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ABSTRACT

The combination of digital television and computing/networking technologies can provide solutions to many problems confronting higher education. Old Dominion University (Virginia) is committed to discovering how to exploit these technologies to produce a more effective teaching environment at a lower cost than traditional classroom teaching. The goal is for the system to accommodate itself to "technology hostile" instructors and students, but to allow students and teachers to use its additional capabilities as they become more familiar with it. The current prototype implementation uses both satellite transmission analogue video signal and Internet and Ethernet LANs to transmit data and low quality video. The prototype is on the main campus in three classrooms in one building; the full system will include several specially equipped instructional classrooms for student use and a few broadcasting facilities located across the state and on the main campus. Each student facility will consist of several multimedia workstations, networked to each other, the main campus and the Internet. The instructor's facility will contain similar multimedia workstations as well as two additional operator-controlled cameras, one used to project images of the instructor and the classroom from a distance and the other images of material the instructor has chosen to support the presentation. Advantages of the system include: online class lists, ability to see faces of discussants, integration of computers into teaching, VCR-type playback, flexible classrooms. Some disadvantages are small screens, loss of readability on markerboards, varying quality of video images. (Contains six references.) (AEF)

Melding Television, Networking, and Computing for Interactive Remote Instruction: Exploiting Potentials

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Abstract

Televideo instructional techniques have yet to exploit the advantages made possible by continuing cost reductions in video electronics, computers, and communications. In these technologies lies the potential both to reduce costs and simultaneously improve the quality of instruction. For example, Virginia expects colleges and universities to teach more students with no additional faculty but has not suggested how this can be done. Approaches such as what is described here can make this possible, particularly if used for upper division and graduate courses which may have low enrollments unless offered at several locations. The synergistic combination of these technologies can allow a degree of interactive participation among students and teachers – even when located across the state – which currently is only possible when people are in the same room. With computer-assisted control, multi-way video, audio, and text, instructors and students can participate in a virtual shared classroom which supports traditional instructional modes and encourages modes of instruction not previously feasible. The ability to continue the use of traditional, proven instructional techniques as well as supporting development of new modes of instruction in a way which allows faculty, not experts in computer science, time to become competent in the use of new approaches is crucial to the success of the approach. In this paper we describe a prototype system which will enable us to learn what capabilities are most useful and how to use them.

Background

The combination of emerging digital television and computing/networking technologies can, when properly exploited, provide solutions to many problems confronting higher education (DeLoughry 1993, Douglas 1993 and Mudge & Bergmann 1993). The changing costs in these technologies now allow the development of truly interactive remote instruction in ways previously impossible or too expensive to consider. The combination of these technologies can now provide, at reasonable costs, an effective virtual traditional classroom (i.e., one in which all students and instructors present in the same room) in a form which allows not only the use of traditional instructional methods (e.g., lecture, question/answer, audio-visual, or small group discussions) but also new capabilities (discussed below) largely as instructors or students prefer.

Old Dominion University is fully committed to discovering how to exploit these potentials. We currently enroll more than 2,000 students in telecourses and have awarded more that 200 degrees to students across Virginia since 1987. Our televised courses are received at approximately 100 higher education centers, community colleges, high schools, hospitals, and military installations within the state. These courses support a complete baccalaureate program in engineering technology, a nursing program leading to a BSN, and continuing teacher education. We also offer graduate engineering degree programs at 20 sites in Virginia.

However the technology currently used to support these courses is largely the same that has been used for two decades or more (except for the transition to digital transmission); interaction between students and instructors is limited. It largely fails to incorporate any computing or computer networking technologies. Old Dominion University is currently funded by the state of Virginia to explore the feasibility of expanding our existing remote education program by offering 500 :ourses per year to a total of 12,000 students in 20 different academic degree programs at 30 specially equipped sites. Each site would have the computing and television facilities necessary to support this vision of interactive remote instruction.

This paper describes our vision of how computers, networking, and television can be combined to produce not only a better, more effective teaching environment but also at a reduced cost compared with traditional classroom teaching. It outlines how such a system can be implemented with current technology and how its delivery can be improved with the coming availability of ATM networks. It also gives a description of the functionality of the current prototype system and what technology is used with deployment for a demonstration project. We discuss advantages and disadvantages of the system and some of the decision which went with the implementations of the prototype. We outline our plans for a demonstration project and future expansion to support on offering of hundreds of courses at dozens locations in Virginia.

The Vision

Our goal is to hide the technologies (computer, networking, and television) which enable interactive remote teaching (IRT) whenever possible so that neither instructors nor students need deal with them. Basic instructional modes should be "natural" to instructors and students alike; the overhead of use (e.g., preparation of classroom materials by instructors and students' use of the system) must be minimal, at least for basic modes. The system must accommodate itself to "technology hostile" instructors and students alike. But it should also allow both students and teachers to exploit its additional capabilities when they choose. An individual's use of advanced features should be allowed to easily evolve as she becomes more familiar with system and sees a personal benefit in their use. We believe that the ability to continue use of traditional, proven instructional techniques as well as supporting development of new modes of instruction in a way which allows faculty time to become competent in the use of new approaches is crucial to the success of the approach.

The key to the success of these technologies is that they allow faculty to be more effective teachers. Effectiveness involves both productivity (how much time faculty must spend in preparing classroom material, evaluating student work, and interacting directly with students) and the quality of the educational experience for the students. Computer-aided instruction has long and dismal history in this respect due less to equipment costs than the intensive labor required both to prepare course material and then keep that material current.

The drop in costs for the necessary supporting hardware makes possible the development of truly interactive facilities for educational use. These are not passive TV courses with a simple audio channel for questions; the facilities should allow students to be fully engaged in presentations. But we will have to learn what capabilities are most useful and how to use them.

The current prototype implementation uses both satellite transmission analogue video signal and Internet and Ethernet LANs to transmit data and low quality video. This mix of analogue and digital signal is necessitated more by current costs than availability of technology. At this point it is not clear what technology we will eventually use to transmit information, it may be optical fiber, wireless transmission, ATM or HIPPI and SONET; however, it is clear that to provide a truly effective environment we need to have all information in digital form. Hence in the long-term we see the classrooms containing workstations connected by a network, in whatever form is appropriate, and all the manipulation, control of discourse, and features described below will be done by application software on computers rather than such devices as analogue video mixers.

Current Prototype System Description

The facilities for the f: ll system will include several specially equipped instructional classrooms for student use and a few broadcasting facilities. The student facilities will be located across the state and on the main campus. Currently, the system is being prototyped on the main campus within three classrooms within one building. The regular TV offering at Old Dominion University sends video/audio to remote sites through satellite but in this prototype we use coax cables because everything is within one building.

Each student facility consists of several multimedia workstations, all networked to each other and the main campus and to Internet which will be used for data transfers among various sites. At this stage we use regular 10 Mb/s Ethernet with multicasting IP and a T1 connection to Internet for data traffic. In the near future we will replace the 10 Mb/s Ethernet with a 30 Mb/s parallel Ethernet using Parallel IP (Maly et al. 1993). As a multimedia workstation, each is a general purpose computer and provides a windowing system, has the ability to display both analog television images in a window (delivered to the site by cable or satellite), can display digital video images in some windows (delivered by the computer network), text and graphics in others, can play audio, and has a mouse and a keyboard. Each workstation also has its own video camera which can transmit a picture of the student seated at the workstation and a stylus which the student can use for input. Each classroom will also have one camera which sends an image of the entire room back to any of the central broadcasting facilities.

The instructor's facility will contain similar multimedia workstations as well as at least two additional operator-controlled cameras, one used to project images of the instructor and the classroom from a distance, the other images of material the instructor has chosen to support her presentation: for example, prepared text or graphics, or notes being written while seated at a desk. The instructor can also use her workstation and computer network to transmit notes, graphic images, or animated output of simulations to all student workstations. The system will allow instructors to share software tools with all students (such as spreadsheets, word processors, graphics tools, or simulations) so that all participants can jointly or individually manipulate the same tools (Abdel-Wahab & Feit 1991 and Abdel-Wahab & Jeffay 1994).

Students' view of the Interacting Remote Teaching System

The student can choose mode A, in which the workstation is used most like a typical TV lecture image: most of screen is used to show the instructor and perhaps the whiteboard on which the instructor is writing. The student can also choose mode B in which most of the image is of the material presented by the instructor.

Typical Interactions:

a) *to ask a question of the instructor:* a student clicks on the "Attention" button: the button turns green from red; when the button starts blinking, the students clicks on the button and asks question (the student's image will now appear on all screens); to terminate the connection the student clicks on the button and it turns red.

b) *to answer a question put by the instructor:* the "Attention" button will turn green and blink (and beep); the student clicks and answers then, clicks to terminate.

c) *to operate a tool on instructor's request:* the student clicks on blinking "Tool", then the student can operate the tool while the instructor and all other students watch: the effect of all actions taken by the student will appear on everyone's screen. Examples of such tools are: text editors, spreadsheets, drawings, mathematica, or slide show.

Window Management:

The student can control the windows displayed on her workstation, If the student wishes, she can take a completely passive role and just watch. Students more familiar with the system will be able to operate the windowing systems as they choose to meet individual needs.

Note Taking:

If the student clicks on "Notes"; the whiteboard will appear; the student can type or write with stylus or mouse; click on notes; image at time of second click will be recorded together with notes; notes will disappear after interval.

Playback:

If the student missed class or wishes to review what was presented in class, the student can put the appropriate CD ROM disk in player. Invoke "Interactive Teaching" with playback option.

Instructor's Use of System:

a) *to ask a question of a particular student:* click on "Attention," a class list will appear; the instructor selects a name by clicking the name in the list, student image will appear. Can click on more names to get discussion going; click on "Attention" to terminate interaction. Optionally click on any in class list then all students' Attention will blink; names in class list will blink (those who want to answer); click on one and all others will be disconnected after 10 seconds.

b) *to answer a student:* click on blinking "Attention;" a list of names will appear for whoever has clicked an Attention button; the instructor clicks on one name, then the system behaves the same as when the instructor asks a student a question.

c) *to delegate control of a tool:* click on "Tool;" the class list appears; the instructor selects a student; if desired, the instructor might orally assign an area in computer whiteboard to a student; click to break.

d) *to invoke a particular tool:* type tool name in console. Output produced by tool (wordprocessor, spreadsheet or whatever) will appear on all workstations.

The instructor can take back the floor at any time by clicking.

Typical Scenarios:

Class Discussion:

One or more students initiate a discussion or attempt to ask a question by clicking the Attention button. The Attention button at the instructor's desk will blink and beep. The instructor clicks on the Attention button and selects from the queue of blinking names a student and clicks on it. The selected student's image will appear on screen and that student's Attention button will blink and student can talk after clicking the Attention button. The instructor selects another student to join by clicking on her name in the class list and her image will also be displayed. Fig. 1 illustrates this.

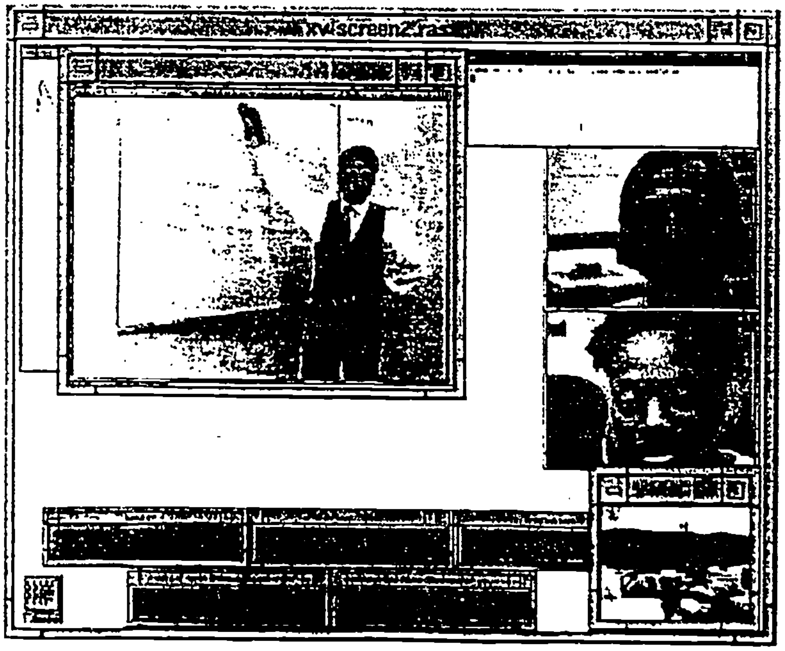

Fig. 1: Workstation Image, Student Discussion

"Joint" editing of English assignment:

The instructor switches to the Computer White Board by clicking on Teaching/Tool and invokes Wordperfect from the Console and places the window in the White Board. She brings up in Wordperfect a file containing an assignment and asks a specific student to show his paper by clicking on Tool and selecting a name from the Class List. That student clicks on his "Tool" button and can now operate that Wordperfect tool and bring up his file for the class to see. The instructor takes back the floor by clicking on her Tool button and makes changes and then dismisses the tool.

Teaching of WorldWideWeb:

The instructor switches to the Computer White Board by clicking on Teaching/Tool and invokes WorldWideWeb by calling the browser xmosaic from the Console and places the window in the White Board. She uses WorldWideWeb to connect to the Library of Congress and searches for publications on virtual reality. She then delegates (clicks on Tool) the tool to a particular student (clicks on Class list) and tells her to search Old Dominion University's Library for books on early childhood learning disabilities. The student takes over the tool and uses it to connect to the library and does the search while all other students see how she performs the task. Meanwhile another student types a note (clicks on Notes) on his private White Board to remind himself to check the availability of xmosaic on his system. The first student gives back the tool (clicks on Tool) and the instructor terminates the session (clicks on Tool).

Discussion

Many states are searching for less expensive ways to meet the demands for both higher education and continuing education, particularly since the enrollment increases which will occur in the next few years will probably come without comparable growth in revenues. Experience has shown that in most cases video tapes of typical college classes are not a sufficient substitute the traditional classroom. But rapidly evolving network technologies will, when coupled with the right tools, enable a degree of interaction among teachers and students which we believe will make the use of distributed classrooms which incorporate both video and networking technologies feasible.

This system should result in minimal loss of the capabilities usually available in a traditional classroom (e.g. question - answer interaction, note taking, group discussion). Instructors who choose to do so should be able to present material in ways similar to what they have done in the past. The instructor is in control in how material should be presented rather than the technology dictating what can be presented and how.

But as important, the system provides the instructor more capabilities such as:

-on-line class lists
-students can see faces of discussants
-integrating computers into teaching
(using tools in class-apprenticeship)
-VCR type playback
-classrooms can be anywhere (but need video and network connections).

While this system has some disadvantages (only talking heads of students, small screens, and if the teacher uses a markerboard, loss of readability can be a problem) and the quality of some video images is largely determined by the capabilities of the supporting network, many of these obvious deficiencies will be addressed when network bandwidth is increased through the use of ATM.

We have used technology to emulate one traditional way of teaching in a distributed classroom environment. We can now use the computers and the networks to truly provide an interactive, collaborative environment for students and instructors and support many modes of instruction, such student presentations, small group discussions. The instructor can provide may kinds of additional information stored in the computer system, e.g., images, text, movies, programs, data, and students can interactively modify this information. These can be used as part of regular classes, support out-of-class assignments, and allow students to review materials individually to support individual learning speeds and needs.

With government and industry interest in networking capabilities, it is likely that the quality of network services, particularly in the form of a significant increase in bandwidth, will continue to improve in the future. The prototype we have described can function effectively with the network capabilities now commonly available, though the use of some types of presentation materials (particularly those relying on digitally transmitted images) will need to be restricted to get acceptable performance. As network services continue to improve however, restrictions on the use of "wide-bandwidth" tools will be relaxed giving presenters more choices in presentations and will support higher fidility images (both in the form of more rapid updates and better resolution).

In addition, once the network exists, it can be used to handle many administrative aspects of the course such as on-line course registration and announcements of various university activities. The instructor can distribute homework, reading lists, video images, and assignments over the network and students can submit their work electronically as well as ask questions of the instructor at any time of the day using e-mail. Since much of the information about the course, the instructor and the students will be available in digital form it will be possible to measure many aspects of the effectiveness of the paradigm. Many of the skills and knowledge students have acquired will be demonstrated on the computer and can be captured electronically for later analysis.

Since our current prototype is limited in its capabilities and has been used primarily to evaluate the effectiveness of existing network services, many key issues are yet to be dealt with. Once more geographically dispersed networks are used, latency may become a problem and require some synchronization between the analog video/audio and computer networked data signals. Until the system has been used by people with other than a computer science background, various aspects of the user interface both for students an instructors cannot be evaluated. These issues will be addressed as our prototype becomes more complete.

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