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Interoperability for Individual Learner Centred Accessibility for Web-based Educational Systems

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ABSTRACT

This paper describes the interoperability underpinning a new strategy for delivering accessible computer-based resources to individual learners based on their specified needs and preferences in the circumstances in which they are operating. The new accessibility strategy, known as *AccessForAll*, augments the model of universal accessibility of resources by engaging automated systems and builds upon the previous development of libraries of suitable resources and components. It focuses on individual learners and their particular accessibility needs and preferences. It fits within an inclusive framework for educational accommodation that supports accessibility, mobility, cultural, language and location appropriateness and increases educational flexibility. Its effectiveness will depend upon widespread use that will exploit the 'network effect' to increase the content available for accessibility and distribute the responsibility for the availability of accessible resources across the globe. Widespread use will depend upon the interoperability of *AccessForAll* implementations that, in turn, will depend on the success of the four major aspects of their interoperability: structure, syntax, semantics and systemic adoption.

Keywords

E-learning systems, Interoperability, Accessibility, AccessForAll, Learner profiles, Resource descriptions

Introduction

This paper describes the effort to give effect to the interoperability goals of a new strategy for delivering accessible computer-based resources to learners based on their immediate specific needs and preferences. There are many reasons why learners have different needs and preferences with respect to their use of digital resources, including because they have disabilities. Instead of classifying people by their disabilities, the '*AccessForAll*' approach emphasizes the resulting needs in an information model for formal structured descriptions of those needs and the resources available. It provides a common language for describing the needs and preferences of all people, for whatever reason their accessibility is hampered, when they have special requirements. It may be useful to those who are simply trying to gain access to information in a language other than one they comprehend. It will be essential for those with very restricted access capabilities.

AccessForAll uses the same formal, structured information model for describing the needs and preferences of users and the accessibility characteristics of resources. Both sets of descriptions are required so resources can be matched to the needs and preferences of the learner. The goal is to enable systems to share the benefits and burdens of making resources accessible. It must be easy to record the necessary information and it must be in a form that will make it most useful and interoperable.

There is no doubt that an important aspect of achieving interoperability is the widespread adoption of common solutions to problems. The new framework aims, where possible, to inherit this from extensively used specifications and standards. In addition, it will depend on the widespread availability of suitable resources, appropriately described. In the case of educational resources and services, there are many major communities concerned with relevant aspects of descriptive standards and of those, a number have been engaged in the development of the *AccessForAll* model. Cross-domain metadata also has well-established standards that have been considered. The model is based on a set of principles that, when implemented in a variety of standard languages or systems, should maintain their interoperability at structural, syntactic and semantic levels. It also depends upon widespread systemic adoption to generate the required volume of information about available accessible components.

The *AccessForAll* strategy complements work about how to make resources as accessible as possible (universally accessible) done primarily by the World Wide Web Consortium Web Accessibility Initiative (W3C/WAI). The focus of that work is technical specifications for the representation and encoding of content and services, to ensure that they are simultaneously accessible to as many people as possible. W3C also develops protocols and languages that become industry standards to promote interoperability for the creation, publication, acquisition and rendering of resources.

Similarly, the strategy complements the work of organizations such as the Royal National Institute for the Blind (RNIB), The Library of Congress National Library Service for the Blind and Physically Handicapped (NLS), the Speech-to-Text Services Network and similar institutions in other parts of the world.

In the United Kingdom, the RNIB developed and maintains the National Union Catalogue of Alternative Formats (NUCAF) for people with vision disabilities (Chapman, 2002). The American NLS maintains a Union Catalogue (BPHP) and a file of In-Process Publications (BPHI) that can both be searched via the NLS website. The Speech-to-Text Services Network (STSN) makes accessible content alternatives for content that cannot be used by people with hearing disabilities. They offer three types of services based on the technology used: Steno machine-based systems, commonly called CART (Communication Access Realtime Translation), Laptop-based speed typing software systems (C-Print and TypeWell) and Laptop-based Automatic Speech Recognition software systems (e.g., CaptionMic, iCommunicator).

Such organizations provide access to resources through catalogues but as most of them pre-dated the Web, and certainly the widespread use of metadata as it is used today, their records are not in a common form and they do not all contain the same information in the same structure or syntax. Their catalogues provide search facilities of the type upon which the new *AccessForAll* strategy needs to be built.

The focus of *AccessForAll* is ensuring that the composition of resources, when delivered, is accessible from the particular learner's immediate perspective. It complements the W3C work by enabling a situation where a particular suitable resource is discoverable and accessible to an individual learner even when it may not be accessible to all learners. In some cases, this may mean discovery and provision of alternative, supplementary or additional resource components to increase the accessibility of an original resource. In such a case, those institutions that already have suitable resources may be able to lead to their discovery. The distinguishing feature of *AccessForAll* is that it depends upon software to manage the process of determining if the resources are suitable and, if not, replacing or augmenting them with the necessary resources. It assembles distributed, sometimes cumulatively-created, content into accessible resources and so is not wholly dependent upon the *universal accessibility* of the original resource and goes farther than mere discovery of a suitable resource.

The *AccessForAll* specifications, while initiated in the educational community, are suitable for any user in any computer-mediated context. These contexts may include e-government, e-commerce, e-health and more. Their use in education will be enhanced if they are adopted across a broad range of domains and used to describe the accessibility of resources available to be used in education even if that was not their initial purpose. The *AccessForAll* specifications can be used in a number of ways, including: to provide information about how to configure workstations or software applications; to configure the display and control of on-line resources; to search for and retrieve appropriate resources; to help evaluate the suitability of resources for a learner, and in the sharing and aggregation of resources.

The *AccessForAll* specifications are designed to gain extra value from what is known as the 'network effect': the more accessible content becomes available, the more likely accessible components will be available for individual learners; the more people use the specifications, the more there will be opportunities for interchange of resources or resource components, and the more opportunities there are, the more accessibility there will be for learners.

Early versions of the specifications were developed by the Adaptive Technology Resource Centre (ATRC), at the University of Toronto. They were developed further by collaboration between IMS Global Learning Consortium; the Dublin Core Metadata Initiative Accessibility Working Group, and others. They have been considered formally by CEN ISSS MMI-DC, CEN ISSS (WS-LT) and ISO JTC1 SC36 as well as at the national level by government agencies in Canada, the UK, and Australia.

Provision of Networked Accessible Resources

There are a number of approaches to making networked resources accessible, whether on the Internet or on an Intranet.

The first and most common approach is to aim to create a single resource (Web site, Web application) that meets all the accessibility requirements. Such a resource is known as a universally accessible resource. While this approach would work well in many situations, it is not often that authors succeed in making their resources 'universally accessible', especially when they contain interactive components. As well, it is possible to make a resource that satisfies the guidelines but is, in fact, not accessible to everyone. There are also potential problems due to lack of attention to usability principles that may account for lack of satisfactory access (Disability Rights Commission (UK), 2004). The DRC rigorously tested sites that had passed the W3C accessibility tests by asking people with disabilities to use them and, in this process, followed standard usability testing techniques.

In their report, the DRC said that:

> 2.2 Compliance with the Guidelines published by the Web Accessibility Initiative is a necessary but not sufficient condition for ensuring that sites are practically accessible and usable by disabled people. As many as 45% of the problems experienced by the user group were not a violation of any Checkpoint, and would not have been detected without user testing.

and

> FINDING 5: Nearly half (45%) of the problems encountered by disabled users when attempting to navigate websites cannot be attributed to explicit violations of the Web Accessibility Initiative Checkpoints. Although some of these arise from shortcomings in the assistive technology used, most reflect the limitations of the Checkpoints themselves as a comprehensive interpretation of the intent of the Guidelines.

(The authors of the guidelines, W3C, have recognized these short-comings and are in the process of producing a revised set, Web Content Accessibility Guidelines Version 2 (W3C/WAI WCAG 2.0), that should better match their intentions.)

Indeed, a resource may be accessible to everyone, but optimal for no one. Unfortunately, authors concerned about accessibility often avoid resource components that may be very effective, entertaining or efficient for some learners, for fear they will not be accessible to all learners (Macromedia's Flash application is a typical example).

The second approach used by a number of educational content providers is to create two versions of a resource: a media rich version and an "accessible version," the latter being stripped of all media that may cause accessibility problems. Typically these alternative versions are available as 'text only' versions for selection by a user. UsableNet have developed a Lift Text Transcoder (UsableNet) that dynamically produces text versions of pages. This was done to avoid the mismatch of maintenance of pages where the pages were not automatically generated and content providers would up-date their media-rich pages but forget to do the same for their text-only versions. In many cases, media-rich pages are made available as text-only pages by conversion of the text and thus a lot of valuable content is simply not available to those who cannot access the media objects.

While the provision of text-only pages solves some of the problems with the first approach, it can also cause other problems. In some cases, learners with disabilities only get an out-of-date view of the information but more often, students who perhaps need more assistance get less because they are using an impoverished version of the resource. The idea that learners with disabilities are a homogenous group that is well served by a single bland version of a resource is flawed.

The third approach differs from the first two in a number of ways. Accessibility requirements are met not by a single resource but by a resource system. Rather than a single resource or a choice between two resource configurations, there can be as many configurations as there are learners. The ability of the computer mediated environment to transform the presentation, change the method of control, to disaggregate and re-aggregate resources and to supplement resources is capitalized upon to match resource presentation, organization, control and content to the needs of each individual learner. The availability of automated services as described makes it feasible for all learners to consider their needs and preferences and to record them for use by such a system. An approach that is inclusive in this way significantly increases the multiplicity of presentations available from a given source and thus shifts the responsibility for personalisation of presentations from the content provider, as designer of presentations, to the user. It also decreases the effort required on the part of individual content creators to anticipate the necessary combinations. It is an approach that lets the user select their desired content rather than one that depends on the website designers' best guesses at the options that may be required.

Extending the range of presentations of content as proposed by the third approach, the *AccessForAll* approach literally means moving towards mass customization of content provision. It is not merely relevant in the context of people with special needs, or disabilities, but for everyone. It is applicable in a range of contexts as it will lead to highly personalized learning experiences, on demand learning and content assembly and publishing, automated generation of content, and more. The availability of the information about the needs and preferences of the user is the key feature here. Many existing systems provide descriptions of content, and many provide customized assemblies, but the new approach provides for these to be user driven.

The notion of universality of personalization, of inclusiveness as a characteristic of learning resources for everyone, differentiates the *AccessForAll* approach from the more traditional universal accessibility of resources approach, described above. The goal is not new, and has been considered many times, but it is contended that the new approach to user needs and preferences management actually makes it possible and, perhaps then, a necessary response to the needs of learners if all learners are to be catered for equally.

The possibility is not of great value, however, unless the costs associated with this approach are clearly appropriate. Given that accessibility is a requirement, not just a nice thing to do, there are already significant costs to be borne by many content providers. The third approach lessens the need for all resources to be developed in a strictly universally accessible way just in case they are required. It also allows for the resources to be provided to individual users to be distributed, meaning that they can be shared amongst content providers. This is not new in itself, but it is new that this sharing can be dynamically applied. If a content provider has not made some content fully accessible, another can make available the necessary extra content and the system can combine the components, so the authoring of accessible content becomes more of a distributed, cumulative activity. Although there is no data to prove that this is more efficient and cheaper, there is reason to believe it will be and research to test this can take place as soon as there are sufficient metadata and systems available for such testing to be undertaken.

Describing Control and Display Requirements for interoperability

One aspect of interoperability is the ability to share the same kind of information with others using the same systems and acting with the same goals. Another is to work across devices including using different hardware and software without losing the necessary ‘look and feel’ that facilitates learner mobility between devices.

W3C has a Device Independence Working Group, another focused on the Mobile Web and a third working on Evaluation and Repair. All three Working Groups produce specifications that are important to the interoperability of AccessForAll. These groups do not work specifically on specifications for learners but learners are included in the user groups of concern to them.

The Device Independence Working Group is responsible for a protocol known as Composite Capabilities and Personal Preferences (W3C CC/PP). Its general aim is to enable the quick identification of the needs of a device, such as a mobile phone or a desktop computer, so that user requests will initiate delivery of resource components that are necessary for the correct functioning of the device. A typical example is that when a large display page such as a newspaper page is to be presented on a tiny phone screen, it needs to be accompanied by a transformation that will facilitate navigation through the content without relying on a global view of it. Another important example is given when the mode of transmission of the content has to change to accommodate the device or user. The Device Independence Working Group, like all other W3C groups, is directed to take into account the accessibility aspects of this, and so Personal Preferences are included. The resulting CC/PP protocol provides an interoperable way of automatically transmitting information to Web servers from devices. This is what AccessForAll wants to do and so it is important that AccessForAll is in harmony with the CC/PP protocol.

The W3C Mobile Web Working Group wants to ensure that information about users is available for devices wherever they are but is concerned that such information is not available for abuse by other people or agents. This requirement is one that is shared by the AccessForAll: there is no need for a person to be identified with or by the set of needs and preferences they choose to use (Nevile, 2005).

The W3C Evaluation and Reporting Working Group have developed a language for managing the evaluation of content, typically the validation of it against formal test criteria. It enables the evaluations to be both distributed and cumulative, and at least identified with their evaluator and the time and date of evaluation. AccessForAll descriptions of learners’ needs and preferences, and resources’ accessibility characteristics, need to be trusted and this information is therefore of interest in their case too.

Describing Content Needs and Preferences and Resources for Exchange

For a network delivery system to match individual learner needs with the appropriate configuration of a resource, two kinds of descriptions are required: a description of the individual learner's needs and preferences and a description of the resource's relevant characteristics. Experience has shown that by catering for needs, everyone can benefit, as has been the case with curb-cuts that are now used by people in wheel-chairs, children on skate-boards and men with heavy trolleys.

The *AccessForAll* approach involves specifications for describing learner needs and preferences that define a functional description of how a learner prefers to have information presented, how they wish to control any function in the application and what supplementary or alternative content they wish to have available. It was found that these were the three main classes of such needs that should be in the descriptions. Specifically:

- display requirements usually include the use of screen readers or enhancers, tiny phone displays, reading highlights, Braille, tactile displays, visual alerts and structural presentation;
- control requirements usually include the use of keyboard enhancements, onscreen keyboards, alternative keyboards, phone keypads, mouse emulation, alternative pointing, voice recognition and coded input, and
- content requirements usually include the use of alternatives to each of the modes of display (auditory, visual, tactile and what is classed as textual). It includes learner scaffolds, personal style sheets and extra time.

AccessForAll deals with the needs and preferences of learners. It might seem unnecessary to be concerned about preferences at this level, but for some learners with disabilities, they have very limited means to access resources, and it may be essential to them that they have their exact needs satisfied. It is necessary to distinguish them from learners who have the capability to use other systems but prefer a particular set. It would be inappropriate to limit the acquisition of resources for the more flexible learners just because their first preference was not satisfied. There is also a third situation that needs to be considered; some learners can have dangerous conditions induced by certain sets of features, such as when flashing content causes them to have epileptic fits. (Many others are distracted by these and wish to avoid them, if possible.) For this reason, the three classes of essential, preferred, and prohibited need to be available to qualify the requirements.

The *AccessForAll* approach requires finer than usual details with respect to embedded objects and for the replacement of objects within resources where the originals are not suitable on a case-by-case basis. Embedded objects include components such as images that appear integral to a Web page or resource. It is important that there is no significant difference between the handling of embedded and distributed components. Distributed components are those that form part of the Web page or resource but do not come from the same source as other components. Knowing which component is being rearranged in the *AccessForAll* process and having general information about the component will often be necessary when a system searches for an alternative to that component. In some cases, the creator of the appropriate alternative will not know of the existence of the original and certainly not have related the alternative to it in any way. This may mean that sometimes it will be necessary to determine the source of a component so that alternatives can be found by reference to it. For example, when looking for a video of signed language for use as an alternative to the sound track of a film of the play Hamlet, it may be possible to find a sign-language presentation of the play. Managing such a discovery challenge will benefit from interoperability.

In defining requirements, *AccessForAll* does not mention the reason for any of the requirements. In some cases, learners with disabilities use assistive technologies to emulate other technologies, such as when a head-pointer is used to emulate the standard mouse so that as far as the functioning of the computer and the resource is concerned, there is no special accommodation. When the assistive technology impacts other technologies, as happens when a section of a screen is used for an on-screen keyboard, there are often detailed requirements not only for the display functions but also for the keyboard itself. Some learners need to specify the attributes of their keyboards, such as the size and separation of the keys, and others want to take advantage of features of the keyboard software they are using. Another kind of problem arises when a learner who has previously used a resource on a desktop computer tries to continue to use the resource on a telephone screen.

The required interoperability happens at many levels.

Interoperability between Needs and Preferences and Resources

If learners are to be able to quickly configure their devices, they require their needs and preferences to be quickly recognized and implemented by the device they are using. Also, if they are to search for appropriate resources (including where their search for resources causes their system to search for accessible components from which to make the resource they want), their needs and preferences descriptions have to be available to the search engine for searching and matching with the resources and their components. Where this is happening across collections of resources, a common way of describing the resources will be necessary and it will need to mirror the descriptions of the resources. So interoperability between the two sets of descriptions is necessary so that, even though one is concerned with the user's needs and the other with a resource, they can both be used by search engines. When a request is made for a resource, the search engine may need to look for both the user's needs and preferences and the resource. Both will be necessary to constrain the search results to appropriate resources and their components. In effect, this means that for simplicity, the description of the learner's needs should be in the same format as the descriptions of the resources.

Interoperability between Devices

Typically, learners with special needs will be looking for resource components that are developed by specialists. Usually, specialists who have not made the original resources produce closed captions, image descriptions and video files of people signing. They are likely to know the standard assistive technologies and what they will require and can do to use the special components. In automating the matching process for the learner, it is very important that the standard triggers are available for the assistive technologies. This means that the resources should be described in the way they can be understood by particular assistive technologies but also so that there is a generic description specification that all the assistive technologies can be expected to refer to. For this reason, care has been taken in *AccessForAll* to ensure that there is a seamless match and the established industry terms are used. The implications for interoperability here are for exchange between systems known as 'user agents', including browsers.

It is well known that browser developers pride themselves on the non-standard features they offer and that it is not easy to satisfy all browser specifications simultaneously. Fortunately, assistive technology developers who have a much smaller market are often more concerned to serve their customers and their industry associations. Nevertheless, it is important to recognize their differences and allow for their use so the *AccessForAll* model has to be capable of such flexibility. In fact it aims for some generic functions to be described in a common way while allowing for extensions to accommodate custom functions or features.

Interoperability across Information Sectors

Many, but not all, resources used within educational institutions are described by or for the educational community, usually according to standards designed for the educational community. Having worked with the goal of sharing resources for some time now, the many educational communities have a number of 'standards', the best-known being the LOM developed by IEEE (the IEEE 1484.12.1-2002 Standard for Learning Object Metadata). Clearly, the accessibility characteristics of resources that are 'learning objects' need to be described in a way that interoperates with all other aspects of LOM descriptions.

The IMS Global Learning Project, a consortium of educational organizations, has adopted the LOM and added the Learner Information Profile (LIP) that describes the attributes of the learner. *AccessForAll* was an IMS initiative and so it closely resembles their versions of the LOM and LIP in order to operate as an extension of them. In fact, the IMS versions are known as AccLIP and AccMD (IMS Global Learning Consortium, 2005).

Often, however, educational activities involve learners using resources that have been developed and described by other communities for their own purposes. For example, technical manuals are often used in Computer Science courses but they are not usually written for this purpose. Government information is often used in education, as are images of paintings and objects held in museums and galleries. The resources to be used by learners then, do not always originate from the educational or even the same communities and their description for discovery purposes can be very specific to the community from where they come. In order to discover resources across communities, or disciplines then, the descriptions of the accessibility characteristics of resources need to be consistent with descriptions used in those communities.

The simple Dublin Core Metadata Element Set (DCMES) is an ISO standard (ISO 15836) for core resource description metadata. There is also a set of qualified Dublin Core elements with additional terms and extensions (DC Metadata Terms). Dublin Core metadata is not domain specific. The Dublin Core Metadata Initiative (DCMI) has worked on cross-disciplinary metadata (DC metadata) for resource description and provides a base set of descriptive elements that support cross-domain discovery. Where domain specific communities want to extend the Dublin Core set, they develop what are known as Application Profiles for their community (DCMI, 2003). Given that governments, museums and galleries, and other sectors use DC metadata for information sharing, AccessForAll aims to take advantage of the interoperability of DC descriptions. DC metadata also has the advantage that it is used in many countries for resources that are created in many different languages and so can be used for cross-language discovery.

DC metadata is for describing resources and does not support rich descriptions of people but as people are not described in the learner needs and preferences profile, this is not a problem. It would be necessary, however, for there to be DC usable descriptions of learners' needs and preferences but, as stated above, these need not be Dublin Core descriptions although, as argued elsewhere, they could be DC-style descriptions and described as DC resources to allow for their discovery (Nevile, 2005).

Interoperability across Information Models

DC Metadata and IEEE LOM and IMS LIP metadata belong to very different information models. DC metadata has a 'flat' structure with a set of 'tags' that can be applied individually or collectively to resources. IEEE LOM, and therefore IMS LIP, models are very different. IEEE LOM (and IMS LIP) structure is deeply hierarchical. The difficulty of matching information from 'flat' to 'heirarchical' models, and the reverse, has separated the two communities for some time. Recently there have been agreements to work towards a common structure in the future, and some attempts to find suitable temporary solutions for the present.

The DC and IEEE LOM communities do share the use of standard syntax including HTML, XHTML, eXtensible Markup Language (XML), in particular, and the more narrowly defined Resource Description Framework XML (RDF). Both XML and RDF are extensible, however, so that they are used by two systems does not necessarily mean very much in terms of functional interoperability. On the other hand, it is this extensibility that makes it possible for the best attempts at interoperability.

In summary, *AccessForAll* needs to interoperate with a number of other relevant metadata specifications and standards.

The History of the AccessForAll Interoperability Efforts

Originally, the *AccessForAll* descriptions were developed for an in-house application. The original prototype Inclusive Learning Exchange (TILE), was a system that chose among a set of resource components according to the learner's needs and preferences. The resources were treated at the atomic level, each image and chunk of text, such as text articles, captions for other rich media resources, and so on, being separately stored and described. The learner's needs and preferences information was set within the system and variable at any time the system was being used. The descriptive information was related in a hierarchical decision-tree that allowed for different levels of detail appropriate for the circumstances. The resource components in the learning system were described so that their potential for matching was available to the application that chose and assembled the components to be delivered as the resource. There was no need for interoperability with other systems in this case as the system was in-house and contained all the resources, components and user profiles.

The original specifications for TILE were adopted by the IMS Global Learning Project with the aim that they would become interoperable by extending the IEEE LOM and the IMS LIP in a consistent way. They were dependent upon their common expression in an XML binding, inherited from TILE, for interoperability.

The IMS Accessibility Special Interest Group sought permission to work towards an open standard with participation from others (including the DCMI Accessibility Working Group) in order to increase the opportunities for widespread adoption and interoperability. This collaboration led to the deconstruction of the original AccessForAll model and a new construction, without loss of particulars, as an abstract model (see below). During this process, it was crucial to the success of the outcome that it would not compromise its relationship with the LIP or the LOM.

Before the adoption by DCMI of AccessForAll as a recommendation to the DC users community, and in anticipation of a revised, interoperable IMS version of the AccLIP and AccMD, the IMS specifications were forwarded to the International Standards Organisation (ISO JTC1 SC36) for adoption as a multi-part international standard. The ISO process involves the support and participation of a range of nations and helps foster international adoption of the specifications. According to the agreement by which the specifications were contributed by IMS, unlike many of the ISO standards, they will be free to those who want to use them.

Enabling Interoperability with Abstract Models

Between them, IEEE LOM and DC metadata describe many of the resources that are of interest in education. Some educational systems use LOM-based metadata sets to describe their resources but others use DC-based sets and others use a combination or different metadata. Although it is not clear how many do what, there has been careful analysis of the use of IEEE LOM and it is clearly an important player as is DC metadata, particularly as the latter is often used for government or document-type resources (Godby, 2004). It makes sense that these two communities should be able to exchange metadata records about their resources so they can, in fact, share their resources. To do this, they need to be able to transform metadata from one specification to the other. There is an activity, started in 2001 by the production of a joint article (Duval et al, 2002) that aims to bring the two sets of specifications into harmony. It cannot be done easily because LOM and DC metadata are based on very different information models.

In 2004, to clarify the nature of DC metadata, the DCMI developed an abstract model of DC metadata (DCAM) that was adopted in early 2005. The model defines the scope and functions of DC metadata that enables its implementation using a range of syntaxes without loss. Where the syntax is standard, as where standard XML or RDF is used, both the structure (defined in the abstract model) and the syntax will be interoperable across all DC metadata applications. Such applications are formally known as application profiles (CWA14855).

Once abstract models are agreed, it is relatively easy to develop information models (instantiations of the abstract model) and to create the syntax for representation of the information and then it is up to the community to agree on the terms to be used (semantics) for complete technical interoperability. The DCMI community developed their abstract model ten years after their information model, but fortunately for them, had a relatively simple information model. The IEEE LOM information model is extensive and complex and so far there is no corresponding abstract model for it.

DCMI introduces its abstract model as follows:

> This document specifies an abstract model for DCMI metadata. The primary purpose of this document is to provide a reference model against which particular DC encoding guidelines can be compared. To function well, a reference model needs to be independent of any particular encoding syntax. Such a reference model allows us to gain a better understanding of the kinds of descriptions that we are trying to encode and facilitates the development of better mappings and translations between different syntaxes. (DCMI, 2005)

In order to be recommended by the DC Usage Board for general adoption by the DC community, *AccessForAll* metadata needed to be explained in DC terminology. In effect, by late 2005, this meant it had to comply with the DC Abstract Model. As AccessForAll did not have an abstract model, developing one seemed like a good exercise. In the end, it was a very constructive exercise.

The AccessForAll Abstract Model

Developing abstract models is not easy when what they are to represent is already defined but in the case of *AccessForAll*, there was the opportunity to redefine the *AccessForAll* information model concurrently with developing its abstract model. The main problem was finding an abstract way to define *AccessForAll* that would maintain interoperability with all the relevant information models (structure), syntax (easier), semantics (relatively simple), and encourage systemic adoption.

The *AccessForAll* Framework includes, significantly, both the user's needs and preferences profile and the resource profile.

In presenting its abstract model, DCMI provides a set of definitions and rules followed by a diagram expressed in a formal graphical representation format known as Unified Modeling Language (UML). The *AccessForAll* abstract model is now similarly described.

To simplify the scope of the *AccessForAll* and to increase interoperability with other metadata, only those things that are necessary for the *AccessForAll* process are contained in its abstract model. Other descriptions should be managed according to other relevant metadata specifications.

As unique definitions and rules, *AccessForAll* has the following:

The abstract model of the preference sets defined in the *AccessForAll* framework is as follows:

- Each person has zero or more *needs and preferences*.
- Each needs and preferences has zero or more *adaptability statements*.
- Each needs and preferences has zero or more *contexts*.

The abstract model of the resources defined in the *AccessForAll* framework is as follows:

- Each resource meets the *needs and preferences* (of a person).
- Each resource has zero or more *adaptability statements*.
- Each resource may be related to zero or more *alternative resources*.

The abstract model of the adaptability statements defined in the *AccessForAll* framework is as follows:

- Each adaptability statement may contain *access mode* information.
- Each adaptability statement may contain zero or more *related descriptions*. [DC-AWG, 2005]

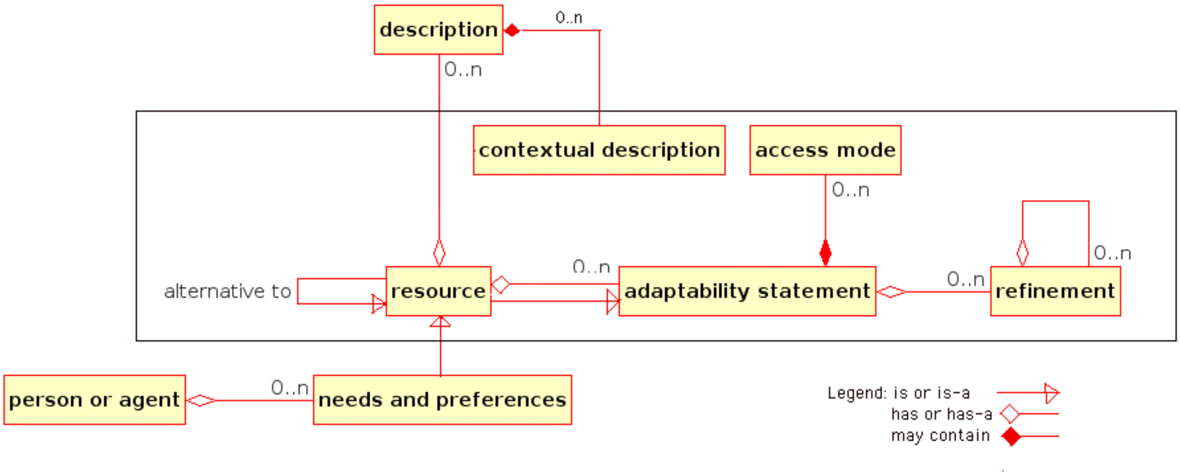

Figure 1: A graphical representation of the *AccessForAll* abstract model.

Figure 1 shows that a user, a person (a learner) or agent (perhaps a device or application), has needs and preferences that can be expressed as a resource, their Personal Needs and Preferences (PNP). This PNP is, or is closely associated with, an adaptability statement. It should describe the access mode they need or prefer. It may also have other descriptions (metadata) to make it easily discoverable and easily differentiated from other PNPs they use. Often a user will refer to the PNP they want simply by using a name for the context in which they use it. In some cases, the provision of needs and preferences information has already been tried on (Web-4-All) smart cards that can be used to provide some of this information.

When the learner searches for a resource using the *AccessForAll* process, they want its adaptability statement, its Digital Resource Description (DRD), matched to their PNP adaptability statement. When a resource does not satisfy this rule, existing or alternative components or resources may need to be substituted, augmented or transformed until it does. As with the PNP, the resources they seek may have other descriptions but these, although useful, are not within the scope of the AccessForAll abstract model, except in as much as they may provide the context description.

Adaptability statements can be very simple, merely showing a single attribute of the resource, or they can be quite complex, using the refinement of a refinement model to capture hierarchical information.

Interoperability with DC Metadata

The *AccessForAll* abstract model now closely matches the Dublin Core Abstract model. Not everything that will be useful to have as *AccessForAll* metadata is unique to the *AccessForAll* model so a significant amount of information will be expressed using standard DC elements. Exactly how to do this will be described in what is known as a DC Application Profile for which specific terminology (semantic values) will be defined. The value of this work for DC users is that they will be able to express the *AccessForAll* metadata in DC compliant ways so it will interoperate with other DC metadata. They will also be able to use standard DC applications without significant modification.

Interoperability with IEEE LOM and IMS LIP Metadata

An encoding of *AccessForAll* metadata for use in an IEEE LOM Application is under construction by the CEN-ISSS Learning Technologies Workshop (CEN/ISSS (WS-LT), Accessibility Properties for Learning Resources Group.

Nilsson et al. (2005) have recently worked on developing what they call a future metadata standardization framework. They say:

> We have demonstrated that true metadata interoperability is still, to a large extent, only a vision, and that metadata standards still live in relative isolation from each other. The modularity envisioned in application profiles is severely hampered by the differences in abstract models used by the different standards, and efforts to produce vocabularies often end up in the dead end of a single framework. In order to enable automated processing of metadata, including extensions and application profiles, the metadata will need to conform to formal metadata semantics.
>
> To achieve this, there is a need for a radical restructuring of metadata standards, modularization of metadata vocabularies, and formalization of abstract frameworks. RDF and the Semantic Web provide an inspiringly fresh approach to metadata modeling: it remains to be seen whether that framework will be reusable for learning object metadata standards.

This suggests that it may not be until there is a shared LOM/DC abstract model for education that there will be perfect interoperability between DC and LOM resource descriptions but it is hoped to be possible sooner, in the particular case of *AccessForAll* metadata, because it is based on a more interoperable abstract model.

Adoption of specifications and standards

The value of specifications and standards is only known some time after their release, when it becomes possible to gauge how widely they have been adopted and how well they have solved identified problems for organizations. Insurance that they will be adopted is not possible but open development of specifications, consensus among a wide range of types of implementers, and points of contact that support dissemination of the specifications are all known to help in the process.

In the case of *AccessForAll*, the needs and preferences have come from those who actually have them; people who use technology in a wide range of situations, overcoming what often seem like insurmountable odds.

The needs and preferences are not new, they have been around since computers were first developed and are tried and tested by their users. The provision of statements that describe needs and preferences is new. It is to be done in a way that separates the user from the needs and preferences, while allowing them to have several sets. Nevertheless, there is little doubt that this will not be a problem for many as already these settings have to be entered into computer systems. In addition, there is more pressure on those providing education and training to be more mindful of the special needs of their clientele, so they will be alerted to the need for such specifications in the normal course of business, as well as by those specifically promoting these specifications. The only difference for those already registering such needs is that they will be entered once and used many times. The experience of several projects where such specifications have been stored on smart cards for re-use is well-known in the field and has contributed to this work (Web-4-All).

The description of the accessibility characteristics of resources is new but it has been foreshadowed by the development of applications that help organizations assess the accessibility of their resources, and to record their characteristics in metadata. The difference is that rather than just do this for evaluation and penalty avoidance,

organizations can do this now to promote accessibility by preparing their collection of resources to interoperate with others.
The last community that needs to be engaged with the specifications is the industry that develops the technologies that are used for accessing resources. These players have been consulted and provide more or less of the relevant features. They have indicated that what is proposed will work for them.

Finally, there is the question of who will use metadata anyway? If, as hoped, the distribution and accumulation of accessibility solutions is enabled by the specifications, and those responsible for providing learning resources are increasingly doing this through systems that work on metadata, it can only be hoped that they will be adopted. Presentations, workshops, journal articles, and other forms of dissemination are already active but in the end it will probably be good references from one person to another that will provide the final evaluation.

Future Work and Conclusions

In summary, the interoperability of the *AccessForAll* strategy is relevant in many circumstances. The process of making *AccessForAll* has involved significant technical work and collaboration between representatives of several communities, all with the goal of making education more accessible. The associated specifications show how the *AccessForAll* strategy can be implemented. They are not prescriptive about the encoding that should be used. Significantly, they are not prescriptive about what constitutes accessibility. The work that follows to support the adoption and implementation of the *AccessForAll* approach will be the true test of its interoperability: nothing is seriously interoperable unless people use it to interoperate. In addition, the network effects, upon which ultimate success will depend, cannot be expected to show until there is widespread adoption of the approach.

There are endless opportunities, given the model and strategy, to take further advantage of new technologies. The Semantic Web offers one obvious technology that will be enabled by the *AccessForAll* approach. Already the first *AccessForAll* specifications recommend using the Semantic Web Evaluation and Reporting Language (EARL) so that the metadata will be as flexible and rich as possible. The range of other extensions includes opportunities for valuable cross-lingual exchanges to suit learner needs as well as cross-disciplinary changes of emphasis. Applications and Web services that transform resources or resource components to suit the needs of users with cognitive disabilities is a huge area that has hitherto not received the attention it deserves. The interoperability of specifications that purport to implement the new *AccessForAll* is clearly a major factor that will determine its effectiveness.

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Glossary

AccessForAll: an Accessibility Framework: http://dublincore.org/accessibilitywiki/AccessForAllFramework.

CWA14855, CEN Workshop Agreement, Dublin Core Application Profile guidelines:
http://www.cenorm.be/cenorm/businessdomains/businessdomains/isss/cwa/cwa14855.asp.

CEN/ISSS (MMI-DC), European Committee for Standardization, Meta-Data (Dublin Core) Workshop:
http://www.cenorm.be/cenorm/businessdomains/businessdomains/isss/activity/wsmmi.asp.

CEN/ISSS (WS-LT), Workshop on Learning Technologies:
http://www.cenorm.be/cenorm/businessdomains/businessdomains/isss/activity/wslt.asp.

DCAM, Dublin Core Metadata Initiative Abstract Model: http://dublincore.org/documents/abstract-model/.

DCMES, Dublin Core Metadata Element Set: http://dublincore.org/documents/dces/.

DC Metadata Terms: http://dublincore.org/documents/dcmi-terms/.

IEEE 14.84.12.1 - 2002 Standard for Learning Object Metadata: http://ieeeltsc.org/.

IMS Global Learning Consortium: http://www.imsglobal.org/accessibility/.

ISO JTC1 SC36: http://jtc1sc36.org/.

NLS: http://lcweb.loc.gov/nls/.

Object Management Group, The Unified Modeling Language: http://www.uml.org/.

STSN: http://www.stsn.org/servicechart.html.

TILE, The Inclusive Learning Exchange: http://www.inclusivelearning.ca/.

UsableNet Lift text Transcoder:
http://www.usablenet.com/products_services/text_transcoder/text_transcoder.html.

W3C CC/PP, Composite Capabilities and Personal Preferences: http://www.w3.org/Mobile/CCPP/.

W3C EARL, Evaluation and Reporting Language: http://www.w3.org/TR/EARL10/.

W3C HTML, HyperText Markup Language: http://www.w3.org/TR/html4.

W3C RDF, Resource Description Framework: http://www.w3.org/RDF/.

W3C WAI, W3C Web Accessibility Initiative: http://www.w3.org/WAI/.

W3C WAI, Web Content Accessibility Guidelines for creating accessible Web pages:
http://www.w3.og/TR/WAI-WEBCONTENT/.

W3C/WAI WCAG 2.0: http://www.w3.org/TR/WCAG20/.

W3C XHTML, Module-based XHTML: http://www.w3.org/TR/xhtml1.

W3C XML, Extensible Markup Language: http://www.w3.org/XML/.

Web-4-All: http://web4all.atrc.utoronto.ca/.

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