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A Multimedia Integrated Framework for Learning Management Systems

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1. Introduction

In recent years, increasingly developing information and communication technology has altered the landscapes of social life and industrial activities for mankind. Every day, new Internet applications and more efficient ways of doing existing tasks are being discovered. Proliferation of the Internet, decreasing cost of hardware, enhancements in wireless communication, emergence of smart phones, and development of high resolution display technologies etc. are all leveraging technologies of the state of IT development that we witness today.

Development of information technology has been changing the way of teaching as well as learning; in that, e-learning opens new dimensions for education ranging from simple *file sharing* systems that facilitate dissemination of didactic material to sophisticated *smart classrooms* (Pishva, 2007) that transfer technology and know-how cultivated through years of rigorous academic/research endeavor from one location to many other locations. Forms of e-learning in today's context dominantly use computer software for delivering, tracking, and managing lectures; televised broadcasts and video conferencing characterize the earlier generations of distance education. Starting from educational policy concerns that e-learning initiatives are justified on the basis of cost efficiency, or the need to provide access to learners in educational settings, where face-to-face instruction is not feasible; today, we face a challenge of enhancing the quality and accessibility of educational resources via means that adapts to the lifestyles of learners. This challenge has opened interesting research streams to investigate technologies that leverage the best blend of *face-to-face* and *distant* education, referred to as *blended education*.

Today, *Learning Management Systems (LMS)* (Bersin, 2007) have become a readily available resource that provides an array of functionalities for content dissemination, student evaluation, and administration, to ensure effective delivery of education. Notwithstanding these functionalities, LMS in its current shape appears to be a system that has not captured the lifestyles of students (and teachers) in the modern society. A current day student (Veen, 2009) is a dynamic character immersed in a networked society, where education has to compete with many other vices in the *virtual marketplace*. This competing marketplace has not only detracts learners from academic efforts via many interesting vices such as online games, social networking systems, virtual avatars, on-demand video etc., but also bombards academic repositories with loads of information due to ever accumulating

unsorted knowledge on the Internet. Additionally, decreasing study efforts due to "study while working" habits has placed a special demand for creating user-centered LMSs that adapt to the lifestyles of students and teachers.

In Ritsumeikan Asia Pacific University in Japan (APU), the authors have developed a prototype version of multimedia enhanced learning management system. APU, whose mission is to create world leaders in science, management and economics through a bilingual curriculum, has shown an increasing interest in adopting computer supported methodologies in its education system. Recent statistics show that the use of web-based instruction, as a supplement means to face-to-face instruction, has increased rapidly in APU (Nisantha, 2009), where Blackboard is used as an integral part of its education system since its establishment to serve nearly 6000 concurrent students and more than 200 teachers. Hence, the authors believe that their findings of the research endeavors in this very conducive environment, APU, will not only provide the reader with knowledge on practical and cost effective solutions on the authors' experience in custom tailoring an LMS with home grown technologies, but also conceptual framework solution for upgrading IT enabled education to accommodate modern students.

1.1 Leaning Management Systems (LMS)

Computer modalities and software systems, which are used to achieve blended learning objectives coupled with support to administrative and monitoring of educational courses, are generally termed Learning Management Systems[1] (LMS) (Bersin, 2007). The ever growing competition for education, which is mainly attributable to the vast amount of free form of information available over the Internet, has enforced the typical LMS systems to evolve from the conventional forms of mere record keeping and simple file distribution systems to complex systems with broader functionalities. This section explains the functional modules of a generic LMS, and presents a rationale to build up the thought process for future LMSs.

1.1.1 Learning Management Systems functions

The basic description of LMS is an application (usually a web based application) that automates the administration, tracking and reporting of learning/training events. The concept of LMS in today's context ─ range from simple systems for managing lecture notes to complex systems that provide an array of functionalities such as content authoring, course building, online examination, student evaluation, grade book, and collaborative learning ─ illustrated in Figure 1.

Some system modules, which are generally considered as complementary such as video conferencing, distance collaboration, and smart classrooms, are also included in the latest versions of LMS. However, not every LMS has all of above listed features ─ depending on

[1] Conventionally, LMS is referred to as the domain that takes control over the user interaction and user management of the learning process whereas *Learning Content Management System* (LCMS) is referred to as the domain that is responsible for managing the content. When the functionality of the learning platform concentrates more on handling courses it is called a course management system (CMS). In this paper we have been referring to the term LMS as a common term for LMS, CMS, and LCMS.

scale and needs, organizations can choose a suitable LMS for their operation. According to a survey conducted by Learning Circuits, the most valuable features of an LMS are shown in Figure 2.

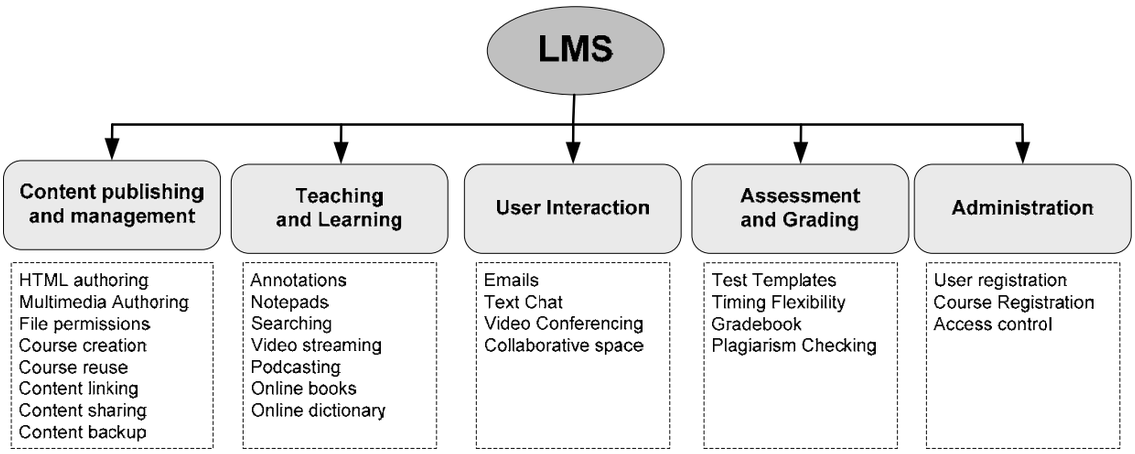

Fig. 1. General LMS functions categorized according to usage purpose

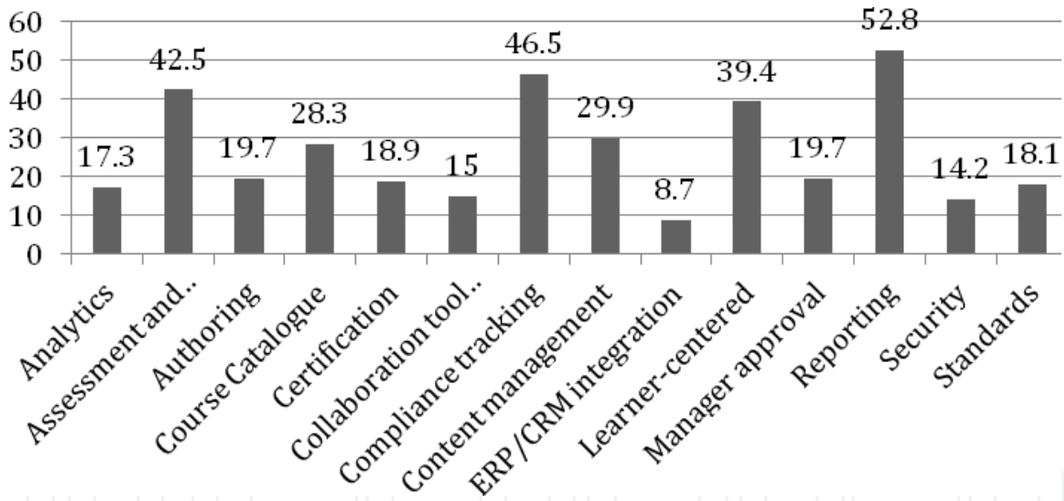

Fig. 2. Most valuable features of an LMS (%)

1.1.2 LMS Market

LMS solutions are currently available in both open source and commercial forms; popular representative solutions include Blackboard and Moodle. According to LMS evolution information, as illustrated in Figure 3, emergence of LMS has been very active in the late 1990s followed by its rapid evolution through many LMS generation in the next decade. Blackboard, which has claimed biggest share among the market players, acquired Prometheus in 2001, WebCT in February 2006, and Angel Learning in May 2009. It now clearly dominates the LMS market, with around 80% shares among US universities and over 50% among all universities around the world. Moodle - the most popular open source LMS

solution also has achieved a great growth in recent years. Number of registered educational sites has increased from 25 thousand in 2008 to around 50 thousand as on March of 2010 giving evidence for the great trends and potentials of open source LMS.

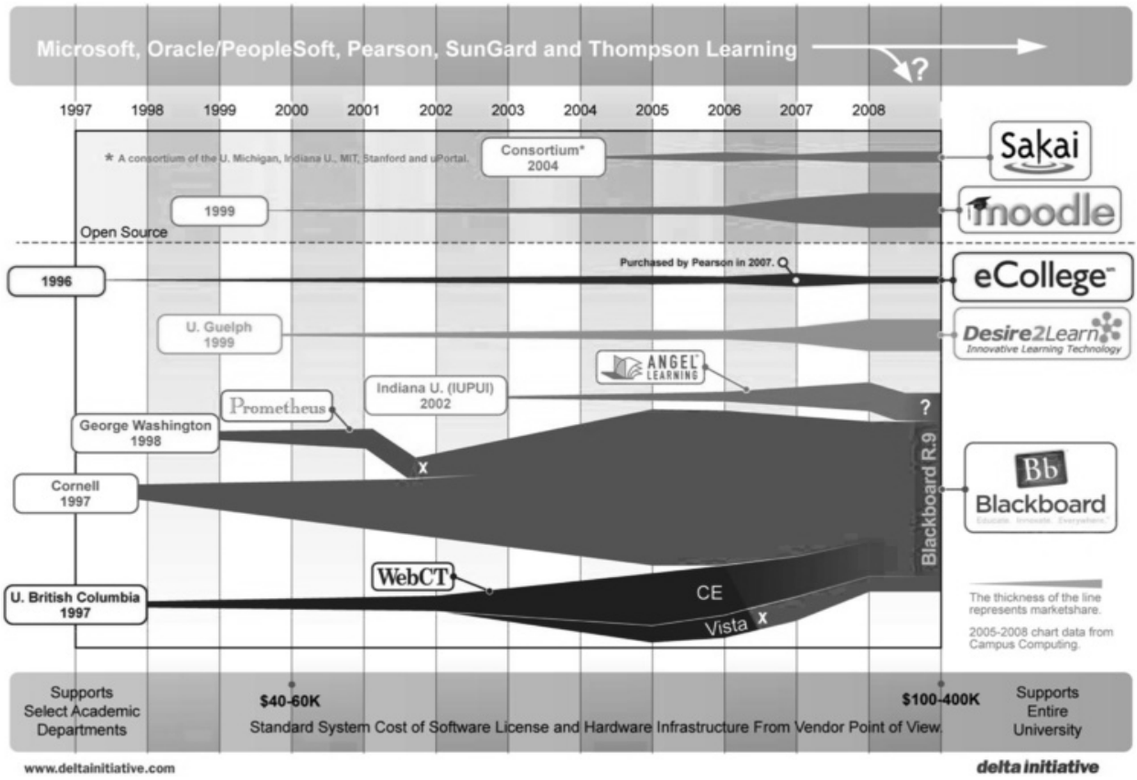

Fig. 3. LMS market share time line (Copyright http://www.deltainitiative.com)

1.1.3 LMS potential

The launch of new generation LMS such as Blackboard 9.0, D2L 2GO has resulted in a significant improvement in interaction among various parties: learners, teachers, instructors, and administrators. The potential of mobile technologies have also enhanced the functions available in LMSs with increasing numbers of mobile devices that can access Internet resources conveniently. Emergence of smart phones and smart devices such as iPod, iPhone, iPad, and Android are now being supported by major LMS like Blackboard Learn 9.0. Other LMS providers are also aware of the importance of LMS services via mobile devices. For instance, Desire2Learn Inc. ("D2L"), a global provider of enterprise e-Learning solutions, has also developed a mobile learning application called "Desire2Learn 2GO" which allows users to access course information from a BlackBerry mobile device. Moodle has also stated supporting mobile devices, including all Japanese mobiles, iPhone, and iPod touch since 2009.

According to The Instructional Technology Council, the top 5 growing areas of LMS segments are, namely: (a) online student organization and web services, (b) online counseling and advising, (c) online plagiarism evaluation, (d) online Audio\Video streaming, and (e) online textbook sales.

2. Multimedia in e-learning

As the name suggests, multimedia is a combination of different forms of media that contains information stored at varying granularities of time and space resolution. For example, a still image represents certain time of space with varying special resolution whereas an audio/video segment represents both time and special information in continuous form at varying resolutions. Text on the other hand is human interpreted state of certain event or series of events in time and space.

People understood the efficiency of using multimedia since long time ago: surgery model has become standard equipment in the biology class, the molecular model is a standard equipment of chemistry, and there is no geographic lecture if there are no maps. Modern multimedia encompasses assimilation of more media forms to deliver its contents to the consumers in a highly usable manner, in that, people can make use of their multiple senses at the same time to grasp information quickly and accurately. Virtual reality and augmented reality technologies have enabled perceiving things even beyond the perception of human senses.

2.1 Impact of multimedia in e-learning

Use of multimedia has been identified as an important element (Evans, 2007) in educational systems. High efficiency of using multimedia in education is caused by its characteristics, which includes:

- Mirrors the way in which the human mind thinks, learns, and remembers.
- The combination of media elements in a multimedia lesson enables trainees to learn more spontaneously and naturally, using whatever sensory modes they prefer, extending their experience to discover on their own, enable them with varying levels of literacy and mathematical skills to learn by using sight, hearing, and touch.
- Multimedia programs (expert systems) are designed to allow learners to pause, branch, or stop for further remediation, exploration, or enhancement opportunities; encouraging non-linear thinking.
- With the rapid development of mobile technology, the transfer speed of wireless mobile networks has dramatically increased with mobile access to multimedia contents, such as high quality on-demand video, video call, on-demand TV, etc. Multimedia is the only viable and effective content format that could be used effectively for education due to the mobile nature of users as well as due to small screens of devices.

Figure 4 illustrates positive effects of multimedia usage in education for two example cases. According to United States Department of Defense data (Oblinger, 1991), some useful conclusions are made on the effect of multimedia in education: short-term retention of approximately 20% of what is heard, 40% retention of what is seen and heard, and 75% what is seen, heard and done. Trainees can complete courses with multimedia in one-third of the time and reach competency levels up to 50% higher, compared to the performance of traditional instruction modes. Furthermore, in most of the cases, the overall cost of instruction is lower.

According to a separate study in CERT® (CERT, 2007) virtual training environment (VTE), as illustrated in Figure 5, it is a known fact that the best way to ensure mastery and retention of a specific instructional subject is to present the subject to the user in multiple increasingly-engaging formats. In an experiment where students read about a topic, hear about it, see it,

and then put it into practice; the subject mastery level continues to increase as one utilizes more of his/her sensory powers.

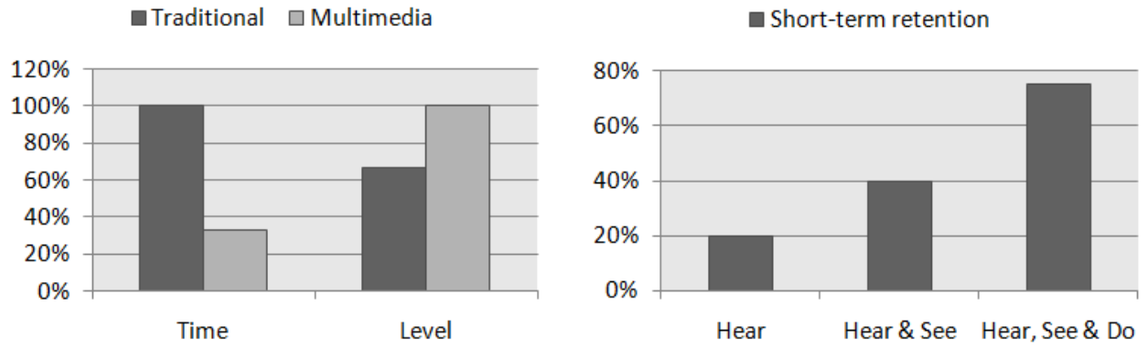

Fig. 4. Positive affection of multimedia on education

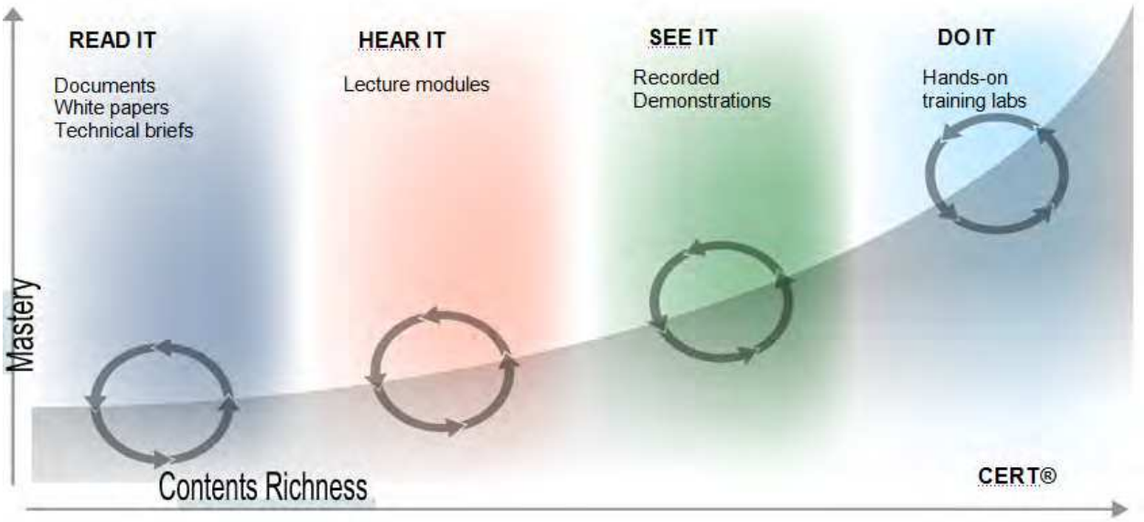

Fig. 5. Multi-modal learning reinforcement in VTE

2.2 Multimedia usage in current LMS

Despite the mighty of multimedia content in didactic material, its usage in learning management systems is still not straightforward due to many reasons. First, multimedia handling involves large amount of computing power and storage volume requiring improvements to current equipment; second, multimedia dissemination requires high-band width links which needs costly investment for network improvements; third, student-side gadgets are not readily available for all students to capture and render multimedia; and fourth, teaching pedagogies have not yet captured the important semantics of multimedia based learning.

Due to the reasons explained above, multimedia content usage in LMS is not fully explored yet. The way multimodal contents is used in education, today, is by making use of classic

file transfer and media handling technologies to disseminate multimedia in parallel to LMS operation. In Ritsumeikan Asia Pacific University, a content authoring dissemination system that uses a combination of FTP server, multimedia server, and Blackboard has been used for this purpose, as illustrated in Figure 6.

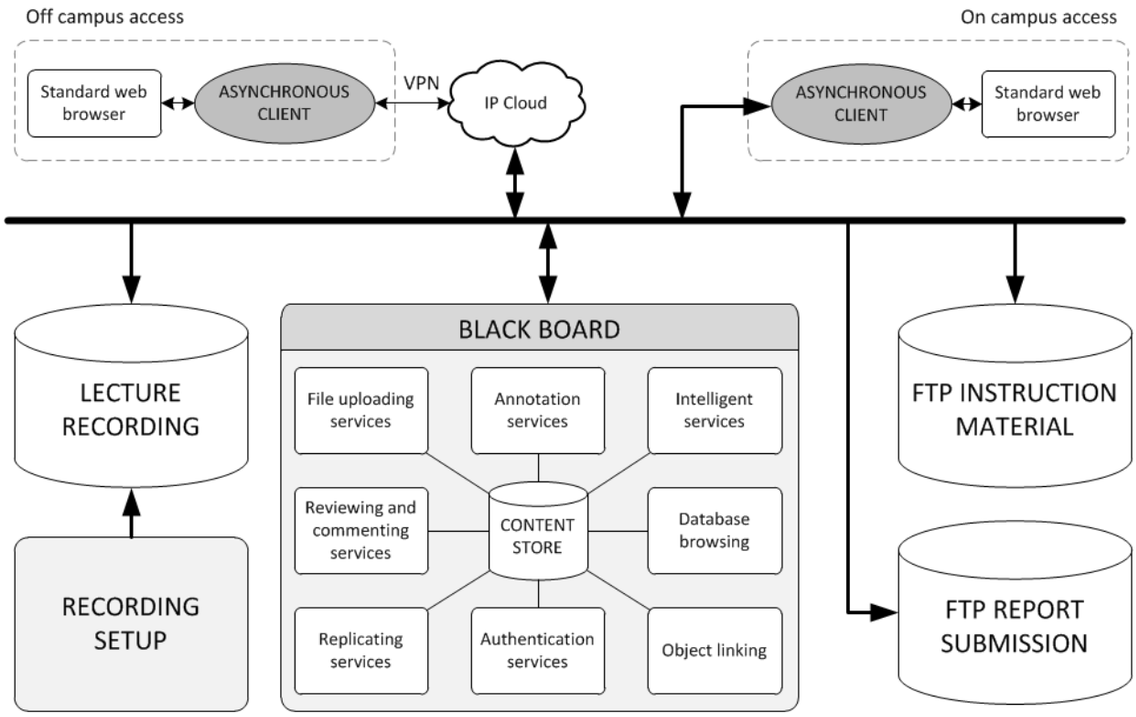

Fig. 6. Components of the ICT based educational platform in APU

- **FTP file server**: File Transfer Protocol file server holds two sub-folders, Instructional Material and Submit Report for all lectures. Instructional Materials contain course contents while the Submit Report folder is used for students to submit their assignments.
- **WebCT/Blackboard system**: From the year 2000 to 2007 APU used WebCT, a web-based course management system and in 2008, APU upgraded the LMS system to Blackboard because it was found to be more user-friendly and supports more functions. Presently APU is still using Blackboard and the Blackboard site is accessible off campus requiring virtual private networks (VPN) for some specific pages.
- **Lecture recording and Multimedia streaming server**: Class discussion and lectures can be recorded using a special mobile recording equipment set (fixed installation is limited to a few lecture rooms) and the recorded clips are uploaded to the multimedia streaming server that uses synchronous multimedia integration language (SMIL).
- **Custom-made LMS**: Some lectures in APU are using their own LMS. In the ICT institute in APU the creators use a custom-made LMS, basically a modified version of Claroline, to best accommodate their teaching pedagogy.

It can be also observed that trials of close integration of multimedia in LMS are emerging. WebCT/Blackboard system (BlackBoard inc., 2009), heavily used commercial LMS today,

has integrated virtual classroom/collaboration functionality in its latest (Windows Vista compatible) version. Moodle, a heavily used open source LMS, has also integrated a multimedia plug-in, named DimDim, to facilitate primitive video conferencing capability. Many academic institutions reportedly have added an array of custom multimedia functionalities either as an integrated tool to the LMS or as and independent tool to quickly cater the demanding needs for multimedia functionalities. While the technology is moving toward a multimedia rich learning management system, its practical deployments is still far away, due to many unsolved technical and pedagogical problems. Therefore, in Asia Pacific University in Japan, we have started developing a Ubiquitous Multimedia Enhanced Learning Management System (umeLMS) to enhance its education quality while reducing the user burden. The term ume (ゆめ：pronounced as Yume) in Japanese Language means dream: hence we envision an ideal LMS (dream LMS) to enhance the quality of education.

3. Multimedia integrated e-learning framework

In devising the integrated framework for LMS implementation, requirement of all stake holder groups are to be addressed: a user-centric, customized, content rich, and ubiquitous learning environment is aimed. The target LMS must ensure a leaning environment that characterises a consolidated system with many tangible features, such as (a) reduced cost and time consumption, (b) reduced workload, (c) enhanced educational quality, (d) enhanced system accessibility, and (e) enhanced usability. This section elaborates the integral components of multimedia integrated framework, namely: input integration, content generation, and access integration scenarios used to accomplish this task.

3.1 LMS content model

Figure 7 illustrates the life cycle of a generic course indicating its didactic contents, associated access scenarios, and interaction of its stakeholders (i.e. administrators, teachers & lectures). Involvement of multimedia in this model covers major portion of content volume and plays a significant role in supporting the learner and teacher in understanding the course content, evaluating students' progress, report back to the lecturer, and participate in group discussions. Although continuous multimedia is recorded with relevant time-space information in full, its usefulness is a relative measure; without user having access to smooth reception of multimedia, and without user having required access modalities to traverse a multimedia clip over its full length of duration, usability of multimedia content is very low. Multimedia should always reach users with high availability both in time and space with adequate metadata embedded, supporting application metaphors to implement semantic navigation modalities (through book marking, cross linking, filtering, and data mining etc).

3.2 Integrated framework architecture

The LMS framework proposed in this work essentially addresses several important design aspects through a modular design approach. Figure 8 illustrates this modular architecture with corresponding implementation technologies shown on the right side of the diagram. *Content Store* (CS) facilitates storing of content in the hard disk with required backup and synchronizing support. *Content management and integration module* (CMIM) is responsible for content management functions such as authoring and versioning. Two separate modules

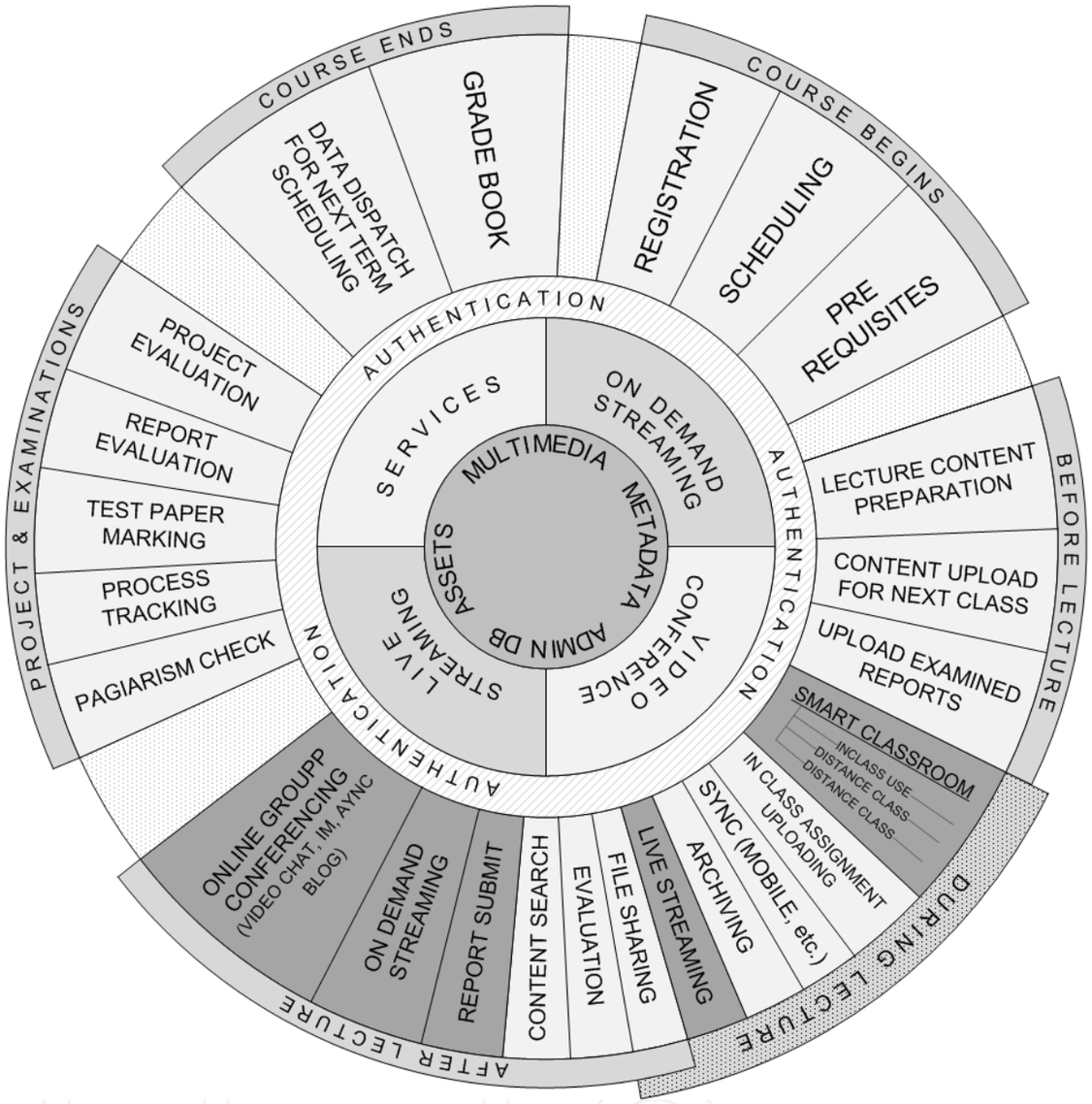

Fig. 7. Content model and access scenarios for a course life cycle in integrated LMS

that operates on top of CMIM are dedicated for input and output functionalities namely; *learning management module* (LMM) to support various learning/teaching scenarios and *multimedia management module* (MMM) to house functionality to handle multimedia content authoring and dissemination metaphors associated with LMM functions. *User management module* (UMM) module is indispensible to manage the front-office of the system such as registration, authentication, and notifications. UMM manages users as well as user groups and implements access authorization to the system resources through the functional modules LMM and MMM. UMM also passes very important parameters to its underlying service interfaces on the access behavior of users, which makes sophisticated user-centric implementation possible. This modular design also enables interfacing with complementary modules that the authors have proposed as separate work such as project management and evaluation system (Long, 2008) industrial student internship program (SIIP) (Tanaka, 2009)

and smart classrooms (Pishva, 2008). These modules essentially support a framework that characterizes three modes of system integration, namely: (a) input integration, (b) content integration, and (c) access integration.

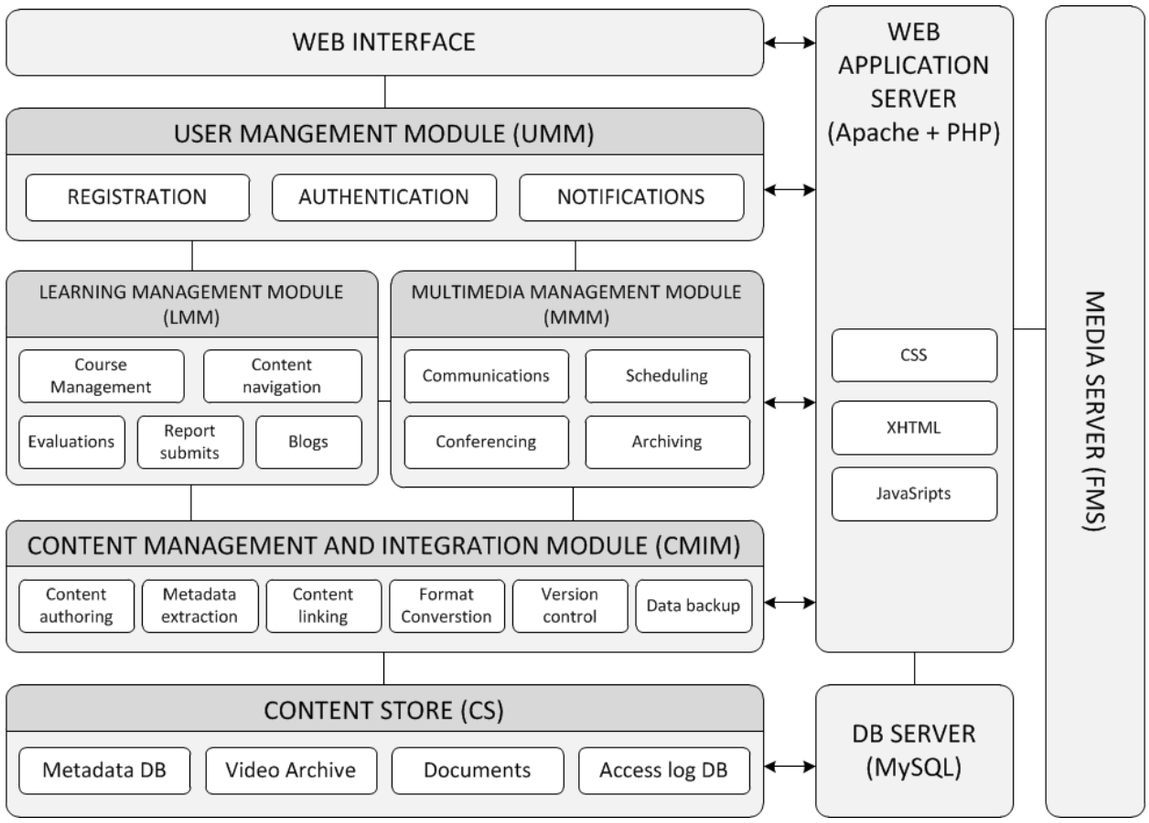

Fig. 8. Modular architecture of umeLMS

Figure 9 illustrates multimodal sources of content originated by both teachers and learners, devices involved, and various access scenarios of the proposed *user centric learning* (u-learning) framework.

3.3 Input Integration

Input integration refers to capturing various multimedia inputs to enhance the richness of lecture content. Following multimedia input methods are of major concern for maximizing multimedia richness in teaching as well as learning:

3.3.1 Lecture recording

Lecture recording has become more and more popular in all types of academic institutions, nowadays. However, in most cases it is used as a single stream audio video recording and often not integrated to the LMS, but facilitated as an adjunct multimedia dissemination system supported by loosely coupled cross links with the LMS. In most systems (e.g. the recording system currently used in Asia Pacific University), human interaction is required for recording, uploading, and creating a hyperlinks. The recording mechanism proposed in

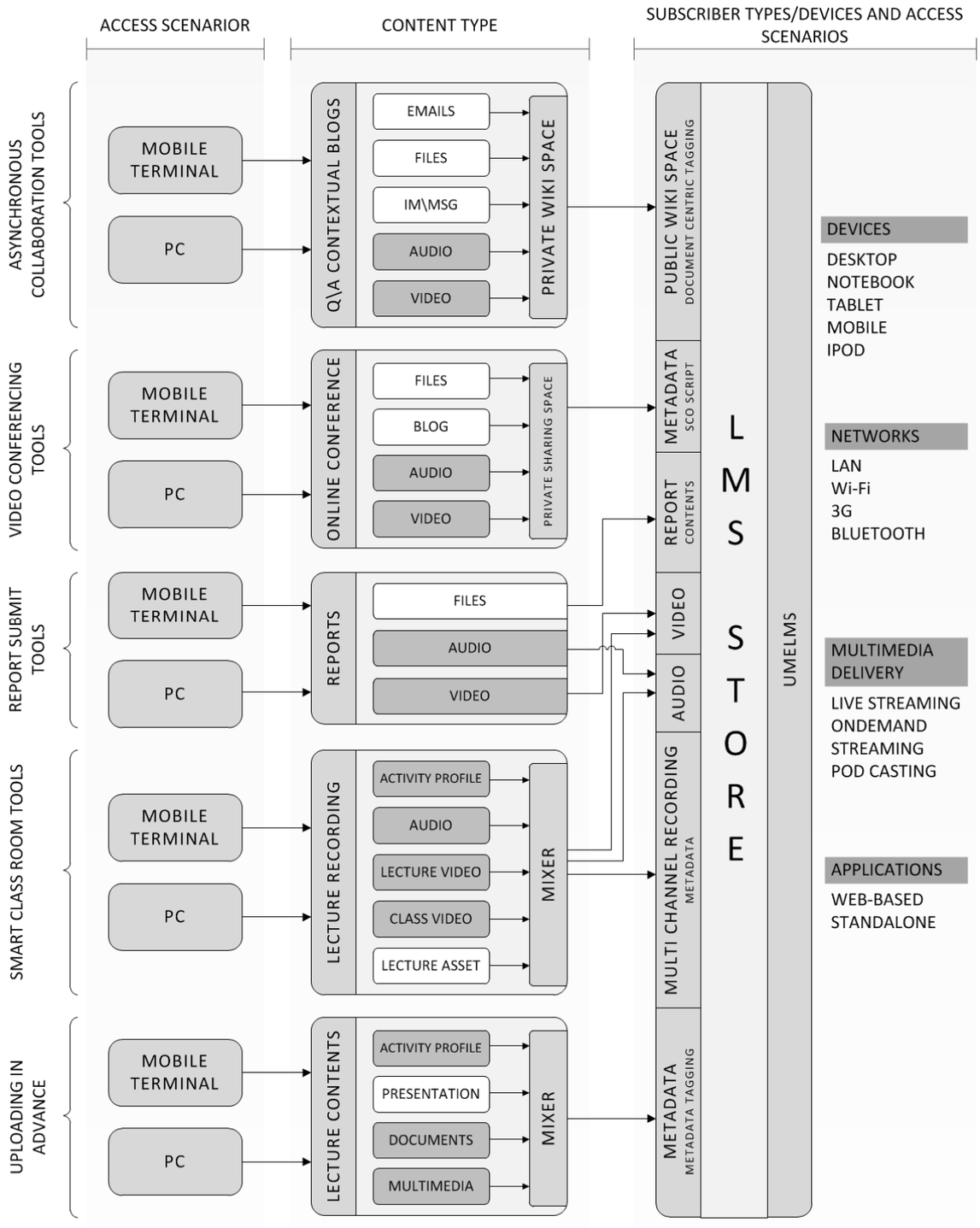

Fig. 9. Content, devices and access scenarios in multimedia enhanced u-Learning framework

these papers essentially involves automated capturing of multiple video channels, multiple audio channels, and projector/PC screen on which the teacher is presenting. The recording captures the important activity of the classroom by automatically analyzing the behavior of signals in various input streams and then forming a combined streaming for recording. This form of recording is proposed by other research as well such as *smart classroom* implementations (e.g. Pishva, 2008), but they often require sophisticated and costly equipment.

In this work we propose a cost effective methodology that uses a single dedicated PC per classroom to process multiple audio-visual inputs and form a composite stream for recording as illustrated in Figure 10.

Video inputs are captured from three IP cameras pointing to the lecturer's desk, whiteboard and the students. Voice of the teacher is captured from the main audio system in the classroom and the audio from the students is captured from the microphones in IP cameras. The lecturer's screen is used as the default video input. Depending on the classroom activity inferred by the system on various inputs, the recording PC forms a composite video stream and transmits it to the video server for archiving. Flash Media Server (FMS) (Adobe, 2010) technology is used to implement the streaming functionality at the server.

3.3.2 User side recording

Existing LMSs allow the user (teacher/student) to submit their reports, suggestions, and comments as document attachments. The user centric learning framework proposed in this work suggests that the users should be facilitated with application metaphors submit multimedia reports through devices they use in daily life. This enables enhanced interaction among students and teachers by providing an interface to query and answer without wasting time, without the need to purchase special devices and software, and without the need to be familiar with multimedia processing knowledge. By combining the user-side recording function with content integration feature, users are given privilege to manipulate their own multimedia rich resource database, which is attributable for establishing a sustainable learning process. A client side recording solution involves a similar, but less complicated, system implementation as in the lecture recording architecture illustrated in Figure 10.

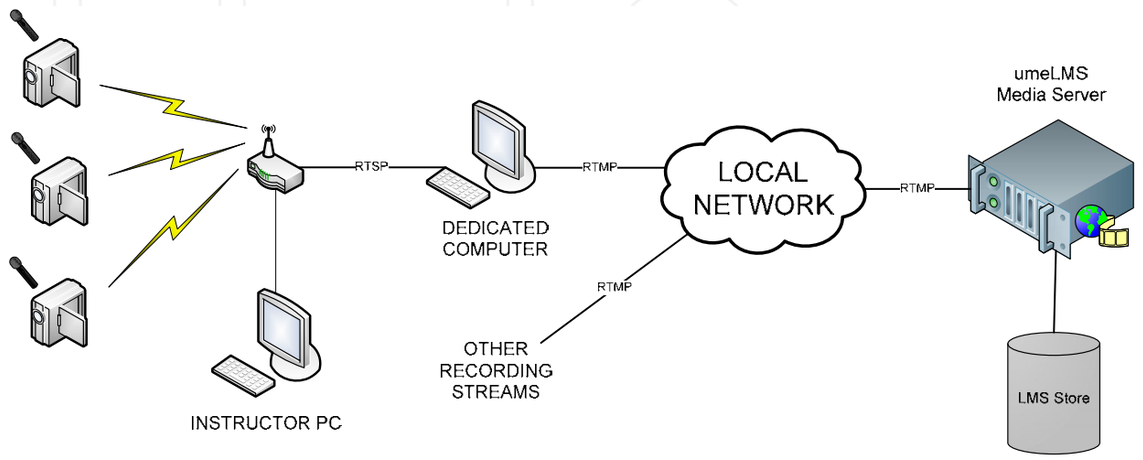

Fig. 10. Lecture recording architecture

3.3.3 Live conferencing

Live conferencing features are used in many fields including education, office management, business interactions, clinical activities, and e-commerce services. In education, live conferencing is strongly supported by commercial LMS; open source LMS have less built-in-features for live conferencing. Existing live conferencing modules, anyway, are not fully integrated in to LMS — some complementary tools like Skype, and conferenceXP, are used in collaboration with LMS, in most cases. The proposed framework deploys flash media server (FMS) that can provide high quality and flexible synchronous media streaming ,which can closely integrate live conferencing with the core LMS. Media contents are streamed via links between client and FMS through RTMP protocol (HTTP tunneling supported). LMS media server implements many support functions such as, stream forwarding, multi-stream recording, and multi-party session controlling to enable close integration of live conferencing with LMS. In live conferencing, each client will receive the downstream multimedia streams from the media server and transmits the upstream components into the media server, synchronously. The media server receives all video streams and forward multimedia to respective members, as governed by its session controlling mechanism.

3.3.4 Multimedia blogs

The proposed e-learning framework support blog based asynchronous group scenarios to use more multimedia contents. This means using of multimedia objects (image, video, audio, and vector graphics) to replace the conventional modes of text based interaction in blogs.

3.4 Content integration

Having built up the content store with a mixture of related hypermedia elements (i.e. lecture contents, lecture recording, report submissions and client side multimedia), it is required to relate different elements for enhanced accessibility. We adopt a metadata model to implement a semantic linking mechanism as presented in (Hiromitsu, 2005) to relate different elements in the LMS store. The content model we adopt allows context aware navigation rather than conventional hierarchical browsing, which enables flexible content views such as lecturer centric, student centric, course centric and activity centric as illustrated in Figure 11.

The students/lectures are given an interface to store the contents in an inter-related way using semantic cross-links such that the content navigation becomes easier and faster. The need for creating manual links is avoided as far as possible. Different elements inherit relations are based on the context that it creates. The access rights are also defined on contextual grounds at the time the object is created. The lecturer/course admin are given privileges to override these access rights.

3.4.1 SCO content model

We propose a Sharable Content Model (SCO) that enables content sharing and in the LMS. We adopt this model, similar to SCORM, to facilitate a well defined content structure while keeping the content development burden as low as possible to the teachers. However, in order to keep this SCO methodology less complex, we keep away from the standard SCO models, but use a simple and structures custom SCO model for content management. Here,

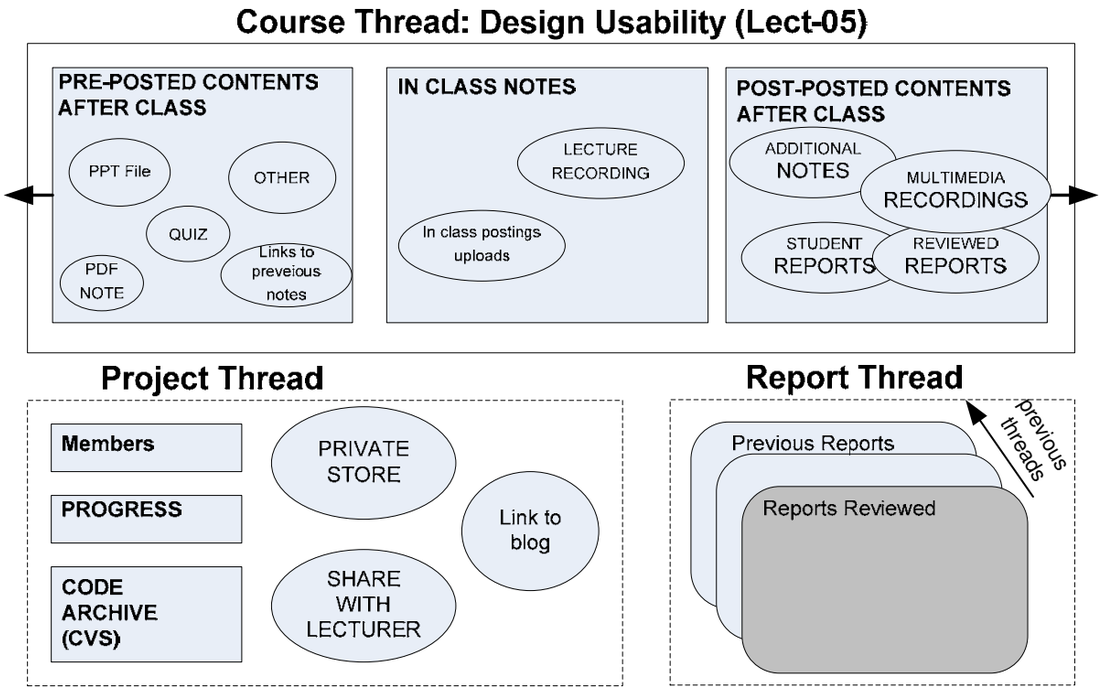

Fig. 11. Schematic of the integrated content model. (Relate this to SCO)

content associated with a course are stored physically in a flat file store, but conceptually placed within an abstract folder as dictated by metadata-content relationships. All metadata is stored in a single file named manifest.xml (here we use the same methodology adopted in SCORM), and content files (i.e. documents, multimedia files) are stored in the file store without any alterations.

3.4.2 Content authoring

Figure 12 (left side) shows the formation of SCO script in manifest.xml. The SCO publisher assimilates different types of hypermedia inputs as shown in (II.b) and generates manifest.xml file (III.b). Hypermedia input in (II.b) is saved in the proper service location (ie. Data Server, Web Server or Media Server). Metadata for generating the SCO object is captured from user behaviour, user input, and scanning the input content by the system. Input files that do not generate any metadata description, will all be stored as linked *assets* of the course contents. In this approach, content corresponding to one course are packaged in to one abstract container with a *manifest* file.

3.4.3 Content rendering

With reference to Figure 12, when a client request to access an object from Web Server (1) , the web Server will check the data server and get the metadata information of that object (SCO compliant) (2,3). After receiving the requested information from the data server (objects permission, file info, etc.) (4), web server will render the HTML output, with embedded objects or hyperlinks to contents. In case of media streaming, the web server will pass the required information for the client to communicate directly with the media server (6,9) and instructs the media server to service the client (7,8).

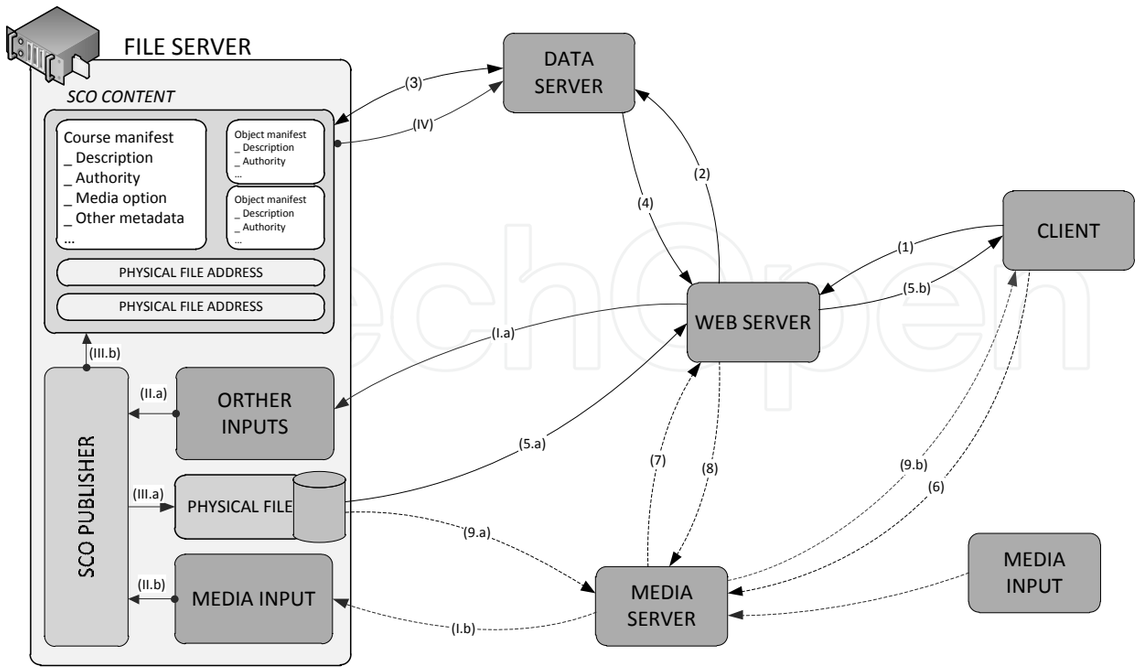

Fig. 12. SCO content integration

3.5 Access integration

Ubiquitous access is one of major goals of the development of proposed e-learning framework by which the LMS system is open to ubiquitous access through desktop as well as mobile devices. This is made possible by using *flash streaming technology* which currently a dominating element of *rich Internet application* (RIA) market. Flash technology is supported by almost all internet browsers and installed virtually in all computers irrespective of the operating system. The media streaming system in this framework adopts Flash Media Server (FSM), which provides the ability to stream live videos or video on demand contents, flexibly. Using FMS, multimedia can be accessed by almost all desktop platforms as well as mobile devices without the need for tedious software installations.

Mobile clients can access the content store using most of the smart phones. Moreover, the mobile network having been dramatically developed over the last 5 years and 3G/4G streaming is capable of smooth streaming of high data rate videos such as live TV, even in fast moving environments (e.g. while traveling by busses, trains etc.) There is not much differences in developing desktop applications and mobile application, due to the advent of Flash 8, which brings the gap between mobile and desktop content closer by supporting FLV video, H.264 video, as well as On2 VP6, and Sorenson video codecs. This framework majorly adopts streaming in FLV video format, which can be realized by FSM in a highly scalable manner.

4. Implementation of UMELMS

UMELMS, *Ubiquitous Multimedia Enhanced Learning Management System*, has been prototyped and tested in Ritsumeikan Asia Pacific University (APU) in 2010 for six months, as a

supplementary system, to support the delivery of some selected course. Especially, the lecture recording system of UMELMS was used to record some of the lectures (ICT courses) in the university followed by an attempt to cross link all other didactic materials to lecture recording through meta data tagging. Using this LMS, the course creators can manage and create new multimedia content including lecture records by a central control panel. The experiments conducted in APU network environment resulted good performance proving the system efficiency in many aspects, such as system robustness, device compatibility, and scalability.

4.1 Working environment

APU is a pretty young and international university, where nearly 6000 foreign and domestic students are served with a bilingual curriculum. Currently, around 2500 PCs are used in APU to realize IT enabled education; PCs are connected through a 100Mbps local area network with an external connection operating at 400Mbps. A fast Wi-Fi network that covers a large area over APU campus and facilitate concurrent access to a large number of mobile phones and other smart devices. In conclusion, APU's network environment is highly conducive to reap the best potential of multimedia rich content delivery for education, making it an ideal place to benchmark the UMELMS system. APU's IT enabled resources setup is illustrated in Figure 13.

Fig. 13. Classrooms and device setup in APU

4.2 UMELMS system setup

UMELMS system is developed using the framework explained in Section 2. A Web Server is built upon the resources, L(W)AMP stack (which stands for Linux or Windows), Apache, MySQL and PHP. UMELMS Media Server, powered by Flash Media Interactive Server, was hosted in another dedicated Windows server. All the servers of UMELMS are connected with the APU network through 100Mbps Ethernet connection. The testing server is equipped with Intel Xeon X3353 2.66GHz, 4GB of RAM, Broadcom NetXtreme Gigabit Ethernet Card, and Barracuda ES.2 SATA 3.0Gb/s 500GB HDD x 2 with average speed of 80MB/s. UMELMS does not require any complicated installation in order to perform a new recording, editing, and playback. For example, the only requirement to perform a new class record session is a camera connected to a certain computer that can access the APU network. The recording process is mangled through a web interface on the PC with camera connections. In the practical system, a dedicated computer with Adobe platform applications can be used as a part of recording system to manipulate videos before streaming them up to the server; the process can be done either automatically or manually.

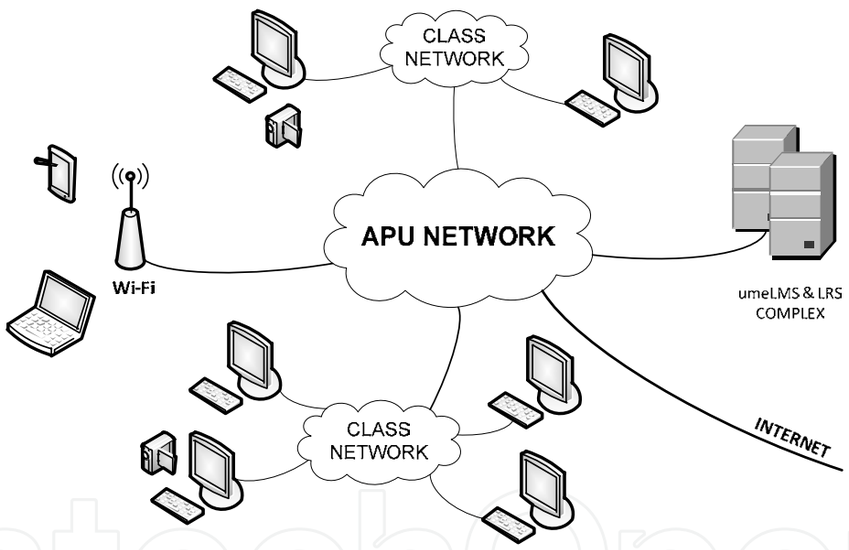

Fig. 14. Network environment in APU

4.3 Implementation and deployment

UMELMS Web Server and *UMELMS* Media server communicate with each other through a low-level API system (i.e. interface of multimedia management module (MMM) and learning management module (LMM). When Media Server wants to communicate with the web server, it will uses the web service (written in PHP) and make an XML-RPC (Remote Procedure Call) to request the user authenticating data. On the other hand, when Web Server wants to initiates media services (e.g. make a Live Conference through Media Server), it will request Media Server through a similar method. The client (desktops or handheld device) only need a Flash supported browser to access Web Server, everything will be taken care in server-side.

Figure 15 illustrates a snap shot of UMELMS showing video playback and student's personal notes. By this way, each student can maintain his/her own study profile.

Fig. 15. A snapshot of umeLMS showing video playback and student's personal notes

4.4 Evaluation

Experiments show that the system requires 1Mbps bandwidth to handle one streaming session at high quality (720px*405px 24fps). According to the estimation from evaluation result, the archiving server is able to handle approximately 360 concurrent recordings while keeping the system workload under 70%. The number of current recording sessions is limited to this value mainly because of the memory usage.

As UMELMS multimedia controls are Flash based, users can access its content using a wide range of devices that supports flash. The Lecture Recording System is fully automatic and eliminates unnecessary delays caused by manual uploading, making the lecture record able to be used as live streaming during the lecture, and as on demand streaming after the lecture.

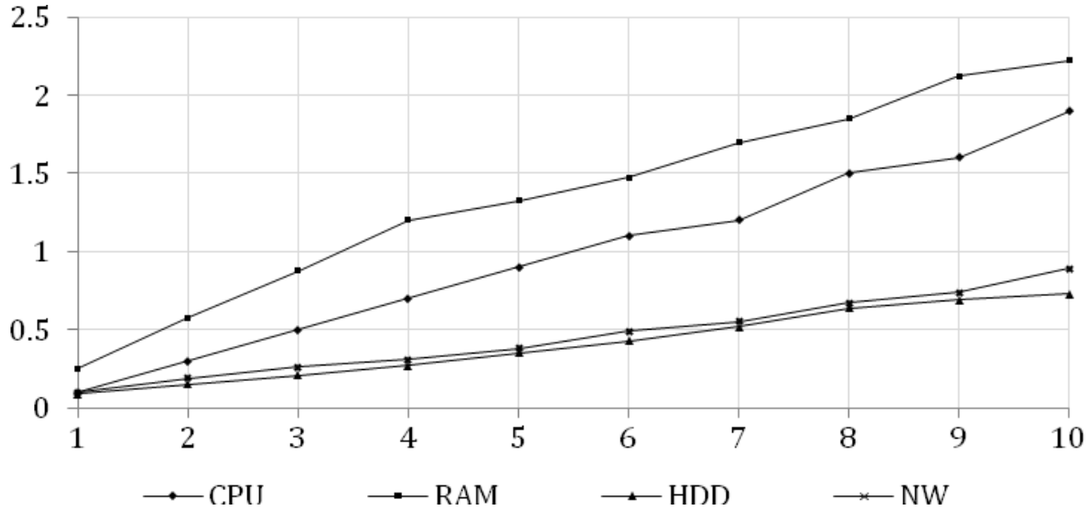

Fig. 16. Server resource usage (%)

5. Conclusion

In this work we presented a framework for implementing a content integrated learning management system with specific focus on multimedia enrichment in learning content. To implement this we propose SCO based content model and a flash based multimedia framework, with which content captured from various sources is integrated. This concept is demonstrated by implementing ubiquitous multimedia enhance learning management system (umeLMS) in Ritsumeikan Asia Pacific University.

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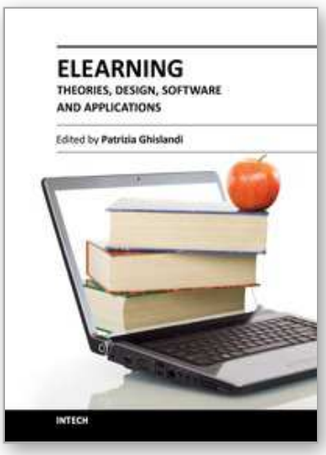

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The term was coined when electronics, with the personal computer, was very popular and internet was still at its dawn. It is a very successful term, by now firmly in schools, universities, and SMEs education and training. Just to give an example 3.5 millions of students were engaged in some online courses in higher education institutions in 2006 in the USA1.eLearning today refers to the use of the network technologies to design, deliver, select, manage and broaden learning and the possibilities made available by internet to offer to the users synchronous and asynchronous learning, so that they can access the courses content anytime and wherever there is an internet connection.

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