Engineering Education and the Internet: A Project for Global Access to Quality Education

J. C. Olabe, M. A. Olabe[+], J. Mouzna[*]

Christian Brothers University, 650 E. Parkway South, Memphis, TN 38104, jolabe@cbu.edu
[+]Escuela de Ingenieros de Bilbao, University Basque Country, Al. Urquijo, s/n, 48013 Bilbao (Spain)
[*]ESIGELEC, 1 rue du Maréchal Juin - BP 14, 76131 Mont St Aignan Cedex, (France)

Abstract: This paper examines the use of Internet-based technologies in the delivery of higher education courses and full programs primarily in US Universities. After a brief description of some of the most recognized programs on-line, this paper describes the different phases that one of these institutions, Christian Brothers University, has designed to incorporate new technologies and new academic paradigms into its engineering programs. This phases include: Phase 1: Video; Phase 2: Distance Learning Classrooms; Phase 3: Internet Presence. A brief description of the main components of the software and hardware infrastructure created is provided. In addition, examples and web links to illustrative material is provided.

Keyworkds: On-Line Education, Asynchronous Learning, Video Streaming, Internet Broadcast

1. Introduction

This paper examines the use of Internet-based technologies in the delivery of higher education courses and full programs primarily in US Universities. After a brief description of some of the most recognized programs on-line, this paper describes the different phases that one of these institutions, Christian Brothers University, has designed to incorporate new technologies and new academic paradigms into its engineering programs. This phases include: Phase 1: Video Technology - Fall 1997 (Ability to record, store, and transmit large quantities of high quality digital video, and to systematically incorporate new technologies; Phase 2: Distance Learning Classrooms - Spring 1999 (Ability to produce electronic versions of traditional courses, with quality, reliability, and in large scale; Phase 3: Internet Presence - Fall 2000 (Ability to support the Internet delivery of these courses - lectures, transfer of documents, faculty-student communication, inter-student interaction, etc.) A brief description of the main components of the software and hardware infrastructure created is provided. In addition, examples and web links to illustrative material is provided. The broadband network of the future is expected to carry a combination of video, data, and voice traffic in an integrated form. The transmission of compressed video in any on-line education infrastructure will undoubtedly require the highest bandwidth segment of the broadband network.

2. On-Line Delivery of Higher Education

In the past few years, more and more colleges are moving into cyberspace from the top tier universities, such as Stanford and Columbia to state universities (such as California and Florida) to for-profit virtual universities (such as the University of Phoenix and Jones International) (Morris, 1999). About 900 U.S. colleges and universities currently offer distance-learning courses, often known as "cyber-learning" (Callahan, 1999). A recent accreditation acceptance of Jones International University by the North Central Association of Colleges and Schools (Olsen, 1999) has pushed distance learning in the U.S. forward significantly. Numerous studies have indicated that there is no significant difference in distance learning and traditional face-to-face instructions (Goldberg, 1998; Smeaton and Keogh, 1999; Trinkle, 1999). Some studies even indicate better results in distance learning mode as compared to the traditional classroom mode (Koch, 1998; Wisher and Priest, 1998). Some claim they have missed nothing by choosing to have their education on-line (Conlin, 1999). In some areas, especially engineering, where the job market is so hot, they do not have time to continue their education in the traditional setting. More and more engineers are choosing distance learning to update their skills (Folkers, 1999).

There are at this time thousands of higher education institutions offering tens of thousands of on-line courses and countless programs. A report by the University of Illinois (U. of Illinois, 1999) reports that in 1999 the New York Times estimated that online courses number in the thousands (Koeppel, 1999.) The following Table lists a sampling of accredited institutions making significant online progress.

Table 1. A Sampling of Universities Offering Online Programs

URL	URL
American Military University www.amunet.edu Berean University www.berean.edu	Oxford University www.conted.ox.ac.uk Pennsylvania State University www.worldcampus.psu.edu
Duke University www.fuqua.duke.edu	Stanford University scpd.stanford.edu
Int. School of Inf. Management www.isim.com	University of Illinois www.online.uillinois.edu
Jones Int. University www.jonesinternational.edu	University of Phoenix www.uophx.edu

The following table lists a selected group of journals and professional communities with especial emphasis in on-line education .

Table 2. On-line and Distance Journals

Journal	Journal
The Journal of Asynchronous Learning Networks www.aln.org/alnweb/journal/jaln.htm	*The Technology Source* horizon.unc.edu/TS/
ALN Magazine www.aln.org/alnweb/magazine/alnMaga.htm	*The Journal of Distance Education* www.hil.unb.ca./Texts/JDE/homepgENG.html
Cause/Effect (published by Educause) www.educause.edu/pub/ce/cause-effect.html	*The Journal of Educational Multimedia and Hypermedia* www.cde.psu.edu/ACSDE/Jour.html
Educom Review (published by Educause) www.educause.edu/pub/er/erm.html	*The Journal of Interactive Learning Research* http://www.aace.org/pubs/jilr/

3. Christian Brothers University and On-Line Education

Christian Brothers University (CBU) begin its work in the area of Internet-based higher education delivery in 1997 with the development of a hardware/software infrastructure that would allow the reliable delivery of high quality video-audio signals from its classrooms to the rest of the university via its intranet, and to the rest of the world via the Internet.

Although other alternatives for on-line education had been developed and tested requiring much less bandwidth because of their high reliance on text-based courses, CBU decided to pursue the option of high bandwidth applications for two academic reasons: The production of live classes requires a minimum investment of time and effort on the part of the faculty, and the final product is very similar to the experience of students in the traditional academic environment.

Technically the recent developments of narrowband, real-time, video applications using the Internet as the transmission media had opened a new area in packet-switched communications: (relatively)-high bandwidth and low delay streaming applications (Perkins 1997, Jinzenji 1997) making possible the successful delivery of on-line courses with this format.

Unlike other Internet applications (e-mail, telnet, ftp, etc.), the transmission of video sequences is defined by three special characteristics: 1) The flow of information is fairly constant at the call level, although it could be bursty at the packet level; 2) The loss of packets due to late arrival is allowed; and 3) The delay requirements are highly restrictive.

The following sections describe the hardware-software implementation of a live broadcasting system using the Internet and a delay evaluation of the quality of these transmissions.
The hardware/software infrastructure was designed to provide a source of real video traffic data, as well as a physical environment to evaluate the quality-bandwidth performance of these applications and test the validity of conclusions obtained in the simulation studies.

The second section reviews the preliminary performance evaluations of the broadcasts performed during the Fall of 1997. These broadcasts were implemented for different quality settings, including the transmission of events with medium and high video/audio requirements. Recorded examples of these broadcasts can be viewed visiting the CBU Webcast at http://www.cbu.edu/Video/. These broadcasts include class lectures, volleyball games, play performances, etc., and were intended to evaluate the viability of such broadcasts as well as determining the present Internet limitations for reliable real-time video transmission.

The last section describes the procedure for the data collection from live broadcasts to be used in traffic modeling tasks. From these experiments, the audio and video traffic demands were analyzed, and a set of probabilistic traffic models were obtained using statistical approximation. These traffic models will be used in simulation studies with the purpose of estimating the impact of multiplexed video streams in the performance of Internet communications.

4. Hardware/Software Infrastructure

The platform selected for the live transmission of video streams was RealVideo from RealNetworks (Realnetworks 1999.) This platform was selected in order to achieve several goals:

a) Maximizing the viewing audience: Although Mbone has successfully been used for years in the transmission of video signals, its access is still severely restricted. RealPlayer resides in millions of PCs, and has become a standard feature in Explorer and Netscape.

b) Good Quality/Bandwidth performance: The compression algorithms offer an acceptable audio and video quality even at low transmission rates.

c) Relatively-Narrow bandwidth transmission: These video transmissions were designed to be between 28 and 56 Kbps in order to limit the network traffic congestion, and to allow dial-up users access to the broadcasts.

d) Global access: The broadcasts were intended to traverse heterogeneous network infrastructures.

e) Low cost: both for the transmission and the reception.

For multimedia conferencing the appropriate transport protocols are real-time protocols. UDP (User Datagram Protocol) is a connectionless protocol that does not attempt to recover from lost packets either by hop/hop or end/end techniques as does TCP (Transport Control Protocol). This technique prevents the problems generated by non-deterministic delays and stalling effects due to retransmission after loss and timeout in TCP.

The selected platform for these broadcasts uses UDP as its default protocol, but it can be automatically switched to TCP depending on the current conditions of network congestion, or the presence of firewalls and firewall proxies. This feature allows the delivery of content to all users using the most efficient available method.

When an automatic switch from UDP to TCP is necessary it is done at the expense of degradation of picture quality and frame-rate. Voice maintains the highest priority under any conditions.

The infrastructure included a PC-based encoding station were the incoming video and audio signals were encoded in real time. The video and audio signals were obtained from a digital mixer which received feeds from four TV cameras. This encoding station uses a dual Pentium Pro system for fast and high quality image compression in real time, and it is the most computing intensive element of the broadcast system.

The compressed data packets were then sent to the Server Station, a Windows NT based station. This station performed the tasks of setting, monitoring, and collecting statistics with every individual connection. Its hardware demands, however, are not very critical. A Pentium 120 would use less than 30% of the CPU cycles to process continuously 100 simultaneous connections.

Although the final connection and the delivery of video packets is established directly between the RealServer and the Viewer's Player, the initial contact is made through the Web Server, in this case the University's Web server, and the Viewers Browser. Figures showing several frames from live broadcasts, including class presentations can be found at http://www.cbu.edu/Video.

The Web Browser displays a Web page that contains a link to a metafile. The Web Server delivers the metafile when the user clicks the link. This in turn activates the RealPlayer as a helper application and passes it the metafile. The RealPlayer reads the URL from the metafile and requests it from the RealServer. In a live transmission this begins the streaming of the packets being received from the encoder to the viewer's player. No messages are passed between the RealServer and the Web Server. The Web Browser provides the URL to the RealPlayer.

Christian Brothers University has a T1 access line to Internet. This limits the total number of simultaneous streams to about 50 if each stream is 28 Kbps, or 25 if the transmission rate is 56 Kbps.

5. ECE Courses On-Line

In the Spring of 1999 three courses of the Electrical and Computer Engineering Department at CBU were transmitted live over the Internet in their entirety at multiple rates up to 150 Kbps. Each course consisted of 42 lectures of 50 minutes each taught over a period of 14 weeks. The recorded classes were later made available from a video streaming server. In addition to the video-audio segments of the lectures, the instructors class notes, which were recorded in the instructors computer, were also made available. The figures below show some examples of the web sites with access to these classes and class notes, as well as some of the frames of the lectures.

Figure 1. Web Links to Archived Lectures

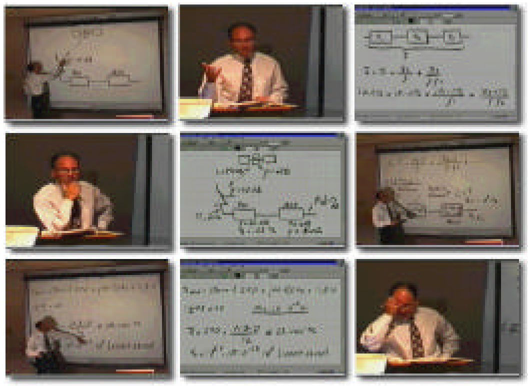

Figure 2. Frames of an Archived Lecture

One of the goals of this phase was to develop an infrastructure that would allow the broadcast and recording of lectures without to many demands of time and effort on the part of the instructor.

The classroom where these lectures were recorded included a set of four video cameras. An operator selected the appropriate video input based on the activity of the professor. An additional video signal was obtained from the instructors monitor to provide access to his notes or his use of computer programs in class.

During a second semester in 1999, a group of professors of different departments of the School of Engineering scheduled their classes in this classroom, and their classes were also broadcast and recorded.

6. Integrated Environment

The third phase of this project consists in the creation of an Internet based environment that will allow the adequate communication between the professor and the students when they are physically apart. For this task the environment WebCT was selected for offering good performance and a friendly interface both fot students and professors.

WebCT is an integrated environment that allows password-protected access to class materials as well as a complete suite of communication tools.

Some of the features offered by WebCT include:

1) an organized access to class materials, such as video files of the lectures, class notes, handouts, sylabus, etc.

2) a structured interface to send students homework assignments and collect their work, with a time stamp of each transaction, and an efficient infrastructure for the transmission and delivery of documents in electronic form.

3) Student access to their grades and progress in the class.

4) Access to self tests and on-line quizes which are automatically timed and could be automatically graded.
5) Communication tools for the students and professor, including class bulleting board, class chat room, private class email, and an electronic white board for the real time transmission of graphics, equations, etc.

For this phase, one of the professors of the Electrical and Computer Engineering Department at CBU will spend the academic year 2000-2001 at ESIGELEC, in Rouen, France, from where he will teach several courses to students in the US using the technologies developed in the previous two phases. This project has as one of its main goals to test and develop the tools and techniques that will allow high quality education and good communication between professor and students in environments where they are physically separated, while connected via the Internet.

7. Conclusions

This paper presents the state of on-line education in universities of the US and abroad, and review some of the technical and academic aspects critical in the successful operation of these environments. A list of universities and journals dedicated to on-line higher education is provided. Finally, the three phase approach of CBU to integrating on-line education in their program is discussed. This three phase approach includes: Phase 1: Video Technology - Fall 1997 (Ability to record, store, and transmit large quantities of high quality digital video, and to systematically incorporate new technologies; Phase 2: Distance Learning Classrooms - Spring 1998 (Ability to produce electronic versions of traditional courses, with quality, reliability, and in large scale; Phase 3: Internet Presence - Fall 2000 (Ability to support the Internet delivery of these courses - lectures, transfer of documents, faculty-student communication, inter-student interaction.)

8. References

Callahan, T., "Go to School Again," *Parade Magazines*, pp. 4-6, August 1, 1999.
Conlin, Michelle, "Cyberspace Learning: I Give It an A-," *Business Week*, p. 92, August 9, 1999.
Folkers, R., "Update Your Job Skills Without Stepping On Campus," *U.S. News & World Report*, Special Issue on America's Best Graduate Schools, pp. 68-70, 1999.
Goldberg, D., "Teaching Online," Education Review, *Washington Post*, April 5, 1998.
Jinzenji H., and K. Hagishima, *"Real-Time Audio and Video Broadcasting of IEEE GLOBECOM'96 over the Internet Using New Software"*, IEEE Communications Magazine, pp 34-38, April 1997.
Koch, J. V., "How Women Actually Perform in Distance Education," *The Chronicle of Higher Education*, p. A60, September 11, 1998.
Koeppel, D. (1999, April 4). Distance Learning: A Sampler of Cyberschools. New York Times.
Morris, K., "Wiring the Ivory Tower," *Business Week*, pp. 90-91, August 9, 1999.
Olsen, F., "Virtual Institutions Challenge Accreditors to Devise New Ways of Measuring Quality," *The Chronicle of Higher Education*, pp. A29-30, August 6, 1999.
Perkins C., and J. Crowcoft, *"Real-Time Audio and Video Transmission of IEEE GLOBECOM'96 over the Internet"*, IEEE Communications Magazine, pp 30-33, April 1997.
Realnetworks, RealServer Administration and Content Creation Guide. Progresive Networks, Inc, Seattle, Wa, 1999.
Smeaton, A. and Keogh, G., "An Analysis of the Use of Virtual Delivery of Undergraduate Lectures," *Computers and Education*, Vol. 32, pp. 83-94, 1999.
Trinkle, D. A., "Distance Education: A Means to An End, No More, No Less," *The Chronicle of Higher Education*, August 6, A60, 1999.
University of Illinois, Teaching at an Internet Distance: the Pedagogy of Online Teaching and Learning The Report of a 1998-1999 University of Illinois Faculty Seminar.
Wisher, R. A. and Priest, A. N., "Cost-effectiveness of Audio Tele-training for the US Army National Guard," *The American Journal of Distance Education*, Vol. 12, No. 1, pp. 38-51, 1998.