CONTENT PACKAGE ADAPTATION: A WEB SERVICES APPROACH

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Abstract: The IMS Content Packaging Specification is a format that facilitates the deployment of discrete units of learning resources based on an XML structure called a manifest. The contents and structure of a content package are determined at design time when it is created. Since the package has been authored for use in a particular instructional setting, re-purposing the content package to meet the demands of a different instructional setting is difficult. Although there have been attempts to improve the flexibility of the package such as using IMS Simple Sequencing, the adaptation provided is still inadequate. In this paper we argue that Web Services can be used to facilitate the dynamic adaptation of a content package so that it can be reused in diverse instructional scenarios and accessed by additional learners who otherwise would not be able to utilize it. We present a framework for adaptation based on web services and identify a representative set of web services that could be used for content package adaptation. We then discuss in detail the Media Integration and Translation Services for Accessibility (MITSA), a category of web services designed to promote media accessibility of a content package. Finally, we conclude by highlighting the benefits of the web services approach for content package adaptation.

1 INTRODUCTION

An IMS content package (CP) (IMS Content Packaging Information Model, 2003) is a format that can be used for storing learning objects. A learning object is commonly understood to be an independent and self-standing unit of learning content that is predisposed to reuse in multiple instructional contexts (Polsani, 2003). A content package contains a set of digital learning resources as well as a manifest that describes how the learning resources should be organized to form a unit of instruction. If learning objects are stored in the form of an IMS content package, the content package essentially combines learning content into a discrete unit of learning that could potentially be reused in different instructional platforms and scenarios.

One approach for reusing learning objects stored as content packages is to disaggregate and assemble the learning resources contained in the package to form new units of instruction. However a more recent approach by Fraser and Mohan (2004) suggests that a content package can be imbued with knowledge about web services that can facilitate dynamic adaptation when used in different instructional scenarios. In this paper, we argue that a web services approach can be used to provide a more sophisticated form of content package adaptation. This in turn promotes a deeper kind of reusability of learning resources than what is possible using the ‘pure’ learning objects approach. We present a viable framework for content package adaptation and identify a representative set of web services that could be used to facilitate content package adaptation. Additionally, we briefly review and discuss other service-oriented frameworks for adaptation in learning systems. We also present the Media Integration and Translation Services for Accessibility (MITSA), a category of web services designed to promote media accessibility of content packages.

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2 CONTENT PACKAGING

The IMS content packaging specification was designed to address interoperability issues with regard to the import and export of aggregate and disaggregate packages of content between learning management systems (LMS). It is a standardised format for specifying the assembly of learning resources into an interoperable unit at different levels of granularity. A content package consists of a single top-level manifest file together with the physical files it specifies. It is shipped via a single digital resource called a package interchange file (PIF), which could be in some appropriate archive format such as zip, cab or jar. The basic structure of a content package is shown in Figure 1. The function of the manifest is to specify the structure of the content in the package by means of an organizations section (currently, only hierarchical structures are permitted). The resources section of the package identifies the physical files that comprise the content package. It may also identify URLs, which are links to external resources. Items in the content structure are linked to the resources that are required for rendering the content on a learner's web browser.

The manifest is serialized in XML and optionally describes a set of simple sequencing rules and a learning design. Additionally, the content package may contain metadata that describes its characteristics. The IEEE Learning Object Metadata (LOM) standard can be used for this purpose (IEEE LTSC). Metadata instances can be used to describe the entire content package (i.e., learning object) or individual resources and items within the package. A resource may also refer to a sub-manifest. Thus, a manifest may consist of other sub-manifests, each of which is a content package in its own right. This enables the aggregation of learning resources into coarser-grained structures of learning.

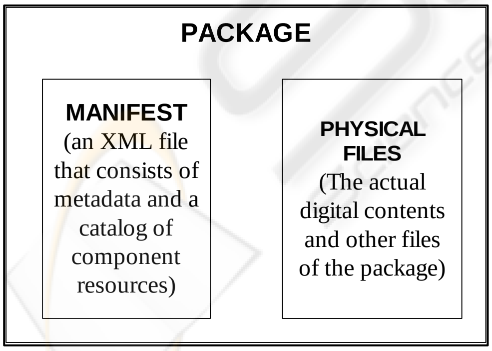

Figure 1: IMS content package – basic structure

In its present form, the IEEE metadata standard does not contain enough information to allow re-purposing of a content package in a new instructional scenario (Farance, 2003). When a content package is assembled, it is intended for use in a particular context and instructional scenario. A unit of instruction refers to a content package with an appropriate instructional design. Thus, a learning object is really a unit of instruction at different levels of granularity. When learning objects are dis-aggregated and assembled into new content packages, the instructional design that applied to the original content package is no longer applicable. It is important to note that some researchers (Koper, 2001) do not consider a learning object that does not have an associated relevant learning design to be a unit of instruction. The specification does not address this limitation.

Another limitation is that the content package specification does not facilitate the dynamic adaptation that responds to the changing needs of learners. Since the delivery structure has been designed and shipped with the package (i.e., the items of content and the physical media associated with those items have already been determined), it is not possible for the LMS to adapt the content package to new learner requirements. This is also true when an item of content references an external resource since the same resource is shipped to every learner whether or not a server has prepared it dynamically. This is the classic, traditional client-sever paradigm of server-side applications. The problem is that the resource is independent and largely irrelevant of the new instructional scenario since the request for the resource on a web server has been hard-coded in the CP and cannot change. Thus, the assumption that a CP is a reusable resource is misleading since it cannot be re-purposed in a timely manner. The main goal of the paper is to address the latter limitation and show how more sophisticated forms of reusability are permitted using a web services approach.

3 ADAPTIVE LEARNING SYSTEMS

An adaptive learning system (ALS) is one that facilitates a learning environment that meets the goals and objectives of the learner by presenting pedagogically sound learning material as the needs of the learner change. Since the learning materials on the WWW commonly take different media forms, ALS are sometimes called Adaptive Hypermedia Systems (AHS). ALS is based on a move away from the "one size fits all" thinking as regards the distribution of learning material (Brusilovsky, 1996). The navigational freedom in conventional hypermedia applications leads to comprehension and

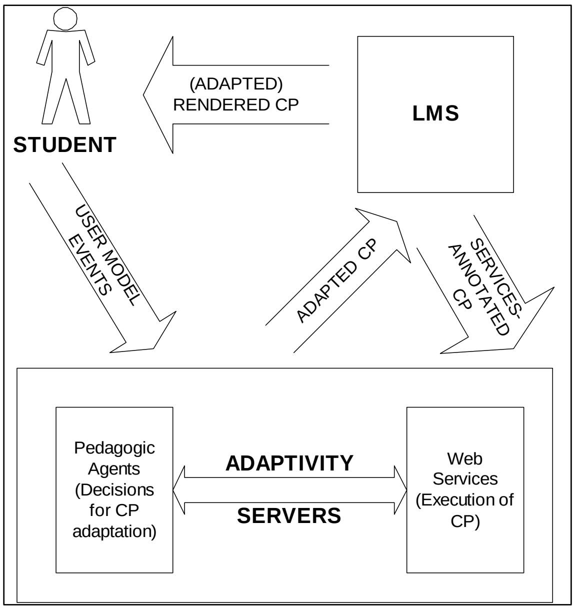

Figure 2: Content package adaptation via web services

orientation problems (Brusilovsky, 1996). Adaptive hypermedia attempts to overcome these problems by adapting the presentation of information and the navigation structure, based on a user model (Brusilovsky, 1996). This guidance and direction essentially channels and fosters the cognitive links that learners seek to create in order to truly understand the concepts the media aims to teach. The most popular techniques used in ALS can be classified into two main types (De Bra, Brusilovsky and Houben, 1999). These are:

- Adaptive presentation - system determines what the user currently experiences
- Adaptive navigation support – system decides where the user goes next

The user model, which importantly measures the student's grasp or knowledge state of a concept, drives the adaptation.

For adaptive navigation support, the user model is applied to classify learning items into several groups according to the user's current knowledge state and interests or goals. The ALS manipulates the link structure to guide users towards interesting, relevant information (Brusilovsky, 1996). A classic example of this strategy is in a recently proposed architecture that identifies and groups learning elements that share common concepts into candidate groups. The user model then motivates the system to guide the user to learning items in a particular candidate group (Dagger, Conlan and Wade, 2003). Other techniques under this category include link hiding, link annotation, link disabling, and link removal (Brusilovsky, 1996).

Adaptive presentation adapts the presentation of the current page according to the user model particularly the knowledge state. It is typically used to provide "scaffolding" for the learner. Scaffolding is a term used to provide additional support to learning beyond the mainstream delivery. This may include providing prerequisite, additional, or comparative explanations for "hard to understand" concepts (Brusilovsky and Maybury, 2002). Techniques used to provide adaptive presentation include:

- Conditional inclusion of learning fragments based upon the user's knowledge state (De Bra, Aerts, Berden and de Lange, 2003)
- Stretch text: system initiated stretching or shrinking of learning fragments and subsequently controlled by user (De Bra, Brusilovsky and Houben, 1999)
- Providing alternative explanations (Vassileva and Deters, 1998)
- Reordering of presented items on a page (De Bra, Brusilovsky and Houben, 1999)

4 WEB SERVICES ADAPTATION

4.1 Overview of Web Services

A web service is a service provided on the Web by a server computer that may be invoked by several clients in a distributed framework. In order to communicate with a web server that provides a service, a client uses SOAP (W3C, 2004) - a packaged, XML-formatted method call to a service on a particular server. The web server provides a catalogue of available methods from which the client may choose to access a particular service. This catalogue is in XML format and conforms to a platform independent Web Services Description Language (WSDL) (W3C, 2003), which is an API for the service invocation. It indicates a parameter list and return type of each method belonging to a particular web service. After executing the client's request encoded in a SOAP envelope, the web service replies to the client using a SOAP message of its own. The client then unravels the SOAP package to retrieve the response. In this way, web services provide a run time environment for executing methods over an HTTP or HTTPS wire (i.e., over the Web).

4.2 Architecture

We propose that web services can act as a runtime environment for the execution of services identified in a CP. CP services are standardised XML formatted tags that identify the resource to be adapted, a description of the specific adaptation to be carried out and the actual endpoint address of the web service that carries out the adaptation. These service tags are invisible to the LMS so that they do not intrude on the traditional model of interaction that exists between the LMS and the CP. In the classic model of interaction, the LMS receives a content package from a digital repository and simply renders it to the learner. See Figure 2.

Software agents use the information recorded in a CP to actually invoke the web services specified by the endpoint address. These agents are aware of the services specified in the CP and continually monitor the user model (student profile) for noteworthy changes. There are also agents that create, manage and update the user model based on the learner's interaction with the system. Information in the user model may include the user's learner preferences and style, competencies, objectives, learning history and browser and client capabilities. Agents that determine user model changes that warrant adaptation invoke the web service endpoint address in the CP - called a CP web service (CPWS). When the web service has carried out the adaptation of the CP (or part of it), the result is returned to the adaptation agent. This agent then forwards the adapted CP to the LMS so that it can render the newly adapted learning resource. Since the user model drives the adaptation, the new change improves the user's learning experience and leads to better learning. Thus CP services, via specified web services, dynamically re-purposes reusable online learning resources by adapting the CP to learner needs (Fraser and Mohan, 2004). The capability of the web client to correctly display any adapted content also affects the agent's decision-making process for adaptation. In the main, this web services approach provides dynamic (on the fly) adaptation. Particularly, it provides a powerful mechanism for adaptive presentation. It is thus an effective service-oriented approach to adaptive e-learning.

It may be necessary to procure learning resources based on the type of adaptation they are capable of undergoing. Thus, adaptive capability forms part of metadata search criteria and digital repositories can be queried for specific service types. We will now suggest some candidate web services for e-learning and look closer at the MITSA services.

5 WEB SERVICES AND IMPLEMENTATION

5.1 Candidate Web Services

To support our argument that the web services approach is a viable means of providing dynamic and meaningful content package adaptation, we present a non-exhaustive list of representative classes of basic web services for e-learning. These are listed in Table 1.

5.2 Overview of MITSA

There is a need to provide quality educational content to the differently able. However in most cases, the educational material is not aimed at persons who possess hearing and visual impairment or some other form of impairment. Both the W3C Accessibility Initiative Policies and Web Content Accessibility Guidelines (W3C WAI, 2004) strongly encourages that content providers on the WWW take this target audience into account in the design of

Table 1: A representative set of web services for content package adaptation

Candidate Set of Web Services		
Service class	**Functional Description**	**Benefits**
Language Translation Services (LTS)	Translate the language of the resources and any associated metadata	Extend the reach of learning resource to speakers of diverse languages thereby increasing reusability
Media Integration and Translation Services for Accessibility (MITSA)	Transform media type of learning resource from one to the next	Makes content accessible to a new learner type and increases the didactic effectiveness of resource
Dynamic Metadata Adaptation and Generation for Interoperability (DMAGI)	Translate one metadata profile to another, adapt metadata profiles to a change in resource, generate new profile from resource	Improve interoperability between learning systems, promote better resource discovery and reusability

their sites and products. The policy also generally defines requirements for educational content providers.

MITSA aims to fulfil the need to reach a broader range of individuals including those who could not otherwise access quality educational content because of the alienation imposed upon them by traditional forms of text and other multimedia. It facilitates translation from one multimedia format to another and also reintegrates disparate pieces of processed multimedia so that the resulting product is meaningful and pedagogically viable. MITSA is intended to widen the reach of reusable learning content by distributing educational content equitably thereby bridging the accessibility barriers.

Consider the following use case of MITSA. This use case is for ‘normal’ learners who wish to get a text to voice translation of a learning resource. First, the learner clicks on an item from the content package (usually generated as a hierarchical frame display by the LMS). The monitoring agent senses the request and on checking the user-modelling agent, determines that the learner has new preferences for both textual and voice formats of a learning resource or certain competency levels demand both. An agent then retrieves the appropriate learning resource from the LMS. The adaptation agent then examines the content package and finds the web service identified for translation. This web service is invoked with the learning resource as a parameter. The web service returns its results in the form of an audio file, which is passed to the LMS for delivery. The LMS then streams the audio file to the learner’s browser and simultaneously displays the textual content.

5.3 MITSA Implementation

The MITSA implementation is based on the architecture presented in Section 4. The implementation involves the inclusion of a *services* element in the general element of the metadata section of a CP, its individual items or resources. MITSA and other candidate services implement the CP services alluded to by the architecture in a way that extends the CP specification. Examples of services that reside under the umbrella of MITSA include text to voice services such as that described in the use case and text to Morse code services. Consider the sample excerpt of content package metadata that elaborates one MITSA service element below.

```
<cpws:services>
<service class=”cpws:mitsa”>
<parameters>
 <parameter type=”resource”>
  <id>resource1</id>
  <mime-type>text/plain</mime-type>
  <encoding>ASCII</encoding>
 </parameter>
</parameters>
<loc>http://sage.uwi.tt/cpbehave/audio</loc>
<method>toAudio</method>
<description>text to audio</description>
<return>
 <mime-type>wav</mime-type>
 <encoding>base64</encoding>
</return>
</service>
</cpws:services>
```

The agent gathers the necessary information for adaptation by parsing the *cpws:services* element. In the above example, the agent recognises the service as belonging to the MITSA *class*. The web service will take one parameter, which is *resource1* and is plain text. The name of the web service that will execute the action in the *description* element is *toAudio*. It will *return* a *wav* file but it will be in base64 format. This information is necessary to inform the agent how to store and deploy the media to the LMS. Many *service* elements are possible each belonging to its own class. This is a simple yet very powerful example of adaptive presentation using web services. We will now discuss and compare other service-oriented approaches to adaptive e-learning.

6 DISCUSSION

Other researchers are increasingly recognising the value of learning services in adaptive e-learning. For example, a system (Dolog, Henze, Nejdl and Sinteky, 2004) provides a framework for personalized e-learning using web services and describes an architecture for personalised learning support in a P2P, distributed e-learning environment. They identify two sets of services. These are personalization services and supporting services. Web services are used as a means of carrying out personalization functionalities for personalized learning support. However they are not used to directly adapt a learner resource. That is, their approach does not use services in a way that extends the reach of the CP (learning resource) for accessibility by increasing its plasticity for different learning types.

A major benefit of the web services approach is the quality of adaptation that may be performed by the most powerful and sophisticated software that underlie the web services. For example, for the MITSA, Java Web Services are used and the text to voice conversions are done by software that uses the Java Speech API (JSAPI). There are several third party software firms who specialise in the creation and execution of particular services. This specialisation of labour leads to greater productivity as is well known in the field of economics. As the learning services industry becomes lucrative other firms will be attracted to participate. As more participate, competition and market forces will cause service provision and execution costs to learning systems to become cheaper. The quality of services increases further as firms attempt to remain competitive in their service provision and execution portfolios for education. In sum, the web services approach promises affordable, personalised and adaptive quality learning.

7 CONCLUSION

The web services approach has been presented in this paper as a viable means of extending the reach of a rigidly and statically designed content package. Much effort has been spent in specifying standards for packaging learning objects and describing them using metadata. Our approach integrates well with these existing standards. It simply extends the content package with information related to services that can lead to dynamic adaptation in diverse instructional scenarios. In doing so, it takes reusability and adaptability to a new level, allowing service providers on the Web to augment the potential of learning objects in many different ways, media translation and formatting being one of them. We feel that providing services that can enrich content in a more controlled environment is potentially a more viable means of reusability than the pure learning objects approach that has been promoted over the past few years. Of course, the development of tools to annotate these services in the learning object will encourage adoption of the approach.

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