

Design and Implementation of a Teleteaching Environment

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Abstract

The ever increasing need for education combined with the recent advances in communication technologies, have encouraged the introduction of numerous remote learning systems and services. In this paper we describe a distance learning system we have developed at the University of Geneva. We also describe the experience we have gained by using the system for conducting telelectures during a period of three academic years.

1. Introduction

The ever increasing need for education combined with the recent advances in communication technologies, have encouraged the introduction of numerous remote learning systems and services [WCT] [LSP]. Educational institutions that once provided education via correspondence are now offering network based distribution of courses and seminars, ranging from off-line non-interactive courses to real-time interactive attendance at a class [Ara98]. At CUI (Centre Universitaire Informatique) at the University of Geneva we have started an incremental development of a telelearning environment. The environment is used for a series of real-time interactive telelectures between CUI and GMD (the National German Research Institute for Information Technology) at Bonn (750 Km away from Geneva). Telelectures started at the academic year 96/97 and continue up today on a regular weekly basis. The main difference of our system from other systems lies on two points. The first is the integration of ISDN-based services and Internet-based services in one consistent environment. The second is the "two-site educational scenario" supported by our system. These features can be found independently in different teleteaching environments [Tele] [Pus94] [Leve] but not as an integrated set.

The two-site educational scenario is the following: there are two lecturers, one located at GMD and one at CUI. The audience (the students) is located at CUI. We will designate the lecturers from the point of view of the audience at CUI, calling the lecturer at GMD "*the remote lecturer*" and the lecturer at CUI "*the local lecturer*". Telelectures are given for two university courses: "Systems Programming" and "Internet Tools". The duration of each lecture is two hours. The remote lecturer is not necessarily the same person in every session. He or she is an expert on a particular area and presents a subject in the area of his expertise by means of a presentation. He may also make comments on the local lecturer's presentation and participate in discussions with the local lecturer and the audience. The local lecturer is responsible for the course administration as a whole throughout the academic year. He or she invites an expert to be the remote lecturer depending on the subject being taught. For each lecture a script is agreed between the two lecturers in advance.

In this paper we give an overview of the developed system and describe our experience in using it. More precisely, section two describes the hardware and software components of the telelearning environment while section three describes the experience gained from using the system. In the last section we describe our conclusions.

2. The telelearning environment

CUI and GMD are currently connected with an ISDN line for transmitting the audio and video signals. We can chose the bandwidth of the ISDN line to be either 64 Kbps, 128 Kbps, 256 Kbps or 384 Kbps. The ISDN connection allows us to exchange good quality audio and video images between the two main sites involved in a telelecture. Video images can be projected on projection screens or monitors big enough for classrooms containing approximately up to 50 students. The left picture in Figure 1 shows the classroom at CUI and the right picture in Figure 1 shows the control room at CUI.



Figure 1 Classroom at CUI(left) and the control room at CUI (right)

Besides the ISDN connection we have also tested two other types of network configurations. In the first configuration we used a 25Mbps ATM line. In the second configuration we used a 250 Kbps satellite link. Among the three alternative set up that of ISDN was the most appropriate for our purposes. Even though the quality of the video images that we can transmit over ISDN is lower than that over an ATM connection, it is sufficient for our purposes. Furthermore, the hardware infrastructure and transmission costs for ISDN are much lower than for ATM and satellite. Finally, the procedure for establishing the network connection is much simpler for an ISDN connection than for the other two types of connections. That is, while for an ATM and satellite connection we need to specify 3 to 5 days in advance the exact required connection times, with ISDN we can dial up at any moment.

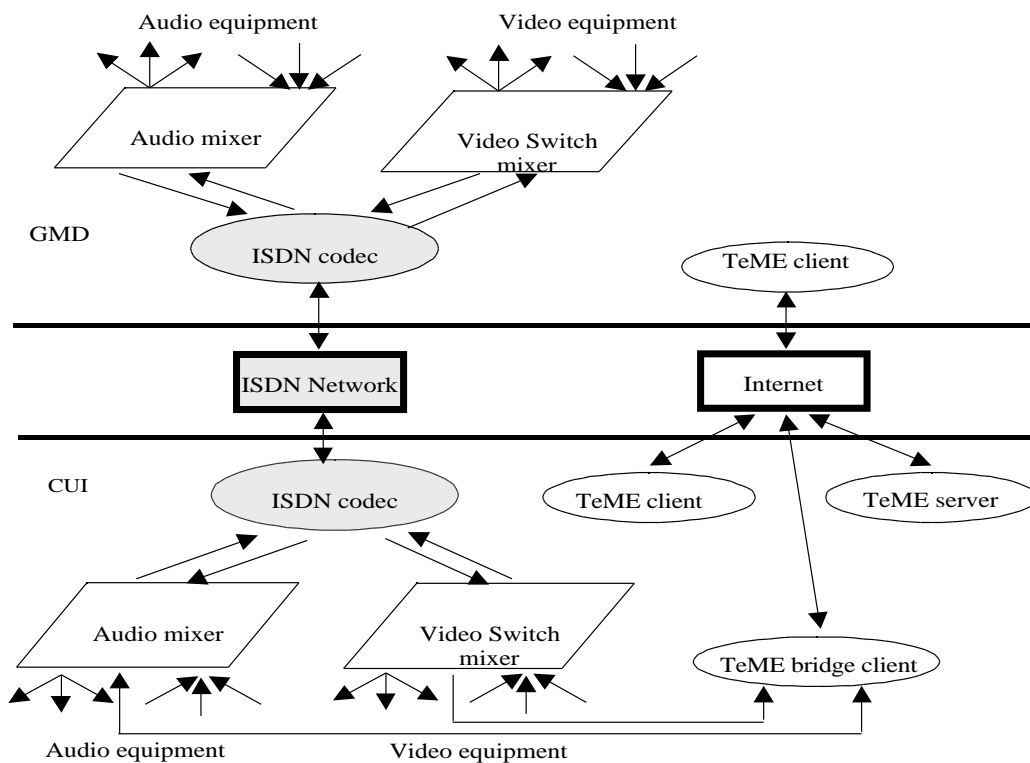


Figure 2 GMD-CUI audio video stream flow

Figure 2 shows the hardware and software configuration we have set up for running telelectures. In each site, audio devices are connected to an audio mixer and video devices are connected to a video switch. The audio mixer and the video switch are connected with an ISDN codec. The ISDN codec compresses the audio and video signals and transmits them to the other side. At the other side, the ISDN codec decompresses the data coming

from the ISDN line and feeds the audio signal to the audio mixer and the video signal to the video switch. Our set up allows us to easily switch from one network configuration to another. The parts that should be changed are drawn in gray color in Figure 2. For example, if we want to use an ATM connection, the audio mixer and video switch should be connected with ATM codecs.

The lecturers' presentations are performed using a telemeeting/teleconferencing system which part of TeME (Telemeeting/Teleconferencing Management Environment) [Ara99]. TeME's teleconferencing system is a client/server application. Client programs running on each user's PC communicate with a server. The main task of the server is to broadcast the data received from one client to all other clients, restrict access to the telelecture session to authorized users and enforce a floor policy for performing telepresentations.

TeME clients run in CUI and GMD; a TeME server runs at CUI. In fact, the purpose of using TeME is not only for assisting the lecturers' presentations: TeME provides real-time access for users willing to follow a telelecture over low bitrate lines, for example, students in their homes connected to the Internet via a home modem over an analogue telephone line. In other words, the rationale of combining ISDN and Internet is that a few "privileged" sites where several users are sharing the teleconferencing equipment are connected over ISDN while "individual" use is performed over Internet.

TeME includes six basic services: *telepresentation*, *audio connection*, *webcam broadcasting*, *electronic mail*, *text chat* and *telelecture archiving*. The telepresentation service of TeME is based on the web browsing capabilities of the SUN's HotJava component [HotJa]. One of the participants can become a *presenter*. The WEB pages that the presenter displays on her/his screen are displayed on the screens of all participants. The audio connection allows users to have full duplex audio communication with all other participants. The webcam broadcast service provides similar functionality to that of webcam client/server programs. It allows users to broadcast to all other participants images refreshed at low rates (few images per minute). Figure 3 shows the interfaces of the telepresentation service and image broadcast service. The electronic mail allows users to broadcast messages to all the participants of a session. The text chat allows users to broadcast a line of text to all the participants of a session. Finally, the "telelecture archiving" service records telelectures into files. More precisely, the data recorded are of two types: events and the mixing of all participant's audio streams. Events include URLs of WEB pages broadcast during a telelecture, the broadcast of an email, the broadcast of a chat line, the arrival or departure of users from a telelecture and the change of presenters. The recorded telelecture can be accessed at a later time through the WWW. More precisely, users can enjoy a synchronized replay of the telelecture: listen to the audio stream and at the same time view the slides they have been presented during the telelecture with the same chronological order and duration [Tedu].

The integration between the two types of networks, ISDN and Internet, is performed by executing a "TeME bridge client". The "bridge client" is a TeME client that receives a video signal coming from the video switch. The "bridge client" also receives an audio signal coming from the audio. This way we provide TeME users the audio and video signals transmitted over ISDN. Note however that the video stream transmitted over ISDN is "sampled" at a few images per minute and is made available to the telelecture participants as webcam images.

3. The user's feedback

An essential part of a real-time distance learning system is the software and hardware components establishing the audio communication. Indeed, in the absence of audio communication telelectures simply cannot be conducted. Users that attended telelectures from their home acknowledged that the audio communication is the most important service and ranked in the second place of importance the telepresentation service. The webcam image broadcast service has been judged contributive but not essential: participants acknowledged that they could follow the telelecture without the webcam service. The text chat service and the email service were rarely used.

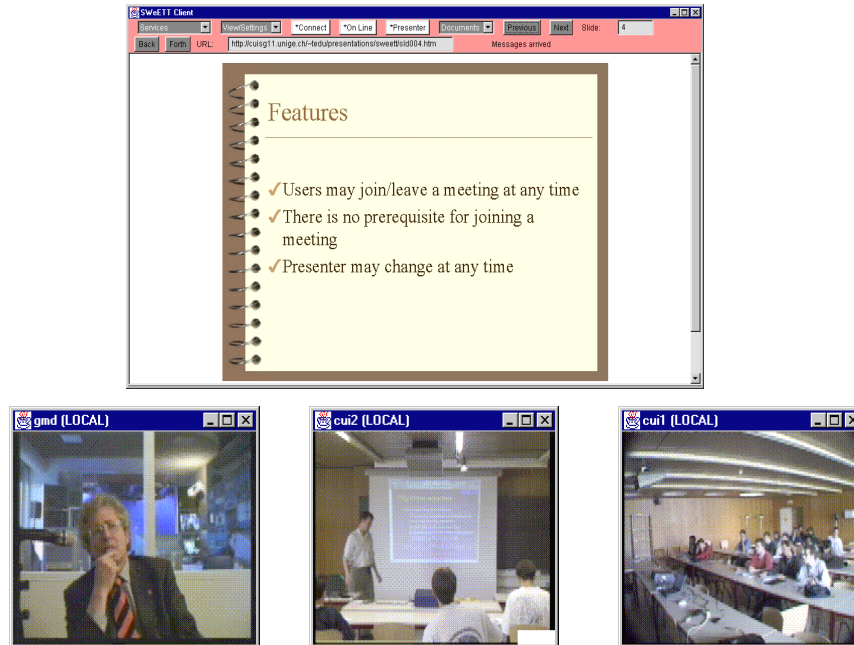


Figure 3 Telepresentation and image broadcasting facilities of SWeETT

Access to the telelecture archive was one of the most appreciated services from both lecturers and students. Lecturers accessed the telelecture archive either for ensuring themselves that a particular subject has been taught during a lecture or for recalling the level of detail in which a particular subject has been taught. Lecturers have also accessed the telelecture archive for re-listening those parts of a lecture for which the presentation were judged not satisfactory. Students have used the telelecture archive either because they have missed a course for some reason or because they may be looking for additional information/explanation on a given subject. This usually happens when students review their courses. Even though the student might have been present at the course, her/his notes might be incomplete. Re-listening to the course allows students both to clarify points that were misunderstood and review points that had not been considered worth paying attention.

Tuning the audio hardware and software components of the telelecture system was the most difficult task. A source for many of the audio problems was the bad design of TeME's audio interface: the user has to explicitly select the audio I/O ports in her/his machine for listening and speaking. Most users expect TeME to open audio default ports. Establishing the audio connection was also difficult for many users. Audio problems were difficult to solve since the majority of users are not used to the chat service to get assistance. But even when the audio connection was established, it was sometimes difficult to get the right audio record and play levels.

Following a lecture from home using a 14.4 Kbit/s modem was problematic. Since the audio connection requires 13 Kbit/s bandwidth there is a shortage of bandwidth when the telepresentation service requests a new Web page to be loaded. The consequences of this bandwidth shortage are audio cuts and slow download of web pages. When the lecturer changes pages at a fast pace, the student's TeME client may be several pages behind. To remedy this situation, we plan to replace the actual audio compression algorithm with an algorithm achieving higher compression probably at the expense of audio quality and higher processing power.

The classroom where the lectures were given was not designed for conducting teleconferences. As a result the acoustics at the room were very poor and the recording of students' questions was problematic (wide range sensitive microphones were capturing high background noise). Wireless portable microphones required the students to wait for getting the microphone which they were forgetting to do. As a consequence the remote lecturer could not hear the question and when the question was addressed to him the student had to repeat it a second time. A possible solution to this problem is to provide an audio installation with several microphones covering the whole area of the classroom.

Lecturers expressed several criticisms concerning the telepresentation service. Many of the telelecturers were using multimedia authoring software packages for producing their course material and they had to convert it to HTML format, required by the telepresentation service. Even though most authoring software packages do provide converters from their native format to HTML, the converted documents lose many presentation features. For example, fancy slide transition such as “fade”, “wipe” and “dissolve” are not reproduced in HTML. On line changes of fonts and in general scaling of web pages may not work since many converters convert a document into GIF images and then include the images inside Web pages. Lecturers also expressed the wish to be able to write/make notes on their course material during the lecture much like the way notes can be made on a transparency shown with an overhead projector.

4. Conclusion

In conclusion, our distance learning system allows a remote lecturer to give his presentation using either a high quality ISDN connection (which requires specialized material) or a normal PC with a simple camera and microphone, and Internet connection. As a result the remote lecturer can give his presentation from almost anywhere in world. On the other hand TeME allows the interactive transmission of the course and (audio, low quality video and course material) and supports interactive discussions with the remote users over the Internet with low bandwidth requirements. In this way users can follow the course from their location using standard low cost material, ask questions and in general have an active participation in the lecture. Furthermore, users can make interactive presentations from their home to the classroom using TeME and standard WWW technology.

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