On the Improvement of course interoperability in E-Learning Models

ICEE 2002 CONFERENCE

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Abstract— *Nowadays, a wide variety of e-learning systems integrate proprietary developed courses. These courses cannot be easily reused and interchanged between various Learning Management Systems (LMS) over the Internet*
In this paper, an improved WBT Model based on the Learning Technology Systems Architecture (LTSA) standard will be presented. This model includes all "WBT Enhance Model" concepts and facilitates courseware interchange between LMS. It also considers the LTSA development process of portable courses as an interoperable component. This LTSA process will be based on a portable course structure, interoperable hierarchical course content, portable runtime environment, and interoperable metadata
For illustration, a scenario based on the LTSA content developer stakeholder perspective will be presented. In this scenario WebCT will be used as the E-learning platform. Realnetworks will be used for the development, hosting, streaming, and playing of multimedia courses that are integrated in WebCT. Moreover, Microsoft Netmeeting will be integrated in WebCT to provide audio/video/sharing of application between the coach and learner and among learners.

INTRODUCTION

Proprietary courseware is widely available over the Internet. However, the courses cannot be easily reused and interchanged between various Learning Management Systems (LMS) over the Web. This is due to their lack of compliance with e-learning standards developed by learning technology organizations such as ISO/IEC JTC1/SC36[1], IEEE LTSC[2], IMS[3], and ADL[4]. These organizations have raised the importance of reusability and interoperability in their developed standards.

In this paper, a new WBT Model will be presented based on the Learning Technology Systems Architecture (LTSA) standard[2]. This model includes all "WBT Enhance Model" concepts[5]-[6]. Moreover, it identifies the components, requirements, and specifies the interoperable components. For this purpose, all LTSA processes are considered as interoperable components with more emphasis on the process of course development (Delivery Process). This interoperable process will be based on a portable course structure, course content, interoperable Metadata, and portable runtime behavior. The portable course structure will be based on the IEEE CMI[2]. The interoperable course content will be based on hierarchical object Model that will use the IMS-QTI[3] for tests, and the MPEG-4 technology for media scenarios. This results in an improved course interchange between various LMS, a reduced course development time and cost, and an enhanced e-commerce market.

For illustration, a scenario based on the LTSA content developer stakeholder perspective will be presented. In this scenario WebCT[7] will be used as the E-learning platform. Realnetworks [8]will be used for the development, hosting, streaming, and playing of multimedia courses integrated in WebCT. Microsoft Netmeeting[9] will be added to WebCT to provide audio/video/sharing of application between the coach and learner and among learners.

In this paper, standards are presented in section II. The architectural framework LTSA and the Enhance WBT model are presented in section III. The new WBT/E model for open systems is introduced in section IV and illustrated in section V. Concluding remarks are given in section VI.

SCORM, MPEG-4, MPEG-7

SCORM (Sharable Content Object Reference Model)[4] is a set of standards that define a Web-based "Content Aggregation Model" and "Run-time environment" for learning objects. The Content Aggregation Model aggregates resources (Assets/SCO) into a cohesive unit of instructions

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with a defined structure. It defines Assets as an electronic representation of media, graphics, text, and others. Assets require to be launched by LMS without a need for communication using API or data model with LMS.

On the other hand, the SCO (Sharable Content Object) is the lowest aggregated course content level to be tracked by LMS. It is composed of one or more Assets with their specific launch mechanism. The run–time environment has three mechanisms to be considered between learning resources and LMS. They consist of common launch, API, and data model. The launch feature specifies a common starting way of the Assets/SCO. It also specifies the procedures for the communication between the SCO and LMS while using a standard API. The API get and set data between LMS and SCO, and reports their status. The Data Model specifies the standard data element to be communicated between the LMS and the SCOs.

MPEG (Moving Picture Experts Group) is a committee of ISO/IEC in charge of the development of standards for the coded presentation of digital audio and video and for their synchronizations. MPEG seeks to avoid a multitude of proprietary, non-interworking formats and players. They developed MPEG-4 [10] standard for streaming rich media over the Internet. It supports streaming over the narrowband and broadband Internet with a bit rate from a few kbits/s up to several Mbits/s. Moreover, MPEG-4 supports coding for synthetic and natural audio-visual objects. These objects can be combined to form a media scene. The BIFS (Binary Format For Scenes) is used to describe the information needed for scene composition. Moreover, the elementary streams are synchronized using common system timing and framing. They include the scene description stream, encoded representation of media objects streams, and object descriptor stream. The scene description stream provides a spatio-temporal relation and behavior for the presentation over time. The object descriptor is linking the elementary streaming resources of an MPEG-4 encoded presentation and the media object within a scene description. In addition, it provides information for media decoding, intellectual property, and URL address of elementary stream at the receiver station. In addition, the DMIF (Delivery Multimedia Integration Framework) is the session protocol for multimedia streaming management over generic network technologies.

MPEG-7 [11] standard will provide media content searching over the web as it is for text nowadays. It provides standardized Descriptors (D), Descriptors Schemes (DS), and a Description Definition Language (DDL). The descriptors bind media type dependent basic features to values. The DS is the data model of the media object description. It identifies the structured and semantic relationships between the combined elements that include descriptors and other DS. Several categories of DS are defined. The multimedia DS describes a content that is a combination of natural and synthetic audio, video, and text. The audio (resp video) DS specifies the features dedicated to an audio (resp video) categories. MPEG-7 specifies several generic and complex multimedia DS. The generic DS include vector, time etc. The complex DS includes Description schemes for content management, content description, Navigation and access, content organization, user interaction, content management, media description, and so forth. The DDL is used to modify, extend, and create new DS or D.

THE ARCHITECTURAL FRAMEWORK LTSA AND THE ENHANCE WBT MODEL

The IEEE LTSC has developed the Learning Technology System Architecture standard IEEE LTSA [2]. This standard is composed of five layers. The first layer represents the learner/environment interaction. The second layer specifies the learner related design issues. The third layer identifies the system components that include processes, stores, data, and control information. The fourth layer specifies stakeholders perspectives. The last layer identifies interoperable components such as APIs, Coding, and Protocols.

The Enhance Model [3]-[4] developed for the European Aeronautical Industry is composed of eight concepts. The organization concept discusses the general organizations and various platform structures. The user interface concept provides necessary tools to the role player. The communication concept identifies types and tools for communication between platform users. The tracking concept specifies courses and students tracking. The evaluation concept identifies the method used for testing and certification. The course structure concept specifies a hierarchical structure composed of modules and having didactic objects at the nodes. The course development is composed of five steps to enhance reusability. Finally, the network concept identifies security features, access principles, and QoS.

The eight concepts of the Enhance Model map to layer 3 of the IEEE LTSA and provide necessary details for web applications. Therefore, the IEEE LTSA embraces the Enhance Model at a higher level of abstraction.

THE NEW WBT/E MODEL FOR OPEN SYSTEMS

In this section, the improved model designed for open system WBT will be presented. It is based on the LTSA architecture and includes all Enhance Model concepts. Moreover, it has requirements, specifies components, and provides interoperability:

- Requirements: The model promotes open E-learning systems. It specifies requirements such as accessibility, nomadicity, flexibility, extensibility, reusability,

interoperability, scalability, availability, and security. Moreover, it supports personalized, collaborative, objectivist, and constructivist learning. This can be done synchronously with a multicast media delivery or asynchronously with a unicast media delivery while using the cross platform Internet browser.

- Components: The model components are the same as those defined in layer 3 of the LTSA architecture. The necessary details of their implementation are defined in the Enhance Model.
- Interoperability: The API, protocols, and coding are defined as interoperable components in LTSA. The Process of Content Development is also suggested as another interoperable component.

Our objective is to facilitate the courseware interchange between LMS by the development/use of portable course. In a previous work [14], database design and data structures models were suggested as interoperable components. In addition, the use of IEEE learner profile model and CMI course structure standard were suggested to provide portability at the learner and course structure level. It was also suggested [15] to have the AU lowest level of CMI based on the IMS QTI in the case of testing.

In this article, course interoperability is enhanced by considering its development process as interoperable component. During the development process, the course structure will be separated from its content. The course content will be based on a common templates model and on a hierarchical Object Model. In this hierarchical Object Model, synchronized media content will be based on MPEG-4 technology, and tests will be based on QTI(Question and test interoperability). In addition, an interoperable hierarchical data structure Model for communication between LMS and courses is introduced. A standard authoring tool is needed to develop these portable courses that can be interchanged between LMS. The process of portable courseware development will include:

- A portable course structure based on IEEE 1484.11 Computer Managed Instruction (CMI)[2] for Courseware Aggregation Data Model. Each course is composed of a grouping of AU (Assignable Units) and other blocks in an order implied in a list or explicit using the prerequisite. The metadata are associated with the course or AUs to facilitate the sharing and exchange of learning objects.

- A portable course content development where the instructional elements are based on common templates and hierarchical object models. This will enable the launch and the tracking of the student progress from the highest to the lowest object level of the hierarchical Model. For this purpose, the AU which includes course introduction, lessons, course summary, and tests etc, will be based on common templates model and interoperable hierarchical object model. Moreover, the common templates model of instruction units will be based on hierarchical parts. Each template is composed of parts and each part can be composed of subparts. However, in the test case, the instruction units will be based on a common test template and will use the IMS QTI. The IMS QTI[3] describes a basic structure for the question and test and their corresponding result. Moreover, this IMS QTI identifies the ASI Model where the assessment is a collection of one or more sections, the section is a collection of zero or more items and/or other sections, and the item is a combination of interrogatory, rendering, and scoring information. On the other hand, the media units case will be based on a common media template and use MPEG-4 technology. The media scene will also be based on hierarchical structure where the nodes will include a list of features related to behavior, MPEG-4 audio-visual synthetic and natural objects. In addition, the spatio-temporal relation for the hierarchical media objects presentation over time will be provided by the scene description during the delivery of the learning content.
- A Portable Run time behavior of the course content as defined in the SCORM [4] in order to have a common way to launch the hierarchical object model, a common API to inform the LMS of the status of this hierarchical object Model, and a common hierarchical data Model that can be exchanged between LMS and the hierarchical object level of course content. We suggest to include the event Model of the hierarchical object Model in the hierarchical data Model for a complete tracking of all the activities of the user at all object levels. Such detailed tracking wouldn't be possible in classroom.
- Incorporating the developed portable courses, modules, lessons, hierarchical object Model, and media objects in a digital library. Each of these items will have descriptive information Metadata to enhance the search and reuse. The interoperable IEEE P1484.12 Learning Object Metadata (LOM) [2]will be used to describe the courses/blocks at the curriculum level, and the AUs. In addition, an extended IEEE LOM [15] will be used to describe the assessment, section, and item of QTI ASI Model. Finally, the MPEG-7 media content description will be used to describe the AU based on MPEG-4 media learning resources and media coded objects. This will enable interoperable searching, indexing, and filtering in media digital library.

An example on the use of the IEEE CMI, MPEG-4, MPEG-7 is shown in Figure 1 below. Figure 2 represents the reusability at the MPEG-4 media coded objects. The MPEG-4 media coded objects database can be used with different BIFS to develop different AUs/lessons.

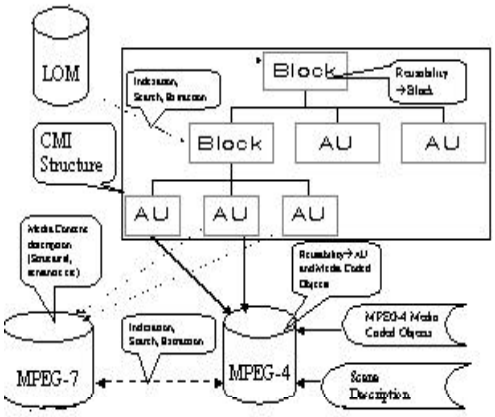

FIGURE.1

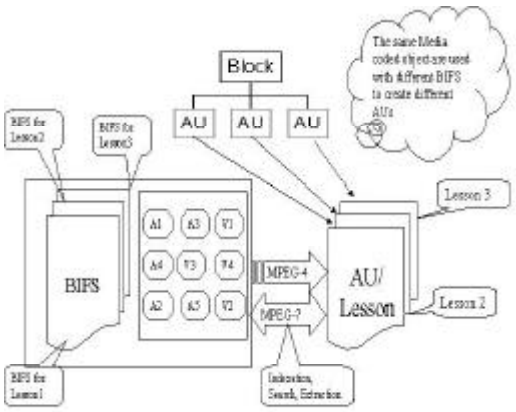

FIGURE.2

ILLUSTRATIVE EXAMPLE

In this section, an implementation of the new developed Model will be presented using the content developer LTSA isolated stakeholder perspective. The primary LTSA design priority emphasizes the organization of the learning resources, queries, catalog information, locator of learning resources, and the development process to transform learning content to multimedia presentation. In addition, it specifies the delivery of multimedia presentations, protocols, and formats of multimedia flow components etc. A secondary LTSA design priority emphasizes the learner entity collaboration, the learner and coach collaboration etc. WebCT [7] E-learning platform committed to IMS and SCORM standard will be used. This platform does not support multimedia development, multimedia streaming and synchronization, and audio/video collaboration. It neither supports the library concept and professional search engine. To overcome these problems [10]-[11], the following were used:

- Development and delivery process: In WebCT, the course structure is not separated from the content. It is up to the content developer to organize the course structure using the content module and table of content. In addition, there is no prerequisite of media content, no API, and no data Model for communication between the course and WebCT. However, the WebCT COBALT release will overcome these problems and provide a course and section hierarchy to improve the content sharing. Moreover, the tracking is based on the web page and is not media object-based. The reusability between WebCT's platforms at the course level is possible by backup/restore or using the course as a template for other courses while keeping the course structure defined by the designer. In addition, the course content modules, lessons, web pages can be based on developed templates that are stored outside the platform. WebCT includes the IMS Content Migration Utility that uses the IMS QTI 1.1 which allows importing and exporting content, learning objects, and assessment from any other IMS compliant platform. The reusability at the question level in the same platform is achieved in WebCT using the Questions Database of each course. It contains categories for organizing the questions. Each question in the database has a set of default attributes assigned automatically by WebCT. In addition, these questions are searchable using their attributes that include the title, type and category. Other attributes can be added to the database. Reusability at the quiz level in the same platform is achieved using other quizzes in the same course as template. RealNetworks family is used to develop media modules/courses. In this family, RealSytem IQ [8] supports fifty media types including MPEG-4. The addition of Envivio MPEG-4 plug-in to the Server and client side will enable the support of the MPEG-4 technology. Moreover, RealNetworks use SMIL XML based language in order to bundle and describe several content objects or media files in a media presentation. It groups the media objects sequentially or in parallel while synchronizing them in time and space. These media files include streaming audio/video content objects, static text, streaming text, static image, animation etc. Moreover, it specifies time events for start, stop, and duration of content objects. In addition, it defines navigational hyperlinks by using time-triggered events or user interaction triggered events. Finally, RealNetworks does not use MPEG-7 for media content description, but uses meta elements to describe presentation information such as author, title, abstract, and copyright. However, the developed clip/presentation has a proprietary format Real Audio and Real Video. Therefore the reusability is limited to

LMS integrating RealNetworks family. As for protocols, RealNetworks is based on RTSP that uses the RTP(Real Time Protocol) data packet format for delivery over the UDP. It also uses TCP control connection to send instructions and commands. RTP format is Internet dedicated and cannot be applied directly on other system like digital cable or DVD, whereas DMIF defined in the MPEG-4 covers a multitude of network environments.

- Learning resources and their flows: The library concept and its corresponding tagging is not supported within WebCT. Each module, lesson, Web page have to be duplicated in each course if needed. To overcome this problem, all needed modules, lessons etc. are stored outside the platform and a referenced from within the platform. Moreover, to provide the possibility to search a digital library for articles or books, a URL Link that points to the university digital library is added to the platform. WebCT lacks a powerful and professional search engine to the whole platform.
- The learning preferences flows collaboration: WebCT provides a set of low bandwidth synchronous and asynchronous communication tools that are accessible from the course interface. These tools are internal to the platform and cannot communicate with third party tools. They include E-mail, chat, discussion, and whiteboard. Microsoft Netmeeting was embedded into WebCT to allow audio/video synchronous communication among the learners.

CONCLUSION

In this paper, an improved WBT Model based on the Learning Technology Systems Architecture (LTSA) standard was presented. This model includes all "WBT Enhance Model" concepts and facilitates courseware interchange between LMS. This was achieved by standardizing the LTSA development process of portable courses and by T having a portable course structure, interoperable hierarchical course content, portable runtime environment, and interoperable Metadata. This model reduces the time and cost of development, increases the value of good and high quality content, and enhances e-commerce market. A scenario based on the LTSA content developer stakeholder perspective was presented. In this scenario WebCT was used as the E-learning platform, Realnetworks for the development, hosting, streaming, playing of multimedia courses that are integrated in WebCT. Moreover, Microsoft Netmeeting was integrated in WebCT to provide audio/video/sharing of application between the coach and learner, and among learners

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