An Integrative Accessibility Engineering Approach Using Multidimensional Classifications of Barriers in the Web

Diana Ruth-Janneck
Technical University of Dresden
Private Lectureship for Applied Computer Science
01062 Dresden, Germany
+49 351 463 38 256
diana.ruth-janneck@pdai.de

ABSTRACT
This paper proposes classifications of barriers in various dimensions we registered in the German study "Web2.0/ Accessible" regarding the use of web2.0 applications by persons with disabilities [1, 2]. These classifications define dimensions and aspects of barriers, which can be used for the development and evaluation of web applications concerning accessibility issues. Various categories of disabilities and their usage pattern concerning web applications are included in the study for the first time. Decision makers, web developers and editors are able to deduce which barriers emerge and how they can be overcome. A contribution to the conception, design and evaluation of accessible web applications is made with the help of these classifications. Due to the integration of the data into a proven process model, an integrative accessibility engineering approach is enabled and presented here.

Categories and Subject Descriptors
H.5.4 [**Information Interfaces and Presentation**]: Hypertext/Hypermedia – *User issues;* K.4.1 [**Computers and Society**]: Social Issues – *Assistive technologies for persons with disabilities*

General Terms
Design, Human Factors.

Keywords
web accessibility, people with disabilities, evaluation, classification, Study Web2.0/Accessible, barriers

1. INTRODUCTION
For a comprehensive participation in society it is essential in the current computer age to also make web applications accessible. People with very different needs, conditions and restrictions are thereby able to fully use the interactive and communication functions. The German organization "Aktion Mensch" established a study "Opportunities and Risks of the Internet of the Future from the Perspective of People with Disabilities" regarding the use of web2.0 applications by disabled people in 2008 in whose evaluation the author significantly participated. This study offers reliable statistical data concerning the use of web applications by people with disabilities as well as which barriers and problems of use occur. It forms the statistical and qualitative basis for the statements and classifications made in this paper.

W4A2011 – Communications, March 28-29, 2011, Hyderabad, India.
Co-Located with the 20th International World Wide Web Conference.

1.1 Study Web2.0/Accessible
The study Web2.0/Accessible [1] involved three steps of the inclusion of data in order to collect both quantitative and qualitative data. On the one hand, experts from science and self-help organizations have been consulted to capture the current state of knowledge on Internet use by people with disabilities. Additionally, advanced Internet users with disabilities were questioned in group interviews about their experiences, habits and the barriers they noticed with web2.0 applications. On the other hand, disabled Internet users were questioned about use habits and barriers with the help of an accessible online survey (including audio files and sign language videos). A total of 671 people have completed the online questionnaire. This number allows making precise statements about the test results. The data of the study proved that the interviewees are very experienced in dealing with Internet applications. They have a high usage frequency and a high technical standard of Internet access available. Accordingly, factors like inexperience, low affinity to the Internet or lacking technical equipment can be excluded [2].

1.2 Methodology
After the mere statistical analysis of the results of the online survey and the transcription of the statements given in the interviews, these data could be related. For this paper, applications with high usage frequency, and therefore with high priority, have been identified and compared to the recorded problem rates. In combination with the statements from the interviews, specific barriers, problems, advantages and strategies in the use of these applications have been worked out for the individual user groups. Correlations between user groups and the problems in applications experienced by them (table 1) and between certain barriers in specific application classes (table 2) appeared in the analysis. A possible interpretation of the collected data is given in this contribution. For a quick inclusion and comparison of the results, they have been organized in matrices at the end of this paper. This type of representation also supports the

implementation of the results in the practical development and evaluation of web applications shown in section 4.

2. DIMENSIONS OF BARRIERS

Barriers in the use of web applications can be caused by various factors and thereby affect different user groups or users with different properties. Besides, the various factors that influence the accessibility of a web application should be considered as dimensions and subdivided into respective items. The dimensions are the user groups or *types of disabilities*, the *application classes* and the *types of barriers*, which contain the areas of accountability in the development and operation process of web applications.

From the emerged classifications of barriers it can be deduced for the different user groups, in which application the recorded barriers exist and which area of accountability is responsible for it. In all dimensions, the items are not to be isolated finally because the transitions between the items can be smooth (e.g. caused by multiple disabilities). In the following, the different items are introduced shortly.

For the following considerations the different kinds of disabilities are summarized into groups because the Internet is used with the help of similar assistive technologies (AT) or use strategies due to the respective disability-related restrictions. A definition and differentiation of the types of disabilities cannot be given at this point. In the following, the most used assistive technologies for the different groups are given:

Visual impairment and blindness: screen magnifier, screen reader, audio response, Braille terminals.

Hardness of hearing and deafness: screen magnifier, audio response.

Motor and dexterity impairments: screen magnifier, special scroll wheels or track-ball mouse, special keyboard/on-screen keyboard, voice recognition software.

Learning disabilities and cognitive impairments: spell assist programs, voice-recognition facilities, screen magnifier, screen reader [4].

Altogether, we questioned 133 people with visual impairments and 124 blind people, 96 people with hearing impairments and 260 deaf people as well as 75 people with motor and dexterity impairments and in total 89 people with dyslexia, learning disabilities or cognitive impairments [2].

The study inquired, among other things, prominence, use and problems in dealing with various web2.0 applications and their functions. Therefore, the following grouping of the applications based on the type of dominant interactions is reasonable and is used in the following:

Form-based applications: e.g. user registration, editing user profiles, comment functions, wiki applications and weblogs.

Extended form- or editor-based applications: e.g. writing in wiki applications and weblogs.

Media-rich applications: e.g. look at, publish and embed photographs, videos and podcasts [1].

Various areas of accountability and contributors in the development and operation process of a web application have to be determined for the emergence of barriers. They should be responsible for ensuring accessibility in their respective field of action. The dimension of barriers is divided into four items, from which one can derive how the barriers for users emerge and which area of accountability is responsible in most cases. In addition, causes, examples and guidelines for the accessible implementation are given:

Technical barriers based on used techniques (e.g AJAX, JavaScript), programming styles and restrictions in hard- and software because of AT. Examples are Captchas, insufficient operability of flash-players or missing semantics in web forms. **Web programmers**, service provider and producers of utilities and AT are responsible. Guidelines for these groups are e.g. the documents from the W3C Web Accessibility Initiative: WCAG, UAAG and ATAG [http://www.w3.org/WAI/guid-tech.html] and evaluation tools like validators.

Editorial and content-related barriers contain insufficient editorial or structural content preparation for Internet requirements, e.g. difficult language, missing textual structures or missing semantics of media content. Guidelines for **web editors** are e.g. European standards for making information easy to read and understand.

Design barriers based on inadequate accessible design of user interfaces, e.g. insufficient contrast, background images or too small font sizes. **Web designers** can use the WCAG too.

Organizational barriers based on organizational circumstances and a lack of awareness for accessibility issues. Examples are missing budget for videos in sign language and alternative preparation. **Orderers** and customers are responsible [1].

3. CLASSIFICATIONS OF BARRIERS

The classifications in the tables 1 and 2 at the end of the paper lead from the general to the specific. That means that everybody is concerned by the barriers mentioned first. Appropriate types of disability or types of applications are additional affected by those mentioned in the course of the paper.

Table 1 relates the critical aspects in the use of web applications to the causing type of barrier and to the user groups affected by it. A striking feature in this comparison is the distribution of barriers concerning the different types of disabilities. Thus, the technical barriers, which are for the most part caused by insufficient **operability** of the applications with assistive technologies, are especially noticed by visually impaired, blind and physically disabled persons. Hearing impaired and deaf Internet users particularly encounter **problems of understanding.** This includes difficult language and foreign words (especially in explanations, expected input data, links and error messages) and deficient text editing and structure. These problems are caused by insufficient or superficial preparation of content and media into formats they understand, e.g. videos in sign language or with subtitles, so that primarily organizational and editorial barriers are perceived. The linguistic barrier concerning reading and writing, for instance of comments, applies to deaf users because the German sign language differs substantially from the spoken and written language. The deaf hence experience a more difficult access to the written language. Even users with reading disabilities as well as with learning disabilities are affected by editorial barriers so that restrictions on account of the linguistic competence are experienced [4].

Navigation and contents must be offered well and identifiably structured (paragraphs, headings) and with sufficient font size for the **orientation and clear arrangement**. These factors and problems with quality, size and contrast of the media can be attributed as well to editorial as to designer barriers. On the one hand, the design should intend suitable format templates and place holders and on the other hand the editorial staff has to process contents and media for the Internet and appropriately integrate it into the format templates.

Table 2 illustrates which aspects of the applications can lead to which barriers and it thus facilitates the awareness of barriers in the development and evaluation of a web application. The critical points in all application classes are operability, understandability and perceptibility of the content. Thus, the focus should be on the operability of the interactive elements. Content and media should be prepared and formulated thoroughly.

A very high number of problem rates with regard to the **use of forms** have been indicated for visually impaired, blind and physically disabled persons. Forms and in particular Captchas limit the independent use here. Much the same applies to form-based and editor-based applications as for example the writing in wikis or weblogs. Therefore, central importance should be admitted to the accessibility especially of web forms. These measures are beneficial to all user groups because the readability, usability and accessibility of form elements are crucial for the independent participation e.g. in social networks.

Problems associated with visual media, which are especially experienced by hearing impaired and deaf Internet users, are caused by insufficient **media quality** as well as the unlimited operability and availability of appropriate media players. The processing for the Internet in terms of size, quality and contrast of the media (recognition, transmission times) is very important with regard to media such as photos and videos. Otherwise the content cannot be seen due to small images, small video windows or poor resolution, audio streams which are too noisy or added with background noise or due to the unavailability of subtitles or sign language videos. Summarizing visually impaired users experience problems especially in the visual field and hearing impaired users in the auditory field of media content [1, 4].

4. APPLICATION OF THE CLASSIFICATIONS

A possible schematic application of the classifications presented in the tables is given in the following. This fits smoothly into the development process of web applications following the principles of web engineering and usability engineering, and can therefore be seen as an integrative accessibility engineering.

The crucial point is that we have to apply the use-centered approach in the development of web applications, since users for the implementation of methods of a user-centered approach are often not available [3]. Therefore, the classifications developed above are used to model the user, the tasks and the environment and to identify key problem areas. Several different scenarios should be created to develop a broad understanding of possible use cases and to identify as many requirements as possible in accordance to Mayhew [3]. The focus concerning each activity has to be extended regarding issues of accessibility and the use of the application by persons with disabilities.

The formulation of quantitative and qualitative usability goals should be one of the main results of the requirements analysis to ensure their compliance throughout the complete process. As an extension to this, quantitative and qualitative accessibility goals can be formulated with the help of the classifications mentioned above. The observance of the established usability goals and in extension also the accessibility goals have to be reviewed after each phase. In the design and implementation phase for example mockups and prototypes are tested in focus groups or by usability experts. The different sub-phases are (each) iteratively run through until the complete fulfillment of the defined usability and accessibility objectives [3]. This approach is the essential foundation for an accessible implementation of the application. In the evaluation phase the classifications can be applied, e.g. with a checklist by accessibility experts. They can focus on critical use cases in user tests so that especially the operability of players, for instance, can be checked with regard to different user groups and assistive technologies.

The developed classifications could be integrated into established models of usability engineering with the advantage that the results obtained can be included into the usual development processes by experienced usability experts without much additional effort. The data focus on potential barriers, which should be detected as early as possible in the requirements analysis and can be evaluated throughout the development process. Thus, an inexpensive and effective development of usable and accessible web applications is possible. In particular, the effort in the final evaluation and implementation of usability and accessibility aspects can be reduced by permanent monitoring of critical points.

5. CONCLUSION

The most important barriers for all user groups are the understandability in the broadest sense, the use of forms and the operability of multimedia components, particularly with assistive technologies. With the help of the presented classifications, it is possible for decision makers and participants in the development and life process of a web application to identify potential barriers for users, to define areas of responsibility at an early stage and to initiate remedial action.

The statements can be used both in the conception and design phase and evaluation phase of web applications in terms of accessibility. By extending the proven usability activities with accessibility issues, a cost-effective integration of accessibility activities in the development process is obtained. With the use of the proposed classifications, different user groups and classes of applications can be included. With this approach, all stakeholders can consider the interests of accessibility holistically.

6. ACKNOWLEDGMENTS

I give thanks to ”Aktion Mensch“ and to ”Stiftung Digitale Chancen“ for providing the study data and the opportunity to evaluate it in that detail.

7. REFERENCES

[1] Berger, A.; Caspers, T.; Croll, J.; Hofmann, J.; Kubicek, H.; Peter, U.; Ruth-Janneck, D. and Trump, T. 2010. *Web 2.0/Barrierefrei*. Eine Studie zur Nutzung von Web2.0 Anwendungen durch Menschen mit Behinderungen. publisher: Aktion Mensch e.V. Bonn. 12/2010

[2] Cornelssen, I. and Schmitz, C. 2008. Chancen und Risiken des Internets der Zukunft aus Sicht von Menschen mit Behinderungen. *Aktion Mensch-Fachtagung „Einfach für Alle – Konzepte und Zukunftsbilder für ein Barrierefreies Internet“*. http://www.einfach-fuer-alle.de/studie/.

[3] Mayhew, D. J. 1999. *The Usability Engineering Lifecyle: A Practitioner's Handbook*. Morgan Kaufmann.

[4] Ruth-Janneck, D. 2009.: Multidimensionale Klassifizierung von Barrieren in Webanwendungen. In: *Mensch & Computer 2009* (Berlin 2009). 13-22

Table 1. Critical Aspects Affecting the Accessibility for the Certain User Groups with Disabilities (modified according to [4])

Type of disability	**Technical barriers**	**Editorial & content-related barriers**	**Designer barriers**	**Organizational barriers**
All	Operability, Semantics of web forms & buttons, Error messages, Semantics of media content, Operable & available player	Understandability, Orientation & clear arrangement, Quality, size & contrasts of media content, Descriptions of media content	Perceptibility, Orientation & clear arrangement, Perceptibility of functions, Quality, size & contrasts of media content	Support in language problems, Quality & transparency of the given content, Refresh period
Visual impairments	Forms in PDF, Captchas, Operable forms & editors, Operability with AT (JavaScript, flash, AJAX) & without mouse	Semantics of content, Descriptions of media content, Numerous links (impaired reading flow in screen reader), Names of links	Quality of pictures, Optimization for certain screen resolution, Size of buttons & interactive elements	
Hearing impairments	Download & control of podcasts	Videos in sign language & with subtitles, Quality of podcasts		Videos in sign language & subtitles, Quality of podcasts
Cognitive impairments		Understandability	Orientation & clear arrangement	Support in language problems
Motor & dexterity impairments	Operability of: web forms, buttons, drop-down-menus, players, activation of links, Operability without mouse	Semantics of content (support operability with AT)	Arrangement of links	

Table 2. Problematic Aspects in Application Classes (modified according to [4])

Application Classes	**Technical aspects**	**Editorial & content-related aspects**	**Designer aspects**	**Organizational aspects**
all	Operability, Problems with screen readers, JavaScript & flash content, Pop-up windows	Understandability, Orientation & clear arrangement, Quality, descriptions & semantics of media content	Perceptibility, Orientation & clear arrangement, Font sizes & contrasts	Quality & transparency of the given content, Refresh period
form-based	Captchas, Semantics of web forms & buttons	Understandability of explanations, required fields & error messages	Design of web forms	Videos in sign language for explanation
extended form- or editor-based	Operable editors, Font sizes in editors, Problems with JavaScript & AJAX	Clear assistance to functions	Design of web forms, Perceptibility of editor functions	Support in language problems, Alternative ways for participation
media-rich	Operable & available player, Download & control of podcasts & videos	Quality, size & contrasts of media content	Operability & perceptibility of player functions	Subtitles & videos in sign language, Quality of podcasts