Log-Based Personalization Tool as an Assistive Technology

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Abstract. Solutions for personalizing websites by automatically changing user interfaces (UI) to fit users' needs have been proposed by the industry and the academy in order to provide individualized user experience. However, the users' perception of changes in the tailored UI is still a topic to be studied. This work presents a tool developed to capture logs, generate, and apply individual adjustments, personalizing websites as people use it. In addition, the tool is proposed as a log-based personalization assistive technology and it is published to the community. The tool was evaluated in depth, qualitatively, counting with the participation of 4 blind users fluent in using the Web, knowing personalization existing features, and fluent on using computers. They were invited so that the understanding of outcomes and limitations of the personalization features offered could be better understood. Based on the results, we highlight possible scenarios where similar approaches could be used to assist people with disabilities and reinforce the importance of considering the users' perception of changes automatically performed in UIs.

Keywords: Self-tailoring website, adaptive website, website evaluation, user interface evaluation, remote evaluation, accessibility, usability, event logs.

1 Introduction

Accessibility is already recognized as a fundamental requirement of user interfaces (UIs). Moreover, the task of removing accessibility barriers to guarantee accessibility is motivated by legislation and guidelines from organizations and governments.

Although there are worldwide organizations and legislation supporting Web accessibility, more than 95% of the websites fail when confronted to minimum accessibility requirements, such as to provide adequate descriptions of visual elements [24].

Web Accessibility means that people with different types of limitation can perceive, understand, navigate, interact, and contribute with the Web. Accessibility barrier is anything that makes difficult or impossible for people with disability to use the Web [25]. The traditional concept of Usability – as the capacity of a product to be used by specific users to achieve certain goals with efficiency and satisfaction, in a certain context of use – already brings to focus the context of use, which involves

M. Kurosu (Ed.): Human-Computer Interaction, Part I, HCII 2014, LNCS 8510, pp. 433–444, 2014.

users, tasks, equipments (hardware, software, and other materials), physical and social environment in which the product is used [11].

The evaluation of websites is a way of identifying issues and supporting the removal of accessibility barriers. When an evaluation aims at improving accessibility, characteristics related to the context of use need to be considered. However, as software configuration and environment variables are difficult to replicate in labs, remote evaluation is an interesting approach for analyzing the real context of use.

After the analysis of data resulting from UI evaluations, tools can provide reports on features, suggest improvement, or they can change the UI in order to remove any identified issue. This last action is referred in literature as UIs that are personalized, adaptive, individualized, or self-tailored. However, such approach on changing the UI is only part of the solution, since it is also important to analyze the users' perception and the users' satisfaction with the changes. Thus, the objective of this work is two-fold: to present a self-tailoring evaluation tool and to analyze how blind users perceive, interact, and deal with a website tailored according to a previous usage.

This paper is organized as follows: section 2 gathers definitions and the background of the work; section 3 presents the developed tool; section 4 details method and experiment design; section 5 shows the results; section 6 draws the conclusions.

2 Background

The automation of evaluation tools may involve the following steps: **capture** (i.e., logging the usage data), **analysis** (i.e., identification of problems), **critic** (i.e., suggestions on how to improve the evaluated UI) [12]. In addition, it may also involve **adjustments** (i.e., the elimination of identified problems by changing UI elements).

UI events are a natural result of the usage of UI based on windows and their components (e.g., mouse clicks, key strokes). Moreover, from the possibility of recording these events and the fact that they indicate users' behavior during UI usage, they represent an important data source regarding UI evaluation; they allow to analyze performed paths, repeatedly triggered events, time spent to perform certain actions, etc. [9]. In this context, event logs can be seen as a temporized set of UI events.

Evaluation of UI can be **local**, when the participant and evaluator are in the same place (e.g., a UI evaluation lab), or **remote**, when participant and evaluator are in different places. Moreover, evaluation can be considered **synchronous** (evaluator and participant are working on the evaluation at the same time) or **asynchronous** (there is no need for evaluator and participant to work on the evaluation at the same time).

Asynchronous remote evaluation is interesting for the context of website evaluation because it avoids biases (e.g., related to environmental, software, and hardware variables) in the use of UI and, consequently, in the data logged. It is also a way of enabling the number of sessions to scale up. In the context of accessibility, it is an interesting approach because it is hard to replicate configurations of hardware and software when users are using assistive technology (AT) support [5]. Another point in favor of this combination is that, according to Rubin [22], tests in controlled environments are artificial and may influence the results. In addition, the variety of needs and

the wide diversity of physical, sensorial, and cognitive characteristics of users make the UI design very complex [1]. However, this approach has also limitations, e.g., capturing users' verbalizations, expressions, and actions performed before the event logging takes place. Literature presents different tools for evaluating UIs; in what follows we present a brief history of related tools.

WebVIP is a logger for formal tests; i.e. when the participants are required to execute specific and predefined tasks. The vocabulary of events, which stands for the number of different event types, is restricted to a few events (i.e., press/hold keys, press/hold/move the mouse pointer, enter/leave a widget, and enter/exit the window). The environment configuration requires a local copy of the entire website being evaluated [18]. **WET** is another example of a logger for formal tests. It uses cookies to store logged data, which leads to the reduction on the vocabulary of events due to storage issues [7]. These tools represent the first efforts to capture client-side events.

WebRemUSINE is a tool that performs the automatic capture and analysis of website interaction logs in order to detect usability problems through remote evaluation. The analysis of logs is based on the comparison between the paths used by users and the optimum task model previously defined. The user must select the tasks she or he is performing to allow comparison of the captured events with the task selected by the user [19]. **MultimodalWebRemUSINE** is the latest version of the tool that aims at exploiting the possibilities opened up by recent technologies to gather a richer set of information regarding user behavior. The tool allows traditional graphical logs to be analyzed together with the logs from webcams and portable eye trackers [20].

Google Analytics is an example of automatic capture and analysis tool. The default data source used by the tool represents page-views. The tool requires the evaluator to register him/herself and to insert a JavaScript code into the Web pages to be evaluated. It provides different report formats, allows actions to be registered as virtual page-views, and has a feature to register customized events at the client-side. These customized events in Google Analytics are events that can be named by the evaluator and triggered in any Web page component configured to communicate with the JavaScript data-logger (e.g., a Flash video or HTML event handler). However, the tool has a limit of logging 500 customized events per visit [8].

WebQuilt is an automatic capture and analysis tool that uses page-view level logs as data source. It uses a proxy-logger that mediates between users and Web servers and stores the communication between them [10]. **MouseTrack** is a proxy-based usability evaluation system that performs automatic client-side capture and analysis. It provides an online configuration and visualization tool that shows the mouse path followed by website visitors [2]. **UsaProxy** is a proxy-based usability evaluation system that performs automatic capture and analysis of client-side events. It uses JavaScript and focuses on usability tests [3]. **WebinSitu** is an enhanced version of UsaProxy that focuses on behavior comparisons between blind and sighted users [5]. **WAUTER** is a proxy-based Web usability evaluation tool, which employs a functional set of tools that automate the capture and analysis by considering client-side logs and task models [4]. **Web Usability Probe** (WUP) is a proxy-based remote usability evaluation tool that considers formal use situations. The data source considered is client-side data on user interactions and JavaScript events. In addition, it allows the

definition of customized events, giving evaluators the flexibility to add specific events to be detected and considered in the evaluation. The tool supports evaluation of any Web site by exploiting a proxy-based architecture and enables the evaluator to perform a comparison between actual user behavior and an optimal sequence of actions [6]. In some cases, proxy-based tools require reconfiguration of the user's browser or a proxy setup. Moreover, they may result in Web server processing overhead, due to additional requests/responses, or compatibility problems, which may occur when inserting JavaScript code into the evaluated Web pages.

The presented tools have drawbacks, e.g., limited vocabulary, dependency of task model development, limit of events captured, among others. Thus, the proposed tool (detailed in the next section) addresses the presented shortcomings. Next we present the background on personalization and how it is considered in the proposed tool.

According to Pierrakos et al. [21], personalization improves the experience of a visitor by presenting the information she or he wants, in an appropriate way, and at the appropriate time. Mobasher et al. [15] define personalization as any action that adjusts Web experience to a particular user or group of users. Nielsen [17] defines personalization as when the computer changes its behavior to adequate itself to the users' interests. Mikroyannidis and Theodoulidis [14] define self-adaptive UIs as those that improve their structure and design by learning how the UI is used. Model-Based User Interfaces Incubator Group (MBUI-XG) [13] defines adaptive UI as a UI that is capable of considering the usage context and (automatically) reacts to context changes in a continuous way, changing presentation, content, navigation, or even behavior. Mørch [16] uses the term tailoring as the adaptation of information systems to specific practices of developers, end users, or group of users. The author presents a classification of 3 levels for tailoring, as follows: Customization – Modification of the objects presentation or edition of attributes by the selection of predefined values; Integration – Creation or recording of a sequence of actions that result in a new functionality, stored within the application as a component or a command; Extension – Improvement of the functionality of an application by the insertion of new code.

Considering the related works, the tool proposed in this work advances the state of the art by presenting an approach that generates adjustments code based on client-side events captured continuously. The proposed tool identifies usage patterns, generates adjustment codes, and applies the adjustments, evaluating whether the change was well succeeded or not. Thus, considering the presented terms, the tool continuously applies Mørch's tailoring of level 3 (i.e., extension); next section details the functioning of the proposed tool.

3 The Proposed Tool

The proposed evaluation tool, called WELFIT (Web Event Logger and Flow Evaluation Tool), supports remote/non-remote, synchronous/asynchronous, and formal/informal tests. The data source considered is client-side events log. Regarding the effort level to configure an evaluation, the evaluator is required to register and to insert the logger into Web pages; on the part of the participant, it requires the

acceptance of the invitation to participate in the evaluation. The automation performed by the tool involves logging client-side events, generating graphical/statistical reports, and generating UI adjustments automatically.

The basic requirement of the developed system is to capture and log user interface events, which is available in interactive systems, reducing the need for specific evaluation devices (e.g., eye tracking) that take for granted certain characteristics of the user population (e.g., sight). The system is composed by two main modules:

- Client module, which is responsible for: capturing events at the client-side; iteratively compacting log lines using the Run Length Encoding algorithm; transmitting the packages of logged data asynchronously to the server; controlling that logged data is only discarded when the server confirms the proper storage, and; inserting adjustment code to the evaluated website.
- Server module, which is responsible for: receiving the data sent by the client module; unpacking the lines; storing received data; generating reports using JGraph[1] library, and; generating the adjustment codes.

For the evaluator, the environment configuration requires the following steps:

- The website administrator must register him/herself at the tool's Web administrative interface.
- Once logged, the administrator must register the websites s/he wants to evaluate.
- Once the website is registered, s/he includes the call to the JavaScript client-module in all website's pages that are to be evaluated.

At the client module, as soon as a package containing the logged data reaches the configurable size limit, it is sent to the server. Thus, as soon as some interaction data is stored at the server, the evaluator can login and view the resulting usage graph, which is the digraph representing the UI usage in which each node represents an event triggered in a certain Web page element. The report format used follows the structure presented by Santana and Baranauskas [23].

The usage graph can also be seen as the combination of walks (non-empty alternating sequence of nodes and edges) representing what, where, and when users performed actions. In the usage graph, a node is identified by its label, which is the concatenation of the event name and an identifier of the UI element where the event occurred. Each node counts on information regarding the total of sessions in which they occurred, mean distance from the root node, mean timestamp, among others.

The generated adjustments aim at reducing the identified usage incidents, available at the usage graph structure built from the client-side events log. Thus, after each visit, the rules matching previously identified patterns with adjustments are verified and, if it is the case, one or more adjustments are generated to next sessions. Then, in the next visit the tool applies the adjustment and the new observation is compared to previous ones in order to verify whether the number of usage incidents was reduced. Finally, if it is the case, the adjustment is applied in the future visits, else, the applied rule is marked as not well-succeeded for the specific participant.

[1] http://www.jgraph.com/

Regarding the insertion of adjustment code, at each new visit, the client-side module requests any generated adjustment for the current participant. Thus, if there is any adjustment code to be applied, then the client-module receives it and applies it to the current Web page.

The developed tool avoids the limit of client-side events captured, captures all types of events triggered at the client device, provides simple environment configuration, summarizes usage patterns, and points out usage incidents. This work contributes to the field by detailing an approach and providing a tool to evaluate how UIs are used by people with/without disabilities under the Universal Design philosophy. Moreover, a case study was carried out to increase the understanding of how the participants perceive adjustments performed by such tool.

4 Method and Experiment Design

This section presents characteristics of participants, materials, and the experiment design considered in the case study. The objective of the experiment was to investigate how IT experienced blind users perceive, interact, and deal with a website tailored according to a previous usage.

Participants: The participants invited to be part in the evaluation are blind people that are researchers, workers, or students at the university where the project was conducted. They had already had previous contact with the evaluated website, as this condition is essential for getting their perception to adjustments in the website. The point in inviting users with experience on IT is that they might present a more critical point of view, enriching the results of the study, since they have contact with different initiatives on evaluation of UI and insights involving the proposed approach may emerge. To invite participants, we counted one people that mediated the interaction with the team and the participants. The invitation was sent by email to 13 persons; 4 accepted to participate in the evaluation. Regarding gender, 2 are men and 2 are women. Regarding screen reader, 2 participants use NVDA and 2 use JAWS.

Materials: The website that was object of the evaluation is the portal of a research group from the university where the study took place. The research group develops research on topics related to accessibility and the support needed for the access and the permanence of people with disabilities in higher education. The target audience of the research group and its website is composed by students, researchers, and teachers. The website was chosen because it was developed and it is maintained considering accessibility requirements. Thus, the probability of users to face accessibility barriers is reduced and then interaction techniques can be analyzed with minor impacts of coding problems. Other important characteristic of the evaluated website is that part of its audience is composed by people with disabilities. The website uses the Plone® Content Management System (CMS), which is one of the most popular CMSs.

The tool developed in this research supports remote informal and formal tests. For a formal test, which is the case reported in this study, it requires the evaluator to send specific URLs to each of participants. These URLs help evaluators to track sessions

and to identify tasks performed as well. The tool also allows evaluators to insert specific adjustment code into the URL in order to evaluate adjustments generated by the evaluator instead of adjustments generated automatically by the tool. Moreover, the adjustments can be plain JavaScript or jQuery code. In this study the adjustments were sent via URL to participants.

Design: The experiment design considered two evaluation stages. The first one to capture detailed data on how participants performed the tasks. The second one to apply adjustments and to analyze how participants interacted with the adjusted UI. All the tasks initiated from predefined links sent to the participants. For each participant, these links provide information allowing us to identify details of the evaluation (e.g., tasks performed) and to apply changes in the UI being evaluated (e.g., adjustments).

The tasks were proposed to identify usage patterns and ways that the evaluation tool could adjust the UI to allow detailed analysis of a posterior adjustment. The tasks were defined to observe how users access certain linked images, available resources, and the contact page. The tasks involved in the study were the following: Search and access the link to an audio book available at the research group portal; Search and access the link to the website used as a reference to develop accessible websites, available at the research group portal; Access the contact page and send a message informing what AT is being used and what is your opinion about the website, including any difficulty faced. The last task was proposed to evaluate the contact page channel, to gather information regarding the user software context (i.e., AT), and, considering the profile of the participants, to ask about difficulties or missing features.

In the second stage the link sent to participants already had the adjustments designed to shorten the tasks considering the interactions strategies used by the participants in the first stage. The adjustments were generated after detailed analysis of each usage graph resulting from each of the sessions. The adjustments are presented in details in the results section. In addition, a questionnaire was sent to the participants in order to gather further opinions on the adjustments applied and on the proposed approach. The questionnaire was composed by the following questions: A) Have you noticed any change in the website? If this is the case, which one? B) In your opinion what are the negative and positive aspects of this kind of evaluation in which the participants use their own computer, but have not explicit contact with evaluators? C) If a website under evaluation informs that it changed to fit the strategies you use to interact with it, what would be your opinion regarding this feature? D) What features do you think a self-tailoring system should have?

5 Results

In the evaluation, from the 13 invitations sent by email to blind users of the website who are also experienced IT users, 4 accepted to take part in the evaluation. Thus, the acceptance rate was 30.77%.

First Stage: the tasks performed by the participants were analyzed and the path performed by them was considered in the generated adjustments. The tool provides reporting features that summarize the actions performed by the participants. These reports

were analyzed, the incidents indicated by the tool were mapped back to the studied UI, and the adjustments were created in order to reduce the incidents identified.

The participant 1 mentioned that the evaluated website is very concerned about accessibility and that she did not face any difficulty when performing the tasks. In addition, she said that she uses the shortcut 'H', available at NVDA, to navigate through all Web page's headers. She reported that this feature allows users to navigate through the content quicker than, for example, using the TAB key. During the first task, the participant also identified that one Web page had a missing link to the appropriate file; this fact was also pointed out by participant 3.

The participant 2 informed that he did not find any difficulty to use the evaluated website. However, the participant reported that the calendar feature, available at the right side of the homepage, has links that are not read by the screen reader. According to the participant, it is hard to understand what is available in the calendar, which is a standard feature offered by the Plone® CMS and it is located at the right hand side of the website (Figure 1).

Fig. 1. Plone®'s calendar feature

The participant 3 commented that the shortcuts (using the ALT key) available at the web page did not work. Moreover, she identified that a flash movie available at the homepage (showing different pictures) affected negatively the navigation.

The participant 4 mentioned he performed the tasks without problems. He also reported that the level of accessibility of the evaluated website is "very good [...] excellent for what is found in our country." The participant also informed that the submit button, at the contact page, was not accessible and that he had to ask for help to someone else that could see the link.

As a result of the interactions of these participants, it was possible to observe the following issues that led to the adjustments applied during the second stage (Table 1).

Table 1. Features and respective adjustments generated for all participants of the second stage

Feature/issue	Adjustment
The flash animation, located at the homepage, interfering negatively in the navigation.	Remove the flash animation, which has only decorative information.
Contact links available at the accessibility toolbar.	The structure of the accessibility tool bar was changed in order to show the contact link as the first item of the list.

Besides the issues regarding the animation available at the homepage and the submit button, participants reported that UI elements were easy to reach.

Second stage: The adjustment codes generated to address the incidents pointed out by the tool are presented in Table 2. Following we present participants' comments and questionnaire answers regarding the second stage:

- **Question A):** one answer pointed out that "[...] it looks like some accelerators were created and content was inserted [...]"; however, two participants commented that they did not noticed any change. These comments suggest that the adjustments applied were rated by one participant as an accelerator, suggesting improvement in the usage. Additionally, for other participants the adjustments were not noticed, meaning that at least they did not disturb the interaction.
- **Question B):** one participant mentioned that a positive point for developer is that "he can reach more participants." Another fact reported was that "for the developer it may not be evident whether the portal is working with the most used screen readers, because, in the course of time, users end up using features offered by these systems and beginners may find it difficult to navigate." As a positive point, a participant also highlighted that "[...] the remote evaluation without the presence of the researcher makes the user feel more comfortable [...]" These comments bring interesting facts related to the skill level of participants on using screen readers and about the comfort level of users participating remotely.
- **Question C):** one participant informed that he "would be very happy and satisfied because [...] [he] uses the internet a lot [...]"; another comment pointed out that "it is a big frustration to try to access something and fail to do it due to lack of accessibility." Moreover, one participant opined that "when we talk about changes to be applied to a website, they should be thought as a whole, and not only for the most accessed items." Another participant mentioned that she "would be satisfied for the [application of adjustments] and would focus on verifying the changes in order to report my opinion." These opinions suggest that participants would receive positively the information that a website applies adjustments considering the user´s strategies to navigate through some website. It is also worth noting the wish of participants on expressing opinions and giving feedbacks on tailoring features.
- **Question D):** the participants indicated the following features: "adjust the web page so that all the content can be accessed by the keyboard, insertion of accelerators in the most accessed items"; "at websites that require users interaction as drag and drop an item, that should be adjusted into something accessible and to be manipulated in other ways instead of by clicking and dragging"; "adjustment of improving contrast for people with difficulty on seeing", and; "reduction of the complexity for typing CAPTCHAS".

The features pointed out are strongly related to barriers faced by people with disabilities and, with exception of the CAPTCHA issue, all of them can be addressed as adjustments in an analogous way as presented in this study. One participant informed the following: "I do not know to what extent it is possible to adjust functionalities of an information system according to the strategies used by the users either because of the plurality of the strategies used or because of the generality of foreseen and

unforeseen situations." In this comment the participant seems somewhat skeptical. The participant is right when pointing out the plurality of strategies used, however, all strategies are sequences of actions that, in turn, underneath the UI, are translated to UI events. Thus, the challenge resides on identifying who is using assistive technology and then analyzing patterns in these UI events streams. Moreover, the emphasis on foreseen and unforeseen situations corroborates the approach of the continuous evaluation supported by the WELFIT.

Table 2. Adjustment codes applied in the second stage related to the results of the Table 1

Adjustment code	Effect of applying the adjustment
document.getElementById('region-content'). getElmentsByTagName('p')[1]. setAttribute('style', 'display:none');	Plain JavaScript code used to change the layout of the web page, hiding the flash movie for the participants of the second stage of this evaluation.
$('#portal-siteactions').prepend($('#siteaction-contact').html()); $('#siteaction-contact'). style('display', 'none');	jQuery style of code used to change the structure of the accessibility toolbar, placing the contact link as the first element of the toolbar.

6 Conclusion

The evaluation of websites is essential for identifying issues and supporting the removal of accessibility barriers. Evaluation tools provide reports on problems, suggest improvements, or they can change the user interface in order to remove an identified issue. While solutions for adapting websites to fit users' needs are being proposed by the industry and academy, the users' perception of the changes in the tailored UI has not received the same attention.

The evaluation of adjustments is a key step for personalization systems, since an adjustment may solve an issue for a certain context of use, but the same adjustment might cause a usability problem or hamper access for others. This case study presented the perception of blind users to adjustments made in a website they use, based on their previous experience with it.

The first stage supported the identification of issues related to content (missing link) and to markup (calendar coding). In addition, the data generated in the first stage was analyzed with the support of the reporting features provided by the evaluation tool used and then used as input for generating adjustments. It is worth noting that the type of analysis performed in this study, in which UI events were analyzed one by one, was only possible because of the limited number of participants. Such detailed analysis does not scale if the number of participants grows. In cases where there is a large number of participants, it is required to consider summarization features highlighting the most relevant patterns, the most critical sequences, the usage incidents that have greater impact, to name a few.

The second stage findings suggest that the adjustments were not harmful for the evaluated UI in the presented case study and that they were perceived as accelerators

or bypassed by participants. In addition, participants reveal that adjustment features are welcome and that one interesting application of such feature is to fix known accessibility problems, providing such a tool as an assistive technology.

Despite involving the participation of only 4 users, the data set obtained is rich in details and the presented results may help people working with personalization in the context of Web Accessibility. The gathered data is rich in the sense that the participants are real users, they were willing to be part in the evaluation, and they provided detailed information regarding how they perceive a self-tailoring website, using their own configurations of software and hardware. It was possible to verify that, when noticed, adjustments were perceived as improvements.

The presented approach supported the test of UI and UI adjustments remotely, in the real environment of the users. This work presented a promising direction regarding UI evaluation tool in the context of accessibility, supporting the fix of common accessibility barriers.

Acknowledgements. We would like to thank the participants, Deise Pupo for the support in contacting participants, and FAPESP for supporting this research (grant #2009/10186-9).

References

1. Abascal, J., Nicolle, C.: Moving towards inclusive design guidelines for socially and ethically aware HCI. Interacting with Computers 17(5), 484–505 (2005)
2. Arroyo, E., Selker, T., Wei, W.: Usability tool for analysis of web designs using mouse tracks. In: Proceedings of ACM CHI 2006 Conference on Human Factors in Computing Systems, Work-in-Progress, vol. 2, pp. 484–489 (2006)
3. Atterer, R., Schmidt, A.: Tracking the interaction of users with ajax applications for usability testing. In: Rosson, M.B., Gilmore, D.J. (eds.) CHI, pp. 1347–1350. ACM (2007), http://doi.acm.org/10.1145/1240624.1240828
4. Balbo, S., Goschnick, S., Tong, D., Paris, C.: Leading web usability evaluations to wauter. In: AusWeb 2005 - Australian World Wide Web Conference 2005 (2005)
5. Bigham, J.P., Cavender, A., Brudvik, J.T., Wobbrock, J.O., Ladner, R.E.: Webinsitu: a comparative analysis of blind and sighted browsing behavior. In: Pontelli, E., Trewin, S. (eds.) ASSETS, pp. 51–58. ACM (2007), http://doi.acm.org/10.1145/1296843.1296854
6. Carta, T., Paternò, F., de Santana, V.F.: Web Usability Probe: A Tool for Supporting Remote Usability Evaluation of Web Sites. In: Campos, P., Graham, N., Jorge, J., Nunes, N., Palanque, P., Winckler, M. (eds.) INTERACT 2011, Part IV. LNCS, vol. 6949, pp. 349–357. Springer, Heidelberg (2011)
7. Etgen, M., Cantor, J.: What does getting WET (web event-logging tool) mean for web usability? In: Proceedings of 5th Conference on Human Factors & the Web (1999)
8. Google analytics (2009), http://www.google.com/analytics
9. Hilbert, D.M., Redmiles, D.F.: Extracting usability information from user interface events. ACM Comput. Surv. 32(4), 384–421 (2000)
10. Hong, J.I., Heer, J., Waterson, S., Landay, J.A.: Webquilt: A proxy-based approach to remote web usability testing. ACM Transactions on Information Systems (2001)

11. International Standardization Organization: ISO-9241 - Ergonomic requirements for office work with display terminals (VDTs), Part 11: Guidance on usability (1998)
12. Ivory, M.Y., Hearst, M.A.: The state of the art in automating usability evaluation of user interfaces. ACM Comput. Surv. 33(4), 470–516 (2001)
13. MBUI-XG – Model-Based UI XG. Model-Based UI XG Final Report (2010), http://www.w3.org/2007/uwa/editors-drafts/mbui/Model-Based-UI-XG-FinalReport.html
14. Mikroyannidis, A., Theodoulidis, B.: A Theoretical Framework and an Implementation Architecture for Self Adaptive Web Sites. In: Proceedings of the International Conference on Web Intelligence (WI 2004), pp. 558–561 (2004)
15. Mobasher, B., Cooley, R., Srivastava, J.: Automatic Personalization Based on Web Usage Mining. Communications of the ACM 43(8) (2000)
16. Mørch, A.: Three Levels of End-User Tailoring: Customization, Integration, and Extension. In: 3rd Decennial Aarhus Conference, Aarhus, Denmark (1995)
17. Nielsen, J.: Customization of IUs and Products. Jabob Nielsen's Alertbox (2009), http://www.useit.com/alertbox/customization.html
18. NIST – WebVIP (2002), http://zing.ncsl.nist.gov/WebTools/WebVIP/overview.html
19. Paganelli, L., Paternò, F.: Intelligent analysis of user interactions with web applications. In: IUI 2002: Proc. of the 7th Int. Conf. on Intelligent User Interfaces, pp. 111–118 (2002)
20. Paternò, F., Santoro, C.: Remote usability evaluation: Discussion of a general framework and experiences from research with a specific tool. In: Maturing Usability (2008)
21. Pierrakos, D., Paliouras, G., Paratheodorou, C., Spyropoulos, C.D.: Web Usage Mining as a Tool for Personalization: A Survey. User Modeling and User-Adapted Interaction 13, 311–372 (2003)
22. Rubin, J.: Handbook of Usability Testing: How to plan, design, and conduct effective tests, 1st edn. John Wiley & Sons Inc. (1994)
23. Santana, V.F., Baranauskas, M.C.C.: Summarizing observational client-side data to reveal web usage patterns. In: Proc. of the 2010 ACM Symposium on Applied Computing, SAC 2010 (2010), http://doi.acm.org/10.1145/1774088.1774344
24. Santana, V.F., Paula, R.A.: Web Accessibility Snapshot: An Effort to Reveal Coding Guidelines Compliance. In: 10th Int. Cross-Disciplinary Conf. on Web Accessibility (2013)
25. Web Accessibility Initiative – Introduction do web accessibility (2005), http://www.w3.org/WAI/intro/accessibility.php