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OVERCOMING BARRIERS IN VIRTUAL MUSEUMS

1. Introduction

A virtual museum is often intended as a way to allow a virtual visit, where the user can browse the content, looking at the museum catalog and descriptive data. In many cases, advanced technologies are used to enrich the user's experience, adding multimedia presentations, or having a 3D experience, moving virtually in the museum space and sometimes having the possibility of handling and moving objects. Such possibilities are often advertised as special features and are greatly appreciated by users.

However, to really fulfill its goals, a virtual museum should be something more, giving the opportunity to go further than mere visualization of the museum content. The user should be able to build "virtual exhibitions" putting together objects that are related but belong to other museums, as is the case of fragmented works of art or of ones physically accessible in their original place, or the user can set up monographic or thematic exhibitions, combining information and items usually stored in different rooms.

Cultural heritage is inherently very rich in semantic associations, both among documents within the same discipline and in those related to different ones, like history, economics, religion, ethnology. A virtual museum must support an interdisciplinary approach, through implementation of complex semantic associations, which will allow the user to understand the culture that is behind the objects and contextualize them. The virtual museum concept comes into the scene in different scenarios, where issues like *accessibility*, *interoperability*, *semantics*, *security* emerge:

– Remote access before visiting, to make better plans and prepare the visit. This includes getting more information about the museum content and the related topics (like history, culture, etc.), buying tickets, reserving places, etc.
– Contextual aid during the visit, using a mobile device.
– Remote access after visiting, to refresh the impressions and better understanding.

Web technologies are a key for implementing and offering virtual museums to a wide audience. We can easily see how the World Wide Web Consortium[1] (W3C) issued technical specifications, called W3C Recommendations[2],

[1] http://www.w3.org/.
[2] See http://www.w3.org/TR/ for a complete list.

covering the full range of user needs, and how well they conform to the W3C long-term goals for creating *one World Wide Web*:

– *Web for Everyone*. Making the social benefits of the web available to all people, whatever their hardware, software, network infrastructure, native language, culture, geographical location, or physical or mental ability.
– *Web on Everything*. Make web access from any kind of device as simple, easy and convenient as web access from a desktop.
– *Knowledge Base*. Developing a web that holds information for both human and machine processing.
– *Trust and Confidence*. A web where accountability, security, confidence, and confidentiality are all possible, and where people participate according to their individual privacy requirements and preferences.

In the remaining portion of this paper we will discuss preliminary user interface issues, the concept of disability and the components of web accessibility. Section 5 is concerned with the design of accessible web sites, hence user accessibility. Section 6 describes the frame of reference of regulations for accessibility, and section 7 describes in further detail the Web Content Accessibility Guidelines issued by W3C. Sections 8 and 9 give information about the next steps, namely Rich Internet Applications and the semantic interoperability. The Appendix describes accessibility features of W3C Recommendations about 2D graphics and multimedia.

2. User interface issues

Availability of usable and accessible interfaces is a basic requirement for scholars as well as for common users. It may be that the various features will have different importance for different users, but a well designed site will consider different abilities, interests and skills of the potential users, to offer a significant and interesting experience. A careful designer will consider the different user needs, and will try to design accordingly, and publish in different ways (as would be the case for mobile devices). However, as noted by Bowen 2003, many museum sites are not accessible to impaired people.

It is worthwhile to spend a few words to explain what we intend for “experience” in a virtual museum. As pointed out by Nevile, McCathieNevile 2002, «the communities of people with disabilities are slowly finding their way on the web, up to the virtual ramp, as it where. […] Good practice has ramp integrated into the design of institutions from the start, and everyone can feel equally welcome and share the experience beyond the ramp». The question is what can be considered an “equivalent” experience. As we will see in the next sections, technology can supply means for producing accessible content.

According to the IMS Guidelines for Developing Accessible Learning Applications[3], solutions designed to make education accessible can be grouped into two categories: *direct access* and *compatible access*, which both offer different advantages to different stakeholders in the web context. A *directly accessible* product allows a person with a disability to operate all on-screen controls and access all content without relying on the aid of an AT (Assistive Technology). Alternatively, the *compatibly accessible* application, software, or web site is an application designed with AT in mind. This level of access assumes that the user has a preferred AT package installed and is relatively competent and comfortable with the AT (s)he is using. A compatibly accessible product is designed with "hooks" built into the software that facilitate the use of a screen reader, screen magnifier, or alternative input devices such as adapted keyboards or single switches.

When considering accessibility of applications and software, it is important to understand the differences between equivalent and alternative access. *Equivalent access* provides the disabled user with content identical to that used by the non-disabled user, but is presented using a different modality. Providing a course textbook in Braille format, on audiotape, or in digital format are examples of equivalent accessibility. *Alternative access* provides the disabled user with an activity that differs from the activity used by the non-disabled user, but is designed to achieve the same objectives. Equivalent access should be provided whenever possible; the alternative one should be provided only if equivalent access is not possible. However, there are numerous examples where software developed for alternative access has become the mainstream choice when its value to all users was recognized.

In the virtual museum context, the question is what will provide a virtual visitor with the richest experience, given that some visitors have special needs. The solution may be one that offers all users an equivalent experience, according to the modality in which they participate. In other words, the provision of resources in multiple modalities may not be sufficient to satisfy the original intention of the resource when the full range of users is taken into account.

3. What does disability mean?

Accessibility is a direct consequence of the W3C's vision of the web, and has been one of its concerns since its inception. In fact, technologies developed by W3C can help in fulfilling the basic requirements of scholars and other users, supporting interoperability both at a *syntactic* as well as at a *semantic* level. It is important to emphasize that accessibility is not just related

[3] http://www.imsglobal.org/accessibility/accessiblevers/sec2.html.

to disabilities, but has a much wider meaning, as can be easily seen looking at the different definitions given by the World Health Organization (WHO) in 1980 and 2001.

The International Classification of Impairments, Disabilities and Handicaps issued by WHO in 1980 gives the following definitions:

– *Impairment*: «any loss or abnormality of a psychological, or anatomical structure or function».
– *Disability*: «any restriction or inability (resulting from an impairment) to perform an activity in the manner or within the range considered normal for a human being».
– *Handicap*: «any disadvantage for a given individual, resulting from an impairment or a disability, that limits or prevents the fulfillment of a role that is normal… for that individual». The classification of handicap is a classification of circumstances that place individuals «at a disadvantage relative to their peers when viewed from the norms of society». The classification of handicap deals with the relationship that evolves between society, culture and people who have impairments or disabilities, as reflected in people's life roles.

The WHO's International Classification of Functioning, Disability and Health (2001), known more commonly as ICF, is a «multi-purpose classification intended for a wide range of uses in different sectors. It is a classification of health and health-related domains – domains that help us to describe changes in body function and structure, what a person with a health condition *can do* in a standard environment (their level of capacity), as well as what they *actually do* in their usual environment (their level of performance). These domains are classified from body, individual and societal perspectives by means of two lists: a list of body functions and structure, and a list of domains of activity and participation. In ICF, the term *functioning* refers to all body functions, activities and participation, while *disability* is similarly an umbrella term for impairments, activity limitations and participation restriction. […] ICF is WHO's framework for health and disability. It is the conceptual basis for the definition, measurement and policy formulations for health and disability. […] ICF is named as it is because of its stress is on health and functioning, rather than on disability. […] ICF put the notion of 'health' and 'disability' in a new light. It acknowledges that every human being can experience a decrement in health and thereby experience some disability».

4. Web accessibility and its components

An accessible web will mean unprecedented access to information for people with disabilities. Further, web accessibility is a cross-disability issue, as the web can present barriers to people with different kinds of disabilities:

– *Visual* disabilities (unlabeled graphics, undescribed video, poorly marked-up tables or frames, lack of keyboard support or screen reader compatibility).
– *Hearing* disabilities (lack of captioning for audio, proliferation of text without visual signposts).
– *Physical* disabilities (lack of keyboard or single-switch support for menu commands).
– *Cognitive or neurological* disabilities (lack of consistent navigation structure, overly complex presentation or language, lack of illustrative non-text materials, flickering or strobing designs on pages).

Web accessibility is also a *marketplace* issue, as 10% to 20% of the population in most countries has disabilities, and average age of population in many countries is increasing (aging sometimes results in combinations of accessibility issues like vision and hearing changes, dexterity). Few organizations can afford to deliberately miss out on this market sector.

Several different components of web development and interaction work together in order for the web to be accessible to people with disabilities. In fact web *developers* usually use *authoring tools* and evaluation tools to create web *content*. *People* ("*users*") use web *browsers*, *media players*, *assistive technologies*, or other *user agents* to get and interact with the *content*. There are significant interdependencies between the components, which must work together to achieve web accessibility. When accessibility features are effectively implemented in one component, the other components are more likely to implement them, while, if an accessibility feature is not implemented in one component, there is little motivation for the other components to implement it when it does not appear in an accessible user experience.

5. Designing for usable accessibility

Web accessibility is generally seen as a *technological* challenge. But accessibility is not just a technical issue, because it is not a matter of the creator producing one resource and then leaving it to technicians to make alternatives for those with special needs. The creator should instead consider from the earliest stages all the different formats and modalities and include their design as part of the main planning process. (S)he must *think accessible*, considering physical impairments, cognitive deficiency, scarce literacy, differences in culture, user interface quality and semantic interoperability.

Designing a web site we must pay attention to design effective, efficient and satisfying user interfaces, being sure to give due consideration to elements important for *usability*, like learnability, memorability, effectiveness, efficiency, satisfaction. All these elements are good for accessibility as well. It is a matter of debate if accessibility is a particular aspect of usability, or if they are two different issues, showing a significant overlap. The distinction between usability and accessibility is especially difficult to define when considering cognitive and language disabilities or different situational limitations.

In short, usability problems impact all users equally, while accessibility problems hinder access to a web site by people with disabilities. In the usability context, accessibility is mainly concerned with designing user interfaces to be effective, efficient and satisfying for more people in more situations. However, accessibility is more concerned with making web sites *perceivable*, *operable* and *understandable*, than with user satisfaction. In practice, even if accessibility is related to usability, many designers approach accessibility because of national regulations (we will return to this issue in the next section), consequently emphasizing technical aspects at the expense of human interaction ones. Hence we have to adopt a broader definition of accessibility, focusing not only on technical aspects, but also recognizing that usability is an important aspect of accessibility, and goes beyond technical accessibility to achieve *usable accessibility*.

An established and proven process for designing hardware, software and user interfaces is the User-Centered Design (UCD), which considers usability goals and users' characteristics, tasks, workflow and environment in the design of an interface. In spite of many papers and books written about this topic, consideration of user needs (especially those of disabled people) is relatively uncommon, and the design process rarely takes into account a wide range of users. In fact, it is common for web sites to be designed on the basis of the individual designer's preferences, abilities and environment, ignoring that many users may be operating in contexts very different from that of the designer. Integration of accessibility (considering all possible users and environment) into a UCD process is often called inclusive design. "Design for all" and "universal design" address the same concepts. Universal design, originally referring to buildings, has been recently used in describing an approach to accessibility for ICT: «Universal design is the process of creating products (devices, environments, systems, and processes) which are usable by people with the widest possible range of abilities, operating with the widest possible range of situations (environments, conditions, and circumstances), as is commercially practical»[4].

It is clear that many design aspects that are *good* for usability are *required* for accessibility, and accessible design benefits all, as often results in a quality enhancement, contributing to better design for other users in several ways:

– *Multi-modality* (support for visual, auditory, tactile access) benefits users of mobile phones with small display screens, Web-TV, kiosks, and increases

[4] Universal Design of Consumer Products: Current Industry Practice and Perceptions http://trace.wisc.edu/docs/ud_consumer_products_hfes2000/index.htm.

usability of web sites in different situations, like *low bandwidth* (images are slow to download), *noisy environments* (difficult to hear the audio), *screen-glare* (difficult to see the screen), *driving* (eyes and hands are "busy").
– *Redundant text/audio/video* can support different learning styles, low literacy levels, second-language access.
– *Style sheets* allow for separation of content from presentation, and can support more efficient page transmission and site maintenance.
– *Captioning* of audio files supports better machine indexing and faster searching of content.

When browsing a web site designed for usable accessibility, psychologically the user will have the sense of *inclusion* and an *equal opportunity* to participate.

It is a common misconception that designers, in order to make an accessible web site should take out images and colours, "dumb it down" in terms of sophistication, and, essentially, make it boring and scarcely attractive[5]. Instead, accessibility doesn't have to limit design, and taking away visual appeal doesn't serve the interests of the overall audience. A site designed having the usable accessibility in mind will make the site usable, aesthetically pleasing and commercially viable to all users (see Appendix for additional discussion). Another common approach towards accessibility is to supplement a text-only version. While it is advantageous to provide truly equivalent information that can be accessed graphically or textually from the same source, there are several problems in providing a separate accessible site. First of all, two different versions will inevitably be out of synchronization, even if new technologies tend to minimize this problem. Secondly, when there are two different versions, the primary version is likely to miss even the most basic accessibility requirements. Finally, accessible design is a technical challenge (even not simply a technical issue) and opportunity to be prepared to take advantage of emerging technologies

As a separate, but converging issue, we must consider benefits coming from the adoption of standards and Semantic Web technologies. Standards are a component of web site quality, and a key for interoperability (they can support, for example, access to information from different devices). Conforming to standards is of great help in safeguarding investments and cost reduction. Semantic Web technologies are the key for representing, sharing and exporting knowledge, which is very important for semantic interoperability.

In conclusion, it is worthwhile stressing how web accessibility is a *quality* issue. In fact, any web designer concerned with the quality of the web site

[5] We have made extensive reference to *Understanding Web Accessibility*, by S.L. Henry (http://uiaccess.com/understanding.htlm).

would carefully consider issues as correctness, comprehensibility, navigability, which are essential characteristics of accessible web sites. It is not a coincidence that the Minerva Project[6] paid so much attention to the accessibility issues.

6. Frame of reference for accessibility regulations

A number of governments require web accessibility for certain kinds of sites, often for government web sites first, sometimes other sites, to implement anti-discrimination policies, or policies that directly address web accessibility[7]. In the following paragraphs we will give a brief description of some actions in the web accessibility area: the Web Accessibility Initiative at W3C, the USA Section 508 and the Italian legislation.

6.1 *The W3C Web Accessibility Initiative guidelines*

The Web Accessibility Initiative[8] (WAI) is supported by a variety of government, industry supporters of accessibility and organizations, including the European Commission. WAI enables different "stakeholders" in accessibility to work together to ensure that web technologies support accessibility[9]. WAI develops web accessibility guidelines which play a critical role in making the web accessible, by explaining how to use web technologies to create accessible web sites, authoring tools, or browsers. There are three different guidelines to address these different needs: WCAG, ATAG and UAAG.

Web Content Accessibility Guidelines (WCAG) explain to authors how to create accessible web content. WCAG addresses web content, and is used by developers, authoring tools, and accessibility evaluation tools. WCAG 1.0 became a W3C Recommendation in 1999. WCAG 2.0 is currently under development. We will discuss WCAG in more detail in the next sections.

Authoring Tool Accessibility Guidelines (ATAG) cover a wide range of recommendations for assisting authoring tool[10] software developers in making them, as well as the generated content, more accessible to all potential web content end users and authors, especially people with disabilities. ATAG 1.0 became a W3C Recommendation[11] in 2000, and ATAG 2.0 is under

[6] http://www.minervaeurope.org/.

[7] See http://www.w3.org/WAI/Policy/Overview.html for a list.

[8] http://www.w3.org/WAI/.

[9] Several specifications, namely HTML 4.0, CSS, SMIL and MathML already include support for accessibility, like style sheet linkage, alternative representation, navigation, improved table mark-up, layout, fonts, user control, aural CSS, synchronization of captioning and audio description, semantic representation of math content.

[10] ATAG 2.0 defines an "authoring tool" as: «any software, or collection of software components, that authors use to create or modify Web content for publication».

[11] http://www.w3.org/TR/ATAG10/.

development[12]. Their guiding principle is that «everyone should have the ability to create and access web content». Authoring tools play a crucial role in achieving this principle because the design of the authoring tool user interface determines who can access the tool as a web content author and the accessibility of the resulting web content determines who can be an end user of that web content.

User Agent Accessibility Guidelines (UAAG) which address web browsers and media players, including some aspects of assistive technologies, became a Recommendation late 2002[13]. They explain what the software developers can do to improve the accessibility of mainstream browsers and multimedia players so that people with hearing, cognitive, physical, and visual disabilities will have improved access to the web. UAAG 1.0 explains the responsibilities of user agents in meeting the needs of users with disabilities.

6.2 *Section 508*

American Law for regulations of US web sites Section 508[14] requires that Federal agencies' electronic and information technology be accessible to people with disabilities. The law requires Federal agencies to purchase electronic and information technology that is accessible to employees with disabilities, and to the extent that those agencies provide information technology to the public, it too shall be accessible by persons with disabilities.

The final Section 508 rule includes so-called *functional* standards that require, for example, that there be a way for a person who is mobility impaired or blind to use your product or web site. In addition, and more importantly, the Section 508 standards say your web site has to satisfy sixteen *specific* items for web accessibility. Eleven of them are drawn directly from the WAI WCAG, in some cases using language more consistent with enforceable regulatory language. Five of the 508 standards do not appear in the WAI checkpoints and require a higher level of access or give more specific requirements. On the other hand, there are four priority 1 WAI checkpoints that were not adopted by the Access Board.

6.3 *The Italian legislation*

The law 4/2004 of 9th January 2004 requires that impaired people should not be discriminated against and must have access to the services supplied using ITC technologies[15]. The definition of the technical rules was quite

[12] http://www.w3.org/TR/ATAG20/.
[13] http://www.w3.org/TR/UAAG10/.
[14] http://www.section508.gov/.
[15] http://www.pubbliaccesso.it/normative/law_20040109_n4.htm.

a complex task, as the most authoritative reference was WCAG 1.0, which is the only referable W3C document, but it is tied to HTML and was issued some years ago, while WCAG 2.0 is still in progress. The "Italian way" has been aware of the need to harmonize and to define a set of rules that could be referred to in case of controversy. It was also considered that some WAI checkpoints can be automatically verified by imposing a strict conformity to formal grammars (e.g. XHTML).

The technical rules provide for *technical/heuristic* and *subjective/empiric* accessibility checking. Definition of specifications took into account international standards and guidelines, Universal Design principles, scientific literature. Heuristic evaluation requires that a certain number of appropriate requisites have to be checked by an expert, using automated or semi-automated tools. Empiric evaluation considers several characteristics, and can result in assigning different levels of accessibility, above the minimum level gained at the heuristic evaluation stage.

Many of these characteristics refer to general usability principles, like perception, use, consistency, safety, security, transparency, fault tolerance, etc. The most relevant point regarding the empiric evaluation is that beside the evaluation by an expert, done using the cognitive walkthrough method, there will be an in depth involvement of the users, setting up an appropriate user panel where people with disabilities must be included. It is suggested that users shall be involved from the early stages of development.

7. Web Content Accessibility Guidelines

7.1 *WCAG 1.0*

WCAG 1.0 was issued in 1999, and is universally recognized as an authoritative document about accessibility. These guidelines are widely described in the literature and likely well known to any web designer; therefore we will not go into details. We wish to point out however that they are organized in 14 guidelines, and each guideline has a certain number of checkpoints (65 in total) arranged according to three priority levels. Conformity levels are A, AA and AAA, respectively when all priority 1, or 1 and 2, or 1, 2 and 3, are satisfied.

7.2 *WCAG 2.0 principles and guidelines*

The WCAG 2.0 Guidelines are organized according to four *principles* which lay the foundations necessary for anyone to access and use web content, offering information about how to increase the ability of people with disabilities to *perceive*, *operate*, and *understand* web content. Under each principle there is a list of guidelines addressing the principle.

– Content must be perceivable.
    Provide text alternatives for all non-text content
    Provide synchronized alternatives for multimedia
    Ensure that information and structure can be separated from presentation
    Make it easy to distinguish foreground information from its background

– Interface components in the content must be operable.
    Make all functionality operable via a keyboard interface
    Allow users to control time limits on their reading or interaction
    Allow users to avoid content that could cause seizures due to photosensitivity
    Provide mechanisms to help users find content, orient themselve within it, and navigate through it
    Help users avoid mistakes and make it easy to correct mistakes that do occur

– Content and controls must be understandable.
    Make text content readable and understandable
    Make the placement and functionality of content predictable

– Content should be robust enough to work with current and future user agents (including assistive technologies).
    Support compatibility with current and future user agents (including assistive technologies)
    Ensure that content is accessible or provide an accessible alternative

Under each guideline there are *success criteria* used to evaluate conformity to this standard for that particular guideline. The success criteria are written as statements that will be either true or false when specific web content is tested against the success criteria, and are grouped into three levels of conformity (see below). They are all testable: some by computer programs, others by qualified human testers, sometimes by a combination of the two[16].

The principles, guidelines, and success criteria represent concepts that address accessibility issues and needs, regardless of the technology used. This approach makes it possible to apply WCAG 2.0 to a variety of situations and technologies, including those that do not yet exist. WCAG 2.0, therefore, does not require or prohibit the use of any specific technology. It is possible to conform to WCAG 2.0 using both W3C and non-W3C technologies, as long as the technologies are supported by accessible user agents, including assistive technologies.

[16] Several success criteria require that content (or certain aspects of content) can be *programmatically determined*. This means that the author is responsible for ensuring that the content is delivered in such a way that software can access it. This is important in order to allow assistive technologies to recognize it and present it to the user, even if the user requires a different sensory modality than the original. For example, some assistive technologies convert text into speech or Braille. This will also allow content in the future to be translated into simpler forms for people with cognitive disabilities, or to allow access by other agent based technologies. This can happen only if the content itself can be programmatically determined.

7.3 *The baseline concept in* WCAG 2.0

In choosing web technologies (HTML, scripting, etc.) that will be used when building content, authors need to know what technologies they can assume will be supported by, and active in, the user agents[17] (including assistive technologies) that people with disabilities will be using. If authors rely on technologies that are not supported, then their content may not be accessible.

The set of such technologies that an author assumes are supported and turned on in accessible user agents is called a *baseline*. Authors must ensure that all information and functionality of the web content conforms to WCAG 2.0 assuming that user agents support all of the technologies in the baseline and that they are enabled. Authors may use technologies that are not in the specified baseline, but shouldn't rely exclusively on those technologies for conveying any information or functionality[18]. Also, all content and functionality must be available using only the technologies in the specified baseline, and the non-baseline technologies do not interfere with (break or block access to) the content when used with user agents that only support the baseline technologies or that support both the baseline and the additional technologies. Both conditions are necessary since some users many have browsers that support them while others may not.

Baselines may be set by many different entities including authors, organizations, customers, and governmental bodies, and may also vary by jurisdiction.

WCAG 2.0 does not specify any particular baseline, because what is appropriate in a baseline may differ for different environments and therefore different scenarios lead to different baselines: in some cases it may be possible to assume that user agents support more advanced technologies, in other cases a more conservative level of technology may be all that can be reasonably assumed. Finally, the level of technology that can be assumed to be supported by accessible user agents will certainly change over time.

An organization which publishes information intended for the general public will specify a baseline which includes only technologies that have been widely supported by more than one accessible and affordable user agent for more than one release. Periodically the baseline required for authors of public sites will change to reflect the increasing ability of affordable user agents (including assistive technology) to work with newer technologies.

[17] The term *user agent* means: «any software that retrieves and renders web content for users». This may include web browsers, media players, plug-ins, and other programs, including assistive technologies, that help in retrieving and rendering web content. It is important to note that this definition includes assistive technologies, hence screen readers, screen magnifiers, on-screen and alternative keyboards, single switches, voice recognition, and a wide variety of input and output devices that meet the needs of people with disabilities.

[18] Additional information on baselines can be found at http://www.w3.org/WAI/WCAG20/baseline/.

A museum providing all visitors with user agents that support newer technologies will be able to specify a baseline that includes these newer technologies.

An organization (public or private) could provide its employees with the information technology tools they need to do their jobs. The baseline for intranet sites used only by employees includes newer technologies that are supported only by the user agent that the organization provides for its employees. Because the company controls the user agents that will view its internal content, the author has a very accurate knowledge of the technologies that those user agents (including assistive technologies) support.

It is important to stress that baselines are not specified in terms of specific user agents, but in terms of the web content technologies that are supported and enabled in those user agents (including assistive technologies).

7.4 *Conformance to WCAG 2.0*

Conformance means that web content satisfies the success criteria defined in the WCAG 2.0 document. The success criteria for each guideline are organized into three levels. Level 1 and 2 can be applied reasonably to all web content, and achieve *minimum* or *enhanced* level of accessibility respectively. Level 3 achieves *additional accessibility enhancements*, and is not necessarily applicable to all web content.

We note that because not all level 3 success criteria can be used with all types of content, Triple-A conformance only requires conformance to a portion of level 3 success criteria, and guidelines do not necessarily contain success criteria at every level. Assuming user agent support for only the technologies in the specified baseline, conformance levels A and AA are achieved when all level 1, or all level 1 and 2 are satisfied. Level AAA requires, in addition, that at least 50% of level 3 success criteria are met.

Conformance claims apply to web units[19], and sets of web units. They are not required, but if present must include several assertions, like date of the claim, guidelines title/version, conformance level satisfied (Level A, AA or AAA), baseline used to make the conformance claim and scope of the claim. Some others components can be added to a conformance claim. Among them, a list of user agents that the content has been tested on (including assistive technologies), information about audience assumptions or target audience. This last could include language, geographic information, or other pertinent information about the intended audience, but *cannot specify anything related to disability or to physical, sensory or cognitive requirements*.

[19] A web unit is any collection of information, consisting of one or more resources, intended to be rendered together, and identified by a single Uniform Resource Identifier (such as a URL). Web pages are the most common type of web unit. The broader term was chosen because it covers web applications and other types of content to which the word "page" may not apply. For example, a web page containing several images and a style sheet is a typical web unit.

7.5 *Confronting WCAG 1.0 and WCAG 2.0*

The method of grouping success criteria differs in important ways from the approach taken in WCAG 1.0. Each checkpoint in WCAG 1.0 was assigned a "priority" according to its impact on accessibility. Thus, Priority 3 checkpoints appeared to be less important than Priority 1 checkpoints. As the WCAG Working Group believes that all success criteria of WCAG 2.0 are essential for some people, the system of checkpoints and priorities used in WCAG 1.0 has been replaced by success criteria under Levels 1, 2, and 3 as described above. Note that even conformance to all three levels will not make web content accessible to all people.

8. Towards accessible Rich Internet Applications

There is presently a great emphasis on dynamic web content, which however can cause problems to people with disabilities. Rich Internet Applications (RIA) can be defined as: «web applications that have the features and functionality of traditional desktop applications». RIAs typically transfer the processing necessary for the user interface to the *web client* but keep the bulk of the data (i.e., maintaining the state of the program, the data, etc.) back on the application server.

Accessibility is often dependent on Assistive Technology (AT) tools that provide alternate modes of access for people with disabilities by transforming complex user interfaces into an alternate presentation. This transformation requires information about the role, state, and other semantics of specific portions of a document to be able to transform them appropriately. Rich web applications typically rely on hybrid technologies such as DHTML and AJAX that combine multiple technologies: SVG, HTML and JavaScript for example. Until now, the accessibility regulations discouraged the use of JavaScript, which is, however, found in the majority of web sites.

One of the main accessibility issues is that authors don't have the ability to provide the appropriate accessibility information in the markup (like HTML or SVG) to support the accessibility APIs on the target platform. W3C will address some of these issues through the introduction of declarative markup, which has the added benefit of reducing the enablement effort by authors through leveraging the existing accessibility information stored in these markups to offload some of the accessibility work to the User Agent. A recent work inside W3C, leading to a Roadmap for Accessible Rich Internet Applications (WAI-ARIA Roadmap)[20] has the goal of building a bridge which

[20] http://www.w3.org/TR/2006/WD-aria-roadmap-20060926/.

will fill the accessibility gaps on today's HTML markup which will lead to broad applicability to today's markup while moving forward with declarative markup.

A GUI Role Taxonomy specification, currently under development and written in RDF, will contain roles which are representative of document structure, necessary for assistive technologies to navigate complex documents and to know when entering active areas of a web page.

The various technologies provide much but not all of the information needed to support AT adequately. The XHTML Role attribute module[21] has been designed to be used to help extend the scope of XHTML-family markup languages into new environments. It provides a web-standard way to identify roles in dynamic web content, resulting in an interoperable way to associate behavior and structure with existing markup. The attributes defined in the WAI-ARIA States and Properties specification[22] enable XML languages to add information about the behavior of an element. States and Properties are used to make interactive elements accessible, usable and interoperable, by declaring important properties of an element that affect and describe interaction.

These properties enable the user agent or operating system to properly handle the element, even when these properties are altered dynamically by scripts. The user agent may map the States and Properties to the accessibility frameworks (such as a screen reader or accessibility API of the operating system) that use this information to provide alternative access solutions, or can change the rendering of content dynamically using different style sheet properties. The result is an interoperable method for associating behaviors with document-level markup.

9. Semantic interoperability

Accessibility issues are of concern for everyone in some stage of his/her life, but also can be the object of more general considerations, mainly related to *cross culture* and *internationalization* issues, often neglected by web designers. Names, dates, colors, etc., all can have a different meaning in a multicultural distributed environment. For example, *dates* are based on different calendars in different cultures (western, Islamic, Jewish), and, even in the same culture, like the western one, USA and European formats differ. Internationalization is also an issue, as different alphabets or writing directions (left to right or right to left) can be needed. Finally, we can't ignore that in presenting information an *implicit knowledge* is often assumed.

[21] http://www.w3.org/TR/xhtml-role/.
[22] http://www.w3.org/TR/aria-state/.

At the inaugural Museums and Web conference in 1997, a possible scenario for preserving our cultural heritage and enhance the world's access to it was presented (FINK 1997). The envisaged scenario for 2005 was that successful models for integrating our cultural heritage would exist, and any user would be «able to search the online universe seamlessly as if the images and text about culture were available in one vast library of information». To overcome search barriers, some crucial developments were supposed to take place:

– Joining of cultural information with that of other institutions.
– Information architecture for effective integration of cultural heritage resources, therefore identification of metadata that could help establish deeper and more intelligent links across the digital resources available on the web, and agreement on metadata standards for cultural heritage information.
– Providing vocabularies and tools to help navigate the online universe more effectively, overcoming language differences, spelling variations, and vernacular preferences.
– Resolving intellectual property rights issues.
– Definition of universal guidelines and practices for gathering, digitizing, storing, and distributing images and textual information.

The paper also pointed out that technology is not the chief barrier to this vision, rather, the main obstacle is the need for cultural organizations to become willing to collaborate and form new partnerships. «Working alone, we can produce a lot of impoverished weed patches that, given the competition from the business and entertainment sectors, no one will want to visit. Working together, we can create a magnificent garden with something for everyone».

About ten years later we can see how the scenario has changed and goals have been achieved. There has been a major effort made towards uniting cultural information, implementing appropriate aids as authority files, thesauri, iconographic classification systems, common description schemas. However, the efforts towards a *unified schema* have all failed, as scholars have well established and solid cultural traditions, and are reluctant to accept a schema different from their own.

Many initiatives moved towards data integration and metadata standards, but metadata vocabularies tend to diverge, and probably cannot exploit the full richness of possible semantic associations. A more useful approach is to attempt to formulate a language as a basis for "understanding". This is what we can define as a *core ontology* which incorporates basic entities and relationships common to the diverse metadata vocabularies. Both a core ontology and *core metadata*, such as Dublin Core[23], are intended for information integration, but they differ in the relative importance of human understandability.

[23] Dublin Core Metadata Initiative, http://www.dublincore.org/.

Metadata is in general thought for human processing, while a core ontology is a formal model for automated tools that integrate source data and perform a variety of functions. Vocabularies based on ontologies that organize the terms in a form that has clear and explicit semantics can be reasoned over, which is a fundamental process in enriching knowledge, inferring new information about resources. CIDOC Conceptual Reference Model[24] is a formal ontology for cultural heritage information specifically intended to cover contextual information. It can be used to perform reasoning (e.g. spatial, temporal).

In the past years, a big emphasis has been put on XML data structuring, but everyone realizes that XML is semantically poor. The Semantic Web stack higher levels technologies (RDF[25], OWL[26], etc.) can supply the appropriate technical environment to *represent*, *export* and *share* the knowledge needed to implement intelligent retrieval and browsing systems and reason upon data. In the peer-to-peer web architecture, Semantic Web technologies allow fully decentralized semantic markup of content (for example, using classes and properties defined in CIDOC-CRM). Intelligent software agents can then use knowledge expressed by the markup.

Once again, technologies pushed by W3C support the fulfillment of the ambitious goal of reaching a true semantic interoperability.

10. Conclusion

Virtual museums must support a large variety of users, differing in personal abilities and cultures. Disability is an impairment, activity limitation or participation restriction that can apply to everyone in some stage of her/his life. The web can result in an unprecedented access to information, resulting in the promotion of the culture of e-inclusion, if sites are designed for usable accessibility. Several national regulations require that web sites be accessible, and W3C is defining the new technical specifications for accessibility and a roadmap for accessible rich internet applications. W3C technologies can still support accessibility in graphics (including GIS) and multimedia. Besides the technical accessibility we must consider the need for a semantic interoperability to overcome cultural differences. Semantic Web technologies can help in reaching the ambitious goal of representing, exporting and sharing knowledge.

[24] The CIDOC Conceptual Reference Model, http://cidoc.ics.forth.gr/.
[25] Resource Description Framework (RDF), http://www.w3.org/RDF/.
[26] Web Ontology Language (OWL), http://www.w3.org/2004/OWL/.

APPENDIX

SOME EXAMPLES

In this Appendix we will briefly discuss some accessibility features of W3C Recommendations in the areas of 2D graphics and multimedia (namely SVG[27] and SMIL[28]). The interested reader is referred to the original documents for a more detailed description[29] of their accessibility features.

It should be recalled that the *alternative text content* is most valuable to users with a wide range of disabilities, as it may be rendered on the screen, as speech, or on a refreshable Braille display, and can be easily indexed to be subsequently processed by search engines.

1. Accessibility features of SVG

Scalable Vector Graphics is an Extensible Markup Language (XML) application for producing web graphics. SVG provides many accessibility benefits to disabled users, some originating from the vector graphics model, some inherited because SVG is built on top of XML, and some in the design of SVG itself. In the following, we will just briefly recall some of the SVG accessibility features. We think that it is important to stress how SVG can be the basis for GIS applications, resulting in effective and light applications.

SVG images are *scalable* and can be zoomed and resized by the reader as needed, so helping users with low vision and users of some assistive technologies (e.g., tactile graphic devices, which typically have a very low resolution).

The most common way authors make a raster image (e.g., GIF or PNG images) accessible on the web is to provide a text equivalent that may be rendered with or without the image. Often, this text equivalent is the only information available for non-visual rendering, as the raster image is stored as a matrix of colored dots, generally with no structural information. SVG's vector-graphics format stores structural information about graphical shapes, eventually complemented by alternative equivalents and metadata, as an integral part of the image. This is much less tedious than managing it separately, and makes it more likely that authors will create and use it with greater attention. This information can be used by assistive technologies to increase accessibility.

An SVG image is an XML document, hence it is a *structured document* which may consist of several *logical components* combined hierarchically, each of which may have a text *description* and a *title* to explain the *component's role* in the image as a whole. The combination of the hierarchy and alternative equivalents can help a user who cannot see to create a rough mental model of an image. SVG authors should therefore build the hierarchy so that it reflects the components of the object illustrated by the image.

The *rendering* of SVG images can be defined differently for different media. This is beneficial for accessibility as people with disabilities often use assistive technologies. For instance some media such as screens are suited to high-resolution graphics, while other media such as Braille are better suited to lower resolution graphics, and some people use audio instead of graphics. Authors can provide a variety of ready-made stylesheets to cover different user needs (for example audio rendering). CSS can be used to provide an appropriate default presentation for all these different devices.

The more information the author can provide about an SVG image and its components the better it is for accessibility. Adding *metadata* to a document can help the user search for information, for example documents with a suitable accessibility rating.

[27] http://www.w3.org/TR/SVG/.

[28] http://www.w3.org/TR/2005/REC-SMIL2-20051213/.

[29] http://www.w3.org/TR/SVG-access for SVG, and http://www.w3.org/TR/SMIL-access/#ref-SMIL10 for SMIL.

2. Accessibility in multimedia

Multimedia presentations rich in text, audio, video, and graphics are very common in virtual museum sites. There are several accessibility challenges to people with disabilities and to authors in creating and accessing dynamic multimedia. First of all, authors must provide *alternative equivalent content* to audio and video so that users with visual or auditory impairments may make use of the presentation. Such alternatives to video and audio content must be *synchronized* with video and audio tracks. Should they be improperly synchronized, the presentation may be confusing or even unusable. Secondly, a presentation may occupy *multiple sensory channels* (eyes, ears, and touch) in parallel, and therefore any content, including the alternative one, that is presented to a given sense must be coordinated to ensure that it remains intelligible when rendered with other content meant for that sense. Finally, in a synchronized multimedia *content changes without user interaction*, posing an orientation challenge to some users with blindness, low vision, or cognitive disabilities. These users may still access a presentation as long as the author has provided adequate alternatives and players allow sufficient control over the presentation.

Formats such as SMIL can be used to create dynamic multimedia presentations by synchronizing the various media elements in time and space. Authors can make SMIL presentations accessible to people with combinations of visual, auditory, physical, cognitive, and neurological disabilities by observing the principles discussed in WCAG, creating documents that account for the diverse abilities, tools, and software of all web users. This does not mean creating a great number of separate presentations but rather one integrated and accessible presentation.

Responsibility for making SMIL presentations accessible lies part with the author and part with the user's software (the SMIL player). Authors must include equivalent alternatives for images, video, audio, and other inaccessible media, must synchronize media objects correctly and describe relationships among objects, should design documents that transform gracefully for players that do not support a particular feature, and so that players can ensure user control of rendering.

User control of presentation and configuration are central to user agent accessibility, therefore SMIL players must allow users to control document presentation to ensure its accessibility, even if that means overriding the author's preferences. For instance, users with low vision must be able to enlarge a presentation and users with color deficiencies must be able to specify suitable color contrasts. Players must provide users access to author-supplied media objects, their accessible alternatives, or both. Users must also be able to turn on and off alternatives (e.g., captions and auditory descriptions) and control their size, position, and volume. For instance, users with both low vision and hearing loss must be able to enlarge text captions. Users might also want to specify how to render synchronized audio tracks, for instance, by changing the volume or other available attributes of an auditory description to distinguish it from the audio track.

Since users with some cognitive disabilities or people using combinations of assistive technologies such as refreshable Braille and speech synthesis may require additional time to view a presentation or its captions, players must allow them to start, stop, and pause a presentation (as one can do with most home video players). Where possible, users should be able to control the global presentation rate.

Multimedia presentations may include two main types of equivalent alternatives: discrete and continuous. *Discrete* equivalents do not contain any time references and have no intrinsic duration, while *continuous* equivalents, such as text captions or auditory descriptions, have intrinsic duration and may contain references to time. Continuous equivalents may be constructed out of discrete equivalents, and must be synchronized with other time-dependent media.

Discrete text equivalents, when rendered by players or assistive technologies to the screen, as speech, or on a dynamic Braille display, allow users to make use of the presentation even if they cannot make use of all of its content. For instance, providing a text equivalent of an image that is part of a link will enable a blind person to decide whether to follow the link. Authors specify discrete text equivalents for SMIL elements through attributes like alt (a short text equivalent that conveys the same function as the media object), longdesc (a link to a long, more complete description of media content, useful for descriptions of complex content, such as charts and graphs, or to designate a text transcript of audio and video information), or title (used, for example, to describe the target of a link). Other SMIL attributes including author and abstract specify text metadata about document elements, and are useful to promote accessibility by providing more context and orientation.

Two *continuous equivalents* that promote accessibility are captions and auditory descriptions. A *caption* is a text transcript of spoken words and non-spoken sound effects that provides the same information as a presentation's audio stream and is synchronized with the video track of the presentation[30]. An *auditory description* is a recorded or synthesized voice that describes key visual elements of the presentation including information about actions, body language, graphics, and scene changes[31]. Both captions and auditory descriptions must be synchronized with the video stream they describe, as well as with other audio streams. Auditory descriptions are generally timed to play during natural pauses in dialog. If these natural pauses are not long enough to accommodate a sufficient auditory description, it will be necessary to pause the video in order to provide enough time for an extended auditory description. At the end of the description, the video should resume play automatically[32].

The following example is a movie that consists of four media object elements: a video track, an audio soundtrack, and text streams of captions and Latin language terms. All the elements are to be played in parallel due to the `<par>` element. The captions will only be rendered if the user has turned on captioning.

```
<par>
<audio alt="The everyday life in ancient Rome, English audio"
       src="lifeInRome.rm" />
<video alt="The everyday life in ancient Rome, video"  src="video.rm" />
<textstream alt="glossary of common use latin terms" src="glossary.rt" />
<textstream alt="English captions for the everyday life in ancient Rome"
           system-captions="on"
           src="lifeInRome-caps.rt" />
</par>
```

SMIL allows authors to create *multilingual presentations* by using subtitles and overdubs (which are text and audio streams respectively) in another language. Multilingual presentations themselves do not pose accessibility problems. Providing additional tracks (even in a different language) will instead help many users.

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[30] Captions benefit people who are deaf, hard of hearing, or who have auditory learning disabilities, and also benefit anyone in a setting where audio tracks would cause disturbance, where ambient noise in the audio track or listening environment prevents them from hearing the audio track, or when they have difficulties understanding spoken language.

[31] Auditory descriptions benefit people with blindness, low vision, or some kinds of visual perceptive learning disabilities. They also benefit anyone in an eyes-busy setting or whose devices cannot show the original video or graphical media object.

[32] Interested readers are refered to the National Center for Accessible Media (NCAM): http://ncam.wgbh.org/.

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ABSTRACT

A virtual museum is a real challenge, especially when the goal is to contextualize its content and overcome physical, cognitive and cultural hurdles. A good user interface should provide everyone with an equivalent experience, irrespective of their disabilities. On the other hand, disability is a stage in everyone's life. Web accessibility has several components, and is not merely a technical issue. A good quality web site should be designed for usable accessibility, considering both usability and accessibility issues, giving to the disabled user the sense of inclusion and equal opportunity to participate. Web accessibility has been a concern to several governments, and in many countries accessibility is required by law. The World Wide Web Consortium (W3C) has provided web accessibility guidelines since the birth of the web, addressing all the web accessibility components. Presently a new release of WCAG is going to be issued, characterized by several important novelties (baseline, conformance level, etc.), which will be a big step forward from the previous WCAG. W3C Recommendations also include some accessibility features for 2D graphics and multimedia. The Rich Internet Applications are emerging, and W3C defined a roadmap towards a declarative markup. To overcome the difficulties related to different cultures, Semantic Web technologies and ontologies can give the appropriate support for exchanging and sharing knowledge.