Enhancing Synchronous Distance Education with Pervasive Devices

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Abstract. *In this paper we present a system that enhances typical synchronous teleteaching environments. The key idea is to compensate the lack of social awareness and interactivity of a telelecture by allowing students to use hand-held devices and wireless communication to interact with the lecturer and with other students. One example of the interactions enabled by the system is a feedback mechanism that allows the students to provide the lecturer with information about how the speed and difficulty of a lecture is perceived by the students. Another example is the ability of the lecturer to hold quizzes with the distributed audience. The system has been implemented as a prototype and it is currently being evaluated in regular lectures at the University of Mannheim.*

1. Introduction and Problem Statement

Synchronous computer-based distance education has become a very popular application in the recent years. Individual participants or groups of participants connected by a network are using synchronous CSCW (Computer-Supported Cooperative Work) systems for the purpose of remote teaching and learning. These systems typically include multipoint videoconferencing for transmitting audio and video in real-time to the remote sites but also application sharing tools, joint editing tools and shared whiteboards. Research in this area identified the need for additional software support beyond those more basic communication means [5, 4]. In distributed scenarios social protocols or rules that control the human interaction and establish awareness are not automatically available as in the face-to-face situation and they are difficult to reproduce. In order to overcome these weaknesses, a couple of so-called collaborative services have been identified and integrated into existing systems. These services include, for instance, session and floor control, hand raising, voting, online feedback, messaging, and chat [4].

Experiences using these services in the teleteaching project VIROR [2] indicated that they were only rarely used. This had several reasons. First, participants simply did not know that these tools were available and thus did not use them. Second, the usage of the tools was too clumsy and the user interfaces were not intuitive. Third, the direct access to the services was not possible or simply too complicated since students had to make use of the session facilitator to articulate themselves. While reasons one and two can be overcome by improving the software, the third reason is inherent to the teleteaching environment: groups of participants are distributed across at least two lecture rooms that are connected by a network. In addition individuals (e.g., students at home), each using her own computer, are also connected to this session (see Figure 1).

In this environment each seminar room needs a facilitator who is responsible for the technical setup and the organization of social interaction. Individual participants in the seminar rooms are typically not equipped with computers, i.e., communication with remote participants needs to be moderated by the facilitator.

If a participant in the seminar room raises her hand to ask a question, the facilitator sitting at the computer has to use a "hand raising" tool (if provided at all) to indicate to the remote participants that there is a question. When the remote lecturer signals that she is ready for taking the question, the facilitator has to "pass the floor" to the local participant. This procedure is cumbersome and very inhibitive to spontaneous interaction and communication.

Online feedback in such a scenario can only be realized by having the facilitators in the seminar rooms collect the opinions of the individuals present and type these into the computer. The feedback is thus not anonymous anymore and the process is very clumsy and time-consuming. This is particularly problematic since online

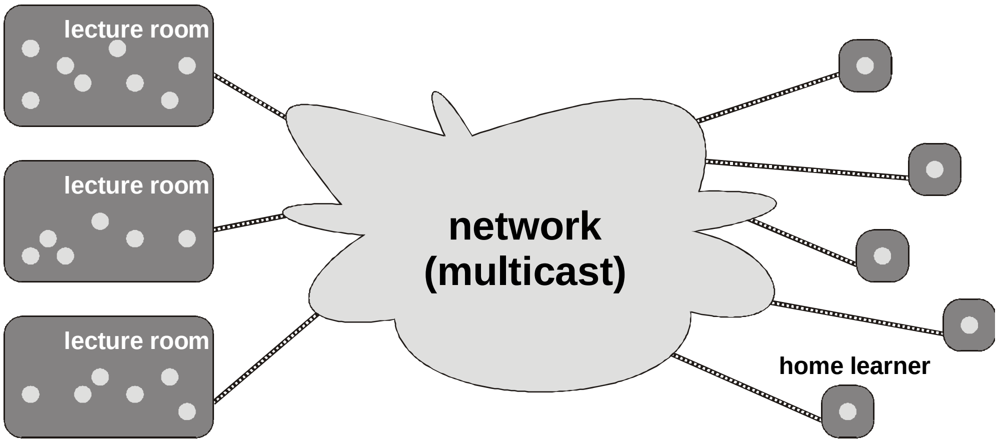

Figure 1: Typical Teleteaching Scenario

feedback is thought to provide additional speaker feedback in a distributed scenario, e.g., on speaker performance, technical quality, speed etc. In the described environment only the facilitator can give real-time ratings even though she is not representative for the people in the seminar room. Therefore, in most cases online feedback tools are not used in such a scenario.

The participants in a seminar room have also only limited awareness (through a small video image) of who is present in the other seminar rooms. Personal messaging, chatting or side talks like in a face-to-face situation are not possible.

For these reasons synchronous distance learning environments still suffer a severe lack of interactivity, feedback, and awareness when compared to the face-to-face situation. Due to the technical and social barriers described, people tend to be less interactive than usual. Collaborative teleteaching sessions most often are degraded to simple remote presentations without much feedback or discussions.

The straightforward solution to this problem seems to be the provision of desktop or laptop computers to the participants in the seminar room such that each one can interact individually with the system. The great disadvantage of this approach is that having a computer in front of each participant destroys social interaction in the seminar room. Communication becomes very unnatural for the people in the room. Moreover, people also tend to get distracted by the computer since they can use it for other than lecture-related tasks. A more appropriate approach would be the provision of wireless hand-held devices that support specialized forms of interaction.

2. Pervasive Devices for Distance Education

Portable hand-held computing devices (e.g., Palm Pilots, iPAQs or e-books) have become ubiquitous in recent years. Meanwhile some manufacturers also supply wireless communication technologies for these systems, providing great flexibility and functionality to the user. Today these technologies are mainly used for remote access to information (e.g., Web-based information retrieval) [6]. However, in the area of teaching these technologies have also been employed to support regular lectures [1, 3].

At the University of Mannheim we started to use the combination of wireless access and hand-held devices to overcome the lack of interactivity, feedback, and awareness that is inherent to synchronous distance education settings. The key challenge is to design and develop an overall system that can be readily integrated into existing synchronous teleteaching environments and that provides the following services:

Online Feedback. One of the most important issues in synchronous distance education is that the lecturer typically cannot notice how well the students in the remote lecture rooms are able to understand the lecture. Online feedback provides a solution to this by allowing the lecturer to create a number of categories, such as speed or difficulty of the lecture. Using the hand-held devices each student can assign a value to each category (e.g., too slow, just right, too fast) at any time during the lecture. The results of this student feedback are displayed to the lecturer so that she can react to problems immediately.

Hand Raising. This service allows students in any lecture room to raise their hands. The lecturer is notified of this event with the information about the lecture room the student is in and the name of the student. It is therefore very easy to call the student and allow her to ask a question.

Telepointer Control. When a student asks a question it is often necessary to point to a certain area of the shared workspace to show what the question refers to. Integrating control for a telepointer as a service can support this. The student can then use the hand-held device to point the telepointer to a certain area on the shared workspace.

Audio Input. When a student wants to ask a question, the audio has to be captured by a microphone, so that it can be transmitted to all other participants of a session. Currently this requires that the facilitator of the session in a lecture room hands over a microphone to the student. Alternatively the entire lecture room could be equipped with numerous microphones, which is fairly expensive. The audio input service would use the microphone of the hand-held device to capture the question and transmit it to the remote participants.

Quiz. One way to make lectures more interesting is to incorporate elements of competition. With this service the lecturer is able to ask a question to the audience and the hand-held device is used by the students to answer the question. Awards (such as bonus credits) can be given to those students that reply correct and within a given time. Furthermore the first student who answers the question correctly may receive some extra benefit. By creating competition the lecture is likely to become more interesting for both students and lecturers.

Many more services can be imagined, however the ones described above are those that have been identified with the highest priority by participants in real-world synchronous teleteaching environments.

3. System Architecture

The general architecture of the system is shown in Figure 2. The hand held devices connect over a wireless link and an access point to a server that can be located anywhere in the Internet. When a hand-held device connects, an authentication mechanism makes sure that the user is allowed to connect and that the user is assigned a role. These roles may be student, lecturer, or super-user. Depending on their role, users may perform different tasks. Students may use the services as is. A lecturer may adapt the services to fit to her lecture. For example, a lecturer may configure the criteria for online feedback or set-up the questions for a quiz that will take place later

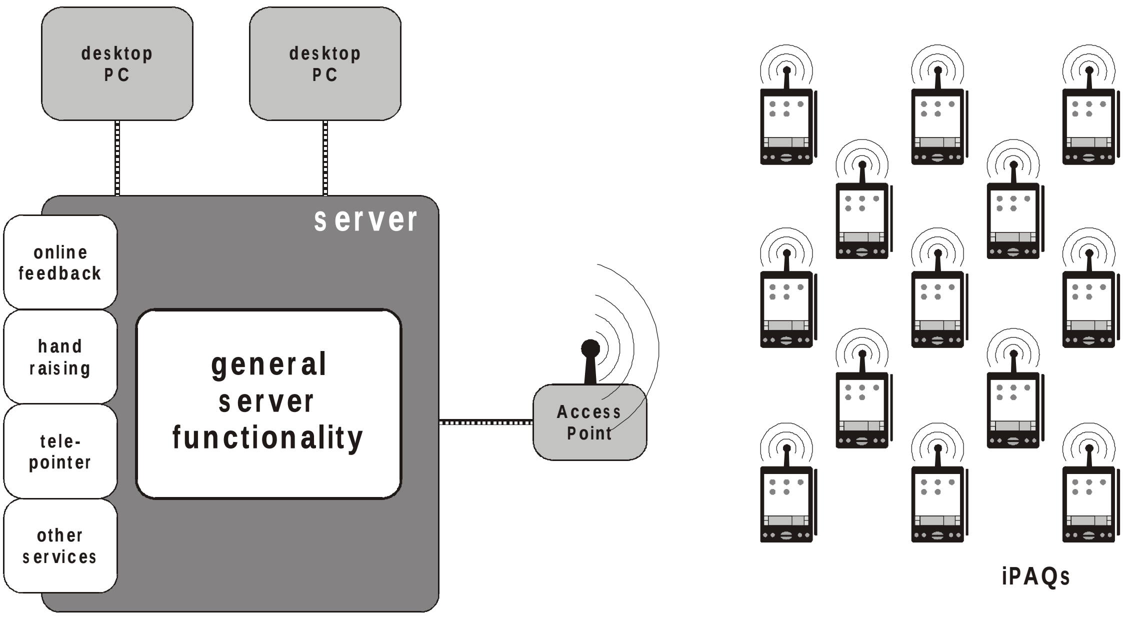

Fig. 2. Prototype architecture

during the lecture. The super-user role allows multiple instances of the server or an instance of a server and an external application to be connected together so that the data they maintain for the individual services is the same on all server- and external application instances.

The authentication is handled as a general server functionality that is independent of the individual services. A further element of the general server functionality is connection management: in a wireless environment connections may break (e.g., due to interference) and are reestablished later on. This must be made transparent to the user. Therefore the server automatically tries to reconnect if a connection is taken down in a non-graceful manner. Only if these reconnection efforts fail for an extended period of time will the user be removed from the server. Another element of the general server functionality is user management. User management allows checking who is online, where people are location-wise (e.g., in which lecture room), or what kind of device they use.

The individual services, such as online feedback or hand raising are realized as plug-ins within the server. The plug-in modules make use of the general server functionality and, thus, implement their own functionality on top of it. For the online feedback service, for example, this entails the creation of categories and the accumulation of the students' feedback.

One main requirement for the system is that it has to blend naturally into existing synchronous teleteaching environments. This is made possible by allowing the server to synchronize with external applications. For this purpose external applications may connect to the server and exchange information about the data the external application and the server maintain for each service. The server notifies the application when this data changes and requires vice versa that the application notify the server if information is changed within the application.

A typical scenario looks like the situation depicted in Figure 3. In this scenario two lecture rooms are connected over the Internet (possibly using multicast). Furthermore there is one "home learner" who participates in the session. In both lecture rooms there are a number of students (not shown in the figure) who are equipped with hand-held devices and who are connected to the hand-held server. The individual hand-held servers in the lecture rooms are connected with the shared whiteboard system and the audio and video tools, so that the overall system forms a homogeneous unit.

In a typical situation a student in lecture room A would use the hand raising tool to indicate that she has a question. The server in lecture room A would tell the shared whiteboard system about this (suppose that the shared whiteboard system has an integrated hand raising mechanisms). Then the shared whiteboard system would notify the shared whiteboard instance of the lecturer that someone has raised the hand. In this case let the lecturer be located in lecture room B. Therefore the hand raising functionality of the shared whiteboard instance in lecture

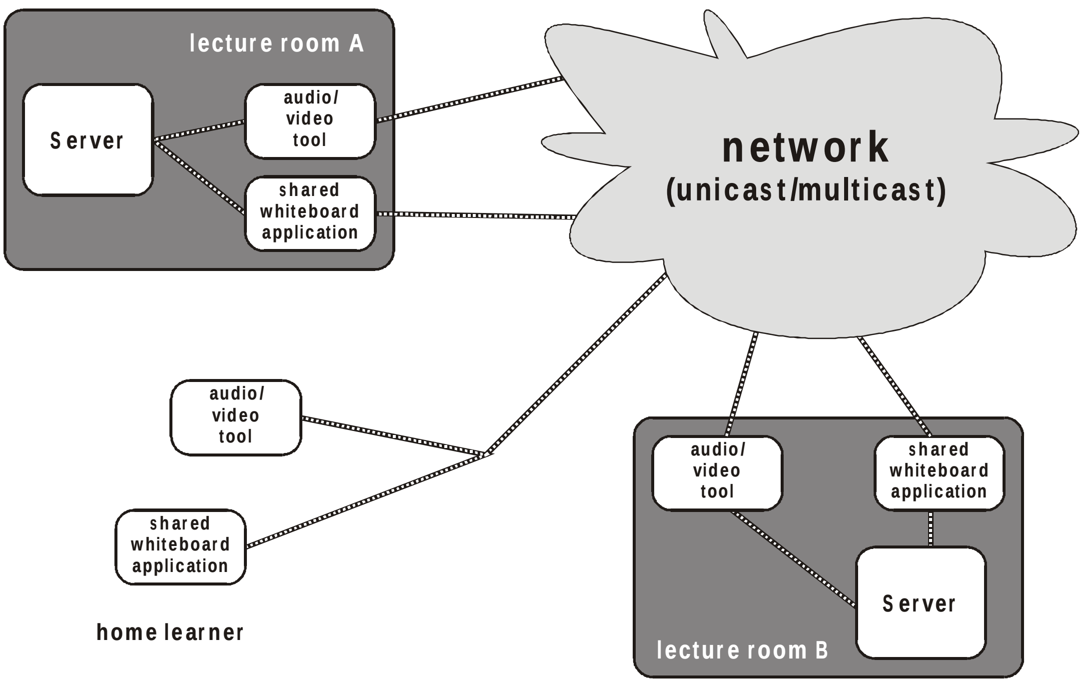

Figure 3: Typical Scenario

Figure 4: The Online Feedback Service

room B would notify the lecturer. Once the lecturer has called the student, the student may use the microphone of her hand-held device to ask the question. The audio is then transmitted to the server, which will forward it to the audio/video tool, so that it can be broadcasted to all participants. This example shows how the system may blend seamlessly into existing teleteaching environments, reusing functionality such as multicast communication for shared whiteboard- and audio/video data whenever possible.

4. Prototype

During the past year we have developed a first prototype of the system. The whole campus of the University of Mannheim has been equipped with IEEE802.11 base-stations to allow wireless communication. The hand-held devices currently in use are iPAQ palmtops with IEEE802.11 PCMCIA cards. Our first implementation is Java-based in order to maintain platform independency. The functionality of the prototype comprises the general server functionality including the possibility to connect external applications, the feedback service, and a short message service for communication between arbitrary participants. We have also implemented a client on an iPAQ for these services (see Figure 4). Currently, we are in the process of evaluating the prototype during a regular lecture, before employing it in a synchronous teleteaching lecture of the VIROR project during the winter semester 2001/2002.

Our experiences with developing the prototype were mostly positive. The wireless communication over IEEE802.11 with iPAQs did not cause any problems. The only limiting factor, so far, is the availability of an appropriate Java Virtual Machine for the iPAQs. Currently we use a beta version of SUN's Java 1.1 for pocket PC (formerly known as Windows CE).

5. Conclusion

We have presented a system that uses mobile devices and wireless communication to compensate the lack of social awareness and interactivity in synchronous teleteaching sessions. The main idea is to provide a set of services, such as online feedback and hand raising that can be accessed by the students through a hand-held device while these services are highly integrated into existing teleteaching environments. We have developed a first prototype that is currently being evaluating it in a regular lecture.

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