Converting Content to Reusable Learning Objects Adaptable to User Preferences and Infrastructure

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Abstract: A number of e-learning courses based on the e-MINDMAP concept were developed and placed in a learning management system (LMS) as solution to support the supervised and guided self-instruction concept of learning. The main challenge was to produce e-learning courses which are re-usable and can be implemented in various LMS platforms. As the current e-SCHEMA authoring system, which supports the generation of e-MINDMAPS, does not guarantee the reusability of the learning content, nor the interoperability of the MINDMAP course modules, a new solution based on the "conceptual model of content object" was designed and constructed by decomposing the learning content into small chunks which are initially placed in a hierarchic structure of units and blocks. The raw content components, being considered as the atomic learning objects (ALO), were linked to the blocks. All the content components have been structured in a data model in the database.

The existing authoring system was re-engineered into an authoring/assembling system assembling the source content components into a learning object (LO), and taking into account the requirements posed by the international standards. An object-class diagram and architecture were developed as the basis for the new system and a first prototype was developed. As a result, the learning content constructed is becoming re-usable at three levels: first, based on the same source content the user can make a selection of blocks brought into the LO, second more LOs are brought with the same content but presented in another layout fitting the preference of the user, and the third option is similar to the second but with the addition of fitting the device of the user.

1.   Introduction

Learning models are evolving from instructor centred, over learner centred to learning team-centred approach. A supervised and guided self-paced learning concept including collaborative learning in a virtual class is set forward as our learning model. [1] Part of the self-instruction consists of the individual learning of the fundamentals of the learning topics. It can be organised as an e-learning activity.

Previously the learning content has been compiled in a textbook or a syllabus. In the new e-learning situation the teacher delivers it as electronic documents and puts it in a learning portal of a learning management system (LMS).

The source learning content has to be converted into e-learning content defined as learning objects (LO)

The source learning content has been decomposed manually into small chunks of content structured in units, blocks and sub-blocks following the logical tree structure of the content.   The content belonging to the blocks and sub-blocks have to be decomposed in raw content components or atomic learning objects (ALO) (text, figures, summary of text, keywords of text) and have to be supplemented with additional ALO's to create interactivity and animations. The LO's include the tree structured learning content presented in a pre-defined layout realised as a scenario composittion of the ALO's. An e-learning course can be built by packaging a set of LO's.

The e-MINDMAP presentation [2] is set forward being a concept in which we take care of the learning styles [3] of the learners. A number of e-learning course modules are developed following this e-MINDMAP concept. The e-MINDMAP LO's are centralised in an e-learning portal as part of our Learning Object Management System (LOMS).

Our current e-SCHEMA authoring system, which supports the generation of e-MINDMAPS, does not guarantee the reusability of the learning content and the interoperability of the MINDMAP course modules. A problem arised due to the fact that the integration of those LO's(e-MINDMAPS) in the learning paths of our courses is not easy. And even worse, the export of them to other learning systems is impossible.
It is our challenge to produce LO's that are reusable and interoperable.

2. Re-Usability of Learning Content

Re-usability in e-learning means that content and code can be assembled, disassembled and reused quickly and easily, and completed with some new functionality. Object-oriented methods and tools are usually utilized to realise the re-usability of code. The object, which is a small component that results from splitting the process into several sub-processes, may contain its own functions and attributes. The required system can therefore be built by combining several objects which can be implemented in other systems. Accordingly, all systems using an object will change as a consequence of any change in the object itself. Nonetheless, the advantages of re-use include increased development efficiency and ease of changing the code. In addition content objects can be adapted and used in a context other than that originally designed for.

A learning object (LO) is thus defined, according to IEEE standards, as an entity that can be used, re-used or referenced during technology supported learning [4]. Examples of LO include multimedia content, instructional content, instructional software and software tools, and in a wider sense learning objectives, persons, organisations or events. The fundamental idea behind the LO can be seen as a decomposition of the learning content into small chunks of content [5]. Consequently, in the development of an e-learning course or module, the LOs play a central role.

The conceptual model of content object shown in Fig. (1), however, describes a technical infrastructure for developing, assembling and managing re-usable granular content objects [6-7].
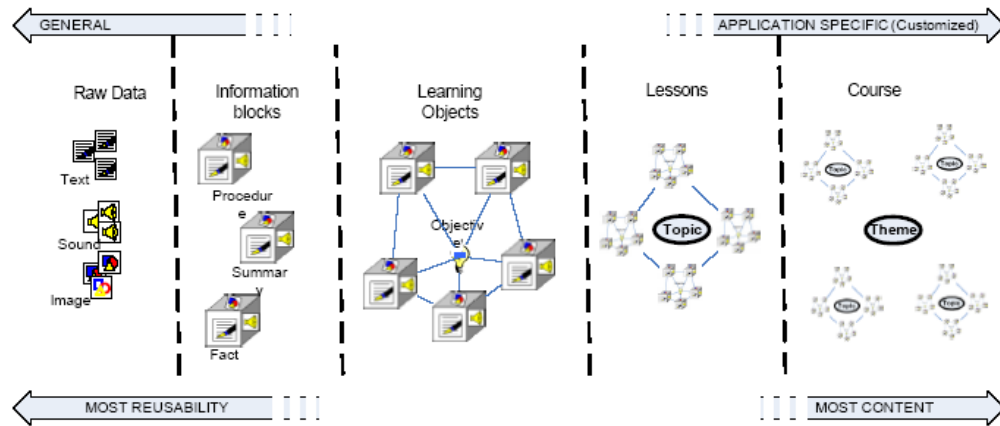
Fig. (1): Conceptual Model of Content Object. [6]

Each component is composed of a set of elements from a lower level with the two highest levels correspond to the traditional course view. Each lesson is a set of LOs which is composed of a composition of a set of information blocks which are composed of a set of raw data elements, full text, summary text, key terms, figures, and so on, usually referred to as atomic LOs or simply ALOs. However, the raw information blocks are of little use to the learning process if examined as individual information units as they are not bound to any specific application. Those information blocks can be assembled into learning objects by adding context or metadata to them. The resulting LOs, which stand in between the raw information and the e-courses, are rich in content since they incorporate many resources, convey context that serve general learning needs and may be re-used. Thus, all content components and LOs can be stored in a database which could be made accessible for use in e-learning courses.

3. Interoperability of Learning Content

An LO is considered re-usable if it can be discovered, found and used by the system, in addition to being able to operate on different systems. Therefore the object must contain metadata and deliver information describing itself to the system. Three categories of metadata can be distinguished:

- the category of general metadata contains general information about the object: title, author, data,
- the technical metadata contains technical information about the object: file type, operating system,
- the "semantic" metadata category contains information about the course domain, the topics in the course, the difficulty level, ect.

Furthermore, content from multiple providers is interoperable if it can easily be disseminated within consumers and in a variety of systems. Transparent interaction of systems is then achieved. As such, a set of content and/or a learning module can be processed and used by different learning systems and servers, which consequently requires an open standard technology. Products that incorporate such standards can easily be integrated and work together effectively. The most important issues on the interoperability of e-learning tools and technologies, which at the same time attract the attention of standardisation organisations, are content description via metadata, packaging, learner management and communication of the educational process results

A number of important organisations, such as Dublin Core Metadata Initiative, Instructional Management Systems Initiative, and Advanced Distributing Learning have developed guidelines about which system components are required and how they must operate together, metadata standard for web documents, and the standard Shareable Content Object Reference Model (SCORM), being a kind of umbrella standard [8].

As part of the SCORM model, the learning content has been decomposed in small objects, or assets on the lowest content level, which are the building blocks of the LOs, called atomic learning objects (ALO) [9]. Examples are a small text, a picture, an audio. The individual small chunks of media have no special meaning. Only when joined with those assets into a sharable content object (SCO) they represent a small component of learning content.

A composition of a set of SCO's will result in a course or SCORM module. All parts of the course contain metadata, based on the IEEE LOM (IMS) standard [8]. The courses must have a content structured formats (CSF), being a XML file containing the information about the content and the organisation of the package. CSF is based on the IMS packaging standard.

4. Development of E-learning content

The production of an e-learning course module can be done in 3 phases:
a. Decomposition of learning content,
b. Content storage,
c. Content assembling and packaging delivering the end product, the learning object LO.

4.1. The decomposition of the learning content

The decomposition of the learning content is a manual process. The source learning content has to be decomposed and structured as a hierarchical tree of chapters, units and blocks. [10-6]. A course is similar with a book while a chapter contains many blocks, being smaller content parts. If the chapter can really be split into more individual content topics, or which can be learned as individual topics, then the learning content is split into two or more independent content units, put together in a sequence. The learner will subsequently learn them as one logical content module. Each unit is composed of a set of blocks, corresponding to smaller content parts, being structured as a relational tree. The learning content is split into a set of full text documents each linked with a block in this structure. The example shown in Fig. (2), the course "Business Driven Technologies" with the chapter "supply of ICT professionals" is decomposed into blocks.

In a second part of the decomposition phase, the block content is split in raw content elements or ALOs: the source text, its summary, figures and tables, and the key terms of its content. Some other ALOs can be added, such as a video telling the story, Q & A, URL of additional information, ect. Accordingly, metadata will be defined for all content components [9].
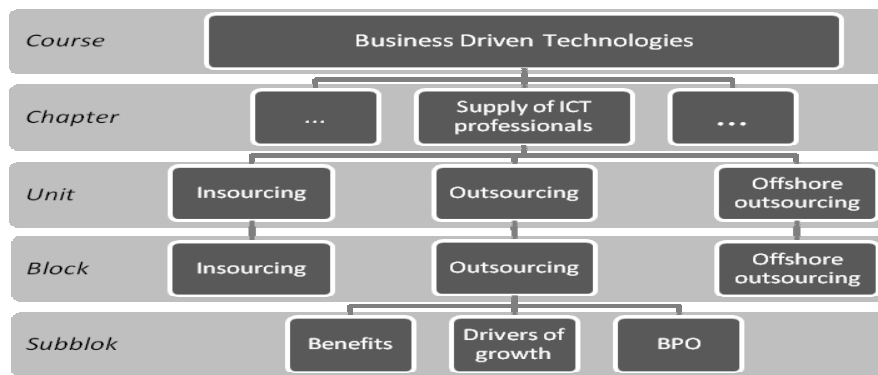
Fig. (2): Decomposition of Content in Course "Business Driven Technology".

4.2 Metadata

SCORM differentiates between 3 levels of objects and different requirements on point of metadata are set forward for the three different levels:

1. An asset or an ALO, where the compulsory metadata consists of the title, the description and the copyright. Additionally the creation-date, the format and the type can be added.

2. A SCO or a BLOCK, being the smallest content element that is an independent content component that delivers significant information about a topic. The compulsory metadata already required for an asset, supplemented with two additional metadata items, the language and the elapsed time

3. An LO or a course module will be built by packing a set of SCOs, being stored as a content aggregation model or CAM. A special characteristic of a CAM is the possibility of "nesting" different CAMS. A CAM can be compared with the chapter of a course or a book, being a learning path composed of several e-learning units. The compulsory metadata consists of the metadata already required in a SCO, supplemented with the title, the learning level of the content and the required foreknowledge.

4.3 Storage of Content in Database

Starting from the source learning content, the hierarchical structure of units and blocks are identified in it. To create the learning objects the content will be structured in the database following the hierarchical content structure. And to assemble the content linked with the blocks the content components or ALOs are tracked from the data tables. ALOs include full and summary text, figures, questions and answers, audio files.
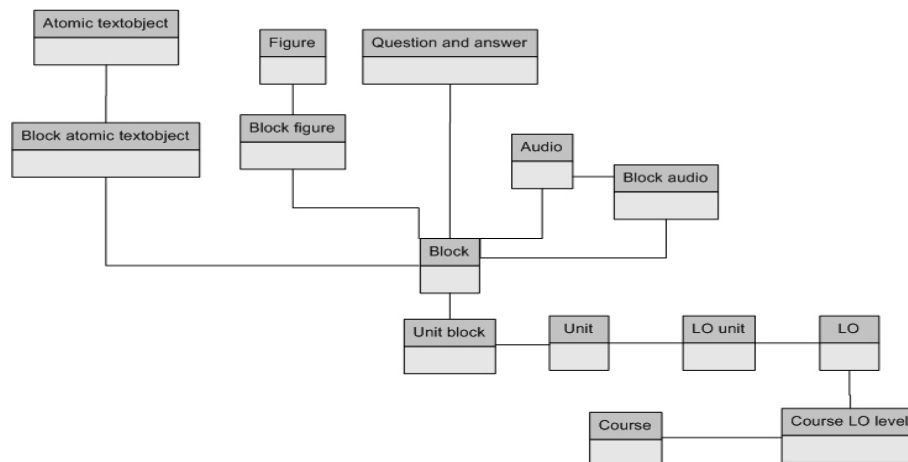
Fig. (3): Database Structure

5. Development of the LO Authoring/Assembling Tool

5.1 Architecture of the LO authoring/assembling system

In the adapted "Content Object Model" (Fig.(1)), the information blocks are via the database structure linked from one side with the units and LOs to which they belong and from the other side with their raw data components. On the third level or the LO level of the model, the learning designer is responsible for selecting the relevant information blocks from the second level and assemble them into application specific learning objects, taking care for the built in hierarchy of the content. The design of the presentation of the LO is also part of the assembling activity [9].

We translate this in our 3 layer architecture for the LO authoring/assembling system, being the database and two subsystems

This LO assembling/authoring tool is composed of two subsystems. The first will create an LO without layout and the second one will present the LO with the preferred layout as chosen by the user or as adapted to the infrastructure of the user s shown in Fig. (4).

LO Authoring/ Assembling tool	Subsystem 2: LO Creation	User selects layout scenario	Delivery of LO version fitting the users device
	Subsystem 1: Generic LO Assembling	User selects units and blocks from the given content	
Database level: storage of ALO and LO			
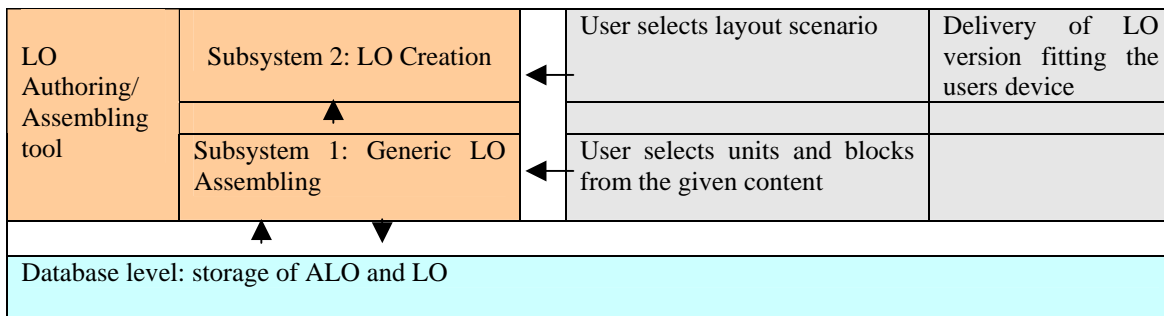
Fig. (4): Architecture of the LO Authoring System.

Education experts can build in advance some layout templates which were built in the assembling/authoring system. As a result, the LO will select the layout requirements fitting the preferred learning styles of the learners.

5.2 system requirements: dynamic Learning Objects and re-usability of learning content in Los

The "generic assembling system" (subsystem 1) is building a standard and generic LO when the learner activates it. Its ID and the metadata are physically stored in the data table LO. This LO is generic in the sense that more LOs can be built upon it. Indeed this LO is useless unless some layout has been added to it. That is why subsystem 2, the "LO creation system" is added to the subsystem 1. This latter system will, based on the input of a presentation layout template, create the final LO. This is also a dynamic LO. It is only created when the learner activates it. If the LO is available in more presentation layouts, then the learner can select its preferred layout.

For re-usability, the following possibilities in mind: first, based on the same source content, we can make a selection of blocks we bring in the LO, second we bring more LOs with the same content, but presented in another layout fitting the preference of the user, and third the same as the second one, but fitting the device of the user.

The first LO includes all the source content and structured following the built in hierarchical structure. Another LO can be built on a selection of the source content. The first LO can contain the learning content on detailed level and the second one selects from all included topics the introductory blocks.

In the presentation of the learning content of the LO, one must take care of the preferences of the user and of their learning styles. Different presentation templates can be developed in advance and the LO can be presented in that way. It is up to the user to select the layout that fits best his/her learning style.

Furthermore, mobile devices such as PDAs and mobile phones have limited presentation facilities and as a consequence in the course design the screen layout has to be simplified. Flexibility of different devices means that course materials can be automatically adjusted in order to be accessed by a variety of devices. The e-learning system will identify the type of device used by the learner and starts the e-learning course in the most appropriate built in presentation design.

5. 3 System Development

The new system has been analysed and designed in the unified modelling language scheme (UML) and modelled in the class diagrams shown in Fig. (5) and Fig (6), following the analysis based on the Larman methodology [11].
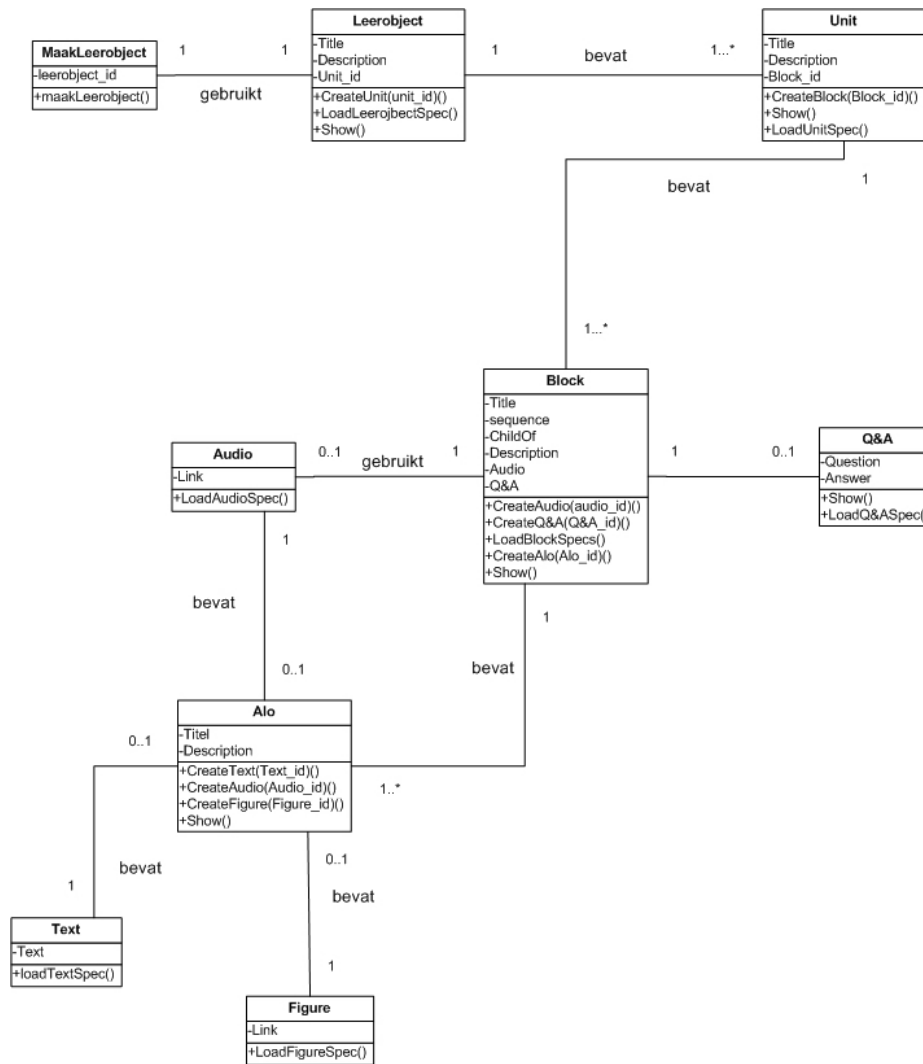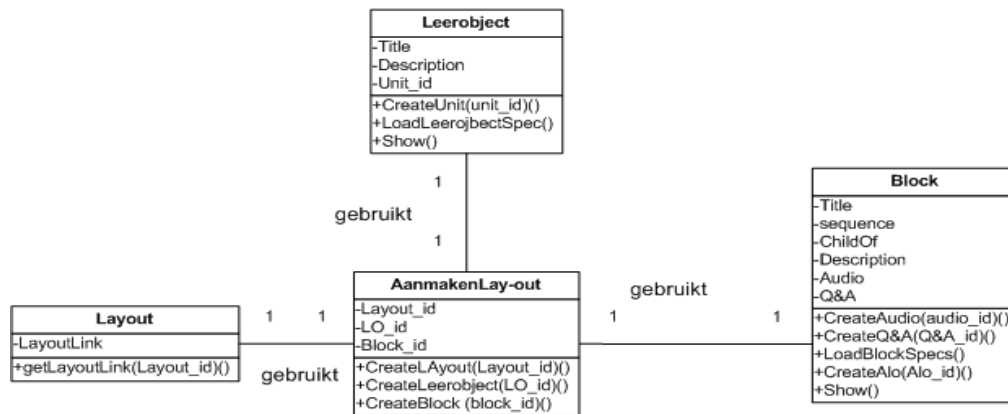

Fig. (5): Class Diagram of subsystem 1

The method handles the conversion of a problem in a software schema based on object oriented design and analysis (OOA/D). In this approach the following diagrams and schemes were developed: use case, system sequence diagram, domain model and sequence- and collaboration- diagrams. The last step is the creation of the class diagram, being a synthesis of the previous ones. Each class consists of three parts, the name of the class, the attributes and the last one the methods and their parameters. In this scheme, the connections present the relations between the classes and the multiplicity.

In Fig (5) the resulting class diagramme for subsystem 1 is presented, and in Fig (6) this of subsystem 2.

A prototype of subsystem 1 has been developed in PHP and the content organised in an MySQL DBMS on a Windows 2003 and IIS server. The LO created for the course module "Supply of ICT professionals" and based on the content structured in the database are presented in Fig.(7) and (8).

Fig.(6): Class Diagram of sbsystem 2

Fig. (7): LO Units and Blocks.

Fig. (8): Outline of the Block.

A view of the course module "Supply of ICT professionals" in a e-MINDMAP presentation can be found on the website: [14]

Conclusions

A new self-instruction learning management system (LMS), based on the conceptual model of content object, is developed to offer learners e-learning courses which can be studied and completed independently. The self-instruction was organised as an e-learning course which follows the e-MINDMAP concept recently developed. The main challenge was to produce re-usable e-learning courses which can be implemented in a number of SCORM-compliant LMS platforms. A number of e-learning courses have actually been developed and made available in the new LMS after being re-engineered to take into account the requirements posed by the international standards. Both the database structure and the class diagram were defined as the base architecture of the LO authoring/assembling tool. A first prototype was then developed where the learning content could be reused on the same source content by selection of blocks, or with the same content but presented in another layout fitting the preference of the user, and with an additional possibility of fitting the device of the user.

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