Videoconferencing with Advanced Services
for High-Quality Teleteaching

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Distance education can be divided into synchronous and asynchronous teleteaching according to the event timeline. The quality and diversity of teleteaching approaches depends strongly on the available bandwidth (e.g. teleteaching over ISDN vs. technologies with high bandwidth consumption, like MBONE or real-time ATM transmissions). With the increase of available network capacity teleteaching applications improve enormously in quality and quantity. Synchronous teleteaching which was initially just a video-stream based transmission is meanwhile enriched with multimedia applications and changed over to multimedia-videoconferencing sessions.

This paper introduces teleteaching scenarios which are based on high-quality approaches using standard MBONE audio/video tools on the one hand and transmission of media streams with high transfer rates over ATM codecs on the other. These different strategies for synchronous distance education are combined in a flexible technical teleteaching environment, in support of the lecturer by integrating multimedia resources into the lecture and access to remotely connected students. These advanced services led to the development of an integrated teleteaching terminal that is currently installed in one lecture theatre and two conference rooms and is used for the transmission of lectures and practising courses within the University of Erlangen-Nuremberg. The main target of the technical development is the enhancement of the working environment for teleteaching scenarios.

The research work described in this paper is conducted within the scope of a research project at the University of Erlangen-Nuremberg. The project started in February 1999 and is sponsored by the German Ministry of Education and Research.

Keywords: videoconferencing, high-quality teleteaching, distance education, teleteaching infrastructure, ATM-based teleteaching

1 Teleteaching at the University of Erlangen-Nuremberg

In the scope of the research project “Teleteaching/Telelearning Reference Systems and Service Center within the German Research Broadband Network (TTRef)” and the former project MMTT [4], teleteaching has become an important component of the curriculum at the University of Erlangen-Nuremberg. The TTRef research project has been focusing on the following aspects:

- Development of Reference Systems
  Based on the experiences of former projects sample solutions have been developed for a specific teleteaching-application-scenario. In this context technical solutions are developed, which provide a working environment for the lecturer and students, equipped with information and communication technology.

  The development in this area is concentrated on the integration of technical components in a control-platform and the realization of a media-control-tool which enables the lecturer to
coordinate presentation material and available devices during the teleteaching lecture, virtually "on the fly".

- **Establishing and Operating a Service Center**
  The teleteaching service center offers consulting and support services for teleteaching reference-systems within the German Research Broadband Network (B-WiN) and the Gigabit High-Speed Research Network (G-WiN).

In recent years different technologies for synchronous teleteaching were developed which are currently in use. In respect to the transmission most of the available technical solutions in this field work quite well taking in consideration the respective transfer rates they provide. The main problem with video-conference systems is that they are not very user-friendly, particularly the coordination and control of different devices for the use of distinguish multimedia presentation materials.

## 2 Videoconferencing with Advanced Services

In this section different synchronous teleteaching approaches will be introduced, which are currently used at the University of Erlangen-Nuremberg. The different video-conference approaches (ISDN, MBONE, ATM) are listed in ascending order according to the transfer rate respectively quality.

The transmission of audio/video streams of the lecturer and the far-end participants into the opposite side, is the conventional method of synchronous teleteaching scenarios. Therefore a first approach to synchronous teleteaching is to establish a point-to-point video-conference between two remote access points (e.g. Broadband-ISDN with 128KBit/s). This permits the exchange of audio-visual signals with low-quality.

The multicast network MBONE (Multicast Backbone) allows videoconferencing with approximately 500KBit/s. MBONE tools (‘vic/vat’ for video/audio, ‘wb’ for shared whiteboard applications and ‘sdr’ for session creation and announcement) are freely available and used for transmission of medium-quality audio/video streams (e.g. CIF resolution with 15-20 fps). Advantages of using this software package include the possibility to transmit several video streams, to conduct point-to-multipoint conferences and the availability for different computer platforms.

The quality and the number of transmitted audio/video streams are closely related to available network capacity. For high-quality videoconferencing ATM has been proved as an efficient transmission mechanism. ATM enables high transfer rates which are required for video-conference applications. In this context high-speed networks can meet these requirements without any problems [1]. Advantages of ATM networks compared to the specified transmission approaches above include the definition of a quality-of-service parameter, thus reserving bandwidth for real-time applications. ATM transfer mode, with its ability to transmit point-to-multipoint and a principally smooth scalability, covers all the necessary requirements for synchronous teleteaching [5].

ATM codecs for transmission and reception of high-quality audio/video streams at the teleteaching access points, are able to code analogous signals directly into native ATM cells. The receiver decodes the ATM cells back to audio/video signals. The advantage of this method is that the transmission procedure is completely transparent and analogous audio-visual signals are available at all access points. Another possibility for receiving such ATM-coded streams are workstations with ATM interfaces. In this approach the ATM cells are received, decoded and presented by the workstation without the need for an additional ATM receiver codec. Unlike other forms of high-quality teleteaching (e.g. special videograbber cards for the SUN workstations), no software is required for transmitting, thus make it less susceptible to crashes.

The following paragraphs will give an overview of ATM-based teleteaching. In this context the additional multimedia presentation material and especially the usage in synchronous teleteaching will be introduced. In the scope of ATM-based teleteaching the additionally shown instructional materials as well as the blackboard inscriptions, are forwarded via ATM codecs besides the audio-visual signals
of the lecturer. Bandwidth requirements are approximately 15 MBit/s for the video channel and 1 MBit/s for audio. Figure 1 gives an example of an ATM-based teleteaching scenario.

![Figure 1: ATM-based teleteaching scenario](image)

For high-quality transmission of selected media streams (PAL resolution with 25 fps) ATM codecs or special videograbber cards are used. As it cannot be assumed for every remote access point that these devices are available, an additional video stream of medium-quality via MBONE is transmitted. The audio/video back channels from the remote access points are always forwarded via MBONE tools. Computer based presentations and simulations or animations are also transmitted with an additional video stream.

Another common type of electronic media propagation for lectures are computer based distributed presentations. Because of its great distribution in the PC world, the PowerPoint presentation software has become a de-facto standard and is used for realizing distributed computer based presentations. The scenario consists of one controlling PC located in the lecture theatre in Nuremberg running a PowerPoint presentation and several controlled PCs in each remote access point, connected to the controlling computer via Internet. Whiteboard systems are used for instructional material, too.

For the support of conventional instructional material (e. g. slides, articles, demonstration objects) a video presenter is installed in the lecture theatre. This device is used like a normal overhead projector and supplies a high resolution video signal of the presented material that can be projected locally and forwarded in a high-quality state to the remote access points.

The high transfer rate of ATM enables advanced services for high-quality videoconferencing and is therefore very important. The advanced services of video-conference sessions are in the additional transmission of multimedia presentation material and in the coordination and control of these materials with available devices during the video-conference. The added value to high-quality videoconferencing with the media-control-tool for coordination and control of presented material and devices will be introduced in the next section.
3 Teleteaching Infrastructure

The University of Erlangen-Nuremberg owns a network connection to the Gigabit High-Speed Research Network (G-WiN) of 622MBit/s. The G-WiN has a network capacity of 1.2GBit/s which will be enhanced to 2.4GBit/s in 2001. The connection between the neighbour cities Erlangen and Nuremberg has a transfer rate of 155MBit/s. Figure 2 shows the network connections in the area between Erlangen and Nuremberg.

![Network infrastructure diagram](image)

*Figure 2: Network infrastructure*

At the University of Erlangen-Nuremberg one lecture theatre and two multimedia conference rooms are equipped. These access points constitute the basic infrastructure for all teleteaching applications discussed in this paper. The equipment used in the lecture theatre and conference room in Nuremberg is described in detail in [2]. The teleteaching terminal is designed to support the lecturer during teleteaching events as well as to enrich conventional lectures with multimedia material. The goal of the development of the terminal was to integrate most devices needed for teleteaching into a single intuitive and efficient controllable entity. Figure 3 shows the teleteaching terminal.

![Teleteaching terminal](image)

*Figure 3: Teleteaching terminal*
The improved prototype of the terminal includes

- one PC for computer based presentations and for serial control of certain teleteaching devices,
- two touchscreen monitors (presentation and media-control),
- one camera for the lecturer and one camera for instructional material (video presenter),
- one video cassette recorder and one DVD-Player,
- four small control monitors for remote participants,
- switching devices for audio, video and RGB sources and transceivers.

The coordination of different presentation material (e.g. slides, video, animations) is not an insignificant effort for the lecturer. In most cases the lecturer has to become acquainted with the technical devices. An integrated and freely configurable media-control-tool for serial control of several devices is developed, to reduce these efforts for the lecturer and to give the possibility for focusing on the presentation. Figure 4 shows the structure of the media-control system.

The underlying hardware in the system structure can be controlled in different ways. One possibility is to use ATM codecs, the other to use serial interfaces. In this context it is also possible to use infrared remote controls for the hardware link. The direct integration of JINI-devices is also one possibility. The service layer between JINI and the hardware enables to embed device interfaces in JINI-services. The service layer creates additional service-objects which read the device parameters for the JINI-service. The interface of the media-control with the underlying system occurs with the JINI-technology.

The graphical user interface of the media-control-tool will be programmed in JAVA with well-defined interfaces to JINI. The media-control-tool will provide the lecturer with a summary of all available electronic devices in the media-pool of the video-conference system. Besides the media-pool the media-control-tool will also offer standard configurations which are pre-configured for particular teleteaching scenarios. The lecturer will have the opportunity to configure a media selection for the presentation on the graphical user interface. The connection will be made automatically by the system. Figure 5 shows the planned graphical user interface of the media-control-tool.
Figure 5: Graphical user interface of the media-control-tool

The media-control-tool will enable a comfortable usage of available electronic devices without knowledge of location, configuration or even performance of the devices. This is an helpful add-on for the lecturer during the presentation and gives the possibility for a comfortable, effective and high-quality service by videoconferencing.

4 Teleteaching Applications

Different scenarios of teleteaching applications have already been realized. In particular “virtual lectures” and “virtual practising courses” have become an essential part of the curriculum and are conducted routinely.

4.1 Virtual Lecture

For several years synchronous teleteaching lectures are regularly practised at the University Erlangen-Nuremberg. Lectures are always held and recorded in the specially equipped lecture theatres in Erlangen and Nuremberg and are viewed in the corresponding conference rooms. Another possibility for attending virtual lectures are computerised multimedia places of work (computers with distinct multimedia equipment and high capacity network connection).

4.2 Virtual Practising Course

Corresponding practising courses for the virtual lectures are also offered for transmission. The high degree of interaction between students and lecturer constitutes a particular challenge in this scenario. Furthermore whiteboard systems and/or distributed applications are more often used in virtual practising courses than in virtual lectures.

4.3 Virtual Seminar

In this scenario the attending lecturers and audience are spread out over different locations and communication takes place alternately between the respective access points. The audience at the remote access points is able to ask questions to the lecturer or discuss points with other students.
4.4 Virtual Excursion

Virtual excursions are especially conducted in cooperation with companies. They are designed to save students and company employees time and money. The goal of this teleteaching scenario is the introduction of the company, e.g. by short lectures by employees and/or video material, documenting company strategies and places of work.

4.5 Lecture-on-Demand

For evaluation of asynchronous teleteaching applications, certain lectures are digitally recorded and saved on the university's video-on-demand server. Additional high-quality snapshots of blackboard inscriptions or other instructional material (e.g. slides, PowerPoint presentation) are made and synchronously tied to the MPEG video stream. Students can connect to this lecture-on-demand service with conventional web browsers and select the interesting parts of the lecture by themselves.

5 Conclusions

High-quality videoconferencing with advanced services will become more widely-spread with the increase of available network capacity. With fewer restrictions in available bandwidth the quality of videoconferencing systems will be measured by user-friendly applications. That means a comfortable use of available electronic devices with different advanced multimedia presentation material.

References


Vitae

Mustafa Soy, born in 1974, studied electrical engineering at the University of Erlangen-Nuremberg from 1993 to 1999 when he received his Master's Degree. Since 2000 he has been a Ph. D. student at the Department of Information Systems at the University of Erlangen-Nuremberg. His main research fields are integrated environments for telecooperation in virtual teams where he focuses on the development of flexible and innovative user interfaces for collaborative work, especially communication management systems for virtual teams.