EM²: An Environment for Editing and Management of Educational Metadata

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ABSTRACT

Educational metadata are attracting increasing attention, since they can facilitate the description, indexing, searching and retrieving on-line learning objects and educational resources. This paper describes the difficulties raised in retrieving educational resources from the Web, and discusses the current state-of-the-art in educational metadata technologies and the advantages of their use. The most popular software tools for editing and/or managing XML metadata files are presented, and their limitations in the e-learning context are discussed. The paper outlines the design considerations of educational meta-data management toolkits, and proposes EM², an educational metadata management tool, which supports editing and management of XML educational metadata documents. EM² aims to facilitate the effective and efficient search, accessibility and navigation of educational resources through e-learning applications and services.

Keywords

educational meta-data, re-usability of learning objects

1. Introduction

Internet-based education and training offer many potential benefits specific to adult learners with emphasis given to learner-centred and self-directed instruction models empowered by web-based educational resources. Indeed, the recent growth of the World Wide Web (WWW) has greatly increased the amount of information and educational resources available to the education community.

The full exploitation of this mass body of knowledge resources available on the Web, can be, however, compromised, by the difficulty in describing, classifying and maintaining those resources in such a way that they can be retrieved in an "*educationally efficient and effective way*". Today, the web community has embraced the collection and use of metadata to characterise and index educational resources, which lead to semantically more accurate retrieval of information than search engines. In general sense, metadata is information about data. In the context of resource discovery, descriptive metadata is a characterisation that aims to represent the intellectual content of the resource. The most popular technology for representing metadata is XML (eXtensible Markup Language, http://www.w3.org/TR/REC-xml).

Educational metadata (EMD) are attracting increasing attention in this context, since they facilitate the description of educational resources, so that they can be easily retrieved (Duval et al, 1999; Greenberg, 1999; Burda & Hilier, 2000). A number of international efforts have been initiated during the past few years, aiming to define EMD specifications for the common description of educational resources. These specifications include fields that are considered necessary for the description of educational resources – such as the type of the resource (i.e. whether it is an experiment, simulation, questionnaire, assessment, etc), the target learner age, difficulty level, estimated learning time, etc – as opposed to "general purpose" meta-data standards (e.g. the Dublin Core, http://purl.oclc.org/dc), or standards that have been developed for different fields of knowledge (e.g. geo-spatial meta-data standards, http://badger.state.wi.us/agencies/wlib/sco/metatool). The most well-known international EMD standardisation initiatives are the IEEE LTSC (http://ltsc.ieee.org), IMS (http://www.imsproject.org), AICC (http://www.aicc.org), ARIADNE (http://ariadne.unil.ch), and CEN / ISSS (http://www.cenorm.be/isss/Workshop/lt/) (Bacsich et al, 1999).

This paper describes the difficulties raised in retrieving educational resources from the Web and discusses the current state-of-the-art in educational metadata technologies and the advantages of their use. The most popular software tools for managing XML metadata files are presented and their limitations on the educational sector are discussed. The paper proposes EM^2, an educational metadata management tool, to support editing and management of educational metadata documents, which are represented in XML. EM^2 aims to facilitate the improvement of search, accessibility and navigation of educational resources and to promote the usability of educational metadata specifications.

2. Scenario Analysis

At present, learners often have full-time jobs while pursuing professional and personal development. Consequently, working and learning are no longer exclusive activities. Learning through the Web allows new forms of education to be offered by corporations and higher education institutions to a diverse and distributed population of learners. Educational metadata is a proposed possible solution aiming to overcome the problems arising in most e-learning environments, related to relevant information retrieval and access to education resources based on user's specific needs.

Metadata can be used for a number of e-learning scenarios (Figure 1). Each scenario of use may address different dimensions in terms of the:

- Type of educational resources (digital, non-digital);
- Category of users accessing or uploading educational content;
- Category of users editing or managing the educational metadata of the educational resources;
- Educational metadata standard/specifications used to describe the educational resources (i.e., IEEE LOM, Dublin Core, etc);
- Technologies used to represent the metadata document (XML, RDF, HTML, etc);
- Software tools used to create the educational metadata document.

In the next section a typical scenario of use of educational metadata is described by focusing on the above mentioned dimensions.

2.1. Scenario of use: Vertical Learning Portals

Vertical Learning Portals (VLP) provide a possible solution for web-based learning that responds to the needs of the learners for adaptive, resource-based and collaborative learning. In its simplest form, a learning portal is a web site that offers a broad range of resources and makes it easier for users to locate online information. More involved vertical learning portals provide personalised access to academic courses, tutorials, training programs, e-books, on-line tests (Sampson et al, 2002c).

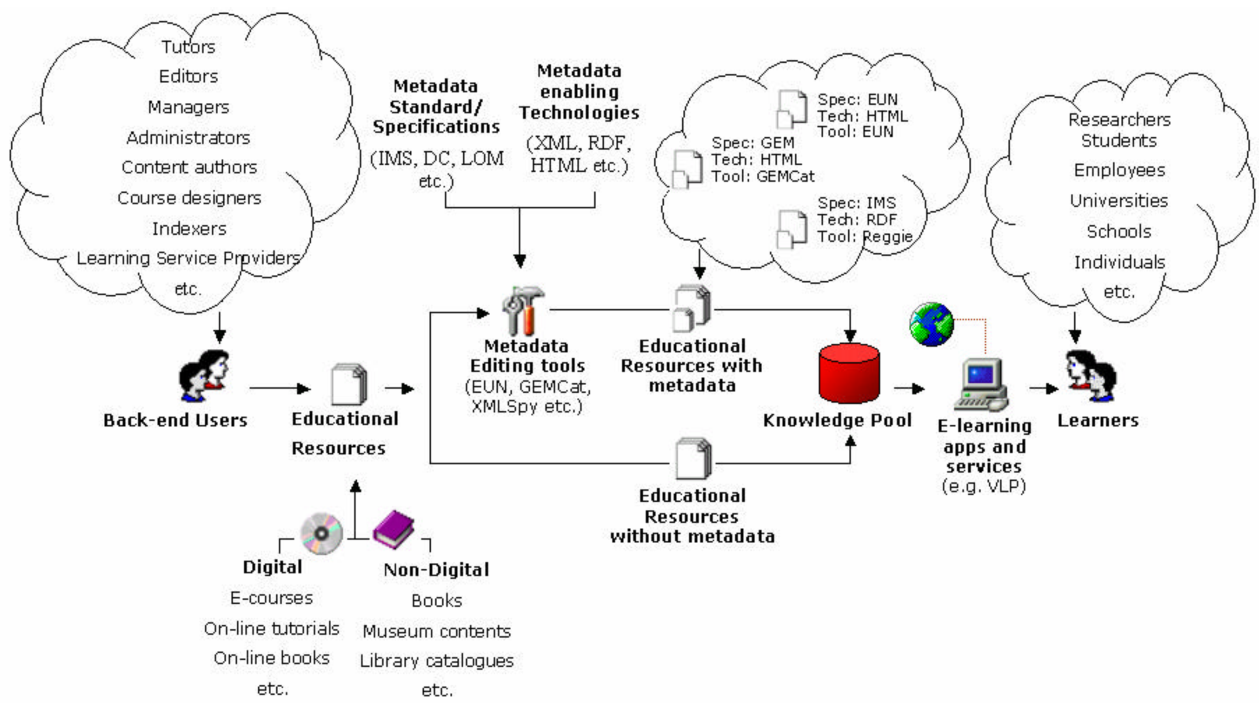

Figure 1. Dimensions of an e-learning environment

The users involved in this scenario can be divided in three categories:

- Learners: VLPs may address to professional trainers and managers, to enterprise employees, to higher education students or individuals. Typically, large corporate organisations enjoy the benefits of budget and resources to build training programmes customised to the needs of their employees. Nevertheless, through VLPs it might be also possible for small and medium enterprises and organisations to have on-demand access to quality training material.
- Editors: educators, trainers, employees and individuals who use various authoring tools to upload courseware, educational resources and information onto the web. The majority of those people are not computer literate and they do not have knowledge on metadata concepts and technologies.
- VLP Managers: computer experts using various management tools to manage and maintain all the information uploaded by the editors into the knowledge pool of the vertical learning portal.

Metadata technology can be important for delivering intelligent, adaptive and personalised services through learning portal. Educational metadata, when created by the owner of the resource allows semantic and relevant retrieval of information. Hence, educational metadata provides Learning Portals with the means to offer learners the information they need according to their demand, skills and learning style. The technology used to describe the metadata and the metadata specification in this scenario is also dependent on the metadata-editing tool.

The following list summarises the addressed dimensions in this scenario.

- Type of educational resource: Both digital and non-digital
- Users accessing educational content: VLP Learners
- Users uploading educational content: VLP Editors
- Users managing metadata documents: VLP Managers
- Educational Metadata Specifications: Depends on the software tool
- Metadata technology: Depends on the software tool

A software tool to address all the users of this scenario should provide both metadata authoring and metadata management features. Some of the most common tasks that the users of a vertical learning portal perform are summarised in Table 1. Figure 2 presents a typical UML diagram from the VLP manager operations.

Task	User
Create new metadata document (e.g. for an uploaded research paper)	VLP Editor
Modify existing metadata document (e.g. update fields in the existing document such as publication status: on review/accepted)	VLP Editor
Create new metadata specification that applies to specific needs and it is an extension or modification of existing ones	VLP Manager
Validation of metadata documents, to confirm that there are no human errors (e.g. date format instead of text)	VLP Editor, VLP Manager
Conversion between standard/specifications to allow maintenance of a collective, harmonised metadata repository	VLP Manager
Retrieve specific documents from the metadata repository (e.g. how many e-courses have been uploaded by a certain educator, how many books are available of a certain author, etc)	VLP Manager
Group all metadata documents by a specific field (e.g. created a certain date, or published by the same publisher etc.)	VLP Manager

Table 1. Tasks performed by the users of vertical learning portal perform

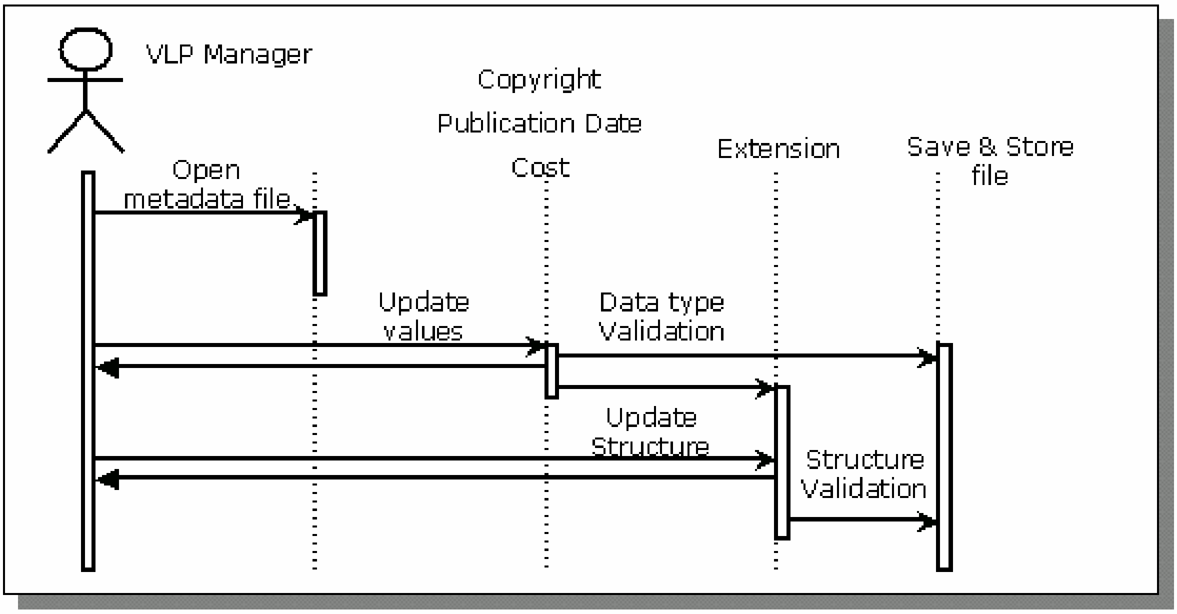

Figure 2. UML Diagram, the VLP manager is updating a metadata file, which describes a book

2.2. Discussion on the Scenario of Use

Other scenarios of use can involve the deployment of metadata technologies to describe the e-content of an on-line library, a virtual university, a virtual museum, as well as research papers in a repository of publications addressing the needs of researchers in different fields etc. Although the dimensions in each scenario are different there are common limitations on each one of them. The quality of the metadata depends on the software tool chosen to be used for creating the educational metadata. It should be easy to use and provide a number of proposed metadata specifications since, in the majority of scenarios, it is addressing non computer literate people and without prior knowledge on the metadata technologies.

Consequently the software application is of great importance on providing metadata that can improve the effectiveness and the quality of information retrieval (Curtis et al, 1999). Studying the above scenarios we conclude that an educational metadata application tool should provide the user with the following features (Figure 3):

- Creation of new metadata files
- Modification of existing metadata files (data values and structure)
- Support of all the educational metadata standards, specifications
- Validation of the values completed by the users

- Mapping of metadata between available educational metadata specifications/standards to allow a collective and harmonised metadata repository
- Allow metadata document management (e.g. multiple updates, queries, sorting features etc.)

In the next section a number of available software tools are outlined. The paper focuses on applying the existing tools on the above scenarios of use, and presents their limitations on supporting all the requirements mentioned.

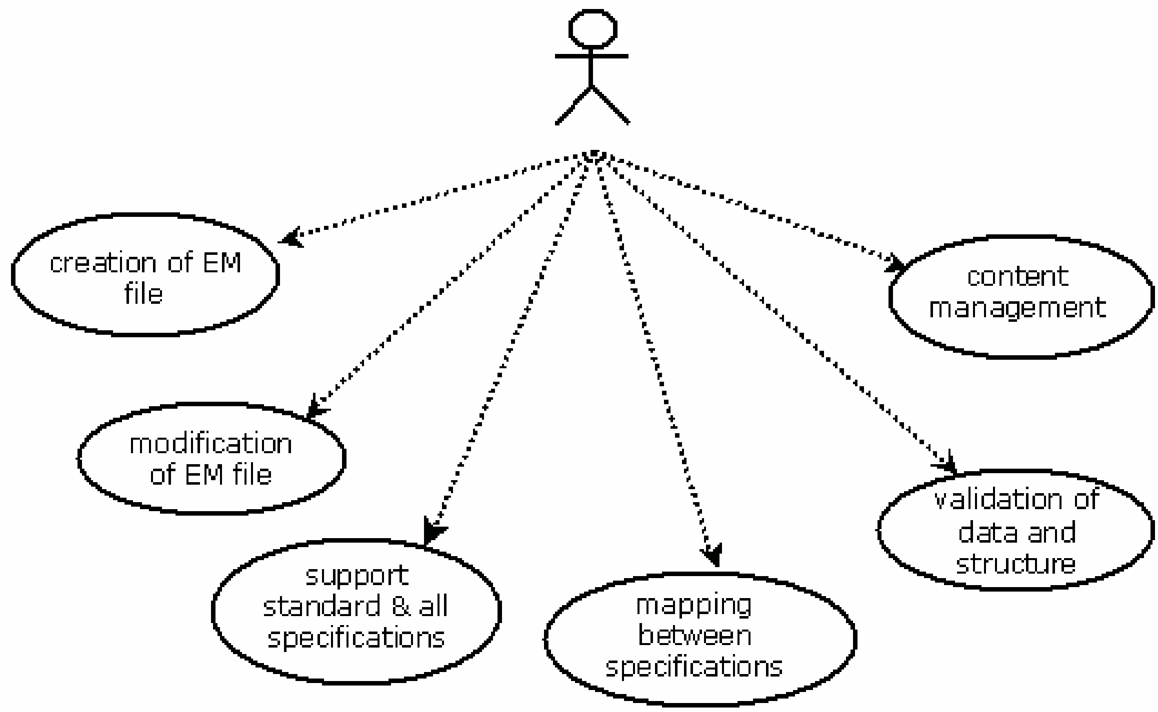

Figure 3. Design Considerations of an Educational metadata management tool

3. Metadata software tools

The need for creating and managing metadata had lead to the development of numerous software tools addressing the needs of metadata editors and managers/administrators of metadata repositories. Commercial and freeware tools are available for creating, changing, validating and managing metadata documents.

3.1. Existing tools

Currently a wide range of components related to XML, are available. Some of these components are:

- XML Editors
- DTD Editors
- XML Parsers
- XML Schema Processors
- Validators
- XSL translators
- XML-RDBMS tools
- RDF tools
- Mappers

The available software tools that support the metadata technologies and the metadata specifications are combinations of the above components and can be divided into two major categories:

- **XML Tools**: These applications provide users a way of generating XML documents. Any standard text editor can be used to create XML documents. The main problem is that there are features that text editors don't tend to provide that are critical, such as view of entities permitted and validation. The available XML tools support one or more features of a wide range of functional requirements: generating XML documents, mapping XML documents to other metadata formats (e.g. RDF), updating, validating, searching and manipulating XML documents. Some of the most popular XML tools are:

- **EditML** is an XML editor and produces XML documents. It has tree and list views and can edit more than one document at a time (http://www.editml.com)
- **XMLSpy** is a professional validating XML editor. Provides three advanced views of the documents, and XML document management (http://www.xmlspy.com).
- **XML Pro** is an XML editor, but it allows only one file open at a time, it does not support other metadata formats except XML and the XML document must be well formed or it is not supported (http://www.vervet.com).
- **BladeRunner** is an XML tool allowing editing, validation and management of metadata documents (http://www.interleaf.com).
- **XMetal** is a tool for authoring XML files, it supports validation against any DTD and it automatically converts database content to XML (http://www.softquad.com).
- **GoXML search** is a scalable, context-based XML search engine that delivers precise results. The engine is a server-based application that indexes XML documents and provides standards-based query interfaces for search and retrieval (http://goxmlsearch.xmlglobal.com).
- **TIBCO XML turbo** is an environment for developing and managing XML documents. It supports DTDs, XMLSchemas and validation (http://www.extensibillity.com).
- **Xeena** is a visual XML editor by IBM, for editing valid XML documents derived from any valid DTD (http://www.alphaworks.ibm.com/tech/xeena).

➢ **Educational metadata tools**: These applications create educational metadata documents. They are easy to use providing a simple interface (a number of fields should be completed by the user) and they address to editors with no knowledge on metadata technologies. Furthermore, they support one or more educational metadata specifications. The most common of these tools are:

- **Ariadne** indexing tool provides an interface for creating and opening metadata files that conform to the ARIADNE specification and provides data validation (http://dl004.rz.uni-karlsruhe.de:8998/tm5).
- **ADL Scorm Metadata Generator,** is an application for creating XML metadata files based on SCROM specification and provides data validation (http://www.adlnet.org).
- The resource description tool of **EUN**, created by Lund University in Sweden. It is an HTML page where the user can fill a number of fields that represent the EUN proposed specification of educational metadata (http://www.en.eun.org/menu/resources/set-metaedit.html).
- **Reggie** metadata editor. Reggie supports a number of metadata educational specifications. The user has to complete the required fields and to select the metadata format required from a list of technologies available (RDF, HTML) (http://metadata.net/dstc).
- **ImseVimse**: It is an IMS editor, for creating and opening XML metadata files of the IMS specification. It does not provide data validation (http://imsevimse.sourceforge.net).
- **LOM Editor**: It is an application for creation and modification of XML metadata files based on a previous version of LOM v1.4 (http://www.kom.e-technik.tu-darmstadt.de/~abed/lomeditor).

3.2. Discussion on Limitations

Each of these tools can provide functionalities for meeting specific requirements, however a number of limitations come across when applying them in the above described scenarios.

The first category of tools in mainly focused on XML technologies and the main disadvantages are:

➢ Not oriented to educational needs. For example, they do not provide a list of available educational metadata specifications.

➢ They require the editor to be a metadata expert, having prior knowledge of at least XML and DTD technologies.

The solution that would apply better to the educational community for creating and managing educational metadata documents would lie on the second category of tools. The main characteristics of the second category are the focus on educational metadata and the user-friendly interface, however they fall short on functionality compared to the users needs derived from the scenarios.

Currently, it appears that we are lacking a toolkit that covers all the above mentioned design considerations. Most of the educational metadata tools are limited only to metadata authoring and they do not provide validation or support of any metadata specification. In addition they do not provide management of resources and "translation" to other specifications.

Table 2 summarises the features of the main educational metadata tools mentioned above, compared to the requirements concluded on the previous section.

Tasks	Ariadne	Imse Visme	LOM editor	EUN	ADL SCORM	Reggie
Creation of new metadata files	✓	✓	✓	✓	✓	✓
Modification of existing metadata files in terms of data	✓	✓	✓			
Support any educational metadata standard, specification						✓
Modification of existing metadata files in terms of metadata structure						
Validation in terms of data values	✓			✓	✓	
Validation in terms of metadata structure						
Support of the XML		✓	✓		✓	
Mapping of metadata between available educational metadata specifications / standard to allow a collective and harmonised metadata repository						
Allow metadata document management (e.g. multiple updates, queries, sorting features etc.)						

Table 2. Features of some educational metadata tools

In the next section, EM^2, an educational metadata management tool, that falls in the second category of metadata tools, but combines functionality features of the first category of applications, is described. The proposed educational metadata tool, satisfies all the required functions summarised in table 2.

4. EM^2 - Educational Metadata Management Tool

The back-end users of a web-based educational environment need an educationally oriented application, which can be used by metadata non-experts and can provide authoring and management features. Study of the described scenarios suggests that there is a need for an easy to use tool, which is focused on educational metadata (to meet the needs of metadata editors) and which allows document management features (to meet the needs of metadata repository managers). In more detail, the application should meet the following set of criteria:

- Support of XML
- Creation of educational metadata documents
- Support all existing educational metadata specifications and import of new ones
- Creation of new educational metadata specifications by the user by updating, extending or restricting existing ones
- Support conversion between educational metadata specifications and standard
- Provide easy to use interface for non-metadata experts (extensive explanations on elements/tags, wizards etc.)
- Validate entries and metadata structure and allow easy error tracking
- Allow multiple management on existing metadata documents (find, replace, sort by, update, group by)

At present there are various tools available as mentioned in the previous section, that support one or combination of the above criteria. However, they are either educationally oriented, user-friendly but too simple allowing only limited features, or they are very general complex tools, allowing editing and management but address only to advanced users. As a result, there is no available tool to meet the needs of both managers/administrators of a metadata resource repository and editors of metadata documents. At present back-end users should use either a combination of the available tools or a single tool but minimise their expectations on usability and functionality.

The current version of EM^2 is an educational metadata editor providing an easy way for characterising educational resources (creation and modification) based on three main metadata specifications (DC, IMS, LOM). The offered features are limited compared to the criteria mentioned above. The proposed tool EM^2 meets all the above criteria and is an attempt to build some bridges between the current players in this field (editors, managers) drawn from higher education, companies, etc. and the metadata specifications initiatives.

4.1. EM^2 Features

Extension of the previous EM^2 versions (Papaioannou et al, 2001) allows the toolkit to be used by a wide range of services. Based on the above mentioned design considerations, the new version of EM^2 can support all the requirements extracted by the scenario analysis:

- **Creation of educational metadata documents:** Vertical learning portal editors require a tool that can offer simple and effortless creation of educational metadata based on recommended metadata specifications. Assuming that this category of users has no knowledge on either metadata (i.e., existing specifications) or metadata technology (i.e., XML, DTD, XML Schemas etc.) the proposed environment can offer a user-friendly interface with the ability to choose the desired metadata specifications from a pre-selection list. Based on the selected specification the new metadata document can be generated where the editor has simply to fill in values in a list of fields. Description of each field and wizards is available to guide the editor through the selected specification. Furthermore, the wizard allows the editor to select which of the metadata elements of the selected standard are required and only these will be presented on the screen to fill in.

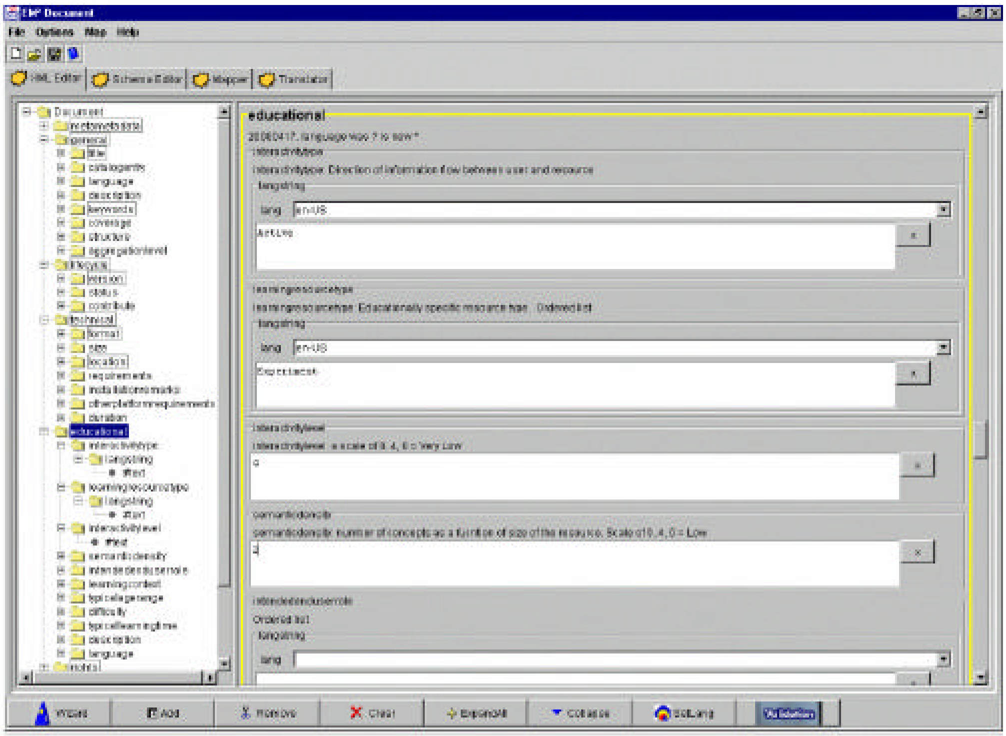

Figure 4. Metadata Editor

- **Creation of semantic educational metadata:** The main disadvantage of the metadata documents is that they might contain inaccurate information due to human errors. The proposed tool provides the feature of data validation wherever this is possible. The user is informed if the entries in the fields are unacceptable (e.g. text instead of date). Therefore the final metadata document contains validated semantic information on the educational resource, free of human errors.
- **Mapping of metadata specifications:** As the number, size and complexity of content metadata specifications continue to co-exist and grow, supplying the metadata for each specification becomes time consuming and tedious. A metadata repository maintains a huge amount of metadata documents based on different specifications due to creation in different points in time or by using different editing tools. In order to minimise the amount of time needed to create and maintain the metadata and to maximise its usefulness there is a need for metadata created and maintained in one standard to be accessible via related content

metadata specifications. The proposed tool provides the ability to create and maintain metadata documents, and to map each document to any other number of related content metadata offering harmonisation.

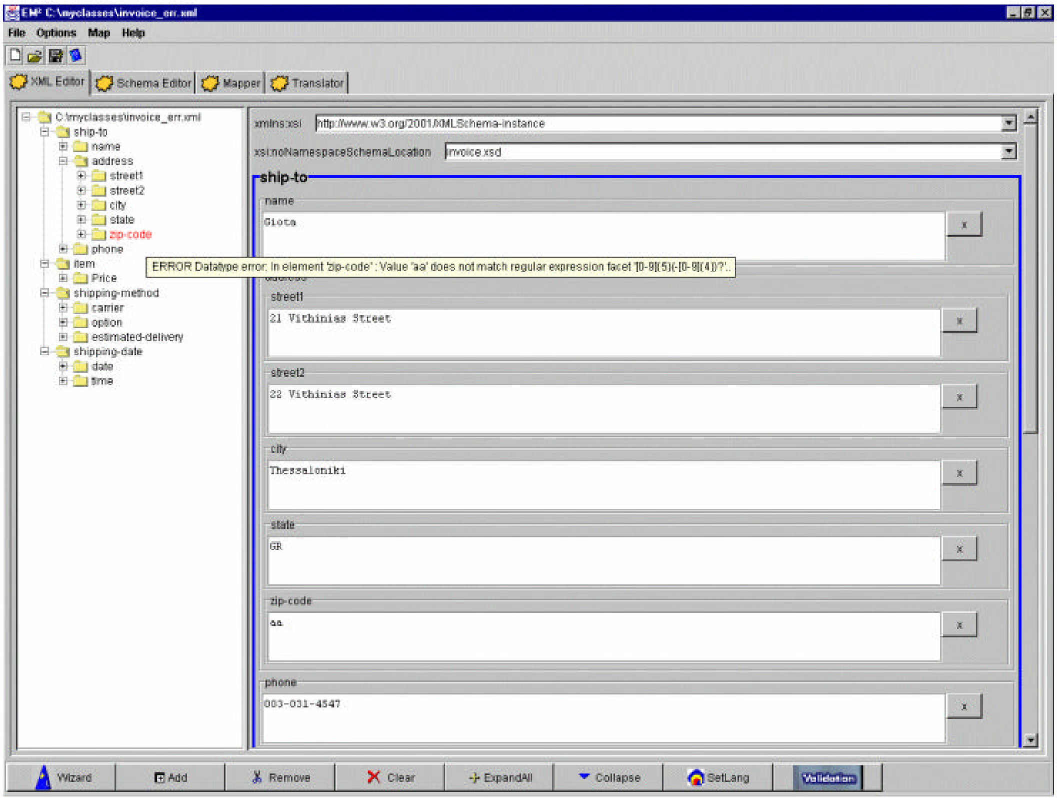

Figure 5. Data Validation

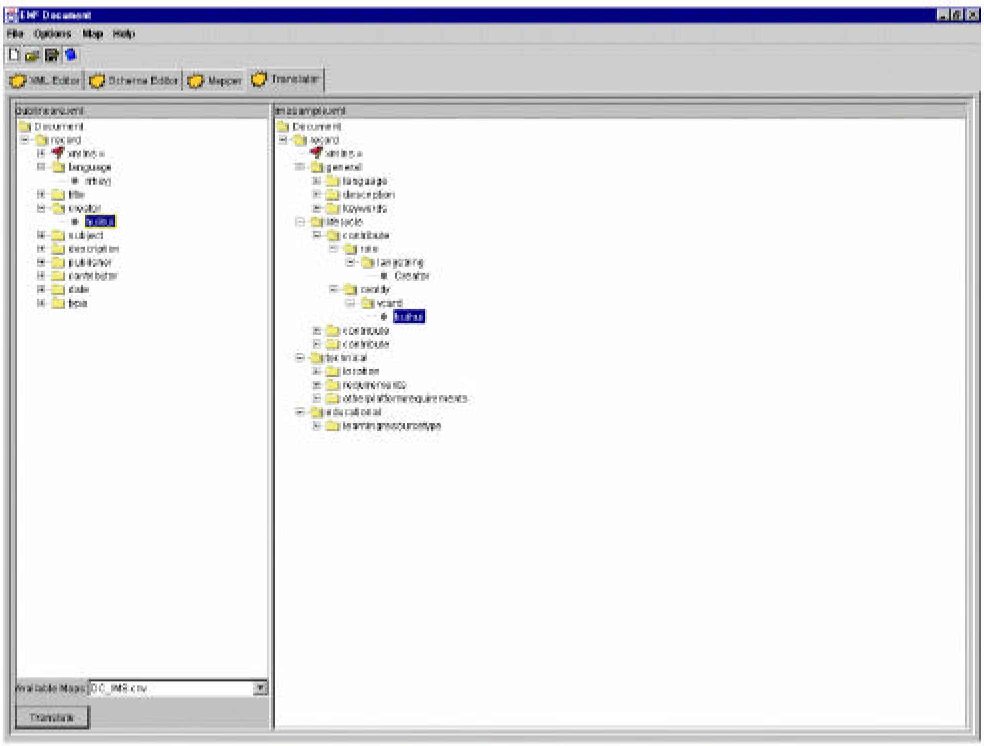

Figure 6. Conversion of metadata files between specifications

- **Support of all educational metadata specifications:** A number of metadata specifications have already been developed. The proposed tool provides the ability, to the vertical learner manager, to import in the pre-selected list all the newly created educational metadata specifications. In result, educational metadata editors can select their preferred standard from an updated list. In addition, the tool allows creation of a new standard by the user, by extending/modifying the ones already available.
- **Metadata document management:** The proposed tool offers the ability to manage the existing metadata documents. Repository managers can find, update, delete, sort and group metadata documents through multiple document selections, multiple editing in metadata documents and with the help of a graphical interface including drag & drop features. Therefore the metadata application is enhanced from a simple educational-metadata authoring-tool to an educational-metadata management-tool.

5. EM^2 Architecture

In this section the architecture of $EM^2$is described. The components, their relationship to each other, the environment and the principles guiding the design of the EM^2 architecture are outlined.

5.1. System Purpose

The aim of EM^2 application is to provide a tool targeted to a wide range of educational metadata editors/managers, which overcomes the limitations of the existing metadata tools.

As it has been mentioned in the previous section, the system must satisfy the following functional requirements:

- Support of XML technology (both DTD and XML Schemas)
- Create a new XML file
- Update/modify existing XML files
- Support existing educational metadata specifications
- Create new educational metadata specifications
- Update/modify educational metadata specifications
- Mapping from one educational metadata standard to another
- Metadata file validation in both structure and content
- Multiple management of existing metadata documents (find, replace, edit, sort by, update, group by etc.)

In terms of non-functional requirements the system should meet the following principles:

- Extensibility: the system must be extendable (e.g. metadata specifications should be kept in a metadata repository and not hard coded to allow import of new metadata specifications, allow translation of interface language to other languages)
- Portability: the system should be able to run in any platform

5.2. Structure

Figure 7 presents the EM^2 architecture diagram showing the structural components of the system and their interconnection paths. Components can be passive or active, created at system start up or be created and deleted at any time at runtime, and they can be system specific or be reusable repository components. Interconnection between components is modelled by associations (directed arrows). The direction of each association shows which component initiates communication. These associations can represent direct connections or they can also be used to abstract away details of more complex connection and communication patterns (e.g. indirect communication based on events). Interfaces are shown by the round interface symbol and by adding dependency arrows between the interfaces and the components using them.

Figure 7 presents a view of each component of the EM^2 application at the highest level of abstraction. Each of the components is described in the following sections of this paper in more detail.

The components of this architecture can be grouped into two different layers.

- Interface layer: A layer visible by the users of the EM^2 application. It contains all the components of the user-interface. These are the wizard, the XML editor, the XML Schema editor, the DTD editor, the management interface and the map generator.

➢ A layer non-visible by the users of the EM² application. It contains all the repositories involved and the operations, which are performed. The repositories involved are XML files repository, XML Schema repository, DTD repository, XML files databases and maps repository and the operations are validation and mapping.

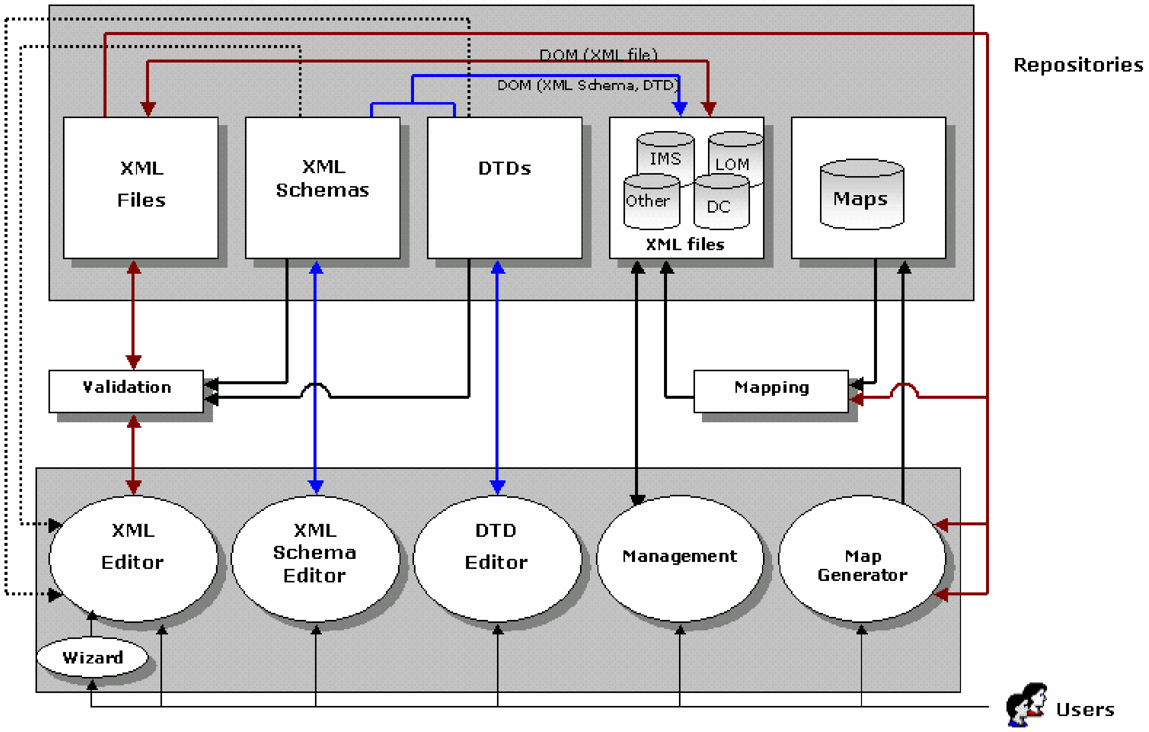

Figure 7. Architecture Diagram

5.2.1. Repositories

Every metadata XML file is accompanied by a DTD or an XML Schema file (http://www.w3c.org). The purpose of a DTD (Document Type Definition) is to define the legal building blocks of an XML document. It defines the document structure with a list of legal elements. XML Schema contains all the information of a DTD and additional information such as the type of the elements. A DTD or XML Schema file can be declared in the XML document, or as an external reference. To store and manipulate all these different type of files EM² tool is using a number of repositories:

➢ "XML files repository": This repository is a system file containing all the educational metadata files of XML type that have been created or modified by the EM² tool or they have been created by other XML tools and they have been imported in this repository.

➢ "XML Schemas repository": This repository is a system file containing all the XML Schemas that have been created or modified by the EM² tool or they have been created by other XML Schema tools and they have been imported in this repository.

➢ "DTD repository": This repository is a system file containing all the DTDs that have been created or modified by the EM² tool or they have been created by other DTD editors and they have been imported in this repository.

➢ "XML file databases": Each metadata XML file stored in the "XML file repository" is also stored in a database. The database is created based on the DTD/XML Schema file that defines the building block of an XML document and represents a metadata standard. A number of databases are maintained by the application, one for each educational metadata standard. Every time the user creates or imports a new DTD or XML Schema in the relevant repositories the application creates automatically a new database to store the XML files of the formats. Therefore all the XML files are grouped by their DTDs or XML Schemas and stored to relevant databases. Each database contains a number of tables equal to the number of elements of the educational metadata standard to which is relevant. For example the DC educational metadata standard contains 15 elements and therefore the "DC database" consists of 15 tables, one for each element. In addition each database stores information about the value of the elements together with information on the type of the element (integer, string etc.) and the multiplicity of the element (can appear 0 to 1 times, can not be deleted, can appear 2 to ∞, etc.) if this information is available by the associated XML Schema file or the DTD. Maintaining such a number of databases may be a drawback, since the number of required resources (number of databases, number of tables in each database) are dramatically increasing each time a new DTD or XML Schema is imported or modified. However this is a useful procedure that allows management of multiple XML files, as it will be described in following sections.

- "Maps database": EM^2 allows mapping of XML files between educational metadata specifications. Maps are generated by a mechanism of the EM^2 tool and are used to these conversions, by associating a number of elements of one standard to a number of elements of another standard. For example there is a map for converting IMS to LOM and vice versa, from DC to IMS and vice versa etc. All these maps are stored in the "maps database". The process of mapping will be described in a following section.

5.2.2. Associations of repositories

Associations between the repositories, the databases and the XML files are achieved by using the DOM (http://www.w3c.org). The XML Document Object Model (DOM) is a programming interface for XML documents. It defines the way an XML document can be accessed and manipulated. The objective for the XML DOM has been to provide a standard programming interface to a wide variety of applications. The XML DOM is designed to be used with any programming language and any operating system. With the XML DOM, a programmer can create an XML document, navigate its structure, and add, modify, or delete its elements. The DOM represents a tree view of the XML document. The document element is the top-level of the tree. This element has one or many child nodes that represent the branches of the tree and are associated to the elements of the XML file. A program called XML parser can be used to load an XML document into the memory of the computer. When the document is loaded, its information can be retrieved and manipulated by accessing the DOM. In addition by accessing the DOM any format of files can be generated (XML files, DTD, XML Schema and DB XML files) as shown graphically (Figure 8) and therefore one format can be converted to another through DOM.

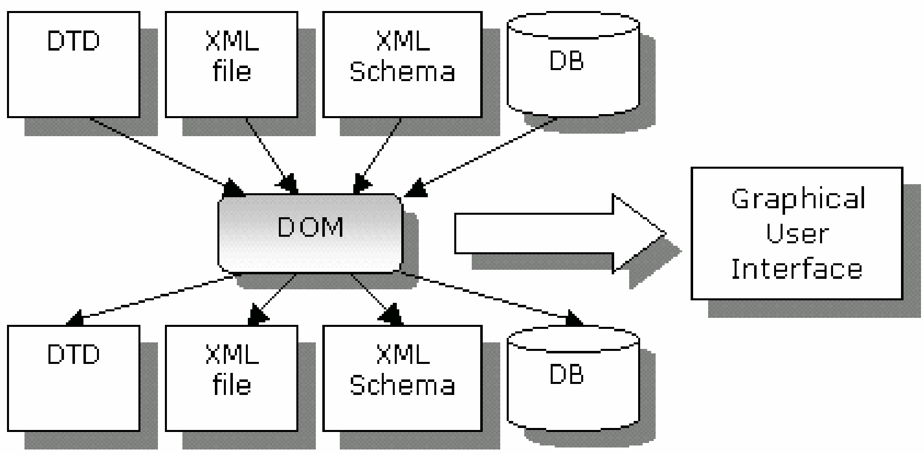

Figure 8. Functionality of XML Document Object Model (DOM)

The EM^2 tool uses DOM to generate XML files, DTDs, and XML Schema files (e.g. generate unknown DTD from an XML file through DOM). In more detail the tool uses two different document object models. The first one is generated from the XML file, when the user opens an existing or creates a new XML file. The second DOM is generated from DTD or XML Schema files and it contains additional to the structure information (e.g. multiplicity, element type etc). The following diagram (Figure 9) illustrates how the associations (shown in Figure 8) between the two DOM models and the repositories are implemented in the EM^2 tool.

5.2.3. XML file, XML Schema and DTD Editors

The XML Editor provides the interface for creating a new XML file or loading and modifying existing ones. These components and their associations are represented in Figure 7.

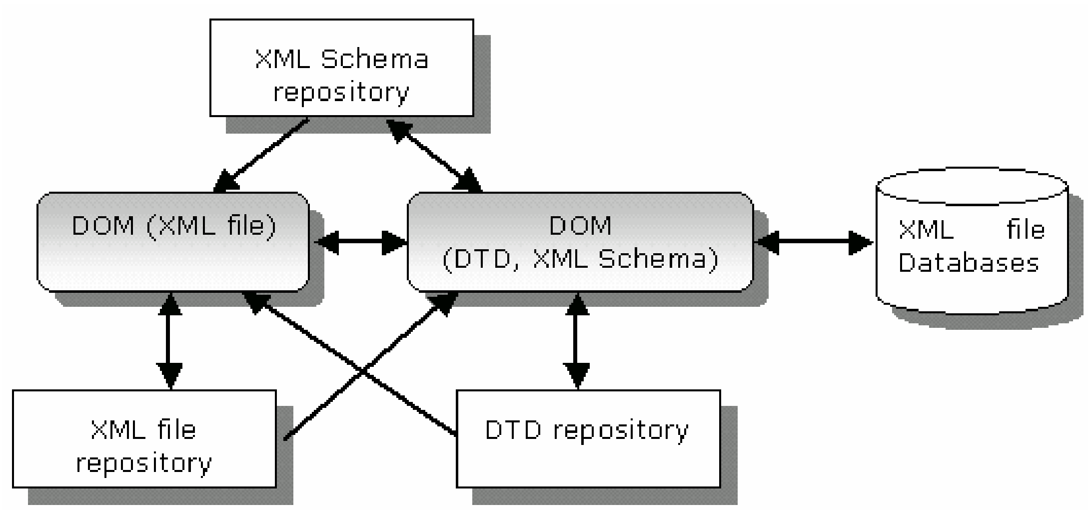

Figure 9. Interactions of DOM models and repositories

Create a new XML file (Figure 10): When the user creates a new metadata file, one educational standard must be specified from a list, which contains all the available educational specifications that are stored in the repositories as DTD or XML Schema files. Therefore the associated DTD or XML Schema of the new XML file is loaded into the DTD or XML Schema editor respectively. A user-friendly interface provides a graphical representation of the selected metadata file in tree view and a number of panels for completing the values of the metadata file. At the same time the DTD or XML Schema editor provide a graphical representation of the DTD or XML Schema respectively. The output of this operation is a new XML file stored into the "XML file repository" and into the "XML file database".

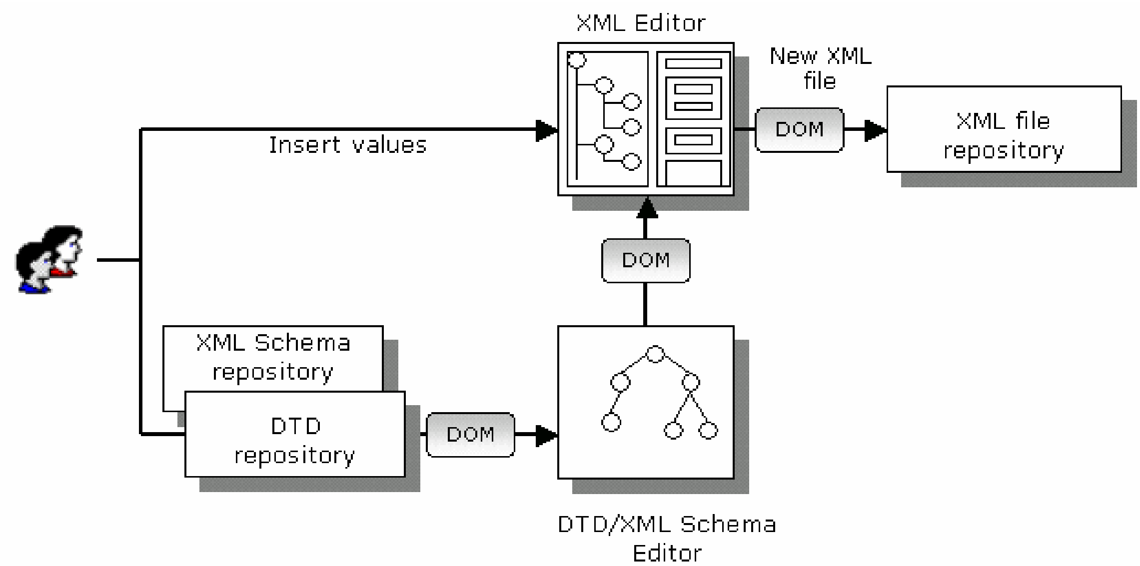

Figure 10. Creation of new educational metadata file

Open an existing file (Figure 11): When the user opens an existing file, a selected file stored in the "XML file repository" or in a specified directory is loaded into the XML editor. The graphical representation of the XML file is shown together with the panels, where the user can modify the values. If the DTD or XML Schema of the XML file is known it can be retrieved and loaded to the respective editors. The outcome of this operation is a new XML file stored in the "XML file repository". If DTD or XML Schema is not specified (shown with grey arrows in Figure 11), the tool can automatically create a new DTD or XML Schema to associate it with the current XML file and loads it into the DTD or XML Schema Editors. The outcome of this operation is a new XML file stored in the "XML file repository" together with a DTD or XML Schema stored into the respective repositories.

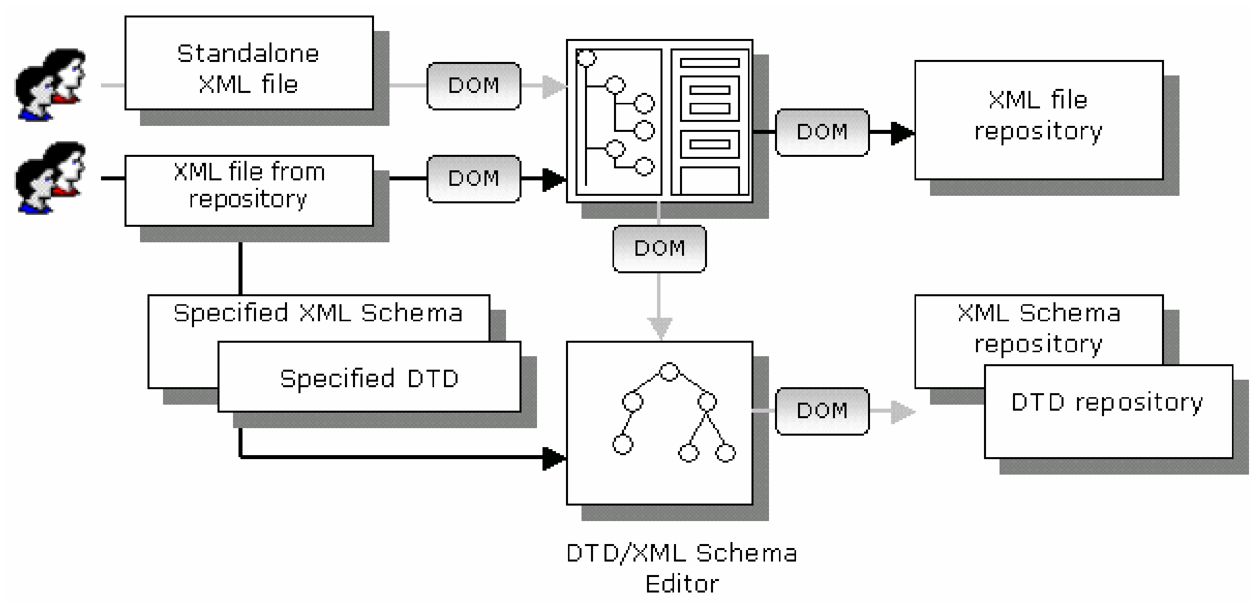

Figure 11. Open an existing educational metadata file

Modify the structure of a loaded DTD or XML Schema (Figure 12): The user can change the structure of a DTD or XML Schema when it is loaded in the respective editors. The new DTD or XML Schema can be saved as new educational metadata standard and stored in the repository. Therefore it can be available for retrieval the next time the user wishes to create a new metadata file according to this standard. The outcome of this operation is a new DTD or XML Schema stored in "DTD repository" or "XML Schema repository" respectively. (Figure 12 is an extension of both Figures 10 and 11.)

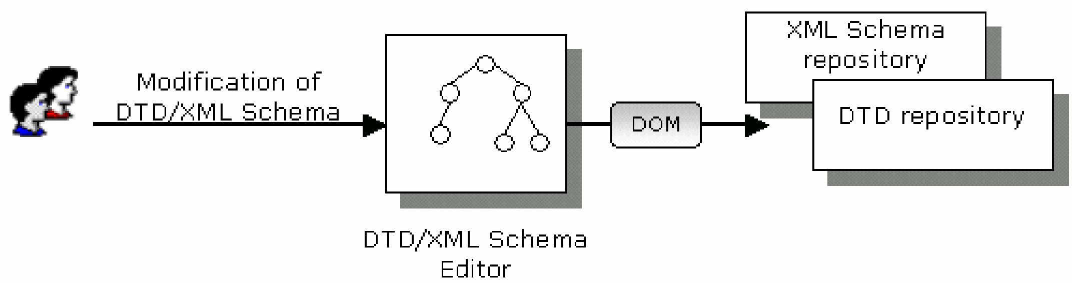

Figure 12. Modification of DTD and XML Schema

5.2.4. "Map generator" and "Mapping"

The "Map generator" and the "mapping" components allow the user to convert XML files from one educational standard to another (Figure 13).

The "Map generator" component requires as input two XML files. For example if the user creates the IMS to LOM mapping then an IMS XML file and a LOM XML file are required. Both these XML files are created and completed by the user into the "XML Editor" with unique values for each element and the generated XML files are stored into the "XML file repository". The outcome of this operation is a map. The generated map is stored into the "Map database".

In more detail, this operation retrieves all the elements of the first XML file that have the same values with certain elements of the second file and generates a table, which contains all the corresponding elements between the two files. This table is the "map" between the two educational metadata specifications.

To convert one XML file from a certain metadata educational standard to another the map between these files should exist into the "Map Database". The inputs to the "Mapping" component are the XML file for conversion and the map. The XML file and the map are stored in the respective repositories and the user specifies them. The outcome of this component is a new XML file of the required educational metadata standard and it is stored into the "XML file repository".

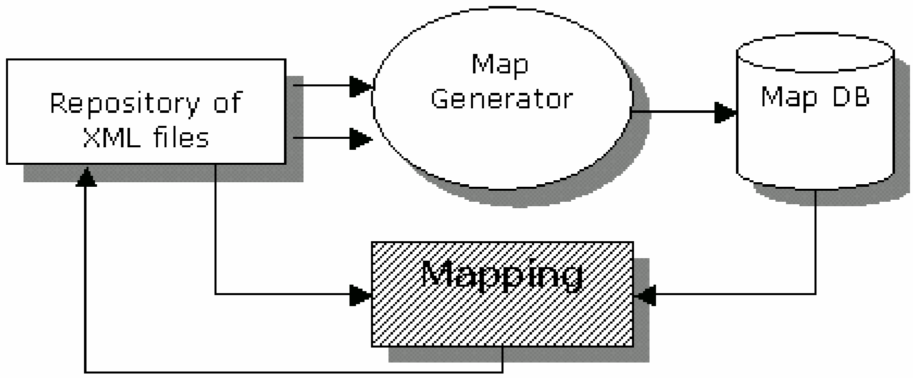

Figure 13. Mapping between educational metadata specifications

5.2.5. Validation

The "Validation" component of the EM^2 tool provides two different types of XML file validation: structure validation and data validation.

Structure validation checks if the XML files conform to the element structure and hierarchy of the associated DTD or XML Schema files. On the other hand data validation checks if XML files conform to the associated XML Schema (if any) in terms of data type. To achieve validation, two different document object models are required, which have been explained in a previous section (5.2.2).

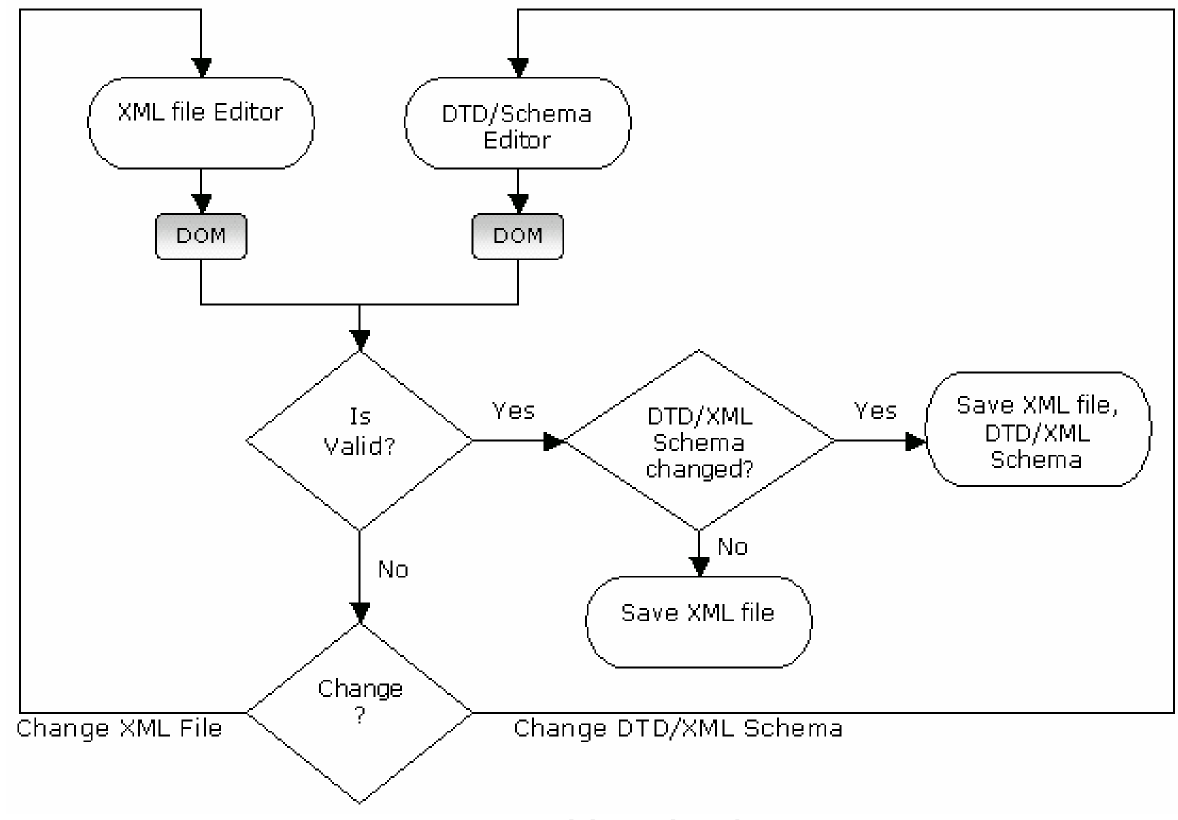

Figure 14. Validation Flow Chart

When an XML file is loaded into the "XML Editor" (either in "Create" or "Open" mode) the corresponding DTD or XML Schema is loaded into the respective editor. In the memory two different DOMs are generated. The DOM generated from the XML file, and the DOM generated from the DTD/XML Schema file. These two DOM are compared to define to define if the loaded XML file is valid. When the user modifies the structure of the loaded XML file, the corresponding DOM is modified as well. The XML file DOM is compared to the DTD/XML Schema DOM to define whether the XML file is valid or not. If the XML file has been modified and it does not conform to the DTD/XML Schema the tool prompts the user to either correct the XML file or modify the corresponding DTD/XML Schema. The following diagram shows is a flow chart of the described process (Figure 7). The output of this component is a validated XML file that is stored in the "XML file repository" and in case the DTD/XML Schema are modified, a new DTD/XML Schema stored in the respective repositories.

5.2.6. Wizard

The Wizard is an interface component offering a user-friendly environment for the novice user. The wizard is a layer between the user and the "XML Editor" (Figure 7). The component provides the available features of the "XML Editor" but with some restrictions. It does not allow modification of the XML file structure and therefore the modification of the DTD and the XML Schema files are restricted. The aim of the wizard is to encrypt the complicated operations of the EM^2 and provide an interface where the user just completes values in a number of fields. It provides guidance for creating XML files that conform to IMS, DC and LOM. The three educational metadata specifications are hard coded and not imported dynamically by the DTD/ XML Schema repositories. Therefore some extra features are provided to the graphical interface, such as guidance in selecting the required educational metadata specifications, guidance in selecting required elements of the specifications and allowance of pre-selected values in certain fields.

5.2.7. Management

"Management" is a user interface component allowing manipulation of multiple XML files. The component and the "XML files database" are associated, which allows retrieve, update and sorting of XML files by their element values. The Management interface will provide the user with a graphical representation of all the XML files stored in the repositories. The user will be able with simple commands (sort by, update, select, edit etc.) or with graphical features (e.g. drag and drop) to manage the available XML files.

5.3. System Requirements

The EM^2 tool is under development in Microsoft Windows NT platform, by using Java programming language. An advantage of Java is interoperability; therefore the tool is not platform dependent. The following list provides all the system requirements necessary for using EM^2.

- Java Virtual Machine. It can be easily obtained by installing the Java Development Kit (jdk) provided by Sun. In particular version jdk1.3 is used for implementing EM^2. Earlier versions of jdk can support the tool but not earlier than jdk1.2. This requirement can be easily fulfilled at anytime by simple download from the Internet.
- Additional API classes should be installed, which will be provided together with the application.

6. Conclusions

It is widely accepted that use of metadata can improve the efficiency and the effectiveness of information retrieval from the web. In addition, it can provide the means for customised retrieval, based on users knowledge and preferences. This paper focused on the educational community and outlined a number of reasons that make the use of educational metadata essential in e-learning environments. It described the main design considerations that should be satisfied to provide an effective metadata management tool in the context of web-based life-long learning framework.

The proposed EM^2 architecture promotes the use of educational metadata specifications. It offers features such as the creation and modification of educational metadata, data and structure validation, support of emerging XML technologies, support of any learning standard or specification, mapping between specifications and creation of these maps. Finally, it provides metadata management features, enabling the user to manipulate (update, edit, sort, search, etc) existing metadata documents.

EM^2 can be used as a standalone tool in real-world scenarios mentioned in section 2, or it can be integrated to more complex e-learning scenarios. In particular, EM^2 has been developed to provide the basic educational metadata management component of the European IST projects KOD ("Knowledge-on-Demand") (Sampson et al, 2002a) and NEMO ("Non Excluding Models for Web-based Education"). Future work on EM^2 development includes the use of a deductive object-oriented database system to facilitate data storage, efficient information retrieval and management. The use of the object-oriented database model for XML document storage provides a number of advantages as opposed to the relational database model (Sampson et al, 2002b). In addition, external agents can access and benefit from the EM^2 services in an automated way, without the need for human participation. An agent-based architecture for the invocation of services from the EM^2 is proposed (Manouselis & Sampson, 2002). This approach uses wrapper agents to utilise the validation and translation services of the EM^2 tool, without encapsulation of the whole EM^2 application into the agent's knowledge base. Such features can be proven extremely useful in applications, such as the validation of large numbers of educational metadata content packages or the translation of such packages to another standard.

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