Mobile Web 2.0

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Chapter 1

The blind leading the blind: Web accessibility research leading mobile Web usability.

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Abstract

Web 2.0 is truly here: Web applications are becoming widespread and pervasive, powerfully combining social networks, user-generated content, and the ability to make Web pages dynamically update. In the rush to implement these new ideas, however, insufficient regard has been given to enabling all users to access, and interact with, the information. In particular, people with visual impairments can struggle to understand even what a page is offering, let alone use it effectively, and those with motor impairments find it difficult to input information. Web Accessibility refers to the practice of making pages on the Web accessible to all
users, especially to those with disabilities. Disabled people typically use assistive technologies to access Web pages in alternative forms such as audio or Braille, or to ease data input, and research has shown that many of the difficulties encountered by these users are also encountered by people using mobile devices to access the Web. Given the overlap between the needs of disabled users and mobile users, we examine this relationship in the context of Web 2.0 — can the emerging solutions for Web 2.0 accessibility, such as WAI-ARIA, also benefit those people wishing to access the same sites using mobile devices?

1.1 Introduction

The World Wide Web (Web) is characterised by a set of innovative and rapidly changing technologies. While the power of the Web is due in no small part to its ability to facilitate these rapid changes, a Web constantly in flux introduces problems and complexities for both users and slower moving technologies such as hardware devices, programming paradigms, and operating systems. Nevertheless, the Web is re-purposing these slower moving technologies by becoming mobile, by becoming the platform, and by reinventing the programming paradigm. In all cases, the Web updates old tools, techniques, and technologies placing network connectivity at their heart, to build a world of Remote Procedure Calls, Representational State Transfer (RESTful) interfaces, and Web-centric Application Programming Interfaces (API). Indeed, the rush of technical innovation has happened so quickly that terms have been proposed to differentiate the original Web from its genuses; Web 2.0 is one such term.

While everyone agrees that we are in the Web 2.0\(^1\) age, there is still a lack of understanding as to what ‘Web 2.0’ actually means, implies, or requires; the term can mean radically different things to different people. For instance, many people talk about Web sites degrading gracefully, but the addition of Asynchronous JavaScript and XML\(^2\) (AJAX) scripting to Web pages can render them completely unusable to anyone browsing with JavaScript turned off, using a slightly older browser, or using a browser as part of a mobile device. In the rush

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\(^1\) A phrase coined by O’Reilly Media, referring to a supposed second-generation of Internet-based services.

\(^2\) Extensible Markup Language [http://www.w3.org/XML/](http://www.w3.org/XML/).
to implement these new ideas insufficient regard has been given to enabling all users to access, and interact with, the information. In particular, people with visual impairments can struggle to understand even what a page is offering, let alone use it effectively, and those with motor impairments find it difficult to input information.

Web Accessibility (see section 1.2) aims to help people with disabilities to perceive, understand, navigate, interact, and contribute to the Web. There are millions of people who have disabilities that affect their use of the Web. Currently most Web sites have accessibility barriers that make it difficult or impossible for many people with disabilities to use the sites. Web accessibility depends on several different components of Web development and interaction working together, including software, developers, and content. The World Wide Web Consortium (W3C) Web Accessibility Initiative (WAI)\(^3\) recognises these difficulties and provides guidelines for each of these interdependent components. There are also other organisations that have produced guidelines, but, the WAI guidelines are more complete and cover the key points of all the others. There are, however, no homogeneous set of guidelines that designers can easily follow. Disabled people typically use assistive technologies\(^4\) to access Web pages in alternative forms such as audio or Braille, or to ease data input, and research has shown that many of the difficulties encountered by these users are also encountered by people using mobile devices to access the Web. Indeed, the link between mobility and impairment is suggested by Sears and Young (2003) who define a new type of impairment (see section 1.3.1) in which an able-bodied user’s behaviour is impaired by both the characteristics of a device and the environment in which it is used. This behavioural change is defined as a situationally induced impairment and is often associated with small devices such as mobile phones or Personal Digital Assistants (PDAs) used in a mobile setting or constrained environment.

Web technologies have become key enablers for access to content through desktop and notebook computing platforms. These same technologies have the potential to play the same role for content access from mobile devices too. However, mobile Web access suffers from interoperability and usability problems that make the Web difficult to use for many people (see section 1.3). Current work in mobile Web accessibility focuses in two main

\(^3\)See [http://www.w3.org/WAI/](http://www.w3.org/WAI/).

\(^4\)Assistive technology refers to hardware and software designed to facilitate the use of computers by people with disabilities.
areas: (i) developing a set of technical “best practices” and associated materials in support of the development of Web sites that can be easily viewed and interacted with on mobile devices, and (ii) identifying device information required for content adaptation which includes the development of services that provide device descriptions in support of Web-enabled applications. In practice there is a tremendous commonality between the Mobile Web and Web accessibility, and this is why lessons learned creating Web accessibility are important for the Mobile Web. However, little is understood of the inter-play which will take place between the mobile Web and Web 2.0 domains (see section 1.5). Indeed, accessibility specialists are only just beginning to find solutions for making Web 2.0 content, in the form of AJAX, accessible. The main focus of this accessibility effort is directed toward Accessible Rich Internet Applications (ARIA and now WAI-ARIA) which defines new ways for functionality to be provided to assistive technology, and thereby tries to make these updates visible in “live regions”, in addition suggesting how updates are handled (see section 1.5.2).

Given the overlap between the needs of disabled users and mobile users, we examine this relationship in the context of Web 2.0 and conclude (see section 1.6) that the emerging solutions for Web 2.0 accessibility, such as WAI-ARIA, can also benefit those people wishing to access the same sites using mobile devices. The aspects of WAI-ARIA which enable visually disabled users to access Web pages may also enable mobile users to be alerted to off-screen updates, trivial and non-trivial information updates, and interaction conformation.

1.2 Accessibility

The Web is a primary source of information, employment and entertainment for people with disabilities (European Union Policy Survey 2005), and its importance cannot be underestimated. Ensuring it is accessible is not always straightforward, however: both the technology used to access the Web and the underlying design of a site can have a huge impact on how open it is to someone with a disability.

Input devices and displays can significantly affect not only Web access, but computer access more generally. As the standard keyboard, mouse and monitor set-up is not always
1.2. ACCESSIBILITY

appropriate for, or indeed physically usable by people with certain disabilities, assistive technologies provide an alternative means of access. There is no ‘catch-all’ solution to providing accessibility to Web based resources for disabled users. Instead, each disability requires a different set of base access technologies and the flexibility for those technologies to be personalised by the end-user.

Motor impaired users may be able to read a standard display, but can find it difficult to operate a standard keyboard or mouse (Trewin 2008). A number of specially developed input devices can help users with varying types and levels of disability, including keyboards with specially programmed shortcuts and sticky keys, software (on screen) keyboards operated using a joystick, switch or mouse, pointing devices attached to a movable limb or the head and speech recognition or eye tracking input software.

Profoundly blind users are unable to see a display or operate a mouse, so generally use a keyboard to provide input to a computer, and receive audio output through a screen reader, which ‘speaks’ the contents of the display (Barreto 2008). Visually impaired users who have some vision may use a screen magnifier, with or without a screen reader, to enlarge small parts of the display.

Although deaf users initially appear to be able to access a computer, and therefore the Web, using a standard set-up, this is not necessarily the case (Cavender and Ladner 2008). The primary language of many hearing impaired users is not English but sign language, and textual rendering is therefore not necessarily accessible or appropriate (Huenerfauth 2005). Users with cognitive impairments (termed learning disability in the United Kingdom and intellectual disability in Australia, Europe, Canada), may also find some content difficult to understand (Lewis 2008).

It is not only users with hearing or cognitive impairments who find that it is aspects of the Web content itself, rather than the equipment used to display or interact with it, which renders it inaccessible. The serial nature of audio output means that the visual interaction model, and XHTML structure created to support this model on the Web, must be moved into an audio interaction paradigm (Organisation 2004) so that visually impaired users can access to it. At a basic level, screen readers perform this translation by reading the
As the complexity of Web pages has increased, screen readers and Web browsers for visually impaired users have been created to access the deeper document structure, by directly examining the XHTML or the Document Object Model (DOM). Examining the precise linguistic meaning of the text allows more complex meanings (associated with style, colour etc.) to be derived, and enables users to move between different HTML elements on the page, such as links or headings. This technology is still largely unable to comprehend the meaning of the underlying structure, however, so much of the implicit information provided by layout and appearance is lost.

People with disabilities cannot necessarily be divided into neat groups — many will have a combination of needs that must be met in order to ensure they can effectively access the Web. One section of the population in particular often exhibit unique combinations of disabilities: ‘seniors’ (Czaja 2006). Many members of the ageing population have multiple disabilities that are not necessarily severe, but in combination can still cause decreased Web accessibility (Hawthorn 2000; Kurniawan 2008). Although assistive technologies can be useful to the older user, there is sometimes a perceived stigma in using such devices due to a reluctance to admit to a limitation or disability. As such the assistive technology developer must achieve Web accessibility along with the additional challenge of camouflaging of the access technology itself.

### 1.3 Disabled or Mobile: Same Barriers

There are millions of people whose disabilities affect their use of the Web in ways like those described above, and although an accessible Web means unprecedented access to information for these people, their access remains limited. Likewise, accessing Web pages from mobile devices (e.g., PDAs and other portable gadgets) is becoming increasingly popular. But here too, difficulties arise, this time due to device limitations, such as the small screen size, low bandwidth, and different operating modalities.

The problems that mobile users face when interacting with the mobile Web are similar in many ways to the problems that disabled users face when interacting using a traditional
1.3. DISABLED OR MOBILE: SAME BARRIERS

desktop computer. For example, hearing impaired users have hard time accessing multimedia content if the content does not have captions, while mobile users will miss auditory information if they have the sound turned off (e.g., in public places such as trains or hotel lobbies) or if they are in noisy places. The similarities and commonalities are many (more examples are given below) and the challenges for designing for the mobile Web are similar to those of designing for the Accessible Web (Trewin 2006; Leventhal 2006), but despite this there has been very limited work on systematically comparing these two domains. Unfortunately, previous work has only looked at accessibility problems from a single user group perspective such as visually impaired (Asakawa 2005), motor impaired (Mankoff et al. 2002) or mobile users (Brewster 2002). If designers want to create a page that is accessible by both mobile and disabled users, they have to follow a number of different guidelines and validation tools which means it will be time consuming and costly.

If we understand the overlaps and integrate research into the accessible and mobile Webs, we can develop a common infrastructure where both users and developers could benefit. However, to compare these two domains, we need to consider all the key factors in the Human-Web Interaction. These include input, which refers to various approaches and devices used to deliver information to the Web, content, which is the information that forms Web pages (the code and markup) and output, which refers to the rendering of the Web content by a particular user agent. In the following sections, we discuss each of these factors and pose the question: “do disabled Desktop users and mobile users experience similar interaction barriers”?

1.3.1 Input Impairment

Regarding input, existing studies show that there are two common problem domains, target acquisition and typing input. A dexterity impairment can have high impact on these with regard to the accuracy, completion times, and error rates of clicking and pointing to a target. For example, because of Arthritis (an inflammation of the joints) one might be unable to make the necessary movements. Similarly, spasms (sudden, involuntary contractions of a

5Web accessibility evaluation tools, http://www.w3.org/WAI/ER/tools/.
CHAPTER 1. THE BLIND LEADING THE BLIND: WEB ACCESSIBILITY RESEARCH LEADING MOBILE WEB USABILITY.

muscle) can cause unwanted diversions or mouse clicks during pointing movements. People with Parkinson’s disease click more slowly, giving even greater opportunity for slippage (Trewin 2006). Similarly, a situationally-induced impairment, such as a change in lighting (Barnard et al. 2005) or movement (Lin et al. 2007), can also have high impact on accuracy, completion times and error rates of typing and clicking and pointing to a target. Bradykinesia (a slowness in the execution of movement) will cause typing rates in a physical keyboard to be greatly reduced (Sears and Young 2003). Similarly, Brewster (2002) show that when a mobile device is used in a more realistic situation (whilst walking outside), usability is significantly reduced (with increased workload and less data entered) than when used in a laboratory.

Different techniques and devices are available for text input such as keypad, voice recognition system, eye-tracking, head-tracking, etc., however, the keyboard is still the most widely used. Either because of an impairment or a situationally-induced impairment (Sears and Young 2003), the task of inputting text can easily become challenging. The common barriers experienced range from very well-defined problems, such as pressing a key unintentionally, to very generic problems, such as not being able to use a keyboard. Detailed information about common input errors can be found in Chen et al. (2008). For example, Bounce error occurs when a user unintentionally presses a key more than once, producing unwanted copies of the intended key. This problem is observed for both motor impaired and ageing users, and is mainly due to a user’s finger twitching when releasing a key (Trewin and Pain 1999). Small device users mainly experience this problem when they use a multi-tap input system where the user presses each key one or more times to specify the desired letter (MacKenzie et al. 2001; James and Reischel 2001). A multi-tap method works by cycling through letters on a key with each successive press, however this causes problems when two letters on the same key are entered consecutively (Silfverberg et al. 2000). Another common input error is Transposition error, which refers to the situation where two characters are typed in reverse order (Trewin and Pain 1999). This problem is observed with motor impaired, ageing and mobile users Trewin and Pain (1999); MacKenzie and Soukoreff (2002).

The second major task when considering input is target acquisition: pointing and selecting. The two main reasons for these problems are the difficulty of positioning the device
1.3. DISABLED OR MOBILE: SAME BARRIERS

cursor within a confined area, and the challenge of accurately executing a click (selection). *Pointing* and *Dragging* with a mouse is difficult for motor impaired and ageing users due to their limited hand movement and control. Trewin and Pain (1999) suggests that motor impaired users have problems pointing at small on-screen objects using a mouse, and that the smaller the object is, the harder it is to pinpoint (Hwang et al. 2004). Pointing accuracy also affects mobile users who rely on the touch-screen and stylus for input. Brewster (2002), illustrates that as the on-screen button becomes smaller, the subjective workload of mobile users increases, and the overall performance decreases. Pointing is also a problem for visually impaired users who cannot see clearly (Jacko et al. 2003). *Clicking Error* refers to the situation where a user slightly moves the mouse while performing a clicking task. This may cause the cursor to move out of scope of the target object and thus generate a clicking error. Studies (Trewin et al. 2006) suggest that clicking error affects motor impaired users as well as ageing users (Smith et al. 1999; Moffatt and McGrenere 2007; Chaparro et al. 1999). Additional studies (Brewster 2002), find that ‘slip-off’ error is also experienced by mobile touchscreen users and similar work (Jacko et al. 2003) shows that clicking error also affects visually impaired users. Finally, another generic common problem is *Inability to use a mouse*. Severely motor impaired users find mouse use difficult (Sears and Young 2003) as do some visually impaired users with low vision (Jacko et al. 2003). In addition, mobile users cannot use the mouse due to device size limitations (Greenstein 1997).

1.3.2 Output Impairment

Output refers to the rendering of the Web content through user agents. User agents include “any software that retrieves and renders Web content for users, such as Web browsers, media players, plug-ins and assistive technologies” (Gunderson and Jacobs 1999). People encounter output problems when their disabilities hinder the access to Web content of certain formats. On the other hand, it is the user agent that delivers Web content to end users, which means a badly designed user agent can result in output problems even if the Web content is created accessible for disabled users. Furthermore, disabilities and limitations of the device can

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6Pointing is also referred as “target acquisition”, “area pointing”, “mouse pointing”, etc. which is the action of acquiring on-screen targets with the mouse cursor or with a pen/stylus (Wobbrock and Gajos 2007).

7Also referred as accidental clicks (Trewin et al. 2006) or drifting errors (Moffatt and McGrenere 2007).
also affect the installation and configuration of the user agents with which people access the Web. Small device users and disabled users can experience similar output problems. The User Agent Accessibility Guidelines Working Group (UAWG) from Web Accessibility Initiative (WAI) has published User Agent Accessibility guidelines 1.0 (UAAG 1.0) (Jacobs et al. 2002). UAAG 1.0 provides guidelines for designing user agents that lower barriers to Web accessibility for people with disabilities.

When we look at the accessibility problems experienced by disabled and small screen device users, we can see that there are also common barriers regarding output. For example, people with visual impairments have limited access to information that is visually presented, thus making it difficult to perceive or use. Similarly, mobile users’ vision is limited by the size of the screen and lighting conditions (Barnard et al. 2007; Duchnicky and Kolers 1983; Jones et al. 1999; Reisel and Shneiderman 1987). Therefore, both of these user groups can experience barriers in accessing and using the user agent. Another common barrier example is having limited access to structured elements in Web pages. Lazar et al. (2007) conducted a survey on what frustrates screen reader users on the Web with 100 blind users; one of the top causes of user frustration was the confusion caused by page layout. Screen reader users sometimes have difficulties locating themselves within a page, especially when tables are used to display texts or other objects in proximity. Similarly, it is difficult to fit large tables into small displays on mobile phones or PDAs due to the restriction posed by the screen size. To reduce the width of a table, either the Web content developer or the user agent must reduce the number of columns by splitting a table into multiple, narrower tables. However, this will increase the use of vertical scrolling, and a user’s ability to compare information in one table will be hindered by the complications of reading multiple tables (Watters et al. 2003).

Finally, both mobile users and disabled users experience an output barrier when there is a lack of confirmation. Zajicek and Hall (2000) have conducted experiments with older visually impaired Web users using a voice Web browser. After a user made input, the browser provided speech dialogues that reassured a user the interaction was going well. Results showed that such confirmatory messages increased a user’s confidence in the interaction and aided the construction of conceptual models of the web pages. The trade off, however, was between increasing confidence and adding to the length of the interaction. Confirmatory
messages demanded yet more attention from the user and could be irritating to confident users (Zajicek 2004). Another problem that sighted aged Web users experience is that they do not know what is clickable and what is not (Coyne and Nielsen 2002; Chadwick-Dias et al. 2003). They need specific confirmation, such as the pointer changes to a pointing finger over a link, to indicate that an item is clickable. Morell (2002) suggested that additional feedback should be provided to aged users for confirmation after they click a clickable item. Small device users experience similar problem: Chen et al. (2008) showed that when accessing the Web from a PDA, mobile users can easily get confused if not enough feedback was provided after an input. For example, a mobile user would keep clicking a button on a Web page several times if no feedback was given after the first click. They suggested that immediate feedback should be provided for user actions, such as page redirecting, and widget loading. The function of providing feedback should be configurable: for aged and inexperienced Web users, more feedback should be provided for basic actions, for example, clicking on a link; and for experienced Web users, feedback should only be provided for advanced actions, e.g., form submission.

1.3.3 Content Impairment

As with input and output, existing research suggests that when people without disabilities access Web content with mobiles they experience situationally-induced impairments and they face similar barriers to when people with disabilities access the Web (Trewin 2006; Sears and Young 2003; Wobbrock 2006). To illustrate the common barriers to content between mobile and disabled users, we give some examples below under the following four principles (Yesilada et al. 2008; Chuter and Yesilada 2008):

1. **Perceivable:** Information and user interface components must be presentable to users in ways they can perceive. For example, if information is conveyed solely with colour, then users who are blind or colour blind can miss or misunderstand information (Disability Rights Commission (DRC) 2004; Coyne and Nielsen 2001). Small device users might also experience similar problems — many screens have a limited colour palette and colour difference is not presented, or the device may be used in poor lighting (e.g.,
outdoors) where colours are not as clearly perceived (Barnard et al. 2007; Duchnickicky and Kolers 1983; Jones et al. 1999). Due to the decline in vision, older users usually have problems with visual acuity, distinguishing colours of similar hue, contrast discrimination and a reduction in the efficacy of parafoveal vision (Kurniawan 2008; Zhao 2000; Newell et al. 2006).

Another common example of a perception barrier is when non-text objects in a page have no text alternative. A user who is blind, or using a browser or assistive technology that doesn’t support the object (Earl and Leventhal 1999; Takagi et al. 2004), cannot perceive this type of content so will be unable to access the information it contains. A similar problem can face mobile users, who may turn off images to reduce download times and costs, or whose user agents have limited support for non-text objects. Equally, some mobile user agents shrink images in size to fit the device’s screen; this can make them meaningless.

2. **Operable:** User interface components and navigation must be operable. An example of a barrier to operability is when a page does not have a title or if the title is inappropriate. In this case, disabled, aging and mobile users, all of whom have difficulty scanning a page, cannot get an overview of the content. Additionally, blind users typically use a screen reader feature to get a list of the currently open windows, by window title (Disability Rights Commission (DRC) 2004). Therefore, if the page title is long, inappropriate or missing, the user cannot perceive the content. With mobile devices, the page title is truncated to fit the narrow viewport (Rabin and McCathieNevile 2005).

Another common barrier to operability is that faced when link labels are not descriptive. In this situation, the user cannot determine whether or not to follow a link because the link label does not contain sufficient information. Screen reader users often access a list of the links on a page, which are presented without context — if a link label is not descriptive, the user will be unable to determine the purpose of that link (Penev and Wong 2008). Older users have also been shown to be hindered by non-descriptive hyperlinks, such as ‘click here’ (Dalal et al. 2000; Caldwell et al. 2008), and to benefit from expanding the link text to describe the result of clicking (Sayago et al. 2009).

3. **Understandable:** Information and the operation of the user interface must be under-
standable. Examples of the types of problems that can be faced by users here are those caused when content spawns new windows without warning. In this situation, the user can become disoriented among windows, is unable to use the ‘back’ button as expected (Bailey et al. 2005; Chadwick-Dias et al. 2003), or can close a window, not realising it is the last in stack, accidentally closing the browser instance. While potentially difficult for all users, these problems are exaggerated for users with low vision, or restricted field of vision, or cognitive disabilities, who do not realise the active window is new (Craven and Brophy 2003; Coyne and Nielsen 2001), and for those using small screen devices, where multiple stacked windows hide each other. Blinking, moving, scrolling or auto-updating content can also be difficult to read or comprehend or interact with, particularly for older users and people with reading or learning disabilities or cognitive limitations (Lewis 2008; Ellis and Kurniawan 2000; Zhao 2000; Groff et al. 1999). The reduced viewport size or poor ambient lighting can make it difficult to see this type of content on mobile devices.

4. Robust: Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies. An example of the problems that may arise when content is insufficiently robust is what happens when content has invalid and unsupported markup. While such content can sometimes be rendered correctly by standard browsers, assistive technologies (Edwards 2008) and older mobile browsers (Siek et al. 2004) may be unable to display it, causing problems for both disabled and mobile users. Similarly, if a user’s assistive technology or browser doesn’t support scripting, or the facility is turned off (Rabin and McCathieNevile 2005) (e.g., to enhance security), content that requires scripting will not be accessible.

1.4 Disabled or Mobile: Same Solutions

At present, most solutions are designed only to solve problems for a single user domain. However, with an understanding of the common problems discussed in the previous section, it is possible to migrate solutions from one domain to another to benefit all users. Some solutions are common between mobile and disabled users and some solutions are disjoint,
however there are some solutions that are not common and can potentially be migrated between these user groups. For example, regarding input, small–device users share the following solutions with motor impaired users: Soft Keyboard (Hinckley 2003), joystick, voice, prediction facility, tablet, touchscreen and multi-modal interface (Chau et al. 2006; Wobbrock et al. 2004; Mankoff et al. 2002; Felzer and Nordmann 2006; Silfverberg et al. 2000). Similarly, voice interaction is also used on small devices for speech dialling or editing text messages (Karpov et al. 2006) and used by motor impaired (Neto et al. 2009) and visually impaired users (Manaris and Harkreader 1998) as a substitute for both the keyboard and mouse. A text entry facility, which ‘predicts’ the words a user is entering by looking for the most relevant key combination in its internal dictionary (Minneman 1986) has also been adopted to speed up input. Multi-modal interfaces which combine a number of modalities such as head movement and speech for motor impaired users (Malkewitz 1998) and handwriting and speech for mobile users (Serrano et al. 2006) have also been suggested as possible input solutions, and are gaining popularity.

Some solutions exist for disabled users, but not for small device users. For example, regarding input, the following solutions exist for motor impaired users but not for small device users: One-handed keyboards (Matias et al. 1996), trackballs (Wobbrock and Myers 2006), eye tracking (Majaranta and Räihä 2002), and switch interfaces (Mankoff et al. 2002) as well as predefined texts or graphical icons (Majaranta and Räihä 2002). Similarly, regarding output, non-speech output and tactile output are used to help visually impaired desktop users and aged desktop users to access the Web (Ramloll et al. 2001). These solutions may also be useful to small device users who access multi-media content in a noisy environment or small device users who cannot access heavy Web content due to traffic cost or connection quality.

Finally, some solutions exist for small device users but not for disabled users. For instance, regarding input the following solutions exist for small device users but not for motor impaired users: chording (where a few keys are used in different combinations to represent a large number of characters), auditory feedback, haptic feedback and handwriting input. As chording requires many fewer keys than a standard keyboard, a chording keypad can be used with just one hand and thus may be useful to small device users who usually need to
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type with one hand (Lyons et al. 2004) only. Some motor impaired users have difficulty in pressing keys simultaneously, so they may not be able to use chording keyboards. However, for motor impaired users who lose one hand but have fine control over the other, chording keyboards may improve their typing performance.

1.5 Web 2.0

So far we have discussed the similarities in Web access between mobile users and disabled users in the context of the ‘traditional’ Web. The Web is evolving, however, and ‘Web 2.0’ is widely available on mobile devices (Holmquist 2007) (‘Mobile 2.0’(Holmquist 2007) or ‘Mobile Web 2.0’ (Jaokar and Fish 2006)). Even though the benefits of Web 2.0 in mobile settings is indisputable, there are some technological limitations: while some mobile devices, especially smart phones, are quite powerful, devices can still be a technological barrier to using Web 2.0 on mobile devices. User agents, critical in supporting mobile Web 2.0, are also still limited. This means that barriers to effective Web use are changing for both disabled users (Gibson 2007) and mobile users.

We have seen that users of mobile devices encounter barriers to Web access that are the same as, or similar to, the barriers that people with a range of disabilities face when using traditional desktop equipment. In section 1.3 these barriers were introduced with reference to input, content, and output, and issues were identified in each area. So while the similarities in barriers, and overlapping solutions (both actual and potential), are valid for the ‘traditional’ Web, how are they different when the content is Web 2.0?

1.5.1 Web 2.0 Accessibility Challenges

‘Web 2.0’ is a mixed-bag, with different meanings to different people. Often it is characterised by social networking, and user-generated content; to others it is more technological — the use of technologies such as AJAX allowing Web pages to appear and behave more like an application than a document. Which of these aspects of Web 2.0 pose accessibility problems,
what are the characteristics of these problems, and what is being done about them?

While noting the potential for social exclusion if sites are inaccessible, social networking is not inherently problematic for either disabled or mobile users. That is not to say that current implementations are easy to use: indeed they suffer the same accessibility barriers as many other traditional Web sites (e.g., registration problems (Meiselwitz and Lazar 2009)). No, the problems with social networking sites arise from the way in which they typically incorporate the other major aspects of Web 2.0: user-generated content and dynamically updating content.

As with social networking, of which it is an integral part, user-generated content need not necessarily create accessibility problems. In reality, however, it often appears to lead to pages which are busy, cluttered and disorganised, and can thus be difficult to understand. Users inexperienced in Web development will often generate content with sole consideration for how it looks, an approach that can lead to poor use of semantic tags from HTML. For example, headings might be differentiated from the rest of the text only by colour or font size, instead of using the HTML heading tags. When these pages are encountered in a non-visual medium, such as through a screen reader, the differentiation is lost and understanding the text becomes more challenging. Even many of the more sophisticated users generating this type of content will be unaware of recommendations such as WCAG 2, indeed many will probably not even consider that their content will be accessed using any means other than those they employ themselves.

Authoring tools, both stand-alone and those built into pages, have an important role to play here, in terms of both their input and their output. User-generated content involves users at both ends of the process, so true accessibility means that not only must the output, the resulting Web page, be accessible, but also that the tools used for generating this content must be accessible (Power and Petrie 2007). Since content generation requires much more input than traditional ‘Web surfing’, it is here that the input barriers become particularly problematic.

Perhaps the greatest challenges of Web 2.0 for users of assistive technologies arise from the technological advances that enable content to update dynamically. Traditionally, Web
pages did not change once they had been served. In this context, they have many of the characteristics of a document. Despite the potential for multimedia, with sound and video components, the page acted as a page: it could be read (or watched, or listened to), and not (except in a very limited sense) interacted with. Web pages did not contain controls and did not change over time: they were static. The rise of scripting technologies, and particularly AJAX, has changed this. Pages are often now dynamic and interactive — the whole model of a page has changed quite dramatically. Not only do readers have the challenge of navigating the Web, and understanding and relating different sections of a page, but now they may also need to understand whether the page has changed, which parts have changed, and whether the changes are of interest.

A typical use for AJAX is in Web-based email access. These are often designed so that the page appears like a standard desktop mail client, with a list of folders, a list of messages in the currently selected folder, and the contents of the currently selected message. The list of messages is a list of links, but selecting one does not take the user to a new page; instead it dynamically updates the region of the page showing the current message. The list of folders behaves in a similar manner. Consequently, users are able to read many different emails, all without actually moving to a new page. Making changes, then perceiving and understanding what has changed is critical to the usability of the system.

While these Web applications are seen as being appealing to users, in fact they can pose multiple problems to some people. Returning to the four principles of WCAG, for applications to be accessible they must be perceivable, operable, understandable and robust (see section 1.3.2). AJAX Web applications can fail on all counts. Since HTML has limited native controls, more sophisticated ones, such as sliders and trees must be generated using graphics and scripting; these are known generically as widgets. When the function of a widget is only implicit in its appearance, screen reader users cannot recognise it (the control may appear simply as a list of links): the widget is not perceivable. Furthermore, keyboard access to these widgets is usually lacking, meaning that only mouse users are able to control them: the widget is not operable. A different barrier faces users of sites with “hotkeys” enabled, since using these can require screen readers to be put into an unfamiliar and difficult to use mode (Hailpern et al. 2009). Even if a user manages to operate a control, it can be difficult
or impossible to discover its effect — while sighted users can scan the whole page to quickly identify changes, users with a restricted visual or audio view of the page must search around to find it (screen readers do not typically notify users of dynamic updates (Brown and Jay 2008; Hailpern et al. 2009)). The widget operation is not understandable. Finally, the use of scripting in widgets necessarily means that the Web application is not usable by people whose access technology does not support this: the widget is not robust.

1.5.2 Research

Currently, the most significant attempt to tackle the accessibility of Web 2.0 widgets is WAI-ARIA: the Accessible Rich Internet Applications Suite (ARIA) (Gibson 2007) from the W3C’s Web Accessibility Initiative. The essence of the ARIA solution is to add semantic metadata to a page, and through doing so can address the accessibility problems outlined above\footnote{The WAI has a primer on ARIA: http://www.w3.org/TR/wai-aria-primer/}. First, WAI-ARIA extends the HTML tabindex, which allows controls to be focusable, allowing users to perceive and operate controls as they move around the page. Second, it introduces the role attribute to define the function of a widget, e.g., role='treeitem', allowing the information implicit in the visual construction to be made explicit to both the user and their assistive technology. Third, WAI-ARIA has tags to hold any states or properties of a widget; these may be queried to allow the user to understand the current state of a control (e.g., a slider is at position 30 out of 200). Note that ARIA tags are not expected to be hand-coded into static HTML, but set and modified as part of the scripting. Finally, ARIA provides a mechanism for noting live regions — those parts of a page that may be updated. These can have further attributes to denote what types of update to announce (e.g., just additions), how important it is to announce the update, and how much of a region should be read when part is updated.

While the information the ARIA attributes and properties provide can help, it cannot be used in a naïve manner. Thiessen and Chen (2007) explored the difficulties in scaling ARIA for highly active pages; they found using ARIA effectively became problematic when updates occur frequently. Understanding how to use ARIA tags, both from the point of view
of the developer (which settings to choose) and from that of the user-agent and assistive
technologies (how to use the tags to help determine exactly when and how to present an
update), is difficult, and we believe that a good understanding of how sighted users interact
with dynamic updates, and why, is essential.

At the University of Manchester, we are undertaking such a project — SASWAT: Single
Structured Accessibility Stream for Web 2.0 Access Technologies\textsuperscript{9}. Eye-tracking studies with
sighted users have given us an understanding of how attention is allocated to different types
of dynamic update, and the model resulting from these studies has been used to propose
techniques for audio interaction with these pages. This research showed that while most
updates that happen automatically are ignored, those triggered by user actions are usually
attended to, at least briefly (Jay and Brown 2008). This latter group could be split further,
with those updates that were explicitly requested (e.g., by clicking a control) viewed by 98%
of participants, and those that were simply initiated by user action (e.g., typing in an input
box) viewed by 82%.

Borodin et al. (2008) have also been investigating the problem of presenting updates to
screen reader users, but have concentrated more on the ways of detecting changes than how
they should be presented. In particular their system, known as Dynamo, takes the approach
of dealing with all changes, both within the page (i.e., dynamic updates) and between pages
(i.e., moving to a new page) in the same way. Users were notified that a change had taken
place by a short non-speech sound, and could move to the new content with a command.
They found that participants in their evaluation liked the ability to jump to new content
when pages dynamically updated.

Unifying these two types of change could be advantageous for pages using older technolo-
gies. For example where a page needs to be refreshed to show new information, comparing
the two could allow the user’s focus (e.g., screen reader focus, or the position of the view port
on a small screen device or magnification system) to remain roughly constant, eliminating
the need to navigate past the top of the page to reach the new content.

\textsuperscript{9}http://hcw.cs.manchester.ac.uk/research/saswat/
1.5.3 Crossover

In section 1.3, we saw how mobile users share many of the problems that different disabled users face when Web browsing. We have also seen (section 1.5.1) some of the particular challenges that Web 2.0 is posing disabled users; which of these are likely to pose problems to mobile users?

Probably the most obvious similarity is the difficulty screen reader users have in identifying that an update has had an effect, and finding which region of the page it has changed. The small screen can mean that only a small region of the page is in view at any one time, so it may be necessary to use the control, then move around the page trying to find the new region. Spotting such changes when the region is visible is usually easy, since the attention is attracted towards such events (Carmi and Itti 2006), but if not visible, it is necessary to use a combination of memory and context to discover it.

Keyboard access is another issue that may also affect mobile users. Even using a stylus on a touchscreen, high resolution screens displaying large portions of a page will end up with small controls that make clicking errors more likely, particularly if the user is actually moving. Interactions initiated by hovering the cursor over a field prove difficult for mobile and disabled users alike. Mobile and screen reader users often have no pointer to hover, while people with motor impairments can find holding a mouse in one position difficult (Hwang et al. 2004). Indeed, research for the SASWAT project showed that even sighted users have difficulties with this type of interaction (Jay and Brown 2008).

So we see that Web 2.0 poses difficulties not only for disabled users, but also for people wishing to access it via mobile devices (while noting that there is overlap between these groups). This apparent bad news is potentially, however, beneficial to all. As we saw for the traditional Web, when two groups face similar barriers, solutions may also be transferred. So those technologies currently being developed to help disabled users may be leveraged by mobile systems, and vice versa.

The information provided by WAI-ARIA markup, and the models produced by research such as SASWAT can be used, independently or together, to improve handling of dynamic
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updates on small screen devices. Changing the position of the view to show updates can help users understand how an interface works, and to use it more efficiently, but it is not appropriate for all types of update. If WAI-ARIA were to be used to help mobile users, we run into the possibility of a virtuous circle: technology developed for disabled users helps mobile users, which accelerates the uptake of ARIA amongst developers, thereby benefiting disabled users. The main obstacle to this, that mobile browsers do not currently support ARIA, demonstrates how little the overlap between these communities has been recognised thus far.

The same process might be seen for the problems of data input. If content is designed to be accessible to assistive technology users (e.g., by following WCAG 2.0 guidelines), Widgets become perceivable and operable without a mouse, so it should also be usable by mobile users. Here we see benefits for both groups: if developers reject interfaces which are unusable for mobile users, the results should be better for users of assistive technologies. Additionally, the increasing importance of data input might speed migration of those techniques mentioned in section 1.4. This could benefit disabled groups as increased demand leads to further development and lower costs. The very ability to use the Web while mobile can cause problems, with usage of mobile devices when driving associated with an increased risk of accidents. This, along with the other difficulties highlighted above is prompting research and development from device manufacturers and software developers into simplifying interfaces so that a minimum of attention is required. There is potential here for improvements, both in hardware and software, which may also benefit aging or disabled users.

While concrete technologies can be used to aid users, improving the quality of the content is less easy. One way of achieving accessible content is to give users authoring tools that ensure, or at least facilitate, accessible content generation. Another is to give users (and, indeed, authoring tool developers) guidelines as to what constitutes good practice. Even though W3C recognises barriers experienced by both user groups and provides such guidelines, these are published as two independent resources – The Web Content Accessibility Guidelines (WCAG) (Caldwell et al. 2008) and The Mobile Web Best Practices (MWBP) (Rabin and McCathieNevile 2005). However, identifying the overlaps would provide benefits to both groups. Allowing pages to be developed and evaluated for both accessibility and
mobile web support together would mean that designers do not need to follow two separate methodologies independently, saving time and reducing the costs.

1.6 Conclusions

We have seen that people using mobile devices to access the Web suffer limitations that reduce the ease with which they can use sites, or even make it impossible. These may result from the limitations of the device or from the circumstances and environment in which it is used. We have also seen that the barriers they face are often remarkably similar to the barriers faced by other groups, such as disabled users or older people, and that, although Web 2.0 is changing the barriers, many commonalities remain.

Sadly, the majority of research and development concentrates on one group or another. The commonalities are not just in the barriers however — the solutions can also be transferred. Technologies, techniques and guidelines designed to benefit one set of users can often also be applied to help a different set. This has been the case for the traditional Web, and remains the case for Web 2.0. Developments such as WAI-ARIA, designed for disabled users, and visually disabled users in particular, have the potential to help mobile users too.

Importantly, we believe that recognising the relationships between the barriers faced by different users has the potential to deliver benefits far beyond a few improvements in assistive technologies or mobile user agents. As the Web transforms into Web 2.0 and the world fully embraces mobile technologies, it is possible that these changes will have a transformative effect on content too. Thus far businesses and organisations have often paid only lip-service to accessibility, wrongly believing that it is an unnecessary cost, rather than a motivator for really considering the usability of their site. It is hard to believe, however, that the same attitude will be taken with mobile accessibility — this is a growing group, and one that is perceived as a wealthy group of customers worth attracting. Furthermore, while very few developers will have explored their sites with screen readers or other assistive technologies, it is likely that the majority will have used mobile devices. In this way, any shortcomings become quickly apparent to those best placed to fix them. We believe that a growing
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consciousness of the issues that surround accessing the Web using devices other than the desktop computer can only benefit all users.
Bibliography


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