New Tools for Synchronous and Asynchronous Teaching and Learning in the Internet

Volker Hilt
Christoph Kuhmünch
Lehrstuhl für Praktische Informatik IV
University of Mannheim
Germany
{hilt,cjk}@pi4.informatik.uni-mannheim.de

Abstract: In this paper we describe the new tools for synchronous and asynchronous learning developed within the context of the TeleTeaching Projects at the University of Mannheim. With our tools, students are enabled to follow lectures not only in the lecture halls of the connected universities but also at home. The innovative processing of course material allows the production of educational documents that consider the requirements of synchronous and asynchronous learning modes out of a single primary document. Course material is provided within a Web-based training unit designed specifically to support asynchronous student learning.

1. Introduction

In the Fall of 1995 the University of Mannheim initialized a joint Teleteaching project with several partner universities (Eckert et al. 97) in Germany. Three different synchronous Teleteaching scenarios were implemented and evaluated. In these synchronous learning scenarios, production and consumption of the educational material takes place at the same time. The first scenario is called the ``*Remote Lecture Room Scenario''* (RLR). Lectures are transmitted live via the Internet to lecture rooms at the partner universities. Transmission is entirely based on the Internet protocols so that students from anywhere can participate easily. The second scenario we explored is called the ``*Remote Interactive Seminar''* (RIS). In contrast to the RLR scenario, a seminar is much more interactive since a discussion between the three sides usually takes place after each talk. The third scenario is called ``*Interactive Home-Learning''* (IHL). Its target users are students running Linux or Windows 95/98 on their PC at home having an Internet connection via ISDN. This scenario is the most widely distributed among its members. The Goal of the IHL project is the provision and interactive usage of multimedia teachware within the bounds of academic education over digital networks in order to gain experience. From a pedagogical point of view information about the acceptance and learning success of such a scenario should be retrieved.

In addition to the synchronous scenarios, *asynchronous* learning is supported. In the asynchronous scenario, the student is provided with course material for the lectures and seminars. This material can be reviewed at any time and at the speed the student desires. Especially in the preparation for an exam, access to course material is viable for the students. Besides the material used in the lecture (slides etc.) additional documents are handed to the students in the asynchronous scenario. E.g. the video and audio recordings of the lectures provide access to the explanations by the professor of a specific topic. Further educational material (texts, animations etc.) may provide background information on selected topics of the lecture.

Many other related projects in the area of distance education exist (Bacher et al. 97) (Baehring et al. 98) (Schill et al. 98) (Parnes 97) (Maly et al. 97). Howerver in contrast to the other projects, our approach integrates synchronous and asynchronous forms of learning. The main features are the automatic production of educational material for both forms of learning from a single primary document. Furthermore we provide students access to the synchrounous and asynchronous learning scenarios from their home.

2. Synchronous Scenario

Our main goal in the synchronous scenario was to gain experience in the transmission of lectures to student households via ISDN. Thus an infrastructure had to be established and software components designed and implemented. From an pedagogical point of view information about the acceptance and the learning success of the scenario had to be obtained. (Fig. 1) depicts the synchronous IHL scenario. Lectures were transmitted via high-bandwidth ATM connections to the remote lecture rooms and simultaneously to the student PC at home via a low-bandwidth ISDN connection.

2.1. Implementation

During the summer semester 1998 we evaluated the scenario. Four groups of participants were selected and equipped in order to attend to our teleteaching lectures. The first group of participants attended the lectures directly in the classroom where the lecture took place. The second group of participants was located at a partner university, connected via ATM links with a reserved bandwidth. The reserved link allowed the transmission of high-quality video of the lecturer. The third group consisted of participants who attended the lectures individually at various universities in Germany, connected via the public MBone, i.e. they depended on the best effort IP protocol for packet delivery without bandwidth reservation. The fourth group consisted of students who attended the lectures individually at home. These participants were connected via ISDN and used multimedia PCs running Linux or Windows 95/98 or NT. Since ISDN provides a reserved bandwidth of 64 kbit/s or 128kbit/s (if two channels are combined) the students could depend on a relatively reliable connection, although the bandwidth available is relatively low.

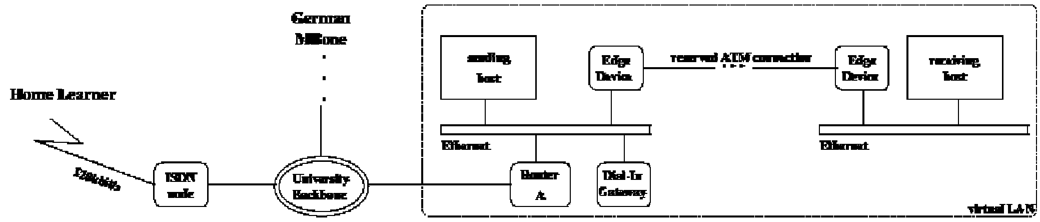

Figure 1: The Integrated Home Learning - Teleteaching Scenario

It proved to be a complex task to set up a multicast connection among these different groups of participants. (Fig. 1) depicts our solution: The reserved ATM connection to the participants of the second group was provided as a Permanent Virtual Circuit with a peak bitrate of 3 MBit/s. Upon this PVC a LAN emulation was set up: At both sites Edge Devices were installed which acted similar to remote repeaters. Ethernet frames were transmitted over ATM connections. Since participating hosts could be connected through conventional ethernet this solution allowed a flexible integration of new hosts into the virtual LAN. A dedicated router equipped with two Ethernet interfaces acted as multicast gateway to the MBone (router A in (Fig. 1)).

The simultaneous transmission of multicast streams through high-bandwidth ATM connections and low-bandwidth ISDN connections creates two technical problems: At first, the transmission of high-quality video requires a high bandwidth of at least 600kbit/s but ISDN provides only 128kbit/s. . Second, broadcasting networks like Ethernet inherently allow multicasting. Since ISDN is not a broadcasting channel, a tunnel must be set up dynamically in order to transmit multicast data.

The *Dial-In Multicast Gateway* allows the transmission of selected teleteaching lectures sent via IP multicast, over dial-in connections such as ISDN. It sets up tunnels dynamically; thus selected multicast sessions can be transmitted through channels without multicast capabilities. Furthermore it includes a simple filtering mechanism that scales the bandwidth needs of transmitted streams according to given priorities. For each selected media stream of the lecture the desired quality of service parameters can be set interactively, e.g. a certain share of the available bandwidth can be reserved. In order to allow a graceful scaling of video we integrated a simple scaling mechanism for H.261 video streams that controls the temporal resolution of the video.

In principle the gateway works in the following manner: Users connect to the server through the client application. Once a user has logged in the client will receive a list of lectures available for transmission. The user will then choose which lecture to join. A request for each selected media streams of this lecture will be sent to the server, which then will transmit and rescale the media stream according to the bandwidth available. A more extensive description of the Dial-In Gateway can be found in (Kuhmünch 98).

2.2. Evaluation results

During the summer semester 1998 a lecture on Multimedia Technology by Professor Effelsberg was implemented with the technology described above. The remote classroom was located at the University of Freiburg. A Web-based questionnaire was used for the evaluation of the synchronous scenario. Besides sozio-demographic information it assessed aspects of motivation, the technical, organizational and didactical quality of the scenario and several aspects of the subjective bearing and perception during the teleteaching lessons. The questionnaire was similar to the standardized questionnaire HILVE (Rindermann et al. 94). Also assessed was information on the software tools for the ISDN users.

A total number of 65 students attended the lectures. 43 students participated directly in the classroom, 12 students studied at home and 10 students in the remote classroom, connected through the virtual LAN. Since the number of participants in each group is small and differs widely we had to dispense with inference-statistical evaluations. The following evaluations therefore are purely descriptive but we refer to related evaluations of other projects where possible in order to buttress our interpretation of the evaluation data.

Comparisons between the ``remote situation" and the ``local situation" showed that the students always gave a higher rating to the ``local situation". The Home Learning students as well as those in the remote classroom rated perception in a ``normal" face-to-face lecture higher. The reasons mentioned were the unfamiliarity of the video on the screen or the video beamer and the poor audio quality combined with the merely sufficient visual quality of the slides in the whiteboard. Additionally students in remote situations do not feel themselves to be perceived by the lecturer as well as they would have been in the local situation. They also reported difficulties concentrating for a full, uninterrupted 90-minute lecture. In order to overcome this problem, we introduced a 5-minute break after the first 45 minutes. These evaluation results coincide with those in (Eckert et al. 97).

We evaluated how the students assessed the quality of the three media types audio, video and whiteboard with respect to their importance in the learning process. Since Home Learning students and those in the remote classroom received the lecture in differing qualities the interpretation of their results are discussed separately. (1.) Home Learning students: The evaluation data gives reason to the hypothesis that video is only of minor importance in computer science lectures, although the received quality was rated as merely sufficient. In contrast the importance of audio and whiteboard was rated high. While the whiteboard quality received good ratings the audio again was perceived as merely sufficient. (2.) Students in the remote classroom: Obviously the students in the remote classroom demanded higher quality of the video. They rated to the importance of video average and the importance of whiteboard and audio as high. While the video and whiteboard quality fulfilled the student demand the audio quality was rated as needing improvement.

Specific questions designed for the evaluation of the Home Learning scenario indicated that the participants were partly motivated by technical interest in ISDN and partly by personal contact to the department. Additionally some students found it advantageous that they did not have to commute to the university. Frequent problems with the gateway router (router A in (Fig. 1)) caused the reliability of the connection to receive only an average ranking. Nevertheless all students would participate in the experiment again, especially if higher bandwidth (provided for example over ADSL) were available.

An important finding is that the Home Learning scenario is generally accepted by students although higher bandwidth is obviously necessary. Nevertheless students in the remote classroom as well as the home learning students reported a less personal atmosphere. This result coincides with other evaluations (Eckert et al. 97).

3. Asynchronous Scenario

3.1. Objectives

One of the main goals of the asynchronous scenario is to provide the student with educational material that can be visited selectively depending on one's personal learning process. The material usually accompanies a lecture that is held in the synchronous scenario. In contrast to the synchronous scenario, where content is *pushed* towards students, the asynchronous scenario enables a student to selectively *pull* the desired material. Due to this fundamental conceptual difference, the range and the amount of material presented in the asynchronous scenario may be much greater than in the synchronous scenario. Additional material may also be used to explore certain topics of the lecture in more depth or to address different needs of learners by providing compact explanations for fast learners and full texts for slower ones. Since students interact directly with the material, highly interactive material like animations and simulations can be handed to them.

3.2. Preparation of Course Material

The lecture material of the course on Multimedia Technology given in the summer semester of 1998 was presented not only during the synchronous lectures but was also provided for asynchronous learning. Since the demand of lecture material in both scenarios differ, a novel authoring process was developed that allows efficient production of material for both. We also set up a system which allows the material to be captured that was created during the synchronous lecture.

3.2.1 Authored Material

For the material authored by hand (e.g. the slides of a lecture) we found it to be a great advantage to leave the choice of the authoring tool to the lecturer. This enabled the lecturer to efficiently create the course material because no time was needed to learn the operation of a new tool. The lecturer may also reuse any material he has created previously with his favorite authoring tool. This will tremendously reduce the amount of time required to prepare a lecture, especially if material from previous semesters is used. The documents produced with the chosen authoring tool are in a tool-specific document format (e.g. Microsoft Word format) which is usually not appropriate for the presentation of the material. We call this document format a *primary format.*

As mentioned above, the lecture material in the synchronous scenario is presented using the MBone whiteboard wb (Jacobson 92) which is able to process documents in postscript format. Within the asynchronous scenario, the course material is provided on the teachware Web server. Since both scenarios must be considered during the authoring process, a conversion from the primary format to multiple *presentation formats* is required. This conversion process should be executable with minimal user interaction. In particular, it should not be necessary to edit the conversion results, because these changes would be lost if the conversion process is repeated.

The authoring process we have implemented allows to produce the presentation formats postscript, PDF and HTML out of a single primary format document. The authoring process is subdivided into three steps. In the first step, the document is edited using the desired authoring tool (in our case, Microsoft Word). In the second step, the document is converted to the presentation format. In contrast to postscript and PDF, the conversion to HTML proved to be very difficult. Our experiments with HTML export filters showed that the resulting HTML documents often could not be post-processed any further. Very good results were achieved by exporting a document to the RTF format and converting the RTF document to HTML. This process is suitable for all authoring tools that are able to export RTF documents and therefore does not restrict the flexibility in the choice of the authoring tool.

In the third step of the authoring process, the HTML document resulting from step two is post-processed for its actual presentation. Using a Perl script, the WBT described in Section 3.3 is automatically generated. To accomplish this task, the script reads a configuration file in which the linking structure of the WBT is specified and inserts appropriate links into the HTML documents. The configuration file can be edited by the author to specify further material that should be integrated into the WBT.

3.2.2 Captured Material

Course material can be gathered during the live lecture by recording the audio and video data. In our case, we recorded audio and video using the MBone VCR recorder (Holfelder 97).

Besides audio and video, an important source of material are the slides that are presented by the lecturer using the wb. In contrast to the audio and video data, wb data cannot be recorded with a state-of-the-art recorders like the MBone VCR. But even if the data of the wb could not be recorded directly in the past semester, it proved to be a good source of information for assigning parts of the recorded audio and video to the corresponding slides of the lecture. The recording of a lecture comprises the full 90 minutes. In order to determine the parts which belong to a single slide, the recording must be indexed. This indexing is done automatically during the recording of the lecture by our tool *listenwb*. This tool examines the data stream produced by the wb. It records the time at which a slide is changed in the wb. This point in time is converted to a timestamp relative to the start-time of the video and audio recording by subtracting an offset. At the end of a recording, an index is created by listenwb which contains the timestamps of page changes relative to the beginning of the video and audio recording. This index is the foundation of the configuration file used by the perl script in the generation of the WBT.

3.3. Web-Based Training (WBT) Unit

The complete course material of the 1998 Multimedia Technology course was combined into a WBT (Effelsberg 98). This WBT integrates all the material (hand-authored and captured) and provides access through the common user interface of a Web browser (Fig. 3).

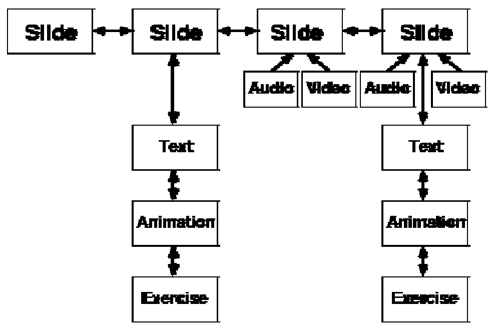

Figure 2: Instructional design of the WBT

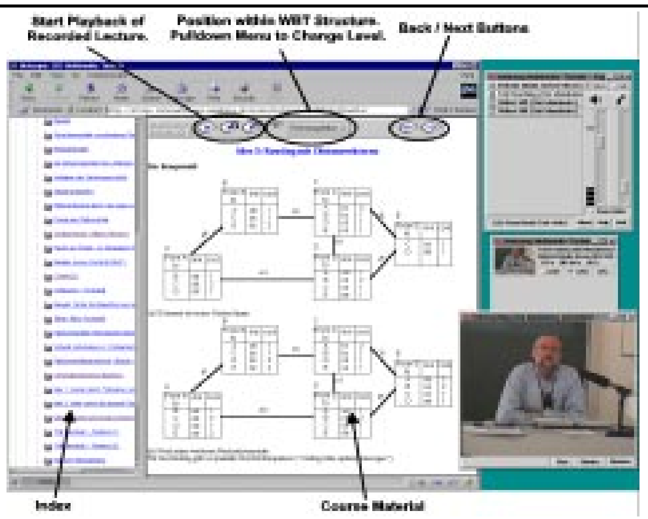

Figure 3: Screenshot of the WBT

3.3.1 Applying an Instructional Design

A very important aspect of a WBT is the appropriate structuring of the material it contains. For this reason, the instructional design of the WBT (Fig. 2) was developed in cooperation with a research group at the Department of Psychology at the University of Heidelberg under the direction of Professor Reimann. The foundation of the WBT consists of the slides of the lecture. These slides are linked in the order in which they were presented during the lecture. Each slide contains a forward and a backward button in the *navigation bar* on top of the screen (Fig. 3). This allows a student to successively walk through the complete course. Additionally, a self-expanding index enables a student to access material on a specific topic. Each slide contains a link to the corresponding part of the video and audio recording of the lecture. Some of the slides contain links to additional material. This additional material is structured in multiple layers where each layer contains different material (full text, animations and exercises) on the same topic as the slide. Thus, a student may descend through different layers until the topic has been completely understood. Afterwards, the student ascends to the upmost level and continues with the next slide. Currently we have integrated Java animations and exercises into the WBT; the integration of full text will follow

4. Conclusions

In this paper we summarized our synchronous and asynchronous teaching and learning scenarios. We described details of the technical implementation and presented initial evaluation results which prove that teleteaching in its synchronous mode is generally accepted by the students although they expect high technical and organizational quality. For the asynchronous scenario, we presented an innovative course material processing scheme that enables the production of educational documents considering the requirements of different learning modes out of a single primary document.

Future work aims to add interactive media such as VRML or Java animations and simulations as new educational paradigms to our asynchronous and synchronous teleteaching scenarios. This comprises the development of a general framework for the transmission and recording of interactive media (Mauve et al. 98).

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