A Novel Distance Learning System for the TIDE Project.

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A distance learning system architecture that exchanges information in real time among lecture rooms is discussed. Forty-eight functions are implemented into subsystems and used for the information exchange. Which and how many functions are implemented into each subsystem depends on system design. The distance learning system and a case study of the system design is presented. The system was implemented for the support of two undergraduate courses and was evaluated by a student survey questionnaire. Data from the questionnaire showed that the distance learning system was successfully implemented and transparent for the undergraduate users.

Keywords: **Real-time System, International Project.**

1 Introduction

Research in distance learning has primarily focused on two types of systems: storage based and real time. Real time systems have been seen to be advantageous for interactive discussions between a lecturers and students. For the purposes of this paper, the phrase "distance learning system" refers to a real time type of system. The present paper, addresses the implementation of a real time system to support the TIDE (Trans-Pacific Interactive Distance Education) project. TIDE is a collaborative project among Kyoto University, University of California Los Angeles (UCLA), and Nippon Telephone and Telegraph Corporation (NTT). System architecture, the integration of 48 functions to support the distance learning goals, and other technical issues are discussed. The implementation of the real time system in two undergraduate courses was assessed using questionnaire and survey data.

2 Distance Learning System Architecture

2.1 Information about the lecture

The term lecture is commonly defined as communication between a lecturer and students in a typical lecture hall. However, communication is not limited to that which occurs between the lecturer and the students. Thus, for the purposes of this paper, we use the term "participants" to refer to both lecturers and students. In a typical lecture hall, participants can communicate using all five senses. While audio and visual exchange is easy during a typical lecture, information exchange through smell, taste and touch are more difficult. Thus, in discussing information exchange over a distance, we focused on communication by visual and audio information exchange. Handouts, electronic documents, writing on blackboards, and other nonverbal materials are essential tools for participants involved in a lecture. Additionally, there needs to be a method where participants can point out the visual information of interest to share with other participants. In distance learning situations, pointing needs to be shared among the lecture rooms involved. Thus, in a distance learning environment, the following seven kinds of information need to be exchanged. 1) non-verbal information, 2) content of physical material, 3) content of the electronic material, 4) content of written material, 5) pointing information about the physical material, 6) pointing information about the electronic material, 7) pointing information about the writings. Verbal communication among participants is one of the most important communication exchanges. Teaching materials like videotapes make sounds. These sounds can be mixed with verbal information easily without degradation. Thus, exchanging verbal information is discussed within the framework of exchanging audio information.

2.2 Function classes for the information exchange

In order to exchange information among lecture rooms, the distance learning system needs to 1) capture, 2) encode and 3) transmit the information to the other lecture rooms. The transmitted information needs to be 4) received, 5) decoded and 6) presented in the other lecture rooms. Thus, six function classes are required for the system.

2.3 System Architecture

From the eight kinds of the information and the six function classes, forty-eight functions are required of the distance learning system. Which and how many functions are implemented into a subsystem depends on system design. The following describes the case study of the system design for the TIDE project. Fundamentally, the visual information can be captured as video streams using cameras. Thus, we initially designed a camera subsystem to implement the seven capturing functions to support visual communication. Because visual information can be presented with projectors, we designed a projection subsystem to implement the seven exposing functions of visual communication. Verbal information can be captured with microphones and exposed with speakers. The exposed sounds are captured with the microphones and causes acoustic echo. In order to cancel the echo, we have implemented the capturing and exposing functions into an audio subsystem. The visual and audio information need to be encoded at the same time for synchronization and the encoded information needs to be decoded at other lecture rooms. To address these issues, we designed a codec subsystem. For transmitting and receiving encoded information from the codec subsystem, we designed a quality of service guaranteed network subsystem. During a lecture, several video streams need to be exchanged because the talking participant and the teaching material are not always occurring in the same location. Unfortunately, our network subsystem has limited bandwidth and it allows the codec subsystem to exchange only one video stream at a time. Thus, we redesigned our system using PC based subsystems as follows: Using an electronic whiteboard, writing content can be captured as vector data. The data can be encoded and decoded on a PC. Thus, we designed an electronic whiteboard subsystem to implement capturing, encoding and decoding of the writing. Because vector data does not require the bandwidth required for audio/video streams, it is transmitted and received over the Internet. When the material on a PC is used, content and pointing information exists locally on the PC and needs to be transmitted and synced with the rest of the components. Thus, we designed a teaching material synchronizing subsystem to implement capturing, encoding and decoding whiteboard functions. The synchronizing subsystem also transmits and receives information over the Internet. Based on the discussion above, Figure 1 shows our distance learning system architecture. Each block in Figure 1 represents a subsystem.

3 Distance learning system for the TIDE project

3.1 Audio subsystem

The audio subsystem needs to address problems with acoustic echo and electronic echo. The electronic echo occurs when a received signal is mixed into the transmitting signal. In our audio subsystem, multiple audio mixers are used to separate the received signal and the transmitting signal.

3.2 Camera subsystem

The camera subsystem consists of four observation cameras and four shooting cameras. Checking the motion region in the successive two frames of video images from the observation camera detects the region of the participant on the image frame. The location of the participant is calculated by giving, in advance, the camera parameters of location, direction, focal length, image aspect, etc. After that, the appropriate camera, camera pan, tilt, and zoom, are chosen to shoot the moving object and/or speaking participant [4].

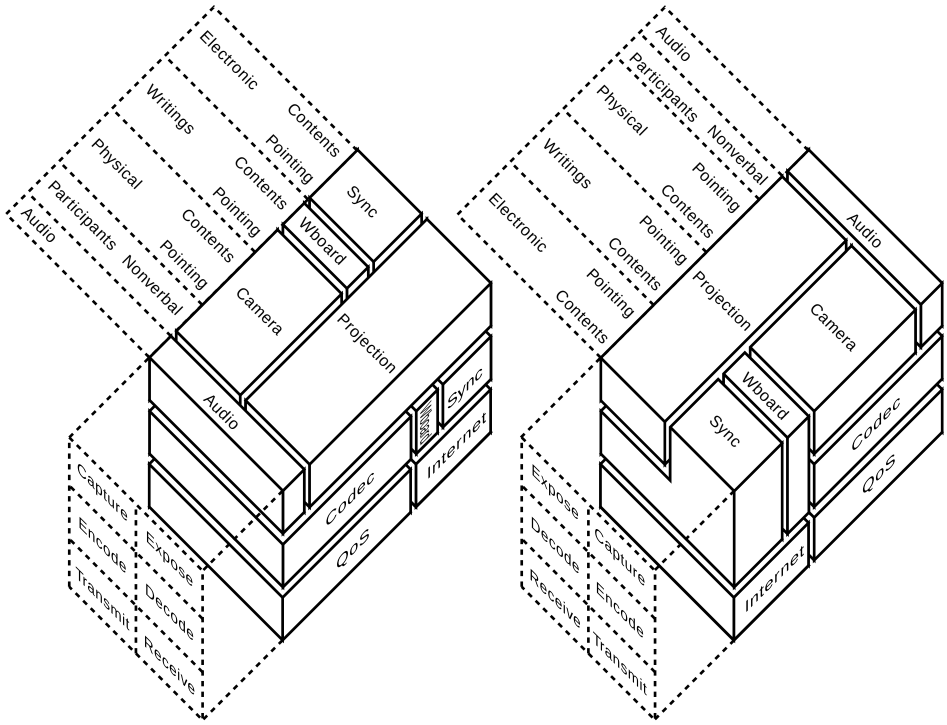

Figure 1: The system architecture of the distance learning system designed for the TIDE project.

3.3 Codec subsystem

For real time communication among participants, the delay caused by encoding and decoding needs to be minimized. It is very time consuming to make highly compressed data streams without degrading quality. For the purposes of this system, the MPEG2 standard was chosen for our codec subsystem. The codec encodes and decodes audio/video signal of 3Mbps in 300 msec.

3.4 Electronic whiteboard subsystem

The electronic whiteboard has two laser scanners on the top and observes position and color of writing marker. The observed position and color information is transferred from the whiteboard to the PC via serial connection. The transferred information can be easily browsed on a PC monitor. Additionally, the whiteboard information can be browsed simultaneously in multiple locations over the Internet.

3.5 Projection subsystem

The projection subsystem presents visual information on video screens. In a lecture hall, it is optimal if students are able to see the screen and the lecturer at the same time. Likewise, it is important that the lecturer also see the screen and students simultaneously. To address these issues, our projection subsystem has large screens behind the lecturer for student viewing, as well as small video monitors in front of the lectern for lecturer viewing.

3.6 Quality of service guaranteed network subsystem

For the stable transmission of the data stream, the system mainly uses ATM (Asynchronous Transfer Mode) network technology. The network subsystem is composed of three parts: GEMnet[1], CalREN2 [2] and Abilene[3]. GEMnet is an intra ATM network of NTT. CalREN2 and Abilene are parts of Internet2 in the United States. GEMnet interconnects Kyoto University and the NTT America Cupertino office over the Pacific Ocean. On the GEMnet, a PVC(Permanent Virtual Channel)connection is reserved with a guaranteed bandwidth of bi-directional CBR(Constant Bit Rate) 5Mbps.

Table 1: Regression coefficients of the principal component of the questionnaire survey.

Principal Coefficient	Middle	End
Interactivity	0.322	0.382
Quality of the teaching materials	(0.107)	0.414
Effectual manipulation of the system	0.304	(0.168)
Presence	0.561	0.637
Unstability of the system	-0.257	(-0.143)

3.7 Teaching material synchronizing subsystem

In order to present the electronic material to all lecture halls simultaneously, the synchronizing subsystem pre-loads the teaching material and transmits the mouse events. This software is appropriate for presenting dynamic teaching materials like movie files.

4 Evaluation

We have conducted two courses between Kyoto University and UCLA from October through December 1999 using our distance learning system. The distance learning system is evaluated by survey questionnaires given to the students at the middle and upon conclusion of each course[5]. The questionnaires asked students to rate various factors of the course on a scale of 1 to 5. We performed a principal component analysis of the survey and found following principal components: 1) interactivity, 2) quality of the teaching materials, 3) manipulation of the system, 4) presence and 5) instability of the system. We also performed a regression analysis to identify predictions of satisfactory grades in the courses. Table 1 shows the regression coefficients derived from the analysis. The coefficients in parentheses exceed the significance level of 5%. As the course proceeded, students' attention shifted from the novelty associated with the new technologies to the teaching materials and course content. This indicated that our system was of high enough quality to be a transparent medium for the students.

5 Conclusions

In this paper, we discussed a distance learning system architecture that exchanged information in real time among lecture halls. After identifying that there exist forty-eight functions required for information exchange, the distance learning system was introduced as a case study. We introduced the seven necessary subsystems and the technical issues surrounding the implementation of these subsystems. Our system was used for two undergraduate courses and evaluated by a survey questionnaire. The data from the questionnaire showed that our system, over time, became transparent for the students.

References

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