An Empirical Study on Remote Lectures Using Video Conferencing Systems

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***Abstract*—We have been holding remote lectures among 5 universities in Japan using video conferencing systems supported by Polycom. Initially, we connected Kyushu University, the center and information source of the remote lectures, with 4 other universities using the function of Multi-point Control Unit (MCU) located in Kyushu University. However, this setting was unstable and the quality of the lectures could not be guaranteed. Therefore, we tried later to employ a new set-up by utilizing dedicated equipment for MCU for enhancing the lecture quality. In this paper, we describe and report our experience on the remote lectures using MCU. In addition, we have conducted a survey of the students on the environment and the method of giving the remote lectures. The analysis results of the survey and our corresponding proposals will be presented as well in the paper.**

***Keywords*-Remote Lectures, Video Conferencing Systems, Multi-point Control Unit**

I. Introduction

Remote lectures have gradually become more popular and been expanding their usage for sharing lectures among multiple universities. **QITO** (**Kyu**shu University **I**nformation Communication **T**echnology Architect Educational Pr**O**gram) has also been holding remote lectures using video conferencing systems supported by Polycom (http://www.polycom.com/). However, some fatal problems were encountered such as lecture interruption due to breakdown in Internet communication. To resolve these problems, we introduced **MCU** (**M**ulti-Point **C**ontrol **U**nit).

In addition to traditional lectures given so far, the QITO program, a two-year education course for master students, provides special curriculums centering on "Project-Based Learning (PBL)", "Long-Term Internship", and "ICT All-Round Education/Omnibus", which were insufficient in the past.

In PBL [1], learning basic skills such as software development and project management is scheduled for the 1st-year 1st semester. Moreover, in the 2nd semester and the 2nd-year 1st semester, students are requested to deal with practical problems assigned by teachers from industries or universities.

The long-term internship does not aim at company experiencing. The 1st-year students in QITO program are anticipated to participate in the internship for more than one month (up to two months) in summer, and to work on a real company project for software development.

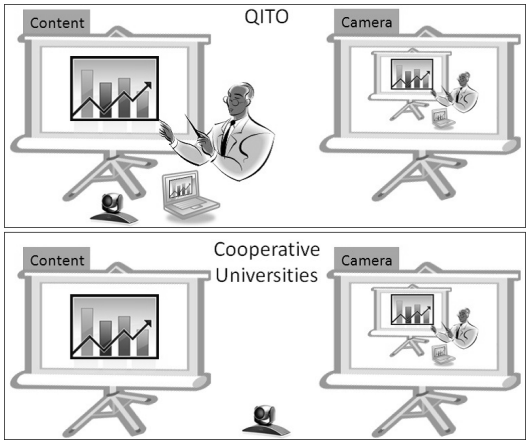


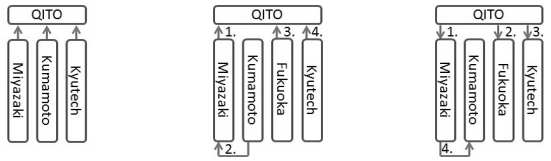
Figure 1. Screen location

The omnibus lectures consist of ICT Society Business Special Course (1st-year 1st semester), Advanced ICT Engineering Special Course (1st-year 2nd semester), Project Management Special Course (1st-year 2nd semester), and Advanced ICT Leaders Special Course (intensive course in 1st-year only). These courses, given by first-class managers, technicians, and researchers from industries, explore the most advanced ICT technologies and their trends.

Omnibus lectures, especially the ICT Society Business Special Course and the Advanced ICT Engineering Special Course, are remote lectures that utilize video conferencing systems in between Kyushu University and "cooperative universities" (Kyushu Institute of Technology (Kyutech for short), Kumamoto University, University of Miyazaki, and Fukuoka University). The ICT Society Business Special Course is held every Thursday from 2.50pm to 6.10pm in 1st-year 1st semester, and the Advanced ICT Engineering Special Course is held every Thursday from 2.50pm to 6.10pm in 1st-year 2nd semester. Totally, 10 and 7 lectures for each respective course have been held in 2012.

QITO, Kyutech, University of Miyazaki, and Fukuoka University use HDX 9002, while Kumamoto University uses PVX. These video conferencing systems are products of Polycom. HDX9002 is a video conferencing unit and PVX is a video conferencing software application.

Information distributed among QITO and the cooperative



(a) 4 locations (b) 5 locations (c) 5 locations (improved)

Figure 2. Traditional method to connect to some locations

universities includes: screen pictures (e.g., powerpoint lecture slides) displayed in a PC placed at QITO (hereafter called ***content***), the image of a camera also placed at QITO for filming a lecturer, and sound from all universities. A sketch of the screen of all universities is shown in Figure 1. The upper part of the figure shows the screens at QITO and the lower part shows the screens at the cooperative universities. The screen for the camera at QITO can also be switched to show screens of cameras located in each cooperative university.

The previous version of this paper was presented at ICET2013 [2]. In this paper, we extend the work in [2] by including a survey on the remote lectures, the analysis results of the survey, and our proposals. In particular, the following additional information will be presented:

- We describe the primary purpose of the survey and the timing when it was conducted. In addition, we show the number of students who attended the remote lectures and the number of valid answers.
- We obtained some opinions about the *environment* of the remote lectures from the survey, which was designed originally for finding out students' opinions about the contents of the lectures. We extracted some complaints from those opinions and classified them into ones for the environment of the remote lectures and ones for the method of giving the lectures.
- We describe how our solution for improving the environment of the remote lectures, which have already been proposed in [2], relate to the survey results, especially to the complaints. We report, as an analysis result of the survey, a fact that the more we improve the environment of the remote lectures, the less the complaints occur.
- For the complaints, we describe what we have already solved and what we plan to solve in the future.

II. Traditional Problems

We have been holding remote lectures using MCU (Multipoint Control Unit) function of HDX9002 at QITO till now. MCU facilitates remote conferencing (in our context, lectures) among multiple locations. In particular, the MCU function in HDX9002 supports connection of 4 locations at the same time. Since there were only 3 cooperative universities before 2007, we did not encounter any problem using HDX9002 (Figure 2(a)). From 2008, we encountered problems since one more cooperative university (Fukuoka University) was added and we had to use HDX9002 for connecting 5 locations all together.

A. Connecting to 5 locations

We adopted the method shown in Figure 2(b) to connect 5 locations. Each cooperative university connected to QITO. Here, the numbers attached in the figure represent the order of connection. Kumamoto University was set to connect to University of Miyazaki because MCU function in HDX9002 can only connect 4 locations at most at the same time. As a result, some problems occurred.

- Connection to the cooperative universities was down unexpectedly.
- *Content* was not distributed to the cooperative universities.
- QITO could not receive sound and images from the cooperative universities.

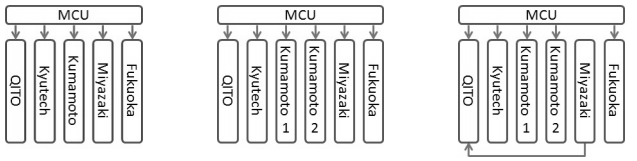
When the connection was down unexpectedly, a lecture had to be interrupted. Therefore, students in the cooperative universities might not be able to understand the lecture sufficiently. Moreover, the screen for the camera at QITO could not automatically switch to the camera image of the cooperative university, whose students were talking through a microphone (e.g., for answering a question posted by the lecturer at QITO). This is contrary to our expectation and the lecturer at QITO could not see the student who was talking.

Since a connection might become even more unstable if it lasted for long time, we periodically turned off the connection to all locations manually and re-established the connection again later on. However, this method could not essentially solve the problems. In addition, following the suggestions of an engineer from Polycom, we reversed the connection direction (as shown in Figure 2(c)) between QITO and the cooperative universities, but the problems still could not be solved.

B. Introducing dedicated equipment for MCU

MCU function in HDX9002 can connect maximally 4 locations at the same time. Using HDX9002 for connecting 5 locations is not recommended. Therefore, we decided to use a RMX2000 located in Information Infrastructure Initiative center of Kyushu University. RMX2000 is dedicated equipment for MCU that supports connecting 5 locations. Through utilizing this dedicated equipment, we expected that the remote lectures could be held smoothly and the problems (Section II-A) could be solved.

Before using the dedicated equipment for MCU, we made the following settings: 1) we set the duration of a conferencing call to 360 minutes so as to cover the whole lecture till its end, 2) we enabled H.239 [3] protocol. H.239, which is a recommendation of the ITU-T (International



(a) Basic (b) For Kumamoto University (c) For University of Miyazaki

Figure 3. The connection method through the dedicated equipmemnt for MCU

Telecommunication Union Telecommunication Standardization Sector), is a standard to show not only the images from a video conferencing system but also the pictures of PCs.

Previously, we had to make the connection manually among QITO and each university. After we introduced the dedicated equipment for MCU, all universities were connected by MCU automatically at 2:45pm (Figure 3(a)). MCU was set to turn off the connection automatically at 6:45pm, but each university could turn off the connection manually because the lecture ended at about 6:10pm.

We could change the screen at QITO in a way shown in Figure 4 by operating HDX9002 manually. The image from the camera at each respective university is automatically switched and displayed at QITO at 15-second intervals. In addition, if a student of a certain university talks through a microphone, the image of that university will be displayed at QITO.

Although the connection process was simplified thanks to the introduction of the dedicated equipment for MCU, some new problems occurred. We describe these new problems and our solutions to them in Section III.

III. New Problems Occurred and Our Solutions

In this section, we show concrete examples of the problems occurred after introducing the dedicated equipment for MCU, and our solutions. The time slots when problems occurred after we introduced the dedicated equipment for MCU are shown in Figure 5. During holding the remote lectures, we used Skype (http://www.skype.com/) to communicate with the staffs of the cooperative universities. The graph is made from the log of Skype. In the figure, vertical axis shows the days of lectures and the names of universities, and horizontal axis shows the time of the days. The lines painted denote time slots when some problems occurred.

A. Content was not shown when lectures started

[Problem] The resolution of the PC used by lecturers was set to 1600×900, which is the maximum value. On this setting, the *content* was not shown in all cooperative universities when lectures started.

[Solution] We understood that the *content* would not be shown at the cooperative universities if the resolution was too high. Therefore, we changed the resolution to 1024×768.

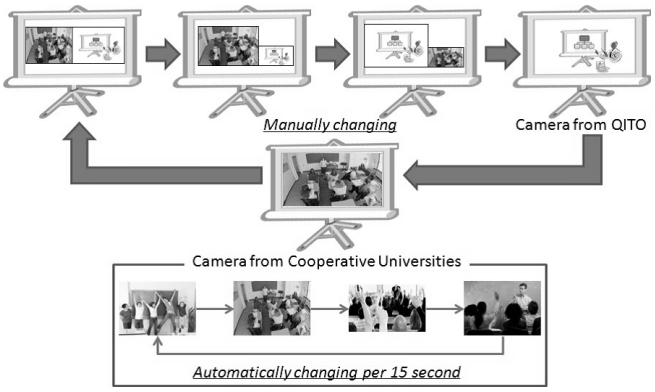


Figure 4. Screen transition

B. MCU could not connect to the cooperative universities when lectures started

[Problem] Some cooperative universities were not connected from MCU automatically. This happened when video conferencing systems located in the cooperative universities were not started up. If MCU could not connect to a video conferencing system when a lecture starts, MCU will try to re-dial to that system and thus the connection could be restored. Normally, such re-dial actions are done automatically until MCU could connect with the conferencing system.

[Solution] However, if the connection could still not be able to restore, a MCU manager is requested to make the re-dial and connection manually.

C. Content became invisible in lectures

[Problem] The *content* became invisible during lectures at some cooperative universities. The resolution of the PC used by the lectures had already been lowered (Section III-A).

[Solution] As mentioned earlier, in remote lectures, not only the screen pictures of the lecture PC but also the images from cameras will be distributed. We found that, when the *content* became invisible, the transmission rate of the images from cameras was set to 1920Kbps. Our network was jammed by this setting. This problem was solved after we changed the transmission rate of the images from cameras into 384Kbps, which was the minimum value. Although this solved the unexpected loss connection problem, the image quality became worse especially when lecturers moved quickly. It is possible to set the transmission rate to a value of 384Kbps, 512Kbps, 768Kbps, 1024Kbps, 1472Kbps, or 1920Kbps. After examination, we found that 768Kbps was the best balanced value that could avoid the loss connection problem as well as provide a satisfactory image quality.

D. The connection was down after 90 minutes (Kumamoto University)

[Problem] The connection between MCU and Kumamoto University was down 90 minutes after a lecture started.

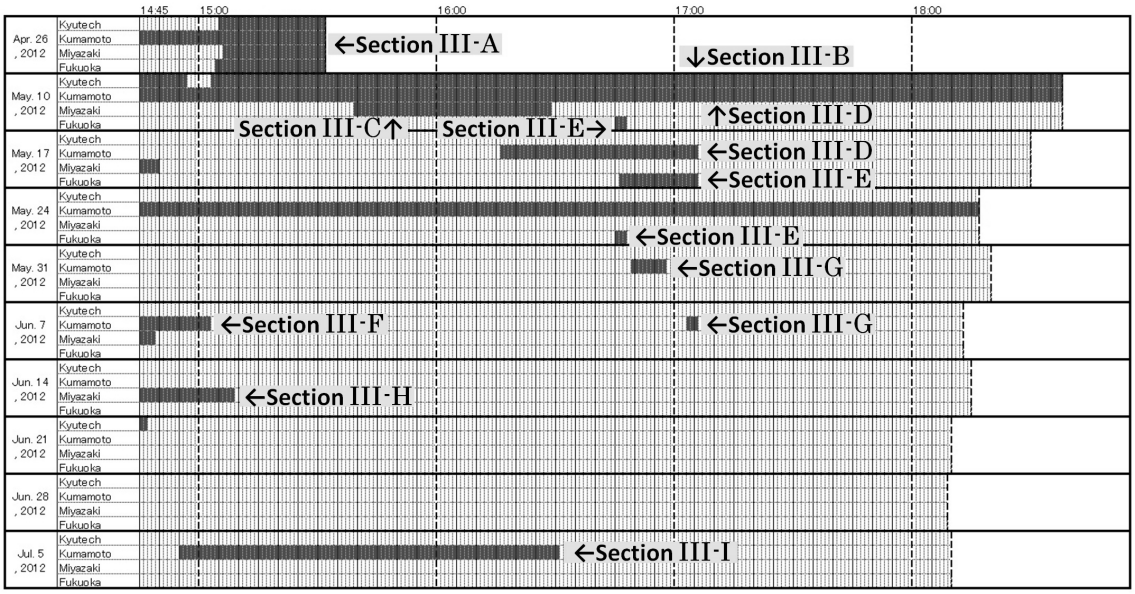


Figure 5. Time slots when problems occurred

[Solution] The reason was that the maximal conferencing time of the PVX used at Kumamoto University was set to 90 minutes, the default value. We solved this problem by changing the default maximal time from 90 minutes to unlimited

E. The connection was down after 120 minutes (Fukuoka University)

[Problem] The connection between MCU and Fukuoka University was down 120 minutes after a lecture started. We confirmed the default maximal conferencing time of the HDX9002 used in Fukuoka University, but that value was not 120 minutes. So the problem was not related to this setting.

[Solution] Video conferencing system of Polycom uses the H.323 [4] protocol. Using this protocol, MCU keeps a connection with each location with UDP after the connection is initially made with TCP. Moreover, both systems send keep-alive packets to each other. The connection will be turned off if there are no responses.

Having this fact in mind, we reconfirmed the network of Fukuoka University and found that timeout of firewalls was set to 30 minutes in Fukuoka University. In other words, TCP connection between MCU and Fukuoka University was disconnected after 30 minutes. When 120 minutes passed, the connection was turned off due to no responses to keep-alive packets.

Therefore, through the Information Processing Center of Fukuoka University, we changed the timeout of firewalls from 30 minutes to 180 minutes. As a result, the connection between MCU and Fukuoka University became normal.

F. Connection failed (Kumamoto University)

[Problem] At the start of a lecture, only Kumamoto University was not able to be connected automatically by MCU. Kumamoto University used the same lecture room as before when normal connection had ever been successfully made. Moreover, the manager of MCU at QITO side could not make the connection manually either.

[Solution] The students in Kumamoto University then moved to another room. And this time, the MCU manager succeeded to connect the MCU with that room.

Since there was the possibility that MCU could not connect one of the two rooms, we decided to connect, as shown in Figure 3(b), MCU with both lecture rooms for Kumamoto University. As a result, if MCU cannot connect the first lecture room, the second lecture room will be tried (Section III-B). After students in the first room move to the second room, the connection should be established automatically.

G. The connection was down after 120 minutes (Kumamoto University)

[Problem] This problem was similar to the one of Fukuoka University (Section III-E). However, we did not find any problem about firewalls in Kumamoto University, and thus, we could not solve the problem by following the method discussed in Section III-E. Moreover we had no idea on how to solve this problem.

[Solution] We divided the connection duration into 2 parts. In the first part, MCU was set to connect QITO and the cooperative universities from 2:45pm to 4:30pm. In the second part, a connection was made from 4:30pm

to 6:45pm. More precisely, the connection was turned off at 4:29pm and re-established at 4:30pm. Since the turning-off and re-establishment happened in the break between two lecture sessions, there was no influence to the lectures. Thanks to the above division, the connection between MCU and Kumamoto University returned to normality because the connection was turned off after 105 minutes. In addition, in the second part, the connection duration was 135 minutes in total, and thus, there would be no problem even if the lecture was extended over 6:10pm (when the connection duration should be 100 minutes).

H. Connection failed (University of Miyazaki)

[Problem] At the start of a lecture, University of Miyazaki had not been able to be connected by MCU.

[Solution] This problem occurred because IP address of University of Miyazaki was not registered in MCU correctly. Since the lecture could not continue as it was, we decided to let University of Miyazaki connect QITO directly (as shown in Figure 3(c)). Later, we registered the correct IP address of University of Miyazaki in MCU and the connection returned to normality in the form shown in Figure 3(b).

I. Sound could not be sent to other universities (Kumamoto University)

[Problem] It often happened that the sound of Kumamoto University could not be sent to other universities. We supposed that the cause of this problem is due to that Kumamoto University used PVX, a video conferencing application, but other universities used HDX9002, a video conferencing unit. However, we have not found the true reason for this problem so far.

IV. Questionnaire Survey

We have conducted a questionnaire survey on the remote lectures in 2011 and 2012. While we asked the students for filling the questionnaire after all remote lectures ended in 2011, the students were given the questionnaire before the first lecture started in 2012. This questionnaire consists of the following questions for each lecture.

1) Which part of the lecture are you interested in?
2) An overall impression of the lecture.
3) Comments for next year's lectures.

Although the primary purpose of the questionnaire is to obtain students' opinions about the contents of the remote lectures, we supposed that there might exist potential opinions about the environment or the method of giving lecture. After we reviewed the results of the questionnaire survey, as we expected, the results of the questionnaire did contain opinions about the environment of the remote lectures or the method of giving lectures. This questionnaire was conducted for the students who attended the remote lectures. They can decide whether to return the questionnaire by themselves. In Table I, we show the number of the students who attended the remote lectures and the number of answers we received. In this section, we give description of our analysis results.

Table I
Attendance and answers

	2011		2012	
	1st semester	2nd semester	1st semester	2nd semester
Attendance	73	58	73	57
Answer	47	22	68	44

A. Opinions about the environment of remote lecture

The opinions about the environment of the remote lectures are summarized as follows.

- *I couldn't concentrate on the lecture enough because the network connection was disrupted. (Kumamoto University, the 1st semester, 2011)*
- *I wish the staff could improve the image quality of the camera. (Fukuoka University, the 2nd semester, 2011)*
- *I have to study by watching a DVD record of the lecture because a network disturbance happened in the lectures. (Kumamoto University, the 1st semester, 2012)*

In 2011, some students who attended the remote lectures were dissatisfied with the lecture environment because some serious troubles occurred that interrupted the lecture (Section II-A). In the 1st semester of 2012, we introduced a dedicated equipment for MCU to try to improve the environment of the remote lectures (Section II-B). However we still got some complaints about it because there were various problems caused by a lack of knowledge of using MCU (Section III). In the 2nd semester of 2012, the problems, such as connection failure, did not occur. Then there was no complaint from the students for the environment of the remote lectures.

B. Opinions about the method of giving lectures

We had concentrated on improving the environment of the remote lectures from 2011 to the 1st semester of 2012. We thought that being interrupted was the biggest problem for a lecture. Although we achieved to improve the environment, some students left their opinions as follows.

- *I would be happy if the lecturer could listen to opinions of the students. (Kyushu Institute of Technology, the 1st semester, 2011)*
- *The lecturer should take care of not only Kyushu University but also the cooperative universities. (Kyushu University, the 2nd semester, 2011)*
- *I think that the lecture was conducted at Kyushu University only. (Kyushu Institute of Technology, the 1st semester, 2012)*

The lecturers did their best to accomplish their lectures. Thus, they sometimes tended to continue their lectures without listening to opinions of the students because they concentrated on explaining their themes. In addition, some

(a) Distributable path (b) Undistributable path

Figure 6. Camera information path

lecturers questioned the students in Kyusyu University but did not question the students in the cooperative universities.

Therefore, we requested the lecturers to ask questions to the students in all universities in the 2nd semester of 2012. Moreover, we asked the lecturers to designate in advance the students whom they expect to speak. These means allowed the students in the cooperative universities to speak positively without being left.

Furthermore, we obtained the following opinion.

- *It was difficult to read some letters or pictures drawn in whiteboards located at each university. (Kyushu Institute of Technology, the 1st semester, 2012)*

Some of the remote lectures used whiteboards. In such lectures, the information written in whiteboards at each university had to be distributed to each university. The information in Kyushu University's whiteboard can be distributed to the cooperative universities using the camera equipped in Kyushu University, and the information in the cooperative universities' whiteboards can be also distributed to Kyushu University using the cameras equipped in each cooperative university (Figure 6-(a)). However, the information in a cooperative university's whiteboard can't be distributed to other cooperative universities (Figure 6-(b)). Then, to distribute an image from a cooperative university to other cooperative universities, we distributed the image, which was distributed to Kyushu University, to other cooperative universities through the camera equipped in Kyushu University. Using this way, it was difficult for the students in the cooperative universities to read clearly the details on the whiteboard because the image was corrupt during Internet transmission.

Therefore, based on these facts, we decide to utilize digital cameras for those lectures that use whiteboards from 2013. The staffs of each cooperative university will be requested to take pictures of their whiteboards and send them via emails to Kyushu University, then we will distribute the whiteboard pictures to the cooperative universities using the same way as we transfer the *content* mentioned in Section I. We believe, in this way, the students in the cooperative universities will be able to read the images of whiteboards equipped in other universities clearly.

V. Related Work

In this section, we discuss two papers about the consortium of higher education in Shinshu, Japan. Eight major universities constitute the consortium: Shinshu University, Nagano College of Nursing, Saku University, Tokyo University of Science-Suwa, Seisen Jogakuin College, Nagano University, Matsumoto Dental University, and Matsumoto University.

A. Practice of "K^3 Salon"

"K^3 Salon" is an activity hosted by the consortium of higher education in Shinshu for practicing remote lectures and promoting communication among universities. K^3 is an abbreviation of the Japanese spelling (**K**outou **K**youiku **K**ouryu) of "higher education exchanging". The paper [5] reports results of constructing and operating a remote lecture system that is claimed to be easy-to-use by teaching and technician staffs themselves.

In this consortium, remote lectures among universities were operated by using dedicated equipment for MCU (RMX2000 of Polycom), which was located at Shinshu University. Staff members of each university used a touch panel to start a remote lecture manually and to end the lecture manually after 90 minutes. When a remote lecture was extended over 120 minutes, the firewall problem as described in Section III-E occurred and the staffs manually re-established the connection.

In Kyushu University, the dedicated equipment for MCU is managed by Information Infrastructure Initiative Center. QITO and the cooperative universities cannot connect to it forwardly. Instead, MCU connects to each university automatically and remote lectures are able to be operated easily. Moreover, in QITO, we deal with long-hours remote lecture.

B. Automatic Control and Extension of Control Devices

To solve the problems mentioned in paper [5], the paper [6] reported construction and implementation of "automatic remote lectures starting and ending", "automatic lecture content sending", "remote control of cameras", and "control program using iPad". In QITO, we record remote lectures just for those universities to which connections fail, not for later distribution. In addition, controlling remote cameras and using control panels through touch panels are not considered as important for us. Thus, we focus on "automatic remote lectures starting and ending".

In the consortium of higher education in Shinshu, duration of remote lectures is just 90 minutes. To operate the remote lectures, staffs start and end the lectures automatically. Due to this, even if a lecture is extended, the remote lecture (content distribution) will be turned off automatically before the real end of the lecture. Furthermore, when using RMX2000, an announcement will be sent to all cooperative universities 5 minutes before a remote lecture is to be turned

off automatically. This announcement becomes a noise and makes it hard for lecture audience to listen to the lecturer clearly. The consortium solved this problem by delaying the scheduled ending time for 5 minutes.

QITO introduced the mechanism of automatic connection and disconnection as well (section III-G). However, the disconnection (i.e., turning off) is not made during a lecture. Since our remote lectures last for long hours, the disconnection is automatically made at break time in between two lecture sessions. Moreover, the announcement does not cause any harm because the automatic ending time is set to be 30 minutes after the supposed lecture ending time.

VI. Conclusion

This section concludes the MCU introduction (Section VI-A), the questionnaire survey (Section VI-B), and the whole of our paper(Section VI-C).

A. MCU Introduction

When we simply used MCU function, many problems occurred, which became obstacles to the remote lectures. To solve the problems, we decided to utilize dedicated equipment for MCU.

After that, the connection became stable, but some new problems occurred (Section III). These problems are divided into those caused by general network (Section III-A, III-C, and III-E), and those caused by device units (Section III-B, III-D, III-F, III-G, and III-H). We believe that our solutions to the problems of the second category are also applicable outside QITO.

The problems considered in Figure 5 comprise various problems mentioned earlier in this paper. As we continue operating the remote lectures, quality of the lectures becomes gradually better. After we introduced the dedicated equipment for MCU, the connection became more stable and lecturers could confirm now students of the cooperative universities who were answering their questions.

Although we have solved almost all problems encountered, the problem described in Section III-I has not been solved. The difference between the device units used by the universities or the construction of network may be one of the causes of the problem. In the future, we plan to further investigate solutions to this problem for providing more comfortable circumstance for remote lectures.

B. Questionnaire Survey

We conducted a questionnaire survey of the remote lectures, and then we obtained some complaints about the environment of these lectures (Section IV-A). Before confirming the opinions from the questionnaire survey, we had already recognized the problems described in the complaints. No complaints occurred after we solved the problems mentioned in Section II and Section III.

While we gave improvement of the environment of the remote lectures the highest priority, we obtained some opinions about the method of giving lectures (Section IV-B). The students in the cooperative universities became not to be left because we decided to propose some questions to these students consciously. To distribute among the universities the images of the whiteboards equipped in each university, we decided to distribute some pictures of whiteboards taken by digital cameras.

Thus, some complaints that we obtained from the questionnaire survey are expected to be resolved.

C. Summary

In this paper, we reported device setting experience obtained through holding remote lectures in QITO. Moreover, we have conducted a questionnaire survey and solved some problems realized from the survey.

We changed the environment and the method of giving the remote lectures in 2011 and 2012. Our work contributed to reducing students' complaints, that is, to improve the quality of the remote lectures. In our future work, we will investigate the method to improve the remote lectures in more detail, and consequentially increase the students' motivation of learning.

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