ON OPERATIONAL SCHEME FOR REMOTE LECTURES IN INTER-UNIVERSITY DISTANCE LEARNING PROJECT

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Abstract: This paper proposes an operational scheme to support remote lectures in an inter-university distance learning project. Besides the significant improvement of video conference systems, the operational aspect of remote lectures among participating universities tends to be less attended because its operation is basically independent in each university. Lack of a practical experience on operating remote lectures will introduce factors of reducing the quality, scalability or sustainability of the distance learning project. Our solution is to standardize the operational scheme among participating universities based on the concept of Layered Architecture of the remote lecture environment, Administrator that can access and maintain the entire environment, and Centralized Application Network to achieve these features. The proposed scheme has been evaluated at the actual operation of more than 600 remote lectures in an inter-university distance learning program in Japan since 2007.

1 INTRODUCTION

The evolution of broadband Internet and Videoconference system has led to a rise in the sharing and distribution of video and audio lectures among universities around the world. Inter-university distance learning promises to build a new educational curriculum that will improve lecture lineups at each participating university. However, general guidelines regarding how to operate an entire remote lecture have yet to be actively addressed. This is largely due to the fact that the operations of distance learning environments are independently managed at each participating university. This situation prevents inter-university distance learning projects from keeping the quality of remote lectures high and continuing them throughout a semester or an academic year.

This paper proposes a method for the operation of distance learning environments that ensures 1) consistent communication among remote classrooms, 2) scalable operations and 3) sustainable lectures. This scheme has been conducted since 2007 to support more than 600 remote lectures.

This paper shares best practices for conducting remote lectures through one or more academic semesters. We expect our findings will benefit those who want to launch new distance education projects, or improve existing ones in a practical manner.

2 DISTANCE LEARNING ENVIRONMENT

2.1 Remote Lectures

We define a conventional lecture in this paper as being composed of a talk from a lecturer to students, and a Q&A session between the lecturer and students during or after the lecture. A distance-learning environment for remote lectures consists of one or more remote classrooms that are connected to the Internet and attended by student participants. Students may either be present in the actual room with the lecturer, in a remote classroom, or both.

This research assumes that a remote lecturer performs this conventional lecture with multiple remote classrooms in real-time. A lecturer's talk is primar-

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ily delivered via video and voice. Other lecture materials, such as PowerPoint slides, writings on a black board, or images from a document camera are sent via video to the viewer's screen . Gestures of the lecturer are also included in the video to add more contextual information, such as pointing to materials, etc. Meanwhile, students send feedback to the lecturer via video and audio by chatting, clapping, laughing, raising a hand and/or asking a question.

2.2 Requirement Organization

The distance learning environment is the remote lecture facility within the university, including Internet connectivity, videoconference tools, and other multimedia communication tools. Distance learning environment operations are classified into one of three categories: (1) maintaining remote classrooms before and after a lecture, (2) troubleshooting during the lecture, and (3) designing and installing a new remote classroom to invite another university.

This paper introduces the following three requirements to conduct remote lectures: (1) positional awareness and countenance recognition to ensure consistent communication and quality, (2) mechanism to share one or a small number of skilled operators among remote classrooms, and (3) engineering to account for the heterogeneity of remote classroom environments and sustain operations. The following section explores solutions that satisfy requirements to these issues.

3 ISSUES ON OPERATION

3.1 Inconsistent Classroom Layout

Classroom layout tends to be inconsistent among remote classes because the layout is not attended as much as the performance of facility or network connectivity. The inconsistent layout reduces the positional awareness among remote classrooms and the countenance recognition in communication.

In Figure 1 the lecturer and the lecture material are located in opposing position between two classrooms. If the lecturer gazes to the material screen (the dashed arrow to upper right), it is natural students at the remote classroom follow the gaze direction. However, the material is screened at the opposite side in the remote classroom, and thus it may makes the students in remote feel uncomfortable. Use of relative terms, such as ”on your right side” to indicate direction, also introduces the same conflict.

Meanwhile, the layout in Figure 1 makes face-to-face communication unavailable. The lecturer turns to the remote classroom screen to talks to student (the solid arrow to upper left). Hence the student in remote looks at the lecturer from the camera in back of the room. In this situation, it is difficult to recognize their countenance with each other.

3.2 Complexity of Operation

Each component of a remote classroom relies on its underlying facility, thus operating the classroom requires understanding and high operational skill on audio and visual facility, video conferencing tool and network. For example, if the audio quality gets radically reduced during a remote lecture, the cause of trouble should be quickly found and then fixed. However, the cause may be the hardware trouble of audio facility, inappropriate configuration of video conferencing tool or sudden change on network state possibly in both the classroom in local or remote.

Given that a lecturer and students should focus their lecture, at least one dedicated operator should be assigned to conduct a lecture in each remote classroom. However, in general, it is difficult to cultivate such an operator in each participating university. Hiring a skilled operator is expensive and not cost effective, depending on the frequency of remote lectures. These situation indicates that current operational scheme is not scalable, and distance education projects will suffer from lack of skillful operators.

3.3 Lack of Sustainability

Heterogeneity and accessibility among remote classrooms reduce the sustainability of conducting a series of remote lectures during a semester or an academic year. In an inter-university project, the specification or functionality of remote classroom can be different from each other in terms of facility, video conferencing tool or network connection. If not all universities can assign their own operator in each classroom, such heterogeneity introduces difficulty for an operator to handle another remote classroom by necessity.

Even if an operator has enough skill to handle multiple classrooms, access to the remote classroom in another university may not be available. The operator has to be granted the network access from outside to the university and the facility or video conference tool of remote classroom need to support remote monitoring and control over network. Besides the issues on operational policy in each participating university, enabling more monitoring and control functionality requires a large investment.

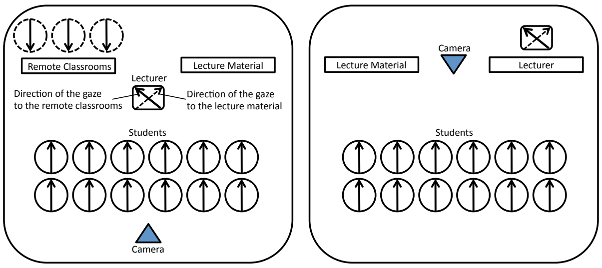

Figure 1: Example of Inconsistent Layout between Two Remote Classrooms.

4 SCHEME DESIGN

This section proposes three concepts to improve the operational scheme of inter-university distance learning environments: **Layered Architecture**, and **Centralized Application Network**.

4.1 Layered Architecture

The layered architecture is a method for classifying the distance-learning environment into classroom components and illustrating the relationships between each layer. We classify the environment into four layers according to function: User, Facility, Application, and Network (Figure 2).

By using this, differences in each layer become unvisible to users. At classrooms, available network bandwidth or existing A/V equipment are different in each case. However, each layer is independent from other layers, the layered architecture provides a consitent user experience.

In each layer we highlight the factors necessary to standardize the quality of remote lectures. The following sections describe the design of the architecture's components.

4.1.1 Administrator and Users

An "Administrator" is defined as one or a very small group of operators that can take over the operation of remote classrooms participating in a lecture. The administrator is granted access to all layers in the proposed architecture. 'Users' are defined as the participating players of a remote lecture, including: a lecturer, students and a teaching assistant who is assigned to support the lecture at each university. Normally, users do not operate the remote classroom. One requirement for users is the capability to communicate with an administrator online. One user is enough to satisfy this requirement, thus a teaching assistant is a promising vehicle for this type of communication, especially in the case of hardware trouble in the remote classroom. The biggest benefit of this proposed scheme is that a remote lecture can be conducted without an operator in the remote classroom. This is possible by enabling remote monitoring and control of well-organized classroom components.

4.1.2 Standard Classroom Layout

The standard classroom layout is defined in the facility layer to assign the appropriate position of users and video devices in each remote classroom. This layout enables both the consistency of direction awareness and countenance recognition between the lecturer and students in a remote classroom. In the following scenario, one lecturer gives a talk to students in the same classroom and the remote classrooms. As shown in Figure 3, this layout requires three screens and two video cameras to screen and send videos for the remote lectures.

Camera 2 sends the video of lecturer's talk in the center of the classroom, and the lecturer's talk is screened on Screen 2 in each of the remote classrooms. Screen 1 is dedicated to screen the video of the presentation material. Screen 3 screens the video of students from Camera 1 in the remote classrooms, so that the lecturer can give the talk or answer questions face-to-face with students in the remote classrooms. In the remote classrooms, Screen 3 and Camera 2 allow students to present in the lecturer's position. Normally, this would not be capable in a remote lecture involving a lecturer's talk and Q&As. With this layout, the consistency of eye-gaze direction and the face-to-face communication is preserved among participants.

4.1.3 Standard Audio Environment

The audio environment of the remote classroom is also defined in the facility layer. In addition to the sampling frequency of audio, suppressing echoes and sharing classroom environment sounds is a key factor to maintaining audio quality in remote lectures. Echo

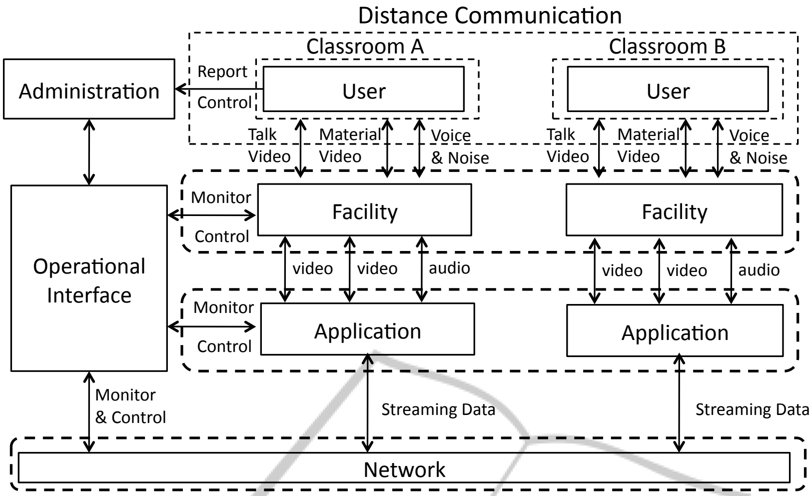

Figure 2: Layered Architecture Overview and Interaction between Layers in Proposed Operational Scheme.

suppression is an important factor for creating natural conversation among remote classrooms where microphones and speakers are active in the same room. Echo suppression has to be ensured either in this layer, or the underlying layers. Sharing environment sounds in each classroom contributes to a feeling of togetherness among remote classrooms. This sounds also provides feedback to a lecturer and helps him gauge his talk according to the students' reactions. As long as echo suppression is effective and well managed, additional microphones to catch environment sounds in the classrooms will have a positive effect.

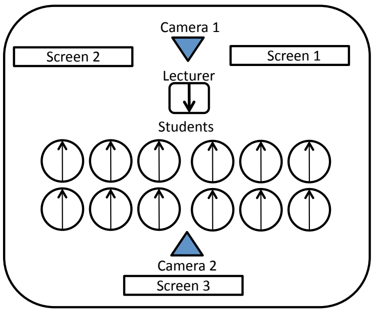

Figure 3: Standard Layout of Remote Classrooms.

4.1.4 Facility Operation

The objective of operations at the facility layer is to remotely monitor and control the audio and visual (A/V) facility in each classroom. This paper introduces two methods to achieve remote operation: 1) a system controller to monitor and control the A/V facility, and 2) a networked camera to monitor actual audio and video in the remote classroom. The system controller needs to support the following operations remotely: 1) power management of A/V equipment, 2) input selection for the various video and screen devices, 3) output selection for the video devices used to send video to the remote classrooms, 4) muting and unmuting outgoing audio, and 5) classroom volume control. This system assumes remote access will be performed using the Internet, so that various authenticated devices can control the A/V equipment in an appropriate manner. The use of a networked camera helps the administrator to monitor the actual ongoing audio and video status of the classroom facility. The system manager only provides feedback regarding the values of each managed parameter. Through the combination of a system controller and a networked camera, an administrator can monitor and control the status of remote classrooms more accurately and appropriately.

4.2 Centralized Application Network

The Centralized application network allows the interface to monitor and control the application layer. As shown in Figure 4, the topology of this network includes the following components: 1) A center HUB to aggregate the video conference sessions among remote classrooms, 2) Classroom Terminal to provide video conference to and from the remote classrooms, 3) Unified Monitor and Controller to provide an operational interface to the administrator, 4) VPN Gateway and Client to create an end-to-end path between the center HUB and the classroom terminal through a firewall or NAT, and 5) a Portable Terminal to install temporarily in the classroom.

The center HUB extends the number of classroom terminals that simultaneously join to a single videoconference session. The Unified Monitor and Controller provides control and power schedule of spe-

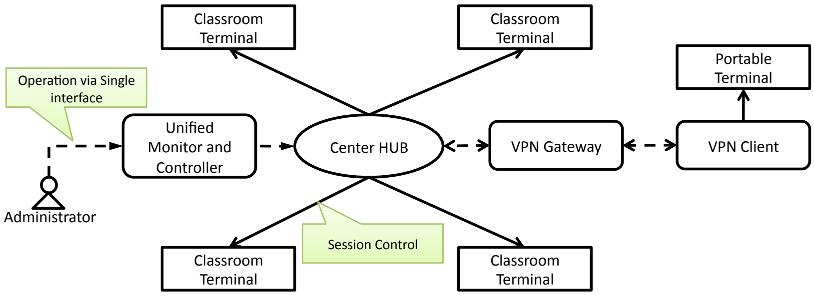

Figure 4: Application Network Connecting Each Components in Application Layer.

cific classroom terminals. This allows the videoconference session of each remote class to be automatically established and scheduled among remote classrooms. By applying the system controller and the centralized application network concurrently, the remote lecture can be scheduled to start automatically without requiring any staff to be on standby in the classroom.

5 IMPLEMENTATION

We implemented a remote lecture environment for the Information Technology Specialist Program (ITSP)(Keio University, 2010). The ITSP is an educational collaboration project made up of 5 graduate schools from 4 universities, 2 commercial companies, and a NPO. Figure 5 illustrates an overview of the implementation. Section 5 describes this implementation. The implementation consists of 5 classrooms, one in each graduate school, and control and monitoring facilities on the Internet.

5.1 Facility Operation

For this project, we implemented the system controller to control the classroom facilities and acquire their status. In this implementation, we introduced a touch panel user interface in the classroom and enabled web-based access to an administrator in a remote location, as shown in Figure 6, 7. The controller's configuration parameters on the touch panel interface and the web-based interface were identical.

The system controller asks the user to select whether the classroom is receiving or sending the lecture, so that it can appropriately configure classroom facility.

Due to differences in the size and capacity of each classroom, A/V equipment differs in each classroom. Even using a different equipment, function and accessibility is unified among these remote classrooms. Networked cameras were installed in positions that allowed the administrator to monitor screens 1, 2, and 3 in each classroom. Through the web interface, the administrator is able to remotely monitor and manage audio and video with a camera control (zooming and moving direction).

5.2 Scalable Video Conference System and Operation

The centralized application network is implemented as a H.323 videoconference system, as shown in Figure 8. The actual equipment we installed in the classroom are Polycom HDX series, also RMX 2000 is used for the MCU. The following describes the mechanics of how the system works.

1. When connected to the network, the endpoints are configured to register themselves to Gate Keeper(GK)
2. The GK monitors the status of the MCU and the endpoints.
3. An administrator makes a reservation for lectures in advance.
4. 10 minutes before the lecture, the GK cinstructs the MCU to establish the connection.
5. 10 minutes after the lecture, GK instructs MCU to terminate the connection.

In this system, we used 720p H.264 video, 14 KHz G.722.1C audio, and 720p H.239 lecture material with at least a 2 Mbps connection between each endpoint and the MCU. 720p video has become popular in the marketplace and is good enough to provide visibility of shared lecture materials, as well as countenance recognition. Likewise, 14 KHz audio has enough quality for students to focus on the lecture (Rodman, 2003). These parameters (especially the encoding) may vary depending on the network conditions of the classroom. Weak network conditions may require the use of SD video quality.

Monitoring the functionality of the application layer is enabled on the GK. Since it monitors and controls all the endpoints and the MCU, it can acquire

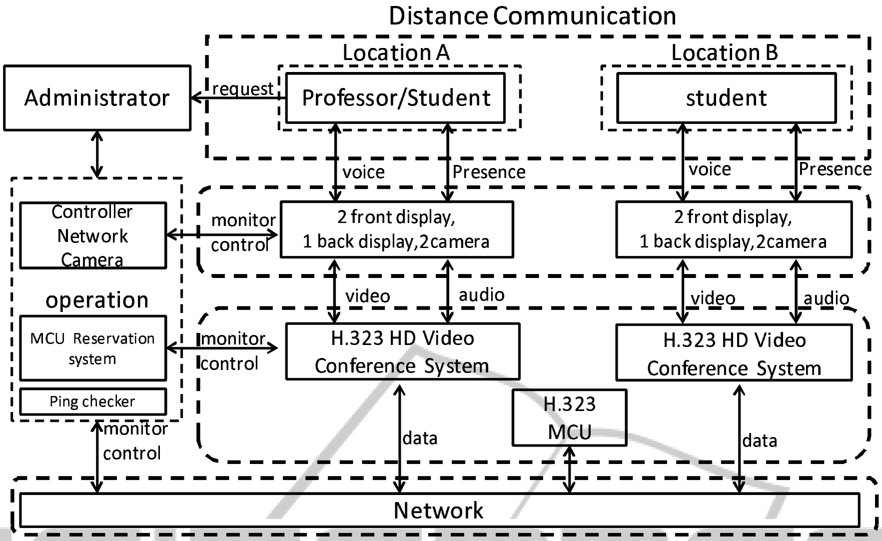

Figure 5: The ITSP Remote Lecture Environment.

their status through a single interface. In the case of ITSP, the administrator received an alert from the GK when a problem was detected.

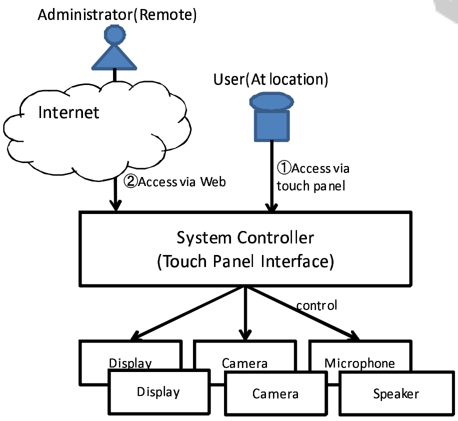

Figure 6: System Controller Overview.

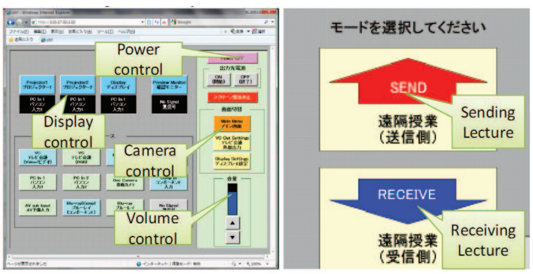

Figure 7: System Controller: Touch Panel User Interface.

5.3 Temporary Classroom

To add temporary classrooms, a VPN Gateway and Client are used to mitigate the difficulties caused by networks, such as firewalls and NAT. Also, preconfigured equipment set which is made up with following components are made.(1) an endpoint (2) VPN Client, (3)required cables, and (4)instruction for user installation.

5.4 Network Connectivity

Our remote lecture environment used a commodity network, which is maintained by each participating university. Operation of the remote classroom also uses the commodity network.

Basically, the administrator's role in the application layer is to monitor the connectivity, and contact the network operator of each university to manage troubleshooting activities if and when needed.

Compared to the remote classrooms, bandwidth requirements for the MCU are high. This is because all the traffic from the remote classrooms comes into the MCU, and the aggregated traffic is then sent back out to them. For example, HD 720p connection over H.323 requires at least 2Mbps. In order to accommodate the MCU, we installed a gigabit Ethernet uplink directly to the campus network backbone. The bandwidth required at the MCU will differ depending on the number of classrooms being connected.

To monitor the end-to-end connectivity of each remote classroom, we use the ping-monitoring tool to capture the state. It sends a ping message once a minute to all network connected equipment. If conse-

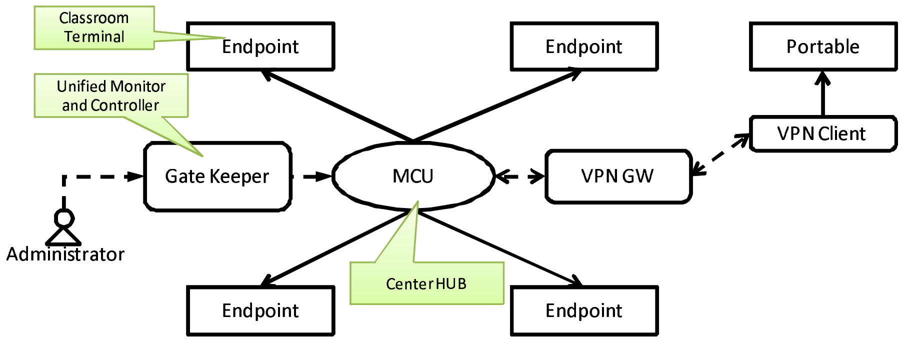

Figure 8: H.323 Based Application Network.

cutive failures are detected, an alert message is sent to the administrator. When the source of a failure is located and needs to be inspected inside the participating university, the administrator contacts the local network management division of the university for trouble shooting.

5.5 Sustainable Operation

We designed the operation scheme to be operated remotely by an administrator. The system is capable of operating fully by remote management. This includes the monitoring of actual video and audio, which is played in the classroom to confirm the situation. However, when the number of classrooms becomes large, the administrator's load becomes too high. For example, checking the actual video and audio in each classroom may take too much time. After the classroom is connected automatically, communication between the administrator and TA just before the lecture starts can reduce this time. If a problem is detected, then the TA can immediately ask the administrator for support.

6 DISCUSSION

6.1 Lessons from ITSP Lectures

Through this system, we have operated more than 600 remote lectures from 2007 to 2009, and continue to use the system today. Some of these lectures are not limited to the original 5 ITSP classrooms we described, and share lectures with additional universities.Therefore we have opened upto 6 points remote lectures. From the operation of the ITSP environment, we have learned three major lessons.

Having a TA Present in the Classroom is effective in maintaining the quality of the environment. When remotely operating the classroom environment, a TA can verify the facility's operations, and quickly respond to troubles in the classroom. Also, the TA can provide additional support to the administrator on specific operations that cannot be performed remotely. This is critical when administrator cannot access the equipment remotely due to network or equipment failure.

Backup is Extremely Important. If a lecture is cancelled due to technical issues, scheduling make up classes and so forth can cause a great deal of irritation and disruption to all users. To avoid such problems, it is important to implement system redundancy. For example, in the event of an MCU failure, the ITSP environment has an alternative MCU instance at one of the endpoints. With support from the administrator, the system may continue working. The ITSP environment also provides video archives to participants, allowing them to view past lectures that they may have missed, or wish to review.

The Administrator Took Care of Multiple Classrooms. In ITSP environment, single administrator was enough to take care of 5 remote classrooms. This is a promising step towards improving the scalability and sustainability of remote lecture environments, especially when compared to the legacy way of having 5 dedicated operation staff for each classroom.

Moreover, the portable terminal package allows remote lecture projects to be flexible both in the short term and long term regarding changes to which universities are participating and how many. This feature also contributes to the improved sustainability of interuniversity distance learning projects.

6.2 Consistency of Communication

Our remote lecture environment can share a lecturer's eye gaze, and enable face-to-face communication among class rooms. We have confirmed the following: (1) When a lecturer is speaking to a student in a remote classroom, eye contact is made between the lecturer and students. (2) When a lecturer gazes at his/her lecture material on the screen in the classroom, students can follow the direction of their gaze in the remote classroom.

However, we have noticd the current videoconference systems has a latency problem which is coming from a encoding and decoding of Audio/Video and network transmission. In general, when round trip time for conversation becomes more than 500 msec, it becomes hard to have heavy interaction such as counting numbers mutually or playing ”rock, paper, scissors game”. We have observed that when playing the game, a person in remote is delayed in showing his/her gesture in our implementation.

Since we use this environement mainly for lectures with Q&As style teaching method, we didn’t face too much problems regarding to the latency. However, a professor who gave lecture for ITSP feels uncomfortable when having discussion with remote students. We have learned that, it is important to consider latency when giving a lecture.

6.3 Scalability and Sustainability

Our concept of a ”Centralized Application Network”, allows the implemented remote lecture environment to be scalable. We have confirmed that our portable equipment set is easily added to the environment, and that it is possible to easily add more classroom terminals (Endpoint) to the environment. Since CenterHUB (MCU) is able to handle additional capacity, network bandwidth is the largest concern in adding a classroom. Bandwidth being the only limiting factor, as long as the network allows, the environment is scalable.

Figure 9 shows an example of temporary classroom in Kaetsu University. A portable equipment set is installed in the classroom with existing A/V equipment. Even such configuration, the layout of the screen and camera is consistent.

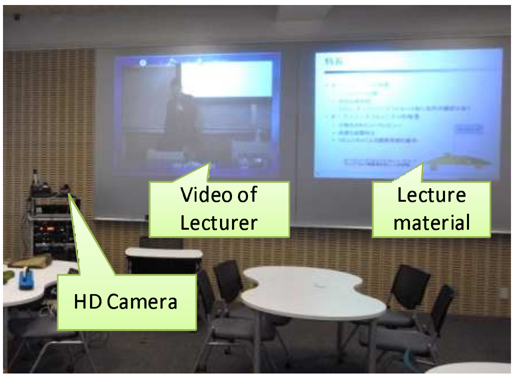

Figure 9: Classroom at Kaetsu Univ.

7 RELATED WORK

The School on Internet Asia (SOI Asia) project provides real time remote lectures to the Asia region(Mikawa et al., 2008), (School Of Internet Project, 2010).

Participating universities manage their environments individually. SOI Asia provides operators with practical skills through remote workshops using virtualization-technology(Patcharee et al., 2008). Their DokoDemo SOIAsia provides a similar mechanism to the temporary software based terminal in our implementation.

Since SOI Asia is using a multicast based application, it is easy to add new locations. Internet2 Commons (Internet2 Commons Project, 2010) provides vender free scalable H.323 video conferencing services to its members. This project does not define a standard classroom facility and AV equipment. To assure the quality of distance communication and operation, the Internet2 commons trains the operation staff to be gcertified site coordinatorsh. Site coordinators are trained and have knowledge about video conferencing. At each location, they construct and support video conferencing activities.

There is a large amount of research on sharing eye gaze or eye contact in distance communication. Eye gaze sharing has an educational impact in remote lectures (Yatagai and Sakai, 2006). Tele-presence solutions that have eye gaze and eye contact functions are now becoming popular in the enterprise market. Currently, Cisco(Cisco Systems, 2010), Polycom(Polycom, 2010), HP(HP, 2010), Lifsize(Lifesize, 2010), and other vendors are releasing solutions and products that provide remote operation and automation.

8 FUTURE WORK

8.1 Audio Environment

In this paper, we proposed the sharing of environmental noise from remote classrooms to the lecturer as means of the lecturer obtaining feedback from his/her students. However in our implementation, this mechanism did not work successfully due to the difficulty in balancing volume between classrooms. It was useful in catching questions from students without the need for a microphone; however, the audio sent to the local classroom was too loud for feedback. Discussions regarding methods for volume control and other ways of sharing environmental noise information is still on going. Discussions on audio and video synchronization where the video camera and audio input devices have different encoding delay were not covered in this study. The gap of delay between audio and video may bring discomfort to the conversation and experience of the remote lecture environment. Filling such gaps is necessary when the encoding delay is not regulated between audio and visual devices.

8.2 Evaluation of Distance Communication Environment

The sharing of eye gaze and eye contact between classrooms was observed in our environment. However, we have yet to finish evaluating the quality of this distance communication. Correcting data on lecturer and student's eye gaze tracking maybe needed to evaluate the environment from the view point of communication. Also, the method to measure the educational impact of distance learning has been under discussion.

9 CONCLUSIONS

This paper proposed an operation scheme to solve problems with, (1) Inconsistent classroom layouts, (2) the complexity of operation, and (3) the lack of sustainability in distance learning environments. Our solution enables (1) positional awareness and countenance recognition, (2) reduction of the number of required operators, and (3) sustainable operation.

Our design focused on standardizing both the operations of remote lecture environments and the facility's layout. We implemented our system for the ITSP inter-university distance-learning program, which has been successfully operating on our design since 2007.

This implementation proved that a dedicated operator is not required in each remote classroom. Alternatively, a single administrator may remotely manage operations for multiple classrooms. Moreover, a teaching assistant with no training or experience is able to operate our system through a simplified user interface, if and when necessary.

We also proved that a portable equipment package is a flexible and effective way to smoothly extending the remote lecture environment to underequipped classrooms. We conclude that our operation scheme is effective in reducing operational costs and contributes to the sustainability of conducting remote lectures.

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REFERENCES

Cisco Systems (2010). Video collaboration solutions. http://www.cisco.com/telepresence.

HP (2010). Hp halo telepresence and video conferencing solutions. http://www.hp.com/halo/.

Internet2 Commons Project (2010). About internet2 commons. http://commons.internet2.edu/.

Keio University (2010). The Information Technology Specialist Program Web Page. http://itsp.keio.ac.jp/.

Lifesize (2010). Lifesize conference technology hd telepresence system. http://www.lifesize.com/telepresence.

Mikawa, S., Okawa, K., and Murai, J. (2008). Sustainable education collaboration architecture on digital infrastructure. *Keio SFC journal*, 8(2):77–93.

Patcharee, B., Mikawa, S., Basuki, A., and Okawa, K. (2008). An educational development on learning paradigm of region-wide it hands-on workshop. *Keio SFC journal*, 8(2):59–75.

Polycom (2010). Polycom Real Presence Experience (RPX). http://www.cisco.com/telepresence.

Rodman, J. (2003). The effect of bandwidth on speech intelligibility.

School Of Internet Project (2010). About soi asia project. http://www.soi.asia/.

Yatagai, M. and Sakai, S. (2006). Analysis of education effect among eye-contactable or former-type of distance learning through video conferencing systems and face-to-face learning. *Journal of Japan Society for Educational Technology*, 30(2):69–78.