Toward Advanced Network Education using Integrated Remote Lecturing System:

A Case Study in Osaka University

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Abstract

This paper reports our trials toward advanced network education in 'Advanced Lecture Course on Information Networking' conducted in the 1st semester of 2006, at the Department of Information Networking, Graduate School of Information Science and Technology, Osaka University, Japan. This lecture course consists of the following two main lessons: 'Advanced Introduction to Information Networking' (90min. x 15 weeks), and 'Exercises on Information Networking I' (180min x 15 weeks). In the Advanced Introduction to Information Networking, 15 lectures were conducted by various lecturers: 10 professors from academia and 2 lecturers from industry. In the Exercises on Information Networking I, students first conducted surveys on diverse security issues in the current computer networks, and made presentation on their survey results. They then tackled two programming exercises, aimed at better understanding of TCP/IP protocol internals and its security concerns. Finally, students were divided into 12 groups and made presentations discussing 'Towards the Secure Networking'. Since the lecture was conducted in three distant locations in Osaka and Tokyo (approximately 500km away), we utilized the integrated remote lecturing system in our satellite campus, Osaka Nakanoshima Center. The integrated remote lecturing system is a full-featured and fully-automated remote lecturing system using modern networking and information technologies. The integrated remote lecturing system is composed of the following building blocks: multipoint remote lecturing system, lecture broadcasting system, lecture contents distribution system, contents archiving system, on-demand distribution system and contents editing system.

In this paper, we first review the details of the lecture course and our integrated remote lecturing system. We then discuss lessons learned from our remote lecturing experiences and future works.

Keywords

Information Networking, Network Education, TCP/IP Network, Network Protocol, Integrated Remote Lecturing System

1. Introduction

The Department of Information Networking, Graduate School of Information Science and Technology, Osaka University [1] is a new organization that was established in 2002 and implements specialized and advanced education relating to network technologies. The Department of Information Networking was established on the basis of the following philosophy.

The Department of Information Networking in particular conducts encompassing education from basic technology for networks to service technology and proceeds with educational research aimed at the organic fusion of various technologies like computers and communication, wire and wireless/mobile technology, hardware and software, communications and broadcasting, and electronics and photonics that were previously developed separately while actively liaising between courses as well. Beginning with a system-oriented approach, creation of new systems and services that are truly useful for industrial society and civil society will be possible.

The Department of Information Networking offers the following six courses.

(1) Multimedia networking course

To conduct education and research with regard to computer network configuration technology for construction of multimedia information network infrastructure.

- Media communication processing technology
- Multimedia communication Quality-of-Service (QoS) technology
- Multimedia communication protocol
- Network middleware

(2) Intelligent networking course

To conduct education and research with regard to intelligent networking architecture based on new paradigms integrating multimedia information transmission networks and network control networks.

- Intelligent optical network technology
- Network technology fusing communications and broadcasting
- Advanced service control architecture

(3) Information sharing platform course

To conduct education and research from the aspects of both hardware and software with regard to information sharing platforms combining network and information processing features for the support of information industries such as e-commerce, inter-corporate communication, and content distribution.

- High-reliability platform configuration technology
- Content distribution networks
- E-commerce architecture

(4) Mobile computing course

To conduct education and research with regard to construction of large-scale network systems and middleware fusing mobile communication environments and high-speed information communication networks and new information processing technology fusing wireless communication technology and distributed processing technology.

- Mobile computing and ad-hoc networks
- Network protocols
- Information processing technology for networks

(5) Advanced network architecture course (cooperative course with Cybermedia Center, Osaka University)

To conduct education and research with regard to advanced network architecture for high-speed broadband networks to construct advanced information communication infrastructure.

- High-speed protocol processing technology
- Photonic Internet technology
- High-speed switching processing technology
- High-speed end-system configuration technology

(6) Cyber-communication course (in cooperation with Nippon Telegraph and Telephone Corporation)

To conduct education and research with regard to a variety of technology to achieve natural communication between people in cyberspace.

- Cyber-community formation technology
- Cyber-communication basic technology
- Multimedia content distribution technology

This paper reports our trials toward advanced network education in ‘Advanced Lecture Course on Information Networking’ conducted in the 1st semester of 2006, at the Department of Information Networking, Graduate School of Information Science and Technology, Osaka University, Japan. This lecture was conducted for 25 graduate students and 12 visiting students from IT (Information Technology)-related Japanese companies. The lecture was

conducted at three distant locations: the main campus in northern Osaka for graduate students, two satellite campuses in central Osaka and Tokyo (approximately 500km away from Osaka) for visiting students.

Since the lecture was conducted in three distant locations in Osaka and Tokyo, we utilized the integrated remote lecturing system in our satellite campus, Osaka Nakanoshima Center. The integrated remote lecturing system is a full-featured and fully-automated remote lecturing system using modern networking and information technologies. The integrated remote lecturing system is composed of the following building blocks: multipoint remote lecturing system, lecture broadcasting system, lecture contents distribution system, contents archiving system, on-demand distribution system and contents editing system. The multipoint remote lecturing system is a highly-customized H.323-based multipoint video conferencing system for distributing live lectures and presentation materials to distant locations. The contents archiving system automatically records lessons and presentations without human intervention as high-quality and well-indexed e-Learning contents. The on-demand distribution system is a Video on Demand (VoD) system, which allows students to review past lessons at home. With the aid of the contents editing system, we also created several types of e-Learning contents for satisfying students' different needs and requirements.

The rest of this paper is organized as follows. Section 2 introduces the methodology of our trials, which includes the contents of 'Advanced Lecture Course on Information Networking' and the description of the usage of the integrated remote lecturing system. In Section 3 we discuss the effectiveness of the course and introduce the impressions from students taking the course. Finally, Section 4 summarizes this paper with some future directions.

2. Methodology

2.1 Course Contents

2.1.1 Overview

This lecture course consists of the following two main lessons: 'Advanced Introduction to Information Networking' (90min. x 15 weeks), and 'Exercises on Information Networking I' (180min x 15 weeks). In the Advanced Introduction to Information Networking, 15 lectures were conducted by various lecturers: 10 professors from academia and 2 lecturers from industry. The content of the lectures includes: mathematical theories on Internet technologies, networking protocol details, mobile networking technologies, Quality of Services (QoS) issues, performance evaluation techniques, network management issues, and so on. In the Exercises on Information Networking I, students first conducted surveys on diverse security issues in the current computer networks, and made presentation on their survey results. They then tackled two programming exercises, aimed at better understanding of TCP/IP protocol internals and its security concerns, by mastering existing network analyzers and developing their own network analyzers. Finally, students were divided into 12 groups and made presentations discussing 'Towards the Secure Networking'.

2.1.2 Advanced Introduction to Information Networking

The objective of this lecture is to introduce the fundamental networking technologies and latest technological issues, as well as the methodologies for performance evaluation of computer networks: computer simulation, mathematical analysis. The detailed contents are as follows:

(0) Introduction (Prof. Murakami: 12th Apr.)

(1) Introduction of the Internet mechanisms: what is the essence of packet-switching networks?

- Network algorithm (Prof. Imase: 12th Apr.)
- Network design methods (Prof. Imase: 19th Apr.)

- Internet routing mechanisms (OSPF, etc.) (Prof. Tode: 26th Apr.)
- VPN, MPLS, and GMPLS technologies (Prof. Tode: 10th May)
- Computer simulation techniques for performance evaluation (Prof. Wakamiya: 17th May)

(2) Mobile networks: what is the essence of the mobility control?

- Control mechanisms for mobile networks, mobile agent technologies (Prof. Higashino: 24th May)
- Design issues of mobile network software (Prof. Higashino: 31st May)
- Technical issues in mobile IP and mobile phones (Prof. Nakano: 7th Jun.)

(3) Network QoS: how can we guarantee?

- Multimedia QoS technologies (Prof. Murata: 14th Jun.)
- High-speed network protocols (Prof. Murata: 21st Jun.)
- Issues in IntServ/Diffserv (Prof. Wakamiya: 28th Jun.)
- Performance evaluation of TCP (Prof. Hasegawa: 5th Jul.)
- Performance evaluation of Active Queue Management (AQM) mechanisms (Prof. Ohsaki: 12th Jul.)

(4) The reality in network operation

- Operational issues for VoIP networks (Dr. Hatanaka with NTT WEST: 19th Jul.)
- Operational issues for VPN and SpotAccess services (Dr. Koui with NTT WEST: 19th Jul.)

2.1.3 Exercises on Information Networking I

Details of the contents of Exercises on Information Networking I will be explained in this section. This exercise consists of the three parts: (1) survey of network security issues, (2) network analyzer programming, and (3) final presentation.

2.1.3.1 Survey on Network Security Issues (4 weeks)

First, the students were divided into 8 groups, each of which had two or three students, and made survey for network security issues, based on the latest five-years reports from CERT Advisory, Internet Security Systems Advisory, magazines on network security, and so on. The topics of the survey are as follows:

(1) Mail server and client software (MTA, POP, IMAP, etc.)
(2) UNIX WWW servers
(3) Windows WWW servers
(4) WWW browsers
(5) Remote login services (telnet, SSH, etc.)
(6) File sharing services (CIFS, FTP, NFS, etc.)
(7) Database services
(8) Other services (RPC, DNS, NIS, LDAP, etc.)

Each groups has one or two weeks for survey, and makes presentation on the survey results for 20-30 minutes.

2.1.3.2 Network Analyzer Programming (7 weeks)

In this programming exercise, all of the students participating were not assembled into a classroom; instead, the exercise was conducted in laboratories the individual students participating were assigned to. Thus, all of the materials relating to exercise problems were put on WWW pages and e-mail was used for contacting students from instructors and questioning from students to instructors. Three exercise problems as conducted in this seminar are introduced below.

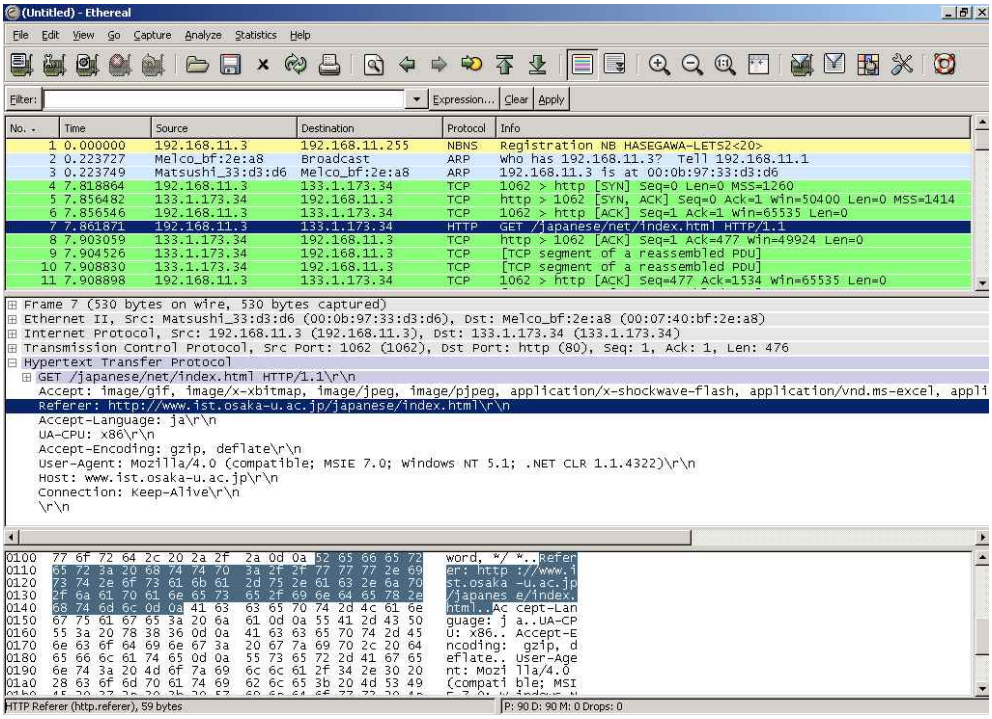

Fig.1 Snapshot of Ethereal

Problem 1: Create a simple program to use tcpdump/Ethereal

Goals

Learn how to use a free network analyzer such as tcpdump or Ethereal. Using VMware Workstation, consider what sort of information and to what extent can be obtained with these tools by actually collecting packets.

Exercise preparations

(1) Install the trial version of VMware Workstation 3.2 [5]

You can try the application for 30 days with the trial version, so install it on the PC you are using (we will switch to a licensed version later). Use Windows 2000/XP for the host OS. Contact the instructor responsible before Nov. 8 if you want to use Linux as the host OS.

(2) Install Linux (either RedHat 7.3/8.0 English version or Debian GNU/Linux 3.0) as the VMware guest OS

Be sure to use the version specified.

(3) Install tcpdump [3] and Ethereal [4]

Use version 3.6 or above for tcpdump and version 0.9.4 or above for Ethereal.

(4) Carefully read the manuals and related documents for tcpdump and Ethereal

Refer to online manuals, related WWW pages, etc. and understand both tools. Understanding of these tools is required for Problem 2.

Exercise content

(1) Learn methods of traffic analysis using Ethereal.

You can observe network traffic in a variety of protocols between the host and guest OSs; capture it using the Ethereal tool. Based on those results, check in detail what sort of information can be obtained.

(2) Learn methods of traffic analysis using tcpdump.

You can observe network traffic in a variety of protocols between the host and guest OSs; capture it using the tcpdump tool. Based on those results, check in detail what sort of information can be obtained.

(3) Discuss the differences in these two tools (tcpdump and Ethereal) and their advantages and disadvantages.

Run tcpdump and Ethereal in a guest OS in VMware. Do not capture network traffic in the laboratory without obtaining permission from the instructor of the laboratory you are assigned to.Use host-only mode as the type of network when installing the VMware guest OS. If you inadvertently use bridged mode, this may cause inconveniences to other computers, so use with caution.

Problem 2: Create traffic volume analysis programs

Goals

The goals of the current exercise are to master skills for creating the following programs.

(1) A program to collect traffic flowing on a network using a pcap library.

(2) A program to analyze a variety of traffic characteristics based on collected packets.

(3) A program to display the traffic characteristics analyzed on screen as a graph.

Exercise content

(1) Create a traffic collection program using a pcap library.

Create a program using libpcap to collect all of the packets flowing on the network. With regard to each packet collected, display as much information as possible such as the sending time, protocol type, protocol version, and packet length in text format. With regard to IP packets, display as much information as possible such as the IP address of the sending host, the IP address of the receiving host, and IP options. With regard to UDP/TCP packets, display as much information as possible such as the port number of the sending host, the port number of the receiving host, the sequence number, and checksums. You can refer to source code of tcpdump or Ethereal. Use C or C++ as the development language. You are free to select an OS and a type of computer for the development platform.

(2) Create a program to analyze traffic characteristics.

Using results output from the program developed in (1), analyze statistical information for traffic flowing on the network. Specifically, create a program to check statistical information of network traffic like that below. You are free to select a development language, development platform, compiler, and the like. This would probably be easy using a scripting language such as Perl or Ruby. It may be implemented as an Excel macro program.

- Analyze statistical information of network traffic

Create a program to output in text format statistical information of network traffic.

- Average transmission rate [Mbit/s]
- Total amount of data transmitted [byte]
- Average packet length [byte]
- Average packet arrival interval [s]

With regard to both sent packets and received packets, output four types of results for all packets, IP packets, TCP packets, and UDP packets. Analysis of the traffic distribution is the goal of this exceceise. You are free to design program details such as the output format.

(3) Create a program to display analysis results as a graph.

Create a program to display statistical information and the distribution of network traffic obtained with the program developed in (2) as a graph. The goal is to visualize how statistical information for traffic varies and what sort of distribution traffic takes for each type of protocol. Devise a technique allowing an easily understandable graph such as using a three-dimensional graph or histogram. Collect network traffic and display statistical information and the distribution for that traffic as a graph. You are free to select a development language, development platform, compiler, and the like. This would probably be easy using a scripting language such as Tcl/Tk, Perl/Tk, or Ruby/Tk. Use of

Excel, Gnuplot, or the like is acceptable.

Problem 3 (optional): Create protocol analysis programs

Goals

The goals of the current exercise are to be able to create/design the following programs.

(1) A program to trace TCP sessions and analyze the content of communications.

(2) A network application.

Exercise content

(1) Create a program to trace TCP sessions and analyze the content of communications.

Create a program to collect packets flowing on the network and analyze the content of communications for a specific TCP session. Display analysis results in a text format. Use the traffic collection program created in Problem 2 (add features if necesary) to collect packets. TCP session is differentiated by the IP address of the sending host, the IP address of the receiving host, the port number of the sending host, the port number of the receiving host, and the initial sequence number. Output from Ethereal (choose 'Follow TCP Stream' from the menu) may serve as a reference. Be careful with establishment/disconnection of TCP sessions and retransmission control of TCP. You are free to design program details. You are free to select a development language, development platform, compiler, and the like. This would probably be easy using a scripting language such as Perl.

(2) Design an application.

Use the knowledge you obtained in the 'network analyzer exercise,' consider two types of applications, and design one. We are expecting your creativity. Example applications include a program to detect Denial-of-Service (DoS) attacks or an intrusion detection system (IDS) through the collection of traffic flowing on a network.Perform concept design of the application considered and summarize those details in a report (one per application in 2–4 pages). Include necessary information such as the concept, usage, features, characteristics, advantages, disadvantages, method of accomplishment, operation algorithm, and a block diagram.

2.1.3.3 Final presentation (3 weeks)

Based on the knowledge obtained through the survey and programming exercises, the students made final presentation. The students were again divided into 8 groups and discussed 'Towards the Secure Networking,' and made presentations.

2.2 Remote Lecturing System

2.2.1 System Overview

Since the lecture was conducted in three distant locations in Osaka and Tokyo (approximately 500km away), we utilized the integrated remote lecturing system in our satellite campus, Osaka Nakanoshima Center. The integrated remote lecturing system is a full-featured and fully-automated remote lecturing system using modern networking and information technologies (see Fig. 2). The integrated remote lecturing system is composed of the following building blocks: multipoint remote lecturing system, lecture broadcasting system, lecture contents distribution system, contents archiving system, on-demand distribution system and contents editing system.

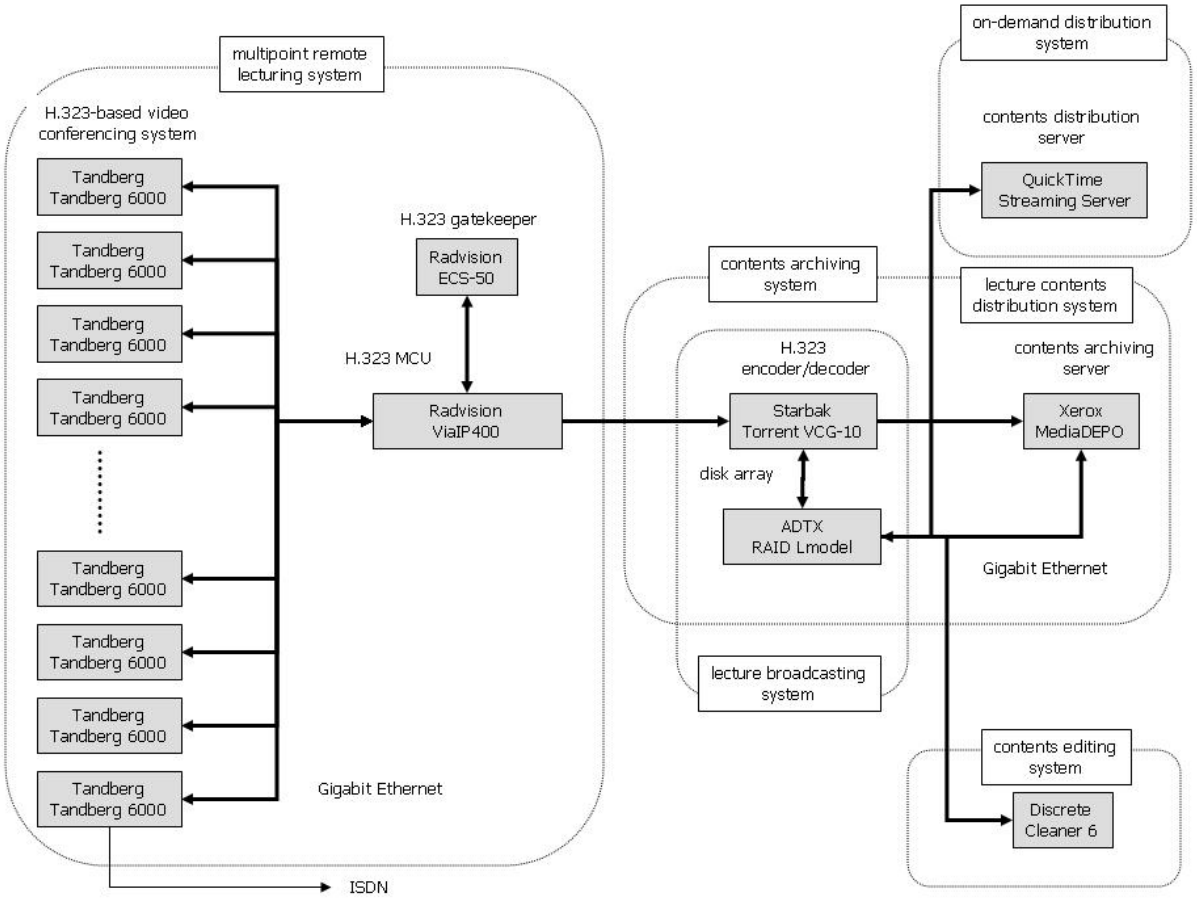

Fig.2 System Overview

2.2.2 Multipoint Remote Lecturing System

The multipoint remote lecturing system is a highly-customized H.323-based multipoint video conferencing system for distributing live lectures and presentation materials to distant locations. The multipoint remote lecturing system basically consists of 43 sets of an H.323-based video conferencing system (Tandberg 6000 and Tandberg 550), an H.323 MCU (Multiple Conferencing Unit) (Radvision ViaIP400 series), and an H.323 gatekeeper (Radvision ECS-50).

Tandberg 6000 and Tandberg 550 are conferencing systems conforming to the ITU-T H.323 standard, which supports over 768Kbps TCP/IP connection and 64Kbps ISDN connection. Tandberg 6000 has its internal MCU (Multiple Conferencing Unit), supporting up to 4 simultaneous connections. In Osaka Nakanoshima Center, every room is equipped with either Tandberg 6000 or Tandberg 550. Radvision ViaIP400 is a multiple conferencing unit conforming to the ITU-T H.323 standard, which supports more than 10 simultaneous conferences and more than 40 simultaneous connections. Radvision ECS-50 is a gatekeeper conforming to the ITU-T H.323 standard. This device provides name resolution service for H.323 video conferencing systems such as Tandberg 6000 and Tandberg 550. Namely, the gatekeeper translates a conference name (e.g., `*1234`) to the corresponding IP address (e.g., `192.168.0.1`).

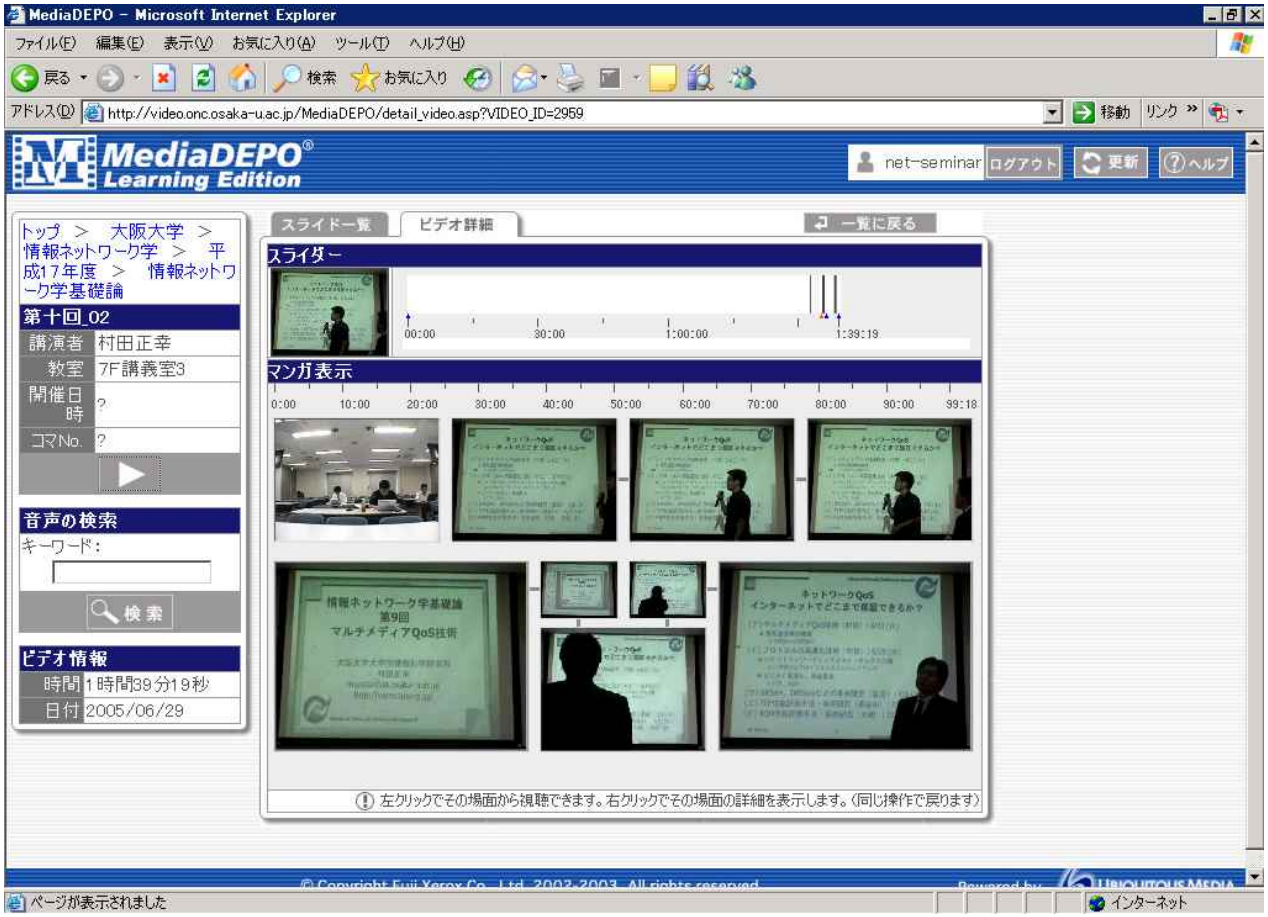

Fig3. User-friendly Interface of Contents Archiving System

2.2.3 Contents Archiving System

The contents archiving system automatically records lessons and presentations without human intervention as high-quality and well-indexed e-Learning contents. The contents archiving system consists of an H.323 encoder/decoder (Starbak Torrent VCG-10), a network storage (three IBM x345's with ADTX RAID Lmodel), and a contents archiving server (Xerox MediaDEPO).

Starbak Torrent VCG-10 converts H.323 streams into RealVideo streams, which can be viewed by, for example, Apple QuickTime player. Starbak Torrent VCG-10 supports conversion of more than ten H.323 streams, each of which is encoded with no more than 1.5Mbps bitrate. Three IBM x345's with ADTX RAID Lmodel are network-based storage having the capacity of more than 5TB (i.e., 250GB hard disk × 210). The interface between IBM x345 and the disk array is FC (Fibre Channel). Xerox MediaDEPO is a software for archiving and distributing e-Learning contents. In Osaka Nakanoshima Center, a fully-customized version of Xerox MediaDEPO is installed. Xerox MediaDEPO has really cutting-edge features such as automatic generation of e-Learning contents in RealVideo format using its SMIL extension, voice recognition for enabling keyword-based search for audio and video contents, and user-friendly interface allowing quick browsing of video contents (see Fig. 3).

2.2.4 On-Demand Distribution System

The on-demand distribution system is a Video on Demand (VoD) system, which allows students to review past lessons at home. The on-demand distribution system basically consists of a contents distribution server (QuickTime Streaming Server), which cooperates with Xerox MediaDEPO.

2.2.5 Contents Editing System

With the aid of the contents editing system, we also created several types of e-Learning contents for satisfying students' different needs and requirements. The key component of the contents editing system is Discrete Cleaner 6, which allows importing and exporting of contents created by the contents archiving system from/to various audio and video formats.

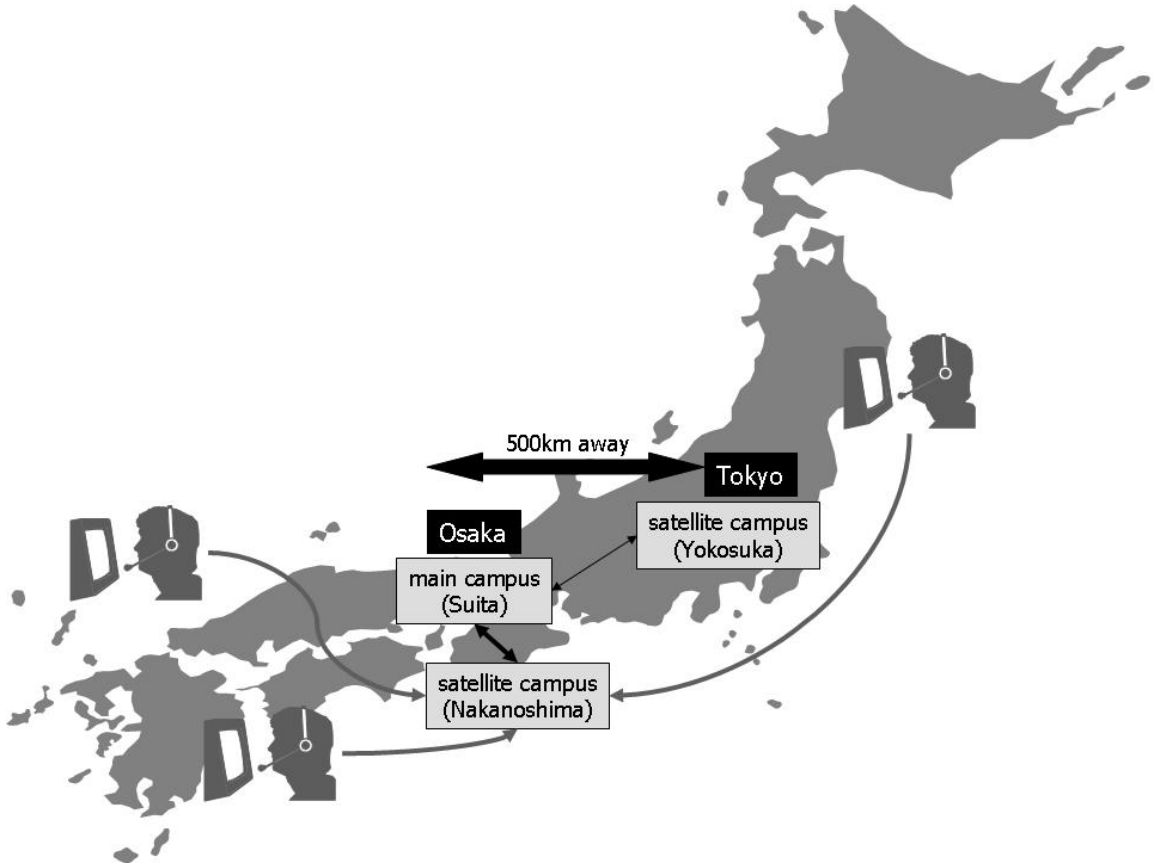

Fig.4 Lecture Environment

2.2.6 Lecture Environment

In the Advanced Introduction to Information Networking and the Exercises on Information Networking I, we utilized the integrated remote lecturing system in our satellite campus, Osaka Nakanoshima Center. The overview of our lecture environment is shown in Fig. 4.

We have the main campus in Suita, Osaka and two satellite campuses in Nakanoshima, Osaka and Tokyo. The main campus and the satellite campus of Osaka Nakanoshima Center is connected by WDM. The main campus and the satellite campus is connected by ISDN.

3. Discussion

We have obtained some comments from the students from their term reports. Here, we summarize comments from visiting students from IT-related companies, since this is the first time for us to invite the students from companies:

- I have obtained really good experience and knowledge from the lecture course, whereas the amount of exercise, in addition to my daily company job, is a little hard for me.
- I have learned many things which I could not obtained if I did not take the lecture course. This was very good

opportunity for me.

- Very interesting contents, such as survey on network security issues, and tcpdump/Ethereal applications which are useful tools for my company job.
- I felt very interested to survey and exercises cooperating with university students.
- It was really good that various kinds of networking technological issues could be learned from the lecture course.

4. Conclusion

This paper reported our trials in Advanced Lecture Course on Information Networking conducted in 2006 at the Department of Information Networking, Graduate School of Information Science and Technology, Osaka University. Through this seminar, the students participating acquired a variety of knowledge with regard to information networking. We have successfully completed the lecture course and we found that most of the students taking the lecture course satisfied the contents and environment of the exercise and lessons.

For the next year's lecture course, we are planning to improve the lecture quality, especially focusing on the following points. Currently, the networking environment of Tokyo satellite campus is not satisfactory: 128Kbps ISDN for connecting to the integrated remote lecturing system and 64Kbps PHS for students to access the Internet. Therefore, we should upgrade the network environment for clear audio/visual transmission for lecture and high-speed Internet access for students. We are also planning to introduce other networking technologies, such as BBS and Weblog/SNS, for activating communication.

5. References

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