The Impact of Accessibility and Usability on the Development of Web Applications

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Abstract. Ease of use is definitively one of the key aspects characterizing the quality of web applications and includes accessibility and usability. In this paper we describe how these factors can affect the development of web applications. In particular, we describe the activities that should be targeted at accessibility based upon the W3C guidelines and propose a list of elements that could be used as predictors of the effort needed to ensure accessibility. As for the usability, we report on the tasks carried out to achieve this goal and the time commonly devoted to these tasks.

1. Introduction

Several studies are currently being carried out to identify the factors that better define the quality of web applications [4,5,6]. Although some factors are not clearly understood, "ease of use" is definitively recognized to be one of the key aspects to distinguish the quality of a web site. As a matter of fact, a European Commission's benchmark study carried out in November 2003 on quality and usage of public e-services in Europe reports that the most important factor for citizen satisfaction is ease of use of the web sites and for that reason many efforts are devoted to face the task of improving web sites [9].

Several usability features contribute to determine ease of use, such as ease to find information/service, orientation and navigability, ease to learn. Many heuristics and guidelines are provided in the literature to design usable web sites [7]. Moreover, evaluation techniques have been widely experimented to measure user satisfaction [3,7]. Such techniques can be profitably exploited in a user-centered iterative development process.

For users with disabilities the accessibility is a basic pre-requisite for the ease of use. Indeed, web accessibility is the ability to access to the web regardless of disability, thus it concerns with the possibility to read web pages, to navigate through the web sites, to interact with the procedures requiring choices and the input of data, to activate hypertext links, to download documents and so on.

Since 1997 the World Wide Web Consortium (W3C) has started an initiative, called WAI (Web Accessibility Initiative), in order to guide web developers to the realization of accessible web pages for the greater number of people. In particular,

guidelines for developing accessible web sites have been conceived, together with a checkpoint list and automatic tools useful to verify several aspects of the web accessibility [10-15].

In order to ensure the construction of usable and accessible web sites, a careful planning of the development process has to take place, which takes into account the corresponding design guidelines and the evaluation and testing techniques.

In the present paper we report on an investigation we have started with the aim to analyze the impact on effort of accessibility and usability compliance. In particular, we carried out an experiment involving students of the Academic courses of Web Engineering and Human-Computer Interaction. They realized web sites by following a development process suited to accommodate the accessibility and usability guidelines along with the necessary testing activities. Such experimentation has been useful to understand which phases are especially affected by the accessibility and usability goals. Moreover, it has suggested us some elements which could be used as predictors for the effort estimation. Finally, it has allowed us to successfully experiment the approach for the usability testing suggested by some experts.

The paper is organized as follows. Section 2 describes the tasks to perform in order to achieve accessibility and provides some indicators that could be considered for the accessibility effort estimation. Section 3 is focused on usability. In particular, we identify the activities that are mainly affected by such nonfunctional requirements and the effort commonly devoted to each task. Some final remarks conclude the paper.

2. Towards Accessible Web Sites

Nowadays, Internet is widely used as instrument to retrieve news, to access information, to communicate with the external world. However, the fast technological evolution, the more and more diffused use of the web to provide and share several sources of information have also created new technological barriers and new exclusions. The “disabled world” should represent the more important reference for the web. Indeed, people with sensory limitations find in the web the most interesting reference for their daily necessities since they have difficulty in moving and communicating. Among the sensory limitations, those involving the sight and the hearing are most likely to compromise the web accessibility. In order to make some examples, let us consider people with visual sensory limitations who find difficult to consult some web pages with a web browser; or people with auditory sensory limitations who need captions for the audio sections of the multimedia files. Developing accessible web sites is not only a social requirement, but it is also a way for increasing market share and audience reach, improving efficiency and reducing legal liability (see [16])

The objective of the international community is the elimination of these technological barriers for giving the users the possibility to navigate through web sites to efficiently accomplish their needs. As a matter of fact, many countries require that the sites of public organizations are accessible.

To this aim, since 1997 the World Wide Web Consortium (W3C) has started an initiative, called WAI (Web Accessibility Initiative), in order to guide web developers to the realization of accessible web pages for the greatest number of people. In par-

ticular, guidelines for developing accessibile web sites have been published, together with a checkpoint list, organized by concepts, which can be used by developers to verify the web accessibility [11].

The list of checkpoints for the Web Content Accessibility Guideline 1.0 (WCAG 1.0 in short) is organized based upon the priorities assigned to checkpoints. Three priority classes are used, so that a checkpoint can have associated Priority 1, Priority 2, or Priority 3 on the base of its impact on accessibility. Priority 1 means that a web content developer must satisfy the checkpoint, Priority 2 means that a web content developer should satisfy the checkpoint, and Priority 3 means that web content developer may address the checkpoint.

Moreover, three conformance levels have been provided:

- Conformance Level "A": all Priority 1 checkpoints are satisfied;
- Conformance Level "Double A": all Priority 1 and 2 checkpoints are satisfied;
- Conformance Level "Triple A": all Priority 1, 2, and 3 checkpoints are satisfied.

Several tools have been also proposed to validate markup including syntax and style sheets, such as *Bobby* [13], *CSS validation service* [15] or *HTML Validation Service* [14]. However, accessibility is a parameter of web sites involving not only the syntax of the HTML code but also the semantic of the web content. So, a program able to validate the syntax of a web site is not sufficient to guarantee its accessibility, but also the human control is needed.

Thus, it is obvious that the suitable integration of the basic accessibility characteristics requires careful design and testing phases with additional effort in the web applications developing process.

Nevertheless, all the software companies we have consulted admitted to invest few resources for web site accessibility. Indeed the most accessible web sites they have realized were committed by public administrations. In those cases in order to gain the contract, companies usually apply the "Price to Win" approach to estimate the development costs. Since the effort is underestimated, very little time is spent to ensure accessibility. As a result, we can easily find also on the Internet many denunciations against web sites which show the accessibility logo but are very poorly accessible in practice.

On the other hand, as far as we know there is no method that allows us to effectively estimate the actual effort to develop accessible web sites. This is also due to the lack of historical data. Such considerations have motivated us to start an analysis on this matter. Thus, we have developed several accessible web applications during the academic courses on Web Engineering and Human-Computer Interaction. Such applications were realized by teams of students. Each group included an art director[1], a functional analyst, two web designers, two web programmers, and two testers. The adopted development process was heavily influenced by the use of the WAI guidelines. In the following we will describe only the activities concerning the accessibility design goal.

[1] The art directors were graduated students in Communication Science.

During the design phase the designers planned the tasks to be performed in order to build accessible web pages, so that both graphic and textual web contents could be navigated by disables and could be understood by all categories of users. In this phase they also evaluated with the client the level of visitors engagement needed for the web site. In one case of an e-commerce application, designers chose to construct an alternative accessible web site to meet both a high level engagibility and the accessibility. In all the other cases, designers decided to directly integrate accessibility aspects. In particular, they analyzed the web contents required by the client and chose the web pages to be made accessible and the corresponding level. Furthermore, they evaluated the possibility of executing elegant transformations during the design phase to make the graphical interfaces more accessible by considering the required informative level and the technologies which will be used. Transformations were performed by considering the WAI guidelines. In particular,

the art director

- selected color tonalities recognizable also by people having sight problems and whose shades were easily identified also with grey scale displays. In general, colors were not considered as the unique instrument to communicate information.
- selected fonts so that scalable elements were allowed and different typologies of browsers could consistently recognize the elements;
- designed the graphical user interface so that information would be presented with the same order and semantic also by using a textual browser;
- designed the graphical user interface so that increasing the font size the content was still presented in a consistent and comprehensible way;
- identified further navigation bars to allow user to easily navigate;
- avoided to insert too many multimedia objects and images into the graphical user interface and identified the right compromise between an attractive graphics and ease of use.

The functional analyst

- identified the functionality needing a high degree of accessibility;
- analyzed the needs of client and identified the accessibility level the web site should be compliant;
- identified the content needing specific linguistic clearness.

The designer

- devised the editorial plan in collaboration with the art director avoiding link overcrowding and too lengthy textual sections;
- identified documents needing indexes and captions;
- identified the best logical structure for contents;
- determined the technical strategies to increase the performance of the site.

During the development phase web programmers built web pages following WAI guidelines, which summarized in the following.

Organization of the web page content

To ensure consistent transformations of the web pages when different visualizations can be chosen by the users, the web content, its structure and the presentation are separately modeled by using style sheets (CSS).

Image and animations

The use of such components is limited to the case of true usefulness by also providing captions and textual descriptions. Moreover, the use of blink scripts is avoided.

Image maps

Client-side image maps instead of server-side image maps, equipped with captions and textual descriptions, are provided.

Multimedia components

For each graphic or auditory presentations the corresponding textual descriptions or an equivalent visual alternative is provided.

Links

The target of each link is clearly identified by using short label or phrase and avoiding generic words. Moreover, navigation mechanisms are used in a consistent manner. The use of popup windows is avoided.

Interactive components (*e.g., scripts, applets, plug-ins*)

The use of such components is limited to the case of true usefulness, and alternative visualizations are provided when they cannot be managed with assistive technologies for disable people.

Frames

Each frame is named to facilitate its identification and navigation, and an alternative to its use is provided since people with sight problems prefer the use of the whole screen in order to read bigger characters. In general, frames are avoided.

Tables

Tables are built so that they make sense when they are read cell by cell or row by row, and an equivalent alternative is provided when the mean is not clear.

Forms

Explicit labels are associated to each form control.

During the testing phase, testers verified the conformance to the WCAG 1.0 [11]. A complete and exhaustive verification combines semi-automatic, manual, and user testing of accessibility features.

In order to identify accessibility problems the following checks were performed:

- page selection was verified with three graphical user interface browsers, Internet Explorer, Netscape and Opera, by considering also different versions;
- images were turned off, and the presence of alternative and appropriate text was verified;
- sound was turned off, and it was verified that its content was provided by equivalent text;
- the usability of the web pages was verified by varying the font-size;
- the adequacy of color contrast was evaluated by changing the display color to grey scale;
- the accessibility through keyboard commands was verified for all links and HTML form controls;
- the accessibility through a voice browser (and a text browser) of the web site was verified in order to prove that the information was equivalent to that provided by a graphical user interface browser, and was understandable when serially read;
- the web pages were validated by using *HTML Validation Service*;

- the style sheets were validated by using *CSS validation service*;
- the web site was verified by using *Bobby*.

It is worth noting that even if a site strictly follows the technical accessibility standards, it can still be very hard to use for people with disabilities. Thus, a usability test involving also people with different disabilities is necessary to ensure effective accessibility. In our experiment we have benefit from the collaboration of a low sighted albino boy and a deaf boy who evaluated the designed interfaces.

The reports obtained at the end of the testing phase were used to retrofit the web site in order to repair the identified accessibility barriers.

Although we were not able to collect reliable effort data due to the novelty of the experience, the conducted experiment has been useful to understand which phases are especially affected by the accessibility goal. Moreover, it has suggested us some elements which could be used as predictors/cost drivers for the effort estimation, namely: Colors, Fonts, Links, CSS, External Input, Audio/Video, Additional Navigation Bars, Indexes, Images, Client Scripts, Table Indexes, Lengthy Textual Sections, Frames. Such items allow us to take into account the different elements that the WAI guidelines focus on. We plan to replicate the experiment to verify if they can be used along with the Web Objects metrics [8] to predict the effort for the development of the accessible web sites.

3. Activities and Effort for the Usability Goal

As we have pointed out in the previous section, technical accessibility is necessary, but not sufficient to ensure usability of a web site. On the other hand, when dealing with web applications, focus on usability is expected throughout the development process, involving several activities, that start from the requirement analysis phase. Several specific factors should be taken into account in order to meet the usability requirements. Factors like ease of learn, retrievability, navigability, content comprehension, are all committed at assuring an acceptable level of user performance and satisfaction with the system. Of course, a necessary basis for that, is the collection of detailed usability requirements, in terms of a thorough task analysis, and of an appropriate user modeling. A user-centred approach is therefore highly recommended for web engineers, who are further supported by the usability guidelines resulting from the several studies carried out on this matter [3,7].

Since usability strongly depends on visitor's psychology and habits, the evaluation process is usually carried out by means of field observations on a group of users who are representative of the category of people who will be visiting the site under construction. Once the usability requirements are determined, the analyst embeds them into the general system specification. Then the activities that are mainly affected by the usability design goals are design and testing.

In the following we describe the tasks carried out during such activities to ensure usability and for each of them we specify the time that is commonly allocated to perform it. It is worth noting that both task specifications and time indications have been devised based upon the opinion of experts from several companies that have developed many web applications in different application domains, such as e-government,

cultural heritage, e-commerce, web portals. All the experts of the consulted companies confirmed that the scheduling of resources for such tasks is usually based on their past experiences.

In order to meet the usability goal a basic task during the design phase is the definition of an overall editorial plan meant to describe the web site structure and the navigability criteria to adopt, together with useful suggestions for art directors, developers, and content creators. So, the document usually includes:

- A navigation structure, whose thoroughness and formal correctness is ensured by the designer;
- The visitors' habits and experience with web site navigation;
- The visitors' global view of the site;
- The traceability of the web section containing the searched information.

On the basis of the experience of our experts, usually 10% to 20% of the design phase is devoted to define such overall editorial plan.

As for the testing phase, it is quite intuitive that the effort required for testing can be significant. It is therefore necessary to carefully balance between the benefits coming from usability testing and the consequent effort overhead. Thus, it usually consists of the following tasks for which we also indicate the time commonly allocated.

1. Creation of the testing check list – 4 to 7 days.
   During such activity, a check list of the usability factors which are meant to be verified is prepared. Focus is only on the areas considered crucial. A group of 5 users is selected, if the web application is targeted at a single category of users, otherwise 3 to 4 users are selected for each target category (3 if more than two categories are identified). The check list usually includes the following items:
   - a check on the adequacy of all members of the selected group of users for the testing tasks
   - the testing activities to be performed in order to achieve the required usability characteristics
   - a check on the appropriateness of the time period allocated to each test
   - guidelines for the different usability characteristics
   - questionnaires that should be administered.
2. Test planning and scripting, through a "think aloud" observational technique –3 to 4 days.
   - presentation and description of the observer's role
   - explanation of the testing goals
   - task description
   - explanation of the methodology, encouraging users to criticize the web application he/she is experiencing
   - creation of the right natural context for the user, in order to reduce possible biases in the results
   - documents that ensure privacy should also be signed by users in this phase.
3. Testing – 5 to 7 days.
   The user explains the task he/she is trying to perform and comments on the result of each single action relating it to the task goal. For each action, he/she gives a

prediction on the subsequent actions, and he/she identifies possible problems or points of confusion.

4. Rework - about 7 days.

   After testing, about one week is allocated for solving possible usability problems. The following problem typologies can be distinguished:

   - Problems which are not directly concerned with usability
   - Aesthetic problems – they will be solved only if time is left before the delivery
   - Minor usability problems – low priority for their solution
   - Major usability problems – high priority for their solution
   - Critical usability problems – solutions to be supplied prior to the product release.

The classification of a problem as minor, major or critical depends on the degree of criticality of the problem for the user experience.

All the projects developed for the courses of Web Engineering and Human-Computer Interaction have been realized in agreement with the above methodology by considering the corresponding time resource allocation. Such approach has turned out to be cost-effective, simple, to require little experience and to be still able to provide useful insights into problems with web applications. Moreover, it helps to detect possible confusion determined by vocabulary differences between designers and users, and to better understand user's point of view.

4. Conclusions

The achievement of web accessibility and usability goals necessarily affects the required development effort. Nevertheless, as far as we know, no analytic study has been reported in the literature to determine the actual effort to put on these nonfunctional requirements. On the other hand, we have consulted several international software companies operating in our territory, which confirmed us that they do not use any algorithmic models for accessibility and usability. Moreover, they presented us a chaotic situation determined by several factors such as the excessively rapid technological evolution, the pressing for quick product delivery, the keen competition, so that very few resources can be dedicated even to collect historical data.

Such considerations reinforce our opinion that in the future only companies which decide to invest on quality will survive in a market where web applications development companies spring up like mushrooms. Thus, it is important to understand the impact of quality factors on the development process in order to carefully plan and schedule resources.

The initial study we presented in this paper has been useful to understand which phases are especially affected by the accessibility goal. Moreover, it has suggested us some elements which could be used as predictors for the effort estimation. We plan to replicate the experiment to verify if they can be used along with the Web Objects metrics [8] to predict the effort for the development of accessible web sites. As for the usability goal, we have experimented the approach suggested by some experts.

Such an approach also takes into account the time required for each task, which results from the trade-off analysis that the experts carried out between usability gains and testing costs. It would be interesting to investigate how the approach and the time required for the tasks change if automated usability tools are used, like those proposed by Chi et al. in [2], Blackmon et al. in [1], and Ivory in [6].

References

1. M.H. Blackmon, P.G. Polson, M. Kitajima, C. Lewis, "Cognitive Walkthrough for the Web", in *Proceedings of Conference on Human Factors in Computing Systems* (CHI'2002), pp. 463-470.
2. Ed H. Chi, A. Rosien, G. Suppattanasiri, A. Williams, C. Royer, C. Chow, E. Robles, B. Dalal, J. Chen, S. Cousins, "The Bloodhound Project: Automating Discovery of Web Usability Issues using the InfoScent[tm] Simulator", in *Proceedings of Conference on Human Factors in Computing Systems* (CHI'2003), 2003.
3. A. Dix, J. Finlay, G. Abowd, R. Beale, *Human-Computer Interaction*, 2nd edition, Prentice-Hall, 1994.
4. R. Fitzpatrick, "Additional Quality Factors for the World Wide Web", in *Proceedings of the Second World Congress for Software Quality*, Yokohama, Japan, Union of Japanese Scientists and Engineers (JUSE), Tokyo, Japan, 2000.
5. R. Fitzpatrick, P. Smith, B. O'Shea, "Software Quality Challenges", *Proceedings of the Second Workshop on Software Quality at the 26th International Conference on Software Engineering* (ICSE 2004), Edinburgh, Scotland, IEE, Stevenage, Herts, UK.
6. M. Y. Ivory, R. R. Sinha, M. A. Hearst, "Empirically Validated Web Page Design Metrics", in *Proceedings of Conference on Human Factors in Computing Systems* (CHI'2001), 2001, pp. 53-60.
7. J. Nielsen, *Designing Web Usability: the Practice of Simplicity*, New Riders Publishing, Indianapolis, IN, 2000.
8. D. Reifer, "Web-Development: Estimating Quick-Time-to-Market Software", *IEEE Software*, vol. 17, no. 8, November/December 2000, pp. 57-64.
9. Top of the Web - Survey on quality and usage of public e-services http://www.topoftheweb.net/docs/Final_report_2003_quality_and_usage.pdf
10. WAI Resources. http://www.w3.org/WAI/Resources/#gl
11. Web Content Accessibility Guideline 1.0. http://www.w3.org/TR/WCAG10/
12. Checklist Checkpoint. http://www.w3.org/TR/WCAG10/full-checklist.html
13. Bobby™ Portal. http://bobby.watchfire.com/bobby/html/en/index.jsp
14. Markup Validation Service v0.6.6. http://validator.w3.org/
15. CSS validation service. http://jigsaw.w3.org/css-validator/
16. Auxiliary Benefits of Accessible Web design. http://www.w3.org/WAI/bcase/benefits.html