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WebQuilt and Mobile Devices: A Web Usability Testing Analysis Tool for the Mobile Internet

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Abstract

Given the difficult design challenge posed by mobile devices, the WebQuilt and Mobile Devices project involved extending WebQuilt [8], a Web site testing and analysis tool, to work with PDAs (Personal Digital Assistants) and Internet phones. This included background research regarding the principles of Human Computer Interaction and usability testing, understanding WebQuilt, and researching mobile technologies, mobile Web site design, and how to best serve mobile designers with WebQuilt. The necessary changes were implemented to allow for PDA proxying and visualization and similar changes were started for Internet phones. The project involved designing and building the framework for deploying the tests to mobile users, and running usability tests to gauge the effectiveness of WebQuilt for mobile devices. The tests showed that WebQuilt has potential for helping mobile Web site designers find usability problems.
Keywords: mobile, web, usability, Human Computer Interaction.

1. Introduction and Motivation

Making computers, technology, and the Internet accessible to all people is a challenging task. In order for people to be able to access technology, they need to easily understand how to interact with and control it. The ease at which people can use something to complete tasks is called its *usability*, and the goal in creating new technology and software should be to increase its usability so more people can actually benefit from it. The field of Human Computer Interaction (HCI) is concerned with exactly this goal. HCI researchers consider human behaviors and cognition as the motivating factors in software design. The user interface (UI) of a piece of software, or the medium through which the software's functionality is expressed to the user, is one of the key research areas for HCI computer scientists. Software can fail in the marketplace due to a poorly designed UI [14]. Because of its importance, about half the effort in developing and testing software applications is typically put into the UI [6].

Due to the diversity of its users, the interface design of the Internet is one particularly interesting direction for HCI work. A variety of people with differing skills, backgrounds, ages, education, and physical abilities use the Internet. In addition, many studies show that users have trouble completing common tasks online [13]. As we enter a new age of computing where mobile connectivity becomes more common, the unsolved usability problems of the Internet are simply being transferred to mobile devices, and further complicated by their small sizes and limited input mechanisms.

To find usability problems, or obstacles that prevent users from completing tasks, designers conduct *usability testing*. WebQuilt, an application created by the Group for User Interface Research at

Berkeley, is intended to answer the need in the field of Web design for better usability testing tools. WebQuilt uses a proxy-based logging mechanism for tracking users. A proxy is like an intermediary between the user's browser and the Web server. WebQuilt's proxy tracks a user's actions on a Web page and logs the data. To conduct usability testing, a designer must simply create a list of typical tasks the site supports, recruit participants, and email the WebQuilt start page link and task descriptions to the participants. By clicking on one of the links to start a task, the user's subsequent actions are sent through the proxy. This method is simple, fast, and interoperable. It does not require the user to download software, it allows for remote testing (users can test wherever they choose), and it is compatible with almost any platform. Designers can test any Web site (even a competitor's) and the method is fast and cost effective, allowing for large sample sizes. In addition to the benefits of the proxy-based approach, WebQuilt adds the functionality of aggregating collected data and visualizing it. This component allows designers to easily see usability problems on their site, something that looking at proxy logs may not always afford. After conducting usability tests and analyzing the resulting visualizations, a designer will know what to fix and redesign to improve the usability of his/her site.

This paper will discuss the project to extend WebQuilt to deal with Internet enabled mobile devices, specifically PDAs (Personal Digital Assistants) and Internet phones. The key parts of the research included background research about the principles of HCI, usability research and testing, understanding WebQuilt, and researching mobile technologies, mobile Web site design, and how to best serve mobile designers with WebQuilt. With this information, changes were implemented to WebQuilt to allow for PDA and phone proxying and visualization, including the implementation of a Wireless Markup Language (WML) proxy. Finally, usability testing was conducted with WebQuilt, which involved designing and building the framework for deploying the tests and analyzing the test results.

2. WebQuilt for Mobile Devices

The bulk of the project involved researching mobile devices and implementing changes to WebQuilt so it would work with PDAs and Internet phones. In order to decide what direction to proceed with WebQuilt, it was necessary to understand the usability challenges posed by mobile devices, such as their small screen, limited input, slow transfer rates, and low memory. With an understanding of these issues, it was necessary to next investigate Web design for mobile devices to understand the users' (the designers') work area and perspective. To see some of the options designers have for the mobile Internet, the project involved looking at other industry solutions. Analyzing their drawbacks showed how to proceed with extensions to WebQuilt. Finally, changes were implemented to WebQuilt to deal with PDAs and work was started for Internet phones.

2.1 Usability Issues for Mobile Devices

Mobile devices pose a particularly challenging frontier for UI designers. With a usable screen size of around 5.4 x 5.4 cm (based on the Palm V), PDA designers are severely limited in the amount of content their sites can contain and in ways they can lay out their pages. Internet phones have even less space: about 96 x 65 pixels (based on the Nokia 7110 phone). This allows for only six lines of text on the screen at one time. Given that neither device has a keyboard or a mouse, traditional input methods are not available. Therefore, designers cannot design their sites with mouse and keyboard input in mind (as they would for a PC). PDAs have predominantly pen-based input, including both tap menus and applications and pen-written recognition. Unfortunately, the pen recognition is often not as accurate as a keyboard. Phones are more drastically limited, with most having only two to six buttons for Internet input and a wheel for scrolling. To complicate matters further, the Internet input buttons often have different functionality mapped to them for different pages. Designers face the problem of helping users understand what buttons do what for their sites.

Slow transfer rates and limited available memory space present more design challenges. Internet transfer rates to PDAs are a very low 8 kilobytes per second (kbps). After transferring the necessary headers, the effective transfer rate of page content is reduced to 2 kbps [9]. This limits the designers ability to include pictures, scripting code, or large amounts of text or Hypertext Markup Language (HTML). In fact, most PDA browsers or Internet services (which often implement a proxy) perform compression algorithms on site code before sending it to the user's screen. To deal with slow transfer times, phones sites

use a different mark-up language: WML. WML is a subset of Extensible Markup Language (XML), and includes a severely limited set of tags to reduce code size.

Usability must be a crucial concern to mobile device designers due to the difficult UI issues the devices present. In a usability study of Wireless Application Protocol (WAP) phone users in London, the Nielson Norman Group found that poor usability is a major reason people dislike and refuse to use WAP phones. People were given a WAP phone with mobile Internet access for a week. At the end of the week, 70% of users said they would not use WAP phones within a year. In another phone usability study by mobile technology provider Argogroup, 89% of 1,596 sites "failed usability, reliability or interoperability tests [3]." The results of the study suggest that unless WAP phone usability is greatly improved, people will simply not use them [8]. PDAs supply better usability due to their larger screens and pen-based input, but they still need major improvements. Overall, mobile devices present difficult design challenges and designers could benefit from a usability testing and analysis tool like WebQuilt.

2.2 Web Site Design for Mobile Devices

Each type of device needs content that is meant for, meaningful, and usable on that device. For example, content from a newspaper cannot be directly converted into a Web page as is; Web sites cannot be directly converted to Internet TV; and likewise, Web sites meant for PC viewing and use should not be automatically converted into compressed versions for PDAs or Internet phones. Nielson states that the failure of WAP usability is caused by a "misguided use of design principles from traditional Web design [7]." With similar limitations to their physical design, the same can be said about PDAs. Therefore, the future of Web design for PDAs and phones should include sites designed specifically for them that meet the needs the devices are meant to serve.

Among the other Web design issues for mobile devices, is the question of site content: not all sites include information that is of interest to PDA and phone users, so what should be included in mobile Web sites? Think of the users of such devices: people who are on the road or away from their PC. They will most likely be looking for specific information such as weather, directions, and flight information, and leave their casual browsing for their PC. Nielsen asserted, "Most users will continue to have a base station in the form of a full-screen device in their home or office [7]." Therefore, only companies that have information or services mobile users need would benefit from creating a site tailored for mobile devices.

2.3 Current Industry "Solutions" to the Mobile Usability Problem

Various companies and organizations currently offer different solutions to the need for PDA or phones specific Web sites. Internet phones use the WAP transfer protocol for Internet access. WML was introduced as a special markup language for phones. The two allowed for secure, faster transfer between the Internet and phones. Presently, many WML sites are readily accessible over the Internet by phone users.

Direct access to Web sites from PDA browsers is slightly more complicated. The three main solutions to providing PDA Internet access are Palm™ Web clipping applications, AvantGo® channels, and HTML sites created specifically for PDAs and accessible by anyone over the Internet. Web clipping applications come from Palm and work on the Palm OS® (Palm Operating System) only. These applications are made by companies that want PDA users to have access to the company's Web site content. In contrast to ordinary PDA Web sites, Web-clipping applications include much of their static Web content (home pages, images, certain text) in a downloaded application on the Palm device. The application is essentially the company's Web site, part of which is stored on the PDA and the rest which is accessed through the Internet. AvantGo channels are specially made PDA Web sites that are accessible only through the AvantGo software and server. Some of the Web site content is also downloaded onto the PDA. However, if the Uniform Resource Locators (URLs) for the AvantGo channels were publicly available, it would be possible for any HTML-enabled browser to access the sites.

Both Web clipping applications and AvantGo channels involve downloading special software and Web content onto the PDA. Incredibly slow data transfer rates between the Internet and PDAs cause Web clipping applications and AvantGo channels to be useful since they avoid much of the transferring. However, these technologies are costly in that they take up valuable memory resources on the PDA. They also require downloading, desktop syncing, and registering with the companies (AvantGo or Palm). Web

clipping applications are even more limited because they work only with the PalmOS. In other words, Web clippings and AvantGo channels are not freely accessible to all PDA users over the Internet.

As an alternative to Palm Web clipping applications and AvantGo channels, creating sites specifically for PDAs that are accessible by anyone over the Internet is the most simple, direct, and extensible choice. This could simply be an HTML page that includes few images and text and is formatted to fit on a small screen. The transfer rates for Internet content to PDAs will improve with time, causing the advantages of Web clippings and AvantGo channels to minimize and their disadvantages to become more prominent. PDA specific sites do not incur any of these disadvantages, since they are more readily accessible.

For WebQuilt, we decided to deal with PDA or phone specific sites that are freely accessible over the Internet. True mobility necessitates free access to Internet content, and faster transfer rates will make Internet usage on PDAs and phones more common.

2.4 Extending WebQuilt for PDAs

WebQuilt was not designed for PDA use. Its functionality and appearance were based upon the needs of PC Web site designers. In order to determine how to change WebQuilt for PDAs, it was necessary to look at what a mobile Web site designer would want in a usability analysis tool. The most visually obvious was that the large, desktop-style browser used to create visualizations did not accurately model a PDA browser. Though it would have been possible to include an actual PDA browser in the visualization, since the sites being used for the study were made for PDAs, the same browser being used for PCs would work if sized correctly. We compared the measurements of various PDA-specific sites on the Internet Explorer desktop browser and on an actual Palm V PDA. The size the desktop browser should be to most accurately correspond to the PDA user's experience was then determined. The amount of usable space in the PDA browser was 5.4 x 5.4 cm and the corresponding desktop browser size was 5.4 cm in width and 7.5 cm in height. Though not entirely ideal, this solution provided a fairly accurate representation and was quick to implement.

Another issue was to consider the testing environment with which PDA users could best interact with WebQuilt. This led to the design of a new WebQuilt start page. The original start page was not intended for PDAs and not surprisingly, it did not work well for PDA users. First, the width of the page would cause users to have to scroll horizontally, which is cumbersome. As previously concluded, however, the PC page should not simply be sized down to fit on a PDA: other considerations needed to be addressed. The most important consideration is the difficulty of entering text into PDAs. The original start page required users to enter the URL of the site they were testing. URLs are often very long and users could spend a great deal of time entering in characters even for just a couple of sites. To address this concern, the input box was removed and replaced with a series of six links to six different tasks the user could test. With this change the user needed only to enter the URL of the WebQuilt start page once and from then on, click on links to complete the testing.

Considering the user's perspective, the original method of conveying the task to the user provided a problem. At first, the plan was to email task descriptions to the user. However, this could be difficult for a PDA user. Instead, when users clicked on the task link on the WebQuilt start page, they came to a page that included the task description and another link that began the proxying.

An additional alteration to WebQuilt involved the WebQuilt Options links that were inserted at the top of each proxied page by the WebQuilt proxy. The links allowed the user to "Leave Task" if he/she got stuck, or to indicate a "Task Complete." If the user forgot what to do, he/she could also "View Task Description." On a PC, the links took up little space and did not affect the user's experience. However, on the tiny size of the PDA screen, these links greatly affected how a site looked to the user. Moving the links to the bottom of each page helped minimize the distraction the WebQuilt Option links caused.

Finally, in looking at the results WebQuilt produced, it was clear that designers might need help from the users to interpret the logfiles and visualizations. WebQuilt did a good job of collecting quantitative data, but it did not include any qualitative responses from the users. The experiences and opinions of the user are critical to designers. Even if a user is able to successfully complete a task, they may not have liked the feel or the layout of the site. They may have been confused, but still managed to figure out what to do. Such feedback is not apparent in WebQuilt's logs or visualizations, but is invaluable to designers looking to improve the usability of a site. In order to understand the user experience and gather some qualitative information, a short survey was added at the end of each task. When the user clicked on

the end or leave task links in the WebQuilt Options, a customizable survey would appear. The questions included for our WebQuilt usability testing included both general questions about how usable the person thought the site was and questions about WebQuilt: if the user noticed any latency, if they had any problems with the proxy, etc.

2.5 Extending WebQuilt for Internet Phones

Extending WebQuilt to work with Internet phones posed a more complicated problem than did PDAs. As with the PDAs, a new WebQuilt start page in WML was created for the phone that included links to different tasks. Since the phone display is smaller, only five links could be included on the start page. The WebQuilt options were also moved to the bottom of each page. Aside from these cosmetic and user interaction issues, two major internal updates needed to occur for WebQuilt to work with phones. First, the proxy worked only with HTML pages and phone sites are written in WML, so it was necessary to extend the proxy to deal with WML. Second, the phone display is drastically different from the desktop PC browsers, which also do not render WML. So it was essential to include a phone browser in the visualization.

2.5.1 Implementation of a WML Proxy

The WebQuilt proxy is the intermediary between the user and the Web server. For a desktop PC user, the URLs are decorated to pass requests through the proxy. For example, the Yahoo! URL is: http://www.yahoo.com. When decorated, it is: http://ProxyServerIPAddress/webquilt/webproxy?replace=http://www.yahoo.com (where ProxyServerIPAddress is the IP Address of the machine running the proxy server). The proxy sends a request to the Web server and (for GET requests) gets the requested page and saves a copy of it for the visualization. Then, the proxy takes the HTML code within the page and rewrites it, changing all links so they are also decorated to pass through the proxy. It also inserts the WebQuilt Options links at the bottom of the page (though previously, the links were inserted at the top of the page). Finally, the proxy logs the request in the logfile and sends the edited page to the user.

Two main classes compose the proxy: WebProxy and ProxyEdit. WebProxy is the main proxy class that manages the proxying. ProxyEdit provides methods that go through the HTML and convert links. ProxyEdit uses various TagEditor classes: TagEditor is an interface and any tags (like links, frames, and forms) that need to be edited extend it. WebProxy initializes and manages instances of ProxyEdit to perform the proxying. ProxyEdit uses an HTML Tolkenizer [2] to separate pieces of the HTML code.

In order to add WML proxying capabilities, the proxy code was re-engineered to better support future additions of multiple markup languages. First, ProxyEdit was made an interface class. The HTML proxy code was moved into HTMLProxyEdit, which implemented ProxyEdit, and the WML proxy code was written in a similar WMLProxyEdit class. Future language support could be added to the proxy by creating a new class that implements the ProxyEdit interface. In addition, a WML Tolkenizer was written, similar to the HTML version from which much of the code was borrowed. The WML proxy is not currently complete.

2.5.2 Including a Phone Browser for Visualization

To complete the addition of phone support for WebQuilt, it was necessary to determine a way to visualize the pages phone users saw during testing. This would require a phone browser that could be integrated with the Java visualization code. We are considering various options. Since interoperability is important for WebQuilt, the best option would be to select a Java-based, open source phone browser. We are currently searching for a browser that meets the needs of the project.

3. Usability Testing with WebQuilt

In order to determine that WebQuilt fulfilled its purpose of facilitating Web usability testing and aiding designers, it was necessary to conduct usability testing. It was also important to perform the tests in the same way a Web site designer might. The PDA and Internet phone users who were recruited for the

tests were asked to perform tasks through the WebQuilt proxy. The data WebQuilt collected from the user tests were invaluable for evaluating WebQuilt, providing a means to test its performance and guide future work.

3.1 WebQuilt Usability Testing vs. Usability Testing Using WebQuilt

The phrase "usability tests" is ambiguous: it could mean several things. When "usability tests" is referred to here, it means usability testing of Web sites *using* WebQuilt. Usability testing *using* WebQuilt is users performing tasks on Web sites through the WebQuilt proxy, while WebQuilt logs data from the users' actions. Such testing is extremely useful to *designers* of the Web sites being tested: hence the reason WebQuilt is a tool made for designers. Usability testing using WebQuilt was also useful for finding errors with the WebQuilt code, performance problems, and difficulties with using WebQuilt. Quite a different kind of testing is *WebQuilt usability testing*, which would entail having actual designers use the WebQuilt proxy to perform their own tests with users they choose and then visualize and analyze the data logged. The key factor in defining WebQuilt usability testing, is naming its targeted users. WebQuilt is a tool created for Web site designers, so usability testing would require us to observe designers using WebQuilt.

Since the usability testing we performed was usability testing using WebQuilt, we (the creators of WebQuilt) acted as the "designers" or "WebQuilt users" and the "users" in this case were the people performing tasks on the actual Web sites.

3.2 The Process of Usability Testing

The process of our usability testing included selecting the users and sites to be tested, having the users perform certain tasks on the sites, visualizing the data logged from the testing, and analyzing the results. Given the goal of opening mobile technology to a broader audience, ideally a diversity of users would be selected. Unfortunately, time and cost restraints prohibited us from running ideal tests. The need for volunteers was communicated to Usenet groups and email listservs of PDA users. Most likely, respondents had a great deal of computer and PDA experience, and did not represent a diverse cross-section of society.

Before contacting the users, the sites on which to perform the usability tests were chosen. Since WebQuilt is supposed to aid designers in pinpointing usability problems with their Web sites, we focused on finding sites with usability problems for the testing. For example, if a site does not have consistent navigation (i.e., through an unchanging navigation bar or menu located in an easy to see place on each page) it causes confusion. The sites chosen also had to be made specifically for PDAs and accessible directly over the Internet by any HTML-enabled browser. Sites were also selected based on how likely a PDA user would access them. Most PDA users access sites that provide information they need while on the road: airline information, stock and financial information, maps, news, nearby restaurants or hotels, and so on.

Relevant sites were divided into three categories: e-commerce, mapping, and information. Four sites were selected with at least one site from each category and six tasks were defined between them for users to perform. We included simple tasks such as finding information, and more complex tasks such as entering information and searching. The tasks defined for the users to perform on each site were carefully chosen to allow the users to encounter the usability problems we had found. For example, users were asked to find a list of Italian restaurants in their city on InfoSpace Yellow Pages. However, the categories on the site were not completely intuitive and often required some searching to find the intended results. The task was defined to purposefully encounter this problem.

3.3 Results of our Usability Testing

After a number of users performed the set of tasks for several Web sites, enough data was collected to create visualizations of the tests that would show a realistic picture of each site's usability. The visualizations included thumbnail images of each Web page visited and arrows indicating navigation. They showed some potential areas where people may have been confused about how to complete a task. When a large percentage of the users spent a long time on a page or clicked on the wrong links, the WebQuilt visualizations indicated both that there was a problem and on which page it occurred.

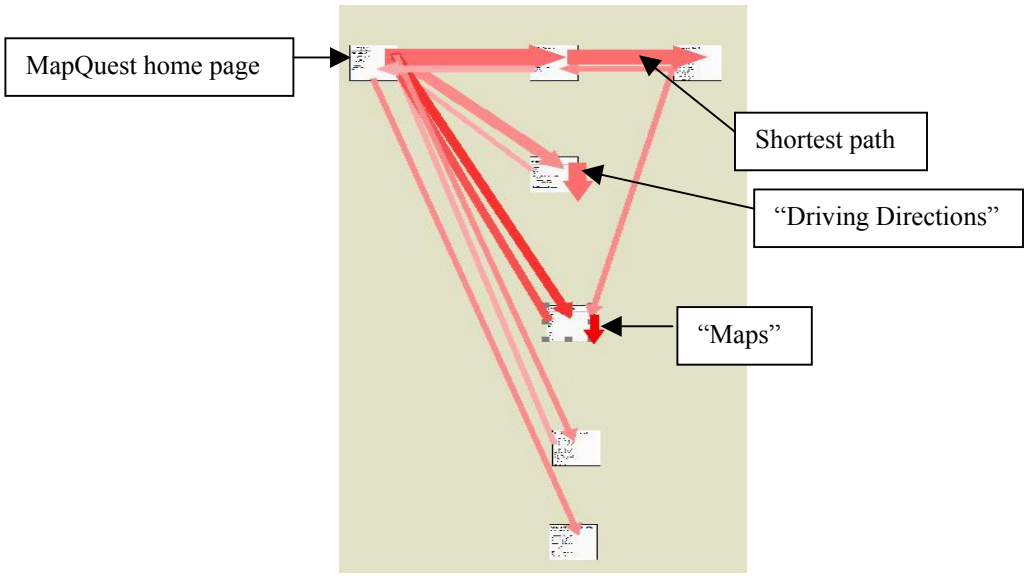

Figure 1: MapQuest A visualization

As an example of the results of the usability testing, the results produced by the MapQuest task can be examined. Users were asked to find if there were any traffic delays on I-490 East in Rochester, NY. Thirty people tried the task and filled out a survey at the end. The survey, WebQuilt logs, and the visualizations were used to find potential usability problems. Figure 1 shows the site map view of the MapQuest task visualization. The white squares are the individual pages people visited and the arrows indicate how people went from page to page. The thickness of the arrows indicates how many people took that path and the color shows how long they took. The longer a person spent on a page, the darker the arrow. The thick arrows between the top three pages shows the path most people took, which was in fact the shortest path. However, some people seemed to have problems finding the shortest path, as shown by the two thick arrows pointing to the "Driving Directions" and "Maps" pages. In order to determine what the people tried to do on these two pages, we examined the WebQuilt logfiles since they contain the recorded query strings. Query strings include the input people enter on a page. Some of the people tried to find Rochester, NY on a map, which indicates that they may have been confused. The logfiles also showed that some people were just surfing for maps of their own areas.

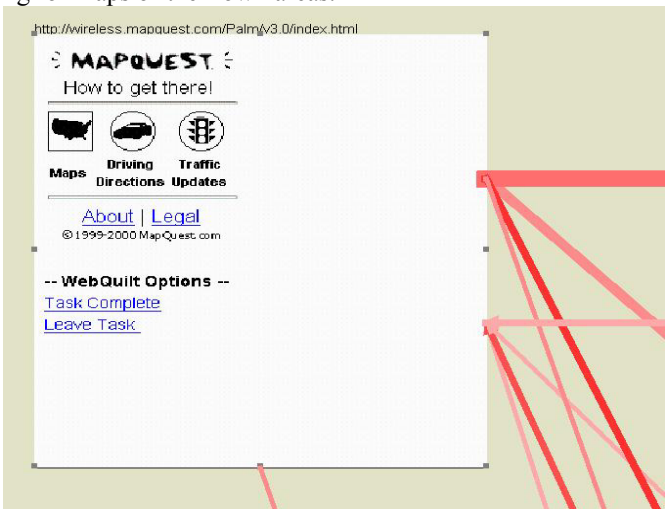

Figure 2: A closer view of the MapQuest home page, using WebQuilt's zooming functionality.

Can WebQuilt help us determine why people were confused? If we use the zooming functionality to take a closer look at the MapQuest home page (see Figure 2 along and the top left corner of Figure 1), we can see in detail the page where people took different paths to complete the task. Designers would try to

interpret the source of users' confusion. For example, perhaps some people, thinking about traffic, instinctively clicked on the picture of the car on the "Driving Directions" link. Whatever the source of confusion, it is clear that WebQuilt has definite potential for helping designers find usability problems on PDA Web sites.

From the testing results, we also saw some improvements that could be made to WebQuilt. For example, having to refer to the logfiles in order to determine what people were doing in the MapQuest example (by viewing the query strings) was cumbersome and required technical knowledge designers may not have. In the future, it may be good to consider including query string information in the visualization. Also, the size of the browser in the visualization included far too much white space. The rendering size needs to be reconsidered. Additionally, for pages with URLs that are distinguished only by their query strings, one copy of the page was included in the visualization. Navigation between these different pages was interpreted as navigation on the same page. The result was that the navigation arrows in the visualization do not point anywhere. See the arrows on the "Maps" and "Driving Directions" pages in Figure 1. We need to find a way to distinguish these pages, without including a different path for each user.

5. Closing Remarks

Through the WebQuilt and Mobile Devices project with GUIR at Berkeley, we were able to extend WebQuilt's remote usability testing capabilities to PDAs and start similar work for Internet phones. To determine if WebQuilt helped pinpoint usability problems on PDAs and their causes, we designed and conducted usability testing with WebQuilt, recruiting real PDA users as our test subjects. The preliminary results of the testing showed that WebQuilt has potential for helping to find mobile usability problems.

Our contribution to PDA and phone Web usability research will hopefully lead to more usable sites that open mobile connectivity to a wider range of people. In helping more people benefit from greater communication, ease of information accessibility, and the increased efficiency technology affords, I hope our work has had at least a small impact on the human users.

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