WebELS: Enabling e-Learning in Higher Education over Low Bandwidth Environment

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Abstract: As information and communication technology (ICT) becomes more robust and widely used, there is an increasing number of higher educational institutions (HEI) adopting e-Learning system for delivering various educational programs. However, there is still an underlying challenges in the successful implementation of e-Learning approach in higher education, such as the lack of IT skills for most instructors, the complexity of e-Learning platforms, technical limitation of users' environment like the network bandwidth and computer hardware, among others. In this paper, we present the design and implementation of the Web-based e-Learning System (WebELS) for enabling the globalization of higher education in science and technology particularly in low bandwidth environment. The system supports asynchronous and synchronous e-Learning approaches, such as on-demand learning for self-learning, online meeting for multi-location group discussion and online lecture for real-time remote lecture distribution. The system has been designed to address the difficulty of creating and maintaining an e-learning course to non-IT users by providing an easy-to-use course authoring tool. Additionally, it supports archiving and dissemination of multimedia contents on the Internet by its contents management system. Usage in low bandwidth environment such as a dial-up line has been the design goal in order to reach a wider range of users especially in developing countries.

Keywords: Advanced learning technologies, e-Learning, distance learning, online learning, blended learning, online presentation, video meeting, virtual presentation

1. Introduction

As information and communications technology (ICT) becomes more robust and widely used, there is an increasing number of higher educational institutions (HEI) adopting e-Learning system for delivering various educational programs, such as continuous education, online academic lecture, online meeting and similar activities (Kim, et al., 2006). The enthusiasm to adopt e-Learning system in higher education is primarily to address the need of those individuals who have limited opportunities for traditional classroom-based education due to time and/or distance limitations. Nowadays, graduate students and company employees are compelled to gain advanced knowledge not only to be globally competitive as an individual but to contribute for the sustainable growth and development of a nation.

There are three basic e-Learning approaches - (1) Asynchronous e-Learning which is achieved by online self-learning at their own pace and time through course content available online, and may have supplemental activities such as discussion boards and e-mail, (2) Synchronous e-Learning which is achieved by real-time interaction between instructors and students and often facilitated by activities like video conferencing and chat, and (3) Hybrid e-Learning where the activities of both asynchronous and synchronous approaches are combined to improve the quality of online education. Synchronous e-Learning approach, as a complement to asynchronous approach, can positively affect personal participation from learners by inducing interest and motivation (Hrastinski, 2008). Nowadays, there are e-Learning technologies supporting each approach, but it is very rare to find an all-in-one technology that supports a hybrid e-Learning system.

Although ICT in education has been existing in the past few years, there is still an underlying challenges in its successful implementation (Carnoy, 2004). Stakeholders in the implementation of a Web-based e-Learning system must possess basic ICT skills. Some instructors are conservative on introducing e-Learning as some of them do not have the necessary IT skills, nor do they have the specific trainings needed to be able to use specific e-Learning system. Moreover, some systems have complex method of creating and updating an e-Learning course demanding time and effort, and usually requires an instructional designer with a professional IT skills. Because of this, there is scarcity of educational content in the higher education in science and technology, coupled with issues on security and exclusivity of educational resources.

Another challenge in the implementation of an e-Learning system is the technical limitations, i.e., network bandwidth and computer hardware. As most of the online courses integrates various materials such as text, images, audio and video, some students might not have the network access and computer hardware capable enough to support multimedia content. In the case of an online lecture or meeting, video conferencing requires high-bandwidth network for providing better output quality. Thus, the usability of an e-Learning system in low bandwidth environment is limited in this situation.

In this paper, we present the design and implementation of the Web-based e-Learning System (WebELS) for enabling the globalization of higher education in science and technology particularly in low bandwidth environment. Through continuous development, the new system supports a variety of asynchronous and synchronous e-Learning activities, such as on-demand learning for self-learning, online meeting for multi-location group discussion and online lecture for real-time remote lecture distribution. The system has been designed to address the difficulty of creating and maintaining an e-learning course to non-IT user by providing an easy-to-use course authoring tool that can integrate various media such as slide presentation, image, audio, and video data. It has user management system where users are classified hierarchically as admin, faculty, staff, and students, with the function to assign user to several viewer groups. It also has course management system for allowing instructors to assign permission to courses visible only to specific viewer groups. Additionally, it supports archiving and dissemination of multimedia contents on the Internet by its contents management system. Usage in low bandwidth environment such as a dial-up line has been the design goal in order to reach a wider range of users especially in developing countries such as in Asia and Africa.

2. System Design

WebELS is designed to meet the requirements mainly for supporting global higher education as a content management e-Learning system (CMS) (Ueno, et al., 2011). It is an all-in-one e-Learning system supporting synchronous and asynchronous approaches implemented in two separate modules, i.e., WebELS Learning for online self-learning, and WebELS Meeting for online meeting and lecture.

WebELS is a client-server system functioning on a Linux OS on the server-side, and Java and Flash applications for the client user interfaces for achieving a multiple OS system to be used in Windows, Mac OS and Linux. Every user can use the system over the Internet using any popular browser, such as Internet Explorer, Google Chrome, Mozilla Firefox and Safari.

2.1 Asynchronous e-Learning Approach

WebELS Learning system is designed to support flexibility and globalization of higher education in science and technology in asynchronous mode. Lecturers can use the system to create and maintain contents to be distributed online. Learners can browse the content list and start to learn using the content by themselves. The system provides all necessary tools during e-Learning process. Tools like content authoring, content management, user management, course management, on-demand viewer and offline viewer are included in the system.

Currently, WebELS Learning system supports authoring for video-based Flash media content. WebELS content is slide-based, which make it easier to edit after it has been created. Each slide in the

presentation document (.pdf, .ppt,.pptx, .doc, .docx, .odp) are converted series of slide images (.jpg). Using the Flash-based authoring tool, slide images and raw video recorded from the presentation or lecture are made to synchronize to create a video-based content as shown in Figure 1. In many universities and institutes, undoubtedly, there are numerous slide presentations and recorded videos aiming to be reused but are just left unpublished because there is no system that can easily manage its online distribution. The learning system technology provided by WebELS can help these valuable information be distributed online.

Audio-based content are usually preferred in low-bandwidth environment than the video-based content. In the current version, Java-based content is still available since it supports voice recording per slide to create an audio-based content. However, WebELS Flash-based content have adaptive video streaming qualities, such as high, medium and low-quality, thus it would still be useable even in low bandwidth environment.
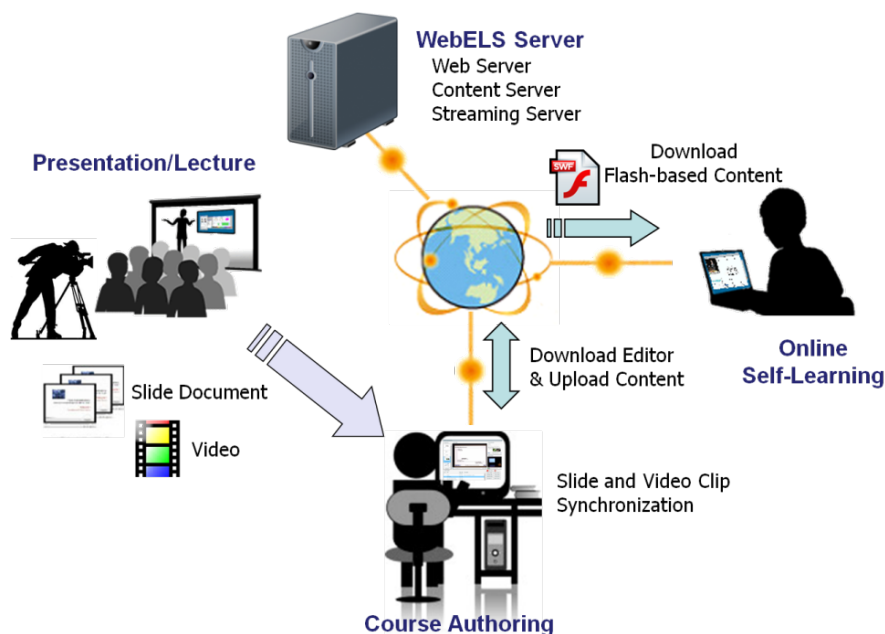

Figure 1. WebELS Learning System and the Video-based Content Authoring

2.2 Synchronous e-Learning Approach

WebELS Meeting system shown in Figure 2 supports synchronous e-Learning approach. There are three servers in the server side, i.e., database server, content server and streaming server. Database and content server are used for content and user data management, while streaming server is used for real-time audio-video communication. The system provides necessary tools for administering users and online meetings. Furthermore, the system supports easy content authoring, online slide presentation, online annotation, chat messaging and video conferencing.

The video meeting system is based on client-server architecture, in contrast with the peer-to-peer architecture utilized by a number of similar systems. With client-server architecture, more than two users can join the video meeting at the same time. The video meeting panel is designed to be independent from the presentation panel, thereby participants logged-in on the video meeting can still open a different presentation content, while keeping the video meeting connection. There can be only one meeting administrator at one time. Administrator can assign presenter, mute all listeners, kick out a user, and manage the viewing focus to the presenter.
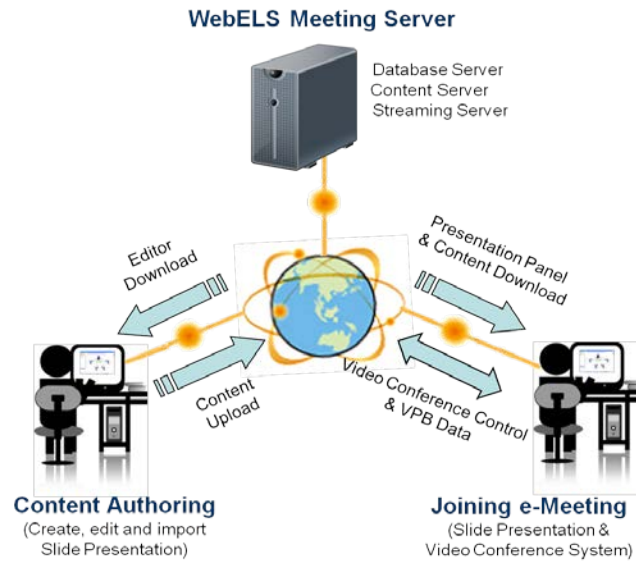
Figure 2. WebELS Meeting System

3. System Implementation

3.1 WebELS Learning System

Figure 3a shows the user interface of the authoring tool. It is divided into six panels, namely (1) Slide Navigator Panel for showing all slide pages and for quick slide changing, (2) Raw Video Panel for displaying raw video stream, (3) Slide Preview Panel for previewing a selected slide, (4) Aggregated Video Preview Panel for displaying an aggregated video which is synchronized to a selected slide, (5) Content Information Panel for showing all details of synchronization slides, and (6) Editing Control Panel for managing learning content. Editing Control Panel contains buttons for video and slide start/stop synchronization, remove synchronized video, add blank slide, remove slide, pointer movement management and slide information editor. Synchronization mechanism is based on video key-marking concept where start and stop times are utilized to trigger slide change automatically at playback. Slide and video synchronization is easily done using this tool without any third-party software.

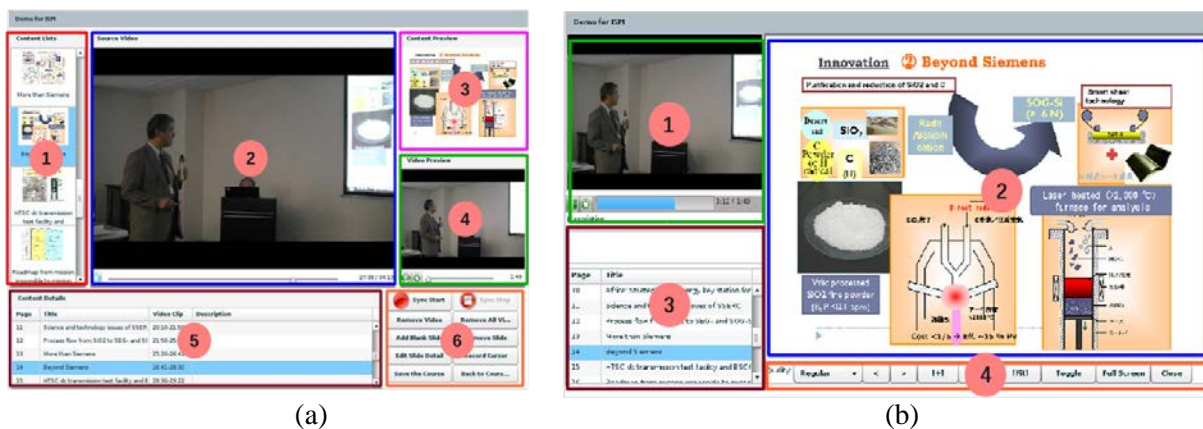(a)   (b)

Figure 3. (a) Authoring Tool and (b) Viewing Tool

Figure 3b shows the user interface of the viewing tool. The interface consists of four panels, namely (1) Aggregated Video Panel for displaying the aggregated video of a current slide, (2) Slide Panel for displaying the current slide, (3) Content Information Panel for showing slide information, and (4) Control Panel for controlling online learning content. Control panel contains quality control, zoom control, toggle view control and full screen mode. Video and slide panels can be toggled to display in

the main panel. Both can also be zoomed-in to examine more closely or in greater detail. The pointer mark displays and follows the movement while the video is playing. For low bandwidth environment, users can select an appropriate video quality for smooth viewing. Progressive downloading and buffering mechanisms are implemented to further support usage in low bandwidth environment (Chunwijitra, et al., 2013).

3.2 WebELS Meeting System

Figure 4 shows the user interface for online meeting consisting of video meeting and online presentation where participants convene via the Internet in real-time. The Flash-based video meeting interface consists of (1) Video Conferencing Panel for audio-video communication system and (2) Chat Messaging Panel for text based real-time communication. While the Java-based online presentation interface consists of (1) Whiteboard Panel for online slide presentation and (2) Control Panel for slide control and other supported functions.
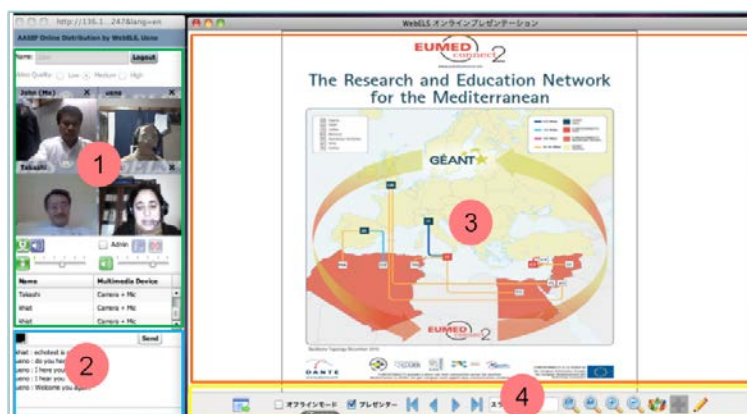
Figure 4. An example of online meeting using WebELS Meeting System consisting of a video meeting and an online presentation user interfaces
(Participants: 2 from Japan, 1 from Algeria, and 1 from United Kingdom)

The video conference and chat messaging systems use Real Time Messaging Protocol (RTMP). RTMP is a protocol used for streaming audio, video and data over the Internet between Flash player on client side and streaming server. Parameters for audio-video quality have been optimized in order for the system to adapt the users' network environment without suffering from a bad audio-video quality. These parameters include video resolution, video frame rate, video encoding quality, and audio sampling rate are used to provide three video quality settings such as low, medium and high, which can be selected in manual or automatic mode.

Online slide presentation is a technique wherein the presentation panel of one user is mirrored to one or more users by means of a shared virtual presentation board (VPB) data stored at the server. The presenter of the online presentation updates the VPB at the server every time there is a new slide event by sending the data onto the server. While listeners poll the server every one second in order to retrieve the updated VPB and synchronize their slide presentation. The VPB data used to attain slide synchronization is in the order of 10kbytes, thus data transfer delay is negligible. Online presentation features synchronized slide control between the presenter and the listeners for slide changing, scrolling, zooming, cursor positioning, and playback control for video embedded on the slide. It also features online annotation that allows the presenter to write using a pen function on the slide display panel (Berena, et al., 2013).

4. Evaluation and Discussion

We used an online questionnaire in conducting the user acceptance evaluation for the system. The questionnaire has 18 questions divided into three main sections - 8 questions on the authoring function, 6 questions on the viewing function, and 4 questions on the overall system. Each section provides questions that measures the user acceptance of the proposed tool based on the three factors, namely, (1) Usefulness,

(2) Ease-of-use, and (3) User satisfaction. We use the Likert scale to measure the responses from the respondents. Five ordered response levels are used, such as (1) Strongly disagree, (2) Disagree, (3) Neither agree nor disagree, (4) Agree and (5) Strongly agree, and have corresponding scores as 1, 2, 3, 4 and 5, respectively.

We sent out invitation to a group of prospective respondents via email indicating the purpose of the survey, user guide of the system, and the link to the online questionnaire. These prospective respondents consist of IT users who are familiar with computer technologies, and also non-IT users who can use the computer and Internet technologies with little assistance. A total of 73 respondents consisting of 9 instructors and 64 students in the higher education completely answered the questionnaire after using the authoring tool and learning content in actual situations.

The results of the survey shows that most respondents responded "Agree" to the usefulness, ease-of-use, and user satisfaction of the authoring function, viewing function, and the overall system. The results further show that the proposed authoring and viewing tools have higher user acceptance as a proposed tool for e-Learning.

6. Summary

This paper presented the design and implementation of Web-based e-Learning System (WebELS) for the flexibility and globalization of higher education in science and technology particularly in low bandwidth environment. WebELS supports asynchronous and synchronous e-Learning activities, such as online self-learning, online group meeting discussion, and online lecture. Through the years of development, WebELS continue to address the underlying challenges in the implementation of e-Learning in higher education. Currently, WebELS Learning system implements a Flash-based easy-to-use authoring and viewing tools. Usage in the low-bandwidth environment have been the designed goals, thus an adaptive video quality for video-based contents were implemented. For WebELS Meeting, online presentation combined with video meeting creates a virtual room for e-Meeting where participants convene via the Internet in real-time. Parameters for video streaming have been optimized to allow more users who can join the meeting.

Acknowledgements

References

Berena, A.J., Chunwijitra, S., Okada, H., & Ueno, H. (2013). Shared Virtual Presentation Board for e-Meeting in Higher Education on the WebELS Platform. Human-centric Computing and Information Sciences. SpringerOpen Journal. Vol.3, No.6. DOI 10.1186/2192-1962-3-6.

Carnoy, M. (2004). ICT in Education: Possibilities and Challenges. In: Inaugural Lecture of the UOC 2004-2005.
<http://www.uoc.edu/inaugural04/dt/eng/carnoy1004.pdf>

Chunwijitra, S., Berena, A.J., Okada, H., & Ueno, H. (2013). Advanced Content Authoring and Viewing Tools Using Aggregated Video and Slide Synchronization by Key Marking for Web-Based e-Learning System in Higher Education. IEICE Transaction on Information and Systems. (To be published.)

Hrastinski, S. (2008). The Potential of Synchronous Communication to Enhance Participation in Online Discussions: A Case Study of Two e-Learning Courses. Information & Management. Elsevier Publishing. Vol.45, No.7, pp.499-506.

Kim, K. J., & Bonk, C. J. (2006). The Future of Online Teaching and Learning in Higher Education: The Survey Says... Educause Quarterly, Vol.29, No.4.pp.22-30. Nov. 2006

Ueno, H., He, Z., Sriprasetsuk, P., & Berena, A. (2011). WebELS: Content-Centered General Purpose e-Learning Platform for Higher Education in Science and Technology for Low Speed Internet. In Claudia F.

MacTeer (Ed.). Distance Learning (33-66). Nova Science Publishers. ISBN: 1617288586 & 978-1617288586.