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# Learner-centred Accessibility for Interoperable Web-based Educational Systems

Liddy Nevile  
La Trobe University  
Bundoora  
Victoria, Australia  
+61 3 9479 1111

[liddy@sunriseresearch.org](mailto:liddy@sunriseresearch.org)

Martyn Cooper  
Open University  
Walton House  
Milton Keynes  
+44 (0) 1908 274066

[m.cooper@open.ac.uk](mailto:m.cooper@open.ac.uk)

Andy Heath  
Sheffield-Hallam University  
Howard Street,  
Sheffield, UK  
+ 44 (0) 114 2 255555

[ak.heath@shu.ac.uk](mailto:ak.heath@shu.ac.uk)

Madeleine Rothberg  
CPB/WGBH NCAM  
125 Western Avenue  
Boston, MA 02134  
+1 617 300 3400

[madeleine\\_rothberg@wgbh.org](mailto:madeleine_rothberg@wgbh.org) [jutta.treviranus@utoronto.ca](mailto:jutta.treviranus@utoronto.ca)

Jutta Treviranus  
University of Toronto  
130 St. George St  
Toronto  
+1 416 978-5240

## ABSTRACT

This paper describes the need for an information model and specifications that support a new strategy for delivering accessible computer-based resources to learners based on their specific needs and preferences in the circumstances in which they are operating. The strategy augments the universal accessibility of resources model to enable systems to focus on individual learners and their particular accessibility needs and preferences. A set of specifications known as the AccessForAll specifications is proposed.

## Categories and Subject Descriptors

H.1.2 (User/Machine Systems): *Human factors, human information processing*

H.3.7 (Digital Libraries): *collection, dissemination, standards, user issues*

H.3.3 (Information Search and Retrieval): *retrieval models, selection process*

H.3.5 (Online Information Services): *data sharing, Web-based services*

## General Terms

Management, Human Factors, Standardization.

## Keywords

E-learning systems, accessibility, learner profiles, AccessForAll

## 1. INTRODUCTION

This paper describes the requirements, model and specifications for 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 a computer, including because they have disabilities. Instead of classifying people by their disabilities, this new approach emphasizes the resulting needs in an information model for formal structured descriptions of them. It then provides a complementary formal, structured information model for describing the characteristics of resources required for the matching process. The aim is to make it easy to record this information and to have it in a form that will make it the most useful and interoperable.

This work builds on work being done primarily by the World Wide Web Consortium Web Accessibility Initiative (W3C/WAI) [1] to determine how to make resources as accessible as possible. The focus of the new work is how to make sure that accessibility is learner-centered and supportive of good educational practices. The distinguishing feature of the current work is that it provides an approach that assembles distributed content into accessible resources and so is not dependent upon the universal accessibility of the original resource.

The specifications for a common description language, 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 there are accessibility descriptions of resources available to be used in education even if that was

not their initial purpose. The 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 aggregation of resources.

An extra value of the specifications described will be in what is known as the network effects: 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.

## 2. OVERVIEW

Virtually any student, irrespective of any disability, can be enabled to effectively interact with a computer. Some students with disabilities require alternative access systems, usually referred to as “assistive technology,” to enable them to do this and others need the way content is presented to them by the computer to be appropriate or they may need to interact with the computer using methods other than the conventional keyboard and mouse. There are well-established principles for how to promote accessibility in software design and electronic content [2]. These promote compatibility with assistive technology and ensure that different ways of interacting with the computer can be accommodated.

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 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 the resource is fully ‘universally accessible’, especially if it contains interactive components. Worse, so-called universally accessible resources are so judged by conformance to W3C accessibility conformance and this approach is not infallible, as the guidelines are not ‘perfect’. There are examples of when the guidelines can be followed without the resource actually being accessible as expected and there are many vagaries due to lack of attention to usability principles that also account for lack of satisfactory access [3]. Indeed, the resource may be accessible to everyone, but optimal for no one. Often, resource components that are very effective, entertaining or efficient for some but not all learners are rejected or not displayed. New technologies and techniques are often not used for fear that they will not meet the requirements.

The second approach used by a number of educational content providers is to create two versions of the resource: a media rich version and an “accessible version,” which is stripped of all media that may cause accessibility problems. While this solves some of the problems with the first approach, it can also cause other problems. In some cases, the accessible version is not maintained as well as the default version, giving learners with disabilities an out-of-date, different view of the information. More often, students who perhaps need more assistance get less because they are using the impoverished version of the resource. The notion that learners with disabilities are a homogenous group that is well served by a single bland version of a resource is also 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. This is known as the AccessForAll approach.

For a network delivery system to match learner needs with the appropriate configuration of a resource, two kinds of descriptions are required: a description of the learner’s preferences or needs and a description of the resource’s relevant characteristics. These two descriptions are the subject of the AccessForAll specifications [4]. The Accessibility for Learner Information Profiles specification (AccLIP) is a specification for describing a learner’s needs and preferences and the AccessForAll Meta-data specification (AccMD) is a corresponding specification for description of the resource.

The AccessForAll specifications were developed by IMS Global Learning Consortium; the Dublin Core Metadata Initiative Accessibility Working Group, and others.

### 2.1 Accessibility for people with disabilities

It is not the purpose of this paper to give an introduction to accessibility. The authors and numerous others have done that many times. In order to understand the rationale for this work, however, it is important to realize that virtually anyone, irrespective of disability can be enabled to use computers. They just require one sense (visual, aural, or tactile) that they can use to interpret the output from the computer and control input to the computer. Most people with disabilities are able to employ technical aids usually referred to as assistive technology. These include screen readers that can transform well-formatted text into synthesized speech; screen magnifiers that enlarge the display in a well-managed way; and alternative input devices that replace or augment the conventional keyboard and mouse. Other people require content on the computer to be presented to them in a particular way. For example, they may find text much easier to read if it is presented in a high contrast as yellow on black and in a particular font. Others will, of course, prefer alternative fonts and color schemes. Sometimes only a part of the content is not accessible to a learner and they require the same information to be presented in an alternative way. For example, a blind person may not be able to access video material but can benefit from an audio description of the same material or a deaf person can benefit from captions (sub-titles) that replace the dialogue. It should be stressed that not all such requirements arise from a disability but can also be because of the circumstances the computer is being used in. For example, when working in a large lecture theatre, a noisy environment, hands free, or on a small screen PDA.

### 2.2 The value of the accessibility agenda

There are many well-documented arguments for why web content and service providers in general, should be concerned about accessibility [5]. Major arguments are often cited; social responsibility, market-share, financial benefits and legal liability. By not dealing with accessibility issues a provider excludes a large number of people from using their site.

Recent research in the US for Microsoft has shown that 60% of the working community would benefit from accessible content. Of these, perhaps 10% have no access unless the content and services are fully accessible. The moral and market arguments are obvious. Those who do provide accessible resources will have exclusive access to a significant sector of the market. In Australia in 2004, a large publishing house re-built their website to make it fully accessible. They have reported that they now save \$1,000,000 in transmission costs per year [6]. Finally, in many countries there is increasingly strict legislation requiring access for all citizens and in education, the standard is often quite demanding and the consequences of failing can be expensive anti-discrimination penalties.

In education, where the requirements are usually more demanding, many countries are now practicing what is sometimes called 'inclusive' education that aims to include and provide equally for all potential students. Lack of accessibility is a serious problem.

### 2.3 Describing Learner Needs and Preferences

The AccessForAll approach involves specifications for describing learner preferences and needs 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. This requirement for functional specifications is based on the philosophy that disability is a mismatch between a learner's needs and preferences and what they are presented with. It is an artifact of the relationship between a learner and an interface or application. Thus a learner who is blind does not have a disability in an audio environment but a learner who is using a computer without speakers or a headphone does.

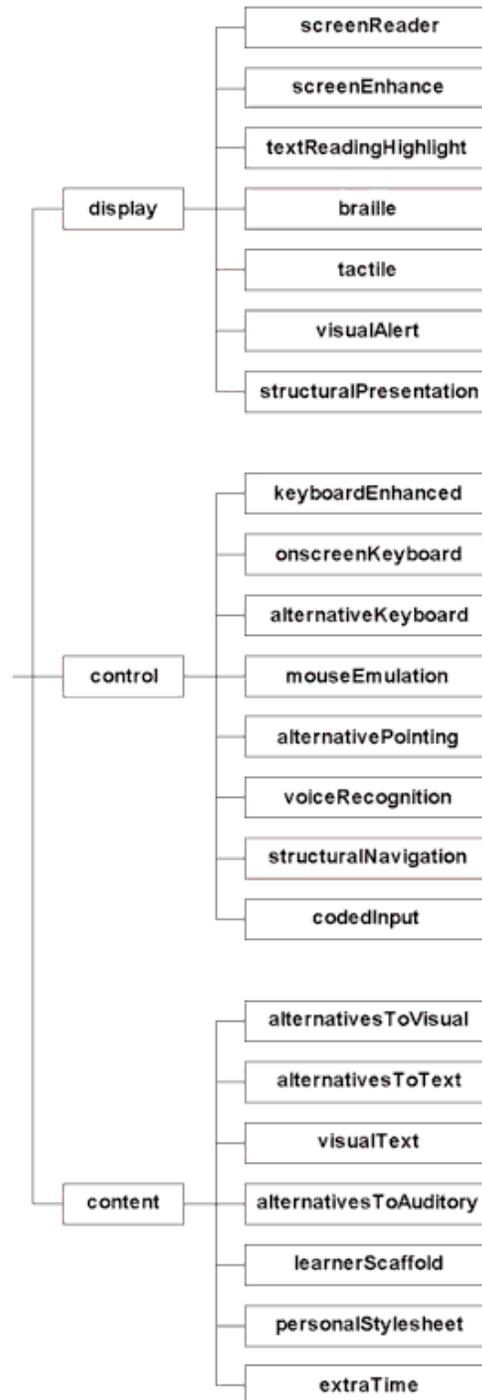
This description should be created by learners or by their assistants, usually with a simple preference wizard. It should be of needs and preferences that are essential to a learner's functioning as a consequence of their having a disability or it may be that the circumstances, devices, or other factors have led to the mismatch between them and the resources they wish to use. Each learner may need more than one description of needs and preferences or accessibility profiles to accommodate their changing needs within different contexts. A learner may have one profile for work and another for home if the bandwidth is different, for example. In addition, these profiles should be able to be changed to suit immediate needs and preferences, to accommodate changes in circumstances or context.

### 2.4 Describing Resource Characteristics: The Content Model

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. This is made possible by describing the resources in terms of their modalities – auditory, visual, tactile, and text. In addition, the separation between primary and equivalent resources is necessary to permit flexible dis-aggregation and re-aggregation to meet the individual needs.

Most resources consist of multiple objects combined into what are commonly known as pages. Sometimes this is done once and there is a static version available and sometimes it is done dynamically for the learner. What is unusual about the new accessibility approach is that the objects that

Figure 1: The AccessForAll profile criteria



comprise the version of the resource that is sent to the learner need not be located in the same place, that is, they may be distributed. In fact, the original composite resource may contain objects that need to be transformed, replaced or augmented; the equivalent objects used for replacing or augmenting may have been created in the original authoring process, or in response to some other learner's difficulties with the original resource.

Resources and objects within resources should be classified into two categories: primary and equivalent. Most resources are primary resources and require a simple set of statements: how transformable is this resource, what access modality is used (vision, hearing, text literacy or touch) and what is the location of any known equivalent alternative. The workload of the creator of the primary materials' metadata should be kept as light as possible. The accessibility characteristics of equivalent alternatives such as caption files or image description files also need to be described

## 2.5 The Process of Matching

### 2.5.1 Authors and Authoring Tools

The authoring requirements for the content creator using the AccessForAll approach are different and sometimes easier than in other approaches to creating accessible materials. Objects are treated in a more modular fashion, and universal accessibility is not expected of each object, just the combination of objects. The responsibility is, as always, with the author to provide as many accessible pieces as possible but mainly on the resource server to combine them appropriately for the learner. For this approach, there are the usual basic authoring principles, requiring that each part of the resource be created following the standards for accessibility, but when there is an object that may not be accessible, it can be described as inaccessible and the location of an alternative identified. This means that the author does not have full responsibility for creating accessible content and also that a second or later author can make an inaccessible resource or object accessible, by providing or identifying an equivalent alternative and contributing its accessibility profile.

The W3C/WAI guidelines offer specifications for accessible authoring tool [7]. Accessible authoring tools provide authors with guidance in the authoring process as well as making it possible for people with special needs and preferences to participate in the authoring process. Many of these assume little 'accessibility' expertise on the part of the author. Some tools are specifically for the production of content but others help in the process of making content accessible. Some of these tools are already able to help in the production of content profiles.

### 2.5.2 Cumulative and Collaborative Authoring

The AccessForAll approach supports cumulative and collaborative authoring by allowing new equivalent resources to be added to a collection independently of the original resource authors. Subject matter experts can create primary content, while organizations or educators with experience in alternative access strategies can create the equivalents. Over time, a resource collection can grow richer with alternatives and thereby provide more complete access.

### 2.5.3 Dynamic and Static Content Publishing

Where content is to be stored ready for presentation to learners, it may be in complete resource form or it may be held as objects that will be accumulated and presented within a template at the

time of a request from a learner. Static content publishing, the former, requires the content to be in a universally accessible form, replete with all the alternatives that may be needed within the single resource. Dynamic publishing allows for the customization of the resource, with objects being selected as they are combined. This form of publishing is easier to adapt to the new approach. It is also a more common form of publishing for larger educational institutions.

### 2.5.4 Transforming, Supplementing and Replacing

The process of selection of objects for combination into resources according to learner profiles can take three forms: transforming, supplementing and replacing. When there is no visual ability, images need to be replaced by either audible or tactile equivalents. Where there is a need for intellectual support, a dictionary may be needed as a supplement to a resource or an object. Where transformation of objects occurs most frequently is with text. Well-formed text can be rendered visually, as characters, or a sign language, or aurally, perhaps by a screen reader, or transformed into a tactile form as Braille or simply changed in color, size and other display features.

### 2.5.5 Metadata interoperability

The AccessForAll descriptions of learner needs and resources for them are metadata. Metadata is information, usually structured, about an object, be it physical or digital. It can be thought of as similar to a library catalog record of a book. As with a catalog record, metadata does not have to be part of a resource, although it should be associated with it, and it does not have to be made at the same time as the resource or even by the resource's author or owner. A good general description of metadata is available in "Metadata Principles and Practicalities" [8].

Metadata is most commonly associated with the resource discovery process. In the case of AccessForAll metadata, resources and objects can be filtered according to needs and preferences identified in a learner's profile, or metadata. Thus, in the new strategy, the matching of metadata enables the matching of resources to needs and hence accessibility.

The difference between what is commonly done with metadata and what is described here is perhaps in the way in which the resource is often seen both as a composite resource and as a set of objects, as described above. A resource, whether a service or content of another kind, often has components that are in different modalities; such as a Web page with some text and a picture. The text, if properly formed, can be transformed into speech but the image will need to be replaced by text that can then be rendered as speech. This means that not only is it important to note that the resource as a whole has some text and an image, but it may also be necessary to have some detail about those items that together form the resource. Metadata is most useful if it confines its scope to the thing it is describing but those descriptions, if correctly written, can often be combined to provide a description of the whole. In the approach described in this paper, the objects that will eventually comprise the whole resource are most easily discovered and used if they have their own metadata, as well as if the composite has its own metadata. This is considered quite reasonable practice in the metadata world.

Two metadata sets, the IEEE LOM and the Dublin Core Metadata Set (described below) together account for a vast

amount of metadata used in education worldwide. It is essential that interoperability be maintained among the different communities using metadata but also across sectors such as education, e-government, e-commerce, e-health and other activities that want to share resources. The approach described in this paper was explicitly developed to be compatible with both IEEE LOM and DCMI metadata.

- **IEEE LOM [9]**  
The IEEE LOM (Institute of Electrical and Electronics Engineers' Learning Object Metadata Standard) is a profile for learning object metadata. It contains a description of semantics, vocabulary, and extensions. An encoding of accessibility metadata that harmonizes with AccessForAll metadata and is suitable for use in an IEEE LOM Application is under construction by CEN-ISSS Learning Technologies Workshop [10].
- **Dublin Core Metadata Element Set [11]**  
The Simple Dublin Core Metadata Element Set is the ISO 15836 standard for core metadata. There is also a Qualified Dublin Core Metadata Element Set with additional terms and extensions. Dublin Core metadata is not domain specific. Dublin Core elements include a new special one for accessibility to be used for AccessForAll metadata.

### 2.5.6 Accessibility and eLearning systems

A key challenge in accessibility is the diversity of need; different people require different accommodations. Established approaches towards addressing this are to allow customization by the end learner (e.g. text size and color) and to offer alternative presentations of the same content where automatic customization is not possible (e.g. text description of diagrams or audio descriptions of video content).

Integrated eLearning systems potentially offer an efficient way of managing and even extending this. They can personalize the way the interface and the content are presented to the learner and further, which content is presented to the learner can be determined by the system on the basis of stored information about the individual learner and their preferences.

Such eLearning systems offer the educational institutions the opportunity to efficiently manage their requirement to meet the needs of their disabled students. If they implement student profiles and adopt the AccessForAll approach, the system will "know" how best to present content and interfaces to each individual learner. If they implement the approach for the metadata of the content stored in their repositories, then the system can automatically offer the learning content, and other information, in the most appropriate format to meet individual learner needs. Furthermore, disabled students and their faculty or advisors will be able to instigate automated searches of the content associated with any particular course or module, and determine if any of it presents particular accessibility problems for that student. With this information, they will be able to commission alternative formats of the same content or locate an alternative learning activity ahead of time if that is more appropriate.

## 2.6 The Information Models

A detailed description of use of cascading learner profiles and of the preferences and requirements that can be recorded in a learner's profile is a necessary part of the AccessForAll

specifications. The other specifications necessary for the AccessForAll approach are for the description of the accessibility characteristics of resources and components.

The specifications developed by the IMS/DCMI collaboration contain an information model that can be implemented in a variety of ways. A typical implementation at the time of writing is likely to be in eXtensible Markup Language (XML) and so there is an XML binding and schema to accompany the model. The metadata specification for describing content has specific data structures within it that directly map to the data structures in the specification for describing preferences for how content should be presented to the learner. Understanding the learner profile model, the AccLIP makes understanding the resource profile model, the AccMD, a lot easier as the latter is derived from the former.

### 2.6.1 The AccLIP Model

The AccLIP information model is for a detailed machine-readable description of a learner's needs and preferences in the way they interact with the computer. This includes information about any accommodations the learner may need in the way that content is presented to them and display and control approaches they may adopt when using the computer.

The AccLIP model includes accommodations and approaches needed or adopted by learners with disabilities but is more general than that. There are no elements that enable a description of a learner's disability by medical classification to be declared, nor should there be. The description is of the preferred human computer interaction approaches and preferred content characteristics needed to enable the envisaged automated functions of the system to be implemented. It is in line with the philosophical stance that moves away from a medical model of disability to a social one.

#### 2.6.1.1 The AccMD Model

The AccMD model is for metadata that expresses a resource's ability to match the needs and preferences of a learner's AccLIP profile. It is intended to assist with resource discovery and also provides an interoperable framework that supports the substitution and augmentation of a resource or resource component with equivalent or supplementary components as required by the accessibility needs and preferences in a learner's AccLIP profile. For example, a text caption could be added to a video when required by a learner with a hearing impairment or in a noisy environment.

In general, metadata can be used for two main accessibility related purposes: to record compliance to an accessibility specification or standard (e.g., for adherence to legislated procurement policies) or to enable the delivery of resources that meet a learner's needs and preferences. The AccMD specification addresses the latter purpose. Metadata to assert compliance to an accessibility specification or standard is not within the scope of this specification. It may be useful, however, if it is in a form that allows it to be transformed and re-purposed as AccMD metadata.

#### 2.6.1.2 Overview of the AccMD Information Model

The AccMD specification is defined in terms of two basic classes that are then further refined and detailed. A description is either of a <primary> resource or an <equivalent>. This mirrors a common practice in the accessibility world for an equivalent to be produced not by the original author of the

resource but by someone else, that person or organization having expert knowledge of how to make that resource accessible in the specific context.

A resource could contain its own equivalents (such as an image with alternative text description) and therefore could have a primary **and** one or more equivalent resource descriptions.

A primary description is very simple and consists of a simple classification of the access modalities of the resource with terms selected from *hasVisual*, *hasAuditory*, *hasText* and *hasTactile*. For each modality a simple binary judgment can be made as to whether that access modality is required for the resource to be useful.

A primary resource description can also have links to EARL [12] statements recording machine-readable adaptability properties that describe the transformability and flexibility for interface control of the resource. EARL is the Evaluation And Report Language, a Resource Description Framework (RDF) language developed by W3C that can express the outputs of evaluation and repair processes in machine-readable form. Typically, EARL statements contain the results of evaluation processes operated or managed by tools that can execute tests, possibly with some human intervention and guidance. The AccMD specification references EARL statements, to describe the display transformability and control flexibility of a primary resource. Such EARL statements are metadata with the constraint that they make it clear when the statements were made and by whom.

A primary resource description can contain a pointer to an equivalent for the resource or for a part of it. Equivalent resource descriptions provide a mechanism whereby an alternative (i.e. replacement for) or supplementary for a resource or part of a resource can be provided. The distinction between these is made with a Boolean field “supplementary”, the interpretation being that if this is false then it is an alternative.

An equivalent resource description will have a link to the object and part for which it is an equivalent. For the case where an object contains its own alternatives this will be a link to itself. An equivalent or supplementary object may need to be synchronized with the primary or other objects and so there may also be a synchronization file.

The final part of a resource description according to the AccMD specifications is data drawn from the range of values in AccLIP fields. For example, the <colorAvoidance> elements defined in the <alternativesToVisual> class match the <colorAvoidance> values defined in the AccLIP specification.

The AccMD specification [13] provides guidance on how to match accessibility metadata (i.e. a resource profile) to the properties defined in the AccLIP specification (i.e., a learner profile). It also defines the behavior applications should exhibit in some specific contexts; see the Best Practice Guide [14] for more information. While AccLIP and AccMD are designed to work together, there is no prescription about how they should be implemented beyond necessary behaviors that should be standardized for the sake of interoperability.

## 2.7 The Process of Matching Learners with Resources

Given metadata about the learner’s needs and preferences and metadata about the accessibility characteristics of the resource or

object, the process of matching the resource to the learner’s needs and preferences can begin.

A typical diagram showing the behaviors of systems using the metadata specified in the AccessForAll model is below (Figure 2).

## 2.8 Pilot Projects

Three projects described briefly here illustrate the diversity of application where the approach offers real benefit to both the end-learners and the service providers.

### 2.8.1 TILE

The Inclusive Learning Exchange [15] (TILE) is a learning object repository developed by the Adaptive Technology Resource Centre at the University of Toronto that implements both AccMD and AccLIP. When authors (educators) use the TILE authoring tool to aggregate and publish learning objects, they are supported in creating and appropriately labeling transformable aggregate lessons (codified by the TILE system using AccMD). Learners of the system define their learner preferences, which are stored as IMS-AccLIP records. TILE then matches the stated preferences of the learner with the desired resource configuration by transforming or re-aggregating the lesson.

### 2.8.2 Web-4-All

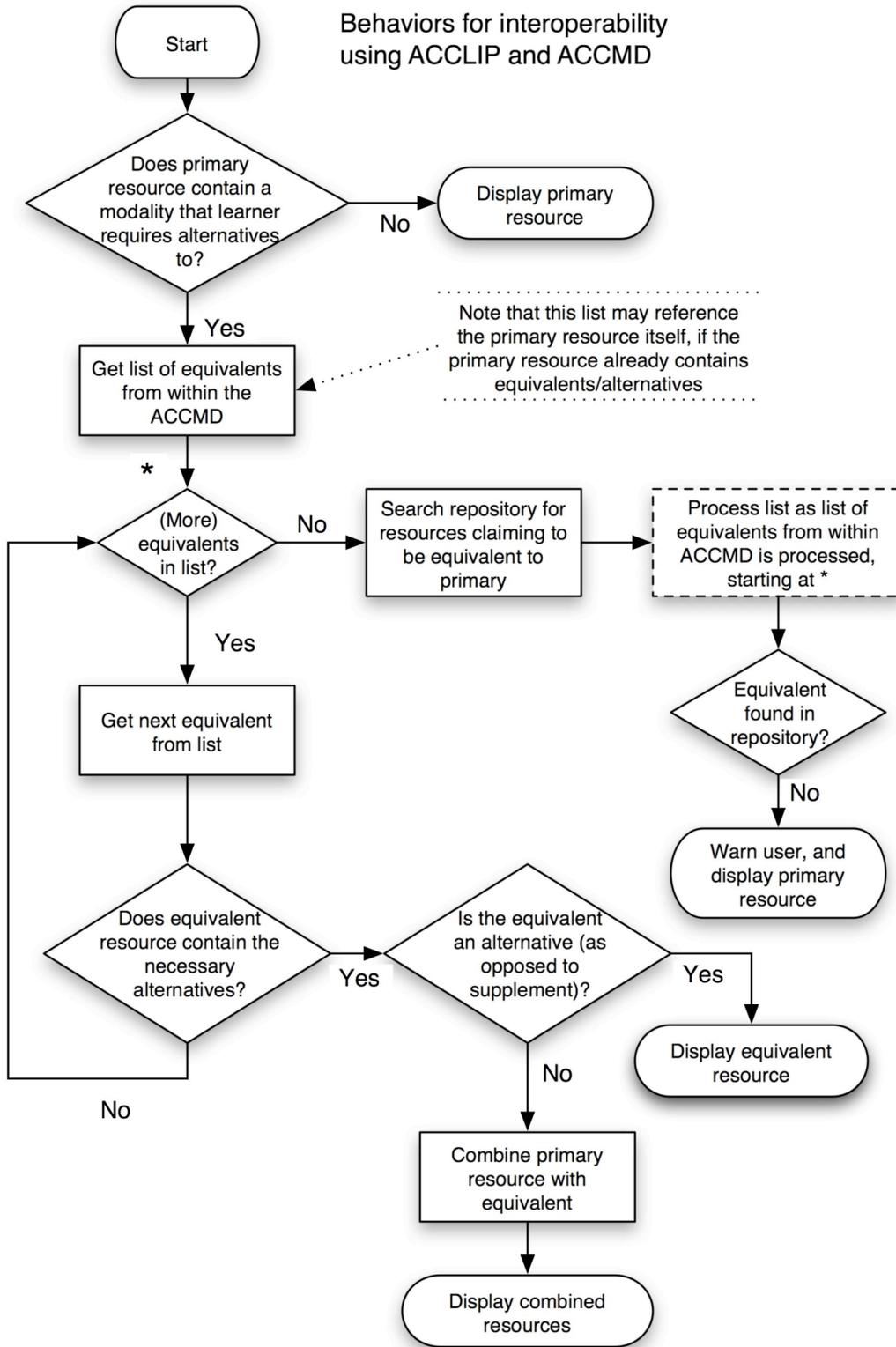
The Web-4-All [16] project is a collaboration between the Adaptive Technology Resource Centre at the University of Toronto and the Web Accessibility Office of Industry Canada to help meet the public Internet access needs of Canadians with disabilities and literacy issues. Web-4-All allows learners to quickly and automatically configure a public access computer using a learner preferences profile implemented with the AccLIP and stored on a smartcard that the learner keeps and can take from one public workstation to the next. When the smart card is read by the workstation, the Web4All software automatically configures the operating system, browser and necessary assistive technology according to the learner’s AccLIP. These settings are returned to their default values and applications terminated once the card is removed in preparation for the next learner. This significantly reduces the technical support required for the public workstations, avoids conflict between the assistive technologies used by consecutive learners and allows the learner to begin using the workstation without lengthy manual reconfiguration. If the assistive technology requested by a learner is not available on a workstation, the program will launch and configure the closest approximation.

### 2.8.3 PEARL

The PEARL project (Practical Experimentation by Accessible Remote Learning [17]) was an early European Commission funded project led by the Open University, UK. It developed a technical framework teaching laboratories for science and engineering to be offered to students remotely. One motivations for this was to increase the participation of disabled students in these subjects by offering enhanced access to practical work. Hence accessibility was a priority for the project.

The project implemented a learner interface approach in which interfaces were generated “on the fly” from XML descriptions of all the interface elements and the type of interaction they supported. The project explored an extension to this approach where, as well as XML descriptions of the activity and its

Figure 2. Behaviours for AccessForAll interoperability.



control and display elements, the “interface generator” was presented as an XML description of the learner and how they preferred to use their computer. This learner description was based on the then current draft IMS LIP <accessForAll> elements. It was possible to optimize the interface for individual learners taking into account, as examples, assistive technology requirements or the fact that students might be working hands-free.

### 3. FUTURE WORK AND CONCLUSION

The AccessForAll 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. 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 AccessForAll specifications recommend using 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 authors wish to contribute to the valuable work being done by others and welcome involvement in their work.

### 4. ACKNOWLEDGMENTS

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- [14] IMS AccessForAll Meta-data Best Practice and Implementation Guide Version 1.0 Final Specification, available at: [http://www.msglobal.org/accessibility/accmdv1p0/imsaccmd\\_bestv1p0.html](http://www.msglobal.org/accessibility/accmdv1p0/imsaccmd_bestv1p0.html)
- [15] <http://www.inclusivelearning.ca/>
- [16] <http://web4all.ca>
- [17] <http://iet.open.ac.uk/pearl>