Web-based Asynchronous Synchronous Environment

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Abstract

In the face of the coming of new information technology era of 21st century, web-based learning has become the major trend of future teaching and learning model. The web-based learning systems are created to simulate the real teaching-learning environment in the classroom using computer software and web-based tools. Learner can study web-based teaching materials according to their individual needs and instructional schedule. Although web-based learning has a lot of advantages over traditional face-to-face learning, the lack of the explanations and interpretation of teaching materials from human teacher in most existing web-based learning system is critical. This project proposed an innovative solution to the problem by combining the benefits of classroom learning in the web-based education.

In this project, a prototype Web-based Asynchronous Synchronous Environment (WASE) is developed that not only combines the benefits of tools such as WebCT and AudioGraph, but also integrates lectures given by the human teacher within the system. WASE provides simultaneous low-bandwidth streaming of lecture video and presentation, while facilitating students with presentation annotation facilities, and peer discussion on particular issues related to the topic.

The prototype system is built using a three-tier, client-server architecture. The client tier is a set of HTML frames embedded with RealPlayer running in the students' web browsers to provide course contents and navigation guide. The middle tier is an application server which consists of Java Sevlet, JSP engine, and application programs to receive the students' requests and send the corresponding course contents and navigation guide information to the client side. The third tier is the relational database for storing the course structure and contents, and for recording the interaction between students and teachers.

This project provides a solution where the off-campus students are able to enjoy the explanations and interpretation of course materials from human teacher just as normal on-

campus students do in the traditional face-to-face learning environment, while still reaping the benefits of web-based learning.

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Chapter 1 Introduction

1.1 Introduction

In the face of the coming of new information technology era of 21st century, web-based learning has become the major trend of future teaching and learning model. Most educational organizations are now using some sort of internet technologies in their distance education offerings. Many web-based learning systems are being created and implemented to simulate the classroom teaching environment, using various computer software packages and web-based tools (Chen & Shih, 2000). Learners can study web-based teaching materials according to individual needs and instructional schedule. Although web-based learning has a lot of advantages over traditional face-to-face learning, it lacks the explanations and interpretation of teaching materials from human teacher. In most cases, the learning just changes from books to web page (Chen & Shih, 2001).

The aim of this thesis is to design and implement a web-based learning system, where the off-campus student can get the explanations and interpretation of teaching materials from human teacher while enjoying the benefits coming from new web technology.

In the next section of this chapter, we shall discuss the types of learning environments. Then the limitations of current web-based learning systems are described by comparing traditional face-to-face learning and distance learning. Finally the objectives and methodology of this project are presented.

1.2 Types of learning environments

Learning can take place in variety of environments, which can be classified into four major types according to two critical dimensions: time and place as shown in table 1-1 (Aggarwal *et al.,* 2000).

Table 1-1 Time and place dimensions of learning environments

		TIME	
		SAME	ANY
PLACE	SAME	Type 1 Traditional Classrooms	Type2 Lab modules
	ANY	Type 3 Distance learning	Type 4 Correspondence Course

Type 1 represents the traditional face-to-face classroom, where students congregate at the same time, at the same place, to be taught simultaneously the same material by the same person. The interaction between students and faculty is "many-to-one" during class time and one-to-one during office hours. Students work individually or in a group during class time and/or in their own time.

Type 2 represents learning environments where students come at different times to receive modularized instruction at the same place, such as a lab, information center, or library.

Type 3 environments are distance learning programs where students from different geographic areas can be taught simultaneously through one-way or interactive audio and video technology.

Type 4 environments have traditionally been represented by correspondence courses, where students can learn on their own anywhere, anytime, and take exams as needed.

Type 1, Type 3 and Type 4 learning environment are focused on in this thesis. Most people are accustomed to learning in Type 1. However, with the advances of new web technology, more and more people begin to enjoy learning in Type 3, more so because it is flexible, time independent and place independent. These two types of learning environments are discussed in following sections.

1.3 Traditional classroom

The traditional classrooms facilitate face-to-face education. Teacher and students sit in the same classroom at same time. The teacher presents the necessary material in the class. The students look at the material and listen to the teacher's explanations to understand the lesson. This situation has a number of features (Bandoh *et al.*, 2000):

- The teacher is able to express his or her ideas naturally.
- All the students can look at what the teacher is writing or drawing, and can focus their attention on it.
- The teacher can see the students' faces and expressions. The teacher can therefore adjust the pace or the contents of the lesson according to the feedback received from the students.

This approach represents the industry-based model used for hundreds of years to provide university-level instruction in large lecture, mid-size, or even small classroom environments. It has three key components:

- ***Human teacher expression and explanation:*** the lecturer uses natural language and body language to explain the learning material in the classroom.

- ***Student note taking***: the students usually take notes during the lecture according the teacher's explanation.

- ***Peer communication***: in the classroom the teacher and students have possibility to exchange ideas by discussion and asking questions.

The greatest advantage of traditional face-to-face education is the personal interaction with students, and the opportunity for both students and instructors to take advantage of paralinguistic cues to make points and to verify that a point or a question has been understood (Rea *et al.,* 2000). There may be a wide variety of involvement levels based on the size of the class and the willingness of the instructor to facilitate communication. Certainly, large lectures with hundreds of students are not conducive to high involvement levels of an interpersonal nature. Rea *et al.* (2000) pointed out that there are three kinds of strengths and weaknesses involved in the traditional face-to-face education. The strengths of traditional face-to-face education are as follows.

- *Interpersonal Involvement:* The traditional face-to-face education tends to lead to the greatest level of involvement between instructor and student. The personal interaction provides students with the opportunity for spontaneous discussions in a non-threatening manner. The interpersonal communication in this approach also provides the greatest opportunity for the instructor to perceive body language and other indications of understanding or confusion.

- *Familiarity:* The traditional face-to-face education may provide the most conformable environment for students and instructors, as it is the continuation of the approach used by most education facilities all over the world.

- *Flexibility*: The traditional face-to-face education provides the lowest cost for technology and allows for the lack of any technology skills on the part of the instructor. Likewise, the lack of technology allows for freedom to pursue many different approaches to the same course whether it is a laboratory exercise, a lecture, or a performance.

Rea *et al.* (2000) reviewed following weaknesses of the traditional education:

- *Lack of Convenience:* The traditional face-to-face education limits students in that they must be present locally, travel to campus, and utilize office hours. Dependency on time and location may eliminate certain students from the opportunity to study at the university and might also force students to progress through the course at a pace that is not comfortable for them.

- *Loss of Interpersonal Interaction:* As college enrollments increase, it may become difficult for universities to meet the demands of the growing population in the short run. This may drive administrations to implement larger class sizes and thereby promote less personal interaction with students.

- *Failure to Develop Real World Skills:* Students may fail to develop skills they need in the real world, such as sending e-mail, or interacting via telecommunications links. As larger numbers of corporations embrace technological solutions to management, students need to develop skills for survival in the technological workforce.

Due to these problems and advances in the internet technologies, the distance education is becoming popular. Many persons are enjoying this type of learning environment.

1.4 Distance education

Within the context of rapid technological change and shifting market conditions, the education system is challenged with providing increased educational opportunities without increasing budgets. Many educational institutions are answering this challenge by developing distance education programs. At its most basic level, distance education takes place when the teacher and students are separated by physical distance, and technology (i.e., voice, video, data, and print), often in concert with face-to-face communication, is used to bridge the instructional gap. These types of programs can provide students with a second chance at a college education, reach those disadvantaged by limited time, distance or physical disability, and update the knowledge base of workers at their places of employment.

Many educators ask if distant students learn as much as students receiving traditional face-to-face instruction. Research comparing distance education to traditional face-to-face instruction indicates that teaching and studying at a distance can be as effective as traditional instruction, when the method and technologies used are appropriate to the instructional tasks, there is student-to-student interaction, and when there is timely teacher-to-student feedback (Moore & Thompson, 1990; Verduin & Clark, 1991).

However, current off-campus students often feel isolated and lonely. Some of the characteristics experienced by off-campus students are as follows.

- ***No explanation and expression from human teachers*** – Off-campus students usually use printed material and learn by themselves. They do not have possibility to see human teacher's expressions and receive face-to-face explanations like internal students. This may prove very difficult for many students.

- ***No contextual discussion*** – Unlike internal students, off-campus students do not have possibility to discuss their questions with the lecturer and classmates within the context of that topic. Typically off-campus students use email or some sort of web discussion forum to discuss their problems, but these mediums work in isolation of any other resource used for the study, hence the queries do not remain in the context of their current study of topic.

- ***No regular channel to get help*** –There is generally no class time, no office hours, no laboratory exercise and no contextual discussion with classmates for off-campus students. So it is difficult to get help when they encounter some problems.

- ***No regular channel to give feedback*** – Internal students may give feedback to their teacher in class time, office hour or laboratory exercise. Then the teacher may adjust his/her teaching accordingly. But off-campus students do not have such possibilities.

- ***No Social Help*** – Since there is no real class for off-campus students, they do not have possibility to forge friendship and receive encouragement. They may feel isolated and lonely.

Although the new internet technologies make it possible to solve above problems, current web-based systems do not seem to solve them.

1.5 Problems of current web-based educational systems

The explosive growth in technology and the expanding access to the web has resulted in its increasing use for education and training. Web-based educational systems (WBES) refer to education delivered in whole or in part using Internet technologies. Existing web-based educational systems, how potential they might be, still exhibit a range of limitations for learning process. These limitations are described below.

- ***Lack of match between course material and its explanation*** – Current WBES are usually used as supporting tools in the courses. Students are expected to use them in conjunction with printed material. Since this is no integration of WBES with other learning resources, there is possibility of mismatch between the explanations provided in the WBES and any other learning material that student might use.

- ***Lack of contextual discussion*** – Existing WBES do not allow the integration of discussion with the domain content. Therefore the discussions do not take place in the context of a domain problem or example as they do in face-to-face tutorial environment.

- ***Lack of human teacher expression and explanation*** – Most existing WBESs are text and graphic based systems. The students do not get human teacher expressions and oral explanations. The students therefore miss out the impact of teacher's gestures in the learning process.

- ***Lack of human interaction*** – Most students have become conditioned to receiving instruction in a face-to-face mode. While some will adapt more easily than others, it will take some time for all to become accustomed to a computerized learning environment. Sometimes access to an instructor who can answer student queries is problematic, especially if the students attempt to access materials during non-business hours (in teacher's time zone). Learners can miss the support of a group or cohort of fellow learners.

- ***Lack of contextual understanding*** – Unlike in traditional classroom, the students in online learning do not have contextual discussion or explanation for certain concept. This leads to the lack of contextual understanding.

1.6 Objectives of the project

This project is funded by Massey University under the funds for Innovation in Education and Teaching. Current off-campus students at Massey University find it difficult to grasp the concepts without any explanations from a human expert. This project proposes an innovative solution to this problem by combining the benefits of classroom learning in the web-based education. A prototype Web-based Asynchronous Synchronous Environment (WASE) is developed that not only combines the benefits of learning management tools such as WebCT, but also integrates lectures given by the human teachers within the system. Using WASE, off-campus students can enjoy the benefits of face-to-face learning in asynchronous learning environment by:

- getting the expression (gestures) of the human lecturer;
- getting the explanations from the human lecturer;
- taking contextual notes during the learning process; and
- communicating with peers for contextual discussion.

1.7 Methodology of the project

In order to achieve above objectives, WASE provides simultaneous low-bandwidth streaming of lecture video and presentation slides, backward and forward play of the lecture videos (with synchronised presentation slides), annotation facilities, and peer discussion on particular issues related to the topic. The system includes the following components:

- Low-bandwidth streaming of lecture video and presentation – to get explanation from a human lecturer
- Low-bandwidth streaming of lecture video – to get human expression

- E-Note – to take contexture note for the lecture
- Discussion Board – for discussion among classmates
- Discussion Board – to get help from lecture and classmates
- Offering learning mode selection – to make the system flexible. This component provides an opportunity for the students to choose learning mode with different combination of lecture video and presentation, E-Note, and discussion board.

1.8 Outline of the thesis

This thesis describes the rational behind the development of WASE system, the methodology used in the project, the outcomes and the way forward. The outline of the thesis is shown in figure 1-1.

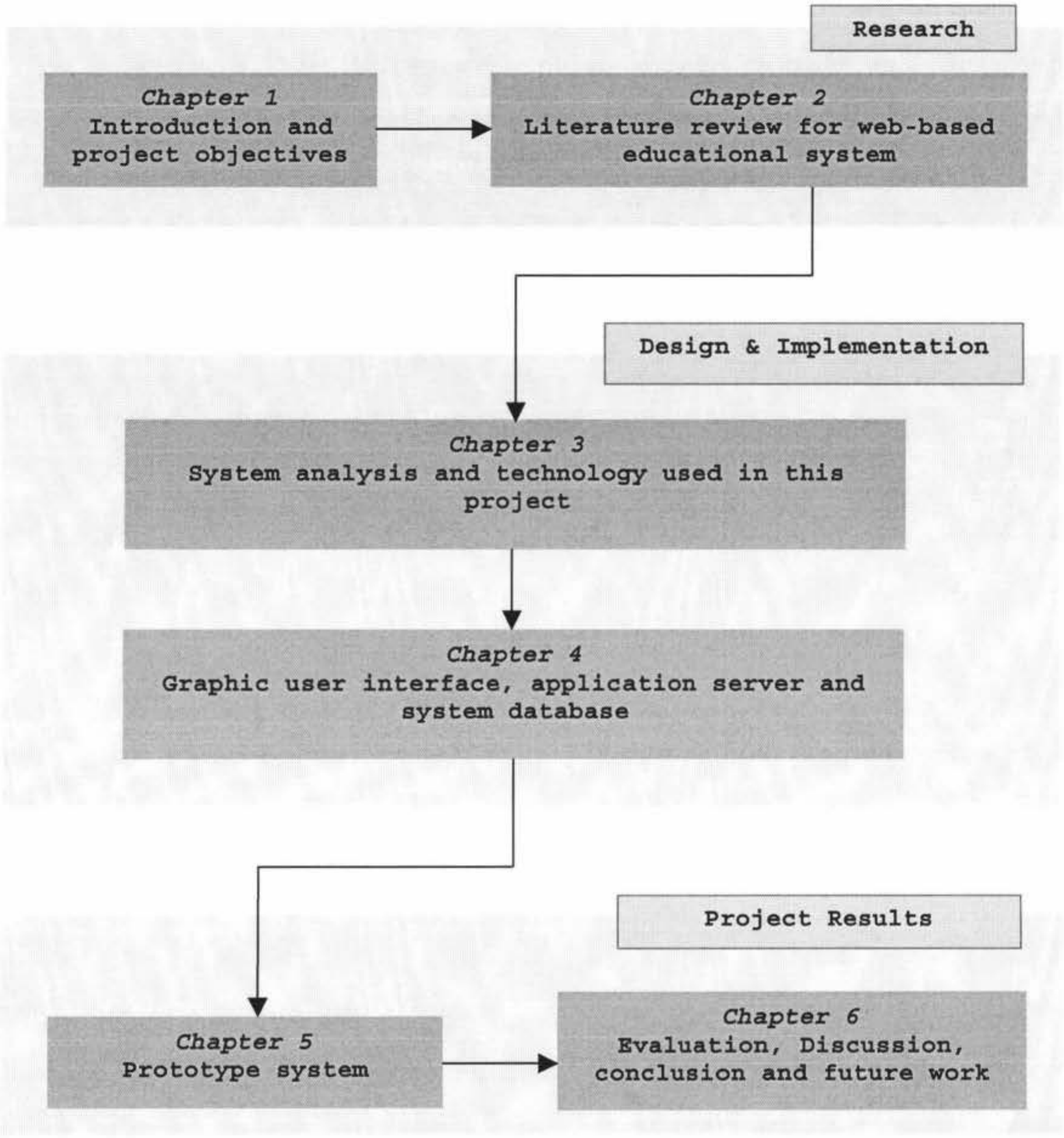
The thesis is largely divided into three sections:

- The first section presents the existing research in the field, which includes the two chapters (chapter 1 and 2) – introduction and literature review.

- The second section talks about the system design and implementation, which include two chapters (chapter 3 and 4) – system architecture and technology, and system design and implementation.

- The third and final section is the project results, which include two chapters (chapter 5 and 6) – prototype system, and evaluation, discussion, conclusion and future work.

The next chapter will discuss how existing web-based learning systems simulate the traditional face-to-face learning environment, what are the benefits by using web-based learning systems, and what kind of the technologies are being used in existing web-based learning systems.


Research
Chapter 1
Introduction and project objectives
Chapter 2
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Design & Implementation
Chapter 3
System analysis and technology used in this project
Chapter 4
Graphic user interface, application server and system database
Project Results
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Evaluation, Discussion, conclusion and future work

Figure 1-1 Outline of the Thesis

Chapter 2 Literature Review

2.1 Introduction

Less than ten years since its emergence to common people, the World Wide Web has become a prominent space for people to communicate, work, trade or spend leisure time. Increasingly it is also being used for learning (Berenfeld, 1996; Sherry, 2000). Its growth-rate is impressive: from a few dozens of servers/sites in the beginning of last decade to more than ten million servers today; from a limited and clearly defined population of users (mostly dealing with academic, research or institutional tasks) to a large and varied world community of users (an estimate of about 300 millions) across different countries, ages, occupations, interests, and purposes (Mioduser & Nachmias, 2002). With increased awareness of the potential of WWW for education, increasing number of educational organizations are attempting to integrate web technology features within their educational and pedagogical infrastructure to support students' learning goals. This has resulted in a growing population of web-based learning systems (WBLS).

This chapter first discusses the benefits of using web-based learning systems. It is followed by an overview of the technologies used in existing systems. Web-based learning systems typically support one or both of the following modes of communication among their users: synchronous and asynchronous. The chapter discusses the differences between these two modes and the peculiar features of both of them. Although the communication bandwidth is continuously improving, most of the current users still use 56KB modem to connect to the internet. On such low bandwidth modem users experience long download time while viewing the multimedia content in a WBLS. Therefore streaming technologies have been developed to cope with this problem. Streaming technologies let the low-bandwidth users view the multimedia content smoothly. This chapter finally reviews the streaming technologies to deliver the content, that are used in the web-based learning system developed in this project.

2.2 Why using web-based learning system?

The typical aim of web-based learning systems (WBLS) is to let the off-campus students have the similar learning environment as the on-campus students have. They generally simulate the activities/functionalities taken place in the traditional face-to-face learning environment, by using various kinds of information technologies. We first look at these activities and then discuss how WBLS perform these activities.

2.2.1 Activities in traditional face-to-face learning environment

Aggarwal & Bento (2000) pointed out that the activities in a learning environment are mainly undertaken by two actors: faculty and student. These activities correspond to the five components of the environment: content, delivery, access, interaction and assessment/feedback. Each actor performs different activities in each of these components.

Content

- Content preparation – this activity is conducted by the faculty. The content normally includes lecture notes, presentation slides, assignments and exams.
- Homework preparation – It is conducted by the students. The student should do the homework (assignment) based on the knowledge they primarily gained in the classroom.

Delivery

- Content delivery – It is conducted by the faculty. It usually includes course syllabus delivery, lecture delivery, lab demonstration and lab class and practices.
- Homework delivery – it is conducted by the students and includes giving presentations and handing in the assignments.

Access

- Accessibility of contents – this functionality usually focus on the students, because the content is prepared by the faculty. The students should get the course syllabus, listen to the lecture, view the lab demonstration, review the lecture notes, and read the assignments and homework.

- Accessibility of teacher – sometimes the students may ask for the help and get the detailed explanation of the content.
- Accessibility of peer/group – The faculty or the students may make the groups for learning. The group member should contact each other and exchange the idea about the content.

Interaction

This activity is conducted by both the faculty and students. It includes in-class interaction of students with the instructor, discussions with peers and getting feedback from instructor. It is usually divided into two types: synchronous and asynchronous interaction.

Assessment/Feedback

The students take the exams, do the homework and give individual or group presentations. The faculty then assesses the students' performances and gives feedback as appropriate so that the students can improve their domain competence.

2.2.2 Web-based learning environment vs. traditional face-to-face learning environment

The existing web-based learning systems facilitate the activities/functionalities that typically take place in the face-to-face mode of instruction.

Content

Lectures and homework can be developed for the web by using any word-processing package with html capabilities, or directly created in the web. For example, WebCT (http://www.webct.com) includes six tools for content preparation.

Syllabus – Allows you to create a customized course outline. Contains pre-defined sections such as course information and instructor information, and allows you to add custom sections.

Calendar – Allows you to post dates, and to provide information about course-related events. You can include links to course content and to relevant websites.

Content Module – Allows you to create and organize course material such as lecture notes and assignments. To assist students with their studies you can provide students with additional tools such as learning goals, references, glossary entries, and multimedia presentations, all within a Content Module.

Content assistant – Allows you to search or browse the e-Learning communities to find content for your course.

Goals – Allows you to provide students with learning objectives for a Content Module. Goals are linked to a specific page of course content and can apply to an entire module, section, or specific page.

Glossary – Allows you to create a fully searchable glossary of terms. Students can search the glossary by keyword or partial word.

Delivery

Instead of being delivered in-class, lectures can be placed on a server (owned by the university or by the service provider contracted for web-based learning). For example, the Wisconsin Web-Based Learning System (WWBLS) (http://www.uwsa.edu/olit/utility/) allows instructors to post lectures on the web, including video, animation and audio contents.

Access

Web-based course requires Internet access through an Internet service provider (ISP). Multimedia data require high-speed connection. For students on the move, wireless connection is also becoming economically feasible. In addition, students may need a Java capable browser with plug-ins capable of running streaming audio, video and animation. Netscape Navigator, Microsoft Internet Explorer and many other browsers are capable of viewing multimedia data (Aggarwal & Bento, 2000).

Interaction

One of the biggest advantages of the traditional learning system is face-to-face interaction. In spite of bandwidth restrictions, interactive learning environment can be created using web tools such as threaded discussion boards, forums, document sharing, message centers, bulletin boards, email and others for asynchronous communication and online chat rooms for synchronous interaction. Many of these tools provide features to support group activities and presentations. Some of the popular conferencing packages are FirstClass (http://www.firstclass.com) which is using text and voice mail, and fax, WWBLS which is using email and online chat room, and WebCT which is using email and discussion board.

Assessment/Feedback

Traditional forms of student assessment and feedback can be adapted to web-based environments. For example, students can take on-line exams that may be automatically graded online, in real time (e.g., multiple choice, True/False test) or may be stored in the server and then the instructor grades them. WebCT supports both assessment types while WWBLS only supports the auto-grading type.

2.2.3 Advantages of web-based learning system

Literature suggests that the web-based learning systems not only facilitate the tasks of traditional face-to-face leaning environment, they have some distinct advantages over traditional approach. These advantages can be grouped into three major categories: logistical, instructional and economic, which are summarized in table 2-1 (Hannum, 2001).

Logistical advantages refer to those advantages of WBLS that have to do with ease of distribution and use. Compared with other forms of learning, WBLS has several logistical advantages (Khan, 1997; Saltzberg & Polyson, 1995). The greatest logistical advantage of WBLS perhaps is its flexible, distributed delivery that allows the learner to learn at any time and any place. The flexibility of WBLS provides the facility that the learners may learn at their own location and on their own schedule. The learner doesn't have to come to the classroom to take a lecture scheduled at a specific time on a specific day. The course content can be delivered to the learner's desktop or laptop at the worksite, at home or while traveling. This makes the course be learned by people living different countries.

Table 2-1 Advantages of Web-based Learning System (Hannum, 2001)

Logistical	Instructional	Economic
Flexible delivery of training	Delivery of multimedia	Less costly than traditional training
Learn any time, any place	Learner control	Reduces duplication of effort
Delivery to learners' desktop or notebook computer	Immediate delivery of updated programming	Doesn't require expensive facilities
Cross platform compatibility	Variety of instructional event	Requires less technical support
No scheduling problems	Collaboration	Can bill per use
Easy distribution	Consistency	Inexpensive, widespread distribution of materials
Security through registration	Supports EPSS	
Links to other sites		
Ease of content update		

The distribution for WBLS is much simpler than traditional face-to-face learning. Traditional learning requires considerable scheduling to arrange for the course, the instructor, and the learners to be at the same location at the same time. Classroom must be scheduled; course materials must be ordered and distributed in advance. The learner must take a separate certification examination upon course completion to demonstrate that they finished the course and learned from it. In WBLS most of these activities happen online automatically. A learner can register for a course in WBLS at any time and any place online. All the course materials are available online. Access to any proprietary or sensitive material in WBLS is controlled through course registration. Thus WBLS offers easy distribution of education while maintaining security. Because the course materials reside on the central server, it is much easier to update the content than to revise and reprint learning materials.

Instructional advantages refer to those advantages that directly impact the quality and potency of the instruction delivered via WBLS. An obvious instructional advantage of WBLS is the ability to provide the delivery of rich multimedia to the learners (McManus, 1996). It may include video segments, audio, graphics, animation and text. Of course, it is not necessary to have all multimedia elements in all lessons, but when used appropriately, these elements enhance instruction and learning (Bagui, 1998). Using WBLS the learner may control some aspects of the course. The learners may advance at their own rate, going quickly through more familiar material and slowing down for newer, less familiar material. The ability to include many forms of collaboration is another instructional advantage of WBLS. The learners can use the internet, or intranets, to communicate with other learners or instructions via email, discussion forums, or chats. The learners at different sites can work as virtual group member to complete case studies or assignments. When compared with traditional education system, WBLS offers a needed education consistency. In traditional education system, the education consistency is not assured, even when the same instructor conducts different educational sessions.

Economic advantages refer to the cost advantages of WBLS. The primary advantage of WBLS is the lower cost of WBLS when compared to the traditional education system, because WBLS eliminates the need for travel and time away from home or worksite (Hannum, 2001). Since WBLS development and distribution are centralized, it reduces expensive duplication of education efforts. Once WBLS is developed, it can be used by any instructor and learner. Duplication of education effort is very common in traditional education system because different instructors at different locations are developing and offering very similar courses. Also, using WBLS does not require much training or technical support since WBLS runs on familiar web browsers.

Web-base learning system offers many advantages to both educational organizations and learners. In order to achieve these advantages and the basics of a learning system, lots of technologies might be used, such as email, discussion forum, annotation, chat and so on.

2.3 Technologies used in existing web-based learning system

A growing number of researchers highlight the importance of interaction among the members of a WBLS course. Research show that learning occurs best in a cultural context that provides both enjoyable interaction and substantial personal support. Despite not seeing each other face-to-face, both of these essential elements can be provided to distance learners through Internet based communication tools. There are several options for facilitating communication between instructor and students and between the students - some synchronous, some asynchronous. More than one can be used in any course.

2.3.1 Email

E-mail (electronic mail) consists of messages that are transmitted through a communications network. They are typically stored in the recipient's computer mailbox to be read when convenient, so this is an asynchronous communication mode. It allows an individual to send messages to other individuals. Other forms of online documents can be included as attachments. Email communication can last as long as the participants want. Email is the most common tools for any collaborative learning environment (Klobas & Renzi, 2000). Learners use this technology to supplement their interactions in the environment. Email is ubiquitous as systems are compatible with each other, unlike the technologies described in the next few sections which required the learner to use the same environment or tool. Now Email is used in almost all web-based learning system.

2.3.2 Distribution lists (Newsgroup, Mailing List)

Distribution lists are systems where email messages are sent to a centralized server, and from there distributed to a list of addresses. Use is as simple as sending email. Archives of messages can be accessed through the WWW and users may subscribe from a web page or by sending email to a server (Klobas & Renzi, 2000).

For example, ONEList (http://www.onenw.org/bin/page.cfm?secid=32) offers web-based creation and maintenance of distribution lists with a range of options and the list's archive is searchable. It is therefore possible to use a free web-based service to establish and maintain distribution lists, without the need to maintain a local server or software mounted locally.

2.3.3 Discussion forum (Discussion board)

Discussion forums support asynchronous discussions. A user can log on and read the contributions (such as notes or messages) and can either respond to the messages or create a message for a new thread. More recent web-based discussion forums allow the inclusion in a message of other media like pictures and links to web page or other information. Several software products either free or commercially available enable the setting up of discussion groups on the WWW. Some of them include additional features like the ability to organize the messages by author, by topic theme, by keywords, or by chronological order. It is being used in many WBLSs. Examples include Blackboard (http://www.blackboard.com/), FirstClass, TopClass (http://www.wbtsystems.com/) and WebCT.

2.3.4 Annotations

Hypertext makes it possible to use the document as a means for supporting dialogue and commentary. An annotation to a document is a comment on or question about the document or a reference to another annotations (Looi, 2002). For example, they can answer questions or refute arguments. Annotations can be compared to *Post-It* notes attached to the margin of a paper, except that other people can see them, and refer to them. Annotations can be placed in context or inline, at various places in the document that the author selects. When a document is read a list of all the existing annotations at that place is displayed, showing the author, title, and date. Thus, annotated documents show the trail of an argument as well as the participants in the discussion, as comments are written on comments.

CoNote is an experiment in how people can collaborate when working with a set of shared documents (Davis & Huttenlocher, 1995). It allows a group of people to share a set of documents and to make comments about the documents which are shared with the other members of the group. CoNote allows document owners to specify who can see the document and who can see or add annotations, providing some measure of privacy and security.

2.3.5 Chat

Chat is text-based synchronous communication. Some richness is provided by the immediacy of communication where another person's words appear on the screen line-by-line or character-by character (Klobas & Renzi, 2000). Chat systems are often structured in "room" with public or private conferences. The chat has the nature of an ongoing dialogue between people that has several interesting characteristics. Firstly, one of the attractions of chat groups is that individuals can be anonymous. Secondly, a temporal history of the conversation can recorded from the text discussion. Thirdly, through the use of dedicated computers to provide the chat services, an individual's personality can be persistent over different sessions allowing the kind of role differentiation that newsgroups provide (Looi, 2002).

Text chat provides several affordances that make it an effective medium for useful online interactions, despite its limitations and the advent of newer technologies like graphic chats, audio and video conferencing. Text chat is usually fast and does not require broad bandwidth for the networked communications. It puts the message before the medium. Many projects that study distributed learning environments and commercial offerings include a chat facility, e.g. Blackboard, FirstClass and WebCT.

2.3.6 Audio and video tool

Asynchronous audio and video have a long history as educational media for presentations and for interactive activities. One of the most significant advances in one-way presentation of material from the WWW has been the family of streaming technology and related software (e.g., RealAudio and RealVideo) that not only enables educators to record interesting material with surprisingly little effort but also allows broadcast of audio and video via the WWW (Klobas & Renzi, 2000). Client software to play material is usually distributed for free.

2.3.7 MUDs and MOOs

A MUD (Multiuser Dungeon, Dimension, or Domain) is a software program that allows connections from multiple users across the Internet, extending the functionality of text-based chat. It provides access to an online environment. This environment is usually organized as a metaphor, such as a city, campus, or building with a collection of rooms, exits and other objects in the rooms. As a learner moves in MUD, he or she reads what is being said in the room and can join in the conversation, talk in private with other learners, manipulate objects in the room (pet a cat, play a video tape, use tools, etc.) or move to other rooms. A learner can also create new objects and allocate behavior. A MOO is a MUD built using object-oriented technology that makes it easier for a learner to create new objects (Looi, 2002).

MUDs and MOOs became popular in the early 90s. Now they are being used for distance education as well as for supporting classroom activities (Kouki & Wright, 1996).

2.3.8 WOOs: web-based MOOs

In recent years, MOO technology has been advanced through integration with the WWW. Web-based MOOs (known as WOOs) combine the graphic capabilities of the WWW with the synchronous capabilities and flexibility of doing things in the text-based MOO. An example of a WOO is SpaceALIVE! That integrates the text-based MOO with the WWW (Looi, 1999; Looi & Ang, 2000). It communicates through http and HTML protocols, thereby supporting multimedia on the web page. SpaceALIVE! can be accessed from a Java-enabled browser. The SpaceALIVE! client is a normal web browser with a special Java applet running at the bottom as a telnet ssession and connecting back to the MOO server for all MOO activities. SpaceALIVE! exploits the combined power and ubiquity of the WWW, Netscape and Java.

2.3.9 3D virtual space

In 3D virtual space, a user is represented by a physical presence in the space called an avatar and navigates within the 3D space. He or she can communicate with other avatars in the space just as in chat groups. 3D communities do not subsume MUDs and MOOs (Selfridge, 1997). Visitors can add customized content more easily in a MUD or MOO because 3D appearance is not relevant and behavior can be programmed without regards to an existing 3D structure. 3D communities are a complementary medium with their own unique characteristics.

An example of a technology of enabling 3D communities is NetEffect (Das *et al.*, 1997). NetEffect is a networked Multiuser architecture for distributed virtual environments. It supports multiple servers, dynamic load balancing, migration of users between servers, synchronization between transient and persistent user states on different servers, and partitioning of the environment into a hierarchy of spaces.

By using appropriate techniques, WBLS may also support one or both of leaning modes: synchronous learning mode and asynchronous learning mode which are supported by face-to-face learning system.

2.4 Synchronous learning vs. asynchronous learning

When course instructor and students come together at the same time, the teaching/learning process is described as "synchronous". When the teaching/learning process takes place at anytime, the process is described as "asynchronous". The use of technology to support synchronous learning differs from the use of technology to support asynchronous learning. In designing a WBLS, it is important to identify which technologies are able to access as well as which technologies are needed to achieve the course objectives.

2.4.1 Synchronous learning

Synchronous learning is instruction and collaboration in real time over the Internet. Synchronous learning lends itself primarily to the traditional style of instructor-led, lecture-format training that is common in many traditional classrooms. The video component of training using a synchronous online learning environment tends to be limited to a talking head. Online conferencing, then, remains primarily audio-based.

Usually, the instructor is in control of the session and decides which participants can speak and when. Students can have input and ask questions, usually expressing their desire to do so through some form of electronic "hand-raising". Additionally, tools such as whiteboards and application sharing can be used to enhance presentation and interaction.

Synchronous learning typically involves tools such as:

- Live chat
- Audio and video conferencing,
- Data and application sharing,
- Shared whiteboard,
- Virtual "hand raising",
- Joint viewing of multimedia presentations and on-line slide shows.
- Instructor control and viewing of student monitors

Currently many web-based synchronous learning system appears. LearnLinc (http://www.mentergy.com/) is a live virtual classroom environment that enables corporations to deliver live e-learning courseware to employees or students via the Internet, corporate intranet, or wide area network.

The ONE TOUCH Knowledge Systems e-learning solution (http://www.onetouch.com/) is a fully integrated suite of patented hardware and software applications that enable highly interactive distributed learning over any broadband network. By integrating full-motion video and full-duplex audio with two-way interactive data, ONE TOUCH e-learning solutions can be configured to deliver live, presenter-led e-learning sessions to participants in networked classrooms as well as at individual PCs.

Virtual Educator (http://www.cinecom.com/virtualeducator/) is an instructor-controlled distance learning solution for use over a LAN, WAN, and the Internet, utilizing video conferencing, multi-point video and audio, instructor-led Web discussions, shared whiteboard, and help-desk applications.

2.4.2 Asynchronous learning

Asynchronous learning simply refers to the provision of learning opportunities and support that can take place or be accessed at any time, i.e. is not fixed to standard timetabled lectures, seminars, labs etc. Through asynchronous learning (AL) technology faculty can supplement classroom teaching with additional information about the course such as lecture notes, links to related Internet sites, multi-media applications of audio and video, homework problems and solutions, on-line reference materials, on-line quizzes, immediate grading and feedback, as well as being more available to students electronically. AL offers the students an additional venue to access information at their convenience, to communicate with each other or the instructor, to exchange information in group discussions, and to collaborate in problem solving sessions remotely; the instructor can monitor and guide the discussions as needed and gauge students' progress. Preliminary data suggest that the use of interactive computer-mediated communication technology in the classroom significantly enhances the learning process by increasing student performance as well as faculty productivity.

Asynchronous instruction does not require the simultaneous participation of all students and instructors. Students do not need to be gathered together in the same location at the same time. Rather, students may choose their own instructional time frame and gather learning materials according to their schedules. Asynchronous instruction is more flexible than synchronous instruction. Moreover, in the case of telecommunications such as email, asynchronous instruction allows and even may encourage community development. Forms of asynchronous delivery include email, audiocassette courses, videotaped courses, correspondence courses, and WWW-based courses.

The advantages of asynchronous delivery include student choice of location and time, and (in the case of telecommunications such as email) interaction opportunities for all students. Asynchronous learning methods use the time-delayed capabilities of the Internet such as:

- Email,

- Threaded discussion
- Newsgroups and bulletin boards
- File attachments
- Learning content downloads
- Collaborative work spaces

Courses are still instructor led/facilitated but not in real time in asynchronous learning mode. Learning does not need to be scheduled in the same way as synchronous learning allowing students and instructors the benefits of anytime, anyplace learning. Some of leading asynchronous learning environments are Learning Space (http://www.lotus.com/products/learnspace.nsf/wdocs/homepage) and Top Class (http://www.wbtsystems.com/). More information on asynchronous learning can be found on the Asynchronous Learning Network (http://www.aln.org/) site.

2.4.3 Advantages and disadvantages of synchronous and asynchronous Learning

Asynchronous learning provides

- Freedom of time, so that learners participate when, and if, they choose
- Time for reflection
- Opportunities to research and backup one's assertions
- Allows global communication, un-bounded by time zone constraints
- Greater anonymity and potential lack of responsibility by individual users.

Synchronous learning provides:

- Immediacy
- Faster problem solving, scheduling and decision making
- Increased opportunities for developing affect
- Better for class parties

The detailed advantage and disadvantage between synchronous and asynchronous learning is shown in table 2-2.

Table 2-2 Comparisons of Synchronous and Asynchronous Learning

Mode	Advantage	Disadvantage
Fully Synchronous (Same Time – Same Place)	• Most people have experience with this mode • Students are often most comfortable in settings they have experience with • Students can see each other's eyes, facial expressions, body language or hear voice inflections and tones during communication • Students can participate in activities in laboratories and studios under direction of the instructor • Feedback to questions and issues raised in class is immediate; face-to-face interaction with no delays in communication occurs • Technical skills with a microcomputer and related software are not needed except as they relate directly to course material • Audio and/or visual media delivery is not limited by current computer technology	• Everyone in the course must gather in the same place • Everyone in the course must gather at the same time • Some students would need to travel to campus one or more times a week • Some students would need to leave employment, families, and community responsibilities to attend RIT classes • Some students do not actively participate in class activities, choosing to be passive, although present, learners

Mode	Advantage	Disadvantage
Fully Asynchronous (Any Time – Any Place)	• Students do not need to unduly disrupt critical parts of lives - employment, family life, community responsibilities - to relocate to Rochester or to travel to campus • Collaborative or group learning is more easily accomplished when group members do not need to mesh schedules • More active participation in the learning process is encouraged through computer conferencing • Students can fit course work into their own schedules at times that work best for them • Some students communicate best in an asynchronous mode • Sharing of work may be more easily accomplished; e.g., drafts of student works can more easily be shared through electronic communication • Different learning styles and disabilities may be easier to accommodate; self pacing of learning is facilitated	• Visual and aural cues during communication are reduced or absent; limited reading and writing skills may reduce communication effectiveness • Requires self-direction and self-motivation to attend to the course work • Students need instructor assistance to feel a part of a "course community" in this mode • Providing laboratory and studio experiences for students may be more challenging • Hardware and software requirements and related skills may limit access for some students • Feedback to questions and comments is delayed

No matter what learning mode is adopted in a WBLS, WBLS developer should consider the speed of the students viewing the course content. Nowadays most existing WBLS include multimedia content. If the video is so large, the students would take very long time to download it and view it. It would make WBLS impracticable. Fortunately streaming technologies have emerged that enable students to view the video while downloading it.

2.5 Streaming system

2.5.1 "download-and-play" vs. "real-time" streaming

Until recently, audio and video on the Web was primarily a download-and-play technology. People had to first download an entire media file before it could be played. It was like pouring milk into a glass and then drinking it. But because media files are usually very large and take a long time to download, the only content found on the Web was short 30-second clips – often even shorter. Even these files could take 20 minutes or longer to download.

Watching audio and video files that stream is more like drinking straight from the carton; streaming media files begin playing almost immediately, while the data is being sent, without having to wait for the whole file to download. Other than a few seconds of delay before the file starts to play, people don't have to wait to start watching, no matter if the file lasts 30 seconds or 30 minutes.

There are two types of streaming:

- HTTP Streaming (download-and-play)

  Also known as progressive streaming, this method takes a compressed media file and downloads it to user computer's hard drive before playback using any web server such as Apache, Roxen, Microsoft Internet Information Server or Netscape.
- Real Time Streaming

  Real-time streaming broadcasts to people's computer directly from a server and plays back as the information is received from the server, without waiting for the whole file to download. Real-time servers include the RealSystem Server and QuickTime's Darwin streaming server.

2.5.2 Components of streaming system

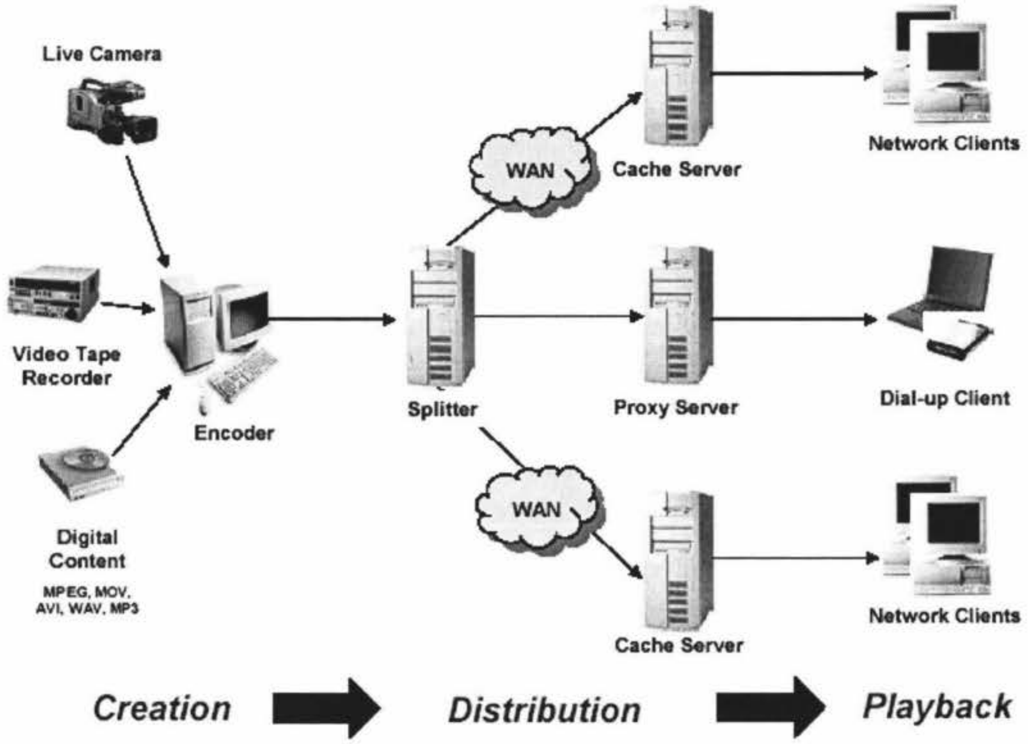


Figure 2-1 Components of Streaming System
(http://www.approach.com/content/expertise/digital.asp)

All streaming media solutions share a similar set of components:

- Encoding tools for converting existing or live media to streaming format.
- Authoring tools for integrating rich media.
- Server tools for delivering live and on-demand streams to clients.
- Reflectors, splitters, caches or proxies for optimizing network bandwidth and reliability when delivering streams and players for displaying the stream on users' desktops.

The figure 2-1 illustrates how these components interact to form a streaming system.

2.5.3 Streaming content

The streaming server software determines the types of digital media-such as WAV or AVI files-it can stream. RealSystem Server can stream over 45 different data types, mainly different formats of video and audio:

- Video Content
  RealVideo, AVI, QuickTime, ASF
- Audio Content
  RealAudio, WAV, AU, MPEG-1, MPEG-2, MP3
- Others
  RealPix, RealText, GIF, PNG, JPEG, SMIL, Flash

Whenever you encode some content, you're utilizing a codec. "Codec" is an abbreviation for compression/decompression. A codec can be either a software application or a piece of hardware that processes media through complex algorithms, which compress the file for streaming and then decompress it for playback. Unlike other kinds of file-compression packages that require you to decompress a file before viewing or listening, codecs decompress the media on-the-fly, so your audience can view or listen to a file from its original compressed format. Your audience sees your content immediately with minimal loss of quality from the original.

2.5.4 Streaming methods: web server vs. streaming media server

As audio and video streaming over the Internet has become more popular, two primary methods for streaming content have emerged. The first method is the Web server approach, in which a standard Web server is used to supply data to the client. The second method is the streaming media server approach, in which a specialized streaming server delivers the data to the client. Both methods have advantages that we will discuss, but first let's take a look at the way each process works.

2.5.4.1 *Streaming with a web server*

Posting and hosting

Deploying streaming media content with the Web server approach is actually only a small evolutionary step away from the download-and-play model. Uncompressed audio and video is first compressed into a single "media file" for delivery over a specific network bandwidth such as a 28.8 kilobits per second (Kbps) modem. This media file is then placed on a standard Web server. Next, a Web page containing the media file's URL is created and placed on the same Web server. This Web page, when activated, launches the client-side player and downloads the media file. So far, the actions are identical to those in the download-and-play case. The difference lies in how the client functions.

Data delivery

Unlike the download-and-play client, the streaming client starts playing the audio or video while it is downloading, after only a few seconds wait for buffering, the process of collecting the first part of a media file before playing. This small backlog of information, or buffer, allows the media to continue playing uninterrupted even during periods of high network congestion. With this delivery method, the client retrieves data as fast as the Web server, network and client will allow without regard to the bit-rate parameter of the compressed stream. Only certain media file formats support this type of "progressive playback", e.g., ASF, RM. Web server streaming uses the Hyper Text Transport Protocol (HTTP), the standard Web protocol used by all Web servers (such as Microsoft® Internet Information Server) and Web browsers (such as Microsoft Internet Explorer) for communication between the server and the client.

2.5.4.2 *Streaming with a streaming media server*

Posting and hosting

In the streaming media server approach, the initial steps are similar to the Web server approach, except that the compressed media file is produced and copied to a specialized streaming media server (such as Microsoft Windows Media Services) instead of a Web server. Then a Web page with a reference to the media file is placed on a Web server. Windows Media Services and the Web server may run on the same computer.

Data delivery

The rest of the streaming media server delivery process differs significantly from the Web server approach. In contrast to the passive burst methodology employed in Web server streaming, the data is actively and intelligently sent to the client, meaning that it delivers the content at the exact data rate associated with the compressed audio and video streams. The server and the client stay in close touch during the delivery process, and the streaming media server can respond to any feedback from the client.

While streaming media servers can use the HTTP/TCP protocols used by Web servers, they can also use specialized protocols such as the User Datagram Protocol (UDP) to greatly improve the streaming experience. Unlike TCP, UDP is a fast, lightweight protocol without any re-transmission or data-rate management functionality. This makes UDP an ideal protocol for transmitting real-time audio and video data, which can tolerate some lost packets. As a bonus, because of the back-off policies implicit in the TCP protocol, UDP traffic gets higher priority than the TCP traffic on the Internet. And instead of the blind retransmission scheme employed by TCP, streaming media servers such as Microsoft's Windows Media Services use an intelligent retransmission scheme on top of UDP. Windows Media Services' *UDP Resend* feature ensures that the server only retransmits lost packets that can be sent to the client in time to get played.

2.5.4.3 *Streaming with a web server: the advantages*

There is really only one major advantage to streaming with a Web server rather than with a streaming media server -- utilizing existing infrastructure. Because the Web server approach uses only the standard Web server--that presumably already exists in the organization--no new software infrastructure need be installed or managed. The Windows Media server approach, on the other hand, requires the content producer and/or the systems administration staff to install and manage additional server software. This can result in incremental training and staffing costs to learn and manage the more complex, but also more powerful, Windows Media server environment.

It is important to note that the increased load that Web server-based streaming puts on existing Web server infrastructure often results in the need for additional Web server hardware to service the client requests. Choosing Web server streaming over a dedicated streaming media server based on hardware cost alone usually does not result in any financial savings.

2.5.4.4 ***Streaming with a streaming server: the advantages***

Designed specifically for the task of delivering live or on-demand streaming media rather than many small HTML and image files, a streaming server offers many advantages over standard Web servers.

1. **More efficient network throughput.** One of the main advantages is the ability to use UDP, the specialized protocol optimised for live and on-demand streaming. The TCP-based transfer used in Web server streaming is designed to repeatedly drive the slowest network link (likely the 28.8 Kbps modem link) to packet loss. This wastes bandwidth by: (i) re-transmitting data to replace the lost packets; and (ii) under-utilizing the network link while re-estimating the throughput that can be supported by the network connection.

   The UDP protocol allows higher bandwidth to be delivered to the client (resulting in better video quality), even when assuming the same network connectivity between server and client and the same level of congestion on the Internet. By having a specialized streaming media server, we know what rate the data is going to be consumed, based on headers of the compressed media file. The streaming server sends data to the client only at this required bit-rate, and it doesn't drive the bottleneck network link to loss. Thus the network throughput is better, resulting in better quality audio and video for the client.
2. **Better audio and video quality to the user.** Better network throughput is only one of several ways that a streaming server delivers superior audio and video quality for users. Here are two more examples:
   - Because the streaming server and the client remain in contact throughout the play interval, the server can dynamically respond to client feedback. If network congestion is allowing only 22 Kbps of data to reach the client (instead of 28.8 Kbps), the server can decide to retain the audio quality but slightly lower the frame rate of the video stream so that it doesn't overshoot the available 22 Kbps. This ability is

not possible with the Web server approach. In a Web server scenario, with no feedback from the client and no ability to dynamically prioritise audio over video, the audio/video delivered by a Web server would be stop-and-go at the client, causing the insidious "rebuffering" delays common to early implementations of streaming media. In contrast, the Windows Media server provides a continuous, smooth stream with barely perceptible changes in video frame rate during periods of network congestion.

   - Streaming with a streaming server takes advantage of UDP's inherent higher priority over HTTP traffic to give the streaming audio and video data higher priority than file and Web page transfers. This increases the likelihood of uninterrupted viewing.

3. **Support for advanced features.** The streaming server approach supports such advanced features as detailed reporting of streams played, VCR controls (seek, fast-forward, rewind), live video delivery, and delivery of multiple streams to the client. With Web server streaming such features, if they are even possible, are difficult to implement and inefficient to support.
4. **Cost effective scalability to large number of users.** In the early days of streaming media, deployments often needed to serve only a small number of users simultaneously, making Web server streaming an adequate solution. But as delivery of audio and video has increased, sites often serve hundreds or thousands of simultaneous users. In these situations, two key capabilities of the streaming server provide increasing advantages over a Web server:
   - **Specialization.** In the Web server approach, the Web server is used to deliver the media files to the client. Web servers, however, are optimized for delivering lots of small HTML files, not large media files. With high volumes of file requests, a streaming server greatly improves performance by optimizing how media files are read from the disk, buffered in main memory, and streamed onto the network. A streaming server can easily improve scalability by a factor of 2 to 3 over a Web server.
   - **Multicast support.** One way to get live or stored audio and video to large audiences with minimum network congestion is to use multicast networking technology. Multicast allows a single media stream to be

played simultaneously by multiple clients, drastically reducing bandwidth use. Only a specially designed streaming media server has this capability.

5. **Protection of content copyright.** Because Web server streaming creates a local cached copy of every media file played, there is no way to prevent end users from copying the files to a personal directory for later viewing. This hurts content providers who have a pay-per-view business model, or who have an advertisement-based revenue model, as the end users need not visit their site repeatedly. With a streaming server, users can only stream data and are prevented from downloading the file directly to their hard disk. As data packets are received over the network, they are delivered directly to the client application with no easy way for the end user to intervene and make a copy.
6. **Multiple delivery options.** With a streaming server, the media may be streamed with the optimal UDP or Multicast protocols when possible, and streamed with the TCP protocol when necessary. This enables corporate users to view Internet content without compromising firewall security and ensures that all users on all networks can access all streaming media content. The streaming server implements its own version of the HTTP protocol to enable streaming through a firewall or proxy server while still retaining most of the advantages.

The streaming server will automatically switch to the appropriate protocol so no client-side configuration is necessary. The server will initially attempt to transmit files using the optimal UDP or Multicast protocols. If unable, the server will then attempt to send first via the raw TCP protocol, then via TCP with HTTP-based control.

In next section, the most famous streaming product, RealSystem platform, will be described, which is used in this project.

2.5.5 RealNetworks system

RealNetworks (http://www.realnetworks.com/) is the market leader in digital media on the Internet and on corporate networks. In 1995, RealNetworks pioneered the mass medium of Internet broadcasting and has been meeting the challenges of digital media ever since. Today, thousands of the world's leading corporations, educational and governmental institutions, and media companies manage media creation, distribution and security with RealNetworks end-to-end systems technology. More than 270 million end-users in corporate and home settings use the company's popular RealPlayer products.

RealNetworks provides a complete suite of industry-leading solutions for media creation, delivery and protection. The universal nature of RealNetworks products means that their systems software supports any type of media, on any operating system, over any transport mechanism, to any Internet-enabled computer, consumer device or appliance. It means users can deploy digital media solutions without expensive hardware upgrades, and can integrate with existing systems and applications.

RealSystem platform

The RealSystem platform integrates the RealNetworks Producer, RealNetworks Server, and the RealOne and RealPlayer media players (see Figure 2-2). RealNetworks systems technology supports workflow automation, administration and systems monitoring. Their self-aware, digital media network architecture works with the existing network to ensure effective delivery using innovative capabilities like SureStream technology, robust packet resend and broadband error-correcting codes. These capabilities ensure the audience gets the best media experience their network connection allows, while making the best use of the existing infrastructure.

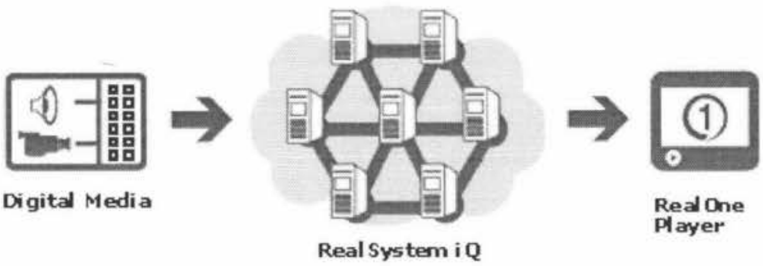


Figure 2-2 RealSystem Architecture (http://www.realnetworks.com)

RealNetworks gives organizations the flexibility and power to explore new educational opportunities, while integrating with existing applications and infrastructure.

- RealSystem handles more than 54 media types, including RealAudio, RealVideo, Flash 4, QuickTime and MP3.
- RealSystem Supports nine operating systems, including Windows 2000, Windows NT, Linux, Solaris, HP/UX, AIX and FreeBSD.
- RealSystem is configurable to work on terrestrial fiber, wireless or satellite networks.
- RealSystem delivers media to any of the more than 250 million PC-based RealOne and RealPlayer media players as well as to the growing number of RealSystem compatible media players both in the living room (such as HP's DEC) and on mobile devices (such as the Nokia 9210).

Benefits

RealNetworks sets the standard for reliability, capacity and redundancy in the world's most demanding and high-profile content deployments. Following are some of the benefits of RealNetworks innovations that make media distribution more cost-effective, reliable and compelling:

- Defer expensive systems upgrades — Because RealNetworks technology works on a wide variety of hardware and operating systems, people may get the most out of their existing investments.
- Improve performance and productivity — Because content users can take advantage of the distributed network protocols, content is pushed to the edge of the network, closest to where it can be used. End-users spend less time waiting and more time experiencing content.
- Ensure quality of service and stream availability — RealNetworks Neuralcast Technology leverages error-correcting codes, redundant protocol support and multicast routing. In the event of equipment issues, RealNetworks servers automatically share information about capacity allocation and capacity fail-over to ensure the highest quality user experience possible.

- Save bandwidth, save money — Accessing content at the edge of the network means that redundant network traffic is minimized, which saves network costs.
- Improve overall responsiveness of the network — Managing the digital media delivery in an efficient manner means that all the network applications work better.
- Increase network capacity — the existing network can handle more traffic by leveraging RealNetworks distributed architecture.
- Improve organizational responsiveness —RealNetworks technology lets branch offices and subsidiaries publish content "at the edge," giving organizations more flexibility to respond to different or changing markets.
- Save money — Manage, configure and monitor the entire content network on the fly from a single location.
- Optimize savings and quality of service — RealNetworks technology lets people bypass network bottlenecks, and distribute redundant live streams with satellite multicasting.

2.6 Summary

Typical traditional face-to-face learning environment should include five components or functionalities: content, delivery, access, interaction and assignment/feedback. By using various web-based information technologies, almost all the functionalities in the traditional face-to-face learning environment can be achieved in WBLS. So the proposed project has following functionalities for each component:

Content

- Function of editing a course: it includes creating a new course, modify an existing course and deleting an existing course.
- Function of edition a lecture within a course: it includes creating a lecture, modify an existing lecture and deleting an existing lecture
- Function of taking note for a lecture

Delivery

All textual content is presented by html format. As discussion in the Chapter 1, a real lecture video and presentation slides are used to let the off-campus students enjoy the human teacher's explanation and expression. Regarding the low bandwidth internet connection, the real-time streaming technology is used to deliver the video and presentation slides.

Access

In order to keep security for the sensitive information for each user, two functions: login and logout are employed. The function of managing user account lets the teacher to add and delete user for a course. Each user should have an identical user id and password. After login the users may see their own private information, view the enrolled lectures and contact with the teacher or other classmates using that particular id. At the end they should logout.

Interaction

There are two type interactions: synchronous and asynchronous. The proposed project only supports asynchronous interaction because asynchronous interaction is more flexible that synchronous interaction. Email and discussion forum are adopted to implement this function. As discussed in Chapter 1, this contextual discussion forum is lecture-based. Each lecture within a course should have a discussion forum, where the students and teacher may discussion any issue related to this lecture.

Assignment/feedback

It will be implemented in the future. It is out of the scope of this thesis.

Based on the requirements and functionalities discussed in this chapter, the next chapter will present the system analysis and technologies used in this project.

Chapter 3 System Analysis and Technology

3.1 Introduction

In this chapter, we examine the functionalities of the system developed in this project. Then various technologies are discussed that are used to develop the system. We apply the use case approach to gather the dynamic functional requirements of the system. A *use case* is a description of a complete course of events initiated by an actor and the interaction between the actor and the system (Jacobson, *et al.,* 1992). The use case approach requires creating use case diagrams and creating a use case description for each use case-actor relationship identified in the use case diagrams.

As discussed in the previous two chapters, the typical traditional face-to-face learning environment includes five components: content, delivery, access, interaction and assessment/feedback. Web-based learning system may implement all these components/functionalities by using various information technologies. But existing WBLSs face some problems:

- Lack of match between course material and its explanation
- Lack of contextual discussion
- Lack of human teacher expression and explanation
- Lack of human interaction
- Lack of contextual understanding

While implementing the basic functionalities of typical learning environment, this thesis is aimed to solve these problems. Therefore the proposed prototype system should have:

- Course content maintenance – this functionality lets the instructors maintain the materials for the course. The student may use e-note to make notes for the course.
- Content delivery – this functionality lets the instructors present the course materials to the students. In order to get the human explanation and expression

from a human lecturer, the low-bandwidth streaming of lecture video and presentation are used.

- Access – this is system security mechanism, which includes work flow control, user authentication and information security
- Interaction – textual discussion forum and email are adopted to let the users communicate with each other.
- assessment/feedback – the students may give feedback to the instructors using discussion board.

For any learning system, as well as proposed system, there are two types of users: instructor and learner. The instructor conducts teaching while the learner conducts learning. In terms of use case approach, the users are called "actors" and what the actor does is called "use cases". We will first describe the functionalities of each actor in our system and then give the details for each use case.

3.2 System requirements

The two actors: instructor and learner in proposed system perform the same tasks as they do in a traditional face-to-face learning system. The instructors prepare the teaching materials for each course, manage the user account for each course and give help for the students while the learners view the lectures, take notes for each lecture and discuss with their classmates and teachers. So for instuctors, the system is expected to provide:

- Add new course
- Edit an existing course
- Remove an existing course
- Add new lecture in a particular course
- Configure an existing lecture
- Remove an existing lecture
- Add users for one course
- Remove users for one course
- Discuss with students in the forum

For students, the system is expected provide:

- View lecture – include lecture video and slides
- Take notes for a lecture
- Discuss with other students or lecturer for a particular lecture

In order to control the access to the course content and keep the privacy for each user, the system is expected to provide:

- Login
- Logout

All functions will be discussed in next section.

3.3 Use cases

The use cases diagram (figure 3-1) gives an overall view of all functionalities in the proposed system. The details of each use case are described below.

Use case: Login
Actor: Student or Teacher
Goal: User authentication
Description: The user should provide the user name, password and the user type (teacher or student). The system will check if there is such user registered in the system. If not, the system will give some information. The user name should be unique in the system. The system should check the uniqueness when user registering.

Use case: Add Course
Actor: Teacher
Goal: To create a new course for the student
Description: After login, the teacher enters all necessary information such as course title, coordinator, course description and etc. The system will store all these information in the database.

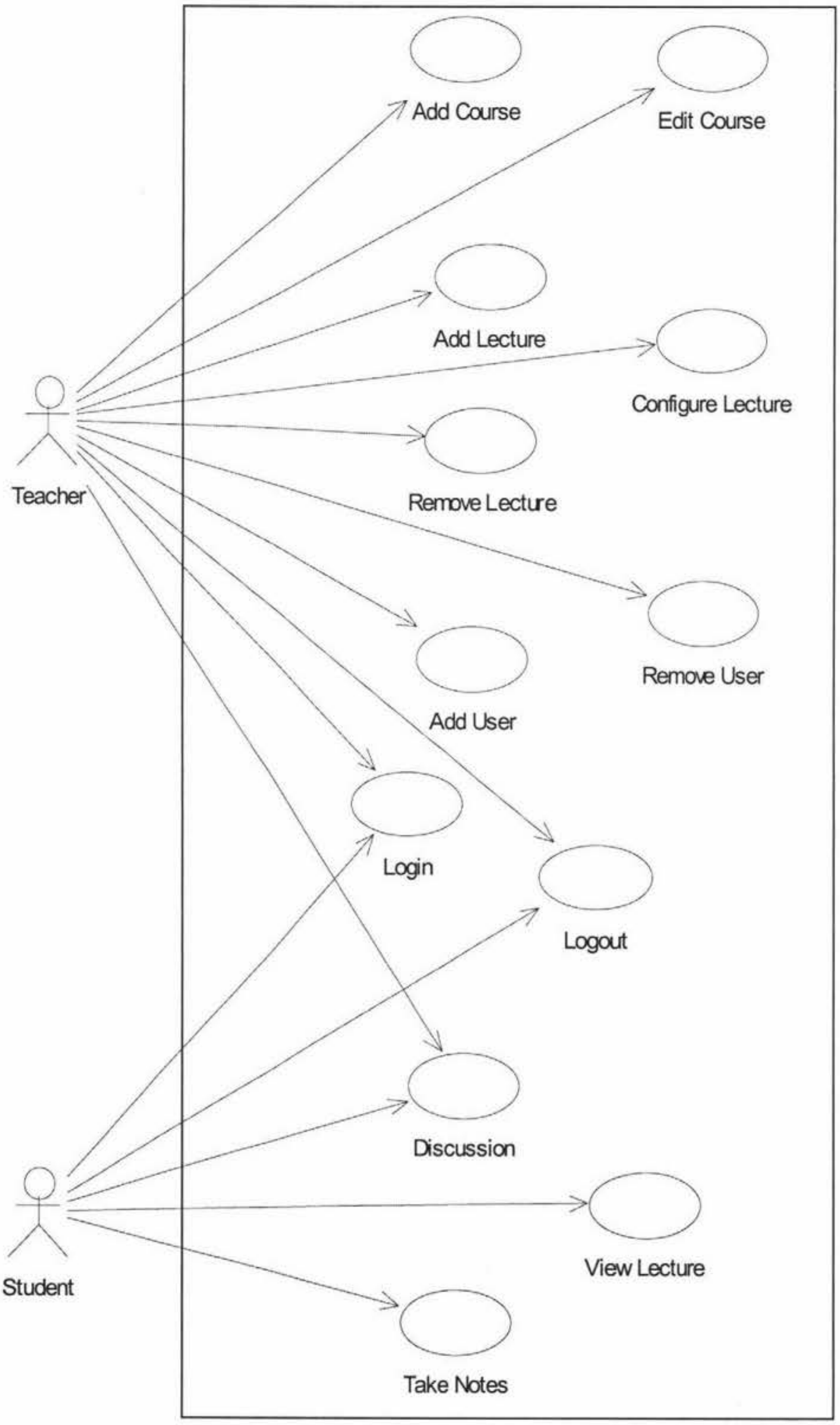


Figure 3-1 Use Case Diagram

Use case: Edit Course

Actor: Teacher

Goal: Modify a course

Description: After login, the teacher selects one course from the course list. The information about this course will be display. The teacher may make changes and submit it. The system then stores these changes in database.

Use case: Remove Course

Actor: Teacher

Goal: Delete one course from the system

Description: After login, the teacher selects one course from the course list and then deletes it. The system removes all the information about this course form database.

Use case: Add Lecture

Actor: Teacher

Goal: Create a new lecture for one particular course

Description: After login, the teacher selects one course from the course list. The information about this course will be display. The teacher then selects the function of creating new lecture. The system provides a blank form for the new lecture. After inputting necessary information, e.g., title, available date and etc. the teacher may or may not upload lecture video and slides for this lecture. The system stores the information for this lecture.

Use case: Configure Lecture

Actor: Teacher

Goal: Synchronize the lecture video and slides

Description: After login, the teacher selects one course from the course list. The information about this course will be display. The teacher then selects the function of configuring a lecture. The system presents all the information about this lecture. The teacher needs to upload lecture video (avi format) and slides (ppt format) for the lecture if the video and slides are not uploaded. Now teacher should convert the video into RM format and convert the slides into JPG format. Then, the teacher should synchronize the video and slide by using embedded real player. After confirmation, the system stores this information in the database.

Use case: Remove Lecture

Actor: Teacher

Goal: Delete one lecture from one course

Description: After login, the teacher selects one course from the course list and deletes it. The system then removes the information about this lecture from the database.

Use case: Add User

Actor: Teacher

Goal: Add new user for one particular course

Description: After login, the teacher selects one course from the course list. Then the teacher may add new user for the course by entering the information about this user. The system then stores the information for this user.

Use case: Remove Student

Actor: Teacher

Goal: Remove a user for one particular course

Description: After login, the teacher selects one course from the course list. Then the teacher may delete a user for the user list, except the paper coordinator. The system then removes the user information from the database.

Use case: Discussion

Actor: Teacher or Student

Goal: Discussion between teacher and student, or students

Description: After login, the user enters one course. Then the user goes to the discussion board for one particular lecture. All the threads about this lecture are displayed. The user may add, reply, quote or just view a thread. The system then stores all the new information about discussion in the database.

Use case: View Lecture

Actor: Student

Goal: Watch the synchronized lecture video and slides

Description: After login, the student selects one course from the course list and one lecture from the lecture list. Then the student may view the synchronized lecture video and slides like an internal student attending a lecture. The student may forward, backward, pause or stop watching.

Use case: Take Notes

Actor: Student

Goal: Make notes for one particular lecture

Description: After login, the student selects one course from the course list and one lecture from the lecture list. Then the student may take notes while watching lecture video and slides, or discussing with other students or teacher. The system stores these notes in the database.

Use case: Logout

Actor: Teacher or Student

Goal: End the session

Description: Once a user chooses to log out, the user's session is terminated, all the function and links that requires user identification will be unavailable until user chooses to login again.

Since the system is aimed for off-campus students, it is necessary that it is accessible through internet at a reasonably low bandwidth. For this purpose, the system uses three-tier architecture as discussed in next section.

3.4 Three-tier system architecture

The system in this project is implemented with a *three-tier, client-server* architecture. The client contains the presentation logic, including simple control and user input validation. This application is also known as a thin client. The middle tier is also known as the application server, which provides the business process logic and the data access. The data server provides the business data. Figure 3-2 shows the three-tier architecture of the system.

There are some of the advantages of three-tier architecture
(http://aortiz.cem.itesm.mx/three_tier.pdf):

- It is easier to modify or replace any tier without affecting the other tiers.
- Separating the application and database functionality means better load balancing.
- Adequate security policies can be enforced within the server tiers without hindering the clients

3.4.1 Client tier

The client tier is the user interface running on a web browser in the student or lecturer computer. The browser is responsible for handling presentation of course materials.

Most of the interfaces use HTML frames that are generated by JSP engine in the middle tier. The Real Player is embedded in the some web pages. For course maintenance, the teacher synchronized the lecture video, which played in embedded Real Player, with the lecture slides, which are in JPG format. For student, the synchronized video and slides both are played in an embedded Real Player. The e-note and discussion thread are presented as HTML files below the embedded Real Player.

3.4.2 Middle tier

The middle tier that resides in the server side provides the web service and data streaming service. It is responsible for receiving client requests, retrieving information from database if needed, processing the data contained in the requests, generating a client response, and require the database to store the necessary data. The middle tier consists of two types of Java objects: the JavaBeans and the JSP engine interpreting the JSP file, and two types of servers: web server and data streaming server. The web server gets the requests from the client html form and passes them to JSP engine. The JSP engine interprets these requests, invokes methods in the JavaBeans and sends the responses to the web server. The web server then produces presentations back to the client. The JavaBeans uses the JDBC engine to access objects in the data management tier during processing the requests from client. The different channel is used by the embedded Real Player to send the requests to the RealSystem server. The streaming server then processes these request using a SMIL file and sends the response back to the client Real Player.

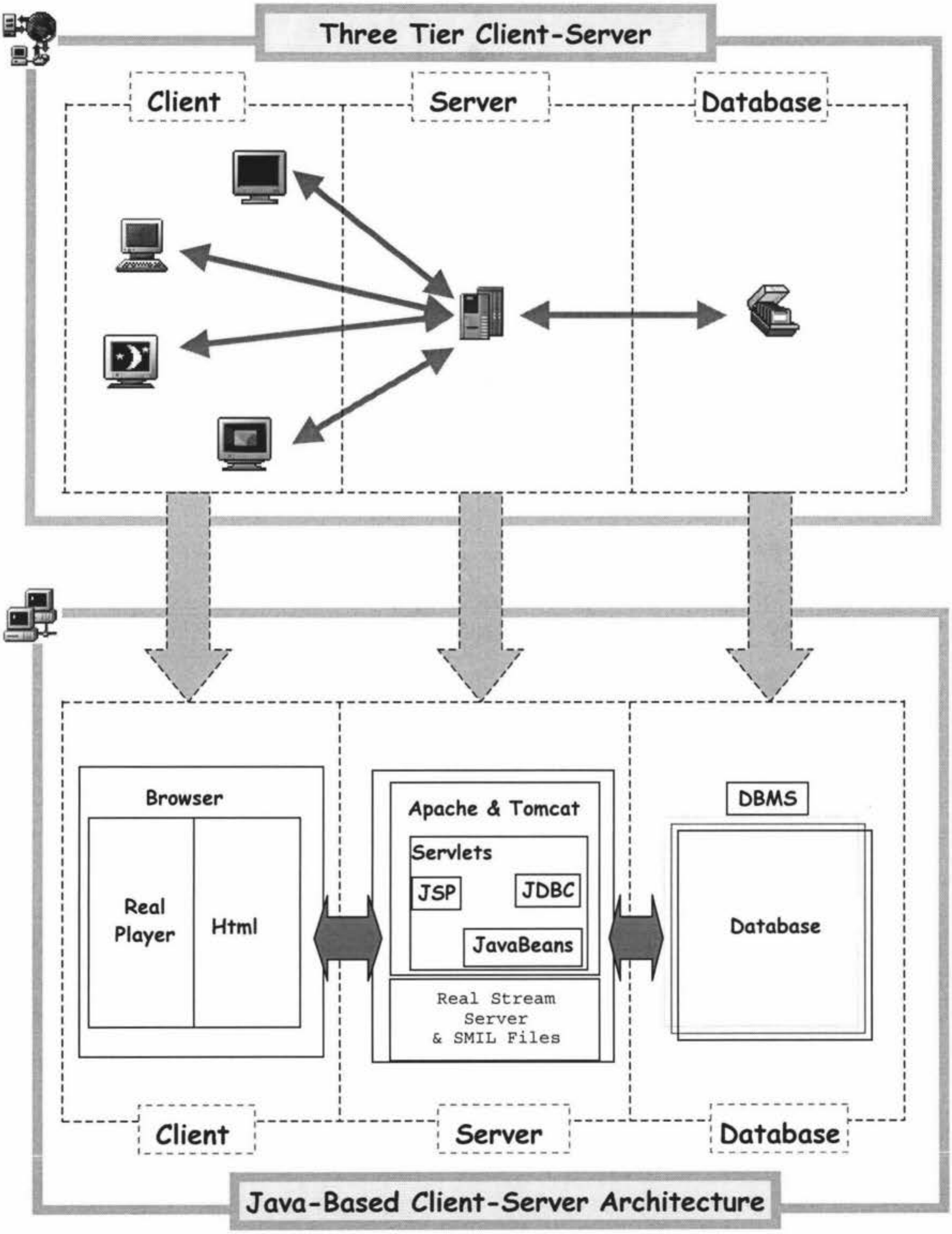


Figure 3-2 Three-tire architecture of the system (Based on Han, 2001)

3.4.3 Data management tier

The database management system (DBMS) stores the data required by the middle tier. It also resides on the server side and is composed of a back-end database server - MySQL. By using JDBC API, the Java application components can access the database by using the SQL call-level interface.

3.4.4 Client-server communication

Two channels are utilised for client server communications in this project. One channel is used for the web service. Port 8080 is adopted. The HTML form in the front-end client captures the user's actions and passes the information to the back-end server. The web server and Java application server process these data and then send the adaptive contents back to the client.

Another channel using port 554 is adopted for streaming data transmission. The Real Player in the front-end client captures the user's behaviour and sends the command to the RealSystem Server. RealSystem Server transfers the data to the Real Player according to the SMIL configuration file.

Both channels are implemented by TCP/IP.

Since each tier has different functions, different technologies are adopted in different tiers.

3.5 Technologies used in the project

In the client end, the key technologies adopted are HTML and JavaScript. The user system interface is a collection of HTML/JSP pages embedded with Real Player. The middle tier is implemented by Java, Java-related tools, Real Streaming Server and Apache. The third tier employs MySQL server.

3.5.1 HTML

HTML - the HyperText Markup Language - is the *lingua franca* for publishing hypertext on the World Wide Web. It is a non-proprietary format based upon SGML, and can be created and processed by a wide range of tools, from simple plain text editors - you type it in from scratch- to sophisticated WYSIWYG authoring tools. HTML uses tags such as <h1> and </h1> to structure text into headings, paragraphs, lists, hypertext links etc (http://www.w3.org/MarkUp/). Any inforamtion contained in the HTML form can be passed to the web server through GET or POST method.

3.5.2 JavaScript

JavaScript is a scripting language that can be inserted into an HTML page. JavaScript is supported by both Netscape and Internet Explorer. Because JavaScript can put dynamic text into an HTML page and can be set to execute in response to a number of web browser events, it is used to perform the tasks needed when certain student actions take place. For instance, a JavaScript function was written for controlling the embedded Real Player.

3.5.3 Java

Java is a powerful, platform-independent programming language. Java has the benefits of being simple, object-oriented, distributed, interpreted, robust, secure, architecturally neutral, portable, high-performance, and dynamic. No programming language makes it as easy to access the Internet as Java. With Java's java.net package, elegant stream-based I/O classes, and easy-to-use multithreading capability, network programming becomes straightforward.

Due to its object-orientated features and powerful networking capabilities, Java is considered as the most natural and efficient platform for developing and delivering this distributed web-based application.

Jbuilder is an integrated Java development environment that provides visual tools and wizards for easy and rapid application development. *Jbuilder* supports for the latest Java standards. *Jbuilder4* is used to develop the prototype system.

3.5.4 Java^{TM} Servlet

Servlets are modules of Java code that run in a server application (hence the name "Servlets", similar to "Applets" on the client side) to answer client requests. Servlets are not tied to a specific client-server protocol but they are most commonly used with HTTP and the word "Servlet" is often used in the meaning of "HTTP Servlet".

Servlets make use of the Java standard extension classes in the packages javax.servlet (the basic Servlet framework) and javax.servlet.http (extensions of the Servlet framework for Servlets that answer HTTP requests). Since Servlets are written in the highly portable Java language and follow a standard framework, they provide a component-based, platform-independent method for building web-based applications, without the performance limitations of CGI programs. And unlike proprietary server extension mechanisms (such as the Netscape Server API or Apache modules), servlets are server- and platform-independent. This leaves developer free to select a "best of breed" strategy for your servers, platforms, and tools.

Servlets have access to the entire family of Java APIs, including the JDBC^{TM} API to access enterprise databases. Servlets can also access a library of HTTP-specific calls and receive all the benefits of the mature Java language, including portability, performance, reusability, and crash protection.

The traditional way of adding functionality to a Web Server is the Common Gateway Interface (CGI), a language-independent interface that allows a server to start an external process which gets information about a request through environment variables, the command line and its standard input stream and writes response data to its standard output stream. Each request is answered in a separate process by a separate instance of the CGI program, or CGI script (as it is often called because CGI programs are usually written in interpreted languages like Perl).

Servlets have several advantages over CGI:

- A Servlet does not run in a separate process. This removes the overhead of creating a new process for each request.
- A Servlet stays in memory between requests. A CGI program (and probably also an extensive runtime system or interpreter) needs to be loaded and started for each CGI request.
- There is only a single instance which answers all requests concurrently. This saves memory and allows a Servlet to easily manage persistent data.
- A Servlet can be run by a Servlet Engine in a restrictive Sandbox (just like an Applet runs in a Web Browser's Sandbox) which allows secure use of untrusted and potentially harmful Servlets

3.5.5 JSP

JavaServer Pages™ (JSP™) technology allows web developers and designers to rapidly develop and easily maintain, information-rich, dynamic web pages that leverage existing business systems. As part of the Java™ family, JSP technology enables rapid development of web-based applications that are platform independent. JavaServer Pages technology separates the user interface from content generation enabling designers to change the overall page layout without altering the underlying dynamic content.

JavaServer Pages technology uses XML-like tags and scriptlets written in the Java programming language to encapsulate the logic that generates the content for the page. Additionally, the application logic can reside in server-based resources (such as JavaBeans™ component architecture) that the page accesses with these tags and scriptlets. Any and all formatting (HTML or XML) tags are passed directly back to the response page. By separating the page logic from its design and display and supporting a reusable component-based design, JSP technology makes it faster and easier than ever to build web-based applications.

JavaServer Pages technology is an extension of the Java™ Servlet technology. Servlets are platform-independent, 100% pure Java server-side modules that fit seamlessly into a web server framework and can be used to extend the capabilities of a web server with minimal overhead, maintenance, and support. Unlike other scripting languages, servlets involve no platform-specific consideration or modifications; they are Java application components that are downloaded, on demand, to the part of the system that needs them. Together, JSP technology and servlets provide an attractive alternative to other types of dynamic web scripting/programming that offers platform independence, enhanced performance, separation of logic from display, ease of administration, extensibility into the enterprise and most importantly, ease of use. In this project most web pages are implemented by JSP.

3.5.6 JavaBeans

JavaBeans is a portable, platform-independent component model written in the Java programming language. It enables developers to write reusable components once and run them anywhere -- benefiting from the platform-independent power of Java technology. JavaBeans acts as a Bridge between proprietary component models and provides a seamless and powerful means for developers to build components that run in ActiveX container applications.

The principal difference between ActiveX controls and JavaBeans are that ActiveX controls can be developed in any programming language but executed only on a Windows platform, whereas JavaBeans can be developed only in Java, but can run on any platform. There are serval JavaBeans are used in this project, e.g., paperBean, lectureBean, userBean and etc.

3.5.7 JDBC

JDBC technology is an API that allows access to the tabular data sources from Java programming language. It provides cross-DBMS (database management system) connectivity to a wide range of SQL databases. To use the JDBC API with a particular database management system, a JDBC technology-based driver is needed to mediate between JDBC technology and the database. In this project, JDBC was employed to access the database that is managed by MySQL - a relational database management system.

3.5.8 Tomcat

Tomcat is a Java servlet running environment or a servlet engine that manages execution of servlets and server pages. It is an open-source implementation of Java Servlet and JavaServer Pages technologies developed at the Apache Software Foundation. Tomcat can be used as either a stand-alone container (mainly for development and debugging) or as an add-on to an existing web server (currently Apache, IIS and Netscape servers are supported). Since Tomcat is considered as the most stable and efficient open-source servlet container, it was selected as the servlet running shell in co-operation with Apache HTTP server to perform client-server communication tasks in this project.

3.5.9 SMIL

Recommended by the World Wide Web Consortium (W3C), the Synchronized Multimedia Integration Language (SMIL, pronounced "smile") is designed to be the standard markup language for timing and controlling streaming media clips. SMIL is typically used for "rich media"/multimedia presentations which integrate streaming audio and video with images, text or any other media type. SMIL works for a media player similar to the way that HTML works for a Web browser. And just as HTML markup displays in any browser, the standardized SMIL language fosters interoperability between media players.

In a SMIL presentation, all of the media elements -- images, audio clips, video clips, animations, and formatted text -- are referenced from the SMIL file, similar to the way an HTML page references its images, applets, and other elements. A number of advantages come with such an approach to streaming media. First, the plain-text nature of the SMIL file means that it's easy to create, easy to edit, and can even be assembled on-the-fly by Java servlets or CGI scripts accessing a database. It also allows a very bandwidth-friendly way to do great looking multimedia. Rather than streaming images and text as many redundant frames of encoded video, you can stream the image or text data just once, and display it however you like.

3.6 Summary

This project is constructed as a distributed three-tier, client-server architecture in which two types of actors: instructors and students are identified. The key role of the instructors is to maintain the whole course. On the other hand the key role of the students is to learn by viewing the lecture video and presentation slides. Instructors and students may discuss using context discussion board.

Java programming language is used for implementing the system. Several Java and network related technologies are used, which include HTML, JavaScript, Java Servlet, JSP, JavaBeans, JDBC, Tomcat and SMIL. The next chapter will present the system design and implementation with these techniques.

Chapter 4 System Design and Implementation

4.1 Introduction

Based on the system analysis in the chapter 3, this chapter presents the system design and implementation. The high-level design is first described, followed by the detailed design. According to the functionality, the whole system is divided into four subsystems: paper management subsystem, lecture management subsystem, learning subsystem and contextual discussion subsystem. The design and implementation of each subsystem is described in detail.

4.2 System design

Bennett *et al.* (1999) pointed out that there are two level designs in the system design:

- Architecture Design
- Detailed Design

The architecture design is the high-level design for the system, which may include:

- Package diagram
- Component diagram
- Deployment diagram
- GUI Design
- Database design

The detailed design is the lower-level design for each component or subsystem. According to the functionality, the proposed system includes four subsystems:

- Paper management subsystem
- Lecture management subsystem
- Learning subsystem
- Contextual Discussion subsystem

This section discusses the high-level design. The detailed design is described with the implementation of each subsystem in the following sections.

4.2.1 Package diagram

Package is a grouping mechanism for model organization. The package diagram for the system is shown in figure 4-1. There are five packages in the system: UI Package, Control/Process Package, Business Domain Package, Exception Package and Database Package. UI package consists of all the interfaces including graphic user interface and the interface between application server and database (figure 4-2). Control/Process package consists of all the control mechanism in the system, such as user authentication, work flow control and etc (figure 4-3). Business domain package consists of all the domain knowledge in the system. In this project the business domain package includes paper, lecture, learning and discussion (figure 4-4). Database package consists of all the components related to the database. Exception package deals with all the exceptions in the system.

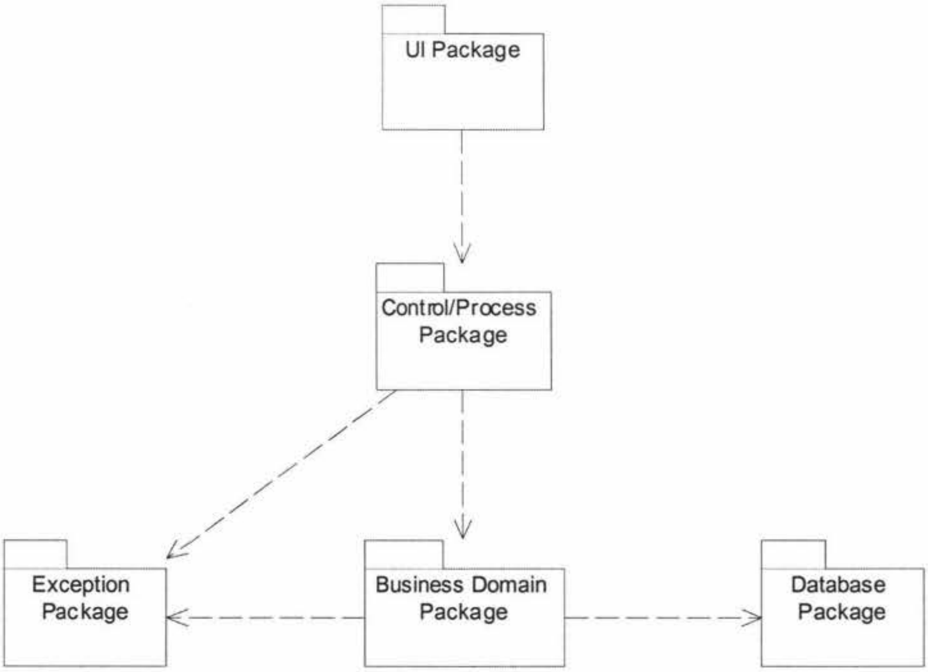


Figure 4-1 First Level Package Diagram

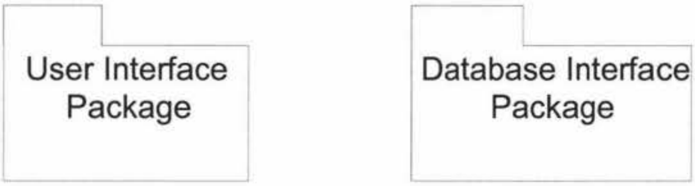


Figure 4-2 Second Level UI Package Diagram

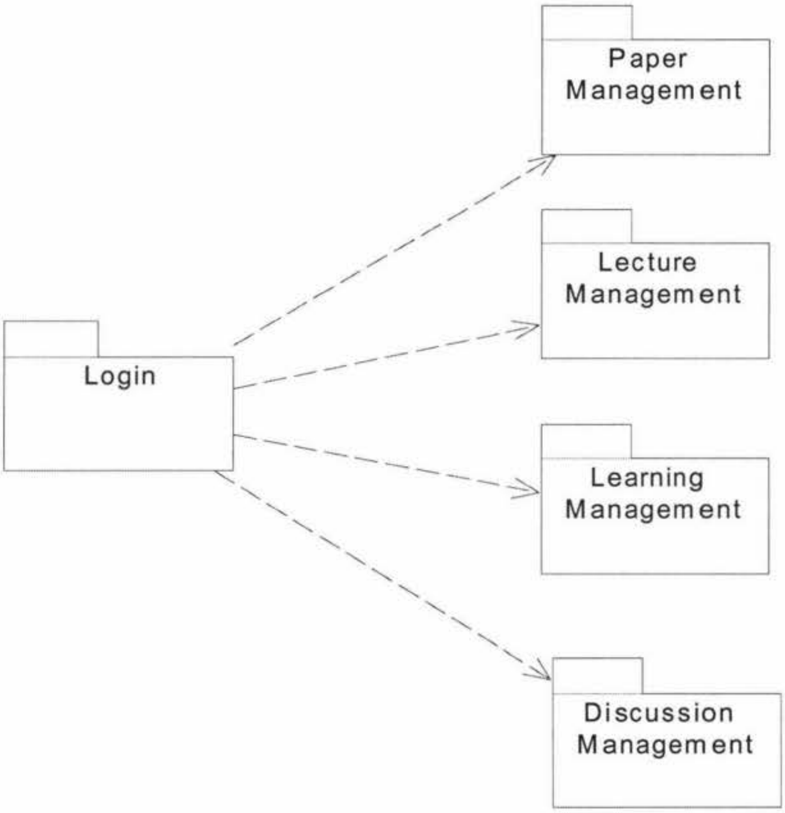


Figure 4-3 Second Level Control/Process Package Diagram

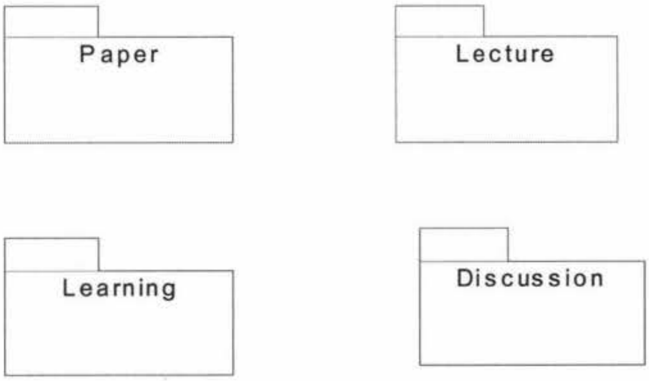


Figure 4-4 Second Level Business Domain Package Diagram

4.2.2 Component diagram

The component diagram describes software components and their dependencies to each other, representing the structure of the code. The components are the implementation in the physical architecture of the concepts and the functionality defined in the logical architecture.

For this system, we develop 12 components, which including

- Interface component (UI interface),
- Application components (Paper management, Lecture management, Learning management and Discussion Management),
- Business object components (User, Paper, Lecture, E-Note, Thread, Reply),
- Database component

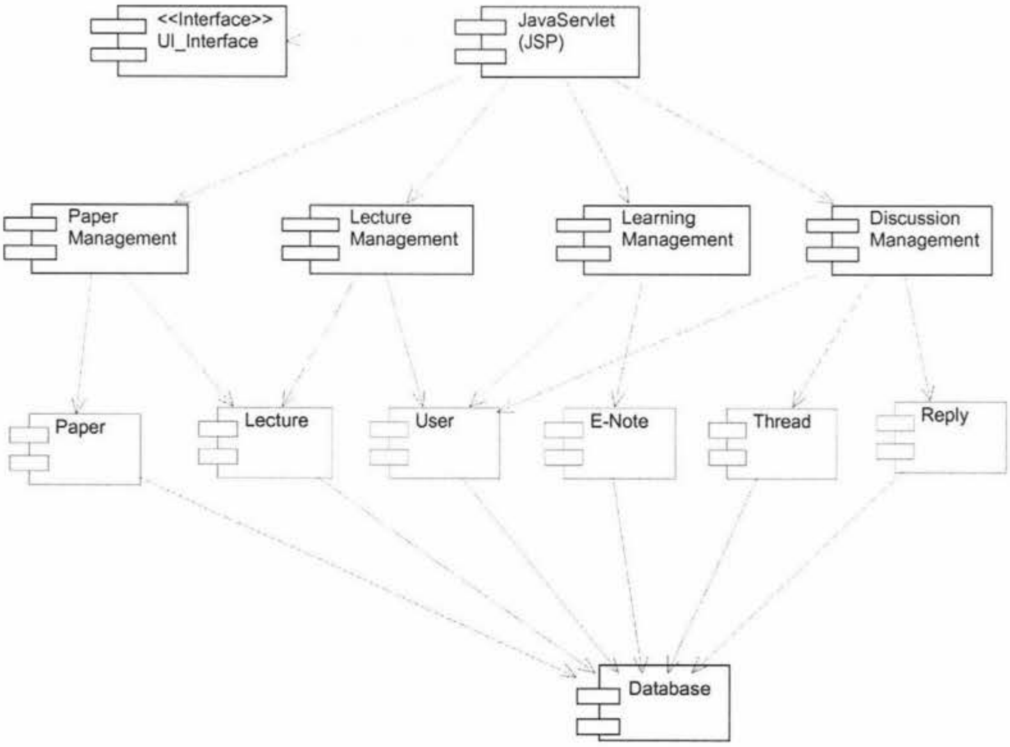


Figure 4-5 System Component Diagram

The Component Diagram is shown in figure 4-5. Java programming language doesn't natively support components. It can only declare a class, but not a component. So a system interface class should be created for communication between components. The system interface class accepts messages from external objects of a component and passes the message to the appropriate class and object within the component.

4.2.3 Deployment diagram

The deployment diagram depicts a static view of the run-time architecture of processors, devices, and the software components that execute in this architecture. It is the ultimate physical description of the system topology, describing the structure of the hardware units and the software that execute on each unit.

The deployment diagram is shown in figure 4-6. We use TCP/IP to connect client and server. Both client and server may connect to the printer and the server communicates with MySQL database by using JDBC.

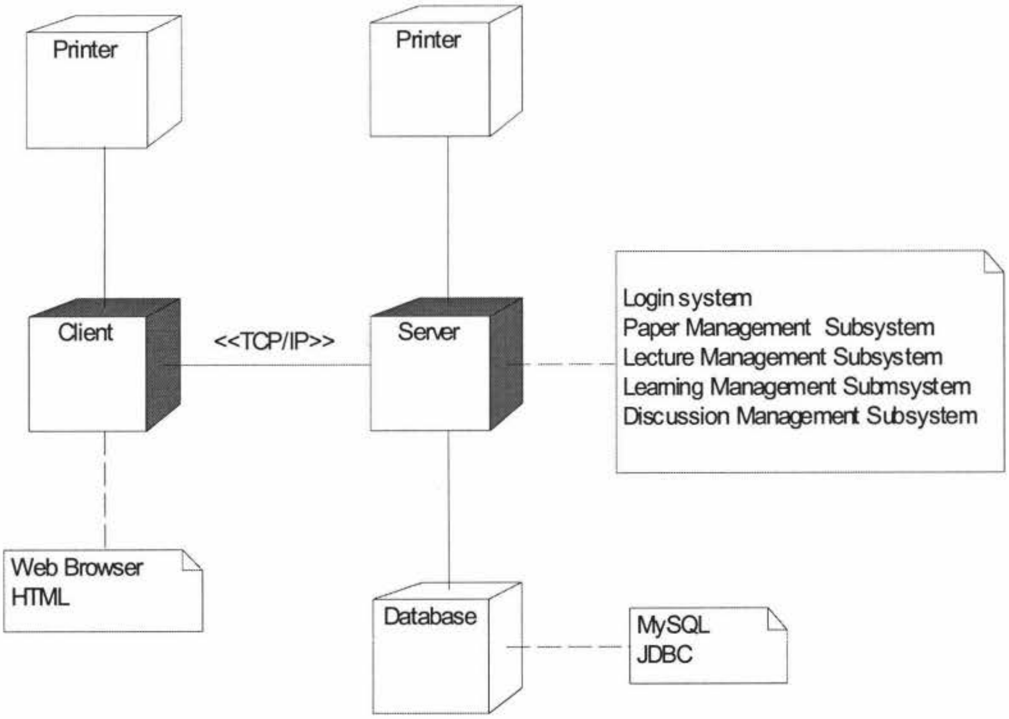

Printer
Printer
Client
<<TCP/IP>>
Server
Login system
Paper Management Subsystem
Lecture Management Subsystem
Learning Management Submsystem
Discussion Management Subsystem
Web Browser
HTML
Database
MySQL
JDBC

Figure 4-6 System Deployment Diagram

4.2.4 GUI design

Careful consideration is given to graphic user interface in order to improve the usability of the interfaces for both teachers and students. The users should feel comfortable to interact with the interface, so that it is made simple and usable. Each window has minimum content, and consistent style. Feedback is an important part of interface and a good interface provides feedback in a very helpful manner so that the cognitive overload is minimum on the users. In order to provide more time for subject learning, the learning of use of computers is kept to a minimum. To accomplish this, only two types of controls are used throughout the programs, buttons and links. The use of these controls is also made considerably intuitive.

The requirements for the interface are:

- The users should know where they are at any time.
- The users should know what the system is doing at any time.
- The users should get a very clear feedback when they do something wrong.
- The users could logout at any time.
- The user could change use cases (functions) easily at any stage.
- The user could cancel any action easily.
- The user could go to home page at any time.
- The interface would be in window style and should be consistent.

Interface for Login and Logout

The login interface (figure 4-7) is used to identify if the user is system-registered user. The user should enter user ID, password and user type. If there is something wrong with login, a warning message will be display in the login interface to inform the user login failed. If the user ID and password is confirmed and the user type is lecture, then the system will go to paper or lecture management subsystem. If the user ID and password is confirmed and the user type is student, then the system will go to learning subsystem. Within the paper or lecture management subsystem, and learning subsystem, the user may go to discussion subsystem. If the user would like to logout, the user may just click the logout link in each interface and then the system will go to the initial login interface.

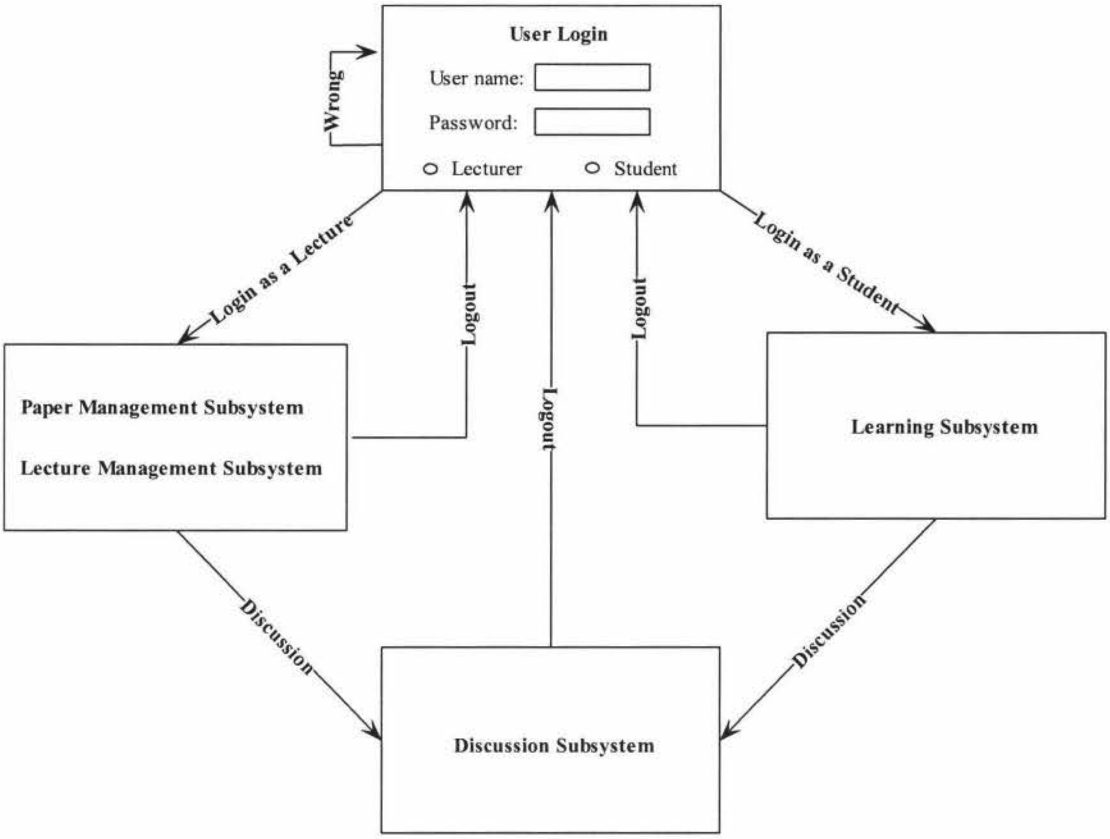


Figure 4-7 Interface for Login and Logout

In order to keep the integrity of each subsystem, the interface for each of **paper management subsystem, lecture management subsystem** and **discussion subsystem** will be described in following corresponding section.

The high-level design gives overall view of the system. From next section, the detailed design and implementation of each subsystem is presented.

4.3 Database design and implementation

In this system, there are three kinds of databases:

- *System Configuration Database* – store the system environment variables

- *Knowledge Domain & Learning Database* – store the course materials and the notes taken by students
- *Peer Communication Database* – store the information for context communication

4.3.1 System configuration database

System configuration database is used to store all the settings for configuring the whole system. It includes:

Learning mode of a paper

Each paper should be assigned a learning mode, e.g., internal or extramural. In this system each paper will be one of following three learning mode:

- Internal: the paper is taught as an internal paper. That means only internal student may take it.
- Extramural: the paper is taught as an external paper. That means all the students may take it.
- Block Course: the paper is taught as an internal paper. Only the internal student may take it. But this paper is taught in several block and doesn't last for a semester.

Credit point for a paper

Each paper should also be assigned a credit point. In the system, each paper will be in one of four kinds of points: 12.5, 25.0, 50.0 and 100 (according to Massey University regulations).

Semester for a paper

Each paper should be taught in particular semester. In the system, the paper will be in one of four categories:

- 1st Semester – the paper is taught in first semester from February to June
- 2nd Semester – the paper is taught in seconde semester from July to November

- 3rd Semester – the paper is taught in third semester from November to February
- Double Semester – the paper starts in 1st semester and finishes in 2nd semester

Table 4-1 Entities and Attributes of System Configuration Database

Entity	Attribute	Data Type	Constraint	Null Value
sys_pape_mode	mode	varchar (20)	Primary key	No
sys_paper_point	point	varchar (8)	Primary key	No
sys_paper_semester	semester	varchar (20)	Primary key	No
sys_var	id	int (3)	Primary key	No
	lecture_store_dir	varchar (100)		No
	host	varchar (100)		No
	username	varchar (100)		No
	password	varchar (12)		No
	path	varchar (100)		No
	realwebserver	varchar (100)		No
	webserver	varchar (100)		No
	rtspserver	varchar (100)		No

System environment variables

In order to make the system working smoothly, some important information should be stored in the database, such as the web server address, RealSystem Server address, where to store the lecture video and slides, and so on. So following information should be provided:

- Lecture Store Path – where to store lecture video and slides
- Database Information – host name, user name and password
- Web Server Address – the URL for web server
- RealSystem Webserver Address – the web address for RealSystem Server
- RealSystem Streaming Address – the URL of RealSystem Server for data streaming

The entities and their attributes of system configuration database are defined in Table 4-1.

4.3.2 Knowledge domain & learning database

Knowledge domain model is needed for representing course contents and the relationship between the content elements. The knowledge domain model is based on the following assumptions:

- Each paper has only one coordinator and perhaps several associated staffs
- Each paper should have paper code, paper title, credit point, paper prescription, paper coordinator, paper mode and paper semester
- Each paper may have paper prerequisites and paper restrictions
- Each paper may contain several lectures
- Only paper coordinator may add new paper
- Paper coordinator and associated staffs may delete paper or modify paper information
- Paper coordinator and associated staffs may add students or associated staffs and delete students for one paper.
- Each lecture should have lecture name, lecture video, lecture slides and available date.
- Each lecture should have a path to indicate where the lecture video and slide are stored
- Each lecture should have information for synchronizing the lecture video and slides
- Any associated staffs may add, delete or modify a lecture.
- Any associated staffs may configure the setting for synchronizing the lecture video and slides.
- Each student may enroll in several papers.
- Each student may view the lecture video and slides within the registered paper.
- Each student may take e-note for each lecture within the registered paper.

Based on above requirements, the knowledge domain and learning database is designed by the entity relationship model (figure 4-8). The entities and their attributes of knowledge domain and learning database are defined in Table 4-2.

Table 4-2 Entities and Attributes of Knowledge Domain & Learning Database

Entity	Attribute	Data Type	Constraint	Null Value
Paper	paId	int (4)	Primary key	No
	pCode	varchar (7)		No
	pMode	varchar (50)		No
	pTitle	text		No
	pPrescription	text		
	pSemester	varchar (50)		No
	pPoint	varchar (5)		No
	pRestriction	varchar (100)		
	pPrerequisite	varchar (100)		
Lecture	lId	int (8)	Primary key	No
	lPaId	int (4)		No
	lName	varchar (50)		No
	lAvailableDate	date		No
	lTime	int (3)		
	lStatus	enum*		No
	lVideoStatus	enum**		No
	lSlideStatus	enum***		No
	storeDir	varchar (200)		No
Media_setting	mLId	int (8)	Primary key	No
	slideNum	tinyint (3)	Primary key	No
	startPoint	bigit (20)		No
Staff	sfId	int (8)	Primary key	No
	sfPId	int (8)		No
	sfTitle	varchar (50)		
Controller	cSfId	int (8)	Primary key	No
	cPaId	int (4)	Primary key	No
	position	enum****		
Student	sId	int (8)	Primary key	No
	sPId	int (8)		No
	sPost	int (8)		
Enrollment	enSId	int (8)	Primary key	No
	enPaId	int (4)	Primary key	No
Enote	eLId	int (8)	Primary key	No
	eSId	int (8)	Primary key	No
	note	blob		
Person	pId	int (8)	Primary key	No
	pName	varchar (50)		No
	pPassword	varchar (12)		No
	pEamil	varchar (50)		

* There are three values: un-upload, un-configure, and configrued

** There are four values: not upload, not processed, processed, configured

*** There are four values: not upload, not processed, processed, configured

**** There are two values: coordinator and staff

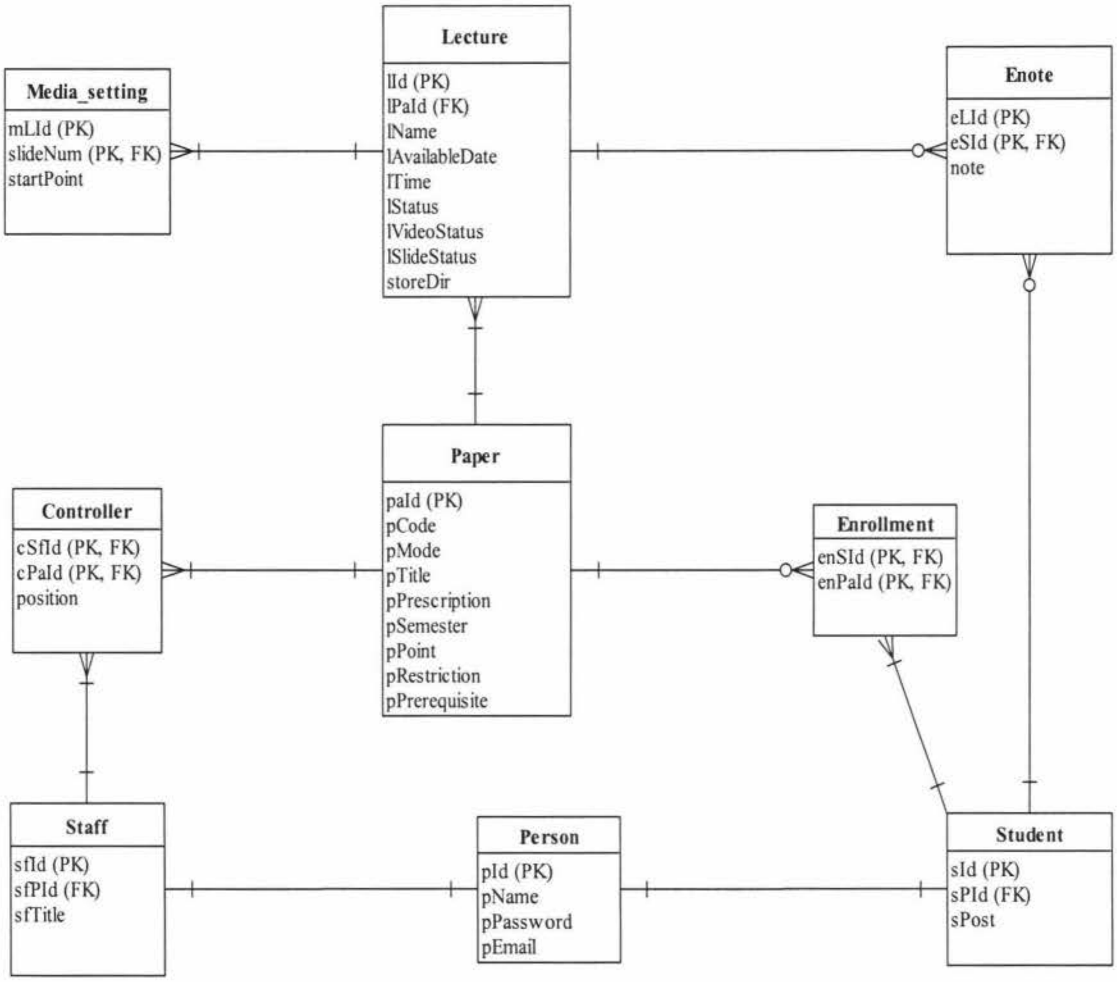


Figure 4-8 ER Diagram for Knowledge Domain & Learning Database

4.3.3 Peer communication database

Peer communication database stores all the information about discussion among students and teacher. It is based on following assumptions:

- Every discussion board is based on one particular lecture
- Each discussion board may contain many threads
- Each thread may contain many replies.
- Any student or teacher may post a new thread or reply a existing thread

Peer communication database was also designed by the entity relationship model (figure 4-9). The entities and their attributes of knowledge domain and learning database are defined in Table 4-3.

Table 4-3 Entities and Attributes of Peer Communication Database

Entity	Attribute	Data Type	Constraint	Null Value
Thread	tId	int (16)	Primary key	No
	tLId	int (8)		No
	tPId	int (8)		No
	tSubject	varchar (100)		No
	tMessage	text		
	tPostTime	datetime		No
	tNumberOfReply	int (4)		No
	tLastPostTime	datetime		No
Reply	rId	bigint (24)	Primary key	No
	rTId	int (16)		No
	rPId	int (8)		No
	rMessage	text		
	rTime	datetime		No
Person	pId	int (8)	Primary key	No
	pName	varchar (50)		No
	pPassword	varchar (12)		No
	pEmail	varchar (50)		

* For entity "staff", "student" and "lecture", please see table 4-2.

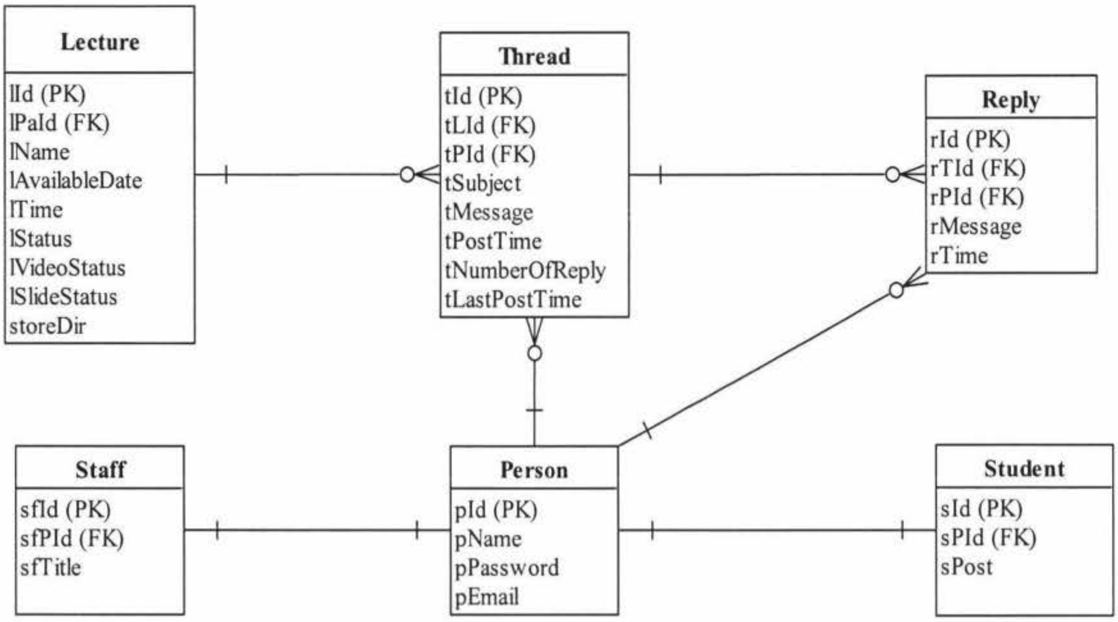


Figure 4-9 ER Diagram for Peer Communication Database

4.4 Paper management subsystem design and implementation

The actor of the paper management subsystem is teacher. The function of this subsystem is to let the teacher to maintain the course and the user account. It implements four use cases: Add Course, Edit Course, Add User and Remove User.

4.4.1 Interface design and implementation (Client Tier)

There are seven main interfaces for the paper management subsystem (figure 4-10 and table 4-4). In each interface there is a control bar to let the user to change functions. So the user may go to home page and logout at any time by clicking corresponding link.

Paper List

This is the home page for the paper management subsystem. Every other interface may go to this page by clicking "home" link on the control bar. This interface lists all the paper associated with this user. Each paper includes paper code and paper title. After selecting a paper, the user may go to paper information detail interface by pressing "maintain" button, may go to learning subsystem by pressing "view" button, may go to edit user profile interface by clicking "edit profile" link and may go to creating new paper interface by clicking "new paper" link.

Edit User Profile

There are two areas in this interface. One is to let the teachers to update their email addresses and titles (e.g., professor, lecturer, tutor and etc.). The other is to let the teachers to change their passwords by entering old and new password.

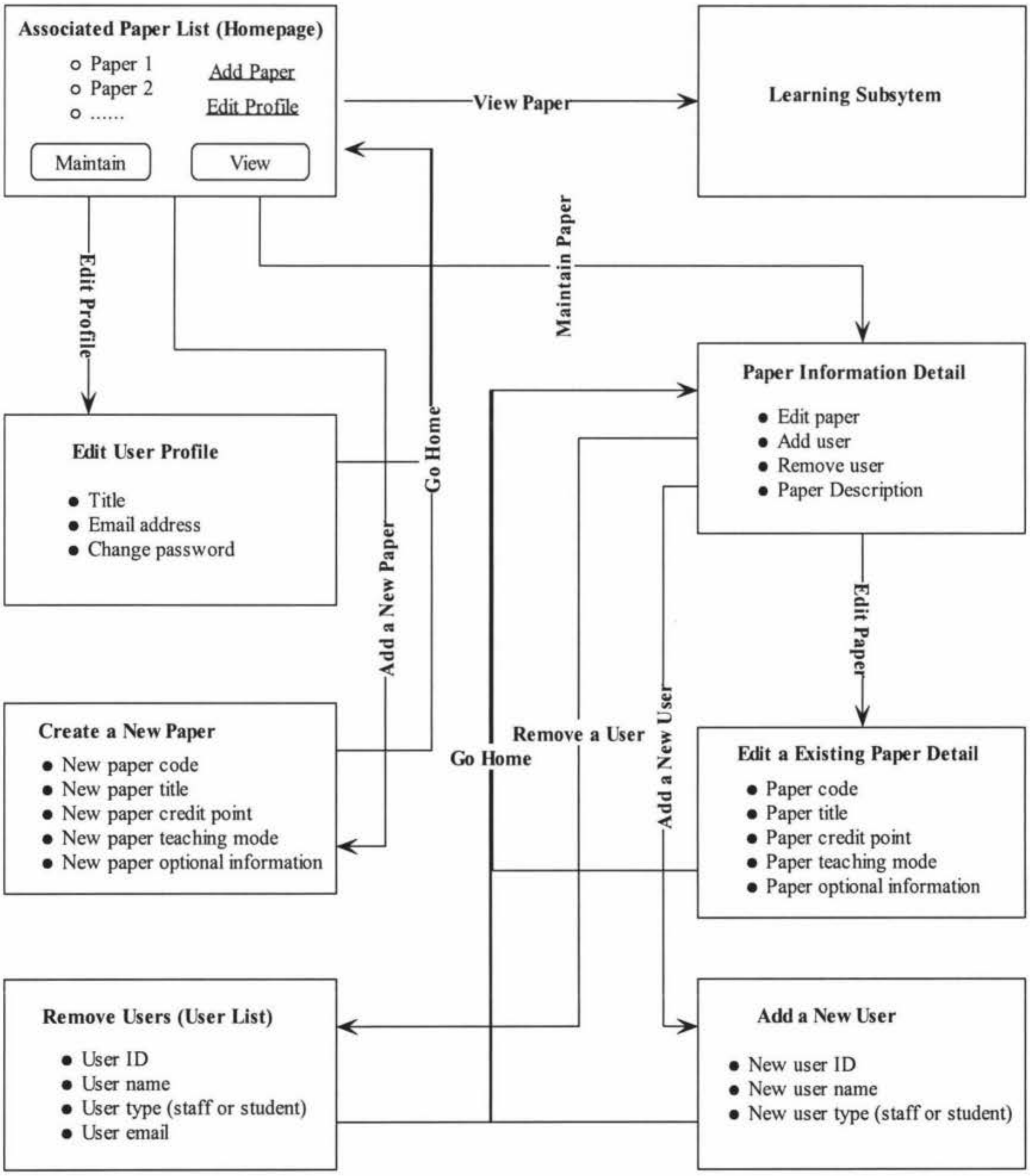


Figure 4-10 Interface for Paper Management Subsystem

Table 4-4 JSP Files and Their Functions

File Name	Function
paper_maintenance.jsp	Display available paper list. From here, the teacher may select "add paper", "edit profile" and "maintain" or "view" paper.
add_paper.jsp	Display a blank form for teacher to input the information of new paper. After submitted, the page will go to the page created by update_paper.jsp.
edit_profile.jsp	Display a form for teachers to modify their profiles.
mode_selection.jsp	This works as a switch. If the teacher would like to maintain a paper, the page created by paper_info.jsp will be display. If the teacher would like to view the paper, the system will go to the learning subsystem.
title_of_maintenance.jsp	It integrates into all following jsp files. It works as a control panel in each interface.
paper_info.jsp	Display selected paper information details.
edit_paper.jsp	Display a form with the paper information. The teacher may change the information.
update_paper.jsp	After editing a paper, this page will be displayed to tell the teacher what is the new information of the paper.
add_user.jsp	Display a blank form for teacher to input the information of new user.
new_user.jsp	After the information of the new user submitted, this page is displayed to show the new user information.
del_user.jsp	Display a registered user list without the coordinator of selected paper. After the selected users deleted, the updated user list is display.

Create a New Paper

This interface first displays a blank form to the teacher. Then the teacher should input all necessary information for a new paper in the form including paper code, paper tile, paper teaching mode, paper credit point, paper semester and some other optional information (e.g., prerequisites, restriction and etc.). After filling and submitting the form, the new paper details will be displayed to let the teacher know what information of the new paper is already stored in the database.

Paper Information Detail

In the interface, the detailed information of the selected paper is display. The teacher may change the functions by clicking the links on the control bar. It may go to interface for editing a paper, adding a new user and removing existing users.

Add a New User

In this interface the teacher inputs the user id, user name and user type (staff or student). After the form is submitted, the new user information is displayed and the default password for this new user is his/her user id.

Remove Users

The interface lists all the users associated with the paper. Each user includes user id, user name, user email and user type. The teacher may select one or more users to delete. After deleting, the updated user list is display. The teacher may select users and remove users again. Or the user may go to home page.

Edit an Existing Paper Detail

In the interface there is a form with all stored information of this selected paper. The teacher may modify the information and finish updating by pressing "update" button.

4.4.2 Back-end application design and implementation (Middle tier)

The function of server side application in paper management subsystem is to store the new paper information, update the existing paper detail, store the new user information and delete the user information according to the message obtained from the client.

There are nine classes in the subsystem. Classes of UserBean, PaperBean and ControlBean are control classes, which communicate with interface. Classes of UserData, StudentData, StaffData, PaperData and ControlData are entity classes, where JDBC is used to communicate with the database. Figure 4-11 is the class diagram for the subsystem, which is designed using UML and Rational Rose. The functions of each class are shown in table 4-5.

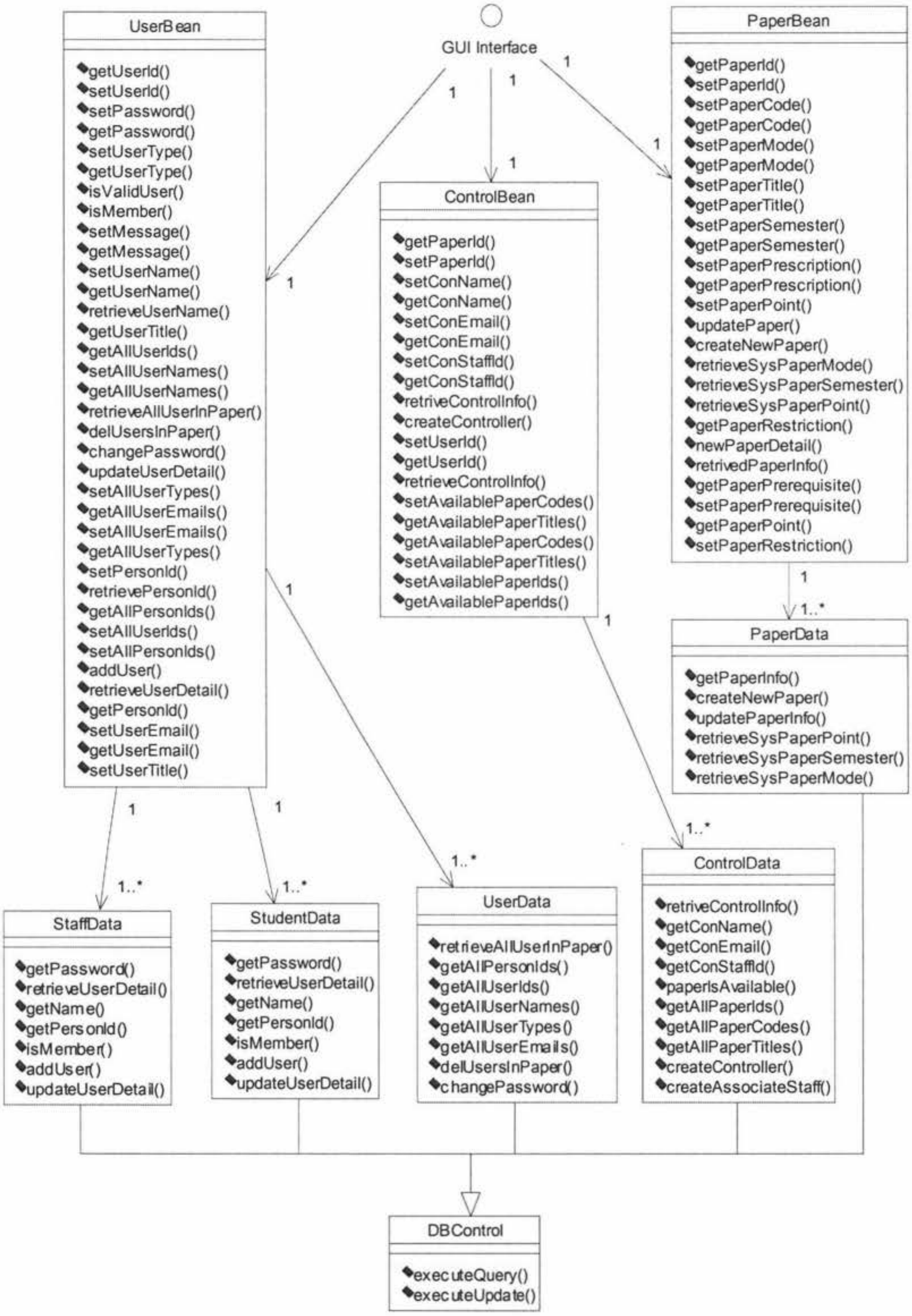


Figure 4-11 Classes Diagram of Paper Management Subsystem

Table 4-5 Classes and Their Functions

Class Name	**Class Function**
PaperBean	▪ Contain detailed information on a paper (paper code, paper title, paper credit point, paper teaching mode, paper teaching semester, paper prescription, paper restriction, and paper prerequisites) ▪ Load a paper or all papers from the database by calling methods of the relevant database access class (PaperData) ▪ Save paper back to the database by calling methods of the relevant database access class (PaperData)
PaperData	▪ This is a database access class ▪ Retrieve a paper or all papers information from the database ▪ Store or update a paper information in the database
UserBean	▪ Contain detailed information on a user (user id, user name, user email, user type and password) ▪ Load a user or all users from the database by calling methods of the relevant database access class ▪ Save user back to the database by calling methods of the relevant database access class
UserData	▪ This is a database access class ▪ Retrieve a user or all users information from the database ▪ Store or update a user information in the database
StaffData	▪ This is a database access class ▪ Retrieve a staff information from the database ▪ Store or update a staff information in the database
StudentData	▪ This is a database access class ▪ Retrieve a student information from the database ▪ Store or update a student information in the database
ControlBean	▪ Contain detailed information on an associated staff (user id, staff id, associated paper information) ▪ Load an associated staff from the database by calling methods of the relevant database access class (ControlData) ▪ Save an associated staff back to the database by calling methods of the relevant database access class (ControlData)
ControlData	▪ This is a database access class ▪ Retrieve an associated staff information from the database ▪ Store or update an associated staff information in the database
DBControl	▪ All database access classes are extended to this class ▪ Directly get and update information in the database

4.4.3 Database for paper management subsystem (Third tier)

The database for this subsystem includes nine tables: controller, person, staff, student, enrollment, paper, sys_paper_semester, sys_paper_point and sys_paper_mode. For the details of these tables, please see Section 4.3.

4.5 Lecture management subsystem design and implementation

The actor of the lecture management subsystem is still the teacher. The function of this subsystem is to let the teacher to maintain the lecture in a paper. It implements three use cases: Add Lecture, Configure Lecture, and Remove Lecture.

4.5.1 Interface design and implementation (Client tier)

There are seven main interfaces for the paper management subsystem (figure 4-12 and table 4-6). In each interface there is a control bar to let the user to change functions. So the user may go to home page and logout at any time by clicking corresponding link.

Paper List

It is same as that in the Paper Management Subsystem. Please go to section 4.4.1 to see the detail.

Paper Information Detail

In the interface, the detailed information of the selected paper is display. The teacher may change the functions by clicking the links on the control bar. It may go to interface for adding a new lecture, removing existing lectures and configuring a lecture.

Create a New Lecture

After clicking the link for add a new lecture in the interface of "Paper Information Detail", this interface is displayed where there is a blank form for the new lecture. The teacher should input the name for the new lecture, may enter the data available and may upload the video file in AVI format and the slide file in PPT format. After the form is submitted, the interface of "Edit an Existing Lecture" displayed and the new lecture information will be displayed to let the teacher know what information of this new lecture has been saved in the database.

List of Lecture in the Paper

In this interface, a list of all lectures in selected paper is displayed. Each lecture in the list includes lecture name, lecture duration, date available, video & slide status and lecture status. To delete the lectures, the teacher should select the lectures and submit the form. After that, an updated lecture list is displayed.

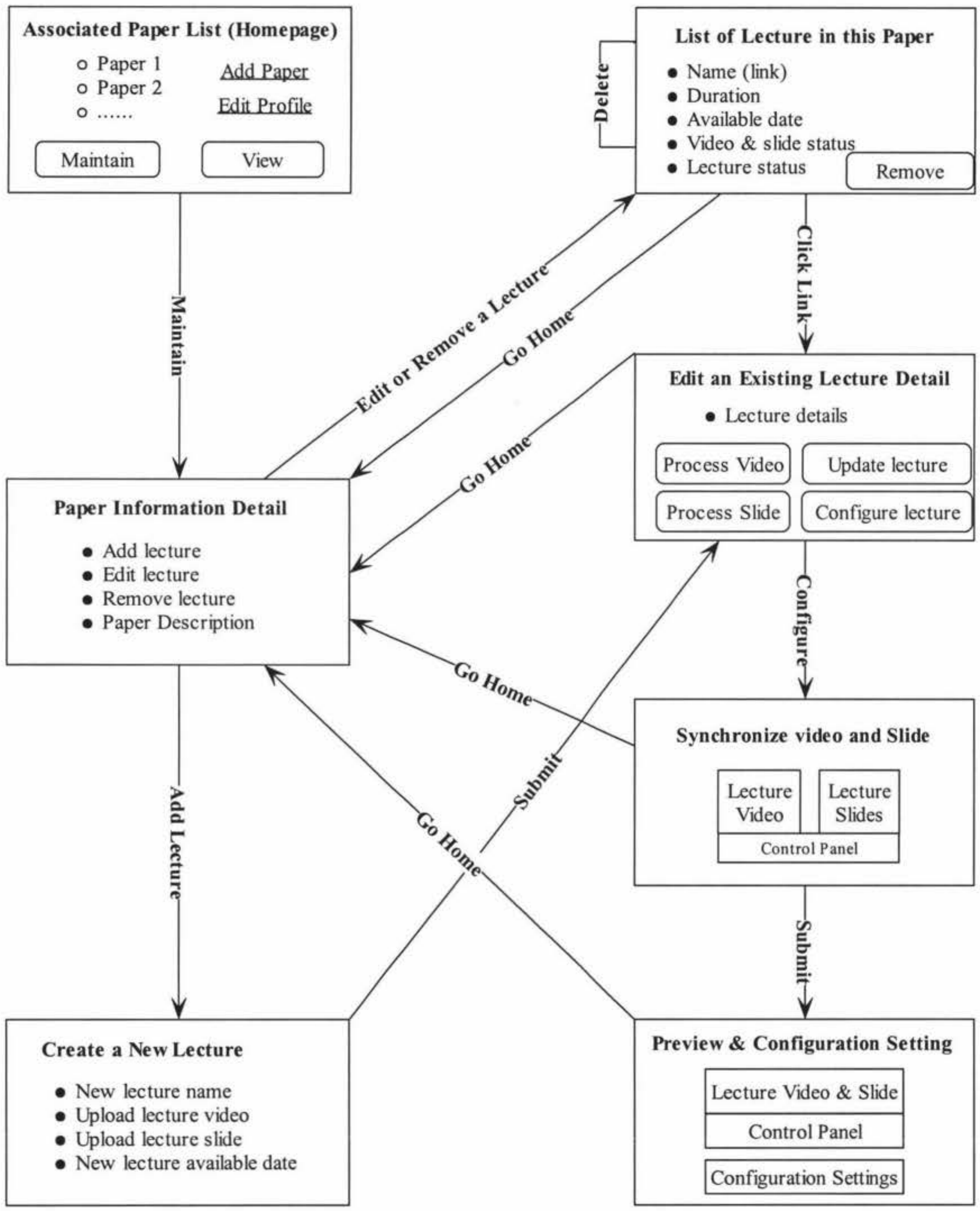


Figure 4-12 Interface for Lecture Management Subsystem

Table 4-6 JSP Files and their Functions

File Name	Function
paper_maintenance.jsp	See table 4-5
mode_selection.jsp	See table 4-5
title_of_maintenance.jsp	See table 4-5
paper_info.jsp	See table 4-5
add_lecture.jsp	Display a blank form for teacher to input the necessary information of the new lecture.
creating_lecture.jsp	Store the uploaded the video file and slide file in the hard disk and pass the details of new lecture to the server.
newLecture.jsp	Display the new lecture details. If both the video and slide files are uploaded, the teacher may invoke the file conversion process.
process_files.jsp	Determine what kind of file conversion is requested by teacher and then call the methods in the server to convert the file.
list_lecture.jsp	List all the lectures in the selected paper. The teacher may select one or more lecture and then delete them.
edit_lecture.jsp	A form containing lecture's details. The teacher may modify the lecture's detail and then update them. If both the video and slide files are uploaded, the teacher may also invoke the file conversion process.
editing_lecture.jsp	Store the uploaded the video file and slide file in the hard disk and send the modified details of the lecture to the server.
lecture_configuration.jsp	Synchronize the lecture video and slides by using embedded Real Player.
lecture_preview.jsp	Preview the synchronized video and slides by using embedded Real Player.
configuration_completion.jsp	Show the message to inform the teacher the lecture has finished configuration.

Edit an Existing Lecture Detail

To edit or configure a lecture, the teacher may click the link under each lecture name in the interface of "List of Lecture in the Paper". Then this interface is appeared. The details of this lecture including lecture name, available date, video file name and slide file name are shown in a form. The teacher may modify the name and date available, and may also re-upload the video and slide file for the lecture. Then the teacher may presses the button of "Update Lecture" to update the lecture.

Because the RealSystem Server is used to stream the data, the video file in AVI format should be converted to RM format. To do this, the teacher may press the button of "Process video" if the video is uploaded and is not in RM format. Then a message is displayed to show conversion progress. After conversion is finished, the button of "Process video" is disabled. The teacher may press the button of "Process slide" to convert slide file in PPT format to JPG format. The reason is explained later. Initially the button of "Configure Lecture" is disabled. After processing video and slide, the button is enabled. Now the teacher may synchronize the video and slide by pressing the button of "Configure Lecture".

Synchronize Video and Slide

In this interface, there are three areas: video playing, slide show and control panel. An embedded Real Played is used to play video. The area for showing the slide is just an image field. There are two kinds of functions in the control panel. One series of buttons in the panel are used to control video playing. The video can be forward, backward, pause and stop. The other series of buttons are used to change the image in the slide show area. It may go to first image, previous image and next image. Also there is progress bar to show the progress and field to show how many images are left. After finishing synchronization, the teacher may press the button of "Preview" to go to the next interface "Preview & Configuration Setting".

Preview & Configuration Setting

An embedded Real Player with all controls is used to play the synchronized video and slides. Below this, a table shows all the configuration settings for this lecture. The teacher may view the lecture video and slides using embedded Real Player. If satisfied, the teacher may press button of "finish" to finish lecture configuration. Otherwise, the teacher may go back and re-synchronize the lecture.

4.5.2 Back-end application design and implementation (Middle tier)

The function of lecture management subsystem is to store the new lecture information including name, duration, date available and configuration settings, update the existing lecture detail, and delete the lecture information according to the message obtained from the client. The core processes of synchronization and conversion of video and slide files are taken place here.

Table 4-7 Classes and Their Functions

Class Name	Class Function
LectureBean	▪ Contain detailed information on a lecture (lecture name, date available, duration, video file, slide file, store path, configuration settings and etc.) ▪ Load a lecture or all lectures from the database by calling methods of the relevant database access class (LectureData) ▪ Save lecture back to the database by calling methods of the relevant database access class (LectureData) ▪ Convert video file's format by calling third party application "RealSystem Producer" ▪ Convert PowerPoint file to image files (JPG format) by calling a VB application ▪ Create streaming data schema (SMIL files)
LectureData	▪ This is a database access class ▪ Retrieve a lecture or all lectures' details from the database ▪ Store or update a lecture's detail in the database
DBControl	▪ All database access classes are extended to this class ▪ Directly get and update information in the database

There are two java classes, two third-party java packages, one third-party application and one VB application in the server side. Class of LectureBean is control classes, which communicate with interface. Class of LectureData is entity classes, where JDBC is used to communicate with the database. The functions of each class are shown in table 4-7. Figure 4-13 is the class diagram for the subsystem, which is designed using UML and Rational Rose.

One third-party Java package is SmartUpload which is used to upload video and slide files to the server. It may allow one or more files at one time and may check the file's format and size. The other third-party Java package is FtpBean which is used to transfer files from one computer to another computer using ftp protocol. There are two machines working in the server side. One is called "maintenance server" that is used for teacher to maintain the course. This machine only may be accessed within intranet where the bandwidth is high. Then the teacher may upload files fast. The other machine is called "learning server" that is used for student's learning. So after the teacher finishes configuring a course, the video and slide files are transferred form "maintenance server" to "learning server" using FtpBean.

The third-party application is RealSystem Producer which is used to convert the video file from AVI format to RM format.

The most significant function of this subsystem is to synchronize the lecture video and lecture slides. In normal class, the teacher gives explanations to the students using a PowerPoint file containing several slides and changes the slides one by one. In order to do this, the PowerPoint file is converted to many image files in JPG format using a VB application after it is uploaded. Each image file refers to each slide in that PowerPoint file. When the teacher configure the lecture using the interface of "Synchronize Video & Slide", the teacher first starts playing the lecture video and then sets the lasting time for each image file using the button in the control bar. The system records the lasting time for each image file. Finally a streaming schema for playing a synchronized video and slides is created using SMIL. So when student learning, the synchronized video and slides is played according to that particular streaming schema. Since the PPT file is the default file format of MS PowerPoint, it should be installed in the "maintenance server". A VB application is developed to MS PowerPoint to convert a file from PPT format to JPG format.

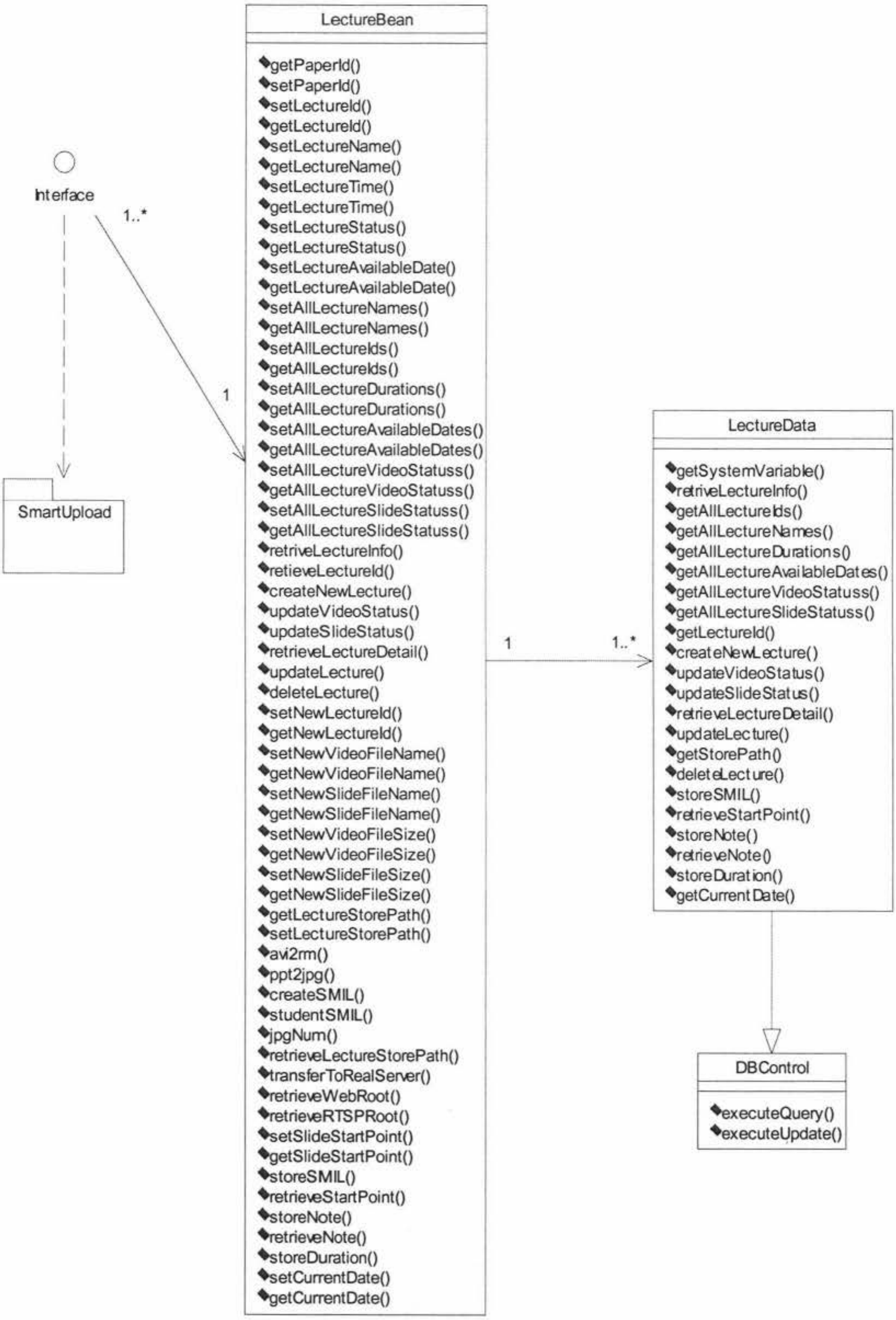


Figure 4-13 Class Diagram of Lecture Management Subsystem

4.5.3 Database design and implementation (Third tier)

The database for this subsystem includes three tables: sys_var, lecture and media_setting. For the details of these tables, please see Section 4.3.

4.6 Learning subsystem design and implementation

The actor of the learning subsystem is the student. The function of this subsystem is to let the students learn the course by viewing the lecture video with the slides and taking notes for the lecture. It implements two use cases: View Lecture and Take Notes.

4.6.1 Interface design and implementation (Client tier)

There are four main interfaces for the learning subsystem (figure 4-14 and table 4-8). In each interface there is a control bar to let the user to change functions. So the user may go to home page and logout at any time by clicking corresponding link on the control bar.

Enrolled Paper List

After login, the system displays this page where all the enrolled papers are listed. The student may select one for learning or click "edit profile" link to edit his/her profile.

Edit User Profile

There is a text field for the student to update email address. From this interface, the students may also change their passwords by providing old password and new password.

Lecture & Study Mode Selection

In this interface, beside the paper description there is a control panel, where a drop down box lists all lectures available at that time and another drop down box lists all learning mode. The students should select which lecture they would like to learn and which learning mode they prefer.

Student Learning Page

There are three areas in the interface. In the upper area a typical full functional embedded Real Player is used to play the synchronized video and slides. The students may use the standard control bar to control the video play. The left side is the lecture video and the right side is the lecture slides. There is a text field in the middle where the students may take notes for the lecture when learning. The down area is the discussion board where the students may discuss with their teacher and other students. The details of discussion boards will be discussed in next section.

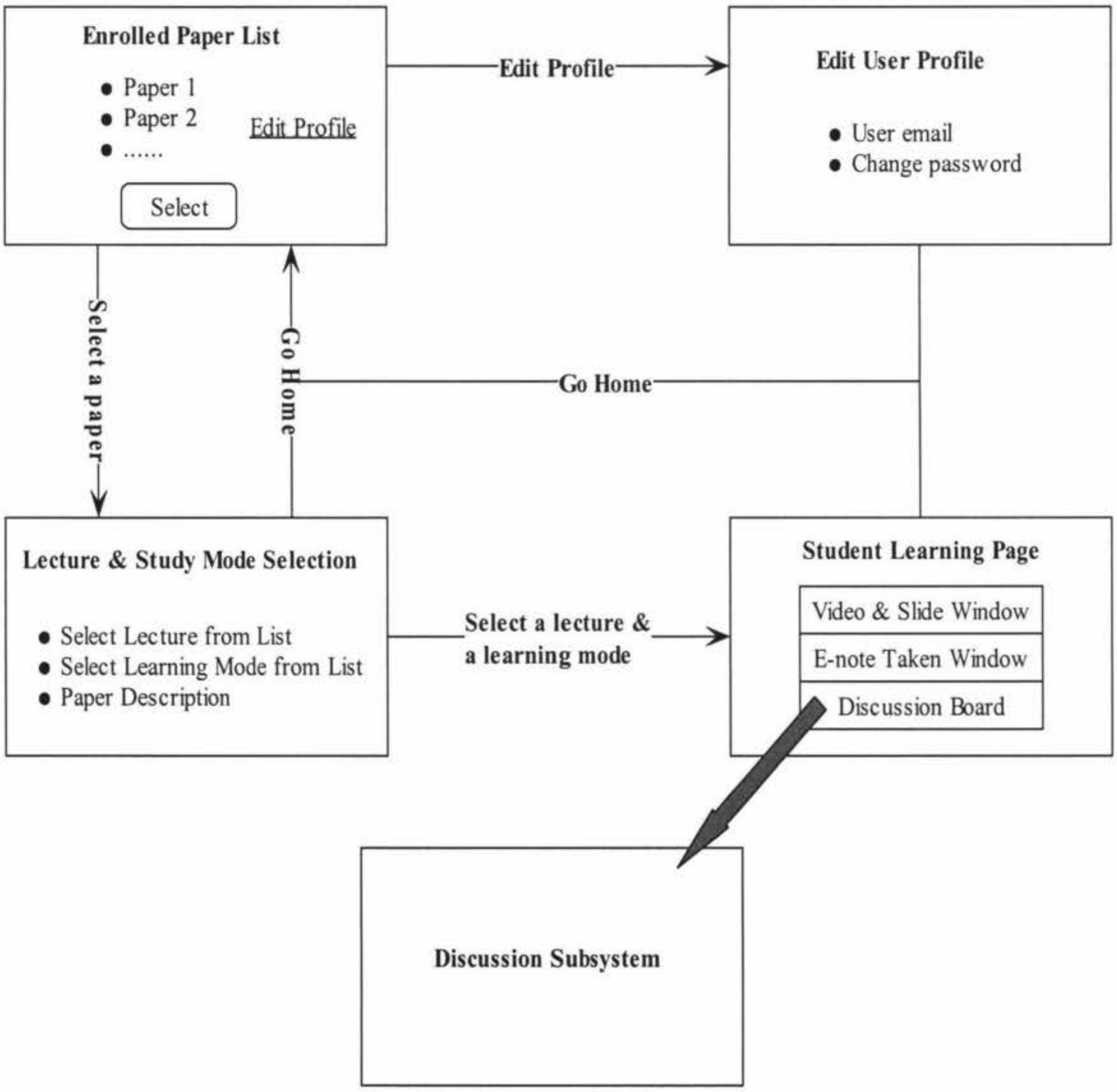


Figure 4-14 Interface for Learning Subsystem

Table 4-8 JSP Files and their Functions

File Name	Function
paper_selection.jsp	List all the papers available to the user. The students need to select one paper for learning. Or they may edit their profiles from here.
edit_profile.jsp	The students may change their email addresses and passwords.
title.jsp	It integrates into all following jsp files. It works as a control panel in each interface. The students should select lecture and learning mode from here.
paper_outline.jsp	Description of selected paper.
learning.jsp	It is dynamically generated according to the selected learning mode. It may contain only discussion board or lecture video playing area and taking notes area or all of them.
mode_VSE.jsp	The page is used to playing synchronized video and slides and taking notes for the lecture
discussionBoard.jsp	This is the first page of contextual discussion subsystem. Please see next section for the detail.

4.6.2 Back-end application design and implementation (Middle tier)

The function of learning subsystem is for students to view the lecture, that means to view the synchronized video and slides, and take notes for the lecture.

The system includes thirteen java classes. Classes of PaperBean, LectureBean, UserBean, ControlBean, EnrolBean and StudyModuleBean are control classes, which communicate with interface. Classes of PaperData, LectureData, UserData, StudentData, StaffData, ControlData and EnrolData are entity classes, where JDBC is used to communicate with the database. Figure 4-15 is the class diagram for the subsystem which is designed using UML and Rational Rose. The functions of each class are shown in table 4-9 (please refer to table 4-7 & 4-5 for some classes' functions).

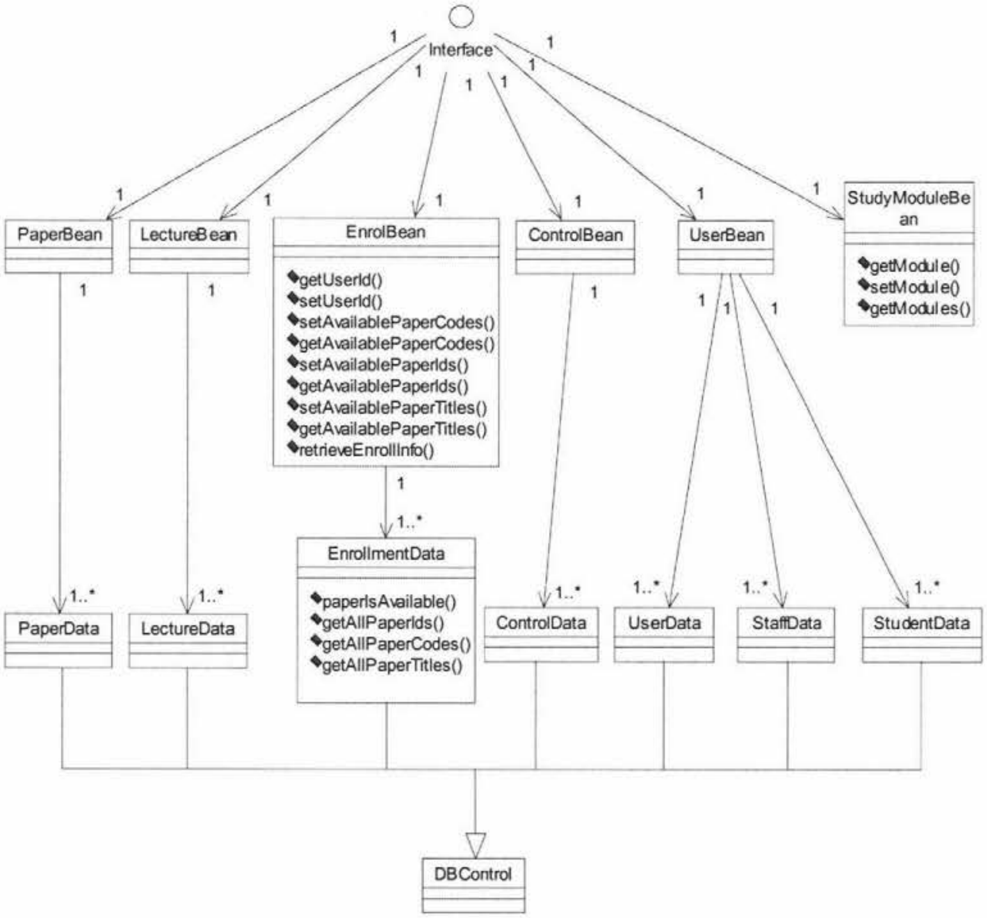


Figure 4-15 Class Diagram for Learning Subsystem

(Please refer to figure 4-13 and 4-11 for some classes' details.)

Table 4-9 Classes and their Functions

Class Name	Class Function
StudyModuleBean	▪ Contain detailed information on learning mode
EnrolBean	▪ Contain detailed information on a student's enrollment ▪ Load all the enrolled paper from the database by calling methods of the relevant database access class (EnrollmentData)
EnrollmentData	▪ This is a database access class ▪ Retrieve the enrollment information for a student from the database

4.6.3 Database design and implementation (Third tier)

The database for this subsystem includes three tables: sys_var, lecture and media_setting. For the details of these tables, please see Section 4.3.

4.7 Contextual discussion subsystem design and implementation

The actor of contextual discussion subsystem is the teacher and the student. The function of this subsystem is to let the teacher and students discuss particular lecture, exchange ideas and provide helps. It implements only one use case: Discussion.

4.7.1 Interface design and implementation (Client tier)

There are four main interfaces for contextual discussion subsystem (figure 4-16 and table 4-10).

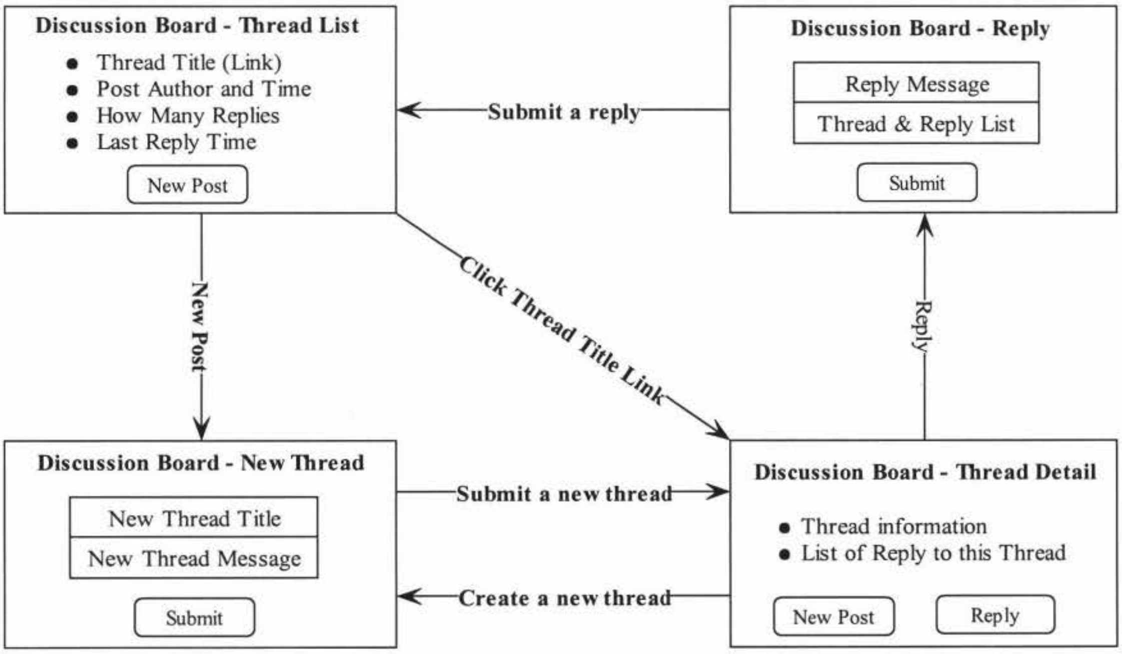


Figure 4-16 Interface for Contextual Discussion Subsystem

Discussion Board – Thread List

This is the home page of contextual discussion subsystem. It lists all the threads in the selected lecture. Each thread contains thread topic, thread author, post time, total number of replies and the last reply time. The user may click the link under each thread topic to go to next page to view the thread detail. The user also may click the link of "new thread" to post a new thread.

Table 4-10 JSP Files and their Functions

File Name	Function
discussionBoard.jsp	List all the threads in the selected lecture. There are two links to let the user to view the thread details and post new thread.
new_thread.jsp	It contains a blank form to let the user to input all the necessary information for a new thread.
post_completion.jsp	This is not a page. It stores the information of the post in the database and then goes to of page created by "thread.jsp".
thread.jsp	Display all the information of a thread, including all the details of all its replies. There are several links to let users to post new thread, reply thread, email to author, quote a post and go back to thread list.
reply_thread.jsp	It contains a text field to let the user to input the message for a reply.

Discussion Board – New Thread

It contains a blank form to let the user input the necessary information for a new thread. The information should include thread topic and message. The user may click the button of "cancel" to cancel it and go back to the thread list or click the button of "submit" to post a new thread. After submitted, an updated thread list is displayed.

Discussion Board – Thread Detail

It contains the details of the selected thread and all the replies' details. The thread and each reply should have author, post time and message. The user may reply this thread by clicking the link of "reply thread", quote a post by clicking the link of "quote", post a new thread by click the link of "new thread" and send an email to the author by clicking the link of "email" if the user's email address is stored in the database. The user may also go back to thread list by clicking the link of "back".

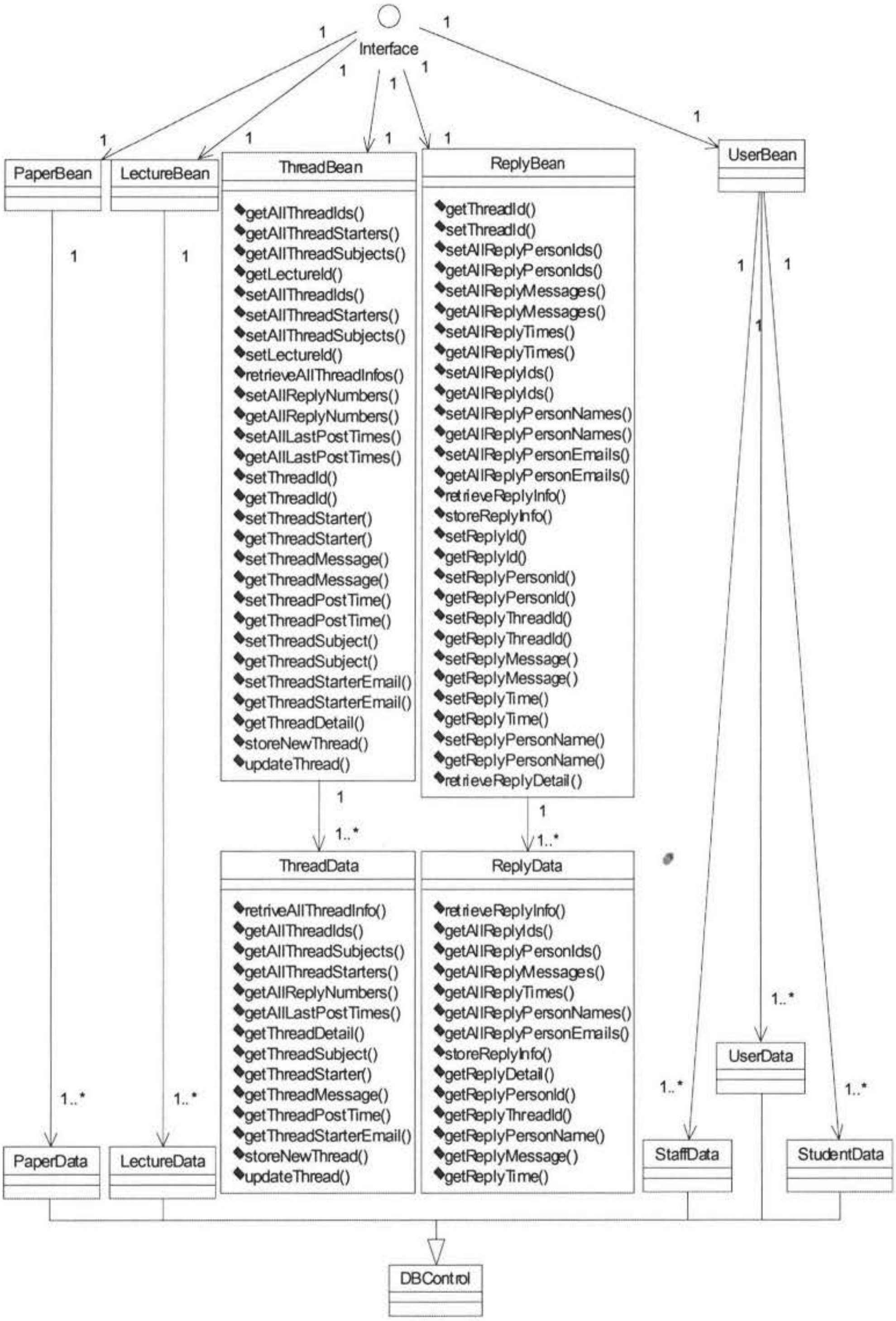


Figure 4-17 Class Diagram for Contextual Discussion Subsystem

(Please refer to figure 4-13 and 4-11 for some classes' details.)

Discussion Board – Reply

There is text field to let the user input the message of the reply. And the thread author, thread topic, all replies' authors and all replies' topics are listed below this text field. The user may post the reply by pressing the button of "submit" or cancel it by pressing the button of "cancel".

4.7.2 Back-end application design and implementation (Middle tier)

The function of contextual discussion subsystem is to provide a place where the teacher and the students may discuss about the particular lecture.

The system includes thirteen java classes. Classes of PaperBean, LectureBean, UserBean, ThreadBean and ReplyBean are control classes, which communicate with interface. Classes of PaperData, LectureData, UserData, StudentData, StaffData, ThreadData, ReplyData and DBControl are entity classes, where JDBC is used to communicate with the database. Figure 4-17 is the class diagram for the subsystem which is designed using UML and Rational Rose. The functions of each class are shown in table 4-11 (please refer to table 4-7 & 4-5 for some classes' functions).

4.7.3 Database design and implementation (Third tier)

The database for this subsystem includes three tables: sys_var, lecture and media_setting. For the details of these tables, please see Section 4.3.

4.8 Summary

This chapter has described the system design and implementation. The system includes four subsystems: paper management subsystem, lecture management subsystem, learning subsystem and contextual discussion subsystem. Each subsystem is designed and implemented using three-tier, client-server architecture. All the program classes are organised into different packages according to their functions. The interface package consists of all JSP and HTML files. The business domain package includes the classes for all course materials. The database access package is made up of the classes that facilitate the database operations for the business domain package.

Next chapter will discuss the prototype system based on above discussion.

Table 4-11 Classes and their Functions

Class Name	Class Function
ThreadBean	▪ Contain detailed information on all threads in one lecture (thread topic, thread author, post time, total number of replies and the last reply time) ▪ Load all threads from the database by calling methods of the relevant database access class (ThreadData) ▪ Save a thread back to the database by calling methods of the relevant database access class (ThreadData)
ReplyBean	▪ Contain detailed information on a reply or all replies to a thread including reply author, reply time, to which thread and reply contents) ▪ Load one reply or all replies to a thread from the database by calling methods of the relevant database access class (ReplyData) ▪ Save a reply back to the database by calling methods of the relevant database access class (ReplyData)
ThreadData	▪ This is a database access class ▪ Retrieve the details of a thread or all threads in a lecture from the database ▪ Store or update a thread information in the database
ReplyData	▪ This is a database access class ▪ Retrieve the details of a reply or all replies in a lecture from the database ▪ Store or update a reply information in the database

Chapter 5 Prototype System

5.1 Introduction

This chapter introduces the structure of the prototype web-based learning system developed in this project. At first, the setup procedure is described. Then the functions are described one by one.

5.2 System structure and requirements

5.2.1 System structure

The figure 5-1 shows the hardware nodes structure of the prototype system. In the server side, there are two servers. One is called "learning server", where web server, application server, streaming date server and database server are installed. The other is called "configuration server", which also contains separate web server and application server.

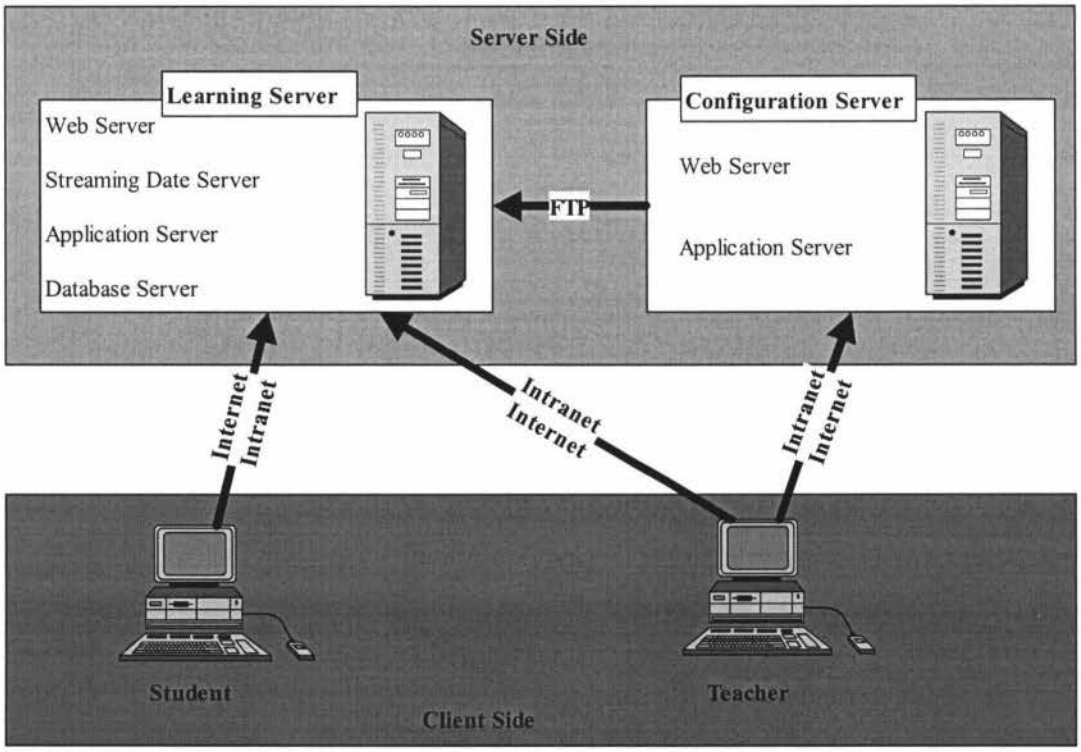


Figure 5-1 Hardware Nodes of the Prototype System

The learning server is used by the students and therefore is accessible from the Internet. The configuration server is used by the instructors. It is better for instructors to use high-speed connection because they need to upload large video file to the server. Therefore configuration server is located within the organisation's intranet. This also provides added security to the configuration files. After configuring the course, the instructor requests the configuration server to send the configured files to the learning server using ftp. The students connect to the learning server using Internet. They cannot connect to the configuration server. The application servers in both learning server and configuration server use the same database server installed in learning server.

In order to use this prototype system, some hardware and software are required. They are described in the next section.

5.2.2 System requirements

The prototype system requires two machines on the server side. Both should be at least Pentium III 500Mhz and 256MB RAM. Following software are also required on the server side:

- Tomcat
- JRE (Java RuningTime Environment) 1.3 or above
- Real Player
- RealSystem Producer
- RealServer
- MySQL Server
- FTP server
- Linux or Windows (Learning Server), depending on the version of RealServer
- Windows NT or Windows 2000 (Configuration Server)
- Microsoft PowerPoint

On the client side Real Player and Internet Explorer should be installed on the machine.

5.2.3 System setup

The prototype system can be set up according to following steps:

Step 1:

- Install Linux (with FTP server and MySQL server) in learning server
- Install windows in configuration server
- Install Tomcat, JRE, RealPlayer, RealSystem Producer in learning server
- Install Microsoft PowerPoint, Tomcat, JRE, Real Player in configuration server
- Create database in MySQL server in learning server

Step 2:

- Create a folder named "wase" under the document root in the web server in both learning server and configuration server
- Configure FTP server in learning server so that configuration server may connect the folder "wase" using ftp
- Copy all JSP files and Class files in the proper folder according to the instruction of Tomcat
- Copy the VB application in the folder "wase" in configuration server, which will convert ppt file to jpg file

Step 3:

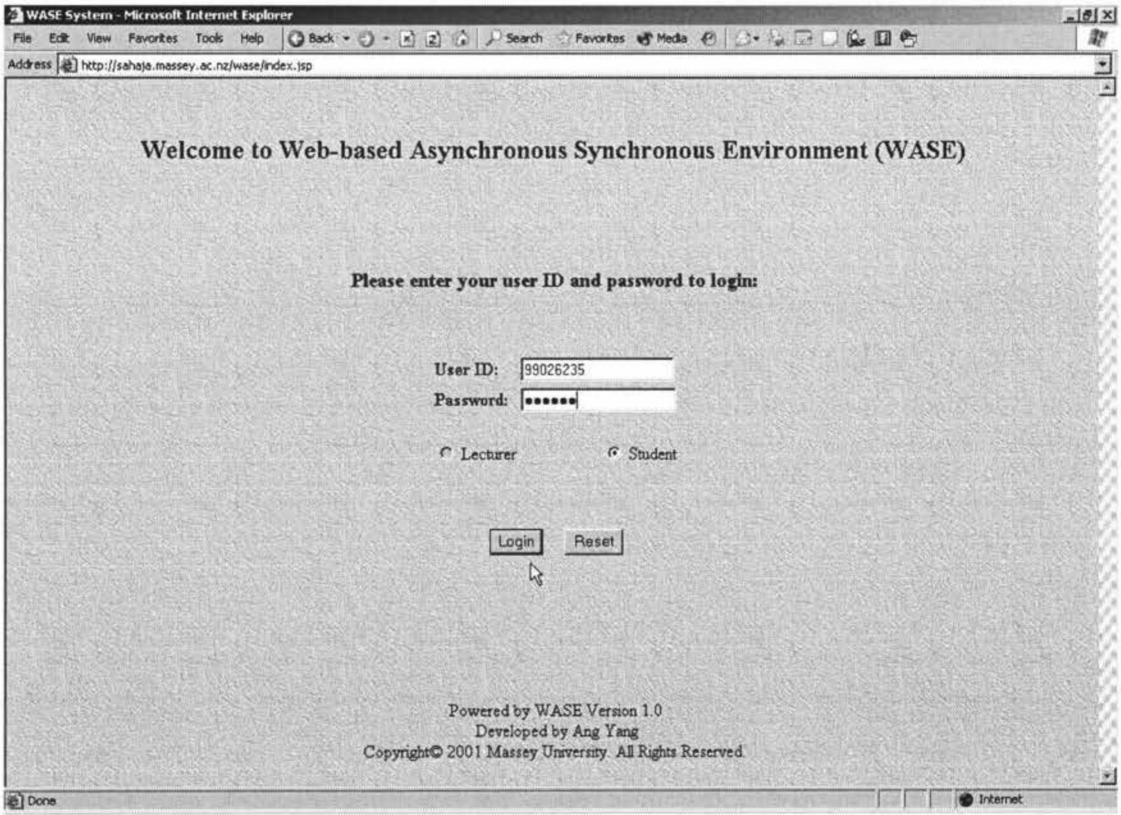
- Set the system environment variables including user name and password of database, host of database, lecture storing path, web server path, streaming server path and etc. in the database
- Store the course options including paper learning mode, paper credit and paper teaching semester in the database

After finishing above steps, the system should be ready to use. In following sections, all the functionality is described that was mentioned in the use cases in chapter 4.

5.3 User Login/Logout

In order to use the system, every user should login first. In the login interface (figure 5-2), the user should enter the user name and password, and select the user type. If login failed, a warning message appears and ask user to try again (figure 5-3). Otherwise, all papers available for that user are listed (figure 5-4, figure 5-5).

There is a "logout" link in all web pages. The user may logout at any time by clicking that link. Then that session will be terminated and the login interface will be displayed.


WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://sahaja.massey.ac.nz/wase/index.jsp
Done
Internet

Welcome to Web-based Asynchronous Synchronous Environment (WASE)

Please enter your user ID and password to login:

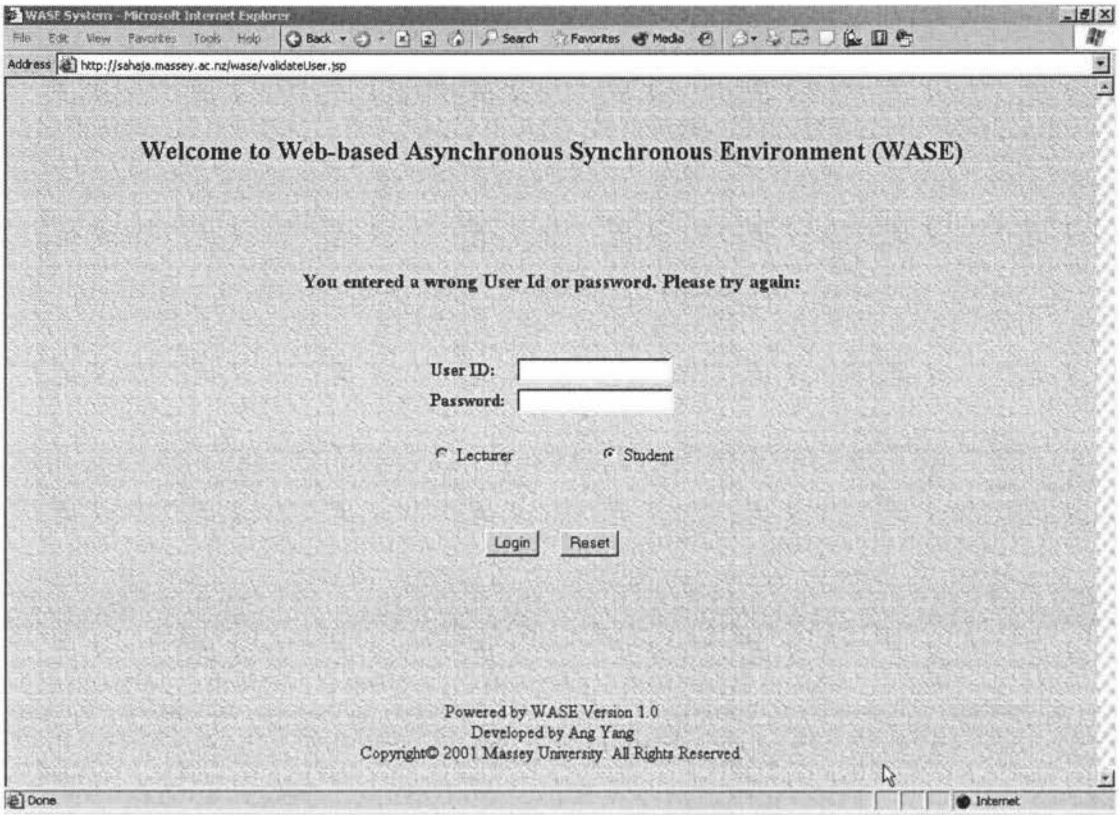
User ID: 99026235

Password: ••••••

○ Lecturer ● Student

Powered by WASE Version 1.0
Developed by Ang Yang
Copyright© 2001 Massey University. All Rights Reserved.

Figure 5-2 Interface for Login



WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://sahaja.massey.ac.nz/wase/validateUser.jsp
Login
Reset
Done
Internet

Welcome to Web-based Asynchronous Synchronous Environment (WASE)

You entered a wrong User Id or password. Please try again:

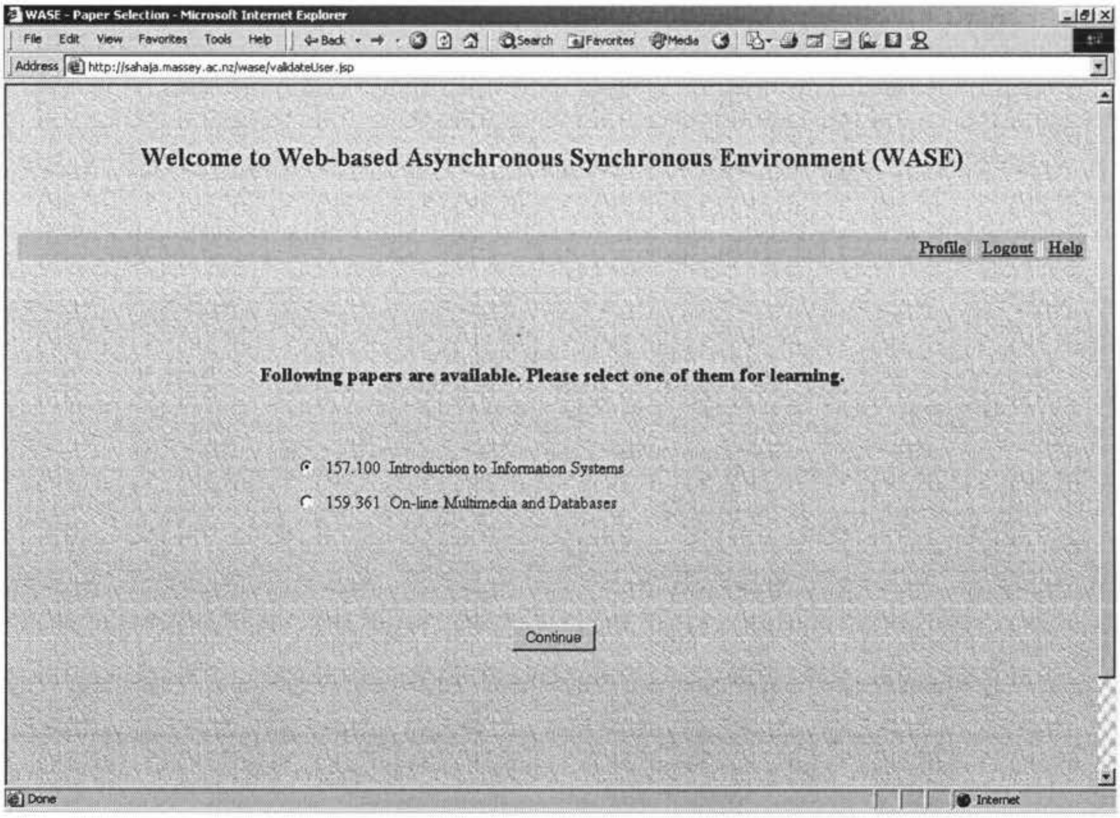
User ID:

Password:

○ Lecturer ● Student

Powered by WASE Version 1.0
Developed by Ang Yang
Copyright© 2001 Massey University. All Rights Reserved.

Figure 5-3 Login Failed



WASE - Paper Selection - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://sahaja.massey.ac.nz/wase/validateUser.jsp
Profile
Logout
Help
Continue
Done
Internet

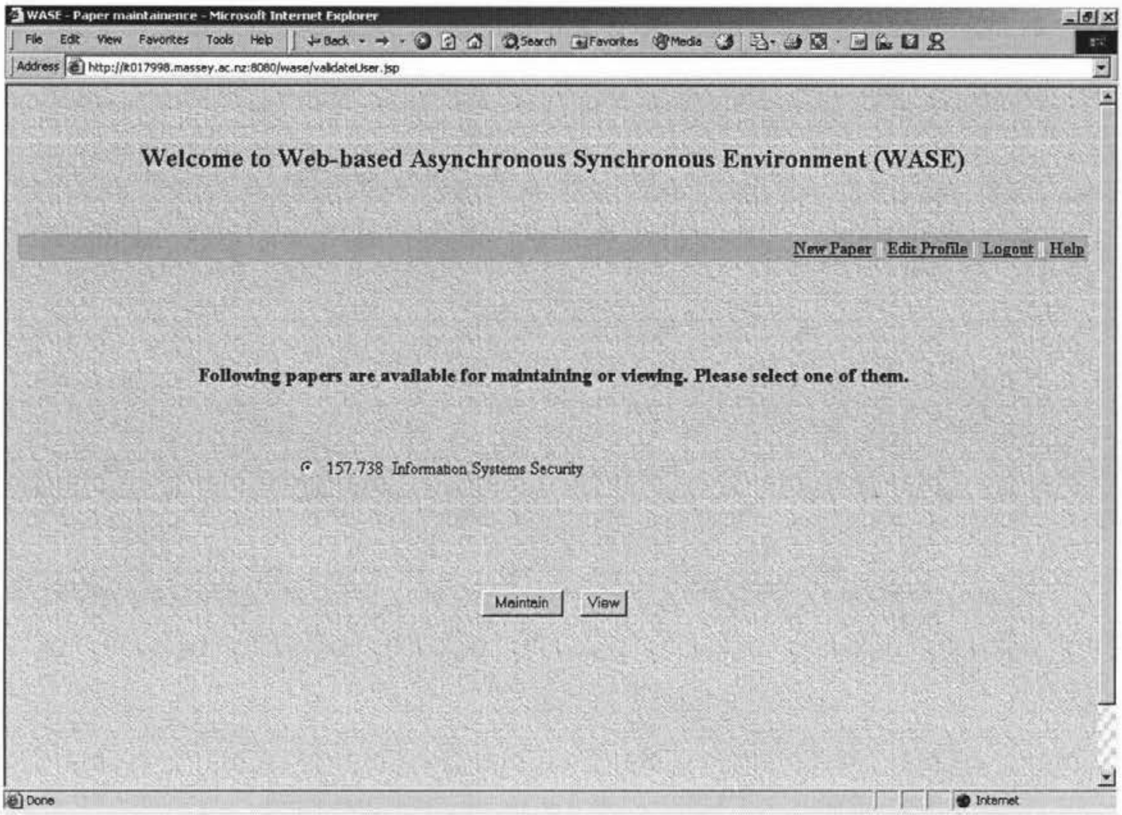
Welcome to Web-based Asynchronous Synchronous Environment (WASE)

Following papers are available. Please select one of them for learning.

● 157.100 Introduction to Information Systems

○ 159.361 On-line Multimedia and Databases

Figure 5-4 Paper List for Student


WASE - Paper maintainence - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://it017998.massey.ac.nz:8080/wase/validateUser.jsp
Done
Internet

Welcome to Web-based Asynchronous Synchronous Environment (WASE)

New Paper Edit Profile Logout Help

Following papers are available for maintaining or viewing. Please select one of them.

● 157.738 Information Systems Security

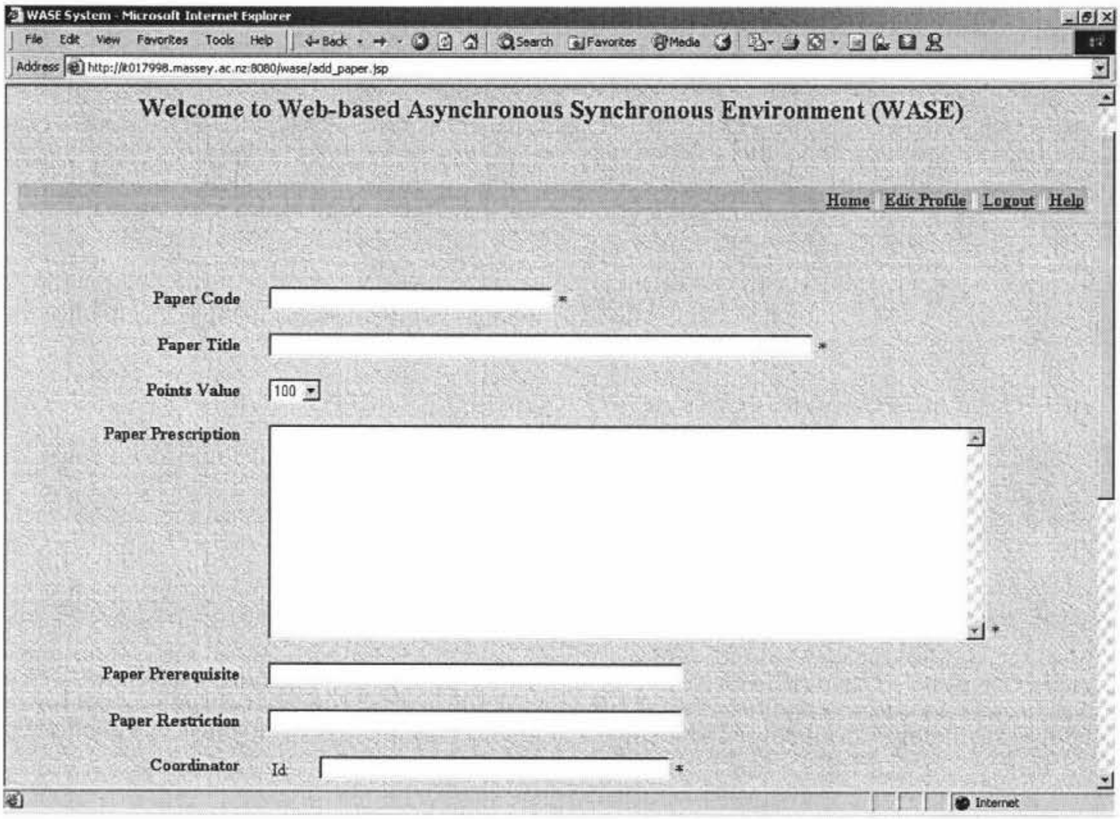
Figure 5-5 Paper List for Teacher

5.4 Course management

After login, the teacher may create a new paper, edit an existing paper, add a lecture to a paper, modify a lecture in a paper and delete lectures in a paper. The teacher may also change his/her person profile, add users to an existing paper and delete users in a paper.

5.4.1 Paper creation and edition

In the paper list interface (figure 5-5), the teacher may click the link of "New Paper" to go to the interface for create a new paper (figure 5-6). After entering the necessary information for a new paper, the teacher may submit the form and then the details of this new paper are displayed (figure 5-7).

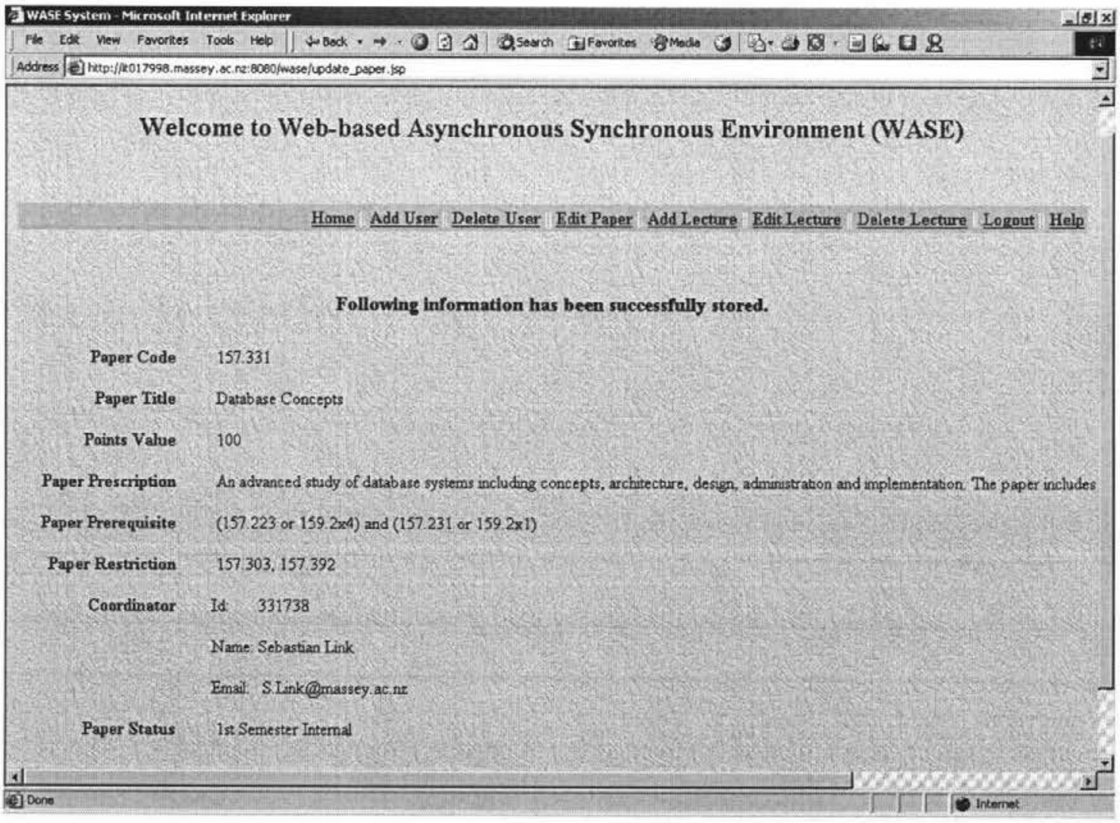

WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://it017998.massey.ac.nz:8080/wase/add_paper.jsp
Internet

Welcome to Web-based Asynchronous Synchronous Environment (WASE)

Home Edit Profile Logout Help

Paper Code	*
Paper Title	*
Points Value	100
Paper Prescription	*
Paper Prerequisite	
Paper Restriction	
Coordinator	Id *

Figure 5-6 New Paper Creation


WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://it017998.massey.ac.nz:8080/wase/update_paper.jsp
Done
Internet

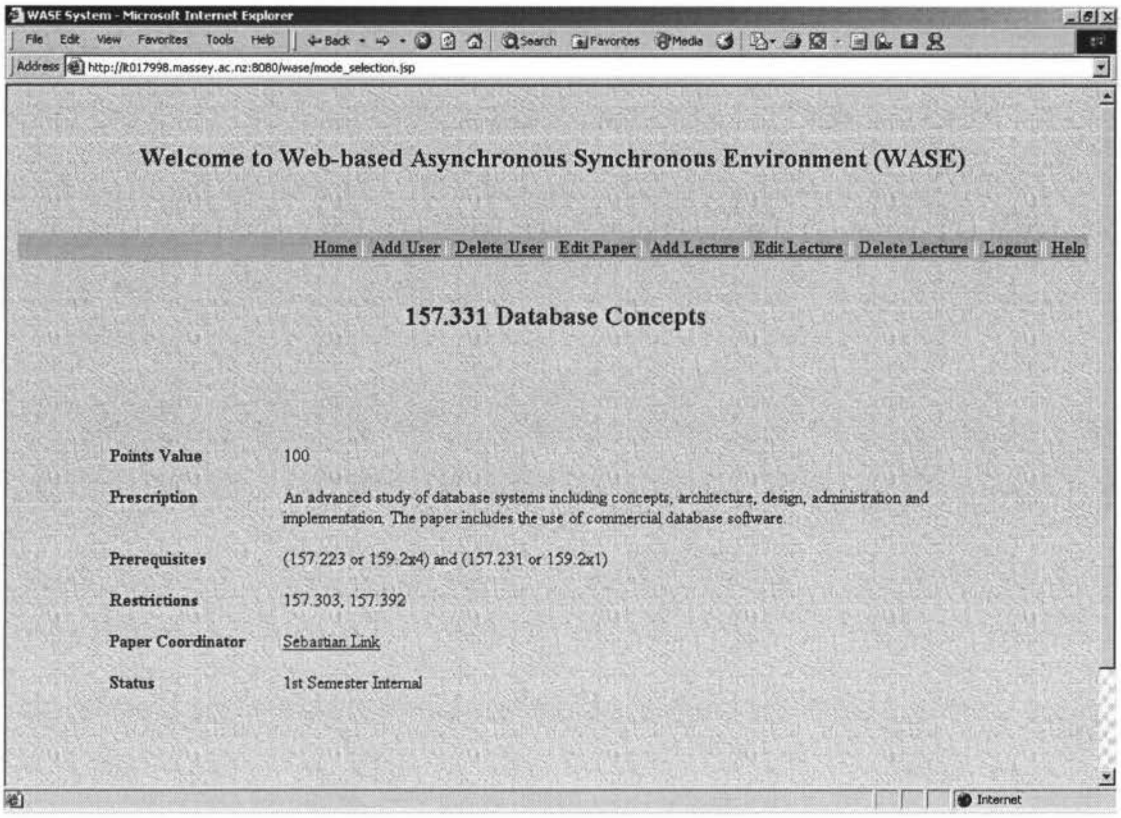
Welcome to Web-based Asynchronous Synchronous Environment (WASE)

Home Add User Delete User Edit Paper Add Lecture Edit Lecture Delete Lecture Logout Help

Following information has been successfully stored.

Paper Code	157.331
Paper Title	Database Concepts
Points Value	100
Paper Prescription	An advanced study of database systems including concepts, architecture, design, administration and implementation. The paper includes
Paper Prerequisite	(157.223 or 159.2x4) and (157.231 or 159.2x1)
Paper Restriction	157.303, 157.392
Coordinator	Id: 331738
	Name: Sebastian Link
	Email: S.Link@massey.ac.nz
Paper Status	1st Semester Internal

Figure 5-7 Details of New Paper


WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://it017998.massey.ac.nz:8080/wase/mode_selection.jsp
Internet

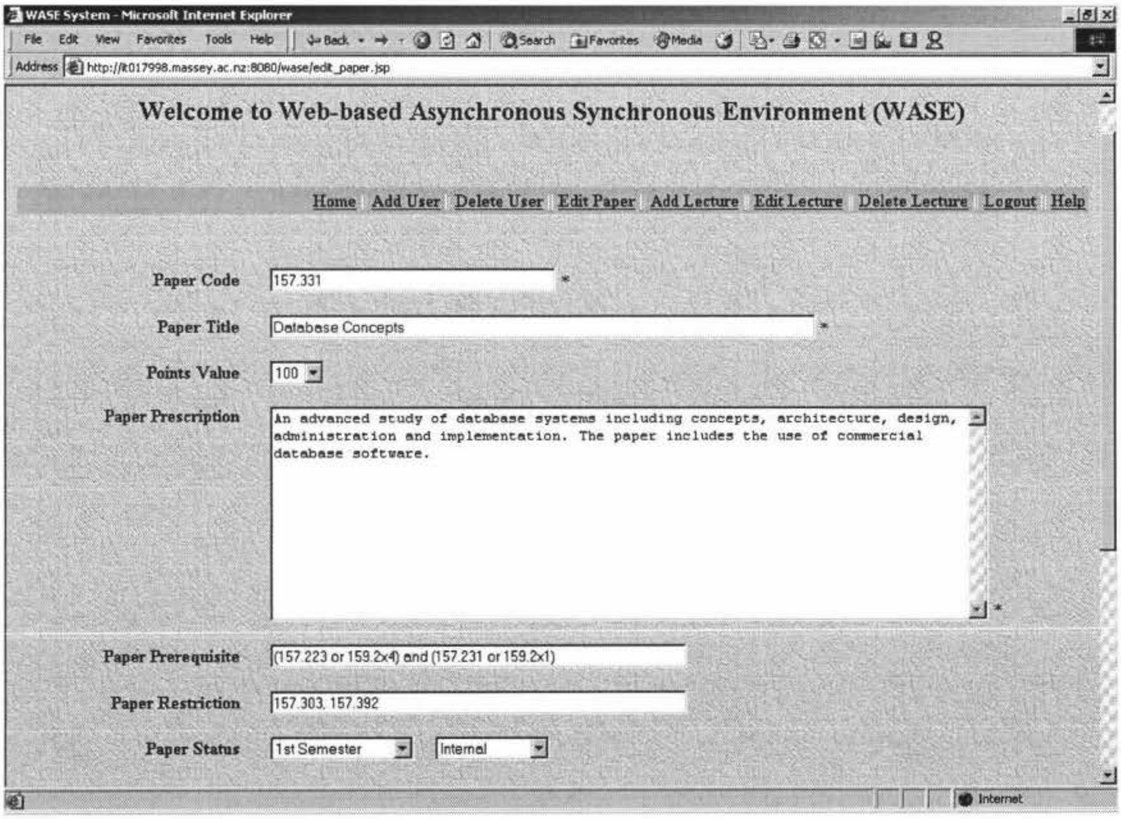
Welcome to Web-based Asynchronous Synchronous Environment (WASE)

Home Add User Delete User Edit Paper Add Lecture Edit Lecture Delete Lecture Logout Help

157.331 Database Concepts

Points Value	100
Prescription	An advanced study of database systems including concepts, architecture, design, administration and implementation. The paper includes the use of commercial database software.
Prerequisites	(157.223 or 159.2x4) and (157.231 or 159.2x1)
Restrictions	157.303, 157.392
Paper Coordinator	Sebastian Link
Status	1st Semester Internal

Figure 5-8 Paper Information


WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://it017998.massey.ac.nz:8080/wase/edit_paper.jsp
Internet

Welcome to Web-based Asynchronous Synchronous Environment (WASE)

Home Add User Delete User Edit Paper Add Lecture Edit Lecture Delete Lecture Logout Help

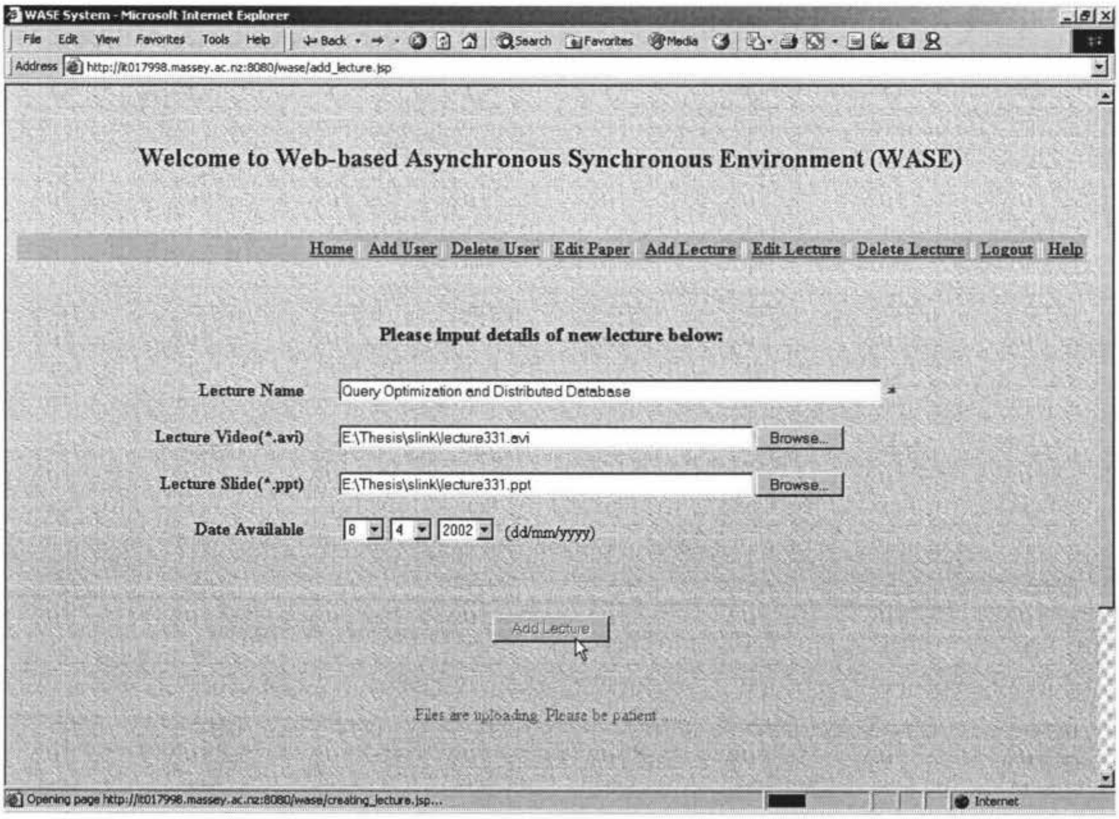
Paper Code	157.331 *
Paper Title	Database Concepts *
Points Value	100
Paper Prescription	An advanced study of database systems including concepts, architecture, design, administration and implementation. The paper includes the use of commercial database software. *
Paper Prerequisite	(157.223 or 159.2x4) and (157.231 or 159.2x1)
Paper Restriction	157.303, 157.392
Paper Status	1st Semester Internal

Figure 5-9 Editing Page

After selecting a paper and clicking the button of "Maintain" (figure 5-5), the information about this selected paper is shown in figure 5-8. Then the teacher may edit this paper using the link of "Edit Paper" in that page. After modifying the information of the paper in the form in figure 5-9, the teacher may submit the form to update the paper. So updated paper information is displayed.

5.4.2 Lecture creation, edition and deletion

After creating the new paper, the teacher should add lecture to this new paper. The teacher may click the link of "Add Lecture" in the control bar in each web page. The teacher should input the lecture name and date available, and may upload lecture slide file and video file (figure 5-10). Then the lecture information is displayed in figure 5-11. From this page the teacher may convert ppt file to jpg file by clicking the button of "Process Slide File" and convert avi file to rm file by clicking the button of "Process Video File". Unless the video and slide file are converted to ppt format and rm format, the button "Configure Lecture" is not enabled.



http://lt017998.massey.ac.nz:8080/wase/add_lecture.jsp

Welcome to Web-based Asynchronous Synchronous Environment (WASE)

Home | Add User | Delete User | Edit Paper | Add Lecture | Edit Lecture | Delete Lecture | Logout | Help

Please input details of new lecture below:

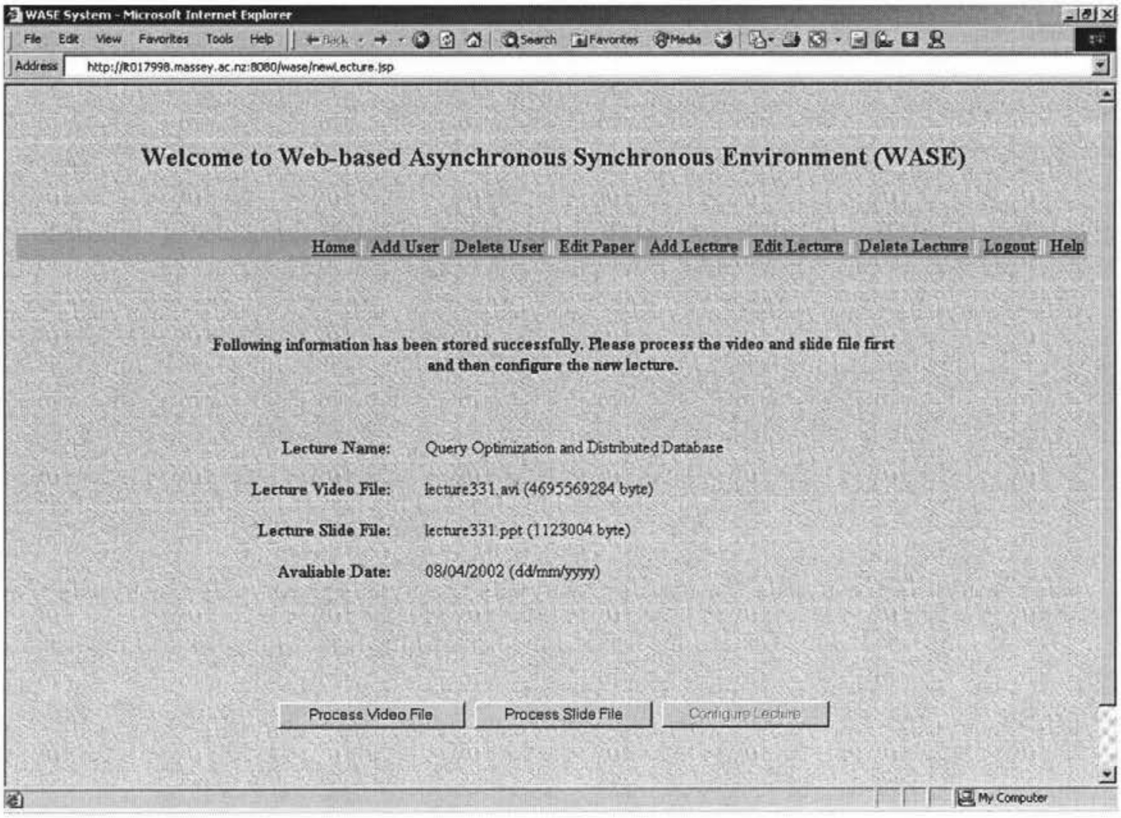
Lecture Name	Query Optimization and Distributed Database *
Lecture Video(*.avi)	E:\Thesis\slink\lecture331.avi Browse...
Lecture Slide(*.ppt)	E:\Thesis\slink\lecture331.ppt Browse...
Date Available	8 4 2002 (dd/mm/yyyy)

Add Lecture

Files are uploading. Please be patient ......

Opening page http://lt017998.massey.ac.nz:8080/wase/creating_lecture.jsp...

Figure 5-10 Add New Lecture



WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address http://it017998.massey.ac.nz:8080/wase/newLecture.jsp

Welcome to Web-based Asynchronous Synchronous Environment (WASE)

Home | Add User | Delete User | Edit Paper | Add Lecture | Edit Lecture | Delete Lecture | Logout | Help

Following information has been stored successfully. Please process the video and slide file first and then configure the new lecture.

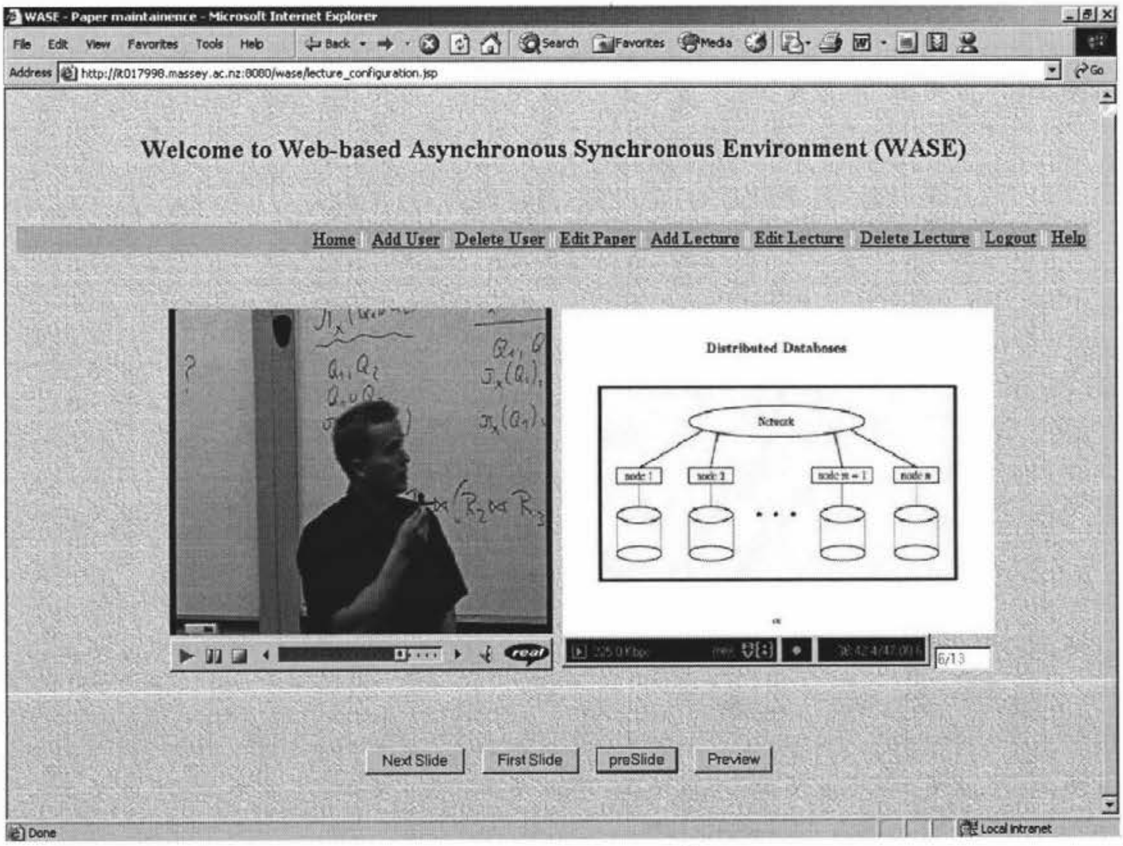
Lecture Name: Query Optimization and Distributed Database

Lecture Video File: lecture331.avi (4695569284 byte)

Lecture Slide File: lecture331.ppt (1123004 byte)

Avaliable Date: 08/04/2002 (dd/mm/yyyy)

Figure 5-11 Converting Video and Slide File



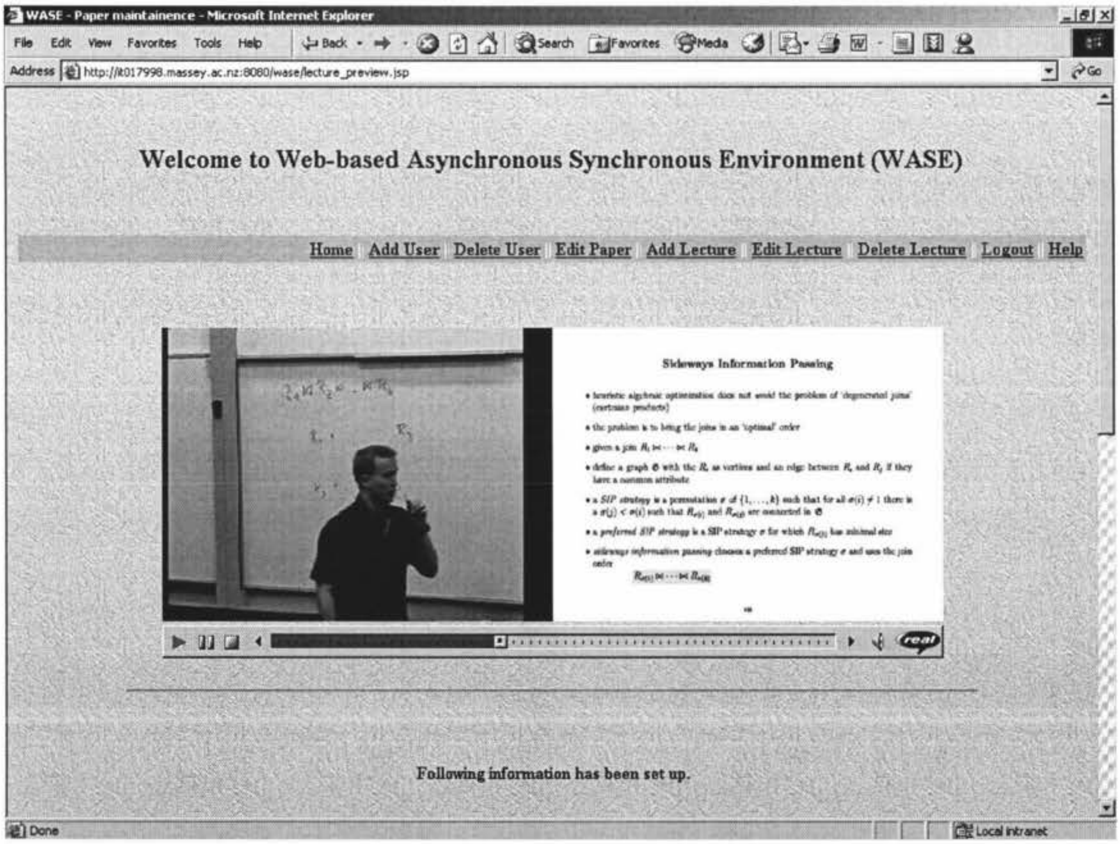
WASE - Paper maintainence - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address http://it017998.massey.ac.nz:8080/wase/lecture_configuration.jsp

Welcome to Web-based Asynchronous Synchronous Environment (WASE)

Home | Add User | Delete User | Edit Paper | Add Lecture | Edit Lecture | Delete Lecture | Logout | Help
Distributed Databases
Network
node 1
node 2
node n-1
node n
6/13
Next Slide
First Slide
preSlide
Preview
Done
Local intranet

Figure 5-12 Synchronize Video and Slide

After the button "Configure Lecture" is enabled, the teacher may click that button to go to figure 5-12 to configure this lecture. In this page, the teacher may set the lasting time for each slide using the buttons of "New Slide", "First Slide" and "preSlide". The teacher may also forward quickly, pause and stop the video using the left side control panel. The right side panel shows the lasting time, total video time, the streaming speed, current slide number and total number of slides. After finishing synchronizing the video and slides, the teacher may click the button of "preview" to view the synchronized lecture. The upper part of the page (figure 5-13) is an embedded Real Player to play the synchronized lecture. It is same as normal Real Player. The down part of the page (figure 5-14) shows the synchronizing setting of the video and slide. After viewing the synchronized lecture, the teacher may go back to figure 5-12 to re-configure the lecture if it is not correct. Otherwise the teacher may click the "submit" button to finish configuration.


WASE - Paper maintainence - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://it017998.massey.ac.nz:8080/wase/lecture_preview.jsp
Go
real
Done
Local intranet

Welcome to Web-based Asynchronous Synchronous Environment (WASE)

Home | Add User | Delete User | Edit Paper | Add Lecture | Edit Lecture | Delete Lecture | Logout | Help

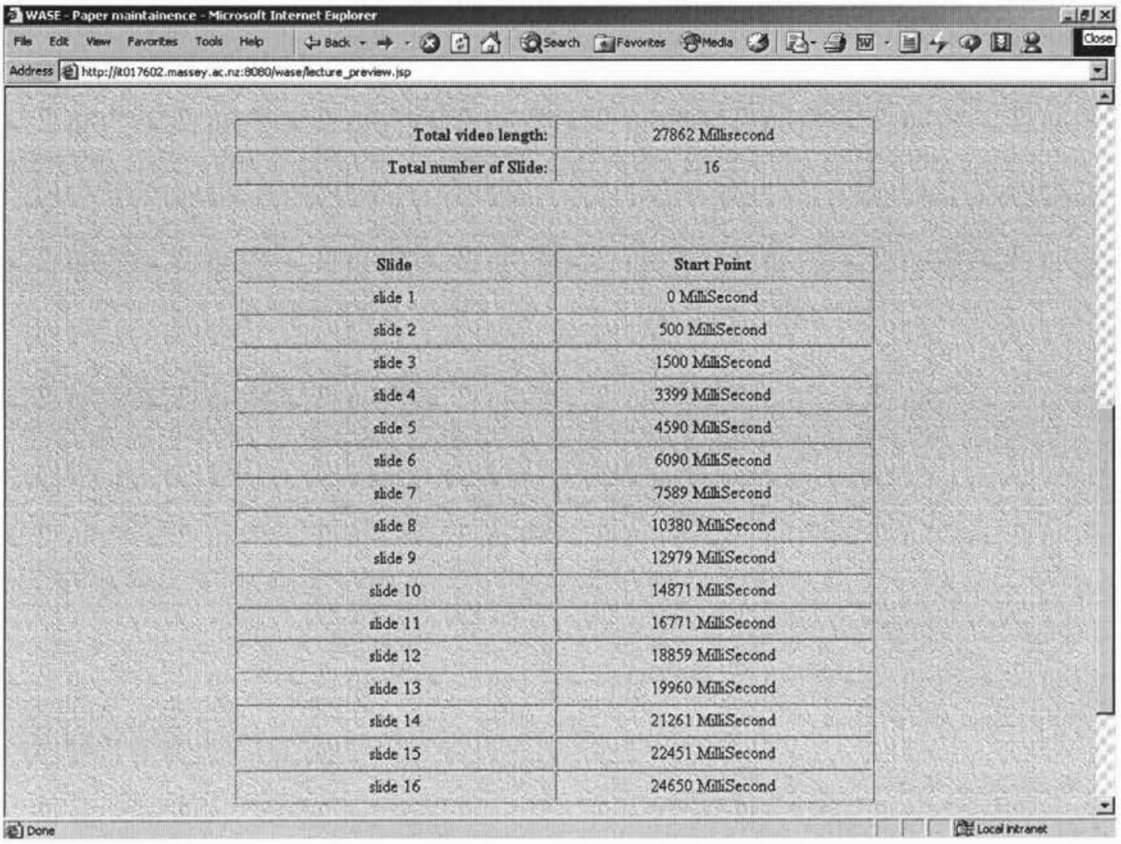
Sideways Information Passing

- heuristic algebraic optimisation does not avoid the problem of 'degenerated joins' (cartesian products)
- the problem is to bring the joins in an 'optimal' order
- given a join $R_1 \bowtie \cdots \bowtie R_k$
- define a graph G with the R_i as vertices and an edge between R_i and R_j if they have a common attribute
- a *SIP strategy* is a permutation σ of $\{1, \dots, k\}$ such that for all $\sigma(i) \neq 1$ there is a $\sigma(j) < \sigma(i)$ such that $R_{\sigma(i)}$ and $R_{\sigma(j)}$ are connected in G
- a *preferred SIP strategy* is a SIP strategy σ for which $R_{\sigma(1)}$ has minimal size
- sideways information passing chooses a preferred SIP strategy σ and uses the join order

$$R_{\sigma(1)} \bowtie \cdots \bowtie R_{\sigma(k)}$$

Following information has been set up.

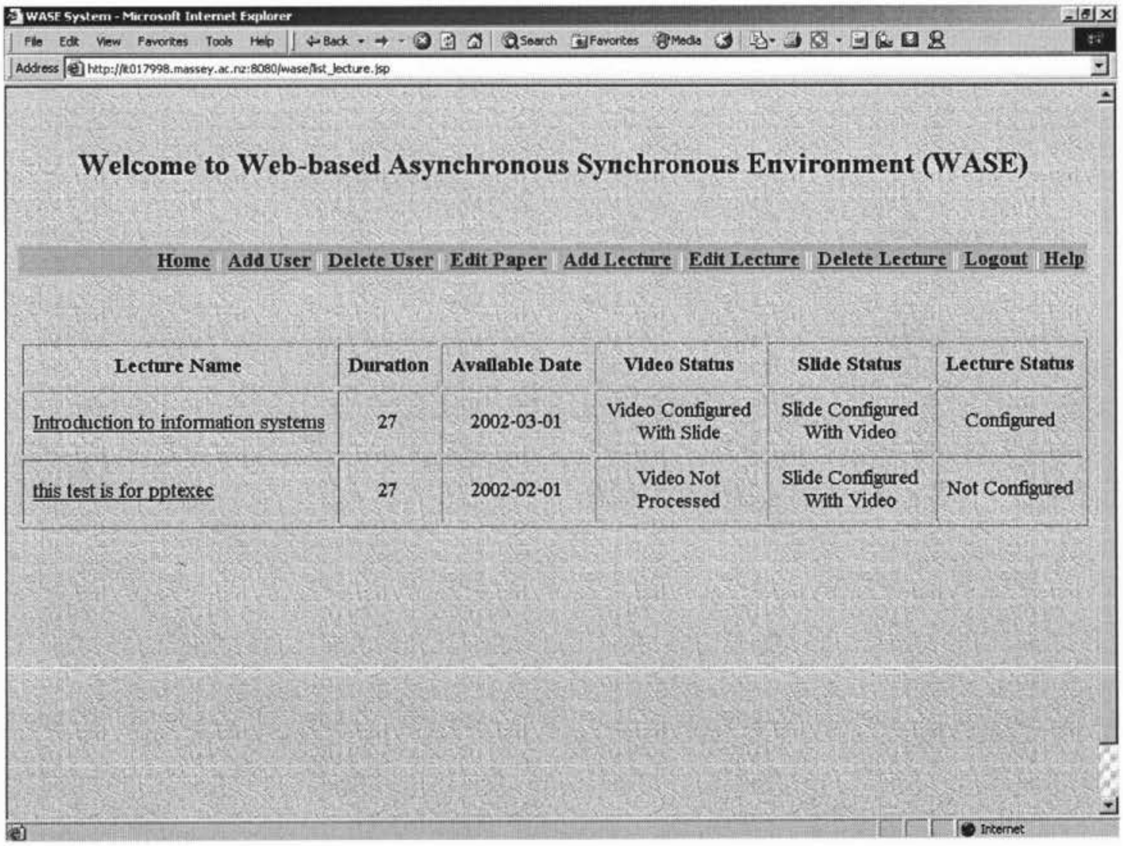
Figure 5-13 Preview the Lecture


WASE - Paper maintainence - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Close
Address http://it017602.massey.ac.nz:8080/wase/lecture_preview.jsp
Done
Local intranet

Total video length:	27862 Millisecond
Total number of Slide:	16

Slide	Start Point
slide 1	0 MilliSecond
slide 2	500 MilliSecond
slide 3	1500 MilliSecond
slide 4	3399 MilliSecond
slide 5	4590 MilliSecond
slide 6	6090 MilliSecond
slide 7	7589 MilliSecond
slide 8	10380 MilliSecond
slide 9	12979 MilliSecond
slide 10	14871 MilliSecond
slide 11	16771 MilliSecond
slide 12	18859 MilliSecond
slide 13	19960 MilliSecond
slide 14	21261 MilliSecond
slide 15	22451 MilliSecond
slide 16	24650 MilliSecond

Figure 5-14 Synchronization Setting


WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://it017998.massey.ac.nz:8080/wase/list_lecture.jsp
Internet

Welcome to Web-based Asynchronous Synchronous Environment (WASE)

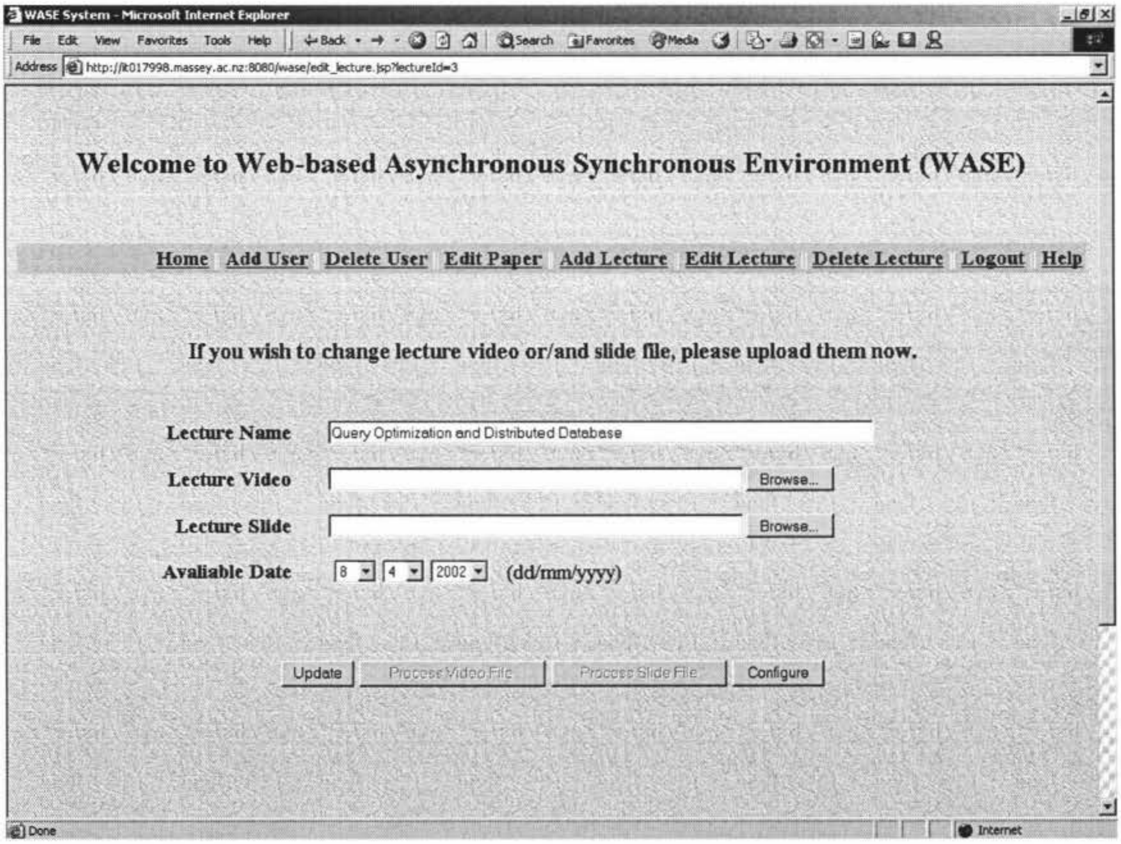
Home Add User Delete User Edit Paper Add Lecture Edit Lecture Delete Lecture Logout Help

Lecture Name	Duration	Available Date	Video Status	Slide Status	Lecture Status
Introduction to information systems	27	2002-03-01	Video Configured With Slide	Slide Configured With Video	Configured
this test is for pptexec	27	2002-02-01	Video Not Processed	Slide Configured With Video	Not Configured

Figure 5-15 Lecture List

To edit an existing lecture, the teacher should select a lecture from the lecture list (figure 5-15). If the lecture is not configured, the teacher may change its name, the date available, and re-upload the slide file and video file (figure 5-16). If the lecture is already configured, the teacher may only change its name and the date available (figure 5-17).

To delete lectures, the teacher may select the lectures which he/she would like to delete from the lecture list (figure 5-18) and then submit the form. After that, an updated lecture list is displayed. The teacher may delete lectures again or do other jobs.


WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://it017998.massey.ac.nz:8080/wase/edit_lecture.jsp?lectureId=3
Home Add User Delete User Edit Paper Add Lecture Edit Lecture Delete Lecture Logout Help
Browse...
Browse...
Update
Process Video File
Process Slide File
Configure
Done
Internet

Welcome to Web-based Asynchronous Synchronous Environment (WASE)

If you wish to change lecture video or/and slide file, please upload them now.

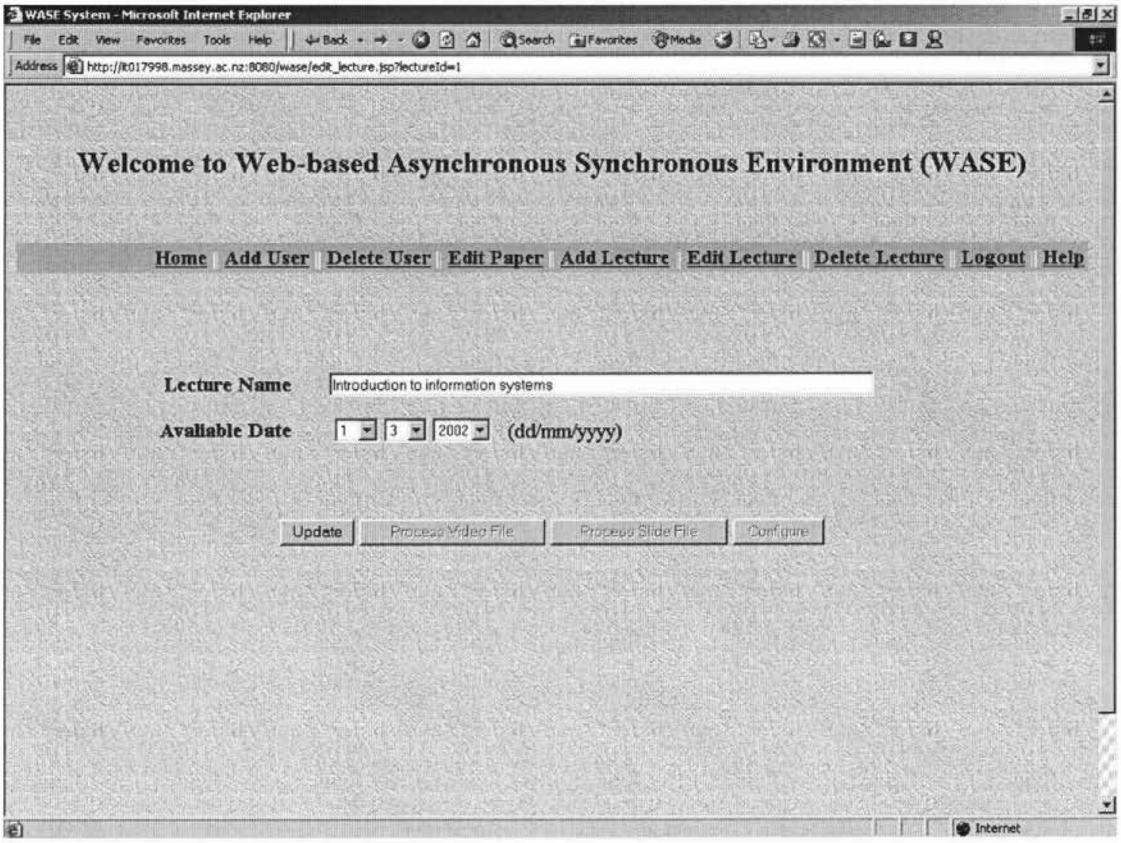
Lecture Name: Query Optimization and Distributed Database

Lecture Video:

Lecture Slide:

Avaliable Date: 8 / 4 / 2002 (dd/mm/yyyy)

Figure 5-16 Lecture Editing (1)


WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://it017998.massey.ac.nz:8080/wase/edit_lecture.jsp?lectureId=1
Internet

Welcome to Web-based Asynchronous Synchronous Environment (WASE)

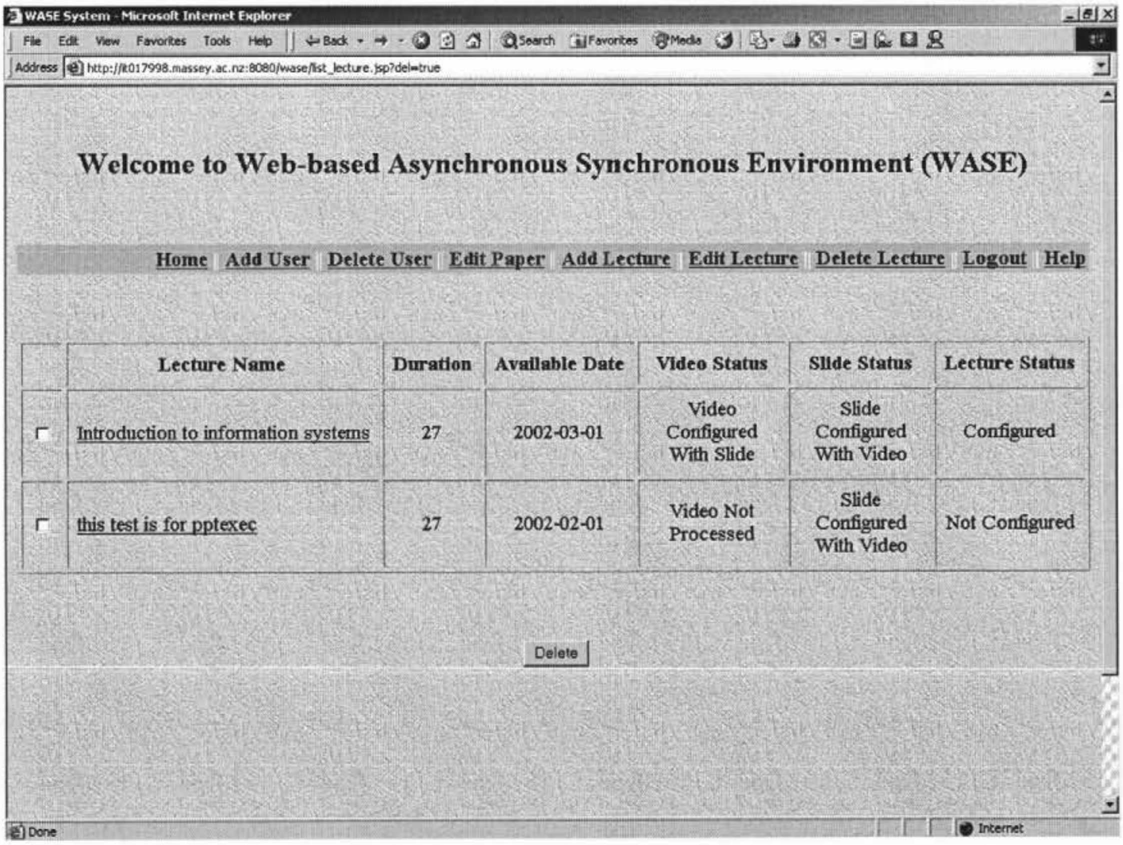
Home | Add User | Delete User | Edit Paper | Add Lecture | Edit Lecture | Delete Lecture | Logout | Help

Lecture Name: Introduction to information systems

Avaliable Date: 1 / 3 / 2002 (dd/mm/yyyy)

Update | Process Video File | Process Slide File | Configure

Figure 5-17 Lecture Editing (2)


WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://it017998.massey.ac.nz:8080/wase/list_lecture.jsp?del=true
Done
Internet

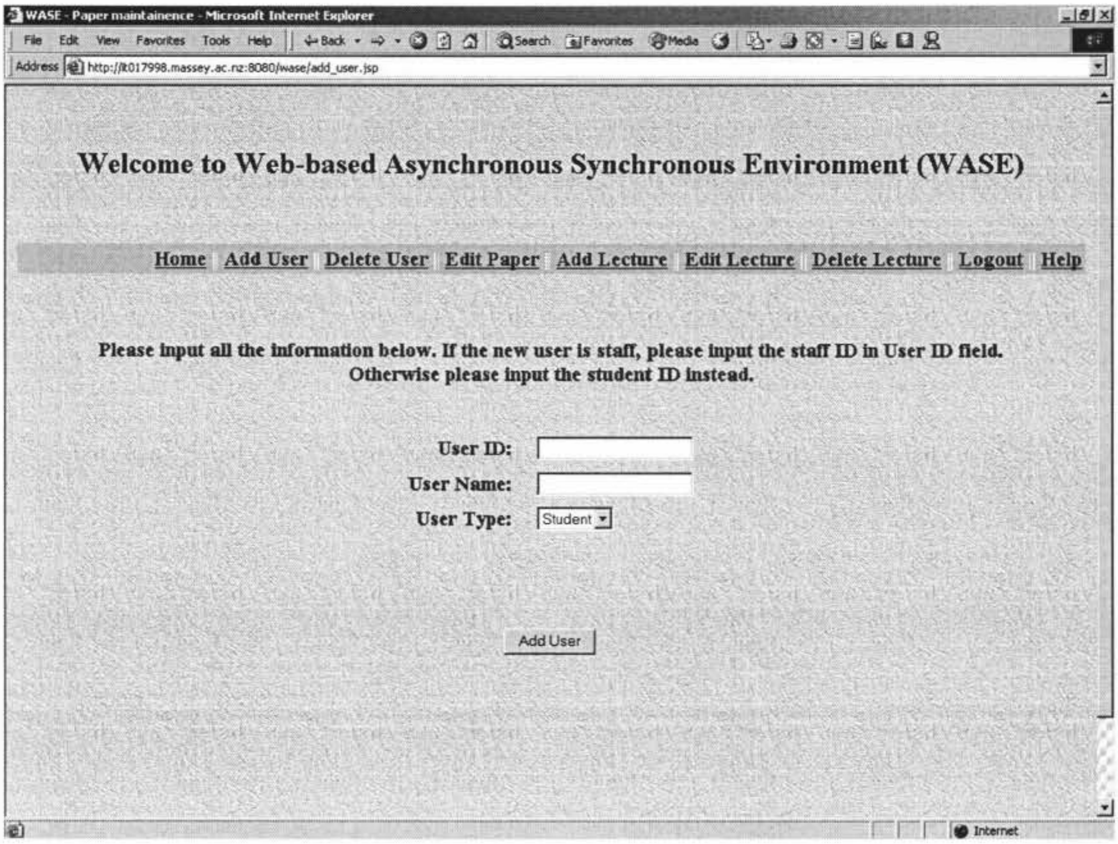
Welcome to Web-based Asynchronous Synchronous Environment (WASE)

Home | Add User | Delete User | Edit Paper | Add Lecture | Edit Lecture | Delete Lecture | Logout | Help

	Lecture Name	Duration	Available Date	Video Status	Slide Status	Lecture Status
□	Introduction to information systems	27	2002-03-01	Video Configured With Slide	Slide Configured With Video	Configured
□	this test is for pptexec	27	2002-02-01	Video Not Processed	Slide Configured With Video	Not Configured

Delete

Figure 5-18 Lecture Deletion

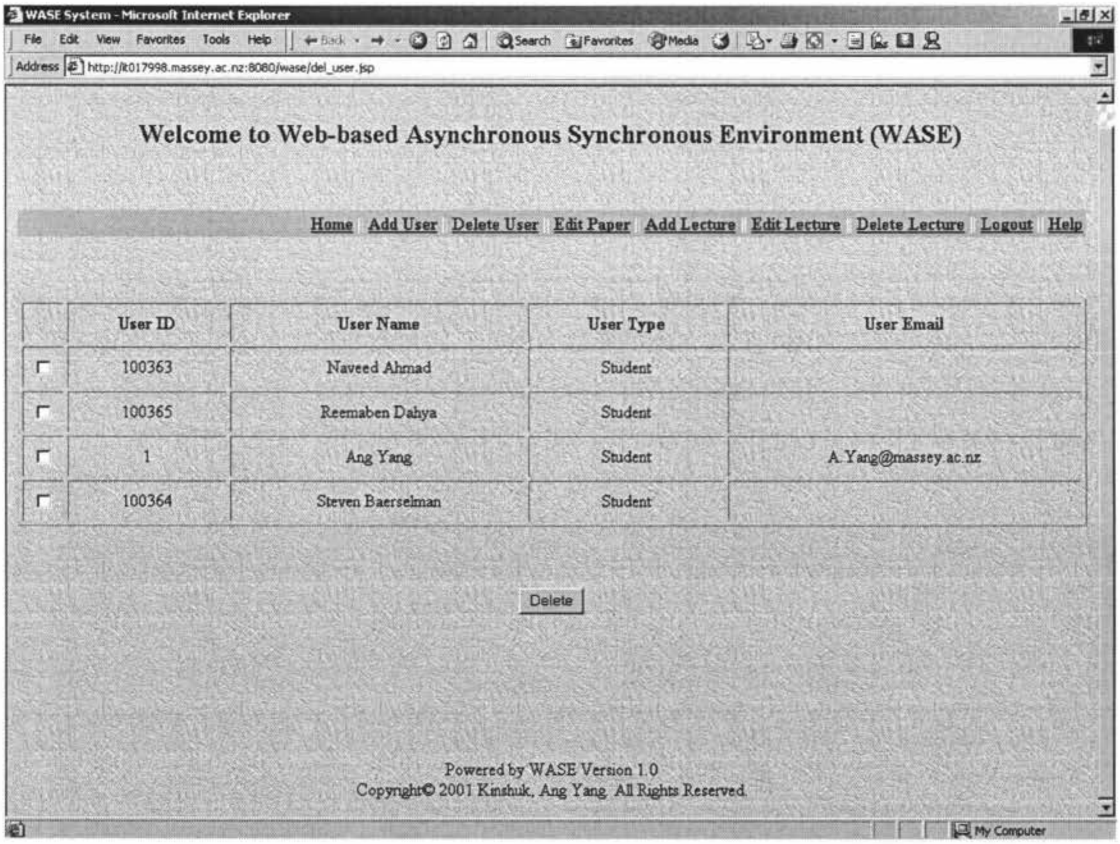

WASE - Paper maintainence - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://it017998.massey.ac.nz:8080/wase/add_user.jsp
Home Add User Delete User Edit Paper Add Lecture Edit Lecture Delete Lecture Logout Help
Add User
Internet

Welcome to Web-based Asynchronous Synchronous Environment (WASE)

Please input all the information below. If the new user is staff, please input the staff ID in User ID field. Otherwise please input the student ID instead.

User ID:	
User Name:	
User Type:	Student

Figure 5-19 Add New User


WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://it017998.massey.ac.nz:8080/wase/del_user.jsp
Home Add User Delete User Edit Paper Add Lecture Edit Lecture Delete Lecture Logout Help
Delete
My Computer

Welcome to Web-based Asynchronous Synchronous Environment (WASE)

	User ID	User Name	User Type	User Email
□	100363	Naveed Ahmad	Student	
□	100365	Reemaben Dahya	Student	
□	1	Ang Yang	Student	A.Yang@massey.ac.nz
□	100364	Steven Baerselman	Student	

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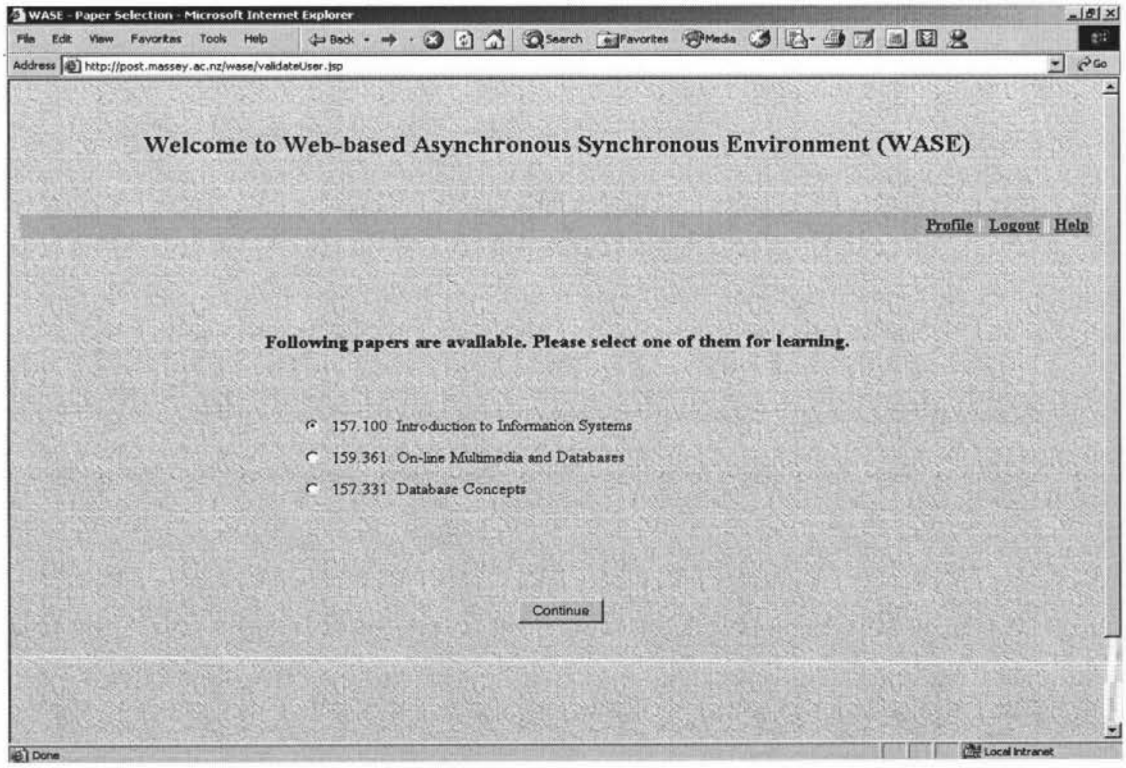
Figure 5-20 User Deletion in a Paper

5.5 Student learning mode

Now we examine the functionalities for the students. The key role of the students is learning. Dependent on students' needs in certain time, the system provides three learning modes for students.

- Contextual Discussion – There is a discussion forum for each lecture. The students may discuss with their classmates or teacher about this particular lecture in this forum.
- Lecture & E-Note – The students may take electronic note for the lecture while viewing the lecture.
- Lecture, E-Note and Discussion – mix contextual discussion and lecture & e-note

After login, the students should select the paper they would like to learn (figure 5-21). Then they should select the lecture and learning mode (figure 5-22).


WASE - Paper Selection - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back
Search
Favorites
Media
Address
Go
Profile
Logout
Help
Continue
Done
Local intranet

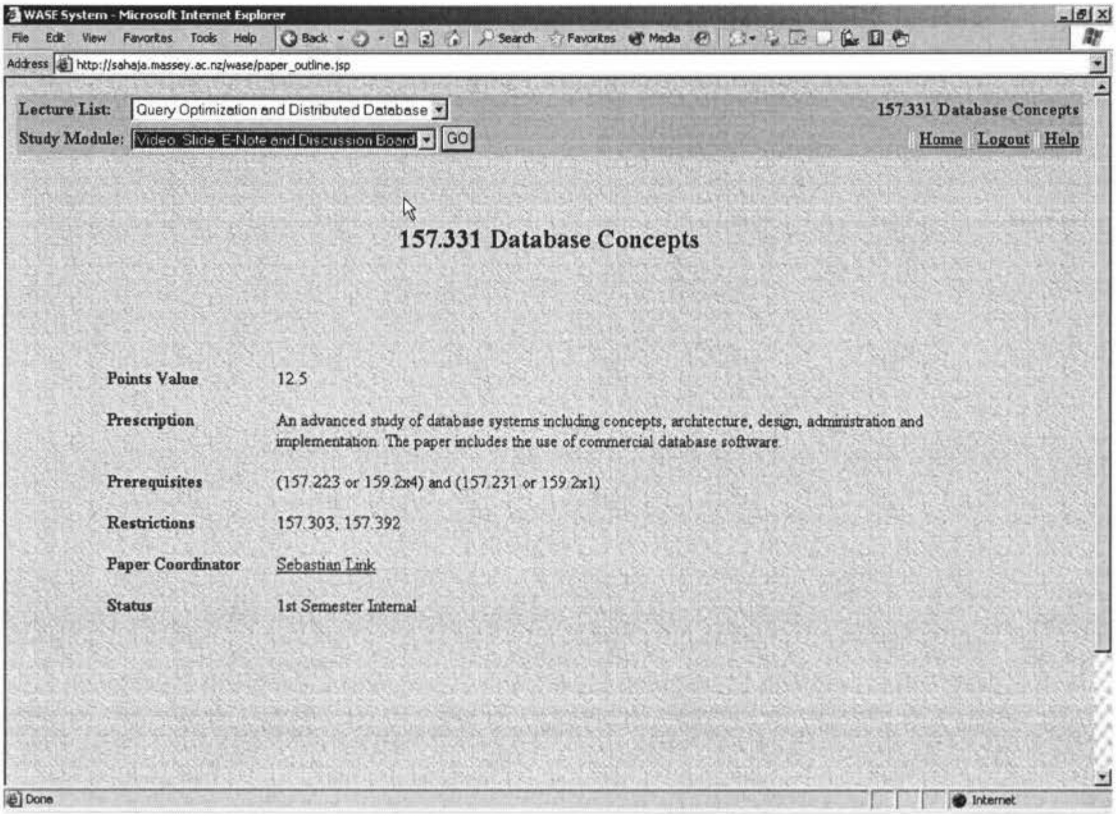
Address: http://post.massey.ac.nz/wase/validateUser.jsp

Welcome to Web-based Asynchronous Synchronous Environment (WASE)

Following papers are available. Please select one of them for learning.

● 157.100 Introduction to Information Systems
○ 159.361 On-line Multimedia and Databases
○ 157.331 Database Concepts

Figure 5-21 Available Paper List for Students



WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://sahaja.massey.ac.nz/wase/paper_outline.jsp
Home Logout Help
GO
Done
Internet

Lecture List: Query Optimization and Distributed Database

Study Module: Video Slide E-Note and Discussion Board

157.331 Database Concepts

157.331 Database Concepts

Points Value	12.5
Prescription	An advanced study of database systems including concepts, architecture, design, administration and implementation. The paper includes the use of commercial database software.
Prerequisites	(157.223 or 159.2x4) and (157.231 or 159.2x1)
Restrictions	157.303, 157.392
Paper Coordinator	Sebastian Link
Status	1st Semester Internal

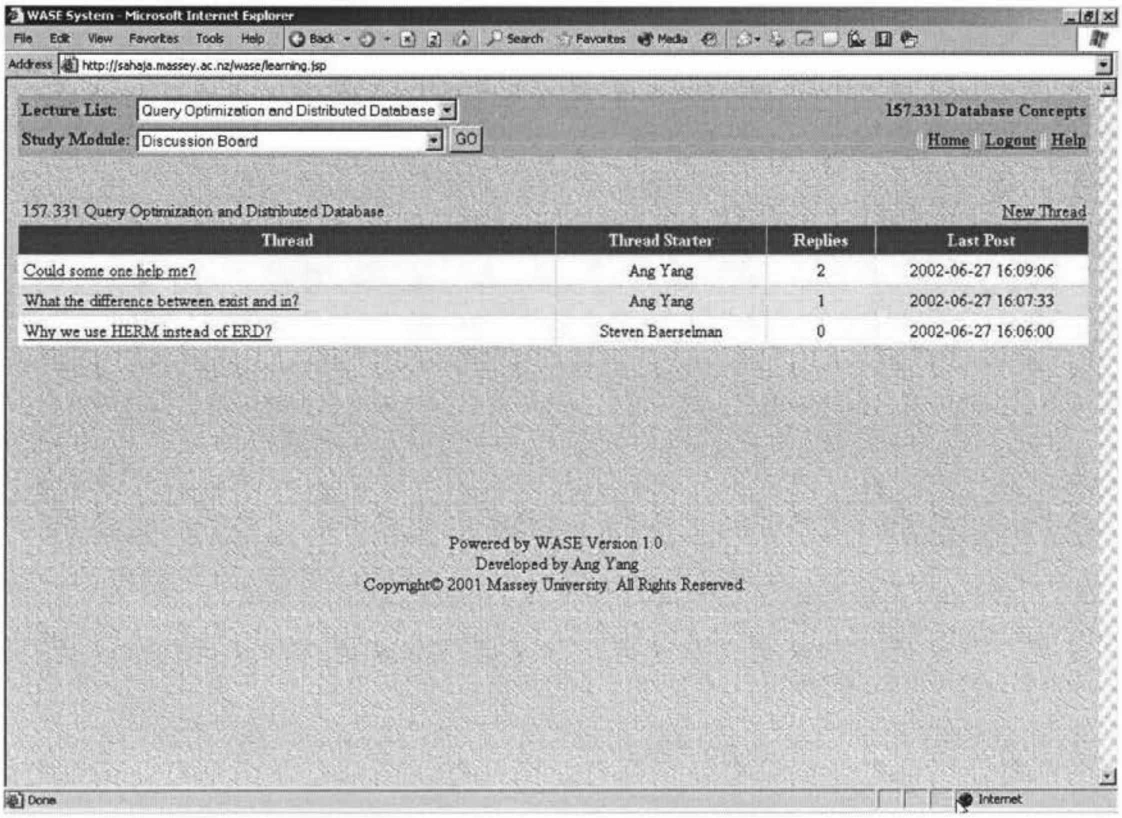
Figure 5-22 Lecture and Learning Mode Selection

5.5.1 Mode 1 – contextual discussion

In this learning mode, the students can only discussion the selected lecture with their classmates and teacher. The main page is shown in figure 5-23. They may post a new thread (figure 5-24), reply a thread (figure 5-25) and quote a post (figure 5-26). The detail of one thread is shown in figure 5-27. Each post should include the author, post time, message and email address of the author.

5.5.2 Mode 2 – lecture and E-note

In this mode (figure 5-28), the student may view the lecture including video and slides and take notes at same time. The system stores these note. Next time the students may view these notes and also modify them.


WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://sahaja.massey.ac.nz/wase/learning.jsp
GO
Home Logout Help
New Thread
Done
Internet

Lecture List: Query Optimization and Distributed Database

Study Module: Discussion Board

157.331 Database Concepts

157.331 Query Optimization and Distributed Database

Thread	Thread Starter	Replies	Last Post
Could some one help me?	Ang Yang	2	2002-06-27 16:09:06
What the difference between exist and in?	Ang Yang	1	2002-06-27 16:07:33
Why we use HERM instead of ERD?	Steven Baerselman	0	2002-06-27 16:06:00

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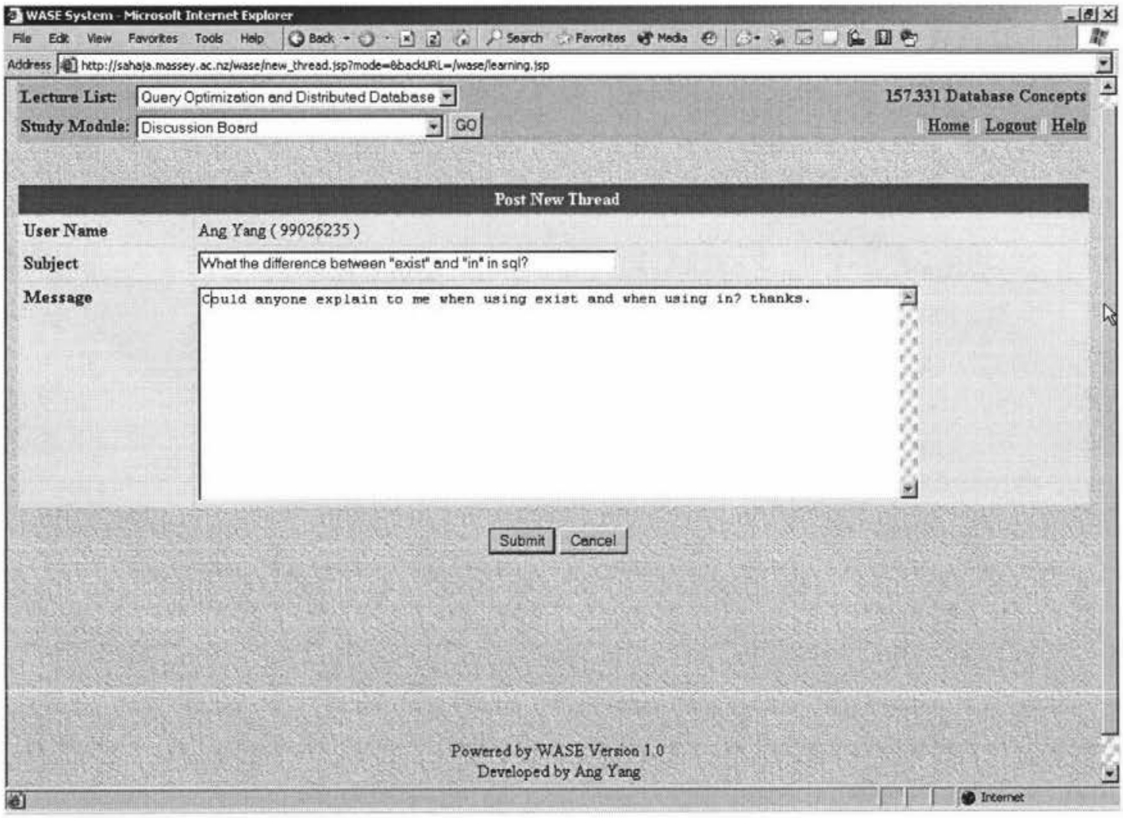
Figure 5-23 Main Page of Discussion Forum


WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://sahaja.massey.ac.nz/wase/new_thread.jsp?mode=8backURL=/wase/learning.jsp
GO
Home Logout Help
Submit
Cancel
Internet

Lecture List: Query Optimization and Distributed Database

Study Module: Discussion Board

157.331 Database Concepts

Post New Thread

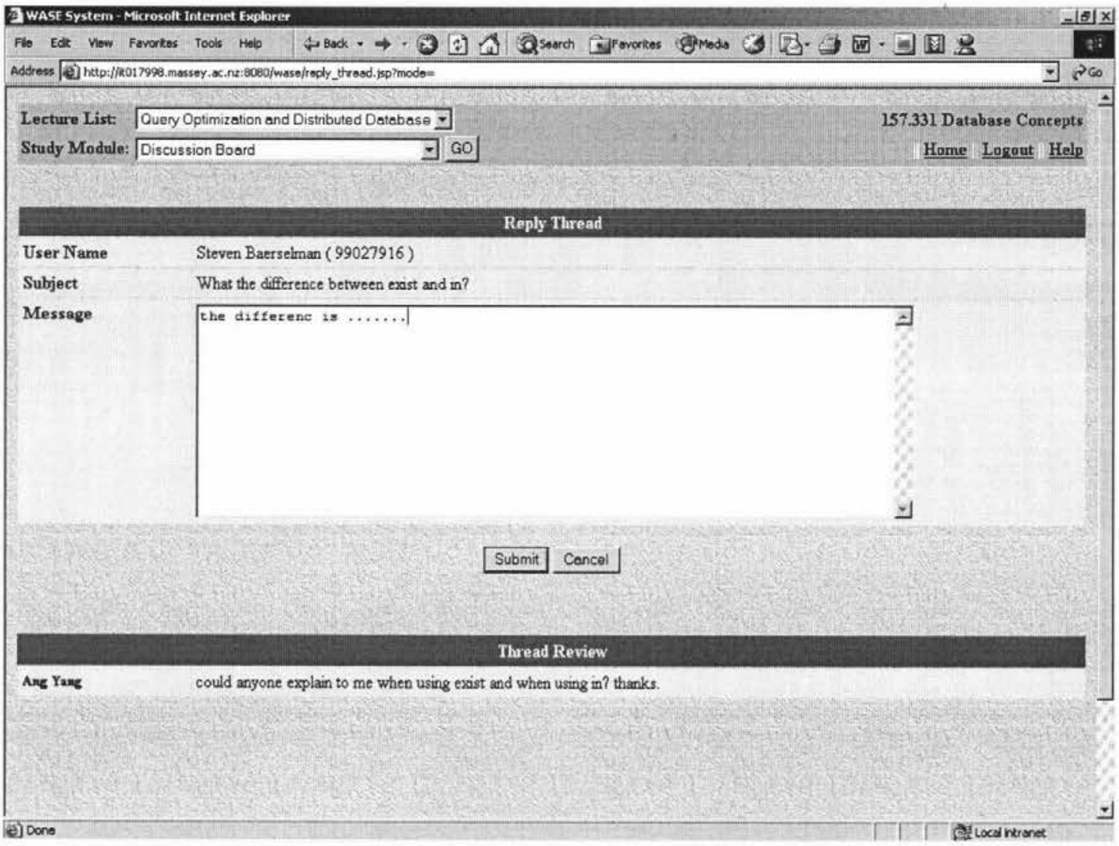
User Name: Ang Yang (99026235)

Subject: What the difference between "exist" and "in" in sql?

Message: Could anyone explain to me when using exist and when using in? thanks.

Powered by WASE Version 1.0
Developed by Ang Yang

Figure 5-24 Post New Thread


WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://R017998.massey.ac.nz:8080/wase/reply_thread.jsp?mode=
Go
GO
Home Logout Help
Submit
Cancel
Done
Local intranet

Lecture List: Query Optimization and Distributed Database

Study Module: Discussion Board

157.331 Database Concepts

Reply Thread

User Name Steven Baerselman (99027916)

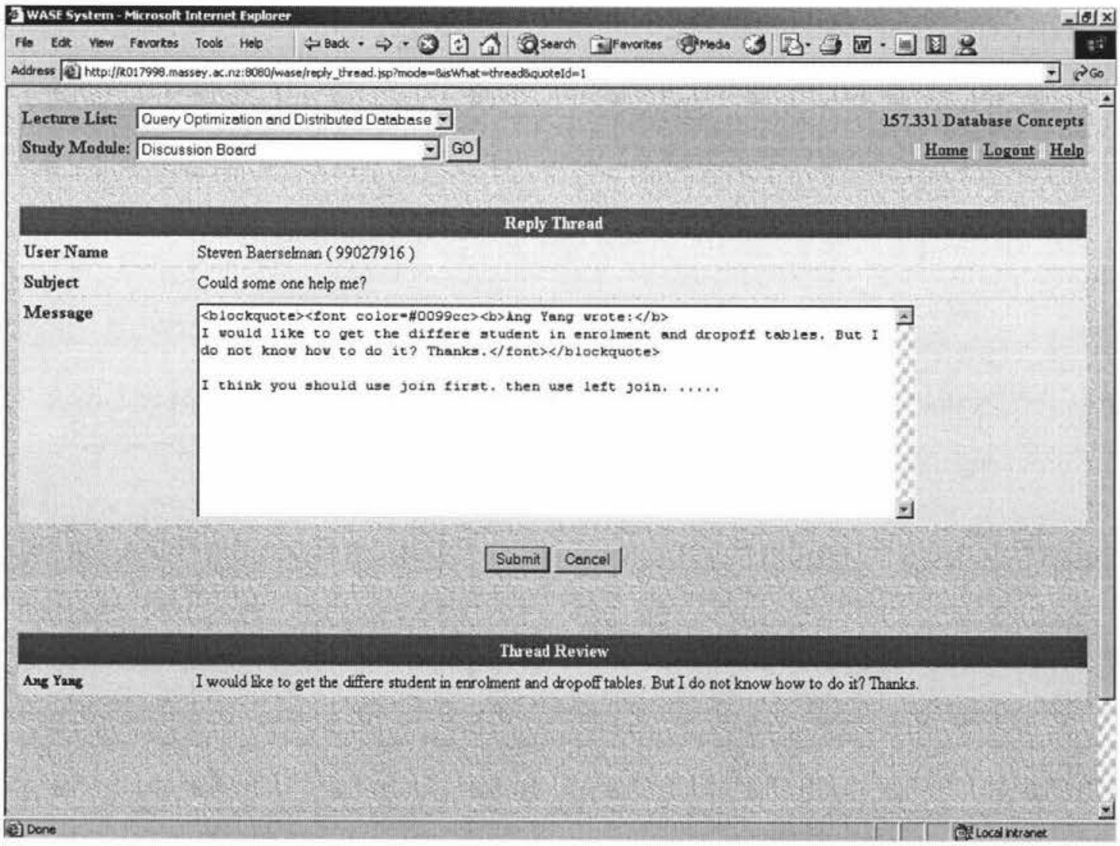
Subject What the difference between exist and in?

Message the differenc is ....

Thread Review

Ang Yang could anyone explain to me when using exist and when using in? thanks.

Figure 5-25 Reply a Post


WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://R017998.massey.ac.nz:8080/wase/reply_thread.jsp?mode=&isWhat=thread&quoteId=1
Go
GO
Home Logout Help
Submit
Cancel
Done
Local intranet

Lecture List: Query Optimization and Distributed Database

Study Module: Discussion Board

157.331 Database Concepts

Reply Thread

User Name Steven Baerselman (99027916)

Subject Could some one help me?

Message

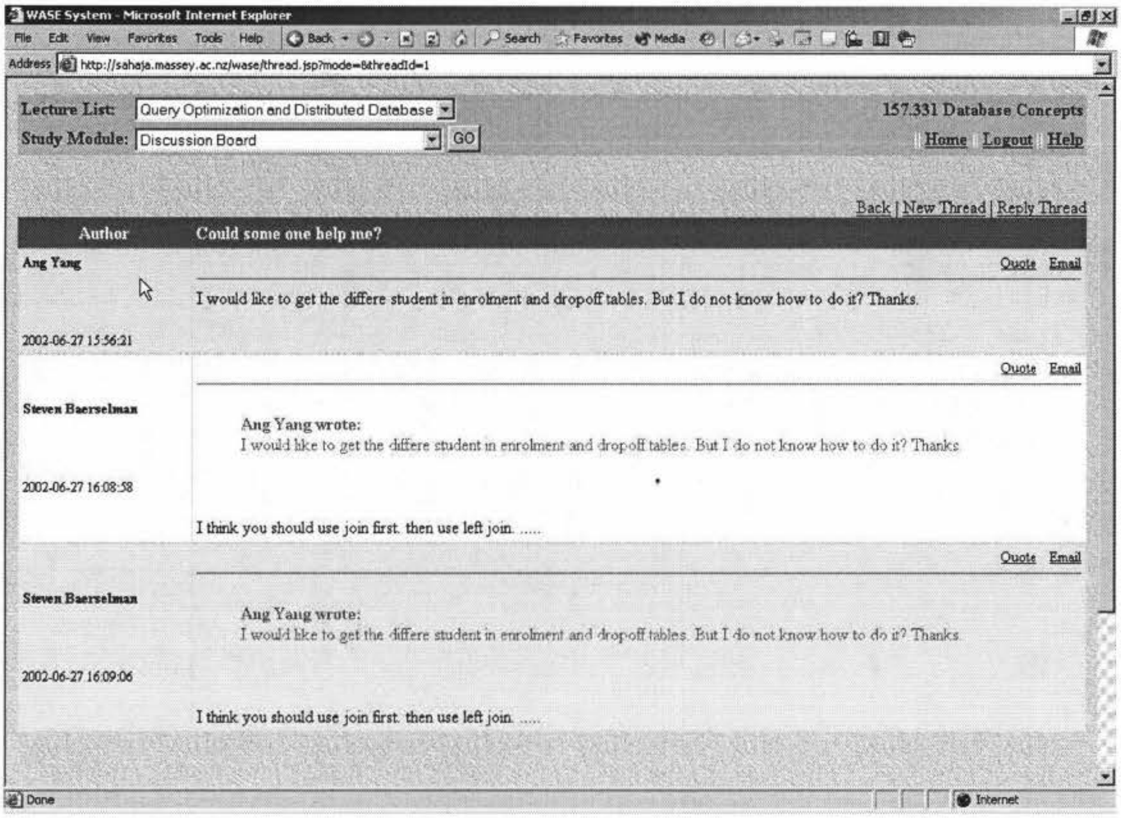
```
<blockquote><font color=#0099cc><b>Ang Yang wrote:</b>
I would like to get the differe student in enrolment and dropoff tables. But I
do not know how to do it? Thanks.</font></blockquote>

I think you should use join first. then use left join. .....
```

Thread Review

Ang Yang I would like to get the differe student in enrolment and dropoff tables. But I do not know how to do it? Thanks.

Figure 5-26 Quote a Post


WASE System - Microsoft Internet Explorer

Address http://sahaja.massey.ac.nz/wase/thread.jsp?mode=8threadId=1

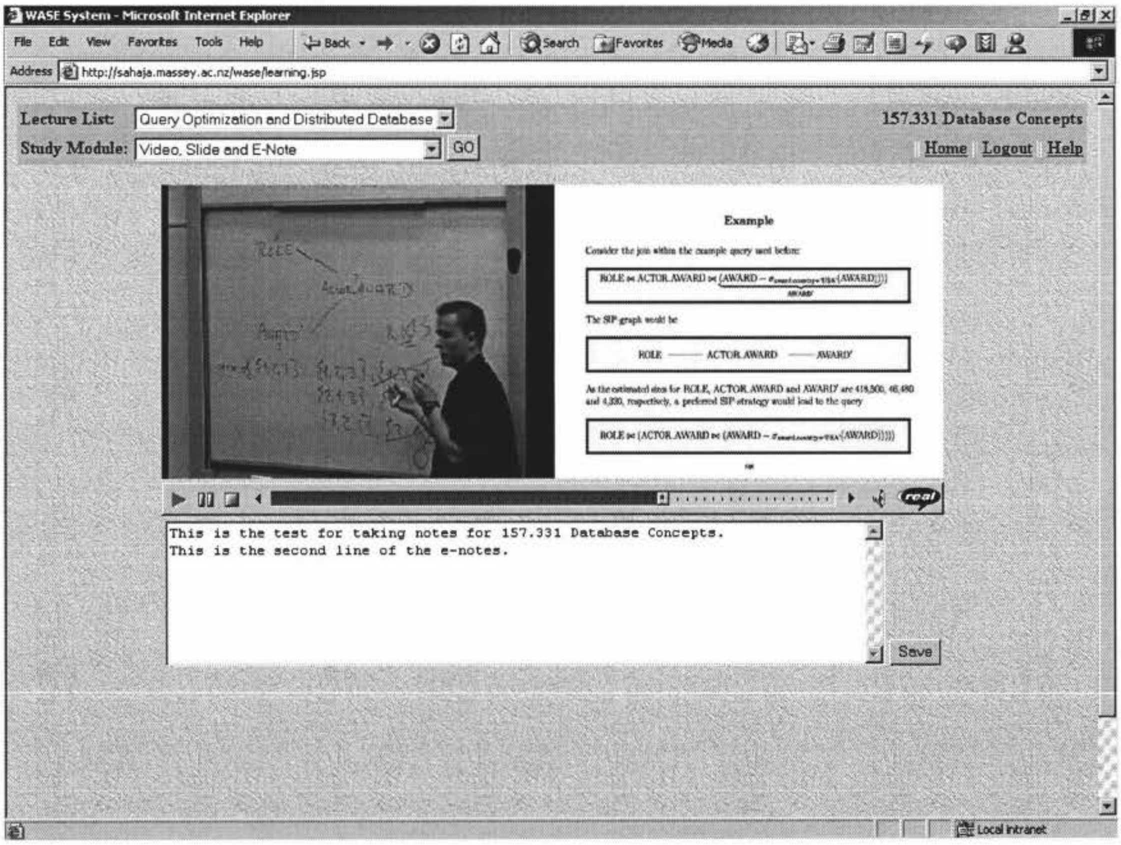
Lecture List: Query Optimization and Distributed Database

Study Module: Discussion Board

157.331 Database Concepts

Author	Could some one help me?
Ang Yang 2002-06-27 15:56:21	I would like to get the differe student in enrolment and dropoff tables. But I do not know how to do it? Thanks.
Steven Baerselman 2002-06-27 16:08:58	Ang Yang wrote: I would like to get the differe student in enrolment and dropoff tables. But I do not know how to do it? Thanks I think you should use join first. then use left join. .....
Steven Baerselman 2002-06-27 16:09:06	Ang Yang wrote: I would like to get the differe student in enrolment and dropoff tables. But I do not know how to do it? Thanks. I think you should use join first. then use left join. .....

Figure 5-27 Detail of a Thread


WASE System - Microsoft Internet Explorer

Address http://sahaja.massey.ac.nz/wase/learning.jsp

Lecture List: Query Optimization and Distributed Database

Study Module: Video, Slide and E-Note

157.331 Database Concepts

Example

Consider the join within the example query used before:

ROLE ⋈ ACTOR.AWARD ⋈ (AWARD − σ(AWARD))

The SIP graph would be

ROLE —— ACTOR.AWARD —— AWARD'

As the estimated sizes for ROLE, ACTOR.AWARD and AWARD' are 418,500, 46,490 and 4,330, respectively, a preferred SIP strategy would lead to the query

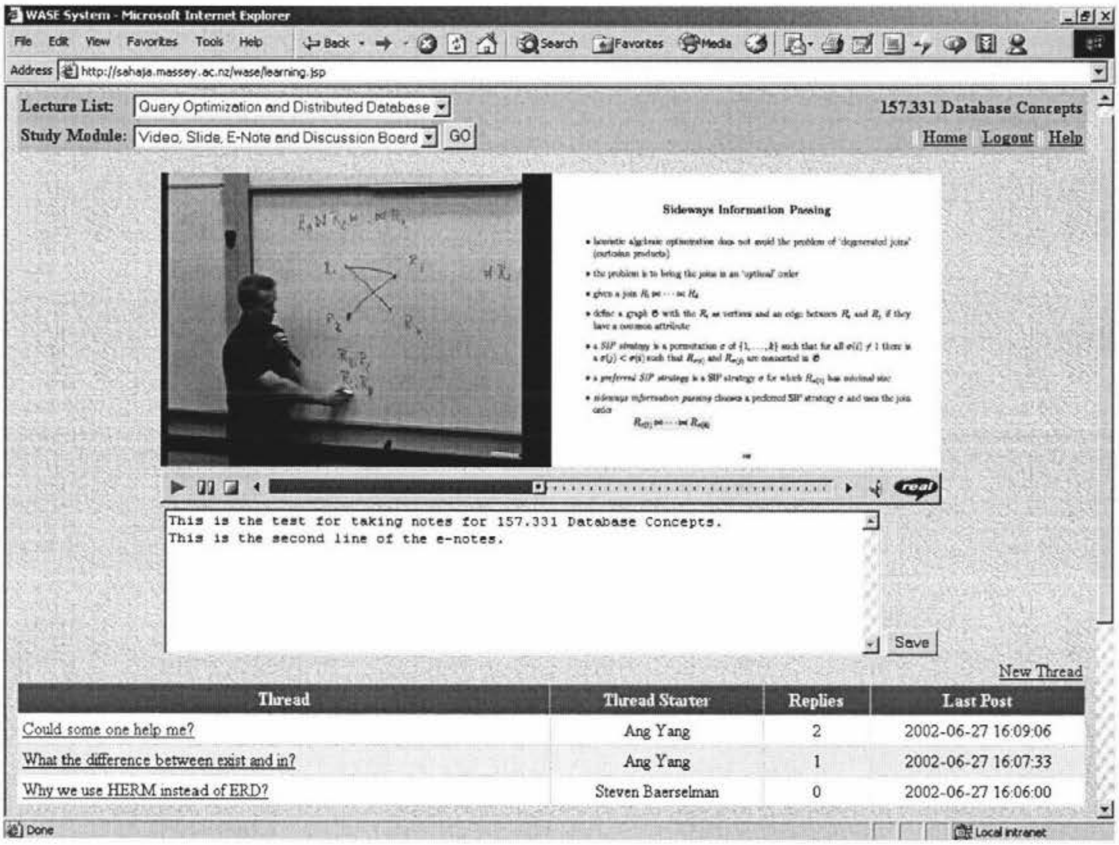
ROLE ⋈ (ACTOR.AWARD ⋈ (AWARD − σ(AWARD)))

```
This is the test for taking notes for 157.331 Database Concepts.
This is the second line of the e-notes.
```

Figure 5-28 Learning Mode – Lecture & E-Note

5.5.3 Mode 3 – lecture, E-note and discussion

In this mode (figure 5-29), the student may view the lecture, take notes for this lecture, and discuss with their classmates and teacher.



WASE System - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://sahaja.massey.ac.nz/wase/learning.jsp
Home Logout Help
GO
Save
New Thread
Done
Local intranet

Lecture List: Query Optimization and Distributed Database

Study Module: Video, Slide, E-Note and Discussion Board

157.331 Database Concepts

Sideways Information Passing

- heuristic algebraic optimisation does not avoid the problem of 'degenerated joins' (cartesian products)
- the problem is to bring the joins in an 'optimal' order
- given a join $R_1 \bowtie \cdots \bowtie R_k$
- define a graph $\mathfrak{G}$ with the R_i as vertices and an edge between R_i and R_j if they have a common attribute
- a *SIP strategy* is a permutation σ of $\{1,\ldots,k\}$ such that for all $\sigma(i) \neq 1$ there is a $\sigma(j) < \sigma(i)$ such that $R_{\sigma(i)}$ and $R_{\sigma(j)}$ are connected in $\mathfrak{G}$
- a *preferred SIP strategy* is a SIP strategy σ for which $R_{\sigma(1)}$ has minimal size
- *sideways information passing* chooses a preferred SIP strategy σ and uses the join order

$$R_{\sigma(1)} \bowtie \cdots \bowtie R_{\sigma(k)}$$

```
This is the test for taking notes for 157.331 Database Concepts.
This is the second line of the e-notes.
```

Thread	Thread Starter	Replies	Last Post
Could some one help me?	Ang Yang	2	2002-06-27 16:09:06
What the difference between exist and in?	Ang Yang	1	2002-06-27 16:07:33
Why we use HERM instead of ERD?	Steven Baerselman	0	2002-06-27 16:06:00

Figure 5-29 Learning Mode – Lecture, E-Note and Discussion

5.6 Summary

The prototype system is implemented to provide off-campus students the benefits of face-to-face learning. The instructor should first synchronize the lecture video and slides for each lecture by using functions provided in the prototype system. Then the students may access the synchronous video and slides at any time and anywhere through Internet. With the prototype system the off-campus students may get the expressions (gestures) and explanation from the human instructor, take the notes for each particular lecture during their learning processes and discuss with their classmates or instructors the issues related with each lecture.

In the next chapter, the evaluation of this prototype system by both instructors and students is provided. Then the conclusion and future work are discussed.

Chapter 6 Evaluation and Lessons Learnt

6.1 Introduction

This chapter focuses on the experiences gained during the design and implementation of the system. The discussion starts with how the objectives of the project were achieved and how various problems during design and implementation were tackled. Then we describe the formative evaluation of the prototype system by both instructors and students. After that, the future work for improving the existing system is discussed. Finally the conclusions on this research are drawn.

6.2 Discussion

The key objective of this project is to let the off-campus students enjoy the benefits of the traditional face-to-face learning. The prototype system developed in this project aims to fulfill that objective. The prototype system not only contains the benefits of the traditional face-to-face learning, but also overcomes various shortcomings of current web-based learning systems, such as the lack of contextual discussion, lack of human teacher expression and explanation, lack of human interaction, and lack of contextual understanding. The following discussion attempts to describe how the prototype system overcomes these shortcomings.

The prototype system consists of four subsystems: paper management subsystem, lecture management subsystem, student learning subsystem and contextual discussion subsystem. Each subsystem is implemented with the *distributed, three-tier, client-server* architecture. The client is a set of JSP files presented in a web browser with embedded Real Player. The JSP engine and Java application programs, used for the course and learning management, reside in the middle tier server, which can communicate directly with the third tier database. This type of system architecture is flexible, and easy to manage and maintain. By using such system structure, all objectives proposed in chapter 1 are achieved.

6.2.1 Objective 1 – getting the expression of the human lecturer

In order to let the off-campus students get the expression of the human lecturer, a Real Player is embedded in the web page (see figure 5-29 and 5-30) and a RealSystem Server is employed at the server side. Using this embedded Real Player, the students can view the whole lecture in the web page. They can see the expressions and gestures of the human lecturer. It may give the student a sense of being in a real classroom and it is easy for the students to understand the domain concepts.

6.2.2 Objective 2 – getting the explanation from the human lecturer

Using the embedded Real Player, the students can also hear what the lecturer says and see what the lecturer writes on the whiteboard. Thus they get the explanations from the human lecturer. This may help the students understanding the concepts and the whole lecture much easier.

6.2.3 Objective 3 – taking contextual notes for the course

While watching a lecture presentation, students have possibility to take notes in a text area available in the web page just below the lecture presentation (see figure 5-29 and 5-30). The students can make notes for individual lectures just as they would be in a traditional classroom based lecture. Next time the notes will be automatically displayed if the student selects the same lecture. The student can then modify those notes and save again with that lecture. Since the notes are lecture-based, they retain contextual understanding of the concepts.

6.2.4 Objective 4 – peer communication

A discussion forum is created to achieve the peer communication between students, and students and their lecturers (see figure 5-23, 5-24, 5-25, 5-26 and 5-27). Each lecture has its own discussion forum. That is, the discussions are lecture-based, similar to the e-notes. It is easy for the students to look for help and discuss issues related to a particular topic. The lecturer may also identify what are the problems the students face in a particular lecture and then give more detailed explanation to these points or guide the students how to solve these problems by themselves. If the problem is quite common among the students, the lecturer may post a thread in the discussion forum. The lecturers can also find suggestions for improvement in their teaching styles in the discussion forum, and then they may improve it for future lectures.

By achieving these objectives, the system provides the off-campus students some additional benefits which are not provided in the face-to-face education system. They are discussed in next section.

6.3 Advantages over face-to-face education

First of all, like any other web-based learning systems, this system may be accessed as many times as possible. Therefore the students can **view the lecture video with synchronized presentation repeatedly**. This is an added advantage over the face-to-face education, where the students cannot ask the teacher to repeat the lecture if they miss something. If the students do not understand some points, usually they cannot ask the teacher to explain it over number of times. But if the students use this system, they can view the explanation any number of times as they want. It is very important for those students who have slow rate of comprehension and those whose native language is not English.

Most of the students experience a typical problem every now and then: they miss some parts of the lecture when they take notes during the lecture, because the lecturer does not stop the lecture when the students take notes. However, if this system is used, the students have possibility to stop the video, take notes, and then resume the video. In this way the students do not miss anything. Thus the students get another benefit that they **do not fall behind while taking notes**.

As long as this prototype system is web-based, it will have two additional features: it is accessible any time and any where. Therefore the third advantage is that the students can **learn at their own pace** using this system. They can go through the lecture whenever they have time and wherever they have access to the Internet. When facing some problems during learning, they can stop the video and think about the content, and then resume the video. This is unlike face-to-face education, where there is no time for students to think during the lecture. The students can also ponder over other peoples' comments in the contextual discussion area before going any further.

Another major advantage is that the students can **consult other materials during learning**. If the students cannot understand some points, they may stop the video and think about it. If they still cannot understand it, they may look for information from discussion forum. If they still cannot understand it, they may read some other books or materials and then resume the video.

A number of problems were encountered during the design and implementation of the system that could have become obstacle in achieving the objectives of this project. Following section describes the major problems and the solutions adopted to these problems in this project.

6.4 Difficulties and solutions

Normally when the video is transferred from a digital video camera to the computer, the whole video is saved as an avi format file. Therefore the first problem we faced was **how to get the video in the format which the RealSystem server can stream** because we used the RealSystem Server as the streaming server. There are two ways to solve this problem. One is to transfer the video from a digital video camera directly to a rm format file in the computer. This requires some special hardware and software. Another way is to use certain software in the server to convert the avi format file to rm format file after an avi file is saved. We used the later solution by using the RealSystem Producer because it is simple.

The most important and critical problem was **how to synchronize the video with the PowerPoint presentation file**. The only solution we found is that each slide in a PowerPoint presentation file is first converted to an image in JPG format. Then according to the presentation duration for each slide the lecturer provides, the slide in JPG format will be displayed one by one while the video is playing. This led to another problem: **how to transfer each slide in a PowerPoint presentation file to an image file automatically**. The PowerPoint is a Microsoft products. There is a function in PowerPoint that saves each slide in a PowerPoint file as an image file. But this requires Microsoft PowerPoint to be installed in the server. In order to convert the files automatically, a custom VB tool is created.

The last major problem we encountered was **how to control the embedded Real Player using buttons instead of default control panel**. In order to synchronize the video and slide images some additional functions were required. The default control panel of embedded Real Player does not provide inefficient functionality. Therefore some control buttons were created using JavaScript according to the Software Development Kit provided by the RealNetworks Company.

6.5 Evaluation

In order to evaluate the prototype system, total eleven people (Table 6-1): five instructors, five students and one research officer were asked to use the system and then complete a questionnaire. The evaluation at this stage is of formative nature. Based on the feedback received at this stage, the enhancements will be made to the system. The summative evaluation is placed for future and is outside of the scope of this thesis.

Five instructors include two lecturers who are teaching both undergraduate and postgraduate papers, one assistant lecturer who is teaching undergraduate papers and two tutors who are teaching undergraduate papers. Three of them are male and two of them are female. One of them is over 40 years old, three are between thirty and forty years old and the last one of them is between twenty and thirty years old.

Five students include three postgraduate students and two undergraduate students. Three of them are male and two of them are female. Two of them are under thirty years old and others are over thirty years old.

The research officer is male, between thirty and forty years old.

Table 6-1 Summary of Evaluator

Category	Number	Gender		Age (years old)		
		Male	Female	< 30	30 ~ 40	> 40
Instructors	5	3	2	1	3	1
Students	5	3	2	2	3	
Research Officers	1	1			1	
Total	11	7	4	3	7	1

The questionnaire included seven questions. The comments for each question are as follows.

Q1: Do you think the system is useful for students? For Which level students? Why?

All evaluators thought the system is useful for the students, especially for the off-campus students because the system provides a flavor of the internal classroom and the student may review the lecture easily. Nine evaluators thought all level students may benefit from it, especially for the high level students. But one instructor thought the undergraduate students would benefit the most because undergraduates are still dependent largely on lecturers while courses at post-graduate level should motivate the students to be independent. One instructor also pointed out that the direct contact to the lecturer cannot be replaced by the system because there is not enough interaction.

Q2: Do you think the system is useful for instructors? For which modes? Why?

Nine evaluators thought the system is useful for the instructors, especially for the papers taught in distance mode in which the students do not need to go to the university to attend the lectures. The instructors who teach both internal and extramural paper may benefit most from it because they do not need to repeat their work. But one instructor thought it is hard to judge this fact because the system requires the instructors to spend time and do some technical work to configure the paper. One instructor thought the system provides another benefit for instructors to improve their teaching. As a lecturer, you do not usually see yourself in action. Videotaping is used in sports heavily to improve techniques and study. The lecturer may also be able to see which parts of the lecture were well-received by the students and which were not.

Q3: Do you think the system is easy to use? Which part/functionality is the easiest?

Eight evaluators thought the system is easy to use, especially for the part of learning. There were no comments from two instructors and one instructor thought there is a problem for instructors that the system requires the instructor to have some techniques and devices to transfer the video from a digital camera to the computer and save as an avi file.

Q4: What do you think the biggest problem with this system is?

The evaluators proposed three problems. One is higher resources requirements both for the hardware and the software. The system also requires that the instructor should have the knowledge to transfer video from the digital camera to computer. Another is the video file size. They think the video file size in both avi and rm format should be reduced and at same time the video quality shouldn't be reduced. The last is the video quality. One instructor thought that only one camera is not enough to record the lecture. There should be several cameras from different angles to record different parts of the classroom, such as the lecturer, the whiteboard, the transparencies and the students.

Q5: If you are asked to give only one suggestion for improvement, what will it be?

Four evaluators thought that the system should support more formats for video file and slide file. Three evaluators thought the system should support audio plus slide instead of video plus slide, because it is easy to record an audio for the lecture. Four evaluators did not give comments on this question.

Q6: As a student, would you like to use it?

Nine evaluators thought that the students may like to use it, especially the off-campus students. But they also pointed out that if there is an option, the students may still opt to attend the traditional class. Two evaluators thought that the student may not like to use it.

Q7: As an instructor, would you like to use it?

Eight evaluators thought that the instructors might use it. But two evaluators did not think so because they thought using it might increase their workload.

Table 6-2 summarizes the comments to Question 1, Question 2, Question 3, Question 6 and Question 7.

Table 6-2 Summary of Comments

Question	Answer to question		
	Yes	No	Other
Q1: Do you think the system is useful for students? For Which level students? Why?	11		
Q2: Do you think the system is useful for instructors? For which modes? Why?	9		2
Q3: Do you think the system is easy to use? Which part/functionality is the easiest?	8	1	2
Q6: As a student, would you like to use it?	9	2	
Q7: As an instructor, would you like to use it?	8	2	

Based on the comments received during evaluation and the problems faced during design and implementation phase, a number of enhancement possibilities emerged. The next section discusses the possible future work to carry out these enhancements.

6.6 Future work

Although the prototype system achieves all the anticipated objectives and has some additional advantages over the face-to-face education, the system can be improved in many ways. The most important thing, which needs to be improved, is the method used to convert PowerPoint file to graphic format. Currently Microsoft PowerPoint is used for this conversion process. That is the reason why two servers had to be used. One server requires Window operation system where PowerPoint application is installed. Another server is Linux server used to run RealSystem server. If the

PowerPoint file can be converted to graphic file in some way on Linux, then there is no need to have two separate servers. Although having two servers enables additional security for configuration files, it is still too expensive.
According to the suggestions made by the evaluators, more formats for video file and slide file should be supported. Also, the system may provide more learning modes, such as "audio plus slide", "slide plus e-note" and so on. These may make the system more flexible.

In future, an administration subsystem should be created. This subsystem should be used to let the system administrator set the system environment variables and some other system administration work. It may make the system more robust and easier to use.

In the contextual discussion forum, more functions can be added. A search function may let students find the information quickly. System could also support synchronous communication by providing chat facilities.

6.7 Conclusion

The life long learning is becoming popular day by day and more and more people, who do not have possibility to attend the lectures at the university, are learning at distance. There is a need to allow these people to get the explanations from the human teacher, to experience the expressions of the human teacher, and not feel isolated during learning process. This thesis described a web-based system that provides the off-campus students the advantages of web technologies combined with the benefits of traditional face-to-face learning.

The system developed in this project can be used for a wide range of papers in different domains. The system is not domain dependent. The development and evaluation of the system also proved that the well-structured web-based learning system may do what the traditional face-to-face education system usually does and more. Further enhancements should make the system even more flexible, adaptable and robust.

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