Adaptable Accessible Resources: A Technology Perspective

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Abstract. A number of technology standards can facilitate the development of an accessible framework for eLearning. These include user modeling, device modeling and metadata standards. These standards have the potential to be used together to form a coherent platform that can support the provision of adaptable accessible learning material. The paper describes a number of important international standards and technical issues that need to be addressed to enable them to be used together.

Keywords: accessibility, AccLIP, AccMD, eLearning standards, IMS, ISO.

1 Introduction

The European Unified Accessible Lifelong Learning (EU4ALL) project seeks to establish a Service Oriented Architecture (SOA) framework to support the delivery of accessible e-learning material to all. Creating the framework involves integrating a varied mix of international learning technology standards and specifications. This paper presents how a tiny sample of the available technical components can be combined together to form a small part of an accessible, adaptable e-learning framework that which could be used to augment face-to-face teaching. Although it is accepted that a truly accessible system should allow learners to request individual psychological and educational support from a wider institutions, e-learning standards form the focus of this paper.

It is implicitly assumed that learning material will be delivered through the Internet. Material could be delivered to web browsers running on desktop workstations or to mobile devices that may or may not be connected to a network. It is a tenet of this paper, for which space precludes justification, that the provision of fully accessible digital learning material will involve adaptation of content and interfaces to meet the needs of individual learners. This paper identifies a number of key topics that need to be explored so this can be achieved.

The following section briefly presents some relevant aspects of the European Unified Accessible Lifelong Learning project and introduces the import topic of how metadata can be used to describe learning material. This is followed by a description of an interesting learning technology user modeling standard named AccLIP. This is contrasted with a different standard that is used to describe devices, called CC/PP. The third section describes how these different technologies can be combined together to form elements of an accessibility architecture that can adapt learning material to user needs and identifies some important practical issues and research directions that need to be addressed. The final section summarises.

2 Accessibility for all Framework

In an ideal world technology standards would be complete and mature. There would be no inconsistencies. Standards would be able to interface to others without schedule, political, organisational or structural difficulties. We would use problem-free specifications that would fit together easily. Since it is impossible to understand the needs of all users for all situations we must pragmatically work iteratively. This paper paints a picture of how some of the important standards might be able to work together.

Whilst it is possible to see how 'standards based' pieces of a framework for accessible eLearning can be built, a number of technical issues need to be addressed to make it work. It is essential that these are addressed because National and International infrastructures supporting eLearning are beginning to emerge, [1]. The issue of standards is a key focus since it is possible that the intention of creating an accessible e-learning architecture may at some point inform the development of emerging standards and specifications.

2.1 Describing Learning Material using Metadata

Metadata is data that can be used to describe other data. Metadata has many uses. It can allow time, date and user ownership information to be associated to files and can be used to indicate how digital resources have changed over time. Importantly, metadata can be used to help users to find digital resources they wish to use.

The ability to search for learning resources is important to the area of educational learning systems. Much effort has been expended into the development and creation of effective learning resources. In some cases, digital resources are placed within communal repository systems which are made available to institutions for use. The effectiveness of repositories relies heavily on the effectiveness of the metadata schemes that are used.

There are many different metadata schemes. Two significant metadata schemes include the IEEE Learning Objects Metadata (LOM) and Dublin Core (DC) specification [2], [3], [4]. These schemes are not yet complete since there are important areas they do not yet address. Support for cognitive learning styles is limited and they do not consider the need for places, events and off-line resources. LOM and DC use different, although not entirely compatible technologies and the consistency and continuation of these approaches cannot be guaranteed.

The LOM Survey, [5], has shown that there are difficulties associated with completing metadata fields that are not automatically supplied by software. As the difficulties of using metadata have been discovered, the focus of mainstream e-learning standards development has shifted away from use of colloquial (or local) descriptive terms. Whether human-readable terms should be represented in metadata schemes is still an open question and LOM and DC approach this differently. We may be best served by machine-readable multilingual registries of vocabulary terms permitting the maximum international interoperability, [6].

Some metadata schemes have been created with the issue of accessibility in mind. The IMS AccMD (Accessibility Metadata) has been designed to allow the discovery of accessible resources. An AccMD structure describes the access modality, how amenable the resource is to transformation, and whether there is a known equivalent [7]. AccMD has a counterpart in the International Standards Organisation (ISO) entitled Individualized Adaptability and Accessibility: Digital Resource Description scheme. At time of writing there are technical inconsistencies between the IMS and ISO versions of this work that need resolution but the principles remain applicable. The AccMD principle is complemented by a 'user profile' or a 'user model' called AccLIP, which also has an ISO equivalent. User models are is described in next section.

Metadata it is only useful if it is available. If it is available, it must also be accurate. Although metadata can help to discover and to combine digital learning material together in unique ways, much can be done without the use of metadata through the adoption a simple rule-based or heuristic approach to provide information about learning content.

One of the most widely adopted learning technology standards is the IMS Content Packaging (CP) specification [8]. CP allows parts of digital resources to be brought together to form larger units that are described using a manifest file that can be though of as a 'table of contents'. One of the intentions behind future developments of the CP specification is to provide a mechanism to allow alternative representations of the same resource to be maintained in the same file. A CP may contain, for example, an auditory presentation of an idea or concept in the form of an mp3 file, or a video that communicates the same concept through sign language. The metadata of a CP would emerge from its structure and the choice of individual digital resources. A mp3 file, for example, possesses the capability to store text equivalents (lyrics) to accompany an audio track. The accessibility (or available modalities) of such a resource could be described using a machine readable data structure.

The main difficulty may not be the willingness of content developers to tag learning material with appropriate metadata, but their willingness to provide appropriate alternatives representations

of material using an authoring tool that is not a substantial burden for users. A further difficulty may lie in the checking and testing of adaptability. Again, it is possible to draw on existing standards work and seek inspiration from the forthcoming publication of the Evaluation and Report Language (EARL) from the W3C[1]. Just as a web page can be checked for accessibility using an accessibility checker, a content package could be checked (and potentially validated) by an 'alternatives checker'. Finally, editing of adaptable content packages could be carried out by modifying existing authoring solutions, such as RELOAD[2].

2.2 User Modeling

Researchers have shown that guidelines such as the Web Accessibility Initiative Web Content Accessibility Guidelines 1.0 (WCAG), the forthcoming version 2.0 and the US Section 508 guidelines, [9], [10] cannot guarantee accessibility for all users since they can only address typical use cases [11]. Whilst guidelines might recommend that content should contain potential variations and adaptable features it is not feasible that all situations can be catered for since the precise requirements for all users can not be known until learning material is required to be delivered to users. Commercial providers also find it difficult to support all possible user situations. Something more is needed. What is missing from the picture is a *model* of the user.

The term *user model* has many different meanings. For large on-line retail stores, such as Amazon or auction sites such as eBay the term could be used to describe a representation of the users previous and likely spending patterns and browsing habits. Interaction design researchers (previously known as HCI researchers) may use the term user model to refer to an applications internal representation of the information that a user may have attended to, and a set of potential actions that a user may prefer to carry out given the previous actions they have performed. As new interactive systems are developed, the number of different incompatible models increases. For an extensive review of generic user models, see [12].

Another way to use the term user model is to refer to data that can be used to describe Functional User Preferences, namely data that describes was user may want or need in terms of content, material, or what kind of device or system the user is using or prefers to use. This notion of user modeling to support adaptability can be seen within the work of the earlier AVANTI project [13]. The AVANTI project integrates user modeling, internal message passing and communication, performing content adaption using a rule based system. Recent technological developments within standards have given rise to the development of web-service based service oriented architectures (SOAs) and an independent movement towards the standardisation of new functionally-oriented user modeling techniques.

An engineering student might one day use a public terminal in a library (quiet environment, fixed device), and on another day retrieve information from a laptop whilst working in a coal mine (low light environment, portable device) or check details learned on a course using a hand held device whilst servicing an airplane (noisy environment, mobile device). A functional model is required that expresses the essence of properties such as “I need content delivery that does not depend on visibility”. Being in a coal mine does not imply blindness and being in a noisy environment does not imply deafness, yet the delivery requirements are the same as they might be in those cases.

One such functionally-oriented user modeling approach is the IMS AccessForAll Learner Information Package Accessibility for LIP (AccLIP) [7]. The specification has been adapted as an ISO standard where it is known as Individualized Adaptability and Accessibility for Learning, Education and Training: Personal Needs and Preferences Statement (PNP), [14]. The intention behind AccLIP (or PNP) is to provide a standard way to describe a specific set of functional preferences or requirements for accessibility.

The specification expresses requirements for characteristics of the display, content (such as colour-independence) and required control features (such as sticky-keys). It can provide a system-independent way for information to be recorded to be passed to a learning management system which will adapt presentation and learning material to the users needs. The notion is that a learner may have one or more requirements description (an AccLIP) and use whichever one is appropriate

1 http://www.w3.org/WAI/intro/earl.php visited 13 April 2007
2 Http://www.reload.ac.uk visited 13 April 2007

for the context (environment) in which she or he is currently situated. For example, a learner may have one AccLIP instance for college and another for home.

The current AccLIP specification uses an XML binding that is also part of the IMS Learner Information Package Specification, [15]. The ISO description consists of definitions but does not contain a formal binding. Work is also underway within ISO to incorporate requirements in respect of places, events and blended learning contexts such as the use of off-line resources and services.

2.3 Device Modeling

To create a fully accessible and extensible architecture is is necessary to consider not only the needs of the individual users themselves, but also the forms of devices (or user agents) that learners could use. Not only is it necessary to model the users, it is also necessary to model and describe devices. The W3C Composite Capability/Preference Profiles (CC/PP): Structure and Vocabularies provides a way to describe device capabilities such as display width and height, operating systems and versions, software supported and many other properties, [16], [17].

The CC/PP specification uses a technology called Resource Description Framework (RDF). RDF can be used to represent information in a form that can be held on different systems that can be parsed, processed and analyzed in different ways. RDF is considered, by many, to be one of the cornerstones of the semantic web. RDF is, to some degree, at odds with the 'tree structured' user modeling and metadata approaches described in the previous two sections. To engineer a complete system, these different ways of representing digital systems and resources need to be reconciled.

3. Combining the Technologies

Figure 1 illustrates how the different technologies could be combined together. This diagram is not a formal architectural description of a system. Instead, it is a conceptual model that describes how the previously described elements may sit alongside each other. The diagram assumes that accessible learning material is held within a content management system or learning object repository system. It is also assumed that the content within such a systems might have been transferred using a content package that may describe and contain alternative representations of learning materials. The learning material in the form of learning objects may be described using Learning Object Metadata (LOM) and accessibility metadata (AccMD). Although the issue of learning design is considered to be important, for the sake of illustration, it is excluded from this scenario.

The shaded area represents a virtual learning environment. A central part of the system is the 'adaption engine' featured in the center of the diagram. The adaption engine requires descriptions of the metadata, user and device. For sake of simplicity, these descriptions are presented as being in RDF. RDF poses several advantages over traditional tree-structured XML. From a technical perspective, different RDF structures can combined easily. This factor allows RDF structures (or ontologies) to be extended more easily. As well as RDF relation being available in a form that can be human readable, RDF data can be processed programmatically. RDF data is also easier to process within propositional logic systems.

The adaption engine is illustrated as having a 'rules' component. This abstract component has a parallel with earlier adaptive hypermedia work. The rules are used to match the available learning resource which has been described using metadata, with the current device and user profiles. In the cases where there is incomplete metadata the system shall offer 'default' information regarding the digital resources that are available. These 'defaults' will be presented a description of digital resources in terms of their suitability to particular presentation modality. When a resource is presented to a user, the required digital resources will be obtained from a material repository.

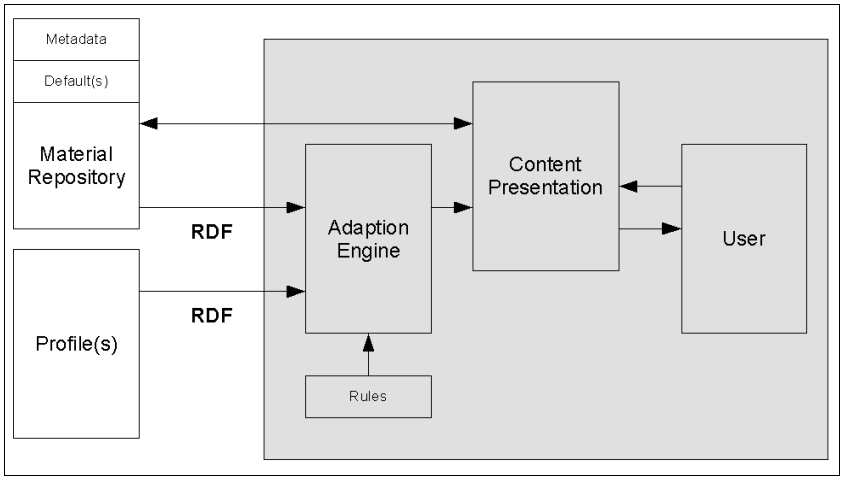

Figure 1 : Illustration of components

There are a number of issues that need to be addressed and explored before this illustration could be converted into a functioning prototype. The key issues are as follows:

1. The operation of the system relies on providing learning material that contains suitable alternatives. It is necessary to engineer tools to facilitate the efficient and effective construction learning material to contain alternatives. Only by constructing alternatives can we hope to offer users the richest learning experience.

2. The logic of matching content to the basic AccLIP can be complex[3] and matches can be partial. Matching with CC/PP is likely to be more complex.

3. It is necessary to construct an RDF binding of the AccLIP and the corresponding learning object metadata. This would simplify the implementation of a matching engine and provide accessibility descriptions in a form that can be processed by machine, potentially improving and enhancing how accessible material can be found.

4. It is necessary to construct a rule-based inferencing/matching engine that can accept and parse the metadata descriptions, a user profile instance, a CC/PP device description instance and perform resource matching.

Another approach might be to construct a whole new model (information model, schema, binding etc.) that describes the information from each of these areas of work. It should be stated that the standards are presented in this paper have been developed through a structured process that takes into account many different stakeholders and use cases.

This paper has not addressed many principles and technologies that impinge on and are crucial to a complete architecture. These include the need to address blending of on-line and off-line services, interoperability with existing and emerging Learning Management Systems, and accessibility evaluation, conformance and repair tools.

3. Summary

A number of learning technology standards and specifications can be used to inform the development of an accessible e-learning system. The central tenet of this brief paper is the notion of the *adaptable learning resource*. This is a collection of orthogonal electronic resources, components or files that can be selected and presented in a way that suits the needs of individual

3 for examples of complex logic matching AccMD to AccLIP see http://www.imsglobal.org/accessibility/accmdv1p0/imsaccmd_infov1p0.html#1651699 visited 23rd February 2007

users[4]. A description of how a number of components can be combined together has been made and a number of issues that remain outstanding have been identified. Although the outstanding technological work is considered to be substantial, such work may have the potential to inform the design and development of future e-learning systems and standards.

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Acknowledgements

Many thanks are extended to the reviewers whose comments were very instructive. Further thanks are extended to Andy Heath of the Institute of Educational Technology at the Open University, UK whose experience in international learning technology standards and specifications has proved to be invaluable.

4 Orthogonal in the sense of modality.