Distance Learning Into the 21st Century

Monson H. Hayes and Lonnie Harvel
School of Electrical and Computer Engineering
Georgia Institute of Technology
Atlanta, GA 30332

Abstract

The Georgia Institute of Technology is in a unique position of having a campus located across the Atlantic in the heart of the Lorraine region of France. Offering masters degree programs in electrical and mechanical engineering, Georgia Tech Lorraine (GTL) must deliver more courses than can be staffed by resident faculty. Consequently, GTL must offer courses by videotaping courses that are taught by faculty at the Georgia Tech campus in Atlanta. Delivering courses by videotape, however, is relatively expensive, introduces a two week delay between the two sections of the courses, and is not the most convenient method of course delivery for the student. The internet, however, offers some unique opportunities for the remote delivery of courses. Over the last eighteen months, we have been delivering graduate courses between France and the U.S. using streaming media. In this paper, we describe the approaches that we have used, enumerate the investment in time and resources necessary to deliver these courses, and give some predictions for what we envision internet delivery of courses will be like in the 21st century.

I. Introduction

Over the last few years, there has been considerable interest in using the internet for distance learning. The reason for this interest is that there are a number of advantages of internet educational delivery systems over the more traditional approaches of mailing videotapes or delivering live satellite broadcasts. Compared to videotape, for example, the internet allows for very rapid distribution of course materials to remote students, and is free from the problems associated with different video standards throughout the world. Delivering video across the internet also allows for much more efficient browsing of video material. Specifically, the video may be indexed so that the viewer may quickly jump to specific portions of the lecture. Or a scroll bar may be used to skip easily and quickly to the start or the end of the lecture, or to randomly access any specific location within the video clip. Compared to live delivery, internet course materials may be enriched graphics, scrolling marquis, hyperlinks to other materials etc.

In discussing internet distance learning, there are two scenarios that come to mind. The first is that in which a team of professionals is assembled to produce a course or set of training materials. This team may consist of a dozen or more people, including graphic artists, computer programmers, course instructors, and others. Although these courses may take six months or longer to produce, once completed, one has a high-quality professional looking course that may be delivered over the internet on demand, or distributed through stores or mail order companies on CD-ROM. Although supplements could be made available to keep the course material up to date, generally these courses are assumed to be *static.* The other internet distance learning scenario includes courses that are "captured" for remote delivery across the internet. We refer to this as *bringing the classroom on-line*, where the goal is to recreate the classroom environment on the remote computer and, possibly, enrich the lecture material with additional material. When bringing a classroom on-line, it is important to make a distinction between live and time-delayed delivery of courses. The live model requires collaboration between the local and remote sites, and a delivery system that can handle high bandwidth media of various types. With live broadcasting, there is no audio or video editing and the simultaneous delivery of supplemental multimedia material is difficult, at best. In addition, each lecture is one–dimensional, i.e., the student views each lecture from start to finish with no opportunity to pause and go backwards or forwards, or to delve into related material through hyperlinks. The on-demand model, on the other hand, produces a "captured" version of the class, which, after some processing, provides the remote student with a replay of the classroom experience. Unlike the live broadcast, captured courses may be enriched with various forms of multimedia information, and may be hyperlinked to a textbook, other lectures, and other sites on the world wide web.

In this paper, we are concerned with capturing the classroom experience, and putting it online. We begin, in Section II, with an overview of what we have done at Georgia Tech over the last eighteen months in internet course delivery. Then, in Section III, we turn our sights to the future and describe the projects that are on the horizon, and speculate about what internet distance learning may be like in the 21st century.

II. Distance Learning at Georgia Tech

In 1991, a campus of the Georgia Institute of Technology was opened in Metz, France, offering masters degrees in electrical engineering. In 1997, a masters degree program in mechanical engineering was added. Since the number of courses that must be offered for a masters degree exceeds the number of courses that can be taught by resident GTL faculty, each term a number of courses are offered by video. These courses are taught in Atlanta by Georgia Tech faculty, and are videotaped for students at GTL. Due to the cost of this method of delivery, and the long delays that often occur in mailing videotapes across the Atlantic, in the summer of 1997, it was decided to experiment with delivering courses from one campus to the other using the internet.[1] In the Fall of 1997, a graduate level course in *Neural Networks* was given to students at GTL, and delivered by internet to students in Atlanta. With the Atlanta section being six hours behind the section in France, it was possible to have students at each location viewing the lecture on the same day. This course was produced and delivered as follows.

1. Due to the high technical content of the course, slides for each lecture were prepared using LaTeX. GIF images of each slide were then created, and integrated into a Power Point slide slow.
2. For class, the Power Point slide show was projected onto a screen using an LCD projector for the in-class students and the audio portion of the lecture recorded using a Real Audio encoder.
3. After each lecture, timing information for each slide was extracted from Power Point, and these timings were used to created a slide show that was synchronized with the audio of the lecture. This was a simple procedure that consisted of two steps. First was the creation of a text file in which each line contains a start and stop time in the audio file, and a pointer to the slide that is to be shown during the given audio segment. Second, the text file and the audio file were merged using software available from Real Networks. Finally, it was necessary to create the HTML files that link together and index the lecture slides. The entire process of producing real media and HTML files took approximately two hours for each one-hour lecture. Although this process could have been automated, given that the format and delivery mechanisms of the course were expected to evolve, automation was not undertaken at this point.
4. Once the real media files had been generated, the course materials were then sent electronically by ftp from GTL to Atlanta. These materials included postscript files of the lecture slides, real audio files of the lecture, and updated HTML files for the course homepage. The postscript and HTML files were placed on the Georgia Tech web server, and the real audio files placed on the Real Server operated by the Center for Distance Learning at Georgia Tech.

Once all of the files for a given lecture were on-line, students had access to the lecture slides in either postscript or Adobe PDF formats, which could be printed out for note taking, and a slide show that was synchronized to the audio of the lecture. Using a slide index that was provided for each lecture, the student could skip to any part of the lecture by clicking on the appropriate slide.

Based on student feedback, it was clear that this mode of course delivery was enthusiastically received. When students were asked to compare the internet version of the class to those classes offered by videotape, the responses were consistently in favor of the new technology. From a course administration point of view, a big advantage of internet delivery over videotapes was the near instantaneous availability of the lecture material to the student.

A web-based course that is delivered over the internet using streaming audio is relatively straightforward to produce, and is relatively inexpensive in terms of its hardware requirements. Specifically, all that is required is a computer with an internet connection, an LCD panel for the projection of slides, and a microphone. However, an audio-only lecture does not give the student any sense of ‘‘being in the classroom.” It was felt that a video of the instructor would help the student ‘‘participate” in the classroom experience by being able to ‘‘see” the instructor, to observe the instructor’s gestures and expressions, and allow him or her to follow more closely the material that is being presented on the slides. Therefore, in the Winter of 1998, a graduate level course in *Statistical Digital Signal Processing* was offered to a section of students in Atlanta, and delivered to GTL using streaming audio and video. For this course, the Power Point mode of delivery was dropped in favor of using a set of LaTeX macros for preparing slides. Postscript and Adobe PDF versions of the slides were prepared, two to a page, and made available on the web to the student, and full page copies of the slides were printed and used to present the lecture material to the live section in Atlanta. These slides were captured by an overhead camera, and projected onto a set of monitors that were distributed throughout the classroom. What the in-class student was able to view on the monitor was the slide, along with the instructor's hand or pen pointing to an equation or underlining a key point on the slide. At the same time, a small head and shoulders video of the instructor was occasionally inserted into an empty region of the slide. The video was recorded and used to generate the streaming video for the remote section. After electronically transmitting all of the files for a lecture from Atlanta to a Windows-NT server at GTL, the student was able to access postscript and PDF versions of the lecture slides, which he or she could print out for note taking, and could view a streaming video presentation of the lecture that was linked and synchronized to the slides. Thus, by clicking on an icon for ''Viewing the Lecture,'' a Web page consisting of three frames was displayed on the computer. In the upper left-hand corner a Real Video console appears, which delivers streaming audio and video to the student, and contains a video control panel that allows the student to fast forward, reverse, or pause the lecture. Below the Real Video Player is an index of the slides that the viewer may click on to have immediate access to that portion of the lecture. Finally, in the third frame, which occupies the majority of the screen, is a GIF version of the current slide. This format is illustrated in Figure 1.

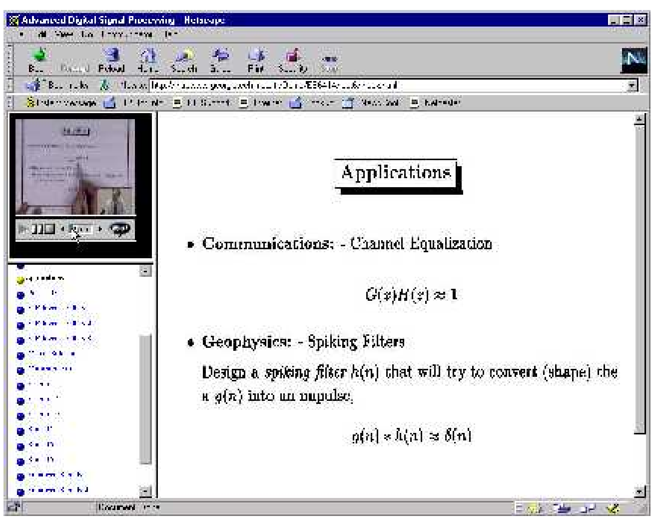

Figure 1: A real video presentation of a course over the internet.

In putting together a streaming video course, one question needed to be addressed: *Given a finite bandwidth, how should it be allocated to deliver streaming audio and video?* Although the bandwidth is expected to increase over the next few years, we selected 28.8 kbs as the target bit-rate. At this rate, the Real Video encoder assumes that 20 kbs can be used for audio and video. Although the video quality is poor with only 15 kbs, it is possible for the instructor to transmit a fair amount of information to the student. For example, the instructor is able to gesture, point to equations, and underline key points on a slide. As a result, the student is able to feel a bit closer to the live classroom. For a 50 minute lecture, audio and video delivered at the rate of 20 kbs requires only 7.5 MB. Therefore, an entire ten week, three hour quarter course can be saved using only 225 MB (audio and video only). Postscript and PDF files of the slides without too many embedded JPEG or GIF images requires less than 0.5 MB per lecture.

In the Spring Quarter of 1998, we continued our distance learning experiment by offering a course in *Adaptive Filtering* to GTL students using the internet. This course was run in much the same way that the winter quarter course was, except that the lectures were produced using chromakey, which is a procedure commonly used to deliver weather reports on TV. While standing in front of a blank screen, the image of the instructor is overlaid on top of a computer-generated slide, giving the student the sense that the instructor is standing in front of a large screen onto which the slide is being projected. The advantage of this approach was to give the remote student much more information about what the instructor was doing in the classroom, without sacrificing on the quality of the slides. The disadvantage, however, is that producing a chromakey video requires extra hardware and personnel. Shown in Figure 2 is a snapshot of an internet chromakey production.

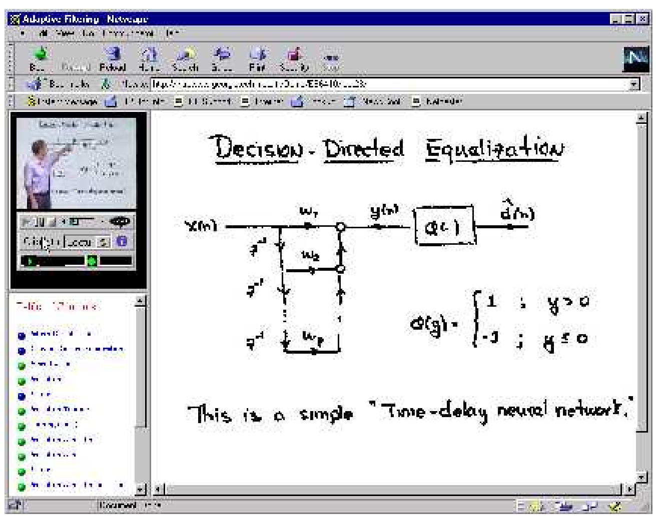

Figure 2: Internet course delivery using chromakey.

Late in 1998, the RealSystem G2 became available, which allows text and images to be streamed along with audio and video, and provides for the possibility of encoding audio and video at up to six different bandwidths. In the Winter of 1999, when the course *Statistical Digital Signal Processing* was scheduled to be delivered over the internet to students taking the course through the National Technological University (NTU), the previous version of the course was redesigned to take advantage of the new G2 features. As with the previous offering, what was delivered was a slide index, a streaming audio and video of the lecture, and GIF images of the slides. Unlike the previous course, however, all of the media was streamed together (text, images, audio, and video) and integrated together into the real player screen. A snapshot of the real video player for the first lecture is shown in Figure 3 below.

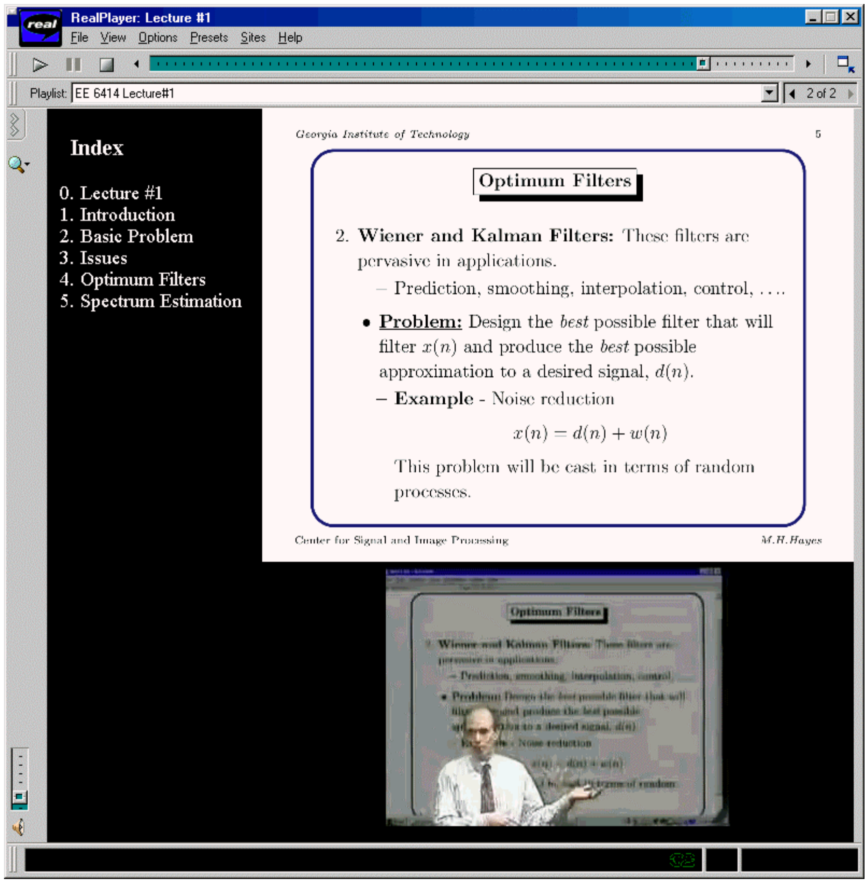

Figure 3: Internet delivery using RealSystem G2.

III. Visions of the future

Every year the available bandwidth for Internet based delivery increases. It is reasonable to assume that full motion video will be available to the majority of students within the near future. As bandwidth increases, the ability to move from an on-demand model to a live model becomes feasible. Therefore, beginning in the fall of 1999, we will begin delivering remote courses to Armstrong Atlantic State University in Savannah Georgia. The recently developed “Ring Around Georgia” will provide us with a high-speed connection between the institutions. This level of bandwidth will allow us to provide full motion video and audio for the delivery of course materials, anticipating what will be generally available in future years. Thus, the question has rapidly changed from “what can we provide to our remote students” to “what should we provide.”

Developing distance learning environments offers the opportunity to redefine the classroom concept and expand the repertoire of tools available to the instructor. These tools can be considered in two categories: lecture delivery and enhanced materials. The first provides the applications necessary to produce and deliver the fundamental lecture from the primary site. The latter category deals with those materials that enhance the learning environment and expand the resources available to the student.

The lecture is made up of the course notes, the visual image of the instructor and/or classroom, and the audio component. The goal in delivery is to create the highest sense of presence possible for the remote student. Higher bandwidth allows for the "live" delivery of these materials. Return audio and video will allow for direct teacher/student interaction. Tools have been developed at Georgia Tech to digitally capture the classroom experience so that they may be viewed on demand for review or for students who are not able to directly access the live environment. For the delivery to Armstrong Atlantic, a live G2 broadcast will be used in conjunction with a modified version of Classroom 2000 that will allow for collaborative interaction between the remote sites. The Classroom 2000 environment provides the capturing tools for the audio, video, and notes automatically.[2] The final product is similar to the ones mentioned above without the video refinement. More "polished" video will be produced in courses delivered in the manner described above. The impact of the two methods will be compared to provide a cost-benefit analysis of the production overhead.

Enhanced materials are being produced for a number of courses in Electrical and Computer Engineering. They provide expanded information, examples, and interactive environments for the students. Streaming media tutorials, Flash animations, Java based demonstrations, and example questions and problems are among the many applications that have been developed to augment both the remote and the local experience. The majority of these applications are designed to be used outside of the "classroom" to expand the students understanding of the material. Remote labs, which use network connectivity to provide access to oscilloscopes, virtual circuits and other analysis equipment, allow for the delivery of fundamental electrical engineering courses.[3]

The communication requirements inherent in the teacher-student relationship are another obstacle that must be overcome in a remote learning environment. Currently we are using traditional teleconferencing via PictureTel systems for group sessions. We have also used Internet based video conferencing for online office hours between students and teachers. We are expanding the use of the Internet based solution for cost reasons, and availability to the student population. Several packages are being evaluated for use in the production environment; Microsoft NetMeeting and Netscape Conference are primary candidates.

The management of these courses must also be considered. Georgia Tech has selected WebCT as our online tool. WebCT provides a structured environment for course notes, references, enhanced materials, online quizzes, grades, and assessment. Class email lists and bulletin boards complete the communication tools available to the instructor.

As bandwidth continues to increase, the ability to sustain multiple audio/video connections will become feasible. The creation of advanced communication applications, perhaps in the area of enhanced reality, will allow for a completely non-geographic definition of the classroom. The goal of distance learning is not to recreate the local classroom for the remote student, but instead, to create a new, richer environment for all students and for the instructor as well.

As we move into the 21st century, we will begin to see some new technologies being used in courses that are delivered over the internet. These new technologies will undoubtedly include the following:

1. Tools that will automatically search and index audio using voice recognition technologies,
2. The incorporation of natural language interfaces for information searching and retrieval,
3. Synthesis of speech from text to facilitate learning for the visually impaired, and automatic captioning for the hearing impaired.

However, perhaps the most important change that the next century will bring is the availability of production tools that will enable faculty to develop and deliver courses easily across the internet. Today, the process is extremely expensive and time-consuming. As a result, internet education is not yet widespread. We believe that internet distance learning will continue to gain momentum and, given the need for production tools, they will begin to appear on the marketplace.

Bibliography

1. M.H. Hayes, "Some approaches to distance learning with streaming media", *1998 IEEE Workshop of Multimedia Signal Processing,* p. 514-519.
2. Jason A. Brotherton, Janak R. Bhalodia, and Gregory D. Abowd, “Automated Capture, Integration, and Visualization of Multiple Media Streams”, in *Proceedings of IEEE Multimedia '98*, July, 1998.
3. D. Light, D. Elshazly, and G. May, "Progress Towards Developing a Web-Based Virtual Packaging Laboratory," to appear in *Proc. 1998 Elec. Comp. & Tech. Conf*., San Diego, CA, June, 1999.

MONSON H. HAYES

Monson H. Hayes is a Professor of Electrical and Computer Engineering at the Georgia Institute of Technology in Atlanta, Georgia. He received his B.A. degree in Physics from the University of California, Berkeley, and his M.S.E.E. and Sc.D. degrees in Electrical Engineering and Computer Science from M.I.T. His research interests are in digital signal processing with applications in image and video processing. He has contributed more than 100 articles to journals and conference proceedings, and is the author of the textbooks Statistical Digital Signal Processing and Modeling, John Wiley & Sons, 1996, and Schaum’s Outline on Digital Signal Processing, McGraw-Hill, 1999. He received the IEEE Senior Award for the author of a paper of exceptional merit from the ASSP Society of the IEEE in 1983, the Presidential Young Investigator Award in 1984, and was elected to the grade of Fellow of the IEEE in 1992 for his ``contributions to signal modeling including the development of algorithms for signal restoration from Fourier transform phase or magnitude."

LONNIE D. HARVEL

Lonnie Harvel is a Research Scientist II in the School of Electrical and Computer Engineering and the Director of Computer Enhanced Educational Services. He is affiliated with the Center for Signal and Image Processing and the Graphics, Visualization & Usability Center at Georgia Tech. He holds an MS in

Computer Science and a BFA in Theatre from the University of Georgia. Mr. Harvel's research interests are in Future Computing Environments, digital content creation, distance learning, and computer enhanced curriculum.