Course Material Model in A&O Learning Environment

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Abstract: One of the problematic issues in the content development for learning environments is the process of importing various types of course material into the environment. This article describes a method for importing material into the A&O open learning environment by introducing a material model for metadata recognised by the environment. The structure of metadata in A&O material model is defined and encoded using XML (Extensible Markup Language) vocabulary. To motivate our work, we briefly introduce basic ideas of structured documents and reflect our work with some learning standards related to this field. Finally, we illustrate our work with a simple example of using the material model in the A&O learning environment.

Introduction

The article discusses the problems in producing interactive learning material to learning environments. As an example, we introduce the material model designed for the A&O learning environment. A&O is a learning environment produced in the Open Learning Environment (OLE) project in the Hypermedia Laboratory of the Tampere University of Technology. The main features of the A&O learning environment are: possibility to accommodate any number of courses and their materials, user identification, tools to assist the learning e.g. communication and constructive tools, and connectivity to databanks. Technically, A&O is mainly a Java technology based distributed application. [Pohjolainen, S., et al. 2000]

In the first chapter we discuss about different ways of creating learning material to WWW-based learning environments and define the context to which the A&O material model design was based on. Then we introduce the concept of structured documents and XML (Extensible Markup Language), and the notion of metadata which constitutes a big part in the A&O material model. We also take a look at some learning-related standards that can have great affect on the evolution of the learning material production. We describe the A&O material model with some examples and definitions. Finally there we draw some conclusions about producing learning material and the A&O material model.

Constructing Interactive Learning Material

There are many ways in constructing learning material to various learning environments in the World Wide Web. Some people like to use HTML (Hyper Text Markup Language) while others prefer traditional publishing programs to create PDF-files (Portable Data Format). There is also a possibility of defining rigorously typed documents by using XML or SGML (Standard Generalized Markup Language) like Solvig Norman [2000] has done in Open Learning Agency. In addition, what would be the correct way to produce interactive elements such as exercises and various other constructive tools? Faced with a bundle of pedagogical questions to consider in creating learning material, it seems that we should be able to use the tool that we feel most comfortable with. Of course, sometimes we have to make compromises in favouring our own and the learners' convenience. For example, the technical constraints imply that we can’t use very large pictures even if they would be easy to produce and pedagogically appropriate. However, this is something we must all live with.

Fortunately, some of these restrictions can be hidden, simply by choosing the right tools. Selecting to use a specific tool, however, tends to limit our possibilities to import learning material into learning environments. This is not really the fault of the learning environment; there simply exists almost uncountable number of different kind of formats to multimedia documents to deal with. Although some of these formats are very suitable in describing the material, not all of them provide the right kind of information, e.g., to be used as a basis for the search engines of learning environments. Even if the format did contain the appropriate information, e.g., based on a global standard, there is the risk that it would eventually be a limitation for producing material utilising the latest technology. This implies a need for two levels of standardisation.

Structured Documents

The idea of describing the structure of course material presupposes the concept of a structured document. To put it simply, structured document is a text document consisting of two kinds of characters: data and markup. Markup is mainly used to organise content into hierarchical element structures. The ultimate goal is to provide a unique and simple syntax for representing relations between different types of elements in a document. The approach of structured documents is usually used for two reasons: to describe abstract data structures and to separate the content of documents from their appearance.

The first major mechanism for describing and writing classes of structured documents was SGML (Standard Generalised Markup Language). SGML received the status of an ISO standard in 1986. SGML is not a markup language itself but a metalanguage; an open-ended industry level standard for defining logically structured information. The key idea of SGML is to provide standard means for the construction of hardware and software independent document encoding schemas, called SGML applications. The most famous SGML application is by no doubt HTML. The complexity of SGML, and the success of the simplicity of HTML, led to the development of a markup language that would combine the best parts of both worlds in a modern networked computer environment. This work culminated in XML (Extensible Markup Language) 1.0 recommendation published by W3C (World Wide Web Consortium) in 1998 [W3C, online]. XML provides both a metalanguage for describing document classes consisting of logical element structures and an actual markup syntax for writing documents. The basic idea is to markup text documents into logical element structures in a specific machine-readable form. It is also possible to declare a type (including the vocabulary of documents) for an XML document, providing a basis for automated validation of the logical structure of documents. The meaning of logical XML structures is not stated in XML, but can be globally fixed using Namespaces names prohibiting collisions of names of different applications.

As such, XML 1.0 is sufficient only for very abstract tasks such as describing data exchange formats between applications. Other practical applications of XML require also, e.g., agreements of specific vocabularies. With this in mind, W3C introduces a whole family of XML-related standards, including XML Namespaces, XML Schema, XLink, and XSL (some of which have not received a status of W3C recommendation yet).

Metadata

In principle, standardising all document encoding using specific document schemas and vocabularies would provide a powerful way to promote interoperability of documents, e.g., for transferring educational content between learning systems with different architectures. In reality, however, this is too much for a requirement since majority of authors wants to produce their material with a wide range of different techniques, aimed to radically different Web client configurations. Fortunately, from the practical point of view, the question whether the internal structure of documents can be formalised and interpreted by different learning systems or not, is not as important as the question whether meaningful descriptions of documents can be shared and successfully applied among them. This is where standardised formats of metadata come into the picture.

As the term puts it, metadata is information about data. The basic idea is to provide short, informative, and a useful description of a large amount of related information whose internal structure is too complicated or even irrelevant to be used as such. Most metadata structures deal with taxonomic systems characterising information some sort of queries in mind. Given an application, the question what is good metadata, is answered by evaluating the intended usage of it. For instance, considering educational course material, a good metadata description might provide a standard format for stating the topics of the material, the intended organisation of the material when taught as a course, and the list of exercises or quizzes prepared for each topic.

Learning-related Standards versus Reality

There are two major levels of standardisation of metadata to be considered. First, the intent and format of metadata within a specific learning system (say, A&O), and second, the intent and format of metadata between two or more different systems (say, between A&O and WebCT). The application area of the former is to provide a mechanism, e.g., for uploading diversified course material into a specific learning system, while the latter deals with interoperability standards, e.g., transporting course material between different learning system architectures.

It might be tempting to assume that an ideal solution would automatically combine these two objectives in a form of a universal learning standard. Unfortunately unified standardisation only comes with a price, either by accepting overwhelming complexity of such a standard, or allowing oversimplifications in descriptions of learning objects and concepts. We will not address this issue further here; for a more detailed discussion about the pitfalls of "fossilisation", see, e.g., (Robson, 2000). Of these two levels of metadata standardisation, we shall first consider the latter more general case, and then return to the first, in which this article will mainly be focused on.

It is obvious that in order a metadata format independent from learning systems to be applicable, it must be both well standardised and agreed among vendors of different (major) learning systems. Without a mutual commitment and a concrete specification, the abstract idea of metadata doesn't carry too far. This implies that an influential forum for developers and system vendors is required. At the time of writing, there exists several groups promoting learning technology standards. According to [Robson, 2000], general interoperability standards are developed by IEEE LTSC, the IMS project, and ADL. Standard development is done, e.g., in IMS, Ariadne, Gestalt, and AICC. These organisations have actively participated in the development of LOM (Learning Object Metadata), developed by the IEEE learning technology standards committee [IEEE, online]. LOM aims providing an abstract data model for describing educational material. Abstract LOM is implemented via LOM bindings, concrete implementations of data structures proposed by it, e.g., using XML document schemas.

There are, of course, general metadata standards applicable also to describing learning material. A good example of a general approach towards a practical metadata standard is W3C's RDF (Resource Description Framework) candidate recommendation (see, e.g. [W3C, online]). According to the specification, "...RDF is a foundation for processing metadata; it provides interoperability between applications that exchange machine-understandable information on the Web." In principle, provided that a suitable vocabulary is agreed upon, RDF provides a way to describe any Web resource from the viewpoint of learning in the same fashion that LOM would do. Another example of a suitable general metadata system is Dublin Core metadata, a short and concise set of properties developed for classifying Internet resources [Dublin Core Metadata Initiative, online].

However, from the viewpoint of a specific learning system, interoperability standards come with at least two major shortcomings. First, much of the standardisation work is still experimental or under development, and second, the standards do not necessarily provide support for the information that is crucial for the specific features of the learning system at hand. A practical learning system is faced with the evident problem of content production that can't be postponed until the grand standards are settled. In order to be able to upload content here and now, some proprietary format for accepting material is needed.

There are two basic approaches for solving this problem. The first solution is to define, introduce, and essentially fix, a range of authoring tools allowed in the authoring process. The second is to define an exact model for the core structure of the material, acting as an interface between the learning system and the process of content production. In this article, we're promoting the latter line of working since we believe that it has three major advantages to offer. First, it gives authors freedom of using any tool appropriate, as long as material is described correctly via the material model. Second, the complexity and behaviour of the material is not unnecessarily constrained; material may contain components outside the scope of the model, as long as the learning system doesn't have to be aware of them. Third, provided that the mode is rich enough, rigorous modelling of the material creates a concrete basis for future applications of interoperability standards.

The Material Model in A&O

The new A&O material model was designed in team-work in the Hypermedia Laboratory in the Tampere University of Technology by the authors of this article and the other members of the A&O technical development team: Tuukka Arola and Vesa-Matti Hartikainen.

The Realisation of the A&O Material Model Project

The main reason for designing a new course learning material model for A&O was the fact that the old model was only implemented to work with one specific tool which didn't quite meet the new requirements set by material authors [Nykänen 1999]. The new model was designed to be as open and general as possible because there seemed to be quite large number of tools for creating material for the WWW-environment, none of which being significantly better than the other. The decision about selecting the authoring tool was left to the author, and the material model was designed so the author could use his or her favourite authoring tool, bearing in mind that the material produced will be accessed via the WWW. We also wanted to leave room for the considerations of the upcoming standards concerning learning environments and the material.

The A&O learning environment provides many useful services for the learning material, for example, the annotation tool which allows the learner to write and attach notes to certain places in the material. One of the main concerns in the design of the material model was that we wanted to create an easy way for authors to take advantage of the services of the A&O while developing the material. Another major reason for the new material model was the awareness of the increasing need for security in the Internet. The previous implementation didn't explicitly favoured storing course material in a protected and private storage. However, if security issues are not taken care of, course material in a public directory accessible through the Internet to anyone knowing where to look for it. The new model allows situating the material to a private directory in the file system of the server and the material is only accessible to a user when he or she is actually using the system with right privileges. This is achieved by using Java Servlets as gatekeepers for all the material. The identification of the user is done with the comparison of the cookies, client IP-addresses (Internet Protocol), and active user sessions.

The Material Description Document

The A&O material model is based on the idea of collecting metadata from the material and the author. We decided to describe the material with an additional description document, in a similar manner to some proposed interactive learning material standards. The metadata or description document uses the vocabulary listed in Table 1 to describe the course and the material as generally as possible (from the viewpoint of the learning system).

Table 1. The terms defining the structure of the A&O material model.

Course	The term course refers to the actual course, metadata of which we are describing. One course description element contains general information about the course such as name, code and description, authors, and material.
Author	The term author refers to the producer of the material. In addition to the personal information, author element may contain, e.g., contact and copyright information.
Material	The material is the learning material as a whole. It contains general information about the material and it’s presentation and components.
Component	The component term refers to one material topic or a page. It contains general information about the topic, keywords and relations to other components, and references to meaningful subcomponents.
Subcomponent	Subcomponents are smaller bits of learning data identified by the model, for example the image files linked to a HTML page.
Tool	The tool elements describe course dependent tools that can be accessed through an URL (Universal Resource Locator).
Relation	The relation element models an actual relation between two components. The relation includes information about the target of the relation and information about the type and meaning of the

	relation.

Logical structure of the description document providing metadata of a course is defined using an XML document type definition, which, in our case, is stored in a file COURSE.DTD. COURSE.DTD defines the metadata document in a form easy to interpret and validate. The ability to validate metadata descriptions implies that the correctness of the created description documents (and hence the approximate correctness of the material itself) can be checked before importing course material to A&O.

Writing complicated XML documents by hand is tedious. This is mind, we have created a visual tool called MaterialDescriptor that analyses the given concrete material and asks all the predictable right questions from the author. MaterialDescriptor visualises the material as a tree of components and subcomponents, with the intention of easy description and construction of the metadata.

Example

Listing 1 provides an example of using the COURSE document type. The course material described in the example is a simplified description of the Matrix Calculation course held in Tampere University of Technology, Autumn 2000. Due to lack of page space we included only two examples of components in the description. In practice, the components would occupy a major part of the document. Note that the second component is actually a PDF-document, the structure of which can not be interpreted as an XML or HTML document as such.

Listing 1. Example of an A&O material description document.

```
<?xml version="1.0"?>
<!DOCTYPE COURSE SYSTEM "COURSE.DTD">
<COURSE>
  <COURSENAME>Matrix Calculation</COURSENAME>
  <COURSENUMBER>73109</COURSENUMBER>
  <COURSEDESC>The introductory part of the Matrix Calculation course.</COURSEDESC>
  <AUTHORS>
    <AUTHOR>
      <AUTHORNAME>John Doe</AUTHORNAME>
      <CONTACTINFO>
        <EMAIL>john.doe@tut.fi</EMAIL>
        <PHONE>111-1111</PHONE>
        <ADDRESS>Joe's Street 1, 11111 FINLAND</ADDRESS>
        <HOMEPAGE>http://www.tut.fi/~jdoe</HOMEPAGE>
      </CONTACTINFO>
      <COPYRIGHT>Freeware</COPYRIGHT>
      <ORG>Tampere University of Technology</ORG>
    </AUTHOR>
  </AUTHORS>
  <MATERIAL LANG="UK">
    <FRAMESET URL="frames.html" DOCWINDOW="doc" MENUWINDOW="menu" TOOLWINDOW="_new"
        EXTRAWINDOW="_new" />
    <CONTENT>
      <FRONTPAGE RELATIVEURL="frontpage.html" />
      <CURRICULUM RELATIVEURL="curriculum.html" />
      <COMPONENT RELATIVEURL="vector.html" PARENTURL="" TYPE="html" ELEMENTENCODING="NOELEMENTS">
        <HEADER>Vector</HEADER>
        <COMPDESC>Defines the concept of the vector</COMPDESC>
        <KEYWORDS>
          <KEYWORD>vector</KEYWORD>
          <KEYWORD>definition</KEYWORD>
        </KEYWORDS>
        <CREATIONDATE>2/12/2000</CREATIONDATE>
        <RELATIONS>
          <RELATION TO="matrix.html" DESC="" TYPE="prerequisite" />
        </RELATIONS>
      </COMPONENT>
      <COMPONENT RELATIVEURL="matrix.pdf" PARENTURL="" TYPE="pdf" ELEMENTENCODING="NOTMARKED">
        <HEADER>Matrix</HEADER>
        <COMPDESC>Defines the concept of the matrix</COMPDESC>
        <CREATIONDATE>2/13/2000</CREATIONDATE>
      </COMPONENT>
    </CONTENT>
  </MATERIAL>
  <TOOLS>
    <TOOL URL="http://www.tut.fi/minMaple" NAME="MinMaple" DESC=""
        HELPURL="http://www.tut.fi/minMaple/help.html" />
  </TOOLS>
</COURSE>
```

Conclusions

The A&O material model defines an open and effective method to describe learning material. In a world where authoring tools and document formats are developing fast, we feel that the openness of the material and the format independence of the model are very important. The key point is to separate the metadata from the actual material formats of material used in learning environments. This separation has other advantages as well. For instance, it enables editing the course material after importing it to the learning environment, allowing adding information to the description document without having to change the existing learning environment. Using XML in describing and encoding description documents makes it also possible to effectively reuse metadata in a form of interoperability standards in the future. This can be achieved, e.g., with appropriate XSL transformations, one for each interoperability standard or document type. The material model introduced in this article is actually used in developing content for the A&O learning environment. Future experiences will evaluate our work in revealing the hidden gaps and gems of design. The initial work, however, seems promising.

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