The International Journal of

Technology, Knowledge, and Society

Content Adaptation for Handheld Mobile Devices

ROBERT KERBS AND MEHRAK VAHIDI

The International Journal of Technology, Knowledge, and Society is
peer-reviewed, supported by rigorous processes of criterion-
referenced article ranking and qualitative commentary,
ensuring that only intellectual work of the greatest substance
and highest significance is published.

Content Adaptation for Handheld Mobile Devices

Robert Kerbs, California State Polytechnic University-Pomona, USA
Mehrak Vahidi, California State Polytechnic University-Pomona, USA

Abstract: Mobile phone users increasingly browse and search the Internet on their handsets. They want rich and diverse content made for the desktop to be equally accessible on their mobile devices. Thus, there is a need for automatic, on-the-fly, transformation of existing web content for mobile formats. However, mobile devices are restricted in their capabilities, user preferences, and network bandwidth. Although mobile devices typically require specially designed formats for optimal usability, it is not likely that all information available on the web can be translated into this format in advance. In addition, users of mobile devices may need different information in different contexts. Many adaptation techniques have been proposed to statically or dynamically modify the content of web pages for mobile phones. While useful, none of them has been designed to consider accessibility guidelines and content usability. This research project explored content adaptation for mobile phones from the HCI and accessibility guidelines perspectives. The content adaptation system is based upon customized templates that adapt content on-the-fly while also accommodating standard accessibility and HCI guidelines.

Keywords: Content Adaptation, Customized Templates, Mobile Phone Web Accessibility, Tableless Design, Usability, Web Accessibility, Organizing Content

Introduction

As wireless Internet technologies are improved, mobile phones and tablets are replacing traditional desktop and laptop computers in specific applications. These advancements are resulting in an increasing demand to access web information on-the-go.

As of March 2009, the indexable web contained at least 25.21 billion pages (World Wide Web Consortium (W3C) n.d.). However, these pages were almost exclusively designed for use with desktop computers. In unison to the exponential growth of the web during the last few years, usage of mobile phones has evolved to become a basic commodity in the United States and many parts of Europe. The world's largest manufacturers of mobile phones predict that there were 5.3 billion global mobile users and a 61.5% growth in mobile browsing in 2011. Although these client devices have become more powerful in both numerical computing and data caching, low bandwidth connections and small displays remain two crucial limitations. With the introduction of 3G and 4G wireless networks, bandwidth conditions have been somewhat improved but the small display size remains a deficiency.

Web browsing on mobile devices can be a tedious and tiring exercise because of issues associated with navigating a small screen. This process largely results in limited usefulness of these devices because the direct presentation of web pages on small devices is aesthetically unpleasant, hard to navigate, and in the worst case, completely illegible (Fudzee and Abawajy 2008). Therefore, adapting web content to enable effective web browsing on mobile phones is an attractive challenge to address. One of the crucial problems is the development of techniques for the adaptation of information to the usability requirements of mobile devices and also user preferences. In this paper, the primary goal was to develop a technique to adapt web content for use on small mobile devices while taking into account standard accessibility and Human Computer Interaction (HCI) guidelines.

Methodology Used

This research project proposed, implemented, and tested a new model for the presentation layer of a content adaptation system called AccessibleWeb. Part of this research included the creation of a simple but fully functional prototype gateway to demonstrate practical use of the model. The prototype, based on customized templates, adapts content for websites without an additional dependency on a separate static mobile version. This model demonstrates the benefits of using different customized templates for different users: people with disabilities, non-English speakers, children, and seniors. The templated version of various websites was tested via usability studies and the results analyzed. The study presented here used cell phones and not tablets or laptops.

Architecture

As one can see from figure 1, AccessibleWeb is a Firefox Mobile extension which is added to its Fennec Firefox Mobile Browser and customizes the web content (i.e., which is a HTML/XML document).
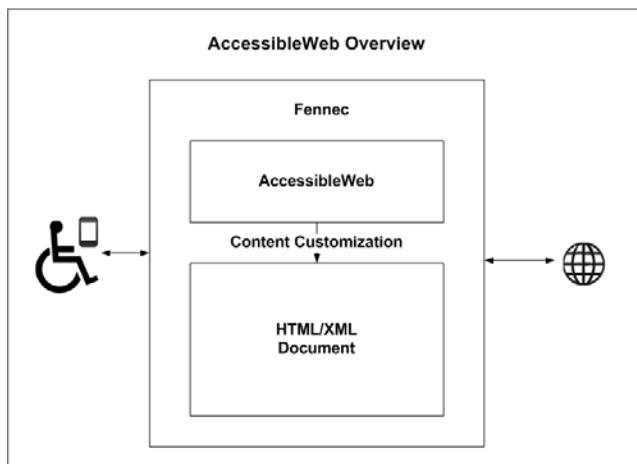
Figure 1 AccessibleWeb as an extension to Fennec Firefox Mobile Browser

In this way, AccessibleWeb acts as a gateway between Web Content and the user and manipulates the HTML/XML document look.

Figure 2 shows the interaction between Fennec and AccessibleWeb. Fennec uses a multi-process architecture to allow the content process to communicate with the AccessibleWeb process via the messaging system (https://wiki.mozilla.org/Mobile n.d.). Based on the message request, Fennec loads the appropriate script and renders the content.

Interaction Between Fennec and AccessibleWeb
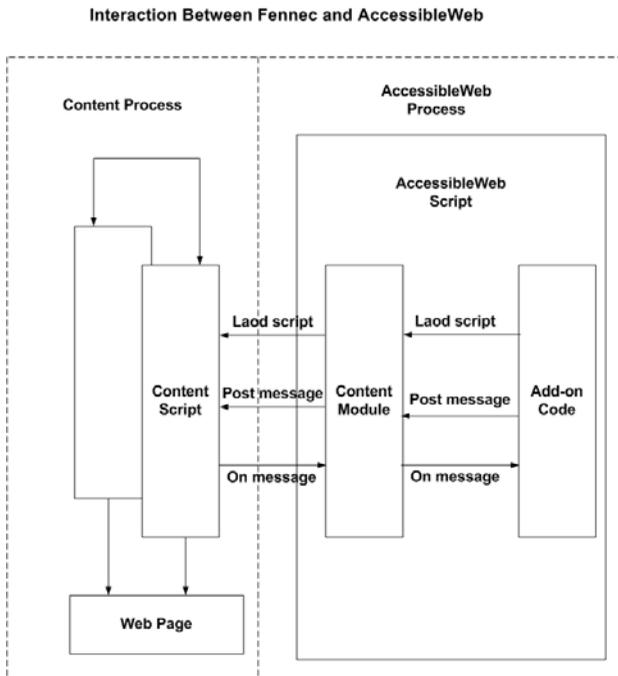
Figure 2 interaction between Fennec and AccessibleWeb

Figure 4 shows AccessibleWeb Components and how they communicate and Figure 5 shows each module's inner process interactions.

Figure 3 AccessibleWeb Components

As can be seen in Figure 5, the Main Process is responsible for displaying web content. It can communicate to all browsers child processes in the window's scope. It can also access an individual child process by using a messaging system (https://wiki.mozilla.org/Mobile n.d.).

Figure 4: Accessible Web Inner Process Interaction

Design

Design Aspects for Mobile Applications (General User Interface (UI) Design for Mobile Devices)

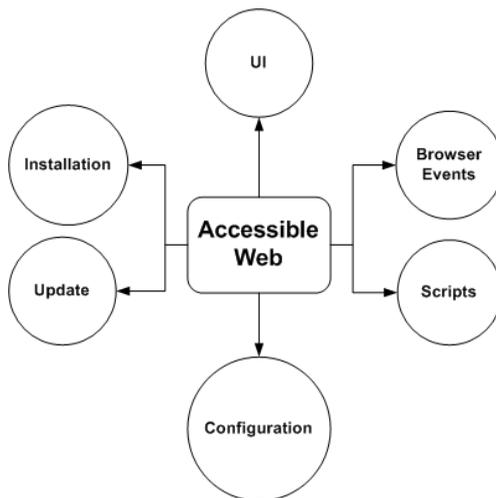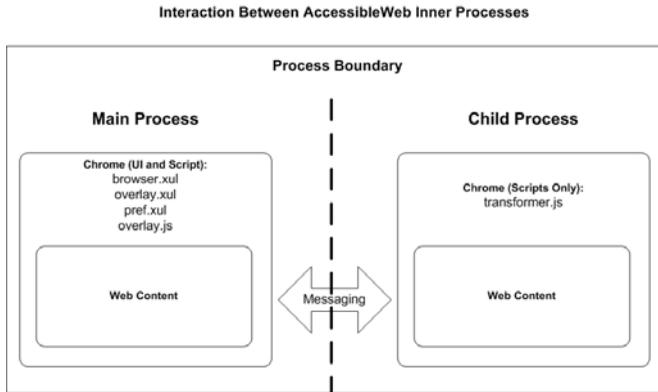There are two major considerations that should be taken into account when designing a UI for a mobile device. The reason is that both parties in the interaction, the device and the person, are different in a mobile context than when using a desktop computer. The first limitation is lack of functionalities available on a mobile device. The second limitation is the fact that people on-the-move interact with and use their devices differently than if they were stationary.

Device Characteristics

The most relevant characteristics of the current generation of cell phones are small screens and difficult (i.e., small) surfaces to type. Additionally, based upon the service, communication interruptions can occur. In AccessibleWeb, users interact by choosing options from a list. Since preferences are saved in AccessibleWeb on the device, interruptions are handled gracefully.

Mobile User Characteristics

People are different in what they want and do while not sitting at a desktop or laptop. Based on a taxonomy for designing the Mobile User Experience by Barbara Ballard (Ballard 2007), some of these differences are: mobility, interrupt-ability, distraction-proneness, and lack of available context.

Customized Web Template

The content adaptation system presented here is based on customized web templates that modify customized Cascading Style Sheet (CSS) files. The most important reason this technology was used was to separate the presentation logic from the business logic. A presentation layer, which is the last layer in an n-tier Web Architecture (Pcmag.com 1994), is where the templates reside. Content presentation systems that follow this method allow users to have the option to change the presentation layer without affecting the viewing of the content.

The main feature of using web templates is easy customization and reusability. This is important because not all web site owners have the willingness and ability to hire developers to

design a separate mobile compatible version. This is why AccessibleWeb was designed for content adaptation for personal websites, blogs, and small business.

CSS Consideration

Cascading Style Sheets (CSS) were introduced in December 1996 by the World Wide Web Consortium (W3C) to improve web accessibility and to make HTML code semantic rather than presentational. CSS is designed to enable the separation of document content (written in HTML or a similar markup language) from document presentation, including elements such as the layout, colors, and fonts (Stephen 2007). This separation can improve content accessibility. While the author of a document typically links that document to a CSS style sheet, AccessibleWeb restyles the document on-the-fly using a user-specified style sheet. This sheet overrides the author-specified sheet — this insures content accessibility for mobile users. W3C (About the W3C Markup Validation Service n.d.) suggests using tableless structures in CSS.

Tableless Design Consideration

Tableless web design is a design philosophy that no longer requires HTML (International Web Accessibility Initiative Press release 1997). AccessibleWeb utilizes CSS, instead of HTML tables, to arrange elements and text on a web page.

Accessibility Considerations

The W3C's Web Accessibility Initiative (WAI) (International Web Accessibility Initiative Press release 1997) was referenced for this project. Additionally, the Rehabilitation Act of United States Access Board Section 508 (Ramirez 2000) was consulted, confirming the undesirability of having the presentation layer modify content. Further study of the literature gave us confidence that tableless web design would considerably improve web accessibility (http://www.w3.org/DOM n.d.). Finally, research into screen readers and Braille devices informed us that fewer problems are experienced with these devices by using tableless designs because they follow a logical structure (http://www.w3.org/standards/webdesign/htmlcss#whatcss n.d.).

By separating the design via CSS and HTML, AccessibleWeb provides different customized layouts on-the-fly on mobile phones for different users. This method gives users the opportunity to try different styles based upon the content they are currently viewing and allows for changes in the style easily and quickly. This approach not only benefits the user but website owners too. Consequently, there is no need for a separate static version for mobile resulting in the whole project being faster, less expensive, and easier to maintain. Another challenge for mobile users is not being able to understand all styling provided by the author. AccessibleWeb helps accessibility in this case by providing a clean, easy to read and search interface independent of style while maintaining content.

AccessibleWeb Modules

As soon as a user installs AccessibleWeb Add-ons and sets the default options in the preferences menu, modules will appear in the site menu while browsing a web page. Within the Site menu are six modules. The Preferences page is located in the Fennec (Firefox Mobile Browser) setting, Add-ons section under AccessibleWeb option and it includes Default Language, Font, Text Size, and Margin.
AccessibleWeb Modules are as follows:

1) Make Accessible

Based on the font, text size, and margin the user selected for their preferences, the main content of the webpage will be re-rendered on the mobile device.

2) *Customize*

The customize module lets users change the font, text size, and margin of the page as they wish.

3) *Change Style*

This module is helpful for users with special needs such as the elderly or children. It currently has four modes: Reading mode, Scanning Mode, Elders' Mode and Kids' Mode. Styles, such as font, text size, background colors, foreground colors, page margin, and line spacing are carefully assigned adhering to accessibility research for finding and accessing information based on user preferences and interests (Chaparro and Bohan, Two Years and Six Hand-held Devices Later: What I Have Learned 2000, Chaparro and Hart, Evaluation of Websites for Older Adults: How "Senior-Friendly" Are They? 2004, Chaparro and Shaikh, The Effects of Line Length on Reading Online News 2005, Chaparro, Bernard and Mills, So, What Size and Type of Font Should I Use on My Website? 2000, Chaparro, Bernard and Fernandez, et al. 2002, Chaparro, Bernard and Liao, et al. 2001, Chaparro, Bernard, et al., A Comparison of Popular Online Fonts: Which is Best and When? 2001, Chaparro, Bernard, et al., Which Fonts Do Children Prefer to Read Online? 2001, Chaparro, Shaikh and Chaparro, Examining the Legibility of Two New ClearType Fonts 2006).

4) Links only

By selecting this option, the program will filter and display the hyperlinks of the web page.

5) Headlines on top

If selected, the headlines (i.e., H1 and H2 Tags) will be displayed at the top of the page before the main content. These headlines are linked to the paragraph to which they are referring. This option helps simplify the "Finding of Information", which is a major task in accessibility guidelines and mobile browsing (http://www.w3.org/DOM n.d.).

6) Translate to

This option targets non-English speakers. It makes web page content accessible in any selected language by redirecting the user to the Google translator API and translates the current page to the selected language.

Implementation

All AccessibleWeb modules were implemented using three steps. Find the main content of the page.

- Remove the author's styling.

- Apply the new style to the main content according to the user's interest and display it in the Fennec browser.

To locate the main content of a page, an intelligent scoring algorithm is used to parse all the paragraphs and determines a score based on the number of words and types of characters found. The Document Object Model (Wai Yip and Lau 2003) is used to find all paragraphs of the page, then based on number of paragraphs with special class names or special IDs (i.e., news, content, text, and body) the score is adjusted. The paragraph with the highest score is recognized as the main paragraph and is cleaned, styled, and re-rendered for the user. This same paragraph is selected and designated as the main content of the page.

Three methods were used to detect and remove author styling from web pages: detection of inline styles, tags utilized inside the HTML document (style information on a single element), and elements specified using the "style" attribute. Also taken into consideration were the embedded style, blocks of CSS information inside the HTML itself, and external style sheets, a separate CSS file referenced from the document. All this styling information was removed from the main content.

For the third step, the main content was repurposed based on the module preferences selected by the user. This step ultimately re-renders the web page on the mobile device.

Results

Two usability methods were utilized to determine the usefulness of our approach: user observation and questionnaire.

User Observation

The user population that participated in this usability test included twelve people (Neilsen 1993) including: different ages (10-60), different languages, people with disabilities, children, and seniors. The tasks were designed to test a subset of the accessibility rules provided by World Wide Web Consortium (W3C)'s Web Accessibility Initiative (WAI) (International Web Accessibility Initiative Press release 1997) and ADA section 508 standards (Section508.gov 2001). The goal was to evaluate if the system could improve users' mobile experience (Table 1).

Name	Age	Sex	Familiarity with mobile browsing	Disability
User1	28	F	Expert	NA
User2	29	M	Expert	NA
User3	30	M	Expert	NA
User4	21	F	Expert	NA
User5	56	M	First Time	Eye Impairment
User6	35	F	First Time	NA
User7	55	F	First Time	English is Second Language
User8	19	M	First Time	English is Second Language
User9	23	M	Returning User	NA
User10	60	F	Returning User	Eye Impairment
User11	14	M	Returning User	Kid
User12	12	F	Returning User	Kid

Table 1 User Observation Participants

A pre-test was administered to understand the background of the user population and to gauge their familiarity with mobile devices to surf the web. A set of nine tasks and a set of post test questions were prepared. In each task subjects visited two web pages. In the first visit, the user browsed the regular website and in the second the user browsed the website using AccessibleWeb. Subjects were not familiar with any of the pages that were chosen for the tasks. For each task, the time to completion was recorded. There was no time limit in performing a given task but users had the option to give up. In each task the participants were asked to think aloud and express what they liked and disliked (Kerbs and Vahidi 2011). After completion of each task, users filled out a form to describe their experience.

Questionnaire

General questions were asked about the performance and usability of the system as well as queries into users' experiences with other content adaptation systems available on the market.

Discussion

Usability Test Results

Since the goal was to compare the user experience between browsing sites on a mobile phone and browsing sites using AccessibleWeb tools on mobile phones, task completion success rate and time on task metrics were calculated in both test conditions. To evaluate the improvement rate by using AccessibleWeb, two metrics were compared: task completion success rate and time on task.

Task Completion Success Rate Result

The result showed in both conditions (performing the tasks using a regular browser and using AccessibleWeb tools) all of the participants completed tasks associated with finding information and reading. While browsing regularly, only 25% of participants successfully finished tasks requiring navigation; however, using the AccessibleWeb tool, the success rate was 100%. The reason for this improvement was that the Link Only option of AccessibleWeb shows the menu of the site as a regular, readable and easy to find link, independent of the site designer preferences who normally considers browsing on desktop computers and not mobile phones. Testing for those with special needs showed an improved success rate using AccessibleWeb from 33% to 91%. Users were more successful because they had the option to select the font, font size, and the margin that they are most comfortable with (Table 2 Task Completion Success Rate).

participants	Finding Information tasks		Reading tasks		Navigation tasks		Special needs tasks	
	R	AW	R	AW	R	AW	R	AW
1	√	√	√	√	X	√	X	X
2	√	√	√	√	X	√	√	√
3	√	√	√	√	X	√	X	√
4	√	√	√	√	X	√	√	√
5	√	√	√	√	X	√	√	√
6	√	√	√	√	X	√	√	√
7	√	√	√	√	X	√	X	√
8	√	√	√	√	√	√	X	√
9	√	√	√	√	√	√	X	√
10	√	√	√	√	X	√	X	√
11	√	√	√	√	X	√	X	√
12	√	√	√	√	√	√	X	√
Success	12	12	12	12	3	12	4	11
Completion Rate	100%	100%	100%	100%	25%	100%	33%	91%

Table 2 Task Completion Success Rate

Time on Task Result

Time on task results also showed an improvement using AccessibleWeb over performing tasks using a regular browser. In some cases, the improvement was significant. For example, for one given task ten of twelve participants could not finish the navigation task using regular browser while all of them were able to do so while using the AccessibleWeb tool (Table 3).

Participants	Finding Information tasks		Reading tasks		Navigation tasks		Special needs tasks	
	R	AW	R	AW	R	AW	R	AW
1	720	240	180	120	*	120	*	+
2	480	360	480	360	*	240	420	300
3	300	360	360	300	*	240	*	120
4	300	240	420	360	*	300	420	300
5	300	240	420	300	*	240	360	240
6	360	240	300	300	*	180	300	240
7	180	120	240	240	*	120	*	420
8	180	120	240	240	180	60	*	180
9	180	240	240	240	120	180	*	540
10	180	120	300	240	*	120	*	180
11	120	180	240	240	*	240	*	300
12	180	120	240	180	240	180	*	120
Total TOT	290	215	305	260	945	185	890	345

Table 3 Time on Task

Post Survey

A post survey was administered utilizing a 5-point rating scale ranging from 1 (Strongly disagree) to 5 (Strongly agree). Mean agreement ratings greater than 3.5 were found for the following questions:

- I would recommend this software to my friends.

- The navigation is simple and practical

- Reading is simple and easy

- The adapted information from the website is useful information

- Finding information is simple and easy.

- I enjoy my sessions with this software

- The way system information is presented is clear and understandable.

- This software seems to disrupt the way I normally like to arrange my work

Conclusion

Content adaptation for mobile devices by using customized templates is a promising approach. When compared with regular browsers, finding information, readability, and the navigation experience were improved for the small population tested. Still, some weaknesses in the system

were discovered using user-observation. For example, some users suggested that the Link Only option, which only displays available links of the content, should keep their own relevant styling for the given task at hand. In other words, if the links are indicating a menu, they should keep the format and structure of a menu. Also, some users suggested that once a feature was selected from the menu (i.e., Link-Only or Headlines-Only), it should be conveyed through the whole browsing session. This would reduce the need to reset the options on each web page. In the future, these design weaknesses will be addressed. Additionally an extension will be submitted to Firefox for the Add-ons collection. This will allow public access for extensive testing and more statistically significant data collection.

REFERENCES

About the W3C Markup Validation Service. Retrieved 3 30, 2011, from http://validator.w3.org/about.html

Ballard, B. (2007). *Designing the Mobile User Experience.*

Chaparro, B. S., & Bohan, M. (2000). Two Years and Six Hand-held Devices Later: What I Have Learned. *Usability News, Software Usability Research Laboratory, Vol. 2, issue 2.* , 12-13.

Chaparro, B. S., & Hart, T. A. (2004). Evaluation of Websites for Older Adults: How "Senior-Friendly" Are They? *Usability News, Software Usability Research Laboratory, Vol. 6, issue 1.* , 32-39.

Chaparro, B. S., & Shaikh, A. D. (2005). The Effects of Line Length on Reading Online News. *Usability News, Software Usability Research Laboratory, Vol. 7, issue 2.* , 1-3.

Chaparro, B. S., Bernard, M., & Mills, M. (2000). So, What Size and Type of Font Should I Use on My Website? *Usability News, Software Usability Research Laboratory, Vol. 2, issue 2.* , 10-14.

Chaparro, B. S., Bernard, M., Fernandez, M., & Hull, S. (2002). The Effects of Line Length on Children and Adults' Online Reading Performance. *Usability News, Software Usability Research Laboratory, Vol. 4, issue 2.* , 16-25.

Chaparro, B. S., Bernard, M., Liao, C., & Mills, M. (2001). Determining the Best Online Font for Older Adults. *Usability News, Software Usability Research Laboratory, Vol. 3, issue 1.* , 16-20.

Chaparro, B. S., Bernard, M., Mills, M., Frank, T., & McKown, J. (2001). Which Fonts Do Children Prefer to Read Online? *Usability News, Software Usability Research Laboratory, Vol. 3, issue 1.* , 6-8.

Chaparro, B. S., Bernard, M., Mills, M., Peterson, M., & Storrer, K. (2001). A Comparison of Popular Online Fonts: Which is Best and When? *Usability News, Software Usability Research Laboratory, Vol. 3, issue 2.* , 50-60.

Chaparro, B. S., Shaikh, A. D., & Chaparro, A. (2006). Examining the Legibility of Two New ClearType Fonts. *Usability News, Software Usability Research Laboratory, Vol. 8, issue 1.* , 9-18.

figures, I. f. *The World in 2010*. Retrieved 10 20, 2010

Fudzee, F. M., & Abawajy, J. (2008). A classification for content adaptation system. *In Proceedings of the 10th International Conference on Information Integration and Web-based Applications \& Services* , 426-429.

http://www.w3.org/DOM. Retrieved 3 8, 2011

http://www.w3.org/standards/webdesign/htmlcss#whatcss. (n.d.). Retrieved 12 01, 2010

https://wiki.mozilla.org/Mobile. Retrieved 12 04, 2010

International Web Accessibility Initiative Press release. (1997).

Kerbs, R. W., & Vahidi, M. (2011). *Content Adaptation for Handheld Mobile Devices.* Pomona: california state polytechnic university pomona.

Neilsen, J. (1993). *Usability Engineering.*

Pcmag.com. (1994). *Wireless portal Definition from PC Magazine Encyclopedia.* Retrieved 12 2010, 10, from Pcmag.com

Ramirez, A. O. (2000). Three-Tier Architecture. *Linux Journal, Volume 2000 Issue 75es* , 7.

Section508.gov. (2001). *Web-based intranet and internet information and applications*. Retrieved 07 08, 2010, from http://www.section508.gov/index.cfm?FuseAction=Content&ID=12#Web

Stephen, J. (2007). A Unit of Info Based Content Adaptation Method for Improving Web Content Accessibility Mobile Internet. *ETRI Journal* , 794-807.

Tableless layout HOWTO. Retrieved 12 08, 2010, from http://www.w3.org/2002/03/csslayout-howto

Techniques for Web Content Accessibility Guidelines 1.0. (2000). Retrieved 09 19, 2010, from http://www.w3.org/TR/WCAG10-TECHS/#tech-style-sheets

Wai Yip, L., & Lau, F. (2003). User-centric content negotiation for effective adaptation service in mobile computing. *Software Engineering, IEEE Transactions on , vol.29, no.12* , 1100-1111.

World Wide Web Consortium (W3C). *Tableless layout HOWTO*. Retrieved 12 08, 2010, from http://www.w3.org/2002/03/csslayout-howto

ABOUT THE AUTHORS

Dr. Robert Kerbs: Dr. Kerbs began his career at Cal Poly Pomona, as a Lecturer, in the Computer Science Department, in 2000. He joined the tenure-track faculty as an Assistant Professor in 2001. In 2007, he was promoted to Associate Professor and received tenure in 2008. He has served as Chair in the Computer Science Department since Fall 2011. He is a member of the Association for Computing Machinery (ACM), Tau Beta Pi honor society, and several other scientific societies. He has substantial industry experience with: Caltech, Texas Instruments, and Kronos Digital Entertainment. He frequently teaches graphics, game programming, human computer interaction, and networking. Dr. Kerbs received his B.S. in Electrical Engineering, from California State University, Long Beach and his M.S. and Ph.D. in Computer Science from Nova Southeastern University. His research interests include computer graphics, networking, data mining, and human computer interaction.

Mehrak Vahidi: Ms. Vahidi received her master's in computer science from California State Polytechnic University, Pomona. Her research interests include human computer interaction and new media applications.

The International Journal of Technology, Knowledge and Society explores innovative theories and practices relating technology to society. The journal is cross-disciplinary in its scope, offering a meeting point for technologists with a concern for the social and social scientists with a concern for the technological. The focus is primarily, but not exclusively, on information and communications technologies.

Equally interested in the mechanics of social technologies and the social impact of technologies, the journal is guided by the ideals of an open society, where technology is used to address human needs and serve community interests. These concerns are grounded in the values of creativity, innovation, access, equity, and personal and community autonomy. In this space, commercial and community interests at times complement each other; at other times they appear to be at odds. The journal examines the nature of new technologies, their connection with communities, their use as tools for learning, and their place in a "knowledge society".

The perspectives presented in the journal range from big picture analyses which address global and universal concerns, to detailed case studies which speak of localized social applications of technology. The papers traverse a broad terrain, sometimes technically and other times socially oriented, sometimes theoretical and other times practical in their perspective, and sometimes reflecting dispassionate analysis whilst at other times suggesting interested strategies for action.

The journal covers the fields of informatics, computer science, history and philosophy of science, sociology of knowledge, sociology of technology, education, management and the humanities. Its contributors include research students, technology developers and trainers, and industry consultants.

The International Journal of Technology, Knowledge and Society is a peer-reviewed scholarly journal.