Ten Years of *Access for All* from WSE 2001 to WSE 2011

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***Abstract*—At WSE 2001 the theme was *Access for All*. A decade later, this theme is revisited for WSE 2011. We take this opportunity to discuss the past, present, and future of Web accessibility. Five representative categories of Web accessibility are considered: accommodating disabilities, Web literacy, user interfaces, lingual barriers, and open data.**

Keywords-Web accessibility; Web literacy; open data; lingual barriers; digital divide; usability

I. INTRODUCTION

At the *3rd International Workshop on Website Evolution* (WSE 2001) in Florence, Italy, the workshop's theme was "Access for All." The forward for WSE 2001 outlined the vision and motivation for this theme as follows [36]:

> "The beginning of the new millennium provides a singular opportunity to view websites in a new perspective: as a vehicle for truly universal communication. Such an inclusive definition implies that websites should provide comparable experiences to diverse users, irrespective of their national language, physical abilities, or computing platform. In other words, access for all.
>
> Expertise in constructing Web pages that are accessible to the disabled is available but not widely utilized. The explosion of non-traditional computing platforms for browsing the Web, such as PDAs, WAP-enabled phones, and Internet appliances, is forcing Web professionals to rethink the separation of form from content. WSE 2001 provides an opportunity for the exchange on information related to exciting new research and empirical results in areas including (but not limited to):
>
> - Migrating to multilingual websites
> - Enhancing websites to make them accessible to the disabled
> - Making Website content available in multiple formats for multiple platforms"

The vision outlined by WSE 2001 of truly universal communication is still valid and prevailing, despite the rapid evolution of the Web in terms of interaction and presentation styles, browser capabilities, novel (input) devices, and Web-related technologies and standards. A decade after WSE 2001, the issues surrounding access for all are still highly relevant, presenting not only challenges and opportunities to society, but also to Web-related research at WSE 2011.

The *3rd Internet Governance Forum* (IGF) in 2008 called for "Internet for All" [28]. At the meeting, Secretary Singh from the Indian Government's Department of Information Technology said: "The underlying principle of inclusion is equity. And how do we define equity? Equity in our view has three dimensions. Is content available? Is it accessible? And is it affordable?"

The Web has continuously broadened its reach and this trend will continue: more and more people are accessing the Internet and this access is primarily through the Web. The Web's significance is also increasing because desktop applications (implemented on top of a native operating system) are being replaced by (cloud-based) Web applications (running within Web browsers) [39]. The diversity of people that access the Web (e.g., in terms of education, age, and cultural background) is growing as well. Recognizing the continuing importance of access for all for the Web, WSE 2011 re-enacts the theme after ten years, providing an opportunity to reflect on the past, discuss the present, and speculate about the future.

In this paper we identify the current (research) challenges that surround Web accessibility, interpreting this theme broadly according to five representative categories: accommodating disabilities, Web literacy, user interfaces, lingual barriers, and open data. We examine previous work that has addressed this theme, focusing on how WSE has contributed to it. Finally, we give an outlook of open issues and future research challenges.

II. WEB ACCESSIBILITY

The WSE community has long recognized the importance of Web accessibility. At the first WSE event in 1999, Eichmann cautioned, "little attention is paid to issues of comprehension, navigation or accessibility" [14]. When discussing research frontiers for Web systems evolution in 2008, Huang emphasized accessibility in particular, seeing it as "one of the prominent research topics facing [the] WSE community" [20].

In this section we outline the key topics relating to access for all. These topics span a broad range, reflecting the theme's socio-technical and multi-disciplinary nature. At the keynote of WSE 2001, Boldyreff pointed out that "Web accessibility encompasses a variety of concerns ranging from societal, political, and economic to individual, physical, and intellectual through to the purely technical. Thus, there are

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many perspectives from which web accessibility can be understood" [6].

A. Accommodating Disabilities

According to the WHO, more than one billion people live with some form of disability worldwide [43]. Disabilities can relate to hearing, visual, motor and cognitive skills [18]. The US Census in 2000 found 19.3% of the surveyed people have some kind of long-lasting conditions or disabilities and that of those 3.6% have a sensory disability involving sight or hearing [42]. In countries with aging populations, accommodating people with disabilities is an increasing concern.

Often a person has multiple disabilities. A survey from the UK government found that of people with sensory (i.e., visual or hearing) disabilities, 29% also have both motor and cognitive disabilities, 45% also have motor disability, and 6% also have cognitive disability [19]. In other words, only 20% of the people with sensory disability have not other disability. Thus, to be most effective, Web accessibility has to consider a whole range of disabilities and provide (customized) solutions for combinations of disabilities [39].

According to a survey by the US Census Bureau from 2002, 28.5% of severely disabled people use the Internet [35]. Presumably, this number has further increased since then. According to a study only 5% of public websites in the EU are accessible [33]. A smaller study of social networking sites (involving, among others, Facebook, LinkedIn and Twitter) found that there was a low level of accessibility with the leading sites only achieving moderate level of accessibility (3 out of 5) [12]. Major factors that affect accessibility relate to images and scripts (based on a questionnaire of eight people with different disabilities).

Legal obligations are an important driver to make websites more accessible. In the US, the so-called Section 508 policy came into affect in 1998, mandating that Federal agencies have to make their websites accessible to the disabled. The www.usability.gov website provides resources for governmental Web designers on how to make their sites more accessible. Similar to the US, in Switzerland the Federal websites have to implement standards according to the W3C. However, such regulations do not extent to commercial sites.

At the moment there is no comparable EU directive. The European Disability Forum (http://www.edf-feph.org/) has started a campaign "to propose binding EU legislation to ensure that public websites and websites delivering basic services of public interest are made accessible as soon as possible." In the UK the Equality Act of 2010 has strengthened the rules for websites in the sense that it prohibits a "substantial disadvantage" of disabled people in comparison with normal people [13]. With previous legislation it was necessary to prove that it was "impossible or unreasonably difficult" for a disabled person to use a Website. With the new act "it follows that in anticipation of a disabled Internet user accessing a website, its provider is under a duty to provide a service as close as reasonably possible to the 'standard normally offered to the public at large'" [14]. As a "companion" to the new act, the British Standards Institute (BSI) has issued the BS 8878:2010 standard on Web accessibility – Code of practice.

Early on during the Web's commercial rise, Web accessibility was recognized as an important concern. The economical advantages of developing an accessible website were clearly stated by Cartel and Markel in 2001 [8]. The W3C established the Web Accessibility Initiative (WAI) in 1997 "to promote and achieve Web functionality for people with disabilities" [41]. Initial support for WAI came from US President Clinton and important industrial players such as IBM and Microsoft. At the first WSE in 1999, Hebenstreit presented the PINNACLE project from the US General Services Administration's Center for Information Technology Accommodation [18]. The project was conceived "as a broad conceptual framework for including the needs of people with disabilities." Moreover, at WSE 2001, Macìas and Sanchez proposed KAI (Accessibility Kit for the Internet) [27], a tool including components for the analysis and transformation of Web pages and an audio/touch browser. KAI includes also a mixed audio/touch browser for the selective reading of contents.

Unfortunately, accessibility is not the unique problem for impaired people. Cesarano *et al* at WSE 2005 [9] addressed the problem of usability of Web pages for blind users. They observed that the Web pages are designed for viewing on a bi-dimensional screen while screen-reader tools allowing blind user to listen the contents in a linear, one-dimensional way. So, the reading order should be redefined for blind users. At WSE 2005, Di Lucca *et al* presented refactoring heuristic techniques for the automatic reordering of the items of a client Web page were proposed, based on structural analysis and on summarization, with the purpose to reduce the Reaching Time (i.e. the time needed to reach the most relevant contents of the Web page) [11].

The difficulty to satisfy accessibility requirements for any category of impaired individuals has been emphasized by Berry [4] at WSE 2001, who provided a detailed classification of characteristics of hearing impaired individuals and of their relative accessibility issues. In particular, he observed how the satisfaction of the accessibility requirements needed by sighting impaired individuals may sometime be in contradiction with the ones needed by hearing impaired individuals. These problems acquired importance in the last years with the advent and the diffusion of technologies and tools such as VoIP, Web conferencing, Skype and so on, that exploits the Internet as a medium to transmit voice and multimedia.

B. Web Literacy

With the increasing use of the Web and its broadening reach into society, it is a growing concern that all kinds of people should be able use the Web in an effective, informed and save manner. Web literacy contains elements from overarching concepts such as language, information and computer literacy. Web literacy is a part of the digital divide as explained by the WHO: "The concept of the digital divide refers not only to physical access to computers … but also to … social factors – such as illiteracy – that create barriers to social inclusion" [43].

At the 3rd IGF workshop a statement called for a "fight against the linguistic digital divide and ensure the participation of all in the emerging new society" [28]. Among the recommendations are "the introduction of multilingualism in a number of areas including domain names, email addresses and keyword look-up" and to "encourage and support development of free software, such as translation tools, to allow for a global and inclusive multilingualism in cyberspace."

Even though the Web has evolved from rudimentary document-centric distribution and browsing environment into a general-purpose software platform [36], the primary means of communication (still) is the written word. At WSE 2001 Boldyreff *et al* argued for the use of plain English to improve Web accessibility [7]. For example, "jargon and slang should be limited as this can lead to confusion and misunderstanding" and the reading style should follow principles such as "one idea per paragraph" and "simple sentence structures."

Another example of the importance of Web literacy is the legal statements that can be found at websites. At WSE 2008, Kienle and Vasiliu analyzed the legal statements of 15 websites (from traditional businesses, e-businesses, and universities) by tracking their evolution in size and readability [24]. The study found that there was a steady growth in the size of legal text. Readability of legal text was measured with established readability metrics: SMOG and Flesch Reading Ease Score (FRES). Based on the results the authors say "legal statements on the web are difficult to read and comprehend, requiring an education that is at least at college level," which is a concern from the perspective of Web literacy.

Standard, guidelines and certification marks can help to improve and promote Web accessibility. The UK-based Plain English Campaign (www.plainenglish.co.uk/) issues the Internet Crystal Mark based on examination of websites' content, design and layout. Currently more than 90 sites have received this mark. The World Wide Web Consortium (W3C) has a Web Content Accessibility Guidelines Working Group (WCAG WG) that has produced a W3C Recommendation that "covers a wide range of recommendations for making Web content more accessible" [41]. While this recommendation primarily targets people with various disabilities, they also "make Web content more usable by older individuals with changing abilities due to aging and often improve usability for users in general."

Assessment and discussion of WCAG guidelines were addressed by several WSE contributions. In 2002 and 2003, Kirchner reviewed [26] and assessed the effectiveness [25] of the existing tools for the evaluation, repair and transformation of Web pages for content accessibility using the guidelines provided by the Evaluation and Repair Working Group of WAI (http://www.w3.org/WAI/ER/).

A more in-depth discussion of WCAG contents and guidelines was reported by Di Lucca *et al* at WSE 2005 [11], where some limitations of the 2004 guidelines were reported, in relationships with the difficulties in discriminating the accessibility issues and guidelines for different types of disabilities and for obsolete software, too.

Equally important is additional tool support for enhancing existing websites. The BrowseAloud tool (www.browsealoud.co.uk) reads out words that the user marks on a Website. The tool is targeted at users with low literacy and reading skills, dyslexia, and English as a second language. It is free of charge for users, but site owners need to pay a yearly fee that enables the tool for their site.

C. User Interfaces

One of the key factors of Web accessibility is the interface available to the user. As discussed by Tilley *et al* at WSE 2001, interfaces depend greatly on the actual hardware, which can range from a small hand-held device to a fully-fledged PC [37]. The Web has predominantly been accessed by users using the WIMP-based interaction style, but other interactions styles are gaining increased significance.

Thus, Web accessibility nowadays needs to accommodate a broader range of interfaces and interactions styles. As Hebenstreit pointed out at WSE'99, the "human interface should be designed to take full advantage of each person's capabilities … For software developers, the overarching principle is to implement a multi-modal design whereby all major features can be performed in a variety of ways" [48].

Examples of interfaces that augment the traditional WIMP-based approach are aural and haptic interactions [10]. Aural interfaces aim at providing access to content, operations and navigation functionality in auditory form. Design for aural interfaces is challenging. Traditionally, in fact, the navigation in a website is made possible by Web pages which visually communicate virtually instantaneously extensive information, including content, overall semantics, orientation cues, and navigation possibilities [40]. For users who are visually impaired or who cannot look at a screen while performing other tasks (e.g. driving or walking), this multidimensional communication may be difficult or even impossible to access. Existing aural technologies (e.g., screen readers, aural browsers) and web accessibility standards—although powerful and enabling—do not fully address this problem, as they "read aloud" content rather than conceptually translating a complex communication process. In particular, audio is a strictly linear channel that makes aural navigation in large information architectures a very difficult and frustrating task. The fact that users have to listen to page items offered one after the other makes current navigation paradigms structurally inadequate to support an efficient movement in the information space [6].

Current research effort aim at creating effective aural interactive experiences on the web that will extend much beyond a technical translation of the content, and must evolve from new, fundamental design strategies. For example, new patterns for aural information architectures for large web systems were first introduced at WSE 2006 [5].

At a basic level, Web accessibility can be enhanced with tools that (automatically) transform input or output. A typical example is a text-to-speech (TTS) tool (e.g., ReadAloud) that enables users to listen to textual output instead of (or in addition to) reading it.

Conversely, automated speech recognition (ASR) tools can replace motor-based input styles. For the hearing-impaired voice-to-text (e.g., closed-captioning of video) or animations with avatars for sign language can be used. (However, it is important to realize that not all hearing-impaired use sign language [4].) YouTube offers since 2009 machine-generated automatic captions based on ASR [17]. There are also approaches that enable the hearing-impaired to experience music in the form of visualizations and haptic response [32].

Transformation of input typically looses fidelity. For example, translations to plain text " may result in severe loss of context, idiomatic usage, and general culture nuances due to the way the language is structured" [19].

As pointed out before, these approaches do not only benefit the disabled, but also broaden the choices for users in general. For example, people with English as a second language may appreciate captions in addition to speech for video.

Web accessibility on mobile phones is an increasing concern. According to a UN report there are an estimated 4.6 billion mobile phone subscriptions in developing countries, which means that 57% of the population are subscribed [15]. However, 41% of the population in least-developed countries is non-literate – and the literate are often novice users. To improve accessibility specific user interfaces are needed [29]. Based on an ethnographic study, Medhi *et al* recommend to provide graphical cues, voice annotation support and local language support, minimize hierarchical structures, and avoiding of non-numeric text input and scrolling menus [30].

D. Lingual Barriers

Another hurdle for Web accessibility are lingual barriers. For example, Medhi *et al* report that mobile banking services in India almost exclusively issue SMS receipts in English and as a result people have difficulties comprehending them, especially for receipts containing multiple transactions [30].

With the origins of the Web having primarily content in English, the need for localization of languages was recognized early on. In 2001, Huang and Tilley presented issues and challenges in development of multilingual websites [19]. In particular, issues regarding content management, localization, domain naming and organization were enhanced and different possible solutions were discussed. Al Helou and Tilley revisited the topic of multilingual websites at WSE 2010 in the context of internationalized domain name homograph attacks [1].

In WSE 2001 there were two different contributions to this topic. Mehta *et al* proposed a tool for the authoring of multilingual websites, based on the separation of contents from scripting code and on the dynamic generation of pages with a tool called by the authors "Content Manager", that anticipated some ideas currently realized by Content Management Systems (CMS) [31]. From the reverse engineering point of view, Tonella *et al* addressed the problems of maintenance and evolution of multilingual websites that were realized by duplicating every Web page in every target language [38]. They proposed automatic techniques based on natural language processing and on structural analysis of Web pages in order to match different contents of translated pages.

Research in this area has mostly focused on how to design a website for multi-lingual content and how to assure consistency across languages. Recent advances in machine translation are reducing lingual barriers with a different approach. Google's Chrome browser offers automatic translation of websites (based on Google translate) from/to many languages. However, as all automatic approaches they suffer from lower fidelity and thus cannot fully replace multi-lingual sites.

E. Open Data

Web accessibility is often discussed exclusively from the perspective of *how* information is accessed on the Web, but equally import is *what* information is available.

The open data and open knowledge movement advocates creating and obtaining knowledge that can be used and built upon by everyone (www.okfn.org). The vision is that open data can improve government and research, and open up new economic opportunities. Governments are starting to recognize the benefits of open data and increasingly make datasets available. For example, the UK Government's open data initiative (www.data.gov.uk) has made over 54,000 datasets available with the goal to "help people understand how government works and how policies are made." The EU project (www.europeana.eu) is a database of more than 15 million multimedia objects from Europe's museums, libraries, archives and audio-visual collections that often allow free reuse of their content based on attribution and for non-commercial use. Recently, datacatalogs.org was launched as a website that "aims to be the most comprehensive list of open data catalogs in the world."

The open data philosophy contrasts with locking up information behind (commercial) pay-walls and digital rights management techniques. Content that is protected by digital rights management can make it impossible to transform it in a suitable manner. For example, if access to raw text in a PDF is disabled then text-to-speech or automatic translation tools cannot operate. Such features are important given that "it is estimated that less than 5% of books published are available for the visually impaired and this number is estimated at less than 1% in the developing world" [16]. There is also the growing realization that commercial scientific publishers hold research results and that these publishers are primarily driven by considerations for profit. As a result, access to scientific knowledge becomes restricted, especially for people outside of the scientific ecosystem and for people in developing countries.

Open data lowers the legal barriers to transform information to increase accessibility. Copyright puts restrictions not only on the distribution but also on the transformation of copyrighted works because a transformation may be a derivate work that infringed on copyright. Translating a work to a different language is a typical example of a derivate work. Another obstacle is that "current copyright law prohibits the distribution of braille books across national borders, leading to a great deal of

wasted effort on the part of charitable agencies that transcribe books as the same books are transcribed multiple times" [16].

Copyright introduces legal uncertainties that may deter, for example, transcribing a work to sign language, adding closed captions, and simplifying content to make it more accessible to people with mental or literacy deficiencies. Complaints of the Authors Guild caused Amazon.com to remove the Kindle's text-to-speech capabilities [21].

Often the law does not explicitly addresses such issues or it lags behind current technology. In the US the copyright code includes Section 121 on "Limitations on exclusive rights: Reproduction for blind or other people with disabilities" that allows "specialized formats exclusively for use by blind or other persons with disabilities" for "copies or phonorecords of a previously published, nondramatic literary work." The law in Uganda explicitly allows for any work to be transcribed into Braille or sign language for educational purposes of persons with disabilities [22]. However, it was found that this provision was "less useful than desired, often due to a vagueness of scope and lack of specific, detailed guidelines."

Generally, information that is closed to public access via pay-walls or registration/membership is a threat to Web accessibility. Berners-Lee calls these "walled gardens," pointing out the following concern: "Facebook, LinkedIn, Friendster and others typically provide value by capturing information as you enter it […] The sites assemble these bits of data into brilliant databases and reuse the information to provide value-added service—but only within their sites. [...] Each site is a silo, walled off from the others. Yes, your site's pages are on the Web, but your data are not" [3].

Open data should be seen as a baseline to equalize access to information and knowledge, but other accessibility issues need to be addressed as well to mitigate the digital divide.

III. CONCLUSIONS

In a recent interview with the BBC, Tim Berners-Lee said that access to the Internet is a human right [2]. If one agrees with this assumption then Web accessibility as discussed in this paper is a part of it. Web accessibility can play a role in reducing exclusion and marginalization of groups of people and of enhancing equality in access to information.

There are those who argue, "this digital age is causing even more barriers for accessing information in suitable formats rather than a level playing field" [34]. Instead of exploring this concern, in this paper we assume the Web's ubiquitousness as a given and based on that discussed how the goal of "access for all" can be furthered. While WSE often focuses on technical aspects of Web accessibility, it is important to approach this topic from a more holistic perspective, including, for instance, socio-technical concerns. A first step in this direction can be to include accessibility concerns into (Web) governance policies [23].

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