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Accessibility of E-Commerce Websites for Vision Impaired Persons

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Graduate Program in Computer Science
A thesis submitted in partial fulfillment of the requirements for the degree in Master of Science
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ACCESSIBILITY OF E-COMMERCE WEBSITES FOR
VISION-IMPAIRED PERSONS
(Thesis format: Monograph)

by

Roopa Bose

Graduate Program in Computer Science

A thesis submitted in partial fulfillment
of the requirements for the degree of
Masters of Science

The School of Graduate and Postdoctoral Studies
The University of Western Ontario
London, Ontario, Canada

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Abstract

In this thesis accessibility problems with websites for vision-impaired persons are discussed in detail. General accessibility problems and those specific to e-commerce websites, especially on-line shopping websites are discussed. Accessibility problems are examined from the perspective of a screen reader user. As a solution to the accessibility problems identified, the WCAG 2.0 guidelines are reviewed and new changes are proposed to improve the existing guidelines. Enhanced solutions using tactile media capable of providing a better web browsing experience for vision-impaired persons are also discussed.

Keywords: Web accessibility, WCAG, Screen readers, E-commerce website accessibility

For my loving parents Susan and Bose

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Chapter 1

Introduction

The advent of computers and the internet has opened up new opportunities of information access for people across the globe. The way people communicate, learn and shop has changed substantially. Visually disabled people also gained much with the use of computers and the internet. They were able to access information and carry out important tasks like bill payment, banking etc. independently through on-line media. Visually disabled people mainly use screen readers, tactile media like Braille displays or special web browsers to access on-line information. Screen readers are the popular choice among the three [40].

As the technology evolved, new techniques are used to present information in web pages in flashy ways. Flash animations, contents developed using JavaScript and CSS are examples of this advancement. However, these flashy contents made web pages inaccessible for blind people. Survey results from WebAIM¹ reveal that the majority of visually impaired people has the opinion that web accessibility has not really improved [44]. Also, studies show that most of the popular websites have some kind of accessibility problem [35].

In this thesis, we are discussing the major accessibility problems with websites and suggest solutions to improve the accessibility. General accessibility problems are discussed under four categories. Inaccessible dynamic content, confusing page layout, complicated navigation and difficulty with page overview are these four categories. Major accessibility problems with e-commerce websites, especially on-line shopping, are also discussed. We have used screen readers along with monitors to assess the accessibility.

¹WebAIM stands for Web Accessibility In Mind

To benefit large population of blind people we attempt to provide a feasible solution to improve accessibility using screen readers. Designing websites according to accessibility standards is the most feasible solution. The problems identified are checked against the WCAG 2.0 guidelines and new recommendations are suggested in cases where WCAG 2.0 guidelines are not capable of providing proper accessibility standards. Other solutions which uses tactile media and multimodal display are also mentioned as solutions to improve web accessibility for vision-impaired persons.

Web accessibility problems of vision-impaired persons in general are discussed in the beginning of the thesis. Chapter 2 discusses the various options available for web browsing for blind people and the work related to our study. General accessibility problems with websites and problems specific to on-line shopping websites are discussed in Chapter 3. In Chapter 4 WCAG 2.0 guidelines are reviewed and new changes to the guidelines are proposed. The last section in Chapter 4 discusses thoughts on enhanced web accessibility solutions for blind people.

Chapter 2

Background and Related Work

In today's world, technology is helping people with disabilities in day-to-day life. Motorised wheel chairs, hearing aids, magnifying glasses are everyday examples of this. Computers and the internet have opened new possibilities of learning, shopping and communication through e-learning, e-commerce, web chats, video call facilities etc. Using the internet and computers, people with vision disabilities can take part in class-room learning more effectively. They have better access to learning materials as well. E-commerce websites aid with carrying out important tasks like bill payments, banking etc. without the need for help from others. On-line media must be made accessible, so that people with disabilities can utilise computers and the internet to full extent. Many new techniques are used in modern web pages to present the information in a more flashy way than before, presumably with the intent to gain the readers attention. These techniques use graphics, images, videos, animation etc. to make the respective website more appealing. Accessibility is not considered when websites adopt such techniques. As a result, accessing the web pages becomes difficult for vision-impaired persons. This thesis focuses on discussing accessibility problems of web pages for vision-impaired persons and feasible solutions to improve web accessibility.

Using screen readers is one of the popular ways by which blind people access web pages [40]. Tactile displays also provide ways to access web pages, however one has to put more effort into getting trained to use such devices. A screen reader is a software program which reads out the web content using text-to-speech conversion [40]. Apart from reading out the content, it can also display the content on a Braille display. Even though screen readers help blind people to

access web pages, proper navigation, reading out the content exactly according to the page layout, conveying image and graphic contents are some of the serious challenges. We list some of the difficulties in this respect by comparing the web experience of a sighted person and a blind person. Screen readers being the popular choice among vision-impaired persons for web page access, the accessibility problems are explained from the perspective of a screen reader user.

Consider accessing the article of the World Wide Web in wikipedia using the on-line screen reader, WebAnywhere [18]. After reading the heading at the top of the page and two lines below that, the screen reader will read out the contents in the rightmost column. On the other hand, a sighted user will go on reading the main content. Apparently, the screen reader does not read out content as it appears visually. This is because, the screen reader reads content based on the markup language [50].

Consider another website <http://www.bbc.com/news/>. One sees a line of text which is being updated every few seconds, showing the latest news below the top heading. This dynamic content enabled by using JavaScript will not be read out by the screen reader [49]. Some screen readers may read out the content of this line, but only once. This web page uses many video and image galleries for presenting more information in less space. These image and video galleries are not accessible using screen readers, while sighted people have access to them. A sighted person can also scroll down the page to find information he needs, whereas the blind person will not be able to use scrolling. The only way to navigate to the information of interest being, to use the tab key to traverse through links or to search using key words.

Consider the on-line shopping website <http://www.amazon.ca>. To find different products a sighted user can go through each department and can check the subdepartments, which will appear upon mouse hover on a particular department. A blind person can easily go through the main department names, but he will never get a clue that they are further organised as subdepartments unless he selects one. After going to a subdepartment, searching for a product in another subdepartment is a tedious process because of the navigation difficulties. It is easy to use the search option to find a specific product. While going through the search results, the screen reader will read out all contents on the page, like headings, menus which are not the current point of interest. In this case, a blind person can use the tab key to traverse through the result, and this will read out the name of the product, its brand, price, the number of reviews

etc. But it will leave out one main information which is whether the item is in stock or not, since this is not a link. For a sighted user this information is highlighted using green or red to indicate in-stock and out-of-stock.

The examples discussed above illustrate just a few accessibility problems, which are encountered with most websites. More specific accessibility problems and the details of screen reader interpretations are discussed in Chapter 3. Also, the accessibility problems specific to e-commerce websites like complicated menu structure, presence of inaccessible graphics and image galleries, difficulty in finding the required information are discussed in that chapter.

There are three main options which facilitate easy access to web pages for vision-impaired persons: Screen readers, tactile media and special browsers or browser extension. We describe the specific properties of various such systems.

2.1 Screen Readers

Screen readers are software programs which use text-to-speech technology to read out the content of a web page from top to bottom, line by line. Some screen readers can also output content to a refreshable Braille display. Key strokes are used for navigation through the web page. If the user does not want the screen reader to read out the entire contents, the tab key can be used to navigate from link to link.

JAWS is a popular screen reader, developed by Freedom Scientific for the Windows operating system. JAWS works well with all Microsoft and IBM Lotus Symphony applications [12]. JAWS is compatible with Adobe Acrobat Reader, Firefox, Internet Explorer and many more software systems. JAWS can output text to an electronic Braille device [13]. JAWS uses many hot keys and key shortcuts. This requires quite a bit of learning for the users to get acquainted with the software. JAWS can handle dynamic contents like flash media. While reading tabular contents JAWS gives an overview of the table by reading out the number of rows and columns in the table. The latest version of JAWS is capable of giving a page overview to some extent by reading out the number of regions, headings and links on the page. JAWS is quite expensive. A single licence currently costs around 1000 USD. Hence not everyone can afford to buy JAWS without government or insurance support.

NVDA (Non Visual Desktop Access) is a free screen reading software for Microsoft Windows. A portable version can also be created. The founders of NV Access, Michael Curran and James Teh, developed this software [29]. It supports all the popular web browsers like Mozilla Firefox, Internet Explorer, Google Chrome. Applications like Microsoft Word, Excel, internet chatting and email are also supported. Recent WebAIM¹ survey results [44] show a steady increase in the use of NVDA, thus making it the most popular screen reader after JAWS. NVDA also makes use of shortcut keys for navigation purposes. It reads out text on mouse hover and supports Braille displays. Dynamic contents using Flash, JavaScript etc. are made accessible to a great extent. Like JAWS, training is required to get familiarized with the use of NVDA.

Window Eyes, VoiceOver, Speakup, Thunder are other popular screen readers.

WebAnywhere is a web-based screen reader developed at the University of Washington [2]. Vision-impaired persons who cannot afford a full screen reader can benefit from this on-line screen reader. On most public machines, screen readers would not be installed because of their cost. Blind users can use WebAnywhere to access the web from such machines. One can access WebAnywhere at <http://webanywhere.cs.washington.edu/wa.php>. Unlike other screen readers, WebAnywhere can provide voice support only to web browser applications. Also it cannot handle web pages with Flash objects and frames. The way it handles dynamic contents also differs from that used by full screen readers. This difference is explained below in the examples mentioned in Chapter 3. Navigation through a web page is mainly achieved using shortcut keys. People comfortable with any screen reader can use WebAnywhere with much ease, since the navigation shortcuts are similar.

Screen readers provide accessibility to a great degree, but they are not free from limitations. Information in the form of images can be conveyed to the user only by reading out the alternative text associated with the image. If the alternative text is missing for an image, that information will remain inaccessible. Since screen readers rely on the markup of the web page, they will not read out the content as it is visually presented to the user. Also screen readers have only limited access to dynamic content and special text like mathematical expressions. Popular screen readers like JAWS and Window Eyes are able to handle dynamic content to some extent, while many others are not. Reading out information in tabular format is also a challenge, since

¹WebAIM stands for Web Accessibility In Mind

the screen reader can read out only row by row and it is difficult to get the overview of the table if the table is large.

2.2 Tactile Media

Different types of tactile media varying from microcapsule paper to tactile displays can be used to present static and dynamic contents for blind people. Braille text and graphical elements can be generated with the technique of embossing. In this technique raised dots will be printed on paper through heat transfer copying or by using embossing printers like the TIGER embosser. Microcapsule paper is another tactile medium in which the capsules constituting the paper will expand upon heating to produce tactile documents. Free hand drawing with pens or standard printing techniques can be used for printing on microcapsule paper. A replica of the document in tactile form can be generated using thermoforming in which a large metal dye is molded into the shape of the document and this mold is placed under a PVC sheet and heated so that the sheet will take the shape of the mold. These techniques are expensive and not suited to present dynamic content since they are immutable. These techniques and various other modes of tactile presentation is discussed in detail in [30].

Refreshable Braille displays show Braille text corresponding to the information displayed on the computer screen, by generating Braille dot patterns by raising and lowering pins electronically. The Focus Blue Braille display by Freedom Scientific and the Esys Braille displays by Euro Braille are examples of refreshable Braille displays available in the market [27]. Many blind people use Braille displays along with screen readers.

Talking Tactile Tablet (TTT) by Touch Graphics is a tactile display which permits the haptic interactions with static tactile diagrams, charts etc. on its surface when connected to a computer. It uses touch icons which when pressed give audio feedback of the content [36].

BrailleDis 9000 developed as part of the HyperBraille project and the Metec Display DMD 120060 are examples of tactile displays. These tactile displays are pin matrix displays which can display tables, tactile graphics and diagrams by raising and lowering the pins. Many papers like [15, 4, 8, 14, 32] mention the use of these displays for conducting experiments related to tactile rendering of tables, tactile graphics, tactile diagrams and tactile web browsing.

A 3D printed refreshable Braille display is a recent proposal in the field of tactile media. One can visit the website of MakerBot Thingiverse (<http://www.thingiverse.com/thing:90144>) for more details.

2.3 Special Web Browsers and Browser Extensions

Apart from screen readers, there are also many web browsers and browser extensions designed to provide access to web pages for visually impaired persons. Some web browsers make the web content more accessible for screen readers by converting the inaccessible content to a readable format or by removing the inaccessible content. Certain web browsers have built-in screen readers, which can interpret the HTML objects in a better way. There are web browsers which offer better navigation through the content and support mathematical expressions. Some such web browsers are listed below.

WebbIE : WebbIE is a dedicated web browser which provides accessibility of web pages for visually impaired persons, making web content more accessible for screen readers. Internally it uses Microsoft Internet Explorer control objects to acquire the web page and parse the HTML into the W3C standard Document Object Model (DOM) [17]. It builds a plain text representation of the web page content and presents this to the user. The active components in the DOM structure like hypertext links are presented on new lines with a title. Most of HTML 4 including forms, tables, frames and embedded multimedia are supported by WebbIE. The entire layout of the page is lost, since the whole web page will be presented as lines of text. WebbIE cannot handle web pages which mainly rely on mouse-related events and heavy use of JavaScript.

MozBraille : MozBraille is an extension of the Mozilla and Firefox web browsers to make them stand-alone accessible web browsers for visually impaired persons [26]. It offers Braille output, text-to-speech output and large character views to its users. It can use all speech engines under windows and supports over 30 Braille displays. Some of the main features include displaying simple XHTML pages without tables, configuring the display of XUL and HTML elements by the user on the three types of output, managing caret movement and selecting the Braille display.

ChromeVox : ChromeVox is a screen reader which is built as a web application extending

Chrome OS [31]. ChromeVox uses text-to-speech technology, and it supports HTML 5 and W3C ARIA. With normal screen readers navigation between web pages, different tabs and tabular contents is a challenge. ChromeVox categorises the page details into group, object, sentence, words and characters, and enables navigation at each level of detail using particular shortcut keys. It also enables navigation between tabs easily using shortcut keys. It supports mathematics which normal screen readers cannot. Earcons are implemented to identify some page events and some HTML constructs such as hypertext links.

2.4 Related Work

Much research has been and is going on to alleviate the web accessibility problems. Rotard et al. [32] developed a tactile web browser which uses Mozilla Firefox and does tactile rendering of web pages. The Metec display (<http://www.metec-ag.de/>) was used as the output device. Tables were linearised appropriately without the need to scroll horizontally, to access one complete row. The use of specialized algorithms helped to preserve the two-dimensional structure of a table wherever necessary. However, handling big tables or tables used for page layout and complex web forms remains a challenge. Interactive exploration of graphical contents like Scalable Vector Graphics (SVG) and raster graphics is possible using this tactile web browser. In interactive mode, the user will be able to get information like title, description and attributes of SVG on Braille and voice output. Zooming of graphical content including 3-dimensional graphics and improved handling of mathematical expressions in MathML is achieved using this browser. Raster graphics with multiple colors is complex to handle with the two-state-pin Metec display. Moreover the display of web page depends on the resolution of the tactile output device, which is much lower than that of usual monitors.

WAB (World-wide-web Access for Blind and visually impaired computer users) [16] presented an impressive approach to deal with the page overview and navigation problem faced by vision-impaired persons. WAB implements a proxy server which acts between web browser and web server to modify the web document. The modified document presented to the user will have a list of titles and links apart from the original information in the document. The list of titles is organised hierarchically, which offers navigation through titles, subtitles and text. The

list of links provides better navigation through the document, and jumping through links helps the user to get an overview of the document.

WAB and WebbIE compares as follows: WAB may not give a good support when web documents have dynamic and graphic content, since there is no particular mechanism to deal with it. A user will not be able to distinguish between the main content and the navigation parts very clearly. On the other hand, WebbIE [17] tries to distinguish the main content and the navigation links, by identifying the HTML elements. WebbIE is a user interface, which provides plain-text representation of web pages by making use of Microsoft Internet Explorer control objects. This representation allows for better accessibility for screen readers [17]. In the plain-text representation, each component in the HTML DOM (Document Object Model) structure is presented to the user with the appropriate title. For example, a hypertext link is titled as Link, which helps the user to identify the HTML element. Both WAB and WebbIE present web forms clearly by inserting appropriate element names before the HTML elements. For example, the text 'combobox' is inserted right before the HTML element combobox. WebbIE supports frame navigation to some extent. However, accessibility to embedded multimedia content and JavaScript is minimal and depends on the abilities of the screen reader. All the information inherent to the spatial layout of the web page is lost, because of the transformation of web pages to linear text format.

ChromeVox conveys the page overview to the user in a different way. Each page can be perceived as groups, objects, sentences, words and characters, forming a hierarchy. That is, a group contains many objects, an object contains many sentences and so on [31]. The user will be able to navigate between different groups and can zoom into objects in the selected group. From objects the user can zoom into sentences and words. Here, even though the user is not aware of the page layout, he will be able to logically organise things in his mind based on the categories and the contents he gets after zooming from different categories.

Embedded multimedia content in web pages is mostly inaccessible using screen readers. The web browser developed by H. Miyashita et al. [25] claims to provide features to make multimedia contents like videos accessible using screen readers. It was reported that by searching sound and media objects in the web page, the browser implements a user interface for each media object. Through the controls in the user interface, the audio can be controlled. Also the

speed of voice output can be controlled, which helps the users to adjust the audio speed to their actual level. The browser offers the feature to add synchronised audio descriptions in text format along with the metadata of the multimedia file. This description will be played at specified times. By making use of the external metadata of different multimedia content like dynamic HTML and Adobe Flash, the browser can provide an alternative user interface. This user interface claims to give greater accessibility to multimedia content and also notifies the user about important events with respect to these contents, which is impossible in normal cases. This special feature of handling multimedia content can be incorporated in other sophisticated browsers for vision-impaired persons, to offer more accessibility.

Chapter 3

Accessibility Problems with Websites

According to the World Health Organisation (WHO) 285 million people have some kind of visual impairment and out of that number 39 million people are blind [46]. Blind and visually impaired people were mostly dependent on their family members or organisations for the blind for information access. This hindered the user's independence and access to the latest information. With the advent of on-line media, visually impaired persons who wanted to be independent, were able to access information in a flexible way. However the poor accessibility of websites brought frustrations and in many cases the visually impaired persons require help from sighted people. A study of 50 popular websites conducted by T. Sullivan and R. Matson yielded the result that, around 82% of the websites considered had some accessibility problems which made them partly accessible or inaccessible [35]. In the survey conducted by WebAIM in the year 2012, almost 65% of the participants had the opinion that websites have become less accessible or there is not much improvement [44]. 75% of the people participating in a survey conducted in 2010, had the opinion that better accessible websites will have more impact than better assistive technology [43]. Flash-based websites and shopping websites were at the top in the list of avoided websites [42]. A detailed study of existing web accessibility problems is necessary to find out feasible ways to build better accessible websites.

Much research exists to identify the accessibility problems with websites. Many studies point out that non-standard page layout and embedded graphical elements make web pages more and more complex and inaccessible [30, 32]. Images often appear without alternate text in many websites. These images does not convey any information to blind users. Dynamic

HTML, especially JavaScript and Flash animation makes web content inaccessible [30, 17]. Around 70% of the participants in a WebAIM survey responded that Flash content is inaccessible and that they avoid using websites with Flash content [42]. Difficulties in navigating tabular data structures and navigation links with graphics attached not serving their purpose was discussed in a paper by C. Power and H. Jürgensen. The paper suggested to avoid the use of tables for storing layout information [30]. Since the Braille display and auditory outputs present text line by line, getting a page overview, understanding the page layout and the relation between different regions, and identifying navigation links are challenges for the blind [32]. With embedded multimedia content, the sound of auditory output used is masked and the user loses control of the page [25].

In this chapter, major web accessibility problems are identified and discussed in detail. The problems are defined based on the screen reader interpretation of the web content. Screen readers are chosen for this purpose since they are the most popular access tool, adopted by a majority of blind people. The web content interpretation by two screen readers, NVDA and the on-line screen reader “WebAnywhere” [3], is inspected to find the accessibility problems. Survey results of WebAIM show that almost 80% of the people with visual impairment in North America use JAWS for screen reading [42]. At the same time, a study conducted among visually impaired people in Australia by K. Williamson and D. Schauder revealed that a majority of the participants finds adaptive hardware and software expensive to afford [47]. The case should not be different with people in developing countries. Keeping this thought in mind, free screen reading software like NVDA and WebAnywhere was chosen for experimentation purposes. In a study conducted to compare the methods of assessing web page accessibility, the combination of monitor and screen reader was found successful and effective in identifying accessibility problems compared to automated web accessibility tools [23]. The same method is adopted here to identify web accessibility problems. Referring to the WebAIM articles to evaluate web accessibility, NVDA was used with Mozilla Firefox for better compatibility [41]. WebAnywhere is used with Google Chrome, since WebAnywhere is an on-line screen reader, which needs no installation to the local system. After learning the techniques to use screen readers efficiently from blind people, we have conducted the experiments. Our proficiency in using screen readers is in a beginner’s level. One can go through the WebAIM article [41]

and the website of the WebAnywhere screen reader [18] to get familiarized with using the respective screen readers.

3.1 General Accessibility Problems with Websites

This section will discuss the general accessibility problems with websites. For ease of discussion, problems will be illustrated under four different categories. In order to limit the size of the document, only a few examples which can convey the relevant accessibility problems will be considered under each category.

3.1.1 Inaccessible Dynamic Content

Dynamic content created using Flash, JavaScript, CSS (Cascading Style Sheets) etc. are used in most of the websites nowadays to provide a good visual presentation. These dynamic contents are inaccessible to visually disabled people, since screen readers are not capable of handling it. Many papers like [30, 32] have mentioned contents rendered using Flash and JavaScript, graphic links etc. as a threat to accessibility. Most of the content is created considering users who are capable of using mouse driven visually-oriented interfaces [17]. The inability to use such interfaces adds to the inaccessibility in the case of visually disabled people. In the following section a few examples of dynamic content using Flash, JavaScript and CSS are examined from the perspective of a sighted and a visually disabled user, to reveal the accessibility problems linked with such contents. Accessibility problems revealed at the end of experiment are discussed in the inference section. Flash and HTML 5 websites chosen to illustrate the problem are from a eBizMBA article listing the top 10 best Flash and HTML 5 websites [6, 7].

Example 1: The Disney new fantasy land website is a flash based website with a lot of animation. One can follow the URL <http://disneyworld.disney.go.com/new-fantasyland> to access it.

Sighted user: On mouse hover on the banner, which has the text, “click to reveal the story”, the user can understand that it is clickable. And on clicking on it, animation starts giving a rich visual experience. On mouse hover on the banners with cartoon character images, the user can find that they are also clickable. On click, they will lead to pages with more information



Figure 3.1: Screen shot of Disney New FantasyLand website

about the cartoon characters. The text “about new fantasyland”, “purchase tickets” and “book your vacation” can be understood as clickable ones on mouse hover. On click, they will lead to respective web pages with more information. The text “SHARE” at the top right corner will display the text “face book” and “twitter” on mouse hover, and on clicking on those, will connect to face book and twitter respectively.

Screen reader interpretation:

WebAnywhere: Once the page is loaded, it reads out, “New fanatasy land Walt Disney World revealed, for new fantasy land experience. Default visibility hidden. End of panel”. No buttons or links are identified by normal reading or by using shortcut keys.

NVDA: All the graphic buttons which appear as banners with images are read as just buttons, no alternate text is read out. Buttons “about new fantasy land”, “purchase tickets” etc. are read as button along with the text. On invoking the SHARE button using the enter key, nothing is read out. All graphic buttons can be invoked using the enter key which leads to animation or associated web pages. Nothing is read out on mouse hover over the graphic buttons. Only when the screen reader reads URL information, the landing page is known to the user, not from reading the headings on the page.

Example 2: We-choose-the-moon, is an informative website showing different stages involved before Appolo 11 landed on the moon. It is an interactive website created using Flash and can be accessed using the URL <http://wechoosethemoon.org>.



Figure 3.2: Screen shot of We Choose The Moon website

Sighted user: While the page is loading, the overview of the page is given through dynamic text, which fades after a few seconds. The overview contains the purpose of the website, how to proceed through animations to view different stages and how to use different control buttons. Once the page is loaded, audio explaining each stage is played. The user can click on the “Launch” button and the animation is played showing the next stage and so on.

Screen reader interpretation:

WebAnywhere: WebAnywhere will start reading the web page after few seconds. By that time, some of the dynamic text has faded. It will start reading the heading appearing on the screen. Even before the page is completely loaded, the screen reader will start reading the links one by one, along with the text associated with the link. Some are read just as link. By the time, the screen reader has read a few links, the audio of the animation will start playing, which will mask the sound of the screen reader and the website will become completely inaccessible.

NVDA: The user experience with NVDA is the same as with WebAnywhere in this case. However, NVDA reads out “clickable button” and “clickable link” without reading any text

associated with it. This information does not add to accessibility, since the user will not be able to understand the purpose of button. The user cannot navigate through or access buttons using the shortcut keys. The text on the button is not read out on mouse hover either.

Example 3: The-expressive-web-beta expresses the potential of HTML 5 and CSS 3. It contains tutorials and many sample code snippets to learn HTML 5 and CSS 3. JavaScript, CSS 3 and HTML 5 are used in this website. It can be accessed using the URL <http://beta.theexpressiveweb.com/>

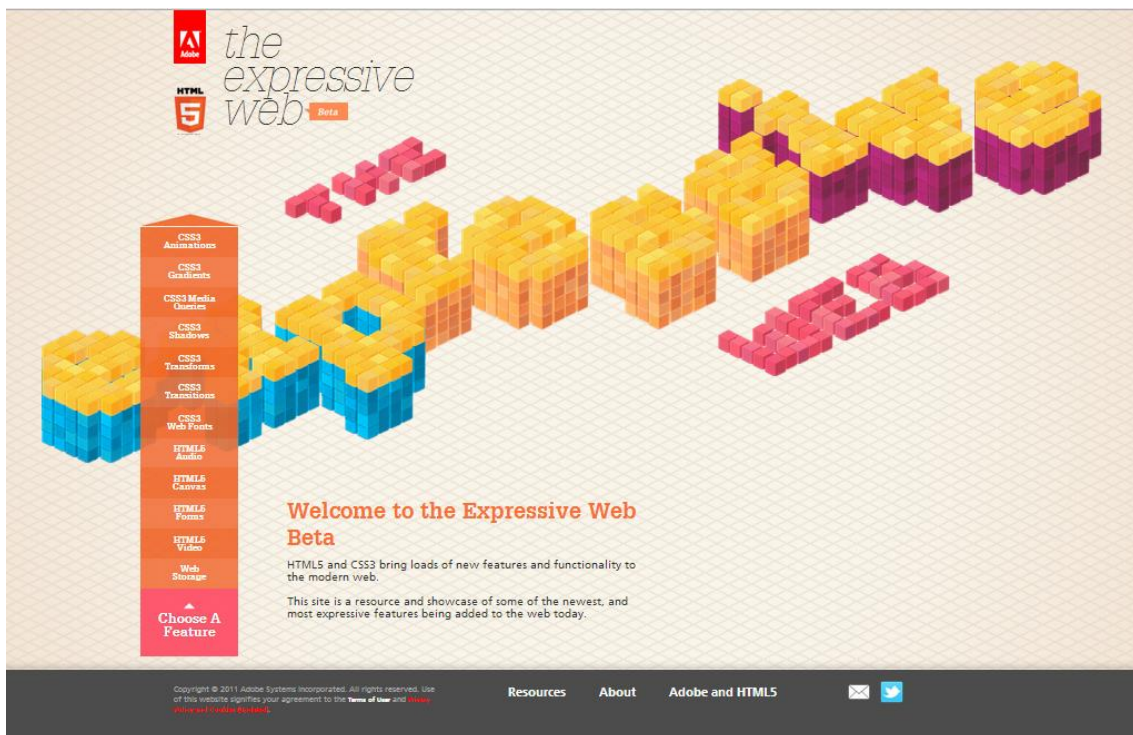


Figure 3.3: Screen shot of Expressive web beta website

Sighted user: A sighted user can enjoy the rich visual effects of the CSS animation on the page. Also on moving the mouse, he can identify all the clickable links. On click of each link on the left pane, animation associated with the particular content is played. Also textual information is shown on the page.

Screen reader interpretation:

WebAnywhere: WebAnywhere was not able to display the page or read any content.

NVDA: All the links in the left pane are read as clickable links along with the text. The main content is read out after reading all the links. Once the user invokes any clickable link using the enter key, the user will not get any notification about what happened to the page. On maneuver using the shortcut keys, content will be read out. But the content which appears in the top text box is inaccessible using shortcut keys, since the text is not available in the HTML markup of the page. The email link and the twitter link are graphic links with associated images. Since they do not have any alternate text, the entire text given as value for href is read out.

Example 4: Flashing dynamic content is often seen in news web pages and web pages displaying stock values. The example considered here is from The Wall Street Journal which can be accessed using the URL <http://online.wsj.com/home-page?mg=inert-wsj>

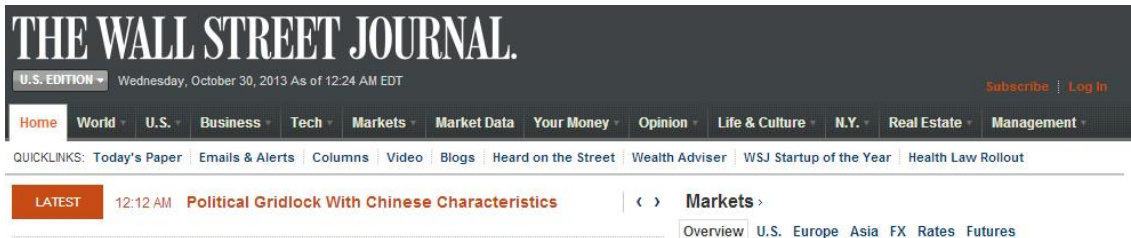


Figure 3.4: Screen shot of flashing dynamic content in Wall Street Journal website

Sighted user: A sighted user can recognise that the text displayed in section “latest”, is a flashing content. It keeps changing every few seconds. He can use the arrow buttons on the sides to scroll through the content.

Screen reader interpretation:

WebAnywhere: It will display the flashing dynamic content as static content. The text which was displayed on the web page when the page was fully loaded will only be read. Other text in the list is ignored.

NVDA: NVDA considers this content as list of text, and reads out all the text in the list at the point of time. The new lines which get added to the list later will be ignored.

Example 5: A slide show using JavaScript or JQuery can be seen in many entertainment, e-commerce and other websites. A slide show from Webby Awards (<http://www.webbyawards.com/index.php>: accessed on 30/01/2013) is considered here.



Figure 3.5: Screen shot of image slide show from Webby Awards website

Sighted user: A sighted user can recognise the content as a slide show having three images. The user can use the circular buttons on the image to maneuver. The user can also read the dynamic text appearing along with each image.

Screen reader interpretation:

WebAnywhere: It shows all the three images in the slide show as static images, one below the other, along with the associated text below it. It reads the text below each image, but does not convey any information about the image or the presence of the image.

NVDA: It reads out “link 1 link 2 link 3”, but these links will not be invoked using the enter key. It also reads the text associated with the image on focus. NVDA does not convey any information about the presence of the image.

Inference: Dynamic contents created using Flash, JavaScript, and CSS (Cascading Style Sheets) create a rich visual experience for a sighted person. However, these contents are mostly inaccessible for the visually-impaired persons. Most of the graphic buttons do not have any alternate text associated with them. So the user will be unaware of the purpose of the button. Most of these buttons cannot be accessed or navigated using shortcut keys. Some screen readers cannot even read the text associated with hyperlinks in such websites. In some cases the audio played along with the animation masks the sound of the screen reader, which makes the web page completely inaccessible even though there are accessible elements. In some websites on

click of a button or hyperlink, the user will not get any notification of the page event or the page content being updated. On maneuver using the shortcut keys, some contents will be read out, but there are some contents which are inaccessible. Flashing dynamic text often appearing on news websites is only partly accessible. No indication is given to the user that new text or content will be added to the existing list at a later point in time. In case of slide shows using JavaScript or JQuery, a blind person is not able to realise the presence of an image, since there is no alternate text. Some screen readers read out the word “link” indicating the presence of hyperlink associated with the image, but these hyperlinks cannot be invoked using the enter key. In essence, the screen reader is just confusing the user in its attempt to provide accessibility in this case. After analysing the screen reader interpretations for the above examples, it is clear that different screen readers handle dynamic content in different ways, but neither of them is successful in providing a fair amount of accessibility of dynamic contents.

3.1.2 Confusing Page Layout

When HTML evolved from its basic version, websites started using complex page layout for presenting data. These include tables, frames, graphic elements and elements which support dynamic contents. As mentioned in many papers like [30, 32] complex page layout causes many accessibility issues including navigation difficulties for vision-impaired persons. Tables are still used in many websites to store layout information other than relational data. In such cases screen readers confuse the user by interpreting tables differently. One reason behind is that semantic and syntactic information is lost when a table is linearized for a screen reader [48, 34]. Even with a table displaying relational data, orientation is difficult for a blind user within the table to gain information in the particular context [30]. Several examples which cover the accessibility issues related to page layout are illustrated below. The observed accessibility issues and causes are summarized in the inference section.

Example 1: Screen readers perform screen reading based on the HTML mark-up of the web page. In most of the web pages which use CSS, JavaScript and complex page layout, the order of contents in the HTML markup will be different from that of visual display of the web page. So the screen reader will end up delivering contents in a different order compared to

the visual page layout. To explain this, the web page of Wall street journal (<http://online.wsj.com/home-page> : effective 01/11/2013 at 12:15 am) is considered. The web page has a complex page layout using many frames, JavaScript, HTML div elements etc. The web page also needs a vertical scroll to read the entire contents in the web page.

The screenshot shows the Wall Street Journal homepage with the following elements:

- Header:** WSJ logo, navigation links (Live, MarketWatch, Barrows, Portfolio, S&P, The Drops, More), and a search bar.
- Main Title:** THE WALL STREET JOURNAL. U.S. EDITION. Friday, November 1, 2013 As of 12:17 AM EDT.
- Navigation Bar:** Home, World, U.S., Business, Tech, Markets, Market Data, Your Money, Opinion, Life & Culture, N.Y., Real Estate, Management.
- Quicklinks:** Today's Paper, Emails & Alerts, Columns, Video, Blogs, Heard on the Street, Wealth Adviser, WSJ Startup of the Year, Health Law Rollout.
- LATEST:** 12:15 AM Number Portability an Opportunity for Dubai's Du.
- Markets:** Overview, U.S., Europe, Asia, FX Rates, Futures. Table showing DJIA, Nasdaq, FTSE 100, Nikkei 225, Crude Oil, and Gold prices.
- Opinion:** Noonan: 'Politics Is a Feeling', R. James Woolsey: Why Spying on Merkel Is So Damaging, Strassel: Driving Dick Durbin, Henninger: Progressive Government Fails.
- What's News:** FAA: Devices Can Be Used at All Times, CFTC Backs Off, Lacking Funding, Europe Sparks Growth Fears.
- Warning Signs:** Cuts in State Aid Leave Cities Reeling.
- U.S. & World:** Court Order Lets NYPD Continue 'Stop-and-Frisk'.
- Don't Miss:** Mosberg Reviews the iPad Air, Curved Smartphone Paves Way for Flexible Devices, Holders Interrupt Obama During Health Insurance Speech.
- Map:** Nuclear-related sites by state.

Figure 3.6: Screen shot of the main page of Wall Street Journal website

Sighted User: A sighted user will read the web page title and may have a look at the navigation bar. He may then continue reading the contents horizontally and later proceed vertically

by scrolling through the web page. He gains much information from the page layout. The page needs vertical or horizontal scroll, which are the main headlines etc. The table showing market values also catches his attention, with the graph and text contrast.

Screen reader interpretation:

WebAnywhere: It loaded the web page in the panel, but did not read anything. When the shortcut key to read the screen from the beginning of the page is used, it read out the contents of the WebAnywhere home page.

NVDA: The screen reader starts reading the web page content by reading the page title. It then reads out all the links in the navigation bar. It reads all the news in the section named “Latest”. It then reads the contents and hyper-links associated with headings “Islamic Rebels”, “As chritie campaigns”, “J.P. Morgan regulators”, “GOP blocks votes”. It proceeds reading the contents under “What’s News” section, contents under headings “Warning signs” and “U.S. & world”. After that it continues reading contents below it till the contents just above the footer section including the advertisements. Later, it focuses the contents on the top of the page, which was not read earlier, like, contents under “Markets” section, “Opinion” section and proceeds by reading contents vertically below it. The screen reader does not read contents according to the page layout, but according to the HTML markup. So most of the times the main content is read after reading much less important content.

Example 2: Many websites use the HTML table structure to store page layout, rather than storing data. In such cases all the columns and rows will not have useful data; some cells will have even a blank space for better alignment. This type of page layout often creates confusion in screen reader users. Screen readers will recognise the element as table and start reading row by row. In a row there will be non-uniformity like: some columns may have blank headings; the amount of data in each cell will be different and so on. This can make the content inaccessible for screen reader users. To illustrate this scenario, flight search results from the website FlightNetwork (<http://www.flightnetwork.com/>) is chosen.

Sighted User: Seeing the search result table, a sighted user can understand that ten results are displayed in the page and there are a few more pages with results. He is able to get the indication of two flights from the two entries under the arrival and departure column. Even if the row contains more than one data entry under some column, the user will not be confused.

Change Your Search

From: Toronto, ON, Canada - Pearson International
 To: Mumbai, India - Chhatrapati Shivaji(BOM)
 Leave: 11/02/2013 Return: 11/05/2013
 Type: Round Trip Class: Economy
 Adult: Child: (2-11yrs) Infant: (0-23m)
 Additional Options: Nonstop only
 Select a recent search

SEARCH AGAIN

Flight Search Results 10 results per page Previous Page 1 of 3 Next

Toronto, ON, Canada to Mumbai, India
 11/02/2013 to 11/05/2013 / 1 passenger

Sort By: Price (CAD) Airline Departure Arrive Duration Stops

\$1272	UNLIMITED PDP	Air Canada / Air India	6:30am	5:30pm	25h 30m	1	Confirm
Incl. Taxes & Fees		Flight Details	9:30pm	12:19pm	25h 19m	2	
		Track this Flight					
\$1272	UNLIMITED PDP	Air Canada / Air India	6:30am	5:30pm	25h 30m	1	Confirm
Incl. Taxes & Fees		Flight Details	1:30am	10:38pm	31h 38m	1	
		Track this Flight					

Depart: Toronto, ON - Pearson International (YYZ) to Mumbai - Chhatrapati Shivaji (BOM)

Air Canada Flight 7468	Departs: Sat Nov 02 6:30am	Toronto, ON - Pearson International (YYZ)	UNLIMITED PRICE DROP PROTECTION You get a Credit (unlimited) if the price of this flight drops after you buy!
	Arrives: Sat Nov 02 8:01am	Newark, NJ - Newark Liberty International (EWR)	
Flight Duration: 1h 31m Connection Time: 9h 24m			
Operated by: AIR CANADA EXPRESS - SKY REGIONAL			
Air India Flight 144	Departs: Sat Nov 02 5:25pm	Newark, NJ - Newark Liberty International (EWR)	
	Arrives: Sun Nov 03 5:30pm	Mumbai - Chhatrapati Shivaji (BOM)	
Flight Duration: 14h 35m			

Return: Mumbai - Chhatrapati Shivaji (BOM) to Toronto, ON - Pearson International (YYZ)

Air India Flight 191	Departs: Tue Nov 05 1:30am	Mumbai - Chhatrapati Shivaji (BOM)
	Arrives: Tue Nov 05 7:15am	Newark, NJ - Newark Liberty International (EWR)
Flight Duration: 16h 15m Connection Time: 13h 50m		
Air Canada Flight 7479	Departs: Tue Nov 05 9:05pm	Newark, NJ - Newark Liberty International (EWR)
	Arrives: Tue Nov 05 10:38pm	Toronto, ON - Pearson International (YYZ)
Flight Duration: 1h 33m		
Operated by: AIR CANADA EXPRESS - SKY REGIONAL		

Price (CAD) Per Person including taxes, fees and surcharges **\$1272**

\$1272	UNLIMITED PDP	Air Canada / Air India	9:00pm	5:30pm	35h 00m	1	Confirm
Incl. Taxes & Fees		Flight Details	9:30pm	12:19pm	25h 19m	2	
		Track this Flight					
\$1272	UNLIMITED PDP	Air Canada / Air India	4:50pm	5:30pm	39h 10m	1	Confirm
Incl. Taxes & Fees		Flight Details	1:30am	12:23pm	21h 23m	1	
		Track this Flight					

NOTE: Prices quoted are per person in Canadian dollars and include taxes, fees and surcharges however may exclude baggage fees.
[select all](#) | [clear](#)

Figure 3.7: Screen shot showing flight search results from FlightNetwork website

Also he can expand the flight details link to get complete flight information.

Screen reader interpretation:

WebAnywhere: This screen reader was not able to load the flight search results section in the web page.

NVDA: It conveys that the table has ninety two rows and nine columns; even though only ten rows are displayed in a page and only eight columns can be seen visually. Column names are read out wherever they are not blank and for a blank space it reads the column number. Before reading the entries in each row, it reads out a row having only one entry – sort by. And then it proceeds reading the actual row as row two. NVDA uses the down arrow key to traverse through cells. In cells having multiple entries like Airlines column, by moving in the cell using the down arrow, only one entry will be read. This gives the effect of having multiple cells in place of one cell. Also on clicking the hyperlink of flight details, the expanded portion is not read readily. Only after reading the current row completely, the contents in the expanded portion will be read, while the user will be expecting the flight details to be read. The expanded portion is read as table with seven rows and five columns. At this point, where the screen reader is trying to convey the nested table, a visually disabled person will surely have lost the track.

Example 3: Sometimes HTML tables are not used to display tabular data structure. Tabular data can be displayed using unordered lists, list items, HTML div elements etc. In such cases screen readers will not be able to convey to the user information about the presence of tabular data. The example considered here is taken from the Wall Street Journal website (<http://online.wsj.com/home-page> : effective 01/11/2013 at 12:15 am), markets section.

Sighted User: The sighted user can very well recognise that the data is in table form. The presence of a graph can also be recognised and the user will be able to understand the contents and indication using color contrast.

Screen reader interpretation:

WebAnywhere: WebAnywhere failed to load and read the website.

NVDA: It reads the hyperlinks, overview, U.S etc. as items in a list. It also reads the column header and row contents as items in a list containing seven items. One entire row is read as one item in the list. Also the screen reader gives no clue about the presence of the graph and reads the x and y axis of the graph as just independent numbers.



Figure 3.8: Screen shot showing tabular data without HTML table from Wall Street Journal website

Example 4: Many web pages use frames for alignment purposes. In most of the instances the visibility of frames will be hidden. Sometimes frames are even used to store values of hyperlinks, which can be used by JavaScript functions. In such cases, frames will not be visible for a sighted user, but the screen reader will recognise the presence and read the values stored in frames, because of its presence in the HTML file. This creates confusion and could be annoying to the user, since the hyperlink values will be lengthier and even contain special characters. The left hand pane of the webby awards (<http://www.webbyawards.com/index.php>: accessed on 30/01/2013) web page displaying links to various social networking sites is taken as an example to show the use of frames in a web page.

Sighted User: The sighted user will understand that the “Follow Us” section contains icons and hyperlinks or buttons to access different social networking websites like Twitter, Facebook etc. He is not aware of the use of frames here, since frames are invisible. Actually, each hyperlink or the button to access a website is enclosed in a frame. In this web page, at many places frames are used to store hyperlink values. In those cases also a sighted user is not aware of its presence and the presence does not cause any difficulty in reading the contents. For him, the neat alignment provides more readability.

Screen reader interpretation:

WebAnywhere: WebAnywhere reads the heading “Follow Us” and after that it reads the alternate text provided for twitter “follow” button. It then skips the other contents and start reading the subscribe section. This is because WebAnywhere is not equipped to handle frames.

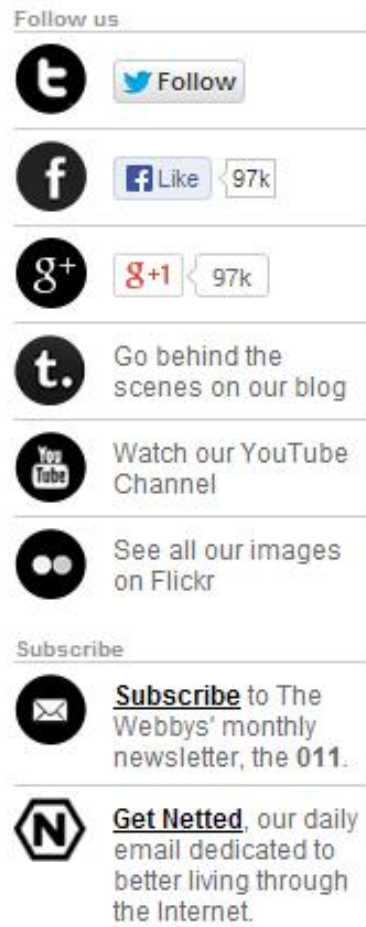


Figure 3.9: Screen shot showing the use of frames to align hyperlinks from Webbyawards website

Frames which were used to store hyperlink values were also not identified by WebAnywhere. In essence, users of the WebAnywhere screen reader are not affected by the presence of frames.

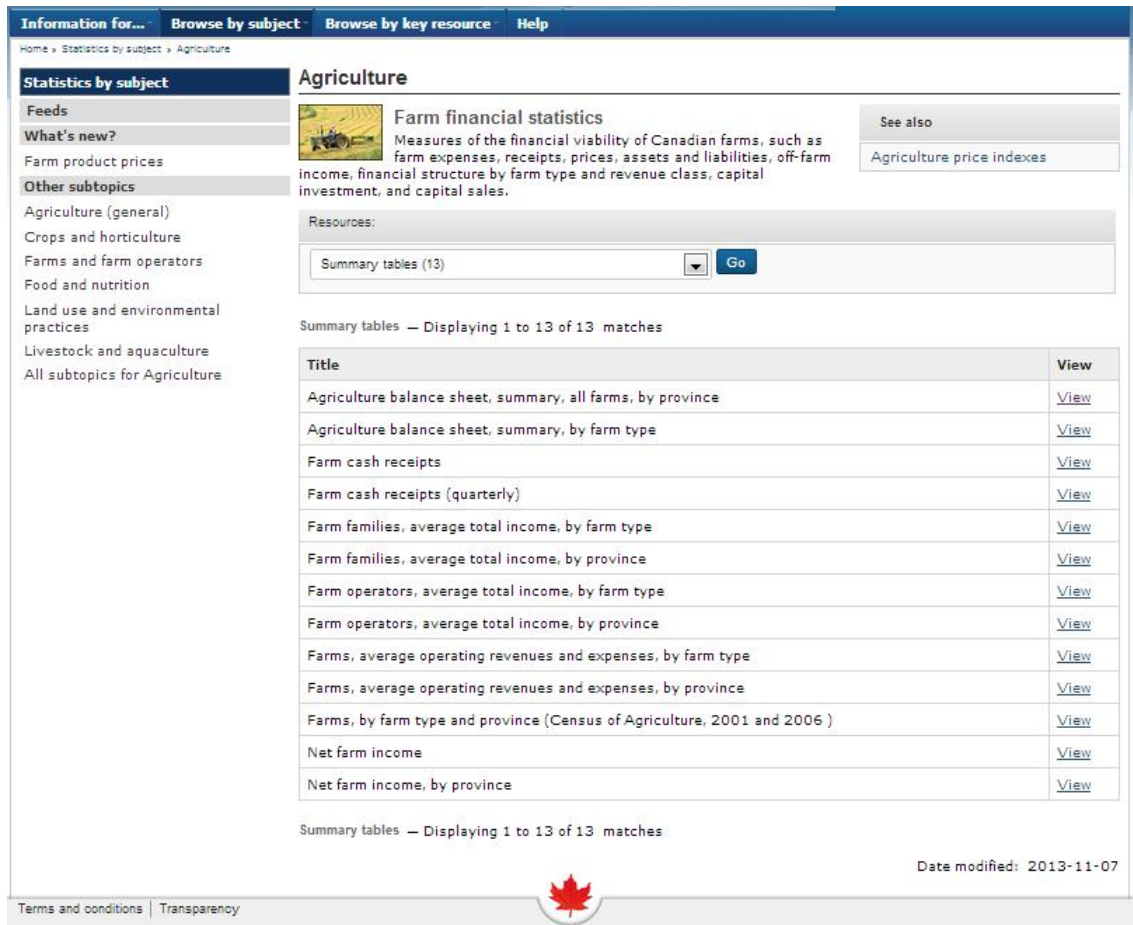
NVDA: It starts by reading the heading “Follow Us”. Then it conveys the presence of the twitter icon by reading “link twitter”. It then reads “iframe link Follow out of iframe blank” to convey the presence of a follow link. Later it continues conveying the presence of face book, google plus etc. in the same fashion. Wherever it encounters a frame, it conveys the presence of frame to the user. In some cases, there will be a blank space inside a frame to adjust the alignment. NVDA reads out that blank space also, which is quite unnecessary. Reading out the lengthy hyperlink values stored in invisible frames is confusing to the user, since in many cases they will not be correlated with the contents read previously.

Example 5: A tabular data structure is used in many websites to organise related data. It is easy to deduce useful information from such tables. Tables can be seen as a means to provide access to huge amounts of information utilizing little space. But in many cases it is tedious to analyse these table, and maneuvering through these table is also a challenge. Accessibility of tables is a problem even today. Many tables are accessible in the sense that a screen reader can read them. But most of the times it is difficult for blind users to draw useful information or to find the required data. To convey this difficulty a table showing the farm financial statistics from the statistics Canada website (<http://www5.statcan.gc.ca/subject-sujet/result-resultat.action?pid=920&id=3953&lang=eng&type=CST&pageNum=1&more=0> : effective 31/10/2013) is considered.

Sighted User: The sighted user can recognise that the table shown is a summary table. And to get details one should click on the View link and refer to the underlying table which will be displayed in a new web page. The summary table is ultimately a gateway to a collection of tables. Even for the sighted user it is difficult to draw a conclusion about the data from such a table. However, if the user is searching for particular data, they can be found without much hassle.

Screen reader interpretation:

WebAnywhere: WebAnywhere reads the title of the table. It starts reading the table by reading the column headings. Later it starts reading out the contents row by row. It also conveys the presence of hyperlink “view”. By listening to the voice translation of this table, a blind



The screenshot shows the Statistics Canada website interface. At the top, there is a navigation bar with links for "Information for...", "Browse by subject", "Browse by key resource", and "Help". Below this, the breadcrumb trail reads "Home > Statistics by subject > Agriculture".

The main content area is titled "Agriculture" and features a sidebar on the left with "Statistics by subject" including "Feeds", "What's new?", "Farm product prices", "Other subtopics", and "All subtopics for Agriculture". The main content area includes a "Farm financial statistics" section with a description: "Measures of the financial viability of Canadian farms, such as farm expenses, receipts, prices, assets and liabilities, off-farm income, financial structure by farm type and revenue class, capital investment, and capital sales." Below this is a "Resources:" section with a search box containing "Summary tables (13)" and a "Go" button.

A table titled "Summary tables — Displaying 1 to 13 of 13 matches" is displayed. The table has two columns: "Title" and "View". The "View" column contains hyperlinks for each row.

Title	View
Agriculture balance sheet, summary, all farms, by province	View
Agriculture balance sheet, summary, by farm type	View
Farm cash receipts	View
Farm cash receipts (quarterly)	View
Farm families, average total income, by farm type	View
Farm families, average total income, by province	View
Farm operators, average total income, by farm type	View
Farm operators, average total income, by province	View
Farms, average operating revenues and expenses, by farm type	View
Farms, average operating revenues and expenses, by province	View
Farms, by farm type and province (Census of Agriculture, 2001 and 2006)	View
Net farm income	View
Net farm income, by province	View

Below the table, it says "Summary tables — Displaying 1 to 13 of 13 matches". At the bottom right, it says "Date modified: 2013-11-07". The footer includes "Terms and conditions | Transparency" and a red maple leaf logo.

Figure 3.10: Screen shot showing a table containing hyperlinks as column values from the Statistics Canada website

user will not be able to infer any useful information. He has to check the contents under the hyperlink “view” to understand the details. Clicking on the view link, the focus will be moved to new page. Essentially one should go through an entire table led by the view hyperlinks, to get the complete information. Moving back and forth between pages is extremely difficult for a blind user and it is even more difficult to trace back the row which led to the new page. This kind of tables will be inaccessible to blind users even though the screen reader can read the contents.

NVDA: The experience of an NVDA user will be similar to that of a WebAnywhere user. The only difference is that, in the beginning, NVDA conveys the size of the table by reading out the number of rows and columns. Also before reading the cell content, it reads out the name of the column pertaining to the data being read.

Inference: Complex page layouts can cause many accessibility problems for a blind user. Often in web pages using CSS, JavaScript etc., a screen reader will deliver contents in an order different from the visual page layout. This is because the order of HTML elements in the HTML markup will be different from that of the visual page layout. It is not a big accessibility issue if the screen reader can read the entire contents. However, many times the main content will be delivered later to the user. This may mislead the user to assume that they have landed on the wrong page. Also the user may not be able to recognise the content as the main content. Rather than an accessibility issue, this can be seen as a major usability issue. Using tables to store page layout is considered to be a serious accessibility issue as well as bad web design. After exploring many web pages for experimentation purposes, it is observed that, most of the popular websites avoid this kind of page design. However, there are quite a few websites which still use tables for page layout. When a table is used for page layout, it may contain data as well as alignment information. This alignment information confuses the user, since he will be expecting tabular data when a screen reader conveys the presence of a table. Also the cells in a table contain multiple entries instead of one, and the tables will be nested. A table and its contents are no longer accessible once such situations are encountered.

Some web pages display a tabular data structure, without using the HTML table element. In such cases the presence of table is not conveyed to the blind user, since the table element does not exist. The user will take data in each row as independent content and will fail to correlate

them. Such content is completely inaccessible even though the screen reader can read it. Also charts and graphs are presented without alternate text, which is inaccessible to the vision-impaired persons. The use of frames in a web page is often annoying to a screen reader user. Frames are used for alignment purposes as well as for storing values and dynamic alignment using JavaScript. Even though the visibility of frames may be set to false, a screen reader will convey the presence whenever it encounters a frame. Sometimes conveying the presence of a frame is irrelevant and many times it is annoying since the screen reader will read the lengthy hyperlink values stored in it. Only sophisticated screen readers can handle frames properly. Some screen readers like WebAnywhere are not able to read the contents inside the frame. HTML tables containing HTML elements like hyperlinks as column values are also a challenge to accessibility. Accessing the hyperlinks in each row for details and returning back to the original position is extremely difficult for blind users. They will not be able to draw conclusions from the data in the table. HTML elements like frames, tables, forms without appropriate labels or titles also confuse screen reader users. Exploring many older popular websites, it is observed that many page design issues which cause accessibility problems previously are now avoided. However, adopting new technologies for page design are creating new accessibility issues. Accessibility issues should be monitored continuously to develop better accessible websites.

3.1.3 Complicated Navigation

Navigation difficulties are one of the biggest challenges vision-impaired people faces while browsing through web content. Often navigation menus are inaccessible to screen readers because of scripting and the use of style sheets. Screen readers deliver contents after linearizing it. A lot of the semantic information is lost while linearizing the content. As observed in [21], it is difficult to form a proper mental model of the navigation space with the linearized content. Tables without proper title and summary, frames without proper title, hyperlinks without appropriate link text, mouse specific navigation structures also constitute navigation difficulties as pointed out by [20, 19]. Appropriate examples from popular websites are chosen to portray navigation difficulties in the sections below.

Example 1: Navigation structures like menus are indispensable elements in a website.

These structures link different web pages in a website as well as different sections within a web page. Often web developers put a lot of creativity into making the navigation structure more appealing. However, this affects accessibility of such structures adversely. Also we can observe that diverse websites implement navigation structures differently. Some navigation structure will expand on mouse hover while some on mouse click or enter key. Many scripts and style sheets are used to achieve the striking appearances. The navigation menu from the website <http://www.windmobile.ca> is considered to explain the navigation difficulties.

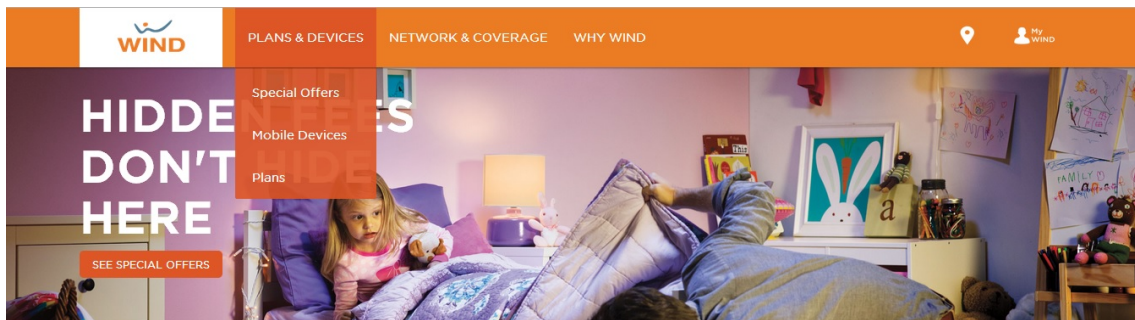


Figure 3.11: Screen shot showing expandable menu on hover from windmobile.ca website

Sighted User: For a sighted user the menu is quite appealing. He can identify that the navigation menu has three main links which connect to different sections. On mouse hover, the options available under each category will be shown as in the figure. He can select the option based on his need. The user also has the flexibility to check all the subcategories under each main category before choosing the option.

Screen reader interpretation:

WebAnywhere: WebAnywhere failed to load the web page.

NVDA: NVDA reads the navigation menu as a list containing three items. And it mentions that each item is a hyperlink. It does not give any clue of the hyperlinks residing under each main category. Even if the user selects a category, for example plans and devices in this case, the submenu is not read out. The only way by which a user can navigate through a submenu is to select the category and use the down arrow to go through the submenu of it. Since the blind user is not aware of the existence of a submenu, he will not try to explore the options further using a down arrow. We can observe that this navigation menu is quite inaccessible using a

screen reader. The menu is completely dependent on mouse hover.

Example 2: The case below is another example of a complicated navigation menu structure. The example is taken from the CNN money website (<http://money.cnn.com/news/> : accessed on 13/11/2013)



Figure 3.12: Screen shot showing 2-tier navigation menu from CNNMoney website

Sighted User: A sighted user can identify that the active web page is “Business News” seeing the navigation menu. Also he can identify that the submenu displayed is the submenu under “Business news”.

Screen reader interpretation:

WebAnywhere : WebAnywhere was not able to perform screen reading.

NVDA : NVDA reads the main navigation menu as one list. And the submenu under Business News as another list. It fails to convey that the displayed submenu belongs to the main category Business News.

Example 3: This is another example for inaccessible and complicated navigation structure. The navigation menu contains a lot of information in this case. The example is taken from the CNN money website (<http://money.cnn.com/news/> : accessed on 13/11/2013)

Sighted User : For a sighted user, on mouse hover the submenu under the main category is expanded. The submenu has more details than just links. It portrays the summary of the page along with the hyperlinks.

Screen reader interpretation:

WebAnywhere : WebAnywhere failed to perform any screen reading in this case.

NVDA: For NVDA the submenu is not accessible. On selecting any item in the list of main categories, the web page corresponding to the category was opened, not the submenu.

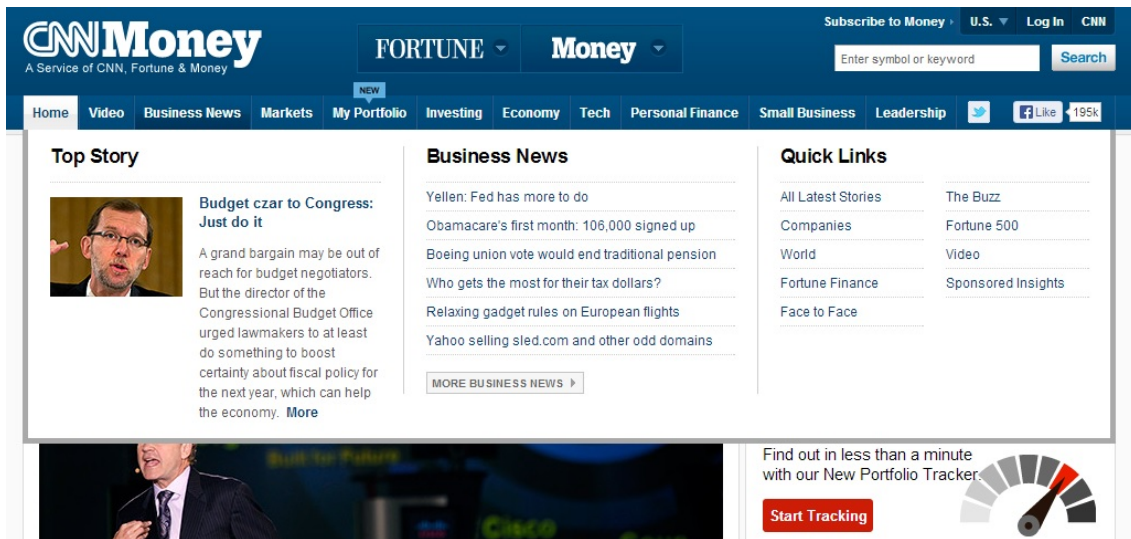


Figure 3.13: Screen shot showing complicated navigation menu from CNNMoney website

In the case of the CNN money website, a screen reader user will not be able to access the submenu. Even though he selects a hyperlink in the main category, he will be redirected to the corresponding web page, where the submenu will be read out as a separate list of hyperlinks.

Example 4: Screen readers offer minimal table navigation. Layout tables and data tables often create confusion among screen reader users if data tables are not given titles. To illustrate the navigation limitations with tables, we are considering the flight search results from the flight network website (<http://www.flightnetwork.com> : accessed on 13/11/2013).

Sighted user : A sighted user can find two main tables in the web page. One table at the top, showing the summary of the search results, and another one with details of the search results. From the top table, he can easily understand the lowest price and which option gives the lowest price. To find out this, he might have to look at the value highlighted in yellow color and might have searched through the row to find the value and column corresponding to it. The sighted user can go through the detailed flight search table and can deduce useful information like which option has fewer stops, less travel duration etc., in the same way as in the previous case. He can also expand the flight details table to check the details.

Screen reader interpretation:

WebAnywhere : This screen reader was not able to load the flight search results section in

Flight Search Results Toronto, ON, Canada to Mumbai, India 11/14/2013 to 11/17/2013 - 1 passenger

Airlines	All Results	JET AIRWAYS	AA	UNITED	CATHAY PACIFIC
Non Stop	---	---	---	---	---
1+ Stop	\$1272	\$1272	\$1281	\$1917	\$2105

Change Your Search

From: Toronto, ON, Canada - Pearson Internat
 To: Mumbai, India - Chhatrapati ShivaJI(BOM)
 Leave: 11/14/2013 Return: 11/17/2013
 Type: Round Trip Class: Economy
 Adult: Child: Infant: Additional Options: Nonstop only

Flight Search Results 10 results per page Previous Page 1 of 10 Next

Toronto, ON, Canada to Mumbai, India 11/14/2013 to 11/17/2013 / 1 passenger

Sort By: Price (CAD) Airline Departure Arrive Duration Stops

\$1272 UNLIMITED PDP Air Canada / Air India 9:00pm 5:30pm 34h 00m 1 Confirm
 1:30am 7:33am 40h 33m 1
 Incl. Taxes & Fees Flight Details Track this Flight

Depart: Toronto, ON - Pearson International (YYZ) to Mumbai - Chhatrapati ShivaJI (BOM)

Air Canada Flight 7475	Departs: Thu Nov 14 9:00pm Arrives: Thu Nov 14 10:31pm	Toronto, ON - Pearson International (YYZ) Newark, NJ - Newark Liberty International (EWR)	UNLIMITED PRICEDROP PROTECTION You get a credit (unlimited) if the price of this flight drops after you buy!
Flight Duration: 1h 31m Connection Time: 17h 54m Operated by: AIR CANADA EXPRESS - SKY REGIONAL			
Air India Flight 144	Departs: Fri Nov 15 4:25pm Arrives: Sat Nov 16 5:30pm	Newark, NJ - Newark Liberty International (EWR) Mumbai - Chhatrapati ShivaJI (BOM)	
Flight Duration: 14h 35m			

Return: Mumbai - Chhatrapati ShivaJI (BOM) to Toronto, ON - Pearson International (YYZ)

Air India Flight 191	Departs: Sun Nov 17 1:30am Arrives: Sun Nov 17 7:15am	Mumbai - Chhatrapati ShivaJI (BOM) Newark, NJ - Newark Liberty International (EWR)
Flight Duration: 16h 15m Connection Time: 22h 45m		
Air Canada Flight 7469	Departs: Mon Nov 18 6:00am Arrives: Mon Nov 18 7:33am	Newark, NJ - Newark Liberty International (EWR) Toronto, ON - Pearson International (YYZ)
Flight Duration: 1h 33m Operated by: AIR CANADA EXPRESS - SKY REGIONAL		

CS-P

Figure 3.14: Screen shot showing multiple tables on web page from FlightNetwork website

the web page.

NVDA : NVDA offers limited navigation with tables. One can use letter “t” in the keyboard to navigate to the next table and a combination of the tab key and letter “t” key to go to previous table. The down arrow and up arrow keys can be used for navigation between cells. With this limited navigation, one has to go through the table several times to find out what the cheapest price is and which option has the cheapest price. To find the column value corresponding to a cell is really difficult. Reading row by row and cell by cell, it is very difficult to compare the prices. The tables used in the flight network search do not have titles. So it is extremely difficult to recognise tables during navigation. Also using cell by cell navigation, the blind user will not understand the table structure of detailed flight search results since the given table has multiple entries in single cells. Sophisticated screen readers like JAWS and windows eyes provide better navigation with tables. Filtering rows, reading contents in a column etc. is possible with these screen readers. However, to utilize such navigation shortcuts, the user should have at least an intermediate level of proficiency.

Example 5: A vision-impaired person navigates through hyperlinks and headings to reach the content easily and to get a page overview. So keeping the headings to a minimum will be useful, since the screen reader user will be able to get an overview of the page with few key strokes. Instead of following this logic, many web pages contain lots of headings which are hyperlinks as well. The home page of the Wall Street Journal (<http://online.wsj.com/home-page> : accessed on 13/11/2013) is used to illustrate this problem.

Sighted user: A sighted user can skim through the web page and get an overview of the page very easily. He will be able to identify the section headers and headings organised below it easily as well.

Screen reader interpretation:

WebAnywhere : WebAnywhere could load the page, but was not able to perform screen reading.

NVDA : The shortcut letter “h” can be used to navigate through h1 to h3 headings. In the case of the home page of the Wall Street Journal, there is no h1 heading. All the headings highlighted in blue are h2 headings. If you consider the section “Opinion”, heading opinion as well as the headings below it are h2 headings. Most of the h2 headings as hyperlinks too.

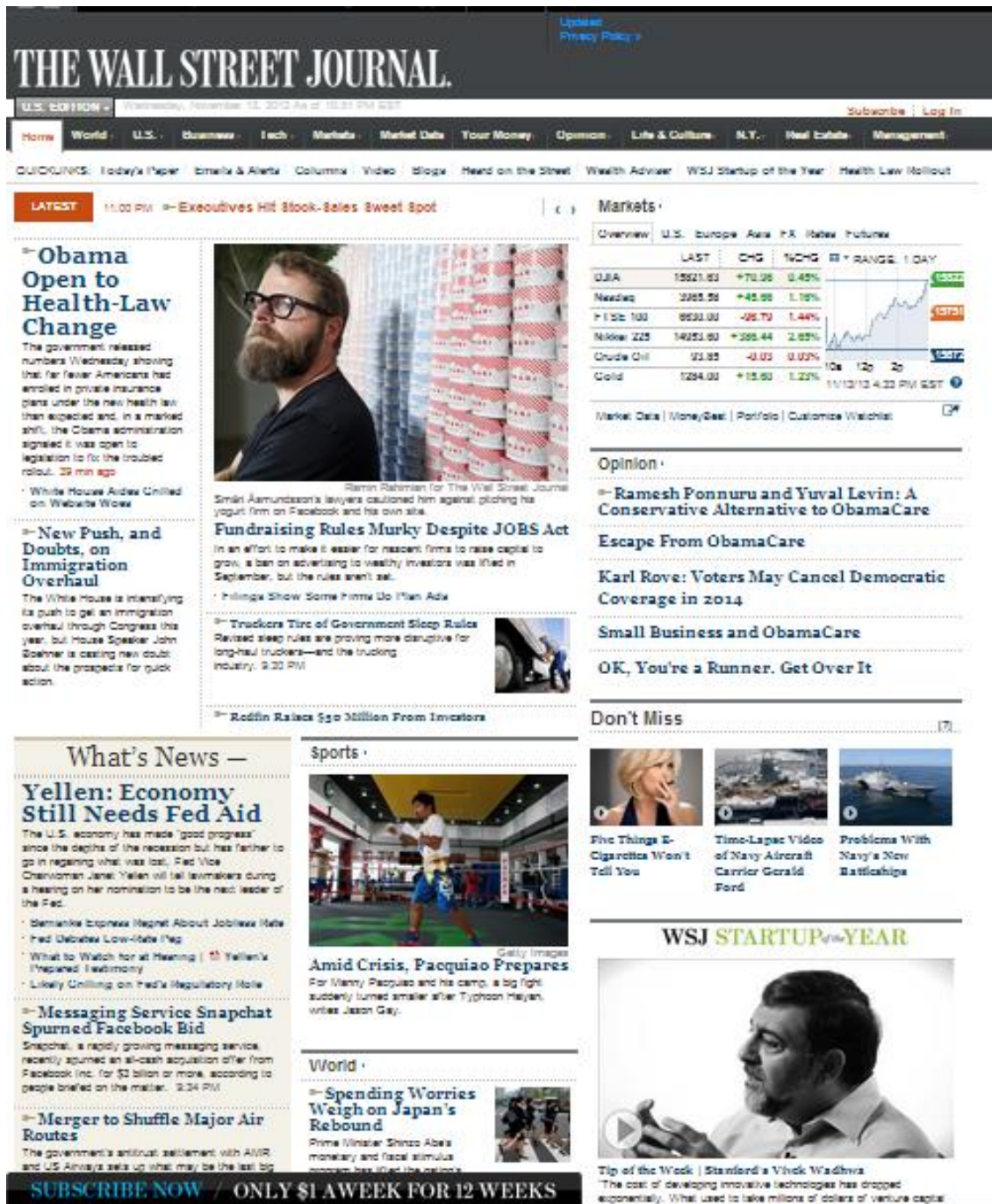


Figure 3.15: Screen shot showing Home page of Wall Street Journal website

So navigating through hyperlinks and headings is somewhat similar and both are tedious. It is difficult to get a page overview in both the cases.

Inference: After analyzing the above mentioned problems it is clear that, for a blind user navigating through web content is difficult. Navigation structures like menus are appealing to sighted users while they create a lot of trouble for vision-impaired. Most of the navigation menus nowadays use JavaScript and CSS for its pleasant look. Menus which expand on mouse hover use JavaScript. In case of such menus the submenu is inaccessible for a screen reader user. The navigation menus are read just as hyperlinks, so for a blind person, it is difficult to recognise the hyperlinks constituting the navigation menu. Also in many websites, especially entertainment websites, lots of hyperlinks are read out before reading the hyperlinks in the main navigation menu. In some websites the main navigation menu and submenu pertaining to the selected menu item are read as two separate lists by the screen reader. The blind user is not able to identify the relation between the main menu and submenu. Menus with many items are also a problem for a blind user, since he will not be able to memorise the whole thing to perform effective navigation.

Navigating through tables is extremely hard for a blind user. First of all, he will not be able to distinguish between a layout table and data table, if the data table does not have proper title. Also finding out particular data, comparing different cell values etc. is nearly impossible since the table navigation is limited. If a data table is not provided with a proper title, recognising the table while navigating back and forth will be a challenge. Tables containing HTML elements like hyperlinks offer additional challenge of navigating between web pages. Navigating between cells in a well-defined 2-dimensional table is manageable. But if the table has multiple entries in a cell or has nested tables, the navigation is hard since the user will not be able to understand the table structure. Many web pages contain frames and inline frames. Mostly inline frames are used to organise or align button elements or hyperlinks or even to store hyperlink values for JavaScript functions. These frames will not have proper titles. In such cases frame navigation will not be useful, since buttons and hyperlinks can be reached using other shortcuts.

Screen reader users often navigate through hyperlinks and headings to get a page overview. People prefer headings to hyperlinks to get a page overview thinking they need only few key

strokes rather than navigating through hyperlinks. In contrast websites keep lots of headings, most of them are hyperlinks as well. In such cases, navigation through hyperlinks and headings will be both tedious and time consuming. Often graphic links are not provided with alternate text which makes navigation through hyperlinks difficult. Many sections have hyperlinks with text like, “read more”. While reading line by line, these types of hyperlinks make sense, since context is clear from the previously read section. In contrast, while navigating through hyperlinks this will not help the user at all. Another problem noticed was that when a menu item is selected and new page is opened the user is not informed on which page he has landed. A sighted user can identify it with the help of highlighted item in the navigation menu, while screen reader does not convey this information.

3.1.4 Difficulty to Get Page Overview

One of the major difficulties in web browsing for blind people is the difficulty to get the overview of the web page. Even the sophisticated screen reader will not be able to give proper overview of a web page. This is because, when the screen reader linearizes the web content, most the structural information is lost. A sighted user can see the web page as whole when he access it, while a blind user is not able to get full view of the page at once. Tactile displays are capable of giving better page overview than screen readers and Braille displays. The planar tactile displays can display a portion of web page at once whereas, screen readers and Braille displays display only one line at a time. Many papers like [30, 32] has discussed the difficulty of blind people to gain information related to page overview. The reasons which cause difficulty in getting page overview is illustrated in the below section.

Example 1: The home page of BBC News website(<http://www.bbc.com/news/>: accessed on 19/11/2013) is taken as an example to discuss the problems related to page overview. The BBC News website contains diverse contents from simple text to videos. Also the page contains lot of information and needs vertical scroll to view the whole page.

Sighted User: A sighted user can gain much information from the web page just by looking at it. He will understand that the web page belongs to News category even without reading the contents. He will get the idea of type of contents displayed in the web page, whether the



Figure 3.16: Screen shot showing Home page of BBC News website

web page contains lots of images, videos or simple text quite easily. From the visual layout he understands the presence of navigation section on the top of the web page. The contents highlighted in the page, like main heading also catch his attention.

Screen reader interpretation:

WebAnywhere: To get the overview of the page, one has to navigate through hyperlinks and headings in the web page. Even after navigating through the hyperlinks and headings the user will not gain much information about the overview of the page. Only when the user encounters an image, a video or an animation, he will realise the presence of such contents in the web page. Essentially he needs to go through the contents line by line to realise the presence of the type of contents in the web page. The user will not have any idea of the category of the web page, whether it is a News website or on-line shopping website till the screen reader reads out the page title or numerous headings or hyperlinks. It is difficult for the user to understand the presence of the navigation menu. When the screen reader reads numerous hyperlinks while performing line by line reading, the user may guess that the hyperlinks read will be part of navigation menu. Also the highlighted contents like headings will be recognised as main headings only from the heading tag used to present the text. If the text is presented using the HTML tag h1, the user will understand that it is a main heading.

NVDA: The user experience with NVDA is similar to that of WebAnywhere. However, NVDA provides better shortcuts for navigating through hyperlinks and headings.

Inference: When we compare the web experience of a sighted person and a blind person, it is really tedious for a blind person to get even the necessary page overview information. A blind person has to traverse through numerous hyperlinks and headings to get at least some kind of page overview information. The presence of contents like images, videos, tables etc. will be realised only when such contents are encountered by screen readers. If hyperlinks do not have descriptive text, a screen reader user will not gain much information by traversing through the hyperlinks. The importance of contents can be realised only from the choice of the HTML tags used. For example, if the text is presented using the HTML tag h1, the screen reader user can identify that it is a main heading. Unless the page title is descriptive and proper, it will be difficult for a blind person to predict the category to which the web page belongs. The presence of structures like navigation menu, footer content is not understood by the screen

reader user most of the times. It is also difficult for a blind user to assess the amount of information presented in the page. The difficulty level will be huge if the web page is not designed according to standards.

3.2 Accessibility Problems with E-Commerce Websites

As discussed earlier, E-commerce websites especially on-line shopping websites are far less accessible compared to others. The WebAIM survey results also reveal that many blind people avoid on-line shopping websites because they are too complex for them [42]. It is interesting to know that in the study of 50 popular websites conducted by T. Sullivan and R. Matson, only one on-line shopping website was found to be highly accessible [35]. This website was Amazon (www.amazon.com). Even for a sighted person on-line shopping websites are complex, so one can imagine the problems a blind person will face when dealing with on-line shopping websites. In an interview with Kirk Reiser who is a visually impaired person and proficient computer user, he mentioned to me that once he spent three hours searching for a portable hard disk in an on-line website and got disappointed with the web experience.

The general accessibility problems discussed in the previous sections apply to on-line shopping websites as well. However, there are some specific problems which make these websites complex compared to others. In this section, specific problems which add complexities to on-line shopping websites are discussed. Only a few problems which we feel are very significant are discussed. One should conduct a detailed study solely on on-line shopping websites to list all their accessibility problems.

3.2.1 Complex Navigation Menu

The navigation menu is very complex in most of the websites. The main menu itself will contain numerous items and each item in the main menu will have again numerous items in its submenu. To explain this problem, the navigation menu from the Walmart Canada website (<http://www.walmart.ca> : accessed on 20/11/2013) is considered. A screen shot showing the submenu items corresponding to the main menu item 'Apparel' is printed below.

Sighted User: A sighted user can go through the main menu items shown in the left pane

The screenshot displays the Walmart Canada website's Apparel section. At the top, the Walmart logo is on the left, and navigation icons for Stores, Flyers, Account, and Cart are on the right. Below the logo is a search bar with the placeholder text "What are you looking for?". A horizontal menu lists "Shop All Departments" and "Top categories: Toys, TVs, Home Décor, Gifts".

The main content area is titled "Apparel" with the tagline "Wear it, work it, be your fabulous self." and features a list of sub-categories:

- Holiday Gift Centre**
- Handbags & Accessories**
 - Ladies
 - Mens
- Ladies**
 - Swimwear
 - Bras
 - Underwear & Hosiery
 - Uniforms & Workwear
 - See all
- Men**
 - Jeans
 - Underwear & Socks
 - Uniforms & Workwear
 - Casual Shirts
 - See all
- Baby & Toddler**
 - Basics
 - Bootsies, Mittens & Hats
 - Boy Bottoms
 - Boy Tops
 - Girl Bottoms
 - Girl Tops
 - Sleepwear
 - See all
- Boys**
 - Underwear & Socks
 - School Uniforms
 - Tops
 - See all
- Girls**
 - Underwear & Socks
 - School Uniforms
 - Tops
 - See all
- Shoes**
 - Ladies Shoes
 - Mens Shoes
 - Girls Shoes
 - Boys Shoes
 - Infants & Toddlers Shoes
- Luggage**
 - Backpacks
 - Travel Accessories
 - Luggage Sets
 - Luggage Coordinates
 - See all
- Ladies Plus**
 - Sleepwear & Robes
 - Knit Tops
 - Casual & Dress Pants
 - See all

Below the Apparel section is a promotional banner titled "Taking care of baby!" featuring images of baby strollers and toys, some with "Rollback" labels. To the right is an advertisement for "Earn Walmart Rewards" with a Walmart Rewards card image and a "Learn More" link.

Figure 3.17: Screen shot showing navigation menu from Walmart Canada website

of the web page quite easily. He can choose a department from the main menu and on mouse hover on that item, the submenu will be displayed. As shown in the figure, the submenu is quite large spanning almost the page. The items in the submenu are again organised under different categories. A sighted person will not have much difficulty in going through the main menu items and its submenu to find out the department and subdepartment corresponding to the product of his interest.

Screen reader interpretation:

NVDA: The navigation menu considered here is quite inaccessible for a screen reader user. The items in the main menu are not accessible while traversing through hyperlinks using the shortcut key. Only when the screen reader is performing line by line reading, the items in the main menu are read out. On selecting an item in the main menu using the enter key, the web page corresponding to that department is opened instead of listing the items in its submenu. The main menu will display submenu items only on mouse hover, which is not possible for a blind user. Even though the submenu was accessible using a keyboard, going back and forth through different main menu items and its submenu to find out the department and subdepartment corresponding to the product of interest would be tedious. This is because each submenu has numerous items. The WebAnywhere screen reader is not used for the experiment since it has difficulties in handling web pages with JavaScript.

Inference: The navigation menus in websites are very complex because of numerous items in the main menu and submenus. Because of this, traversing through the navigation menu to find out the product of interest is a tedious task. Often one has to traverse through main menus and submenus many times to find out the product of interest, unless one is really familiar with the particular website. Also most of the navigation menu is inaccessible using the keyboard which aggravates the difficulty level. The difficulty in accessing navigation menus using the keyboard was already addressed in the section on complicated navigation under the general accessibility problems. Many other problems related to navigation structures have also already discussed in the section above mentioned.

3.2.2 Difficulty to Search Information

In on-line shopping websites it is often difficult to find the required information. If a blind user wants to purchase a particular product or search for a product, it is easy to use the search option instead of going through different departments to find it. The search result will be more refined and number of items listed will be less if the user knows the specifications like product name and brand name. When the user uses more generic words to search, for example ‘cutlery set’, the resulting set may list a few hundred items. It will be extremely difficult to choose the desired one from the list, since this may require traversal through different pages. To illustrate the difficulty to perform search by a screen reader user, search results for the product ‘cutlery set’ from the website Williams-Sonoma (<http://www.williams-sonoma.com/> : accessed on 20/11/2013) is considered.

Sighted User: A sighted user can easily go through the search results which span a few pages. Some of the information like price, name of the product and ratings can be understood by skimming through the search results. Images of the product also add much information about the product. Traversing through different pages to check the complete result set will not be a problem for a sighted user. He can select items in the result set to check the details and come back to the search result page easily.

Screen reader interpretation:

NVDA: While performing line by line reading, before reading the contents in the search result, the complete hyperlinks displayed in the top section and the contents in the left pane are read out. When the items from the search result are read out, alternate text for images, hyperlink text and other information displayed is conveyed to the user. Going through the entire result set line by line will take a long time. Moreover the blind person needs to select particular item and access a new page to get the details. Traversing between pages is a difficult task for a screen reader user. So going through the entire search result is extremely tedious. If the user navigates through hyperlinks, only the product description available as text for the hyperlink link will be read out. So the tactics of traversing through hyperlinks will not be really useful.

Inference: Exploring the items in the search result is a tedious task for a screen reader user. Most of the information displayed will be read out only when one performs line by line

The screenshot shows the Williams-Sonoma website interface. At the top, there is a navigation bar with links for 'My Account', 'Track Your Order', 'Stores', and 'eCatalogs'. Below this is the 'WILLIAMS-SONOMA' logo and a search bar. A secondary navigation bar lists various product categories like 'COOKWARE', 'COOKS' TOOLS', 'CUTLERY', etc. A promotional banner states 'FOR CHRISTMAS DELIVERY, ORDER BY 5PM (PT) DECEMBER 12, 2013'. The main content area displays search results for 'cutlery set', showing 74 products and 0 recipes. The results are presented in a grid of 8 items, each with an image, title, price, and customer rating. On the left side, there are filters for 'Narrow By' including 'CATEGORY', 'BRAND', 'MORE OPTIONS', 'PRICE RANGE', and 'CUSTOMER RATING'.

WILLIAMS-SONOMA

Shipping To: **BASKET** **CHECKOUT**

Search by Keyword, Item # or Recipe

FOR CHRISTMAS DELIVERY, ORDER BY 5PM (PT) DECEMBER 12, 2013

Search Results for: cutlery set

Products (74) Recipes (0) Tell us how we can improve our search >

sort By: Best Match View: 24 Page 1 2 3 4 > View All

CATEGORY
 Cookware (2)
 Cooks' Tools (1)
 Cutlery (69)
 Tabletop & Bar (2)

BRAND
 Opinel (4)
 Jean Dubost (3)
 Laguiole en Aubrac (1)
 Saladini (1)
 Michel Bras (1)
 John McLeod LTD (1)
 Shun (7)
 Global (1)
 View More >

MORE OPTIONS
 Exclusive (24)
 Monogram Available (8)
 New (7)
 Special Offer (46)

PRICE RANGE
 Under CAD 31.51 (4)
 CAD 31.51 - CAD 63.01 (7)
 CAD 63.01 - CAD 126.03 (24)
 CAD 126.03 - CAD 315.07 (22)
 CAD 315.07 - CAD 630.14 (14)
 CAD 630.14 - Above (4)

CUSTOMER RATING
 ★★★★★ (19)









 Wusthof Classic 7-Piece Knife Block Set Special Offer ★★★★★ (22) Sugg. Price: CAD 768.27 Our Price: CAD 378.62	 Wusthof Gourmet 2-Piece Paring Knife & Kitchen Shears Set Special Offer Sugg. Price: CAD 65.55 Our Price: CAD 25.14	 Wusthof Classic Carving Set Video Special Offer Exclusive ★★★★★ (2) Sugg. Price: CAD 378.68 Our Price: CAD 188.98	 Shun Classic Paring Knives, Set of 2 Special Offer Exclusive ★★★★★ (22) Sugg. Price: CAD 151.17 Our Price: CAD 106.76
 Shun Classic 9-Piece Knife Block Set Video Special Offer Exclusive ★★★★★ (2) Sugg. Price: CAD 1457.20 Our Price: CAD 1068.16	 Wusthof Gourmet 6-Piece Steak Knife Block Set Special Offer ★★★★★ (2) Sugg. Price: CAD 214.25 Our Price: CAD 125.96	 Wusthof Classic 9-Piece Knife Block Set Special Offer Exclusive ★★★★★ (3) Sugg. Price: CAD 947.73 Our Price: CAD 594.65	 Wusthof Gourmet 12-Piece Knife Block Set Special Offer ★★★★★ (2) Sugg. Price: CAD 530.58 Our Price: CAD 251.99

Figure 3.18: Screen shot showing search result for cutlery set from the Williams-Sonoma website

reading, which will take a long time. Also one has to traverse through different pages to get detailed information on a product. By traversing through hyperlinks, a screen reader user will not gain much information on the product apart from the information gained from the text of the hyperlink. To check whole items in the search result also one has to traverse through different pages. Also many hyperlinks and headings were read out before reading the contents in the search result.

3.2.3 Presence of More Images and Graphics

In on-line shopping websites important information is presented using images and graphics. Many of the on-line shopping websites have slide shows of images which summarize important information like special offers and new arrival products. For a sighted user, these images and graphics are appealing and easily accessible. But for screen reader user, most of the graphics, images and slide shows are less accessible if they do not follow proper web standards.

The problems with image slide shows, images and graphic contents have already discussed in the sections on confusing page layout and inaccessible dynamic content. We are mentioning this once again, since on-line shopping websites rely heavily on image and graphic content. One main problem identified with images in on-line shopping websites is that, most of the text which is printed in the image is not conveyed in the alternate text.

Inference:

The major difficulty with image and graphics content is that, alternate text is not available in many cases. And some of the graphic links cannot be invoked using the enter key. Also the slide shows are difficult to maneuver and the buttons or links displayed on images in slide shows are not accessible through keyboard. The alternate texts for these buttons are often not informative as well. Another problem is that, text printed in the image is not conveyed in the alternate text.

Chapter 4

Accessibility Improvement Solutions

Web accessibility is important to ensure equal access and opportunity to all, including vision impaired persons in the realm of information access. Accessibility of the web gained more attention when the UN Convention on the Rights of Persons with Disabilities recognised information access including web content as a basic human right [37]. In 2010, the Canadian federal government was ordered to make all the government websites accessible for visually impaired persons when the courts realized that most of the accessibility standards were not followed. One can find the details regarding this court order in the article [22] published at the website of The Globe and Mail. Similar issues around the world forced people to consider accessible web development seriously. Organisations like National Federation for the Blind (NFB), American Federation for the Blind (AFB) and WebAIM are trying to educate people about the importance of accessible websites and conformance to accessibility standards in website development.

Many solutions like special web browsers and tactile displays were proposed by researchers across the world to improve the web accessibility for vision impaired persons. An overview of these solutions is given in Chapter 3. Some solutions like the 2D tactile display the Metec 120060 did not evolve into a successful commercial product, even though many successful experiments were conducted. The new Metec BrailleDis 9000, renamed into “Hyperbraille Display 7200” recently, is likely to be more successful because much needed software compatible with MS office etc. is available for it [11]. Many refreshable Braille displays like the Focus 80 Blue Braille Display by Freedom Scientific are available on the market. However, these displays should be used with a screen reader for better accessibility, since they are single line

displays. Many special web browsers also did not evolve as commercial products. ChromVox by Google Inc., which is used with Chrome the web browser, is available commercially, but many visually impaired users still prefer screen readers. The reason could be the effort and time required to migrate and get comfortable with the new medium. Since screen readers are the popular medium of web access by visually impaired persons, by developing websites accessible for screen readers a large population can be benefited. As part of the Web Accessibility Initiative (WAI) by W3C, Web Content Accessibility Guidelines (WCAG) were developed to make web content more accessible for the disabled [38]. The U.S. government issued certain standards under Section 508 of Rehabilitation Act 1194.22 which enforce the Federal agencies to make their electronic and information technology accessible to people with disabilities [33]. Section 508 laws should be followed in the U.S. whereas WCAG guidelines are international standards for all countries including Canada.

In this chapter, we are examining whether the existing WCAG guidelines are sufficient to make web content accessible for screen reader users. In the discussion section, problems under each category mentioned in Chapter 2 are analysed against the relevant WCAG guidelines. The required modifications in the guidelines and new suggestions to the guidelines are explained in the summary section.

4.1 WCAG Guidelines

WCAG (Web Content Accessibility Guidelines) are developed as a part of the Web Accessibility Initiative (WAI) by W3C. W3C (World Wide Web Consortium) is an international organization that determines the standards and protocols for the world wide web (WWW). WCAG provides accessibility standards for web content, authoring tools, evaluation tools and wherever accessibility should be taken into account in the on-line media. WCAG is developed by individuals and organizations who are part of WCAG working group. WCAG 1.0 was finalized in 1999 with 14 guidelines and many checkpoints which could be used to determine the web content accessibility. Three priority or conformance levels were provided. Priority 1 or conformance level A indicates basic accessibility; priority 2 or conformance level AA indicates a higher level of accessibility; and priority 3 or conformance level AAA indicates the highest

level of accessibility. As web technology evolved, WCAG 1.0 became insufficient, so WCAG 2.0 was developed on the basis of WCAG 1.0. Many guidelines remained as in 1.0. However, the list of basic principles was shortened to 4 instead of 14. The 4 basic principles are : perceivability, operability, understandability and robustness. There are more specific guidelines under these 4 principles and altogether there are 12 guidelines in WCAG 2.0. One can get an overview of the web accessibility guidelines at the WebAIM website [45] and find the details at the W3C website [38]. Also there is WAI-ARIA, the Accessible Rich Internet Application suite which provides guidelines to create better accessible advanced web applications. WAI-ARIA mainly helps with dynamic content and advanced user interfaces developed using JavaScript, HTML, AJAX and similar technologies. The WAI-ARIA guidelines are available at the W3C website in the WAI-ARIA section [39]. This mainly helps content authors, user agents etc. to set attributes and roles to elements, so that assistive technologies like screen readers can transform the user interface behaviour in a way more suitable for their users. Applying these guidelines requires a deep understanding of the implementation of assistive technology.

4.2 Recommendations Review for General Problems

In this section a list of problems identified under each category in the previous chapter is given. The WCAG 2.0 guidelines relevant to the problems are also listed. In the discussion section, it is checked whether the WCAG guidelines are adequate to provide accessibility for the listed problems. Suggestions to improve or augment existing guidelines are recorded in the summary section.

4.2.1 Inaccessible Dynamic Content

Problems identified:

Dc1. Graphic links and buttons do not have alternate text

Dc2. Some graphic buttons cannot be invoked using the enter key

Dc3. Alternate text is not read out by screen reader on mouse hover

- Dc4. The actions of some buttons are different on mouse hover and enter key
- Dc5. Information about the landing page, not even the title is conveyed before the animation starts.
- Dc6. Screen reader audio is masked by the audio on the page
- Dc7. The screen reader user has no control over the start of animation and is not aware how to proceed
- Dc8. The screen reader user is not aware of the presence of animation in the page and page events
- Dc9. No indication is given to convey that flashing content will be updated periodically
- Dc10. It is difficult to maneuver dynamic contents like slide show

These are some of the problems identified under the category of dynamic content. These are contents developed using Flash, JavaScript, HTML 5 and CSS. Dynamic contents which uses AJAX or Java Applets are not included in the scope of this study.

WCAG Guidelines applicable: Below is the list of guidelines taken from the W3C website [45] which are relevant to the above mentioned dynamic content problems.

No.	Guideline	Prob. No
1.	1.1.1 Non-text Content: All non-text content that is presented to the user has a text alternative that serves the equivalent purpose. (Level A)	Dc1, Dc3, Dc10
2.	1.2.1 Audio-only and Video-only (Prerecorded): An alternative for time-based media is provided that presents equivalent information for prerecorded audio-only and video content. (Level A)	Dc7
3.	1.2.3 Audio Description or Media Alternative (Prerecorded): An alternative for time-based media or audio description of the prerecorded video content is provided for synchronized media, except when the media is a media alternative for text and is clearly labeled as such. (Level A)	Dc7

4.	1.2.5 Audio Description (Prerecorded): Audio description is provided for all prerecorded video content in synchronized media. (Level AA)	Dc7
5.	1.2.7 Extended Audio Description (Prerecorded): Where pauses in foreground audio are insufficient to allow audio descriptions to convey the sense of the video, extended audio description is provided for all prerecorded video content in synchronized media. (Level AAA)	Dc7
6.	1.2.8 Media Alternative (Prerecorded): An alternative for time-based media is provided for all prerecorded synchronized media and for all prerecorded video-only media. (Level AAA)	Dc7
7.	1.4.2 Audio Control: If any audio on a Web page plays automatically for more than 3 seconds, either a mechanism is available to pause or stop the audio, or a mechanism is available to control audio volume independently from the overall system volume level. (Level A)	Dc6, Dc7
8.	2.1.1 Keyboard: All functionality of the content is operable through a keyboard interface (Level A)	Dc2, Dc4
9.	2.1.3 Keyboard (No Exception): All functionality of the content is operable through a keyboard interface without requiring specific timings for individual keystrokes. (Level AAA)	Dc2, Dc4
10.	2.2.2 Pause, Stop, Hide: For moving, blinking, scrolling, or auto-updating information, there is a mechanism for the user to pause, stop, or hide it unless the movement, blinking, or scrolling is part of an activity where it is essential. (Level A)	Dc7
11.	2.4.2 Page Titled: Web pages have titles that describe topic or purpose. (Level A)	Dc5
12.	2.4.4 Link Purpose (In Context): The purpose of each link can be determined from the link text alone or from the link text together with its programmatically determined link context, except where the purpose of the link would be ambiguous to users in general. (Level A)	Dc1

13.	2.4.9 Link Purpose (Link Only): A mechanism is available to allow the purpose of each link to be identified from link text alone, except where the purpose of the link would be ambiguous to users in general. (Level AAA)	Dc1
14.	3.2.1 On Focus: When any component receives focus, it does not initiate a change of context. (Level A)	Dc8
15.	3.2.5 Change on Request: Changes of context are initiated only by user request or a mechanism is available to turn off such changes. (Level AAA)	Dc8, DC9

Discussion:

Guideline 1.1.1 suggests giving alternate text to all non-text content including flash objects. Giving alternate text to flash objects will not help to improve accessibility. Instead, an overview of the page and animation should be included in the page description, which is comparatively easy for the web page developer too. This may help to get a better understanding of the page and animation, and it should be read after the page title. Some problems like buttons and hyperlinks, read as clickable button and clickable link can be solved by following guidelines 1.1.1, 2.4.4 and 2.4.9. However, the guidelines need to mention graphic links explicitly. A graphic link is often displayed as an image to the user although there is a hyperlink associated with it. Alternate text for such graphic links should be text which describes the hyperlink. Sometimes even though the button name describes the purpose, it may not be useful for a blind person since the animation as a whole is inaccessible to him. For example, in the case of animation showing the launch of a space shuttle, launch describes the purpose of the button in that context. But for a blind person that text is not enough to understand that he needs to invoke the launch button to proceed with the animation. Such type of buttons which needs interaction should be given more description which conveys the purpose and context. Guideline 1.1.1 is not enough to handle slide shows in a way accessible to vision-impaired persons. While implementing slide shows, buttons/links to maneuver should be kept outside the images. An image and the hyperlink associated with the image can be grouped as one entity, providing an alternate text containing a description of the image and the hyperlink. An example on how to implement

common dynamic contents like slide shows should be included in the guidelines.

All functionalities which can be attained using the mouse can be achieved using the keyboard. By following guidelines 2.1.1 one can achieve this. But whether this will give an experience comparable with that of a sighted user is a question. Essentially it will not. If many mouse events are required for the interaction in the page, replacing everything by keyboard strokes is a tedious work, and the blind user may have difficulties leaving and executing a long sequence of key strokes. Giving a list of keys and the purpose at an easily accessible location on the page may help to some extent. In some cases, an audio description may be needed while replacing mouse events with key strokes. Improving screen reading technology for handling these types of cases with the help of WAI-ARIA can be a better solution for increasing accessibility, rather than relying on the WCAG 2.0 guidelines alone.

Guideline 2.2.2 is not sufficient to handle the flashing dynamic content explained in the previous chapter. These types of contents are very popular in news and entertainment websites. The guideline suggests including pause and restart buttons for such contents. This can improve the accessibility in case of animations and advertisements. However, it will not be a good solution for textual flashing contents which is auto-updating. Implementing auto-updating flashing content using a list will provide better accessibility. The list can be given a description using appropriate HTML elements to indicate that it is an automatically updating content. A screen reader user can use list navigation shortcuts to access this content later. Alternatively a shortcut key can be associated with the list and indicated to the user, if the content has high priority. There is no guideline which enforces to give a proper description about a web page. Guideline 2.4.2 mentions providing appropriate page titles, but for many web pages this will not be sufficient. The guideline should add a recommendation to include a proper page description giving a fair amount of detail about layout and page content like animations in case the of websites, where such information is relevant for understanding the content.

Guideline 1.2.1 suggests to give an audio description for animations and videos for which audio is unavailable. Guidelines 1.2.3, 1.2.5, 1.2.7, 1.2.8 suggest giving synchronized audio descriptions and text equivalents suitable for braille display, to provide better accessibility for video. However, none of these guidelines presents a better way to handle animations. Many times animations are played in the background of the page without any audio, while the main

content is presented using text. In such cases either the animation can be tagged to be ignored by the screen reader if it is not important, or the presence can be conveyed to the user. For the latter case, presence of the animation can be delivered to the user with the help of a page description and a hyperlink to its audio equivalent. One major orientation problem that can occur in web pages having dynamic contents is that the screen reader user is not aware of the page content being changed. In the problem related to 'expressive web beta', by accessing a link, the page content is changed. However, the user is not aware of this. Change in page titles is a means by which the blind person gets to know about the page change. But in this case, page title, side bars etc. remained unchanged, only the content in the main content holder was changed. The guidelines 3.2.1 and 3.2.5 relevant to the situation do not provide any indication on how to handle such cases. A new recommendation can be added to these guidelines suggesting an audio alert once the page content changes when the page title does not inform about the change. After accessing different hyper links, if the blind user is not able to recognise change in page content, most likely he may attempt with a mouse. Designing a page in a way that enables a screen reader to read out the alternate text of graphic content on mouse hover may help in this context.

Providing audio controls by following guideline 1.4.2 will be useful for improving accessibility of animations. Also the problem of screen reader output being masked by web page audio can be solved by adhering to guideline 1.4.2. The case is complex if the animation needs user interaction and has audio. It will be difficult for a blind user to operate the audio controls as well as the buttons for user interaction. To handle such cases, a recommendation should be added to ensure that the audio and the animation both can be controlled using the buttons provided to interact with the animation. There are some flash animations which are not supported in some web browsers. For example, Google chrome does not support shockwave flash. Web browsers should be given guidelines to solve this in a way suitable for assistive technology. Improving accessibility by reviewing the guidelines alone will not be effective for dynamic contents. Techniques like haptic rendering and presenting tactile graphics on a tactile display can be employed to give a better experience for vision impaired persons. These techniques however need more sophisticated and dedicated hardware.

Summary:

Conformance to the highest level (AAA) of accessibility standards may not be sufficient to provide a basic level of accessibility in the case of dynamic contents. By adding several recommendations to the existing guidelines one can improve accessibility to some extent.

Recommendations should be added to guideline 1.1.1 or 2.4.2 to enforce page descriptions, providing an overview of dynamic content in the case of web pages having animations. Guideline 2.4.4 should be modified to provide details about implementing graphic links and adding alternate text, conveying the purpose and context for interactive buttons. Examples on how to handle popular dynamic contents like slide shows should be provided under guideline 1.1.1.

Suggestions like providing a list of keys and functions and adding audio descriptions in relevant cases should be added to guideline 2.1.1. Recommendations on how to implement flashing text content using list elements should be included in guideline 2.2.2. We suggest to add appropriate audio description to informative animations played in the background. This suggestion has to be attached to guideline 1.2.1. Guideline 3.2.1 should be modified to include audio alert to inform page content change. The case of interactive animation with audio should be handled in guideline 1.4.2. Techniques like haptic rendering and tactile graphics can be employed for improving experience with dynamic content.

4.2.2 Confusing Page Layout

Problems identified:

P11 Tables used for storing layout information

P12 Unable to recognize main content

P13 Tabular data structure presented without using HTML tables

P14 Frames used to store values of hyperlinks for JavaScript functions and using frames dynamically using JavaScript

P15 Use of HTML elements like hyperlinks as column values in table

P16 Title and labels missing for HTML elements like tables, forms, frames

PI7 No alternative text for graphs and charts

These are some of the problems we have identified related to page layout. Obviously, the problems mentioned are very limited, since the concentration is mainly on the significant ones. And these are just a small selection from a large set.

WCAG Guidelines applicable:

Below is the list of WCAG 2.0 guidelines which are relevant to the above mentioned page layout problems. These guidelines are taken from the W3C website [45].

No.	Guideline	Prob. No.
1.	1.1.1 Non-text Content: All non-text content that is presented to the user has a text alternative that serves the equivalent purpose. (Level A)	PI6, PI7
2.	1.3.1 Info and Relationships: Information, structure, and relationships conveyed through presentation can be programmatically determined or are available in text. (Level A)	PI1, PI3
3.	1.3.2 Meaningful Sequence: When the sequence in which content is presented affects its meaning, a correct reading sequence can be programmatically determined. (Level A)	PI1, PI3
4.	2.4.1 Bypass Blocks: A mechanism is available to bypass blocks of content that are repeated on multiple Web pages. (Level A)	PI2
5.	2.4.4 Link Purpose (In Context): The purpose of each link can be determined from the link text alone or from the link text together with its programmatically determined link context, except where the purpose of the link would be ambiguous to users in general. (Level A)	PI5
6.	2.4.6 Headings and Labels: Headings and labels describe topic or purpose. (Level AA)	PI6
7.	2.4.9 Link Purpose (Link Only): A mechanism is available to allow the purpose of each link to be identified from link text alone, except where the purpose of the link would be ambiguous to users in general. (Level AAA)	PI5

8.	2.4.10 Section Headings: Section headings are used to organize the content. (Level AAA)	PI2
9.	4.1.2 Name, Role, Value: For all user interface components the name and role can be programmatically determined; states, properties, and values that can be set by the user can be programmatically set; and notification of changes to these items is available to user agents, including assistive technologies. (Level A)	PI4

Discussion:

Some of the problems mentioned above can be solved by following the WCAG 2.0 guidelines mentioned in the above table. These include the following problems: unable to recognize the main content, no proper title and label for HTML elements like tables, forms, frames. However, modification to some guidelines can provide better accessibility. The WCAG 2.0 guidelines lack detailed specifications of tables and their contents.

Guideline 1.1.1 needs clarification. A clear definition should be given of non-text content. It is not clear that HTML elements like frames, tables, buttons etc. can be considered as non-text or that just charts, graphs, pictures etc. are non-text content. It is mentioned in the guideline that invisible decorative content should be implemented in such a way that it can be ignored by assistive technology. In the problems discussed above, frames were used for page organization so they can be considered as a decorative content in this case. They were invisible on the page also. However, frames were read out by the screen reader. The guideline 1.1.1 does not provide any detailed indication on decorative elements, so we are not sure whether to consider frames as decorative content in the above mentioned problem. So the problem related to frames cannot be solved unless the guideline clarifies about decorative content. More detailed guidance should be provided on how to give alternative text for graphs and charts. The guideline mentions giving long description for charts and graphs, but it does not explain which information should be available in the long description. We suggest that long description for graphs and charts essentially should give an overview, details about the X and Y axis if applicable, the information it is conveying and a textual description equivalent to the color coding. We suggest a graph should be presented as one entity with no text or numbers floating.

Guideline 1.3.1 concerns tables. It is not sufficient to provide better accessibility. The guideline suggests giving captions for data tables. However, it does not prohibit using tables for page layout, although it prefers CSS for page layout. The only criterion the guideline mentions is that if a table is used for page layout, a caption should be avoided. A summary attribute is not enforced by the guideline. While a table is used, the guideline mentions to use the `tr`, `td`, `th` tags for row, cell, column respectively. The guideline also advises to present tabular information in a way which preserve relationship within the information even if the table is not visible to the user. The guideline does not restrict the content displayed or dimension of the table. We suggest giving an overview of the table in the summary attribute, if the dimension¹ is more than 2 for better understanding about table.

Also the guidelines state that presentation features like paragraphs, headings etc. and structural information like font changes, layout information etc. should be kept logically separate, and CSS could be used for structural encoding. But this contradicts the use of tables for layout structure. We suggest to require that HTML tables should be only used to display tabular data and not for storing layout information. This restriction would reduce the confusion arising from complicated page layout and improve better navigation. We also suggest to impose the restriction that tabular data should only be presented by HTML tables.

Guideline 1.3.1 states to encode header information with each data cell in case of complex tables. This presentation will help the user to form a proper mental model. The guideline puts usage of tables for page layout into failure criterion, however, nothing is mentioned in the guideline about nesting of tables or tables containing structural information and presentation information combined. We suggest guideline 1.3.1 should impose the restriction not to add blank lines unnecessarily between HTML elements. Blank lines are often read out by screen readers. More sophisticated approaches like tactile displays can make tabular contents more accessible by offering easy navigation and search.

Guideline 1.3.2 suggests that the order in which the content is presented should be logical. Even though the order is logical, the main content might not be conveyed to the user in the initial readings. So in web pages having a large amount of content and where the main content

¹Two dimension table: we mean that each cell in the table will have only one row and one column corresponding to it and vice versa.

is delivered later due to the application of CSS, an option to skip to the main content should be available. Guideline 2.4.1 suggests 'skip to content' functionality. But more care should be taken with large web pages having vertical scroll, because the main content itself may be large and need further bypass to convey the main content in the initial reading.

Even though the link text provides proper meaning as suggested by guideline 2.4.4, such a descriptive text does not add much information when the hyperlink is a column value in a table. We suggest to avoid HTML elements as cell values in a table, since they create difficulties due to page traversal and change in focus.

The guideline 2.4.6 about descriptive headings and labels is given level AA which describes better accessibility. This guideline should be essentially given level A, basic accessibility conformance standard. People will not be able to get an overview of the page without proper headings, which is very important.

Guideline 2.4.9 states that the purpose of a link should be identified from the link text; this is not necessary in the case of links which are used for JavaScript functions and hidden frames. Such type of links should be tagged so that they would not be identified by assistive technology. Section headings specified by guideline 2.4.10 should be raised as a mandate for large web pages which need vertical scroll. And giving a listing of h1, h2 headings in such case will provide better accessibility. No proper guideline was found to avoid the confusion with the use of frames which store values for JavaScript functions. A recommendation should be added in guideline 4.1.2 to tag such frames so that such frames will be ignored by screen readers.

Summary: Modifications should be made to WCAG 2.0 to solve accessibility problems related to page layout. Guideline 1.1.1 should provide a clear definition of non-text content. It should clarify whether HTML elements like frames or buttons can be non-text content. A precise specification should be given that charts and graphs must be presented as one entity without any text or numbers floating outside. Moreover the content required in the alternative text should be specified.

Guideline 1.3.1 should put the restriction that only HTML tables should be used for presenting tabular data and tables should not be used to store layout information. Also a summary attribute giving an overview of tables should be a mandate for tables with more than 2 dimensions. A restriction should be imposed on the type of content that can be displayed using a

table. HTML elements like hyperlinks should be avoided as column values. A recommendation to avoid unnecessary blank lines should be specified.

For guideline 2.4.6, the conformance level could be modified to level A. Guideline 2.4.9 should include that hyperlinks used just for JavaScript functions and in invisible frames should be tagged so as to be ignored by assistive technology. Section headings specified by guideline 2.4.10 should be made mandatory for pages having vertical scroll and a listing of h1, h2 heading should be enforced. A recommendation should be added in guideline 4.1.2, to tag frames which are used by JavaScript functions, so that screen readers can ignore them.

4.2.3 Complicated Navigation

Problems identified:

- Cn1 Navigation menus require mouse specific events
- Cn2 Main menu and corresponding submenu conveyed as two separate list
- Cn3 Submenu space contain text and even image rather than essential hyperlinks
- Cn4 Unable to identify particular table while navigation
- Cn5 Only limited navigation possible with contents inside the table
- Cn6 Unable to identify particular frame or overview of its content while navigation
- Cn7 Numerous headings in web page which makes navigation tedious
- Cn8 Hyperlinks which do not convey the purpose
- Cn9 User is not aware of which web page he has landed while navigating

Above are the major problems related to navigation, observed from different websites. Many navigation difficulties arise from non-standard page layouts as well. An attempt has been taken to cover the common navigation problems. Problems with auto-refresh of the page, navigation between multiple browser tabs and navigation difficulties with forms are not discussed in order to limit the scope of the study.

WCAG2.0 Guideline applicable: Below we list the WCAG 2.0 guidelines applicable to the problems mentioned [45].

Sl. No.	Guideline	Pl.No
1.	1.1.1 Non-text Content: All non-text content that is presented to the user has a text alternative that serves the equivalent purpose. (Level A)	Cn3, Cn4, Cn6
2.	1.3.1 Info and Relationships: Information, structure, and relationships conveyed through presentation can be programmatically determined or are available in text. (Level A)	Cn2, Cn4, Cn5
3.	1.3.2 Meaningful Sequence: When the sequence in which content is presented affects its meaning, a correct reading sequence can be programmatically determined. (Level A)	Cn2, Cn3, Cn5
4.	2.1.1 Keyboard: All functionality of the content is operable through a keyboard interface (Level A)	Cn1
5.	2.4.1 Bypass Blocks: A mechanism is available to bypass blocks of content that are repeated on multiple Web pages. (Level A)	Cn2
6.	2.4.2 Page Titled: Web pages have titles that describe topic or purpose. (Level A)	Cn9
7.	2.4.4 Link Purpose (In Context): The purpose of each link can be determined from the link text alone or from the link text together with its programmatically determined link context, except where the purpose of the link would be ambiguous to users in general. (Level A)	Cn8
8.	2.4.6 Headings and Labels: Headings and labels describe topic or purpose. (Level AA)	Cn7
9.	2.4.8 Location: Information about the user's location within a set of Web pages is available. (Level AAA)	Cn9

10.	2.4.9 Link Purpose (Link Only): A mechanism is available to allow the purpose of each link to be identified from link text alone, except where the purpose of the link would be ambiguous to users in general. (Level AAA)	Cn8
11.	2.4.10 Section Headings: Section headings are used to organize the content. (Level AAA)	Cn7

Discussion:

In WCAG 2.0, guidelines under section 2.4 are mainly included to help user navigation. However, one should not concentrate only on these guidelines to improve navigation facilities. Some of the navigation difficulties occur because of the need of mouse specific events and from non-standard layout. Hence guidelines in other sections also need to be considered while aiming for a website without navigation difficulties.

One of the major problems identified was inaccessible navigation menus. Many websites have menus which work only on mouse hover. And if a keyboard is used to access the menu, either the complete menu is inaccessible or a submenu is inaccessible. If one has to implement an accessible navigation menu, one has to go through guidelines 2.1.1, 2.4.1, 2.4.3 and 2.4.4. These guidelines do not cover all the aspects which need to be considered to create an accessible menu. None of the guidelines explicitly explains the implementation of a navigation menu. Including a section in WCAG 2.0 providing guidelines and examples for accessible navigation menu will be an asset, since almost all websites have some kind of navigation menu. By adhering to guideline 2.1.1, one has to create a navigation menu which is completely accessible by keyboard. Encouraging developers to create a navigation menu using an HTML list is advisable for two reasons. Reason one being, list items are completely accessible using the keyboard and reason two is, a screen reader can convey the main menu and submenu well if the menu is implemented as an unordered list or an ordered list. Implementing menus using lists can be included as recommendation under the navigation menu section. Also a recommendation should be provided to limit the contents in a navigation menu. Only necessary hyperlinks should be added in the navigation menu, no images, sentences or paragraphs should be allowed.

Many times, before reading the hyperlinks in the main menu, numerous links will be read out while navigating through hyperlinks or reading line by line. In such cases, a visually im-

paired person will not recognize the contents in the main menu; he will think that all the hyperlinks read are part of the main menu. To avoid this confusion, a tag indicating the start and end of the main menu can be given before and after the list containing the items in main menu. If the navigation menu is complicated with numerous items in a submenu, providing a short secondary menu structure for the screen reader will be useful. Hence the user should not go through a long menu structure always. A similar thought of implementing a secondary menu structure for navigation was found in the website on Accessible Web Design [5]. If the navigation structure is complicated, it is advisable to provide shortcuts in the web page itself. Providing the best way to navigate through the web page in an appropriate and easily accessible section will be an added advantage for a screen reader user. Implementing a 'skip to navigation section' as mentioned in 2.4.1 will also ease the navigation through web pages. A recommendation which states to preserve the relationship between the main menu and its submenus in all the web pages in a website should also be added. This is to avoid the problem of presenting the main menu and its submenus as two different lists. All the above mentioned suggestions should essentially be added to the new section 'navigation menu' in WCAG 2.0 guidelines.

Giving appropriate titles to frames aids navigation. In the problems identified it was observed that, inline frames or iframes are usually used to align buttons and links or to display hyperlinks. Screen readers do not have the ability to distinguish frames and iframes. Hence using the shortcut to navigate through frames, one can navigate through inline frames as well. Navigating through inline frames will not add much information in the above mentioned case. So it is advisable to tag such inline frames, so that assistive technology will ignore these frames. But make sure the content inside the frame is accessible. This recommendation should be added along with the guideline which mentions to provide title for frames and iframes. Currently recommendations to give titles to frames and iframes exists under guideline 2.4.1. The recommendation about titles for frames and iframes should be included under guideline 1.1.1 which deals with non-text content, so that people will easily notice it.

Another major problem identified under navigation difficulty was the presence of numerous headings. When there are numerous h1 to h3 headings in a web page, getting the overview of a page with few key strokes will be difficult. Most of the times these headings are hyperlinks as well. So navigation through both hyperlinks and headings will be time consuming. To avoid this

problem, a recommendation should be added to guideline 2.4.6 to give headings judiciously. h1 to h3 tags should be given only to main headings and section headers. Giving section headings by following guideline 2.4.10 is advisable. However, one should make sure that the sections headings will be either h2 or h3 and all other heading in the section should take a heading tag below h3. Also recommendations should be added to restrict the text being presented both as hyperlinks and headings of h1 to h3. Only in necessary cases, such a presentation should be used.

Providing descriptive page title as per guidelines 2.4.2 and breadcrumb trails, as per guideline 2.4.8 helps the user to recognise his current location or the page he has landed on. If the website is organized into categories and subcategories, breadcrumb trail show the current location in the hierarchy of categories in a website. This definition of breadcrumb trail is given under guideline 2.4.8 itself. While navigating through hyperlinks using ‘tab’ key, text like ‘read more’ is often encountered. This hyperlink text is informative if the user understands the context. Hence only when a screen reader reads line by line such text describes the purpose of link. In order to avoid this confusion the guideline 2.4.9 which enforces the hyperlink text to be descriptive should be given conformance level A rather than AAA.

Navigating through a table is also a major challenge for screen reader users. Giving proper captions by following guideline 1.3.1 will help to recognize particular tables while navigating. As mentioned in the section ‘Confusing Page Layout’, enforcing restriction on the contents in the table, avoiding HTML elements as column values in the table and providing descriptive summary in the case of complex tables can avoid the confusion to some extent while navigating inside the table. However, this will not ease the navigation inside the table. In the case of a tabular structure, the WCAG guidelines have lots of limitations, whereas, screen readers can provide lots of sophisticated navigation options. Navigating through column values and filtering rows are examples of this sophisticated navigation. The JAWS screen reader provides better navigation facilities for tables. One can find the available options and shortcuts in the JAWS website [12]. Also tactile displays can handle tables more efficiently than screen readers.

Summary :

By following the guidelines navigation menus can be made accessible using the keyboard. However, a new section solely for navigation menus should be added under WCAG 2.0 to help developers in creating accessible navigation menus. Implementing navigation menus using ordered and unordered lists should be encouraged. A short secondary menu should be provided in case the navigation menu structure contains numerous items. Also recommendations should be added to restrict the content of navigation menus to be only hyperlinks. The relationship between a main menu and a submenu should be preserved in all web pages in a website.

Guideline 1.1.1 should include a recommendation to provide titles for frames and iframes. iframes which are used for alignment purpose and storing hyperlink values should be tagged to be ignored by assistive technology. Guideline 2.4.6 should be modified to accommodate the restriction that heading can be put as hyperlinks only in necessary condition. Also the guideline should include the suggestion to present section headers with h2 or h3 headings and all the headings under the section should take a heading level below h3.

The conformance level of guideline 2.4.9 is suggested to be raised to A from AAA, so as to convey the purpose of hyperlinks always. Also guideline 1.3.1 should include suggestions like restricting the contents of tables, providing descriptive summary in case of complex tables and avoiding the use of HTML elements as column values. WCAG guidelines have lots of limitations in the case of tables. Screen readers are able to provide more sophisticated navigation facilities like filter row and navigating through columns. Tactile displays can provide equal or better navigation facilities than screen readers.

4.2.4 Difficulty to Get Page Overview**Problems identified:**

- Po1 It is difficult to recognize the category of web page without reading numerous headings or hyperlinks
- Po2 Presence of different types of content can be realized only after encountering them
- Po3 To get at least some kind of information about the overview of page, one has to go through numerous headings or hyperlinks

Po4 It is difficult to assess the amount of information in a page

Po5 Difficulty in identifying the presence of structures like navigation menu

WCAG2.0 Guideline applicable:

Below list of WCAG 2.0 guidelines applicable to the mentioned problems are taken from W3C website [45].

Sl. No.	Guideline	Pl. No.
1.	1.3.1 Info and Relationships: Information, structure, and relationships conveyed through presentation can be programmatically determined or are available in text. (Level A)	Po2
2.	2.4.1 Bypass Blocks: A mechanism is available to bypass blocks of content that are repeated on multiple Web pages. (Level A)	Po5
3.	2.4.2 Page Titled: Web pages have titles that describe topic or purpose. (Level A)	Po1
4.	2.4.4 Link Purpose (In Context): The purpose of each link can be determined from the link text alone or from the link text together with its programmatically determined link context, except where the purpose of the link would be ambiguous to users in general. (Level A)	Po3
5.	2.4.5 Multiple Ways: More than one way is available to locate a Web page within a set of Web pages except where the Web Page is the result of, or a step in, a process. (Level AA)	Po4
6.	2.4.6 Headings and Labels: Headings and labels describe topic or purpose. (Level AA)	Po3, Po4
7.	2.4.9 Link Purpose (Link Only): A mechanism is available to allow the purpose of each link to be identified from link text alone, except where the purpose of the link would be ambiguous to users in general. (Level AAA)	Po3

8.	2.4.10 Section Headings: Section headings are used to organize the content. (Level AAA)	Po1, Po3
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Discussion:

Web pages should be designed by following W3C standards to gain a basic level of page overview information. Screen reader users traverse mainly through headings and hyperlinks to gain information about page overview. Users who are more proficient with screen readers may also use shortcuts to traverse through different HTML elements like tables, frames, lists etc. to gain page overview information. If a web page is designed to aid such kind of tactics, gaining page overview information will be faster and easier. Keeping h1 to h3 headings minimum and providing proper title, captions and descriptive text for HTML elements is necessary to help screen reader users to ease their task in this regard. These aspects were discussed and proper recommendations were suggested while discussing the problems related to page layout and navigation structures in the earlier sections.

Providing descriptive page titles by following guideline 2.4.2 will help the screen reader user to identify the category of web page without going through numerous web pages.

One has to go through numerous headings and hyperlinks to get the information about page overview. This difficulty can be ameliorated by providing section headers according to guideline 2.4.10 and descriptive headings as per guideline 2.4.6. As discussed under the recommendation review for Complex Navigation, guideline 2.4.10 should include the recommendation to keep the section headers as h2 or h3 and that all other headings under a section header should take a heading tag below h3. This will help to keep h1 to h3 headings minimal so that a screen reader user will get to page overview information with few key strokes. Also all the hyperlink text should convey purpose of the hyperlink as per guidelines 2.4.4 and 2.4.9. Traversing through hyperlinks to gain page overview will be meaningful only if the web page adheres to these guidelines.

Identifying the presence of different types of contents like images, videos, tables, frames etc. in a web page is difficult for screen reader users. They have to essentially encounter those contents to realize their presence. A recommendation should be added to 2.4.2 which demands the provision of a description conveying the page overview information. The description should essentially contain information on how the website or web page is organized, what information

one can expect from the web page, different types of contents used to present the information and details shortcuts if any special shortcut is provided in the web page. This description can be textual or audio. One can use shortcuts to traverse through tables and frames. Providing proper titles for tables and frames by following guidelines 1.3.1 and 2.4.1 will help while traversing through tables and frames.

Screen reader users do have a difficulty with identifying structures like a navigation menu. This problem was addressed in the recommendation review section of Complex Navigation. Our suggestion is to provide a start tag and an end tag which will convey the start and end of the navigation menu. If this recommendation is implemented in a web page, while traversing through hyperlinks, the screen reader user will understand the hyperlinks pertaining to the navigation menu. Also supplying 'skip to navigation menu', 'skip to footer' by following guideline 2.4.1 will help to identify such contents and make later access to them easy.

Following guideline 2.4.5 and implementing a list of contents or a list of web pages or a site map for websites will help to gain page overview information as well as to access the amount of information in the web page or website. Providing an audio description as mentioned earlier also helps to access the amount of information in a web page.

Summary:

Many aspects related to page overview were discussed in the recommendation review section of confusing page layout and complex navigation.

Guideline 2.4.10 should be modified to include details on providing section headers efficiently to reduce difficulties with page overview. Only h2 or h3 HTML tags should be used to present section headings. Guideline 2.4.2 should be modified suggesting giving overview information as textual or audio description. The description should essentially contain information on how the page is organized, what all contents and type of contents are present etc. Also a new guideline should be added under a new section for navigation structure which suggests providing tags indicating the start and end of a navigation menu. This was discussed earlier under the recommendation review for complex navigation.

4.3 Recommendation Review for E-Commerce Websites

In this section we are checking whether the WCAG guidelines are sufficient to provide accessibility of contents in case of online shopping websites. In the cases where the WCAG guideline is observed to be insufficient, new suggestions are included.

4.3.1 Complex Navigation Menus

Problems identified:

- Complex navigation menu with numerous items in the main menu and submenu
- Navigation menu inaccessible using keyboard

Discussion:

Recommendations to make the navigation menu accessible using keyboard were already made in the section Complicated Navigation under Recommendation Review. The main suggestions were to follow guideline 2.4.1 and to add a new recommendations enforcing the use of HTML list elements to create the main menu and submenu. Also a recommendation was suggested to add a new section for navigation structures under WCAG 2.0 guidelines which will include guidelines solely for navigation structures.

To avoid the complication with numerous items in the main menu and a submenu, we would recommend adding textual or audio descriptions to the main menu items. The description for each main menu item should contain the list of items in its submenu and other necessary information which will throw an insight to the products organized under each submenu item. This will reduce the difficulty of traversing through different submenus to a great extent. If description is given to main menu items, the screen reader user will understand the contents in the submenu while traversing through the main items. Hence he can select the proper main menu and submenu item without exploring the entire menu structure. This will lessen the navigation hassle to a great extent. The recommendation suggesting descriptions for main menu items should be included under a new section which will be solely for navigation structures. Also providing shortcuts in websites apart from that provided by screen readers to help efficient navigation is advisable. When such shortcuts are provided, a list mentioning the shortcuts

and their respective functions should be kept in an accessible location. This recommendation is also mentioned in the Complicated Navigation section under Recommendation Review

Summary:

Recommendation to provide textual or audio description for main menu items should be included to the new section solely for navigation structures.

4.3.2 Difficulty to Search Information

Problems identified:

- To check complete list of items in the search result one has to traverse through different pages
- Line by line reading should be performed to gain more information on the product
- Search result set is large
- Many hyperlinks and contents are read out before reading out the search result

Discussion:

To reduce the difficulty in finding the required information, searches should be made easy and items in the search result should be fewer. Also if more product information can be read out on accessing hyperlinks, the screen reader user does not have to perform line by line reading.

No proper guidelines were found in WCAG 2.0 which will provide an efficient solution for search complexity. We will recommend adding a new section in WCAG 2.0 guidelines to deal with search complexities.

In order to make a search mechanism simple, our recommendation is to present the search option after the page title. So that a screen reader user will not have to go through many links and headings to reach the search option. Enforce to give ‘skip to main content’ functionality by following 2.4.1 which mentions about bypassing blocks. This will help the screen reader user to access the search result without waiting until the complete navigation menu and other contents, which comes before search result in HTML markup of the web page have been read. ‘Skip to main content’ functionality should be implemented in a way so that the screen reader will be able to access the search results when this functionality is invoked.

In order to reduce the items in the search result set we have several recommendations. One is to provide more sorting options like sort by brand or manufacturer, availability etc. apart from the existing common ones. Another recommendation is to provide advanced search option which will accept brand name, price range and features along with the product name.

To reduce the problem of traversing through different web pages to explore the entire search result, we have one recommendation. The recommendation is to display all items in the search result on a single page when the presence of assistive technology is detected. If the complete result is difficult to display on a single page, product images can be removed.

Essentially one has to do line by line reading to gain the whole information displayed on the web page related to the product. A recommendation to provide a textual description which contains information like product name, brand name, price, rating and availability should be added to avoid the above mentioned problem. This description should be read out on focusing the hyperlink when the presence of assistive technology is detected. After following this recommendation the screen reader user can gain more information on the product by just traversing through hyperlink. All the above mentioned recommendation should be included in a new section which deals with search complexities.

Summary:

It is recommended to add a new section in WCAG 2.0 which will deal with search complexities. 'Skip to main content functionality' mentioned under guideline 2.4.1 should be enforced. A recommendation to add advanced search options and provide more sort by options should be included in the new section for search complexity. A recommendation should be added which mentions to keep the search option directly after page title. Other recommendations suggested are to display all the items in search result on single page and to provide textual descriptions which give product details on focusing on the hyperlink corresponding to a particular product.

4.3.3 Presence of More Images and Graphics

Problems identified:

- Images and graphics do not have alternate text
- Graphic links cannot be accessed using the keyboard

- Slide shows are difficult to maneuver
- Buttons/links in slide shows do not have informative alternate text
- Whole text displayed on the image is not conveyed through its alternate text

Discussion: There is not much discussion required on the solutions for the above mentioned problems. The solutions for these problems are already discussed in detail in the section Confusing Page Layout and Inaccessible Dynamic content under the recommendation review section.

The guideline 1.1.1 which deals with handling non-text content suggests giving alternate text for images. By following this guideline, images will become more accessible. By following the guideline 2.1.1 which states that all the functionality should be available by using the keyboard, the difficulty in accessing graphic links through keyboard can be solved.

In the previous discussion about slide show in the section Inaccessible Dynamic Content under recommendation review, we have suggested to add a new recommendation to handle slide shows. The recommendation was to include a new suggestion to guideline 1.1.1 which deals with non-text content. The recommendation also says to remove buttons or links from images and to group images and hyperlinks corresponding to the images as one entity and give proper alternate text.

To address the problem that whole text displayed on the image is not conveyed through alternate text, we have a new suggestion. Our suggestion is to add a recommendation to guideline 1.1.1 enforcing the textual content displayed on the image to be conveyed through alternate text as well.

Summary: By following guideline 1.1.1 the problem related to the unavailability of alternate text for image and graphics can be solved. Also the accessibility problem with graphic links using the keyboard can be solved by following guideline 2.1.1.

A recommendation should be added to guideline 1.1.1 to handle slide shows effectively. Also guideline 1.1.1 should include a recommendation which enforces the textual content on the image to be present in the alternate text as well.

4.4 Other Solutions

Designing web pages according to WCAG 2.0 guidelines will ensure accessibility to some extent. However compliance with accessibility standards will not ensure usability. In the paper [20] the relationship between the concept of accessibility and usability is studied. The paper conveys that even if the website completely complies with accessibility standards, it can be still very hard to use for disabled people. This statement actually forces one to think about the aspect of usability which needs to be considered while preparing new accessibility guidelines.

The WCAG guidelines have many limitations. While discussing the navigation problems with tables, we observed that creating accessibility guidelines alone cannot improve the navigation techniques for tables. Potential solutions which can contribute to improved accessibility are discussed in this section.

4.4.1 Educate People about Accessibility

Many times websites are not accessible for blind people since accessibility standards are not followed during page design. Web developers might not follow guidelines because they are not aware of the accessibility problems and the guidelines. Another problem could be, they think it is difficult to implement accessible design. To avoid the first problem, we can suggest including the concept of accessibility and accessibility guidelines in web design courses. The latter problem can be addressed by providing tutorials and sample code for accessible web design in text books and online learning materials.

4.4.2 Recommendations for Screen Readers

To provide better accessibility of web contents, we have some recommendations for screen readers as well. Screen readers can provide more sophisticated navigation facilities for tables like providing a find option inside a table. This can improve the experience of blind people with tabular data. Also conveying the presence of main regions in a web page like the navigation menu, side bar, footer etc. as page overview information will be beneficial. JAWS 14 actually conveys the presence of header, footer, side bar sections based on the HTML markup.

Enabling navigation shortcuts to traverse through images and videos will help to gain information more quickly. Also providing option to include plugins with screen reader can improve the experience of web browsing by blind people.

4.4.3 Recommendations for Web Browsers

We are suggesting recommendations for web browsers as well. This is to ensure that, even if a web page does not follow any standards a basic level of accessibility can be provided with the help of web browser. Our recommendations include providing an option for generating a basic HTML version of web page when the presence of assistive technology is detected. Also accessibility issues due to any incompatible content should be handled by the web browser itself. So that screen reader users will not get affected. For example, Shockwave Flash is not compatible with the Google Chrome Web browser. This issue should be handled by the Chrome browser itself. Another recommendation is to handle pop-ups and advertisements which come as hindrances either by blocking them or by not changing the page focus to these types of contents. Adblock which comes as an extension which can be installed to web browsers is an example for such a step. It will be better to enable such features automatically in web browsers when the presence of assistive technology is found.

4.4.4 Using semantic web

The semantic web is a concept promoted by W3C aiming at providing common framework that allows data to be shared and reused across application, enterprise, and community boundaries [10]. It is a collaborative effort of W3C, a number of researchers and industrial partners. Semantic web concentrates on two things, exchange of data across applications and a common language for representing data. If we perceive from the perspective of a vision-impaired user, assistive technologies are not capable of interpreting all kinds of data format and due to this incapability those content will remain inaccessible. By adopting universal data formats considering people in all realms including the disabled community, data across the web will be accessible even by assistive technologies. For example, if MathML format is used for representing mathematical expressions, both sighted people and assistive technology users will be

able to access such information. Also exchange of data across applications will have better use in day-to-day life of people. Searching information can be made simple since data is linked across applications and even intelligent searches like finding particular images from any website will be possible [9]. Such efforts are going on with industry collaborations, although there is a long way to reach the goal.

4.4.5 Expanding the scope of accessibility

Small devices like tablets and smart phones are nowadays very popular for web browsing and other online activities. According to the study [28] conducted by Nielsen Norman group on the user experience of small devices it is evident that there are usability problems when one browses web page through small devices. And more usability problems are with smart phones than tablets because of the limited screen size. The standards and website design that will be adopted to increase the usability of small devices might also help to improve web accessibility for vision-impaired people.

Some of the WCAG guideline revisions suggested in our study can enhance the usability of smart phones for web browsing. In the online shopping websites we normally encounter large navigation menu with numerous main menu items and numerous submenu items associated with it. In section 4.3.1 we suggested to keep audio listing of the associated submenu items at the main menu level to ease the navigation. This guideline will benefit small devices since navigation through numerous menu items is bit tedious in such devices as well. Suggestions like implementing detailed audio description of the web page and employing shortcuts within the page for easy navigation as mentioned in section 4.2.3 and section 4.2.4 will also benefit small device users since they need not have to go through whole page zooming in and out to get the overview. Tables with HTML elements as contents may also cause inconvenience to the small device users. Including the suggestion of restricting contents inside a table as mentioned in section 4.2.2 to the standards for small devices will be beneficial. Other suggestion like avoiding pop-ups for web pages will benefit both small device users and vision-impaired users equally. When the above mentioned guidelines and other similar guidelines are implemented to increase the usability of small devices it will automatically benefit the web accessibility for

vision-impaired people. And implementing these kind of standards will be more feasible since the targeted group is majority of the population. The recommendations for dynamic content in our study does not seems to be relevant for small devices since the recommendations were aimed to provide alternatives for the visual effects of dynamic content.

4.5 Enhanced Solutions

As discussed earlier, by adhering to existing WCAG 2.0 standards and to our recommendations, accessibility can be improved to some extent. However, there are limitations when screen readers are used to access the web page. Since screen readers linearize the content and present it to users, displaying fully accessible images, graphics, animations and tables is not possible. Also the information on page overview one can gain using a screen reader is also limited. Handling complex navigation menus will also be not efficient since it is hard for a person to remember entire items and the organization of a menu when the content is linearized. In this section we are discussing different solutions which can provide enhanced accessibility in the case of web browsing for blind people.

4.5.1 Page Overview and Navigation Structures Based on Mental Model

Conveying the organization of a web page in a way which can help blind people to create a mental model of the web page will be beneficial to enhance the web browsing experience. If a blind person can gain a mental model of the web page and its navigation structure, he will be able to navigate and find information faster and more efficient way. In [21] it is mentioned that having a mental model about the navigation space is necessary to perform successful navigation. Also [24] mentions that people having a mature mental model can perform better in web interaction and search compared to people having immature mental models. More research needs to be done to find out the ways to present web pages to blind people, so that they can gain a mature mental model.

4.5.2 Tactile Displays for Images and Graphics

When screen readers are used, images and graphics are quite inaccessible. A blind person can gain information which is conveyed through the alternate text corresponding to the image and graphics only, which is very little. Tactile displays like the Metec display mentioned in the section on tactile media can present images and graphics in more accessible way. By exploring the images tactically, a blind person can gain lot of information like shapes, its borders, the connection between different objects in the scene etc. Tactile displays are already used to present graphics like raster graphics and SVG (Scalable Vector Graphics), diagrams etc. One can refer to [14, 32, 8] to get more details. Further study is needed to understand how different types of images can be displayed using tactile displays so that blind people can gain most of the details from different types of images.

4.5.3 Multi Modal Displays for Web Browsing

Presenting textual information using audio output devices is fast and efficient. Tactile displays can present contents like graphics, images, diagrams, tables etc. with much accessibility. Hence by using multimodal displays which use a combination of both audio and tactile output can provide enhanced experiences for blind users. Multimodal displays will be able to present contents which is not accessible through screen readers or Braille displays.

4.5.4 Haptic Rendering Techniques for Animations

Haptic rendering techniques are capable of providing tactile realization of virtual objects. These techniques use a haptic interface like data glove or phantom robot to give touch experience to user by providing essential force feedback. Haptic rendering techniques can be used to improve the experience with complex animation which is almost inaccessible to blind people. The basic haptic rendering techniques for rendering 3D object are discussed in the paper [1]. An application for haptic rendering along with computer vision techniques, which aids wayfinding for blind people is discussed in [51]

Chapter 5

Summary

Visually impaired persons are not able to utilize computers and the internet because of accessibility issues. Websites which use new technologies like Flash animation, JavaScript, HTML 5 etc. have serious accessibility problems when accessed using assistive technology.

In our study we have analysed web accessibility problems under four categories. Accessibility problems because of dynamic contents, complex page layout, navigation structures and limited page overview constitute the four categories. Accessibility problems are analysed from the perspective of a screen reader user. Experiments were conducted using screen readers and computer monitors to find the various web accessibility problems under each category. Accessibility problems specific to e-commerce websites are also considered in the study.

Websites which conform to accessibility standards can provide better accessibility to a large population of visually disabled people who use screen readers. In the study we have checked all the accessibility problems identified against WCAG 2.0 guidelines and have proposed changes to improve the existing WCAG 2.0 guidelines. We have also suggested recommendations for screen readers and web browsers to provide accessibility in case the website has not followed accessibility standards. Including the concept of accessibility in web design courses and adding tutorials on accessible web design in on-line technology websites will be a good way to educate people on web accessibility.

Adhering to accessibility standards alone will not provide a rich user experience for blind people. We have some suggestions under enhanced solutions which we think are capable of providing a sophisticated web browsing experience for blind people. Our further aim is to

explore these enhanced solutions. In our opinion screen readers will remain popular media for web browsing for visually impaired people, unless a solution which requires comparatively less training and provides better web experience than the currently existing assistive technologies comes into existence.

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