

Designing a Handheld-Friendly Web Site

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Introduction

The handheld computer, or PDA (personal digital assistant), represents a new phase in educational technology that allows for a truly portable computational device in an affordable package. From its humble beginnings as an electronic data organizer, the PDA has evolved into a sophisticated computational and informational tool through the development of various third party application programs. Among the most popular applications is AvantGo, which allows for the deployment of web applications on handheld computers. By accessing the AvantGo server during a synchronization operation with an Internet-connected PC, entire web sites can be downloaded to the handheld, then viewed later through use of the free AvantGo client that is resident on the handheld.

Being able to literally carry a variety of web sites in one's pocket provides great educational opportunities that as a profession we have just begun to explore. However, the typical PDA provides only 4-bit grayscale resolution on a 160 x 160 pixel screen display. Given that a "properly designed" traditional web site involves a plethora of multicolored graphical images displayed in a window assumed to be at least 600 pixels high by 800 pixels wide, the browsing experience of such a site on a handheld is usually less than satisfying. In short, the development of handheld-friendly web sites requires a different operational paradigm than that used in traditional web site design.

This paper examines the lessons learned in the development and creation of a new web site for the Electrical & Computer Engineering and Computer Science Department at Ohio Northern University in which the student design team responsible for implementing the design was charged with the task of establishing a site that is "handheld-friendly." We will examine the role that size limitations such as screen resolution, web channel memory allocation, and maximum allowable link depth have on the layout and organization of the web site. Attention will also be given as to how various aspects of the AvantGo client implementation, such as JavaScript, HTML support, and forms, affect web site design. The methodology developed by the design team for creating an acceptable web site suitable for both PDA and desktop viewing will be presented along with general advice and comments suitable for those who wish to undertake the development of a handheld-friendly web site on their own.

Knowing your limitations and opportunities

When a traditional web site (by "traditional" we refer to that which is normally accessed using a desktop PC over an active Internet connection) is designed, the web site author is expected to utilize the features of the client machine to provide for an enriched experience. To that end, one expects to see sites designed for a minimum 600 by 800 pixel resolution featuring colorful graphical images that accentuate the presented informational content. Dynamic aspects, such as sounds or animations, are often added to enrich the visitor's experience.

Handheld computers can also be used to access web sites. The AvantGo client is currently the most popular web browser available, with versions available for Palm OS, Pocket PC, and BlackBerry handheld platforms. By using the free AvantGo Mobile Internet Service, handheld users can access their favorite web content by subscribing to channels registered at the AvantGo web site;¹ this content is made available through both wireless Internet connections and by synchronizing with a desktop PC connected to the Internet. However, viewing a typical web site using one's handheld is a challenge. First and foremost, the display is limited. While some PDAs do offer higher resolution, one typically finds an absolute screen resolution of 160 by 160 pixels. However, AvantGo reserves some screen space for title and scroll bars, leaving an effective display screen of only 150 pixels wide by 140 pixels high.² Furthermore, the pixels usually implement 4-bit grayscale, although higher-end PDA models will sport either 8-bit or 16-bit color. Finally, due to memory and hardware limitations, AvantGo does not support either animations or sound files. As a consequence, if one visits a typical web site using a handheld, the experience would be less than expected, and often downright disappointing.

The design of web sites cannot be accomplished with a "one size fits all" mentality. If one wishes to deliver content to a handheld, then one has to design with the appropriate constraints in mind. Besides the obvious limitations of the screen resolution, developers of handheld-friendly web sites must be aware of a variety of design limitations.^{2,3} First, the AvantGo client does not fully support HMTL, and what is implemented is based on HTML 3.2. This was a design decision based on the limitations of both screen resolution and memory available on the handheld device. Some elements of HTML just do not translate well onto the small screen whereas others are so infrequently used that the memory requirements necessary for their implementation could not be justified. Consequently, the current version of AvantGo does not support frames or image maps. The limitation of fonts on handheld devices causes further restrictions. The tag is not supported at all, and as Palm OS does not support italics, the use of either the <I> or tags results in bold text being displayed.

AvantGo supports all of the form elements except for file input.^{2,3} In addition, there is support for a scribble element,² which allows users to open a small window that can be scribbled on, thanks to the touch-sensitive screen that overlays the LCD display. One notable difference in forms support is that the user of the form on a handheld device probably downloaded it during a HotSync operation, and therefore does not have an active network connection when the form is completed. AvantGo provides a form submissions queue that stores forms until the next synchronization operation, at which time all forms in the queue are submitted, in no particular order, to the appropriate server. The user is able to examine a list of submitted form requests by going to the Form manager page in AvantGo; from here a user can delete a request if necessary,

unless otherwise prevented though use of JavaScript elements to hide the submission. AvantGo also provides for basic JavaScript support, but again the implementation is limited.² The main task of JavaScript in AvantGo is for controlling form submissions; however, by using the "HandheldFriendly" meta tag on a web page, additional elements are supported. These elements include displaying an alert dialog, going one page forward or backward in the browser's page history, and taking the user to one of the AvantGo standard screens such as the Forms or Channel Manager pages.

Graphical images are supported by AvantGo, but should be used sparingly. When downloaded, images will be converted to the appropriate format for the device; for example, an image downloaded to a Palm IIIxe will be compressed into 4-bit grayscale whereas the same image will be compressed into 8-bit color when downloaded onto a Palm IIIc. The height and width attribute tags are not supported, so if a site design needs a particular image size, one has to use an image editor and create an image to that size. Furthermore, AvantGo will resize large images so that the compressed version can be fully displayed on the screen. This design decision was made due to the "memory hog" nature of images. The typical handheld computer possesses only 8 MB of memory; with such memory constraints, one cannot afford the luxury of a large image, especially as only a 150 by 140 pixel portion of the image is visible at any instance in time. A further restriction on the use of images is that AvantGo has a 32k limit for the maximum displayable size of an individual document.² As a consequence of compressing and resizing, the image that initially looked cool when viewed on a desktop can literally be a shadow of its former self when rendered by AvantGo.

Focus on the content

Conduct the following experiment. From your network-connected desktop PC, open a web browser and surf to any popular web site. Examine the site design and you will undoubtedly find a variety of graphical images present. Now ask yourself the following question: How much information is being conveyed, and how many bytes are being used, by each image? Generally, the informational content of a typical web site graphic is very low relative to the number of bytes needed to represent the image. On a handheld, there is limited space on the display for images to begin with, and given the limited memory available per individual page and per channel, a single picture is probably not worth losing a thousand words of text. Simply put, on a handheld device content is king, not flashy graphics, and informational content is best delivered through the written word.

The primary rule to live by regarding the use of graphics on a handheld web site is that, if there is a convenient way to convey the information without using an image, you are better off dispensing with the image.⁴ However, while large, flashy images should be shunned, a handheld-friendly web site need not be devoid of graphics. The appropriate use of well-designed graphical images can make the difference between an adequate and an outstanding site. The best approach is to design your own custom bitmapped images. Keeping things small and simple is the key to good design in this case. The PDA screen offers limited resolution; by keeping the design small, you maintain visible content. Designs based on lines and simple shapes are preferable, as complicated images too often appear ragged and confusing. Color schemes must also be considered; however, the only colors that AvantGo renders on those platforms that

support color displays are the infamous "browser-safe palette" of 216 HTML colors.² Appropriate contrasting colors should be selected for when AvantGo converts images to grayscale for platforms featuring black-and-white displays. Finally, it is important to always use the <ALT> tag when working with images for a handheld-friendly site as the user has the option, when configuring AvantGo preferences, to either display or not to display images. If an image is not displayed, then the <ALT> tag is needed to provide the appropriate content.

There is more to delivering content than just dumping text into a file on your web site. It is the organization of your site content that will make or break the user's experience when visiting your site.^{4,5} Because of the limited resolution of the display screen, it is desirable to limit the length of an individual web page to minimize the amount of vertical scrolling required. Furthermore, it is essential that handheld-friendly web sites eliminate the need for any horizontal scrolling. The reason for the distinction between vertical and horizontal scrolling is simple: some scrolling will have to be supported, and all handhelds are equipped with hardware buttons that allow for easy vertical scrolling. In order to deal with horizontal scrolling, the stylus must be employed on a miniscule scrollbar, which acts as a major hindrance when visiting a site.

One concern when dealing with page length limitation is to maintain a balance between this limitation and the number of levels of nested pages - i.e., the page depth - that a visitor has to traverse in order to access information. Information has to be organized effectively with the limitations of the handheld kept in mind. One successful approach is to adopt a leveled architecture for the design of your handheld-friendly site.⁵ An example would be of a three-tiered model, where the top tier presents a site map of categories, the second tier presents a subject index for each category, and the third tier provides specific information for each subject. This allows information to be spread out amongst several pages, yet maintains accessibility through a minimal number of required link traversals to a particular page.

Implementing the design

Given the differences in what constitutes good design for traditional and handheld-friendly web sites, it was decided that two versions of our new web site – the main one for traditional access and a secondary one for handheld access – would be constructed for our department. Balancing content between versions called for planning the site design more carefully than normal. In order not to subtract from the quality of the main version, it was decided to first design and implement this version, with the restraints of the handheld in mind, then transcribe that content to the handheld version. Because both versions would be presenting the same information in a similar manner, this served to restrict the languages and tools that were available. Limitations such as display size, language support, color restrictions, navigation, and content detail had to be carefully balanced between making the main version presentable for full-size viewing and making the content easily portable to the handheld.

Deciding on what content should be included in the site proved to be a difficult task. Certain content such as program educational objectives, course information, and the department mission statement had to be included and represented in a quality manner to fulfill specific requirements set either by the department, the college, or by external agencies. Other content including pages for prospective students and describing various student organizations and

activities were decided upon in order to make visitors to our site (primarily high school students or their parents) feel at home. Once all of the content was decided upon, each content item was placed into one of four organizational groups. The general information group included links to the college and university web sites and contact information for submitting specific questions to the department or for scheduling a campus visit through the admissions office. The educational objectives group contains the department mission statement plus the program educational objectives for each of our three degree programs. The program information group has a description and curriculum for each degree program. Finally, the people information group lists faculty and staff information, activities, and student organizations. The main version of our web site is organized by a menu bar at the top of each page that presents drop-down menus for the content items in each of the four organizational areas. For those browsers that do not support JavaScript, clicking on any menu bar item calls up a page presenting links to the appropriate content items. In addition, the menu bar also has an "ECCS on PDA" link that, when traversed, leads to a page where one can subscribe to our PDA channel. The result of this hierarchical design was a site that contained pertinent information in a manner that was easy to present on a full-size display.

Developing the handheld version of the site proved to be more of a "try and look" approach than first expected. The information segmentation and design decisions that were specified while developing the main version of the site served the student design team well, but when it actually came down to implementing the handheld version each page had to be individually downloaded and examined to insure its quality. The main problem encountered was that the WYSIWYG web page editors that designers rely upon when constructing a web site do not provide a "handheld computer display" mode, so the designs had to be checked using a PDA. Fortunately, there is a way to do this without the use of a physical device. As part of our set of development tools, we used the Palm OS Emulator (POSE),⁶ which is available free from the Palm OS web site. The emulator can be used to perform a simulated HotSync operation, allowing the channel content to be downloaded via AvantGo and viewed on the desktop PC. One major benefit of using POSE is that, once you register as a Palm developer, you can download any Palm OS ROM image. This allows for testing the web site design on devices (such as the Palm IIIc in our case) that developers do not have physically in their possession.

As part of the handheld site design, a navigation system had to be implemented. Using the four organizational groups from the original design it was decided that a page with a list of links would suffice as a parallel to a menu. The main page of the handheld site corresponds to the menu headers and provides links to pages that represent the menu items under each header. One minor change was required in our content. As the general information group consisted primarily of links to non-departmental content, it was replaced with a link to the chair's welcome message that is presented on the main version's home page. The result is a simple but easy to follow navigation system that works well on a small PDA screen. With knowledge of the restrictions, advantages, and our design plan for the handheld version of the site it was expected that the implementation would follow quickly, and it did for the most part. However, like any young technology, there are still quirks that are encountered and need to be circumvented. To use certain features including tables and certain image attributes requires using a <META> tag that specifies that the page is handheld-friendly.² Differences in PDA operating systems pose specific problems when implementing certain features. For instance, when using the HTML <I>

tag for displaying italics the result on the screen of a Palm OS-based PDA is bold text. Although this was a minor issue, it still sacrifices confidence that the code one writes will appear as expected. An issue concerning the use of an HTML <CENTER> tag within an HTML tag resulted in unexpected results and required a swapping of the tags in order to achieve the intended result. Another issue that was encountered was the idea of a “comfortable” scrolling distance when reading pages. This is an extremely subjective concept and can only be resolved by testing each page and gathering feedback from team members and beta testers. While on traditional pages one pays little attention to the title bar, with the AvantGo browser it pays an integral role in setting the scene for the page being displayed. The Palm OS title bar does suffer from size restrictions, but it is a useful feature. By choosing a well-planned and concise title for each page, less information needs to be presented in the window of the browser, thereby alleviating some scrolling.

Making it accessible

Once the web sites are placed onto an Internet-accessible server, the next step is to make the handheld content available to anyone with a handheld computer that is using the AvantGo browser. In order to do this one creates a custom channel by visiting the Channel Wizard⁷ at AvantGo's web site. First, one enters the URL of the channel location. A channel title is entered next, followed by specifying the maximum size of the channel. As memory space is at a premium on a handheld, size limits are employed to restrict the amount of memory that the channel can possibly consume. AvantGo stores pages in a compressed format on the device and expands only the page being currently viewed, so the PDA memory storage requirements will be less than that used by the web site on its server. A typical size limit for a channel will be between 50k and 100k, with AvantGo setting limits of 32k per individual uncompressed document and 256k per channel.² The ability to follow offsite links is presented as an option; usually, off-site links are not followed as to do so can significantly increase the size of a channel. Consequently, once the size limit for the channel is reached, relevant content from your web site might be lost. The channel depth link is then specified, which informs AvantGo as to the number of levels of links to follow from the main page. Finally, an option is presented as to whether to include images. We chose to do so for our site as it was decided to include photos of our faculty and staff members to assist students in associating names with faces; however, the cost of this decision was a significant increase in the size of the channel. Once all of these snippets of information are submitted, the web site is added as a channel to your handheld device. However, asking users to go through this lengthy process and entering in all of this information is a bit much. Fortunately, it is easy to automate the process. Once you have created a channel with the wizard, you will be presented with the "My Channels" list; click on the "Export Channels" link. The export channels page will present a list of URLs corresponding to your subscribed channels. By copying the URL for your new channel and presenting it as a link on a subscription page on your main web site, visitors can add your channel to their handheld content with just a click of the mouse. As an example, the following URL was generated for the handheld version of the ONU ECCS web site:

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http://avantgo.com/mydevice/autoadd.html?title=ONU%20ECCS&url=http%3A%2F%2Fwww
.onu.edu%2Fengineering%2Feccs%2Fpda%2Findex.html%20&max=125&depth=5&images=1&l
inks=0&refresh=always&hours=2&dflags=127&hour=0&quarter=00&s=00
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In February 2002, AvantGo implemented limitations on the use of custom channels. Intended for personal, non-commercial use, abuse of the service caused the company to restrict the number of subscribers to a custom channel to eight, unless the domain is registered with AvantGo. Custom channels are not considered as official AvantGo Mobile Internet channels, and so the limitation on subscribers was placed in order to limit bandwidth costs. In order to use the Custom Channel function to distribute content to more than eight subscribers, one must submit a "Mobile Marketing & Commerce Contact Form," which is available at AvantGo's website.⁸ While this paper has focused on the use of AvantGo as a web content provider, there are other providers available. One such provider is Mazingo,⁹ that currently delivers content to the Pocket PC. Mazingo does not have any restrictions on the creation of channels, nor does it either charge users to access non-premium service content or charge providers to publish content. The handheld version of the ONU ECCS web site is registered with Mazingo in addition to AvantGo. The process for creating a Mazingo channel consists simply of submitting the URL of the site. Upon approval of the site, one receives a unique site ID that is incorporated into the link for the channel. For our site, the link to Mazingo is:

http://www.mazingo.net/pc/subscribe.php?site_id=558

The design points raised in this paper for proper handheld-friendly web site design and construction are just as appropriate for Mazingo as they are for AvantGo or any other browser for a handheld device.

Conclusion

The result of our efforts is a handheld-friendly web site for the Electrical & Computer Engineering and Computer Science Department.¹⁰ Figure 1 illustrates what a visitor is greeted with when the home page is accessed on the handheld device. Figure 2 shows a set of screen snapshots featuring various components of our site content.

Handheld computers and other mobile devices are rapidly advancing from both a technological and popularity standpoint. More content on the web will have to be considered for use on a PDA and it is important that the people who convert old content and design new content have a grasp on how to deliver the content in a quality manner. The task of creating a site and an equivalent PDA version of that site that is handheld-friendly was also a valuable lesson in design and teamwork. Working with the new and emerging technology of mobile computing and developing a methodology for creating web content for these devices was both interesting and challenging. Defining a design after considering the restrictions of PDAs but before creating an actual page eased and streamlined the actual development process, and it allowed a more consistent representation of the information that users will see at both versions of our site. This method of concurrent web design on desktop and handheld computers has been successful in this case and it is recommended for anyone that wishes to undertake a similar task.



Figure 1. ONU ECCS Department Handheld-Friendly Web Site


<p>CpE Sophomore ...</p> <p>CpE Program Suggested Sophomore Year</p> <table border="1"> <tr><td>Fall Quarter</td></tr> <tr><td>GE 201</td></tr> <tr><td>ECE 164</td></tr> <tr><td>MATH 272</td></tr> <tr><td>PHYS 233</td></tr> <tr><td>PHYS 236</td></tr> <tr><td>Winter Quarter</td></tr> <tr><td>GE 202</td></tr> </table>	Fall Quarter	GE 201	ECE 164	MATH 272	PHYS 233	PHYS 236	Winter Quarter	GE 202	<p>ECCS Faculty</p> <p>Faculty</p> <p>Dr. John K. Estell, Chair Dr. Khalid S. Al-Olimat, Asst. Prof. Dr. Soundararajan Ezekiel, Asst. Prof. Prof. Dennis W. Herr, Assoc. Prof. Dr. Robert A. Hovis, Prof. Dr. Juliet K. Hurtig, Asst. Prof. Prof. David B. Retterer, Assoc. Prof. Dr. Leslie D. Thede, Prof. Dr. Srinivasa Vemuru, Asst. Prof.</p> <p>Staff</p> <p>Mrs. Sharon R. Badertscher, Sec.</p>	<p>Dr. John K. Estell</p>  <p>Dr. John K. Estell</p>
Fall Quarter										
GE 201										
ECE 164										
MATH 272										
PHYS 233										
PHYS 236										
Winter Quarter										
GE 202										
<p>Educational Obj...</p> <p>Educational Objectives</p> <ul style="list-style-type: none"> ▪ Mission Statement ▪ Computer Engineering ▪ Computer Science ▪ Electrical Engineering 	<p>CpE PEOs</p> <p>Computer Engineering Program Educational Objectives (Adopted by ECCS Faculty 27 November 2001)</p> <p>Computer Engineering graduates will:</p> <p>PEO1: Be able to apply their knowledge of math, science and engineering in combination with the use of appropriate techniques, skills and engineering tools to identify,</p>	<p>IEEE</p> <p>Institute of Electrical and Electronics Engineers IEEE</p> <p>Like the ACM, the ONU branch of the IEEE is a nationally recognized branch that takes part in many fun activities outside the classroom. Every year there is a variety of events including industry guest speakers, tours of company facilities, and social events that bring students together. Involvement in</p>								

Figure 2. Sample pages from the ONU ECCS PDA web site.

Bibliography

1. AvantGo. URL: <http://www.avantgo.com>
2. AvantGo HTML Style Guide. URL: <http://ami.avantgo.com/support/developer/styleguide/styleguide.html> (25 Sept. 2001).
3. AvantGo Developer Guide. URL: <http://syncdemo.avantgo.com/devcorner/doc/AvantGoDevGuide.html> (19 Oct 2001).
4. Kacin, Marty. "Optimizing Web Pages for Handheld Devices." *PalmPower Magazine*. February 1999. URL: <http://www.palmpower.com/issues/issue199902/avantgotips001.html> (2 Jan. 2002).
5. Stowell, Carter. "Designing Web Sites for PDAs." *Webmonkey*. May 1999. URL: <http://hotwired.lycos.com/webmonkey/99/20/index2a.html> (3 Sept. 2001)
6. PalmOS Emulator. URL: <http://www.palmos.com/dev/tech/tools/emulator> (2 Jan. 2002).
7. AvantGo Channel Wizard. URL: https://ami.avantgo.com/mydevice/channel_wizard/url.html (2 Jan 2002).
8. AvantGo Mobile Marketing & Commerce Contact Form. URL: http://avantgo.com/products/businesses/marketing_commerce/forms/markcomm_contact.html (2 Jan. 2002).
9. Mazingo. URL: <http://www.mazingo.net>
10. ONU ECCS. URL: <http://www.onu.edu/engineering/eccs>

Biographical Information

JOHN K. ESTELL became Chair of the Electrical & Computer Engineering and Computer Science Department at Ohio Northern University in 2001. He received his BS (1984) degree in computer science and engineering from The University of Toledo and received both his MS (1987) and PhD (1991) degrees in computer science from the University of Illinois at Urbana-Champaign. His areas of interest include interface design and embedded applications. Dr. Estell is a member of ACM, ASEE, IEEE, Tau Beta Pi, and Eta Kappa Nu.

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