Incorporating Accessibility in Web-Based Work Environments: Two Alternative Approaches and Issues Involved

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Abstract

The development of online work and collaboration environments presents a number of opportunities as well as challenges, especially for diverse user populations. They can enhance the mobility of workers and, subject to their design, offer access to people with disability and contribute significantly to tackling existing barriers in employment and social inclusion. At present, a number of web-based work environments have been developed; nonetheless, they hardly reach people with disability due to their low conformance with Web accessibility principles. One of the reasons why incorporating accessibility in online environments remains elusive for most Web service providers is that it is difficult for them to choose among the alternative approaches. This paper examines two different approaches of Web accessibility engineering from a provider's perceptive and in relation to the resources required in each case. In the first approach, interfaces are made accessible by design, whereas the second approach involves the use of "filter and transformation tools" as a means to transform existing non-accessible interfaces into ones that comply with de facto Web accessibility recommendations. Based on the authors' experience and hands-on practice on both approaches gained in the context of several European and national projects and through the development of fifteen accessible online tools in total, a study was conducted to examine the cost effectiveness of each approach. As a result, a set of practical guidelines are offered here for assisting web service providers in identifying the most appropriate approach with regards to the different needs of any given project.

1 Introduction

Disability has traditionally been a barrier to employment for many persons. Recent studies indicate that "*on average, the participation rate of severely disabled people in the European Union workforce is fewer than 35%, compared to 70% of workers without disabilities*" (European Commission 2002, p.13). At the same time, the overall number of people with disability is increasing and it is currently estimated at 7% to 10% of the population worldwide (World Health Organization, 2003). These numbers underline the growing demand expressed nowadays for online services and tools that are universally accessible, so that the entire active workforce can benefit and be (come) active. In a number of countries, Web accessibility is nowadays required by law (e.g., U.S. Code, 1998) and policies (e.g., European Parliament, 2002). As a result, a number of standards, guidelines, checklists and techniques for Web accessibility have been proposed worldwide. For instance, according to the World Wide Web Consortium - Web Accessibility Initiative (W3C-WAI), websites must at least conform to all Priority 1 checkpoints of the *Web Content Accessibility Guidelines* (WCAG 1.0[1]). In the USA, websites are additionally required to comply with the provisions of *Section 508* of the US Rehabilitation Act[2]. However, results of recent surveys show a very low conformance to any of these guidelines and the majority of Web-based communication and information tools remain inaccessible to a large number of people. For example, a survey on websites from Ireland, United Kingdom, France and Germany regarding their conformance to WCAG 1.0 and HTML standards indicated an average of 40% Priority 1 diagnostic violations (Marincu & McMullin, 2004).

Apparently there are quite some reasons why providers are reluctant to introduce accessibility engineering into their development process. Most web service providers claim that creating accessible web services requires, among

[1] Web Content Accessibility Guidelines 1.0: http://www.w3.org/TR/WCAG10/
[2] U.S. Section 508 Guidelines: http://www.section508.gov/

others, a considerable initial investment for equipment and recruitment of a proper team (e.g., training, technical assistance, purchase of authoring software and assistive technologies). Depending on the lifecycle phase of a web tool (e.g., new concept, under development tool, deployed and under maintenance product), incorporating accessibility may vary from simply altering some HTML files and *HTML tags*[3] to (re-) designing from scratch accessible interfaces. The latter is undoubtedly a nontrivial task that may require active participation of accessibility experts and trained Web developers, but even then there are considerable long-term benefits, well demonstrated by a number of experts. Sierkowski (2002) claims that "*incorporating accessibility takes time, planning and research however accessibility allows long-term savings*", and according to Clark (2003), Web accessibility induces an increase of only 2% of the original budget.

However, providers have low awareness of these benefits and almost none of the alternative approaches that they can follow to achieve Web accessibility. Web providers are quite often in the challenging position to (re-) produce an accessible website or tool and therefore in the need to know about alternative approaches and the issues that each one involves in order to enhance appropriately their development processes. One way is to adhere to accessibility engineering principles right from the beginning, during the design phase of application and services (e.g., by means of evaluation and repair on early mock-ups and prototypes). This a priori approach can show significant market benefits (Slatin & Rush, 2002), and according to some is the optimal case, as "*accessibility is more expensive if introduced later in the design phase*" (Clark, 2003). However its adoption in the case of existing products is not always feasible. When dealing with deployed or under (re)development Web tools, which represent the majority of cases, the dilemma that providers are confronted with is whether to redesign from scratch or to follow a posteriori approach by means of transformation and repair through facilitating technologies that are referred to with the general term "accessibility-oriented transcoding" (Alexandraki, Paramythis, Maou & Stephanidis, 2004; Maeda, Fukuda, Takagi & Asakawa, 2004). An important factor which needs to be considered in this respect is the correlation between the investment of providing Web accessibility in these two approaches and the development phase of a product. Although the first approach is perfectly in accordance with the requirements for accessibility, the latter has also some significant advantages to offer that, ultimately, may lead to a longer-term investment.

Keeping in mind the providers' perspective of interest and that incorporating accessibility should not result in considerable increases of the overall cost, each of the proposed approaches can be more preferable under specific circumstances. This paper presents some empirical rules to guide Web service providers in identifying each time which of the two alternatives approaches mentioned above (and described in more detail in section 2) is better to adopt in order to incorporate accessibility appropriately and effectively. The suggested rules are based on the findings of a review of several accessible collaboration tools and web portals that were developed following the two approaches (one at a time). Following the presentation of background and related work, the paper is organised in four subsections. Section 3 describes the data collection process and defines the variables used in the analysis. Sub-section 3.1 discusses the *development status* as a criterion for selecting between the two alternatives, and sub-section 3.2 presents a number of additional factors that may further affect the decision for choosing a specific approach. Section 4 presents the analysis of all cost factors. Finally, section 5 outlines a decision making process based on the characteristics of the project at hand.

2 Background and Related Work

In this study the following two approaches for incorporating accessibility into Web tools are in focus: (a) the implementation of accessible interfaces as a result of a systematic design and development approach that adhere to well-established accessibility design principles ("*Accessibility by design*"); and (b) the use of tools that can be installed "on-top" of a Web tool, to provide accessible versions of its Web pages ("*Filter and transformation tools*").

2.1 Accessibility by design

This approach mainly involves the following steps:

- **Production** of a web template (interface) that is compliant with existing accessibility standards for web content, such as WCAG 1.0 and those provided by Section 508 regulations.

[3] *HTML tags* are text strings used in HTML files to specify a webpage's content and presentation style.

- **Validation** of the produced accessibility
  - through the use of one or more of the available evaluation tools[4], and
  - through manual evaluation by experts.
- **User testing** with various assistive technologies, such as screen readers and user agents to assess whether the final product can be usable by the widest possible range of users. In general, any web tool intended for use by people with disability has to involve disabled users during the entire development process.

Despite the high availability of resources that can be of assistance throughout all these steps, Web accessibility still seems to be a complex issue to address for most web designers and developers, as they all require substantial effort, planning, and well trained personnel. Although it is possible to reuse the same principles and practical solutions for the production of accessible web templates, design and implementation of these web templates is a time-consuming procedure, especially when considering the pre-required training of the involved team.

2.2 Filter and transformation tools

Reasonably, most providers are not thrilled with the idea of redeveloping from scratch existing web tools only for the purpose of making them accessible. Therefore, suitable alternatives are required for incorporating Web accessibility in such cases, such as that of filter and transformation tools[5], which allow web users to access pages through a proxy kind of service that adapts pages according to the needs of individual users. Such an example is the *WebFACE* tool which allows the dynamic transformations of web pages, and automatically introduces web accessibility enhancements to existing web sites (Alexandraki et al., 2004). In general and according to W3C, these tools assist Web users (rather than Web authors) to either modify a page or supplement an assistive technology or a browser. A particular advantage of this approach is the scalability and reusability of such tools. A second and more important reason for choosing this approach is that the control of accessibility features is granted directly to the web user, therefore allowing for different users to precisely define their preferences according to their individual needs. The issue that arises though is: How and to what degree can web service providers utilize such tools effectively?

First of all, it should be noted that such a tool is not be able transform automatically any Web page to an accessible version as, for example, the page may be broken beyond repair (i.e., the page contains invalid HTML and, in most cases, does not look the same in different browsers), which implies that a considerable amount of human effort needs to be put on revising the source code of the existing Web pages. In this process, the existing look-and-feel is not necessarily altered, but proper adjustments must be applied in terms of 'valid web programming code" to conform with standards for web-based technologies (e.g., those set by the W3C for HTML, XHTML, CSS, DOM, and SMIL), as well as to integrate some basic aspects of accessible Web design (e.g., to provide appropriate Alt descriptions to all images). In any case, these adjustments are much easier to implement than the task of producing accessible Web pages by design. Finally, once these adjustments are made, the software package that will allow dynamic transformations of the Web pages into more accessible versions needs to be installed on the hosting server and configured appropriately.

Under the light of the above, the option of producing accessible interfaces through filter and transformation tools can be more preferable in cases of existing user interfaces that adhere to established standards for web engineering so that only some low cost adjustments on the mark-up code are further required. But, in addition to this cost, one must consider the price for acquiring the necessary filter / transformation software. Nonetheless, it should also be noted that such tools have the potential to assist developers with no particular background or knowledge in the details of developing sites that are fully accessible, and can potentially save development time.

2.3 "Accessibility by design" or "Filter and transformation tools"?

To estimate the investment required for the aforementioned solutions for Web accessibility, several cost factors must be taken into consideration. For example, the current lifecycle phase of an end product constitutes a driving criterion for identifying the most appropriate approach for the project in question. In other words, in case of web-based tool that is to be developed from scratch, the most effective and flexible approach is to adopt the "accessibility by

[4] Evaluation Tools: http://www.w3.org/WAI/ER/existingtools.html#Evaluation
[5] Filter and Transformation Tools: http://www.w3.org/WAI/ER/existingtools.html#Filter

design" approach, but in case of an existing or under development tool, it may not always be possible or smart to redevelop it from scratch, thus leaving as a next option the purchase and use of a filter and transformation tool. In fact, a web service provider may be required to take this decision at a number of intermediate phases, and there a number of factors, besides the development status, which can substantially influence the final cost and which need to be carefully considered.

3 Methodology

For the collection and analysis of the findings presented in this paper, a selection of fifteen (15) web tools was made. All the selected tools were developed within the time period 2001 – 2004, and all of them provided networking mechanisms that supported information and knowledge sharing as well as on-line discussion boards for registered members. The cost data includes the costs incurred in all stages of development, as well as other relative costs (e.g., training, deployment and maintenance costs, and cost of external software components that had to be purchased). It must be stated that the following analysis assumes that the entire process for all the developed tools involved the same development team, similar end-user categories, as well as the same development and production platform. The development team responsible for the production of the web products consisted of seven (7) individuals, including three (3) engineers with professional background in user interface design, graphic design, web accessibility and human factors and four (4) programmers without any prior experience in Web accessibility engineering. Finally, accessibility was considered in terms of conformance with AAA level of W3C-WCAG 1.0.

The focus of the performed analysis was to establish a qualitative relationship between the adoption of each of the presented approaches and their impact in terms of development cost. Due to the small size of the sample analysed here, the absolute values cannot be adopted as such. Instead, the authors' purpose is to provide clear assumptions of what approach can lead to lower cost in the middle-long term. To this effect, comparison charts are provided, indicating the behaviour of the investigated cost factors.

3.1 Cost in relation to the product development status

The development status of the end-product plays a key role in determining which of the aforementioned strategies best suits a particular situation. Given that legislation related to web accessibility is in progress in most countries, it must be emphasized that the providers of web products may encounter the need for engineering Web accessibility at any stage of the development lifecycle of a product. Therefore such an analysis should begin by outlining which is the most suitable solution depending on the development status of the product.

It is generally advisable to take accessibility into consideration as early as possible, i.e., during product specification. There are cases, however, in which accessibility is not considered early enough, either due to the lack of the relevant legislation or because providers are unaware of the potential user population of the end product. More specifically, if Web accessibility is considered during the specification of the product, then accessibility-by-design is the optimal approach to follow due to the insignificant increase in overall budget (Clark, 2003). This process, according to the specifications of W3C-WCAG 1.0, should include accessibility validation using both an automated tool and human review. More specifically, W3C-WAI (1999) recommends to *"begin using validation methods at the earliest stages of development. Accessibility issues identified early are easier to correct and avoid"*. This is because the tools and information services can be proactively designed taking into account accessibility.

At the other end of the spectrum, for web tools and especially large information portals which have already been developed and are fully functional, the filter and transformation approach appears to be the most appropriate. In most of these cases, the overhead of redesigning an existing web site from scratch may be unacceptable, since it would require radical changes both at the level of graphic design as well as at the functionality level of the developed portals, especially if they incorporate tools for web collaboration, such as listing of downloadable document archives, web forums, etc.

In the intermediate phases of development of web tools, the overhead cost incurred when adopting each of the two approaches will depend on a number of factors. These factors may for example include the experience of the development personnel on Web accessibility issues (and potential training costs) and the potential reusability of the

end product. These factors may also contribute to the suitability of an approach either at the start or the end of product lifecycle, but not as deciding factors.

3.2 Other cost factors

Besides development status, there are additional factors that must be taken into consideration in order to further analyse the investment required for the two aforementioned approaches to Web accessibility. The key factors used in this analysis are presented below:

- Training on Web accessibility: the cost for training inexperienced members of the development team on the basic topics for creating accessible web sites.
- Design of web templates: resources needed for the graphic design and the construction of early mock-ups.
- Ensuring HTML, CSS validation: the cost for the creation of web templates in accordance with HTML, or XHTML, and CSS specifications (note that WCAG 2.0 requires a valid HTML as a perquisite for level-A accessibility)[6].
- Ensuring WAI-AAA conformance: cost of conforming to W3C-WCAG guidelines for achieving AAA accessibility level.
- Accessibility evaluation: resources needed for the iterative evaluation and repair process according to the above accessibility standard.
- Deployment: resources needed for the installation of the product or tool and the purchase of the required off-the-shelf products or services.
- Maintenance: resources needed for the maintenance of the end-product.

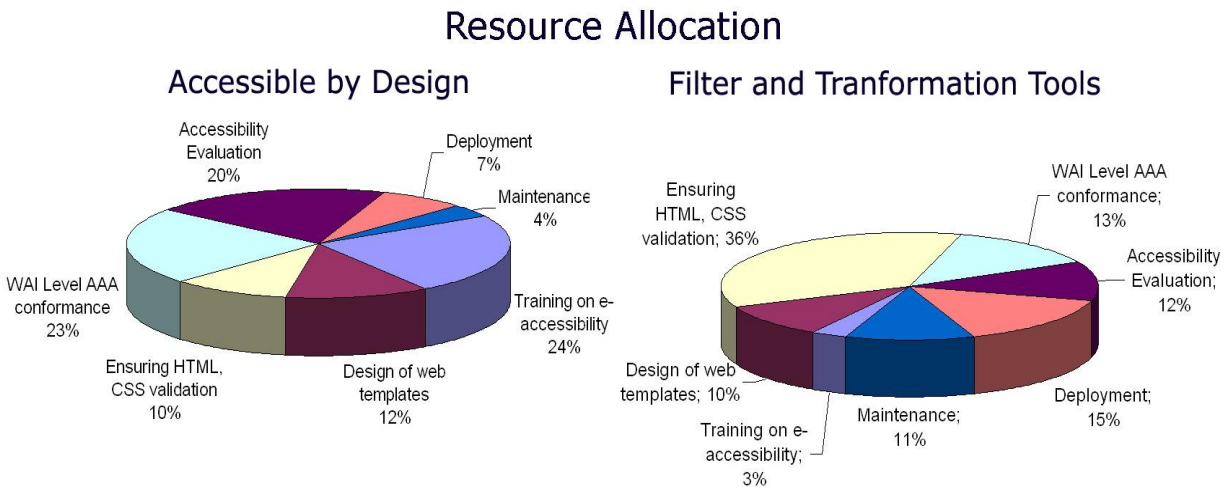

Figure 1: Example of resource allocation for the two approaches to Web accessibility. In each case, the percentages were calculated by comparison of the man-hours spent for each factor.

An illustration of the relative resources that are needed for the accomplishment of each of the previous tasks is provided in Figure 1. The pie chart on the left hand side indicates the allocation of resources needed for adopting an "accessible-by-design" approach, whereas the pie chart on the right hand presents the resources required when adopting the "filter and transformation" approach.

4 Results

The analysis of the relative cost required for each of the aforementioned factors is based on a severity value, which is calculated according to the minimum and the maximum values reported for the resources that were required for the development of the fifteen web products. This data is presented in the following Table 1.

[6] Level 1 Success Criteria for Guideline 4.1: http://www.w3.org/TR/WCAG20/#use-spec

Table 1: Analysis of cost factors associated with development effort (maximum and minimum values may be related to resource allocation for different web products, therefore values do not necessarily add up to 100%)

Individual Cost Factors	Accessibility by design: Ratio of cost of individual factor over the total cost (%)			Filter and transformation tools: Ratio of cost of individual factor over the total cost (%)		
	Average (from 10 tools)	Max	Min	Average (from 5 tools)	Max	Low
Training on Web accessibility	20%	24%	11%	5%	5%	3%
Design of web templates	10%	12%	6%	7%	8%	5%
Ensuring HTML, CSS validation	12%	13%	9%	25%	31%	22%
WAI Level AAA conformance	16%	20%	8%	14%	15%	12%
Accessibility Evaluation	16%	20%	12%	14%	15%	11%
Deployment	6%	7%	5%	13%	14%	10%
Maintenance	4%	4%	3%	11%	12%	10%

According to the previous table, the factors that had the greatest impact on cost in the two approaches were the training on accessibility issues, the need for compliance to standards and the accessibility evaluation process. Hence, the analysis of those factors is significant in order to determine optimal approach suitability.

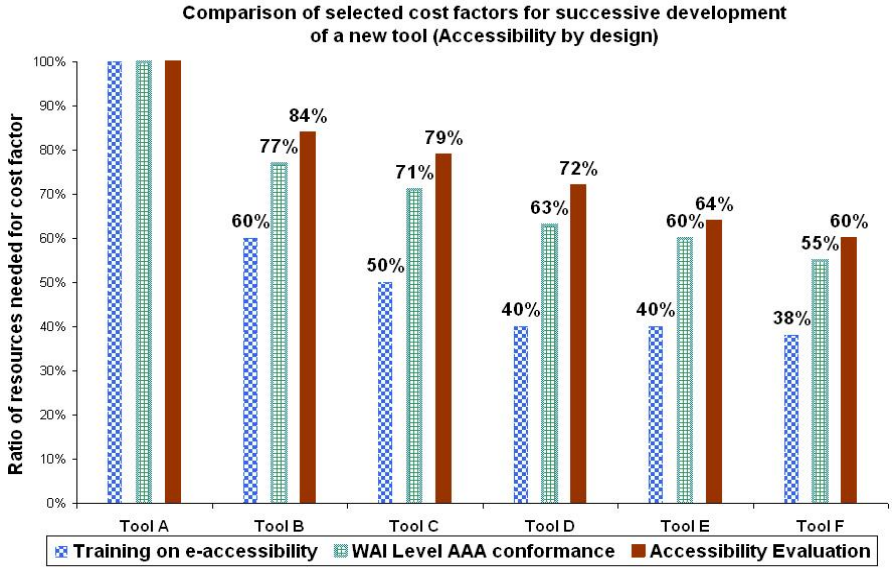

Figure 2: Analysis of the resources (man-hours) spent for incorporating accessibility in the consequent developments of six similar new tools by a single development team (*comparisons are made in relation to the resources spent for the first tool A*).

It could be observed that training and evaluation cost renders the application of the first approach non realistic. However, major training and evaluation costs occur when developing for the first time an accessible product. On the other hand designing and implementing Web accessibility seems a promising and cost-effective investment when a provider deals with several projects that have Web accessibility as a requirement. Based on the findings of this study, it can be concluded that the resources devoted to Web accessibility issues (i.e., WAI Level AAA conformance & Training on Web accessibility) have a downward tendency, reaching almost half of initial resources after several developments (Figure 2) by the same team. A similar tendency also appears in the case of the cost of the evaluation process (i.e., accessibility evaluation), not because the evaluation process is faster, but because the code to be evaluated is more compliant to accessibility standards. Consequently, efficient training of the development team in Web accessibility issues is suitable in the middle-long term and reduces the overall cost considerably.

A comprehensive analysis of the HTML and CSS validity factor showed that the re-development cost in the case of applying the first solution depends on the criticality of the accessibility problems and the amount of time and resources available to fix them. By examining the implementation of four (4) similar cases, that took place after the completion of the projects mentioned above by the same team (so there is no association with training cost), it seems that higher level of conformance with standards results in a reduction of the overall cost (Figure 3). Although the sample is not significant, it could be argued that in cases where there is no validity with mark-up standards, a new implementation process could be followed instead of trying to achieve Web accessibility by altering existing web templates.

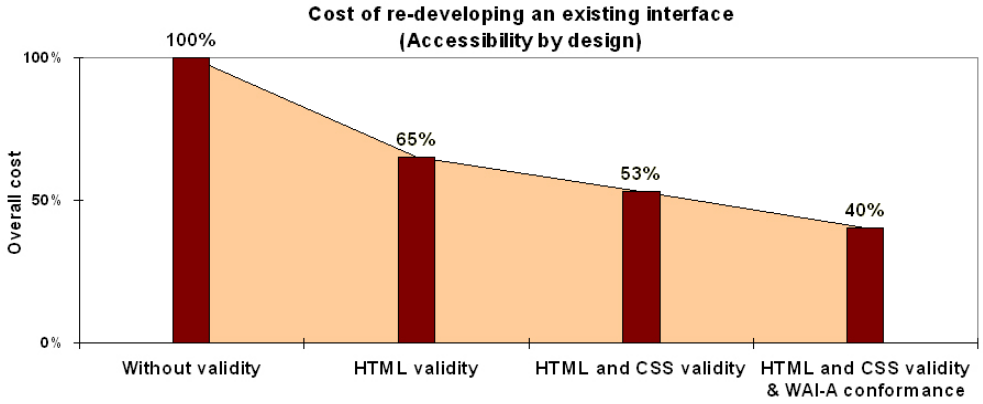

Figure 3: Analysis of the resources (man-hours) spent for redeveloping existing mark-up to meet accessibility conformance in the consequent redevelopments of four similar tools by a single development team (*comparisons are made in relation to the resources spent for the first tool which had invalid HTML*).

When trying to analyse the findings of the investigation concerning the second approach, it could be assumed that transformation/filter tools (e.g., Betsie[7], Web Access Gateway[8], etc) provide similar capabilities and limitations. In the presented study, *WebFACE* was used, which is designed in such a way so that the web interface, generated as a result of HTML transformations, is fully compliant with widely acknowledgeable standards for web accessibility, such as the WAI-WCAG. An analysis of the costs involved in the use of the *WebFACE* for the purpose of five (5) web tools showed that the resources devoted to altering the web templates in order to meet the requirements for the utilization of this tool depend considerably on the pre-existing level of conformance with standards (Figure 4).

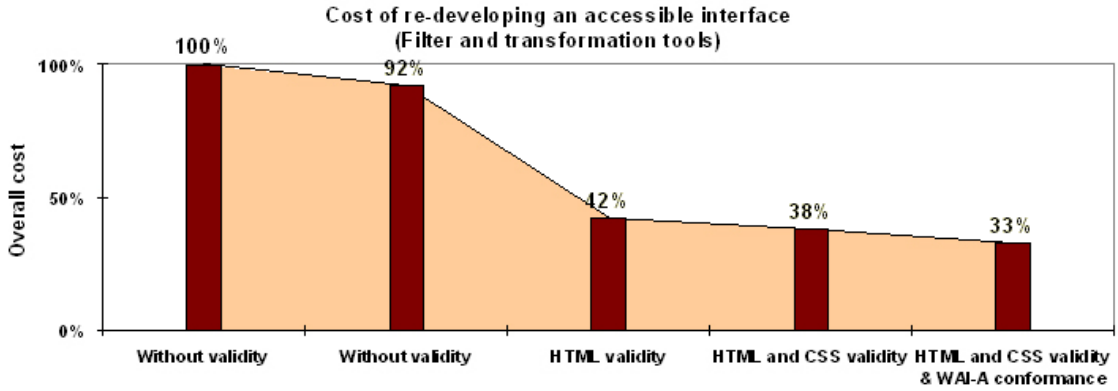

Figure 4: Analysis of resources (man-hours) spent for redeveloping existing mark-up to comply with the rules imposed by the use of the specific filter and transformation tool (e.g., specific tagging of elements) in the consequent redevelopments of five similar tools by a single development team (*comparisons are made in relation to the resources spent for the first tool which had invalid HTML*).

[7] Betsie: http://www.bbc.co.uk/education/betsie/about.html
[8] Web Access Gateway: http://www.cl.cam.ac.uk/~ssb22/access.html

It should be noted that similar costs between an existing mark-up with HTML conformance and another with HTML & CSS conformance occur due to the fact that the *WebFACE* requires specific work in altering class names in the CSS file. This is the reason why significant resources (approximately 33%) need to be utilized even when the existing web interface complies with several mark-up standards.

Finally, considerable attention must be paid to the internal policy of web service providers and their willingness to purchase third-party solutions to be used as web proxies or external programs that reside into their products. An additional consideration concerns whether personal setup by end-users and additional traffic that results in delays could cause visits reduction. Such considerations are even more important in case of applying these tools through a Secure Sockets Layer (SSL) utilized by several web tools. Web service providers may find it difficult to guarantee end-user security, even when this service/tool relies on the provider's hardware infrastructure, and this is likely to raise concerns for end-users.

5 Selecting an approach: Decision-Making and Guidelines

Based on the factors that have been analysed in the previous sections and that are likely to influence the choice of web providers as for the most suitable approach to Web accessibility in a development project, **Figure 5** summarizes the related decision-making process and provides guidelines for arriving at the selection of one of the two approaches.

The following guidelines are additionally offered in relation to the presented decision making process and the involved factors:

- The product development status of the product:
  - Rationale: "Accessibility-by-design" is more expensive if introduced later in the design phase
  - Guideline: For new products and products that have not yet entered the implementation phase, the "accessibility-by-design" approach is recommended.
  - Rationale: Trough the "filter and transformation tools" approach vendors can provide accessible interfaces of existing non accessible products with low cost adjustments.
  - Guideline: For existing products, the use of filter and transformation tools is recommended.
- The experience level of the development team on Web accessibility issues:
  - Rationale: High level of experience on Web accessibility engineering facilitates high performance in delivering WAI conformance.
  - Guideline: If the development team has no experience on Web accessibility engineering, and the product has entered the phase of integration and testing, the use filter and transformation tools is recommended.
- The validity level of the mark-up:
  - Rationale: The development cost to achieve validity is considerable.
  - Guideline: For products with high validity levels use filter and transformation tools.
  - Guideline: For products that contain mark-up broken beyond repair follow the "accessibility-by-design".
- The internal policy of vendors in providing in-house Web accessibility solutions:
  - Rationale: The cost of filter and transformation tools is reasonable.
  - Guideline: In case of non critical applications and in absence of restrictions for such a utilization of third-party proxy tools as an intermediate use filter and transformation tools for incorporating accessibility in existing web tools.

Clearly, there are situations in which it is difficult to determine the most appropriate approach to follow. However, the first two elements are the deciding factors that play the most influential role towards the final decision. When the design and construction of the individual template pages has not yet reached the final stage, one can consider following the first approach. This boundary may be transferred to the next phase of the development life-cycle, in case the development team is experienced enough to alter the existing design to an accessible one with low resources.

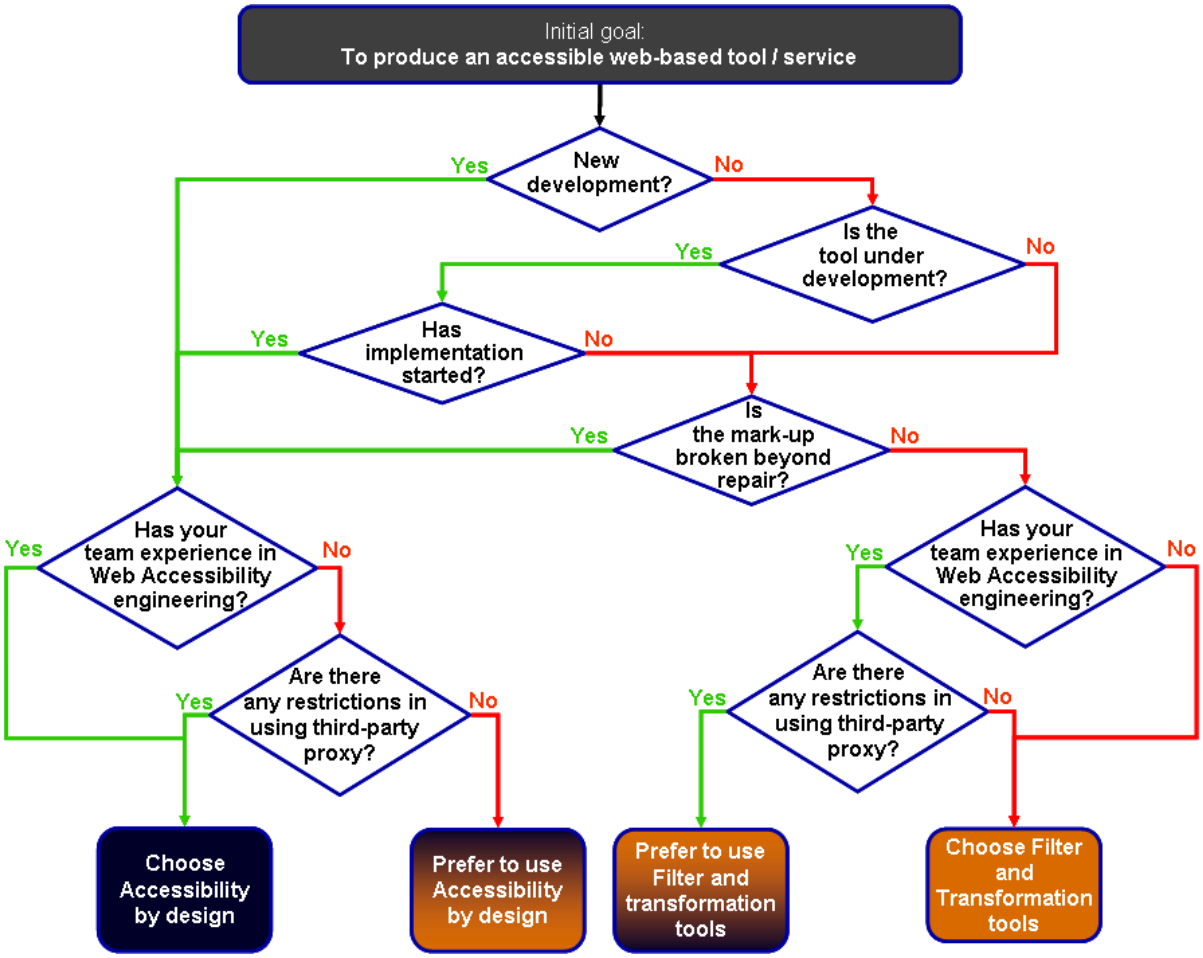

Figure 5: Decision making process

6 Conclusions

Further to previous efforts in literature, this paper has stretched out the importance of web accessibility from the provider's point of view. The fact that web accessibility can contribute significantly in tackling problems such as that of "inaccessible and underused web services", mainly implies that it is important for web service providers to adhere to the technological evolution of web accessibility and invest in training adequately their personnel. In general, web providers should aim at incorporating accessibility early in their developments. In addition, they should think seriously about providing additional, accessible versions of already launched products that were originally designed without taking into account web accessibility guidelines. Two main approaches can mainly be adopted in this respect, namely "accessibility by design" and the utilization of "filter and transformation tools". It is therefore essential that in each development effort the right approach is selected with respect to the resources available and the existing limitations, such as time-schedule, organizational policy and pre-existing know-how of the development team.

An examination of a dataset of collaboration tools and web portals in which the aforementioned approaches for Web accessibility were followed (one at a time), brought forward four basic factors that affect the overall cost of web accessibility: the *development status* of the product, the *experience* of the development team, the *validity level* of the existing mark-up, and the *internal policy* of providers. Therefore, the analysis of those factors is significant in order to determine in each case the most appropriate approach. To this direction, this paper has proposed a decision making process accompanied with a number of guidelines (section 5) for deciding upon the right approach for incorporating accessibility in new and existing web-based work environments. Finally, in terms of future work, a number of sub factors, such as *size* and *complexity* of a web tool, will be examined in a more analytical way.

Acknowledgments

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