Assessment of Web Accessibility and Technical Specifications Conformance of Web Sites from Four EU Member States

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I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of PhD is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

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Abstract

The Internet is playing an important part in our day to day life, through its power of making information universally available.

Provided that web content is designed with accessibility in mind, the Internet can bring immense benefits to people with restricted access to different aspects of life due to various types of disability.

An important source for accessible web design resources is the W3C's Web Accessibility Initiative (WAI).

WAI published the Web Content Accessibility Guidelines (WCAG 1.0)[1] in May 1999, which is now a reference point in web accessibility related policies in many different jurisdictions.

An automated web accessibility surveying system investigating W3C WCAG 1.0 and HTML technical conformance of large samples of web sites, was implemented at the eAccess laboratory at RINCE, D.C.U.,Dublin, Ireland.

In order to evaluate the practical results of the efforts invested in promoting web accessibility in Ireland, the conformance level of a sample of subjectively selected Irish web sites was monitored between April 2002 and December 2004.

In order to place the web accessibility conformance level of Irish web sites at EU level, conformance levels of samples of randomly selected Irish, UK, French and German web sites were also monitored between May 2003 and December 2004.

The findings of the study show that the general level of web accessibility guidelines and HTML standards conformance in all the web samples studied is very poor and there were no clearly distinguishable improvements in the time interval considered. More than that, although the web samples differ greatly through

the number of web sites considered, the results show a high similarity in the failures detected in the five web samples, over the entire time interval in which the investigations were carried out.

These findings show that the efforts invested in promoting web accessibility until now have had a small impact in reality.

The findings also suggest the need for a different, more firm, approach in promoting web accessibility guidelines compliance on the web.

Chapter 1

Introduction

1.1 Web accessibility

The significant benefits brought in our society by the Internet are well known. It reduces barriers of distance and time, and creates a society in which—in principle—anyone can have access to products and services all over the world at any time.

The people who could, arguably, benefit most dramatically from this are those who, because of some disability, have restricted access to information and services in the physical world, but they can have access to the online version of the desired services using dedicated assistive technologies—device or tool (hardware or software which adapts a conventional system for use by a person with disability). For example, a blind user can "read"—using a Braille display or speech synthesizer—the online version of the daily edition of her favorite newspaper or her bank statement; a user with restricted mobility can visit virtual stores from the comfort of his home; a student with cognitive disability can take her own time in understanding the taught material. Depending on the specific disability the Internet user has, the assistive technologies will differ from slow keys and on-screen keyboard to Braille displays and screen readers.[2]

Most of the existing assistive technologies act as an interface between a disabled user and a mainstream web browsing technology. By designing *accessible web content*, web authors will ensure that a user with any kind of disability using an appropriate assistive technology, if needed, can access web content and can get the same benefits as a user with no disabilities using conventional web browsing technologies.

1.2 Web accessibility in the EU

An important source for accessible web design resources is the W3C's Web Accessibility Initiative who, in May 1999, published the Web Content Accessibility Guidelines (WCAG 1.0) [1], which are now a reference point in achieving web accessibility in many of the EU's Member States [3]. In Ireland, The National Disability Authority have adopted WCAG 1.0 into the national "Guidelines for Web Accessibility" [4]. WCAG 1.0 is also a source for the "Guidelines for UK Governmental web sites" [5], published by the UK Cabinet Office in May 2002, the French "Government circular of 7 October 1999 concerning internet sites by state public establishments and services" [6] and the German "Barrierefreie InformationstechnikVerordnung" [7].

1.3 Thesis overview

The work presented in this thesis aims at improving web accessibility awareness among public policy makers at both national and international level.

The thesis concerns mainly with studying the way the efforts invested in promoting web accessibility in Ireland (compared to three other EU Member States) are reflected in practice.

The study investigated the web accessibility level of the Irish web space by studying two samples of Irish web sites. The level of web accessibility in other EU member states was also examined in order to compare the outcomes of web accessibility awareness actions in Ireland with similar actions at EU and EU member states level. Due to practical reasons such as limited resources, only three other EU member states were chosen for investigation: UK, France and Germany.

The methodology used in this work is implemented as a large scale automated web accessibility surveying methodology which can provide systematic and reliable data, monitoring the impact of existing or future policies in practice. The web accessibility conformance level is determined by investigation of web sites conformance to WCAG 1.0 guidelines and HTML technical specifications. The methodology adopted in this study focusses exclusively on a small number of automatically detectable accessibility barriers. As these indicators proved to be very frequent in the investigations carried out, they were monitored in subsequent surveys, as part of the project. In time, if and when the web accessibility conformance of web content improves, the methodology used here will lose effectiveness. For the moment, it proved to be a reliable web accessibility conformance monitoring system.

The study includes analysis of the most common WCAG 1.0 checkpoint failures and HTML mark-up defects encountered, considering their impact on web accessibility. The set of results generated by the tests on the the web samples of the four web spaces are used to compare the level of web accessibility between the Irish, UK, French and German web spaces.

The thesis is structured in nine chapters (including the current one), each of them dealing with a different stage in the research's progress.

Chapter 2 presents background information on web accessibility. The chapter contains a short web history, describes the potential benefits brought by the web to people with disabilities and the need for accessible web design. The chapter also discusses the W3C's WCAG and their implementation in web accessibility policies across the world.

Chapter 3 describes the web accessibility studies carried out in order to evaluate the web accessibility level of the Irish web space and how is it compared to the level of web accessibility of the UK, French and German web spaces. The chapter also describes other web accessibility studies considered to be related to the studies presented in this thesis.

Chapter 4 presents the implementation of the automatic surveying system. This chapter describes the methodology used in sampling the four web spaces, the technology used in sampling the web sites (using the Internet robot Pavuk), the technology used in investigating the sampled web content conformance to W3C's WCAG 1.0 (using the automated assessment tool Bobby) and to HTML technical specifications (using the automated SGML parser and validator OpenSP). This chapter also describes how these technologies were integrated in an automated web accessibility surveying system.

Chapter 5 presents the Bobby (WCAG 1.0 conformance investigation) and OpenSP (HTML technical specifications conformance) tests/diagnostics considered in investigations.

Chapter 6 presents and analysis the latest (more recent) findings of the December 2004 evaluation of the four web samples of randomly selected Irish, UK, French and German web sites.

Chapter 7 presents key results of surveys previous to December 2004 carried out on the five web samples considered.

Chapter 8 provides a brief critical review of the study, of the tools and methodology adopted and ways to develop the work presented in this thesis.

Finally, Chapter 9 summarizes the conclusions of the implementation of the automated web accessibility surveying system and conclusions of the survey, evaluates the overall web accessibility level of the Irish web sample and situates it in the context of the overall web accessibility level of the other three web samples studied.

Chapter 2

Background Information

2.1 Chapter Overview

This chapter presents background information on web accessibility.

When the first web server was set up at CERN in 1990, the importance the web will have in our society was not foreseen. Today, 15 years later, the web is one of the main characteristics of the 21st century society. People have access to products and services all over the world at any time of day or night at minimum costs.

The people who could particularly benefit from what the web has to offer are the people who, because of a disability do not have access to services or products in the physical world.

Such products and services could be accessible to people with disabilities on the web using dedicated assistive technologies, provided that the web sites are designed according to universally accepted guidelines and recommendations.

The Web Accessibility Initiative (WAI) within the World Wide Web Consortium (W3C), has as main purpose ensuring the web is accessible to people with disabilities.

The WAI's Web Content Accessibility Guidelines 1.0 (WCAG 1.0) published in 1999 are now internationally recognized as references in web design with accessibility in mind and a reference point in legislations and recommendation regarding disabilities law across the world.

The present chapter contains a short web history, describes the potential benefits brought by the web to people with disabilities and the need for accessible web design. The chapter also discusses the W3C's WCAG and its implementation in web accessibility policies across the world.

2.2 The World Wide Web

A system in which people could have access in a rapid and flexible manner was early described in Vannevar Bush's *Memex*[1]–the grand-parent of of "hypertext" (early 1930s). The web as we know it today developed gradually from *Tim Berners-Lee*[2]'s idea of "a space in which anything could be linked to anything [...] a single, global information space" [8, p4]

In 1980, the first "web like" application, *Enquire*[9], was implemented by Berners-Lee during a six months consultancy job at the *European Particle Physics Laboratory (CERN)*[3] at Geneva, as a system to keep track of connections among the various people, computers and projects at CERN.

By 1984, CERN has grown in a "micro-cosmos of the rest of the world though several years ahead" through its computers, operating systems and programming language diversity. The facilities provided by Enquire needed to be developed to allow different documents (technical papers, manuals, etc.) to be stored and later retrieved by interested researchers within CERN. The new system would have had

[1] http://www.iath.virginia.edu/elab/hfl0051.html

[2] http://www.w3.org/People/Berners-Lee

[3] http://www.cern.ch

to deal with the diversity of computer systems and networks and would have had to be decentralized in order for anyone to use it without requiring access permissions. The most appropriate implementation that would meet these requirements was a *hypertext system*—system that would allow documents to be processed as a complex network of nodes that are linked together in an arbitrary way. (The basics of hypertext were already laid in 1965 by Ted Nelson [4])

In order to facilitate the communication between computers independent of the network connecting them or the operating systems that would run on such computers, a *remote procedure call (RPC)* program was implemented (by Berners-Lee) that also included an addressing scheme to identify each remote system within a network.

By late 1988, the *Internet* ("a worldwide system of computer networks" [5]) was binding universities and labs in the United States but it was nearly invisible in Europe. The Internet provided a bridge between different computer operating systems and networks. TCP/IP seemed to be the network protocol by choice of the new "hypertext system".

Having set the basic components, a proposal for the hypertext system (renamed in the proposal *"document system"*) was submitted in March 1989 by Tim Berners Lee at CERN, followed by a refined version on May 1990. [10]

Although no reply to the "document system" proposal was received yet, Berners-Lee and other fellow researchers started working on the implementation of what will be later known as the *World Wide Web (WWW)* or simply the *"Web"*. In October 1990 the *Hypertext Transfer Protocol (HTTP)*—"the language computers would use to communicate over the Internet" and *the Universal Resource Identifier (URI)* "the scheme for documents addresses" were implemented [8, p31]. By

[4]http://www.aus.xanadu.com/ted

[5]http://www.hyperdictionary.com/dictionary/Internet

mid-November a *web client* program was implemented that would allow the creation, browsing and editing of hypertext pages. By December 1990 the *Hypertext Markup Language (HTML)* was written to describe how should the pages containing hypertext links be formatted. The *first web server* was set up in CERN. It was given the alias `info.cern.ch` and it hosted Berners-Lee's HTTP, URI and HTML specifications and other WWW project specifications.

HTML was designed as a "simple way to represent hypertext". The web server and the web client would have had to agree on the format that the required document (specified by URI) should be shared so that they both understand it. By default, the common language would be HTML. One of the basic design rule that guided HTML was that "[it] should convey the structure of a hypertext document, but not details of its presentation" [8, p45]. HTML was developed to look like a member of the "Standard Generalized Markup Language (SGML)" [11], considered at that time the only potential document standard among the hypertext community. Quickly HTML was adopted by the web community as the primarily format of sharing information on the web.

> "I never intended HTML source code (the stuff with the angle brackets) to be seen by users. A browser/editor would let a user simply view or edit the language of a page of hypertext, as if he were using a word processor [. . .] But the human readability of HTML was an unexpected boon. To my surprise, people quickly became familiar with the tags and started writing their own HTML documents directly." [8, p46]

On 30th of April 1993 CERN—where the WWW was initially developed and therefore would have been entitled to the intellectual property rights—officially agreed to "allow anybody to use the web protocol and code free of charge, to create a server or a browser, to give it away or sell it, without any royalty or other constraint" [8, p.80]. This announcement set free the development of the web related technologies and was a major step ahead in allowing the web to develop into the web we know today.

By January 1993 the web consisted of about 50 web servers and the web activity was increasing fast. The number of "hits" (web pages visited) on the `info.cern.ch` web server grew from 100 hits a day in 1991 to 1,000 hits a day in 1992 and 10,000 hits a day in 1993. With a fast increasing number of web users, web developers and web servers the danger of the web being fragmented in different parts (like "commercial", "academic", "free", "not free") did arise. The web was in danger of loosing its envisaged purpose: "to be a single, universal, accessible hypertext medium for sharing information" [8, p.82].

An organization that would help developers of servers and browsers to reach consensus on how the web should operate was needed.

The world's first international World Wide web conference was held at CERN in 25 May 1994. 400 users and developers attended and the success inspired the press in naming the event "Woodstock of the Web". [6]

On December 1994 the first meeting of the *World Wide Web Consortium (W3C)*[7] was held at the Laboratory for Computer Science at the Massachusetts Institute of Technology, U.S.A. setting the W3C's main purpose [12] to "lead the web to its full potential" [8, p.100].

The W3C would issue *formal recommendations*, *normative references* rather than setting *standards* considering that obtaining a "rough consensus and running code" would be much faster and beneficial than going through the long international voting process that would be required in setting an actual standard [8,

[6]http://public.web.cern.ch/public/about/achievements/www/history/history.html
[7]http://www.w3.org

p.105]. W3C's role in making the recommendations was (and still is today) to draw attention to the specification and to promote its widespread deployment, enhancing the functionality and inter-operability of the web.

Today, within the Consortium, teams of researchers work on specifications for new or existing web technologies. The recommendations are in a continuous development based on discussion within the members of the Consortium. Notes and drafts are available online and people interested in the development of the web can participate with comments and suggestions, assuring the universality of the web. The first W3C's recommendations were based on the early web specifications available on the `info.cern.ch` web server.

Based on the HTML 2.0 initial document released in April 1994, *the first W3C approved HTML Recommendation* was "Hypertext Markup Language—2.0" [13], published in September 1995. The main purpose of the document was to set an unique universal description for the HTML elements already implemented in the existing major web browsers *Mosaic*[8], *Netscape Navigator*[9] and *Internet Explorer*[10].

At this stage, web technologies and web browsers developers worked independently and W3C was incorporating new technologies in recommendations.

On May 1995 Sun Microsystems introduced Java, a new programming language, and with it Java Applets—small Java applications that can run directly inside a web page, saving resources such hard disk space and RAM on the "client" computer. Netscape was the first web browser to incorporate support for Java and it also introduced JavaScript, a simple, cross-platform, web scripting language only marginally related to Java. Soon after that, the other major web browsers introduced support for, now popular, Java and JavaScript technologies.

[8]http://archive.ncsa.uiuc.edu/SDG/Software/Mosaic/NCSAMosaicHome.html

[9]http://channels.netscape.com/ns/browsers/browsing.jsp

[10]http://www.microsoft.com/windows/ie/default.asp

On January 1997, the W3C's "HTML 3.2 Specifications" [14] became approved recommendation, adding to the elements already introduced by HTML 2.0, specifications for widely deployed features as tables, Java Applets and JavaScript, font style elements and client-side image maps. HTML 3.2 became the current W3C recommendation, HTML 2.0 being kept public for backward compatibility purposes. This HTML version was deployed in collaboration with web technology vendors such as Microsoft (Internet Explorer, Office suite), Netscape Communications Corporation (Netscape Communications suite—Navigator and Composer), SoftQuad (HoTMetaL WWW/HTML editors) and others keeping in mind the very purpose of W3C to have a single, universal hypertext language on the web.

2.3 The Web and People with Disabilities

The importance of the web in our lives has increased dramatically since 1996. Barriers of time and distance have been removed and we live in a society in which—in principle—anyone can have access to products and services all over the world at any time. The global online population was estimated at 934 million users in 2004 with projections for 2007 at 1.35 billion internet users. [15]

With the increased popularity of the web, more and more services and information are available online.

A minority of the web users population but with the most potential benefit of what the web has to offer, are people with disabilities. Having restricted access to information and services in the physical world, people with disabilities can have access to the online version of the desired services using dedicated assistive technologies.

The web provides a mean for conventional media to accommodate people with disabilities at much lower costs. Before the web, written media was made accessible to blind people using audio transcription or Braille format (usually slow and costly). If a blind user would have wanted to access written media in real time, the help of a sighted person would have been needed. With the adoption of the web as alternative mean of publishing, companies reduce costs by saving resources consumed in the printing and distribution processes. One important benefit of the adoption of the web as a publishing format was that people with disabilities could be included as a prospective "market" with small accommodating efforts.

The web also provided more commercial opportunities. Before the web becoming a popular feature of our society, businesses were addressing a specific market, mainly determined by physical locations. Once businesses "went online", services could increase the number of potential clients by addressing a world wide market and by saving resources spent with staff and office spaces (or warehouses) that would be needed in handling the business in company branches. In recent years more and more companies provide online services, some businesses offering services exclusively in the "virtual world". Before this, people with disability were rarely accommodated, usually needing the help of a non-disabled person in order to benefit from services offered. For example, for a blind person or a person with restricted mobility to pay a bill, he would have needed the help of a non-disabled person, having to disclose private and sensitive information in this way. Today, with small accommodating efforts, the potential for people with disabilities to have accesses to such services that in the physical world would have been inaccessible has increased considerably.

The population of able-bodied people outnumbers the population of those with disabilities. Even considering the differences given by country specific official definitions of the term "disability", the community of people with disabilities numbers in tens of millions [16, p11]:

- in the EU, approximately 37 million people (1 in every 10 citizens) have a disability

- 4 million Canadians (1 in every 7) have a disability (1996)
- 3.7 million Australians
- 54 million Americans (1 in 5)—US census 1997.

Some disabilities in the physical world do not constitute a disability in the "online" community. For example, a temporary knee injury could immobilize an otherwise "non-disabled" person, but this doesn't mean that it would affect the person's capability to browse the web. Someone who is paraplegic[11] will likely not have trouble typing, operating a mouse, seeing or hearing unless they have an additional unrelated disability. Someone who can't perform a demanding physical activity due to heart condition won't necessarily have trouble surfing the web, either.

Depending on the specific disability that affects the users capability of browsing the web using common technologies, different problems arise and with them different solutions are required. In most of the cases these solutions are offered by technologies (hardware and/or software) specially tailored for the particular disability and acting like an interface between the user and the mainstream web browsing technology. These technologies are referred to as access systems, assistive technologies, adaptive technologies and adaptive computing.

Initially, no accessibility features were available in popular web browsers Mosaic, Internet Explorer and Netscape Navigator. Ultimately, this led to the development of specialized browsers by assistive technology vendors who focused primarily on web design for people with visual disabilities. Today, the assistive browsers feature audible interpretation of web pages, high contrast screen views

[11]a person who has paraplegia (is paralyzed from the waist down)

and screen magnification. Recently, the addition of touch screens, voice recognition and telephone browsing have increased the level of browsing for people with disabilities. [16, p140]

Assistive technologies that would address more than one kind of disability are rare. An example of such assistive technology is the web browser *MultiWeb*[12], designed by the Equity Access Research and Development Group at Deakin University in Australia. It was developed to be used by people with a range of disabilities by providing different user interfaces for each type of disability. It can be used without other adaptive software and includes a speech engine, text enlargement and scanning for switch devices.

A special case of "multiple-disability" on the web is deafness-blindness, due to the fact that the information presented mainly in an visual medium needs to be translated into a medium other than auditory. When using a computer, a deaf-blind person will rely exclusively on a Braille display.

The current releases of popular graphical browsers (Internet Explorer, Netscape Navigator, Opera) provide support for several core features that make web browsing easier for people with disabilities. Some of these features include support for style sheets, automatic completion of specified web addresses, display of ALT text for images and image maps, keyboard access and navigation, adjustable font colors, sizes and style, turn pictures, videos and sound off.

2.3.1 Blindness

Blind computer users typically rely on *screen readers*, software applications that transform the information displayed on a two-dimensional screen in serial data that can be fed to an alternative sensory medium such as Braille display, speech synthesizer or both.

[12] http://www.deakin.edu.au/infosys/multiweb/mwIndex.htm

A Braille display is a hardware devices that reads, translates and subsequently renders electronic information from a computer interface to the user in Braille.

Generally, Braille displays are very expensive and currently start at € 3,000 and cost up to € 16,500 with the most popular displays costing between € 6,000 and € 12,000. Gigantic Braille displays (almost equivalent to 80 characters/24 rows text screen) can be found at extremely high prices. [17]

Screen readers vary in complexity from generic screen readers (for example *JAWS (Job Access With Speech)*[13]) that "translate" the entire two dimensional graphical space in an alternative medium (audible or tactile) to special purpose applications like web browsers (Home Page Reader) which are designed only for a specific function on a computer.

Some generic Microsoft Windows based screen readers intercept the information sent to the screen by the Windows operating system and store it in a database, creating an off-screen model (OSM), based on which the screen readers create the interface between the computer and the assistive technology. Web specific screen readers (web browsers) are looking at the *document object model (DOM)*[14] of the web page to provide a speech rendering of the web page's content.

> The Document Object Model provides a standard set of objects for representing HTML and XML documents, a standard model of how these objects can be combined, and a standard interface for accessing and manipulating them. *Document Object Model (DOM) Level 1 Specification*[15]

People who are blind and use a screen reader via speech synthesizer hear only one word at a time, rather than seeing the entire web page at once and they rarely

[13] http://www.freedomscientific.com/fs_products/software_jaws.asp

[14] http://www.w3.org/DOM

[15] http://www.w3.org/TR/1998/REC-DOM-Level-1-19981001/

listen to a page in full. Usually they navigate to the content and controls of the page. Screen readers have key commands to move forward and backwards (usually the TAB and the Shift+TAB keys) through the active elements of the page (like links and from controls) and to read by characters, by words, by lines and by sentences.

Screen readers were developed in the late 1970s on character-mode platforms like MS-DOS and Apple II. Now they are sophisticated enough to use multiple voices and (limited) sound effects to interpret web sites. It is quite common to use screen readers with a speed of 300 words/minute (twice the speed of human conversation) which can present even a verbose web page relatively efficient. This is similar to the average speed of reading printed material and considerably faster than the average speed of reading Braille (at around 100 words/minute)[16].

First screen reader for DOS (1985) was IBM Screen Reader later developed into *IBM Home Page Reader*[17], a talking web browser for the blind and the visually impaired users.

The first screen reader to provide access to a graphical user interface was *outSpoken*[18] on Macintosh (1988) but it didn't keep up with later developed screen readers on Microsoft Windows operating systems specially because of lack of accessibility features on Macintosh operating systems.

The most popular screen readers today are *JAWS—Job Access With Speech*[19] for Windows and *Window-Eyes*[20] used by probably over 90% of blind web users population today[18, p56].

Some of the common features of JAWS and Window-Eyes are:

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[16] http://www.braille.org/papers/analys/analys.html

[17] http://www-306.ibm.com/able/solution_offerings/hpr.html

[18] http://www.easytalkcomputers.com/outspoke.html

[19] http://www.freedomscientific.com/fs_products/software_jaws.asp

[20] http://www.gwmicro.com/products/

- provide support for all the standard Windows applications
- can be used in conjunction with Internet Explorer to browse the web, offering additional features such as shortcuts to list of links and frames contained in a web page
- keyboard control of the screen pointer
- output for speech synthesizer (both screen readers also have speech synthesizers included) and Braille displays.
- PDF support, based on the accessibility features provided by Adobe Acrobat [21]

There are no commercial screen readers for X-Windows systems. However there are ongoing open-source/community-development projects aimed at enabling X-Windows access for people who are blind. The structure of the X-Windows system is not conductive to screen reading, because of the lack of focus and object information [18]. Much of the functionality of Unix/Linux platforms can be accessed through text-mode applications, for which a variety of screen-reading access possibilities exist. The *GNOME Accessibility Project*[22] launched in October 2000 "to ensure that people with disabilities can use the standard *GNOME*[23] desktop user-environment". The GNOME 2.0 desktop environment was released in November 2002 and contained accessibility features such as keyboard navigation. Assistive technologies working with GNOME 2.0 were developed such as the *GNOME On-Screen Keyboard (GOK)*[24] and *Gnopernicus*[25], an application including screen magnification, speech synthesizer and support for

[21] http://access.adobe.com
[22] http://developer.gnome.org/projects/gap/GNOME-Accessibility.html
[23] http://www.gnome.org
[24] http://www.gok.ca/
[25] http://www.baum.ro/gnopernicus.html

Braille output. The interest in the new GNOME desktop accessibility features was large, suggestions and improvements being permanently considered (the current release 2.10—March 2005).

The first web browser created to assist blind and visually impaired users of web was *pwWebSpeak Plus*[26]. It interprets HTML and translates web content into speech and a simplified visual display. It supports a variety of output displays including synthetic speech, Braille output devices and large print screen displays. Users can access the page structure (headings for example) and associated links separately from the core page content. Users can audibly render one paragraph, word or character at a time. Users have complete access to tables, client-side images and forms. Also the reading speed is adjustable.

Home Page Reader[27] was developed by IBM's Special Needs Systems group and it uses IBM's ViaVoice OutLoud text-to-speech speech synthesizer (it can also interact with a generic screen reader for speech synthesis) in conjunction with Netscape Navigator to provide spoken output of web information while at the same time providing a visual rendering of the data through the standard Navigator interface. Home Page Reader is able to audibly render web content including graphics descriptions, tables, text in column formats, data input fields. It speaks complete information about web content to the user, including HTML 4.0 range of elements and attributes (tables, frames, forms, alt texts for images and image-maps and additional information including table summary and caption). It attempts to keep the user informed at all times; for example a page which is in the loading process is announced by "beeps" (sounds). Home Page Reader contains a "Fast Forward" key that enables the user to scan a web page for data and a "Where am I" command key that provides navigational feedback, including the members

[26]http://www.soundlinks.com/pwgen.htm

[27]http://www-3.ibm.com/able/solution_offerings/hpr.html

and location of elements on a given web page.

Screen readers and voice browsers are difficult to use because they have to be compatible with any other applications. This results in very complex keyboard commands, that must not clash with any other application commands, but which are difficult to remember.

Text web browsers are much easier to use by the blind and visually impaired in conjunction with screen readers because of their text-based interface. Their only drawbacks involve lack of support for all the web protocols, including multimedia and programming. [16]

Lynx[28] was the first text web browser and still commands a large user base. It is completely accessible to screen readers for the blind and very often is their browser of choice. Current versions of Lynx include support for complex web content HTML markup including forms, frames and tables.

Emacs/W3[29] is a full-featured text web browser that includes complete support for forms, frames, tables and style sheets and runs on most operating systems. It works perfectly with *Emacspeak*[30], T.V. Raman's audio desktop for the blind. [16]

2.3.2 Visual impairment

As opposed to a blind person, a person with a visual impairment has lost a degree of his/her ability to see. Visual impairments include conditions such as low vision and color blindness.

In the real world use, a computer is mostly a display, therefore the visually-impaired people are the most affected computer users with disabilities.

Color blind users have difficulties in distinguishing colors. There are three

[28]http://lynx.browser.org

[29]http://www.cs.indiana.edu/elisp/w3/docs.html

[30]http://emacspeak.sourceforge.net/

main versions of color blindness [31]:

- *red-green color* deficiency, which are the most common form of color blindness. About 8% of men and less than 1% of women have a red-green deficiency. People affected by this deficiency are still able to see all the other colors, they may just get confused with green and red. There are different degrees of severity, some people may not be able to tell green and red apart and others will be able to. But in most of the cases red and green are seen as shades of brown.

- *blue-yellow color* deficiency is a rare form of color blindness and people suffering from this deficiency cannot distinguish color blue from yellow, but can see all the other colors.

- *total color blindness* is an extremely rare form of color blindness and it means that a person suffering from this deficiency sees only black and white (shades of gray).

The most appropriate assistive technology to help color blind web users are style sheets. Provided that the design of the web site allows it, the user can override the colors used in the web site with colors that are most appropriate for his/her needs.

People with visual impairments such as extreme tunnel vision (which is rather like looking through a drinking straw) will only see a small area of the screen. In this case, software applications similar to screen readers, translate the two-dimensional graphical web content into a text stream which will be scrolled across the screen (like MARQUEE).

Some users with low vision have difficulty making out certain font styles. Italic text, for example, may be difficult for a low vision user to read without

[31] http://colourblind.freeservers.com/whatis.htm

assistive software [16, p.8].

Visually impaired users with low vision can use screen magnification to increase the size of text, menu bars, icons and so on, to the necessary size. Dedicated software can scroll text horizontally within a fixed positioned window, alter foreground and background colors, turn the mouse pointer into a magnifying glass. It is estimated that only 10% of people with any kind of visual impairment read Braille [19, p.27].

Screen magnification software uses standard display monitors and is used by people with some degree of visual impairment to increase the size of everything in the display, including text and images in a web page. Screen magnification software provides various degrees of magnification, typically between 1.5 and 32 times. Because of the physical limitations of the monitor, the greater the magnifications, the smaller the amount of content that is shown.

The primary issues when using screen magnification software are [18]:

- small display area preventing users from getting the big picture view of a page
- missing the context around the visible area
- difficulty in finding page elements, such navigation
- alternation between vertical and horizontal scrolling (in case of screen magnification software that do not change the layout of the screen in order to reflect the magnification on the same display area)

VIP Browser[32] was developed by JBliss Imaging Systems to optimize visual displays for people with low vision using screen magnifiers. It could be used by a blind person too because it includes voice output (the speech can be turned on or off on demand). VIP includes 4 types of screen magnified views :

[32] http://www.jbliss.com/SW_Products.html#VIP Browser

- *word wrap* which displays text several lines at a time
- *image view* which splits the screen in two windows so that standard lines of text are displayed in the upper window while magnified text is displayed in the lower window
- *marquee* which displays a single line of text at a time
- *rapid serial visual presentation—RSVP* which displays one word at a time

2.3.3 Mobility impairments

The relevant mobility impairment to web design is a physical disability that affects the use of computer or device (in most cases a disability involving the hands and/or the arms), rather that the understanding or interpreting of the information.

Physical impairments are wide and varied and they include conditions such as muscle weakness, paralysis, joint discomfort and spinal injuries or disease processes such as arthritis and muscular dystrophy. Some people have use of their hands some don't. Some have the ability to use mouth sticks and head pointers while others rely on infrared devices. Functional limitations as a result of Repetitive Strain Injury (RSI) have increased dramatically over the years, with one of the key factors directly related to use of personal computers. [16]

Assistive technologies for people with mobility impairments include [19]:

- speech recognition : software application combined with a speech input device (usually a separate or built-in microphone) that enables the user to speak or issue commands that are recognized and than acted upon.
- keyboard guard and overlays : sheet of thick plastic with holes that lets the user guide his/her fingers to just the right key. They are especially useful if

the user has cerebral palsy[33] or a tremor that makes the user depress more than one key at a time, or if too many errant keystrokes precede or follow a correct key press.

- slow keys and on-screen keyboards : software that automatically discards keystrokes typed in too quick a sequence, and can show the user a picture of a keyboard that can be activated with a switch or a mouse (maybe even predict the words, and even more, predict the next word or phrase after that)
- replacement mice : like foot pedals, gigantic track balls
- switches and scanning software : switch on/off, by a head nudge for example (or blink of an eye, jostling a knee) based on which an on-screen keyboard is repeatedly divided in four parts until the right letter appears under the cursor, and sometimes can predict the word based on the selected letters.

2.3.4 Deafness and hard of hearing

A person who is deaf has no sense of hearing at all while a person who is hard of hearing has lost a degree of his/her ability to hear.

The fact that deafness is included in the category of disabilities on the web is primarily based on the increasing prevalence of web multimedia content that includes dialogue and sound but does not include captioning. Additionally with the growing popularity of speech recognition interfaces, people within the deaf culture who have limited speech capacity (or none at all) run the risk of being shut

[33] A broad term that describes a group of neurological (brain) disorders. It is a life-long condition that affects the communication between the brain and the muscles, causing a permanent state of uncoordinated movement and posturing. Cerebral palsy is the result of an episode that causes a lack of oxygen to the brain.

out of next-generation computing interfaces all together. This could also apply to people with speech disabilities who have weakened speaking ability—low voice or speech impairments like stammering for example.[16]

Computers are largely silent devices that communicate visually so people with hearing disabilities seem to be the category least disadvantaged on the web. One aspect they might be affected by is the fact that for many deaf people, their first language is a a sign language. Therefore, any written version of a spoken language is a "second language" and they may have significantly reduced fluency in it. In this case, the content should be presented in a clear and simple language, as recommended by WCAG 1.0 Guideline 14 [1].

There are assistive technologies ("hearing aids") for people with hearing impairments included in existing software or operating systems. One can, for example, turn the alert-sound off (volume to 0) which may cause the menu bar to flash as a replacement for an audible beep [19]. Captioning[34] system or application combined with a player or plug-in that can render the captioning are the most common assistive technologies used by deaf or hard of hearing (with an hearing impairment) web users.

2.3.5 Cognitive and neurological disability

People with cognitive disabilities have difficulties in processes required to acquire knowledge like remembering, reasoning, understanding, problem solving, evaluating, and using judgment. Cognitive and neurological disabilities affect the perception, processing, understanding and reception of information and other stimuli.

Learning disabilities are characterized by difficulties in the process of understanding and acquiring information. The most common learning disability is

[34]"rendering of speech and other audible information in the written language of the audio"[19, p.37]

dyslexia, characterized by difficulties in processing written or spoken language. 15-20% of the population of the world have a learning disability, 85% of whom have dyslexia (*The International Dyslexia Association*[35]). Dyslexia can have different forms from person to person. Some people have problems understanding basic written language, while others only have problems understanding complex written structures. Some people have problems understanding written language but may have no problems understanding spoken language, while other people might find it much easier understanding written langauge rather than spoken language.

Other related learning disabilities include *dyscalculia* characterized by the difficulty in solving arithmetic problems and understanding mathematical concepts and *dysgraphia* characterized by difficulties in writing letters or writing within a defined space.

Problems experienced by people with learning disabilities include (*The International Dyslexia Association*[36]):

- learning to speak
- organizing written and spoken language
- learning letters and their sounds
- memorizing number facts
- spelling
- reading

Other cognitive and neurological disabilities on the web include [2]:

[35]http://www.interdys.org

[36]http://www.interdys.org/servlet/compose?section_id=5&page_id=50

- seizure disorders (for example epilepsy), characterized by temporary (seconds or minutes) lost of consciousness or unusual sensations or movements triggered by brain cells mal-function (*Epilepsy Action*[37]). On the web, seizure disorders can be triggered by excessive flashing in animations or blinking that occurs within certain ranges of frequencies
- attention deficit disorder, characterized by difficulties in focusing on the given information
- impairment of intelligence (for example some people affected by the Down syndrome)
- memory impairments
- mental health disabilities, characterized by difficulties focusing on information or difficulty with blurred vision or hand tremors due to side effects from medication.

Most of the cognitive and neurological disabilities are characterized by difficulties in understanding the written information. But the essence of the web is text which makes cognitive and neurological disabilities the very hardest disability group to accommodate on the web.

"Text is not a feature of web sites, it is a primitive, a fundamental and unalterable component" [19, p.33].

Individuals with learning disabilities benefit from information being presented in short, discrete units.[16, p11]

Users who are more successful at auditory learning than reading due to a learning disability will use screen readers and voice browsers when browsing the net with speech output at far slower speeds than blind users are accustomed to.

[37] http://www.epilepsy.org.uk/intro/epilepsy.html

One of the assistive technology that tries to accommodate cognitive disabilities is the *Enhancing Internet Access (EIA)*[38] touch screen browser, a web browser specifically designed to enable easier web browsing for people with cognitive disabilities. EIA has an embedded *Awareness and Assessment Protocol (AAP)* used to monitor response times and accuracy. Data can be collected and used to improve the ability for a person with cognitive disabilities to use the web.

There are also other aspects of life that could prove to be an impediment in understanding the information presented by a web page, and the most common one is that the language in which the information is presented is not the first language of the reader. In this case, the content should be presented in a clear and simple language, as recommended by WCAG 1.0 Guideline 14 [1].

2.3.6 Web Accessibility

Web accessibility is a web design concept that aims to ensure that a web page is designed in such way that a person with any kind of disability accessing the web page (using appropriate assistive technologies as appropriate) gets the same benefits as a user with no disabilities, using conventional web browsing technologies.

> "**Anyone** using **any kind of web browsing technology** must be able to visit **any site** and get a **full and complete understanding of the information contained there**, as well as have the **full and complete ability to interact with the site**" (Chuck Letourneau [39])

Usability problems impact all the users equally, regardless of ability. That is, a person with a disability is not disadvantaged to a greater extend by usability issues than a person without disability. As opposed to that, accessibility problems

[38]http://www.elr.com.au/eiad

[39]http://www.starlingweb.com/webac.htm

hinder access to a web site by users of specialized browsing technologies. As most people with disability are users of such specialized technologies, they are more sensitive to accessibility issues than users of conventional browsing technologies. This is why, web accessibility can also regarded to be "web design for people with disabilities". When a person with a disability is at disadvantage relative to a person without disability, that is an accessibility issue [18, p10].

> Accessibility is a subset of usability. In the context of usability, accessibility means designing a user interface to be effective, efficient and satisfying for more people in more situations. Accessibility is more concerned with making web sites perceivable, operable and understandable [18, p8].

The web followed a very typical development process based on standard engineering processes that, all too often, do not include considerations for people with disabilities. Web page designers and content producers observe similar methods. Subsequently, most advanced technologies are not accessible to people with disabilities [16, p12].

Statistics can give a general idea of the most popular web browsers and operating systems used when browsing the net. One example of such survey is the *TheCounter.com*[40] web site which reported in May 2005 that Microsoft Internet Explorer web browser was dominating the market and Mozilla, Netscape and Opera shared a small portion (around 7% of visitors) on Microsoft Windows operating systems, while the Unix/Linux operating systems were represented by under 0.5% of visitors. The *EWS statistics*[41] show that on June 2005 the proportion of visitors using Microsoft Windows operating systems was around 91%, X Window System users around 1% and other operating systems 7.5%, whilst regarding

[40] http://www.thecounter.com/stats/2005/May/browser.php

[41] http://www.ews.uiuc.edu/bstats/latest-week.html

the web browsers, most popular by far is Microsoft Internet Explorer (71.5%), followed by Netscape (around 21.5%) and Opera (around 1%).

But, the server based statistics regarding the web browsers usage are not very reliable regarding text-based web browsers *How Server Statistics Undercount Text Browsers*[42] since most of the tool used in generating such statistics consider only graphical browsers. In March 1993 Lou Montulli, a student at the University of Kansas released *Lynx 2.0*—the 'screen mode' text web browser. (Lynx 1.0 was a 'screen mode' hypertext browser, not integrating the Web). The last stable version of *Lynx*[43] (2.8.4) was released in July 2001 The popularity of Lynx as a web browser is increasing due to its performance (speed, reliability and easiness in use) and to the fact that starting with the 2.8.2 release it is available for Windows/DOS platforms too. Lynx at this stage doesn't provide support for JavaScript, Java Applets, graphics or Cascade Style Sheet but most of the HTML features that make sense in a text-only environment are implemented (including frames, tables and forms).

Because of these and the fact that, like screen readers, Lynx uses a linearized view of the page, it is an excellent test vehicle to evaluate whether or not a web page is usable and readable with these technologies turned off. If more convenient the *"Lynx-like" viewer*[44] can be used. Also, the IBM voice browser Home Page Reader is the easiest assistive technology for sighted people to learn to use, so it could be used in accessibility test (for forms or table accessibility for example).

Current technology development involves computers and web browsers that feature speech input/output subsystems, for example, cars built with web browsers and navigational systems that feature speech-based interfaces. [16, p19]

[42] http://www.awarecenter.org/tips/browser_stats.html

[43] http://lynx.isc.org

[44] http://www.delorie.com/web/lynxview.html

In technology, the best way to implement accessibility is through usability, by focusing on the user's ability to interact effectively and efficiently with the interface and including people with disabilities in the user studies. Web designers are encouraged to develop new, creative solutions, as long as they include all users. Regardless of where one is or what one wants, he should get what he wants the way he wants it. [16, p12]

By ensuring the *separation between presentation and content*, the same content can be rendered in an appropriate format, independent of the technology used, at minimum costs, in concordance with the "write once, read everywhere" principle. For example, in the publishing industry, if the content is developed separately from presentation, different presentation formats could be applied to the same content with minimum costs.

The separation between content and presentation on the web has an important benefit to people with disabilities, offering the possibility of automated tailoring of presentation according to the user's needs. Assistive technologies can produce faster and more reliable results, due to the fact that the process of automatically trying to find and extract the relevant information ("the content") is eliminated.

Although HTML 2.0 contained mostly structural elements, HTML 3.2 introduced elements whose only functionality were to add presentation to web content (like FONT and CENTER), increasing the danger of losing HTML's purpose as a *structural* markup language.

Web accessibility issues is first addressed in the "HTML 4.0 Specification"[20] published by W3C on April 1998. The separation between content and presentation was emphasized as an important step in ensuring accessible web content by "encouraging the use of style sheets instead of HTML presentation elements and attributes". Other accessibility features introduced by HTML 4.0 included:

- Better forms, including the addition of access keys, the ability to group form controls semantically, the ability to group SELECT options semantically, and active labels.
- The ability to markup a text description of an included object (with the OBJECT element).
- A new client-side image map mechanism (the MAP element) that allows authors to integrate image and text links.
- The requirement that alternate text accompany images included with the IMG element and image maps included with the AREA element.
- Support for the title and lang attributes on all elements.
- Support for the ABBR and ACRONYM elements.
- A wider range of target media (tty, braille, etc.) for use with style sheets.
- Better tables, including captions, column groups, and mechanisms to facilitate non-visual rendering.
- Long descriptions of tables, images, frames, etc.

The HTML 4.0 specification were revised and on December 1999, W3C published the "HTML 4.01 Specification"[21]. HTML 4.0 became obsolete, although it is recommended that web browsers keep implementing its features for backward compatibility purposes.

Following the principle of separating structure from presentation in web design, W3C published "XHTML 1.0 : The Extensible Hyper Text Markup language"[22] "the next generation of HTML [...] a reformulation of HTML 4 in XML 1.0" on January 2000. The XHTML family was designed with general user agent inter-operability, integrating XML's advantage of introducing new elements and attributes, through XHTML modules. The "Extensible Markup Language (XML) 1.0"[23] specifications, a subset of SGML that enables generic SGML to be processed on the web in the same way as HTML was a W3C recommendation since February 1998. XML has been designed for ease of implementation and for inter-operability between SGML and HTML.

On May 2001, W3C releases "XHTML 1.1—Module-based XHTML"[24] recommendation based on XHTML 1.0 Strict, removing all the presentation elements deprecated in HTML 4.0 and brought in XHTML 1.0 for backward compatibility purposes. XHTML 1.1 is a reformulation of XHTML 1.0 Strict using XHTML Modules, allowing document authors to define new document types based upon XHTML 1.1.

With XHTML 1.1 web authors can use elements according to their specification in technical specifications, having the benefit of introducing new elements if the structure needed to be implemented cannot be achieved using W3C defined elements. Provided that the new elements are defined according to standards and the element definition is made available to (specification compliant) web browsing technologies, the web content can be rendered as intended by its author independent of user agents.

W3C's main purpose of keeping the web an universal medium in which anyone can have access to any information available online led to the launch of the *Web Accessibility Initiative (WAI)*[45] in April 1997

> "to promote and achieve web functionality for people with disabilities.[...] to [remove] accessibility barriers for all people with disabilities. [...] to work aggressively with government, industry, and community leaders to establish and attain web accessibility goals.

[45]http://www.w3c.org/wai

> [. . .] World Wide Web Consortium will be the central point for the formation of accessibility goals, and will also be an advocate for people with disabilities to web developers and content providers" *WAI Launch Press Release*[46]

In May 1998 WAI released the "Web Content Accessibility Guidelines 1.0"[1] a "reference document for accessibility principles and design ideas". With WCAG 1.0, techniques on how these guidelines can be implemented were also published in the series of documents "Techniques for Web Content Accessibility Guidelines 1.0"[25].

2.4 W3C's Web Content Accessibility Guidelines 1.0

The W3C's "Web Content Accessibility Guidelines (WCAG) 1.0"[1] are internationally the most widely recognized recomendations for determining accessibility. For example, as part of eEurope 2005, the *e-Accessibility: Web and People with Disabilities*[47] action recognizes WCAG 1.0 "as a *de facto* standard for the design of accessible web sites".

2.4.1 Overview

The WCAG 1.0 document explains to web content developers how to make web content accessible to people with disabilities but also, at a larger scale, to all users whatever web browsing technology used (mobile phones for example) or constraints they may be operating under (for example hands-free environment).

[46] http://www.w3.org/Press/WAI-Launch.html

[47] http://europa.eu.int/information_society/topics/citizens/accessibility/web/index_en.htm

The document is structured in 14 *guidelines* addressing two general themes:

1. **Ensure Graceful Transformation**

   Pages that transform gracefully are pages that remain accessible (provide the same functionality and information) despite any web browsing technology used, being assistive or not.

   Keys to designing pages that transform gracefully include:

   - *Separate structure from presentation.*

     Elements should be used for they original designed purpose not for the way they render in different web browsing technologies. For example a first level header HTML element (H1) shouldn't be used to add a font effect of center-bold on text that it is not intended as header. Equally, text that is intended as header should be introduced by HTML heading elements, not by font effects.

   - *Provide text (including text equivalents).*

     Text can be rendered in ways that are available to almost all browsing devices.

   - *Create documents that work even if the user cannot see and/or hear.*

     Provide information that serves the same purpose or function as audio or video in ways suited to alternate sensory channels as well. This can be done by using technologies that are designed to provide/introduce "alternate content". Assistive technologies are designed to provide support for the technologies introducing "alternate content"

   - *Create documents that do not rely on one type of hardware*

     Pages should be usable by people who cannot use mice, with small screens, low resolution screens, black and white screens, no screens, with only voice or text output, etc.

The theme of graceful transformation is addressed primarily by WCAG 1.0 guidelines 1 to 11.

2. **Make Content Understandable and Navigable Content**

   The language used in a web page should be clear and simple.

   The mechanism for navigating within and between pages should be straight forward and consistent across a web site.

   Orientation information should be provided across the web site, when for example large tables are present or long lists of links. This is beneficial to people with non-visual browsing technologies (speech synthesis or braille display), people who cannot see the whole page at once (screen magnification software, small displays), and those with certain cognitive disabilities (e.g., affecting learning or memory).

Each one of the 14 guidelines in WCAG 1.0 includes a list of *checkpoint definitions* explaining how the guideline applies in typical content development scenarios. Each checkpoint is intended to be specific enough so that someone reviewing a page or site may verify that the checkpoint has been satisfied.

Each checkpoint is assigned a *priority level* based on the checkpoint's impact on accessibility.

The three levels of priority in WCAG 1.0 are defined as follows:

- **[Priority 1]**

  A web content developer **must satisfy** this checkpoint. Otherwise, one or more groups will find it impossible to access information in the document.

  Satisfying this checkpoint is a basic requirement for some groups to be able to use web documents.

- **[Priority 2]**

  A web content developer **should** satisfy this checkpoint. Otherwise, one or more groups will find it difficult to access information in the document.

  Satisfying this checkpoint will remove significant barriers to accessing web documents.

- **[Priority 3]**

  A web content developer **may** address this checkpoint. Otherwise, one or more groups will find it somewhat difficult to access information in the document.

  Satisfying this checkpoint will improve access to web documents.

Based on these three priority levels, 3 levels of conformance WCAG 1.0 are defined:

- **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;

2.4.2 WCAG—The Future (WCAG 2.0)

The WCAG guidelines are under ongoing review. The most recent public working draft of version 2.0 was published on 19th November 2004 [26]. WCAG 2.0 Working Draft is structured around 4 major principles for accessibility:

1. *Principle 1: Content must be perceivable.*

2. *Principle 2: Interface elements in the content must be operable.*

3. *Principle 3: Content and controls must be understandable.*

4. *Principle 4: Content must be robust enough to work with current and future technologies.*

Each one of these principles include a set of guidelines (14 guidelines in total). Each guideline is assigned three levels of success criteria. Based on these success criteria a document can claim the following levels of conformance to WCAG 2.0 [26]:

- In order to make a valid conformance claim for a web resource, the resource must satisfy all level 1 success criteria for all guidelines.

- A conformance claim of "WCAG 2.0 Level A" can be made if all level 1 success criteria for all guidelines have been met.

- A conformance claim of "WCAG 2.0 Level Double-A" can be made if all level 1 success criteria and all level 2 success criteria for all guidelines have been met.

- A conformance claim of "WCAG 2.0 Level Triple-A" can be made if all level 1, all level 2 and all level 3 success criteria for all guidelines have been met.

The WCAG 2.0 as of November 2004 are a working draft and the final version of WCAG 2.0 might be totally different from this working draft, therefore, the WCAG 2.0 relevance to the work presented in this thesis is not known and cannot be considered at this stage.

2.5 Web Accessibility Policies

Around the world, web accessibility is considered an important issue in laws and regulations regarding non-discrimination against people with disabilities. The W3C's Web Content Accessibility Guidelines (WCAG 1.0) became a reference point in recommendations on how web accessibility can be achieved (implemented).

The USA "Americans with Disabilities Act of 1990 (ADA)" [27]:

> generally require that State and local governments provide qualified individuals with disabilities equal access to their programs, services, or activities unless doing so would fundamentally alter the nature of their programs, services, or activities or would impose an undue burden. One way to help meet these requirements is to ensure that government web sites have accessible features for people with disabilities, using the simple steps described in this document. [28]

Specifically "ADA Regulation for Title II of 1991" [29]

> prohibits discrimination against persons with disabilities in State and local government services, programs, and activities. All programs, services, and activities of State or local governments are covered. These include public education and social service programs, State legislatures and courts, town meetings, police and fire departments, motor vehicle licensing, employment services, and public transportation programs. State and local governments must operate their programs so that, when viewed in their entirety, they are readily accessible to and usable by people with disabilities. They must provide programs and services in an integrated setting, unless separate

> or different measures are necessary to ensure equal opportunity, and must eliminate unnecessary eligibility standards or rules that deny individuals with disabilities an equal opportunity to enjoy their programs or services. State and local governments must also make reasonable modifications in policies, practices, and procedures and provide effective communication through the use of auxiliary aids and services when necessary to ensure equal access for individuals with disabilities, unless an undue burden or fundamental alteration would result. When State or local governments design and construct new facilities, or alter existing facilities, they must do so in accordance with standards for accessible design adopted under the ADA. Title II (other than transportation) is enforced by the U.S. Department of Justice (DOJ). The U.S. Department of Transportation enforces the provisions of title II relating to public transportation services. [30]

In 1998, the Department of Justice of the USA introduced "Section 508" [31] as an amendment to the Rehabilitation Act, which requires that "Federal agencies' electronic and information technology is accessible to people with disabilities". The "Section 508 standards" [32] document was published in order to give information on how the requirements specified in Section 508 should be implemented. In this document, the criteria considered in the section dedicated to providing accessible "web-based intranet and internet information and applications" (section 1194.22) are based on the W3C's WCAG 1.0.

In 1992, the Australian Government published the "Disability Discrimination Act 1992 (DDA)" [33] whose main objectives are

> (a) to eliminate, as far as possible, discrimination against persons on the ground of disability in the areas of:

(i) work, accommodation, education, access to premises, clubs and sport; and

(ii) the provision of goods, facilities, services and land; and

(iii) existing laws; and

(iv) the administration of Commonwealth laws and programs; and

(b) to ensure, as far as practicable, that persons with disabilities have the same rights to equality before the law as the rest of the community; and

(c) to promote recognition and acceptance within the community of the principle that persons with disabilities have the same fundamental rights as the rest of the community.

A legal precedent was set in 2000 in Australia with the case of "Bruce Lindsay Maguire vs the Sydney Organizing Committee for the Olympic Games" [34].

Maguire, a blind person, filed the law suit against SOCOG with the *Human Rights and Equal Opportunity Commission (HREOC)*[48] based on the Section 24 of DDA [49]:

Section 24: Goods, services and facilities

(1) It is unlawful for a person who, whether for payment or not, provides goods or services, or makes facilities available, to discriminate against another person on the ground of the other person's disability or a disability of any of that other person's associates:

(a) by refusing to provide the other person with those goods or services or to make those facilities available to the other person; or

(b) in the terms or conditions on which the first-mentioned person provides the other person with those goods or services or makes those

[48]http://www.humanrights.gov.au

[49]http://scaleplus.law.gov.au/html/pasteact/0/311/0/PA000320.htm

facilities available to the other person; or

(c) in the manner in which the first-mentioned person provides the other person with those goods or services or makes those facilities available to the other person.

(2) This section does not render it unlawful to discriminate against a person on the ground of the person's disability if the provision of the goods or services, or making facilities available, would impose unjustifiable hardship on the person who provides the goods or services or makes the facilities available.

The three reasons for complaint were:

- failure to provide Braille copies of the information required to place orders for Olympic Games tickets (Ticket Book)
- failure to provide Braille copies of the Olympic Games souvenir programme
- failure to provide a web site which was accessible to the petitioner.

The Commission ruled in favor of Mr. Maguire and ordered SOCOG to do all that was necessary to render its web site accessible to the complainant.

In June 2000, the Australian Online Council, representing the Commonwealth and all State and Territory governments, agreed that the W3C WCAG 1.0 should be the common best practice recommendation for all Australian government web sites[50]. Based on this agreement, the W3C WCAG 1.0 guidelines are given as reference in the Australian HREOC "World Wide Web Access: Disability Discrimination Act Advisory Notes—Version 3.2" [35].

At European level, in December 1999 the European Commission, Information Society launched the *eEurope* initiative:

[50]http://www.govonline.gov.au/projects/egovernment/better_practice/accessibility.htm

> eEurope is a political initiative to ensure the European Union fully benefits for generations to come from the changes the Information Society is bringing. [...] In essence, eEurope aims at bringing the benefits of the Information Society to the reach of all the Europeans.[51]

In June 2000 the "eEurope 2002 Action Plan" [36] was agreed by EU Heads of State and Government.

In the *eAccessibility*[52] action plan it is specified that in order "to achieve the 'Information Society for All' people with special needs need to have the best possible access to information technologies. eEurope proposes several actions to promote 'Design for all' approaches and the adoption of the Web Accessibility Initiative (WAI) guidelines for public web sites".

On 25 September 2001 the European Commission adopted the Communication "eEurope 2002: Accessibility of Public Web Sites and their Content" [37] on improving the accessibility of public web sites and their content which set as a target the adoption of the WCAG 1.0 Level A conformance for EU Member States public web sites by the end of 2001. In a resolution on this communication [38], the European Parliament:

> Stresses the fact that, for websites to be accessible, it is essential that they are double-A compliant, that priority 2 of the WAI guidelines must be fully implemented.

In May 2002, the European Commission adopted a follow-up Action Plan to eEurope 2002, "eEurope 2005" [39], build on the successes of eEurope 2002 and aiming to maintain eEurope as the symbol of European Union policy to develop the information society. The targets of eEurope 2005 regarding web accessibility

[51] http://europa.eu.int/information_society/eeurope/2002/index_en.htm

[52] http://europa.eu.int/information_society/eeurope/action_plan/eaccess/index_en.htm

include adoption of WCAG 1.0 by web sites in the private sectors and the establishment of a network for exchange of accessibility best practices between EU administrations.

The WCAG adoption levels at EU Member States level have been reported in the "e-Accessibility Expert Group report for eEurope Action Plan 2002" [40] published on December 2002. At that time, the progress regarding e-accessibility in the four EU member states considered in this thesis were as following:

- **Germany**

  On July 24, 2002 the "Barrierefreie Informationstechnik Verordnung (BITV) (Decree on barrier free access to information technology) [7] was enacted. The BITV refers to WAI WCAG 1.0, but transfers the guidelines into a German legislative format. Conformance WCAG Double-A is the minimum requirement for all sites of the federal public authorities (new sites and substantial changes immediately, special information for people with disabilities until 2003, others until 2005). Special navigation and entrance ("home") pages are required to conform with WCAG Triple-A.

- **France**

  "Circulaire du 7 octobre 1999 relative aux sites internet des services et des etablissements publics de l'Etat (Government circular of 7 October 1999 concerning internet sites by state public establishments and services)" [6] recommends a WCAG 1.0 A level of conformance for all French public web sites.

  In July 2003, the Inter-ministerial committee for the Information Society published a decision to revise the disability law in France. In this decision measure 2.6 states that the accessibility of public web sites to people with disabilities will be mandatory.[53]

- **Ireland**

  The *Employment Equality Act*[54] (1998) and the *Equal Status Act*[55] (2000) make provisions for general non-discrimination on grounds of disability in Ireland.

  More specific web accessibility related recommendations are the "Recommended Government Guidelines on Web Publication for Public Sector Organisations" [41] which include guidelines in relation to Accessibility, published by the Department of Taoiseach in October 1999 and the national "Guidelines for Web Accessibility" [4], published by the *Irish National Disability Authority*[56] in August 2001.

- **United Kingdom**

  In 1995 the UK Government introduced the *Disability Discrimination Act (DDA)*[57]. The 3rd part of DDA addresses the access to goods and services for people with disabilities, specifying that service providers will have to provide access to their good and services. If before the disabled people had to be accommodated within "reasonable" efforts by service providers, starting with October 2004 "service providers may have to consider making permanent physical adjustments to their premises".

  In February 2002, in support of the Disability Discrimination Act 1995, the Disability Rights Commission published "Code of Practice—Rights of

[53]http://www.ddm.gouv.fr/rubrique.php3?id_rubrique=70
[54]http://www.irishstatutebook.ie/ZZA21Y1998.html
[55]http://www.irishstatutebook.ie/ZZA8Y2000.html
[56]http://www.nda.ie
[57]http://www.disability.gov.uk/dda/index.html

Access, Goods, Facilities, Services and Premises" [42] which specifically names web sites as "services" in Chapter 2 and 5.

In May 2002 the UK Cabinet Office published the "Guidelines for UK Governmental web sites—Illustrated handbook for web management teams" [5] in which is emphasized that government web sites should comply with WCAG 1.0 at least at level A.

2.6 Chapter Summary

This chapter discussed the need for accessible web design and ways in which it can be achieved.

Considering the constant efforts invested in promoting web accessibility, a study of how these efforts are reflected in practice on the Irish web space was carried out between 2001 and 2004. The next chapter (Chapter 3) describes the web accessibility studies carried out in order to evaluate the web accessibility level of the Irish web space and how it is compared to the level of web accessibility of the UK, French and German web spaces.

Chapter 3

Web Accessibility Survey

3.1 Chapter Overview

The present chapter introduces the objectives of the study presented in the thesis and research projects related to the subject of the thesis.

The continuous efforts invested in promoting web accessibility are leading to an increased interest from developers of web content, authoring tools and user agents in providing accessible web content to people with disabilities. The final version of the Web Content Accessibility Guidelines 1.0 were published in May 1999 and they became the EU Information Society recommendation for accessible web content in June 2000 ("eEurope 2002 Action Plan").

The work presented in this thesis represents a research project investigating how are the web accessibility guidelines are implemented in practice. The research was carried out between February 2001 and February 2004 at the eAccess laboratory at RINCE, DCU, Dublin, Ireland under the supervision of Dr. Barry McMullin.

Using only automated testing tools, the "Web Accessibility Reporting Project (WARP)" investigates web content conformance to WCAG 1.0 guidelines and

HTML technical specifications on samples of Irish, UK, French and German web sites. The study analyzes the WCAG 1.0 conformance failures and the most common HTML defects encountered and their potential impact on web accessibility is discussed.

3.2 The survey objectives

In order to evaluate the state of web accessibility of the Irish web space and the results of web accessibility awareness policies and regulations in practice, two samples of Irish web sites were evaluated regarding their conformance to W3C WCAG 1.0 guidelines and HTML technical specifications.

Considering web accessibility policies and regulations at EU level, it was interesting to find out how the level of web accessibility in the samples of Irish web sites compares to web accessibility levels of similar web samples from three other EU member states: UK, France and Germany.

The results of the surveys are presented at web sample level and the study does not make any reference to accessibility characteristic of particular web sites. This was done considering the main objective of this study: evaluating the level of web accessibility of *web samples as a whole* rather than studying the web accessibility characteristics of selected web sites.

3.2.1 Evaluation of web accessibility levels on samples of web sites

- *Evaluation of a subjective sample of Irish web sites.*

  The research aimed to find out the level of web accessibility on the Irish web space.

The web sites in the Irish web sample were selected by members of the eAccess lab, based on subjective judgments and preferences.

- *Evaluation of a random sample of Irish, UK, French and German web sites.*

  Constant effort in promoting web accessibility is invested in all the other EU member states.

  This stage of the WARP project investigates how are the awareness actions reflected in practice on the web space of EU member states, and how are the levels of web accessibility of the EU web spaces compared to the web accessibility level of the Irish web space.

  Due to resource limits, the research was limited to the web space of three other EU member states : United Kingdom, France and Germany.

  Again, due to resource limits, it was considered that a random sample of each one of the three web spaces would be analyzed and the results compared to the results of the random Irish web sample.

  The research also aimed to find out how representative are the results generated by the tests on the web sites in the subjective sample of Irish web sites for the state of web accessibility level on the Irish web space.

  One way in which this could be done was to compare the results of the investigation on the subjective sample of Irish web sites with the results of the investigation of the web sites in the random sample of Irish web sites.

- *Periodic evaluations of the web sites in the subjective Irish web sample*

  Due to the extent of the study it was possible to repeat the tests on the web sites in the subjective Irish web sample, at intervals of 6 months, generating six sets of results across three years.

The research aimed to find out how the level of accessibility is evolving in time.

- *Periodic evaluations of the random Irish, UK, French and German web samples*

  Due to the extent of the study it was possible to repeat the tests at intervals of 6 months, generating four sets of results across two years.

  Again, the research aimed to find out how the level of accessibility is evolving in time in each one of the countries studied. Also, the research aimed to find out how the evolution compares between the four EU member states.

3.2.2 Implementation of automated web accessibility surveying system

Another challenge in the WARP project was to implement all the web accessibility surveying system using only automated tools.

The system was developed considering that it would have to support the web accessibility surveying independent of the number of web sites in the web sample. Of course, practical limits like storage space should be considered, but it shouldn't have a direct impact of the capability of the surveying system functionality. This means that, provided that the resources (such as storage space) are available, the web accessibility surveying system should function correctly.

Also, in the future development plans of the WARP project, a web based automated surveying system is included. So, the web accessibility surveying system implemented should provide support for a web based system with minimum accommodation efforts.

3.3 Related work

Studies regarding accessibility of web content are used to show the problems that people with disabilities encounter while browsing the web, to monitor at some level how the web accessibility recommendations are implemented in practice and to provide support for the implementation of awareness actions.

The studies presented in this section were selected in order to comment upon the similarities and the differences between other web accessibility studies and the work presented in this thesis. More such studies are listed in Schmetzke's "Web Accessibility Survey" [43] collection of web accessibility studies and online resources, aimed at "producers of online resources, including web designers; college and university instructors, administrators, and policy makers; distance educators; librarians; and disability professionals".

Studies of web accessibility similar to the work presented in this thesis in the fact that they included automated conformance testing tools and the web sites considered for evaluation were from the UK web space, were conducted by Sloan et. al. [44], Kelly [45] and Petrie [46].

Sloan D. et. al. [44] studied the level of web accessibility in depth of 11 UK Higher Education web sites during an accessibility audit performed in 1999-2002 at the Department of Applied Computing, Digital Media Access Group in the University of Dundee, Scotland, UK.

The study included a semi-automated evaluation process using automated assessment tools (Bobby and W3C's HTML Validator) and manual evaluation of a representative set of pages of guidelines that cannot be evaluated using automated tools (ex: validity of alternative texts). The study also included viewing with different set of browsers (Lynx, Internet Explorer, Netscape and Opera) and assistive technologies such as pwWebSpeak, JAWS for Windows and 80 character Braille displays. A usability evaluation was also performed.

This study is similar to the work presented in this thesis regarding the semi-automated evaluation process checking both conformance to the WCAG 1.0 (using Bobby) but also to HTML technical specifications (using W3C's HTML Validation service) and the fact that they both considered web sites from the UK web space.

In comparison with this study, regarding the evaluation of the UK web space, the study presented in this thesis considers a much larger number of UK web sites (5,702) from more sectors of interest to web users (e.g.: business, entertainment) and discusses in more detail the most common WCAG Priority 1 and 2 checkpoints and HTML technical conformance failures.

Another study regarding the accessibility level of UK university web sites was completed by Kelly: "WebWatch: An Accessibility Analysis Of UK University Entry Points" [45]. Automated WCAG conformance tests (using Bobby) were performed on entry points of 162 UK University web sites. There were no manual tests performed, so the conformance test methodology is quite similar to the one presented in this thesis. Still, the results are presented as "70 entry points were WCAG 1.0 A compliant and only 4 entry points provided WCAG 1.0 Double-A compliant". Due to the fact that the methodology presented seems to be only automatic it is unclear how the full WCAG conformance investigation was carried out, since Bobby can only fully implement *some* aspects of WCAG 1.0 and it cannot grant a definite conformance level to a web content without human intervention being required.

Again, this is a study resembling the study presented in the thesis in the fact that it performed web accessibility tests on a set of web sites from the UK web space, using the automated test tool Bobby. In comparison with this study, regarding the evaluation of the UK web space, the work presented in this thesis considers a larger number of web pages from each web site, a much larger number of UK web sites from more sectors of interest to web users and it also investigates the web sites conformance with HTML specifications. The thesis also discusses in more detail the most common WCAG Priority 1 and 2 checkpoints and HTML technical conformance failures.

An extensive study regarding web accessibility of UK web space was started in March 2003 at the Centre for Human Computer Interaction Design at the City University London under the supervision of Prof Helen Petrie [46]. An update regarding the study [47] was published in August 2003 and it gives more details regarding the methodology used in research. Phase 3 of the project involves automated testing (using Bobby and LIFT) of home pages from 1000 UK web sites, followed by a more detailed evaluation of a selected 100 web sites (out of the 1000 web sites initially selected) in Phase 4. The final report from the study was published by the UK Disability Rights Commission (DRC) in April 2004 [48]. This found that "... [o]f the 1,000 home pages tested 808 (81%) had Guideline Priority 1 Checkpoint Violations." The report goes on to state that "... [o]nly six (0.6%) of the home pages automatically tested displayed no Priority 1 or 2 Checkpoint violations in automatic tests, and so were potentially AA Compliant. However, subsequent manual checking of these six pages revealed that only two (0.2%) were in fact AA-Compliant."

In comparison with this study, the thesis considers a larger number of pages from a larger number of web sites from the UK web space. The thesis also investigates the web sites conformance with HTML specifications and discusses in more detail the most common WCAG Priority 1 and 2 checkpoints and HTML technical conformance failures.

A study of web accessibility similar to the WARP study in the fact that it considers web sites from the French web space was conducted in 1999 by Duchateau: "The Accessibility of the World Wide Web for visually impaired people" [49].

The study investigated 111 French web sites in order to outline the problems encountered by visually impaired people while surfing the web. The methodology used in research was based on two browsing methods: using the BrailleSurf voice browser (combining speech synthesis with Braille display) and using Internet Explorer 3 with the screen reader DraculaNet and a 20 character Braille display. The study presents the most commonly encountered problems and it was used in several information actions regarding web accessibility.

In comparison with this study, the thesis study considers a larger number of web sites from the French web space, investigating conformance of web content to WCAG 1.0 checkpoints and HTML specifications conformance, addressing all kinds of disabilities on the web.

Studies of web content accessibility considering web sites from EU member states web spaces were conducted by the eAccessibility Expert Group [50] and by Snaprud [51].

In December 2002 the Information Society eAccessibility Expert Group published the "WAI contents guidelines for public Web sites in the EU" report [50]. As part of the study, the Expert Group selected 17 web sites from 11 EU member states in order "to give national evaluation team an opportunity to adjust their own evaluation system". The reviews were conducted during September-October 2002 by the BrailleNet Association and others, based on the methodology proposed by WAI in the article "Evaluating Web Sites for Accessibility" [52]. The results show that "of the 17 Web sites, 11 Web sites had significant accessibility problems and therefore did not meet a Single A conformance level" and "none of the Web sites fully conformed to WCAG 1.0 Double A" [50]

The methodology used is a little similar to the methodology used in the thesis in the sense that as part of the evaluation, automated tools were used in the preliminary review. The semi-automated evaluation played a small part during the study and there is no information regarding which automated tools were used. The thesis considers only 4 EU member states web spaces but the web samples are significantly larger and the results are used to make a comparison/distinction between the web accessibility level between the 4 countries whereas the eAccessibility Expert Group does not make distinction between the EU member states in their study. The thesis also gives in-depth details regarding the HTML specifications conformance failures encountered.

Early results of the "Quantitative assessment of public web sites accessibility" [51] were published by Snaprud at the "Accessibility for All" conference in Nice, France, held in March 2003. At that time, the study was based on the results reported by an Internet Robot (ROBACC) developed to regularly asses accessibility levels of web site contents. The results presented in the conference were based on the assessment of the home page of 130 web sites (European governments and newspapers) at an regular interval of 24 hours between 27-31 of January 2003. In comparison with other web accessibility studies presented here, this survey was not concentrated on investigating the web content's conformance to WCAG, but it set a number of different subjects relevant to accessibility to be inspected such as declarations of the language used in the text, usage of a meaningful alternative text or conformance to HTML specifications. Findings relevant to this thesis show that "Less than 2% of the public online information is conform to the HTML standard" and "Less than 40% of the Public sites in Europe use the DOC-tag".

This study is relevant to the work presented in the thesis by the way in which the methodology used is mostly automated (Internet Robot) but, from the little details seen in the paper it is not clear how close is it to the methodology presented in the thesis. Another resemblance between the study and the work presented in the thesis is the fact that both studies deal with the investigation of HTML specification conformance using automated tools (in this case "validate" v1.1.2 by

Web Design Group). But, Snaprud's study does not consider the details regarding the errors encountered in the HTML specifications conformance tests, only the average number of HTML errors.

In comparison with this study, the thesis also investigates the WCAG 1.0 conformance of the web sites considered. Although the thesis considers only 4 EU Member States web spaces, the number of web sites in the web samples is significantly larger as well as the web content sample from each web site considered.

A study considering access features of governmental web sites in countries across the world was conducted by West in 2001 and it compares results at country level. Ireland, UK, France and Germany governmental web sites were included in the study. The study, "WMRC Global E-Government Survey, October, 2001" [53], considered 2,288 government web sites in 196 different countries. Regardless of the type of system or cultural background of a country, web sites were evaluated for the presence of 28 features dealing with information availability, service delivery and public access. The results regarding the availability of features are described at country level.

Two results categories were more relevant to the work presented in this thesis:

- Disability access: "To be recorded as accessible to the disabled, the site had to display features that would be helpful to the hearing or visually impaired. For example, TTY (Text Telephone) or TDD (Telephonic Device for the Deaf) phone numbers allow hearing-impaired individuals to contact the agency by phone. Second, the site could be "Bobby Approved". Third, the site could have web accessibility features consistent with standards mandated by groups such as the World Wide Web Consortium (W3C) or legislative acts of the national government." [53]

- Overall ratings, on a 0 to 100 points system, (considering all the 28 features) are also provided at country level.

West's study gives an idea regarding the accessibility of governmental web sites in Ireland, UK, Germany and France as part of the details regarding the 196 countries studied. The WARP project investigates in much more detail the accessibility level of a larger sample of web sites covering more areas of interest (not only government) from the 4 countries.

Three studies that investigated access to web content by people with disabilities of web spaces other than the Irish, UK, French and German web spaces, using automated evaluation tools were performed by West [54], D'Amour [55] and Greytower Technologies [56].

Starting with 2000, West conducted an annual study on accessibility of e-government web sites at state and federal level in the United States. The latest one, published in September 2004, was: "State and Federal E-Government in the United States, 2004" [54]. The analysis of 1,629 web sites (across al the 50 states in the USA) included tests regarding the readability of web sites's content (using Flesch-Kincaid Grade Level Readability), web content accessibility conformance (WCAG 1.0 and Section 508 using Bobby), usability through any type of hand-held device or personal digital assistant (PDAs) (like pagers and mobile phones). This study is only similar to the thesis in the fact that is uses Bobby in order to investigate WCAG 1.0 conformance.

A web accessibility survey was conducted in the summer of 2003 on 200 French language Canadian web sites [55]. The study evaluated four significant web pages from each web site. The methodology included semi-automated evaluation using Bobby and A-Prompt and manual evaluation. The validity of HTML and CSS code was also investigated, by manually testing the web pages using an (unspecified) validator and counting the number of errors encountered. This study is only similar to the thesis in the fact that is uses Bobby in order to investigate WCAG 1.0 conformance and that it considers the HTML standards conformance too, although to a much smaller extent than the thesis.

92 governmental Swedish web sites were the subject of investigation of web accessibility level in a study conducted by Greytower Technologies [56] in autumn 2002-spring 2003. The study was part of a larger study commissioned by the Swedish National Audit Office and involved the investigation of each site's conformance with all the WCAG 1.0 checkpoint plus 5 extra points defined by Greytower technologies. The study considered a maximum of 2,500 documents from each web site and used a "proprietary" automated assessing tool in order to investigate the WCAG 1.0 conformance. In addition, the web sites were reviewed independently using a set of user-agents. This study is similar to the thesis in the fact that is uses an automatic assessment tool (proprietary, therefore different from the one used in WARP) in order to investigate WCAG 1.0 conformance.

With increasing requirements for accessible web content by businesses, opportunities for commercial services to consider the web accessibility issue have arise. More and more web design companies include web accessibility audits and web design with web accessibility in mind in the range of services they provide.

Such a private company is Business2www which developed a fully-automated system (SiteMorse) that "can conduct comprehensive tests of a web site, providing a pure diagnostic examination and reports on the errors, problems and failures found. SiteMorse checks for over 100 different problems, including missing images, broken links, violations of W3C / IETF standards, faulty email addresses, DNS errors, etc." An examination of the most commonly visited pages on a web site can be performed on weekly or monthly bases, depending on client requirements. A full web site examination can also be provided.

Details of the methodology used in testing web site contents are not provided, but registered users can access a free summary "based on [Business2www] regular site test". In order to get more details regarding the implementation of the tests or the results generated, a user account was created and the free summary report provided was studied. It was found that the evaluation includes reports on HTML technical specifications and WCAG accessibility guidelines conformance, listing the errors encountered. The report also contains reference to WCAG 1.0 checkpoints that need to be manually checked by the recipient of the report (the client).

The company frequently publishes summary reports on corporate web sites or governmental UK web sites accessibility level. These reports are used as directly marketing tools and do not contain in-depth details of results or methodology used. Based on the available set of results, it seems that the automated WCAG and HTML standards conformance tests are similar to the ones implemented in this thesis. The extend of the similarity cannot be determined due to the lack of published methodology details.

The summarized common features of these surveys and the thesis are:

- Most of the studies use automated tools in investigating WCAG conformance to some extent or another
- Some of the studies considered HTML specification conformance as well, but only to a small extent (counting the HTML errors at most)
- The web sites considered were from EU Member States
- The web sites considered in the studies were subjectively picked.

The particular features of the thesis that were not treated in any of the studies presented are:

- Automated detailed investigation of WCAG 1.0 guidelines and HTML specification conformance of a subjective sample of Irish web sites.

- Automated detailed investigation of WCAG 1.0 guidelines and HTML specification conformance of samples of Irish, UK, French and German web sites, randomly selected from the *Open Directory Project (ODP)*[1] database.

- Detailed comparison between the results of the test on a subjective sample of web sites and a random sample of web sites from the same web space (Irish) and at similar sizes.

- Detailed comparison between the results of the test on web sites in the Irish, UK, French and German web spaces.

- In-depth investigation of the evolution of web accessibility levels at intervals of six months.

3.4 Chapter Summary

This chapter presented the main objectives of the research work carried out as part of the WARP project: the investigation—using automated testing tools—of WCAG guidelines and HTML technical conformance of web samples from four EU member state web spaces: Irish, UK, French and German.

The chapter also presents differences and similarities between the web accessibility study carried out as part of WARP and other relevant web accessibility studies carried out by third parties (related work).

The next chapter (Chapter 4) will describe the methodology used in the implementation of the automated surveying system.

[1] http://dmoz.org

Chapter 4

Methodology

4.1 Chapter Overview

This chapter presents the methodology used in the web accessibility evaluation process.

In order to run the web accessibility investigation an automated surveying system was implemented and its current implementation consists of the following major components:

1. *Web capture*. Each web site considered for web content accessibility investigation is mirrored on the local disk using the *Pavuk*[1] web capture robot.

2. *Conformance investigation*. The web content accessibility investigation component is divided in two major parts: the WCAG 1.0 conformance investigation and the HTML technical specification conformance investigation. Both conformance tests are carried out using tools which automatically analyze HTML pages. The tools used are *Bobby*[2] in WCAG 1.0 con-

[1] http://www.idata.sk/ondrej/pavuk

[2] http://bobby.watchfire.com

formance investigation and *OpenSP*[3] in HTML conformance investigation.

3. *Data gathering*. Using the *PostgreSQL*[4] RDBMS system, information about the overall web accessibility investigation process—including investigation results—is recorded in a specially designed database.

4. *Data analysis*. Based on the investigation results stored in the database, different reports are generated using automated queries on the database.

When investigating possible tools to be used in the automatic process the following requirements were considered:

- support for Linux as this was the preferred operating system due to its reliability
- support for command line executions as the tools were to be integrated into an overall surveying system
- reporting output in XML format for investigation tools as the results were to be automatically parsed for data gathering and database storage purposes.

To coordinate and integrate the tools used in the investigation system, different programs were implemented, generally written in *Perl*[5]. The programs were designed to customize the use of Pavuk, Bobby and OpenSP to the purpose of the study and to register the information generated by these tools in the database allowing a further analysis of the results.

The technology used in this survey was developed within the eAccess team at RINCE My main concern in the project was the HTML conformance investigation and the implementation of an automated surveying system, that would integrate

[3]http://openjade.sourceforge.net/doc-1.4/index.htm
[4]http://www.postgresql.org
[5]http://www.perl.com

the automated investigation tools selected in the preliminary web accessibility investigations by members of the eAccess team.

The work presented in this thesis was performed by the thesis author with contributions from other members of eAccess team. Dr. Barry McMullin provided constant and valuable guidance in his quality of supervisor and, more specifically, performed configuration of the web content mirroring tool Pavuk and WCAG 1.0 compliance investigation tool Bobby, and initial database configuration. Also, Dr Barry McMullin and Esmond Walshe determined the content of the Irish Subjective web sample as detailed in Section 4.2.1.

This chapter describes in detail:

- the sampling methodology of the 4 web spaces (Irish, UK, German and French):
- the technology used in sampling the content of each one of the web sites considered for investigation
- the technology used in investigating conformance to W3C's WCAG 1.0 of the sampled web content
- the technology used in investigating conformance to HTML technical specifications of the sampled web content
- the implementation of the automated web accessibility surveying system, based on automated assessment tools and database management

4.2 Sampling methodology

As previously outlined, the survey was developed gradually based on results and questions triggered by web accessibility investigations.

The study concentrated mainly on applying the same technology to different web samples.

As part of the survey presented, two sampling methodologies were used:

- a methodology based on subjective judgements of members of the eAccess team
- a methodology based on automatic pseudo-random selection.

4.2.1 Subjective sampling methodology of the Irish web space

The selection of web sites in the subjective sample of Irish web sites was implemented by members of the eAccess lab at RINCE. A description of the sampling process follows next, based on [57].

As part of the project presented in this thesis, a web site was considered Irish *only if* its owner/web author is working under Irish jurisdiction, therefore all the legislations or recommendations regarding web accessibility should be found in the implementation of web site content. The physical location of the server is not considered as relevant in this study, as long as the owner of the web site is under Irish jurisdiction.

At the time of the sampling (2001), web directories such as *Open Directory Project (ODP)*[6] and *whois ireland*[7] suggested that there were approximately 10,000 web sites that could qualify as Irish under the criterion considered in this study.

If all the Irish web sites would have been considered in the web accessibility survey, extensive resources and technologies would have been required. To answer that, it was considered that studying a selection of a considerably smaller

[6] http://dmoz.org/

[7] http://www.whoisireland.com/

number of web sites, could be relevant enough regarding the web accessibility level of Irish web space.

Due to the nature of the web, web sites vary between themselves in size, popularity or function.

Ideally, the web accessibility level would be more relevant if studied on web sites with higher popularity. But it is not easy to determine the popularity of web sites and objective statistics are not widely available. Most of the information/statistics regarding web site's popularity are usually available for commercial web sites (for advertisement purposes). Web sites of public and non-commercial organizations are most of the time poorly represented in such statistics.

But public and non-commercial web sites (such as governmental, disability related associations, NGOs) play a very important part in the lives of people with disabilities. Therefore, they should be a considerable part of the sample of web sites considered in the investigation of web content accessibility to people with disabilities of a certain web space.

Considering the fact that representative categories of web sites to people with disabilities might be largely omitted in the study, the selection of web sites based on "popularity" given by existing statistics was not suitable as a sampling methodology for this study.

Alternatively, the web sites in the Irish sample were selected "based on largely subjective judgments of experienced Web users (drawn from within the project team). The ODP category for Ireland was used as a starting point, but sites were also identified from a variety of other sources, including other directories, public advertising, etc" [57].

In the end, a sample of 214 web sites was obtained, judged to be large enough to give a reasonable basis for analysis of web accessibility problems on Irish web sites.

The technology used in the study is not dependent on the number of web sites to be studied. This number of web sites was also considered to be large enough to illustrate the technology used, providing support for subsequent larger scale surveys.

The 214 web sites are distributed across sectors and service types considered more relevant to every day activities and interests. They could be mapped on 10 categories of interest as shown in Table 4.1. The table also contains the number and the percentage of web sites in the sample for each category (the weight of each category in the sample).

Table 4.1: **Web sites in the Irish subjective sample, mapped on categories**

Category	**Number of web sites**	**Percentage of web sites**
Arts and entertainment	6	3%
Business and Economy	84	39%
Education	17	8%
Government	25	12%
Health	10	5%
News and Media	9	4%
Recreation and sports	12	6%
Science and Environment	8	4%
Society and Culture	33	15%
Transport	10	5%

4.2.2 Automated random sampling methodology of the Irish, UK, German and French web spaces

Having the automated survey system implemented and results of the web accessibility tests completed on the subjective sample of 214 Irish web sites, subsequent surveys could be carried out based on the same investigation technology.

The advantage of using the same web accessibility investigation technology over different web samples was that the same technological characteristics will influence the different sets of results, making more feasible comparisons between the level of web accessibility of different web samples. (Different web samples subjected to the same investigation technology can generate results influenced by the same methodology weaknesses which can be "neutralized" in the comparison analysis)

The automated web accessibility investigation technology was used on the other four web samples, in order to:

- investigate the web accessibility level of web samples from the UK, German and French web spaces in order to compare the level of web accessibility of the Irish, UK, French and German web spaces (as discussed in Chapter 3).
- investigate the web accessibility level of two different Irish web samples, in order to get a more accurate image of the web accessibility level of the Irish web space

When investigating the sampling methodology for the four new web samples, the following criteria had to be considered:

- In order for the web samples to generate results suitable for comparison of web accessibility levels of different web spaces, the same web sampling methodology should be used in generating the four web samples.

- In order for the results to be appropriate for a comparison analysis of web accessibility level of *web spaces* (jurisdictions), the web sites in the four samples should be mapped on interest categories, each category having assigned a weight in a web sample which will be considered in all the four web samples. The reason for this was that if, for example, one web sample had 90% of web sites mapping on the business sector (category) while another web sample contained mostly educational web sites, the comparative analysis would mostly reflect web accessibility levels of "web sectors" rather than "web jurisdictions" as the study intended.

The sampling methodology based on subjective judgements, used previously in sampling the Irish web sites, didn't seem appropriate at this point. Possibly this approach would have been suitable when sampling the UK web space due to some similarities between cultures (mainly language and possibly media—like some TV channels, Radio stations, newspapers and magazines). But it would have been inappropriate when selecting web sites in the German and French web samples, since the person based on whose subjective judgements the web sites would have been selected has very little (if at all) knowledge of the French or German language and culture (society).

At this point, the most suitable sampling methodology seemed to be a pseudo-random selection of web sites. The selection wouldn't be "perfectly random" since criteria like jurisdictions and categories of interest had to be considered in the process.

Currently, there are only estimations of the size of the Internet. Considering the large number of web servers and the rate with which the content on the Internet is changing it is difficult to keep track of all the available web sites.

According to *Hobbes' Internet Timeline*[8] by Robert H Zakon in March 2002

[8]http://www.zakon.org/robert/Internet/timeline

(when the sampling process was originally implemented) 38,118,962 web servers were registered world wide (January 2004: 46,067,743 web servers).

One approach in obtaining the web sites listing of the Irish, UK, German and French web samples could be to get the computer hosts from the Internet Domain Name Server database (DNS).

The domains registered in the DNS database can be mapped on two categories: geographical domains ("www.domain.ie", "www.domain.uk") and non—geographical domains ("www.domain.com","www.domain.org").

For the purpose of this study, it could be considered that all the domains containing ".ie" are Irish, ".uk" are UK, ".fr" are French,".de" are German. There are also web sites registered as non-geographical domains (".org",".com", e.g. "www.idaireland.com"—Investment and Development Agency, or "www.todayfm.com"—radio station) which could be detected as belonging to one of the four jurisdictions if an investigation of the owner's address is carried on the web site's information in the DNS database.

Also, the DNS contains a large amount of host names that do not correspond to publicly accessible web sites. They can be either "reserved" for a future web site or they were at one moment in time hosting a web site but they no longer do. This kind of problem could be detected by trying to access every host. If the connection is successful the web site can be considered for sampling. Otherwise not, because the name is not hosting a web site and therefore is not representative for our study.

As a source for the sampling of the four web spaces (Irish, UK, French and German) the DNS approach proved to imply the use of a large amount of resources. After selecting a number of publicly accessible web sites, the ones in the non-geographical domain would have had to be analyzed if they were belonging to the required jurisdictions (Irish, UK, French or German). The listing of web sites (geographical and non-geographical domains) belonging to the required jurisdictions would then have to be separated in categories of interests in order to achieve a reasonable distribution of the final web samples across sectors and service types offered by the Internet.

Another approach of generating a web site listing for the four web samples was using the content of web directories. The structure of a web directory is periodically updated by professional trained people, or "editors", who examine the information for each web site, allocating the web site to the most adequate category.

From this project's point of view, the positive aspect of a web directory is that the registered web sites are already mapped on categories of interest on the web (necessary for the sampling process) and the web sites are most likely to be "up and running". The negative aspect is that, unlike the DNS's database content, there is no web directory that will contain all the publicly accessible web sites, therefore a web sampling methodology based on the content of such web directory might not generate representative samples when a research at a very large scale is conducted. But for the research project presented in this thesis, the content of a web directory as base for a random sampling methodology was decided as suitable.

A chart published by *Search Engine Watch*[9] (January 2003) presents the size of the currently existing web directories. According to this chart, the most important web directory (based on the number of links and people involved in the project) are *LookSmart*[10] and *Open Directory Project (ODP)*[11] followed by *Yahoo*[12]. These web directories are also relevant to the popularity of web sites they contain due

[9]http://searchenginewatch.com/reports/article.php/2156411
[10]http://looksmart.com
[11]http://dmoz.org
[12]http://www.yahoo.com

to the fact that popular search engine like *Google*[13], Yahoo, *AltaVista*[14], *MSN Search*[15] and *Netscape*[16] are based on contents of one of these three web directories.

LookSmart is a web directory professionally edited by 200 people involved in producing the listings (editors). As of August 2001 LookSmart had 2.5 million URLs organized in 250,000 categories. Currently, there is no update regarding the size of the LookSmart directory (March 2004).

Yahoo is another popular web directory maintained by approximative 100 professionals. As of July 2000, Yahoo had 1.8 million URLs, latest updates (January 2004) showing an increase up to approximative 2.6 million web sites [58].

According to the Search Engine Watch chart, the Open Directory Project(ODP) is a web directory maintained by 36,000 volunteers. As of April 2001 ODP had 2.6 million URLs organized in 361,000 categories. Information regarding its size can be found on ODP's home page. At the date of the writing (3rd of March 2004) the ODP had 61,517 editors working on over 4 million sites organized in over 590,000 categories.

Not always does quantity mean quality, but in this case it was considered that more editors working on a web directory can have as result a better quality of the structure of the directory. Even considering that technologies can be used in producing web sites listings in web directories, the difference of human resource between the two web directories is significant.

Also, ODP's bonus point for our project was that the ODP's content is freely downloadable in *RDF*[17] format. This made possible an automatic implementation of the sampling methodology which not only ensures the "random characteristic"

[13]http://www.google.com

[14]http://www.altavista.com

[15]http://search.msn.com

[16]http://directory.netscape.com

[17]http://www.w3.org/RDF/

of the web samples but also is in concordance with the "automated" characteristic of the technology used in the study.

Considering all the above, ODP was the web directory that seemed the most suitable for the purpose of the project.

The information provided by ODP is structured in a hierarchical tree of categories where each web site is assigned to a specific category, representing the subject of the web site as closely as possible.

The main ODP catalog lists web sites (and their description) under U.S. jurisdiction and web sites with web content in English. The "Regional" branch in the ODP hierarchy contains web sites that provide information about a specific region, and/or when the web site is directly relevant to a population within a specific geographic area, *in English*. For example, "Regional/Europe/Germany" would list web sites containing information related to Germany in English. Web sites with *non-English* language content are listed under the respective language under World. For example, "World/Deutsch/Regional/Europa/Deutschland" would list German-language web sites related to Germany with descriptions in German.

Since the official language in Ireland and the UK is English, the web sites relevant to the population of the two countries were considered the ones with English language content, hence, the web sites in the "Regional/Europe/Ireland" and "Regional/Europe/United_Kingdom" ODP categories and their sub-categories. In the case of the French and the German web samples, the web sites relevant to the population of the two countries were considered to be the ones with French/German content, hence, the web sites in the "World/Français/Régional/Europe/France" and "World/Deutsch/Regional/Europa/Deutschland/" ODP categories and their sub-categories.

The online resources for each category considered is shown in Table 4.2, although it should be kept in mind that the ODP content is changing constantly so it is most likely that the content available at the date of sampling (Feb 2003) had changed.

Table 4.2: **The ODP categories considered in the sampling process**

ODP category	**Country Code**	**Number of web sites**	**Online**
"Ireland"	IE	5,509	http://dmoz.org/Regional/Europe/Ireland
"United Kingdom"	UK	114,044	http://dmoz.org/Regional/Europe/United_Kingdom
"France"	FR	30,892	http://dmoz.org/World/Fran%e7ais/R%e9gional/Europe/France
"Germany"	DE	84,860	http://dmoz.org/World/Deutsch/Regional/Europa/Deutschland

Considering the significant difference in the number of web sites available in the four web spaces, it was considered that the best approach when deciding the number of web sites in each sample would be to use a fixed fraction or percentage of the web space's category total. On the basis of the communication, processing, and storage resources available for the study, the percentage was set at 5%.

As already mentioned, in each sample, the selection of web sites will be mapped onto a set of 10 categories of interest on the web. The comparable analysis of web accessibility levels of the four web spaces will be based on the results of web accessibility investigations on web samples. Considering this, web samples will need to reflect in similar ways the web spaces they represent. Therefore, it was considered that the distribution of web sites over categories of interest will have to be similar in the four web samples. More than that, the distribution will also reflect, as close as possible, the distribution of web sites over categories of interest in the subjective sample of Irish web sites.

Based on these principles, the weight of each category of interest in the random samples of web sites was set as shown in Table 4.3.

Table 4.3: **Weight of categories of interest in the web samples**

Category	**Weight in the subjective Irish sample**	**Target weight in the random sample**
Arts and entertainment	3%	5%
Business and Economy	39%	35%
Education	8%	10%
Government	12%	12.5%
Health	5%	5%
News and Media	4%	5%
Recreation and sports	6%	5%
Science and Environment	4%	5%
Society and Culture	15%	12.5%
Transport	5%	5%

The ODP content (as of 13th of February 2003) was downloaded onto the local disk. Due to the fact that only a part of the rather large ODP content (1.12 GB) was relevant to the study, the content related to Ireland, UK, France or Germany was automatically extracted into separate, country specific files (using a C program). Next, using another program (implemented in C and using the *libxml2*[18] library) the content of each country specific file was split into separate files mapped onto the 10 categories of interests considered in this study.

Table 4.4 shows the relative proportions of sites found, in total, under each category of interest in each ODP country specific content.

[18]http://xmlsoft.org

Table 4.4: **Relative proportions of sites found, in total, under each category of interest in each ODP country specific content**

	Sites in ODP country specific content				
Category	**IE**	**UK**	**FR**	**DE**	**Overall**
Arts and entertainment	10.04%	8.59%	4.61%	3.83%	6.77%
Business and Economy	46.47%	53.24%	42.92%	24.57%	41.8%
Education	4.56%	5.37%	4.29%	5.32%	4.88%
Government	1.67%	2.64%	1.18%	2.52%	2%
Health	2.11%	4.8%	1.41%	3.44%	2.94%
News and Media	4.12%	0.8%	0.83%	1.15%	1.73%
Recreation and sports	7.99%	10.53%	10.86%	4.33%	8.43%
Science and Environment	1.11%	0.35%	0.07%	0%	0.38%
Society and Culture	18.53%	11.25%	2.99%	5%	9.44%
Transport	0%	0.01%	0.06%	0.79%	0.21%
Others	3.4%	2.42%	30.78%	49.05%	21.42%
Total	100%	100%	100%	100%	100%

Having extracted the web sites mapped onto categories of interest and jurisdictions, a program was implemented (in Perl) in order to generate a web sample for each jurisdiction, based on:

- the number of web sites the needed in the final sample (5% of the ODP country specific content),
- the weight of each category of interest in the final sample (as in Table 4.3)
- the file containing the country and category specific ODP content.

Details regarding the total number of web sites in the final four web samples generated using the automated random sampling methodology can be seen in Table 4.5.

Table 4.5: **Details on the ODP content considered in the sampling process**

Country	Number of web sites available in ODP	Number of web sites in web sample
IE	5,509	272
UK	114,044	5,702
FR	30,892	1,545
DE	84,860	4,250

Table 4.6 shows the weight of categories of interest in each random web sample. In the sampling process, when the ODP country specific content for one of the categories of interest did not have the required number of web sites for sampling, web sites were randomly selected from other categories than the ones already considered. For example, there were no web sites in the Irish ODP content for the "Transport" category. Therefore, the 5% required (expected) were taken from web sites in the Irish ODP content not belonging to any of the categories of interest (the "Others" category).

4.3 Mirroring tool

The selection and the configuration of the mirroring automatic tool used in this study was implemented by other members of the eAccess lab at RINCE A description of the automatic web content mirroring process follows next.

Web content for each web site considered in the web samples was retrieved and stored for conformance tests and further references, using the web content

Table 4.6: **Weight of random web samples across ODP categories**

Category	Target	Sites in web sample			
		IE	**UK**	**FR**	**DE**
Arts and entertainment	5%	5.15%	5.02%	5.05%	5.01%
Business and Economy	35%	35.29%	35%	35.02%	34.96%
Education	10%	10.29%	10.01%	10.03%	10%
Government	12.5%	12.87%	12.5%	12.56%	12.49%
Health	5%	5.15%	5.02%	5.05%	5.01%
News and Media	5%	5.15%	5.02%	5.05%	5.01%
Recreation and Sports	5%	5.15%	5.02%	5.05%	5.01%
Science and Environment	5%	5.15%	5.02%	1.36%	0%
Society and Culture	12.5%	12.87%	12.5%	12.56%	12.49%
Transport	5%	0%	0.09%	1.04%	5.01%
Others		2.93%	4.8%	7.23%	5.01%
Total	100%	100%	100%	100%	100%

mirroring robot *Pavuk*[19].

Due to technical limitations imposed by the "fully-automated" specific of this survey, web sites where access to content required human intervention (for example user logon) did not have content successfully sampled. Therefore they were counted towards the proportion of web sites not qualified for investigation due to content unsuccessfully sampled. In accordance with the "random" sampling methodology such web sites were not detected and removed from a country specific web sample before the web content sampling process. If desired, such web sites could be pre-emptively removed from the set of web sites studied before the content sampling phase.

[19]http://www.idata.sk/~ondrej/pavuk/

Considering that web sites vary significantly in size and the type of media in which resources are offered, each web site's content was subject to sampling, on the following basis:

- Only HTML resources were captured (due to the specific nature of the study).
- It was assumed that a web site is subject to consistent design and management, therefore, the web accessibility characteristics are the same across a single web site. Therefore it was reasonable to set an overall limit on how much data should be retrieved from a single site. The maximum link depth of the pages to be retrieved was set to 3 (assuming that the most significant pages should be reasonably closely linked to the main–"home" page) and the maximum amount of data captured from a single web site was set to 225 KB based on the available disk space and considering that defects found within such a sample are likely to be repeated over the web site's content).
- It is generally acceptable to suppose that all the components of a single web site should be managed by a single organization and links pointing outside of that organizational responsibility do not belong to the same site. Therefore, when testing web pages on a web site only the pages referred by an URL starting with the top-level host name (i.e. `http://www.domain.org`) were considered as part of the web site. A side-effect of this was that, in case of web sites using top-level redirections, the web site's content will not be effectively sampled.

Post-mirroring process, it was considered that, in order for the survey's results to be reasonably representative only web sites for which the web content sample has at least 3 web pages and at least 100kB of data will be considered in further investigations. Details regarding the exact configuration of the Pavuk Internet mirroring robot can be seen in Appendix A.

4.4 WCAG conformance evaluation tool

The selection and the configuration of the WCAG 1.0 conformance evaluation tool used in this study was implemented in collaboration with members of the eAccess lab at RINCE A description of the automatic web content's WCAG 1.0 conformance investigation process follows next. [57]

There are currently available a number of software products that can be used in order to carry out automated assessments against (subsets of) the WCAG 1.0 guidelines. These tools have a variety of strengths and weaknesses, but are functionally very similar (by definition, as they are largely driven by the WCAG 1.0 guidelines themselves). A list of tools that can be used to check the WAI's WCAG 1.0 conformance of a web page is available on the WAI's *Evaluation, Repair and Transformation Tools for Web Content Accessibility*[20] web page.

Most appropriate for the purpose of this study was an automated WCAG 1.0 conformance investigation tool, which could be integrated in an automated system by having distributions for Red Hat Linux platforms and an output report format suitable for automatic examination.

Two of the most commonly known automated WCAG 1.0 conformance investigation tools ([16], [18]) are *LIFT*[21] and *Bobby*[22].

LIFT is a software package that allows web designers to test and repair accessibility and usability issues, based on a subscription. As part of the LIFT package, *LIFT Onsite* is targeted to web designers who wish to evaluate web content during

[20] http://www.w3.org/WAI/ER/existingtools.html

[21] http://www.usablenet.com

[22] http://bobby.watchfire.com

the creation process, while *LIFT Online* is targeted to web authors who wish to evaluate already published web content.

LIFT is a tool oriented on usability evaluation rather than accessibility, providing not only WCAG 1.0 conformance tests but also other features like checking for broken links. It can be said that LIFT is more a "repair" tool than a "survey" tool because of the generated output format and the information provided, both targeted to human readers (web developers) and therefore less suitable to automatic parsing, as in the case of an accessibility survey.

Bobby was originally developed by the *Center for Applied Special Technology (CAST)*[23]. CAST is an organization involved with W3C's WAI from the beginning, based on which it can be assumed that the Bobby's original development team has a good understanding of the WCAG 1.0 checkpoints and as a result Bobby's WCAG 1.0 investigation reports can be assumed to be reasonably accurate. [18]

Currently Bobby is distributed and maintained by *Watchfire Corporation*[24].

Bobby is not specially designed to be used in web accessibility surveys but more to help web developers understand and implement accessible web content. However, the stand-alone distribution of Bobby provides some features which proved to be very helpful in this research, like the ability to analyze batches of locally stored HTML documents (web pages) and the ability to generate machine readable XML reports. The down side of Bobby is that it can fail unpredictably (most likely to implementation faults in code), which can cause difficulties when integrated in an automatic survey tool.

During the survey, Bobby sometimes malfunctioned in two ways:

- *Bobby terminated with an abnormal status code*: these failures could be triggered by invalid HTML coding on the server (for example the use of

[23]http://www.cast.org

[24]http://www.watchfire.com

invalid characters, such as spaces, in URLs). It is also possible that some of these failures actually indicate defects in Bobby's implementation. (It should be noted that Bobby is not distributed in source form; this makes further investigation in cases such as this problematic.)

- *Bobby appeared to "lock up"*: in this situation, execution was continuing for a much longer period that normal and appeared as if it would continue indefinitely. Again, these failures may be caused by invalid HTML and/or defects in Bobby's implementation. In this case, Bobby's execution was forcibly terminated after a fixed timeout (set at a multiple of three of the maximum time otherwise recorded for successful completion in preliminary testing).

These unpredictable failures may suggest that Bobby results are more generally unreliable. However, during the tool evaluation process, test results generated by Bobby were successfully verified by manual inspection. This suggested that, when Bobby evaluations are successfully performed, results generated are satisfactorily reliable.

In conclusion, after balancing these various factors, Bobby (*Bobby Worldwide, Core 4.0*) was considered to be the most appropriate tool to be used in WCAG 1.0 conformance investigation as part of the automatic web accessibility surveying system implemented in this study.

Bobby implements 91 distinct diagnostics, mapped onto aspects of specific WCAG 1.0 checkpoints.

Aspects of certain WCAG 1.0 checkpoints cannot be verified automatically, human evaluation being necessary in order to asses if the checkpoint is correctly implemented in the web content (such as relevant alternative texts for graphical objects). Based on this, each Bobby diagnostic is assigned a "support level" as following:

- *Full*: Bobby can automatically verify correct implementation of (an aspect of) a WCAG 1.0 checkpoint.

- *Partial/Partial Once*: Bobby can automatically verify to some extent correct implementation of (an aspect of) a WCAG 1.0 checkpoint; human evaluation is required in order to confirm the correct implementation of (an aspect of) a WCAG 1.0 checkpoint.

- *Ask Once/Summary Ask Once*: Bobby cannot automatically verify correct implementation of (an aspect of) a WCAG 1.0 checkpoint; human evaluation is required in order to asses the correct implementation of (an aspect of) a WCAG 1.0 checkpoint.

As outlined for Bobby diagnostics with support level other than "Full", further manual evaluation is required in order to determine WCAG 1.0 conformance. Therefore, in accordance with the automatic specific of the methodology used in the research, *the study will consider only Bobby diagnostics with **full** support.*

Bobby implements 25 diagnostics with full support. These diagnostics and the WCAG 1.0 checkpoints they implement, are shown in Table 4.7

Table 4.7: **Mapping the Bobby diagnostics on WCAG checkpoints**

Bobby diagnostic ID	**Description**	**WCAG Priority**	**WCAG Checkpoint**
g9	Provide alternative text for all images	1	1.1
g21	Provide alternative text for each APPLET	1	1.1
g20	Provide alternative content for each OBJECT	1	1.1

Table 4.7: **Mapping the Bobby diagnostics on WCAG checkpoints**

Bobby diagnostic ID	Description	WCAG Priority	WCAG Checkpoint
g10	Provide alternative text for all image-type buttons in forms	1	1.1
g240	Provide alternative text for all image map hotspots (AREAs)	1	1.1
g38	Each FRAME must reference an HTML file	1	6.2
g39	Give each frame a title	1	12.1
g271	Use a public text identifier in a DOCTYPE statement.	2	3.2
g104	Use relative sizing and positioning (percent values) rather than absolute (pixels).	2	3.4
g2	Nest headings properly.	2	3.5
g37	Provide a NOFRAMES section when using FRAMEs.	2	6.5
g4	Avoid blinking text created with the BLINK element.	2	7.2
g5	Avoid scrolling text created with the MARQUEE element.	2	7.3
g33	Do not cause a page to refresh automatically.	2	7.4
g254	Do not cause a page to redirect to a new URL.	2	7.5
g269	Make sure event handlers do not require use of a mouse.	2	9.3

Table 4.7: **Mapping the Bobby diagnostics on WCAG checkpoints**

Bobby diagnostic ID	**Description**	**WCAG Priority**	**WCAG Checkpoint**
g41	Explicitly associate form controls and their labels with the LABEL element.	2	12.4
g34	Create link phrases that make sense when read out of context.	2	13.1
g265	Do not use the same link phrase more than once when the links point to different URLs.	2	13.1
g273	Include a document TITLE.	2	13.2
g14	Client-side image map contains a link not presented elsewhere on the page.	3	1.5
g125	Identify the language of the text.	3	4.3
g31	Provide a summary for tables.	3	5.5
g109	Include default, place-holding characters in edit boxes and text areas.	3	10.4
g35	Separate adjacent links with more than whitespace.	3	10.5

Each one of the Bobby diagnostics are explained in the *Bobby Report Explanation File*[25].

Given the fact that Bobby can verify correctly implementation of only a set of WCAG 1.0 checkpoints (i.e. the ones with full support), it cannot determine if a web content conforms to WCAG 1.0 without human intervention. But Bobby

[25]http://bobby.watchfire.com/bobby/html/en/browsereport.jsp

can detect clear failures in web content's implementation of WCAG 1.0. In short, Bobby cannot determine WCAG 1.0 conformance (at most it can determine *possible* WCAG 1.0 conformance), but it can determine web content *non conformance* to WCAG 1.0.

In general, when analyzing the results, it was considered that if one diagnostic is triggered at least once in at least one web page of a web site sample, the web site should be counted in statistics regarding the specific diagnostic, disregarding the actual number of times the specific diagnostic was triggered in a web site's sampled content.

It may be argued that this could make the overall results look very strict; however only a relatively small web content sample was taken from each web site considered, and it is sensible to consider that the technologies/implementations used across a web site are similar, so, if the reported defect appeared at least once it is quite probable that it will appear again over the overall web site's content.

More than that, the nature of this study is investigation of web accessibility levels with the purpose of *survey* (as opposed to repair) and from this point of view, the web accessibility levels of a web site is influenced by the occurrence of a diagnostic in its content, rather than the specific number of occurrences of a diagnostic. The study investigates web accessibility levels of web samples rather than comparing web accessibility levels of web sites in web samples.

However, the reporting data storage implemented in this system is conductive to finer reports, if desired.

4.5 HTML technical conformance evaluation tool

The technologies used in rendering web content for people with disabilities are designed to recognize mark-up elements, interpret their functionality and deliver the web content in a form that will keep the structure and the functionality of the web content. Therefore, a major step in reducing the accessibility problems is insuring that the mark-up is correctly built, according to its specifications. WCAG 1.0 Checkpoint 3.2 (Priority 2) expresses this thus:

> Create documents that validate to published formal grammars.

An HTML page is properly built when its mark-up conforms to a technical specification. Each specification is defined by a Document Type Declaration (DTD) document which contains descriptions of the entities, elements and attributes that can be part of an HTML document, and how they can be interrelated. Because most of the existing web browsers are able to process web pages which don't conform to a DTD, many of the failures in the HTML code can pass unnoticed by most users. But such code defects can be a real impediment in access by users with disability helped by special purpose web browsers and dedicated assistive technologies. They also complicate, and therefore inhibit, ongoing development of such niche technologies.

There are different tools that can be used in order to validate HTML code against its description in the corresponding DTD. The output is usually a list of problems encountered (diagnostics) with suggestions as to how could they be fixed. A list of such tools can be seen on the *WAI web site*[26]

The *W3C HTML Validation Service*[27] is a free service that checks HTML documents for conformance to W3C HTML Recommendations.

In the W3C implementation, the service provides the facility to validate HTML documents uploaded or referred by URI. W3C offers the technology used in their HTML Validation Service for free, to be installed and run locally, a feature that was very important in the project presented in this thesis.

[26]http://www.w3.org/WAI/ER/existingtools.html

[27]http://validator.w3.org/

The HTML validation process is implemented in a single Perl program (`check`), a wrapper to the OpenSP SGML parser library. The output is an HTML page containing a list of HTML conformance diagnostics. For each defect found, diagnostic information is given such as the location of the defect in the HTML document and a message describing the defect.

Because, during the surveying process, validations of more than one HTML page were made, some modifications were necessary, such as the possibility to investigate a batch of HTML pages at once, not only an URI or an uploaded file. Subsequently, the format of the output report (originally a list containing the defects found in a single HTML page) had to be modified too. In the new implementation the HTML Validation output was a list in which the items contained information about each HTML page tested such as a link to its URI, a link to the HTML conformance test results and the duration of the validation.

Because all the reports have to be kept for later reviews, instead of generating online reports, for each HTML page tested the report was saved in a file on the local disk and a link to that report was provided.

The new implementation of the HTML Validation service was installed on the local eAccess server, and it was used in successful validation of HTML documents.

The implementation of an automated web accessibility surveying system required the integration of a set of automated investigation tools in a single system (tool). An important component of the surveying system was recording the investigation results in a database for further analysis. Using specially designed programmes, the output files generated by the HTML Validator would have had to be automatically parsed and the information relevant to the web accessibility survey would have had to be recorded in the database.

An HTML format of the output report would be more suitable for human reading than automatic parsing because the structure and the content of the data can't be determined automatically due to the fact that the HTML mark-up used in the reports is not giving any specific information about the structure and the content of the data represented. Parsing such a format of investigation results would have had required a laboriously designed application which would have had to recognize and retrieve the information relevant to the study from the HTML content.

As opposed to HTML, where the element semantics and the tag set are fixed, XML provides the facility to define elements and the structural relationship between them. Given this, an XML format of the output reports could prove to be more suitable for machine processing due to the fact that each element would be specially dedicated to represent the structure and the content of the data presented.

For the purpose of this study, an XML output format seemed to be more suitable than an HTML output format.

Unfortunately, the W3C HTML Validation Service does not have the capability of delivering the output in XML format.

At this stage, there were two options to explore. One solution might have been to modify the W3C HTML Validator wrapper so that the output would be transformed to XML instead of HTML mark-up. HTML is a mark-up language designed to define the structure of a web page (document) as opposed to XML which is designed to represent arbitrary structured content. Considering this, such a solution seemed cumbersome and vulnerable to errors in translations, as a "document structure" would have to be translated to a different, more semantically appropriate, structure. Accordingly, a more robust solution was sought. One such solution was to find another tool that validates HTML documents and delivers the output *directly* in a semantically appropriate XML format. This solution seemed to be more reasonable and was further investigated.

The W3C HTML Validation Service is based on Clark's *SP SGML Parser*[28], using a CGI program that acts like a wrapper for the actual SP SGML parser and provides the interface between the parser and the Internet user.

Another variant of the SP SGML Parser is *OpenSP*[29], a collection of SGML processing applications, including *onsgmls*[30], a parser and validator of SGML files (HTML and XHTML). Since onsgmls cannot be configured, installed and executed by itself but only as part of the OpenSP suite, the thesis will not make direct references to onsgmls but to OpenSP, as an automated tool that can be used in HTML technical conformance investigations.

While the W3C HTML Validation service is built upon (it is a wrapper of) Clark's SP SGML Parser, OpenSP is an open source project that continually develops Clark's SP SGML Parser. Written by James Clark in C++ from scratch and compatible with the old SP SGML Parser, OpenSP is a project undertaken by the Document Style Semantics and Specification Language (DSSSL) community to maintain and extend the related SP suite of SGML/XML processing tools.

The freely available OpenSP source code (version 1.4) was installed on the local server and configured to generate the output in XML format, using a patch developed by *Nick Kew*[31].

Starting with OpenSP version 1.5 (released December 2002), the XML output format was integrated in the distribution package. Further than that, the 1.5 version didn't bring anything new as far the web accessibility project was concerned. At that time, OpenSP version 1.4 was already modified in order to accommodate the needs of the surveying project, and the automated surveying system was already in use (two sets of results were already generated). Considering the con-

[28]http://www.jclark.com/sp

[29]http://openjade.sourceforge.net/doc/index.htm

[30]http://openjade.sourceforge.net/doc1.4/nsgmls.htm

[31]http://valet.htmlhelp.com/xml/

sistency between survey results and the fact that an upgrade would imply further modifications of the OpenSP (v1.5) source code in order to be integrated in the automatic surveying system, the upgrade from OpenSP 1.4 to OpenSP 1.5 was considered unnecessary.

The validation process implemented by OpenSP involves comparing the use of each element in an HTML document with its specification in the document's document type definition (DTD). If an HTML document does not have a document type declaration, OpenSP will assume the default HTML 4.01 Transitional document type (the current W3C HTML technical specification).

OpenSP implements 438 diagnostics and each one of these diagnostics is raised when an element in the HTML content is not used according to its specification in the HTML page's DTD.

Each diagnostic is assigned a severity level. Unfortunately, the documentation for OpenSP does not give details regarding the basis on which the severity levels are assigned to diagnostics. Based on observations it was noted that the diagnostics are classified as follows:

- *warning*—94 diagnostics : warning diagnostics can be selected by a user when additional criteria than the ones specified in the DTD are desired to be checked (i.e. elements not allowed in XML, unclosed end tags)
- *quantity error*—26 diagnostics : OpenSP has a set of variables that determine the limit of some numerical characteristics of elements. If during the validation process a numerical characteristic is not in accordance with such a limit a quantity error diagnostic is raised (e.g. "length of attribute value must not exceed LITLEN less NORMSEP", "the number of open entities cannot exceed ENTLVL"—in the current configuration of OpenSP LITLEN= 24000, NORMSEP=2 and ENTVLV=99999999). OpenSP has these limits set to a default value which is considered to be reasonable for

a valid HTML document. If, during the validation process, these limits are infringed, it can be assumed that there is a problem regarding the HTML content which might lead to an unappropriate rendering of the HTML page by user agents.

- *error*—318 diagnostics : an error diagnostic is triggered when the diagnostic is showing a clear non concordance between the use of a element in the HTML content and its specification in the DTD.

The XML output generated by OpenSP is a collection of elements that contain information on the HTML conformance diagnostics found during the validation, such as diagnostic message and diagnostic location (HTML file name, line number and column number in the file).

Some modifications related to the content of the generated output were performed in order to adapt the information retrieved from the validation result to the structure of the database in which the information will be kept.

The originally generated output represents a diagnostic in an element (`message`) that has as attributes:

- the diagnostic sequential number in the list of diagnostics found (`id`),
- the name of the HTML file which triggered the diagnostic (`location`),
- the line number and the column number in the HTML file where it was encountered (`line`, `column`)
- its severity level (`severity`).

The value of each `message` element is a text describing the diagnostic.

In investigation results, a diagnostic might occur more than once and when there are more than one HTML documents to be validated the number of instances for each diagnostic can get considerable bigger. For each one of these instances the description text of the diagnostic is repeated. Because investigation results were to be recorded in a database, a modification of the output structure was performed in order to save disk space.

In the new output format the actual text describing the diagnostic is no longer part of the information and it is replaced by its identification number (as assigned in OpenSP implementation), the value of a new attribute (`errorid`) of the `message` element.

Some diagnostic text descriptions have one or more parameters. For example the "required attribute TYPE was not specified" diagnostic has the actual text description "required attribute %1 was not specified" and the parameter `TYPE`. When replacing the text description of the diagnostic with its identification number, a sub-element (`argument`) was added to the `message` element. The `argument` element has as attributes a numeric identifier to represent it in the parent `message` element (the `arg-number` attribute) and the value of the parameter in the diagnostic's description text (`value` attribute).

Currently, the modified generated output of the local OpenSP version/implementation lists diagnostics structured in `message` elements, having as attributes:

- the diagnostic sequential number in the list of diagnostics found (`id`),
- the name of the HTML file in which it was located (`location`),
- the line number and the column number in the HTML file where the defect was encountered (`line`, `column`),
- the severity of the defect (`severity`)
- the diagnostic id (`errorid`).

Also, if the original text description of the diagnostic had parameters, the `message` element will contain, for each parameter, an `argument` element whose attribute `value` will contain the parameter's value.

For example in the original OpenSP XML output format a diagnostic is represented as :

```
<sp:message sp:id="mid1"
                sp:location="stuinf.html"
                sp:line="10"
                sp:column="29"
                sp:severity="E">
required attribute TYPE not specified
</sp:message>
```

The same diagnostic is represented in the modified OpenSP XML output format as :

```
<sp:message sp:id="mid1"
                sp:location="stuinf.html"
                sp:line="10"
                sp:column="29"
                sp:severity="E"
                sp:errorid="127">
    <sp:argument sp:arg-number="1"
                sp:value="TYPE">
    </sp:argument>
</sp:message>
```

OpenSP is implemented in C++. A description text and a unique identification number for each diagnostic are kept in a table (in the file `po/cat-id-tbl.c`) and across the implementation, each diagnostic is represented through its identification number. Finally, when the output report is generated, each diagnostic identification number is replaced by the diagnostic description text. This behavior was captured and modified so that in the output text the text description of the diagnostic is replaced by its identification number in the manner described above.

As previously outlined, OpenSP can indicate clear non-conformance of HTML mark-up to HTML technical specifications based on diagnostics with "error" severity level. Therefore, the survey presented in this thesis will discuss only OpenSP diagnostics with "error" severity level, due to the specific "HTML technical conformance investigation" of the study.

Due to the specific hierarchical structure of HTML documents, defects in mark-up will usually influence the validation process of elements within the element with incorrect mark-up. In the end, the diagnostics triggered by OpenSP during a validation process are closely inter-related, such that if one defect is repaired and the validation process repeated, the validations results can be significantly different.

The validation process implemented by OpenSP involves comparing the use of each component in an HTML document with its specification in the DTD of the HTML specification used in the document. Thus, in order for OpenSP to generate consistent validation results, it needs a properly specified DTD, normally done via a DOCTYPE declaration in the beginning of the HTML page. [21, Section 7.2]

Accordingly, if the DOCTYPE declaration is missing (or not recognized), the HTML document (web page) will immediately and automatically fail the HTML validation tests. In such cases it would be possible to configure OpenSP to assume a default DTD against which the document should validate. However, detailed results generated by a validation of such HTML pages are not considered relevant to our study (since the document might validate against *some* DTD—had the correct one been specified).

The mapping between the HTML specification used in a document to be tested and the document type declaration corresponding to that specification is made through formal public identifiers (FPI), components of the DOCTYPE declaration.

For an SGML processor (such as OpenSP) the FPIs and the DTDs they are mapped to are usually specified in a "catalog" file. Appropriate catalog files are generally made public with each HTML specification published. In the configuration used in this study, OpenSP uses case-sensitive matching of FPIs when determining the DTD against which a document should be validated. However, it was found in practice that a significant number of declarations failed to match appropriate DTDs precisely because the FPI differed only in case from one in a known catalog. It was decided to enable validation in such cases, by manually adding additional catalog entries for such case-variant FPIs, mapping them onto the appropriate DTDs. The FPI case-variations permitted in this way are listed in Appendix B.

As in the analysis of the web accessibility guidelines conformance test results, it was considered that if one diagnostic is triggered at least once in at least one web page of a web site sample, the web site should be counted in statistics regarding that diagnostic. However, this rule was not applied to the "no DOCTYPE declaration" diagnostic since over 98% of the total number of web sites considered had at least one page with missing or not recognized document type information. Instead, the web pages that triggered this diagnostic were eliminated from the overall sample and considered separately from the final results. In order for the results of the HTML conformance tests to be relevant to this study (regarding the analysis of the most common HTML defects), each site of the resulting sample (having now only the web pages with usable DTD information) was again tested for conformance with the minimum amount of data (100kB) and the minimum number of pages (3) required, per web site, as previously outlined.

4.6 The automated surveying system

Information about automated surveys, including details regarding the three main components (Pavuk, Bobby, OpenSP) are kept in a database (*PostgreSQL*[32] DBMS), populated with data by specially designed programs.

In order to analyze the web accessibility investigation results, reports based on the data recorded in the database were generated, using specially designed database structures and programs.

4.6.1 Implementation of data gathering stage

4.6.1.1 Gathering overall process information

In order to implement the automated web accessibility surveying system, the web content sampling and the conformance investigation components of the project were coordinated and integrated using an Perl program (`warp-job`), facilitating further integration in regular/periodical surveying systems.

Each run of the `warp-job` program is determined by a collection of web sites (a web sample in the particular case of this survey) and by limitation parameters regarding the web site's content sampling process (as detailed in Section 4.3). A collection of web sites has to be provided in order to start an web accessibility survey (`warp-job` execution). The web content mirroring parameters (4) are optional. If a value for one of these parameters is not specified, a default value will be provided automatically. The optional input parameters are (the justification

[32]http://www.postgresql.org/

for the default values was detailed in Section 4.3) :

- the maximum disk quota for a Pavuk capture of a web site (default 225 KBytes)
- the maximum link depth (default 3) to be followed by Pavuk when retrieving HTML content from a web site.
- the minimum amount of data (default 102400 Bytes =100 KBytes) to be captured by Pavuk for a web site to be considered for further investigation (WCAG 1.0 and HTML technical conformance tests).
- the minimum number of pages (default 3) to be captured by Pavuk for a web site to be considered for further investigation (WCAG 1.0 and HTML technical conformance tests).

The `warp-job` program initiates execution of separate programs integrating the three main system components (`pavuk-job` [*Section* 4.6.1.2], `bobby-job` [Section 4.6.1.3] and `opensp-job` [Section 4.6.1.4]) for each web site in the collection. It also validates web content for investigation, checking that the minimum web sampling requirements are met.

As part of the automated surveying system implemented in this study, the process of investigating WCAG 1.0 and HTML technical conformance of web content samples of a collection of web sites is referred to as a *warp job/process*. Subsequently, the process of sampling the content of a single web site is referred to as a *Pavuk job*, the process of WCAG 1.0 conformance investigation of the web content sampled from a single web site is referred to as a *Bobby job* and the process of HTML technical conformance investigation of the web content sampled from a single web site is referred to as an *OpenSP job*.

The information related to the overall process is recorded in specially designed tables for further analysis and investigations.

The PostgreSQL tables in which information regarding the the web site content's sampling process is kept are:

- `warp_sites`

  A *warp site* defines a web site considered for web accessibility investigation.

  Each warp site is assigned an identifying number (*site id*), which represents the web site uniquely across the database.

  The `warp_sites` table contains information about each one of the web sites considered in the automated surveying process like:

  - the unique identification number ("site_id"), automatically generated once a new row is inserted in this table
  - the "top-level" URL of the web site considered for investigation
  - the jurisdiction (e.g. ".ie", ".uk") and the sector (e.g. ".com", ".org") to which the web site is considered to belong

- `warp_collections`

  A *warp collection* defines a collection of web sites, the unit on which warp processes (jobs) are executed. In the particular case of this study, a web sample is a warp collection.

  Each warp collection is identified in the database by an unique identification number.

  The `warp_collections` table contains information about each one of the web site collections considered in the automated surveying process:

- the unique identification number ("collection_id"), automatically generated once a new row is inserted in this table
- in order to make the insertion of new rows in this table possible another field (that will not have automatically generated value) was needed. It was decided that the extra field will contain information (id) of the user which created the collection. In its current state, the automated surveying system has only one registered user (warp).

- *warp_collection_sites*

  The *warp_collection_sites* table contains information about the web sites considering in warp collections, in pairs of the form ("warp collection id"—as generated in *warp_collections* table, "warp site id" *warp_sites* table).

- *warp_job_descr*

  As mentioned before, a warp job is determined by a collection of sites and by limits to be imposed to the web site content mirroring process. Each warp job is identified in the database by an unique identification number.

  The *warp_job_descr* table stores information regarding the execution of a warp process (`warp-job` program) over a collection of web sites, such as:

  - the unique identification number ("warp_job_id"), automatically generated once a new row is inserted in this table
  - the identification number of the collection of web sites considered in the warp process
  - the start and end date and time of the warp process

- the limits to be imposed on the web content mirroring process (maximum amount of data to be retrieved, maximum link depth to be followed, minimum amount of data and number of pages to be retrieved for each web site)

- `warp_jobs`

  As mentioned before, a warp process/job consists of a Pavuk job potentially followed by a Bobby job and a OpenSP job for each web site in the collection of web sites considered. Information about each Pavuk, Bobby and OpenSP job are recorded in specially designed database tables.

  The `warp_jobs` table contains information coordinating / connecting the Pavuk, Bobby and OpenSP jobs performed on a web site, as part of warp job:

  - the identification number of the warp process that initiated the Pavuk, Bobby and OpenSP jobs (as generated in `warp_job_descr`).
  - the identification number of the Pavuk process that sampled the web content of one of the web sites in the collection as part of the warp process (as generated in `pavuk_jobs`)
  - the identification number of the Bobby process that investigated the WCAG 1.0 conformance of the web content retrieved during the Pavuk process (or NULL if the web content doesn't qualify for further investigation).
  - the identification number of the OpenSP process that investigated the HTML technical conformance of the web content retrieved during the Pavuk process (or NULL if the web content doesn't qualify for further investigation).

4.6.1.2 Gathering mirroring process information

As mentioned before, the mirroring process (mirroring process tool configuration, integration using a Perl program and database design) was implemented by other members of the eAccess team.

In order to ensure an automated process, the mirroring tool Pavuk was integrated in a Perl program (`pavuk-job`), ensuring that a given web site's content is sampled according to given parameters and the information related to the mirroring process is recorded in specially designed tables for further analysis and investigations.

Each execution of the `pavuk-job` program attempts to sample the web content of a web site, according to mirroring process characteristics detailed in Section 4.3.

The PostgreSQL tables in which information regarding the the web site content's sampling process is kept are:

- *`pavuk_jobs`*

  A *Pavuk job* defines the mirroring process of a web site's content.

  Each Pavuk job is assigned an identifying number (*Pavuk job id*), which represents the Pavuk job uniquely across the database.

  The *`pavuk_jobs`* table contains information about each one of the Pavuk jobs carried out using the automated surveying process:

  - the unique identification number (Pavuk job id), generated by PostgreSQL each time a new row (Pavuk job) is inserted in the `pavuk_jobs` table (registered in the database)
  - the identification number of the web site (as outlined previously, see Section 4.6.1.1) whose content is sampled by this Pavuk job

- the start and end time of the web content sampling process

- *pavuk_pages*

  As part of the project, a Pavuk job returns a set of *Pavuk pages* to be investigated for WCAG 1.0 and HTML technical conformance.

  Each Pavuk page is assigned an identifying number (*Pavuk page id*), which represents the Pavuk page uniquely across the database.

  The *pavuk_pages* table contains information about each one of the web pages retrieved during the web content sampling process as part of the automated surveying process:

  - the unique identification number (Pavuk page id), generated by PostgreSQL each time a new row (Pavuk page) is inserted in the pavuk_pages table (registered in the database)
  - the identification number of the Pavuk job (as outlined previously), as part of which the Pavuk page was retrieved
  - the URL from which the Pavuk page was retrieved
  - the URL of the web page which links to this Pavuk page ("parent" web page)
  - the path to the local copy of the captured web page
  - the time and date of the web page capture
  - the status of the web page retrieving process. (error codes, when the retrieval was successful the error code is 0)
  - the size of the local copy (web page retrieved).

4.6.1.3 Gathering WCAG 1.0 conformance investigation information

The WCAG 1.0 conformance investigation (automated evaluation tool configuration, integration using a Perl program and database design) was implemented by other members of the eAccess team.

In order to ensure an automated process, Bobby was integrated in a Perl program (`bobby-job`), ensuring that the sampled content of a web site (collection of HTML documents) is investigated regarding its conformance to WCAG 1.0.

Each run of the `bobby-job` program initiates the Bobby evaluation tool on the set of HTML documents retrieved for a web site during the mirroring process. Once the evaluation is concluded, the reports generated by Bobby are examined (using the *XML::DOM::Parser*[33] Perl library) and the results are recorded in specially designed database tables for further analysis.

The PostgreSQL tables in which information regarding the WCAG 1.0 conformance investigation is kept are:

- *`bobby_diags`*

  As previously outlined (Section 4.4) Bobby implements (at different levels—i.e. "full", "partial") a set of "diagnostics", mapped on WCAG 1.0 checkpoints.

  A *Bobby diagnostic* defines a WCAG 1.0 infringement detected by Bobby. In Bobby's configuration, each diagnostic is assigned a uniquely identifying tag. These tags are used in the warp process to represent Bobby diagnostics uniquely across the database.

  The *`bobby_diags`* table contains information about each one of the diagnostics implemented by Bobby such as:

[33] http://search.cpan.org/ tjmather/XML-DOM-1.43/lib/XML/DOM/Parser.pod

- the diagnostic's unique identification tag, as provided by Bobby's implementation (see Table 4.7).
- the diagnostic's description title (as in Table 4.7).
- the support implemented by Bobby for this diagnostic as outlined in Section 4.4
- the WCAG 1.0 checkpoint (and its priority level) onto which the diagnostic is mapped.

- `bobby_jobs`

  A *Bobby job* defines the WCAG 1.0 conformance investigation process of a set of HTML documents (the sampled content of a web site).

  Each Bobby job is assigned an identifying number (*Bobby job id*), which represents the Bobby job uniquely across the database.

  The `bobby_jobs` table contains information about each one of the Bobby jobs carried out as part of the automated surveying process:

  - the unique identification number (Bobby job id), generated by PostgreSQL each time a new row (Bobby job) is inserted in the `bobby_jobs` table (registered in the database)
  - the identification number of the mirroring process (Pavuk job) that retrieved the web content to be investigated (as generated in `pavuk_jobs` table)
  - the start time and the end time of the web content sampling process in the current Pavuk job.
  - the exit status of the Bobby job:
    - 0—"ok"—the evaluation was successfully finished

* 1—"full fail"—the evaluation on the given HTML documents failed (unknown reasons, see Section 4.4)
* 2—"zero urls"—the evaluation failed because there were no HTML documents to be investigated
* 3—"timed out"—the evaluation failed due to "lock up behavior" as detailed in Section 4.4
* 4—"xml fail"—the evaluation failed due to errors in the XML code of the output report
* 5—"bad usage"—the evaluation failed due to errors in the command line which launched the `bobby-job` program.
* 6—"Pavuk data offline"—the evaluation failed because there was no web content to be evaluated for the given web site (presumably because the mirroring process failed).

- *`bobby_hits`*

  A *Bobby hit* defines a Bobby diagnostic triggered during the investigation process of an HTML document.

  Each Bobby hit is assigned an identifying number (*Bobby hit id*), which represents the hit uniquely across the database.

  The *`bobby_hits`* table contains information about each Bobby hit generated during WCAG 1.0 conformance investigations, such as:

  – the unique identification number (Bobby hit id), generated by PostgreSQL each time a new row (Bobby hit) is inserted in the *`bobby_hits`* table (registered in the database)

  – the identification number of the Bobby job (generated in *`bobby_jobs`*) which generated the hit

- the identification number of the diagnostic whose detection is recorded by the current Bobby hit
- the identification number of the HTML document (as outlined before, generated in `pavuk_pages`) in whose content the infringement was detected
- the actual number of occurrences of the current diagnostic in the current HTML document

4.6.1.4 Gathering HTML technical conformance investigation information

In order to ensure an automated process, OpenSP was integrated using a Perl program (`opensp-job`), ensuring that the sampled content of a web site (set of HTML documents) is investigated regarding its conformance to HTML technical specifications.

Each execution of the `opensp-job` program initiates the OpenSP evaluation tool on the set of HTML documents retrieved for a web site during the mirroring process.

Once the evaluation is finished, the reports generated by OpenSP are examined (using the XML::DOM::Parser Perl library) and the results are recorded in specially designed database tables for further analysis.

The PostgreSQL tables in which information regarding the HTML technical investigation is kept are:

- *`opensp_diagnostics`*

  As mentioned before (Section 4.5), the output generated by OpenSP was modified so that each diagnostic is represented by a diagnostic identification number (as provided by OpenSP implementation).

The `opensp_diagnostics` table contains information regarding each one of the diagnostics implemented by OpenSP such as:

- the diagnostic's unique identification number as provided by OpenSP's implementation.
- the text description of the diagnostic as in the OpenSP's implementation. (ex: "required attribute %1 not specified").
- the text description of the diagnostic as modified for survey reporting purposes. (e.g. "required attribute TYPE not specified" becomes "required attribute not specified").
- the "severity" assigned to each diagnostic (OpenSP's implementation).

• `opensp_jobs`

An *OpenSP job* represents the process of HTML technical conformance investigation of a set of HTML documents retrieved for a certain web site.

Each OpenSP job is identified across the database by an identification number.

The `opensp_jobs` table contains information regarding each OpenSP job, such as:

- the unique identification number, generated by PostgreSQL each time a new row (OpenSP job) is inserted in the `opensp_jobs` table (registered in the database)
- the identification number of the mirroring process (Pavuk job) that retrieved the web content to be investigated (as generated in `pavuk_jobs` table)
- the duration of the validation process (in seconds)

- the (starting) date of the OpenSP job

- opensp_hits

  Similar to Bobby hits, an *OpenSP hit* defines an OpenSP diagnostic triggered during the investigation process of an HTML document.

  Each OpenSP hit is assigned an identifying number, which represents the hit uniquely across the database.

  The opensp_hits table contains information about each OpenSP hit generated during HTML technical conformance investigations, such as:

  - the unique identification number, generated by PostgreSQL each time a new row (OpenSP hit) is inserted in the opensp_hits table (registered in the database)
  - the identification number of the OpenSP job (generated in opensp_jobs) which generated the hit
  - the identification number of the diagnostic whose detection is recorded by the current OpenSP hit
  - the identification number of the HTML document (as outlined before, generated in pavuk_pages) in whose content the infringement was detected
  - the actual number of times the current diagnostic was triggered in the current HTML document

4.6.2 Implementation of data reporting stage

Having recorded information regarding web accessibility investigation processes carried out as part of the automated surveying system, the basis for accessibility analysis was available.

The web accessibility level was determined based on three components:

- web content mirroring process, considering that in order for a web site's content to be accessible, access to the web site has to be provided first.
- web content conformance to universally recognized web accessibility guidelines (WCAG 1.0)
- web content conformance to HTML technical specifications, a major step in achieving web accessibility (see Section 4.5)

In order to extract information stored in database in a format closer to a report, SQL views (virtual tables) were created. These views gathered information stored in separate tables, according to a set of rules imposed by the nature of the question ("query") it would need to be answered.

The benefit of using view rather than tables in report generation is that views implement a set of rules to be applied to the content of a database *when required/inline*. This means that the database size is not increased by redundant information. Also, because views do not store data, queries are much simpler to be implemented/modified, due to the fact that in this case the data backup and restoration is eliminated.

The down side of using views is that, in case of complex queries (views implementing queries based on other views and so on) or large database content (large number of records in tables to be queried) they tend to be slow. As opposed to tables, where a set of rules is applied only once (when the table is created) and than any query on that table has direct access to data, the view have to apply the set of rules on the database content each time a query is applied to the view.

In order to generate reports that would be further on analyzed, Perl programs were implemented for each one of the three components of the WARP automated surveying system.

Using the *Pg*[34] Perl module library, queries were made based on specifically designed views, on the information stored in the database.

The automated generated results show information and statistics regarding a warp process at one time.

4.6.2.1 Reporting web content mirroring process information

In order to extract information and statistics regarding the web content mirroring processes as part of a warp process, a Perl program (`pavuk_rep_gen`) was implemented. The program also reports information regarding the characteristics of the overall process.

The report generated shows:

- details regarding the warp process (start/end date and time, identification number of the collection of web sites to be considered in investigation, limits to be imposed to the web content mirroring processes)
- number of web sites considered in the warp process
- number of web pages and amount of data retrieved in the mirroring process
- number of web sites that qualified for further investigations (regarding the required minimum data amount and the minimum number of pages correctly retrieved as specified in the warp process description)
- number of web pages in the web sites qualified for further investigation
- statistics regarding web sites that didn't qualify for further investigation (didn't meet the required minimum number of pages and data amount retrieved)

[34] http://hea-www.harvard.edu/MST/simul/software/docs/pkg/pgsql/Pg.html

4.6.2.2 Reporting WCAG 1.0 conformance investigation information

The automated generated report (using `bobby_rep_gen`) show information and statistics on the web content's WCAG 1.0 conformance investigation using Bobby. As mentioned in Section 4.4, only a subset of the diagnostics implemented by Bobby were considered in this study. This set is considered when results describe statistics regarding "Bobby diagnostics".

The report generated shows:

- statistics regarding the execution of Bobby (successful completion or not, as discussed in Section 4.6.1.3)
- number of web sites that triggered at least one Bobby diagnostic with Priority 1, Priority 2 or Priority 3 respectively.
- number of web sites with no Priority 1 Bobby diagnostics (as discussed previously, this doesn't necessarily mean that the web sites are "WCAG 1.0 Level A" compliant, since Bobby cannot automatically check the conformance of web content to *all* WCAG 1.0 Priority 1 checkpoints)
- number of web sites with no Priority 1 or 2 Bobby diagnostics (again, shouldn't be interpreted as "WCAG 1.0 Level Double-A" compliant)
- number of web sites with no Priority 1, 2 or 3 Bobby diagnostics (not necessarily "WCAG 1.0 Level Triple-A" compliant)
- density of Priority 1, 2 or 3 respectively Bobby diagnostics on web sites evaluated (for example, "2 web sites triggered 6 distinct Priority 1 Bobby diagnostics). This information could help in evaluating the efforts that would be need to be invested in order to improve the level of WCAG 1.0 conformance of a web sample, by showing information like "most of the web sites in the web samples need to address at least X web accessibility issues".

- web sites on which distinct Priority 1, 2 or 3 respectively Bobby diagnostics were triggered (for example, "the diagnostic 'Provide alternative text for all images' was triggered on 123 web sites."). This statistical information presents the most common Bobby diagnostics triggered during the warp process, based on the number of web sites that triggered each distinct diagnostic at least once (as already outlined, the number of times a specific diagnostic is triggered on a web site is not considered in this survey)

4.6.2.3 Reporting HTML technical conformance investigation information

As detailed in Section 4.5, HTML conformance tests on web pages that didn't have a correctly specified document type are most likely to generate unreliable results. Therefore, HTML defects statistics analysis will not include the HTML defects triggered by the investigation of such HTML documents.

In order to implement this consideration in practice, a set of views were designed to consider only web pages with correct HTML document type declaration in statistics related to HTML defects analysis.

Because of the large volume of data needed to be processed and mostly the complexity of views used in generating the statistics, the operation was extremely time consuming making it is unappropriate for the purpose of automated report generation.

In order to overcome this impediment, tables were added to the structure of the database. The main new table mirrors the content of the `opensp_hits` table for those records related/belonging to web pages with correct document type declaration. The content in the new added tables is automatically updated every time a warp process is completed.

As with the web content mirroring process and web content WCAG 1.0 conformance investigation process, a Perl program was used in order to automatically generate reports containing information and statistics regarding the web content HTML technical conformance investigation. Each type of infringement of HTML technical specifications detected by OpenSP is classified as "OpenSP diagnostic".

The report presents information and statistics such as:

- statistics regarding web pages for which OpenSP didn't generate reliable results

- number of web sites (and web pages) considered for OpenSP diagnostics analysis after eliminating the web pages with missing or incorrect document type declaration (as detailed in Section 4.5)

- density of distinct OpenSP diagnostic on web sites evaluated (for example, "80% web sites triggered 6 distinct OpenSP diagnostics"). This information could help in evaluating the efforts that would be need to be invested in order to improve the level of HTML technical conformance of a web sample, by showing information like "most of the web sites in the web samples need to address at least 6 HTML mark-up defects".

- web sites on which distinct OpenSP diagnostics were triggered (for example, "the diagnostic 'Undefined attribute' was triggered on 85% of web sites."). This statistical information presents the most common OpenSP diagnostics triggered during the warp process, based on the number of web sites that triggered each distinct diagnostic at least once (as already outlined, the number of times a specific diagnostic is triggered on a web site is not considered in this survey)

4.7 Chapter Summary

This chapter discusses the methodology used in sampling the Irish, UK, French and German web spaces and the implementation of the automated web accessibility surveying system based on the Internet robot Pavuk, the WCAG 1.0 conformance investigation automated tool Bobby and the HTML technical conformance investigation automated tool OpenSP.

The automated surveying system was used between May 2002 and December 2004 on five web samples in order to determine the web accessibility level of four web spaces: Irish, UK, German and French.

Based on the results generated in these investigations, comparative analysis of the web accessibility level of the Irish web space compared to the web accessibility level of the UK, French and German web spaces are presented in Chapter 6 and Chapter 7.

Chapter 5

Web accessibility guidelines and HTML technical conformance tests

5.1 Chapter Overview

This chapter presents the Bobby (WCAG 1.0 conformance investigation) and OpenSP (HTML technical conformance) tests/diagnostics considered in investigations. These tests were previously discussed in technical papers authored by members of eAccess such as [59], [60].

In concordance with the specific objectives of the study, only tests fully implemented by Bobby (7 tests of WCAG 1.0 Priority 1 checkpoints and 13 tests of WCAG 1.0 Priority 2 checkpoints) were considered in investigations (Section 4.4).

OpenSP implements 318 tests verifying usage of HTML entities according to their specification in the declared technical specification. Considering the large volume of technical information that would be generated by discussing all the 318 diagnostics and the fact that the study concentrates on discussing web accessibility issues–in which HTML technical conformance are not considered the highest priority–the study will analyze only the 11 most common OpenSP diagnostics generated in investigations as detailed in the following chapters.

5.2 Bobby Priority 1 diagnostics

All the WCAG 1.0 Priority 1 checkpoints must be satisfied in order for a web site content to be accessible to any significant disability groups.

> [Priority 1] A Web content developer must satisfy this checkpoint. Otherwise, one or more groups will find it impossible to access information in the document. Satisfying this checkpoint is a basic requirement for some groups to be able to use web documents. [1]

5.2.1 g9: Provide alternative text for all images

This Bobby diagnostic verifies implementation of one aspect of WCAG 1.0 Checkpoint 1.1 :

> Provide a text equivalent for every non-text element (e.g., via "alt", "longdesc", or in element content). This includes: images, graphical representations of text (including symbols), image map regions, animations (e.g., animated GIFs), applets and programmatic objects, ascii art, frames, scripts, images used as list bullets, spacers, graphical buttons, sounds (played with or without user interaction), stand-alone audio files, audio tracks of video, and video. [Priority 1] [1, Guideline 1]

This particular Bobby test verifies the provision of alternative content to images.

Graphical elements have to be translated into an alternative representation when accessed by non-graphical browsers/technologies (such as screen-readers, braille displays). In order for the translation to be correct, alternative content should be provided, representing the same information or functionality in a non-graphic environment as the graphical element in a graphic environment. This issue is specifically addressed in web accessibility by the general recommendation of "providing alternative content".

Bobby can check only that *some* alternative text is provided with each image. Verifying that the alternate text provided represents correctly the image it replaces cannot be done automatically, human intervention being required.

In the case of images, HTML provides the attribute `alt` for the element introducing images (`IMG`), that should be used to specify the alternative content to be provided when the environment does not support the display of images. [1]

The `alt` text should be short, representing the same functionality and information as the image itself in as few words as possible.

When a longer text is required in order to provide a correct alternative content to the image (for example a chart), the `longdesc` attribute should be also used in conjunction with the `alt` attribute in the `IMG` element introducing the image. The `longdesc` attribute specifies a separate document containing the extended description of the graphic being replaced. Because `longdesc` is not supported by all browsing technologies today, it is recommended that where a long description is required for an image, a link (D-link) to a web page containing the extended description should also be provided in the vicinity of the picture.

If an image is used as a "logo", and its description is considered an important part of the web site, the `alt` text should describe the image on the main/introductory web page of a web site and it could be empty or very short

[1] Simon Willison, *Writing good ALT text*[2]

on subsequent pages as it becomes redundant information.

Although their use shouldn't be encouraged as text is the basis of a web page, if images of text are used `alt` attribute should contain exactly the text in the image.

Such images of text may be used in solutions for unsolicited emails over the Internet ("spam"). Such examples are the image of an email address, hiding the email address from an spam robot or email account identifications (by identifying characters in an image). In such cases, the provision of an alternative text giving exactly the same information as the image would cancel the anti-spam solution. So these cases might seem to justify the omission of an alternative text. But an alternative text should still be present with helpful hints for users with no graphic support such as "username: johnsmith domain: hotmail dot com" or, respectively, "please contact 0800 800 800 to continue with an alternative identification process" [3].

When an image is used as the content of a link, the `alt` element is going to be part of the link text to be presented in a non-graphical browser. User agents normally inform the user of existence of links in a distinct (audible and/or visual) manner from other text in a web page. Therefore, the `alt` text of an image link wouldn't need to contain a reference to the fact that the image is a link (for example, "Link to the next page") since the user was already informed by the user agent.

For images that carry no information (like "border.gif") the `alt` text should be empty (`alt=""`) so that an non-graphical user agent could ignore it, since the image has no other purpose than visual presentation. There are cases in which images with purely visual information are used in "simulations" of lists, when web authors desire a specific "bullet" image, such as arrows, flowers or different color

[3] http://www.w3.org/TR/2003/WD-turingtest-20031105/

bullets. This behavior should not be encouraged on the web as it contradicts the purpose of HTML as a structural language and the general use of accessible web design stipulating the separation between structure and presentation. If a list is desired to be formatted with an particular "bullet" graphic, than one of the HTML list dedicated elements should be used and the visual representation of "bullets" should be modified using CSS properties such as `list-style-image`, for example:

```
<UL STYLE="list-style-image: url(bullet.gif)">

<LI> List Item  1

<LI> List Item  2

</UL>
```

Images representing redundant information such as an image inside of a textual link could also have an empty `alt` attribute since the relevant information will be provided in the link text. For example: a navigation link ("Next page") represented by an "arrow" image in a graphical user agent would normally be implemented in the following manner.

```
<A href="page_02.html">
  <IMG alt="Next page" src="right_arrow.gif">
  Next page
</A>
```

In this case, the user of a non-graphical browser will be informed of both a "Next page" image (which in this case is not an essential information) and an "Next page" link.

In this case, the IMG element should have the alt attribute empty, case in which the following code:

```
<A href="page_02.html">
  <IMG alt="" src="right_arrow.gif">
  Next page
</A>
```

will generate only an announcement for a "Next page" link in a non-graphical browser, while in a browser supporting images, both the image and the link text are displayed.

5.2.2 g240: Provide alternative text for all image map hot-spots (AREAs)

This Bobby diagnostic again verifies implementation of an aspect of WCAG 1.0 Checkpoint 1.1.

This particular Bobby test verifies the provision of alternative content to active regions of client-side image maps.

An image map is a picture that has portions (areas) associated with actions (usually navigation to other web pages—links). When a user selects such an "active" area, the action associated with that area is executed. For example, considering the administrative map of Ireland (Fig 5.1). When the user selects the portion of the image representing County Dublin, the web page containing information on County Dublin is displayed.

Figure 5.1: **Administrative map of Ireland**

Depending on their implementation, there are two types of image-maps: server-side and client-side image maps. Both maps have a main viewable picture ("the map"). The maps differ through the way they handle the client-server interaction.

For server-side image maps, the user agent (web browser) sends the coordinates of a mouse click to the server and, based on these, the appropriate action is taken. In the case of the Irish administrative map, the server-side image map could be implemented in the following manner:

```
<A href="cgi-bin/irish-counties">

<IMG src="ireland-counties.gif" ISMAP alt="Administrative map of
Ireland with access to county specific administrative
information.">
```

```
</A>
```

When the user "clicks" the image at coordinates x=280,y=200 (County Dublin on the map), the server receives a request of the type http://www.adomain.com/cgi-bin/irish-counties?280,200. The script irish-counties interprets the coordinates given as parameter and takes the appropriate action, in this particular case, sending the web page containing information on County Dublin (county_dublin.html).

Because the server-side image maps are based on the use of the mouse in a graphical environment and they do not provide support for alternative content implementation (like keyboard support), they cannot be made directly accessible to non-mouse and non-graphics environments (user agents). In this case, alternative functionality should be provided, using redundant links.

```
<A href="cgi-bin/irish-counties">

<IMG src="ireland-counties.gif" ISMAP alt="Administrative map of
Ireland with access to county specific administrative information.
Alternative navigation provided next">

</A>

<UL> [...]

<LI> <A href="counties/county_dublin.html">
    County Dublin </A>
```

```
[...] </UL>
```

On the other hand, client-side image maps can be implemented in an accessible manner without extra provisions. For a client-side image map, the main picture is divided in physical areas using the `MAP` and `AREA` HTML elements and each physical area (`AREA` element) has an associated action. In a graphical web browser, when the user "clicks" on an active section of a client-side image map, the web browser determines, based on the selected coordinates in the image, which `AREA` element to consider and its corresponding action (if any) is performed. Not only are client side image maps faster than server side image maps in their interaction with the user but they also have in-built support for alternate content. The HTML `AREA` element can have specified `alt` attributes in the same fashion and with the same purpose as with image links. The client side image maps are also accessible to environments that do not allow the use of mouse, since web browsers provide tab-key navigation within `AREA` elements, in the same manner as links. More than that, `AREA` implements other navigation features such as `tabindex` and `accesskey`. Non-graphical web browsers will display client side image maps as lists of links corresponding to the active areas in the image map.

5.2.3 g10: Provide alternative text for all image-type buttons in forms

This Bobby diagnostic also verifies implementation of an aspect of WCAG 1.0 Checkpoint 1.1.

This particular Bobby test verifies the provision of alternative content to image-type buttons in forms.

Forms consist of a number of input and interaction elements between user and web servers (implemented by `INPUT` HTML elements). If these elements are not implemented with accessibility in mind, they can be un-usable in alternative environments (non-graphical, non-mouse), leaving the user confused as to the purpose of these elements. The two main categories in a form are :

- "button" interaction elements between the user and the application provided by the web server, usually associated with actions, event generators
- "input" elements allowing users to provide information necessary for the application implemented by the web server.

Each "button" (web control element) is represented in a graphic environment either by a control element (usually a rectangular shape) with text ("push button") or with an image ("image buttons"). In non-graphical environments, the "push buttons" are represented by the `value` attribute specified in the corresponding HTML `INPUT` element. "Image buttons", to which this particular Bobby diagnostic refers, are displayed in non-graphical environments by the value of the `alt` attribute specified in the corresponding `INPUT` element. The `alt` attribute in image type buttons introduced by the `INPUT` element has the same purpose as the `alt` attribute of the `IMG` and `AREA` elements previously discussed.

5.2.4 g39: Give each frame a title

This Bobby diagnostic verifies implementation of WCAG 1.0 Checkpoint 12.1 :

> Title each frame to facilitate frame identification and navigation. (Priority 1) [1, Guideline 12]

Frames give rise to a wide variety of problems both for general usability and for accessibility by users with disabilities in particular. The functionality provided by frames can be achieved with alternative HTML technologies, properly engineered and with good browser support and accessibility, therefore frames should be avoided wherever possible.

As long as frames are still in use, then it is essential that the special accessibility issues which they raise are adequately addressed [61]:

- documents introduced by frames do not have designated URLs, but they are all displayed within a frameset addressed by an unique URL. This makes it impossible for a user to keep track of his location within a web sites (for example through bookmarks) which makes the navigation of such web site rather complex and difficult.

- frames are not supported in their intended form by all the web browsing technologies (especially by non-graphical web browsers) although most of the contemporary user agents provide an way of accessing the documents within a frameset. In order to provide alternate content, a `NOFRAMES` element should be used but it usually requires a substantial extra effort in implementation. Because of this it is a common practice on the web for the `NOFRAMES` element to contain just a warning that the web content is implemented using frames but because the specific web browsing technology used doesn't provide frame support, the user cannot access the web content.

The particular diagnostic discussed here addresses the need for each HTML frame element to have an associated, textual, `title` attribute, which will be displayed in browsers with no frames support. This serves to provide critical orientating information about the frame organization for users who cannot directly perceive the visual layout or configuration of frames.

In a graphical browser frames are displayed in one single web page ("frameset"), in such a manner that it is transparent to the user the fact that the web page is in reality a collection of web pages ("frames") displayed together in a manner defined by FRAMESET and FRAME HTML elements. Because non-graphical web browsers can handle only one web page at a time, framesets are handled as a collection of web pages and the user is presented with a set of links to the web pages in the construction of the frameset. Depending on the (non-graphical) web browser, each web page in the frameset is represented by the text provided in either the title or name attributes of the FRAME element introducing the web page, or the TITLE element of the respective web page. Most non-graphical browsers will try and use the information in one of these fields when handling frames.

Considering this behavior, it is crucial that a *meaningful* title (value of title and name attributes and TITLE element) is given to each web page (frame), representing as clearly as possible the web page's content in the list of links. This way the user is presented with a choice to view web content he is interested in. If no meaningful titles are provided, the user is left to "guess" the web content he wishes to access, no information of the web content being provided.

5.2.5 g38: Each FRAME must reference an HTML file

This Bobby diagnostic verifies implementation of WCAG 1.0 Checkpoint 6.2:

> Ensure that equivalents for dynamic content are updated when the dynamic content changes. (Priority 1) [1, Guideline 6]

When frames are pointing directly to data types that need special implementation in order to be accessible (such as images), an alternate content cannot be provided. The web content should, instead, be embedded in an HTML file so that appropriate alternate content can be included too.

5.2.6 g21: Provide alternative text for each APPLET

This Bobby diagnostic also verifies implementation of an aspect of WCAG 1.0 Checkpoint 1.1.

A Java applet is a small Java program designed to run on the web client computer, and it can be used to add dynamic content to a web page ranging from pure visual effects (e.g. text highlights) to user interfaces (e.g. forms).

This particular Bobby test raises the issue of applets being not accessible to user agents that do not provide Java support. Applets can be made accessible to technologies implementing Java support as long as they are implemented with accessibility in mind (i.e., keyboard support, label controls in forms). Still, the functionality provided by applets has to be available to user agents that do not provide support for Java (e.g. Lynx) or to users that have disabled the Java support in their web browser for security reasons.

As with graphics, the general accessibility issue of applets is the need of providing the same functionality and information independent of the (specification compliant) user agent. Java applets are introduced by the `APPLET` HTML element which provided the `alt` attribute with similar purpose and function as the `alt` attribute of the `IMG` element: provision of alternative content for user agents not implementing Java.

The incidence of sites that triggered this diagnostic is not that high, although this may mainly reflect the raw incidence of applet use on the web (as opposed to the relative proportion of sites using applets which specifically violate applet related accessibility guidelines). In any case, it should be kept in mind that even one applet wrongly implemented can create serious accessibility problems for the whole site since it might obstruct the navigation from the home page or hide key information from a user whose browser can't handle Java code.

Starting with HTML 4.0, the `APPLET` HTML element is deprecated; its function is provided by the `OBJECT` element.

5.2.7 g20: Provide alternative text for each OBJECT

This Bobby diagnostic verifies implementation of another aspect of WCAG 1.0 Checkpoint 1.1.

The `OBJECT` element was introduced in HTML 4.0, replacing the `APPLET` element and targeted to more data types than just Java applets.

> To render data types [they] don't support natively, user agents generally run external applications. The OBJECT element allows authors to control whether data should be rendered externally or by some program, specified by the author, that renders the data within the user agent. [20, Section 13.3]

The `OBJECT` element is designed in such way that alternate content can be specified using other embedded `OBJECT` elements.

> If a user agent cannot render the outermost OBJECT, it tries to render the content, which may be another OBJECT element. [20, Section13.3.1]

Considering this, the *innermost* `OBJECT` element should be accessible HTML web content, in order to ensure the `OBJECT` is accessible to any web browsing technology.

Even one such object wrongly implemented can create serious accessibility problems for the whole site since it might obstruct the navigation from the home page or hide key information from a user whose browser can't handle the data type introduced by the `OBJECT` element.

5.3 Bobby Priority 2 diagnostics

If a web site satisfies not only all the WCAG 1.0 Priority 1 checkpoints but also the WCAG 1.0 Priority 2 checkpoints, its content should be accessible to a broad range of disability groups. The web site can claim WCAG Double-A level conformance.

> [Priority 2] A web content developer should satisfy this checkpoint. Otherwise, one or more groups will find it difficult to access information in the document. Satisfying this checkpoint will remove significant barriers to accessing web documents. [1]

5.3.1 g104: Use relative sizing and positioning (percent values) rather than absolute (pixels)

This Bobby diagnostic verifies implementation of WCAG 1.0 Checkpoint 3.4 :

> Use relative rather than absolute units in markup language attribute values and style sheet property values. (Priority 2) [1, Guideline 3]

The visual position and size of various elements can be specified in *HTML*—for example, font size for text, widths of tables, or individual table cells, etc. In general, HTML allows such positions and sizes to be specified in either "relative" units (which are scaled according to user's browser settings) or "absolute" units (not scalable). The effect of using relative units is that the browser can very flexibly adjust the visual presentation according to the available visual space on the user's device, and the user's preferences and capabilities.

This is a defect that can be easily corrected with a significant potential for the large category of intermediate visually impaired users. The users with intermediate visual disability are not blind, but require some facilitation, particularly the use of larger font sizes. This is already a large category of disability; furthermore, as its incidence is significantly age-related, and the relative population of seniors is growing, its importance is, if anything, increasing [37].

This defect type also illustrates the general concept of universal design—designing to include the widest possible variety of users. In the current case, by designing a site that uses only relative positioning and sizes, it can automatically adapt to changing user technologies and needs—such as the growing use of Internet enabled TVs, Personal Digital Assistants (PDAs), etc., which have a much wider variety of visual display capabilities than standard computer terminals.

5.3.2 g271: Use a public text identifier in a DOCTYPE statement

This Bobby diagnostic verifies implementation of WCAG 1.0 Checkpoint 3.2:

> Create documents that *validate* to published formal grammars. (Priority 2) [1, Guideline 3]

Properly formatted HTML pages should conform to a set of strict technical specifications, to ensure compatibility between web sites and web browsers [62]. This is true as a general principle, but is especially crucial to ensuring compatibility with the wide variety of special purpose web browsers and assistive technologies that are necessary to address the diverse needs of users with disabilities.

In order for a web browser to render a HTML page's functionality and structure as intended by the author, it will need to know how the document is constructed, according to which technical specification. A "Document Type Definition" (DTD) specifies the elements (and their attributes) that can be used according to a particular technical specification, and what is their intended purpose and structure. The particular DTD according to which a web page is constructed is specified using the DOCTYPE construction. When this information is mis-constructed or missing, the web browser is challenged to properly render an unknown mark-up structure.

In most of the cases the assistive technology is an interface between a user with disability and the technology a user with no disability would use to browse the web. So the behavior of such assistive technology will depend on the output given by a conventional web browser. And if the conventional web browser is challenged in rendering a web content, the challenge will pass on to the assistive technology. In the end, the behavior is unpredictable and may be unusable.

Bobby gives an indication of the incidence of sites that do not have *any* DOCTYPE information specified; however, if DOCTYPE information *is* specified, Bobby cannot check whether it is properly constructed. Additional analysis is required to determine this, as outlined in Section 4.5.

5.3.3 g265: Do not use the same link phrase more than once when the links point to different URLs

This Bobby diagnostic verifies implementation of WCAG 1.0 Checkpoint 13.1 :

> Clearly identify the target of each link. (Priority 2) [1, Guideline 13]

A "link phrase" is the (usually short) fragment of text in a web page that is hypertext linked to another web resource. For users of visual browsers link phrases are normally visually highlighted in some way (perhaps by color, underlining, etc.); and "clicking" within the link phrase causes the browser to load the linked resource. Such users can generally scan web pages visually very quickly to pick out link phrases; and can easily read the surrounding text if they need more context to understand a particular link phrase.

For users of non-visual browsers (say using screen readers, or braille output devices) "scanning" a web page is generally a slower and more complex process. One common technique to help scanning in such cases is to simply skip from link to link; in this circumstance, only the link phrases are directly rendered to the user, and access to surrounding text (for additional context) will be relatively slow (i.e., it will undermine the very utility of this form of scanning).

This being the case, access for such users can be significantly improved if a little care is taken in the selection of link phrases; poor selection of link phrases can create a significant, and generally quite unnecessary, obstacle to users. More than that, if the same link phrase is used multiple times, in the same page, but linking to different resources, this will not be apparent to a user who is scanning only such link phrases.

The WCAG 1.0 HTML techniques explicitly allows link phrases to be the same *if* they are associated with different (meaningful) `title` attributes[4]. However, Bobby does not seem to consider this situation. Once two identical link phrases with two different target URLs are detected, Bobby raises g625, independently of the value of `title` attributes[5], [6]. For example, "`[D]`" links, although correctly implemented and WCAG 1.0 compliant, will fail this Bobby test. Considering these ambiguities, the results regarding the g265 diagnostic were not considered in the analysis conducted as part of this project, although the frequency of this diagnostic was high (overall, 73% of the web sites considered for WCAG 1.0 conformance analysis failed this diagnostic at least once).

[4]http://www.w3.org/TR/WCAG10-HTML-TECHS/#link-text

[5]http://lists.w3.org/Archives/Public/w3c-wai-ig/2004JanMar/0147.html

[6]http://lists.w3.org/Archives/Public/wai-xtech/2001Jan/0001

5.3.4 g269: Make sure event handlers do not require use of a mouse

This Bobby diagnostic verifies implementation of WCAG 1.0 Checkpoint 9.3:

> For scripts, specify logical event handlers rather than device-dependent event handlers. (Priority 2) [1, Guideline 9]

Various HTML coding techniques (commonly using client side scripting) rely on certain kinds of interaction with the user. However, depending on their individual capabilities and preferences, users may adopt a wide variety of interaction devices. In particular, the use of a conventional mouse, or even of some adapted form of screen-pointing device, may be difficult or impossible for some users. Thus, if a page is coded in such a way that certain functionality or features can be accessed only by using a particular form of interface device—such as a mouse in the current case—then that functionality will be unavailable to users with certain disabilities; worse still, such users may not even be aware that such functionalities exist.

5.3.5 g41: Explicitly associate form controls and their labels with the LABEL element

This Bobby diagnostic verifies implementation of WCAG 1.0 Checkpoint 12.4 :

> Associate labels explicitly with their controls. (Priority 2) [1, Guideline 12]

In the visual presentation of a web page there can often be important relationships between different components of the page which are expressed only implicitly by their juxtaposition in the display. A common example arises in the case of

HTML based forms. A form generally consists of information explaining to the user what has to be filled in, interspersed with "form controls"—text entry boxes, radio buttons, drop down lists, etc.—which the user can interact with. Typically, the relative positions in the visual display make it reasonably easy for a visual user to identify which text is associated with which control.

However: for users who are unable to use a visual display in the manner assumed by the site designer (due to blindness, visual impairment, etc.) it will generally not be possible to directly perceive these implicit, but critical, relationships. To address this, HTML provides facilities whereby a particular form control can be explicitly marked as associated with a particular text (the corresponding "label"). This coding (`LABEL`) can then be used by a suitably configured browser to help a user with a disability to recognize the correct relationships. Furthermore, coding these explicit relationships can improve general form usability; for example, the browser can associate clicks on a label as intending to activate a form control, thus providing a larger target for selection with a pointer. This may be particularly helpful to users with motor impairment which limits fine pointer manipulation, but will generally be of benefit to all users. Thus, this again illustrates the applicability of universal design.

5.3.6 g34: Create link phrases that make sense when read out of context

This Bobby diagnostic verifies implementation of WCAG 1.0 Checkpoint 13.1 :

> Clearly identify the target of each link. (Priority 2) [1, Guideline 13]

When link phrases like "click here" or "more" are used, no information regarding the document referenced is provided to users of non-visual browsers, who, in some cases can "scan" through a list of links contained in a document. ("click here to do what?").

5.3.7 g2: Nest headings properly

This Bobby diagnostic verifies implementation of WCAG 1.0 Checkpoint 3.5:

> Use header elements to convey document structure and use them according to specification. (Priority 2) [1, Guideline 3]

One of the core principles in designing accessible web content is *separating structure from presentation*—in order to facilitate, as much as possible, adaptation of presentation to suit the particular needs and capabilities of individual users. That means that the HTML elements should be used always and only for their intended structural purpose, and not for assumed presentational effects.

Users of assistive technologies often use headings as a mean of navigation within a single web page, since scanning the whole page content can be really difficult and especially time consuming (for example when using a non-visual browser). Thus, it is important not only that HTML heading elements are used (and not implied, for example via font effects), but also that they are nested properly, in order to make explicit the structure of the page content.

5.3.8 g273: Include a document TITLE

This Bobby diagnostic verifies implementation of WCAG 1.0 Checkpoint 13.2 :

> Provide metadata to add semantic information to pages and sites. (Priority 2) [1, Guideline 13]

The TITLE element should provide a brief summary or indication of the page content. This information is usually displayed in the title bar of the window rendering the web content, or otherwise made available on user request. It is also used in creating bookmarks. In general it provides important orientation information, which is useful to all users (universal design) but particularly useful to users with a variety of disabilities.

5.3.9 g37: Provide a NOFRAMES section when using FRAMES

This Bobby diagnostic verifies implementation of WCAG 1.0 Checkpoint 6.5:

> Ensure that dynamic content is accessible or provide an alternative presentation or page. (Priority 2) [1, Guideline 6]

The `NOFRAMES` HTML element introduces alternate content for frames, content to be rendered when the web browser does not have support for frames. As in case of the alternate content for graphical elements, the alternate content should provide the same functionality and information as the ones provided through frame implementation. (See previous discussion on diagnostic g39 5.2.4).

5.3.10 g5: Avoid scrolling text created with the MARQUEE element

This Bobby diagnostic verifies implementation of WCAG 1.0 Checkpoint 7.3:

> Until user agents allow users to freeze moving content, avoid movement in pages. (Priority 2) [1, Guideline 7]

One issue raised by the MARQUEE element is that the element is not recognized by any HTML technical specifications, so web content using this element will fail WCAG 1.0 Checkpoint 3.2 : "Create documents that validate to published formal grammars.". The importance of using technical conformant web content is outlined in Section 5.4.

Another notable issue is that the scrolling text effect created with MARQUEE can cause problem for people with different disabilities:

- There are screen readers that can't handle scrolling text
- People with cognitive disabilities can't comprehend the text at the speed of the scrolling or the motion is distracting them from the actual text.

5.3.11 g4: Avoid blinking text created with the BLINK element

This Bobby diagnostic verifies implementation of WCAG 1.0 Checkpoint 7.2:

> Until user agents allow users to control blinking, avoid causing content to blink (i.e., change presentation at a regular rate, such as turning on and off). (Priority 2) [1, Guideline 7]

Again, as in the case of Bobby diagnostic g5 previously analyzed, one issue raised by the BLINK element is that the element is not recognized by any HTML technical specifications.

Another notable issue is that the blinking text effect created with BLINK can cause problems for people with disabilities such as:

- mal-functions with screen readers—which can get stuck and repeat the same text on and on
- people with dyslexia can be affected by blinking text

- people with low vision can have problems reading the text
- people with cognitive disabilities can get distracted from the actual text by the blinking effect

5.3.12 g254: Do not cause a page to redirect to a new URL

This Bobby diagnostic verifies implementation of WCAG 1.0 Checkpoint 7.5:

> Until user agents provide the ability to stop auto-redirect, do not use markup to redirect pages automatically. Instead, configure the server to perform redirects. (Priority 2) [1, Guideline 7]

When the server is configured to handle a page redirection, the process is transparent to the user and causes no problems. But when the redirection is implemented on the client side (using mark-up), it can disorient the user, especially users of screen readers or screen magnifiers.

5.3.13 g33: Do not cause a page to refresh automatically

This Bobby diagnostic verifies implementation of WCAG 1.0 Checkpoint 7.4:

> Until user agents provide the ability to stop the refresh, do not create periodically auto-refreshing pages. (Priority 2) [1, Guideline 7]

Content developers sometimes create pages that automatically refresh (change) periodically their content. The user should be allowed to decide the time he wants to spend browsing the content of a page. If the content is automatically refreshed to soon, the user might not have read/understand the content yet and in some cases he can get confused, not knowing that the content has changed.

5.4 OpenSP diagnostics

The technologies used in rendering web content for people with disabilities are designed to recognize mark-up elements, interpret their functionality and deliver the web content in a form that will keep the structure and the functionality of the web content. Therefore, a major step in reducing the accessibility problems is insuring that the mark-up is correctly built, according to its specifications. This consideration is expressed in WCAG 1.0 Checkpoint 3.2:

> Create documents that validate to published formal grammars. (Priority 2) [1, Guideline 3]

For reasons previously mentioned, the study considered for analysis only the most common OpenSP diagnostics, by their frequency in the investigations conducted in this study, as detailed later.

The HTML technical conformance investigation process can generate reliable results only when the document specification against which the document was created is known–specified using a `DOCTYPE` construction. Considering this particularity, 11 OpenSP diagnostics where analyzed in investigations: the lack or misconstruction of a document type information and 10 most common HTML diagnostics as identified in all the web pages with correct document type information in the investigations. (See Table 5.1)

Table 5.1: **OpenSP diagnostics considered in HTML defects analysis**

OpenSP diagnostic ID	**Description**
	Missing or unusable DOCTYPE declaration
108	Undefined attribute
64	Element not allowed by the document type
127	Required attribute not specified
79	End tag for element not opened
68	Missing required end tag
139	Non SGML character number
25	General entity not defined and no default entity
131	Attribute value not allowed
73	End tag for element not finished
82	Attribute value must be literal

Due to the specific hierarchical structure of HTML documents, defects in mark-up will usually influence the validation process of elements within the element with incorrect mark-up. In the end, the diagnostics triggered by OpenSP during a validation process are closely inter-related, such that if one defect is repaired and the validation process repeated, the validations results can be significantly different.

5.4.1 Missing or unusable DOCTYPE declaration

A correctly specified document type declaration is obviously crucial in the validation process of a web page. But more importantly than this, when the document type information is correctly specified in an HTML document, the web browser knows how the document is constructed and its content and functionality can therefore be rendered consistently and as intended. An HTML document without a usable DTD is a challenge to web browsers to behave consistently or reliably because the mark-up structure is unpredictable.

More than that, starting with Internet Explorer 5.0 on Macintosh (released in March 2000) there is now a trend for the mainstream browsers to more strictly implement standards-conformant behavior. This means that the way that the web content is rendered by the browser depends on the precise document type which is declared (using a *correctly structured* `DOCTYPE` declaration). For backwards compatibility a feature called "`DOCTYPE` switching" is sometimes implemented. In this case, even when a *correctly structured* `DOCTYPE` declaration is present in the web page, the content may be rendered either according to the HTML specification specified—"standards mode"—or in a backwards compatibility way—"quirks mode"—in which the behavior is unpredictable for an arbitrary browser and/or operating system. More than that, the "`DOCTYPE` switch" feature is not guaranteed to be kept for long. It seems likely that future browser implementations will progressively drop it in favor of the "standards mode" only rendering behavior.

5.4.2 Undefined attribute (OpenSP diagnostic ID 108)

In HTML each element can be described by specific attributes specified in the element's DTD declaration. The "undefined attribute" diagnostic is triggered when, during the validation, an element appears as being described by an attribute that is not specified in the element's DTD declaration. This diagnostic can be triggered in the following cases:

- The attribute is *completely* undefined/unknown—it is not valid for any element in any identifiable HTML version. Typically this might arise from a simple mistyping of the attribute name in a manually authored page.
- The attribute is valid for use with *some* elements (in the specified DTD), but is not valid for use with the particular element where it has been detected in the target document. For example the `lang` attribute can be used in HTML 4 with all elements but `APPLET`, `BASE`, `BASEFONT`, `BR`, `FRAME`, `FRAMESET`, `IFRAME`, `PARAM`, `SCRIPT`
- The attribute is valid for the particular element in *some* HTML DTD(s), but is not valid for the particular DTD specified in the target document. For example the `target` attribute can be used for the `A` element in HTML 4 Transitional but not in HTML 4 Strict.
- The attribute is used with an *element that is itself not defined* (per the specified DTD). This is then a propagated defect arising from the fact that the element is undefined.

5.4.3 Element not allowed by the document type (OpenSP diagnostic ID 64)

An element is used in the HTML document within another element, but this should not contain it according to the DTD. These defects are usually due to a misconstruction of nested elements, for example a list item element (`LI`) used directly within a paragraph element (P) when it should only be used directly within a list element (OL or UL).

5.4.4 Required attribute not specified (OpenSP diagnostic ID 127)

This signals that the DTD declares that a certain attribute is required on some element, but it is not present (for example the alt attribute for the IMG and AREA elements. Some specific features addressing web accessibility for users with disability are implemented with the help of compulsory attributes, providing details on the content of an element when the element can't be rendered effectively or directly for any particular user. Thus, this defect is particularly likely to be directly correlated with accessibility problems.

5.4.5 End tag for element not opened (OpenSP diagnostic ID 79)

The content of an HTML element is delimited by a "start tag" (<H1>) and an "end tag" (</H1>)and the way that the elements can nest is described in the DTD. If OpenSP encounters improperly nested elements, it considers that the outer element is implicitly closed before the start tag of the inner element and it triggers a "missing end tag" diagnostic if the end tag is required in the structure of the outer element. Later on in the content of the document, if the original end tag of the outer element is encountered, OpenSP considers it as belonging to no opened element.

5.4.6 Missing required end tag (OpenSP diagnostic ID 68)

This diagnostic is triggered when the DTD declaration specifies that the end tag is required for a particular element, but it is missing from the HTML code in the web page content. Some situations in which this diagnostic can be triggered are:

- XHTML: Both the start tag and the end tag are required for XHTML (as opposed to HTML) elements, including "empty" elements such as `HR`.
- In the case of *improperly nested elements*, OpenSP considers that the outer element is implicitly closed before the start tag of the inner element and it triggers a "Missing end tag" diagnostic if the end tag is required in the structure of the outer element. Later on in the content of the document, if the original end tag of the outer element is encountered, OpenSP considers it as belonging to no opened element and triggers an "End tag for element not opened" diagnostic.

5.4.7 Non SGML character number (OpenSP diagnostic ID 139)

In general, authoring tools may encode HTML documents in the character encoding of their choice, providing the encoding is correctly labelled. The information about the character encoding of a document can be specified via HTTP headers and/or using an embedded `META http-equiv` element. However, due to the implementation characteristics of the system used in this survey, character encodings specified via HTTP headers are not available to the OpenSP processor after the mirroring process discussed above (Section 4.3).

This diagnostic appears to be commonly triggered when the authoring tool which generated the web page uses a character encoding of its own choice but the information regarding the character encoding is not made available in the HTML content. As a result, in order to validate the document, OpenSP will have to use heuristics to determine the character encoding. Although this practice is standards conforming [21, Section 5.2.2], its results are unpredictable.

From the point of view of practical browsing, if the character encoding is not reliably communicated then the rendering of specific characters will be unpredictable, and may be incorrect. This would potentially slow down and confuse comprehension. This can impact all users, but may have a disproportionate effect on particular disability groups. For maximum accessibility it is recommended that an open standard character encoding be used (such as ASCII, UTF-8, ISO-Latin-9 etc.) and that this should be explicitly declared via both HTTP headers and an embedded `META http-equiv` element.

5.4.8 General entity not defined and no default entity (OpenSP diagnostic ID 25)

A given character encoding (method of converting a sequence of bytes into a sequence of characters) may not be able to express all characters of the document character set (a set of abstract characters used in a document and their integer references) [21, Section 5]. For such encodings, or when hardware or software configurations do not allow users to input some document characters directly, authors may use SGML *character references*.

The `&` (ampersand) character is a special character in SGML, marking the start of a character reference. When the `&` is used as such in an HTML document as part of a text (e.g., “Smith&Sons”) OpenSP will look in the document character set for the abstract character represented by the “&Sons” character reference and, of course, it won’t find it so it will trigger the above diagnostic. This should be avoided by “escaping” literal use of the `&` character—that is, by using the character reference `&` everywhere in the HTML document where the `&` character is not intended as the start of a character reference.

The issue of `&` character used as such instead of its character reference `&` arises especially in URLs. When web content is generated dynamically (using a server-side application), the arguments based on which the web page is determined may be embedded in URLs, separated from each other with `&` characters. Links to such URLs should escape the `&` character as discussed before.[7]

5.4.9 Attribute value not allowed (OpenSP diagnostic ID 131)

This diagnostic is triggered usually when the value of an attribute is not one of the values permitted for that attribute in the specified DTD.

5.4.10 End tag for element not finished (OpenSP diagnostic ID 73)

This diagnostic is triggered when an end tag is found for an element, when one or more of its inner elements are still open. In most cases this appears to be an error propagated from other HTML defects already detected by OpenSP, as discussed previously.

5.4.11 Attribute value must be literal (OpenSP diagnostic ID 82)

By default, SGML requires that all attribute values be delimited using either double quotation marks (ASCII decimal 34) or single quotation marks (ASCII decimal 39). Still, some "relaxed" standards allow attribute values not delimited by quotation marks, provided that they follow some rules [20, Section 3.2.2].

[7] http://www.htmlhelp.org/tools/validator/problems.html#amp

This diagnostic is triggered when the value of an attribute is not included between "double quotation marks" although it should be because the specific use wouldn't qualify for the exception rules (e.g. : `<table width=90%>` instead of `<table width="90%">`).

5.5 Chapter Overview

The present chapter discussed the impact on web accessibility of the subset of Bobby (WCAG 1.0 conformance investigation) and OpenSP (HTML technical conformance) tests/diagnostics considered in investigations.

The following chapter (Chapter 6) presents the frequency with which these tests were failed in the four web samples considered in the most recent survey.

Chapter 6

Analysis of web accessibility evaluation results of Irish, UK, French and German web samples – December 2004

6.1 Chapter Overview

In order to evaluate the practical results of the efforts invested in promoting web accessibility in four EU jurisdictions, WCAG 1.0 and HTML technical conformance investigations were carried out between May 2003 and December 2004 on samples of Irish, UK, French and German web sites, as detailed in Section 4.2.

The present chapter presents and analyses the latest (more recent) findings of the December 2004 evaluation of the four web samples, structured in three main sections, based on the three stages of the evaluation process:

- Web content sampling process.

As mentioned in Section 4.3, a web site was considered for WCAG and HTML technical conformance investigation if and only if the web content sampled during the mirroring process for that web site had at least three web pages and 100 KB of data correctly retrieved. Therefore, the "quality" of a web sample in the context of a survey is given by the percentage of web sites in the web sample considered for WCAG and HTML technical conformance investigation. The higher the percentage of web sites considered for investigations in a web sample, the higher the accuracy with which the pervasive WCAG and HTML technical specifications failures can be determined. Web sites failing to qualify for WCAG and HTML technical conformance investigation for other reasons than too little web content in the domain investigated (for example directories or web sites "under construction") can also be an indication of poor accessibility level since the first step in providing an *accessible web content* is providing *access to web content*.

- WCAG conformance investigation of the web sites qualified for investigations.

  As previously outlined (Section 4.4), Bobby executions can fail unpredictably due to technical limitations. Considering these, the analysis of WCAG conformance investigation results is based only on those web sites in a web sample for which Bobby completed successfully. Due to the automated nature of the surveying system, only those Bobby tests that can fully verify aspects of WCAG checkpoints without manual intervention were considered in the WCAG conformance investigation. When determining the incidence of WCAG failures detected by Bobby in the web content investigated, it was considered that if one Bobby test failure (diagnostic) is triggered in at least one web page of a web site's sampled content, the web site is counted in statistics for the incidence of the particular test failure (Bobby diagnostic).

- HTML standards conformance investigation of the web sites qualified for investigations.

  As detailed in Section 4.5, the web content considered in the analysis of HTML defects detected by OpenSP was subject to further selection/sampling. In the absence of usable document type information, the HTML mark-up validation results are not reliable and therefore they couldn't be considered in an analysis of HTML mark-up defects. Thus, the web pages without usable document type information were removed from the sample to be considered for analysis of HTML mark-up defects. In order to ensure that the results generated by the validation of the sampled web content of a web site are representative for the web sample (set of web sites) considered, each site was required to have at least 3 pages with usable document type information, comprising at least 100 KB of data, in order to qualify for analysis of HTML mark-up defects analysis. When determining the most pervasive HTML mark-up defects (detected by OpenSP, hence "OpenSP diagnostics") it was considered that if one OpenSP diagnostic is triggered in at least one web page of a web site's content considered for HTML defects analysis, the web site is counted in statistics for the incidence of the particular OpenSP diagnostic.

Overall, the results show that the level of web accessibility guidelines and HTML standards conformance is very poor in all the four web samples, leading to the conclusion that the poor web accessibility level is a general issue and not characteristic of only some jurisdictions.

Another particular conclusion of the study shows that, not only are the web accessibility levels similarly poor in the web samples investigated, but the failures in web accessibility guidelines conformance and HTML standards are strikingly similar in all the surveys carried out. The surveys discovered similar web accessibility problems in the web content investigated, namely the same Bobby and OpenSP tests failed (diagnostics).

6.2 Analysis of web content mirroring process results

Key results: For 38.2% of the web sites considered in the four web samples sufficient content was retrieved to qualify for WCAG and HTML standards conformance investigation.

The mirroring process was implemented with the purpose of extracting web content to be evaluated for the web accessibility level of web samples in the four jurisdictions. Therefore, the success of this stage in the study was measured based on the percentage of web sites considered for conformance investigations of the total number of web sites considered in the web content mirroring process.

A web site was considered for WCAG and HTML specification conformance investigation if and only if the web content sampled during the mirroring process for that web site had at least three web pages and 100 KB of data correctly retrieved (Section 4.3).

Table 6.1 presents details regarding the web content mirroring process. The results generated by the web content sampling process are remarkably similar across the four web samples, especially considering the large difference in the number of sites in each sample.

Table 6.2 presents details regarding the web sites that didn't qualify for WCAG and HTML specification conformance investigation in the four web samples.

Table 6.1: **Results of the web content sampling process**

	IE	UK	FR	DE	Overall
Total number of web sites in sample	272	5,702	1,545	4,250	11,769
Data amount retrieved	24 MB	499 MB	145 MB	371 MB	1 GB
Web pages considered for mirroring	2,542	57,022	17,056	55,037	131,657
Web pages correctly retrieved (size>0 and no retrieval errors)	2,223 (87.5%)	48,726 (85.5%)	14,364 (84.2%)	47,806 (86.9%)	113,119(85.9%)
Web pages in web sites qualified for conformance investigations	1,769 (69.6%)	38,132 (66.9%)	11,644 (68.3%)	35,749 (65%)	87,294 (66.3%)
Web sites qualified for conformance investigations	100 (36.8%)	2,142 (37.6%)	640 (41.4%)	1,609 (37.9%)	4,491 (38.2%)

The two most common reasons for failure in the web content sampling process were the failure to retrieve more than one web page from a web site and the failure to retrieve more than 100 KB from a web site, accounting for 78.8% of the failures across the four web samples.

The current configuration of the automatic surveying system does not provide more details on the reasons for which Pavuk failed to retrieve at least three web pages and 100 KB from each web site considered. However, a (manual) investigation of a small selection of such retrieval failures suggest that the reasons include:

- Web sites with small amount of data in the given domain name (might have

Table 6.2: **Details regarding the web sites that didn't qualify for investigations**

	IE		UK		FR		DE		Overall	
Web sites not qualified for investigations	172		3,560		905		2,641		7,278	
No data retrieved	24	(14%)	668	(18.8%)	270	(29.8%)	275	(10.4%)	1,237	(17%)
Only the main page retrieved (size>0)	110	(64%)	1,815	(51%)	362	(40%)	1,277	(48.4%)	3,564	(49%)
Less than 3 pages (2) and at least 100 KB retrieved	0	(0%)	4	(0.1%)	0	(0%)	3	(0.1%)	7	(0.1%)
Less than 100 KB and at least 3 pages retrieved	31	(18%)	926	(26%)	236	(26.1%)	976	(37%)	2,169	(29.8%)
Less than 3 pages (2) and less that 100 KB (but more than 0) retrieved	7	(4.1%)	147	(4.1%)	37	(4.1%)	110	(4.2%)	301	(4.1%)

references—links—outside the given domain name).

- Server not found. As web sites were collected from the ODP and not from the "live" web space, it may be possible that web sites in the ODP are no longer available. Within the ODP, a proprietary link checker (*Robozilla*[1]) is used regularly to verify that URLs in ODP content are pointing to valid web sites. When a broken link is detected it is assigned a "red flag" and an ODP editor will investigate the URL and decide what actions will be taken.

[1] http://dmoz.yklaw.net/DDP/Interface_and_Features/Robozilla/

However, due to the large size of the ODP content such operations take a considerable amount of time and it is practically impossible that at any time the ODP content is up to date (without any broken links). The flag set on the broken links is visible only to ODP editors, therefore such links could not be automatically removed in the web sampling process as part of the survey presented in this thesis.

- Redirections outside the given domain name. Automatic redirections are mainly implemented in two ways: on the server-side or on the client-side.

  Server-side redirections are implemented using HTTP and they don't present an accessibility issue as they are handled transparently to the user. When a web server receives a request for a URL for which a redirection is configured, it returns to the user agent an HTTP redirection code indicating that the user agent should retrieve the desired web content from another location, specified in the HTTP header.

  Client-side redirections are implemented using scripting or the `META` element and they can cause difficulties on the user side. Automatic redirections, not transparent to users, may leave users of assistive technologies confused as to their location on a web site and can cause mal-functions in assistive technologies. Client-side redirections cannot be guaranteed to function as intended in any browsing environment, which fails recommendations of web accessibility guidelines and usability guidelines in accordance with the "design for all" principle. Standards and recommendations ([21, Section 7.4.4], [1, Checkpoint 7.5]) strongly recommend avoiding client-side redirection in favor of server-side redirections.

Overall, the main reason for failure was "not enough data in the given domain name", due to domain name changes (often implemented by client side redirections on the home page – hence "only one web page retrieved"), small amount of data on web sites (in the given domain name) or sites ceasing operation completely.

A significant variation can be noted between the percentage of web sites for which Pavuk failed to retrieve any data across the four web samples. The percentage of web sites in the French web sample to fail the web sampling process was almost three times higher than in the German web sample. In the current configuration of the surveying system, the reasons for this difference between the two web samples cannot be clearly determined.

An in-depth and exact examination of practical failure causes and their frequencies in the web samples investigated would have been resource consuming, due to the large number of web sites needed to be analyzed. Although it is recognized that these failures can present accessibility issues, it was preferred not to concentrate the analysis on this stage, but on the actual WCAG and HTML technical specifications failures in the web sites qualified for investigations. However, provided the necessary resources are in place, such analysis could be investigated further as it could reveal explanations such as reasons for the variations in results between the four web samples.

6.3 Analysis of WCAG 1.0 conformance investigation results

6.3.1 Key results

- Overall, 92.4% of the web sites analyzed failed Bobby at minimal accessibility level (WCAG-A)
    - 98.5% of the French web sites

- 93.1% of the German web sites
- 92.7% of the Irish web sites
- 90.1% of the UK web sites

- Almost all the web sites analyzed (more than 99.8% overall) failed Bobby at professional accessibility level (WCAG Double-A)
- All the web sites considered in the four web samples failed Bobby at maximum accessibility level (WCAG Triple-A)

6.3.2 Bobby completion data

The analysis of the WCAG conformance investigation results in the four investigations was based only on the results generated by web sites where Bobby completed successfully (Section 4.4). For most of the web sites considered (89.7% overall) Bobby completed the investigation successfully. Table 6.3 shows this in more detail.

Table 6.3: **Details regarding Bobby executions**

	IE		**UK**		**FR**		**DE**		**Overall**	
Web sites considered by Bobby	100		2,142		640		1,609		4,491	
Bobby abnormally terminated	1	(1%)	101	(4.7%)	40	(6.3%)	94	(5.8%)	236	(5.3%)
Bobby "locked up"	3	(3%)	113	(5.3%)	52	(8.1%)	60	(3.7%)	228	(5.1%)
Bobby completed successfully	96	(96%)	1,928	(90%)	548	(85.6%	1,455	(90.4%)	4,027	(89.7%)

6.3.3 Bobby Priority 1 diagnostics

Table 6.4 presents the incidence of Bobby Priority 1 full support diagnostics encountered in the web sites for which Bobby completed successfully, ordered descending by the diagnostics's overall incidence in the four web samples. These diagnostics and their importance regarding web accessibility are discussed in detail in Section 5.2. It was considered that in order for a web site to be counted for a Bobby diagnostic incidence, the diagnostics should be triggered at least once in the validation of the web site's sampled content.

Web sites in the UK, French and German web samples failed all the seven WCAG Priority 1 tests fully implemented by Bobby. Web sites in the Irish web sample failed six of these tests, the most frequent ones. The Bobby Priority 1 diagnostic with no incidence in the Irish web sample (g20) had a very small overall incidence in the four web samples, 0.3%. Based on this result, it is believed that the diagnostic was not triggered in the Irish web sample due to the significant difference in the number of web sites in the four web samples, considerably smaller in the Irish web sample. Considering this and the fact that the functionality investigated by this diagnostic (usage of `OBJECT` elements) is not very common in web design, it was decided that no particular significance should be associated with this issue.

Five of the seven Bobby diagnostics analyzed had the same ranking position in each one of the four surveys whilst the incidence ranking positions of the other two Bobby diagnostics analyzed varied with one place over the four surveys, showing a pattern in diagnostics incidence over the four web samples.

A remarkably high frequency of web sites failed to provide any alternate text for images in all the four surveys. Repairing this defect could reduce dramatically the web sites failing Bobby at minimum accessibility level from 90% to 33%. Provided that *correct* alternate text for images is provided, the accessibility level

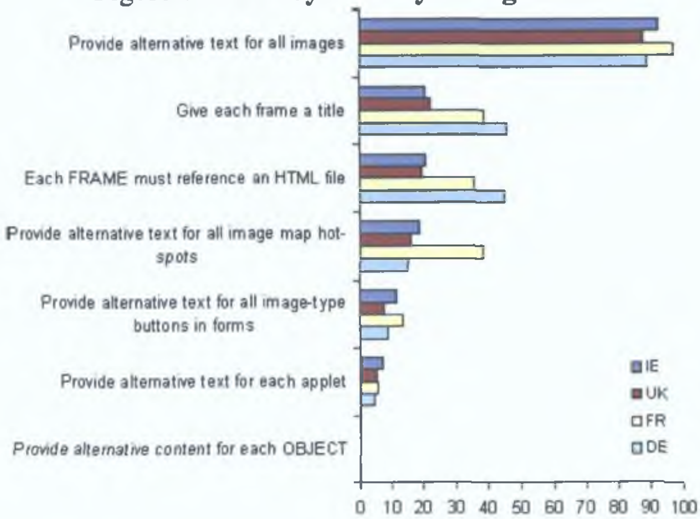
Table 6.4: **Bobby Priority 1 diagnostics triggered during the investigation**

ID		IE	UK	FR	DE	Overall
g9	Provide alternative text for all images	88 (91.7%)	1,685 (87.4%)	530 (96.7%)	1,287 (88.5%)	3,590 (89.1%)
g39	Give each frame a title	20 (20.8%)	421 (21.8%)	211 (38.5%)	664 (45.6%)	1,316 (32.7%)
g38	Each FRAME must reference an HTML file	20 (20.8%)	378 (19.6%)	194 (35.4%)	659 (45.3%)	1,251 (31.1%)
g240	Provide alternative text for all image map hot-spots	18 (18.8%)	307 (15.9%)	209 (38.1%)	218 (15%)	752 (18.7%)
g10	Provide alternative text for all image-type buttons in forms	11 (11.5%)	149 (7.7%)	74 (13.5%)	132 (9.1%)	366 (9.1%)
g21	Provide alternative text for each APPLET	7 (7.3%)	98 (5.1%)	32 (5.8%)	67 (4.6%)	204 (5.1%)
g20	Provide alternative content for each OBJECT	0 (0%)	4 (0.2%)	2 (0.4%)	5 (0.3%)	11 (0.3%)

of a web site could be dramatically improved, especially for blind users. However, Bobby cannot automatically check whether the provided alternate text is correctly specified, representing the same function/information as the image. It is quite possible that the frequency of images with non-usable alternative text is much higher than as detected by Bobby.

A distinct difference was noticed in the frequency of web sites with wrongly

Figure 6.1: **Bobby Priority 1 diagnostics**



implemented frames–almost double in the French and German web sites than in the Irish and UK web sites. However, this difference should not be read as "web sites in the UK and Irish web samples have implemented frames better than the web sites in the German and French web samples". It can be simply the case that web sites in the UK and Irish web sample use frames half less frequently than web sites in the French and German web samples. An application could be developed to determine whether a web site uses frames or not—inspecting HTML code. The application could then be used to determine the frequency of web sites using frames in the four web samples investigated. Based on this frequency (web sites using frames) and the frequency of web sites wrongly implementing frames (determined by Bobby), the frequency of web sites with frames wrongly implemented could be clearly determined–relative to the frequency of web sites using frames–in each one of the four surveys. However, it was considered that the results generated by such application would not have a strong enough significance in the context of this survey to justify the resources necessary for such application to be implemented, but it might be regarded as a future development as part of an application to deliver more details on the tests failed in investigations.

Another distinct difference was noted in the frequency of web sites not providing alternate content for AREAs in client-side image maps–more than double in the French web sample than in the other three web samples. The conclusion that "web sites in the French web sample implement client-side image maps half as successful as web sites in the Irish, UK and German web samples" isn't necessarily true. It can be the case that web sites in the French web sample use client-side image maps more often than web sites in the other three web samples. A methodology similar to the one determining the frequency of frames wrongly implemented could be developed to determine the frequency of wrongly implemented image-maps in the four surveys. However, due to the specific nature of alternate content, human evaluation is required in order to assess the accuracy of the alternate content provided. Since this cannot be automatically evaluated it is impossible to design a purely automated methodology *clearly* determining the frequency of client-side image maps wrongly implemented in the four web samples.

Based on these results, it can be concluded that the level of WCAG Priority 1 checkpoints conformance is very poor in all the four web samples, with web sites in the French web sample implementing WCAG Priority 1 checkpoints at a poorer level than web sites in the Irish, UK and German samples.

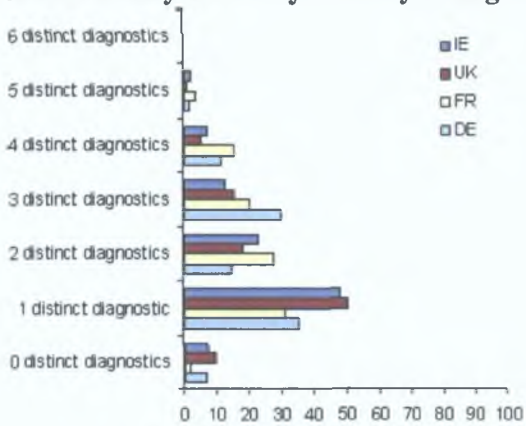
In order to evaluate whether there is a pattern in the number of distinct Bobby Priority 1 checkpoints failed by web sites in the four web samples, the frequency distribution of these diagnostics was analyzed. Such a pattern could give an indication of the number of distinct accessibility issues encountered in the most web sites in the four web samples.

The frequency distribution of distinct Bobby Priority 1 full support diagnostics is presented in Table 6.5 and as a chart in Figure 6.2. A pattern was detected in the frequency distribution of Bobby diagnostics in the four web samples with most of the web sites triggering one to three distinct Bobby Priority 1 full support diagnostics in the four surveys. This pattern shows that even though all the Bobby diagnostics considered were triggered at least once in the four surveys, most of the web sites raised less than half of the accessibility issues analyzed.

Table 6.5: **Density of Bobby Priority 1 diagnostics**

	IE		UK		FR		DE		Overall	
Web sites with Bobby completed successfully	96		1,928		548		1,455		4,027	
0 distinct diagnostics triggered	7	(7.3%)	191	(9.9%)	8	(1.5%)	101	(6.9%)	307	(7.6%)
1 distinct diagnostic triggered	46	(47.9%)	972	(50.4%)	171	(31.2%)	513	(35.3%)	1,702	(42.3%)
2 distinct diagnostic triggered	22	(22.9%)	354	(18.4%)	152	(27.7%)	214	(14.7%)	742	(18.4%)
3 distinct diagnostics triggered	12	(12.5%)	294	(15.2%)	112	(20.4%)	440	(30.2%)	858	(21.3%)
4 distinct diagnostics triggered	7	(7.3%)	105	(5.4%)	84	(15.3%)	165	(11.3%)	361	(9%)
5 distinct diagnostics triggered	2	(2.1%)	12	(0.6%)	21	(3.8%)	21	(1.4%)	56	(1.4%)
6 distinct diagnostics triggered	0	(0%)	0	(0%)	0	(0%)	1	(0.1%)	1	(0%)

Figure 6.2: **Density of Bobby Priority 1 diagnostics**



6.3.4 Bobby Priority 2 diagnostics

Table 6.6 presents the incidence of Bobby Priority 2 full support diagnostics encountered in the web sites for which Bobby completed successfully, ordered descending by the diagnostics' overall incidence in the four web samples. These diagnostics and their importance regarding web accessibility are discussed in detail in Section 5.3.

Web sites in the UK, French and German web samples failed all the 13 WCAG Priority 2 tests fully implemented by Bobby (Bobby Priority 2 full support diagnostics). Web sites in the Irish web sample failed 12 of these tests. The Bobby Priority 2 diagnostic with no incidence in the Irish web sample (g254) had a small overall incidence in the four web samples, 3.1%. Based on this result, it is believed that the diagnostic was not triggered in the Irish web sample due to the significant difference in the number of web sites in the four web samples, considerably smaller in the Irish web sample. Similar to the analysis of Bobby Priority 1 diagnostic g20, it was decided that no particular significance should be associated with this issue.

Two of the 13 Bobby diagnostics analyzed had the same incidence ranking position in each one of the four surveys whilst the ranking positions of the other

11 Bobby diagnostics analyzed varied by an average of two places over the four surveys, again showing a pattern in diagnostics incidence over the four web samples.

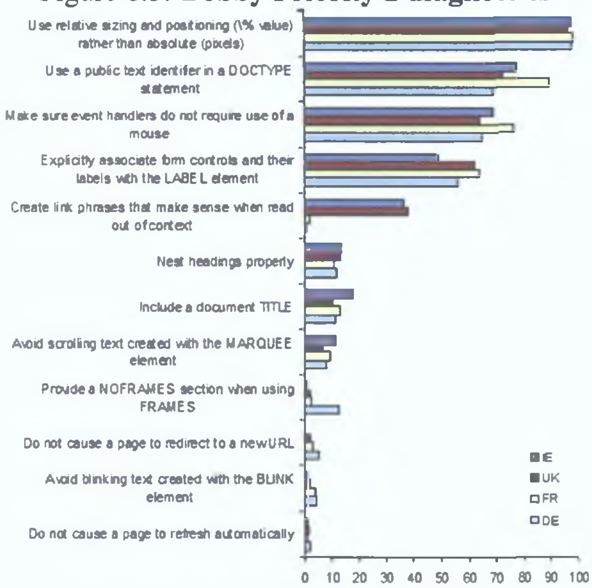
Table 6.6: **Bobby Priority 2 diagnostics triggered during the investigation**

ID		IE	UK	FR	DE	Overall
g104	Use relative sizing and positioning (% value) rather than absolute (pixels)	94 (97.9%)	1,852 (96.1%)	537 (98%)	1,418 (97.5%)	3,901 (96.9%)
g271	Use a public text identifier in a DOCTYPE statement	74 (77.1%)	1,390 (72.1%)	490 (89.4%)	1,001 (68.8%)	2,955 (73.4%)
g269	Make sure event handlers do not require use of a mouse	66 (68.8%)	1,225 (63.5%)	419 (76.5%)	938 (64.5%)	2,648 (65.8%)
g41	Explicitly associate form controls and their labels with the LABEL element	47 (49%)	1,192 (61.8%)	349 (63.7%)	814 (55.9%)	2,402 (59.6%)
g34	Create link phrases that make sense when read out of context	35 (36.5%)	733 (38%)	12 (2.2%)	15 (1%)	795 (19.7%)
g2	Nest headings properly	13 (13.5%)	255 (13.2%)	59 (10.8%)	169 (11.6%)	496 (12.3%)
g273	Include a document TITLE	17 (17.7%)	203 (10.5%)	72 (13.1%)	165 (11.3%)	457 (11.3%)
g5	Avoid scrolling text created with the MARQUEE element	11 (11.5%)	127 (6.6%)	52 (9.5%)	116 (8%)	306 (7.6%)
g37	Provide a NOFRAMES section when using FRAMES	1 (1%)	40 (2.1%)	14 (2.6%)	187 (12.9%)	242 (6%)
g254	Do not cause a page to redirect to a new URL	0 (0%)	33 (1.7%)	17 (3.1%)	75 (5.2%)	125 (3.1%)
g4	Avoid blinking text created with the BLINK element	1 (1%)	38 (2%)	21 (3.8%)	58 (4%)	118 (2.9%)

Table 6.6: **Bobby Priority 2 diagnostics triggered during the investigation**

ID		IE		UK		FR		DE		Overall	
g33	Do not cause a page to refresh automatically	1	(1%)	29	(1.5%)	7	(1.3%)	29	(2%)	66	(1.6%)

Figure 6.3: **Bobby Priority 2 diagnostics**



Overall, the WCAG Priority 2 failures detected by Bobby in the web sites investigated had a similar frequency over the four web samples. A particular exception from this similarity is the one regarding the frequency of incorrect link phrases in the four web samples ("Create link phrases that make sense when read out of context" diagnostic). The figures show a high incidence of incorrect link phrases in the Irish and the UK web samples, whereas the incidence is considerably smaller in the German and and the French web samples. Does this mean that the sites in the French and German samples provide properly formed link phrases?

Or is this difference due to a limitation in Bobby's capability of "matching" only link phrases in English while the German and French equivalent of "click here" ("Cliquez ici" and "Click hier") and the likes are ignored? Ideally this could be resolved through the Bobby documentation or examination of the source code. However, no clarification was found in the documentation, and, as Bobby is not released in source form, source code inspection was not possible. Some controlled tests of this specific point were therefore carried out. The results were consistent with the second conjecture above: it appears that, indeed, in triggering this diagnostic, Bobby only matches some pre-programmed set of English-language phrases (even when correct information as to the natural language of the page is present).

Notable differences were also found in the frequency of web sites without any document type information, highest in the French web sample and lowest in the German sample. This particular failure is relevant to this study in the HTML technical conformance investigations, since a correctly specified document type is crucial to the reliability of HTML standards conformance investigation results. This finding could signal that the proportion of web sites to be considered for HTML technical conformance investigation is much smaller in the French sample than in the German sample. However, Bobby cannot investigate whether the document type information provided is correct. Therefore, it may be the case that the proportion of web sites not to be considered for HTML technical investigation in the four web samples is quite different than the proportion of web sites failing this particular Bobby test.

If the four most common diagnostics would be repaired in the considered web samples, the percentage of web sites to fail Priority 2 Bobby diagnostics would dramatically decrease from 97% to 20%, a remarkable improvement.

Based on these results, it can be concluded that, similar to the results of WCAG

Priority 1 tests, the level of WCAG Priority 2 checkpoints implementation is very poor in all the four web samples.

The frequency distribution of distinct Bobby Priority 2 full support diagnostics is presented in Table 6.7 and as a chart in Figure 6.4. A pattern was detected in the frequency distribution of Bobby diagnostics in the four web samples with most of the web sites triggering between 3 and 6 distinct Bobby Priority 2 full support diagnostics in the four surveys. Similarly to the pattern detected in the frequency distribution of Bobby Priority 1 diagnostics (Table 6.5), this pattern shows that even though all the Bobby diagnostics considered were triggered at least once in the four surveys, most of the web sites raised less than half of the accessibility issues analyzed.

Figure 6.4: **Density of Bobby Priority 2 diagnostics**

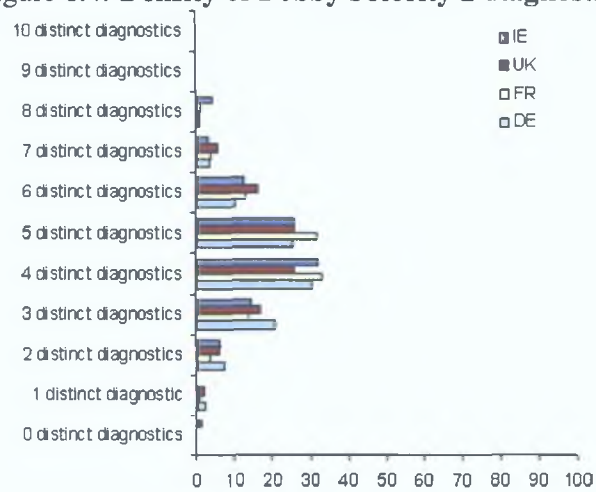


Table 6.7: **Density of Bobby Priority 2 diagnostics**

	IE		UK		FR		DE		Overall	
Web sites with Bobby completed successfully	96		1,928		548		1,455		4,027	
0 distinct diagnostics triggered	1	(1%)	10	(0.5%)	0	(0%)	2	(0.1%)	13	(0.3%)
1 distinct diagnostic triggered	0	(0%)	33	(1.7%)	3	(0.5%)	29	(2%)	65	(1.6%)
2 distinct diagnostics triggered	6	(6.3%)	115	(6%)	19	(3.5%)	104	(7.1%)	244	(6.1%)
3 distinct diagnostics triggered	14	(14.6%	324	(16.8%	76	(13.9%	301	(20.7%	715	(17.8%
4 distinct diagnostics triggered	31	(32.3%	501	(26%)	182	(33.2%	442	(30.4%	1,156	(28.7%
5 distinct diagnostics triggered	25	(26%)	502	(26%)	175	(31.9%	372	(25.6%	1,074	(26.7%
6 distinct diagnostics triggered	12	(12.5%	312	(16.2%	70	(12.8%	148	(10.2%	542	(13.5%
7 distinct diagnostics triggered	3	(3.1%)	105	(5.4%)	20	(3.6%)	49	(3.4%)	177	(4.4%)
8 distinct diagnostics triggered	4	(4.2%)	20	(1%)	3	(0.5%)	8	(0.5%)	35	(0.9%)
9 distinct diagnostics triggered	0	(0%)	5	(0.3%)	0	(0%)	0	(0%)	5	(0.1%)
10 distinct diagnostics triggered	0	(0%)	1	(0.1%)	0	(0%)	0	(0%)	1	(0%)

6.4 Analysis of HTML technical conformance investigation results

6.4.1 Key results

- Almost all web sites analyzed (99.2% overall) contained at least one page with invalid HTML markup.
  - 100% in the Irish web sample
  - 100% in the French web sample
  - 99.1% in the UK web sample
  - 98.8% in the German web sample
- Even after reducing the web sample on the basis of usable document type information as explained, most of the web sites analyzed (95.7% overall) failed the HTML technical conformance investigation.
  - 99% in the Irish web sample
  - 97.2% in the French web sample
  - 95.5% in the German web sample
  - 95.1% in the UK web sample

6.4.2 OpenSP completion data

As explained in Section 4.5, a *correctly* specified document type information–the HTML technical specification against which the document was built–is crucial for reliable results of HTML technical conformance investigations.

In the WCAG conformance investigation, Bobby detected a large proportion of web sites in the four web samples without any such document type declaration, overall 73.4% over the four web samples. However, OpenSP detected that 97.4% of web sites considered in the four web samples didn't have document type information in all the web pages correctly retrieved in the web content mirroring process, or, where such information was provided, it was not recognized as a HTML specification considered in validations (i.e. W3C specifications). The lowest proportion remained in the German web sample and the highest proportion in the French sample.

In order for the results of the HTML conformance tests to be relevant to this study (regarding the analysis of the most common HTML defects) the web pages without usable document type information were not analyzed and therefore they were removed from the web sample investigated. Out of the web sample remaining, only web sites having at least three web pages and 100 KB with usable document type information in the web content sampled–after removing the web pages without usable document type information–were considered in the analysis of the most common HTML technical conformance failures.

After this consideration/compromise to the study methodology, only 41.9% of the web sites considered for HTML technical investigation were considered for analysis of the most common HTML technical conformance failures. Before even analyzing the results of the investigations, this already shows a very poor HTML technical conformance.

Table 6.9 shows details regarding the document type declaration usage in the web pages considered by OpenSP. The French web sample had the lowest percentage of web pages with usable document type information in the four web samples, whilst the percentage was similar in the other three web samples. This could show a possible lower awareness of the importance of document type in-

Table 6.8: **Details regarding OpenSP executions**

	IE	UK	FR	DE	Overall
Web sites processed by OpenSP	100	2,142	640	1,609	4,491
Web sites where all the web pages had usable document type information	1 (1%)	60 (2.8%)	3 (0.5%)	55 (3.4%)	119 (2.6%)
Web sites considered for HTML defects analysis	49 (49%)	904 (42.2%)	196 (30.6%)	734 (45.6%)	1,883 (41.9%)

formation declaration within the French web development community. It could also show a preference towards a certain authoring tool within the French web development community, a tool that does not specify the specification according to which the document was constructed. However, on a limited, manual inspection of web pages in the web content retrieved from French web sites, there were no clear indications of any specific authoring tools used in generating the web content analyzed.

6.4.3 Representative OpenSP diagnostics

Considering only the web sites qualified for HTML defects analysis, the HTML validation process triggered 42 distinct diagnostics in the Irish web sample, 56 distinct diagnostics in the UK web sample, 46 distinct diagnostics in the French web sample and 53 distinct diagnostics in the German web sample. Although the distinct diagnostics triggered by the four surveys varies, the most common 10 OpenSP diagnostics (as measured by the proportion of web sites triggering them at

Table 6.9: **Document Type Declaration in web pages considered by OpenSP**

	IE	UK	FR	DE	Overall
Web pages processed by OpenSP	1,769	38,132	11,644	35,749	87,294
No document type information	1,071 (60.5%)	23,637 (62%)	9,116 (78.3%)	20,456 (57.2%)	54,280 (62.2%)
Incorrect document type information	29 (1.6%)	796 (2.1%)	175 (1.5%)	1,903 (5.3%)	2,903 (3.3%)
Usable document type information	632 (35.7%)	13,209 (34.6%)	2,324 (20%)	13,087 (36.6%)	29,252 (33.5%)
Considered for HTML defects analysis (in web sites with at least 3 web pages and 100 KB of data with usable document type information)	623 (35.2%)	12,980 (34%)	2,217 (19%)	12,853 (36%)	28,673 (32.8%)

least once) are the same for all the four samples. The most common three OpenSP diagnostics were the same in all four surveys, whilst the ranking positions of the seven other OpenSP diagnostics analyzed varied by an average of two places over the four surveys.

The 10 most common diagnostics triggered by OpenSP are listed in Table 6.10, starting with the most common one (and ordered descending by the overall incidence of the diagnostics in the four web samples). The defects and their impact on web accessibility are discussed in detail in Section 5.4.

The most common two HTML mark-up defects regard the mis-use of HTML

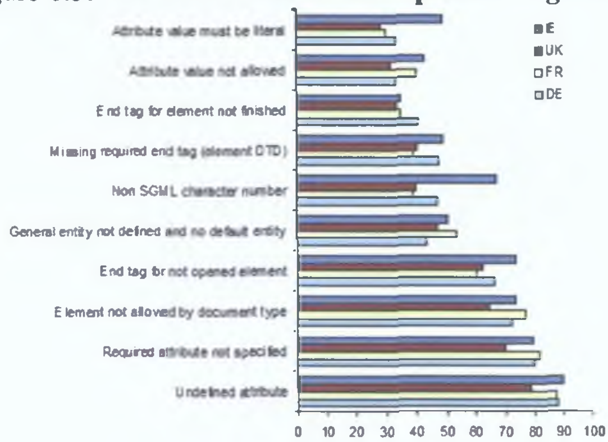
Table 6.10: **The 10 most common OpenSP diagnostics triggered in the investigation**

ID		IE		UK		FR		DE		Overall	
108	Undefined attribute	44	(89.8%)	713	(78.9%)	171	(87.2%)	645	(87.9%)	1,573	(83.5%)
127	Required attribute not specified	39	(79.6%)	634	(70.1%)	160	(81.6%)	589	(80.2%)	1,422	(75.5%)
64	Element not allowed by document type	36	(73.5%)	584	(64.6%)	151	(77%)	532	(72.5%)	1,303	(69.2%)
79	End tag for not opened element	36	(73.5%)	563	(62.3%)	118	(60.2%)	487	(66.3%)	1,204	(63.9%)
25	General entity not defined and no default entity	25	(51%)	428	(47.3%)	105	(53.6%)	319	(43.5%)	877	(46.6%)
139	Non SGML character number	33	(67.3%)	362	(40%)	77	(39.3%)	347	(47.3%)	819	(43.5%)
68	Missing required end tag (element DTD)	24	(49%)	366	(40.5%)	77	(39.3%)	350	(47.7%)	817	(43.4%)
73	End tag for element not finished	17	(34.7%)	304	(33.6%)	68	(34.7%)	300	(40.9%)	689	(36.6%)
131	Attribute value not allowed	21	(42.9%)	290	(32.1%)	79	(40.3%)	246	(33.5%)	636	(33.8%)
82	Attribute value must be literal	24	(49%)	255	(28.2%)	59	(30.1%)	245	(33.4%)	583	(31%)

attributes. As many accessibility features are implemented by HTML attributes, the high frequency of attributes unrecognized or missing may be a sign of accessibility features not implemented.

An analysis of the HTML validation results revealed that the most common attribute not recognized by OpenSP—of the 540 attributes triggering the "Un-

Figure 6.5: **The 10 most common OpenSP diagnostics**



defined attribute" diagnostic—was `height`, followed closely by `topmargin`, `leftmargin`, `marginwidth` and `marginheight`. Overall, this diagnostic was triggered by at least one `height` attribute in 65.6% of the web sites triggering this diagnostic, at least one `topmargin` attribute in 51.5% of web sites, at least one `leftmargin` attribute in 50.6% of web sites, at least one `marginwidth` attribute in 47.9% of web sites and at least one `marginheight` attribute in 47.9% of web sites. The current implementation of the surveying system does not offer details as to which particular HTML element the diagnostic is associated (for example "Undefined attribute *for element X*"). Considering the number of times the diagnostic is triggered in a web site's validation process:

- the analysis of the HTML validation results showed that the `height` attribute triggered the "undefined attribute" diagnostic in 8% of the cases. For 3.6% of the cases the `height` attribute was used—detected "undefined"—in HTML 4.01 Transitional documents, whilst for other 2.5% of the cases the attribute was used in HTML 4.0 Transitional documents. The `height` attribute is allowed in these two HTML standards for the `IFRAME`, `TD`, `TH`, `IMG`, `OBJECT` and `APPLET` HTML elements. Based on the limited information given in the validation results it cannot be clearly decided which was the exact reason why the `height` attribute triggered this particular OpenSP diagnostic.

- The `topmargin` attribute triggered the "undefined attribute" diagnostic in 6.7% of the cases. For 3.1% of the cases the `topmargin` attribute was used—detected "undefined"—in HTML 4.0 Transitional documents, whilst for other 2.7% of the cases the attribute was used in HTML 4.01 Transitional documents. The `topmargin` attribute is a Microsoft Internet Explorer proprietary attribute of the `BODY` element and it is used to define the margin for the top of the web page [2], therefore it was correctly detected as undefined in the two HTML Transitional technical specifications.

- the `leftmargin` attribute triggered the "undefined attribute" diagnostic in 6.5% of the cases. For 3.1% of the cases the `leftmargin` attribute was used—detected "undefined"— in HTML 4.0 Transitional documents, whilst for other 2.7% of the cases the attribute was used in HTML 4.01 Transitional documents. The `leftmargin` attribute is a Microsoft Internet Explorer proprietary attribute of the `BODY` element and it is used to define the left margin for the entire body of the web page [3], therefore it was correctly detected as undefined in the two HTML Transitional technical specifications.

- the `marginwidth` attribute triggered the "undefined attribute" diagnostic in 6.4% of the cases. For 3.4% of the cases the `marginwidth` attribute was used—detected "undefined"— in HTML 4.0 Transitional documents, whilst for other 2.4% of the cases the attribute was used in HTML 4.01

[2]http://msdn.microsoft.com/library/default.asp?url=/workshop/author/dhtml/reference/properties/topmargin.asp

[3]http://msdn.microsoft.com/library/default.asp?url=/workshop/author/dhtml/reference/properties/leftmargin.asp

Transitional documents. The `marginwidth` attribute is defined for the `FRAME` and `IFRAME` elements *only* in Frameset HTML standards (HTML 4.0 Frameset and HTML 4.01 Frameset). The `marginwidth` attribute is also a Netscape 4 proprietary attribute of the `BODY` element and it is used to define the left and right margins for a web page [4]. Given these, the attribute was correctly detected as undefined in the two HTML Transitional technical specifications.

- the `marginheight` attribute triggered the "undefined attribute" diagnostic in 6.3% of the cases. For 334% of the cases the `marginheight` attribute was used—detected "undefined"— in HTML 4.0 Transitional documents, whilst for other 2.4% of the cases the attribute was used in HTML 4.01 Transitional documents. The `marginheight` attribute is defined for the `FRAME` and `IFRAME` elements *only* in Frameset HTML standards (HTML 4.0 Frameset and HTML 4.01 Frameset). The `marginheight` attribute is also a Netscape 4 proprietary attribute of the `BODY` element and it is used to define the top and bottom margins for a web page [5]. Given these, the attribute was correctly detected as undefined in the two HTML Transitional technical specifications.

Another analysis of the HTML validation results revealed that, by far, the two most common attributes required and not specified—triggering the "Required attribute not specified" diagnostic—were `alt` and `type`. Overall, this diagnostic was triggered by at least one missing `alt` attribute in 85.3% of the web sites triggering this diagnostic and by at least one missing `type` attribute in 67.1% of the web sites triggering this diagnostic. Furthermore, considering the number of times the diagnostic is triggered in a web site's validation process, the "Required

[4] http://www.blooberry.com/indexdot/html/tagpages/b/body.htm
[5] http://www.blooberry.com/indexdot/html/tagpages/b/body.htm

attribute not specified" diagnostic was triggered by a missing `alt` attribute in 86.4% of the cases and by a missing `type` in 12.5% of the cases overall. The current implementation of the surveying system does not offer details as to which particular HTML element the diagnostic is associated (for example "Required attribute *for element X* not specified"). In the existing HTML standards, the `type` attribute is usually required by elements introducing content other than HTML mark-up (scripts and style most common) and it may not be directly linked to accessibility. However, the specific purpose of the `alt` attribute is to provide alternate content for graphical information (therefore required for the `IMG` and `AREA` elements in W3C HTML 4.01 technical specifications) and its correct implementation is a major step in providing accessible content.

The high frequency of this diagnostic mirrors the high frequency of Bobby diagnostics investigating the provision of alternate text (Table 6.4), demonstrating/underlining the poor implementation of this very significant accessibility issue in the four web samples.

Considering the hierarchical nature of HTML documents, conducive to single mark-up defects being propagated into multiple validation diagnostics, it is difficult to compare the HTML specification conformance of the four web sample analyzed. However, if it were assumed that the mark-up defects have a similar/proportional propagated effect in the four web samples it could be concluded that the web sites in the Irish web sample implement the 10 HTML diagnostics most poorly as they have the highest frequency for six out of the 10 HTML mark-up defects analyzed. A possible source for this difference may be the preference of Irish community of web developers for certain authoring tools. However, on a limited, manual inspection of a set of web pages in the web content retrieved from Irish web sites, there were no clear indications of any specific authoring tools used in generating the web content analyzed.

The frequency of distinct HTML specification violation detected by OpenSP on the web sites considered for HTML defects analysis is shown in Table 6.11 and as a chart in Figure 6.6. A pattern was detected in the frequency distribution of OpenSP diagnostics in the four web samples with most of the web sites triggering between 6 and 11 distinct OpenSP diagnostics in the four surveys. Again, as already noted, due to the hierarchical structure of an HTML document, once a defect is repaired, a different set of defects can be detected if the validation process is repeated. It is difficult to estimate how many of these defects are "independent" defects and how many are defects propagated from defects on a higher level in the HTML document's hierarchy.

Table 6.11: **Density of OpenSP diagnostics**

	IE		UK		FR		DE		Overall	
Web sites considered for further analysis	49		904		196		734		1,883	
0 distinct diagnostics triggered	1	(2%)	104	(11.5%)	18	(9.2%)	33	(4.5%)	156	(8.3%)
1 distinct diagnostic	2	(4.1%)	10	(1.1%)	0	(0%)	12	(1.6%)	24	(1.3%)
2 distinct diagnostics triggered	2	(4.1%)	34	(3.8%)	5	(2.6%)	21	(2.9%)	62	(3.3%)
3 distinct diagnostics triggered	2	(4.1%)	39	(4.3%)	6	(3.1%)	27	(3.7%)	74	(3.9%)
4 distinct diagnostics triggered	1	(2%)	43	(4.8%)	11	(5.6%)	37	(5%)	92	(4.9%)
5 distinct diagnostics triggered	2	(4.1%)	50	(5.5%)	5	(2.6%)	42	(5.7%)	99	(5.3%)
6 distinct diagnostics triggered	3	(6.1%)	60	(6.6%)	14	(7.1%)	52	(7.1%)	129	(6.9%)
7 distinct diagnostics triggered	0	(0%)	65	(7.2%)	14	(7.1%)	66	(9%)	145	(7.7%)

Table 6.11: **Density of OpenSP diagnostics**

	IE		**UK**		**FR**		**DE**		**Overall**	
8 distinct diagnostics triggered	4	(8.2%)	73	(8.1%)	21	(10.7%	68	(9.3%)	166	(8.8%)
9 distinct diagnostics triggered	1	(2%)	76	(8.4%)	11	(5.6%)	61	(8.3%)	149	(7.9%)
10 distinct diagnostics triggered	7	(14.3%	72	(8%)	22	(11.2%	45	(6.1%)	146	(7.8%)
11 distinct diagnostics triggered	5	(10.2%	44	(4.9%)	14	(7.1%)	73	(9.9%)	136	(7.2%)
12 distinct diagnostics triggered	6	(12.2%	64	(7.1%)	18	(9.2%)	48	(6.5%)	136	(7.2%)
13 distinct diagnostics triggered	3	(6.1%)	50	(5.5%)	15	(7.7%)	45	(6.1%)	113	(6%)
14 distinct diagnostics triggered	3	(6.1%)	42	(4.6%)	7	(3.6%)	29	(4%)	81	(4.3%)
15 distinct diagnostics triggered	4	(8.2%)	23	(2.5%)	5	(2.6%)	25	(3.4%)	57	(3%)
16 distinct diagnostics triggered	2	(4.1%)	25	(2.8%)	4	(2%)	15	(2%)	46	(2.4%)
17 distinct diagnostics triggered	0	(0%)	11	(1.2%)	0	(0%)	16	(2.2%)	27	(1.4%)
18 distinct diagnostics triggered	1	(2%)	7	(0.8%)	4	(2%)	10	(1.4%)	22	(1.2%)
19 distinct diagnostics triggered	0	(0%)	5	(0.6%)	1	(0.5%)	2	(0.3%)	8	(0.4%)
20 distinct diagnostics triggered	0	(0%)	5	(0.6%)	0	(0%)	5	(0.7%)	10	(0.5%)
21 distinct diagnostics triggered	0	(0%)	0	(0%)	1	(0.5%)	1	(0.1%)	2	(0.1%)

Table 6.11: **Density of OpenSP diagnostics**

	IE		UK		FR		DE		Overall	
22 distinct diagnostics triggered	0	(0%)	0	(0%)	0	(0%)	0	(0%)	0	(0%)
23 distinct diagnostics triggered	0	(0%)	2	(0.2%)	0	(0%)	0	(0%)	2	(0.1%)
24 distinct diagnostics triggered	0	(0%)	0	(0%)	0	(0%)	1	(0.1%)	1	(0.6%)

Figure 6.6: **Density of OpenSP diagnostics**

6.5 Conclusions

This chapter provided a comparative analysis of results of WCAG and HTML standards conformance investigation carried out on web samples from four EU jurisdictions in December 2004. Findings show that the web accessibility guideline conformance levels between the four web samples were remarkably similar, with very small (almost non-existent, insignificant) differences in detailed/specific accessibility investigation results.

Web sites in the UK, French and German web samples failed all the 7 WCAG Priority 1 and 13 WCAG Priority 2 tests fully implemented by Bobby. Web sites in the Irish web sample failed 6 WCAG Priority 1 and 12 WCAG Priority 2 of the tests fully implemented by Bobby.

90.1% of the UK web sites, 92.7% of the Irish web sites, 93.1% of the German web sites and 98.5% of the French web sites considered failed Bobby at minimal accessibility level (WCAG-A), an average of 92.4% over the four surveys; 99.7% of the UK web sites, 99.9% of the German web sites and all the Irish and French web sites considered failed Bobby at professional accessibility level (WCAG Double-A); all the web sites considered in the four web samples failed Bobby at maximum accessibility level (WCAG Triple-A). However, it was noted that if the most common three Priority 1 Bobby diagnostics *and* the most common four Priority 2 Bobby diagnostics would be repaired, the frequency of web sites failing Bobby at professional level would dramatically decrease from almost 100% to 20%.

97.4% of web sites considered in the four web samples didn't have usable document type information in all the web pages correctly retrieved in the web content mirroring process. Of web sites considered for HTML technical conformance investigation, 98.8% in the German web sample, 99.1% in the UK web sample and 100% in the Irish and French web samples failed the HTML technical conformance investigation.

After removing the web pages with incorrect or missing document type information, 41.9% of the web sites considered for HTML technical investigation in the four web samples were considered for analysis of the most common HTML technical conformance failures. Of these web sites, 95.1% in the UK web sample, 95.5% in the German web sample, 97.2% in the French web sample and 99% in the Irish web sample failed the HTML technical conformance investigation.

Based on the results and conclusions presented it cannot be concluded clearly that the overall web accessibility conformance level is better or worse for one web sample than the other three web samples analyzed. Considering the differences between the four samples analyzed (such as jurisdiction and number of web site considered), this demonstrates that the general level of conformance of web sites in these jurisdictions is very poor and major efforts still need to be invested to improve this situation.

Chapter 7

Key results of previous web accessibility level conformance investigations

7.1 Chapter Overview

The evolution in web accessibility conformance levels of the four web samples of randomly selected web sites from the Irish, UK, French and German web spaces was analyzed based on surveys carried out between May 2003 and December 2004 at six months intervals. Concentrating on the level of web accessibility conformance of web sites in the Irish web space, a fifth sample of subjectively selected Irish web sites was the subject of surveys carried out between April 2002 and December 2004, again at six months intervals.

Chapter 6 presented a comparative analysis of the latest results (December 2004) of the web accessibility conformance investigation on the web samples of randomly selected web sites from the Irish, UK, French and German web spaces.

The current chapter presents key results of previous surveys. The first section will present only the key results (no discussions), whilst discussions will follow in the next sections. These discussions will be concentrated on three main analyses: cross-state differences over time, overall evolution over time and differences between sampling methodologies.

Overall, the results show that the level of web accessibility guidelines and HTML standards conformance was found to be consistently poor on all the five web samples, with similar web accessibility problems in the web content investigated, namely the same Bobby and OpenSP tests failed (diagnostics). This leads not only to the conclusion that the poor web accessibility level is a general issue and not characteristic of only some jurisdictions, but also that it is an issue that has not improved over time.

7.2 Key survey results

This section presents key results/a summary of the data generated in the April 2002—December 2004 surveys. Detailed results of these investigations can be seen in Appendix F, Appendix G, Appendix H, Appendix I and Appendix J.

7.2.1 Web content mirroring process

Table 7.1 presents the percentage of web site qualified for conformance investigation.

7.2.2 WCAG 1.0 conformance investigation

All the web sites considered for conformance investigation in each one of the five web samples failed Bobby at maximum accessibility level (WCAG Triple-A) in all investigations.

Table 7.1: **Web sites qualified for conformance investigations**

	IE Subj	IE Rand	UK	FR	DE	Overall
Apr 2002	78.8%	n/a	n/a	n/a	n/a	n/a
Dec 2002	74.3%	n/a	n/a	n/a	n/a	n/a
May 2003	72.9%	45.2%	41.7%	48.3%	38.5%	42.1%
Dec 2003	71.5%	40.8%	39.8%	46.7%	38.8%	40.9%
May 2004	75.7%	40.4%	39.3%	45.2%	38.7%	40.6%
Dec 2004	66.8%	36.8%	37.6%	41.4%	37.9%	38.7%

Data in Table 7.2 shows web sites considered for conformance investigation in the five web samples failing Bobby at professional accessibility level (WCAG Double-A).

Table 7.2: **Web sites failing Bobby at professional accessibility level**

	IE Subj	IE Rand	UK	FR	DE	Overall
Apr 2002	100%	n/a	n/a	n/a	n/a	n/a
Dec 2002	100%	n/a	n/a	n/a	n/a	n/a
May 2003	100%	100%	99.9%	100%	100%	100%
Dec 2003	100%	100%	99.9%	99.8%	100%	99.9%
May 2004	100%	100%	99.9%	100%	99.9%	99.9%
Dec 2004	100%	100%	99.7%	100%	99.9%	99.8%

Data in Table 7.3 shows web sites considered for conformance investigation failing Bobby at minimum accessibility level (WCAG-A).

Table 7.3: **Web sites failing Bobby at minimum accessibility level**

	IE Subj	IE Rand	UK	FR	DE	Overall
Apr 2002	93.2%	n/a	n/a	n/a	n/a	n/a
Dec 2002	94.8%	n/a	n/a	n/a	n/a	n/a
May 2003	88.1%	93.9%	94.5%	98.6%	95.4%	95.2%
Dec 2003	87.5%	93.3%	94%	98.4%	95.3%	94.9%
May 2004	85%	93.1%	92.3%	98.1%	95.3%	93.9%
Dec 2004	93.8%	92.7%	90.1%	98.5%	93.1%	92.4%

7.2.3 HTML technical conformance investigation

Table 7.4 presents the percentage of web sites that had no HTML mark-up defects detected by OpenSP *before* reducing the web samples on bases of usable document type information.

Table 7.4: **Web sites with completely valid HTML mark-up–all the web pages retrieved in the web content mirroring process had a usable document type information and had no HTML mark-up defects detected by OpenSP**

	IE Subj	IE Rand	UK	FR	DE	Overall
Apr 2002	0%	n/a	n/a	n/a	n/a	n/a
Dec 2002	0%	n/a	n/a	n/a	n/a	n/a
May 2003	0%	0%	0.2%	0%	0.4%	0.2%
Dec 2003	0%	0%	0.1%	0%	0.3%	0.2%
May 2004	0%	0%	0.2%	0.1%	0.4%	0.3%
Dec 2004	0%	0%	0.9%	0%	0.6%	0.6%

Table 7.5 presents the percentage of web sites qualified for HTML mark-up

defects analysis.

Table 7.5: **Web sites considered for HTML defects analysis**

	IE Subj	IE Rand	UK	FR	DE	Overall
Apr 2002	32.3%	n/a	n/a	n/a	n/a	n/a
Dec 2002	35.8%	n/a	n/a	n/a	n/a	n/a
May 2003	42.9%	29.3%	27.9%	18.7%	36.9%	29.9%
Dec 2003	48.4%	35.1%	31.7%	19.7%	39.2%	33.1%
May 2004	49.4%	40.9%	35.3%	25.1%	42.9%	37%
Dec 2004	55.2%	49%	42.2%	30.6%	45.6%	42.3%

Table 7.6 presents the percentage of web sites that had no HTML mark-up defects detected by OpenSP *after* reducing the web samples on bases of usable document type information.

Table 7.6: **Web sites considered for HTML defects analysis with valid HTML mark-up as detected by OpenSP**

	IE Subj	IE Rand	UK	FR	DE	Overall
Apr 2002	0%	n/a	n/a	n/a	n/a	n/a
Dec 2002	0%	n/a	n/a	n/a	n/a	n/a
May 2003	0%	0.8%	1.2%	2.1%	1.8%	1.5%
Dec 2003	0.7%	0.9%	1.6%	2.4%	1.6%	1.7%
May 2004	0.6%	0.9%	1.8%	3.2%	1.8%	1.9%
Dec 2004	0%	1%	4.9%	2.8%	2.1%	3.4%

7.3 Cross-state differences between the conformance levels over time

This section presents evolution across the web spaces (jurisdictions) investigated in this study. Detailed results of these investigations can be seen in Appendix C, Appendix D and Appendix E.

Less than half of the web sites considered in each web sample qualified for conformance investigations. The smallest percentage of web sites to qualify for conformance investigation was in the German web sample in the May 2003–May 2004 surveys and in the Irish web sample in the December 2004 survey. The highest percentage was in the French sample (Table 7.1).

All the web sites considered for conformance investigation failed Bobby at maximum accessibility level (WCAG Triple-A) and almost all web sites considered for conformance investigation failed Bobby at professional accessibility level (WCAG Double-A). The smallest percentage of web sites to fail Bobby at minimum accessibility level (WCAG-A) was in the Irish web sample (May 2003 and December 2003) and UK web sample (May 2004 and December 2004) whilst the highest percentage was in the French web sample in each survey (Table 7.3).

A consistency was noted in the Bobby diagnostics failures. Web sites in the UK, French and German web samples failed each one of the 7 Bobby Priority 1 diagnostics considered, whilst web sites in the Irish web sample failed the 6 most common of these diagnostics in each survey. Web sites in the four web sample failed each one of the 13 Bobby Priority 2 diagnostics considered in all surveys, except the web sites in the Irish web sample which failed "only" 12 of these diagnostics in the December 2003 and December 2004 surveys. As discussed in Section 6.3, it is believed that this differences are due to differences in the number of web sites considered in the four web samples, therefore no particular significance will be associated with these.

As previously mentioned only web sites with at least three web pages and 100 KB of data with usable document type information where considered for HTML mark-up defects analysis. The highest percentage (although very small in itself, under 1%) of web sites with no HTML mark-up defects was in the German web sample in the May 2003–May 2004 surveys and in the UK web sample in the December 2004 survey. The Irish web sample had the smallest (nil) percentage in all investigations (Table 7.4).

After reducing the web samples based on the usable document type definition criteria, the highest percentage of web sites to qualify for defect analysis was found in the German sample in the May 2003–May 2004 surveys and in the Irish web sample in the December 2004 survey. The smallest percentage was found in the French web sample in all investigations (Table 7.5). The highest percentage (although again very small) of web sites with no HTML mark-up defects was in the French web sample in the May 2003–May 2004 surveys and in the UK web sample in the December 2004 survey. The Irish web sample had the smallest percentage in all investigations (Table 7.6).

The web sites considered for HTML defects analysis triggered between 34 (Irish web sample on the May 2003 survey) and 54 (German web sample on the May 2004 survey) distinct OpenSP diagnostics–on average 47. Still, the most common 10 OpenSP diagnostics were the same in each survey, as discussed in Section 5.4.

Overall, the results were very similar in the May 2003–May 2004 surveys with changes in patterns noticed in the December 2004 survey. Still, cross-state differences between the conformance levels were small and similar over time.

7.4 Overall evolution in conformance levels of the five web samples considered over time

Already small at under 50%, the overall percentage of web sites to qualify for conformance investigation in the five web samples decreased over time (Table 7.1).

All the web sites considered for conformance investigation in the five web samples failed Bobby at maximum accessibility level (WCAG Triple-A). At 99.9% overall, it could also be said that the vast majority of web sites considered failed Bobby at professional accessibility level (WCAG Double-A) (Table 7.2). The percentage of web sites to fail Bobby at minimum accessibility level (WCAG-A) decreased by 2.8% over time but was still high at over 90% (Table 7.3).

An increase over time was noted in the percentage of web sites to have valid HTML mark-up in *all* web content qualified for conformance investigations. Although the overall percentage doubled over time, the total proportion of sites is not that significant at under 1% (Table 7.4).

The overall percentage of web sites to have at least three web pages and 100 KB of data with usable document type information (qualifying criteria for HTML mark-up defects analysis) increased over time with 12.4 percentage points (Table 7.5). This could show an increased interest in delivering specification conformant HTML mark-up. However, the data in Table 7.6 shows that this is not the case as, although increasing, the overall percentage of web sites with specification conformant HTML mark-up is still very small at under 5% of web sites considered for HTML mark-up defects analysis.

Overall, although the percentage of web sites to be considered for conformance investigation decreased, very small (almost insignificant) improvements were noted in conformance investigation results over time.

7.5 Differences between the conformance levels of the Irish web samples of subjectively and randomly selected web sites

This section analyses differences between the results of investigation on the two Irish web samples generated using different sampling methodologies. As the web sites are taken from the same jurisdiction (governed by the same regulations) any existing differences are due to sampling techniques and could be used to determine which one of the sampling methodology is better suited for surveys. Detailed results of these investigations can be seen in Appendix K, Appendix L, Appendix M and Appendix N.

The percentage of web sites to be considered for conformance investigation was considerably higher in the subjective sample (almost double) than the one in the random sample although the subjective sample had 58 web sites less than the random web sample (Table 7.1). The difference between the percentage of web sites failing to qualify for conformance investigation in all surveys is also significant between the two web samples with 8.4% of the total number of web sites considered in the Irish subjective sample (F.2) and 48.5% of the total number of web sites considered in the Irish random sample (G.2). A selective manual investigation determined that the main reason for which web sites did not qualify for investigation was that web content couldn't be retrieved past the main (entrance) web page, usually due to redirection to an URL domain different than the one considered, which could be explained through the origin of the web sites in the web samples. The web sites in the subjective web sample were selected mainly from the media (advertisements) and from the daily activity of members of the eAccess team, so they were expected to be up to date. The web sites in the random web sample were selected from the downloaded content of the ODP directory and, although efforts are made to keep the content up to date, it is almost impossible. Therefore, it is natural for a web sample with web sites subjectively selected (implying human selection) to have a higher percentage of web sites up to date than a web sample with randomly (automated) selected web sites.

The web sites in the subjective sample seem to generate more representative results due to the higher success in the mirroring process. Still, although the number of web sites actually considered for investigation was very different in the two surveys, the results are very similar .

All the web sites considered for conformance investigation failed Bobby at maximum accessibility level (WCAG Triple-A) and at professional accessibility level (WCAG Double-A) in both web samples and all investigations. Most of the web sites considered for conformance investigation in both web samples failed Bobby at minimum accessibility level (WCAG-A). A small decrease can be noticed in the percentage of web sites failing Bobby at minimum accessibility level in the web sample of randomly selected Irish web sites. The same pattern could be seen in the web sample of subjectively selected Irish web sites with the difference that, in the latest investigation (December 2004), the percentage rose up to the highest value in the four surveys (Table 7.3).

There was no obvious pattern in Bobby diagnostics failures. Web sites in the subjective Irish web sample failed all 7 Bobby Priority 1 diagnostics in the April 2002 and December 2002 investigations and the most common 6 Bobby diagnostics in later investigations. The web sites in the Irish subjective web sample also failed all 13 Bobby Priority 2 diagnostics in the April 2002, December 2002 and May 2003 investigations and the most common 12 Bobby Priority 2 diagnostics in the later investigations. Web sites in the random Irish web sample failed the 6 most common Bobby Priority 1 diagnostics in all investigations, the most common 12 Bobby Priority 2 diagnostics in the December 2003 and December 2004 investigations and all Bobby Priority 2 diagnostics in the May 2003 and May 2004 investigations. As previously discussed, the Bobby Priority 1 diagnostic (g20) and the Bobby Priority 2 diagnostics (g254 and g4–avoid using the `BLINK` element) not triggered by the investigations implement functionalities that are not often implemented in web design. Therefore, their nil frequency was considered due simply to the relatively small number of web sites considered in investigations and no particular importance was associated with this issue.

All web site in both web samples had at least one HTML mark-up defects detected by OpenSP in the content considered for HTML specification conformance investigation (Table 7.4).

The percentage of web sites to have at least three web pages and 100 KB of data with usable document type information (qualifying criteria for HTML mark-up defects analysis) was slightly higher in the Irish subjective web sample, but the difference decreased over time from 13.6 percentage points to 6.2 percentage points ((Table 7.5)). This could show an increased interest in delivering specification conformant HTML mark-up, but as the web sites are taken from the same web space it is difficult to attache a particular significance to it. More than that, the data in Table 7.6 shows that the percentage of web sites with specification conformant HTML mark-up is very small at maximum 1% of web sites considered for HTML mark-up defects analysis, so the desire to adhere to technical specifications is only superficial.

The web sites considered for HTML defects analysis triggered between 34 (Irish random web sample on the May 2003 survey) and 40 (both web samples on the December 2003, May 2004 and December 2004 surveys) distinct OpenSP diagnostics–on average 39. Still, the most common 10 OpenSP diagnostics were the same in each survey, as discussed in Section 5.4.

7.6 Conclusions

This chapter presented key results of WCAG and HTML standards conformance investigation carried out on five web samples from four EU jurisdictions between April 2002 and December 2004, at six months intervals. Findings show that the web accessibility guideline conformance levels were remarkably similar, with very small (almost non-existent, insignificant) differences in detailed/specific accessibility investigation results,not only between web samples but also between surveys in time.

The only notable difference was in the percentage of web sites qualified for conformance investigations, almost double in the web sample of subjectively selected Irish web sites compared to the web sample of random selected web sites. The similarity in the investigation results between the web samples generated using the two sampling methodologies, suggests that both methodologies can be used in generating web samples for web accessibility surveys. Still, considering the caveat with web sites changing domain names constantly, it might be more appropriate to use a subjective sampling methodology for small size web samples and a random sampling methodology for considerably large web samples. The web accessibility recommendation conformance investigation technology implemented and used in this study is conductive to investigation of either size of web samples.

Based on the results and conclusions presented in this chapter it cannot be concluded clearly that the web accessibility conformance level is better or worse for one web sample than the other web samples analyzed, nor that distinct changes can be noticed over time. Considering the differences between the web samples analyzed (such as jurisdiction and number of web site considered), this demonstrates that the general level of conformance of web sites in these jurisdictions is very poor and major efforts still need to be invested to improve this situation.

Chapter 8

Critical Review

This chapter provides a brief critical review of the study, and of the tools and methodology adopted.

One of the main objectives of this study was to test the feasibility of a web accessibility surveying system that could be used to verify WCAG 1.0 and HTML technical conformance of relatively large web samples of web sites.

The project presented in this thesis has demonstrated that such a system is technically feasible. Once the appropriate tools have been developed and integrated, the technical resources to carry out such a survey are comparatively modest.

A fundamental issue in the methodology used is the limitation of the study to those accessibility indicators that can be measured by purely automatic means. This allowed the surveying of a comparatively large number of feasible sites, but it runs a real risk of focusing corrective action only on these automatically detectable defects, to the exclusion of action on other—potentially much more significant—accessibility barriers.

Although the same characteristics (mainly distribution of domain of interests) were kept in all the five web samples investigated, implemented in both sampling technologies, the sites selected are not "statistically representative", and the results cannot be directly extrapolated by statistical means. The findings of the investigations carried out in this study show the web accessibility conformance levels of *samples of web sites from web spaces under different jurisdictions* rather than *web spaces under different jurisdictions*. It is not apparent that it is even possible—in principle to carry out a statistically representative sampling of a web space for these particular purposes.

The site capture mechanism used in this study suffers from significant limitations with respect to sites which require user "registration". More generally, automated evaluation of "interactive" sites is fundamentally problematic. This is particularly important given the growing number and diverse roles of such sites. A special issue relates to those sites that allow users to "personalize" site appearance or behavior. In those cases, it might be argued that such a sites content can be tailored to the needs of each user, and is therefore fully accessible even though this may be invisible to an automated mirroring robot. However, since a user needs to access the default web presentation in order to "personalize" it in the first place, the default configuration should conform to WCAG 1.0.

As was found, such automated accessibility surveys can only check *failures* of (some) web accessibility tests. Even if no failure is detected within the web content investigated it shouldn't be read as the web content is accessible, as there are still a considerable number of tests requiring human interventions to be carried out before assessing a web content with a particular level of WCAG conformance.

These show that the system implemented in this thesis can monitor frequencies of failures of a set of web accessibility tests and results should be read as such. When such failures become less and less frequent it may be that the current surveying system will become obsolete. This may indeed mean that web accessibility levels have improved and the purpose of this system was achieved.

But failing this, it will mean that another investigating methodology needs to be developed, considering a different (larger and/or more sophisticated) set of tests.

At the moment, it is recommended that the findings of this automated surveying system should be used as a *starting point* in web accessibility investigations, having the benefit of large scale surveys with modest resources requirement.

There are debates as to how do the WCAG 1.0 provisions reflect the real problems in web accessibility. The guidelines are also considered largely to be complex and difficult to understand when they need to be implemented in practice. Still, they are a reference point in web accessibility policies and regulations in the EU space, therefore they are considered in this study as indicators of web accessibility.

The work presented in this thesis could be further developed:

- new regular samples could be considered to investigate existing trends. As mentioned the work presented in this thesis considered the same web sites in all investigations. As the World Wide Web is a dynamic medium, conformance investigation results could reflect more precisely current states of web accessibility levels if the web samples are generated from current web spaces rather than from an earlier web space. However, considering the very slight changes in conformance level over time in the web samples investigated it may be the case that the two methodologies (considering web samples from current web spaces or web samples from earlier web spaces) would generate similar results. This methodology could be more appropriate once web accessibility conformance levels are visibly improved.

- web samples from new jurisdictions could be considered to create a broader image of web accessibility conformance levels across jurisdictions. The findings generated by surveying new web samples could be used to create comparisons/analysis at diverse levels—geographical, economical or cultural level, combinations of these or other of the multitude of possibilities, depending on the target audience.

The *European Internet Accessibility Observatory (EIAO)*[1] is a recently founded organization with the declared purpose of "[assessing] the accessibility of European web sites and [participating] in a cluster developing a European Accessibility Methodology". Although there are not many details published, the existing information suggest that the project's goal and methodology will be similar to the one presented in this thesis, but at a much larger scale and with possibly more resources. Considering this, further developments in the WARP study at RINCE, Dublin should be carefully considered to avoid replicating the work conducted by EIAO.

[1]http://www.eiao.net

Chapter 9

Conclusions

Web content from five web samples (four EU jurisdictions) was periodically mirrored and subject to automatic WCAG 1.0 and HTML technical conformance investigation using Bobby and OpenSP as detailed in Chapter 4.

The striking overall conclusion of the web accessibility survey carried out as part of this study is not only that the web accessibility recommendations conformance levels is very poor in Irish web sites but that this is not an exception within the EU jurisdiction. Investigations of samples from the other three EU jurisdictions considered in this study (UK, France and Germany) showed strikingly similar results. More than that, as the investigation was repeated, signs of improvement were very small, practically nonexistent. Studying the findings of the investigations of the web sample of subjectively selected Irish web sites, the improvements in web accessibility levels are again very small, very similar to the findings of the investigations on the four web samples of Irish, UK, French and German web sites. Considering these, it can be concluded that the study's findings represent correctly the changes in the (poor) level of web accessibility recommendation conformance.

A particular conclusion of the surveys show that, not only are the web accessibility levels similarly poor, but the failures in WCAG and HTML technical conformance are strikingly similar in all the investigations carried out.

Although the methodology used in the WCAG conformance investigation allowed the test of only a limited number of aspects of WCAG checkpoints (7 tests of aspects of WCAG Priority 1 checkpoints and 13 tests of aspects of WCAG Priority 2 checkpoints) each one of these tests were failed in most of the surveys at least once.

As already mentioned, the WCAG are currently under revision. Considering the current WCAG 2.0 development version (Nov 2004), it is difficult to evaluate to what extent the tests considered in the study can be mapped on the new web accessibility requirements/checkpoints. However, it is expected that popular automatic investigation tools will be revised to incorporate the new provisions. In such case, the system used in the thesis could also be revised to include the updated investigation tools. So, although a delay is to be expected, the system used in this thesis should be conductive to investigation of revised web accessibility guidelines. In the mean time, is expected that, if desired, provisional mapping could be achieved between the system implemented and the new checkpoints. However, it will first have to be evaluated to what extent can such mapping be implemented and whether the accuracy of results will justify the resources required.

Regarding the HTML technical conformance of the web samples considered, the vast majority of web sites did not have a document type information specified in their sampled web pages. As document type information specifies the HTML specification considered in the construction of a web page, the lack of such information is an indication of non-conformance to HTML technical specifications. Even of the web pages with a document type information specified, an insignificant percentage had a correct HTML mark-up, conformant to the HTML technical specification specified.

It can be assumed that the overall similarity in findings may be largely due to defects in common web authoring tools or content management systems. An investigation on a considerable large set of web pages retrieved in the web content sampling process showed that only a very small number of web pages provided information on the authoring tool used in generating the web page. Even where such information was present it was not provided in a consistent/similar manner, conductive to statistics on web authoring tool related web accessibility failures. However, the poor conformance to web accessibility guidelines is presumably due to a lack of information and a misunderstanding of their importance on the part of content designers and authors. It seems that the "write once, read everywhere" concept is still quite far from reality, even though significant efforts in promoting web accessibility are being invested in the studied countries.

The results of this survey do not represent the "exact" level of web accessibility on Irish, UK, French or German web sites, but they demonstrate a widespread lack of concern with accessibility guidelines and technical inter-operability. While it may be argued that the results are still generated based on a sample of sites, the fact that samples generated essentially the same results is suggestive that this situation is probably typical of the web as a whole in these countries. The overall findings of the work presented in this thesis are also very similar to findings of similar web accessibility investigations, presented in Section 3.3. This is disappointing because it means that the web is still not living up to its potential in offering significant improvements in service and opportunities for users with disabilities.

This study signals that, despite very laudable goals in documents such as the e-Europe Action Plan [37], the current commitment to accessibility of the Irish, U.K., French and German web for users with disabilities is, at best, aspirational.

This is doubly unfortunate. It is not just that web technology is not being applied—as it could be—positively to improve opportunities and capabilities for users with disabilities. As web services become more pervasive and essential, it means that those with disabilities in our society will increasingly suffer further disadvantages in accessing information and online services.

It is hoped that the results of this study or other possible studies implemented with the presented methodology will serve to highlight these issues, and to further encourage many agencies and organizations who are already actively promoting and supporting voluntary improvements in web accessibility in Ireland and around the EU. The methodology implemented in the study is conductive to carrying out surveys on sets of web sites of different sizes (from very small to very large), without much human intervention. The summarized results can be used in delivering concise messages, for example "99% of the web sites investigated failed to comply to professional accessibility level". The detailed data can be used in analyzing the most common causes of failure and using them as reference when prioritizing the web accessibility issues in the study, for example "If the most common four failures could be fixed, the percentage of web sites to fail compliance at minimum accessibility level would decrease from 80% to 20%", followed by what do these failures mean and how can they be best repaired.

However, considering the particular conclusions of this study, it might be the case that more is required to be done in order for web accessibility to be considered an integrated part of web design. Only when web accessibility is fully integrated in web design techniques and technologies will we have a web accessible to all.

At the moment it seems that web accessibility is regarded as an (optional) "add-on" to web design that most web authors can do without. Today, the Internet is a place for everyone, a mirror to our world. In a sense, the Internet is playing a similar part as media (TV, magazines) in our society. And still, although the vast majority of web users are also web authors, the community of people that ever heard of web accessibility is very small. In a society where offer is driven by demand, maybe campaigns should be targeted to web users rather than web content providers. A well designed publicity campaign in today's media (TV, magazines) targeted at a vast range of interests (rather than just professional magazines and web communities) and delivering a very simple message could increase web accessibility awareness. Web authors would demand compliant authoring tools and content management systems.

At the same time, major software providers will want to lead by example and should provide complaint web content. The current situation is that web sites of dominant companies are taken as example in avoiding the extra work that a compliant web content would require. But if these companies would provide compliant web content and be proud of it, such arguments would disappear and it would make the work of web content designers much easier. Rather than web authors having to convince their client or resource manager that the resources are well spent in delivering accessible web content, web authors will be required by their customers to deliver such content.

But this would be the ideal behavior in an ideal world. More realistically, the current web accessibility campaigns will still have to invest considerable efforts in convincing web authors that the effort is worth investing and perseverance is needed. Web accessibility is a very complex subject with many issues still debatable. Of considerable help would be to make web accessibility recommendations more clear and accessible to web authors with limited time to spare in acquiring new skills, in a similar manner to tutorials. Maybe governments could be persuaded to invest money in sponsored web accessibility courses and incentives for those providing support and promoting web accessibility, whether they are providers of web content authoring tools and content system or simple web authors and web designers.

As already noted, major efforts are already invested in promoting web accessibility. But as disappointingly discovered in the present study, the results are still to be seen. Hopefully, in the near future, web accessibility awareness will increase enough for it to be an integral part of web design and then the Internet will become truly universal.

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