2006-189: NEXT GENERATION TECHNOLOGIES FOR DISTANCE LEARNING: "SAME TIME, ANYTIME, ANYWHERE"

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Next Generation Technologies for Distance Learning and Computing
"Same Time Any Time Any Where"

Abstract: A variety of socio-economic and technological factors are converging to create an increased demand for distance education. This increasing demand is in turn fueling a change in the ways and methods of knowledge dispersion. Now, more than any other time in history, educational institutions are turning to non traditional and more technological methodologies to reach a wider audience. In this direction, we believe that videoconferencing over the Internet combined with streaming web access to educational courses is the ideal combination to meet the escalating demands for access to educational programs ``*same time, any time and any where*''. In this paper we discuss the transformation from a traditional to a distance education model that is occurring here at the College of Engineering in Virginia Tech. We will specifically explain how synchronous systems like videoconferencing over the Internet (especially video over IP) are being put to use in an attempt to minimize costs while extending the range and reach of educators.

I. Introduction

Distance learning has been around for the last 75 years or more. Since the early 1930's distance learning has seen phenomenal growth both in the number of people opting for a distance learning based initiative as against a traditional classroom and in the technology used. Till about the late 1980's and up to an early part of the 1990's, television was a pre-dominant medium for distance learning. However, with the advent of the internet and multimedia technologies, television has been replaced by Video and Web Conferencing as the medium of choice. Several universities and educational institutions have been offering engineering programs to off-campus students for many years. These programs have typically been concentrated in metropolitan areas with a large number of engineering corporations and/or military installations. However, current technologies and demographics present new challenges and opportunities in reaching engineers who work for small companies which are often located in small towns.

The benefits of using distance learning cannot be emphasized more. Probably the single most significant and obvious benefit of participating in distance learning initiative is the opportunity to take courses without having to physically travel to the instructor's location. This allows a person to conveniently keep their current job while taking a course. With the technology available today, this is possible even if the student lives across the country from the school, in a very small town, or remote location. In addition, because many distance learning students have families, being able to work on a degree without moving can have significant social and economic benefits as well.

Distance learning provides students with unique opportunities to pick courses in their interest area, which are presented by instructors of their choice. Depending on the program rules and guidelines, they may be able to complete a customized degree using credits from several universities. Such access to variety and particular topics of interest can be of particular benefit to students interested in updating skills and broadening their knowledge base.

In this paper, we will highlight up some of the emerging technologies for delivering distance learning mechanisms and also outline a plan to implement them in the Virginia Tech distance learning program.

II. Delivery Mechanisms for Distance Learning

Distance teaching and learning commonly referred to as distance education has experienced rapid change in the last five years. New technologies, especially computer mediated communications on the Internet and World Wide Web, are opening new opportunities for distance education to reach students at a distance, but also to serve students need flexibility. Compression technologies combined with improved computer speeds at reduced costs are making access to interactive, multimedia instruction readily available to the desktop. Distance education has also experienced sufficient persuasiveness within educational institutions and among institutions embracing distance learning as an exclusive delivery method.

The development of the Internet is fostering the creation and proliferation of emerging interactive media, such as the World Wide Web, multi point video conferencing and other shared virtual environments. A medium is in part a channel for conveying content; as the Internet increasingly pervades society, instructors can readily reach extensive, remote resources and audience on-demand as well as just-in-time. Just as important, however, a medium is a representational container enabling new types of messages. Since expression and communication are based on representations such as language and imagery, the process of learning is enhanced by broadening the types of instructional messages students and teachers can exchange.

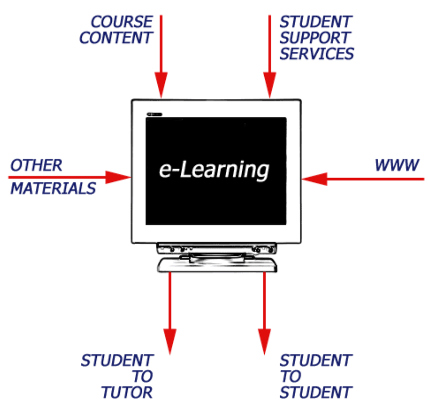


Figure 1. Current e-Learning Stratagem

Delivery mechanisms for distance education can be split into two distinct categories:

1. **Synchronous Delivery Mechanisms**: If instructors want to optimize the performance of learning teams working on complex problems, they will need to consider working with the speed and immediacy of synchronous (or same-time) communication. Based on the accelerating development of such systems, their deployment and the extraordinary growth and availability of fast internet access, we expect synchrony to become the mode of choice for collaborative forms of distance learning. Internet video conferencing an evolving technology is going to be the technology of choice for synchronous conferencing not only because it is cheap but because a system which can transfer data as well as video will be preferred to a system which can transfer only video. Internet video conferencing systems

already exist, however, internet video conferencing is still too expensive for widespread use; it lags behind the broadcast standards to which we have been habituated and, even at its best, fails to capture many of the visual cues that make face-to-face the preferred work medium.

Synchronous conferencing systems of the future will consist of a basic platform from which users can opt to conference using a variety of tools: video, audio, text based chat, and whiteboard. Additionally, such systems will support file transfer, remote launching and control of applications, and more. These systems already exist; what is lacking is only the bandwidth to use them effectively.
Web conferencing with *application sharing*, is another technology that will become an important part of distance learning as the price point improves. Typical Web conferencing systems integrate the phone and networked computer screen so that an unlimited number of participants can talk to each other while viewing the same content. For example, a distance learning team might collaboratively write and edit a document with Microsoft Word or collectively surf various Web sites to research a given topic. The audio element allows the team to coordinate, negotiate, and collaboratively manipulate whatever object (e.g., an Excel spreadsheet) appears on their screens. If one member proposes a change of any sort, the result can be viewed and evaluated simultaneously by all. The resulting cycle of instant action/reaction (the strength of good synchronous team work) allows team members to quickly complete tasks and build documents. Accessing such a Web conference is simple. Participants obtain an 800 number, URL, and password; they then phone in for audio and login online to pull up a common page. Unfortunately, many students cannot meet the requirements associated with Web conferencing: the high cost due to per person/per minute charges as well as the need for a DSL line, two phone lines, or a phone line and a cable modem so that they can access the Internet while talking on the phone.

2. **Asynchronous Delivery Mechanisms**: Asynchronous Delivery Mechanisms are mechanisms where delivery does not take place in real time. Asynchronous distance learning has been around for decades, as traditional correspondence courses and, more recently, prerecorded video classes. Both of these examples rely on materials that are mailed directly to students and are severely limited in the amount and quality of interaction. The popularity of the Internet and increasing bandwidth in access networks have brought new life into asynchronous learning. It seems as if almost every university is teaching or developing web-based courses. Web-based courses have marked advantages over their asynchronous distance learning predecessors. Material is delivered quickly and easily via the web. Communication is improved via e-mail, desktop videoconferencing, web forums, and chat rooms. Students can potentially interact in a meaningful way using web forums and chat rooms. Interactive content, for example implemented as Java applets, can illustrate important concepts. Students have access to a multitude of additional resources using links to other web-sites, posted journal articles, etc. And, there is an opportunity for ongoing self-assessment by students and monitoring by instructors. The success of web-based learning requires taking advantage of the additional opportunities this new medium brings. If a web-based class merely delivers lectures and lecture notes using the web without any of the supporting components, then from a pedagogical point of view it is no different than the correspondence course of the past. In the future, asynchronous conferencing will evolve from being text media to full multimedia. Already, **video email** clients are available, and most **online technology**

newsletters are published in full HTML format. Students, equipped with **multimedia messaging clients**, will be able to embed sound, images and videos into their messages. Current technologies in the asynchronous delivery domain include Central One and Blackboard that are already deployed in Virginia Tech.

III. Distance Learning: The Virginia Tech Perspective

The Distance Learning and Computing Initiative at the College of Engineering, administers graduate engineering distance learning degree programs at Virginia Tech. The program has a long and chequered history. The program which started in 1983, offers several engineering distance learning degree programs through 11 engineering departments. Over the past couple of years, the distance learning and computing office at Virginia Tech. was able to accomplish several major initiatives in the areas of increasing faculty recognition, improving our distance learning student community and moving towards next generation instructional technologies.

III.1. **Increasing Faculty Recognition and Support**

To honor the extraordinary contributions in the area of distance and distributed learning, the College of Engineering at Virginia Tech. has instituted the ``W.S. `Pete' White'' Award for Innovation in Engineering Education. In addition, faculty study groups, which had been initiated a couple of years back, are continuing successfully with approximately one fourth of the faculty in the Engineering curriculum participating in them. These study groups serve as a unique opportunity for new and seasoned faculty to receive feedback on instruction as well as an opportunity to practice new instructional techniques. According to several faculty, these study groups allow faculty to allocate specific time in their busy schedules for the sharing of teaching and learning ideas. This type of intellectual synergy tends to improve overall instructional practices. This year the study groups focused on topics that included some like:

- Ways to apply the "*conceive, design, implement, operate*"' approach to education, teaching and curriculum development
- Discus professional and ethical diversity and why there are so few women in electrical and computer engineering
- Explore various teaching types
- Engage in faculty discourse on issues and cutting edge solutions to improve the individual faculty's ability to teach effectively

III.2. **Targeted Audience and Enrollment**

Research has shown that ``adult learners comprise of 60 percent of the post-secondary student population" (Educause Quarterly, May 1999). According to Eduventures.com, a Boston-based research company, approximately 350,000 students are enrolled in online degree programs (Training, May 2003). Another survey by "The Chronicle of Higher Education", states that more than 1.6 million students (11% of those enrolled in postsecondary institutions) took at least one course online in the fall of 2002 (The Chronicle of Higher Education, 2003).

Resources, support, and marketing strategies are needed to successfully move forward to take advantage of this growing non-traditional student population within higher education. The opportunities include reaching a new student audience, meeting the needs of students who are unable to attend on-campus classes, involving outside speakers who may otherwise be unavailable, and linking students from different social, cultural, economic, and experiential backgrounds.

Recently, Virginia Tech's Institute for Distance and Distributed Learning reported over 52,000enrollments in distance learning courses on VTOnline, the university's virtual gateway to e-Learning. In the past five years, the number of e-Learning course offerings increased 151 percent with enrollment increasing 89%. Currently, 85% of the university's academic departments are engaged in developing and delivering e-Learning courses and programs. Eighty percent of online learners have indicated that they could not have taken their course had it not been online. In addition, Virginia Tech has provided 35% of the total Commonwealth Graduate Engineering Program[i] enrollments for the 2004-2005 academic year (see Figure. 2 for enrollment statistics).

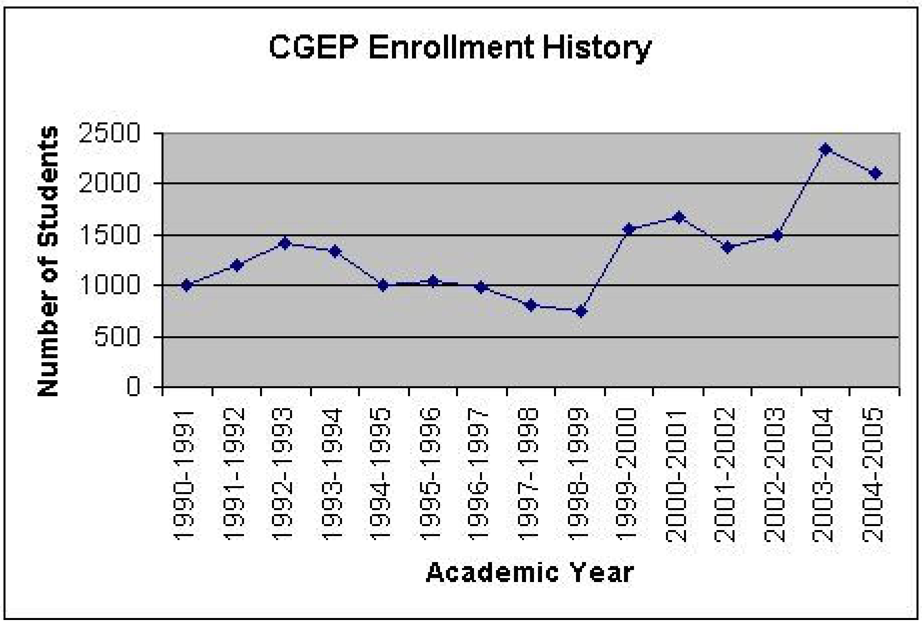


Figure 2. CGEP Enrollment Statistics

With 11 additional courses offered during the 2004-2005 year, Virginia Tech. experienced an 8.8% increase in course offerings. Aerospace and Ocean Engineering offered 15 distance learning courses over the past academic year, two of which were taught during the summer. Civil and Environmental Engineering has offered a total of 45 distance learning courses over the past seven years and offered 17 courses this past academic year. Computer Science joined the college last year and they have offered 12 courses, including two in the summer. Electrical and Computer Engineering is now offering 26 courses including one in the summer and an increase of eight courses over the past academic year. Industrial and Systems Engineering added two courses over past academic year, making a total of 14 with two offered during the summer. Other departments offered a limited number of courses as they worked towards collaborative instructional projects with various university partners. Our goal to offer more courses during the summer, is an initiative based upon information gathered from our student feed-back survey

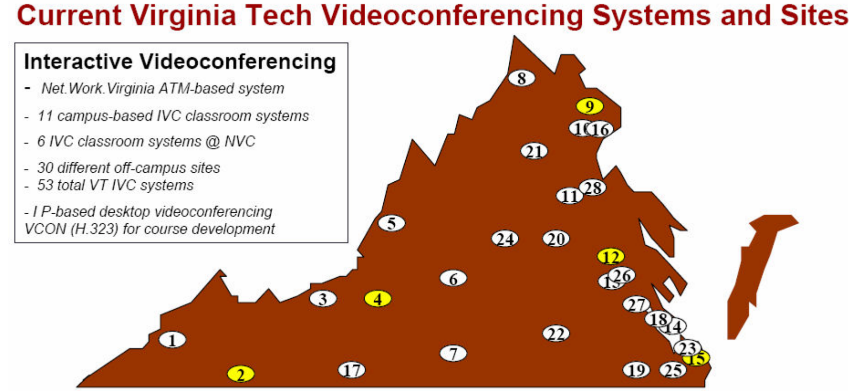
III.3. Delivery Mechanisms adopted and planned

In the recent past a benchmarking initiative was carried out, here at Virginia Tech, to benchmark the distance learning and computing program with other distance learning engineering programs around the country. The target of the study was to identify areas of improvement to stay competitive in providing high quality distance learning education. One of the aspects of distance learning that was examined in the study, dealt with delivery mechanisms for distance learning. It was found that, eighteen universities indicated on their web sites that they have online courses, however, only certain universities offered programs where students can earn degrees completely online. For example, Clemson University uses digital satellite broadcast to 2000 locations. Stanford University, University of Iowa, University of Arizona, and University of Colorado at Boulder use television broadcast technology as one of their delivery methods. University of Iowa uses microwave television as part of its delivery methods. University of Tennessee at Knoxville uses shared electronic whiteboard that allows real time group collaboration.

Distance Learning at Virginia Tech has supported post-baccalaureate education for working engineers and scientists in the United States for over twenty years. The graduate programs offered include Civil Engineering, Computer Engineering, Electrical Engineering, Engineering Administration, Mechanical Engineering, Ocean Engineering, and Systems Engineering. Virginia Tech also currently offers two programs entirely online, the Master of Science in Ocean Engineering and the Master's of Information Technology.

The Distance Learning programs are offered via state of the art technology that includes interactive videoconferencing (IVC) and online delivery methods.

Current Virginia Tech Videoconferencing Systems and Sites



- **Existing Technologies:** Virginia Tech's organization-wide commitment to staying at the forefront of information, computing, communications, and instructional technologies is woven throughout the fabric of the university, beginning with the Office of Distance Learning and Computing, which is recognized nationally for pioneering developments in distance education. The university has created a high speed gigabit data network—as well as an administrative and instructional infrastructure—to ensure that partner businesses and students enjoy access to today's best practices in research, applications, and learning communities. Current technologies for distance education include, streaming media applications and synchronous video conferencing on an ATM backbone.

- **Planned Technologies:** Over the last couple of years, Virginia Tech. is moving towards implementing an IP based Videoconferencing solution. One of the primary advantages of deploying an IP based videoconferencing is the ability to use the existing data network as the means of transport. This leads to enhanced cost savings and efficiency as only one network is required to be deployed and maintained. Using other technologies like ISDN or ATM, on the other hand, requires using a separate network infrastructure and a separate management team which will lead to higher costs. However, on a converged network like the Internet, video over IP has to typically battle for bandwidth with various other forms of IP data which may lead to jitter and frame loss. Widespread utilization of this technology has therefore, suffered from a number of factors which include

    - Complexities in implementing the H.323 protocol
    - Lack of appropriate network infrastructure for time sensitive data
    - Conflict between existing network security practices and the H.323 call requirements
    - Limited and sometimes expensive management platforms that can handle voice and video.

  Therefore, some of the key issues that are being currently resolved to ensure an effective solution for Video over IP are

  - *Quality of Service*: As IP was designed for carrying data, so it does not provide real time guarantees but only provides best effort service. For voice and video communications over IP to become acceptable to the users, the delay needs to be less than a threshold value.
  - *Interoperability*: In a public network environment, products from different vendors need to operate with each other if voice over IP is to become common among users. To achieve interoperability, standards are being devised and the most common standard for voice and video transmission over IP is the H.323 standard, which is described in the next section.
  - *Security*: This is a serious problem that exists and is due to the fact that on the Internet, anyone can subvert and modify the packets meant for someone else. Typical methods to provide some baseline security include tunneling (e.g. Layer 2 tunneling) and encryption (e.g. SSL).
  - *Scalability*: The ultimate aim of any Voice or Video over IP service is to be able to make the cost to the end consumer cheaper than the costs involved in a regular telephone call. Therefore, with such a potential, the ultimate Voice or Video over IP service must be able to handle a large user base and allow a mix of private and public services.

III.4. The H.323 Protocol

The H.323 standard is a cornerstone technology for the transmission of real-time audio, video, and data communications over packet-based networks. The standard involves several different protocols covering specific aspects of Internet telephony. A key feature of H.323 is Quality of Service (QoS). It allows for real-time prioritization and traffic management constraints to be placed on "best-effort" packet delivery systems like TCP/IP over Ethernet.

In general, in a H.323 implementation the following four logical entities are required

a. **H.323 Terminal:** A terminal, or a client, is an endpoint where H.323 data streams and signaling originate and terminate. It may be a multimedia PC with a H.323 compliant stack or a standalone device such as a USB (universal serial bus) IP telephone, which provides for real-time, two-way communications with another H.323 Terminal, Gateway or MCU. This communication between endpoints consists of speech only, speech and data, speech and video, or speech, data and video.

b. **Gateway:** A Gateway is an optional component in an H.323-enabled network. When communication is required between different networks (e.g. between an IP-based network and PSTN) a gateway is needed at the interface. A H.323 Gateway is an H.323 endpoint that provides for real-time, two-way communications between terminals belonging to networks with different protocol stacks. For example, it is possible for an H.323 terminal to set up conference with terminals based on H.320 or H.324 through an appropriate gateway. A gateway provides data format translation, control-signaling translation, audio and video codec translation, and call setup and termination functionality on both sides of the network. Depending on the type of network to which translation is required a gateway may support H.310, H.320, H.321, H.322, or H.324 endpoints.

c. **Gatekeeper:** Once the network is designed for a population of video application, the endpoints need to be monitored and their access to pooled resources controlled. In H.323, the gatekeeper is the standard mechanism that provides control over H.323 entities (endpoints, gateways and multipoint control units). A gatekeeper is essentially software that ensures the smooth operation of an interactive video network. A zone's gatekeeper is logically separate from network endpoints. However, the gatekeeper application may run within any terminal/MCU/ gateway endpoint, or even in a non-H.323 network device. When present in an H.323 network there are three mandatory zone management functions that a gatekeeper **must** perform:

- *Address translation* - a GK translates H.323 aliases into call signaling IP addresses (especially useful for endpoints with dynamic IP addresses). A gatekeeper maintains a database for translation between aliases (such as international phone numbers) and network addresses
- *Admission and access control of endpoints* - this control can be based on bandwidth availability, limitations on the number of simultaneous H.323 calls, or the registration privileges of endpoints
- *Bandwidth management* - Network administrators can manage bandwidth by specifying limitations on the number of simultaneous calls and by limiting authorization of specific terminals to place calls at specified times
- *Routing capability* - A Gatekeeper can route all calls originating or terminating in its zone. Thus, accounting information of calls can be maintained for billing and security

purposes. A gatekeeper can re-route a call to an appropriate gateway, based on bandwidth availability. Re-routing can be used to develop advanced services such as mobile addressing, call forwarding, and voice mail diversion

Regardless of the physical location of the gatekeeper program code, there must only be one active *runtime gatekeeper* per zone. The choice of gatekeeper placement is critical to the optimal operation of a total H.323 solution.

d. **Multipoint Control Unit (MCU):** MCU is an optional component of an H.323-enabled network and it is taking care of establishing multipoint conferences. It consists of:

- A mandatory *Multipoint Controller (MC)* - used for call signaling and conference control.
- An optional *Multipoint Processor (MP)* - used switching/mixing of media stream, and sometimes real-time trans-coding of the received audio/video streams

Although the MCU is a separate logical unit, it may be combined into a terminal, gateway or gatekeeper. The MCU is required in a centralized multipoint conference where each terminal establishes a point-to-point connection with the MCU. The MCU determines the capabilities of each terminal and sends each a mixed media stream. In the decentralized model of multipoint conferencing, a MC ensures communication compatibility but the media streams are multicast and the mixing is performed at each terminal.

III.5. Why is Video-over-IP Important in Engineering Education?

Apart from reducing costs by utilizing the existing network infrastructure to enable video conferencing, this new technology has the potential to impact remote learners significantly. Remote students who need to study part time in order to advance their skills will be the group that is affected the most. With the rapid growth of technology, we envision a future in which lifelong learning for engineers is a requirement. In such a future, we envision that engineering schools that have the capability to supply the need for continuing education in diverse environments while reducing the costs of delivery will the ones that will be most successful at being able to retain their graduates as learners throughout their lifetimes. Other potential remote learners include people changing careers who might not be able to devote the concentrated time required to attend a traditional school and remote learners who are interested in short workshops and courses in their neighborhood. These learners will have the luxury of choosing the very best education at the lowest cost.

IV. Conclusions

In this paper, we briefly described the steps being taken to transition from traditional technologies for distance education to next generation instructional technologies. Issues related to this transformation are far reaching and will impact the entire educational institution including faculty, students, and support services. We strongly believe that the synchronous distance education environment that videoconferencing over the Internet provides is very useful in partnering students and professors from different geographic or cultural regions, thereby allowing them to share and learn from each other.

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[i] The Commonwealth Graduate Engineering Program (CGEP) is a collaborative distance education initiative involving the Virginia Tech (VT), University of Virginia (UVA), Old Dominion University (ODU), Virginia Commonwealth University (VCU), and George Mason University (GMU). Through this program, graduate engineering courses are delivered to students located across the Commonwealth of Virginia and beyond.