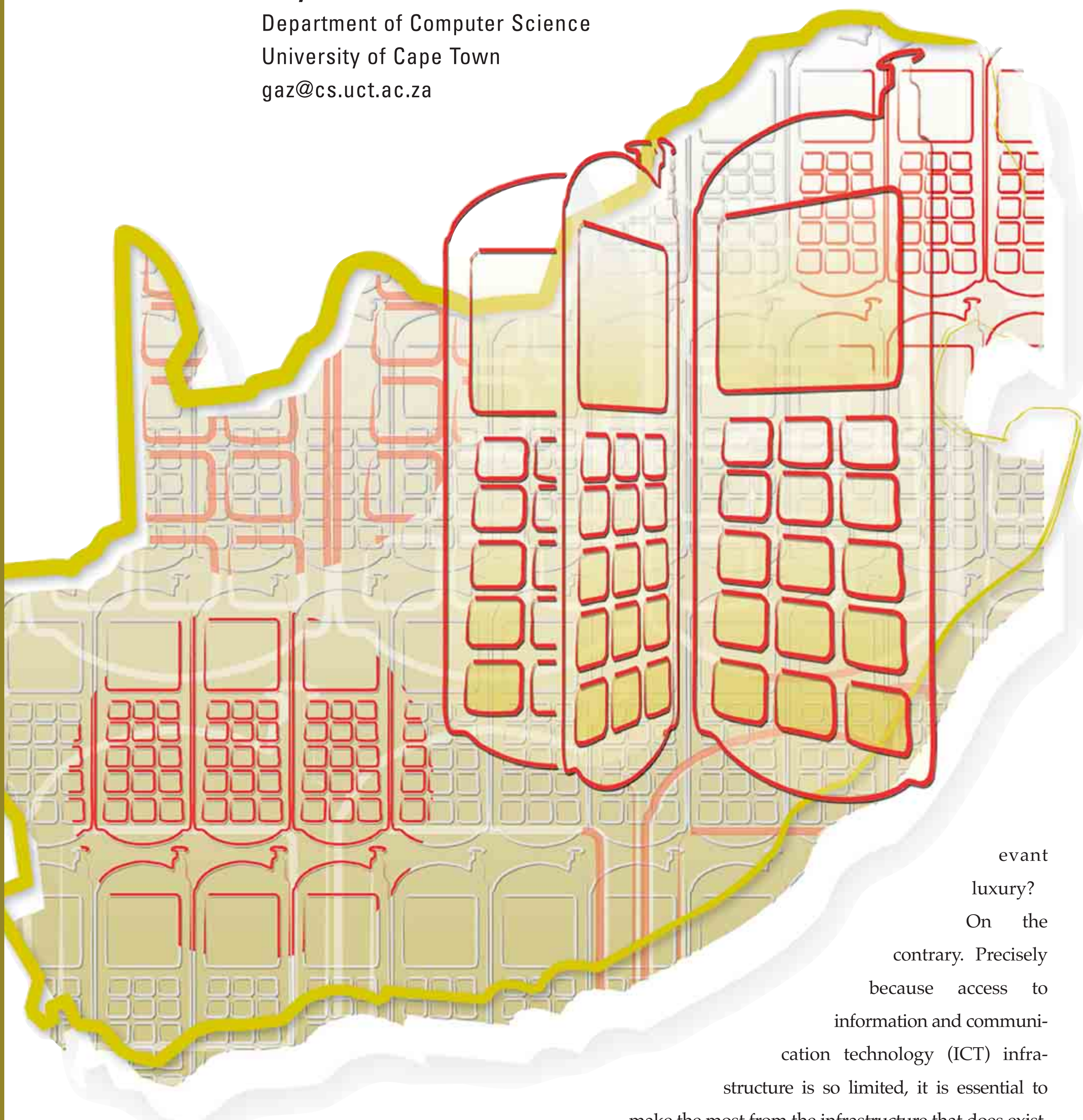
Using HCI to Leverage Communication Technology

Gary Marsden
Department of Computer Science
University of Cape Town
gaz@cs.uct.ac.za



What is the benefit of human-computer interaction (HCI) to a developing country? On a continent where an estimated one in 130 people has access to a personal computer (PC) [3], surely interface design is an irrelevant luxury? On the contrary. Precisely because access to information and communication technology (ICT) infrastructure is so limited, it is essential to make the most from the infrastructure that does exist. Human-computer interaction (HCI) has a large role to play in empowering users and adapting technology to local needs. Among South Africans such empowerment is seen as key to our country's future. The following is taken from an address given by the South African president, Mr. Thabo Mbeki, to the G7 summit in 1995 [6]:

"...it is clear that bringing the developing world on to the information superhighway constitutes a colossal challenge. We have to address the challenge nevertheless, if we are to promote economic growth and development worldwide, consolidate democracy and human rights, increase the capacity of ordinary people to participate in governance, encourage restitution of conflicts by negotiation rather than war and do what has to be done to enable all to gain access to the best in human civilization, within the common neighborhood in which we all live."

So how does one tackle such a challenge?

If we are going to make useful information available to a wide group of people, two key issues need to be addressed:

- **Content:** Although it contains a lot of useful information, the Web is currently clogged with irrelevant and unhelpful information. If the Web is to become a useful tool, then some way needs to be found to filter out material that is not useful and better catalog the material that could be useful.
- **Access:** Typically, a personal computer is required to access the Internet. Expensive, bulky, fragile, and requiring large amounts of power, the personal computer does not seem like an ideal candidate for providing universal access.

Tackling the problem of access first, after television and radio, the one piece of communication technology that most South Africans have access to is the cellular telephone network. In a country where only 11 percent of the population is sufficiently wealthy to pay income tax [10], some 27 percent of the population owns a cellular handset [9]. This is a rare example of the much heralded technology-leapfrogging by developing countries, where the new cellular technology has made the older, cable-based telephone network obsolete (only 11.4 percent of South Africans have access to a fixed-line handset [2]—a pattern repeated in many other developing countries). Furthermore, South Africa is experiencing urbanization, so a large percentage of the population has no fixed abode from which to access land-based telecommunications.

As multimedia messaging services (MMS) and connected digital assistants (like the XDA) currently drive the cellular market in European countries, we in the developing world are somewhat lower on the technology feeding chain and are still purchasing wireless application protocol (WAP) handsets. Although WAP may not be the ideal way to connect to the Internet [8], we believe it is better than no connection at all.

Providing Content

To be an effective tool, not just an entertainment medium, information on the Web needs to be edited, categorized, and stored in a concise and easily searchable way. Although this may seem like a pipe dream, it describes exactly the goal of digital libraries. We have been working with the New Zealand Digital Library Group [7], which has, in turn, been working with the

United Nations and the United Nations Education, Scientific, and Cultural Organization (UNESCO) to develop digital library collections for the developing world. To date they have developed collections such as the Human Development Library, Food and Nutrition Library, and the Medical and Health Library, which are published using Greenstone Digital Library software. These libraries, and many others, contain information that is highly valuable to any developing country. Witten *et al*. [13] list all the collections available on Greenstone for developing countries (some 3,590 in total). The article also points out the costs and benefits to developing countries of delivering information in this way—for example, the Human Development Library alone contains some 1,230 publications, and in print would weigh 340 kg (almost 750 lb.) and cost $20,000 USD!

Distribution

All interaction with Greenstone is currently conducted via hypertext transfer protocol (HTTP) and hypertext markup language (HTML). To bridge the gap with WAP and wireless markup language (WML), we installed a proxy server, details of which can be found in Marsden *et al.* [5]. We were able to generate sensible WML because the Greenstone content is well defined and regular in structure. Having built the server, we had to tackle a variety of usability issues that are not easily solvable. Each issue was tackled using heuristic evaluation with a selection of Web literate users (who were not familiar with digital libraries per se).

Document Structure

Digital library documents tend to be arranged in a hierarchy: collection, document, chapter, section, and so forth. There is a convention of indention to display this information. However, indention on a WAP device is not easily achieved because several of the browsers we worked with ignore white space. After trying a variety of solutions we discovered that the minus sign (-) forced indention without cluttering the display.

Figure 1. Customization tool for digital libraries.

Also, when a user browses Greenstone, only the section headings of a document are retrieved. On our system, we used a plus sign (+) to denote an open branch and a minus sign (-) to denote a closed branch. This caused problems in the usability tests because users familiar with Windows Explorer associated a plus with expanding a branch and a minus with collapsing a branch. Once we altered the design to conform to Windows, users no longer stumbled on expanding and collapsing branches.

Browser

We used several browsers in our evaluation and discovered that each had a different interpretation of the

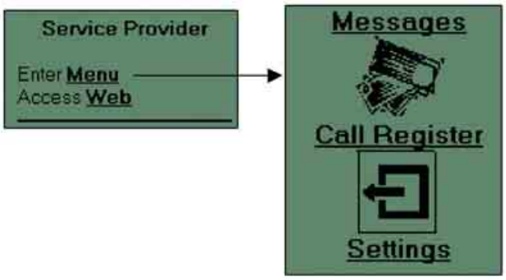


Figure 2. The handset home page (left) allows local and menu access. Selecting the Menu option will present the user with a screen (right) that allows the user access to the normal menu system.

WML standard. We found browsers for which the Back button did not work; browsers that placed buttons in arbitrary screen positions, and browsers that did not display hyperlinks longer than the screen width. Although these are implementation issues, one usability issue common to most browsers was the indication of scrolling. When a page exceeded more than one screen, our users would often not scroll down. When asked about this, most responded they had no idea that there was more information (unless there was an incomplete sentence or other accidental cue). The reason users did not scroll was related to the small size of the scroll bar on most WAP browsers. Designed to take up as little screen area as possible, these widgets are barely noticeable, providing no feedback to the user on the length of the page. If usability of WAP is to improve, then scroll bars need to remind users that more information may be hidden beyond the bottom of the screen.

Digital Libraries

After watching our subjects struggle to retrieve information with our system, we conducted some usability tests with the full, HTML version of Greenstone. Our results showed that some usability issues lay with Greenstone, rather than being artifacts of our system. As our target users have had little experience with libraries, let alone digital ones, we discovered that the basic metaphor of information structure (for example, chapter, section, subsection) proved problematic.

If digital libraries are to make an impact beyond English-speaking, computer-literate users, then several interesting questions need to be answered. It is clear that a simple translation (into a local language) of the interface will not be enough; more fundamental research is needed on how information can be structured and presented to those not familiar with document conventions. Our preliminary work, reported elsewhere in this issue [12], has shown that many cultures struggle with the concept of hierarchies (subjects were unable to draw a simple family tree).

As it stands, our system follows the conventions of the Web and Web searching. This has greatly improved system usability, to the extent that Web-literate users can perform meaningful queries and retrieve useful

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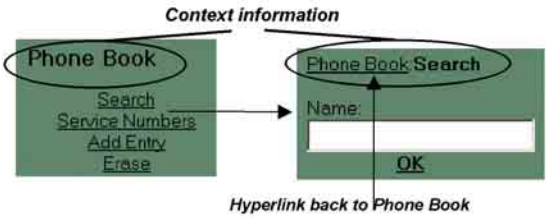

Figure 3. The menu allows several options to be viewed simultaneously. Also, context information can be used for navigation as in an HTML-based Web site.

results. The issues of WAP browser and digital library design still remain. We are confident that as mobile Internet access becomes more common, the usability of mobile browser software will improve. The work of altering digital libraries for use in developing countries, however, has no direct commercial benefit and is only likely to happen, therefore, as an academically motivated project. Currently we are focusing our efforts on building a high-level customization tool that lets novice users create and customize their own collection. In Figure 1 the output is being formatted for a personal digital assistant (PDA) screen.

Cellular Handsets

Besides the usability issues directly related to WAP, we observed that users struggled when switching between WAP and the menu structure of the handset. If handsets do have a browser installed, it would seem sensible to eliminate the menu structure and replace it with a series of WML decks. By doing this, we free the user from having to learn two types of interface; the navigation techniques they learn for the browser can be transferred to navigating the functionality of the handset. To investigate the possibility of providing a WAP interface, we have built a number of prototype systems.

WML Prototypes

The simplest way to replace menu systems is to create WML pages corresponding directly to existing structures. We have already built such a system based on the Nokia 5110, as shown in Figure 2. This prototype presents the user with a home page providing access to handset information or a remote site. If the user selects **Enter Menu**, he or she is presented with the WML pages replacing the menu system. In this way, the menu becomes just another site accessible through the browser. The only interactional benefit of this prototype, however, is that the navigation keys and paradigm for the menu system are identical to those required for a WML browser.

To improve interaction further, we modified the WML to present as many options as possible on the screen at any one time. We then used indention to provide the user with context information about their choices (see Figure 3). In this way, we have created a system that exploits best practice in displaying hierarchical menus and keeps the navigational benefits of the previous prototype.

Both of the prototypes described earlier are based on the structure of current menuing systems. Re-using the structure in this way allows current handset users to transfer their knowledge to the browser-based system. However, as the options are presented as WML pages, it would be straightforward for handset manufacturers to provide users with a WML editor to restructure the menu system any way they choose. This would allow users to exploit the benefits of a graph-based structure and overcome problems of hierarchical classification.

Research [11] was carried out to consider the impact of reducing the size of the display to a menu system. The smaller the display, the fewer options were presented; users had to scroll the list to see any options not shown initially. Although the time it took users to select an option increased as the display size decreased, the

Figure 4. Display from Ericsson R320 showing menu title and three options.

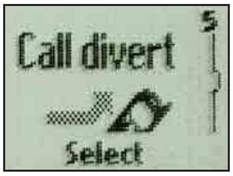

Figure 5. Nokia root-level icon.

impact was not dramatic. Real problems occurred, however, when the display was so small that only one option could be displayed at a time—error rates increased dramatically, and the time taken to access functions was significantly reduced. Therefore, handsets that display more than one option at a time (ideally three or more) have performance characteristics similar to those of desktop systems. A device that displays only one option at a time will be disproportionately more difficult to use.

It appears that cellular handset designers are unaware of this research, because they persist in producing handsets that display only one option at a time. Although some handsets are so small that they support only a single-line screen (for instance, Ericsson T28), others have a large screen capable of displaying multiple options but choose not to do so (any current Nokia or Motorola). To improve interaction, Ericsson adopted a menu system that displays three options simultaneously on the screen (see Figure 4).

Visualization

The benefits of visualization of state in interfaces are well understood. Therefore, one way to improve usage of menus is to give the user visual feedback about where in the menu structure she is. This orientation may be attempted in several ways.

Icons

In the devices examined as part of this work, icons were found to exist in two formats: isolated and context.

Isolated icons are those used to augment understanding of a particular menu items. For instance, Nokia menu systems since the 5110 have displayed an icon beside each of the root-level menu options (see Figure 5). It is not at all obvious what purpose these icons serve, because they are not used in any other context and cannot be manipulated in the same way as icons in a Windows, Icon, Menu, and Pointer (WIMP) environment. More recent releases of Nokia handsets include animated versions of these icons. Research conducted on animated icons for desktop systems suggests that they are most useful to explain some action or verb [1]. However, of the root-level options that have animated icons, only one option is a verb—Call Divert. Even with this option, the animation adds little to understand-

In South Africa, **improving** the user's **experience** only requires the **reworking** of current **solutions**.

ing the role of the menu, because it shows an arrow ricocheting off a small picture of the handset. From our analysis, we can conclude only that isolated icons serve as a marketing feature and add little to the usability of the handset.

Context icons are used to highlight a particular choice from a set of alternatives. Rather than showing a single menu option per screen, context icons can be used to display the full set of alternative choices on a single line; the compact icons can be fitted on the screen where the larger text representations cannot. This type of icon has been used in a curious way in the current range of Ericsson handsets. Rather than exploit these icons to reduce the amount of screen real estate required, the icons are used in conjunction with the text description of each menu option. Although redundant information is helpful to users, the screen space could, perhaps, have been used in more helpful ways: an extra menu option or a scrolling help line, for example. When a suboption is selected, the icon disappears, meaning that the longer text name is used at the top of the screen to describe the submenu. Retaining the icon would be particularly useful for providing context in sub-submenus.

Context Information

For novices using a menu, it is essential that they be provided with some form of feedback about where they are within the structure in order to navigate successfully. The limited screen resources of the cellular handset make this a much more difficult task than with desktop—based menu systems. Given that some of the handsets we examined nested menus up to four levels deep, the problem of navigation becomes all the more complicated.

In the handsets we examined, Nokia provided the most information about location in a menu structure—not only depth choices, but also feedback on the current level. The least information was provided by the Ericsson handsets, which showed only the most recent category choice. This is curious because Ericsson goes to extra lengths to provide smooth scrolling when changing menu levels to provide users with as much contextual and spatial information as possible.

One vital piece of information missing from these visualizations is feedback about which options in the menus are branch nodes (the selection of which will display another menu) or leaf nodes (the selection of which will access a function). From desktop menus we already have an ellipsis (or triangle) convention to denote the difference; leaf nodes have no ellipses beside the name. This type of information is important to novice users exploring a menu structure. They will be more likely to explore the structure if they know their exploration will not affect the handset.

Manuals

Manuals for cellular handsets have limited usefulness; the manual is usually larger than the device itself. Because the point of cellular communication is mobility, it is unlikely that users will carry the manual with the device. Furthermore, research by Youngs [14] shows us that younger users (under 35) are *less* likely to complete a task if they use the manual.

Online manuals, however, can be much more successful. Here, if a user scrolls to a menu option and does not select it, a scrolling description or a piece of stretch text for that option appears on the screen. For example, Lee *et al.* [4] found that adding extra information to menu options could reduce errors by up to 82 percent. Online help was applied seemingly randomly for the handsets we examined; help was provided according to the model and was not consistent for a particular manufacturer.

Conclusion

This article detailed the importance of cellular technology in South Africa and how that technology can be adapted to better improve the user's experience and, it is hoped, extend the functionality of the device into new domains. These adaptations require no new technology, merely the reworking of current solutions.

The work presented in this article is symptomatic of the type of HCI research flourishing at the University of Cape Town and other South African institutions. What may be considered a limitation in developing countries—a lack of computing equipment and Internet access—has been found by us to be a boon. Through necessity we have been forced to focus on the human side of the HCI equation, and that focus has helped reveal shortcomings in technology (such as cellular handsets) that would otherwise have gone unnoticed.

ABOUT THE AUTHOR

Gary Marsden has a Ph.D. in HCI from the University of Stirling in Scotland. He was part of the Interaction Design Centre at Middlesex University in London for three years before moving to the University of Cape Town in 1999 where he is now an Associate Professor. He currently works on a variety of interaction design problems in South Africa ranging from mobile computing to virtual reality systems.

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