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ADAPTABILITY AND ACCESSIBILITY: A NEW FRAMEWORK

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ABSTRACT

This paper presents a new framework for accessibility based on a broad framework for metadata about adaptability. Accessibility is generally associated with the needs of people with disabilities while adaptability includes, for example, the transformation of digital resources and services for users as they change from one access device to another, as is the case when one uses a telephone instead of a desktop computer screen to display a web page. Adaptability with accessibility in mind involves more than device compatibility as it takes into account user's individual needs at the time of delivery of resources and services.

KEYWORDS: *OZCHI 2005, adaptability, accessibility, user needs and preferences, AccessForAll, mobile and ubiquitous computing.*

1. INTRODUCTION

Accessibility has been defined many ways and there have been many attempts to increase the accessibility of digital resources and services. Despite all these efforts, the level of accessibility of digital resources and services continues to be very low. Recently recognition of the importance and widespread extent of accessibility issues has increased as a result of Microsoft research[i] and the failure of current practices to solve the problem has been shown in formal research[ii]. Accessibility is only one reason for resource flexibility. Other situations such as those involving multi-lingual users, multiple international and local locations, educational preferences and more should be enabled as well if the technology is capable.

The move to support distributed, cumulative authoring of accessible content is promising to suit application and assistive technology developers and publishers better than established practices and also to better promote the needs of individual users. This approach, known as the AccessForAll approach, is best located in a framework that is wider than mere accessibility and includes general adaptability. It has the advantage that accessibility and more general adaptability can be managed in the same way. This paper is concerned with adaptability with accessibility in mind. The driver for the new framework has been accessibility but the aim is to use that as motivation for what will be useful in a wide range of situations.

In order to manage adaptability, accessible components are required and their identification, organization and delivery needs to be managed using light-weight keys that can be shared and shipped about quickly and easily in anticipation of the final enjoyment of the resource or service by the user. This means structured machine-readable labelling of service and resource components using what is known as metadata. Within the HCI community worldwide, it is common to find metadata used to describe resources as it is in other disciplines but it is not common to find metadata being used to manage the matching of resources to other than information queries. There are many examples of users being classed by systems in one way or another and resources being served to them according to perceived needs or customised interfaces. The unusual quality of the framework being proposed is that it uses 'descriptive' data (metadata) to achieve the individualisation goals. Further, it aims for interoperability of this metadata

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to enable distributed, cumulative authoring and reformation of resources matching distributed, dynamically modified descriptions of user needs and preferences.

The pioneering research[iii] that supports the new framework has been conducted over the last three years mainly by a team involving the author. It has been undertaken in collaboration with the IMS Global Consortium[iv] acting as the host and other organisations such as the Dublin Core Metadata Initiative[v], CEN ISSS Learning Technologies Standards Committee of the Learning Technologies Workshop[vi], WGBH National Center for Accessible Media[vii] and others building, in particular, on the work of the Adaptive Technology Resource Centre[viii] at the University of Toronto and the W3C Web Accessibility Initiative[ix]. It is currently under consideration by the International Standards Organisation Joint Technical Committee 1, Steering Committee 36[x] for implementation as a standard for education. Interestingly, this work involves consensus among many international organisations and sectors of the community whose endorsement and adoption ultimately demonstrate 'prove' its validity.

1.1. Research Methodology

John Seely Brown, as the Director of Xerox Palo Alto Research Center described research as of two kinds: sustaining and pioneering. Sustaining research involves the careful analysis of the status quo, to determine for instance, its effectiveness. There are well-established methodologies for this work. The other kind of research, he described as pioneering. It is creative of new ideas, products and is not capable of being referenced in the present because it will need to find its place in the future. The computer 'mouse' is a typical product of pioneering research: it did not evolve from precedent but was an innovation without a past. Pioneering research is usually tested by the future, whether or not it is adopted and how well it is integrated into the practices of the future.

The research described in this paper is innovative and collaborative, and builds upon similar work that has been underway for the last decade, as scientists have struggled to find a way to make the Web accessible to everyone so all can participate in the 'information age' equally. It is typical of the research that is at the cutting edge of Web development. Its value will be determined by 'sustaining' research in the future.

The proposed new framework is described showing how accessibility will be increased if it is adopted. Accessibility, adaptability and metadata are defined and described before the advantages of the new approach are discussed.

2. THE ADAPTABILITY FRAMEWORK

2.1. Adaptation for Accessibility

Users request resources and services using a range of software and hardware devices. In most cases, there are constraints built into the devices such as the maximum size of the screen, the size of the buttons for the keyboard, and the number of buttons on a mouse. In addition, there are settings within those constraints that users can select for their device. This means that resources with mixed modality components, such as a web page with an image, some text and some auditory content, may have to be decomposed so components of one of more modalities, such as an image, can be replaced by components in a modality the device can present or the user can sense. Of course, the alternative component has to be suitable, to be discovered, and to be fitted into the original resource.

Discovery of suitable content is only one aspect of the exercise. It may not exist, in which case it has to be created either afresh or as the result of a transformation from something that does already exist.

Images, for instance, are often of fixed size and may need to be enlarged for projection in public presentations, or made smaller for devices that cannot display them appropriately, such as telephone screens. Images come in a variety of formats: raster images are difficult to re-size in ways that improve the visibility of the image because the increased size of representation of the pixels does not increase clarity of the image (Figure 1). By comparison, a vector image drawn according to instructions, can be re-sized with far less damage, as shown. This example shows not only the value of changing format for the image, but the ease of transformability of the component available in some formats.

Many visual, auditory and tactile components can be modified for presentation, as in being made louder, bigger, or whatever, but when the modality itself is not suitable, more significant problems arise. Text is considered to be a visual component but it has the special quality that it can be transformed into other modalities such as sound, using a screen reader, or tactile form, using a Braille output (with exceptions noted below). Text contained in an image cannot be transformed unless or until it has been reproduced as computer text.

Figure 1: Two formats of the same image

The modality and format of content is thus a significant factor in the technical adaptability of resources and services. Adaptability depends on the adaptability of the content components of the resources and services, and often on the choice of components. Similarly, the adaptability of resources and services depends upon their being able to be controlled in a variety of ways.

Digital resources and services require some interaction on the part of (or for) the user. Some devices place constraints on the user interactions by offering particular input/output mechanisms but often even these are modifiable by the user, so devices will have generic settings and user selected settings.

The display or presentation of resources and services must vary according to access device and software capabilities (see Figure 2). It is not obvious how to fit a page of a digital newspaper on to a telephone screen. While having a navigation bar at the top is suitable for many devices, having to work through all the links to get to the substantive content is inappropriate when the content is being displayed on a phone.

Figure 2: A single resource can appear very differently as access devices change[xi]

In summary, there are three dimensions of adaptability that are relevant to accessibility: content, presentation and control.

2.2. AccessForAll definition

Accessibility is defined in this paper and elsewhere as the matching of digital resources and services to the needs and preferences of the user. The definition's authority exists in the field of accessibility of digital resources as well as in the more traditional area of physical access to the built environment. AccessForAll is about the relationship between a resource and its user. It is not a fixed quality of a resource. Resources can be adapted right up until the moment of delivery. The definition places emphasis on what is delivered and does not impose an absolute measure of accessibility on resources and services. It provides for the just-in-time provision of accessible components where the time taken is specified, as in the case of a university that may specify a maximum time from the request for the resource or services. It also provides for satisfaction of the accessibility by the disassembling of the original resource or service and substitution or augmentation with components from third parties.

Most people who have difficulties with one device or another shy away from that device in preference to another that works for them. Rarely are their difficulties recorded. People who have no choice but to use certain devices can be very dependent upon those devices and even slight changes in settings that modify their requirements can be fatal to their ability to use the device and access the resource or service they seek. Their needs can be vital and their preferences may be used to determine what to do in cases of mismatches or near misses.

Accessibility adds a human dimension to the adaptability framework. There is nothing that is required that is not already catered for in the general adaptability framework, but the requirements are explicitly derived from the individual user. Device and software requirements for resource and service components are modified by individual human needs and preferences. While adaptability in general requires matching of resources and services to device capabilities and settings, there may be relevant human factors such as that although the device can project sound, the user is in a noisy place and will not be able to hear any sound. The resource that contains sound will therefore have to be presented in a range of forms for the user(s) according to their device characteristics, their settings and their context: what is defined here as their AccessForAll personal needs and preferences[xii] (PNP).

PNPs vary in the ways that they extend the range of relevant adaptability factors. While a text description of a tiger's image may be appropriate in some cases, as where the image is used in a coat of arms to signify fierceness (a cultural reference) or in a football context to identify a particular team (a local reference) or in a diagram to indicate relative sizes, a blind user depending on a description will probably need more than the description of the tiger in the image to interpret the image. In other words, cultural, location-based, idiomatic and other factors that guide interpretation might not work for someone who does not know their context. Teaching early mathematical principles by doing computer-aided geometry is particularly effective for sighted students but algebra may be better for blind students. People who are dyslexic often find it easier to comprehend content that has reduced text and increased graphical representations.

According to the proposed definition, the extent to which the adaptability of modality and format supports an individual user's needs and preferences at the time of delivery will determine the accessibility of the resource or service. In addition to device and device settings that constrain the control of resources and services, users often have limitations as have already been referred to: the volume of the device may not be sufficient for the user even if it is the maximum offered by the device because they may be in a noisy context. So, just as the adaptability of resources and services depends upon their being able to be controlled in a variety of ways, their accessibility depends upon this being done according to individual user needs.

As well, users may have limitations beyond those of their devices, as in the case of colour-blind users, or users who need on-screen keyboards to accommodate head-pointers and so cannot allow presentation windows to occupy all the screen 'real estate'. Such needs and related preferences do not need to be described by their causes, simply to be described for their requirements.

This definition is designed to include users with disabilities who may have requirements beyond those of device and software capabilities but it is not intended to suggest that only certain people qualify for consideration of their needs and preferences.

According to the WHO International Classification of Functioning, Disability and Health (ICF- May 2001) disability is not entirely an attribute of an individual, but rather a complex social and environmental construct largely imposed by societal attitudes and the limitations of the human-made environment. Consequently, any process of amelioration and inclusion requires social action, and it is the collective responsibility of society at large to make the environmental and attitudinal changes necessary for their full participation in all areas of life.xiii

2.3. The scale of the accessibility problem

While in 2004 the European Commission considered that disability included "People with: - cognitive, learning and developmental difficulties - deafness, hearing impairment; - blindness, visual impairment or partial sight; - deaf-blindness; - speech and language impairments; - physical disabilities" and "The current estimate of prevalence of disability is 10-15%, Microsoft was commissioning a study that led to a far greater recognition of the need for, and value of, attention to accessibility.

In a 2003 study for Microsoft, the overall population in the age range 18 to 64 years in the US was found to be divided into the following four groups: those with severe, mild, minimal and no difficulties, in the following proportions: 25% with severe, 37% with mild, and 37% with minimal or no difficulties xiv.

In summary, the report claims:

In the United States, 60% (101.4 million) of working-age adults who range from 18 to 64 years old are likely or very likely to benefit from the use of accessible technology due to difficulties and impairments that may impact computer use. Among current US computer users who range from 18 to 64 years old, 57% (74.2 million) are likely or very likely to benefit from the use of accessible technology due to difficulties and impairments that may impact computer use.

The report also states:

The fact that a large percentage of working-age adults have difficulties or impairments of varying degrees may surprise many people. However, this study uniquely identifies individuals who are not measured in other studies as "disabled" but who do experience difficulty in performing daily tasks and could benefit from the use of accessible technology.

Note that many or most of the individuals who have mild difficulties and impairments do not self-identify as having an impairment or disability. In fact, the difficulties they have are not likely to be noticeable to many of their colleagues.[xv] These statistics do not account for the aged or aging rate of the community and they do not account for the increasing ownership of multiple devices and their complexity.

3. ACCESSIBLE RESOURCES AND SERVICES

As resources and services are composite objects, it is essential that the components to be delivered within them are accessible.

3.1. Alternative and equivalent content components

Where the content component is altered from one modality to another, it is usually described as being an alternative to the first. The alternative may be a transformation of the original, as when text is rendered as speech by a screen-reader, or it may be provided as an alternative in a different modality, as when a long description of an image is made available for substitution for some users. The only significant distinction here is between alternatives that are provided as part of the original resource and those that are authored later or are located elsewhere. Alternatives that are chosen because they are equivalent in effect to the original but not merely alternative forms of the original are known as equivalent alternatives. A teacher may choose an equivalent alternative for a student who has not got an appropriate background for using an original exercise: so a user may choose an equivalent alternative or automatically be provided with one when information about the resource suggests this is necessary. In addition, many users with disabilities find that they need supplementary materials if they are to make use of a resource or service. Provision of dictionaries and thesauri, for example, may make the difference for some users.

3.2. Text components

Text components can be transformable but are not necessarily so. Text can be embedded within presentation constraints in ways that make it difficult for changes to be made to that presentation. For example, documents prepared in Microsoft Word and transformed into web pages are often encoded so that the original presentation form survives. This makes it difficult for a user to change the font type, size or the colours. WCAG provides good guidance on how to make text objects most transformable but even following those guidelines can be difficult. In particular, content that is represented in symbolic text is often very hard to make accessible. Symbolic languages such as mathematics, chemistry, music and geography can now be expressed in languages that do many transforms but they are still not able to convert to Braille, for instance.

3.3. Universal accessibility – a state of accessibility

Accessibility has traditionally been defined as a property of a resource or service. It has been determined by reference to sets of criteria, many of which are derived from the most globally accepted, the World Wide Web Consortium's Web Content Accessibility Guidelines (WCAG)xvi.

After many years of development, WCAG Version 1.0 recommends that resource creators aim for a universally accessible resource, with appropriate redundancy so it can be adapted for all users. A universally accessible resource contains redundant components just-in-case they are needed. A typical example is given by the example of a resource with a small video, a caption to accompany it, a sign-language video and an audio file. All are packaged as one resource and users access the pieces they need (Figure 4).

Fig. 4: A collection of redundant components for a resource

Such a resource is not easily produced and may never be used in other than the simple form of the video alone. It is not easy to convince content developers to go to the trouble to assemble all the pieces just-in-case. There are, however, more significant problems with universal access. It is derived from a set of specifications developed by a highly respected, collaborative, international team, they are, nevertheless, specifications for developers, not a guarantee of accessibility.

In a formal research study in 2004, the Disability Discrimination Commission of the United Kingdom investigated the accessibility of web sites that were required to be accessible. The DDC report entitled "Formal Investigation: The Web: Access and Inclusion for Disabled People"[xvii] showed the current W3C Web Content Accessibility Guidelines (WCAG 1.0) do not cover all situations and resources can be inaccessible even when they conform fully to the guidelines. In that project, extensive testing was done of

the accessibility (as defined by WCAG) and usability of 1000 websites. Many pages failed the basic elements of the WCAG test. Further, it was found that in some cases, pages that did pass that test were nevertheless inaccessible to live subjects and almost certainly would have failed usability tests.

The proposed new framework, assuming the existence or need for accessible components, anticipates the new guidelines[xviii] due for release in the next few years, but aims to complement them rather than rely solely on them. It is inconceivable that they will solve all the problems, however good they are. Similar results in a number of other studies have led the community to question whether, while there is no question about the value of the WCAG as specifications for developers, it should be used for accessibility testing. The question to be asked is, "Can the users access the resources and services?" and not, "Do the resources and services satisfy the guidelines?"

While the accessibility of a resource or service depends, ultimately, on the accessibility of the components delivered to the user they must exist and be available. It is not necessary for them to exist in advance of delivery, or to be produced by the same developers as the original resource or service. In other words, the components may be distributed and created just-in-time. Individually, however, accessible components will satisfy the WCAG specifications or something similar.

3.4. AccessForAll Accessibility – an accessibility process

A resource that contains some components that will not be accessible to a particular user will need to have those components replaced, transformed or augmented by the time of delivery of the resource to the user. An intelligent service will be needed to determine if the resource contains such components, and what to do if it does. It will need to know how to find the alternatives and how to re-assemble the resource for the user. AccessForAll has been designed to work when this information and such applications are available. It should be noted that universal accessibility, without the AccessForAll process, might result in no accessibility for a user who cannot find a matching service that informs them of the availability of an accessible resource.

4. METADATA

The information about the components that is needed by the system is what is usually called metadata: a structured, machine-readable description of the component that provides the necessary information. This information can be provided in a variety of ways but should use established vocabularies for describing the relevant characteristics where possible. Where the same vocabularies are used, systems can easily swap and share metadata. If they can swap and share the metadata, they can usually share the components it describes. The metadata is used for discovery and it can be stored in federated repositories, where the owner/creator of the metadata contributes it to a central repository but maintains it, or in distributed repositories, where a central service sends search requests to distributed metadata repositories. Either way, discovery can be enabled across the repositories.

The AccessForAll information model encapsulates the information that is required for accessibility. That is, the information about components that relate to the adaptability of resources and services that can affect their accessibility, explicitly including needs and preferences that relate to human modality, control and content requirements. These requirements are defined to match those specified for the description of user needs and preferences.

As user needs and preferences are often affected by the context in which the user is operating, such as when conference participants all need large font text in projected presentations, compared with when they view the same content on a private computer, an individual will use a set of needs and preferences descriptions and also want to be able to change them dynamically. On the other hand, there is no personal information in these descriptions. They do not need to identify the user or any disabilities they may have. The needs and preferences descriptions can usefully be stored and made available on the Web, on smart cards, or otherwise.

As the metadata needed is quite detailed, there may be some concern about who will produce it. Even where the metadata is created by a well-intentioned party, there may be a question about how reliable it is. Fortunately, there are a number of applications available that help with the description process and even

do some of it automatically. Most of these produce their reports in a language called Evaluation and Report Language (EARL[xix]) that requires all statements to be identified with a time and the person or agent making them. This makes it easier to identify the source of the description for trust purposes. EARL statements are generally intended to convey information about compliance to some stated standard or specification. This information is typical of what is needed for accessibility. An example is an EARL statement that includes information about the transformability of text determined by reference to the relevant WCAG provisions.

4.1. Encoding metadata

The World Wide Web Consortium (W3C[xx]) has a working group dedicated to bringing together the technologies necessary for adaptability and accessibility. They show the overlap between adaptability (which they call 'device independence') and accessibility with the following example:

> Pat has been given the task of booking the evening entertainment: a musical event followed by a good meal. On the Web, Pat discovered several potentially good venues but found it hard to follow the details on the pages because there was too much text with insufficient navigation. The form to book the restaurant was the hardest, requiring Pat to type everything instead of selecting from options.
>
> Which of the following is Pat?
>
> Patrick is a radio presenter who is partially blind and has limited use of his hands. Although he uses a screen magnifier and sometimes a screen reader, he finds many Web pages difficult to follow. Web forms are his biggest problem because they require him to do a lot of typing, which is understandably difficult.
>
> Patricia is a marketing manager who is always on the road. Her constant companion is her cell-phone, which is equipped to access the Web. She finds that the Web pages she wants to view will not work on her device. Of those that work, there is too much text to be able to read properly, and Web forms require too much typing with the miniature keyboard.[xxi]

W3C developed Composite Capabilities and Personal Preferences protocols (CC/PP[xxii]) "to permit the conveyance of device characteristics and user preferences. This information may include details of assistive technology incorporated into the browser, and specific user requirements such as the preference for text instead of graphics" (according to the W3C DI Working Group). CC/PP and other W3C languages such as EARL, make it possible to convey the accessibility information in standard, machine-readable ways.

Other metadata standards, of which there are many specially for describing components in ways that enable discovery, will need to be used to identify equivalent alternatives and supplementary components in cases where modal alternatives are not available. Users seeking resource by subject, author, date, coverage and many other facets will use other metadata for this.

Metadata standards, which determine the 'semantics' or information models for the descriptions, also use standard syntax and languages to encode the metadata. The standardisation of the syntax makes it possible to mix and match metadata: pieces of description for a range of sources can be combined in a single metadata record if they are encoded in standard formats.

5. ACCESS FOR ALL: MATCHING RESOURCES AND SERVICES TO NEEDS AND PREFERENCES

In general, the first step in matching resources and services to needs and preferences of a user is to discover the needs and preferences of the user. The second step is to determine if there is a cause for concern: are there components that use what might be difficult modalities according to the identified needs and preferences? If so, are there alternatives available for these components? If so, is their identity available? (The alternatives do not need to be co-located with the main resource components or even produced by the same developers. The alternatives may not yet exist but be able to be generated.) If the alternatives are available and identified, are they suitable? This is a repeat of the first question but with respect to a component instead of the whole resource or service. The process continues and if the needs are satisfied, the resource is re-formed using them. If not, it may be necessary to work with compromised

components or to find another resource and start the whole process over again. (Such a decision will be handled according to the particular implementation being used.)

Accessibility, dependent on the successful matching of resources and services to user needs and preferences, does not have to define syntax for its representation. That is well provided for by other fields of endeavour. Accessibility has to concern itself with the personal aspects of adaptability and how these can be organized and described. The adaptability metadata model, with an information model such as the AccessForAll model, can be incorporated into the general adaptability framework when the relevant information about the user's needs and preferences and the relevant information about the resource and its components are represented as metadata.

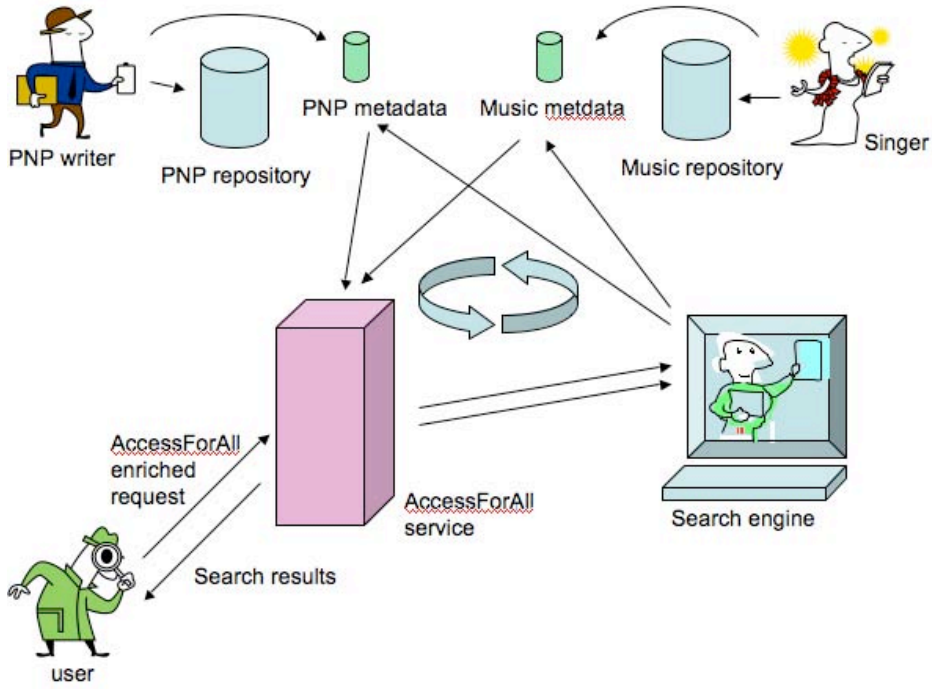

Figure 4: The cycle of activity involved in discovering accessible components[xxiii]

6. CONCLUSION

This paper proposes a significant shift from former approaches to accessibility that focus on the isolated resource or service, attempting to judge accessibility in isolation from the individual user, and not identifying what will suit the user even where accessible components are available. It exploits the potential of metadata to be used in dynamic customization of resources, significantly increasing the flexibility offered by many designing with the user in mind. The new approach does not avoid the need for accessible components but it allows for them to be distributed and cumulatively developed, significantly increasing the publishers' potential to provide accessible resources and services. It depends upon a framework of metadata embodying the adaptability of resources and services that allows for management of the resource and service components in relation to the needs and preferences of individual users at the time of using the resource. The approach proposed is demonstrated in an online system at the University of Toronto called The Inclusive Learning Exchange[xxiv].

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