ATM and Wireless Experiments for Remote Lectures

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ABSTRACT In this article we examine our remote lecture experiments using ATM and UNII wireless devices. We discussed which functions should be improved in the current distance-learning system. UNII/SUPERNet wireless devices are introduced for achieving economical distance-learning systems. Two experiments of remote lectures are detailed: a wireless experiment between two buildings in the Philippines and an ATM experiment between Japan and the United States.

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In this article we examine our remote lecture experiments. Through our experiences we have found two indispensable functions for remote lectures: prepared document handling and unprepared document handling. In our experiments, we have mostly used prepared multimedia documents including text forms, image forms, sound forms and video forms. Between two geographically separated rooms, a teacher gave a live lecture to students over a bi-directional communication link over which they can communicate with each other by video and audio signals. The teacher can remotely control several cameras that can observe the behavior of the students. The role of remotely controlled cameras is crucial to synchronize the pace of students' understanding of the lectured subject, enabling the lecturer to determine whether to proceed to the next subject or review the current subject. Current distance-learning systems including hardware and software need to be significantly improved in order to satisfy the requirements of remote teachers. The cost of distance-learning systems and communications should also be greatly reduced. From the perspective of the system's cost, the use of wireless devices as described in this article might be suitable. Unprepared, timely documents, including today's newspaper articles and new discoveries aired on TV, could be presented and explained in a live remote lecture. Through our remote-lecture experiments, required functions for distance-learning are recommended in this article. Two experiments of remote lectures are detailed: a wireless experiment between two buildings in the Philippines and an ATM experiment between Japan and the United States.

A MINIMUM SYSTEM FOR REMOTE LECTURES

The minimum system for remote lectures might be composed of a communication software program and two networked machines. For example, two video camera-equipped laptop machines with a 10BaseT Ethernet interface can be networked by a single reversed twisted pair cable at a distance up to 100 meters. A video conferencing program such as CuSeeMe (http://www.cuseeme.com/) or NetMeeting (http://www.microsoft.com/netmeeting/) can be run on each machine. Video cameras are available for less than $100. One machine may be hooked up to a TV set or a LCD projector for wide audiences. Ethernet hubs or repeaters can extend the network line distance. Although an inexpensive video conferencing system might be suitable for low quality remote lectures, it is very difficult to cope with unprepared document handling. Low quality video may also discourage students from concentrating during the live lecture. With low quality video in an inexpensive system, it is necessary to have telephone-quality transmission of voice for the live lectures. In order to improve the quality of remote lectures using an inexpensive video conferencing system, real-time video compression/decompression chips such as mpeg4 chips are needed in the near future.

WIRELESS REMOTE LECTURES

We experimented with UNII/SUPERNET (Unlicensed National Information Infrastructure/Shared Unlicensed PErsonal Radio NETwork) [1] wireless devices for remote lectures in Manila, the Philippines in January and February 1998. We placed a laptop machine configured with a clip-video camera on two line-of-sight buildings: one atop the national computer center and the other on the balcony of the University of the Philippines, at a distance of approximately one kilometer. A NetMeeting program was running on each machine. We used inexpensive UNII spread spectrum devices with omni antenna for our experiment of 3 Mb/s communications. The street price of a UNII spread spectrum device or a 2.4 GHz unlicensed device may be less than $2000, with the cost dependent on the communication bandwidth. We successfully demonstrated a remote lecture from the balcony to audiences in the national computer center on a rainy day. Our next wireless experiment for remote lectures will be conducted between two islands.

The idea of UNII/SUPERNET devices [1] was introduced officially by the United States government on January 9, 1997. Before the Federal Communications Commission of the United States introduced UNII regulations, the European Union introduced the new regulation of HIPERLAN (HIgh Performance European Radio LAN) in which the unlicensed frequency range is from 5.15 GHz to 5.30 GHz with power of up to 1 W. HIPERLAN devices are designed for use at 20Mb/s in the European Union. In UNII devices the unlicensed frequency range is from 5.15 GHz to 5.25

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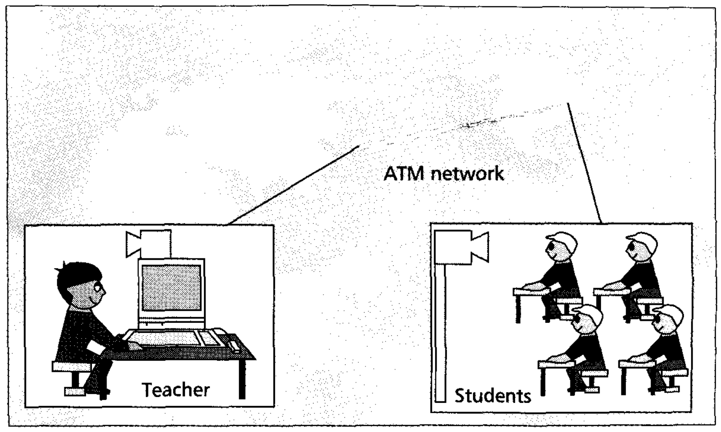
GHz with power of 200 mW EIRP (Effective Isotropic Radiated Power), from 5.25 GHz to 5.35 GHz with power of 1 W EIRP, and from 5.725 GHz to 5.825 GHz with power of 4 W EIRP for use of up to 25 Mb/s. With proper antennas we can establish the high speed communication over a distance of miles without the need for a license both in the European Union and the United States.

Introduction of UNII by the FCC of the United States government:

By this action, we amend Part 15 of our rules to make available 300 mHz of spectrum at 5.15-5.35 GHz and 5.725-5.825 GHz for use by a new category of unlicensed equipment, called Unlicensed National Information Infrastructure ("U-NII") devices. These devices will provide short-range, high speed wireless digital communications on an unlicensed basis. We anticipate that U-NII devices will support the creation of new wireless local area networks ("LANs") and will facilitate wireless access to the National Information Infrastructure ("NII"). In order to permit significant flexibility in the design and operation of these devices, we are adopting the minimum technical rules necessary to prevent interference to other services and to ensure that the spectrum is used efficiently. We believe that the rules set forth herein will foster the development of a broad range of new devices and service offerings that will stimulate economic development and the growth of new industries. We also expect that this action will promote the ability of U.S. manufacturers, including small businesses, to compete globally by enabling them to develop unlicensed digital communications products for the world market.

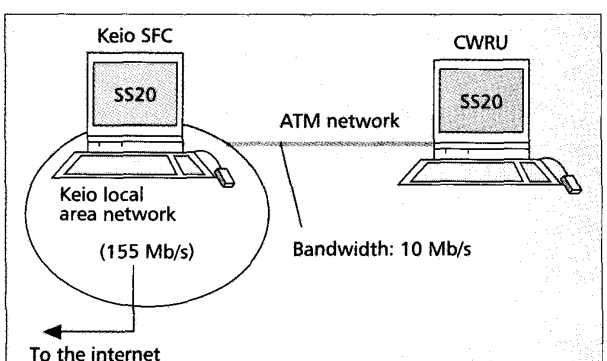


■ **Figure 1.** *ATM remote lectures between Japan and the United States.*

ATM Remote Lectures between Japan and the United States

At the end of 1996, several experimental remote lectures had been conducted between Keio University in Japan and Case Western Reserve University in the United States as a multimedia application of the first international connection experiment using an ATM network between Japan and the United States [2] (Fig. 1).

We now report the results of the experiment and discuss the requirements for sending remote lectures over an ATM network. Distance learning software used in our experiment is discussed from the viewpoint of feasibility and friendliness where advantages and disadvantages are mentioned.



■ **Figure 2.** *ATM network configuration.*

ATM Experiment

We held experimental remote lectures between a room of Shonan Fujisawa Campus at Keio University in Japan and a room of Case Western Reserve University in the United States (Fig. 2). Dr. Takefuji in the laboratory at Shonan Fujisawa Campus as a teacher had taught the total number of more than ten information processing graduate students in the remote lecture room at Case Western Reserve University.

We deployed workstations at Shonan Fujisawa Campus and Case Western Reserve University respectively where they were connected over the ATM network. The communication speed between the two sites was the maximum bandwidth of 10 Mb/s. The workstation in Japan was also connected to the Internet during the lectures.

We used the "Communique!" [3] video conferencing application where a teacher and students could see each other and they could also ask questions. The teacher used the WWW as one source of teaching materials and showed the students various materials, including text on paper, a PDA, or a notebook computer where an overhead camera is used for capturing text and pictures in real time.

During the lecture, the teacher was operating all applications and switches, and controlling the direction of a camera on the students' side by himself. On the students' side, one operator, not a teacher, was controlling sound volume and a layout of applications windows.

We evaluated the effectiveness of four lectures by measuring the ATM cell-transfer rates, by administering questionnaires to the participants, and by interviewing the teacher.

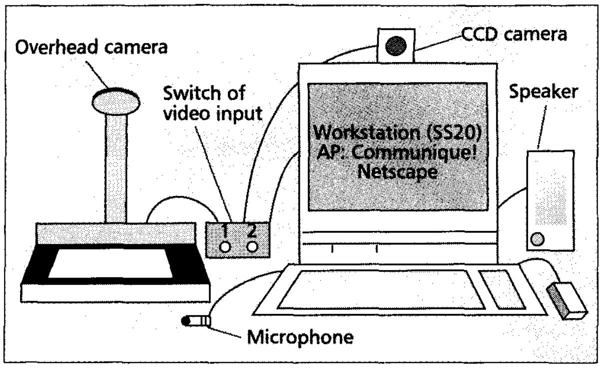
As a trial, we used the Internet and the ATM respectively where the video image was sent by "Communique!" for evaluating the quality of "Communique!" over an ATM network compared with tranmission over the Internet.

Experimental Result

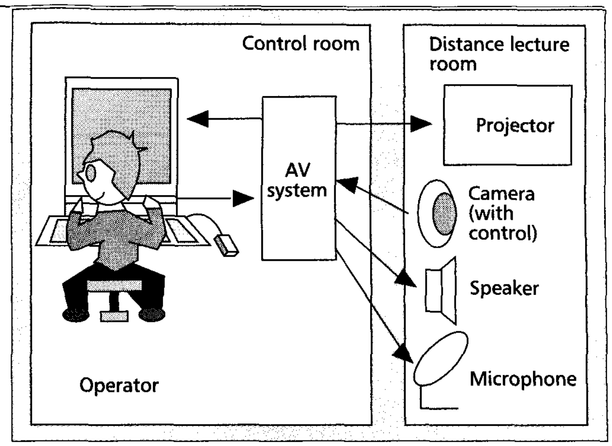
Requirements for remote lectures over the ATM network from the viewpoint of the quality of images and sounds are now summarized.

Quality of the Video Image — When we used "Communique!" the average ATM throughput was 1300 Kb/s, and the average frame rate was 22 fps. The average throughput over the Internet was 900 Kb/s, and the average frame rate was 15 fps. On the questionnaire, eight of ten students considered the video image to be "average" or "smooth."

Quality of Audio — Nine of the ten students described the audio delay as "could not notice" or "very short." Six students



■ **Figure 3.** *ATM environment on the teacher's side.*



■ **Figure 4.** *ATM equipment on the student's side.*

described the audio as "clear" while four said it was "a little unclear." During the question and answer session, severe echoes arose, making it hard to establish a bi-directional communication link. Nine of ten students complained about this problem. When we used "Communique!" over the Internet, the audio was frequently interrupted and was less clear than when transmitted over the ATM network.

Teaching Materials — The workstation on the teacher's side (Fig. 3) was connected to the Internet from which the teacher provided Web-based information as teaching materials. The teacher could use various media and the newest information, and presented more effective lectures to the students.

However, when we used a shared application function to display the same Netscape Browser window at each site, it took more than twice as long as when displayed without this function. There was no appropriate or easy way to present the screen on a PDA or a notebook computer to students through our system. We could only use the overhead camera for this purpose. There was no effective pointing device between the two sites (Fig. 4).

Time Difference — These lectures started at seven o'clock in the evening at Cleveland (students' side) and nine o'clock in the morning at Kanagawa (teacher's side) because there is a fourteen-hour time difference between Cleveland and Kanagawa. Because of the late starting time, the number of participants was small, and it was sometimes difficult to perform remote lectures. This technology may be more effective as a complement to regular off-line lecture courses.

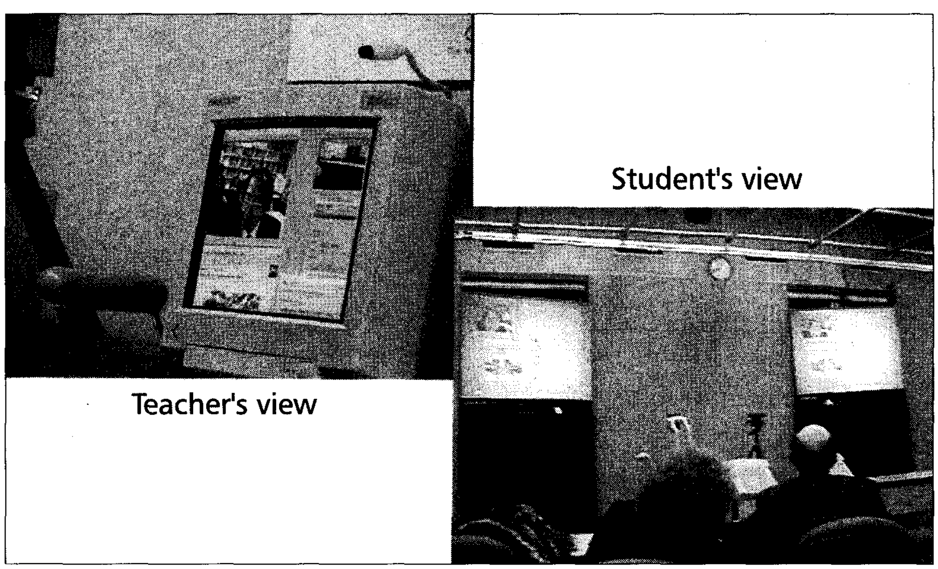
Usability (Fig. 5) — The teacher could operate the direction of a camera on the students' site to check the condition of the students. However, he couldn't see the screen that the students were watching, and it was difficult for the teacher to communicate with the operators. It is very important for a teacher to observe the screen that the students were watching in order for the teacher to point and direct the students to the appropriate material.

Remote Lectures In the Future — In response to the questionnaire, we obtained the following opinions about remote lectures in the future:

- In the near future, tele-education will become very important.
- It is necessary to develop a remote lecturing system that is economical and simple to run, and which can be used without any operator.
- Anyone should be able to attend various lectures sponsored by universities at anytime from anyplace for possible certified degrees.

CONCLUSIONS

- Based upon the result of UNII wireless devices, the experiment of long-distance and wide-area networks should be examined for further study.
- Considering the quality of the video image and the audio, it is difficult to hold remote lectures over the Internet. On the other hand, a 10-Mb/s international ATM connection provides an adequate performance for real-time remote lecturing.
- The audio channel is more important than the video channel for remote lectures.
- It is necessary for teachers to show students various media for teaching materials. Specifically, it is necessary to display all pages that teachers obtain from the Web in real time.



■ **Figure 5.** *ATM remote lecture scenes.*

- A seamless environment must be created in which teachers and students forget about the geographical separation. The teacher should observe the pace of the students' understanding and be able to point to teaching materials as is done in a real classroom environment.

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BIOGRAPHIES

YOSHIYASU TAKEFUJI (takefuji@sfc.keio.ac.jp) has been a professor at Keio University from 1992. He was on the faculties of Case Western Reserve Univ. from 1988 to 1992, the Univ. of South Caroline from 1985 to 1988, and the Univ. of South Florida from 1983 to 1985. He has conducted research in neural computing and hyperspectral computing. He has served as a government advisor to the NCC of the Philippines, the Vietnam Information Technology Training Institute, and the Multimedia Univ. in Malaysia. He has published more than 16 books and more than 160 papers.

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