An interactive distance education service utilising the World Wide Web – a preliminary study

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Abstract

This paper describes an innovative distance education service based on the World Wide Web (WWW) and an Internet based videophone service. The WWW is used to provide a slide display function similar to that provided by presentation systems such as PowerPoint™. By using the WWW, slides for presentation in a lecture are available to students located away from the site of a lecture. The system described in this paper provides the lecturer with a facility to simultaneously control the display of slides to the local audience and to the remote students. A prototype system was used to verify the pedagogical soundness of the approach. In this case, no significant difference was found between the information retained from the lecture between the students attending in the lecturer room and those attending at remote locations. The generic system developed as a result of the prototype, and a verification trial on the system are described

I. Introduction

A number of interactive distance education systems have been devised to allow students (including those with a disability) to participate in lectures in higher education when they can't be physically present in the lecture. [1] Where live access is provided, it invariably provides an audio and video stream where the video is focused either on the lecturer or on the material that is being presented. In each case the video is showing the output of a document camera or a view of the same screen display that is visible to the students in the lecture room. Both of these solutions imply that a video image of sufficient quality to show the details of the material being presented generates a large volume of data that has to be transported to the remote students.

An international project consortium was set up in late 1994 to study the part that telecommunications technology could play in improving access to Universities by students with disabilities. The consortium has partners in Slovakia, Hungary and Austria, and is lead by a team from the University of Dundee in the UK. In considering access to lectures, the project team is constructing a system based on an alternative approach that uses desktop based Internet videophone links with lecture material being made available as HTML pages distributed using the World Wide Web (WWW). In order to ensure that the lecturer is in control of the presentation of the lecture material, there is a requirement for the teaching system to provide the lecturer with a controller that directs the display of the lecture material on the terminals of the remote students.

This solution has the advantage that the material being used by the lecturer is distributed in a text based format, with other media elements embedded but described within the HTML page. This allows the material to be downloaded, transduced into another media or reformatted at the student's terminal. This process is almost impossible if the material were distributed as a live video stream. Furthermore, the system can be used in situations where the link between the local and remote sites is of relatively low bandwidth (PSTN or primary rate ISDN).

II. Pedagogical Verification Study

Before proceeding with a full technological development, a preliminary study was undertaken with a prototype system to consider the following basic question:

"Could the essential facts from a lecture be communicated using a video and audio link together with WWW based lecture slides ?

A comprehensive survey of distance education [2] indicates that, in general, there is no significant difference in the educational achievement of those using or not using educational technology. It is against this background that we sought to verify the validity of this approach. We did not, therefore, perform a comprehensive trial, but a small scale study that would expose the essential educational implications of our ideas.

II.A. Hypothesis

This was translated into the following hypothesis:

"Remote students would be able to assimilate and recall the same information from a lecture delivered using audio and video links together with

WWW based lecture slides as the students present in the lecture room."

An experiment was set up to test the hypothesis, using a rapidly prototyped slide control system.

II.B. Method

A series of three lectures about data communications (Multimedia Lecture, ATM Lecture, Mobile Telecommunications Lecture) lasting for 50 minutes each were prepared in order to test the hypothesis.

All the lecture slides were constructed in HTML format and placed on a WWW server so that they were available for viewing from a WWW Browser. The lecturer's presentation was made available to the remote students using an Internet videophone

The functional components of the system based on this method of remote lecturing are shown in figure 1 below.

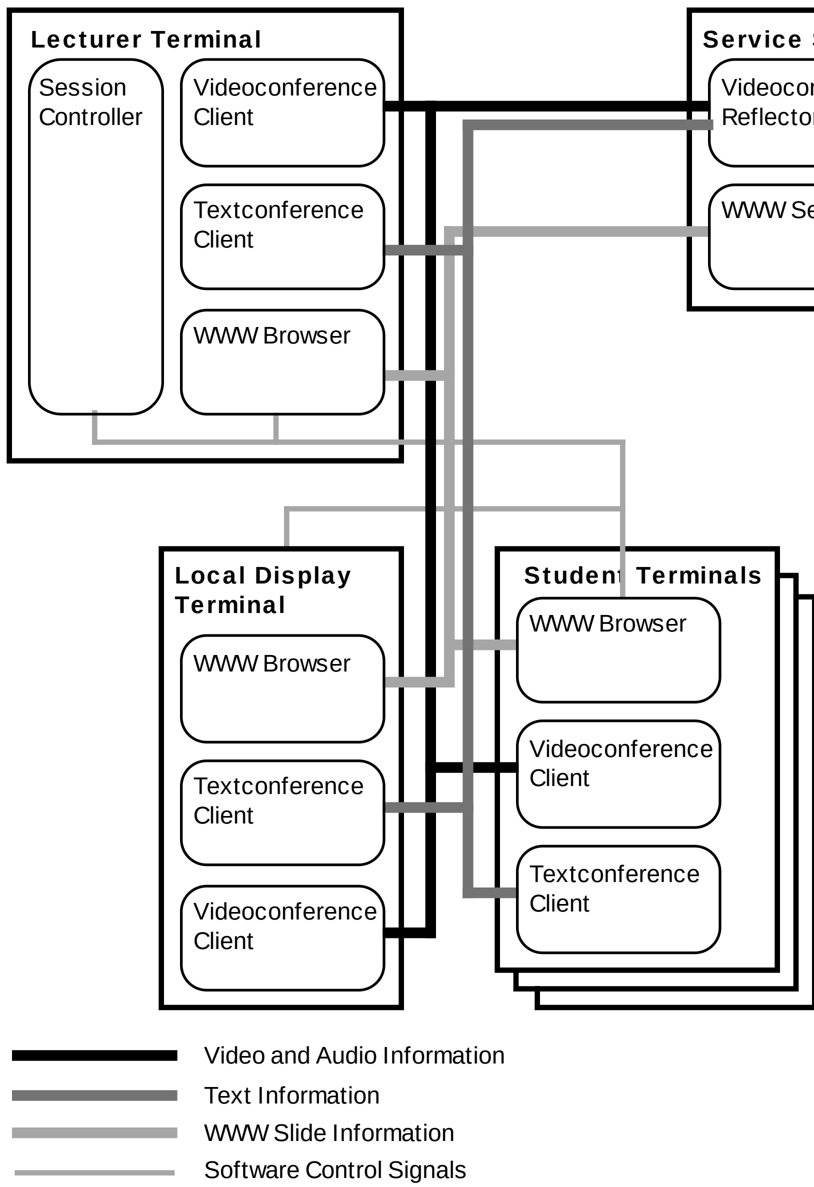

Figure 1: Functional components of a remote lecturing system based on the World Wide Web

The lectures were presented to the students in the lecture room using a projector connected as a display on a computer. The slides were viewed by the local students in the conventional way on an overhead projector screen.

The remote students could see the current lecture slides as pages displayed by the Netscape Navigator WWW browser on their terminal. The video and audio from the lecturer were presented to the remote students by the CU-SeeMe software on the students' terminals. These students could interrupt the lecturer and ask questions using the audio channel available in CU-SeeMe.

The lecturer received video and audio from all the remote students using CU-SeeMe and could change the lecture slides on all participating computers using the prototype remote control application.

At the end of each lecture a 7 question multiple choice examination based on the contents of that lecture was given to the subjects.

After the three lectures had been given a group discussion was held. Certain non-leading questions were prepared before this discussion to keep the discussion going. This discussion was video recorded for later analysis.

During the lecture, project team members in Bratislava in Slovakia, Budapest in Hungary and Vienna in Austria downloaded the WWW pages of lecture slides and followed the lectures as they were being presented using CU-SeeMe across the Internet.

Following the lecture a feedback discussion session took place between project team members in Dundee, Vienna and Budapest using CU-SeeMe. This discussion was videotaped for later analysis.

II.C. Subjects

4 able-bodied students were selected from the lecture class to sit at the remote computers elsewhere in the building, and 4 able-bodied 'academically' equivalent students were present in the lecture. The average academic achievements of the class from the previous academic year were used to match local and remote students.

Able bodied students were chosen for this test as the objective was to test the underlying functional validity of the approach, not, at this stage, it's usability by students with disabilities

II.D. Apparatus

In order to prove the concept of using the WWW for display of lecture slides, a prototype remote control application for Netscape Navigator was developed to run on Macintosh computers. The Macintosh platform was chosen for the development of the prototype because the operating system has a powerful message passing facilities built into it called Appleevents. These Appleevents are the basic messages passed within a Macintosh whenever an action or activity takes place. Many applications, including Netscape Navigator can respond to Appleevents sent to it from other applications, as long as those events conform to a set of events defined in their specific event "dictionary". If Macintosh computers are connected to a network that can transport the Apple Appletalk network protocol, messages can be sent from one machine to another. This allowed a remote control application to be hosted on one machine, and control a copy of Netscape Navigator running on another machine. The prototype application was developed in the Supercard rapid prototyping scripting language. This language has commands and functions that allow inter-machine message passing to be incorporated into applications in a transparent way without having to consider any protocol or low level networking issues.

This application (the session controller) developed provided a lecturer with the facility to build up an index to the slides and then to select from a master a list the specific slides to be used in each different lecture. During the lecture, the lecturer can move to the next or previous, or selected slide according to its name. During a lecture, the session controller passed the Universal Resource Location (URL) reference of the selected slide to the copy of Netscape Navigator running on the lecturer's own terminal. It was also passed to another terminal in the lecture room whose display was connected to an overhead projector, and to the copies of Netscape Navigator running on 4 students' terminals located in other rooms on Campus. This allows both local and remote students to see the same set of lecturer's slides at the same time.

A Sun Microsystems Sparcstation 2 ran a CU-SeeMe reflector so that a multi-party video conference could take place, and a Sparcstation 10 clone was ran a WWW server from where the lecture slides were being distributed to all the other computers.

II.E. Results

The results of the multiple choice questionnaire are shown in the Table 2 below. The scores are all out of 7.

The results show that, taking an average across the three lectures, there is less than one score difference between the local and remote participant, except for pair 4. The remote student in pair 4 was unable to participate in the third lecture due to domestic difficulties, a factor that probably contributed to his poor performance in the earlier lectures.

Given such a small number of subjects, it is not meaningful to perform a rigorous statistical analysis. In general terms however it can be concluded that there is no significant difference between the results achieved by those following the lecture locally or remotely.

Lecture	Student	(Local/ Remote)	Multimedia	ATM	Mobile	Average
Pair 1	GW	R	6.00	7.00	4.00	5.67
	GF	L	6.00	6.00	6.00	6.00
Pair 2	JG	R	3.00	5.00	7.00	5.00
	DB	L	3.00	*	6.00	4.50
Pair 3	TM	R	5.00	4.00	6.00	5.00
	RU	L	6.00	5.00	5.00	5.33
Pair 4	GM	R	1.00	2.00	*	1.50
	RM	L	5.00	6.00	7.00	6.00

Table 1: Multiple Choice Questionnaire Results - Prototype System

* Student was unable to attend the lecture

Feedback from the group discussion following the three lectures raised the following specific issues concerning the technical performance and mechanics of participating in a remote lecture:

1. Video quality was sometimes poor in that movement seemed to “strobe”.

2. Audio for different machines did not arrive at each terminal at the same time. This could be distracting if a number of students have terminals in the same room.

3. Some people felt that they would be less likely to ask questions as a remote user than if they were in the lecture theatre.

4. Camera position and lighting of the lecturer were important to follow where the lecturer was pointing.

5. The local students would like to see the remote students, particularly when the remote students were asking a question were asking a question.

6. The remote students would like to see the local students, particularly when the local students were asking a question

7. In general, despite the poor video quality, it was universally agreed that the system as it existed would be usable if, for practical reasons, the students were unable to attend the lecture. This point was made quite strongly at the end of the discussion.

Further discussions took place exploring the following more general issues:

1) The system could be used to tape the lectures for later recall

2) The fact that the lecture notes were available as HTML pages for access via the WWW after the lecture would be of benefit for later study.

These issues are important when considering wider exploitation of the service, and will be analysed further in future research.

The experience of the participants receiving the lecture over the Internet was that in Vienna it was felt that, subjectively, about 80% of the audio could be followed, with the video picture showing presence and movements quite clearly if not always smoothly. In Budapest, subjectively, about 70% of the audio could be comprehended. Colleagues in Bratislava could not maintain a reliable link for technical reasons associated with their local Internet infrastructure. This issue is being considered within the LEARN-ED project.

II.F. Discussion and Conclusions

Initial results suggest that the students did not feel that the receipt of information suffered because they were remote from the lecture, particularly because they had direct access to the lecture notes. Most of the concerns centred on practical aspects of the social interactions, which depend on factors such as display of remote and local participants. These will also be considered in later research.

Subsequent trials will take place to determine the optimum the videophone transmission and reception settings. This should address some of the concerns about poor audio and video quality.

In situations where more than one student is receiving the lecture in the same room but through different terminals, the audio should be presented through only one machine through a set of loudspeakers, or all participants should wear headphones.

The video and audio quality were generally good, and much better than expected, although the bandwidth available is not reliable.

In conclusion, the trial verified the overall functionality of the service, and showed that it could be used to successfully transmit a lecture to a number of remote participants.

III. Generic System

Following the study, the system has been developed further so that it uses the TCP/IP protocol to transport the messages from the controller to the Netscape Navigator WWW browsers on the remote terminals. The Appletalk protocol as used in the prototype system is not supported beyond the limits of LAN routers or Campus routers, and cannot be handled across the Internet. For this reason, the project partners in Vienna and Budapest were able to follow the lecture audio and video presentation, but had to select the HTML slides themselves. By using the TCP/IP protocol, this limitation has been removed, allowing the system to be used across the Internet.

The decision to move from Appletalk to TCP/IP for the inter machine message passing was also taken to allow the system to be generalised and implemented on the other computer platforms of interest to the project. Implementations have been made for PC (Windows 3.11, Windows 95 and Windows NT), Macintosh (using MacTCP or Open Transport) UNIX and KA9Q.

III.A. Message Passing Daemons

For this functionality to be achieved, a protocol has been agreed to enable communication to be established between two machines connected to the Internet. Having agreed the protocol, a set of Daemons are being developed that will pass a message generated within that machine to the destination machines involved in the lecture. The Daemons make contact across the Internet, open a communication channel, and then verify the types of machines involved in the communication. Once this process is complete, the daemon will provide a transparent path between the controller and the WWW browsers on the remote machines.

Should the link be broken during the lecture, the remote daemon will be able to negotiate a reconnection with the daemon running on the lecturer’s terminal

III.B. Function of the Controllers

The controller is responsible for sending messages containing the URL of the slide to be displayed. Because the system is intended to be multi-platform, the controller receives from the daemon information describing the type of the machine at the remote end of each open channel. The controller then matches the syntax of the URL message to the type of the machine, and sends a machine-specific message through the channel opened by the daemons. This is in the form of:

- Appleevent messages for the Macintosh
- DDE messages for the PC
- X-event messages for the UNIX environment
- command line messages for the DosLynx WWW browser used with the KA9Q based systems.

This process is transparent to the lecturer, who uses the controller to select slides and move through the list of slides regardless of the type of machines connected within the lecture.

III.C. Alerter

In a lecture, students can show that they would like to interrupt the lecture by raising their hand or making some other agreed signal. In the prototype system, the only method available to remote students was to make an audible interrupt request, which could be an unacceptable distraction for the lecturer. For this reason, an alert function has been added to the system that allows students to indicate that they wish to interrupt the lecture in a way that is acceptable to the lecturer.

III.D. Videophone System

The CU-SeeMe software is available with identical functionality on both the Macintosh and PC platforms. It is continuing to be developed both by Cornell University (the original developers) and White Pine software (the commercial licencees). The VAT audio software and the NV video software on the UNIX platform can use the same audio and video streams as CU-SeeMe

IV. Internet System Verification Study

Having constructed a new lecturing system based on the Internet message passing protocol, it was tested in a series of lectures given in Budapest. A series of lectures were included into the curriculum to teach the new remote teaching techniques at ELTE University to allow visually impaired and blind students to participate in lectures when they couldn't be physically present in the lecture room.

In lecture room a Silicongraphics workstation running the MBone tools - nv3.3 (net video) and the modified vat4.0 (visual audio tool) - was used to provide audio and video stream where the video was focused partly on the lecturers and partly on the students being present in the room. The video and the audio from the lecturer were presented to the remote students by the CU-SeeMe software on Macintosh and PCs running Windows across the Internet both in LAN, MAN and WAN.

The lecture slides were constructed in HTML format and placed on a WWW server for viewing using the Netscape Navigator WWW clients controlled via the daemons running on PC Windows, Macintosh and Linux in the lecture room and on the remote sites. The visual impaired and blind students followed the lecture slides on speech friendly terminals with Lynx WWW browsers controlled via a KA9Q daemon. The remote daemon on all platforms were controlled by the lecturer using the PC Windows based controller program.

IV.A. Lecture Schedule

A series of lectures were given as part of a university course called "Remote teaching over networks using multimedia equipment for students, including students with disabilities". The following series of lectures was presented:

The role of computers and networks in the teaching activities
Date: Sep 26, 1996 at ELTE
Remote room: KFKI, University Dundee

The Internet - overview
Date: Oct 3, 1996 at ELTE
Remote room: KFKI, University Dundee

Radio-networks
Date: Oct 10, 1996 at ELTE
Remote room: -

The World Wide Web and the Remote paging
Date: Oct 17, 1996 at ELTE
Remote room: KFKI

CuSeeMe videoconference
Date: Oct 24, 1996 at ELTE
Remote room: KFKI
MBone technology
Date: Oct 31, 1996 at KFKI
Remote room: KFKI in two places (remote sighted and remote blind)

MBone applications
Date: Nov 7, 1996 at ELTE
Remote room: KFKI in two places (remote sighted and remote blind)

Digibook - Digital Talking Book for the Blind
Date: Nov 14, 1996 at ELTE
Remote room: University Dundee

Practical experience with CuSeeMe and MBone
Date: Nov 21, 1996 at ELTE
Remote room: KFKI

Speech synthesiser
Date: Nov 28, 1996 at KFKI
Remote rooms: ELTE

Lectures given by the students, the topics were chosen by themselves
Date: Dec 5/12, 1996 at ELTE
Remote rooms: at KFKI (remote sighted and remote blind)

The lectures were presented by a number of different lecturers, including people who were not directly involved in the project. This allowed value feedback to be obtained from lecturers not involved in the development of the system.

The teaching activities were fulfilled either in ELTE's or KFKI's lecture room in the presence of local sighted students while the remote students were taking part in the lectures in two different remote rooms i.e. in *'remote sighted'* and *'remote blind'* rooms.

IV.B Apparatus

In the lecture room an SGI-Indy and a PC formed the *lecture station*. The PC was used by the lecturer to control the local and remote copies of the lecture slide presentation and the SGI-Indy acted as the lecturers videoconference terminal running the Mbone applications *nv* and the modified *vat* tools and transmitting the audio and video streams to an MBone compatible CU-SeeMe reflector. A PC Windows based lecture station running CU-SeeMe and the controller was also tried during some of the lectures.

The *remote sighted room* was equipped with an Apple Macintosh running CU-SeeMe and a PC with Netscape Navigator for Windows while in the 'remote blind room' two PC were configured, one PC for CU-SeeMe one as a speech friendly terminal for Lynx browser.

The remote rooms were connected to the lecture room via a variety of networks. The Ethernet based Local Area Network in KFKI was connected to the Budapest Metropolitan Area Network by a 2 Mbps microwave link connecting the KFKI LAN to the FDDI based ELTE LAN. The University Dundee was connected via the Internet. This allowed some of the lectures to be followed by students sitting at a student station at University Dundee. This terminal was an Apple Macintosh computer running CU-SeeMe and Netscape Navigator connected to a reflector running at ELTE University. The slides were also controlled by passing messages to the Netscape Navigator WWW browser on the student's terminal in Dundee. The set of network interconnections is shown in figure 2 below.

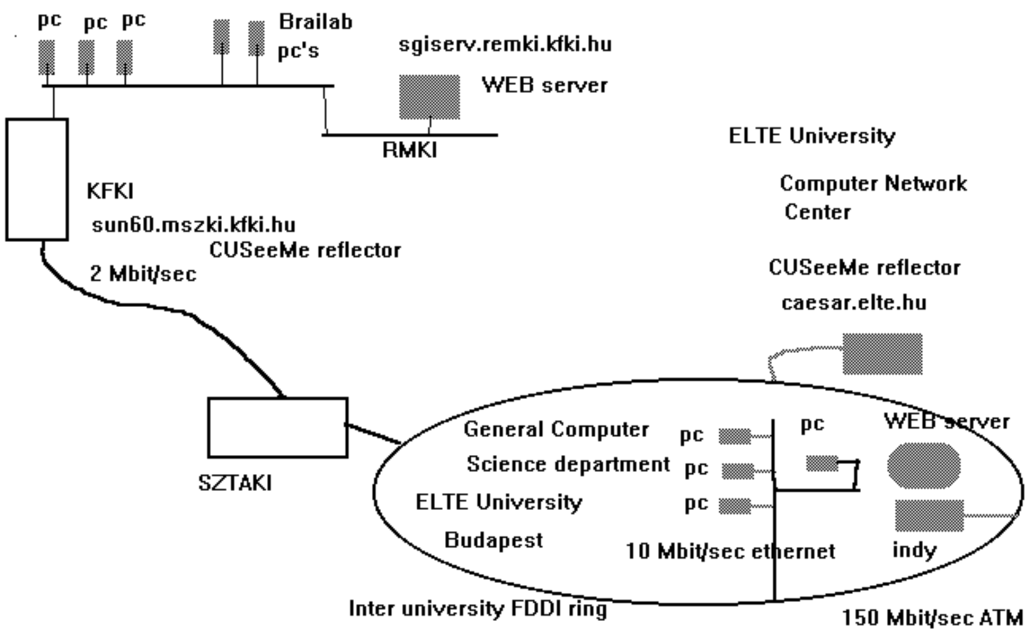

Figure 2: The test network configuration

IV.C. Evaluation Method

In order to prove this teaching method the students were invited to KFKI to attend one of the lectures. *eight* sighted students were selected to sit remotely in the 'sighted room' and *nine* sighted 'academically' equivalent students were present in the lecture room. Additionally *two* visual impaired students attended the lecture remotely in the 'blind room'. After the lecture all students were invited in the same room to fill in a previously prepared test form and to discuss their impressions of the system. The whole discussion was video recorded for later analysis.

The test form contained eight questions referring to the previous presentation and three different answers among them the correct one. The result of this test can be seen in Table 2 below.

location	number of students	result
lecture room	9 students	5 students had 8 correct answers
		4 students had 7 correct answers
remote sighted room	8 students	8 students had 8 correct answers
remote blind room	2 students	1 student had 8 correct answers
		1 student had 7 correct answers

Table 2: Multiple Choice Questionnaire Results - Internet System

Initial result shows there is almost **no difference** in the receive of information whether being present or remote from the lecture.

Feedback from the students raised the following points:

1 The students generally did not feel that the receive of information suffered because they were remote from the lecture.

2 Generally the quality of voice has an important role on listening the lecture a factor that greatly depends on the network overload.

3 An important fact is for the receptivity how many students have to share one student station to watch the presentation's slides. The ideal situation is if maximal two students has to share one station to have a good view of the Netscape Navigator window and the video window.

4 The display of the slides is more important than the video view of the lecturer. Some of the sighted remote students required the presence of the lecturer for his/her personality, look and gesticulation. However the presence of the lecturer has no basic influence on receptivity of the matter and possible this is the only and usual way to learn presently.

5 A good camera presentation focused on the lecturer's face. An other camera showing the students in the lecture room can give the feeling of being present in the lecture.

6 The blind students listening to the lecture did not find any difference in understanding, whether being present or remote. One problem that they did encounter was that they have to share their attention between the two audio streams received from the lecture room and from the speech friendly terminal presenting the lecture slides.

7 The lecture material requires careful preparation, as it mustn't use too much text information on the lecture's slides showed during the lecture. However full text slides are useful in off-line study before or after the lecture.

8 The punctuation’s in the HTML-page is an important help for Blind students to *read* the slides because of the built in intonations.

9 Blind students found the talking slides useful. They were able to follow the lecturer's speech and knew when and what slides were changed by the lecturer.

Feedback from the lecturers raised the following points.

1 The lecturer required the activity of the students in asking questions after the lecture. In the discussion it was pointed out that the students were afraid to ask due to lack of practice.

2 The lecturers also benefited from the presence of students during the lecture. A good camera presentation focused on the faces of the remote students can help to get immediate feedback. Otherwise the lecturer need to force the interactivity by interrupting his/her lecture with any intermediate questions.

V. General Conclusions

The system being developed within the LEARN-ED project provides a powerful environment for real time distance education. Having verified that the concept is useful in this study, a system has been implemented that will allow a variety of different platforms to be used across the Internet.

This study provides a the basis for developing the system that can be used by all students, but can also be enhanced for students with disabilities. In particular, the use of the WWW for distribution of the teaching material ensures that it is in a portable medium that is most suitable for manipulation and presentation for students with sensory disabilities. For example, a talking version of DosLynx is being applied for use by blind people.

The daemon based technology provides a powerful message passing system upon which a variety of teaching applications can be built. For example, for a tutorial, a different controller application could be developed that would allow control to be temporarily handed over to a different participant, with overall control being retained by the chairperson.

The message passing principle upon which the system is built will allow powerful software teaching systems to be developed. Increasingly software is being developed that separates the user interface from the application functionality. In this case, user actions can be trapped and passed as messages to the same software running on a remote machine. The software on the remote machine will then behave according to the actions of local user. A prototype example of this application is currently being tested

By concentrating on the principles of message passing rather than distributing high-bitrate video streams or real time screen capture image streams, bandwidth requirements can be reduced. This will allow the systems to be used, together with Internet video and audio software such as CU-SeeMe, at domestic premises linked by conventional telephone or primary rate ISDN links.

VI. Acknowledgements

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Author Information

Nicolas A. Hine received the B.Sc. Degree in Electronics Telecommunications Engineering from Hull University in 1982. This was followed by a period in industry and 5 years as a vocational training instructor for adults with disabilities and training centre deputy manager. In 1989 he joined a research team at the Katholieke Universiteit Leuven in Belgium, and received the M.Sc. Degree in Biomedical Engineering from there in 1993. In 1992 he joined the telecommunications research group at the MicroCentre, University of Dundee where he is currently a Research Fellow. He is currently undertaking research towards a Doctoral degree in the area of multimedia communications assistance techniques for non-speaking people.

Other research interests include the use of broadband and mobile telecommunications systems by people with disabilities, and the use of telecommunications services and applications in the remote education of students with disabilities.

Dr. Andras Arato PhD obtained MSc in 1974 in St Petersbourg Popov Electrotechnical Institute in Computer Engineering. He has been working for the KFKI MSzKI from 1974 mainly in computer networks and speech technology for rehabilitation. He obtained his PhD in 1993 with work "BraiLab Hungarian Talking Computer Family for the Blind". He is currently leading the Laboratory of Speech Technology for Rehabilitation.