An Advanced Cloud-Based e-Learning Platform for Higher Education for Low Speed Internet

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PHILOSOPHY

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2013 (School Year)
September 2013

A dissertation submitted to the Department of Informatics,
School of Multidisciplinary Sciences,
The Graduate University for Advanced Studies (SOKENDAI)
in partial fulfillment of the requirements for
the degree of Doctor of Philosophy.

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Summary

The social demand for internationalized educational program is continuously increasing. The role of universities is therefore to change the learning environment to e-Communication approach because the traditional classroom-based education cannot respond to this kind of on-demand distant learning and social demands. Moreover, video-based content format is increasing since it has more attractive visualization than former formats. In fact, streaming video can offer very exciting opportunities for online teaching and learning. Not only the video-based content is required to support the new learning environment, but also e-Meeting technology for real time online lecture and meeting. Currently, several e-Learning systems have been established to support academic institutions in rural areas. Likewise, many collaborative projects have the target to increase the number of e-Learning contents based on video materials, and to be shared within the collaborative developing countries. However, it is hard to use video materials for the e-Learning contents, and provide the video meeting system among members, since the Internet infrastructure in these countries is not good enough for applications requiring high-speed network. This dissertation provides two main contributions based on the WebELS system to solve the limitations of existing authoring tools for video-based learning content, and to support the social demand for internationalized educational program and suitable online meeting management requirements in the business sector.

This dissertation consists of seven chapters briefly described as follows:

Chapter 1 presents the background and current technologies of e-Learning platforms. The recent progress of information and communications technology (ICT) and information of society has made Internet-based communication become a popular approach and widely used methodology on delivering various educational programs and organizational business situations. Graduate students and company employees are continuously in need to learn more advanced knowledge, but often-

times have limited opportunities due to time, location, and cost limitations. To support self-learning on higher education, a Virtual Learning Environment (VLE) is considered. Moreover, the trend of video-based learning content is increasing since it can increase the students' intention to learn with the attractive content. Furthermore, cloud computing system, being a popular technology, is considered to serve the server side services because it can be implemented in a wide variety of architectures and technologies. It can also minimize IT investment costs for the education and business sectors. The implementation of a cloud computing to e-Learning system has its peculiarities and therefore needs a specific approach for the developing countries where the Internet condition is not good enough.

Chapter 2 presents the review of related studies and technologies. The background information, recent progression, and approaches of e-Learning and e-Meeting technologies are summarized. E-Learning system can be integrated with a physical learning environment which may be referred to as blended learning. It can take place synchronously or asynchronously. The author summarizes the important components common to e-Learning systems in the point of view of its functionalities. The system consists of five main components such as course management for managing the course programs, content management for managing the learning content, user management for managing users and assigning user permission, communication management to managing communication resources and administrator tool for the administrator to manage the e-Learning system.

Chapter 3 describes the overview of the WebELS system. The proposed concept, overall architecture design, system structure, and system functionality are described. WebELS is an Internet-based content management system for distance self-learning designed to support higher education in engineering and science. It usefully supports online learning, via the Internet, using the slide-based content. It can also support off-line mode learning by downloading the content and play at a stand-alone computer. The system provides an easy authoring tool for creating their learning materials. In addition, the WebELS system is adapted to implement on cloud computing technology as software as a service (SaaS) concept to increase efficiency and performance of the system. The system is also optimized to support cross-platform to break the limitation of various usages.

Chapter 4 introduces the design concept of the proposed video-based authoring tool for the e-Learning system. The proposed architecture, techniques, and data structure are explained. The author proposes an aggregated video by key marking

method for synchronizing raw video stream and presentation slides. Virtual video clips that relate to each slide are produced from key markings, and are encapsulated into aggregated video stream. The virtual video clips in an aggregated video stream are used to synchronize to the slide presentation for creating learning content. The aggregated video also becomes the baseline for the viewing function. A meta-data file is proposed and applied to retain the content definitions, such as content title, description, references, etc. The benefit of using meta-data file is that it is a simple text file. It is small and fast to transfer between client and server. A template is utilized to keep the temporary synchronization data. Several data are contained in the content template, such as video index, key mark values, slide index, and pointer actions. Thus, the learning content package can be a container of learning content. It includes meta-data, presentation slides, video stream, and synchronization data. Furthermore, video and pointer synchronization are also proposed for enhancing the students learning efficiency.

Chapter 5 shows the implementation of the proposed video-based authoring and viewing tools. The system framework, system design and system architecture are described. Functionalities of the system are also presented. The authoring function is used for creating video-based content by the instructor, and the viewing function is for self-learning by students. In the authoring function, the tool can help an instructor to create a new content by automatically generating key markings onto the raw video stream to produce virtual video clips related to each slide. Based on aggregated video stream methodology, it is convenient to create a new content. Some parts of the raw video stream can be easily skipped. It is also easy to edit a created content since content editing requires only the changing of key markings without editing the raw video file. The synchronized content can be previewed immediately at the client computer prior to saving at the server. In viewing function, video quality control and an adaptive video buffering method are implemented to support usage in various network environments.

Chapter 6 focuses on the online video meeting improvement. The author presents a new simple group-based concept for managing users of the system with easier management. The author proposes a meeting management system for controlling member groups and contents in the WebELS Meeting system to meet suitable meeting controls at a reasonable cost in business situations. The system is divided into two parts - the system management and the conference streaming management. The main concept of the system is group-based management of

members and contents. Each group holds two password types - manager password and guest password. The group manager can manage the contents on their group. The system can limit the number of content and concurrent access in each group. Moreover, the system can control the behavior of logging-in members. In addition, the author also presents a quality improvement for video meeting while operating the meeting in the unstable network environment. The author proposes the video meeting automatic re-connection for boosting up the performance of web-based online conference system to be used in the unreliable network environment.

Chapter 7 presents the experimental results of the system. There are two issues that need to be evaluated based on the system framework of the proposed video-based authoring tool, i.e., the system performance on the server side and the client user acceptance of the total system. On the system performance evaluation, the author makes a comparison for the conversion times of the source files and video buffering during playback for each quality condition as this would influence the user acceptance. In the user acceptance evaluation, the author conducts a survey to determine the user acceptance of the system by sending out survey questionnaires to users of the system from four different countries. Most respondents agree with the usefulness, ease-of-use, and user satisfaction of the proposed system. Finally, the overall results show that the proposed authoring and viewing tools have higher user acceptance as a tool for e-Learning. The proposed method can provide easy authoring processes with clear user interface design for instructors, and help students utilize learning contents effectively and efficiently. Regarding to video meeting enhancement, this improved system can help the administrator for managing and controlling the member groups and contents in the meeting system. Furthermore, the proposed solution helps the participants who use the unreliable network by preserving the quality of online conference operation for the best distant meeting.

Chapter 8 concludes the dissertation. This dissertation describes a combination of e-Learning and e-Meeting functions approaches of a new e-Communication to be a flexible instrument for higher education activities. A new online authoring tool for e-Learning system using Flash technology is implemented. The proposed system can be used to support advanced knowledge by self-learning. It is considered to support the classroom-based learning due to the increasing social demand in international scale, and to reduce the limitation of classroom-based traditional learning due to time, location, and cost limitations. Moreover, the author proposes

the suitable meeting management tool for the WebELS Meeting module to meet the requirements of the business sector. The main function of the management tool is to be utilized for controlling user members and contents using simple group-based control concept. The author also implements network connection handler for the online meeting system when used in the unreliable network environment. The proposed system is achieved and optimized to work under the cloud computing technology since it is implemented in a wide variety of architectures, services, models, and other technologies.

Acknowledgments

I would like to thank many people for their support, encouragement and guidance during my years as a graduate student at SOKENDAI/NII.

First and foremost, this dissertation represents a great deal of effort not only by myself, but also my chief advisor and advisor, **Assoc. Prof. Hitoshi Okada** and **Assoc. Prof. Tetsuro Kobayashi**. They have helped me shape my research from the beginning, guided and pushed me to get through all the inevitable research setbacks. I also thank the committee members, **Prof. Haruki Ueno**, **Assoc.Prof. Isao Echizen** and **Prof. Hirotsugu Kinoshita**, and other professors at NII for valuable discussions and comments regarding my research.

This research is indeed a group effort. I deeply thank **Prof. Haruki Ueno** (again) who accepted me to join the WebELS project, wherein I made WebELS as a base platform of my research. I am grateful to **Dr. Arjulie John Berena** for his valuable advice and support for making my research possible. I also thank to **Mohamed Osamnia** for the help, and valuable and fruitful discussions in the WebELS project group meetings. I would like to express sincere thanks to all persons who supported the WebELS project, especially to **Dr. Pao Sriprasertsuk** for his contributions in designing and implementing the video meeting function for the WebELS system. Moreover, my life at NII would not have been smooth without great support from many NII staffs. I thank all of them, especially to **Naonori Kato** and **Atsuko Kumon**.

Most of all, I would like to thank my family who have always been and continue to be there for me all the time.

September 2013

Sila Chunwijitra

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Chapter 1

Introduction

1.1 Background and Current Technologies

The recent progress of information and communications technology (ICT) and information of society has made Internet-based communications become a popular approach and widely used methodology for delivering various educational programs and organizational business situations, such as continuous education, online academic lecture, distant private trainings in companies, and other similar cases. Graduate students and company employees are continuously in need to learn more advanced knowledge, but oftentimes have limited opportunities due to time, location, and cost limitations involved in traditional learning. Distance education by means of a Virtual Learning Environment (VLE) is strongly requested to solve these problems [1], [2], [3], [4], [5].

Internet-based e-Learning and online video meeting systems are timely and suitable technologies to be used to encourage VLE's activities. A variety of benefits from collaborative technologies can boost up the learning curve of learners. E-Learning systems can be easily achieved because of the advancement in internetworking, multimedia and software technologies at a lower cost but higher quality in a global scale [6], [7], [8], [9]. Such systems can help in organizing a meeting comfortably via the Internet. This highly-technological innovation is used to link multiple users to join from any place to meet in a virtual environment. It also bring changes in the business communication by reducing the operational administrative costs and can make business competition stronger [10], [11], [12], [13].

Several video meeting systems and products are widely available with proprietary license. Some well-known online conference systems are Skype [14], Poly-

com [15], Cisco WebEx meeting [16], and Microsoft Live meeting, [17]. Each system has different features and infrastructures. Most products have been integrated with useful services for supporting online meeting , such as chat messaging, file sharing and so on. On the other hand, there are some open-source web-based conference systems which can also be used for real-time meeting, for instance, OpenMeetings [18], and BigBlueButton [19]. In addition, almost products and systems have some limitations such that they require high bandwidth network for providing better output quality in online meeting operations, and also require intricate proxy or firewall setting to access the system. Consequently, the usability conditions of the systems are limited.

Several issues were discussed and considered in the business point of view [10], [11], [20], [21], [22], [23]. For business communication, security and privacy of meeting contents and user information are very important issues. Most open source web-based conference systems do not meet the necessary requirements in business meeting situations. Some strong requirements to make an online video conference product credible and suitable for business companies are examined, e.g., management functions, security issues, and privacy of content. Moreover, the system should automatically connect the video meeting when disconnected from the network. Several video conference systems do not have the function for managing this situation. Participants who lost the network connection manually re-connect the system by themselves. It makes the usage uncomfortable for the meeting participants. Furthermore, online meeting system should have an easy-to-use user interface and configuration that meets the technical abilities of non-IT users.

In response to the issues presented above, a web-based e-Learning system or known as WebELS is proposed to support flexibility for higher education especially in Ph.D education [24], [25], [26]. The system has been distributed based on open source software (OSS) policy. The system includes two main subsystems which are Learning and Meeting systems. In the Learning system, it provides an easy authoring tool to manage the learning contents based on Java technology for cross-platform support. This tool is suitable for slide-based content including audio and cursor synchronization, but it has some limitation for online video-based contents. WebELS Meeting integrates several functions for supporting online meeting activities. The benefit of this system is that it overcomes the network environment that defines strict firewall policy. However, the system lacks functionalities for supporting the business sector requirements [27].

1.2 Characteristics of Higher Education

The social demand for internationalized educational program is continuously increasing. Hence, the role of universities is to change the direction of the learning environment from the traditional classroom-based method into Internet-based learning. To this end, higher educational institutions are expected to spearhead that change direction with distant learning, distant meeting, or distant lecture technologies. Higher education that includes master degree and doctoral degree have various activities and are different from the undergraduate education [4], [24], [28]. Some characteristics are as follows:

- Graduate students are responsible persons who can learn by themselves and can also utilize many materials to support their learning and research activities.
- Regular activities in graduate programs are self-learning, group meeting, teacher-student discussion and academic presentations.
- Major activities are joining research meetings and presentation of academic research articles at international conferences
- Using online content is becoming a trend for obtaining knowledge due to the vast availability of information and content from the Internet. It is considered to support the classroom-based learning due to the increasing of social demand in international communication scale.

Moreover, the policy and target of higher educational program is changing. In a literature review on Understanding the Regional Contribution of Higher Education Institutions [29], they described the characteristics of higher education on the policy contexts, such as innovation systems, lifelong learning processes and contents, collaboration and education partners, and regional governance. The author summarized some policy contexts that is related to the learning activities as follows:

- The rise of the modern university, science and technology : Higher education is now expected to take the lead and to rearrange the structures. Entrepreneurship, technology interchanges and interactive learning can be facilitated and involve the core functions, such as knowledge, freedom of learning and teaching, etc.

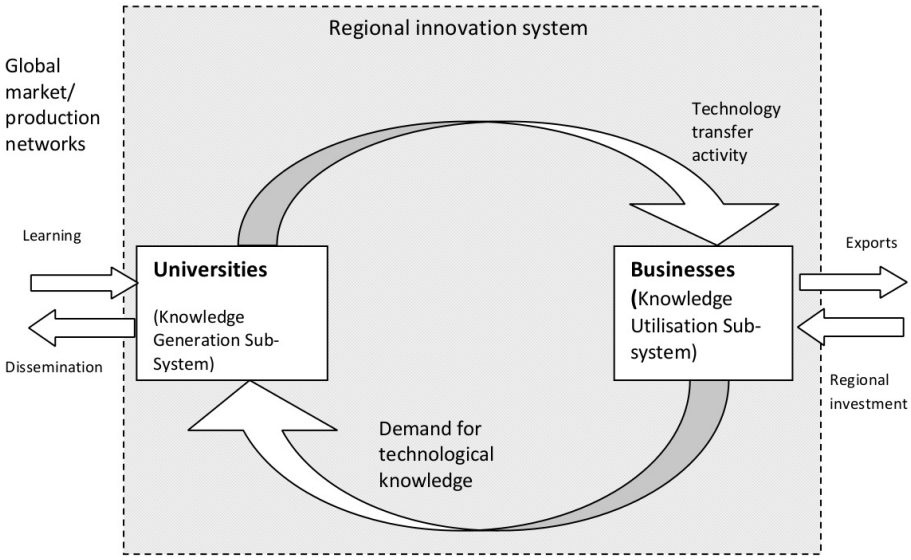


Figure 1.1: The regional innovation system as a local circulation between globally-connected regional innovators

- Knowledge-oriented and Industry-oriented modernizations : A source of innovation and realignment is focused. The intention was to encourage the utilization of research by permitting universities and small businesses to elect ownership of inventions. They become directly involved in the commercialization process. The relationship between the two externally oriented regional partners, are shown in Figure 1.1 [1].

- Systems of innovation and new trends : Globalization is a metaphor that suggests that the world is shrinking. Cross-border connections are being intensified at all levels. This development is being driven by new information and communication technologies, cheaper transport, etc. Important directors also include the inter-communication, which have exploited the new possibilities of managing and coordinating global operations.

- Universities and sustainable development : There is a great potential for higher education sector to play a role in achieving a sustainable development in the knowledge economy because of the rise of the trans-disciplinary, practice-based knowledge generation. Universities offer the chance for an interplay between institutional management and infrastructure development,

[1] Original source owned by Ref. [29]

active research into the technologies and techniques of sustainable development, and the provision of community leadership and support.

In addition, students today are often referred to as 21st Century learners, primarily because of the ubiquitous access they have to technology. What sets them apart from other generations is the way they process information and choose to participate in the educational experience. Dr. Sarah Elaine Eaton, an educational leader, researcher, author and professional speaker, has identified 21 Characteristics of 21st Century Learners [30]. Some interesting characteristics are considered as follows:

- Often have higher levels of digital literacy than their parents or teachers. They do not know a world without computers.
- Demand the freedom to show their wild creativity. 21st century learners balk at rote learning and memorizing. They will do it if you make them, but be prepared to let them loose to be creative, too.
- Want to connect with others in real time on their own terms. They want their social media, their phones and their mobile technology. They want to be connected. All the time. In a way that makes sense to them.
- Expect inter-disciplinarity. It is we, the older generation, who organize topics into "subjects". The 21st century learner understands that subjects are inherently interconnected.

Some educators seek out the ideals of a 21st century learning environment constantly, while others prefer that they lose the phase altogether, insisting that learning has not changed, and good learning looks the same whether it is the 12th or 21st century. In this view, TeachThought developed 9 Characteristics Of 21st Century Learning that considers the potential of social media platforms against its apparent divergence from academic learning [31]. The characteristics are shown in Figure 1.2 [2]. Higher education and life-long human resource development are urgent issues to support the sustainable development of a global society. However, the traditional style of face-to-face education is not able to meet the demands of the society because of the limitations in location, time and cost. An Internet-based e-Learning system should be utilized to support education activities according to the social requirements.

[2] Original source owned by Ref. [31]

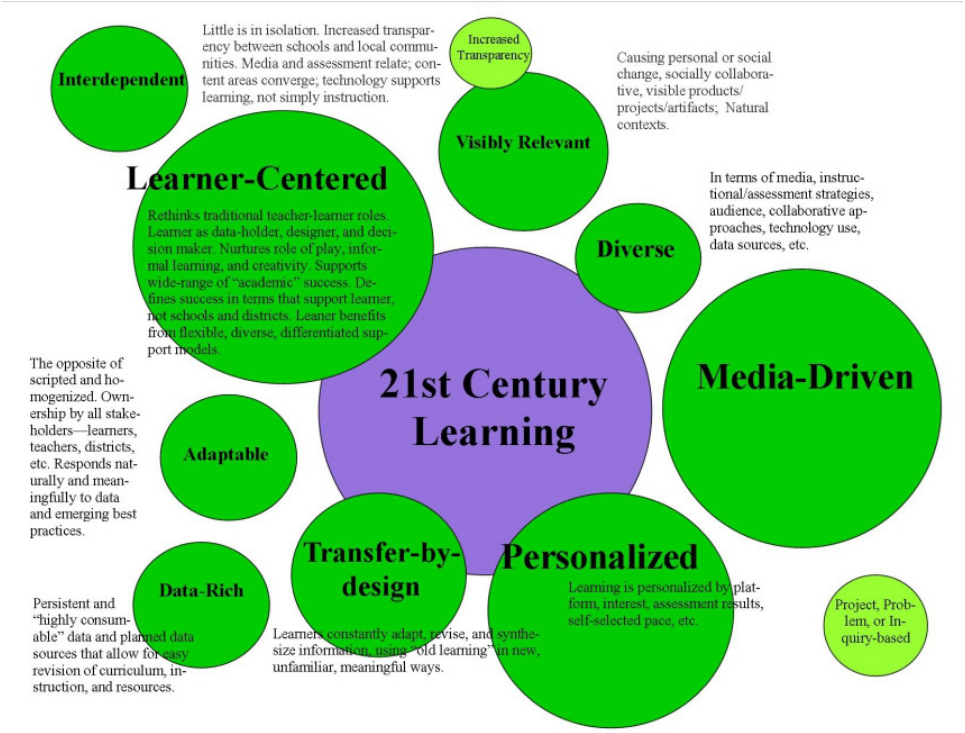


Figure 1.2: 9 Characteristics of 21st century learning

1.3 Trend of Video-based Learning Content

In recent years, methodology of e-Learning services are still moving to the next platform. The typical model of education of 20th century classrooms is becoming unfashionable. The "knowledge society" requires new thinking about what constitutes effective and engaging teaching and learning in different contexts [32], [33], [34]. Learning infrastructures are changing to support new technologies, such as in the case of audio-based contents that is decreasing in popularity, and are being replaced by video-based contents. Streaming video can offer exciting opportunities for online teaching and learning. This form of technology brings courses alive by allowing online learners to use their visual and auditory senses to learn new concepts. Video streaming allows online instructors the opportunity to deliver alternative course materials to students who use e-Learning system. Traditional classroom-based education cannot answer to this kind of social demands.

Focusing on the educational section, the use of videos for teacher learning has long been discussed. Video-based content is growing since it consists of various multimedia types such as image, audio, animation and teacher actions. Teachers can use it to share vivid images of teaching and learning practices in classroom

[35], [36], [37], [38]. These data are more attractive than general slide presentation. Moreover, video recording devices nowadays are more useful while the prices are becoming cheaper. Nowadays, 21st century students are visually sophisticated and accustomed to digital media. Wide access to personal learning devices gives students and teachers greater control over access to content and collaborations. As personal acceptance grows, access to digital media content becomes a classroom expectation.

Corresponding to the research for teaching and learning characteristics in 21st century [39], they proposed a framework for 21st century learning as shown in Figure 1.3 [3]. This framework presents a holistic view of 21st century teaching and learning that combines a discrete focus on 21st century student outcomes with innovative support systems to help students master the multi-dimensional abilities required of them in the 21st century. The figure represents both the 21st century skills student outcomes and the 21st century skills support systems. In their framework, learning environment factor is included. This factor proposed for communicating and collaborating among teachers, students, and any skills. They defined resources to support this factor, for instance, utilize multiple media and technologies, communicate effectively in diverse environments, assume shared responsibility for collaborative work, and value the individual contributions made by each team member, etc.

Hence, the power of video-based approach to teaching and learning is its potential to increase intellectual engagement and foster deep understanding through the development of a hands-on, minds-on and "research-based disposition" towards teaching and learning. It provides opportunities for both teachers and students to collaboratively build, test and reflect on their learning.

1.4 e-Communication and Social Demand

Educational environments are changing quickly as the generation of students grows up with applications, such as Twitter and Facebook, and technologies, such as smartphones, tablets, and other devices. Although schools have been broadly adopting laptop computing and wireless technology for the past decade, students increasingly, and perhaps unwittingly, are accelerating change in teaching and learning. New social media applications and a proliferation of new devices must

[3] Original source owned by Ref. [39]

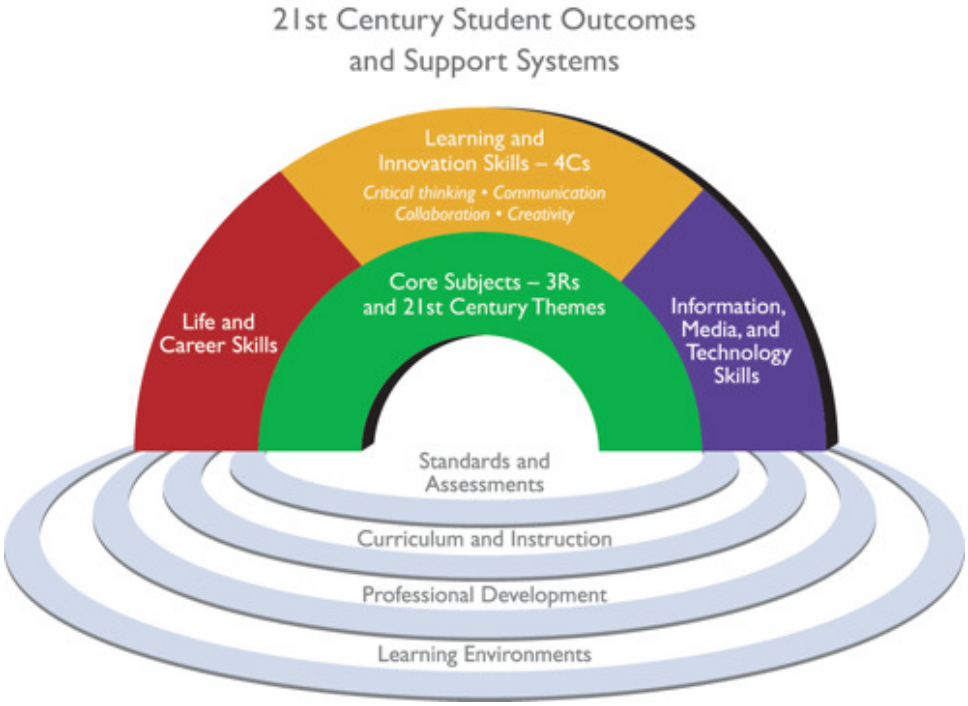


Figure 1.3: Framework for 21st century learning

be integrated into teaching to engage students. In a 2008 article, Rosen and Nelson describe a generation of students "who are comfortable with and enthusiastic about using collaborative technologies to participate in the World Wide Web as creators rather than consumers. These students gravitate toward group activity, seeking interaction within thriving online communities of generative individuals" [40]. In addition to enabling content creation, collaborative technologies, such as video, extend reach beyond the classroom walls. Interactive video can support new learning and teaching experiences across cities, states, and even countries. The competition challenges students to design, deliver and share live interactive content programs for peers and younger students. The contest takes students out of their classrooms and around the world, using Tele-presence technology to share their lessons, teach living history and gain proficiency in 21st century skills [41].

There is a growing trend towards student-teacher collaboration using live video conferencing and tele-presence technologies. The next wave of videoconferencing adoption is expected to consist of increased student collaborative projects and student creation and delivery of content, which will include a shift to desktop video conferencing and other collaborative technologies over time. This growth has been fueled by the obvious benefit of personal, face-to-face communications

that increases student and teacher participation. In addition, these technologies reduce travel costs and allow districts to spread scarce resources among many students. The growing trend toward video seems to substantiate teachers' beliefs that technology devices and web-based systems help them engage students in learning and enable them to do their jobs better. Schools and administrators can also use video technologies for building professional development programs. Teachers often join online professional communities to collaborate and share resources with other teachers and take advantage of professional development opportunities [42], [43], [44].

1.5 e-Communication and Narrow-Band Internet Issue

Recently, several e-Learning systems have been initiated to support these academic institutions in rural areas [45], [46]. Likewise, many collaborative projects have the aim to increase the number of e-Learning contents. For example, Sahara Solar Breeder (SSB) Project aimed to establish video-based learning contents to be shared between Japan and Algeria [47]; UNESCO Collaboration Project has proposed to create new e-Learning contents based on video materials and to be shared within the collaborative countries including Japan, China, Thailand and Algeria [48].

Aside from the lack of e-Learning contents in these collaborative countries, the network infrastructure in these countries is not good enough for applications requiring high-speed bandwidth. Hence, it is hard to use the video materials for e-Learning contents between Algeria and outside the region. Furthermore, several users' technological requirements were raised, such as (1) convenient and quick to create and edit contents, (2) able to save editing stages and able to continue editing in the last saved editing stage, (3) employ existing raw video files to be re-used as new learning contents in suitable method, and (4) able to use applications without software installation. There are some research that describes the experimental evaluation of a cooperative distance learning method on the narrow-band Internet [49]. They tried to gain improvement in the study effect with higher cooperative attitude via the narrow-band environment. The trial have been simulated installation of the environment within the campus assuming a trial of cooperative distance learning in overseas desert circumference area environment.

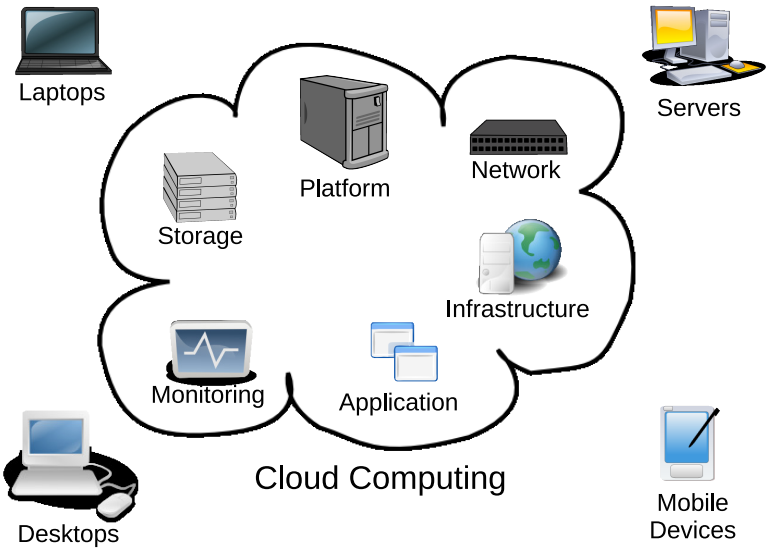


Figure 1.4: Cloud computing logical diagram

The suitable use of advanced ICT in education is needed to meet the social demands especially in developing countries where high-quality Internet service is not available and the prevalent lack of educational resources. It is well recognized that in the future, developing countries would play a key role in sustainable development more than before where opportunities of higher education were limited. To utilize e-Learning and e-Meeting systems for higher education efficiently, high quality services must be able to provide advanced educational environments for those who need educational opportunities in developing countries, but also in advanced countries at a lower electrical energy. Energy saving in communication is one of the issues in global society because huge networking and database facilities are needed to keep the ICT-based society. Technologies achieving high quality in a low speed Internet must also meet energy savings as well.

1.6 Cloud Computing Technology

The Internet and network technologies are now transforming to the next generation. The development of these technologies are fast and rapidly evolving for an advanced utilization to support usage in everyday life. There are many modules, services and technologies which are dependent on the functionalities and several factors to sustain any Internet activities. Cloud computing system, being a popular technology at the present, is used entirely for the server side services.

Cloud computing is all the rage. The problem is that everyone seems to have a different definition [50], [51], [52]. In this dissertation, cloud computing is a technology that uses the Internet and central remote servers to maintain data and applications. This technology allows much more efficient computing by centralizing data storage, processing and bandwidth. It also allows consumers and businesses to use applications without installation and access to their personal files at any computer. Cloud computing technologies can be implemented in a wide variety of architectures, under different service and deployment models, and can co-exist with other technologies and software design approaches. Figure 1.4 shows the cloud computing logical diagram.

There many features that make cloud computing attractive. Some of the most important advantages are as follows:

- Inexpensive : Since all the virtual resources whether application, hardware or data are covered by the service provider. Customer get the greatest cost savings in the cloud.
- Flexible and scalable : Spin up a server in minutes, and take it down just as easily. Customer can easily move their system and data in the cloud without being locked into one provider or a closed, proprietary technology.
- Highly reliable and redundant : Efficient storage and computing services.
- Assures appropriate use of resources as the users are required to pay only for the services they require.
- Widespread availability irrespective of geographical precincts.
- Advanced workplace, empowers employees and enable them to become productive even when outside the office. The SaaS model ensures that corporations save on IT expenditures while delivering the flexibility of productivity software on the cloud.

Since cloud computing system is being a hot technology, the implementation of e-learning system on a cloud computing has its peculiarities and needs a specific approach. Bo Dong, et.at. presented an e-learning ecosystem based on cloud computing infrastructure [53]. There are many benefits of the system, i.e., reliable, flexible and cost-efficient. The system also has mechanisms to guarantee the teaching and learning activities, the quality and the running of the ecosystem.

Paul Pocatilu, et.al. measured the positive impact of using cloud computing architectures upon the e-learning solutions development [54]. They advanced a set of cloud computing efficiency metrics for enhanced e-learning implementation process control. Also, the long-term overall efficiency of cloud computing usage in the field of e-learning system was evaluated. The measured results showed that cloud computing system can reduce the cost of infrastructure maintenance, risk of hardware failure of e-learning system. Normally, E-learning systems usually require much more hardware and software resources. There are numerous educational institutions that cannot afford such investments, and cloud computing is the best solution for them.

1.7 Open Source Software Technology

The phrase open source has become a loaded term in software development. The Open Source Software (OSS) is a license free that allows users to use applications with freedom of use. Users can look under the hood, see how the software works, tinker with it, share it with others, or use parts of it in their own product [55]. OSS is unique in that it is always released under a license that has been certified to meet the criteria of an open source definition. The main advantage for business is that open source is a good way for business to achieve greater market share [56]. The details show as follows:

- Lower costs : OSS usually does not require a licensing fee.
- Flexibility : A programmer can take a standard software package and modify it to better suit business needs. Company, organization and software development department can usually hire a programmer to add a particular function to OSS.
- Reliability and Quality : A lot of developers work together via Internet communication in the software design, implementation, improvement, bug fixing, etc.
- Availability of External Support : External technical support is available for many of the OSS packages. Many open source products have an active online community support that may be able to answer your questions through online forums and blogs.

However, there are some weaknesses to adapt the OSS technology in the business point of view. It is difficult to design a commercially sound business model around an open source paradigm. Consequently, only technical requirements may be satisfied, but not the ones required in the market. In terms of security, open source can be exploited by hackers and exposed the weaknesses or loopholes of the software more easily than closed-source software. It is dependent on the control mechanisms in order to create effective performance of autonomous agents who participate in virtual organizations.

In the proposed system, there are a lot of OSS software that are used to make up the system services and back-end processes such as Linux operating system, Red5 for video streaming server, Apache Tomcat for web services, OpenOffice.org / LibreOffice for freedom document format, GhostScript interpreter for Adobe Systems' PostScript and Portable Document Format (PDF), and other Java family applications. Not only the system services, but also the WebELS system is distributed based on the OSS license.

1.8 Objectives and Scope

In the discussions above, higher education and life-long human resource development are urgent issues to support the sustainable development of global society. The conventional methods of education is not enough to support the global demands because of limitations in technology, geographical location, time zone and financial resources. Therefore, a suitable use of advanced ICT in education is needed to meet the social demands, especially for developing countries where high-quality Internet service is not available and the prevalent lack of educational resources. It is well recognized that in the future developing countries would play a key role in sustainable development more than before where opportunities on higher education were limited.

The features of e-Communication for higher education should be also different from those of the undergraduate education.

Based-on the requirements and demands of higher education, the goals of this research are defined as follows:

- To remove the obstacles of both time and place to post secondary education for individual and corporate by developing and demonstrating innovative, cost-effective approaches in delivering education through the use of rapidly

evolving advanced technology.

- To provide a means for learners to obtain formal recognition of the skills and knowledge obtained outside the traditional higher education context and/or from multiple providers through the assessment and certification of competency.

- To encourage joint development of new learning and assessment materials among universities in the global scale, and technology standards that ensure connectivity.

Trends and methodologies of e-Learning service have been changing, and nowadays, video-based or streaming-based contents are being sought for. The new technology brings courses alive by allowing online learners to use their visual and auditory senses. Authoring tool for video-based content is needed to support this new trend and methodology. The tool should give the opportunity to re-use contents or archives which can be shared to learners. For e-Meeting service, stability of the meeting operation in the unreliable network environment is very important. To preserve the meeting operation, the system should perform automatic re-connection for intermittent network especially in areas with low-speed Internet. A lot of requirements from the business sectors that need to be addressed, e.g., content privacy and system management issues.

In the Internet technology, bandwidth is the capacity or amount of data that can be transmitted over an electronic channel during a specific period of time. Although, the maximum bandwidth is given to the users by the network providers, the actual bandwidth value varies depending on the actual network environment, network infrastructure, etc. Hence, the author classified the Internet bandwidth by bit rate or bits per second into three types to be used in this paper as follows:

- Low-speed bandwidth the Internet bandwidth is *100kbps and below.*

- Medium-speed bandwidth the Internet bandwidth between *100kbps and 500kbps.*

- High-speed bandwidth the Internet bandwidth is *500kbps and higher.*

In this dissertation, the author proposed an advanced cloud-based integrated e-Learning / e-Meeting platform functioning in a low-speed Internet. The proposed

system is designed to support flexibility and globalization of higher education especially for Ph.D education. There are two main functions to support various kind of e-Communication activities, i.e., e-Learning and e-Meeting functions. The WebELS (Web-based e-Learning System) is utilized as the baseline of the proposed system since WebELS consists of two existing modules for e-Learning function and e-Meeting function. To improve the capability of existing WebELS, the proposed functions can co-exist with the existing functions and contents such as slide-based and audio-based contents. The system collaboration of Learning module and Meeting module are considered to enhance the system efficiency and learning ability of students who use the system.

In the e-Learning section, a new video-based authoring tool is developed to synchronize a raw video stream with presentation slides. The synchronization methodology of each slide and virtual video clip, part of raw video stream, is proposed. The author presents the video and cursor synchronization methodologies to enhance the system efficiency. Not only in the authoring section but also the viewing section is considered because the viewing tool makes the lesson more interesting for students. The pointer function is utilized to boost up the system efficiency and increases the students' interest. The viewing tool has more functions, e.g., full screen mode, zoom in, zoom out, etc. The adaptive video buffer size and quality control function were implemented to support usage in low-speed Internet.

In the e-Meeting section, a meeting management system for controlling member groups and contents were implemented. The author designed a new simple group-based structure for easier management. The system can manage the contents on each group by limiting the number of content, limiting the number of concurrent access, and control the behavior of logging-in members. The author also proposed the automatic re-connection network to help the participants who use the unreliable network by preserving the quality of online conference operation for the best distant meeting.

In addition, lightweight application and cross-platform support are important key factors. Therefore, web-based applications which can be accessed via a general web browsers is the proper solution to breakdown a defect of various client limitation.The author implemented the WebELS system as a SaaS concept of a cloud computing to minimize IT investment costs of the education section and business companies. By cloud-based implementation, it means that every software function, as well as data is automatically downloaded from the WebELS server

through an Internet browser to a user's client computer and functioning without any special software modules and devices. A usual computer with usual operating systems such as Windows, Linux and Mac operating systems is enough for use.

1.9 Organization of Dissertation

This dissertation consists of seven chapters briefly described as follows:

- Chapter 2 presents the related studies and technologies review. Background information, recent progression, and approaches of e-Learning and e-Meeting technologies are summarized.
- Chapter 3 describes the overview of the WebELS system. The proposed concept, overall architecture design, system structure, and system functionality are described.
- Chapter 4 introduces the design concept of the new video-based authoring tool for e-Learning system. The author proposes an aggregated video by key marking method for synchronizing raw video stream and presentation slides. Proposed architecture, techniques, and data structure are explained.
- Chapter 5 shows the implementation of the proposed method. The author describes the system framework, system design and system architecture which utilizes to support the design concept. Functionalities of the system are also presented.
- Chapter 6 focuses on the online video meeting improvement. The author presents a new simple group-based concept for managing the users of the system. The author also presents the quality improvement for video meeting when operating the system in the unstable network environment.
- Chapter 7 presents the experimental results of the system. The two main topics are the advanced video-based authoring tool for e-Learning and the improvement of e-Meeting to meet the business requirements and social demands. Finally, it describes the evaluation results based on the user acceptance issue.
- Chapter 8 presents the significant contributions of this dissertation, some limitations of the system, and the future research.

Chapter 2

Related Studies and Technologies Review

2.1 e-Learning system

Distance education has been utilized to provide instructional access to adult students living in remote areas where traditional education is not available [57], [58]. An e-Learning system is a popular technology for distance education. The e-Learning education system based on the web models conventional in-person education by providing equivalent virtual access to classes, contents, and other resources. It is also a social space where students and teacher can interact through threaded discussions or chat. There is a variety of benefits to use e-Learning system. Learner who has limitations of time and location can learn by themselves with the distant-learning system via Internet technology at a lower cost and higher quality in global scale.

e-Learning system can be integrated with a physical learning environment which may be referred to as blended learning. It can take place synchronously or asynchronously. In synchronous systems, participants meet in "real time", and teachers conduct live classes in virtual classrooms. Students can communicate through a microphone, chat rights, or by writing on the board. In asynchronous learning, which is sometimes called "self-paced" learning, students are expected to complete lessons and assignments independently through the system. Asynchronous courses have deadlines just as synchronous courses do, but each student is learning at his own pace [41], [59].

Many e-Learning systems exist nowadays that can facilitate access to learning

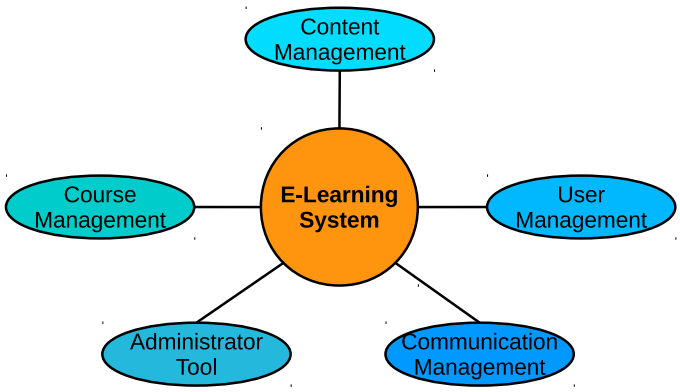


Figure 2.1: Basic components of the e-Learning system

content and administration. The author summarizes the important components common to e-Learning systems in the point of view of its functionalities. The basic components found in e-Learning systems are shown in Figure 2.1. The system consists of five main components such as course management for managing the course programs, content management for managing the learning content, user management for managing users and assigning user permission, communication management to managing communication resources and administrator tool for the administrator to manage the e-Learning system.

In this dissertation, the author focuses on the content management component based on the WebELS Learning system. Authoring tool and viewing tool are important instruments in this component. Authoring tool is used by instructors to create, edit, share and distribute the learning contents, while viewing tool is used by learners to access the contents they intend to learn.

2.2 Learning content characteristic

There are three prevalent characteristics of learning content, namely (1) general web-based, (2) slide-based, and (3) video-based. General web-based learning content is used as a standard e-learning system since web technology was first initiated. It uses standard HTML elements such as text, images, video clips and links for making content. Many CMS systems are supported, such a Moodle, and Joomla LMS.

Slide-based learning content is a slide presentation that uses embedded objects into the slide, such as text, image and others. Some tools can create the learning content from the slide presentation file. For instance, iSpring is a tool used to

convert PowerPoint presentations into Flash video files [60]. One of the best features is that all of transitions, effects, animations, audio/video clips and links are still active after the conversion takes place. However, it only operates on Windows platforms and with Microsoft Office PowerPoint.

Freimut Bodendorf and friends developed a Lecture of Demand (LoD) toolset, java-based authoring/editing tool, for producing reusable web-based multimedia presentation [61]. The LoD authoring tool is standalone application that requires PowerPoint presentation file and video file. However, the LoD system requires the external software, Helix Producer, to encode and consolidate all video files into a single Real video file. The advantage of LoD toolset is that it can create the navigation elements and synchronize slide and video using Synchronized Multimedia Integration Language (SMIL) document. The output learning content is called "LoD presentation" and shared on the learning server. One defect of this authoring tool is that it cannot support online editing.

Video-based learning content is now receiving attention and popularity. The main characteristic of a video-based content is to integrate the video stream and slide presentation to create a learning content. The video stream is used as a baseline of a learning content and presentation slides are automatically changed based on the video timing. However, there are some issues to inspire the video-based authoring tool to be improved. For instance, it is difficult to skip some parts of the video that contains noises or garbage data. Other system cannot directly synchronize the presentation slides with raw video stream, while some does not support cross platform usage. Learning content should be easy to re-edit or reuse without new content recording or re-uploading required. Todai-eTEXT [62] and online database class of Stanford University [63] are examples of this video-based content.

2.3 Authoring Methodology

Several methodologies of the authoring tool for synchronizing video and slide are proposed. The author summarizes and group them based on the characteristics of the methodologies. One method is processed-based, which it may be further classify into pre-processed and post-processed. In case of pre-processed, such as Adobe Authorware and Toolbook, editor must prepare the required data before making the learning content. For example, video clips must be already captured or

cut from the raw video stream using another tool. The system supports SCORM standard. In the post-processed method, editor can create the content without video clips preparation such as in Todai-eTEXT [62]. The authoring tool can help the editor cut the raw video into video clips directly.

Another interesting method is the real-time learning content creation. Nael Hirzallah proposed an on-the-fly creation of the video content from the classroom lecture [37]. He developed the Slide Generation algorithm (SG) used to detect the change of slide by capturing the image from the camera as shown in Figure 2.2 [1]. This system however requires high-end computer performance for saving and comparing the algorithms. The output is saved in SMIL format. The student can use any browser that has installed the RealPlayer add-in for online running. Also, Yi-Chun Liao proposed a story-based editing and browsing system with the automatic video segmentation [64]. The system combines video, audio and screen output in real-time, and inserts the interaction mark to control the presentation slide. It also uses hyper-video for his authoring.

Other software productivities have been released. CamStudio is quite a popular productivity. It is a free software that allows to record all screen and audio activity on the computer and create video files, on-the-fly recording [65]. This product can create streaming videos using built-in streaming Flash video producer. It can also record video from webcam with annotation feature. One disadvantage is that it only support Microsoft Windows family. Mediasite [66] and Capture Station [67] are other authoring products. They allow real-time recording of screen including the presentation and audio activity on the computer to create video-based content. Mediasite and Capture Station allow editing the live presentation before publishing, while CamStudio needs to re-record after the content was created. The disadvantage of Capture Station is that it requires special system and hardware in order to work.

2.4 e-Learning Platform

There are three main types of the e-Learning platform, i.e., the standalone system, the server-client system and cloud computing system. A lot of applications are working as a standalone system, such as iSpring, CamStudio, etc. They do not need the network infrastructure, but they require installation of software application in

[1] Original source owned by Ref. [37]

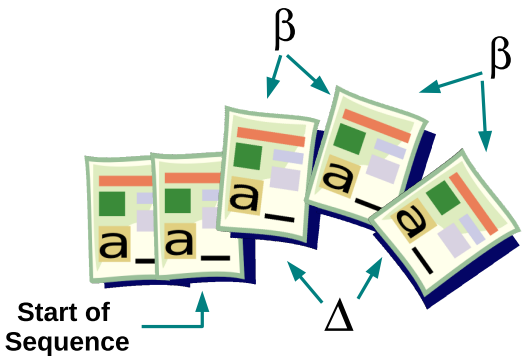


Figure 2.2: The Slide Generation (SG) algorithm

user's computer. They almost support for Microsoft Windows family only.

Web-based Synchronized Multimedia Lecture (WSML) framework shown in Figure 2.3 [2] was initiated for supporting the Web-based Chinese classroom in Taiwan [68]. The WSML system integrates more vigorous types of media such as pictures, streaming audio/video, and animated navigation events with traditionally text media like static HTML pages. The WSML system provides an authoring tool to record the temporal and spatial relationships among media involved and thus can facilitate the synchronized presentation and cross-media access. They used three servers for server side, such as HTML, AV and Event servers. For the teacher who requires to create a content, media files must have been uploaded to the AV server. Authoring tool used to record the relations between media objects or navigation events with a global timer and store relation events on the Event server. For the student, they implemented JavaScript code and dynamic HTML for rendering the learning content to display in a web browser. A little problem of the system is that it requires high bandwidth and stable network connection for uploading media files.

Another platform is in Singapore, and is still on the implementation stage [38]. They have initiated an online community for practice of teachers and designed an online platform where teachers can share vivid images and videos of their teaching practices with other teachers. They used Web 2.0 technology to create the website platform prototype. They also built tools and services for their platform. Their proposed platform is only used to share content, but it could not synchronize video and presentation slides together. Not only in the academic research but also several commercial authoring tool products are available for producing video-based

[2] Original source owned by Ref. [68]

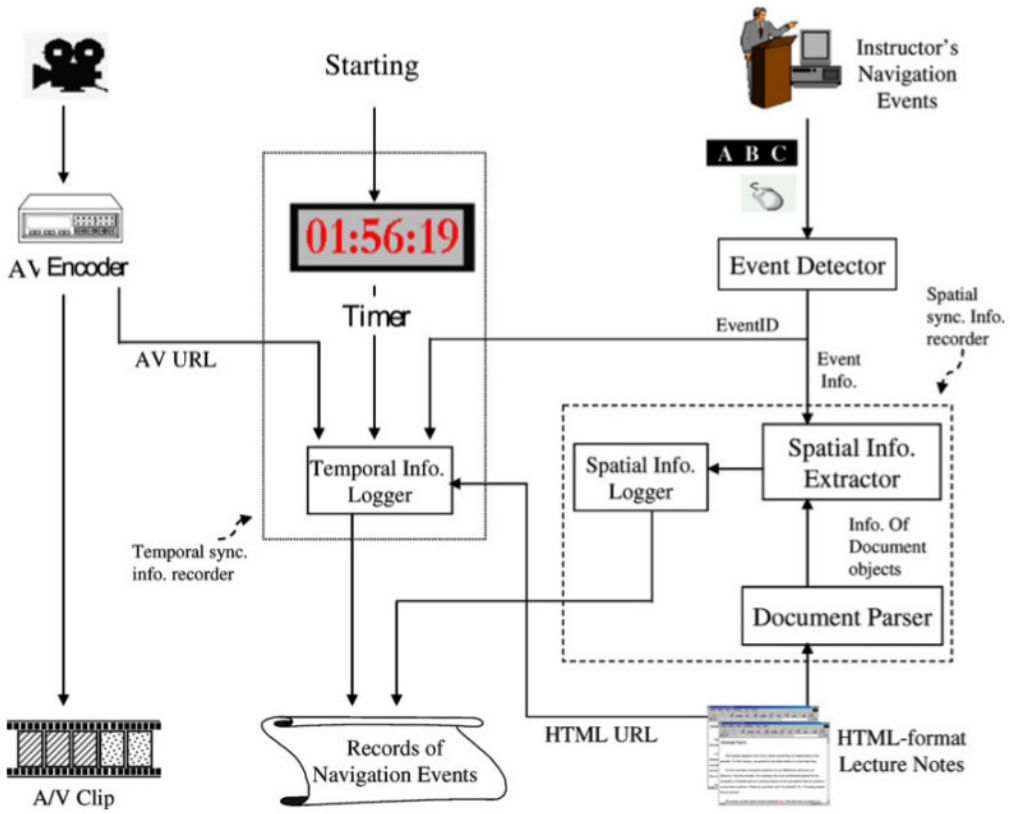


Figure 2.3: The WSML system framework

learning content.

Some popular e-Learning platforms around the world are the Moodle [69] and Joomla [70]. They are an open source Course Management System (CMS), also known as a Learning Management System (LMS) that allows the classroom to extend onto the web. Moodle software is based upon a constructivist pedagogical framework that aims to enhance a students learning experience within the Moodle environment [71]. It is not a program to replace face-to-face teaching, but to support it with a range of flexible online tools, as well as providing a place to upload resources for course units. Furthermore, several developing countries have developed their own e-Learning system for local usage for example, LearnSquare in Thailand [72], etc. Figure 2.5 [3] shows user interface and example content of the LearnSquare system.

Moreover, the implementation e-Learning on a cloud computing platform has its peculiarities and needs a specific approach. Bo Dong presented an e-Learning ecosystem based on cloud computing infrastructure [53]. The benefits of the sys-

[3] Original source owned by Ref. [68]

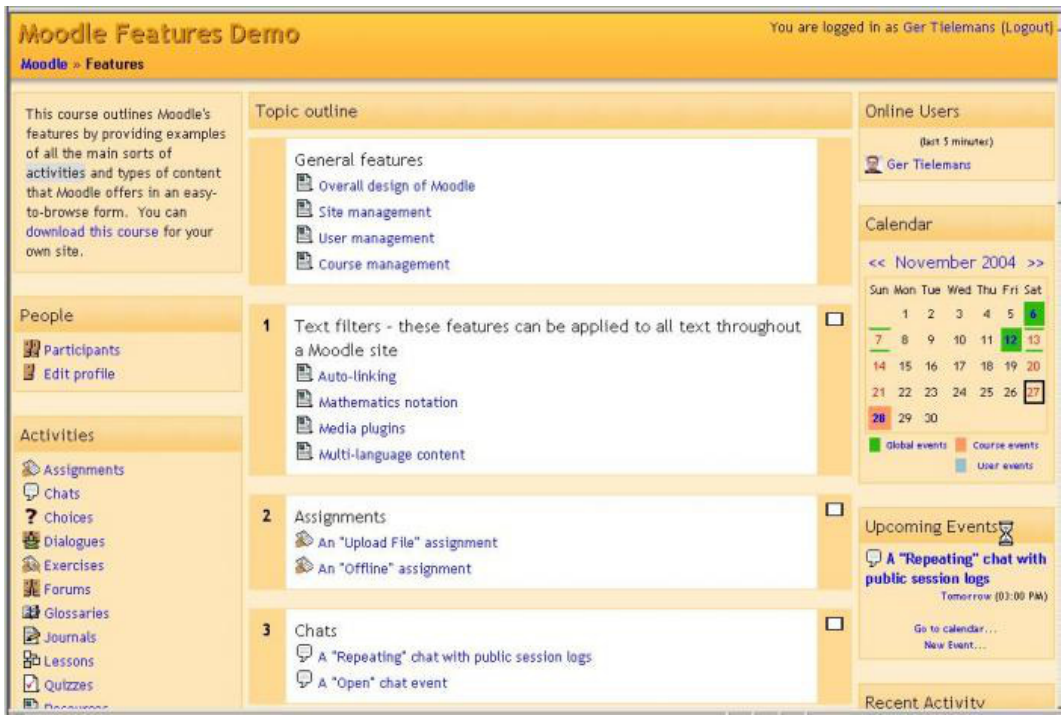


Figure 2.4: User interface of the Moodle

tem are reliable, flexible, and cost-efficient. The system also has mechanisms to guarantee the teaching and learning activities, and the quality and the running of the ecosystem. Paul Pocatilu measured the positive impact of using cloud computing architectures upon e-Learning solution development [54]. The measured result shows that cloud computing system can reduce the cost of infrastructure maintenance and risk of hardware failure of an e-Learning system.

2.5 Video Meeting Technology

Video meeting or conferencing is an audiovisual technology that allows group of users in two or more locations to communicate via simultaneous broadcasts of audio and visual data. It uses computer and communications technology to exchange visual information using a webcam, digital video camera, or streaming video. There are currently two main types of video meeting systems available on the market, such as point-to-point (P2P) video meeting and multipoint video meeting [73], [74]. The technology functions and the differences between them, as well as their associated advantages and disadvantages are described as follows:

Point-to-point (P2P) video meeting is the cheapest and most commonly im-

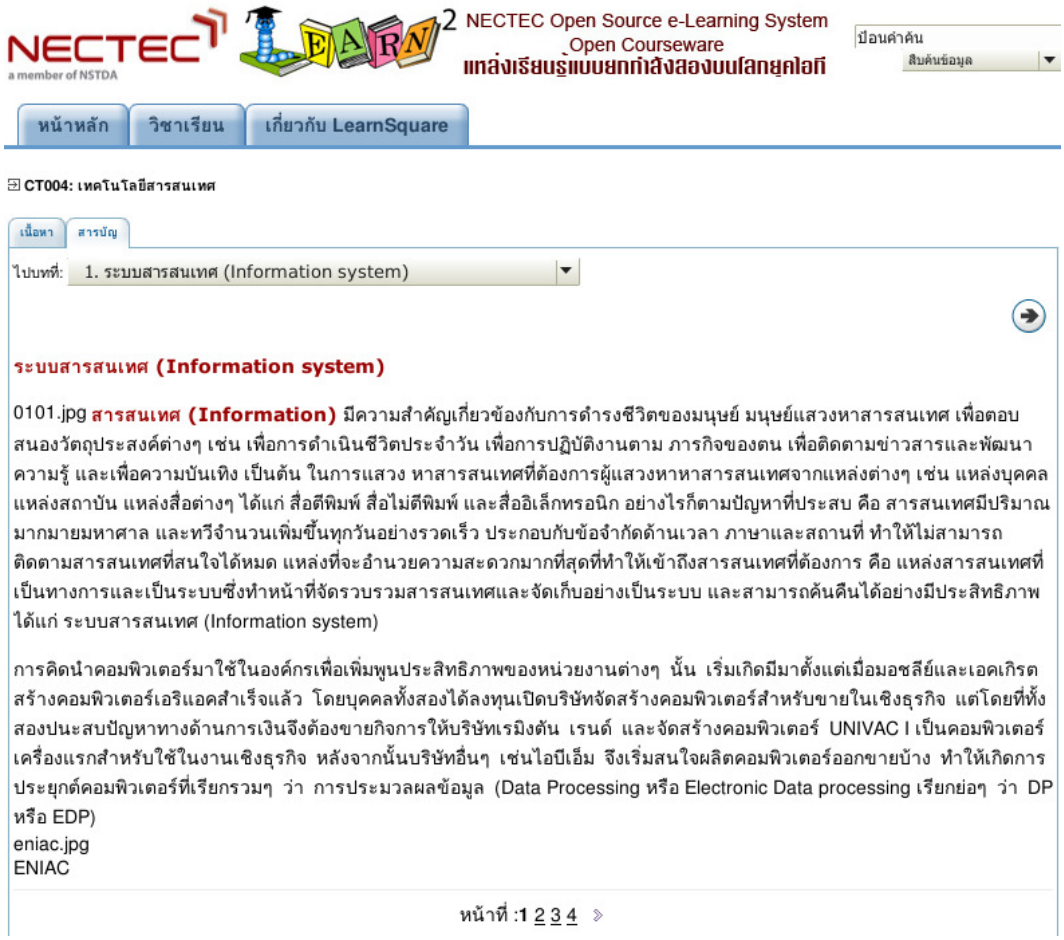


Figure 2.5: Example content of the LearnSquare

plemented type of video meeting system. It is limited to only two participants in different locations, and does not require a bridge to function, unlike in multipoint meeting. Since point-to-point is limited to only two people, this form of video meeting is less technologically demanding. The quality of the broadcast is far superior, and there is much less chance of lag because there are only two parties involved [75], [76], [77], [78]. The weakness is that each party must use the same type of connection protocol in a point-to- point system. For instance, if one user is using an Integrated Services Digital Network (ISDN) protocol while another person is using an Internet Protocol (IP) then it is impossible to use point to point video meeting to connect these two users. As the P2P type of video meeting is relatively simple and needs only basic audio and video inputs and a piece of software to coordinate them, point-to-point systems are often utilized in personal situations as a way of keeping in touch with friends or relatives living in far away locations.

Multipoint video meeting is a system that can have two participants or more in different locations, which means that multiple people can be displayed on screen instead of just one. There are two logical technologies utilized to initiate a multipoint video meeting [79], [80]. The details are explained as follows:

First, extend the scale of P2P by connecting the P2P clients to the multipoint control unit (MCU) for multiple parties [81], [82]. MCU is a device present in all multipoint video meeting systems which allows three or more separate locations to conduct a real time video meeting. MCU consists of either a sole piece of software or a combination of both hardware and software, and come in variations specifically dedicated to IP or ISDN video conferencing. Generally, more expensive MCUs are capable of handling more connections at a faster data transfer rate and allow more than one participant to be displayed on the video screen at one time.

Second, employ an information technology as server-client broadcasting [83], [84]. This form of technology is now becoming the regular function for multipoint video meeting since it can use the general Internet infrastructures for establishing the connections. It also does not require special hardware or resources, like MCU, for handling more connections. However, the quality of the broadcasting videos is dependent on the bandwidth and number of connections during the operation. A delayed time and lag of the video streaming and voice streaming occurs when using the system in the narrow-band network, or by excessive number of connections.

2.6 e-Meeting Platform

There are many popular video meeting systems at the present. Each system has different features. For instance, Saleh A. proposed a technique of the online conference system by using a peer-to-peer protocol, P2P [85]. They implemented the new method for distributing the streaming data instead of JMF. In this method, it requires 600 Kbps of network bandwidth for video streaming.

Skype, Polycom, Cisco WebEx meeting, Microsoft Live meeting, iMeeting and Pc Video Conference are well-known online conferencing systems on the proprietary license [14], [15], [16], [17], [86], [87].

Skype is a peer-to-peer, or end-to-end (E2E), VoIP client that allows its users to place voice calls and send text messages to other Skype users. The network structure of Skype is shown in Figure 2.6. Skype offers three services which are VoIP that allows two Skype users to establish two-way audio streams with each

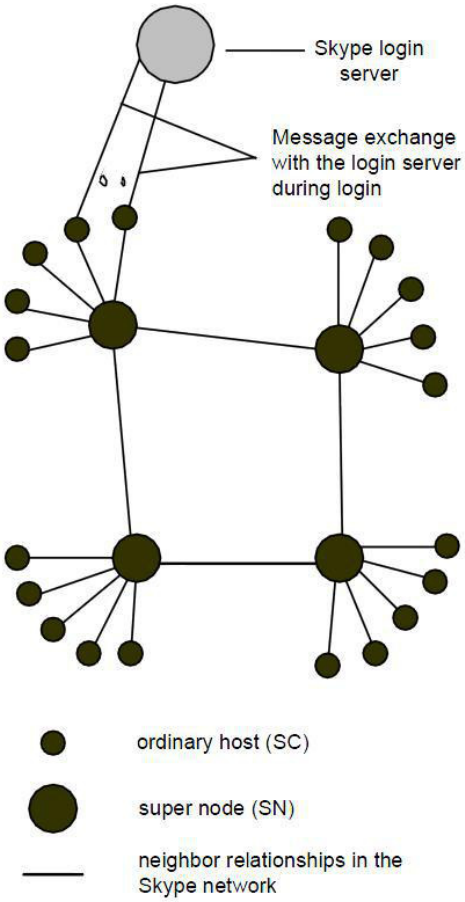


Figure 2.6: Network diagram of Sykpe

other and supports conferences of up-to 4 users, IM that allows two or more Skype users to exchange small text messages in real-time, and file-transfer that allows a Skype user to send a file to another Skype user. Skype also offers paid services that allow Skype users to initiate and receive calls via regular telephone numbers through VoIP-PSTN gateways.

Polycom video conferencing system allows group of users to meet over a distance, enabling more productive meetings and real-time decision making, and also comprise of personal systems that combine ease-of-use with standard definition communication, allowing individuals and teams to interact across various environments. Polycom is a complete meeting solution, but it requires special devices and technologies. It needs specially designed cameras, telecommunication infrastructures, etc. In other words, it is not available for use in general computer or general peripheral devices. Figure 2.7 shows example of Polycom connection diagram.

Cisco WebEx meeting, Microsoft Live meeting, iMeeting and Pc Video Con-

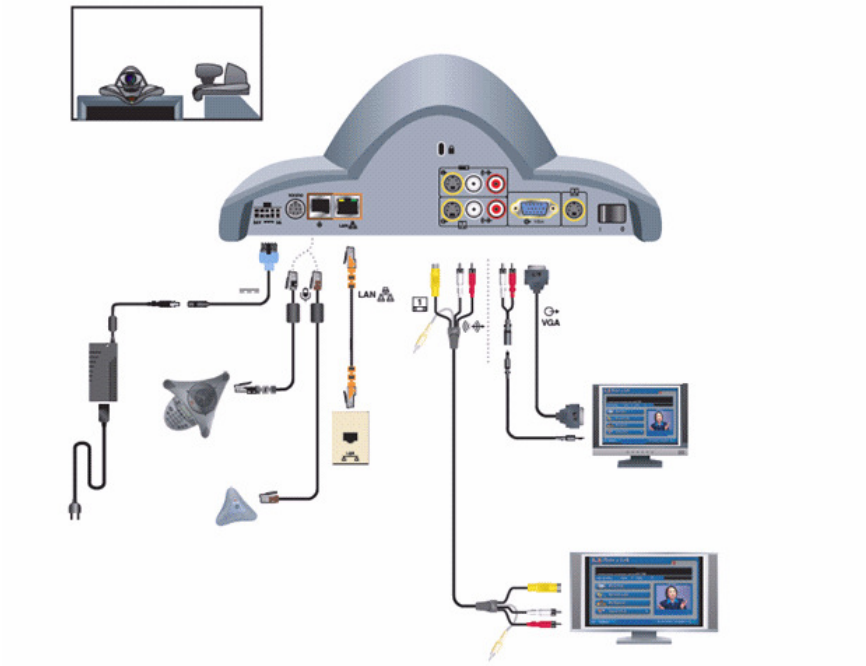


Figure 2.7: Example of Polycom usage

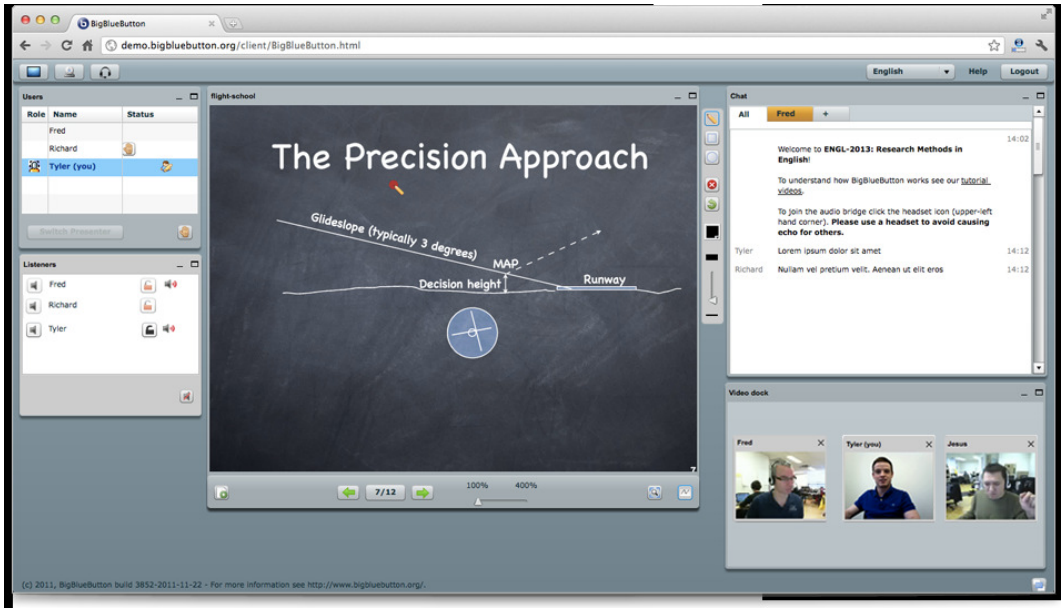


Figure 2.8: BigBlueButton main interface

ference are similar technologies that are commercially used for Internet meeting. These systems can use a general computer with web camera and microphone attached units. Cisco WebEx meeting and Pc Video Conference support the cross platform environment while Microsoft Live meeting only supports cross platform in web access system. In addition, these systems need high-speed Internet and a

specific operating system, usually Windows, and therefore this situation poses a limited use.

For a different purpose, some video meeting systems are published using an open source license, e.g., BigBlueButton and OpenMeetings.

BigBlueButton is an open source web conferencing system developed primarily for distance education. It supports multiple audio and video sharing, presentations with extended whiteboard capabilities, integrated VoIP using FreeSWITCH, and support for presentation of PDF documents and Microsoft Office documents. Moreover, users may enter the conference in one of two roles: viewer or moderator. As a viewer, a user may join the voice conference, share their webcam, raise their hand, and chat with others. As a moderator, a user may mute/un-mute others, eject any user from the session, and make any user the current presenter. The presenter may upload slides and control the presentation [19]. Figure 2.8 [4] shows main interface of the BigBlueButton.

OpenMeetings is a software used for presenting, online training, web conferencing, collaborative whiteboard drawing and document editing, and user desktop sharing. The product is based on OpenLaszlo RIA framework and Red5 media server, which in turn are based on a bunch of open source components. Communication takes place in meeting rooms which are set to different communication, security and video quality modes. The recommended database for backend support is MySQL. The product can be set-up as an installed server product, or used as a hosted product [18].

Most reviewed systems and products above are great video meeting platform. However, they require high-speed Internet in order to operate. Some systems specify the operating system, usually Windows. Some systems need additional resources for operating the meeting or conference. Therefore, this situation poses a limited use to the users.

[4] Original source owned by Ref. [19]

Chapter 3

Overview of WebELS System

WebELS is an Internet-based e-Learning system originally designed to support flexibility and globalization of higher education in engineering and science especially in Ph.D education [24], [25], [26]. The system has been distributed based on open source software (OSS) policy. WebELS system is focused on content authoring for archiving of learning materials and distributing them on the web for on-demand learning and online meeting. The design of WebELS system is based on the characteristics of Ph.D education from point of view of e-Learning in higher education integrated to the concept of Content Management System (CMS). Some key characteristics of Ph.D education are the following: The typical style of Ph.D education is usually discussion or lecture in the classroom with the slide-based presentation. At other times, online meeting, bulletin board and email are required for distant educational activities.

- Ph.D students are individual scientist researchers. Sit-in classroom study is not a main activity of higher education, but also joining or contributing to the academic meetings, seminars and conferences with the slide presentations are considered important activities.

- On-demand contents are important for self learning. Slide-based playback with voice and synchronized cursor seems to reasonable for on-demand self learning. High quality slides, voice and cursor synchronization are requested to be used in the narrow-band network.

- Various types of computer system are used by Ph.D students. E-Learning system must be supported on multiple operating systems that include Windows, Mac OS and Linux.

WebELS was developed as a server-based system functioning to support the above requirements of Ph.D education. WebELS is functioning in a low-speed Internet environment keeping high quality slides, short video clip and audio. Java programming language is a suitable to be used for achieving multiple OS support. A variety of client computers such as Windows, Mac OS and Linux can be used on the same feature, function and system environment. Every user can use the system over the Internet via web browser application, e.g., Internet Explorer (IE), Mozilla Firefox, Google Chrome, Safari and so on. Furthermore, another objective of WebELS is to provide an e-Government and social network operation as an advanced communications instrument.

The design concept of WebELS are as follows:

- Integrated e-Learning / e-Communication system : designed to meet the requests of higher education and business communications.
- Support seamless service of asynchronous and synchronous e-Learning / e-Communication : on-demand self-learning and multi-location Internet meeting using the same contents.
- Multi-OS system : Supports Windows, Mac and Linux users.
- Powerful authoring features for end-users : Easy-to-use editor for MS Office, Open Office, PDF, audio and short video clip contents.
- Multi-language interface to support international use : Automatic language selection for English (standard), Japanese, Chinese, etc.
- "Anywhere, anytime and anybody" system : easy-to-use Java-based system to support a variety of practical usage.
- Open-source service for academic and research collaboration.

The main concept of the system is to provide an advanced and easy-to-use authoring tool for creating the learning content from the actual presentation file. In the authoring tool, presentation file is uploaded to the WebELS server and converted into a series of images instead of using the original file type. Voice and cursor movements can be recorded and synchronized to each slide image. It is possible to embed a short video clip into the slide. After finishing an editing operation, self learning content will be generated and stored in to the learning

archive. Students can access the learning contents for self-learning by a viewing tool. Zooming, cursor pointing and annotation functions are supported in the viewing operation. These functions are useful tools to make the student easily understand the content. In addition, the quality of content is important. WebELS has embedded a voice meeting function to achieve the learning content and online meeting to be used in the narrow-band or low-speed Internet network environment.

There are two main modules of WebELS system, such as WebELS Learning module for self learning and WebELS Meeting module for Internet-based online meeting. Thus, WebELS system is regarded as an "All-in-One" e-Learning system.

3.1 WebELS Learning

WebELS Learning system is an Internet-based content management system for distance self-learning. The system provides necessary tools during E-Learning process such as content authoring, content management, user management, etc. Students can access to the online learning content via the Internet. Students can also learn with off-line mode by downloading the content and play the content at their computer at a later time. Learning content is based on slide presentation such as PPT, ODT or PDF formats. There are several benefits of the system, e.g., user interface and editing procedure of the system are quite simple and easy-to-use for non-IT user, the system does not require high bandwidth network and so on [26]. The overview of WebELS Learning system is shown in Figure 3.1. Figure 3.2 shows an example of an authoring tool user interface for managing the learning content.

The advantage of the authoring tool is that it can record voice and cursor movements to synchronize with each slide. An instructor or a teacher can create their own learning objects (LO) from existing presentation file, image and short video clip data. Each slide is a combination of image, audio, cursor movements, short video clip and slide description. There is no need for the Internet connection during playback time since content data are completely downloaded to the local computer. Regarding to the previous method and technology, the system has some limitation on the synchronization process for raw video content. It is required to prepare short video clips from raw video file by using an external application. Instructor has to take several processes, have more IT skills, and time consuming for editing video clips. Moreover, the system does not support streaming video

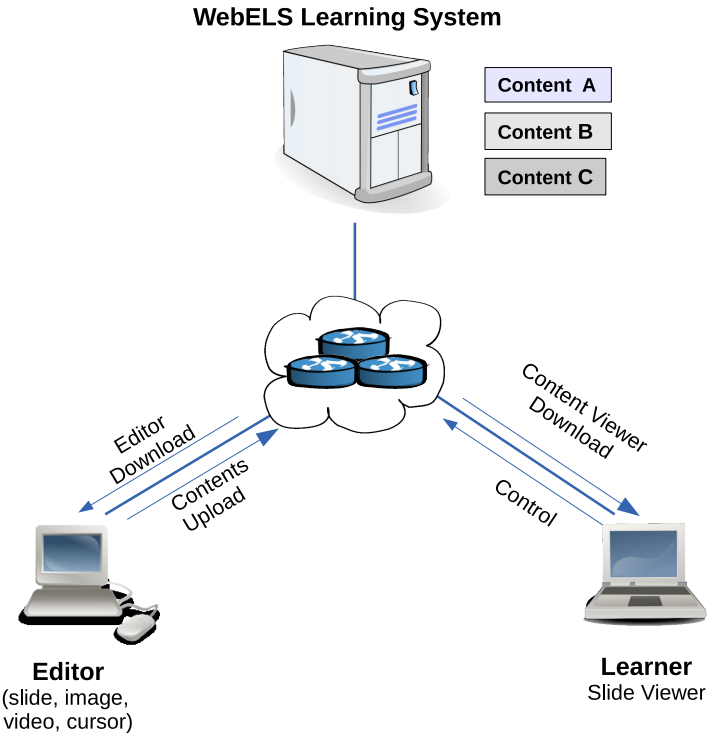


Figure 3.1: WebELS Learning system overview

content.

3.2 WebELS Meeting

WebELS Meeting is designed based on online meeting via Internet-based technology for supporting a content-centered e-Learning platform in postgraduate education. To support online meeting activities, several useful functions were integrated into the WebELS Meeting system such as content-authoring, online presentation, video conference and so on. This system involves integration of synchronous features with powerful authoring tools for Internet meeting [27]. WebELS Meeting is designed as an administrator free system for authoring tool, slide presentation tool and video meeting window. Every logged-in user has the same right. By clicking the presenter button, a user can obtain the presenter right to change slides, point a cursor, annotate drawings, zoom and scroll slides and so on. It also has an easy-to-use interface for non-IT users. Users can edit their own meeting contents on their personal computer and share to the meeting participants. Some main features are listed as follows:

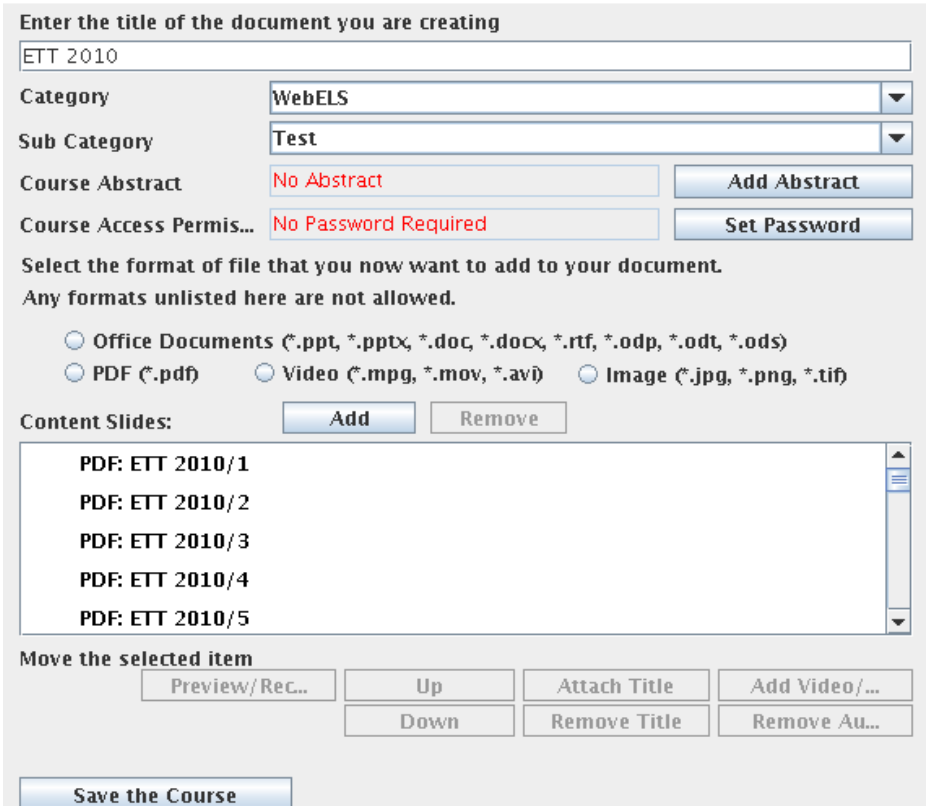


Figure 3.2: User interface of the java authoring tool

- Real-time meeting: Simulates the virtual meeting room. Anytime, anywhere and anybody concept to support a variety of usage.
- Synchronous and Asynchronous: Supports slide synchronized with video and audio while used via the Internet.
- Web-based usage: Easy to use and no need to install special programs. It can be used by any web browser application.

The advantage of the system is that it combines the online video meeting and online presentation document. The participants can follow the presenter's focus of discussion using a synchronized cursor. They can also see and follow the synchronization of the active content with the same slide and quality as in the presenter's panel. While most of video conference systems, such as Skype, Polycom, and similar systems, support only the online video meeting. Furthermore, WebELS Meeting functions even in a low-speed Internet environment because the contents are pre-downloaded onto every participant's computer and only the control signals and data are synchronized to the server and updates by itself. Since

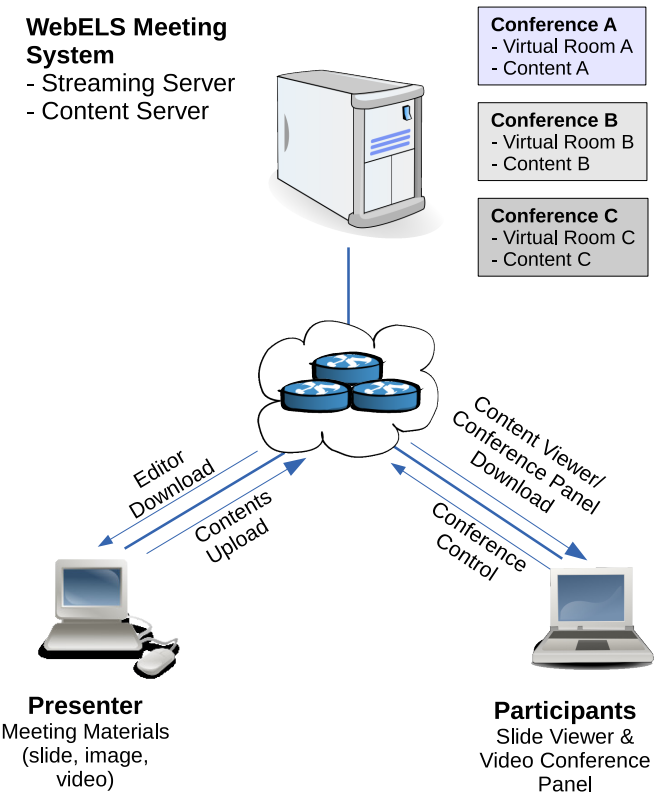


Figure 3.3: WebELS Meeting system diagram

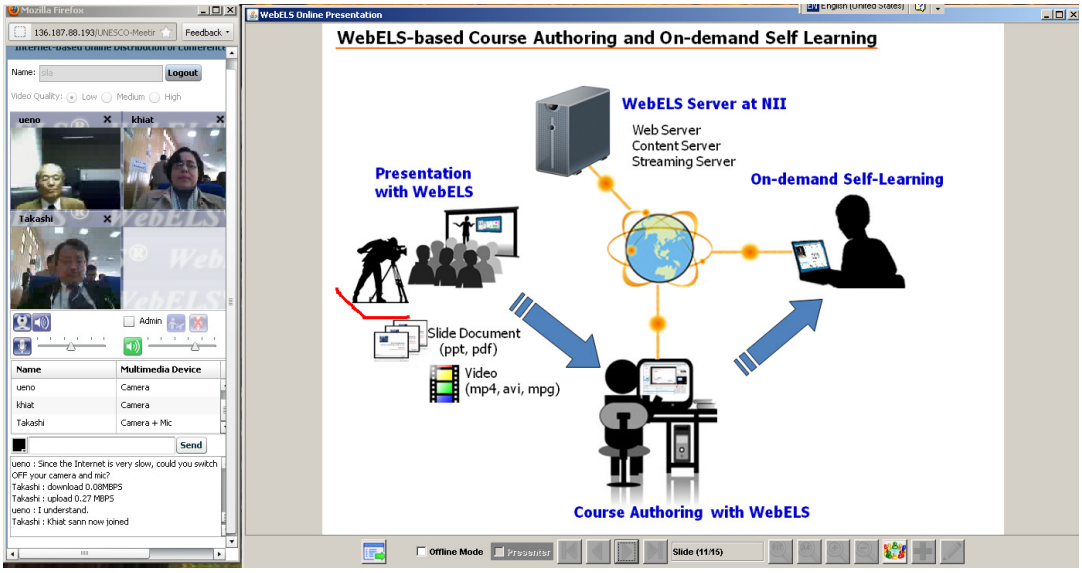


Figure 3.4: Example of using slide presentation and video conference

WebELS Meeting uses HTTP protocol for online presentation over port 80 and RTMP protocol over port number 443 for video conference, the system can be used under strong firewall setting rules [27]. Figure 3.3 shows the system diagram

of the WebELS Meeting. The basic design of WebELS Meeting was proposed for content-based meeting. Each content has its own virtual room that can be used for meeting management. Any users who are accessing to the same content can share the online presentation and join the online video conference at the same time. Figure 3.4 shows an example of online meeting using online presentation function and real-time video meeting function.

Chapter 4

Video-based Content for e-Learning

Learning contents are the essential element of an e-Learning system. The prevalent characteristics of learning content can be categorized in three groups: (1) General web-based learning content – is used as a standard e-learning system since web technology was first initiated. It uses standard HTML elements such as text, images and links for making content. (2) Slide-based learning content – is composed of slides with embedded objects, such as text, image and others. Slide is the main element of the content. It is used to control the embedded object changing. (3) Video-based learning content – is proposed to integrate video stream and slide presentation into a learning content. The video stream is used as a baseline of a learning content. Presentation slides are automatically changed by video timing.

In the educational system, the use of video for student learning has long been discussed since it consists various multimedia types such as image, audio, animation and teacher actions [35], [36], [37], [38]. Teachers can use video to share vivid images for teaching and learning practices in classroom. In the past few years, video contents can be used for streaming data to offer exciting opportunities for online teaching and learning. This form of technology brings courses alive by allowing online learners to use their visual and auditory senses to learn new concepts. Video streaming allows online instructors the opportunity to deliver alternative course materials to learners who use e-Learning system especially in higher education.

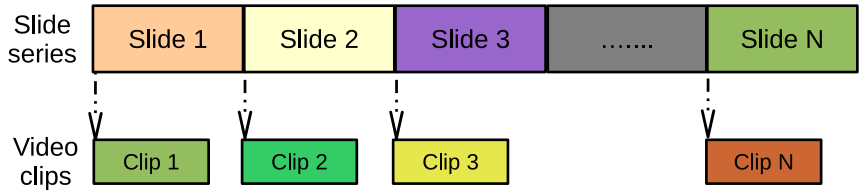


Figure 4.1: Traditional slide presentation with video clip embedded

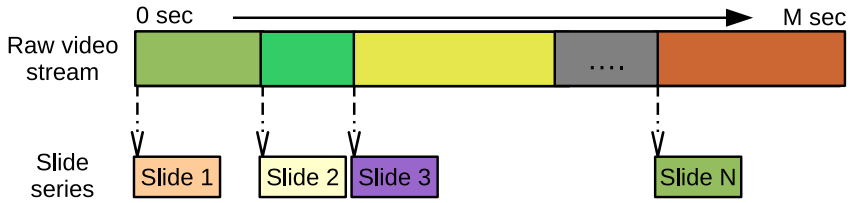


Figure 4.2: Traditional video and presentation synchronization principle

4.1 Traditional Video and Slide Synchronization Methodologies

There are a lot of available technologies and products, and some have similar and overlapping functions. The author conducted literature review related to e-Learning and authoring system for video-based content, particularly on synchronization techniques,. There are two main methodologies for synchronizing presentation slides and actual video streaming data.

The original or traditional synchronization technique is shown in Figure 4.1 which utilizes a presentation slide and an inserted video clip. Video clips are controlled by slide change trigger. In this method, editor must be completely prepare short video clip files using a video editor application before insertion. These video clips are related to the content in each slide. This technique requires more editing skills to use video editor application and takes more time for creating learning content. Moreover, it is harder to edit content in case the editor needs to change some video clip in the content. Editor must repeat the steps to prepare video clip from the raw video stream again. Many applications are supporting this technique, such as Microsoft PowerPoint, OpenOffice.org/LibreOffice, etc.

Another methodology is a video-based content which is becoming popular. This traditional video-based content concept is shown in Figure 4.2. The raw video stream is used as a baseline of a learning content, and presentation slides are automatically changed by video timing. The video stream is played from the

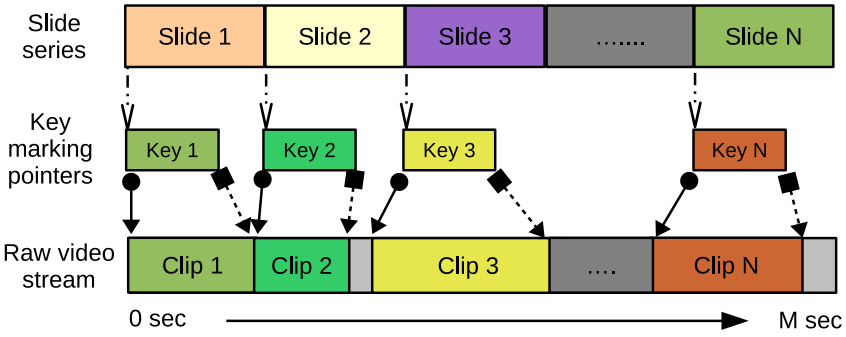


Figure 4.3: Slide synchronized with key marking pointers concept

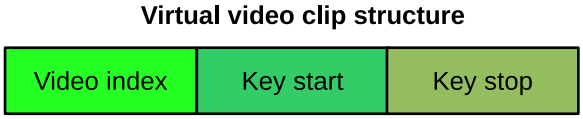


Figure 4.4: Structure of a virtual video clip package

beginning until the end of the video stream. It is an easy way to synchronize video stream and presentation content. The weakness in this method is that it is difficult to skip some part of video that contains noises or garbage data. There are some systems that showcase this methodology, such as Todai-eTEXT [62] and online database class of Stanford University [63].

With the disadvantages of both methodologies, the author presents another technique for synchronizing raw video stream content and presentation slides in this research. The concept is to merge the principle synchronization techniques of both methodologies together. This technique is conceptualized to work on client-server communication with low Internet resources required. This technical concept is shown in Figure 4.3. The most important part of this concept is the key marking pointer that is utilized for the synchronization process instead of using an actual video clips. It is the middle layer which is linked to presentation slides and raw video stream layers, wherein some unnecessary parts of the raw video stream can be skipped. This technique is a fulfillment and answer to the limitations of other methodologies for authoring video-based content as described in Chapter 1 and Chapter 2.

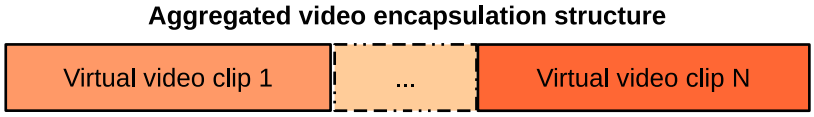


Figure 4.5: Structure of an aggregated video package

4.2 Aggregated Video by Key Marking Concept

To implement the new technique that uses key markings to synchronize raw video stream content and presentation slides, where the unnecessary parts of the raw video stream can be skipped, the Aggregated Video by Key Marking technique is proposed. Aggregated video stream is applied as a virtual layer for connecting presentation slides to raw video stream.

The key marking concept is not a method used to directly create an aggregated video. It is utilized for generating the "virtual video clip" from the raw video stream. The structure of virtual video clip produced by the key marking concept is shown in Figure 4.4. Each virtual video clip does not contain the real data of the video stream. It is composed of video index, key marks for start and stop times of the video index. It is a reference data used to identify the period of time for the actual video content in the raw video stream.

Subsequently, virtual video clips are used to generate and assemble the "aggregated video package". The aggregated video is the set of virtual video clips related to the contents in the presentation. The back-end structure of aggregated video is shown in Figure 4.5.

Finally, the aggregated video stream package is utilized to provide the synchronization process instead of using the actual video clips. The aggregated video stream becomes the baseline of the learning content, instead of the actual raw video stream as used in the traditional method. To collaborate video stream with slide, aggregated video stream package is utilized for synchronization instead of the raw video stream. The mapping structure between aggregated video stream and presentation slides is shown in Figure 4.6.. The key start and key stop times are utilized to trigger slide change for synchronizing a slide presentation with video.

The proposed technique is convenient for creating and editing learning contents. Instructors can synchronize presentation slides with raw video stream directly by means of embedded video clips. They can perform few processes to edit and re-edit synchronized virtual video clips. They are not required to have additional video

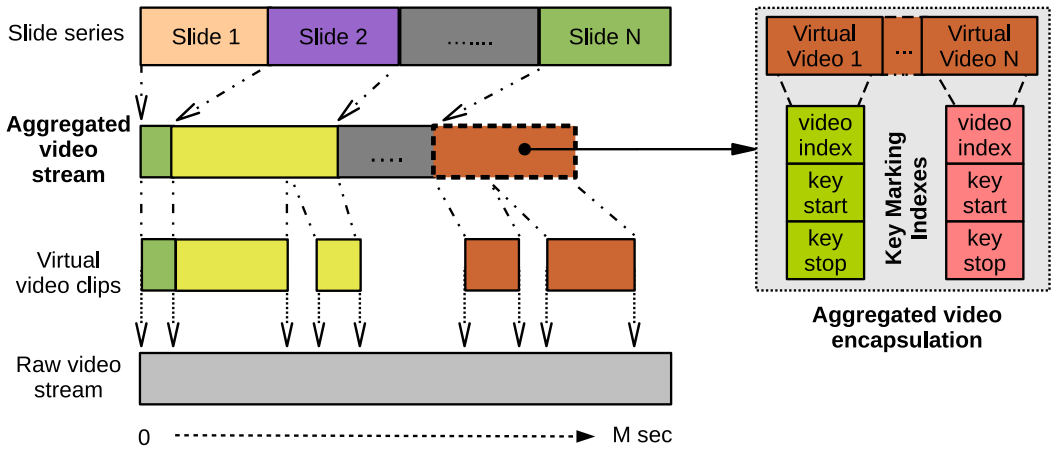


Figure 4.6: Concept of aggregated video stream and slide synchronization

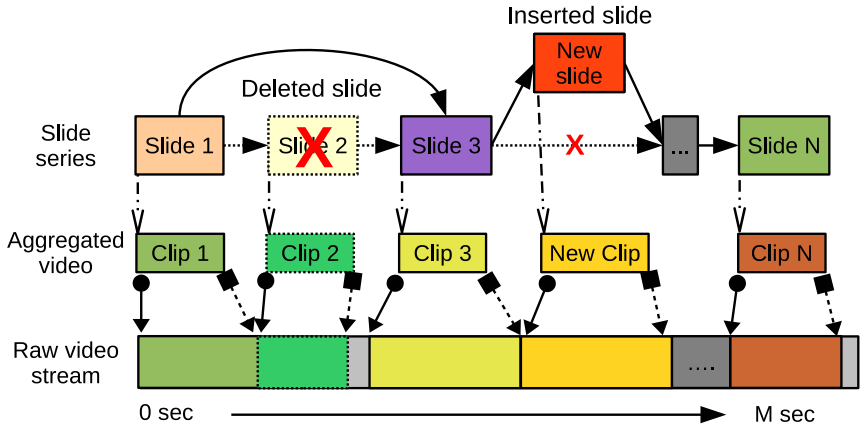


Figure 4.7: Advantages of slide synchronized with key marking pointers concept

editor applications nor skills for editing video clips. Some unnecessary parts of the raw video stream can be skipped. Instructors only change the key marking pointer to generate a new virtual video clip instead. In addition, it is an easier method to edit the learning content after the content has been created. Figure 4.7 shows some advantages of the proposed technique, i.e., deleting an existing slide and inserting a new slide to the learning content. More details are described as follows:

- Deleting a slide : From the example, slide 2 is deleted. The key marking pointer of Slide 2, Key 2, is automatically removed when a slide was deleted. This means the virtual video clip, Clip 2, which is related to the deleted slide will also be removed subsequently. Also, the slide index pointer of Slide 1 is automatically linked to Slide 3.

- Inserting a new slide : A new slide is inserted after Slide 3 in the example. The slide index pointer of the new slide is automatically replaced with slide index pointer of Slide 3, and the slide index pointer of Slide 3 is linked to the new slide instead. After that, the editor can create new key marking pointer to generate a new virtual video clip for the new slide.

4.2.1 Key Marking Pointer

From Figure 4.6, key marking pointer is a set of pointers related to the positions of streaming content in the raw video and presentation slides. Each key marking pointer includes two pointers, such as start key and stop key. Key marks are reference data used to identify a virtual video clip from the raw video stream. They are utilized to simulate as a video clip that is used in the traditional slide-based content shown in Figure 4.1. The same as in Figure 4.2, the raw video stream is used as a baseline of the learning content and the presentation slides are automatically changed by a pointer trigger. Moreover, this methodology can keep the advantages and cut-off the weaknesses of both traditional slide-based and video-based methodologies.

Moreover, there are many advantages that can be provided by the proposed method for synchronizing video and slides of learning content. This technique is a fulfillment and answer to the limitations of other methodologies for authoring video-based content. For instance,

- Editor can skip some part of the video stream that is not related to the slide from the raw video stream as shown in Figure 4.8. For example, a start time position of video stream of Slide 3 is related to a stop time of Slide 2.

- Presentation slide series can be synchronized with non-sequenced content of raw video stream as shown in Figure 4.9. For example, a start time of the current slide, Slide 2, can be synchronized to the time position before a start time of previous slide, Slide 1. Thus, it is possible to set a start time of last slide with the start time position of the raw video stream.

- Editor can combine several parts of video stream into the one virtual video clip as shown in Figure 4.10. This means that a slide can be synchronized to several parts of the raw video stream. For instance, there are 2 parts of raw video stream synchronized to Slide 2.

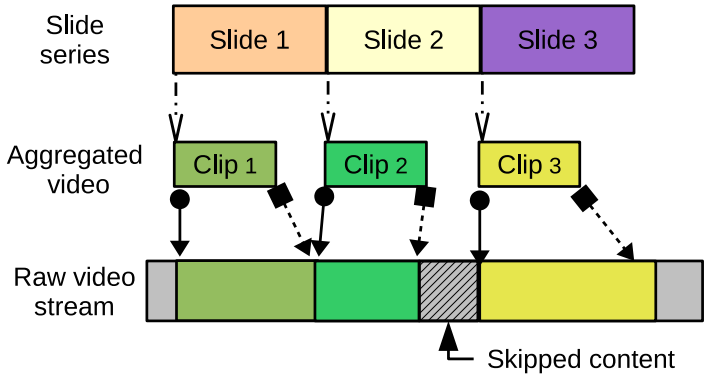


Figure 4.8: Example of advance key marking pointer utilization – skip a part of the raw video stream

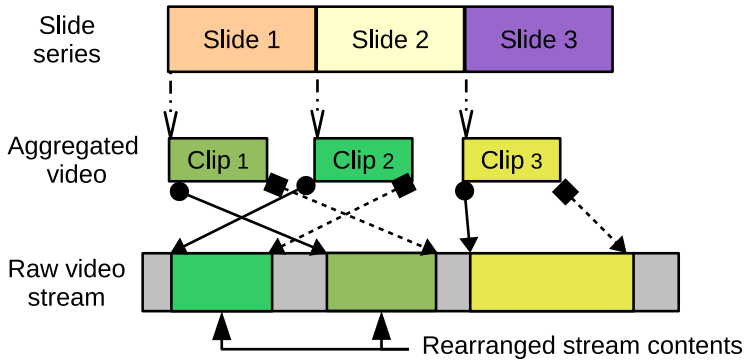


Figure 4.9: Example of advance key marking pointer utilization – Rearrange an order of contents of the raw video stream

- Key mark pointer of each slide can be overlapped and synchronized to some part of another key mark pointer as shown in Figure 4.11. Hence, the system is more flexible authoring tool for producing learning content that contain the collaboration of presentation slides and video stream.

4.2.2 Virtual Video Clip

Key marking pointer is a technique used to produce virtual video clips and to generate an aggregated video clip from the raw video stream. There are three important key marks of the structure utilized to define a virtual video clip, such as (1) *video index* that is used as a pointer to refer to the raw video file, (2) *key start* that is used as a timing value of raw video file which defines the beginning position of virtual video clip, and (3) *key stop* that is used as a timing value of raw

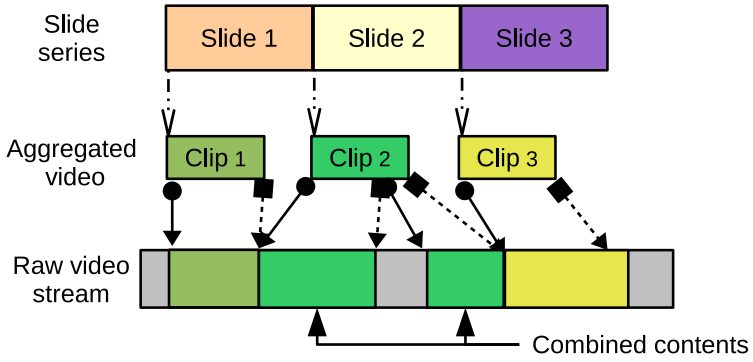


Figure 4.10: Example of advance key marking pointer utilization – Combine several parts of the raw video stream

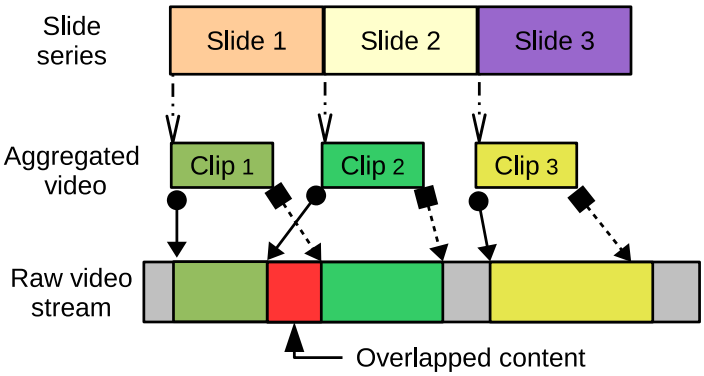


Figure 4.11: Example of advance key marking pointer utilization – Overlapped contents of the raw video stream

video file which defines the ending position of virtual video clip. After defining all needed data, virtual video clip is made up subsequently.

To obtain the synchronizing data for the video and presentation slides, the aggregated video stream is devised for providing the synchronization process instead of the actual video stream. The aggregated video stream composed of a series of indexed virtual video clips have key marks for start and stop times. The key start and key stop times are utilized to trigger the slide change for synchronizing a slide presentation with video. The aggregated video stream becomes the baseline of the learning content, instead of the actual raw video stream as used in the traditional method.

To accomplish the design concept, the aggregated video stream data is stored in the XML document. Each row contains a series of virtual video clips as follows:

For the encapsulated virtual video clip, the structure is:

$$vc \quad = \quad [rv] : [kstart] : [kstop] \tag{4.1}$$

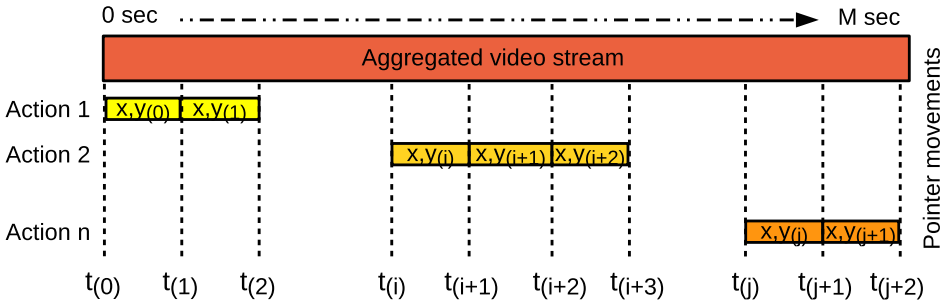


Figure 4.12: Aggregated video stream and pointer synchronization structure

where

vc - is the virtual video clip

rv - is the video index referred on the raw video stream

kstart - is the key mark start time position on the raw video stream for this virtual clip

kstop - is the key mark stop time position on the raw video stream for this virtual clip

And for the encapsulated aggregated video package, the structure is:

$$[vc\_1]|[vc\_2]|...|[vc\_N] \tag{4.2}$$

where

vc - is the virtual video clip encapsulated from (4.1)

4.2.3 Pointer Movement Concept

It is well-known that video-based content is highly evolving and even more compelling for an e-Learning content [88]. In this research, pointer movement concept is also proposed to synchronize pointer movement on the slide as the video plays. Pointer object can be positioned in the slide to make focus on the presenter's discussion as to what the presenter is talking about. This proposed method is intended to increase the learner's desire to learn. It also increases their abilities of proper understanding and retention.

To implement the concept, pointer movement positions are recorded as a series of mouse coordinates (X, Y) that correspond to the aggregated video timing. When the mouse is stationary, it is not necessary to record all the mouse coordinates with the video stream timing. The tool only captures the data when mouse

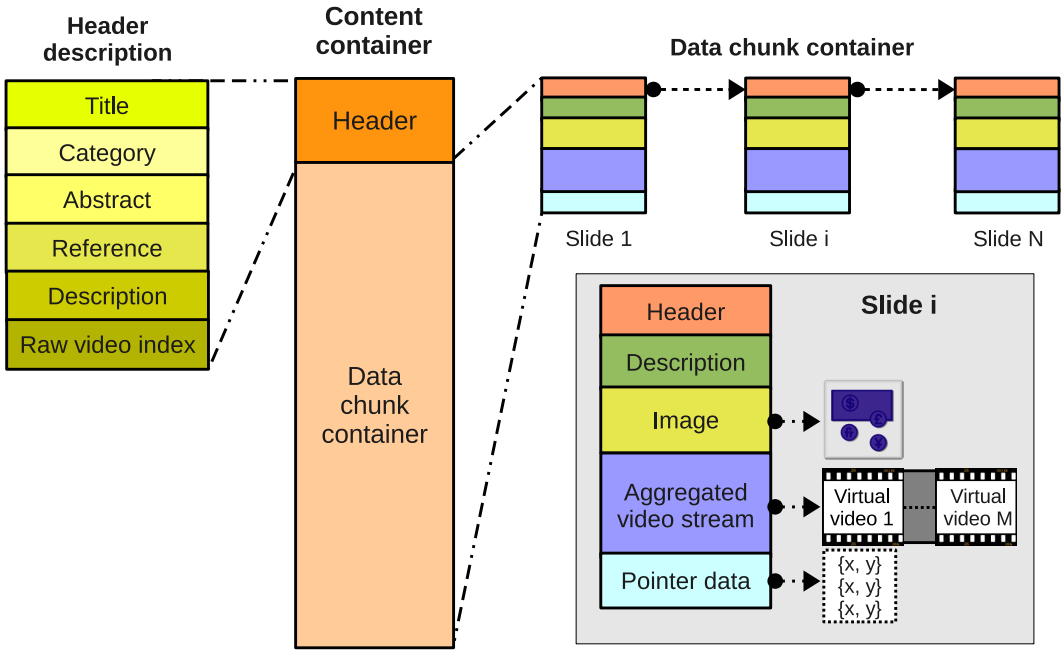


Figure 4.13: Data structure of learning content package

button is pressed and dragged by the editor, thereby minimizing the size of pointer action information. Each slide has its own time-line depending on synchronized video stream. The recorded video and pointer synchronization data are separately stored into an archive. Figure 4.12 shows methodology of online aggregated video and pointer movement synchronization. Values and structure which need to be recorded are shown as follows:

$$pt = [timing]||[position] \tag{4.3}$$

where

pt - is the pointer index

timing - is the aggregated video clip timing in millisecond (ms)

position - is the mouse coordinate (X, Y) at time, timing

4.3 Data Structure

From the proposed synchronization concept shown in Figure 4.6, the author designs the container package as an archived file of video-based learning content. Figure 4.13 shows the data structure of the proposed video-based learning content package. The content package consists of two segments which are the header

information and the slide chunk series of the presentation. The header segment composes of six important fields. It contains the content general information such as title, category and subcategory, abstract, reference, raw video file reference and description of content. In the slides chunk segment, each slide is an independent unit with five fields, which contains important slide elements such as header, image, aggregated video stream, pointer data and slide description.

From the data structure, presentation slide is used as the baseline of content stream. Header information is key data used to reference other data chunks, making it flexible for rearranging the slide sequence that includes the whole data in a chunk. Image data is used for linking to an image file and pointer data also linked to a file that stores pointer action data. Aggregated data are referred to the aggregated video stream that the virtual video clips are encapsulated. Slides data are stored into each file as separate data packages instead of one complete file. It is considered to be the best method for changing the meta-data file during editing and viewing operation. The schema of learning meta-data content is shown in the following:

```
<content>
<slides>
 <slide>
  <page>page_number</page>
  <image>image_filename</image>
  <title>
   Slide_title_of_the_page
  </title>
  <description>
   Description_of_the_page
  </description>
  <keymark>
   aggregated_video_data
  </keymark>
  <pointer>pointer_index</pointer>
 </slide>
 ...
```

```
</slides>

<videos>
 <video id="video_id">
  <file>video_filename</file>
 </video>
 ...
</videos>
</content>
```

The pointer synchronization data are separated and stored as an XML format in the pointer document. An example of an actual details is described in the following:

```
<pointers>
 <point>pointer_movement_coordinate</point>
 ...
</pointers>
```

Each slide has its own time-line depending on the synchronized aggregated video clip, so the pointer actions are separately stored in the individual file for each slide. The author uses the index key of each slide for linking between the slide and pointer document.

Chapter 5

Video-based Authoring Tool

5.1 System Overview

Figure 5.1 and Figure 5.2 show the workflow of the proposed system which is designed for supporting client-server operations in both of authoring function and viewing function. The client side is a web-based application which can be accessed by any web browser by both instructor and students. The author defined the common containers for communicating and sharing data between client node and server system. These are the three files used to support the infrastructure. First, the *meta-data file* that is used to retain the content definition, such as content title, description, references, etc. The benefit of using meta-data file is that it is a simple text file, which is small and fast to transfer between client and server. Second, the *content template* that is utilized to keep the temporary synchronization data created by the editor. Several data are contained in the content template, such as video index, key mark values, slide index, and pointer actions. Finally, the *learning content package* which is the output container of the learning content. It includes meta-data, presentation slides, video stream, and synchronization data.

The authoring function workflow shown in Figure 5.1 is designed for the instructor. It consists of eight main steps for creating a video-based content: (1) requesting the editing tool from the server, (2) preparing the editing tool environment, (3) uploading source files to the server, (4) converting source files to required formats (flash and image), (5) creating *meta-data file* after successful file conversion and automatically sending the data to the client, (6) synchronizing slide and video, and creating *content template*, (7) saving and uploading the content template to the server, and (8) automatically generating *learning content* and storing

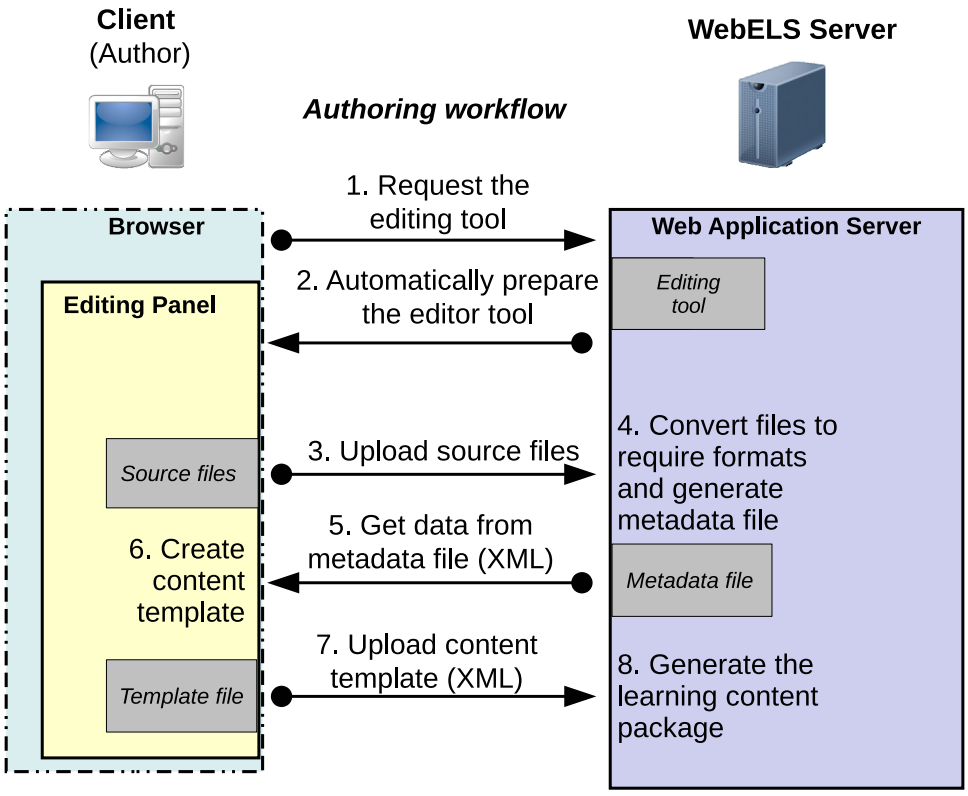


Figure 5.1: System workflow of the proposed tool (Authoring section)

at the server.

On the other hand, the viewing function workflow shown in Figure 5.2 is devised for the student. Student who has permission to access to the learning content can request to view the content. The viewing function workflow consists of four steps: (1) requesting the viewing tool from the server, (2) preparing the viewing tool environment, (3) automatically receives the meta-data content, and (4) automatically plays the complete video and slide synchronized learning content.

In addition, the framework can be applied in a cloud computing environment. It provides efficient computing by centralizing the resources at the server. In authoring and viewing functions, client's computer can the keep the data and use these tools without software installation.

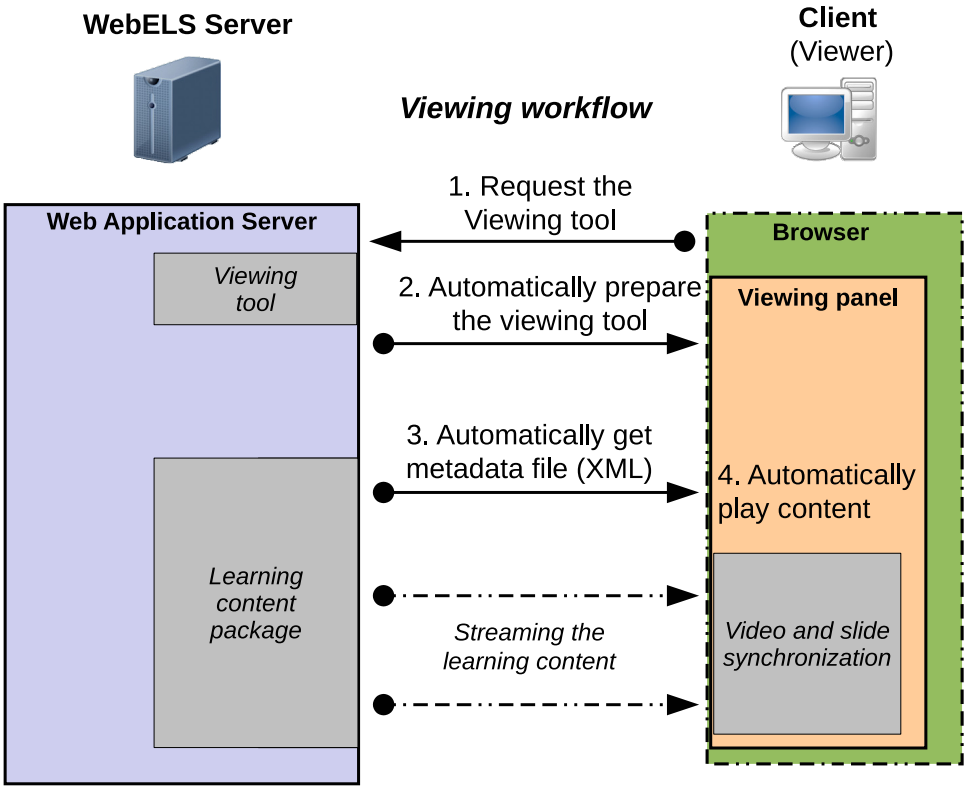


Figure 5.2: System workflow of the proposed tool (Viewing section)

5.2 Required Suitable Technologies

5.2.1 Adobe Flash Technology

For the authoring tool interface, Adobe Flash technology [89] is the best choice because Flash technology is very popular at the moment, and projected to exist still in the future . It has strong benefits, such as lightweight application, cross-platform supported and can be plug-in to any web browsers. Furthermore, Flash has their own technology to use the video stream format (FLV) that can be adapted for real time video playing. This technology is used by several web services, such as YouTube, BigBlueButton, etc.

5.2.2 Video Stream Server

The author decides to use Red5 [90] for managing the video stream data since Red5 is Java-based application, and compatible with Java technology that is used by the existing WebELS system. Red5 is an Open Source Media Server. It is a good productivity software compatible with the Flash streaming content [91].

Red5 delivers powerful video streaming and multi-user solution to the Adobe Flash Player and other exciting client technologies. It supports the RTMP protocol [92] for communicating to Flash clients, which allows them to dynamically interact with the server to stream audio/video, and also allows other functionalities, such as communication with other Flash clients, custom remote procedure calls, etc.

5.2.3 XML

XML (Extensible Markup Language) is a set of rules for encoding documents in machine-readable form [93]. The design goals of XML emphasize simplicity, generality, and usability over the Internet. Although the design of XML focuses on documents, it is widely used for the representation of arbitrary data structures as used in web services. The author uses the XML document for storing editing and output data of learning content.

5.2.4 System Requirement

- Hardware requirement
  - Personal computer or,
  - Notebook/Laptop or,
  - Smart phone/Tablet (only support for viewing content)
- Software requirement
  - Cross platform OS – Windows, Mac OSX, Linux and Android are supported
  - Web Browser – Firefox, Internet Explorer, Chrome, Safari and etc
  - Adobe flash player plugin

5.3 System Framework and Architecture

The author highly considers the reliability and flexibility of the system, thus an application architecture based on client-server system is designed. Contents should be stored on the server side or cloud system to avoid the risk from unstable client's computer. Cross-platform usage should also be supported. Figure 5.3 shows the overview of system framework of the authoring tool. The functions can be divided

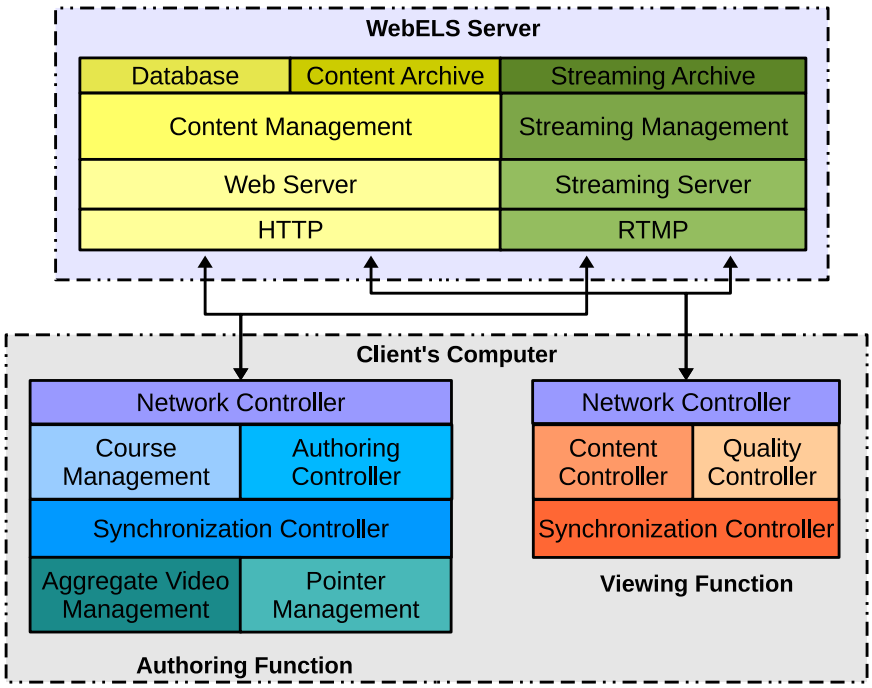


Figure 5.3: Designed framework of the system

into two parts - the server part and the client part. The details are described as follows:

5.3.1 Server Side Processes

The function on the server side is the back-end processes of the proposed authoring tool. The system is performed by Tomcat servlet running on the Linux OS. The author decides to use Red5 for managing the video stream data which supports the RTMP for communicating to Flash clients. The author also uses flash video format (FLV) to contain the video content because it can compress a movie file much more efficient than other traditional video formats, and it takes much less buffering time for playing over the Internet. Several functions are designed for operating the system framework in the Figure 5.3. There are several functions developed to operate the authoring commands. Those main functions can be summarized as follows:

5.3.1.1 Content Management

This function is utilized to process any operations of the raw materials and output package of learning contents. The output packages are stored in the content

archive. The function includes of two important processes described as follows:

Document Conversion : To create a content, source files including video file and presentation file are uploaded to the server and converted to the required formats. Document conversion procedure is utilized for converting the source files that are uploaded by the instructor onto the WebELS server. Conversion includes two sub-processes - (1) video format converter, and (2) presentation converter.

- Video format converter : The raw video stream is converted to Flash format (FLV) in three output qualities such as low, medium and regular qualities to support usage in various network environment. H.264 video codec [94] and AAC audio codec [95] are used for the FLV container. The author uses the FFmpeg program to convert the raw video stream to the required format. FFmpeg is a complete, cross-platform solution to record, convert and stream audio and video [96]. The parameters of the conversion are shown in Table 5.1. In this step, the system requires high resources and processing time depending on the duration of video input stream. After conversion, the FLV output files are fed to the Red5 system for streaming usage.
- Presentation converter : The uploaded presentation file is converted into image file. The system uses a unique output format, PNG [97], to support image conversion from a different format. There are two main programs used to convert the presentation document to PNG format. In the first process, LibreOffice [98] or Openoffice.org [99] is used for converting the Microsoft presentation format (PPT, PPTX) or the Open document format (ODP, SXI) to Portable document format (PDF) . In the second process, GhostScript [100] application is used for converting the PDF to PNG format.

The commands used in the conversion processes are shown as follows:

- Raw video to FLV format

```
$ ffmpeg -i [input_file] -y -b [video_bitrate] -r [video_framerate]
-f flv -vcodec flv -ab [audio_bitrate] -ar [audio_sampling] -ac 2 -s
```

Table 5.1: Parameters setting of conversion process for video qualities

Video-Audio conversion parameters	**Qualities**		
	Low	**Medium**	**Regular**
Video resolution (pixels)	160x120	320x240	640x480
Video bitrate (kbps)	100	200	400
Video frame rate (fps)	25	25	25
Audio sampling rate (kHz)	11	22	22
Audio bitrate (kbps)	32	32	64

[video_size] [output_file]

Ex:

$ ffmpeg -i sokendai.mp4 -y -b 400k -r 25 -f flv -vcodec flv -ab 22050 -ar 64 -ac 2 -s 640x480 sokendai.flv

- Presentation to PDF format

$ soffice --headless --invisible -convert-to pdf [input_file]

Ex:

$ soffice --headless --invisible -convert-to pdf sokendai.ppt

- PDF to Image format

$ gs -r150 -dNOPAUSE -sDEVICE=png16m -sOutputFile=[output_file]-%09d.png -- [input_file]

Ex:

$ gs -r150 -dNOPAUSE -sDEVICE=png16m -sOutputFile=sokendai-%09d.png -- sokendai.pdf

Metadata Generation : After converting the files, meta-data file is generated and automatically sent to the instructor's computer. Metadata generation procedure is used to generate the output learning content. The aggregated video attributes include video index, start time and stop time of the virtual video clip, which are needed to be used for slide synchronization process. Finally, the learning content package is generated and stored in the archives at the server when the save command is called. There are three types of XML file include in the learning content package such as metadata.xml, content_description.xml, and pointer_data.xml.

- metadata.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<description>
 <title>
  National Institute of Informatics
 </title>
 <category subcategory="Higher Education">
  Education
 </category>
 <abstract>
  Future Value Creation through Informatics
  by Advancing Research and Operations
  in Tandem
 </abstract>
 <author>
  Sila Chunwijitra
 </author>
 <ref>http://www.nii.ac.jp/</ref>
 <password>XXXXXX</password>
</description>
```

- content_description.xml

```
<content>
<slides>
 <slide>
  <page>1</page>
  <image>slide-1.png</image>
  <title>
   Slide title for page 1
  </title>
  <description>
   This is a description for page 1
  </description>
  <keymark>
   1 : 100 : 200
  </keymark>
  <pointer>pidx-1</pointer>
 </slide>

 <slide>
  <page>2</page>
  <image>slide-2.png</image>
  <title>
   Slide title for page 2
  </title>
  <description>
   This is a description for page 2
  </description>
  <keymark>
   2 : 200 : 260 | 2 : 300 : 500
  </keymark>
  <pointer>pidx-2</pointer>
 </slide>
</slides>

<videos>
```

```
<video id="1">
 <file>lecture1.flv</file>
</video>
<video id="2">
 <file>lecture2.flv</file>
</video>
</videos>
</content>
```

- pidx-1.xml (pointer_data.xml)

```
<pointers>
 <point>1000 | 100,200</point>
 <point>1010 | 100,250</point>
 <point>1100 | 200,90</point>
 <point>1150 | 210,120</point>
</pointers>
```

5.3.1.2 Streaming Management

Streaming management function is utilized to operate the video stream prepared for learning contents. After file conversion, the video streaming file, FLV format, is generated and stored in the stream archive automatically. This function is operated and controlled by Red5 as a web service application. To use streaming from Red5, the video streaming file must be located in the "streams" directory of Red5 web application. This is because Red5 defines a "streams" directory for each web application. The function works together with Content Management function for aggregated video-presentation synchronization and aggregated video-pointer synchronization operations.

5.3.2 Client Side Processes

The client part is the main user interface used by users, which can be accessed via the general web browsers. Adobe Flash technology is the best choice for imple-

menting the user interface, because Flash technology is popular at the moment, and projected to still exist in the future. It has strong benefits, such as lightweight application and supports cross-platform. It can be plugged-in to any web browsers. Furthermore, Adobe Flash has its own technology for using the video stream format that can be adapted for real time video playing. This part consists of two sections of usage - (1) authoring section for instructor, and (2) viewing section for learner.

Authoring Section : This section is utilized for the instructor to create, edit and manage video-based learning contents. Figure 5.3 provides several procedures for operating the tasks that includes (1) Network Controller, (2) Course Management, (3) Authoring Controller, and (4) Synchronization Controller among aggregated video package, presentation slides and pointer movement positions. The most important procedure is the Aggregated Video Controller which implements proposed key-marking method. Key markings, including video index, key start and key stop, of aggregated videos are processed. This process collects the key marking data map to a selected presentation slide, and generates the synchronized data. It also uses aggregated video timing as baseline timer to synchronize with pointer position movement.

Viewing Section : This section is utilized for learners to access and view video-based learning contents. The selected content is automatically downloaded to the students' computer. Content Controller and Synchronization Controller are used to display the content which contains the synchronized data of video-slides and video-pointer movement positions. The target process is opposite with authoring section. The process uses the aggregated video key markings for time seeking to the actual time position in the raw video, and start the video playback. Moreover, since the author considers the narrow-band usage, Network Controller and Quality Controller are major procedures. They are used to determine the network bandwidth and provide a suitable video quality for the learner.

5.3.3 System Architecture

The author defines the system functionalities for operating the learning contents which are used by users. The user view is separated to two role views which are editing view and viewing view. The relationship of system functionalities and user

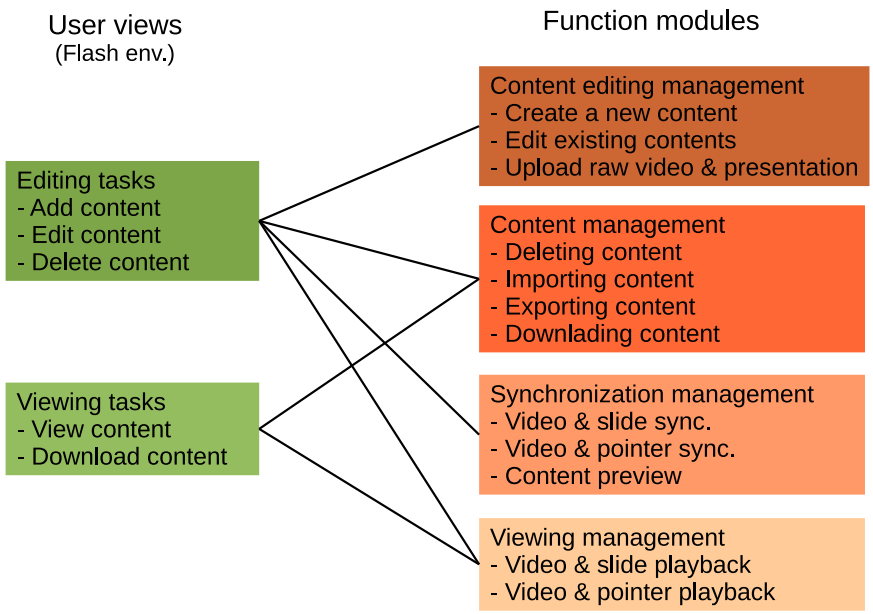


Figure 5.4: Relationship among user views and system functionalities

roles is shown in Figure 3. The proposed system architecture and structure is shown in Figure 5.5. In the server side, the system integrates Tomcat web service, Red5 streaming service, and MySQL database service for supporting the back-end processes. Web service is used to manage raw files uploading, conversion to the required format, and preparing the content archive. While the streaming server is utilized for managing the content streaming, pointer movement data, content template, control , etc. The system handles the learning content by cooperating web service and streaming service, and storing data to the database. Moreover, the server side functions are optimized to support the cloud technology. The system can be installed in the cloud computing environment which allows centralized data storage, processing and bandwidth with other systems.

For the client side, Flash technology is used to implement the user interface for authoring tool and viewing tool used by instructors and students. The tools are proposed based on "easy-to-use" design and minimized for lightweight application usage. Instructors and students can manage and access contents via general web browser environment.

The authoring function is created for the instructor to manage the learning contents by synchronizing raw video and presentation with the proposed key marking concept. It includes several modules, such as network and streaming controller, raw documents uploading management, template management, slide controller,

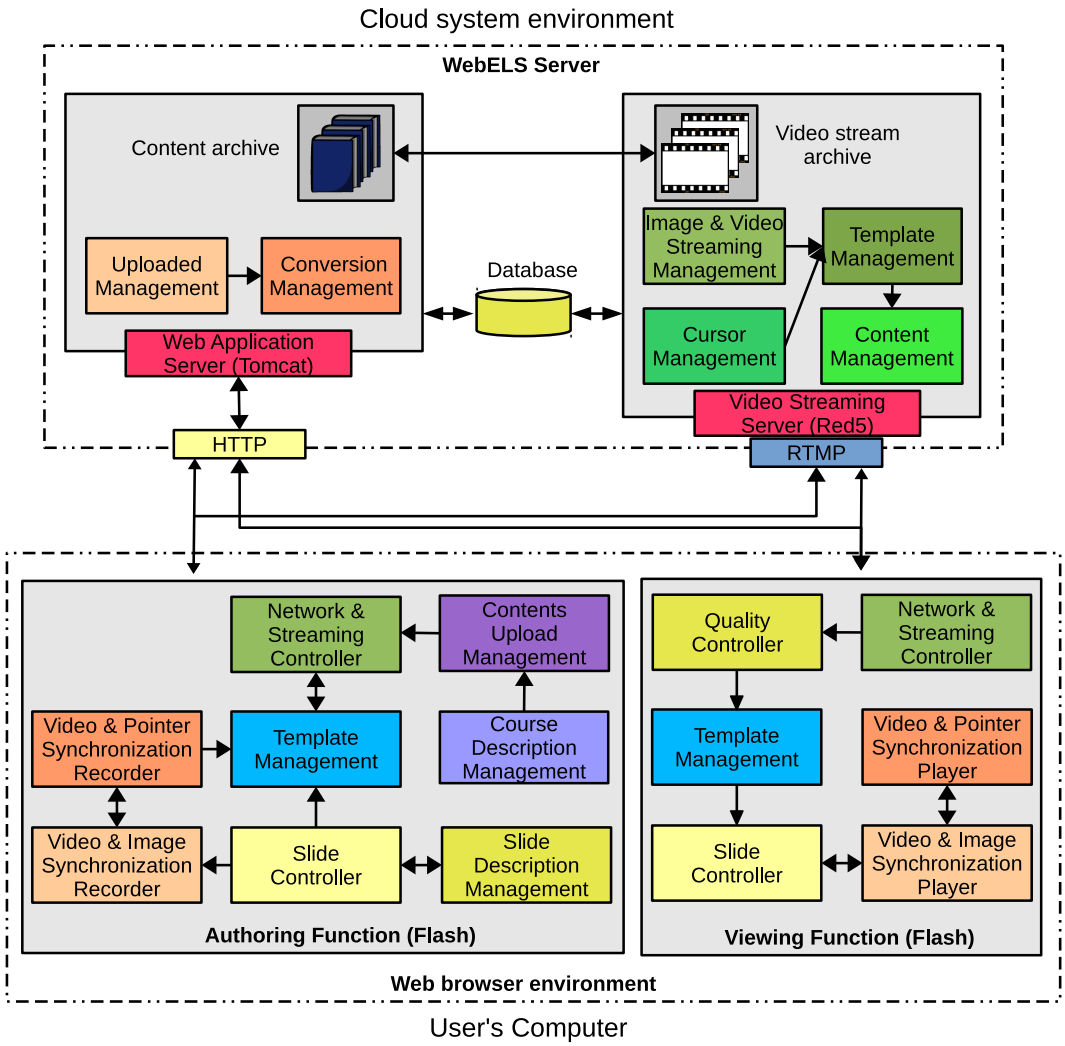


Figure 5.5: System diagram of the proposed system

aggregated video and slide synchronization, aggregated video and pointer synchronization management, and slide description management.

The viewing function is used by students to access the learning contents. The learning content is automatically started to display after downloading. The function composes of network and streaming controller, template management, quality controller, slide controller, aggregated video and slide synchronization, aggregated video and pointer synchronization management.

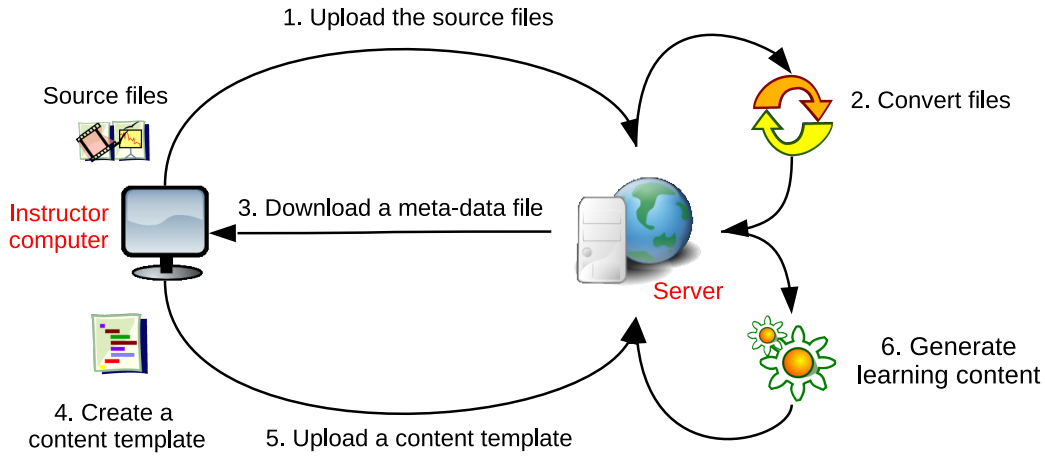


Figure 5.6: Flash authoring tool usage procedures

5.4 System Functionality

In the authoring interface, "easy-to-use" design is the most important feature. Users should keep data and use applications without software installation at their computer. The interface of the proposed system is easy to understand. It has less complicated tasks and has an easy method to manage the learning content. Non-IT users should be able to use it without difficulty. The system should be able to completely support both instructor and learner's tasks. The tool helps instructors create learning activities for learners anytime and anywhere, and manage the contents without the risk from unstable client's computer. Therefore, the author proposes a web-based application which can be accessed via the general web browsers. When viewing the learning content, network connection is always needed for online Flash streaming from the server. Hence, video quality selection function is designed to provide suitable quality content in various network environments without any barriers.

5.4.1 Authoring Function

Authoring function is used by the instructor for managing learning contents. To create a new learning content, source content files, such as video and presentation file must be uploaded to the server. These files are converted to the required formats at the server. After the files have been converted, the tool automatically receives the metadata content from the server for preparing the work environment. Subsequently, the instructor can synchronize the whole video stream with each

slide by means of easy-to-use control buttons. Instructor can manage content, such as inserting slide title and description, and adding mouse pointer action to each slide. Instructor can also add new blank page and delete unused slide. These operations are done at the client machine, and then uploaded to the server after editing is finished to reduce network traffic. Figure 5.6 shows the procedures to create a new video-based learning content.

For the security issue, the author designs the system to embed the password into the learning content for security reason. The embedded password is assigned by the instructor in the authoring function. This password is independent from the user's password of WebELS system. This means that each learning content has double password protection. First protection is from the user management of WebELS system. Second protection is by their embedded password of the learning content. Supported video and presentation file formats are as follows:

- Video formats
  - avi : Audio Video Interleave
  - flv : Flash Video
  - mov : QuickTime File Format
  - mpg : Moving Picture Experts Group Phase 1 (MPEG-1)
  - mp4 : MPEG-4 Part 14
  - ogg : Open standard container format
- Presentation documents
  - ppt, pptx : Microsoft PowerPoint
  - odp, sxi : Open Document Presentation
  - pdf : Portable Document Format

Figure 5.7 shows the design of user interface for the authoring function. 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

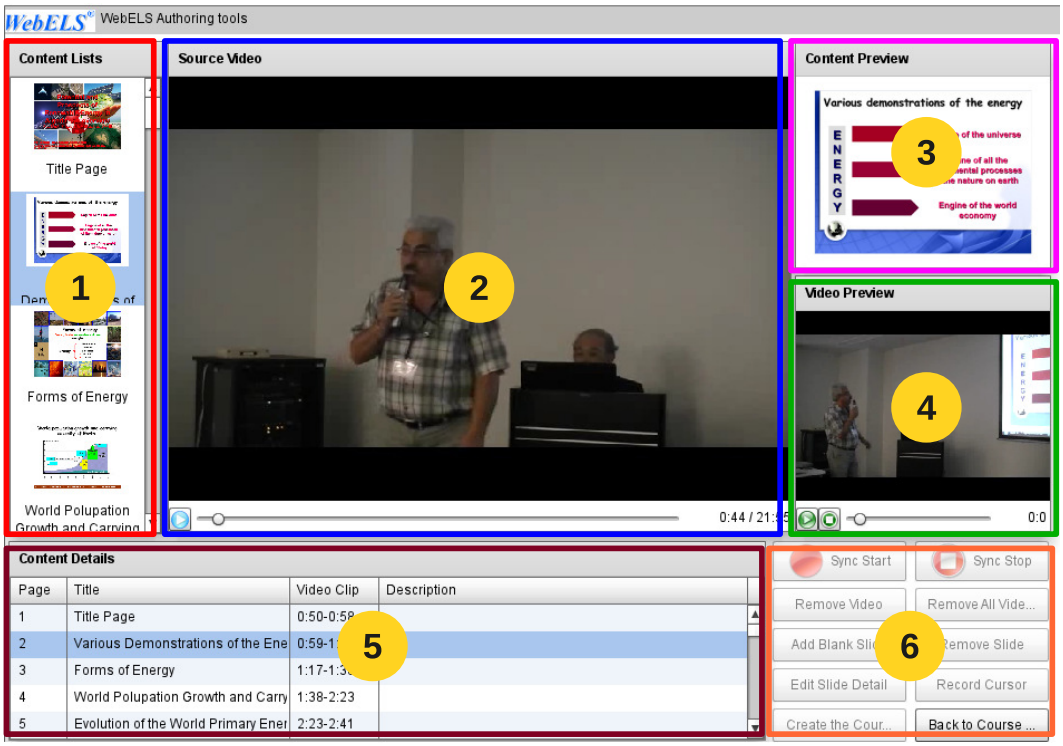


Figure 5.7: Design of user interface for authoring function

slides, and (6) Editing Control Panel for managing learning content. Editing Control Panel contains synchronization tools, remove synchronized video, add blank slide, remove slide, pointer movement management and slide information instructor. The authoring tool can help instructor to quickly create an aggregated video package using key marking from the raw video material by simple processes.

According to the key marking concept, the virtual video clip and aggregated video stream are automatically generated and mapped to the selected slide immediately in the synchronization process. Instructor can preview the synchronized slide and video instantly without saving at the server. To start synchronization, select a particular slide, say the first slide. Video time position is requested as a trigger value to start and stop the synchronization process. A start value is used to define the begin time position of raw video stream for playing and a stop value is used to determine a video time position for stopping the video playback. The synchronization data is recorded and used to produce a virtual video clip subsequently. When the start and stop time positions have been defined, a key marking pointer data is generated. This procedure is used for one virtual video clip. It needs to be repeated for every virtual video clip that is related to the selected slide until it has no related data between the raw video and selected slide.

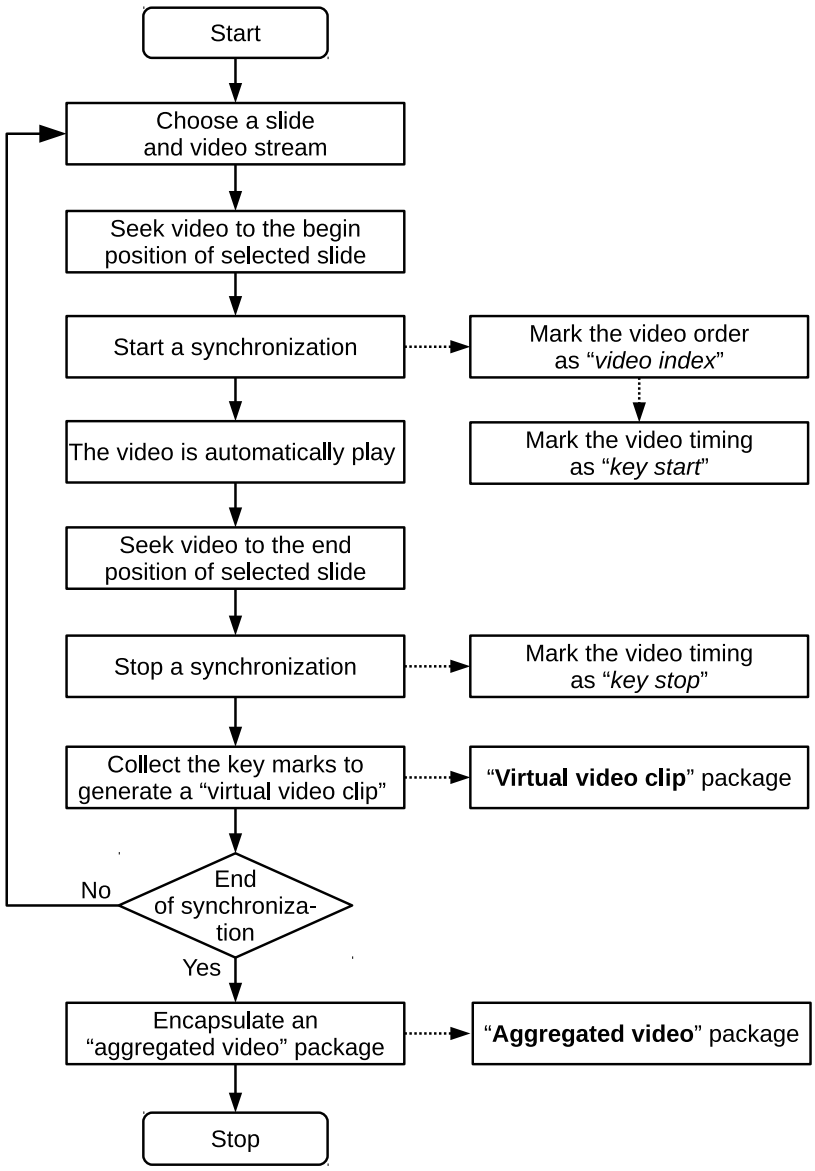


Figure 5.8: Steps to produce "Virtual video" clips and "Aggregated video" stream

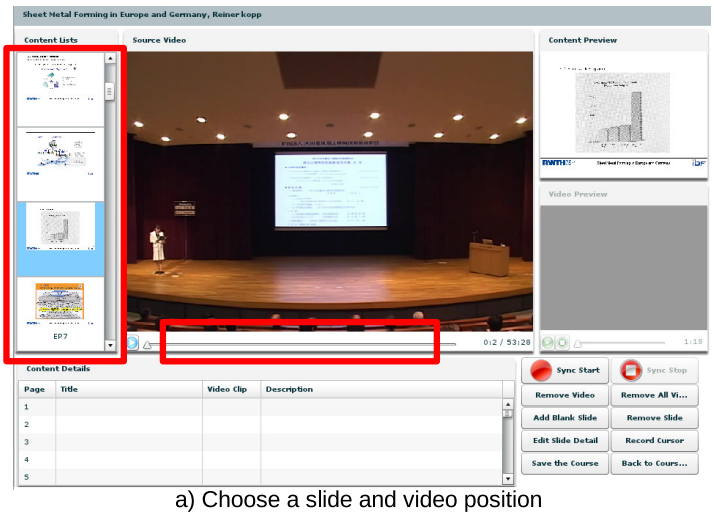
Figure 5.8 shows the steps to produce virtual video clips and how to generate the aggregated video stream.

The two modes of the synchronization process supported by the authoring function, which is used to synchronize an aggregated video from the raw video stream to the slide, are (1) semi-automatic synchronization, and (2) automatic synchronization.

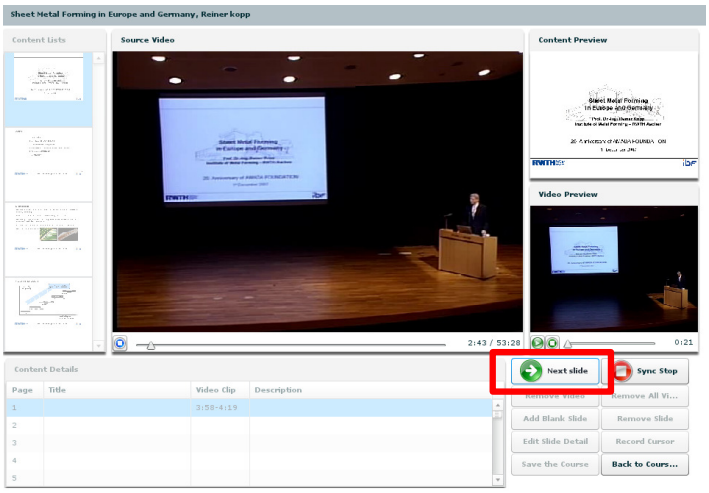
Semi-automatically synchronization mode is utilized to individually synchronize part of the raw video stream to the selected slide with slide-by-slide as shown in Figure 5.9. In this mode, a slide and raw video timing position

are selected at the first step, then start the video and slide synchronization process by clicking the "Sync Start" button. The raw video order is automatically marked as *"video index"*, and raw video timing is automatically marked as *"key start"* subsequently. The raw video is automatically played, and waits until the video timing position move to the end position, i.e., end of the video clip related to the selected slide. However, the raw video timing position can be manually moved to the end position that is related to the selected slide. To end the synchronization process of the selected slide, "Stop Sync" button is required to be clicked for stopping the synchronization. The raw video timing is automatically marked as *"key stop"*, and a virtual video clip is created, and subsequently generates the aggregated video.

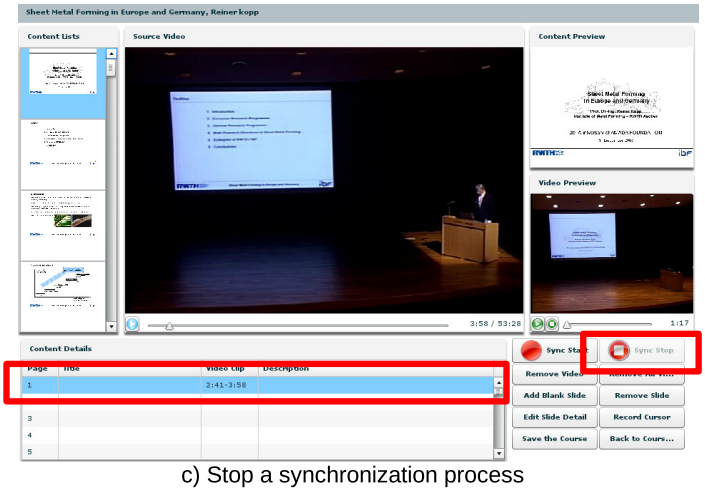
Automatically synchronization mode is utilized to continuously synchronize parts of the raw video stream to the series of the selected slides within a single process as shown in Figure 5.10. This mode is the same as repeating the processes of the semi-automatic synchronization mode. To start the synchronization, a slide and raw video timing position are selected at the first step, then start the video and slide synchronization process by clicking the "Sync Start" button. The raw video order is automatically marked as *"video index"*, and raw video timing is automatically marked as *"key start"* for the first slide. The raw video is automatically played, and waits until the video timing position move to the end position, i.e., the end of the video that is related to the selected slide. However, the raw video timing position can be manually moved to the end position that is related to the selected slide. "Sync Start" button is changed to "Sync Next" button automatically at the same time. Instructor can instantly synchronize the second slide by clicking the "Sync Next" button. In this step, the raw video timing is automatically marked as *"key stop"*, and the virtual video clip is created and generates an aggregated video immediately for the first slide, then change the slide to the second automatically. Then, the system prompts to start the synchronization process by automatically marking *"video index"* and *"key start"* from the raw video timing subsequently for the second slide. Instructor can repeat the synchronization process for the remaining slides until the end of the related video stream for that slide series. To finish the synchronization process, "Stop Sync" button is required to be clicked for stopping the synchronization. The last raw video timing is automatically



a) Choose a slide and video position



b) Start the video and slide synchronization process



c) Stop a synchronization process

Figure 5.9: Semi-automatic synchronization mode

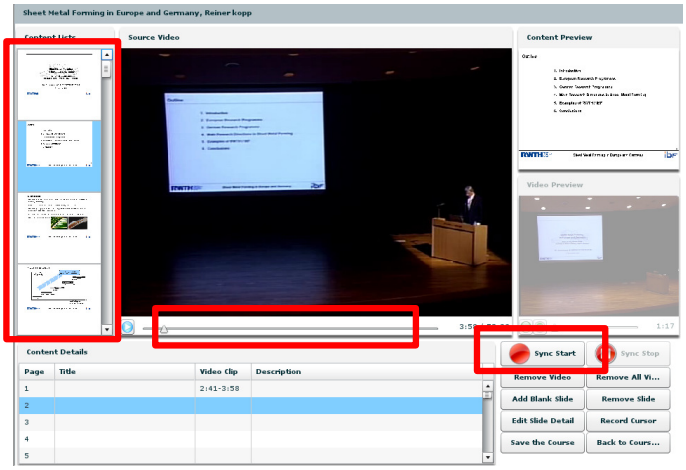
marked as *"key stop"*, and a virtual video clip is created, and subsequently generates the aggregated video.

Figure 5.11 shows the work flow for synchronizing the video stream to a slide for video-based authoring tool. It is easy and a convenient process for synchronization. The flow starts from choosing a slide which needs to be synchronized. After that, seeking a video time at the beginning position that is related to the slide, then start the synchronization process. The video will be automatically played. Move a video time to the ending position for the selected slide. Finally, stopping the synchronization is needed to end the video and slide synchronization work flow. The synchronization data will be recorded and used to produce a video clip subsequently. This work flow is used for one slide. It needs to be repeated for every slide that has synchronization content.

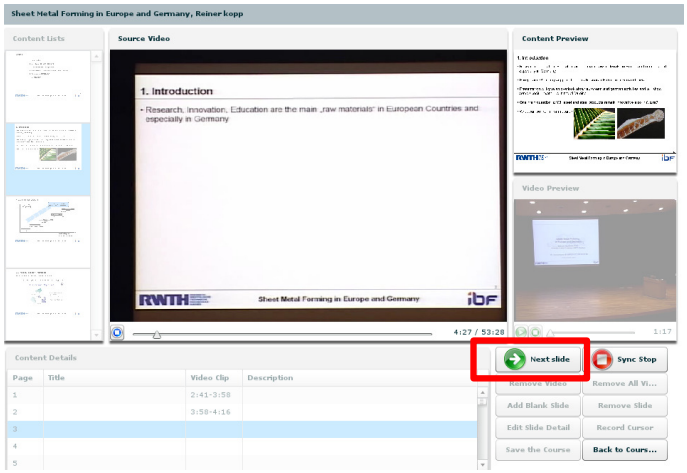
5.4.2 Viewing Function

Viewing function is used for displaying the learning content created by the instructor. The user interface is very easy to use because it has no complicated functions. When a learner selects a specific content, the tool then automatically downloads the content package and extracts at the student's computer. It includes metadata, content template, presentation slides, video stream, and synchronization data. There are two main XML files, such as metadata and content description files. The content definition, such as content title, description, and references are retrieved from the metadata file, while the content description file obtains the synchronization data of each slide.

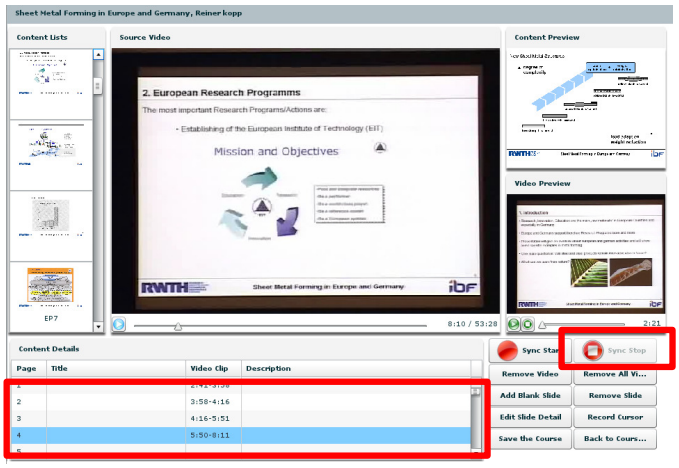
To display a content, the content template is reproduced and prepared for the synchronization process. The required information of each slide includes aggregated video encapsulated package, slide information, and pointer movement synchronization. The encapsulated package of aggregated video stream can be retrieved from the content description, which is extracted for creating virtual video clip subsequently. Then, key marking data of each synchronized slide is split from the aggregated virtual video clip, such as video index, key start and key stop. Finally, the content template data contains control information to manage the synchronization of aggregated video and slides is generated at the local side, and automatically starts the synchronized playback immediately. Figure 5.12 shows the steps to display synchronized slide with "Aggregated video" stream.



a) Choose a first slide and video position



b) Start the video and slide synchronization process. Click 'Next Slide' button to change to the following slide by keeping the slide-video synchronization



c) Stop a synchronization process

Figure 5.10: Automatic synchronization mode

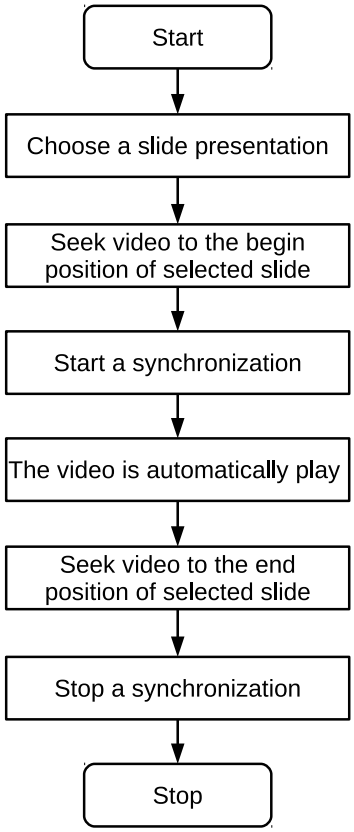


Figure 5.11: User interface of pointer movement synchronization

Using these key marking data, RTMP stream transfers the aggregated video from the Flash streaming server to the client video player, starts the playback when there is enough buffered video data, and playback continuous until end of the aggregated video. When changing slide, video streaming is controlled by a corresponding key marking data. With RTMP streaming, skipping part of the video to create an aggregated video to synchronize with the slides, downloading the entire raw video onto the viewer's video player is not necessary.

The system has three video content qualities for the viewer to support usage in various network environments. During playback, quality controller is utilized to provide suitable video content quality in all network environments. The tool provides the option for students to use video quality optimized for low-speed network environment and to view contents without any inconvenience due to frequent stoppage for buffering.

Generally, video content does not continuously play in the low-speed network, and that it looks like frame-to-frame motion in case of direct streaming delivery for short buffering time setting. To enhance the video playback process synchro-

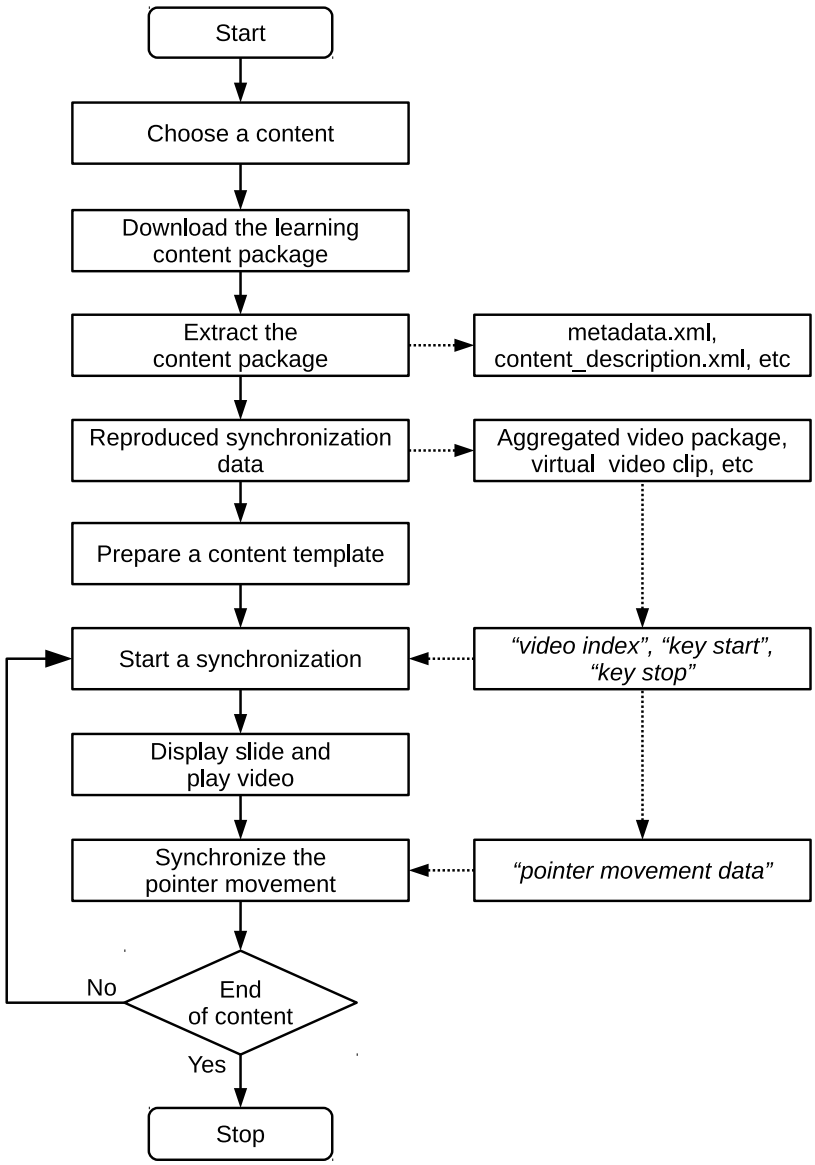


Figure 5.12: Steps to display synchronized slide with "Aggregated video" stream

nized for each slide, a progressive downloading technique is considered [101]. With this technique, video stream data is downloaded and buffered as it is received, and then playback starts after a specified minimum portion of the data has been downloaded. Progressive downloading requires buffer to hold data for the video player to use at a later time. Therefore, the author implements an adaptive video buffering method to the video player section [102], [103]. The method is utilized to keep long buffering time for each aggregated video clip for smooth video playback in the narrow Internet environment. The video buffering time of the player is automatically adjusted based on the Internet bandwidth and the video bitrate. The

adaptive video buffering time equation is shown below:

$$bt' = vl(1 - (bw/vb)) \tag{5.1}$$

$$bt = \begin{cases} k_{max} & \text{for } bt' >= k_{max} \\ bt' & \text{for } k_{min} < bt' < k_{max} \\ k_{min} & \text{for } bt' <= k_{min} \end{cases} \tag{5.2}$$

where

bt' - is the estimated video buffering time (second)

bt - is the adaptive video buffering time (second)

vl - is the aggregated video clip length (second)

vb - is the video bitrate (kbps)

bw - is the network bandwidth (kbps)

k_{max} - is the maximum buffer time constant (second)

k_{min} - is the minimum buffer time constant (second)

In equation (5.2), the author set k_{max} and k_{min} to 60 seconds and 0.1 second, respectively, while *bt'* is dependent upon the network bandwidth and video clip parameters calculated using equation (5.1). The first condition in equation (5.2) happens when *bt'* is equal to k_{max} or more as a result of a higher video bitrate than the network bandwidth. At this condition, the author keeps the video buffering time equal to k_{max}. In the second condition, the video buffering time will be set equal to *bt'* for its value ranging from k_{max} and k_{min}. This condition also occurs when the video bitrate is higher than the network bandwidth and for all aggregated video clips less than k_{max}. The third condition happens when the value of *bt'* is less than this k_{min} regardless of the length of the aggregated video clip. This also means the video bitrate is less than the network bandwidth, such as in the high-speed network environment.

Figure 5.13 shows a mechanism for video playing with progressive downloading and buffering of real-time data streams. When the viewer starts to view content, the video stream is downloaded and buffered until the video buffer becomes full or has reached *bt*, and video playback starts. During playback, incoming video data stream is continuously downloaded and buffered until the end of the video stream, and then video playback stops.

Figure 5.14 shows the viewing function interface design. Students can only view the learning content, but editing is not allowed. The interface consists of four

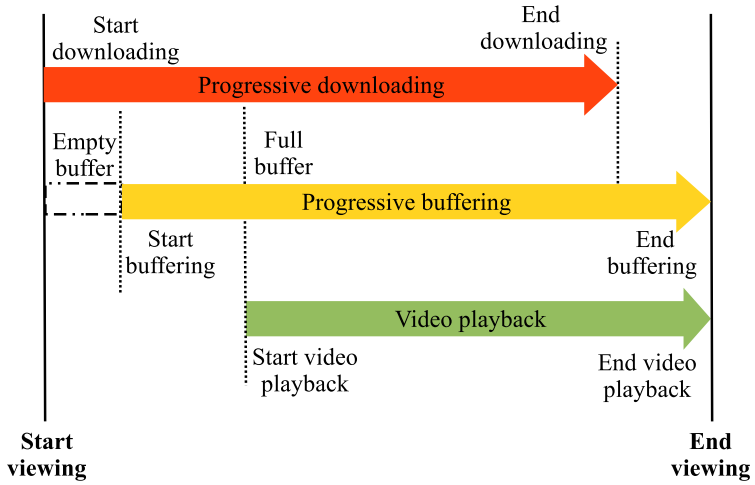


Figure 5.13: Mechanism for video playback with progressive downloading technology

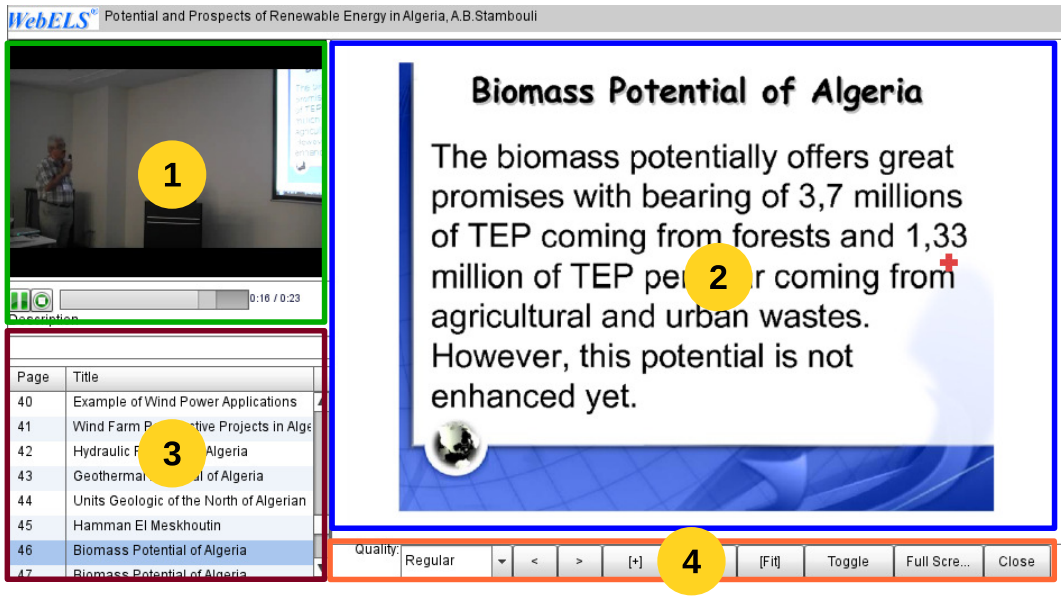


Figure 5.14: The design of user interface for viewing function

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. Student can toggle view between video and slide panels. They can also zoom both video or slide contents to examine more closely or in greater detail. Pointer movement is visualized in this panel in case the

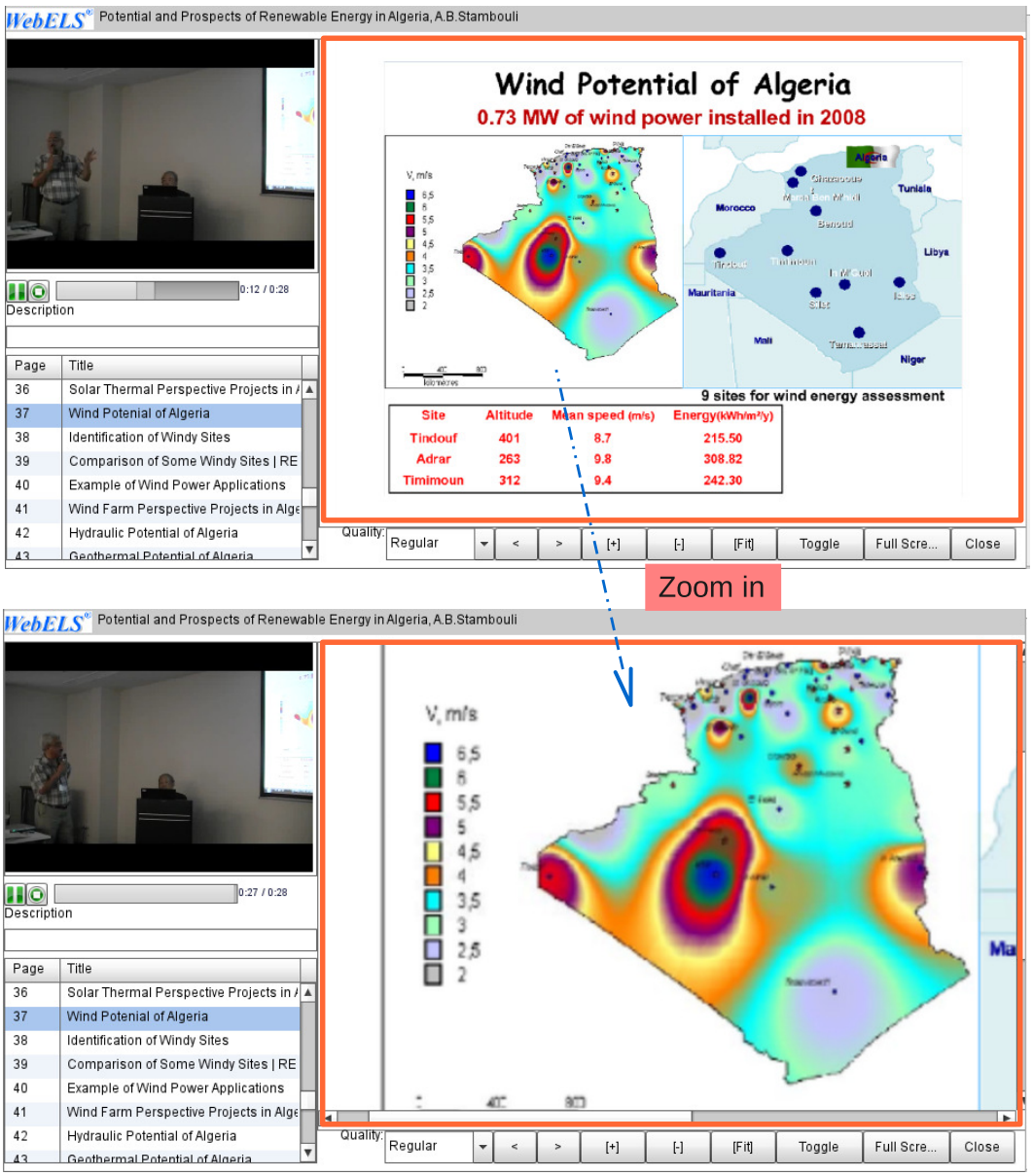


Figure 5.15: An example of zoom-in feature in the viewing function

editor synchronized it with the aggregated video. The pointer mark automatically moves while the video is playing. An example of zoom-in function is shown in Figure 5.15.

5.4.3 Pointer Movement Function

In this research, pointer movement concept is proposed to synchronize special object movement on the slide while the video is playing. Pointer object can be positioned in the slide to focus the presenter's discussion. There are 2 modes of

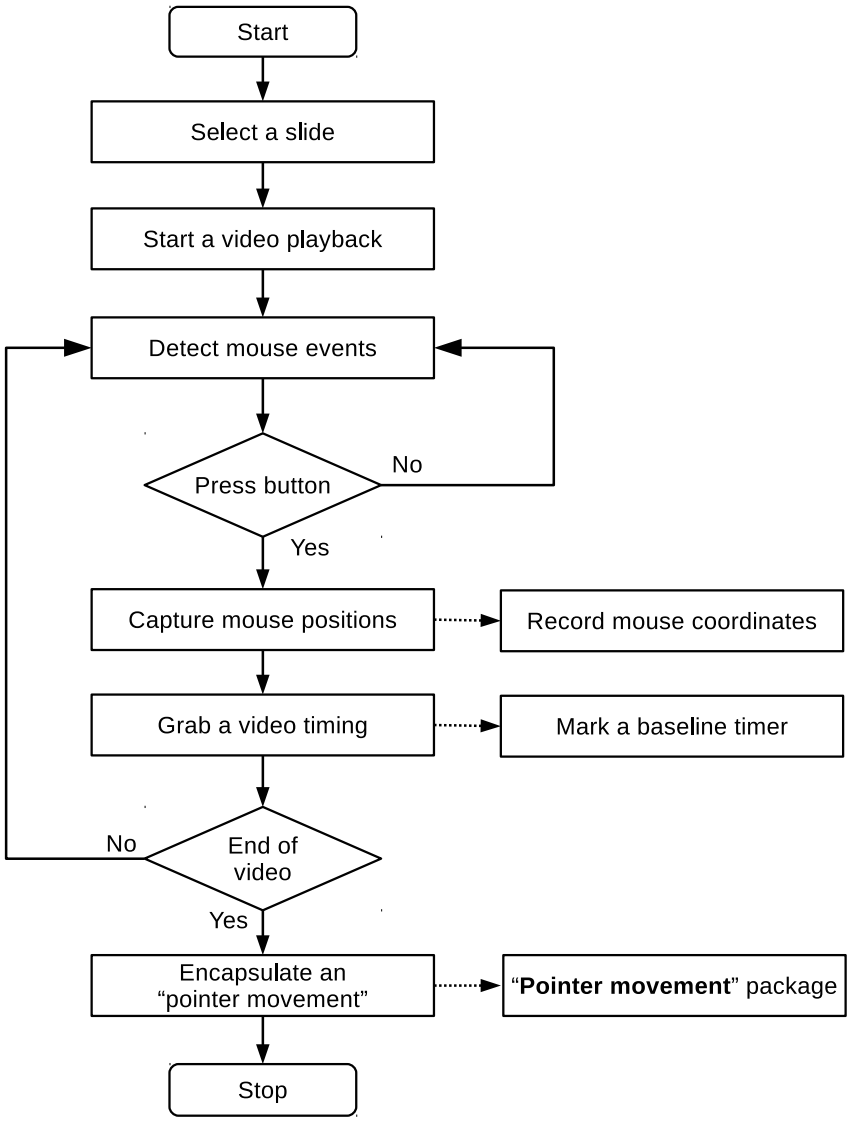


Figure 5.16: Workflow of video and pointer movement recording

the function. The details are described as follows:

Record mode : This mode is utilized to support the authoring function for generating the pointer movement actions. In the implementation, the author uses the aggregated video timing as the baseline timer for synchronization. The pointer movement positions are recorded as a series of mouse coordinates (X, Y) corresponding to the baseline timer while the video is playing. The function only records the data when mouse button is pressed and dragged by the

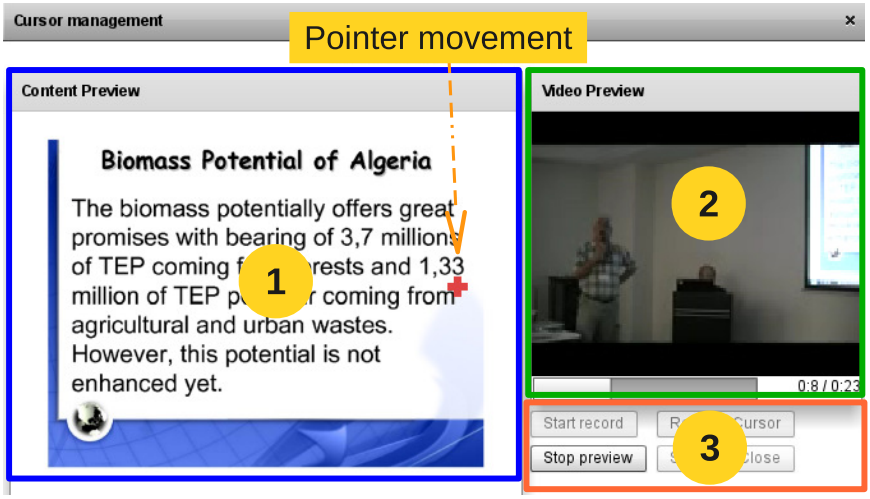


Figure 5.17: User interface of pointer movement synchronization

editor. When the mouse is stationary, it is not necessary to record the mouse coordinate with the video stream timing. This technique can minimizes the size of pointer action data. The recorded video and pointer synchronization data are separately stored into an archive file. Each slide has its own pointer movement data depending on synchronized video stream. Figure 5.16 shows the workflow of online aggregated video and pointer movement synchronization. Instructor can generate pointer movement of each slide which is synchronized with aggregated video stream. The popup interface is separated from the main authoring interface as shown in Figure 5.17 because of the limitation of screen. There are three panels, namely (1) Slide Panel for recording the pointer movement, (2) Aggregated Video Panel for displaying an aggregated video of a current slide, and (3) Control Panel for supporting instructor to synchronize pointer movement with aggregated video stream. It is easy to add, remove and preview the pointer movement. To record the pointer movement, instructor can press mouse button and move mouse position in the slide panel area while aggregated video is playing. A special mark is used to visualize as pointer movement. The tool records movement positions which are synchronized to the aggregated video timing, and saved the data to the file subsequently.

Playback mode : This mode is designed for viewing function. It is the reverse process of the record mode. The aggregated video timing is used as the baseline timer for the synchronization as in the record mode. In this mode, the

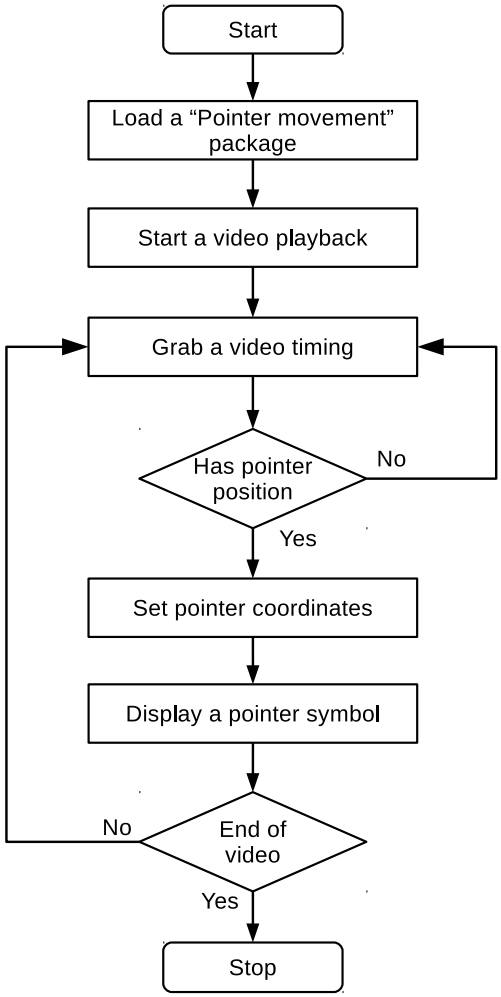


Figure 5.18: Workflow of video and pointer movement playback

pointer object is automatically changing positions corresponding to baseline timer while playing the video stream. This technique can solve issues of various kinds regarding the Internet speed connection, and mainly for low-speed Internet connection. The pointer movement is frozen while the video freeze or stop, and automatically moved after video stream become playing again. The system can keep the corrected display position of the pointer movement while buffering video stream data, or use the system with unstable Internet connection. Figure 5.18 shows the workflow of pointer movement playback. Figure 5.19 shows an example of slide synchronized with pointer movement.

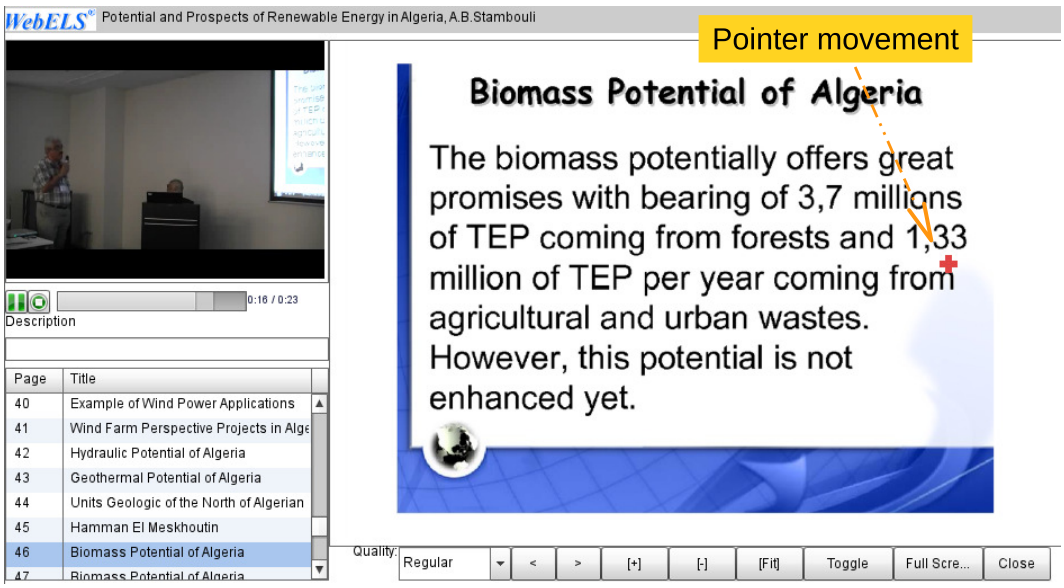


Figure 5.19: An example of slide that synchronized with pointer movement

Chapter 6

Video Meeting Function

WebELS Meeting is one of the video conference applications that integrates several functions for supporting online meeting activities. The benefits of the system are :

- Online cursor synchronization that requires lower network bandwidth compared with other online meeting systems. During online presentation operation, the presenter can spotlight the specific position in the content slide by means of an online cursor. With this, it is possible to know which part of the slide the presenter is focusing. This method can make the content attractive and interesting to students or audiences or joiners.
- The online video conference of the system overcomes the network environment that defines strict firewall policy in their network domain. This feature can eliminate troublesome to users when they use the system in the global scale. The video stream can access through the firewall rules because it uses the general web protocols, such as HTTP (80) and HTTPS (443).

These features of the system has eventually opened the opportunity for the business sector. Nevertheless, several issues were discussed and considered in the business point of view to make an online video conference system credible and suitable for business companies, such as management functions, security issues, privacy of content, etc. Both privacy and security of content are important issues for business communication, since content is an asset of the person who has created the content. For content privacy, each member of the group can only access their own group's content. Moreover, this technique can reduce administrator task, and easy to monitor activities in each group.

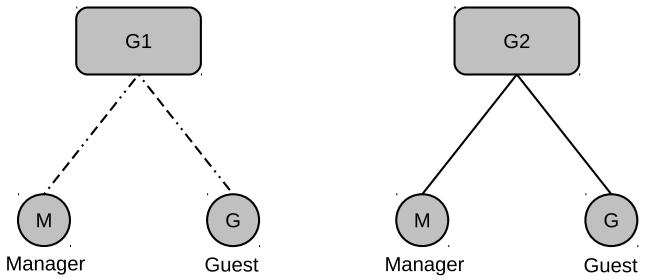


Figure 6.1: Simple group-based concept

6.1 System Design and Architecture

In response to the business meeting requirements, the author designed and implemented a new managing structure to override the existing structure while keeping the same technologies for future development, such as the old structure of the system is being preserved. The concept of the system is based on our simple user-group control. The users in the system consists of member groups and administrator. The administrator can manage the member groups and system, but he/she cannot create and edit contents. For the member groups, each group hold two passwords which are (1) password for group manager, and (2) password for guest of the group. The group manager can manage the contents in own group and also monitor member group activities. Contents in each group cannot be accessed by members of other group which is an important policy in the business situation. Figure 6.2 shows the system design of functional structure for supporting the business sector. In the design, the author separates the system into 3 modules which are (1) Member Verification, (2) Roles Controller and (3) Administrative modules. The details of modules are described as follows:

6.1.1 Member Verification Module

Member Verification module is used to identify the member and separate the member role. The author uses an existing WebELS Meeting for the implementation, therefore almost all existing main functions including front-end functions for user and system backend services must work without any problem. The new group-based concept must be completely integrated to the existing system. The database schema is re-designed to support new requirements because an existing system has been utilize for the traditional user-group management on the database schema and user management tool. Many features are decided to be added, e.g., limitation

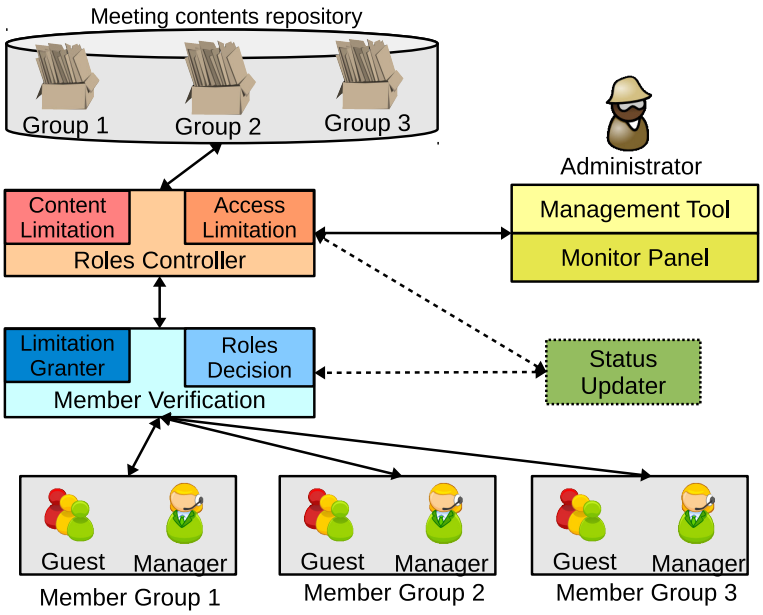


Figure 6.2: System architecture of system management for the business meeting

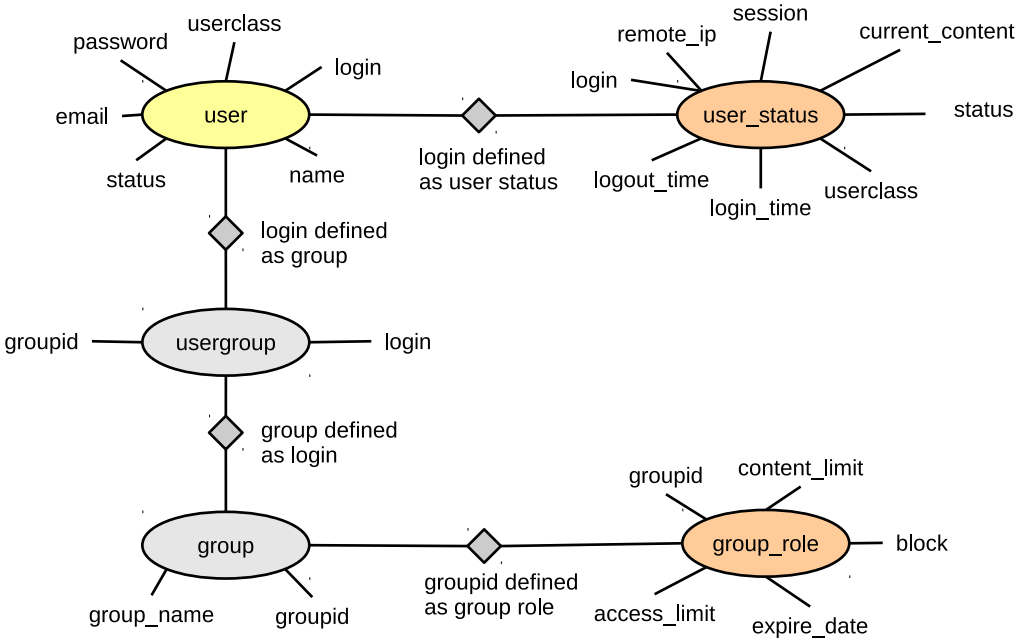


Figure 6.3: Database entity relationship of the system

of contents in each group, limitation of concurrent users, user and group privileges, etc. Figure 6.3 shows a new database schema. There are two new tables that were added, such as "group_role" and "user_status, and also table "user" was modified to achieve these features.

Based on the concept, the author defines the group name the same as the user

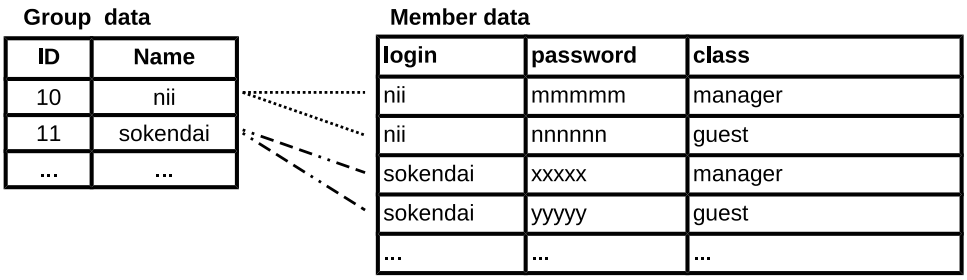


Figure 6.4: Example structure of user and group data

login name. The technique to distinguish the user privilege is to use two different passwords for one group. Hence, the author uses two records of user table to keep the user data and group role as shown in Figure 6.4. To strengthen the security technique, every user password is encrypted in two steps. First, the plain text password is encoded by WebELS key-code. Second, the password is encrypted again by MD5 [104].

This module consists of two main sections such as Role Decision and Limitation Granter sections.

Role Decision : Since the group role is dependent on the user login name and user password, this section matches both user login name and user password. The system uses the user class where the record is specific for the group role. This value is feed to the Role Controller module subsequently.

Limitation Granter : This section is introduced for checking the special member properties. The block property is utilized to allow or deny usage of members in the system. While a member group is blocked, every member cannot access the system even if the contents of this group have existed in the system. When a member group is unblocked, every member can use the system to carry on the existing contents of the group. Not only block property is available but also the expiry time is utilized for controlling the usage limitation time of the system for each group, in the case of free trial service for customers.

6.1.2 Roll Controller Module

Role Controller module is utilized to manage user privilege who accesses the system. There are two important roles needed to control such as content permission

and connection control mechanism. This module consists of two main sections such as Content Limitation and Access Limitation sections.

Content Limitation : This section is utilized for limiting the number of contents in each group. While the group manager creates a new content, the system checks the number of existing contents of their group and compared with the limitation value of that group. In case the number of existing contents equal or more than the limitation value, the permission for creating and any authoring tools will be denied.

Access Limitation : This section is generated for limiting the number of users who access to the system at the same time in each group (concurrent access). The author defines the user status if login succeeds and the status will be cleared after the logout. The system uses that status for counting the number of accessing users. For the logout status, it is complicated to be implemented because we could not control users to do a proper method of logging-out from the system. For example, when someone who has logged-in to the system has accidentally shutdown their computer, or someone closes the browser without logging out from the system, etc. Therefore, user status is not cleared, and the number of logging-in users is incorrect, too. The author solved this problem by creating a system checker that runs in the background mode for clearing the user status automatically.

6.1.3 Administrative Tool

The Administrative tool, a feature for the administrator user, is applied to manage and control the system. User group member, role privilege, system limitation, and system group monitor are focused. This module consists of three main sections which are Management Tool, Uninvited Member Controller and Monitoring Panels sections.

Management Tool : This tool is used for adding, editing and deleting group members and group roles information. For security reason, this tool cannot manage contents in each group. When deleting a group member, this tool removes all contents of deleted group from the system such as, database, virtual room and data in physical storage.

Uninvited Member Controller : This section is used to manage meeting participants while the meeting is running. There are two actions such as break any actions and eject (kick-off) from the meeting. The participant who become an administrator of meeting can use those functions to control an uninvited participant who has a behavior to disturbed other participants during the meeting.

Monitoring Panels : The author designs the monitoring panels for helping the administrator and group manager to monitor their system. This tool is for checking the system information. It is separated into two kinds which are (1) System Monitor Panel is purposely for the administrator. This panel is used for monitoring the overall information of the system, such as number of contents, number of users, content size, etc, and (2) Group Monitor Panel is used by group managers. The group manager can track the activities of each user in their group, such as number of logged-in user, active content and action of each user, etc.

Figure 6.5, Figure 6.6 and Figure 6.7 are examples of user interfaces of the proposed system. Figure 6.5 shows the group management tool used by the Administrator. It includes group information setting, passwords for manager privilege, password for guest privilege, content limitation, access limitation, and uninvited group member protection. Figure 6.6 shows the monitoring interface for group manager. A group manager can determine the number of the current logged-in users, current content of each user, action task of each user, and other information. Figure 6.7 shows the system monitor interface for the Administrator. Administrator can know the information of each group such as number of contents, actual content size in the server, and group privileges.

6.2 Quality Management for Video Meeting

This section presents method for improving the online video conference section and annotation section to work well and have smooth operation in the low-speed Internet network with the convenient functionality. The method is utilized for helping the students or users of using the WebELS Meeting system in the low-speed Internet or unstable network situation in the developing countries. The author set goals for improving the performance of the system such as automatic

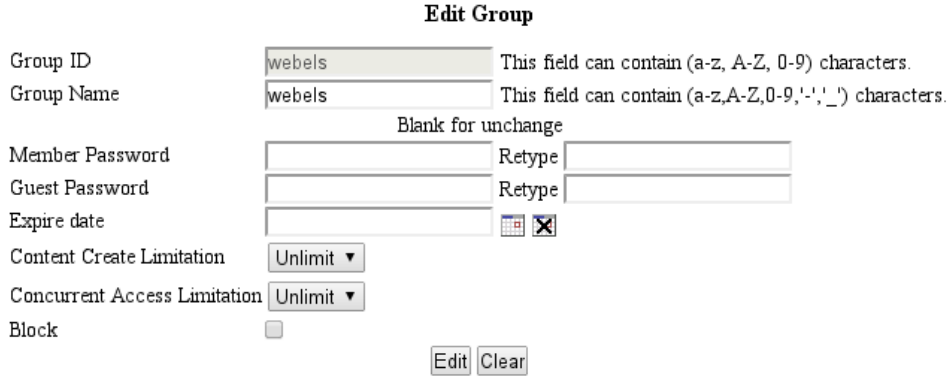


Figure 6.5: User interface of simple group-based management

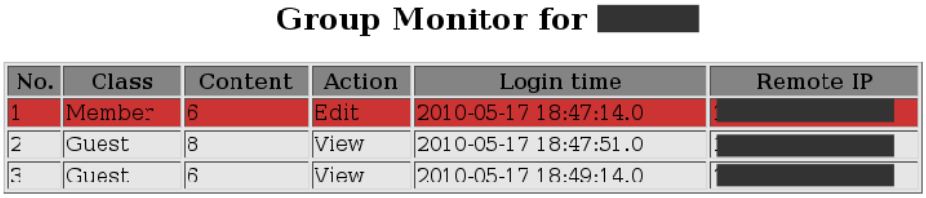


Figure 6.6: User interface of group monitoring tool

re-connection to the conference room when network connection is lost, adjust the video and voice quality parameters by users for low-speed network, reduce the annotation synchronization time in the low-speed Internet environment, smoother use of the system in strict firewall environment, and must support multilingual function for world-wide use.

6.2.1 System and Design

The author separates the improvement into two main parts - (1) online video meeting system, and (2) online annotation system. The details are described as follows:

6.2.1.1 Online Video Meeting System

In the design, the system is separated into two parts - (1) the server side part is mainly for managing the conference services, and (2) the client side part is used for controlling the client processes. The details are described as follows:

System Monitor

No.	Group	Content Limit	Access Limit	Content Number	Content Size (kbytes)
1	[redacted]	Unlimit	Unlimit	2	4,184
2		Unlimit	Unlimit	17	28,553
3		3	10	2	4,526
4		5	2	4	3,610
5		Unlimit	Unlimit	37	13,634
6		Unlimit	Unlimit	4	8,775
7		Unlimit	Unlimit	23	323,622
8		Unlimit	Unlimit	1	3,474

Figure 6.7: User interface of system monitoring tool for Administrator

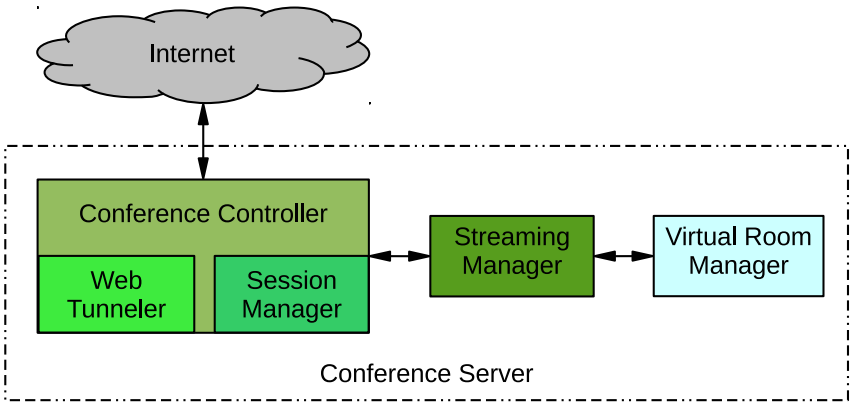


Figure 6.8: System diagram of the conference server side

Server Side Part – The conference server is the main part of meeting system. It is the back-end system used for providing processes of the online meeting. The main function is to receive the conference streaming from client node and distribute to all other client nodes. In addition, the server is to control the conference operation between clients and server. In this part, there are two services running on the server - (1) web server for servicing the web interface, (2) streaming server for servicing the video and voice streaming. Figure 6.8 shows the design structure of server side system. The system consists of three modules as follows:

Conference Controller : It is the front-end for connecting to the client nodes via the Internet network. It is also the main module used for managing the video meeting system. There are two main functions - (1) Web Tunneler function, and (2) Session Manager function.

- Web Tunneler is used to make a streaming tunnel that use HTTPS protocol as gateway on port 443. This makes the system to be used

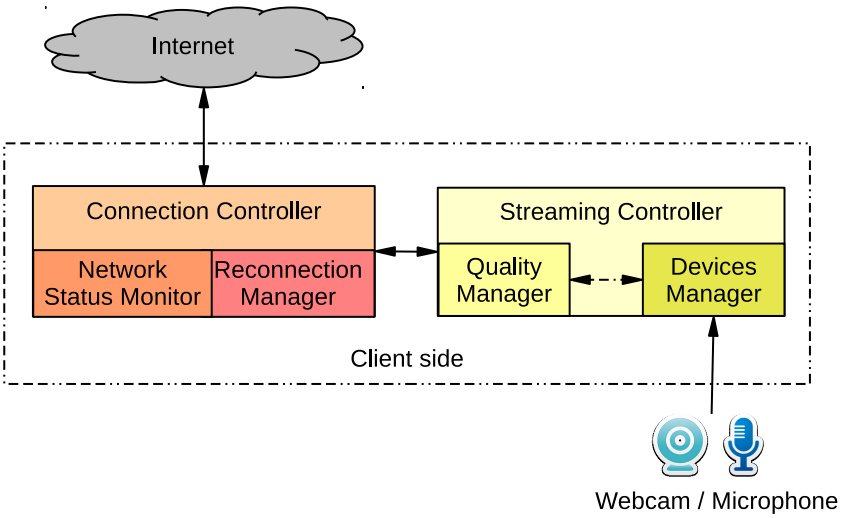


Figure 6.9: A system diagram of the conference client side

in locations where the strict firewall policy is applied. In this case, the web server application should be supported the web reverse proxy.

- Session Manager is used to manage the channel of the conference. It also controls the connection session, concurrent number of the session and other resources of the system in each virtual conference room.

Streaming Manager : It is used to control the conference data such as video and voice streaming. Several parameters are used for configuring the conference streaming data such as streaming connection, streaming data size, streaming limitation, and shared resources of the streaming.

Virtual Room Manager : It is used to manage the physical storage space for servicing the online meeting operation. This space is called "Virtual Room". Virtual room is automatically created when a user creates a content. The virtual room can be used until the content is deleted.

Client Side Part – The client side part is used in the client node for connecting to the virtual room of online meeting system. The system is automatically downloaded and runs on the client computer via web browser when the students access to the conference web page. The system supports cross-platform, thus it can be used in several operating systems (OS) such as Windows, Linux and Mac OSX. Figure 6.9 shows the design structure for the client side. The system consists of two modules as follows:

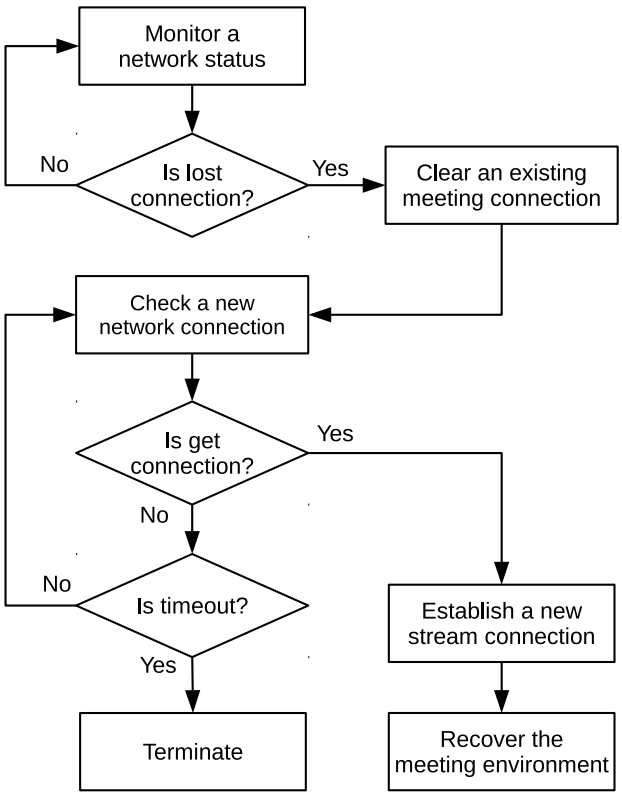


Figure 6.10: Automatic re-connection workflow

Connection Controller Module : It is used to manage and control the network connection of the client nodes. Moreover, display messages of user interface are controlled by this module. Figure 6.10 shows the workflow of automatic re-connection process. There are two functions included in this module as follows:

- Network Status Monitor is used for monitoring the status of network connection while the meeting session is ongoing. After the student logged-in to the system, this function always checks the network connection between the server and client nodes. In case of network disconnection, the reconnection manager function will be triggered for handling the connection process.
- Reconnection Manager is used to keep the network connection when the connection is lost. This function clears the old connection handler for instance, connection session, release and free the devices, etc. This function also waits for the new connection status. When the connection signal appears again, then login process is automatically done by using

Table 6.1: Video and Audio setting parameters for each meeting quality

Video and audio input parameters	**Meeting Qualities**		
	Low	**Medium**	**High**
Video resolution (pixels)	160x120	320x240	640x480
Video compression rate (Video frame rate (fps)	5	5	5
Audio sampling rate (kHz)	8	8	8
Audio bitrate (kbps)	12.8	12.8	20.6

the latest meeting information.

Streaming Controller Module : It is used to control the streaming input of the client node. This module includes two functions.

- Device Manager is used to manage the basic input devices such as microphone and web camera (or video camera). This function detects the input devices from the operating system. In addition, this function is used for controlling the state of input devices such as setting the devices whether ON or OFF. In case the client node does not have web camera and microphone devices connected to it, the system will disable all input features and force the student to only use the chat channel instead of the video streaming.
- Quality Controller is used for controlling the quality of streaming data from the input devices. Several parameters are used for configuring the conference streaming data such as video size, video compression rate, video frame rate, audio gain, audio sampling rate and audio bitrate. Table 6.1 shows the proper setting parameters for video and audio of all meeting qualities in the improvement.

6.2.1.2 Online Annotation System

When the presenter is writing, the annotation data will be sending to server in real time then the system is interrupted for waiting the server response. The annotation movement becomes unsmooth when the presenter wrote much more resulting to a huge annotation data. The data sending function is considered to be

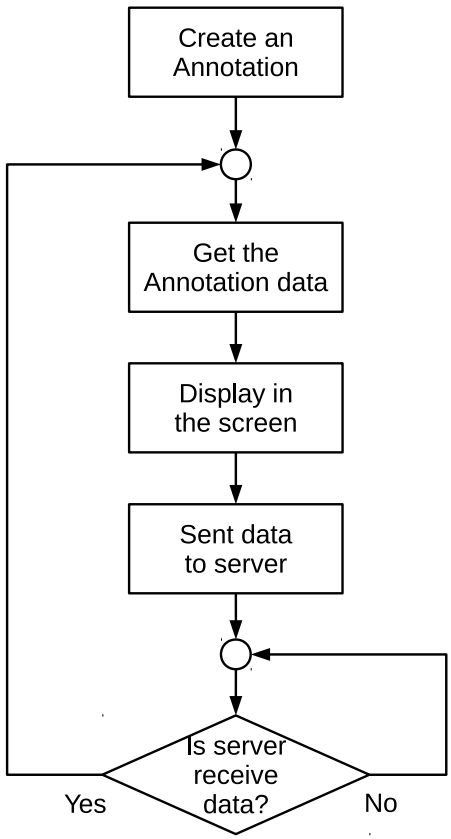


Figure 6.11: Workflow of old method for transmitting annotation data between server and presenter's computer

refined. The concept is to reduce annotation data communication between server and presenter's computer. Real time technique was utilized for sending annotation data to the server, therefore the author modified that function by using queue with a timer to send annotation data instead of a real time technique.

In the old method, when the presenter creates any annotation events, the data are collected and displayed in the presenter screen. After that, the data will be sent to server in real time and waits for the response from server. Until receiving a response, new data will be collected again. In case of huge annotation data, the system takes more time to transmit data to server. Not only huge data transmission but also narrow bandwidth usage takes effect to the response time between presenter's computer and server. Workflow of this method is shown in Figure 6.11. The workflow shows that new cycle for collecting and displaying data are dependent from data sending process. This is the main cause of unsmooth annotation data displaying.

For the new improved method, idea of data queue is applied. The timer function

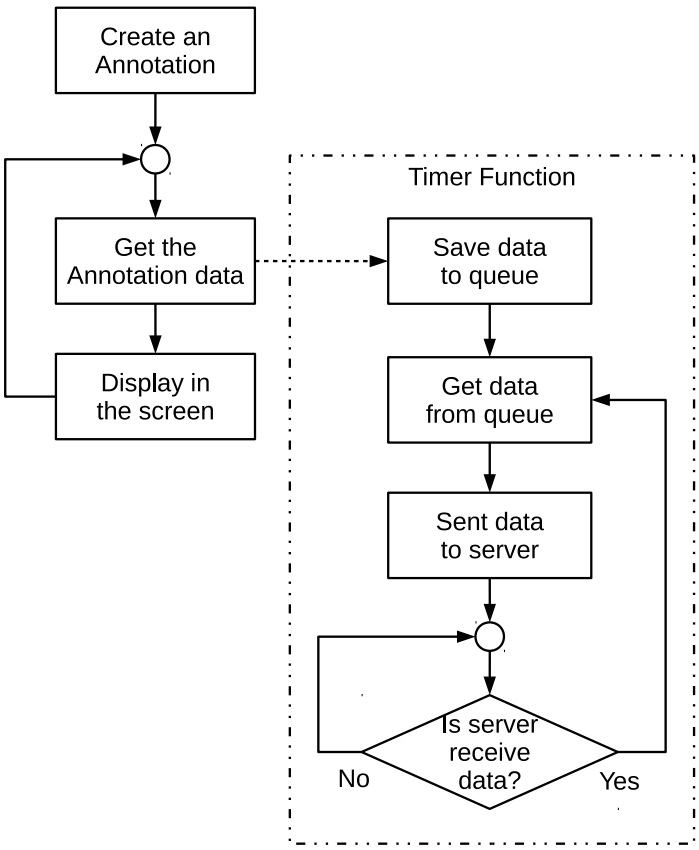


Figure 6.12: Workflow of improvement method for transmitting annotation data between server and presenter's computer

is inserted and is separated from the data sending function run by this timer. This method makes the presenter screen to display the annotation data smoothly. When the presenter creates annotation events, the data are collected. This data is split into two paths. The first path is used to display in the presenter screen. Another path is sent and saved in the annotation queue. After that, the system returns to wait new annotation again. At the time, the timer function retrieves the latest annotation data from the queue and send to the server by interval time trigger. Figure 6.12 shows the workflow of the improved method. The workflow shows that the new cycle for collecting and displaying annotation data is totally separated from the data sending function. This means that the process for annotation is independent from data sending. When the presenter is writing, the annotation data will be displaying immediately without interrupting by the server's response.

Chapter 7

Experimental Evaluation and Results

Since there are two main topics in this dissertation, i.e., authoring tool for e-Learning system and improvement of e-Meeting system, the experimental evaluation and results are separated into two sections as follows:

7.1 Authoring Tool for e-Learning System

Based on the system framework, there are two issues that need to be evaluated - the system performance on the server side and the client user acceptance of the total system. On the system performance evaluation, the author makes a comparison for the conversion times of the source files and video buffering during playback for each quality condition as this would influence the user acceptance. Moreover, the author conducted a survey to determine the user acceptance of the system by sending out survey questionnaires to users of the system from four different countries.

7.1.1 System Performance Evaluation

The author prepared a server machine and installed the proposed system onto that server to evaluate the system performance. The server is driven by Linux operating system on the Virtual Machine server with Intel Xeon Dual-Core @2.33 GHz CPU and 4 GB of RAM. The author uses nine sample contents wherein each content includes source files such as slide presentation and raw video files. The slide presentations are in PDF file format and each has 30 slides. The video streams

are in MP4, AVI and WMV formats and have equally the same specifications as in the following: video bitrate is 930 kbps, video frame rate is 25 fps, audio bitrate is 192 kbps, audio sampling rate is 48 kHz, resolution is 640x480 pixels, duration is 600 seconds and average file size is 70 MB.

In the evaluation procedure, the source files per content were uploaded to the server and the duration of conversion process were determined. The duration of uploading is dependent on the file size and the instantaneous network speed during the entire upload process. The source files were automatically converted to the required formats after finishing the upload process. There are two steps in the conversion process - (1) slide conversion from the PDF file to slide images (PNG) which takes shorter time, and (2) video conversion from raw video file to a Flash video (FLV). The video conversion process requires longer time because it needs to decode raw video and encode to FLV output. The system provides up to three video qualities, therefore the duration for the overall process depends on the number of output qualities selected by the author. The audio-video conversion input parameters for the three qualities and the conversion results are shown in Table 7.1. Low quality results to smaller file size and the fastest conversion time compared to other qualities. For example, if the length of the raw video is 600 seconds, the converted file size for low quality is around 8 MB, while the converted file size is around 30 MB for regular quality. Conversion process for low quality can be done within 60 seconds, whereas for regular quality requires more than 210 seconds.

Furthermore, the author evaluated the adaptive video buffering method in various Internet environments for three video qualities. First, the author measured the streaming bandwidth for the three qualities and made it as the baseline parameters. The average streaming bandwidth for low, medium and high qualities are 150, 250 and 450 kbps, respectively, where each corresponds to the sum of the video bitrate and the audio bitrate. These values represent the minimum bandwidth required for the video playback without necessary buffering before playback starts. Secondly, the author uses the bandwidth shaper application to simulate various Internet speed and measured the actual video buffering times. Figure 7.1 shows the result of implementing the adaptive video buffering method for each video quality on various network bandwidth. The author only considers video buffering time in the measurement, and these values nearly corresponds to the theoretical values when calculated using equation (5). Downloading time of video streaming

Table 7.1: Comparison of conversion process for video qualities

		Qualities		
		Low	**Medium**	**Regular**
Audio-Video parameters	Video resolution (pixels)	160x120	320x240	640x480
	Video bitrate (kbps)	100	200	400
	Video frame rate (fps)	25	25	25
	Audio sampling rate (kHz)	11	22	22
	Audio bitrate (kbps)	32	32	64
Conversion results	Avg. output file size (MB)*	8	14	30
	Avg. conversion speed (second)*	60	120	210

* Based on 600 seconds video length

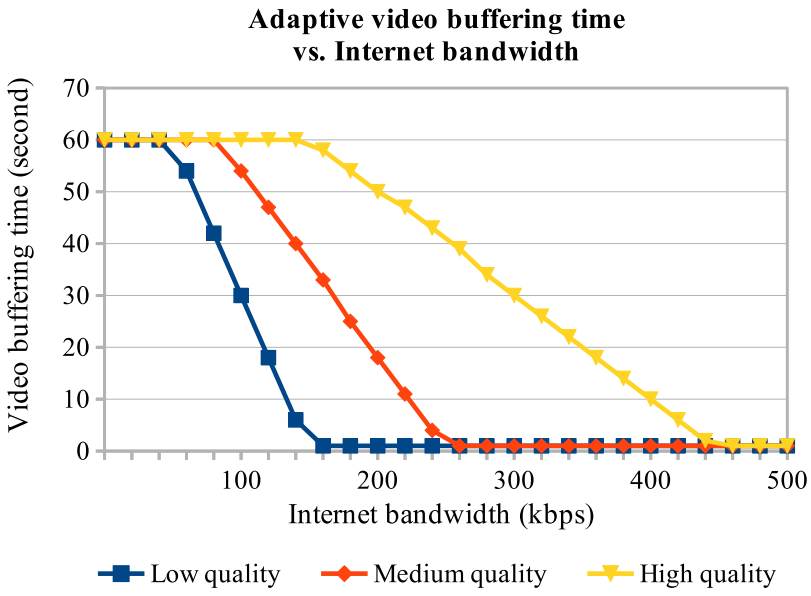


Figure 7.1: Adaptive video buffering time of the viewing function

data until the video buffer becomes full was not included since it depends on the network bandwidth during that time.

However, the actual waiting time of the viewer from the start of viewing until the video plays is always longer than the effect of adaptive video buffering time in

Table 7.2: Average waiting time of aggregated video in various network bandwidth

Internet bandwidth (kbps)	**Avg. video buffering time (second)**		
	Low quality	**Medium quality**	**Regular quality**
50	70	120	210
100	45	90	180
150	3	50	120
200	1	35	90
250	1	3	70
300	1	1	55
350	1	1	30
400	1	1	15
450	1	1	5
500	1	1	1

* Based on 90 seconds of video length

the real situation. This is because the video player requires to download the aggregated video stream, store it into the video buffer until the buffer becomes full, then video player starts playing the video stream data from the buffer. Downloading time is dependent on the network bandwidth and video quality being selected. The author measures the average waiting time for the viewer which includes downloading and buffering time of aggregated video stream until video playback starts as shown in Table 7.2. From the result, longer buffering time occurs when the Internet bandwidth is less than 150 kbps for low quality, less than 250 kbps for medium quality, and less than 450 kbps for regular quality. The viewing tool worked well in three qualities by providing smooth and continuous playback, but have longer waiting time in acutely low-speed Internet environment. In case of viewing high quality video in low-speed network, incoming video data is continuously buffered but eventually buffer data becomes empty during playback. At this instant, video stops and buffering occurs again. As mentioned earlier, these values represents the baseline bandwidth for the three qualities.

7.1.2 User Acceptance Evaluation

For the user acceptance evaluation on the proposed tool, the author prepared the evaluation materials such as test server, raw video files and presentation files, sample learning contents, user manual and an online questionnaire. A group of respondents, mainly higher education instructors and graduate students, were selected from the collaboration members of SSB and UNESCO projects in several countries including National Institute of Informatics – Japan, Sahara Solar Breeder Project (SSB) – Algeria [47], National Electronics and Computer Technology Center (NECTEC) – Thailand [105], Tsinghua University – China [106], and Wuhan University – China [107]. In the process, instructors can download the prepared raw video files and presentation files, or can use their own materials for testing the authoring and viewing functions. On the other hand, learners can examine the viewing function by using the learning contents authored by the instructors, or can use the prepared sample learning contents.

The author used the online questionnaire in conducting the user acceptance evaluation. 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. The author uses the Likert scale to measure the responses from the respondents [108]. 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. Scores were used to determine the user acceptance of the proposed tool based on the three factors mentioned.

The author sent the 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 details of respondents are shown in Figure 7.2.

The tally of results for the 18 questions in the questionnaire are shown in Table 7.3. The results were then analyzed based on statistical mode which represents the

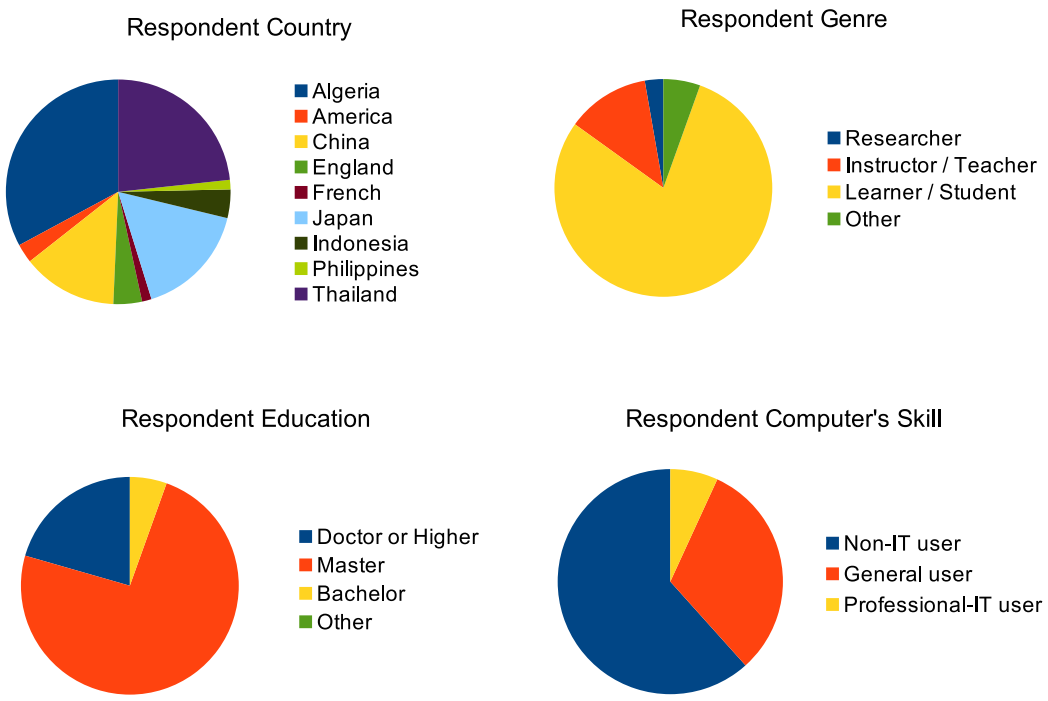


Figure 7.2: Details of the respondents

value that appears often in the data set. The mode is defined as the element that appears the most frequent number in a given set of elements [109]. There are 8 questions on the authoring function consisting of 3, 4, and 1 question on usefulness, ease-of-use, and user satisfaction, respectively. For the viewing function, there are 6 questions consisting of 2, 1, and 3 questions on usefulness, ease-of-use, and user satisfaction, respectively. For the overall system, there are 4 questions consisting of 2, 1 and 1 question on usefulness, ease-of-use, and user satisfaction, respectively. Responses from each group of questions per factor were combined and the tally of the scores per rating scale were then converted to percentage for easier presentation as shown in the summary of results in Table 7.4. The result 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; except for a tie in viewing function where the same number of respondents responded "Agree" and "Strongly agree" for its usefulness. The values in bold character represents the statistical mode converted to percentage. The descriptive overall results simply show that most of the respondents agree to the usefulness, ease-of-use, and user satisfaction of the proposed tool. The results show that the proposed authoring and viewing tools have higher user acceptance as a proposed tool for e-Learning.

Table 7.3: Tally of Results

No.	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Authoring Function					
1.**	0 (0.00%)	2 (2.74%)	18 (24.66%)	32 (43.84%)	22 (30.14%)
2.*	0 (0.00%)	1 (1.37%)	15 (20.55%)	32 (43.84%)	25 (34.25%)
3.*	0 (0.00%)	1 (1.37%)	17 (23.29%)	33 (45.21%)	22 (30.14%)
4.***	0 (0.00%)	1 (1.37%)	19 (26.03%)	29 (39.73%)	23 (31.51%)
5.**	0 (0.00%)	2 (2.74%)	17 (23.29%)	33 (45.21%)	21 (28.77%)
6.**	0 (0.00%)	2 (2.74%)	22 (30.14%)	27 (36.99%)	22 (30.14%)
7.*	0 (0.00%)	2 (2.74%)	18 (24.66%)	29 (39.73%)	24 (32.88%)
8.**	0 (0.00%)	2 (2.74%)	23 (31.51%)	28 (38.36%)	22 (30.14%)
Viewing Function					
9.**	0 (0.00%)	1 (1.37%)	19 (26.03%)	30 (40.10%)	23 (31.51%)
10.***	0 (0.00%)	1 (1.37%)	23 (26.03%)	30 (40.10%)	19 (31.51%)
11.*	0 (0.00%)	1 (1.37%)	17 (31.51%)	28 (40.10%)	27 (26.03%)
12.***	0 (0.00%)	1 (1.37%)	22 (23.29%)	26 (38.36%)	24 (36.99%)
13.***	0 (0.00%)	1 (1.37%)	14 (30.14%)	35 (35.62%)	23 (32.88%)

Continued on next page

Table 7.3 – continued from previous page

No.	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
14.*	0 (0.00%)	1 (1.37%)	15 (19.18%)	28 (47.95%)	29 (31.51%)
Overall System					
15.**	0 (0.00%)	1 (1.37%)	20 (20.55%)	30 (38.36%)	22 (39.73%)
16.*	0 (0.00%)	2 (2.74%)	23 (31.51%)	28 (41.10%)	20 (30.14%)
17.*	0 (0.00%)	1 (1.37%)	18 (27.40%)	30 (41.10%)	24 (30.14%)
18.***	0 (0.00%)	2 (2.74%)	18 (31.51%)	30 (38.36%)	23 (27.40%)
Continued on next page					

* : Usefulness, ** : Ease-of-use, *** : User satisfaction

In addition, the questionnaire solicits comments from the respondents optionally. The author considered the following helpful comments for enhancing the proposed tool: (1) DOC, DOCX and image file formats should be supported, (2) Viewing function should support an offline mode learning, (3) The system should integrate more social functions such as forum, chat, etc., and (4) Tooltip and tutorial documentation should be added.

7.1.3 Discussion

The proposed authoring and viewing tools have exhibited numerous advantages as an e-Learning tool for higher education. The total system can help accomplish the purposes of distance learning among universities. It makes learning activities available anytime and anywhere. In addition, cross-platform and cloud computing are supported to break the barriers in various operating systems and application software installation is not necessary at the users' computer. Table 7.5 shows the comparison of authoring system by mean of usage functions.

The proposed tool can help instructors simplify the process of managing learning contents without external applications required. During content authoring,

Table 7.4: Summary of evaluation results

Rating Scale	**Functions**	**User satisfaction (%)**	**Usefulness (%)**	**Ease-of-use (%)**
Strongly disagree	Authoring	0.00	0.00	0.00
	Viewing	0.00	0.00	0.00
	Overall	0.00	0.00	0.00
Disagree	Authoring	2.74	1.83	1.71
	Viewing	1.37	1.37	1.37
	Overall	2.47	2.05	1.37
Neither agree nor disagree	Authoring	26.03	22.83	27.40
	Viewing	26.94	21.93	27.40
	Overall	27.40	28.05	30.14
Agree	Authoring	**39.73**	**42.92**	**41.10**
	Viewing	**41.55**	**38.36**	**39.73**
	Overall	**41.10**	**39.73**	**39.73**
Strongly agree	Authoring	31.51	32.44	29.79
	Viewing	30.14	**38.36**	31.51
	Overall	28.77	30.14	28.77

instructors can preview the synchronized slide and video immediately without saving at the server, thus it is more convenient and saves time for editing the learning content. Some parts of video content which are not related to the slides can be easily skipped by changing the key start and key stop positions of the synchronization data without modifying the source files. Moreover, the proposed tool can help instructors to archive and re-use contents without the risk from unstable computer since the data are stored at the server.

The viewing tool makes the lesson more interesting for students. The tool supports pointer and video synchronization which can make the content attractive and interesting to students. Students can know which part of the slide the presenter is focusing. Students can also learn more in less time, and learning time is never boring. The progressive downloading technique adaptive video buffering time and quality control function were implemented to support usage in low-speed Internet as the progressive download technique. The video buffering time from equation

Table 7.5: Comparison functions of authoring systems and methods

Functions	**CamStudio**	**Capture Station**	**SG Algorithm**	**Proposed method**
System topology	Stand alone	Stand alone	Stand alone	Client-Server
Synchronize method	Real-time capturing from whole screen	Real-time capturing from whole screen	On-the-fly recording from camera	Manually with synchronization with key markings
Skip some parts of streaming	Yes	Yes	No	Yes
Edit the content	Require a total recapture	Require a total recapture	Require a total rerecord	Re-synchronization by changing key markings
Synchronize video and presentation	Depend on content on the recorded screen	Depend on content on the recorded screen	Yes	Yes
Synchronize presentation and pointer movement	Depend on content on the captured screen	Depend on content on the captured screen	No	Yes
Preview content before save	No	No	No	Yes
Manage slide title / description	No	No	No	Yes
Content player	SMIL player such as Real player	General web browser with flash plugin	SMIL player such as Real player	General web browser with flash plugin
Operating System (OS)	Windows family	Windows family	Windows family	Cross platform OS

(5.2) can help students to view the content smoothly and continuously until the entire aggregated video clip is finished, or until the video buffering data is emptied. During playback, the incoming video stream is continuously downloaded and buffered. The downloading time is dependent on the selected video quality and network bandwidth during that time. Based on Table 7.2, buffering occurs when the Internet bandwidth is less than 150 kbps for low quality, less than 250 kbps for medium quality, and less than 450 kbps for regular quality. Low or medium quality content is appropriate choice for students who have low-speed network environment. For smooth video playing for the desired quality, the author recommends to provide the minimum required bandwidth or higher for the selected quality.

The performance of the back-end system were evaluated by means of the source files conversion processes. Of the three video output qualities, the conversion of low quality is executed faster, and produced smaller file size than the other qualities. However, the actual conversion speed and output file size may have varied results. They are dependent on the source file input properties such as video encoding, audio encoding, video bitrate, audio bitrate, and resolution.

The proposed tool has been evaluated by 73 respondents who are mainly higher education instructors and graduate students in various countries and various environment. By using the statistical mode, it was shown that most of the respondents Agree to the usefulness, ease-of-use, and user satisfaction of the proposed tool. The overall result shows that the proposed authoring and viewing tools have higher user acceptance as a tool for e-Learning. In addition, several respondents located in the developing countries where the network infrastructures are non-stability and not good enough for applications requiring high-speed network. We can imply that the proposed tool can be used in the low-speed and unstable network environment with the accepted content quality based on the evaluation results.

7.2 Improvement for e-Meeting system

7.2.1 Performance Improvement

In this research, the system performance is proven through practical uses in the learning process of higher education under the low-speed situation. Issues that have been improved comparing with the current WebELS Meeting system, such as automatic re-connection, streaming quality and performance of the system are

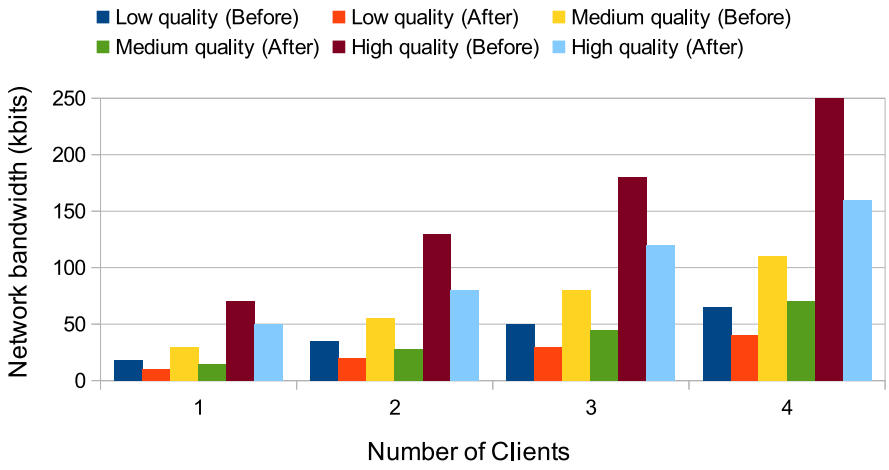


Figure 7.3: Comparison of average network bandwidth load for video meeting at the client side before the improvement and after the improvement

discussed.

The author measured the network bandwidth load which includes video and voice streams on each meeting quality. Figure 7.3 shows the comparison of network bandwidth load of the system before and after the improvements. The results show that the proposed method can reduce the network bandwidth requirement at the client side during the meeting activities up to 40%.

Moreover, the author also measured the network bandwidth at the server side as shown in the Figure 7.4. From the result, the required bandwidth depends on the number of users. If the number of users is increased, then the bandwidth is also duplicated. The required network load at the server can be summarized in the following formulas:

$$sbw = cbw * (c - 1) * c \tag{7.1}$$

where

sbw - is an average network bandwidth at the server (kbps)

cbw - is an average network bandwidth of 1 client (kbps)

c - is a number of clients

The automatic re-connection feature is tested on many OS environments such as Windows, Linux and Mac OSX. In the test, the author focused on the effect in 2

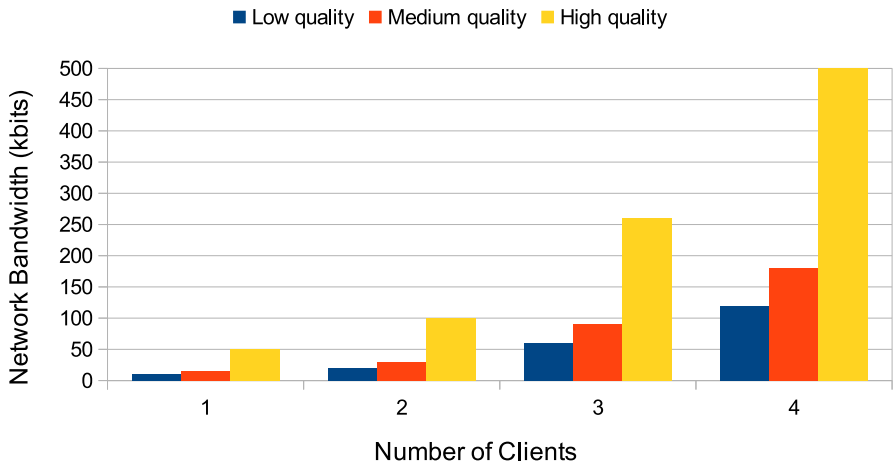


Figure 7.4: Average network bandwidth load for video meeting at the server side after the improvement

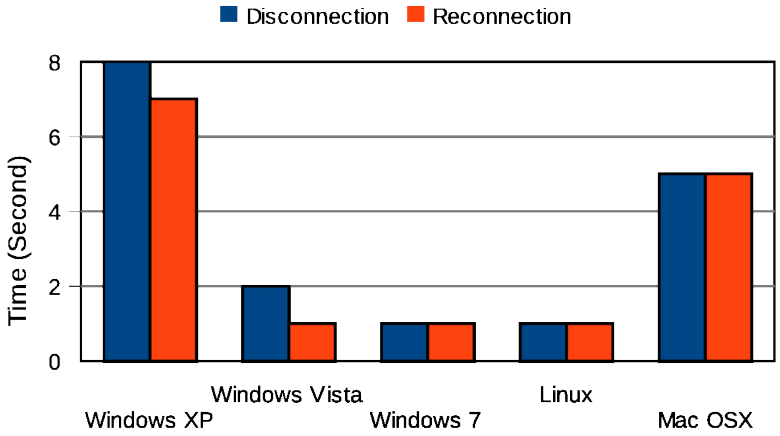


Figure 7.5: Comparison of disconnection and re-connection time in each OS

events, such as (1) a disconnection time range after losing the network connection and (2) a re-connection time range while network status is appearing. When lost connection is detected, the system would attempt to reconnect every 5 seconds. If the system cannot establish a connection within 120 seconds, the system will completely terminate the meeting operation as a connection timeout event. Figure 7.5 shows the approximate automatic re-connection time. This feature can work in all OS, but the time range for automatic re-connection process differs and that it depends on the network connection probing in each operating system.

The streaming quality is tested by using the same devices and OS environment. The author considers the quality in three sections such as video, voice and chat.

Table 7.6: Comparison of the video meeting qualities between old system and new system

Category	**Low speed (<100 Kbps)**		**High speed (>100 Kbps)**	
	Old	**New**	**Old**	**New**
Video quality	N/A	Fair	Good	Good
Voice quality	Bad	Good	Good	Good
Chat message	Bad	Good	Good	Good
Annotation	Frozen in short time	Delay	Good	Good

Table 7.7: Comparison of events when using the system in the low-speed/unstable Internet environment

Events	**Old System**	**New System**
Annotation delay time	1 – 2 sec	<1 sec
Video streaming delay time	>1 sec	<1 sec
Voice streaming delay time	>1 sec	<1 sec
Network disconnected	Delay and frozen later	Automatic clear the connection
Network reconnected	N/A	Automatic re-connection

Table 7.6 shows the worst case qualities of the system. This result confirmed the new system can work well in the low-speed Internet network. It is worthy to stress that chat is the base channel that work well in all situations.

The overall performance of the system is shown in Table 7.7. The new system can reduce the delay time of many events, for instance annotation delay time, video and voice streaming delay time. In addition, the new system can operate fairly well when used in the unstable network environment.

7.2.2 Discussion

The new features in the business meeting system were designed based on functional standard WebELS Meeting version. Several features were developed to support the

Table 7.8: System overview comparison of meeting systems

Criteria	**A**	**B**	**C**	**D**
Objective	Support the e-Learning	Support the business sector	Support the business sector	Support the business sector
Target group	Higher education	Company / Organization	Company / Organization	Company / Organization
Distribute	Open-source	Proprietary	Proprietary	Proprietary
Concept	Content-based	Group-based	Group-based	Group-based
Privacy of content	Open	By group	By group	By group
System Limitation	Unlimited	By group	By product	By product

* Note: A = Standard WebELS Meeting, B = Business WebELS Meeting, C = Cisco WebEx Meeting, D = Microsoft Live Meeting

business roles to meet the requirements from the business sector while important features of standard version are preserved. The administrative tool was developed for managing and controlling the group members. The role controller was applied for group-based control. The author evaluates the system by comparing the new system with the standard system and other business conference systems. Table 7.8 shows the overview comparison of meeting systems. There are contrasts in the objective and usage of all systems. The standard WebELS Meeting was mainly designed for supporting the higher education while the other systems were mainly designed to be used in the business sector. The new system has distinctiveness by introducing the simple group-based for managing and controlling the contents and system.

Only the new system has special functions such as contents limitation, concurrent access limitation and system limitation that is based on simple group-based concept. The author uses the system checker for solving the incompletely logout problem and clearing the member status. The usage time limitation is one significant matter for restricting the free trial customers for the business approach. Furthermore, uninvited member controller is integrated to be operated for the

logging-in participant who has a behavior to disturbed other participants during the meeting operation. In the business sector, security of content is also important. Any content are protected and accessible by the group owner and members who have been granted permission only by the owner. Even the administrator of the system cannot manage the contents in member groups. Moreover, usage time limitation is one significant matter for restricting the free trial customers. That function meets the reasonable security in business situations. The disadvantage of the simple group-based concept is that anyone who access to the system with manager's password can change and delete contents created by others. This is because of the manager's password is shared for the group or project administrator, then they have the same user privilege. The author also optimized the system to work with cloud computing technology for reducing supported cost of the small business companies. This is the benefit for merging the meeting system with SaaS in the business model.

Not only the system management but also the conference streaming management was implemented. The system has a feature to support meeting connection and quality while using the system in the unreliable network environment. Auto-reconnection is a convenient function for participant who lost the network connection during meeting operation. The system can keep the meeting session and automatic operation with the reconnection technique when network connection is restored. This feature is tested on many OS environments such as Windows, Linux and Mac OSX. In the evaluation, the author focuses on the effect in two events, such as (1) a disconnection time range after losing the network connection and (2) a reconnection time range while network status is appearing. Figure 4 shows the approximate automatic reconnection time. This feature can work in all OS but the time range for automatic reconnection process differs and that it depends on the network connection probing in each operating system

Table 7.9 shows the comparison of proposed video meeting system and other video meeting systems including of Skype [110], Polycom [111] and BigBlueButton [112]. Compared with other systems, the proposed system is the only system which fully support all functions including user/group management, online video meeting with online document presentation, and automatic reconnection method when disconnection occurs. With the automatic re-connection method, the system tries to automatically recover the online meeting activities. It is a useful function to keep stability of distant meeting in the unstable Internet or narrow-band network

Table 7.9: Comparison of video meeting systems functions

Functions	**Skype**	**Polycom**	**BigBlue Button**	**Proposed System**
Topology	E2E/P2P	CMA (Converged Management Application) / MCU (Multipoint Control Unit)	Client / Server	Client / Server
Meeting equipment	Web cam/ microphone	Requires special devices	Web cam/ microphone	Web cam/ microphone
User/Group management	No	No	Yes	Yes
Online document	No	No	Yes	Yes
Automatic re-connection management	Yes	No	No	Yes
Narrow-band supported	Yes	No	Voice only	Yes

environment.

This system was proven useful by companies and communities in various countries and various environment, such as GENETEC – Japan [113], e-Communication Consortium (eCC) – Japan [114], Universit des Sciences et de la Technologie d'Oran Mohamed Boudiaf (USTO) [115] – Algeria, Sahara Solar Breeder Project (SSB) – Algeria [47], National Electronics and Computer Technology Center (NECTEC) – Thailand [105], Tsinghua University – China [106], Wuhan University – China [107] and UNESCO CONNECT-Asia – Indonesia [116]. Table 7.10 shows the approximate number of main collaborators who join the WebELS Meeting project. Every feature worked well within the business situations. The system can limit the num-

Figure 7.6: Distant meeting during the e-CC Seminar using the new WebELS meeting for business

ber of contents and number of concurrent user access in case of content limitation or access limitation was defined. The system can provide as a TV conferencing system, like a Polycom system, with high-quality video and audio streaming service. The system can be easily used anywhere and anytime without firewall and proxy settings. Participants can attend the meeting by using their personal computer or laptop that is connected to the Internet. Figure 7.6 shows the distant meeting during the e-CC seminar using the new WebELS meeting for business.

Table 7.10: Approximate number of main participants of the WebELS Meeting project

Organization	**Number**
GENETEC	5
e-Communication Consortium (eCC)	4
Universit des Sciences et de la Technologie d'Oran Mohamed Boudiaf (USTO)	6
Sahara Solar Breeder Project (SSB)	5
UNESCO Connect-Asia	4
National Electronics and Computer Technology Center (NECTEC)	3
Tsinghua University	2
Wuhan University	3

Chapter 8

Conclusion and Future Work

This dissertation describes the combination of e-Learning and e-Meeting functions for a new e-Communication approaches to be a flexible instrument for higher education activities. Since using online content is a trend for obtaining knowledge due to the vast availability of information and content from the Internet, then the proposed system can be used to support advanced knowledge by self-learning. It is considered to support the classroom-based learning due to the increasing social demand internationally, and to address the limitations of the traditional learning due to time, location, and cost. Therefore, the author implements a new online authoring tool for e-Learning system using Flash technology. The authoring tool is used by the instructor to create and edit the video-based learning contents. Moreover, the author proposes the suitable meeting management tool for the WebELS Meeting module to meet the requirements of the business sector. The main function of the management tool is to be utilized for controlling user members and contents using simple group-based control concept. The author also implements the network connection handler for the online meeting system when used in the unstable network environment. The proposed system is achieved and optimized to support the cloud computing technology since the technology is implemented in a wide variety of architectures, services, models, and other technologies.

8.1 Contributions

This dissertation presents an "All-In-One" authoring tool for WebELS Learning system, a new user-group management concept for the WebELS Meeting system,

and performance improvement of the online meeting system when used in the unstable network environment.

The authoring tool includes authoring function for the instructor and viewing function for the learner. The author implements the tool using Flash technology that communicates with the Red5 video streaming server. The proposed authoring function can help instructors simplify the process of managing learning contents without external applications required. They can manage learning content consisting of presentation slides and recorded raw video. The tool utilizes the aggregated video stream from raw video with key marking for synchronizing with the presentation slides. During content authoring, instructors can preview the synchronized slide and video immediately without saving at the server, thus it is more convenient and saves time for editing the learning content. Some parts of video content which are not related to the slides can be easily skipped by changing the key start and key stop positions of the synchronization data without modifying the source files. The tool also supports video and pointer synchronization to enhance the system functionality. The authoring function can manage the slide information, add new blank page and delete unused slides. The proposed function can help instructors to archive and re-use contents without the risk from unstable computer since the data are stored at the server. It also works well in conjunction with an existing Java authoring tool without adverse effect.

The viewing function is used by student or learner to display a learning content. Several useful functionalities are implemented, such as video and slide view toggle, zoom in, zoom out, etc. These functionalities make the lesson more interesting for students. The tool supports pointer and video synchronization which can make the content attractive and interesting to students. The progressive downloading technique, adaptive video buffering time and quality control function were implemented to support usage in the low-speed Internet. These techniques can help students to view the content smoothly and continuously until the entire aggregated video clip is finished, or until the video buffering data is emptied. The downloading time is dependent on the selected video quality and network bandwidth during that time. Low or medium quality content is an appropriate choice for students who have a low-speed network environment.

The performance and usefulness of the proposed authoring tool have been proven by practical uses in UNESCO collaboration project between 4 countries including Japan, China, Thailand and Algeria. There were 73 respondents con-

sisting of 9 instructors and 64 students in the higher education completely answered the questionnaire. Evaluation results show that most of the respondents agree to the usefulness, ease-of-use, and user satisfaction of the proposed tool. The overall result shows that the proposed authoring and viewing tools have higher user acceptance as a tool for e-Learning. In evaluating the system, the author compares the conversion process time for the three video qualities and verified the adaptive video buffering method by playing the content in various Internet environments for three output qualities.

Regarding the Meeting system, there are 2 important contributions in this dissertation, i.e., enhancing the system to support advanced requirements from the business sector, and to support various kinds of usage environment in the global scale. The main function of the management tool is for controlling user members and contents using simple group-based control concept. The administrator could manage the whole system. The group manager could manage the contents and also monitor activities of each user in their group. Member Verification and Role Controller methods were described using our techniques for controlling users and contents. The proposed management tool helps the administrator manage the system easily. In addition, the author presents solutions for improving the performance of the web-based online conference system when used in the low-speed network environment. In case of the unstable network environment, the system can keep the meeting session in operation with the re-connection technique when network disconnection occurs intermittently. Therefore, the proposed system can be used in rural areas having low-speed Internet technology. The system can switch from the video mode to voice mode for decreasing the transfer data streaming size in the network. Both functions are working together to enhance and advance the operations of the meeting system. The WebELS Meeting system was also implemented as a SaaS concept to minimize IT investment costs of business companies.

This system was proven useful by companies and collaborations in various countries and various environment, such as, GENETEC - Japan, Universit des Sciences et de la Technologie d'Oran Mohamed Boudiaf (USTO) - Algeria, etc. Every feature worked well within the business situations. The system can limit the number of contents and number of concurrent user access in case the content limitation or access limitation was defined. The system can provide as a TV conferencing system, like a Polycom system, with high-quality video and audio streaming service. Participants can attend the meeting by using their personal

computer or laptop that is connected to the Internet. In addition, the improved system can reduce the delay time of many events, such as annotation delay time, video and voice streaming delay time. It can also perform network re-connection automatically when used in the unstable network environment. These results confirmed that the new system can work well in the low-speed Internet network. It is worthy to stress that chat is the base channel that work well in all situations.

8.2 Limitations and Future Directions

The author plans to support multi-video files and multi-presentation files for creating one content in the Learning module. The quality of learning content should be improved, while the file size needs to be reduced for faster transferring between server and client nodes. In the Meeting module, the annotation data structure shall be redesigned to compress the annotation data size. Furthermore, automatic streaming adaptation will be added. This feature will adjust the video and voice sampling rate automatically depending on the network traffic and other factors.

Another important function to be added in the future is automation of content authoring. Learning contents should be automatically created simultaneously during the online presentation or online lecture event. Moreover, the system should also work in mobile devices, since it is becoming a trend for e-Communication environment. HTML5 technology should also be considered to replace the current Flash technology base platform to adapt to the ever changing Internet technology.

Appendix A

About Author

Name	Sila Chunwijitra
Birthdate	June 12, 1976
Birthplace	Petchaburi, Thailand
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Status	Married
Educations	- June 1991 – March 1994 : Vocational Certificate (Electonics), Petchaburi Technical College, Thailand - June 1994 – March 1996 : High Vocational Certificate (Technology Computer), Sumutsongkarm Technical College, Thailand - June 1996 – March 1998 : Bachelor of Science in Technical Education in Computer Technology (Second Class Honours), King Mongkut's Institute of Technology (KMITNB), Thailand - June 2001 – September 2004 : Master of Science in Technical Education (Computer Technology), King Mongkut's Institute of Technology (KMITNB), Thailand
Career Experiences	- August 2002 – Present : Research Assistant, Open Source Technology Laboratory, National Electronics and Computer Technology Center (NECTEC), Pathumthani, Thailand - April 1999 – July 2002 : Programmer and Teacher Assistant, Pathumthai University, Pathumthani, Thailand

Appendix B

Related Publications

Jounal Paper

1. **S. Chunwijitra**, A.J. Berena, H. Okada and H. Ueno, "Advanced Content Authoring and Viewing Tools Using Aggregated Video and Slide Synchronization by Key Marking for Web-Based e-Learning System in Higher Education", the IEICE Transactions, vol.E96-D, no.8, August 2013.

Conferences

1. **S. Chunwijitra**, A.J. Berena, P. Sriprasertsuk, E. Okano, H. Okada and H. Ueno, "WebELS Meeting for Business Application", The IEICE2010 Society Conference, B-14-14, pp.370, June 2010.

2. **S. Chunwijitra**, A.J. Berena, P. Sriprasertsuk, H. Okada and H. Ueno, "WebELS Meeting: Multi-Functional Online Conference Tool For Higher Education For Low-Speed Internet", The Third International Conference on Education Technology and Training (ETT2010), vol.2, pp.24–27, November 2010.

3. **S. Chunwijitra**, A.J. Berena, H. Okada and H. Ueno, "Design of Suitable Meeting Management Model for WebELS Meeting to Meet the Business Situations", The First International Conference on Advanced Collaborative Networks (COLLA2011), Systems and Applications, vol.1, pp.52–57, June 2011 (proceedings only).

4. **S. Chunwijitra**, A.J. Berena, H. Okada and H. Ueno, "Authoring Tool based on Flash Technology for WebELS Learning System to Support Higher Education", Technical report of IEICE, KBSE2011-44, vol.111, no.282, pp.49–54, November 2011 (proceedings only).

5. **S. Chunwijitra**, A.J. Berena, H. Okada and H. Ueno, "Authoring Tool for Video-based Content on WebELS Learning System to Support Higher Education", The 9th International Joint Conference on Computer Science and Software (JCSSE2012), vol.1, pp.317–322, May 2012.

Other Collaborations

1. P. Sriprasertsuk, A.J. Berena, **S. Chunwijitra** and H. Ueno, "A Study on an Open Source for Distance Real-Time Learning Environment", Technical report of IEICE. KBSE, vol.109, no.392, pp.53–58, January 2010.

2. A.J. Berena, Z. He, P. Sriprasertsuk, **S. Chunwijitra**, E. Okano and H. Ueno, "Shared Virtual Presentation Board for e-Communication on the WebELS Platform", The 18th International Conference on Computers in Education (ICCE2010), pp.280–284, December 2010.

3. A.J. Berena, **S. Chunwijitra**, H. Ueno, Z. He and P. Sriprasertsuk, "e-Meeting Solution for Higher Education on the WebELS Platform", The International Conference on Education, Informatics, and Cybernetics 2011, pp.19–24, December 2011.

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Appendix C

Questionnaire

Questionnaire for Evaluating the Usefulness and Ease-of-Use of WebELS Video-based Authoring Tool

Thank you for participating in the survey on WebELS video-based authoring tool. The purpose of this survey is to evaluate the usefulness and ease-of-use of the system. The score you give to each item on this survey questionnaire will help us improve the total system performance and effectiveness as an e-Learning tool. Your personal information and the score you give to all items will be treated with absolute confidentiality. The results on this questionnaire will only be handled by WebELS project researchers for the said purpose. For further information or in case of problems please contact: Sila Chunwijitra at sila@nii.ac.jp.

Section A: Personal Information

Please fill in the relevant space your personal data as accurate as possible.

1. Name _____ Surname_____
2. Age _____
3. Country _____
4. Occupation
    - Researcher
    - Instructor / Teacher
    - Learner / Student

- Other

5. Educational
    - Doctor or Higher
    - Master
    - Bachelor
    - Other
6. Computer skill
    - Non-IT user (need some help)
    - General user (can run by yourself)
    - Professional of IT (can help others)
    - Other

Section B: Authoring Function

Please choose the relevant score to each item as accurate as possible by placing a check mark (X).

Rating Scale: **1 - strongly disagree, 2 - disagree 3 - neutral, 4 - agree, 5 - strongly agree**

Topics	Score				
	1	2	3	4	5
1. User interface is clear and easy to use and understand.					
2. Video file types including AVI, FLV, MP4, MOV, OGG, WMV are enough.					
3. Presentation file types including PPT, PPTX, PDF, ODP, SXI are enough.					
4. Uploading time and conversion process time, which depend on file size and video duration, are acceptable.					
5. Synchronizing raw video and presentation slides is easy.					
6. Recording cursor pointer movements synchronized with the video is easy.					
7. Quick operation for creating a learning content.					
8. Easy to edit synchronized slide data including video clip, slide title, slide description, and recorded cursor.					

Section C: Viewing Function

Please choose the relevant score to each item as accurate as possible by placing a check mark (X).

Rating Scale: **1 - strongly disagree, 2 - disagree 3 - neutral, 4 - agree, 5 - strongly agree**

Topics	Score				
	1	2	3	4	5
1. User interface is clear and easy to use and understand.					
2. Quality of video and slide presentation are good.					
3. Video quality is suitable for various kind of Internet speed lower, low, regular.					
4. Playback delay (video buffering) is acceptable.					
5. Pointer movement can make attractive and interesting content.					
6. Control tools (zoom, toggle, full screen) are helpful and useful functions.					

Section D: General Use

Please choose the relevant score to each item as accurate as possible by placing a check mark (X).

Rating Scale: **1 - strongly disagree, 2 - disagree 3 - neutral, 4 - agree, 5 - strongly agree**

Topics	Score				
	1	2	3	4	5
1. The system is efficient and effective e-Learning tool.					
2. The system can help the instructor to archive and re-use contents.					
3. The system can help the learners gain more interest in the lesson.					
4. Overall satisfaction with the performance of the system.					

Section E: Comments

Thank you for your help

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