# A Semantic Accessibility Assessment Environment for Design and Development for the Web

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**Abstract.** The Web is now increasingly being accessed by many people with disabilities. Thus, the great heterogeneity of Web application technologies as well as the provided Web content requires the introduction of accessibility aspects in order to fulfill the preferences for all people with disabilities or not. For that reason accessibility support at all stages of the design and development process of Web applications should be a solution that appears in the horizon. New developed Web applications should be fully adapted to different user needs, and totally accessible regardless of the specific condition of end users. Our approach introduces an advanced semantic accessibility assessment environment which initializes semantic models representing the most of main accessibility constrains and terms which are required for the design and development of Web applications, through the use of generic and domain ontologies. The proposed assessment environment can be used for the accessibility assessment of Web applications during the design and development phase.

**Keywords:** Web accessibility, Semantic Accessibility Assessment, W3C, WCAG, Disabilities

## 1 Introduction

It is important to realise that people with disabilities are not just a tiny minority of the population of the European Union. The lowest estimate, based on the extremes of currently defined disablement categories, puts their total number at around 74 Million persons. However, other estimates that take into account those people in the so-called hinterland between fully able bodied and the classically termed disabled, should considerably raise those numbers, as it is highlighted below:

- In the EU 27 countries about 16% of the population are over 65, a number that is estimated to rise rapidly in the coming years [1].

- Up to 15% of the population across the European Union has a disability, such as a visual, hearing, speech, cognitive, or motor impairment [2].
- Around 20% of people over 50 experience severe physical disabilities

The European Disability Action Plan priorities for 2008-2009 [3] include a focus on accessibility and emphasise that ‘accessible goods, services and infrastructures are essential to sustain non-discriminatory and inclusive forms of participation in many aspects of everyday life', and that ‘Achieving accessibility requires the avoidance and removal of barriers that prevent disabled people from exercising their capabilities and participating fully and on equal terms'. An estimation regarding the user demand for accessible ICT products, services and assistive technologies among the EU (50+ population) has been examined by the European study "The Demographic Change – Impacts of New Technologies and Information Society"[4] (following figure 1). As depicted in this figure, designing and developing for people with disabilities is becoming an increasingly important topic for a variety of reasons.

| Indicator of potential market size | | Demand potential in Mio | | |
|---|---|---|---|---|
| **Indicator for need** | **Degree of impairment** | **2010** | **2020** | **2050** |
| Vision problems | slight/ moderate | 46.3 | 53.1 | 59.1 |
| | severe | 20.5 | 23.5 | 26.2 |
| Hearing problems | slight/ moderate | 44.4 | 51.0 | 56.7 |
| | severe | 8.5 | 9.8 | 10.9 |
| Dexterity problems | slight/ moderate | 32.5 | 37.2 | 41.4 |
| | severe | 17.1 | 19.6 | 21.8 |
| More than one of these | slight/ moderate | 73.5 | 84.3 | 93.7 |
| | severe | 35.9 | 41.2 | 45.8 |

Source: Own calculation demographic data available from SENIORWATCH 2002 and demographic projections from Eurostat 2005

**Fig. 1.** User demand for accessible ICT products, services and assistive technologies among the EU 50+ population

Despite the rapid evolution of ICT over the last years and the increasing acknowledgment of the importance of accessibility, the developers of mainstream ICT Web based products still act and struggle under total absence of structured guidance and support for adjusting their envisaged products and services with their user’s real-time accessibility needs. In addition a similar situation is observed in the development of non-ICT products and services, where developers toil to test and evolve their prototypes in terms of their functionality, without however being able to systematically test their developments in terms of their accessibility. Thus, it is a technological challenge to provide people with systems that could foster the different facets in the perception of quality of life.

For that reason accessibility support at all stages of development and design of Web applications should be a solution that should appear in the horizon since the relevant technologies and applications to be developed has to be focused on the main characteristics of Ambient Intelligence (AmI), in order to ensure that new developed

Web applications should be fully adapted to different user needs, and totally accessible regardless of the specific condition of users.

So, a lack of non accessible Web applications can cause large productivity losses, with many people being unable to fully participate at work, in education, or in a wide range of economic and social activities. People's choice of leisure activities may be narrower than it otherwise could be. The cost of making products and services more inclusive need not be very high. The lack of progress on Accessibility reflects the current fragmented approaches to producing accessible products and services, which rather limit their economic potential, and create a barrier to a thriving single market for these in Europe.

Thus, the development of accessible software requires a strong effort from involved actors. With the additional encumbrance of taking into account different kinds of accessibility requirements such as accessibility standards and guidelines, and different user interface implementation technologies developers are faced with a daunting task. Also, the highly specialised skills required for developing accessible software sets aside most developers. In addition, real end users who they have their own specific characteristics (e.g., abilities, impairments, preferences, knowledge), are often left out of the overall development process.

Thus, capturing the many aspect of user demands and expectations can not be considered as a simple task and requires the effort of many different groups (developers, designers, testers, etc.) in the product development lifecycle.. To mitigate these problems, developers should be guided in their development process about accessibility concerns within user interface development. For that reason a User Centered design approach should be considered as an enabler for the design of accessible Web applications.

To overcome the gap between existing knowledge of all involved actors on accessibility issues and the development of accessible and tailored software applications, we introduce in this paper a Semantic Accessibility Assessment Environment for verifying the accessibility of Web Applications and services in order to improve their accessibility. This framework which has been introduced under the FP7 EC project ACCESSIBLE (Accessibility Assessment Simulation Environment for New Applications Design and Development) [5], provides a set of useful concepts to describe accessibility standards, users functional limitations and capabilities, assistive technologies and Web application technologies, as well as how these concepts can be integrated to form the semantic accessibility assessment of software applications. Through this environment, developers can be assisted on including accessibility constraints within Web application development processes.

## 2 Barriers and needs for Web accessibility

The World Wide Web (WWW) is considered to be a powerful tool enabling people to access a vast and diverse amount of data, cutting across cultural boundaries, as well as breaking down both personal and geographical barriers. Although the WWW has contributed to making access to information easier than before, special attention must be drawn to ensure that all people can equally enjoy the right of access to information.

Internet technology is considered to be relatively tolerant of impairments under certain conditions and therefore holds tremendous promise to improve access to information, goods, and services for many people with disabilities. However, on many occasions, people with some sort of physical, mental, intellectual or sensory impairment have to deal with significant barriers when trying to find and/or understand information available on the Web. In order to overcome these barriers, efforts must be made to establish common templates for presenting Web information in a form that can be understood by all people, regardless of the impairments they may have.

The increasing adoption of technologies from users puts the Web in a central spotlight. The Web, as its major application, is accessed and interacted by users at constant increasing pace, allowing them to quickly seek information, interact with their peers through social networks, or perform transactions from the comfort of their homes. For this reason, the way information is structured and presented is critical for the success of accessing it. Consequently, even if people with disabilities want to be independent and do things for themselves by themselves, unfortunately, most Web applications, services, are not fully accessible today.

The practice of making Web content usable by people of all abilities and disabilities is the main subject of Web accessibility. Web accessibility can be accomplished through the cooperation of: 1) information content on Web pages, 2) Web browsers and media players, 3) assistive technologies' software, 4) users' knowledge and experience in using the Web, 5) developers' experience, 6) appropriate authoring tools and 7) appropriate evaluation and simulation tools. Authoring and evaluation tools are usually used by Web developers to create Web content, whereas Web browsers, media players, assistive technologies or other “user agents” are used by Web users to get and interact with the content. Recent developments in the Web development technology provide unique features such as dynamic content, heavily graphical user interfaces and complicated navigation structures that often make accessibility a complicated challenge.

Although a wide range of principles, guidelines and standards for accessibility and universal design for various types of applications, services, goods and infrastructures are available from standardization organizations (e.g. Mandate 376: Accessibility requirements for public procurement of products and services in the ICT domain or Web content Accessibility Guidelines (WCAG) from W3C) [6,7], adopting and verifying them during design development is not sufficient even in the user–centered design process. Nevertheless, nor the WCAG, nor the national adaptations, can constitute by themselves the technical reference for certifying a Web site, as they do not contain methods for deciding the conformity on a uniquely interpretable, repeatable basis. This is why the various labelling schemes have had to create their own documents in order to make their assessments as objective as possible.

Furthermore, most of Web applications has developed over the latest years, and the importance of accessibility has only begun to be appreciated in the last two or three years. Any solution that is older than that is unlikely to be fully accessible. Making an existing system accessible is often very difficult and expensive, in much the same way as making an existing building wheelchair-friendly.

Also existing development tools and packaged solutions (e.g., several assessment simulations environments) give little out-of-the-box assistance in most cases or, at

worst, make it impossible to develop accessible ICT solutions. In general most assessment accessibility activities are performed after the development process of them instead of the complete lifecycle as a continuous approach to quality. Early testing can significantly lower the cost of completing and maintaining the developing products.

Today there are two main categories of web assessment tools [8], [9]:

- Tools for usability testing (e.g. WebXM, LIFT, WebCriteria) that are based on usability guidelines
- Tools for accessibility testing and repair, like aDesigner (by IBM), Watchfire WebXACT (previously Bobby), Juicy Studio, A-Prompt, 508 Accessibility Suite, Site Valet, AccVerify, LIFT, Imergo (by Fraunhofer FIT), etc. The metrics implemented by these tools correspond (more or less accurately) to official (W3C or Section 508) accessibility criteria.

Although the advantages of measurement in the Web application design and development process are indisputable, the popularity of measurement methods and tools, within accessibility terms, in practice is rather limited [10, 11, 12]. It is important that the development of accessible Web applications must be supported in an automated fashion as much as possible. We need tools that automatically assess the accessibility of a product with regard to specific user groups, and provide process-integrated and constructive guidance to the developer in how to apply accessibility principles.

## 3 A Semantic Accessibility Assessment Environment

Clearly an appropriate assessment environment is needed that allows customised and personalized accessibility verification of developed Web applications. As an extra point, the proposed Semantic Accessibility Environment detailed in this paper provides a fine-grained control of user's functional limitations and their capabilities, and how these can cope with existing Web accessibility guidelines.

We expect that by providing this feature out-of-the-box, Web design and development teams will bring audience-modeling procedures to their development processes. This will give them more control on implementing Web sites and Web applications that are accessible and verifiable during development stages.

In Figure 2 the architecture of the proposed system is represented. As illustrated in the figure, the architecture specifically concerns about automation over accessibility testing and it compromises with independent modules that can interact each other.

These independent modules are:

- The Semantic Assessment module in order to support the overall analysis and verification of Web applications in terms of accessibility. It provides evaluators with an Html parser in order to parse their code as required for the semantic evaluation process and a Web crawler for the online accessibility verification of Web sites (e.g by providing specific URLs). The semantic assessment module, based on the generic and domain ontologies as well as the SWRL rules supports the personalized accessibility assessment for the evaluators. The different ontologies, provide a set of terms and definitions

for accessibility constraints such as user capabilities, accessibility guidelines assigned to specific preferences and disabilities of disabled users, accessibility standards, Assistive technologies, etc. The integration of the Pellet framework [13] allows the execution of appropriate SWRL rules [14] that have been defined by using the Protégé SWLR editor. In addition, the Jena framework [16] allowed us to build ontology representations in memory and perform personalized SPARQL queries [15].

- A developer & designer aid module in order to assist developers during their design and development of accessible Web applications. Its main purpose is to provide appropriate accessibility standards and methodologies as well as application notes and open source tools (e.g. a visual impaired simulator) that can be used within the software development process.
- A user-centred presentation portal directed towards specific users (developers, programmers, testers) that giving them access to appropriate accessibility resources and applications in order to assist them how to include accessibility constraints within the software development lifecycle
- An EARL based Reporting Tool in order to export accessibility evaluation results in a form helpful to potential receivers of test results, including designers, developers and business stakeholders.

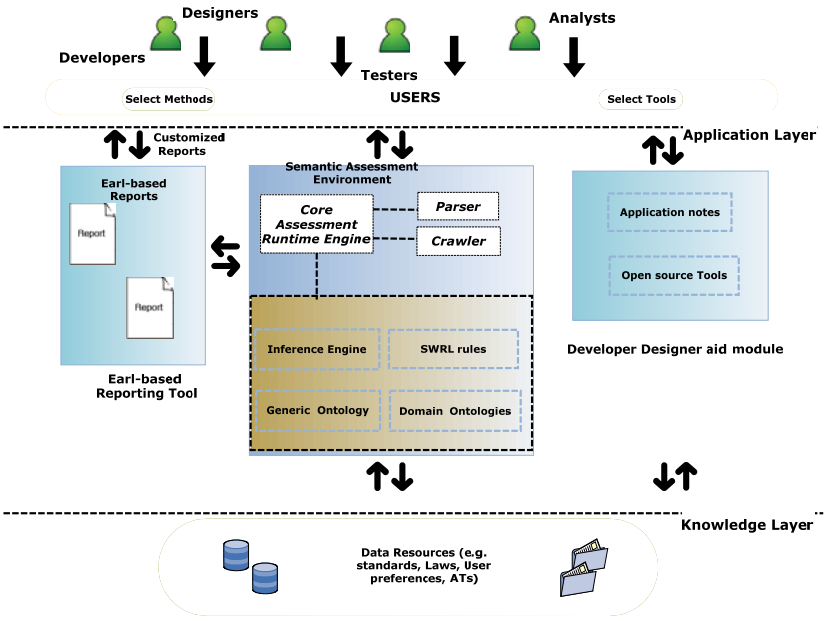


**Fig. 2.** Overall Architecture of the Semantic Assessment Environment

### 3.1 The Generic and Domain Ontologies of the Semantic Accessibility Assessment Environment

In order to establish a common vocabulary for exchanging and describing the complex information that is related to Web accessiblity we have proposed a generic ontology describing the main knowledge domains that represent the terms and constraints of the software development process of Web applications. Thus this ontology provides more abstract and generic knowledge such as general characteristics and disabilities of users, Assistive devices, Web accessibility standards, and other main aspects that constitute the basis for applying accessibility-based approaches into the accessibility validation field.

The generic ontology aims to formalize conceptual information about: (a) The general capabilities and functional limitations of users with disabilities based on ICF [17] classification (an example of disability, Funtional limitations and ICF instances is presented to the following table 1); (b) Devices characteristics, encompasses different assistive devices characteristics and requirements (e.g. screen reader, Braille etc.); (c) Main characteristics of Web accessibility standards based on the well known format which is provided by W3C WCAG 1.0 and WCAG 2.0 guidelines and has adopted by many standardisation bodies (e.g. guidelines, checkpoints, techniques, approaches);

In order to cope with these goals, the generic ontology has been implemented as formal as possible, in order to provide all the necessary definitions in a concise, unambiguous, and unified form; and giving access to information that can be easily processed by relevant users and integrated into software development processes.

**Table 1.** Disabilities with associated functional limitations and ICF classification

| Disability(ies) | Functional limitations | ICF classification |
|---|---|---|
| **Cognitive impairment**<br>Dementia | May have difficulties in language, self-help, independent living etc.<br>They acquire new knowledge at a slower pace than their peers.<br>They have difficulties in understanding instructions.<br>There may be difficulties in fulfilling the every-day duties or organizing one's own work load. These may be difficulty in remembering people's names, a telephone number or important address.<br>In case there are problems in retrieving memories, there may be difficulties in a number of aspects of every day life as previously mentioned, including difficulties in learning new skills. | **b117** Intellectual functions (incl. Retardation, dementia)<br>**b144** Memory functions<br>- b1440 Short-term memory<br>- b1441 Long-term memory<br>- b1442 Retrieval of memory<br>- b1448 Memory functions, other specified<br>- b1449 Memory functions, unspecified |

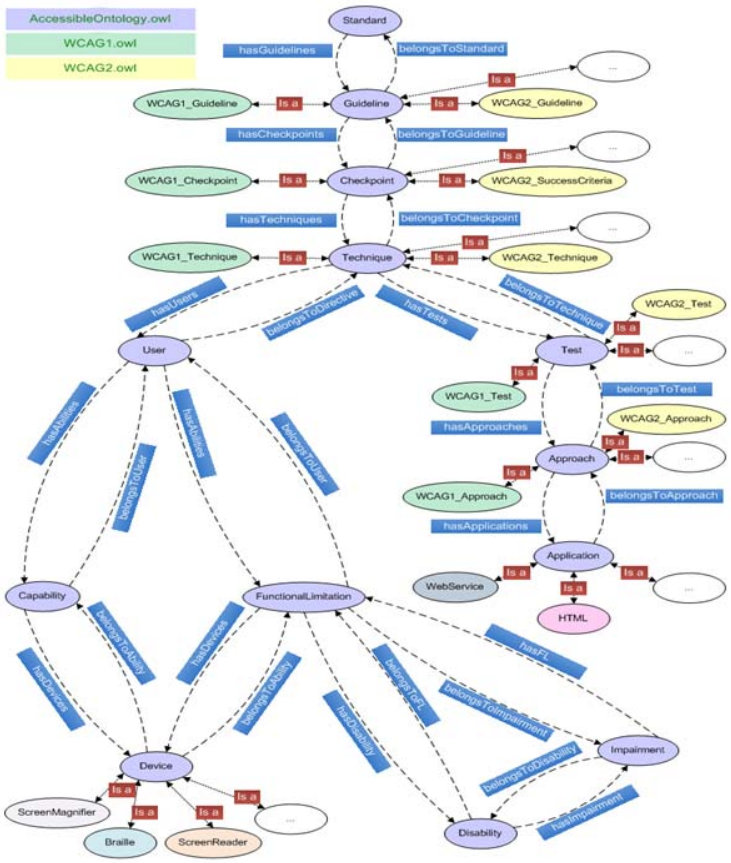


**Fig. 3.** Generic ontology with WCAG 1.0 and WCAG2.0 Domain ontologies

We devised different domain specific ontologies to cope with the specific individual domains of the Web accessbility resources (e.g. WCAC 1.0 domain otology, Screen reader domain ontology, etc.). Each domain ontology uses the basic entities of the Generic Ontology in order to represent a more detailed description of its corresponding domain, thus allowing the insertion of instances as well as the the establishment of mapping relationships between the domain ontologies withthe genric ontology. These relationships can be used, e.g., for efficient navigation and searching inside the ontologies, as well as to afford the creation of semantic rules-based accessibility verification. Generic and domain ontologies are specified in classes and subclasses providing a hierarchical model presenting all the knowledge fields that are required for the semantic accessbility assessment of Web applications. One of the main issues in designing and developing the proposed ontological framework was to make it maintainable and extensible, while assuring model consistency within the framework. A visualisation sheme of the implemented ontologies by using the ToVizTab plugin of the protege tool is depicted to the following figure 4

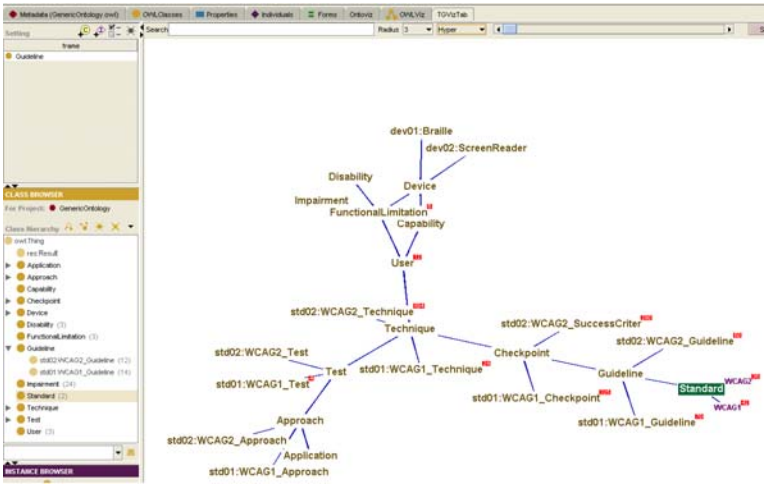


**Fig. 4.** Visualization of the ontologies with the ToVizTab plugin of the Protégé tool

## 4 Conclusions and Future Work

The proposed assessment environment would assist developers in creating accessible Web applications. By clearly separating generic accessibility from domain-specific issues, all the functionalities included in the proposed environment would allow creating a harmonized repository of accessibility constraints which could be shared among developers. Thus Web accessibility becomes simpler to use independently from particular guidelines and, consequently, personalisation can be further explored with appropriate set of guidelines. The usage of multilayer ontological frameworks it guarantees that new accessibility concepts not only for Web applications (e.g. guidelines, impairments, user's capabilities and assistive technologies) will be easily integrated to the system. Thus, while Web accessibility is an important issue to take into account, it is just the starting point because other domains, such as mobile and desktop applications, or even non ICT products must also be targeted by accessibility assessment procedures during early design and development stages.

Ongoing work is currently being done in several fronts, including: (1) providing support for guidelines and standards other than WCAG 1.0 and WCAG 2.0, (2) extend the domain ontologies to cover other application domains outside the scope of the Web, (3) Creating an EARL based output from in order to present personalized reports to the evaluators, (4) improving the Ontologies with SWRL rules to cover more assessment situations, (4) integrate a robust inference engine supporting SWRL rules and/or SPARQL queries, (5) integrate the proposed environment with a Vision Impairment Simulator for simulating a variety of vision impairments that can support developers and designers in the design and development of Web Applications.

## 5 Acknowledgement

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