Object-Oriented Knowledge Base for a Multimedia E-Learning System

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ABSTRACT: - This paper describes the object-oriented model representing the contents of a multimedia knowledge base in the MKBe-Learning System [2]. The object-oriented analysis of the system had produced a set of use cases which were used to derive the model. The instructor view consists of objects in a course, whereas the knowledge base view consists of conceptual objects in a subject. The model combines the instructor view and knowledge base view into classes that will be used for further development of the system.

KEY-WORDS: - Knowledge Base, Object-Orientation, Multimedia Knowledge Base, E-learning System, Knowledge Objects

1. Introduction

Representation of knowledge and learning materials in a computer-based system must be done effectively and efficiently to facilitate the learning process. In e-learning systems, it is important to provide strong support for lecturers to develop lessons in order to improve the quality of the lessons and reduce the cost of repetitive tasks. However, the lessons should be easily retrievable by students so as not to disrupt the learning process.

Initial research of Virtual Learning Environment architecture by Yeoh E.T. et al (1999) [1] has been adapted into the current MKBe-Learning environment. It is a computer-based interactive environment that supports the process of learning and teaching university courses and combines functional blocks to provide facilities for students to learn a university course, either on their own or with the assistance from lecturers or instructors. Fig. 1 illustrates the different 'layers' of the environment.

The lowest layers consist of a collection of media such as image, text, video, audio, animation, etc. The 2nd layer is the knowledge base here concepts are organized using object-oriented approach while the 3rd layer uses the knowledge base to structure courses and lectures and it also deals with the management of the course as a whole. The top layer is the user interface.

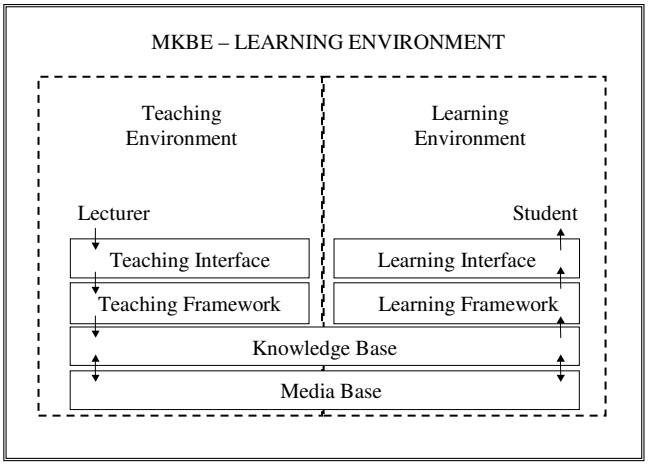

Fig. 1: MKBe-Learning Environment [1]

Based on this architecture, the Multimedia Knowledge Base E-learning (MKBe-Learning) System Project was initiated in January 2004. It is a project funded by the Multimedia Research & Development Grant Scheme under the Multimedia Development Corporation (MDC), Malaysia

The MKBe-Learning System [2] is an integrated e-learning system consisting of intelligent interface,

inference engine, presentation generator, authoring tool, knowledge base and learning management system. The components and their relationship are shown in Fig. 2.

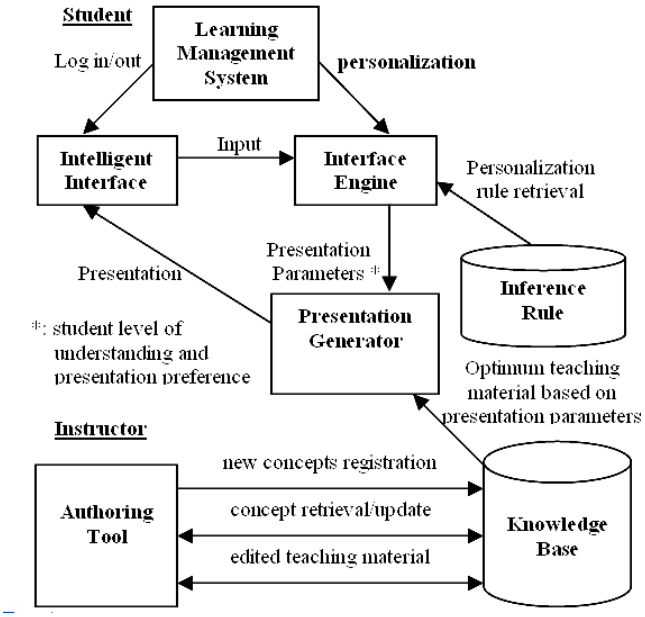

Fig. 2: MKBe-Learning System

The major components of the system are :

- *Intelligent Interface* that provides access to modules, lectures, concepts and medium.
- *Inference engine* that personalize the learning process according to the specific needs of students.
- *Presentation generator* that creates the multimedia presentations for students based on personalization parameters from the inference engine.
- *Authoring tool* that provides facilities for lecturers to create learning modules to be presented to students.
- *Knowledge base* that forms a reusable storage of concepts to be learnt by students and to be prepared by lecturers
- *Learning Management System* that maintains personal details of students and records of their learning process

The MKBe-Learning System is a multimedia e-learning system created to store, manage and retrieve concept-based multimedia education material. With multimedia content, the learning process can be stimulating and engaging. Students will access the course materials using the system either for synchronous or asynchronous lectures while lecturers will use it to organize and store education materials such as tutorials, lectures, animations, videos, etc. A need for having a knowledge base that represents the concepts taught and the relationships between the concepts is identified as reflect to the problem that occur where the existing content and methodology are lecture-specific and presentation oriented. Thus, lecturers have difficulties to reuse the existing materials created by other lecturers, due to the difference in the level of knowledge and presentation style. With the high cost in the development of multimedia education materials, reusability is a major consideration for the developer of multimedia education.

2. Multimedia Knowledge Base

The knowledge base forms a reusable concepts storage or learning contents to be presented to the students. The development of the content in the knowledge base will take into consideration of the Sharable Content Object Reference Model (SCORM) [5] standards. SCORM can be defined as a set of specifications for development, packaging and delivering high-quality educational and training material which published by Advance Distributed Learning, US (ADL). It is built upon the work of the AICC, IMS, IEEE, ARIADNE and others to meet high-level requirement of accessibility, interoperability, durability and reusability of Web-based learning content and systems. Therefore, course providers with SCORM compliant content are able to deliver courses on any of the growing number of LMS that support the SCORM.

The multimedia technology has played an important role as basic demand of the e-learning market. Thus, the solution for multimedia interactivity and fast content development are imperative to e-Learning developers. Significantly shorten the time for developing content that is now perceived as one of the greatest obstacles to broader the dissemination of e-Learning. There are many web-based learning systems that already existed. However, among these systems, the materials of each system can not interchange and reuse efficiently. Therefore, there are many good learning materials only available on a unique platform. Thus, by generating SCORM compliance content helps developers to build learning content that can be reused across any Learning Management System (LMS).

The knowledge base is developed using the object-oriented approach. The development of the contents

of the multimedia knowledge base would be based on the integration of several syllabuses into a generalised syllabus. This syllabus will be analyzed and formalized to produce a 'standard' syllabus for a particular subject as initial development in the MKBe-Learning System. The syllabus would contain the topics that are most like to be reused with the highest percentage of occurrences. Thus, for any lecturer using the knowledge base to create a new course, the content created would be most likely to be reused.

In order to ensure that the learning objectives can be achieved, the standard syllabus will be reviewed by subject matter experts. It is possible that the generalisation process reduces the significance of some topics to be optional and be omitted from the standard syllabus. The subject matter experts are responsible in ensuring that the contents developed from the syllabus are highly reusable. During the verification process, the accuracy and the suitableness of the content is determined. Subsequently, we will proceed to the next stage which is the creation of the lesson. The lesson list description will be prepared and analyzed according to the content structure that has been verified. As a result, multimedia content is created based on these lesson lists. In the final stage, the content of the topics will be reviewed again by the expert to ensure that only suitable materials are being developed.

3. Instructional View

The MKBe-Learning knowledge base structure can be defined in two hierarchies that are useful as the two hierarchies stand as a guideline and procedure to follow in order to classify the different types of content. The first hierarchy is defined as Instructional View which can be referred in Fig. 3 and second hierarchy is the Knowledge Base View which is shown in Fig. 4. Instructional View refers to the instructor's view for developing the lectures. These four levels in the hierarchy are defined as a standard in storing the necessary information or data and can be applied to any content regardless of delivery format.

Based on the instructor use cases [10] which describe the instructor's activities in creating courses, lessons, and all the contents in the e-learning system, the instructional view of the knowledge base is created. The Instructional View structure consists of a course that is collection of several lesson, a lesson that build up by collection of topics and a topic that comprises of several web pages. In Instructional View structure, we have agreed on that "lesson" will be referred as the learning object while "topic" will refer to the information object within a lesson.

A course can be defined as an object dealing with a subject that may include lectures, discussions, simulations, various assignments, tests and exams. This course then can be further explained in several lessons that consist of one or more topics. Lesson here referred to the content that is to be taught or the activity that is to be done which made up of a number of topics while topic is a part of lesson that to be thought and treat as a realization in Knowledge Base concept. A topic can be composed into other sub topics, which are actually topics also hence classified as topics in the knowledge base but have aggregation relationships with the main topic. Each topic contains one or more web pages. A web page is an object that represents the contents and explains the concept. The relationships between the components in the Instructional View and the Knowledge Base View will further explain in the Object Oriented Model.

The first course to be created for the MKBe-Learning System is *Basic Electronics.* The *Basic Electronics* course would consist of a few lessons such as *Basic Electricity* and *Basic AC Theory*. Each lesson consists of topics, for example the *Basic Electricity* lesson can consist of topics such as *Static Electricity* and *Ohm's Law*. A topic can contain subtopics that will further elaborate this topic, for example *Protons* and *Electrons* for *Basic Electricity*. Finally a web page is the actual presentation of a topic to the students. It is possible for a topic to be presented differently in a few web pages.

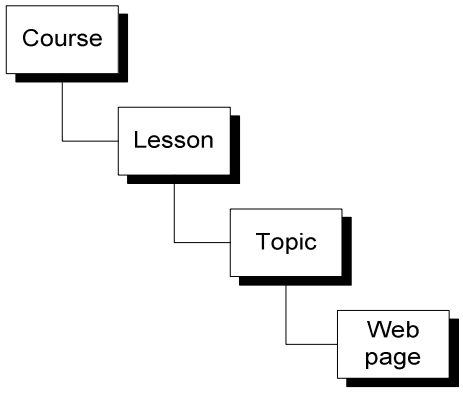

Fig. 3: Instructional View Structure

4. Knowledge Base View

The representation of knowledge in the knowledge base is organized by subjects in the Knowledge Base View. The Knowledge Base View refers to the subject contents of the knowledge base that consists of *subjects, concepts, characteristics* and *media* representations. There are four levels in the Knowledge Base View hierarchy as shown in Fig.4.

A *subject* is defined as a branch of knowledge or field of study that consist of additional information about the content. The *subject* can be further divided into several *concepts*, which referred to an object representing an idea that can be taught, explained, or communicated by the lecturer to the students.

Each *concept* can be explained through a number of *characteristics*. *Characteristics* describe a specific aspect of a *concept* through *general information, core, example, use case* or *demonstration*.

Media is a representation of different types of media files that can be used to present the *characteristics* of a *concept*. The relationships between the components in the Knowledge Base View are described through Object Oriented Model.

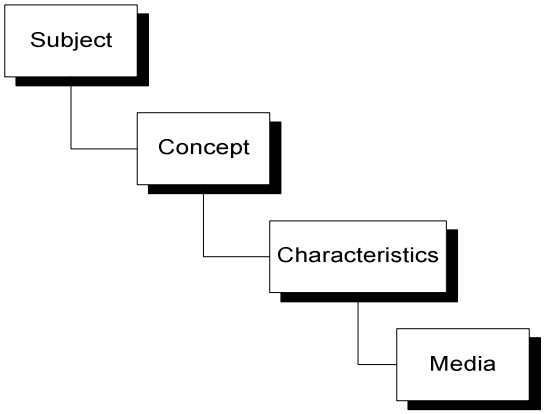

Fig. 4: Knowledge Base View Structure

For example, the *Basic Electronics* subject in the knowledge base would represent all concepts taught for this subject through the different courses created by different lecturers. These concepts are used to create the topics e.g. Basic Electricity, Basic AC Theory, Protons and Electrons. Each of these concepts can be presented through the different characteristics using different media in the knowledge base.

There are five core subjects which will be used to create the first prototype content for the MKBe-learning system. There are *Basic Electronics*, *Computer Programming*, *Management*, *Financial Accounting* and *Database Systems*. These subjects are selected in view of the wide range of students who can be potential users of the system when the time to commercialize comes. The outcome from these subject creations via the system will be the first test bed. The results will be very beneficial in improving the architecture and flow of the whole system.

5. Object-Oriented Model

The object-oriented model can be divided into two portions which is the instructional view and the knowledge base view which have been discussed earlier. The instructional view comprises of *course, lesson, topic* and *webpage* while the knowledge base view consists of *subject, concept, characteristic* and *media*. The object-oriented model for instructional view and knowledge base view using Unified Modeling Language (UML) is shown in Fig. 5.

A *subject* is a branch of knowledge or field of study. A *course* is a realization of a *subject* with specific learning objectives through a set of *lessons*. *Lesson* is the content to be taught. *Lesson* covers the activity to illustrate specific skill and it is made up of a number of *topics*. Each *course* consists of 12 to 15 *lessons*, where each *lesson* can have 10 to 15 *webpages*. These *webpages* contain *topics* and/or their sub*topics*. Each *lesson* consists of 4 to 6 *topics* with possibly 2 to 3 sub*topics* per *topic*. It is estimated that a student will spend 3 to 5 minutes browsing each *webpage*. The contents of the *webpage* are derived from the *concepts* in the knowledge base, and each *webpage* is a presentation of one and only one *concept*.

Concept is associated to many *subjects. Concept* contains attribute which shows uniqueness and values of a *concept.* Attribute of a *concept* also tells whether a *concept* is composed of another *concept* or not. *Concepts* can be related to other *concepts* via typed-relations such as *pre-requisite* and *related-to*.

Each *concept* is described through different *characteristics* and each *characteristic* can be presented by *media*. *Characteristics* can be any of the following:

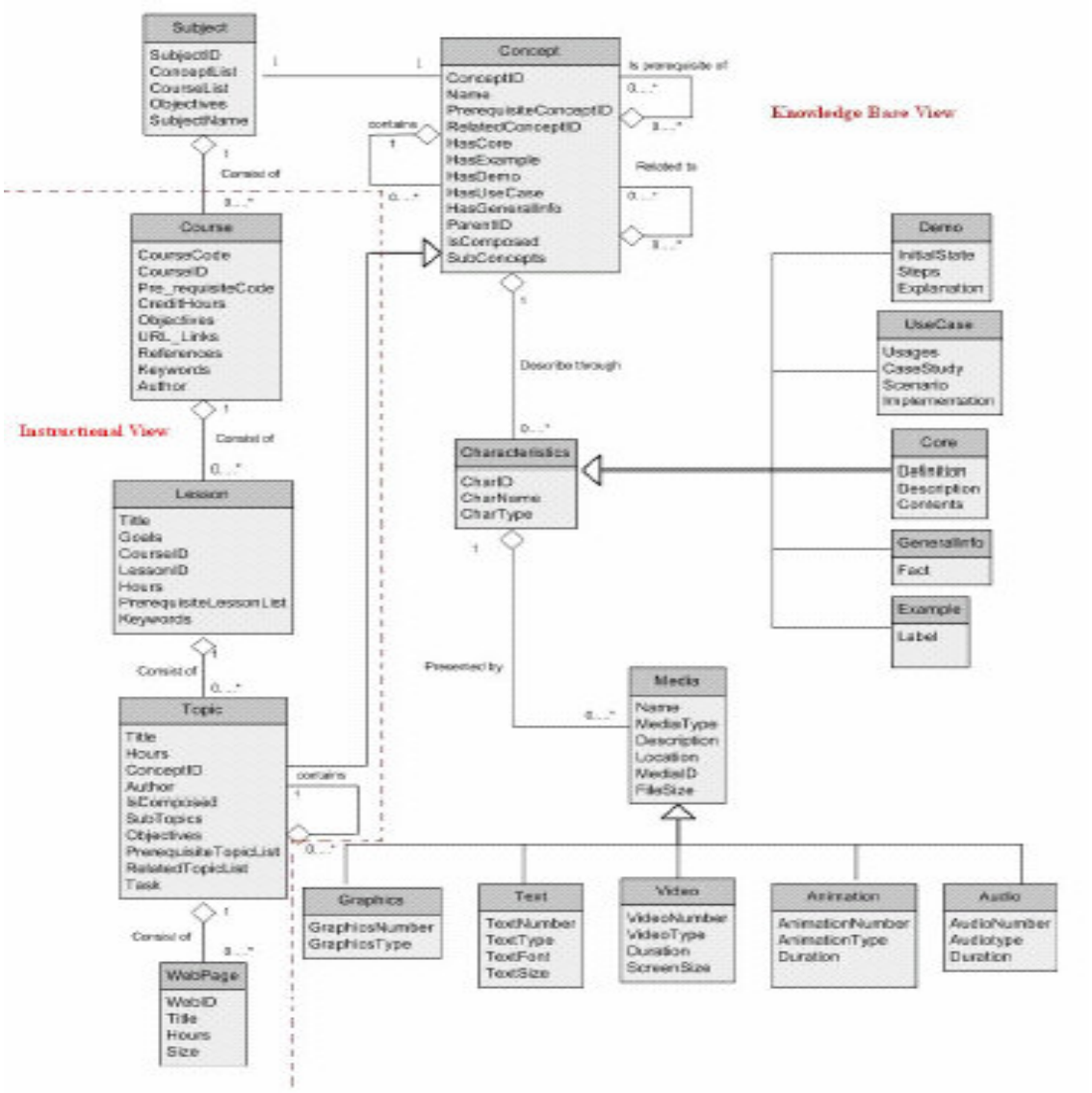

Fig. 5: Object–Oriented Model of the Knowledge Base for MKBe-Learning System

- *General Information*, which is referring to factual information related to a concept
- *Core*, which is a descriptive information of a concept
- *Example*, which is a specific illustration of a concept
- *Demonstration*, which refers to procedural illustration of a concept
- *Use Case*, which contains usage or case-based illustration of a concept

Media represents the different types of media file that can be used to present the *characteristics* of a *concept*. It is not necessary to have all the different type of *media* for a *concept*. Suitability of *media* to present the *concept* matter is an important consideration in identifying the appropriate *media* type. There are five types of *media* identified for the knowledge base:

- *Text*: Primarily concerns on text-based representation or written work. Examples of text-based files are word document (doc), plain text (txt) and rich text format (rtf).
- *Graphics*: Pictorial-based representation, photographs or other visual representations. Graphics, Images, Pictures. Examples of graphics files are bitmap (bmp), JPEG (jpg), GIF (gif) and TIFF (tif).

- *Audio*: Audio-based representation. Examples of audio files are WAV (wav), MP3 (mp3) and AIF (aif).
- *Video*: Video-based representation or movies. Examples of video files are QuickTime (mov), MPEG (mpeg) and AVI (avi).
- *Animation*: Animation based representation. Examples of animation files are Shockwave Flash (swf), Director Exe (exe), and PICS animation (pcs.)

6. Further Development

Object-oriented modeling provides a good view of the knowledge base architecture. Object-oriented modeling coupled with Rational Unified Process provides a systematic approach in integrating and implementing the MKBe-Learning System.

Based on the Object-Oriented Model, a complete course for Basic Electronics will be created. The course will be used for further refinement of the use cases and the Object-Oriented Model to produce a framework for other subjects. The course contents would be used to test the integration of the knowledge base with other components in the MKBe-Learning System.

7. Conclusion

The Object-Oriented Model is a representation of the knowledge base contents in the MKBe-Learning System. It is developed through the analysis of the use cases and would be revised as the use cases are updated. This model consists of instructional view for courses and knowledge base view for subjects, corresponding to the functional requirements of MKBe-Learning System. The knowledge base prototype would be developed based on this model and evaluation of the prototype would be used to improve the model. Further work such as use case updates and integration with other components would provide information to improve the Object-Oriented model of the knowledge base.

8. Acknowledgements

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