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Cost and Benefits for Accessing a Video Streaming System at WPI

An Interactive Qualifying Project Report
submitted to the Faculty
of the
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the
Degree of Bachelor of Science

By

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Date:

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Abstract

Our project focused on streaming media technology, in other words video broadcasts over the Internet. We conducted extended literature and Internet research to provide evidence for the viability of streaming media technology in higher education. We studied three actual media systems that are popular in industry and commonly featured in trade magazines and assessed their benefits and costs. Through surveys targeting the WPI community, we evaluated the positive and negative feedback for the implementation of a proposed streaming media system at WPI.

Authorship Page

This project involved a combined effort from two students. Different sections were divided among group members as follows:

Manuel wrote:

- Literature Review: Survey Research
- Survey Methodology
- Design of surveys
- Survey Analysis
- References

Ekwan wrote:

- Abstract
- Introduction
- Literature Review: Streaming Media Research
- Costs and Benefits of Systems
- Survey Methodology
- References

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Introduction

The purpose of our project was to inform the WPI community (students, faculty and administration) about a new variation on traditional distance learning. Thanks to the massive success of the internet and the world wide web traditional distance learning has evolved. Lectures previously stored and distributed on physical videotape cassette are now stored on video servers and streamed through the internet to individual personal computers on a network. A student can access lectures on a given subject through a front-end interface. This interface can display the whole lecture on demand from start to end. Universities around the world are looking at media streaming systems as a new avenue for educating students.

Our first objective for the project is to emphasize the importance of student learning and how streaming media can increase student learning. Our research on delivery mediums allow our readers to understand the aspect of learning without walls, and thus lay the groundwork for our research on streaming media technology and its uses in education mediums. We follow its uses in education mediums by informing our readers of three educational institutions that have incorporated streaming media technology. That brings us to the research of commercial streaming media systems in the market. We focus on evaluating three streaming media systems. Our focus leads to three leading commercial streaming media vendors in the industry, RealVideo, MediaBase, and Web Theater. The criteria we use in the evaluation focuses on ease of implementation of the given streaming media system to an intranet, the quality of delivery for the video displayed, the quality of live streaming for each system, ease of administration, the

availability and quality of technical support and documentation, and the projected basic ownership cost of each system.

Our next objective tests the interest for a streaming media system at Worcester Polytechnic Institute. We conduct surveys incorporating systematic research and the previous evaluation research on the proposed system. Surveys targeting WPI students, faculty and administration are designed to access the positive and negative feedback for the implementation of the proposed streaming media system. Does the initial cost and additional maintainence of such a system out weigh the obvious benefits for Worcester Polytechnic Institute? That is the question we attempt to answer.

Literature Review

In this section we explain the structure of academic institutions, academic learning time, and how computers effect academic learning time. We want to lay the groundwork for the introduction of streaming media technology by showing the reader the importance of computers in education.

The Structure of Academic Institutions

Work and learning have gradually become similar in today's information economy. To remain marketable, workers must continually upgrade their knowledge base and technical skills. "In this way the ever-changing workplace has given rise to the transformation of college campuses, for the purpose of improving the quality of academic programs and services while potentially reducing costs."[1]

What is Academic Learning Time?

Academic learning time is defined as, "the amount of time a student spends attending to relevant academic tasks while performing those tasks with a high rate of success."[2] Academic learning time is more strongly related to academic success than any other variable over which the professor can exercise control.

A common belief is that the more time you spend doing an assignment, the more you will learn. "Research has proven that this relationship exists for academic activities."[3] But in order to ensure an increase in the student's learning, professors must

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[1] Van Dusen, Gerald C, The Virtual Campus The George Washington University, Washington D.C. 1997
[2] Gilbert, Steven H. Distance Education, Education Network of Maine Nov 1996
[3] Gilbert, Steven H. Distance Education, Education Network of Maine Nov 1996

do more then just assign more study time to a certain subject. Not all students will spend all the time allocated to a task actively engaged in appropriate activities. It is the time the learner is engaged in appropriate activities that is closely related to improved academic success.

In order to utilize time spent on a task, the student must be participating in useful activities at a high rate of success. So to improve, a student must successfully complete worthwhile activities. One way to increase academic learning time is to increase the amount of time spent on tasks. More time must be devoted to essential topics rather then redundant information. Another approach is to create a classroom that operates more efficiently. "The professor must use effective behavior modification to reward on-task behavior and punish deviant behavior."[4]

Whatever the area of instruction, students learn efficiently to the extent that they turn their class and study time into academic learning time. Neither class time or study time automatically qualifies as academic learning time, although both have the potential to become academic learning time to the extent to which the student actively attends to relevant activities with a high rate of success.

The Role of the computer in Academic Learning Time

When computers fail to improve learning, it is very often because they do not increase academic learning time. So when deciding which subjects could computers enhance instruction in, educators should attempt to discover ways in which computers could increase the academic learning time available for effective use by students. "Computers are capable of enhancing academic learning time in many ways. One is by

permitting students to acquire specific information and practice specific skills. And the other is by helping students develop basic tools of learning, which they can apply in a wide variety of settings."[5]

At this point an explanation of media, educational media and subsequently delivery media is imperative to the continued understanding by the reader. Streaming media technology in all its many forms is ultimately categorized in this field.

Media

What is media?

Media is the blanket term used when referring to audio, video or images such as photos, as well as the ways they are used to reach the viewer.

The Role of Computers in Educational Media and Instruction

In the past, teachers have integrated their own methodology with either printed or audiovisual media, such as books, films, filmstrips, tape recordings, or videotapes. When evaluating the effectiveness of the computer, one should compare it to the other forms of media. The computer is capable of supplying a delivery system, which allows for more active and intense interaction by the students. "Computerized tutorials can enhance academic learning time by permitting students to proceed at their own pace, focusing their attention, and placing at their fingertips information they need when they need it."[6]

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[4] Gilbert, Steven H. Distance Education, Education Network of Maine Nov 1996
[5] Jones, A. Kirkup, G. Kirkwood, A. Personal Computers for Distance Education, McGra-Hill, Inc. 1995
[6] Jones, A. Kirkup, G. Kirkwood, A. Personal Computers for Distance Education, McGra-Hill, Inc. 1995

This combination of flexibility and interaction allows students to manage their academic learning time more effectively. In cases where these characteristics would be beneficial to students, computerized tutorials would be recommendable. "Effective computerized drills provide the opportunity for extra practice that is essential for students who need to spend additional time on information they have not mastered as rapidly as other students."[7]

"Computerized drills allow students to make their academic learning time more effective, by allowing individuals to control the level of difficulty. This enables students to perform tasks at a higher rate of success with immediate feedback. Computers can help students acquire high-order skills of problem solving and meta-cognition that will enable them to use their overall learning time more efficiently."[8]

The use of a personal computer is very advantageous in circumstances which require the completion of routine and onerous tasks. This allows the teacher to engage in other productive activities with the students. "Computers individualize instruction by delivering to specific learners the instructional opportunities to move toward important educational goals." Also, computers provide the opportunity for frequent interaction between the student and the learning material, while distributing corrective feedback.

By incorporating computers into the classroom, teachers have more time to communicate with students. "By observing or interacting with pupils working at computers, teachers can learn about their students' needs and therefore communicate with them more effectively." A major advantage of using computers in the classroom is individualization. Students vary greatly in their instructional needs with regard to

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[7] Jones, A. Kirkup, G. Kirkwood, A. Personal Computers for Distance Education, McGra-Hill, Inc. 1995
[8] Jones, A. Kirkup, G. Kirkwood, A. Personal Computers for Distance Education, McGra-Hill, Inc. 1995

concepts and skills covered in the curriculum. Students learn more effectively if they are attempting to solve tasks that are suited to their own needs.

In a typical class, there is usually a wide range of skills present amongst students. "Teachers must give attention to the weaknesses of certain individuals, while trying to enrich the curriculum for the students who have already mastered the prerequisite skills and course objectives. Basic skills must become automatic in order to provide the basis for more advanced learning."[9] Computers provide students with the opportunity for repeated practice of important skills. They also prevent needless repetition of tasks, for those who do not need practice.

Delivery Media

Distance Education

"Distance Education is any form of teaching and learning in which teacher and learner are not in the same place at the same time, with information technology their likely connector."[10] With the development of new technologies, the media for distance learning have become more varied and interactive. These developments have led to an increase in student and institutional interest. Certain educational institutions have committed themselves to distance learning in order to extend educational services to a national or international student base.

Institutions all over the world have implemented video distance learning as part of their curriculum. With video distance learning students have the ability to acquire quality lectures and programs. Professionals and students now have numerous avenues for their

[9] Jones, A. Kirkup, G. Kirkwood, A. Personal Computers for Distance Education, McGra-Hill, Inc. 1995
[10] Gilbert, Steven H. Distance Education, Education Network of Maine Nov 1996

education. Distance learning is now available through many mediums like cable television, public television, satellite, microwave, videotape, CD-ROM and the Internet. Institutions are now capable of delivering courses to students at remote viewing locations. For example many institutions are offering fully accredited courses called Telecourses[11]. Over 3.5 million students have earned college credit through telecourses. The main difference between a telecourse and "regular" course is that the student learns by watching television programs rather than attending on-campus lectures. Students register with a college and study from textbooks, complete assignments and take exams. A faculty member from the college guides the student's learning by designing the syllabus, grading the work and answering ~~answering~~ questions. At the end of the semester, students get a grade that shows up on their transcript and credit that counts toward a degree.

What is Distance Learning?

In the context of education, distance means that the learner and the teacher are not face to face. Thus two-way communication must take place despite the fact that they are not in the same room together. Two-way communication can be established using any medium that is available. "In the 1980's distance education began to be seen to offer unrivalled flexibility for people in employment who wanted updating and further training."[12] Presently, there are numerous accredited institutions, which produce high quality, self-study materials using a variety of media.

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[11] Arkansas Educational Telecommunications Network (AETN) http://www.aetn.org/
[12] Macht, Joshua. Virtual You, Inc. Magazine, pg.112 January 1998

In distance education students are separated not only from their teacher, but also from one another. Also, course writers cannot get immediate feedback on the course material assigned. "For this reason, Open University courses are often presented annually for up to eight years with little change to the basic materials." Distance feedback and evaluation systems must also be developed to inform course designers of any problems with their materials. For most distance learning students, the main teacher is their course material, but they may also have the opportunity to meet with a tutor who would assess their work.

Video and Distance Learning

When institutions choose to use video as the medium for distance learning, most often, classes are delivered to student homes on VHS videotape. Course content and materials are the same as on-campus courses, though instructional methods are sometimes changed to accommodate the medium of delivery. Some courses are pre-recorded, and some courses are recorded during the term in which they are offered to the students. In the case of pre-recorded courses, tapes are shipped in batches to students' homes, usually on a three-shipment schedule. In the case of concurrent recording, tapes are shipped the day after each class, and arrive at students' homes on a two-day-delayed schedule.[13]

The Internet and Distance Learning

Before the world-wide web, computer users began to navigate cyberspace on the world's largest computer network, the internet. A combination of national, regional and

local computer networks, the Internet was rapidly gaining in popularity outside of the scientific community (due to the large number of college students wanting access to electronic mail). But beyond the basic capability of e-mail and several other network services, the Internet was inaccessible to the vast majority of users. Based on a series of complex protocols, the Internet required an intimate knowledge of computers and network operating systems, a knowledge that most users neither had the time or interest to gather.

The Internet had the technical capacity to handle a variety of complex applications (downloading files from distant computers, transferring digitized photos and sounds, etc.), but because it was by no means a user-friendly network, its uses were limited. Then, researchers at the University of Minnesota came up with *gopher*, a network standard which would, with the appropriate software, guide the user from one file to another, as well as from one computer to another. Gopher was a fairly simple idea: a person could point with a mouse to a piece of information (such as a title of an article in an on-line table of contents) and download that file merely by clicking it, and without having to know any complex codes. Moreover, if one of those clickable titles actually allowed the user to connect to computers around the world and download their files, any user could navigate from site to site, scanning for and copying information in a comprehensive environment that only an international network could provide.

Gopher became one of the most popular ways of storing and presenting information over the Internet. But gopher has some serious limitations. It is limited to presenting text files only. Because the gopher structure is based on a menu of textual items, which contain even more text, the layout structure does not lend itself to the

[13] Advanced Distance Learning Network(ADLN) http://www.wpi.edu/Academics/ADLN/

display of graphics. All gopher menus look similar, so it's not unusual to get lost. Finally, gopher links to menus and documents must be summarized in a few words. You can't fit an entire paragraph, let alone an image, into a gopher menu. Simply put, gopher does not lend itself to creativity very well. While it is certainly an excellent method of cataloguing large amounts of textual data, its flexibility and aesthetics leave much to be desired for those who wish to craft their information more stylistically.

In order to give Internet publishers the necessary tools to design complex online multimedia documents, an entirely new protocol had to be formulated. In 1989 at the European Particle Physics Laboratory in Geneva, British computer scientist Tim Berners-Lee developed a protocol he called the World-Wide Web[14]. As the name suggests, the Web allows Internet publishers to intertwine information in multiple directions and layers. Through a similar structure applied to the gopher protocol, the Web offered some fascinating new features. Text and links to other information could now be presented on the same screen. The World Wide Web made it possible to highlight certain words within a paragraph. By selecting these words with either a mouse or by moving a cursor, you can link to any other document on the Internet. These pages, in turn, can offer additional links to even more specific informational nuggets. And beyond its general ease of navigation, the Web also allows for a publisher to present information in a multimedia context. In other words, while a Web page may offer segments of text, it may also include graphics, audio, even video. Essentially, a Web site can easily look like a page of information like a multimedia CD ROM. Unlike a CD, though, the Web interconnects with computers around the world, creating a new dimension to cyberspace, full of images, sounds and ideas.

At first, the Web remained an experimental method of organizing Internet information, and only a handful of research sites around the world were capable of presenting it. In 1993, though, programmers at the University of Illinois at Urbana/Champaign released Mosaic[15], an easy-to-use web browser. It was freely distributed over the Internet. Eventually, other browsers such as Netscape began to proliferate, making the Web more accessible to casual users than ever. "By the fall of 1994, it was estimated that there are anywhere between 7,000 and 10,000 Web sites around the world; by 1998 there were over 10 million."[16] Web sites like Yahoo receive millions of hits per day. The World-Wide Web, originally envisioned to allow researchers and computer enthusiasts better access to each other's information, has now turned into a powerful force on the Information Highway.

Now the reader is immersed into streaming media. From this point we educate the reader on what streaming media technology is, the technical jargon involved in streaming media, how it works, and instances where it has already been implemented.

A New Direction in Distance Learning: Streaming Media

"Streaming media is a method of making audio, video and other multimedia available in real-time, with no download wait, over the Internet."[17] Video on the Web isn't a new concept. Web pages have contained video and audio clips for years. But with

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[14] http://edweb.gsn.org/resource.cntnts.html
[15] http://edweb.gsn.org/resource.cntnts.html
[16] www.cnet.com/web/resource
[17] www.streamingmediaworld.com

the commonly used formats, the video must be downloaded before viewing, a painfully slow process that is rarely worth the wait.

Conventional video files can be viewed in two ways. A helper application that is launched by a Web browser like Netscape Navigator or Microsoft Internet Explorer or when the appropriate **plug-in** is installed, directly in the browser's window.

Streaming video likewise requires player software. But once the software is installed, streaming video is comparable to having a video file "broadcast" to your computer. Although the quality barely approaches that of a "realtime" 30-frames-per-second video transmission, there's theoretically no waiting involved. As soon as the file is requested, a continuous flow of frames commences.

Streaming video varies from non-streaming video in many ways. First of all, non-streaming video must be downloaded from the Web site. Secondly, it doesn't discard any unneeded data before it is played.

With streaming, 30 frames per second analog video is fed by a video camera to a video board within the computer and converted from an analog wave form into **binary** data. The binary representation of the original video is stored on the computer's hard disk. Video compression software reduces the data representing the original analog video wave form to a manageable file size. It analyzes a sequence of video frames to determine which frames are needed. Information that is vital is retained, while redundant information is discarded. In addition to providing the software that Web content providers use to publish the sites, each video-streaming-software developer provides a proprietary **interface** which users (clients) employ to receive the files from a remote **server** on the Internet. This Interface software, often called a player, must be downloaded from the software

developer's own Web site and installed on the client's computer. When a client requests a streaming-video file by clicking on a HTML tag embedded in a Web document, the video-streaming software on the remote server "releases" the video file.[18]

How does Streaming Media Work?

Like most forms of data transmission across the Internet the process of streaming video begins when a user connects to a remote server with a **modem** and requests a video file. A variety of technologies currently exist, and each has its own proprietary client, which means its own **player**, its own **software** and **file type**. You must **download** the player software from a streaming-video-software developer's Web site prior to requesting a file.

Uncompressed video files are huge. They swallow up an enormous amount of space on a computer's hard drive. For this reason, video data must first be encoded using **codecs** that compress the file, discarding as much data as is required to allow it to be transmitted to an average analog modem. When you consider that uncompressed video has a data rate of 100 **megabytes** per second, and that its destination is probably a 28.8-kilobits-per-second modem connection, you get a feel for the massive compression ratios required for streaming video. Some web servers that have been designed specifically for streaming media will perform an analysis of your computer and communications hardware prior to releasing a video stream. The **transmission protocol** will be optimized for the specific connection, and adjustments to the stream can be performed to ensure a consistent flow of image so that the clip does not freeze up in mid-stream. When using a

[18] www.streamingmediaworld.com

28.8 modem, it's reasonable to expect frame rates of up to 10 frames per second with a standard amount of excess data such as double images. Faster connections, such as **ISDN** or **T1 lines**, can result in heightened performance with reduced excess data, although you'll still be far from the ideal scenario of excess data free, 30-frames per-second **real-time** video transmission.

Abuses and Uses of Streaming Media on the Internet

The most widespread and successful use of streaming-video technology on the Web has been at adult-oriented sites, where the ability to view "live" content has proven to be a significant selling point for site developers.

More conventional uses of the technology have been implemented as well. The Web sites of major media organizations such as CNN[19], C-SPAN[20] and Court TV[21] augment features with related streaming-video clips. Music video also enjoys a significant streaming presence on the Web. Sites such as JamTV[22] provide low-resolution alternatives to MTV and VH1 on cable television, and allow a broad base of artists to broadcast their videos over the Internet.

Streaming video isn't only for the mass media. Many educational institutions have been among the first to implement the technology. Universities have made courses available online, complete with streaming-video clips of lectures. Use of the streaming-video technology makes distance learning more viable, and also allows students who

[19] www.cnn.com
[20] www.cspan.org
[21] www.courttv.com
[22] www.jamtv.com

miss a class to catch it later. Artists and political activists have also seized upon streaming-media technology to promote their visions. Currently, a number of film festivals, such as the Reel Time film festival[23] can be screened on your desktop. And activist groups, whose political critiques tend to be ignored by the mainstream media, can disseminate video on the Net at sites such as the Free Speech TV Web project.[24]

In its present state, streaming video on the Internet is still too primitive for prime time, and it's hardly a threat to more conventional forms of video distribution, such as cable, broadcasting and satellites. But as the barriers between the PC and TV continue to blur, it's possible that the Super Bowl may one day be broadcast to a PC courtesy of streaming-video technology and the Internet.

Institutions that incorporate Streaming Media

Williams College: The CyberCollege Program

Williams is launching a program called CyberCollege for alums and students.[25] This program allows students to communicate through a virtual classroom and participate in online discussions with students, all in real time. The CyberCollege program at Williams College uses the most advanced audio-video Internet technology to webcast classes on their network or to individual pc's anywhere. Alums who enroll in these specially designed classes will also be able to participate in an online email conference with Williams students in the course.

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[23] http://pathfinder.com/netly/reeltime/ main.html
[24] www.freespeech.org
[25] www.williams.edu

To watch the lectures the user must have access to World Wide Web from an Internet browser such as Netscape or Microsoft Internet Explorer on a computer. The application used to watch the video lectures is developed by Progressive Networks and is the called the "RealPlayer".

University of Michigan Ann Arbor

"The University of Michigan operates a 60-channel campus television network called UMTV."[26] Along with this massive television network, the University of Michigan also broadcasts this 60-channel network over the internet. Students, and alumni can watch education centric programming from their pc's by using RealNetworks Realplayer. RealNetworks personally configured the network to allow channels to display on the application interface. "Also video programming is distributed every day via satellite. UMTV provides satellite downlinking, bringing these programs down from space and sending them all across campus."[27]

UM is currently capable of encoding, archiving and streaming up to six live events and 1000 concurrent users at a time. Current Streams at the University of Michigan include UMTV webcasts, University of Michigan athletics multimedia, and live Michigan radio streams.

[26] University of Michigan www.umich.edu
[27] University of Michigan www.itcom.itd.umich.edu

Stanford University

Stanford University has been regarded as of a pioneer in terms of educational institutions implementing the latest technologies. Streaming video is no exception and today, various Stanford departments and organizations offer video clips to individuals visiting their Web sites.

"For the last several months, Information Technology Systems and Services (ITSS), through its Communication and Networking Services (CNS) unit, has developed a pilot offering that allows individual Stanford departments and organizations to stream video from ITSS video servers."[28] Many departments are participating in the pilot and providing links from their Web sites to video clips.

"At Stanford, and on the Web, most sites are providing low bandwidth (under 1 megabyte per second) video using RealNetworks' RealServer."[29] Each product provides free viewing software that the user can use as a separate application or as an integrated part of a Web browser. Once the user has downloaded and installed the appropriate applications, they should be able to select a video link from a Web site and watch it on a desktop machine. "Remember, the playback quality of the video as it appears on a desktop machine is controlled by several factors including how the video was encoded (created as a digital file) and the Internet connections speed (on-campus Ethernet connections can receive higher quality video than modem connections)."[30]

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[28] University of Stanford: http://www.stanford.com
[29] University of Stanford: http://www.stanford.com
[30] University of Stanford: http://www.stanford.com

The Communication and Networking Services, as part of a pilot project to explore streaming technologies, is providing centrally the means for members of the Stanford community to stream video from their own Web sites. CNS will take the video, create a digital file, and store the file on one of its Web servers. Stanford provides faculty with a URL that students can include as a link on their Web sites to allow clients to view video over the Internet. During the pilot project, CNS is not charging for this service.

This section is dedicated to the commercial vendors and their flagship software packages. It also gives our evaluations on the leading streaming media systems in the industry today, and accesses the specific benefits of each package and the costs associated with them.

The Players

Initially, the streaming-media arena was chaotic. There were a dozen or more developers providing software solutions that were incompatible with each other. Of this horde, Progressive Networks[31], was the early market leader, because of the high visibility of its first streaming media product, **RealVideo**.

By the fall of 1997, however, Microsoft[32] was muscling its way into the game. In no time at all, the company moved in on the significant competition, purchasing VXtreme[33] outright, and buying stakes in both VDOnet[34] and Progressive Networks. Since then, Microsoft has succeeded in leveling the current streaming media field by

[31] www.progressivenetworks.com
[32] www.microsoft.com
[33] www.vxtreme.com

pushing the Active Streaming Format (ASF), which is used in its Microsoft NetShow software. NetShow[35], which can also play RealVideo files, resembles an electronic program guide and allows the user to bookmark streaming-video "channels" for later recall. The similarity between the NetShow interface and TV-type on-screen guides, such as StarSight[36], signals Microsoft's interest in dissolving the barriers between the PC and TV. Working toward that goal, Microsoft had already bought WebTV[37], and has been involved in the standards-setting hearings for high-definition TV.

Despite Microsoft's incursion into the field, RealVideo continues to be the most popular streaming solution on the market. RealVideo player will support Microsoft's ASF file format, and it generally provides the best image quality available through a 28.8 modem connection. Like the NetShow player, the RealVideo player interface allows the user to store "channels" for repeated viewing, and can be downloaded for free from Progressive Networks' Web location.[38]

Evaluating a Streaming Media System

Despite the countless number of streaming media systems currently on the market, very few offer the ease of implementation, quality of delivery, quality of streaming video, and administration support as these three commercial systems, RealVideo, MediaBase, and Web Theater

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[34] www.vdonet.com
[35] www.microsoft.com/netshow
[36] www.starsight.com
[37] www.webtv.com
[38] www.real.com

RealVideo from RealNetworks

RealNetworks, a child company of Progressive Networks, develops and markets software products and services designed to enable users of personal computers and other consumer electronic devices to send and receive audio, video and other multimedia services using the Web. RealNetworks streaming media system is called RealVideo. ReadVideo is a software based application and can be easily installed on an existing infrastructure. There's no need to purchase an entirely new set of tools, and you avoid many training issues.

The RealVideo solution offers transmissions options and is very scalable. One useful feature is smart networking, an option that allows a server to send content via unicast or multicast, and to use either **UDP, TCP**, and **HTTP** transport protocols, depending on your network conditions and the presence of firewalls. Multicast is the preferred method for sending live broadcasting. With smart networking, video and audio streams are automatically delivered using the most efficient network protocol, whether it's IP multicast, UDP, TCP, or HTTP.

RealVideo Strength: Scalability

As for scalability, Intranet RealServer now supports a robust splitting mechanism that basically allows a live stream to be broadcast to multiple servers on the Internet, which is great for remote locations and an expanding network.

Intranet RealServer comes in AIX, BSDI Unix, DEC Unix, FreeBSD 2.x, Irix 5.3 and 6.x, Linux 1.x and 2.x, SunOS, Sun Solaris 2.5, and Windows NT versions. However, the

client is Windows 95-based with a Pentium processor or Mac OS-based equipped with a PowerPC processor.

Trial Run by Technicians at InfoWorld Magazine[39]

The technicians loaded the Intranet RealServer software with Windows NT 4.0 and the installation went very smoothly. They viewed the license details, were offered a destination directory option, assigned passwords, and set the e-mail option to notify anyone of any server errors. Prior to completion of the installation, a configuration dialog box appeared that allowed the user to view and change settings if needed. After its completion, they used the RealServer Control Center to run a test clip to verity that the server was running. The encoding machine consisted of a Symetra with a 4GB hard drive, 256MB RAM, and two Pentium Pro CPUs. They installed an Osprey-100 capture card and its drivers, and set up all of the clients with the RealPlayer Plus media player. The Osprey-100 card supports Windows 95 and Windows NT.

The RealServer System Manager offers an adequate set of administrative utilities. Utilities for viewing servers, clients, and file listings were all fairly basic but useful. Using the RealVideo software on the encoding system, they were also able to monitor streams and set up passwords and directories.

RealVideo Strength: RealPlayer Plus[40]

Their favorite piece of the puzzle was RealPlayer Plus. They loved this media player. It offered a connection statistic panel where they could view **bandwidth**, and video frame rates. It also had preset buttons that directly connected us to our favorite

sites, destination buttons that connected us to popular audio and video programs, and a status bar that provided file sizes and run time. The statistics panel provided comprehensive streaming details. All of this was offered in addition to the traditional controls found in the other solutions.

Capturing videos and live streaming media were easy tasks to accomplish using RealVideo Encoder's tools. In fact, RealVideo Encoder offers unique features such as bandwidth negotiation, which delivers files that are encoded with different algorithms based on the bandwidth capabilities of the user's system. The synchronized multimedia feature allows content creators to create video that will control their browser activity.

With the RealVideo Encoder, they were able to compress video files or input from a video device into one or more RealVideo formats. The RealVideo Encoder window displayed information about input and output file formats and offered fields for entering descriptive information. Streaming data in real time or on demand was very good when they used the smaller resolution screen sizes, but frame rates dropped or frames were delayed when we used the 640-by-480 resolution.

The RealVideo solution provides a very solid method for streaming realtime live and on-demand video and audio over the Internet or a corporate intranet. Progressive offers three RealServer versions: Professional, for production houses; Intranet, for businesses; and Easy Start, which is a free server that can be downloaded from its site.

RealVideo Components

Encoding station

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[39] RealVideo Trial Run, InfoWorld Magazine, #14, pg.72 2000
[40] RealVideo Trial Run, InfoWorld Magazine, #14, pg.72 2000

- Progressive Networks RealVideo Encoder
- NeTpower Symetra
- MMAC Osprey-100

Streaming server

- Progressive Networks Intranet RealServer
- NeTpower Symetra
- Microsoft Internet Information Server 3.0

Client media player

- Progressive Networks RealPlayer Plus

Pros and Cons of the System

PROS

- Bandwidth negotiation feature
- Multimedia synchronization tools
- Superb media player
- Strong capture and delivery tools
- Easy to set up and administer

CONS

- No Web-based administrative tools
- Only supports proprietary file format
- Synchronization tools are hard to use

Projected Basic Cost

At a price of $42,083.00[41] the RealVideo solution provides the best bargain overall. It furnishes a complete package with effective tools, though it may require more administration time due to the lack of a Web-based administration option[42].

MediaBase From SGI

SGI specializes in high-performance computing technology. The company's systems, ranging from desktop workstations and servers to the most powerful supercomputers in the world, deliver advanced computing and 3D visualization capabilities to scientific, engineering, and creative professionals and large enterprises. In addition, SGI creates innovative software for design, Internet, and entertainment applications. SGI provides solutions in several key industries, including manufacturing, government, entertainment, communications, energy, the sciences, and education

The MediaBase solution from SGI provides a powerful, scalable media-streaming solution complete with all of the tools required to manage, monitor, and integrate media streams into Web applications. This solution was the most flexible and the most costly.

Trial Run by Technicians at InfoWorld Magazine[43]

This solution can deliver resolutions from thumbnail to full-screen size (the highest resolution they tested was 800 by 600). However, though the MPEG standard is a powerful delivery tool, it needs a huge pipe that can deliver video at 1.5Mbps. If the network gets saturated, the solution will just stop.

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[41] RealVideo Project Basic Cost, InfoWorld Magazine, #14 pg 76, 2000
[42] RealVideo Project Basic Cost, InfoWorld Magazine, #14 pg 76, 2000

They used a pre-configured WebForce Origin server, a robust, scalable, and feature-rich server using WebForce MediaBase software. It's an ideal solution to meet today's increasing need for multimedia-rich content on the Web and on corporate intranets. They used the MPEG Video Transmission System as their live streaming and encoding system. The system was basically used as their staging area for video dips, but you will need to be familiar with Unix to use the administrative software. Client workstations can use either Netscape Navigator or Microsoft Internet Explorer Web browsers. Installing the media player consisted of a few steps, including browser selection and network configuration.

MediaBase Strength: Administrative Software

The MediaBase administrative software was in a class of its own. It offered a graphical, easy-to-use Web page abundant in video and server tools. Having their tools centralized and easily accessible was a bonus. InforWorld Magazine was also very pleased with the solution's efficient administrative Web page layout. This was by far the best designed and easiest solution to maneuver through and use.

One of their favorite pieces of this solution was its web page, where users could download MediaBase video players and view show schedules and video listings. The video administration tools were extremely easy to use and provided video-capture, video, and management utilities for broadcasting across the Web.

The video-capture tool provided them with all of the necessary utilities to capture video clips and distribute them in real time over the network, or they could store them in the MediaBase for viewing at a later time. On the server side of the administration tools,

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[43]MediaBase Trial Run, InfoWorld Magazine

elaborate real-time graphics provided instant networking, services, storage, memory, and CPU information. That's not to mention all of the additional information, such as managing video accounts and schedules.

However, the technicians didn't find the mediaplayer controls to be that exciting though they did like the full-screen feature. The **MPEG-1** Player was very similar to that of the Web Theater solution -- it was easy to use, basic, but nothing like the elaborate RealPlayer Plus media player, which they preferred.

Before they began with the capture-and-delivery process, they first needed to create a directory for the staging area on the WebForce Origin. This is where some Unix knowledge will be necessary. When finished, they simply copied them over to the staging area on the WebForce Origin. They used the Video Add tool to select sessions, such as live feed only or capture and live feed. Then they selected and named the video clip, assigned start and end times to it, and gave it a few keywords. After a few seconds they were able to view the complete status of our video clip using the schedule tool.

A client machine could then access the Web page, either looking under today's showings or video listings depending on the video's assigned date and times. It could then select the video clip for viewing. Unfortunately, the live streaming and video-on-demand sessions were not without problems.

As they evaluated the video and audio quality of the MPEG live streaming clip, they noticed a distinct lag between the video and audio. Also, they noticed timing differences between the clients.

Some time was spent evaluating and troubleshooting this problem, but it wasn't until they spoke with an SGI representative that they concluded it was a client buffering

problem. The images were clear and sharp during the video-on-demand session, although they did come across a few clients with audio that had a slight delay.

MediaBase Components

Encoding station

- Optivision MPEG Video Transmission System

Streaming server

- SGI WebForce MediaBase 2.0
- SGI WebForce Origin 200
- Netscape Enterprise Server 2.0

Client media player

- CompCore MPEG-1 Player

Pros and Cons of the System

PROS

- Pre-configured hardware
- Web-based and robust administrative software
- Furnishes a pre-configured user Web page with scheduling and video listings
- Supports the most encoding formats
- Bundled with Progressive Network Video server and 10 streaming licenses

CONS

- Basic media player
- Expensive

Projected Basic Cost

At a price of $86,733.00[44] the MediaBase solution is the most expensive of the three solutions, but it does provide a complete solution that will easily fit into most existing infrastructures. Its useful software-and hardware-management utilities reduce the long-term administrative cost[45].

Web Theater From Vxtreme

Web Theater software from VXtreme is a complete platform for building real-time, interactive video solutions such as on-demand training, executive speeches to the desktop, customer support, and more. The Web Theater platform includes five components for creating, managing, and delivering video-enabled applications over existing networks. These components are the Web Theater Server, Client and Client Gold, Producer and Live Station.[46]

The Web Theater solution does a solid job of creating and delivering content, but it currently lacks administration capabilities. This solutions architecture is different than the other solutions' in that, instead of a media clip consisting of two parts video and audio, combined into one file, Web Theater uses separate files. This model provides some advantages in scalability in large installations by setting up a separate audio and video

[44] MediaBase Projected Basic Cost, InfoWorld Magazine, #14, pg 80, 2000
[45] MediaBase Projected Basic Cost, InfoWorld Magazine, #14, pg 80, 2000

server and letting the client synchronize the content. It also decreases storage requirements for those who need multi-language clips by using a different audio dip for one video file. Designed to streamline video across the Internet, the Web Theater solution is limited to 176-by-144 resolution.

The Web Theater client is a browser plug-in. Each stream has an associated web page that is added to your web server; there must also be a file called vxtreme.ivy in the same directory for the plug-in to be recognized. VXtreme recommends a separate Web server from the video server to get maximum performance.

Web Theater Strength: Quality of Streams[47]

They liked the quality of streams that the Web Theater solution produced. It successfully handled a congested network, and when they simulated 2-second cable disconnect, it buffered enough of the stream to maintain a nice picture and audio without the loss of any frames. Managing the server was not a great task, but there aren't many tools, especially for real-time monitoring. However, the tools are Web-based, which makes it easy to get to from any system. The solution also provides separate passwords for the server and the content manager, so you can split the tasks between different people and still maintain security.

The logs are simple text-based and the logging levels can be adjusted in the configuration screen. The Web-based Content Manager can add streams to the server, but they recommend using the less-complicated Web Theater Producer. Web Theater

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[46] www.vxtreme.com
[47] Web Theater Trial Run, InfoWorld Magazine, #14, pg 81, 2000

LiveStation is simple to install but its limited resolution cannot stream more than 56Kbps at 10 frames per second (fps). Stream set up is easy; a sample HTML template file is there to help customize your server. The stream looked sharp, though small.

The first step in creating content for video on demand is to capture your video using the Producer Capture module, which runs on Windows NT 4.0 or Windows 95. This tool allows you to capture video and audio from any source and save it to an .AVI file. The interface is simple to use, allowing you to select different video and audio capture rates. After saving a file or opening a pre-saved .AVI file, you can use the export feature to compress and create the formatted files needed for modem, ISDN, or LAN bit rates.

Web Theater Producer is where everything comes together to create your streams and HTML pages. When you create a stream, you are given a set of HTML templates that include scrolling tickers, URL page flippers, and a table of contents page. Once a template is chosen and named, the main author window displays all tracks in a time line format. This was the only solution to include this type of synchronized media, and it works very well by adding value to your content.

Pushing the associated button lets you change the properties of the media and add video and audio files. To choose where a media type is shown you pick the time and the information to show. The only properties needed for video and audio are the server name and the URL of the stream.

They liked the fact that the Web Theater solution offered Web-based administration tools, HTML templates, and enhanced synchronization multimedia tools.

However, it didn't fare as well as the other solutions because it lacked real-time reporting capabilities and flexibility for the enterprise.

Web Theater Components

Encoding station:

- VXtreme Web Theater Producer
- VXtreme Web Theater LiveStation
- NeTpower Symetra
- Winnov Videum

Streaming server:

- VXtreme Web Theater Server
- NeTpower Symetra

Client media plug-in:

- VXtreme Web Theater Gold

Pros and Cons of the System

PROS

- Web-based administrative software
- Provides a variety of HTML templates and lets you create your own

CONS

- Restricted live streaming resolution
- Involved process for capture and delivery
- Weak administration tools

Project Basic Cost

The Web Theater solution's middle-of-the-road price was $57,752.00, which isn't bad considering that it also includes some nice media synchronization tools. VXtreme offers free clients, which we chose not to include because they are only capable of streaming at speeds of 28.8Kbps or56Kbps.[48]

Analysis of Solutions

RealVideo Solution

The RealVideo solution, another fine solution, offers the widest array of tools right out of the box and was cheaper than the MediaBase solution. They were impressed by all of the features and tools that allowed them to quickly set up, capture, and deliver live streaming and on-demand multimedia. The capture and distribution tools were extremely easy to use, and features such as smart networking, User Datagram Protocol-based splitting, and bandwidth negotiation also added to the overall package, providing superb transmission options and scalability. The media player contributed to the overall score because it provided the most functions and controls. Destination and preset buttons were fun to have, but when it came down to it, the connection statistic panel offered all of

[48] Web Theater Projected Basic Cost, InfoWorld Magazine, #14, pg 84, 2000

the technical information needed. On the down side, the RealVideo solution didn't provide a Web-based administration page.

MediaBase Solution

If you're shopping for a Web-based media server and want to increase the value of your existing intranet by adding audio and video streaming, SGI WebForce MediaBase 2.0 software and the Origin 200 server is an excellent choice. And, just like everything else, you get what you pay for. You don't have to set up a lot because the system comes pre-configured to your specifications; you only had to install the client software. (Or you can save much as $4,000 if you install it yourself.) For administrators, this solution offered it all, even a preconfigured Web page that provided schedules, video showings, and media players to ease the client media player installation process. You can also create your own Web pages and easily link to assets on the Origin 200. The capturing and delivery process couldn't have been any easier, and it was the only solution that provided MPEG-1 and MPEG-2 encoding formats. Overall, the solution was top notch. One drawback is that MediaBase is geared towards businesses. For educational purposes this would not be the best choice.

Web Theater Solution

The Web Theater solution is similar to the RealVideo solution, but unfortunately it wasn't as easy to administer. For instance, they could only view cryptic log reports in a text editor, and they had to decipher the information. The overall capture and live

streaming process wasn't exactly a picnic either; the too-many steps weren't difficult but the process was lengthy. Compared with the other solutions, where three steps were needed, Web Theater required more. This is the inconvenience of separating capture and authoring tools. In addition, live streaming configurations were limited to 56Kbps with a smaller resolution.

Why Streaming Media Technology fits WPI

Worcester Polytechnic Institute is a top engineering school in the United States that prides its reputation on innovation. With the rapid pace of technological change and the amazing tools of the Information Age, WPI has positioned itself to be amongst the leading institutions for the new millennium.

Streaming Media Technology has been implemented in many institutions for the purpose of broadcasting lectures, for video conferencing, entertainment etc. The biggest benefit that streaming media can bring to Worcester Polytechnic Institute is an increased academic learning time for its students. This technology will open new doors in the overall culture of WPI by allowing many activities to have a new avenue for broadcasting. As many traditional ways of watching educational media migrate to the internet, it would be in the best interest of Worcester Polytechnic Institute to look at this technology as a viable technology to incorporate within its institution.

Accessing the interest for a streaming media system at Worcester Polytechnic Institute must have precise intentions. Our surveys were researched and designed to get systematic results from the students, faculty and administration.

Surveys: Web Surveys

Computer surveys are often used to make research more productive and less costly. A survey questionnaire is programmed as a link in the body of an e-mail message, which can be sent out to nearly anyone with an Internet e-mail address. The e-mail will contain a brief description about the survey and the survey's objectives. Recipients of the e-mail will then be asked to go to a specific URL and complete the survey. Responses will then be returned and tabulated automatically at the touch of the reply key, so results can be constantly monitored, and reported on as required. Web surveys reduce cost and error, and also save time. For example, web surveys eliminate printing and mailing paper questionnaires, calling respondents by phone, deciphering respondents' handwriting, and manually keying in responses.

For the respondents, web surveys eliminate the possibility of the respondent being influenced by the presence of the interviewer. This could lead to the respondent's answers being misleading and not representing the views of the interviewee. Respondents complete the survey online, using any Internet service provider, commercial online service, workstation or terminal. The cost of collecting and processing each response in a web survey is very low because no materials and little labor are required. E-mail surveys are generally more affordable and much quicker for collecting data than mailed questionnaires or most telephone surveys. "Consequently, many more respondents can be included in an e-mail survey than in a conventional paper or phone survey, yielding more complete and accurate results."[49] After all the responses have been tabulated,

[49] S & H Computer Services: http://www.smartmail.com.au/snh/Keypoint/index.html

charts, lists, tables, and statistics can be created in order to express the results more clearly.

There is usually a setup cost involved with conducting a web survey based on the specific survey length and the number of recipients, as well as a nominal charge for sending each survey in addition to a charge per completed and returned questionnaire. These are in addition to typical charges for research design, analysis and reporting. These charges are typical of commercial sites, which prepare and conduct the survey for the surveyor. Costs for this service can range from $250 to $5,000 dollars. Response rates to this technique have also proven to be quite high, making e-mail surveys an attractive alternative for many types of research. In the few years since its inception, the World-Wide Web, or WWW, has grown dramatically in the number of users, servers, and its geographical distribution. "These technologies for the first time hold the potential of ushering in the "Age of Information" to people of all ages, backgrounds, and economic status."[50] Wide spread networking coupled with the ease of publishing multimedia materials within the Web will support radical changes in areas such as education and business.

The universal accessibility of information technologies means that the user population will be extremely diverse in terms of skills, experiences, abilities, and backgrounds. As such, a crucial ingredient to the success of such endeavors is an understanding of its user population. One powerful method of characterizing the background, usage patterns, and preferences of users is by surveys. "Coupled with other

[50] S & H Computer Services: http://www.smartmail.com.au/snh/Keypoint/index.html

methods, these results enable appropriate targeting of services, and the development of intelligent user-centered applications and interfaces."[51]

In most traditional web based surveys, the questions are posted to groups of people, which then require the respondents to visit a website and proceed with the questioning. After the survey has been filled out, the answers can either be submitted or cleared. Once the responses have been submitted, the collection of the data can become problematic, since consistent structure within open-ended responses can only be suggested, not enforced. Techniques such as phone interviews, allow the surveyor more control of the survey, but this method has many shortcomings. Such as, the response data entered by humans are error-prone. Furthermore, respondents cannot review their responses, and are typically subject to time constraints.

"Use of Web technologies help minimize the problems stated above by enabling point-and-click responses, providing structured responses, using an electronic medium for data transfer and collection, presenting the questions visually for re-inspection and review, and imposing very loose time constraints."[52] Although the response rate of e-mail surveys are not as high as those personally administered, on average e-mail surveys will produce a much larger number of respondents then other traditional survey methods. This holds true because even if the response rate is lower, the sample group is much larger using e-mail as the survey instrument.

Although most often successful, web surveys sometimes suffer from a number of technical and design shortcomings. In order to avoid these pitfalls, one must modify the basic structure in order to enhance the capabilities of the surveys. In addition, the range

[51] S & H Computer Services: http://www.smartmail.com.au/snh/Keypoint/index.html

and focus of the questions must be concentrated in order to increase the usefulness of the responses. These changes improve the complexity of the system, the reliability of the data, and the quality of the human-computer interaction. All questions must be relevant to the topic being studied, in order to increase the efficiency of the questions being asked.

In any survey one must attempt to minimize the work required to answer a question. Check-boxes and scales are often utilized in surveys in order to accomplish this. Open-ended are not used unless a free form answer is being sought. Today, various different medias are used in conducting surveys. The web allows the subject to answer the questionnaire with no time constraints. Subjects are allowed to give thought to their answers at their own convenience; therefore they are more likely to give more accurate answers.

On-line surveys are among the cheapest to administer if a computer network is available, since there are no printing, postage, or telephone charges. Responses to on-line surveys are already in a computerized form, which can make the tasks of data entry and data analysis easy or even fully automated. One of the disadvantages of an e-mail survey is that the surveyor does not know if whether non-respondents attempted to respond but encountered difficulties, or simply chose not to respond. These factors must be taken into account when calculating the response rate.

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[52] S & H Computer Services: http://www.smartmail.com.au/snh/Keypoint/index.html

Response Rates

In the past a surveys response rate was used as the main factor in choosing a certain sampling method. "The term *response rate* refers to the proportion of people in a particular sample who participate in the survey."[53] The response rate equals the number of people who responded divided by the number of eligible respondents. "No single response rate is considered the standard."[54] Some surveys may have response rates close to 100% while others may be as low as 20%. This large discrepancy in response rates usually has to do with the survey method, and also the importance of the topic to the potential respondents. Face-to-face surveys would naturally produce the highest response rate in comparison to other survey methods. But in some cases, such as this one, utilizing this method is not feasible. This holds true because the majority of the student body and faculty of WPI are not currently on campus.

Previously researchers were not familiar with the techniques used to increase response rates in surveys. But today surveyors have literature available to them, which explains why people tend to respond to surveys and how to increase the number of respondents. "One can reasonably expect a 60 percent response rate in a mail survey of the general population, given the use of personalized cover letters, attractive questionnaires, and follow-up contacts."[55] Although there are cases in which it is common for the response rate for mail surveys to be around or below 20%.

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[53] Don Dillman; Priscilla Salant, How to Conduct a Survey (New York, New York: John Wiley & Sons Inc., 1994), p. 43.

[54] Fink, The Survey Handbook., p. 35.

[55] Don Dillman; Priscilla Salant, How to Conduct a Survey (New York, New York: John Wiley & Sons Inc., 1994), p. 43.

Usually all surveys encounter lost information due to nonresponse. "These nonresponses may introduce error and bias into the survey's results because of differences between respondents in motivation and other potentially important factors."[56] Another type of response that can also introduce bias to a survey is item nonresponse, which occurs when respondents or survey administrators do not complete all the items on a survey form. The number on nonresponses can be decreased by sending out follow up emails, and offering monetary and gift incentives in return for completing the questionnaire, the latter not applying to this survey due to the nonexistent funding. After all the responses have been gathered, the data will be analyzed, and conclusions will be drawn from the results.

The simple fact of potential respondents not participating in the survey will introduce error and bias into the study. Certain types of individuals in the target population may be underrepresented in the sample, if the proportion of the respondents are different then those of the target population. This may result in the overrepresentation of certain groups in the sample population. There is really nothing one can do to eliminate nonresponse from a survey, because there is no way of forcing people to participate in a survey. But it is imperative that these issues be addressed accordingly in the analysis of the data.

[56] Mettrick, Clive; Business Research Labs:www.busreslab.com

Survey Methodology

Defining the Survey Objectives

Research projects often require the collection and analysis of social data. Surveys are the most popular method for collecting this data. "A survey usually involves collecting data by interviewing or surveying a sample of people selected to accurately represent the population under study."[57] Each person in the sample must be asked the same series of questions, and responses are then organized so that conclusions can be drawn from them. By conducting this survey we intend on gathering the thoughts and opinions of the WPI student body and its faculty members on a certain subject. This survey will deal strictly with assessing the desirability of a system that would be capable of broadcasting video over the Internet. Students and faculty would be asked to express their views in regards to incorporating this technology into the teaching curriculum at Worcester Polytechnic Institute. "When planning a survey and its instruments, the surveyor must define all potentially imprecise or ambiguous terms in the objectives."[58] Prior to creating our questionnaire, we must strategically plan how we will go about obtaining the opinions of the WPI campus.

"The objectives of a survey can come from a defined need."[59] These objectives may also be derived from the literature review and other surveys conducted in the past. "Systematic reviews of the literature tell you what is currently known about a topic; using the available data you can figure out the gaps that need to be filled."[60] The objectives of a survey study can also come from individuals who are experts in the subject being studied.

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[57] Dillman, Mail and Telephone Surveys(New, York, New York: John Wiley & Sons Inc., 1978), p. 4.
[58] Arlene, Fink, The Survey Handbook.(London, England: Sage Publications., 1995), p. 8.
[59] Fink, The Survey Handbook., p. 10.
[60] Fink, The Survey Handbook., p. 10.

In this study, experts may be professors or members of the technical staff at Worcester Polytechnic Institute. Professors can be regarded as experts in the education process. They are very familiar with the learning process, and have knowledge as to what may be helpful to students. Students will also play a vital role in determining the benefits of having such a technology available at WPI. Their opinions are sought in order to determine this technologies uses, and the costs if any, which they would be willing to pay to have it made available to them.

We must always remember that the purpose of this survey is to allow us to draw conclusions about the entire faculty and student body at Worcester Polytechnic Institute. The results of the sample group by itself are of no importance to us, if you were unable to draw any conclusions about the general population the survey would prove useless. This holds true because we are not interested in the characteristics of the sample group, but instead those of the target population.

Choosing the Study Design

Survey design consists of creating the environment in which the survey will take place. "The environment consists of the individuals or groups of people, places, activities, or objects that are to be surveyed."[61] We will implement an observational survey design in this study. This type of survey design is also referred to as descriptive survey design. Descriptive designs produce information on a group of people. The group of people in this survey will consist of the faculty and student body of WPI. In this survey the WPI faculty and student body will be the target population, and the group of people we survey will represent the sample.

Surveys often utilize samples of the population rather than trying to survey the entire target population. Surveying the entire population proves to be impossible most of the time, due in part to time and money constraints. But in this case, we will be capable of surveying the entire target population by broadcasting the survey to the entire WPI student body and faculty through an e-mail message. Since the survey is being administered during the summer over a six day period, there is a good chance that about one-third of the student body and staff will never get a chance to read the email during the period in which the survey was conducted. This holds true because the majority of the faculty and student body are not on campus, and many of them may not have checked their mail during that period of time. This fact alone will lower the response rate drastically.

Normally, unless the survey is administered directly to the respondents, the response rate will usually be well under fifty percent. Therefore we must select a sample that is representative of the target population. The sample group in this survey will consist of the individuals who go to the website and complete the survey. The entire WPI student body and faculty will be eligible to participate in the survey, this is assuming that every single individual would have checked his or her mail during the survey period. And even though we know this is not true, there is no way to find out what percentage of these individuals actually did check their email during this time period. So it is our job to represent these people as accurately as possible in the survey.

So after dealing with the obstacles as best as we could, we then sent out two email messages, one to the student body and another to the faculty. Each email gave a brief description about viewing video over the Internet and its potential uses. We then stated

[61] Fink, The Survey Handbook., p. 23.

the importance of each individual's responses in evaluating the implementation of such a network. Recipients of the e-mail were then asked to go to a website and complete a short survey. Students and faculty members were instructed to first open a web browser and to then visit the website listed at the bottom of the message. Students were directed to the URL: www.busreslab.com/student.htm, while faculty members were to go to the following URL: www.busreslab.com/faculty.htm. *See Appendix 1A and 1B.*

After six days had passed we then obtained the results from Clive Mettrick, who is a consultant at Business Research Labs. Business Research Labs is a company that specializes in surveys, and is based in Houston, Texas. BRL has conducted thousands of online surveys for companies and individuals, and are very knowledgeable in this field. In exchange for his services, we agreed to put up fifteen banners on the Internet, which would link to his company's website. Business Research Labs were extremely helpful in developing the survey, and analyzing the results. After giving them the basic format of the survey, Clive set up the websites in this form. He then connected the survey websites to a spreadsheet that would record the results of the submitted surveys. After the duration of the survey had passed he then forwarded the results to us for further analysis. We would then manipulate the data into useful information relevant to the study being conducted.

Once again, the entire purpose of conducting this survey is to learn more about the critical aspects of this technology and how it would be used. If WPI was to implement this network onto its campus, which they are currently exploring, then they would want be aware as to what the students and faculty would want out of this technology. They would then be able to cater the network in a manner that would satisfy everyone's

expectations. This would be the most determinant factor as to whether the systems inception was regarded as a success or as a failure.

Questionnaire Development

In this section we will discuss how we went about constructing the survey, and why we asked the questions we did. "Because questions are the focus of many surveys, learning how to ask them in written and spoken form is essential."[62] A straightforward question is more likely to extract accurate and consistent information, than a subjective or vaguely worded question. Survey questions must be as clear as possible, and consist of correct grammar and syntax. "Questions are purposeful when the respondent can readily identify the relationship between the intention of the question and the objectives of the survey."[63] In some cases the survey creator may have to state the relevance of a question in regards to the scope of the project. In this survey, I believe that the recipients will be able to identify the relevance of all the questions in regards to the survey's objectives.

Before being sent out, the entire contents of a survey should be reviewed in order to determine the efficiency of the survey in regards to the desired results from the survey. We went over the questionnaire with our project advisor Huong Higgins and Clive Mettrick. Clive was very helpful in setting up the actual survey website. He performed all of the necessary programming in order to establish the site and guarantee its functionality. With their help we were able to setup the two websites. These two websites are the destination for the students and faculty to complete the survey. We will now discuss the crucial process of actually deciding what questions to ask.

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[62] Fink, The Survey Handbook., p. 12.
[63] Fink, The Survey Handbook., p. 13.

The most important part to any survey is the questions that it contains. Questions can be stated in two primary forms, open and closed. When the potential responses to a question have already been chosen, then the question is closed. "Closed questions are more difficult to write then open ones, because the answers or response choices must be known in advance."[64] Though, one advantage to closed questions is that the results are easier to analyze from a statistical standpoint. Also, closed questions limit the number of possible responses, and tend to make the answers more reliable and consistent over the course of the survey. The majority of the questions on our survey were of this type.

There are three forms of responses to closed questions, categorical, ordinal, and numerical. The majority of the closed questions in this survey will be of the ordinal type. Ordinal responses are those in which the respondent is asked to rate or order choices. These responses allow the surveyor to compute the average responses to the questions asked. Questions formed in this manner make it possible to calculate the average rate of importance for all respondents. Categorical responses include those that may be answered yes or no. These responses may also ask the respondents to classify themselves in a certain category.

The survey was then setup in a manner, which gave us the greatest chance of satisfying the survey's objectives. "The surveyor must understand a survey's cultural, psychological, economic, and political context by: identifying specific purposes; preparing appropriately worded, meaningful questions for participants; clarifying research and other objectives; determining a feasible number of questions; standardizing the questionnaire; and standardizing the response choices."[65] We already know that we

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[64] Fink, The Survey Handbook., p. 16.
[65] Fink, The Survey Handbook., p. 21.

plan on finding the desirability for this technology amongst WPI students and faculty. Now we had to figure out exactly what questions we were to ask in order to obtain this information. Often survey objectives can be converted into questions to be researched by changing the sentence structure.

Survey questions will be presented in separate survey categories, which provides several advantages. Respondents will be able to quickly finish each section of the overall survey. One long survey containing numerous unrelated questions may discourage potential respondents, and adds considerably to the survey's complexity. "Also, categorizing questions allows users to decide the importance of a particular question category, and how it applies to them."[66] These categories will not be separated visually on the survey, but will instead be grouped together in order to keep questions regarding the same topic in the same section of the questionnaire.

The first category will ask general questions about the respondent's computer background. These questions about the respondents' background will allow us to identify how familiar the respondents are with computers and the Internet. From these questions we will obtain information on how much time students spend on the Internet or a computer in general. The next category of questions asks the respondent, if he or she had ever viewed video over the Internet, and to rank the most common problems they encountered while viewing the video. We developed these questions in order to get an idea of the average respondent's experience and perception of viewing video over the Internet. *See Appendix 2A.*

[66] S & H Computer Services: http://www.smartmail.com.au/snh/Keypoint/index.html

The next line of questions asked the student if he or she learned more during class lecture or outside the classroom. We also asked the students to rate the effectiveness of certain out of class materials that they had used in the past. We asked these questions so we could determine where and how students accomplished the majority of their learning. The next two questions ask the students if this would be a viable technology for students at WPI, and whether or not it would improve learning in the classroom. We asked these questions to get the student's opinion on the impact he or she feels it will have on the educational process at WPI. Next we asked how much of an increase in tuition would students be willing to pay in order to have this technology made available at WPI. We developed this question in order to get the average price range that a student would be willing to pay for this technology. The questionnaire then asks the respondent, if they would use this technology if it were available at the WPI. The student's response to this question may very well be the single most important response in the entire survey. Because despite student's opinions about the technology, the most important aspect of assessing video over the Internet is whether or not students and faculty members would use it.

We then asked the student and professor to list any additional uses they feel this technology might have. This was done in order to get feedback about any additional topics or concerns we may have left out. The next question would ask the respondent if certain majors would benefit more then others from the use of this technology, and if so which ones. The last line of questions ask the respondent to give a brief background about themselves, these questions included what their major was, what was their class year, and how they would rate themselves as students. Answers to the last question range

from excellent to poor. These questions would allow us to identify different attitudes amongst different students. The final question in both surveys will ask the respondent to add any additional comments or insights he or she may have in regards to this technology and its uses.

Faculty members will be asked different questions then students, regarding this technology. Such as, if faculty members would consider implementing this technology into their teaching curriculum, and if they would be willing to expend any additional time learning about this technology and its uses. Also, we must figure out if faculty members would have any problems with their lectures being recorded. Faculty members would also be asked to rate its usefulness, if any. We felt that this setup was sufficient to help us characterize the WPI community, and their opinion of WWW tools and technologies. *See Appendix 2B.*

Data Collection

Approximately six days after the survey had been sent out, we then analyzed the results in order to learn the opinions and views of the WPI campus. Six days was a sufficient amount of time for individuals to fill out the survey and submit the results. All responses were recorded in a Microsoft Excell spreadsheet. We calculated the averages to questions in which it was appropriate, and created a summary of the results. We then began the analysis of the responses, which will be explained in the next section. *See Appendix 3A.*

Student Survey Data Analysis

An email message containing the survey URL was sent out to approximately 3,500 students, allowing students six days to complete the survey. Around three hundred students responded during this period, which is a considerable amount once you factor that the majority of the students are not on campus during the summer. It seems that the majority of the respondents were computer science majors, which allows us to assume that these individuals are extremely familiar with computers and their potential uses. The downside to this fact is that the survey results are biased towards computer science majors. This adds additional error and bias to the results of the survey.

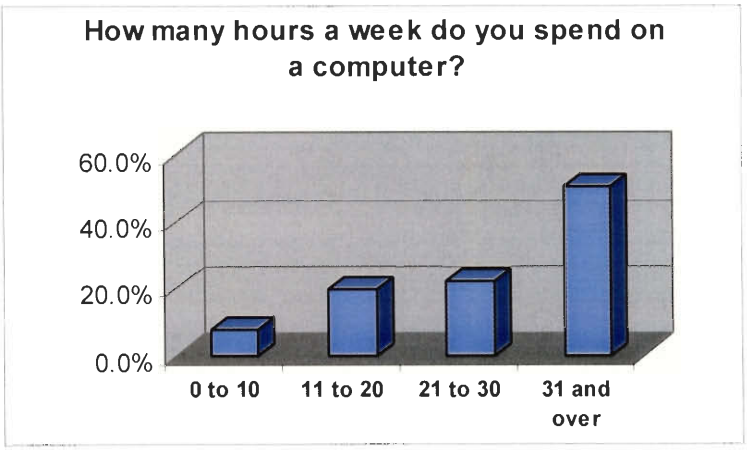
Using the percentages generated from the responses by the sample group, we will be able to draw conclusions about the general population. The most difficult aspect of analyzing the survey results will be in translating the answers to the open ended questions into valuable information. This will be done by manually looking at all the responses and comments. Then listing the most common responses to these questions. In the conclusion we will mention the most common concerns and uses regarding this video-streaming network. All responses that have no relation to the question will be omitted. This analysis will allow us to elaborate on key issues raised by the respondents. A detailed description of the responses to the each individual questions will be provided in the next section of this project.

Student Survey Data Analysis

Question #1 How many hours a week do you spend on a computer?

Sample Size: 303

0 to 10	**7.6%**
11 to 20	**19.8%**
21 to 30	**22.1%**
31 and over	**50.5%**

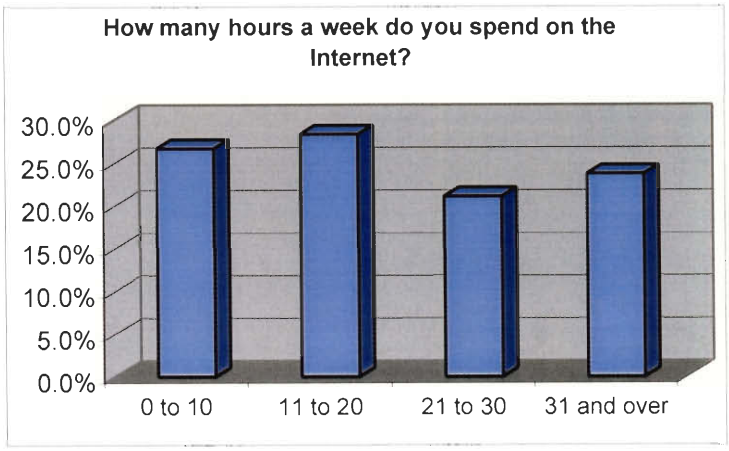


We designed this question for the purpose of measuring student familiarity with computers. From the sample size of 303, 50.5% of the students stated they spent over 31 hours a week on a computer. 72.3% of the sample group spends more than 20 hours a week on a computer. These percentages suggest that whether it is recreational or work related, students spend a great deal of time on a computer. This fact more than emphasizes the role of computers in a WPI student's everyday schedule.

Question #2 How many hours a week do you spend on the Internet?

Sample Size: 303

0 to 10	**26.7%**
11 to 20	**28.4%**
21 to 30	**21.1%**
31 and over	**23.8%**



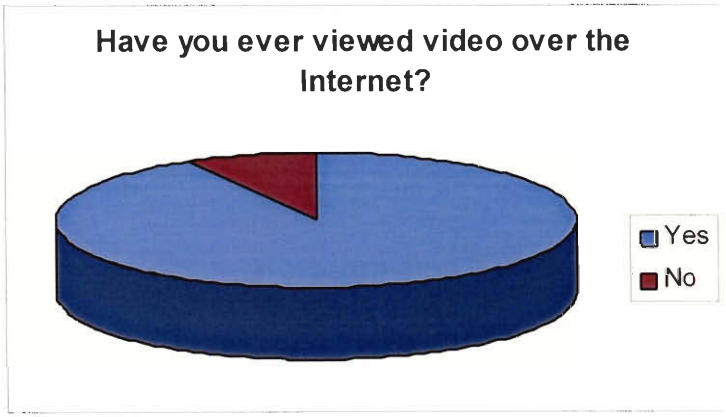
We designed this question for the purpose of measuring student familiarity with Internet. Question #2's responses are distributed more evenly then the previous question. 26.7% of student respondents spend a maximum of 10 hours on the Internet. 28.4% of student respondents spend a maximum of 20 hours, 21.1% of students respondents spend a maximum of 30, and 23.8% of students respondents spend 31hours or more on the Internet. The ranges are relatively similar and we can conclude that students are familiar with the Internet. Anything more than that could not be justified by these percentages.

Question # 3 Have you ever viewed video over the Internet?

Sample Size: 303

Yes 92.1%

No 7.9%



We designed this question see to if students have been exposed to Internet video. The responses to this question indicated that 92.1% of the sample group has viewed video over the Internet at one time or another and 7.9% of the sample group have not. This favorable percentage helps validate the responses to our questions, since the sample group is consistently knowledgeable of video over the Internet technology.

Question #4 Please rank in order the most common problems you have encountered while viewing video over the Internet, with 1 being the most common, and 5 being the least.

Sample Size: 268

	Rank
Video stops in mid stream	**1st**
Video download time	**2nd**
Video is unclear	**3rd**
Video doesn't load	**4th**
Audio is unclear	**5th**

In this question we asked the respondent to rank the most common problems they encountered while viewing video over the Internet. The results are listed above, showing that the video stopping in mid stream was the most common problem viewers had. Download time and clarity followed as the most common problems these viewers had. Problems with the video not loading and audio being unclear were not nearly as common as the other problems listed.

Question # 4; Part 2 Please list any other problems you may have encountered.

Sample Size: 59	**% of responses**
System Compatibility (Software, Plug-ins)	**25.4%**
Video is choppy	**16.9%**
Video download time	**15.3%**
Video is unclear	**13.6%**
Video and audio are not synchronized	**10.2%**
Video stops in mid stream	**6.8%**
Audio is unclear	**5.1%**
Other	**7.5%**

We asked this question in order to determine any other problems people had while viewing video over the Internet. The most common problem was when individuals would attempt to view video using an operating system other then Microsoft Windows. On occasion people listed problems that had already been stated in the previous section.

Other problems included the video and audio not being synchronized and the video being choppy.

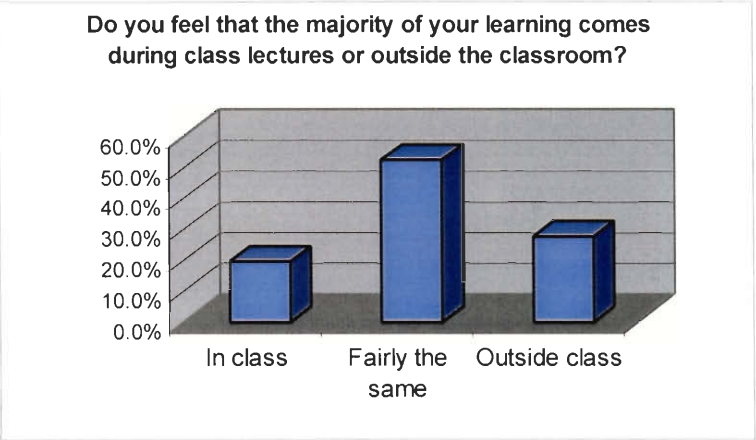
Question #5 Do you feel that the majority of your learning comes during class lectures or outside class lectures?

Sample Size: 302

In class 19.5%

Fairly the same 52.6%

Outside class 27.8%



We designed this question to understand the academic learning time of the sample group, and the ability to learn more with repetition. 52.6% of the sample group felt they learned equally in class lecture as they do outside of the classroom. 27.8% of the sample group learned more outside the classroom, and 19.5% learned more during lecture. The 27.8% is the relevant percentage for our analysis, because this percentage of the sample group would be more inclined to view video lectures outside the classroom. Still these numbers indicate that a substantial amount of a student's learning does come outside the classroom.

Question #6 When searching materials outside of the classroom, how would you rate the following resources?

Web documents
Sample Size: 301
Great Resource 45.5%
Good Resource 45.5%
No preference 8.6%
I don't know 0.3%

Periodicals

Sample Size: 301	
Great Resource	**12.0%**
Good Resource	**41.7%**
No preference	**37.3%**
I don't know	**9.0%**

Books (not the textbook but recommended by the professor)

Sample Size: 301	
Great Resource	**23.3%**
Good Resource	**.2%**
No preference	**19.6%**
I don't know	**13.0%**

Books (not the textbook and not recommended by the professor)

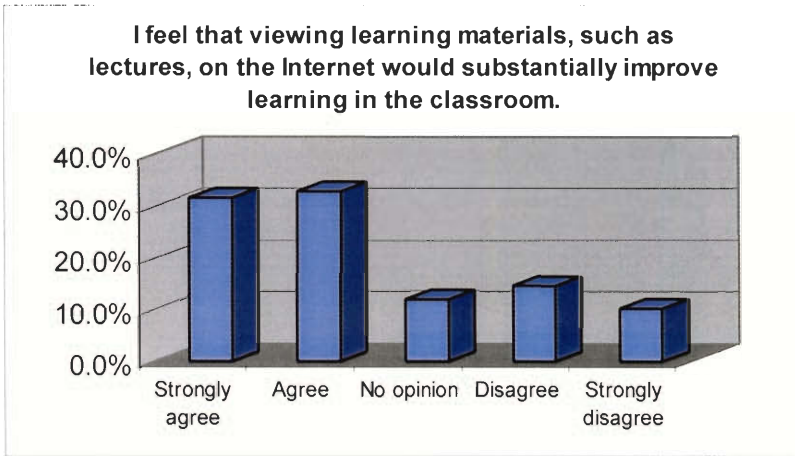
Sample Size: 301	
Great Resource	**12.7%**
Good Resource	**41.0%**
No preference	**29.3%**
I don't know	**17.0%**

We designed this question to evaluate the most popular learning tool for students. We used four common tool resources that students use to study for class. The results show that Web documents are the most popular resource used by the students, with 91.0% of the sample group rating Web documents as a great or good resource. Books recommended by the professor were the most useful resource following Web documents. Periodicals and books not recommended by the professor both lagged in ratings behind the other two resources.

Question #7 I feel that viewing learning materials, such as lectures, on the Internet would substantially improve learning in the classroom.

Sample Size: 300

Strongly agree	**31.3%**
Agree	**32.7%**
No opinion	**11.7%**
Disagree	**14.3%**
Strongly disagree	**10.0%**

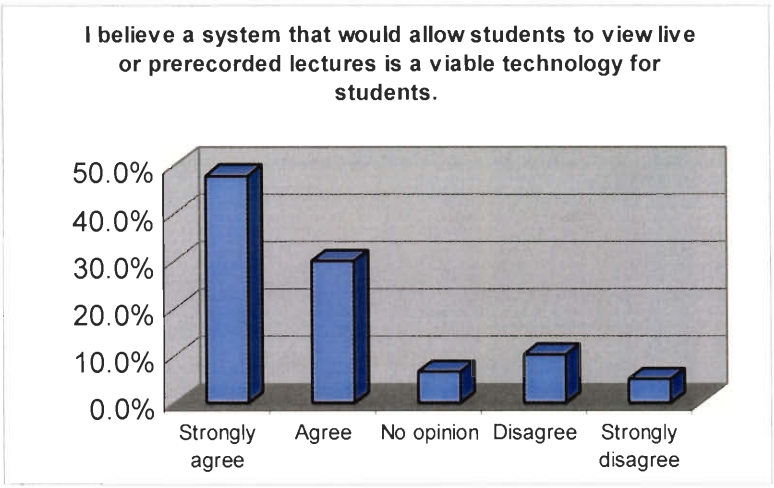


This question was designed to assess if there is a demand for video over Internet technology amongst the students. Of those sampled, 64.0% either strongly agreed or agreed that this technology would substantially improve learning in the classroom. In comparison to 24.3% who strongly disagreed or disagreed that this technology would substantially improve learning in the classroom. These numbers show that the majority of the sample group felt as if technology would substantially improve learning in the classroom.

Question #8 I believe a system that would allow students to view live or prerecorded lectures is a viable technology for students at WPI.

Sample Size: 300

Strongly agree	**48.0%**
Agree	**30.0%**
No opinion	**6.7%**
Disagree	**10.3%**
Strongly disagree	**5.0%**

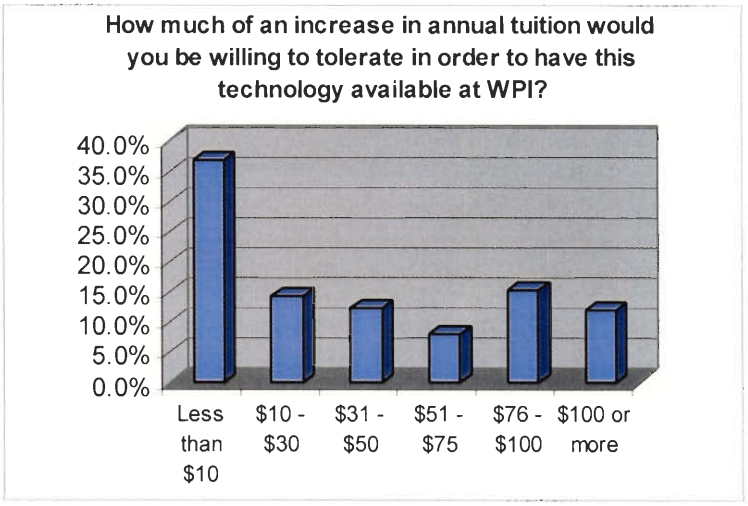


We designed this question in order to assess if the student body would welcome a video over Internet system, which streams lectures and other learning materials streamed over Internet. The results show that 78.0% of the sample group agreed or strongly agreed that this would be a viable technology for WPI students. While 15.3% disagreed or strongly disagreed that this was a viable technology for students at WPI. So once again, the responses were favorable towards the implementation of such a system.

Question #9 How much of an increase in annual tuition would you be willing to tolerate in order to have this technology available at WPI?

Sample Size: 303

Less than $10	**37.0%**
$10 - $30	**14.5%**
$31 - $50	**12.5%**
$51 - $75	**8.3%**
$76 - $100	**15.5%**
$100 or more	**12.2%**

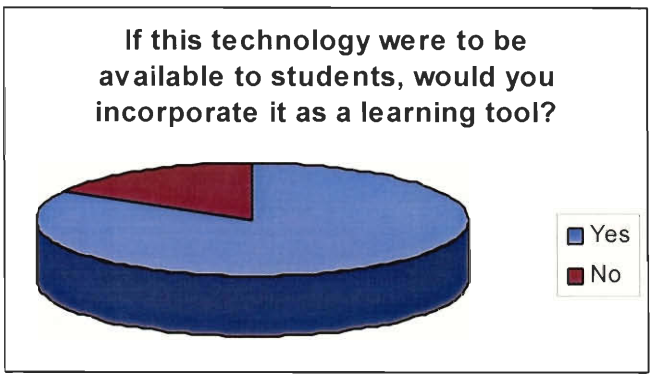


We designed this question with the cost of implementation of a video over Internet system in mind. We wanted to assess the cost tolerance of the sample group at hand. The results show that 37.0% of those who responded would be willing to tolerate an increase of ten dollars or less in annual tuition, in order to have this technology made available to them. While 27.7% of the respondents stated that they would be willing to pay an increase of over seventy-five dollars in annual tuition.

Question #10 If this technology were to be available to students, would you incorporate it as a learning tool?

Sample Size: 305

Yes	**83.0%**
No	**16.7%**



We designed this question in order to weigh the sample groups' acceptance of this technology for use as a learning tool. Of those students sampled, 83.0% said that they would incorporate this technology as a learning tool. This means that if WPI were to implement such a system, more then four out of five students believe that they would use it. These responses are extremely important in terms of the project, since the most crucial aspect to evaluating such a technology is if the students would actually use it as a learning tool.

Question #11 Besides using video for class supplement, what other uses do you think WPI could use this technology for?

Sample Size: 121	**% of Responses**
Broadcast social and sporting events	**23.9%**
Admissions (Advertise to prospective students and faculty)	**15.7%**
Broadcast guest speakers and seminars	**14.0%**
Maintain MQP presentation archive	**13.2%**
Distance learning	**11.6%**
Communication between project centers	**6.6%**
Lab demonstrations	**4.1%**
Other	**10.9%**

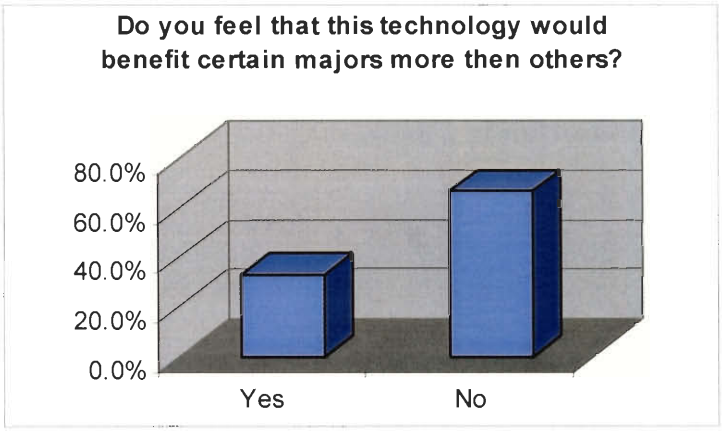
We asked the respondents this question to find out if there were any additional uses for this technology at WPI. While 23.9% would like to see social and sporting events at WPI, another 15.7% felt that this technology would be beneficial to the admissions department in order to advertise to prospective students and faculty. Another 14.0% believed that this technology could be used to broadcast guest speakers and seminars to WPI, while 13.0% stated that a MQP archive could be maintained which would allow students to view past MQP presentations. Other uses for this technology are stated above with the corresponding percentage of responses.

Question #12 Do you feel that this technology would benefit certain majors more then others?

Sample Size: 299

Yes 33.1%

No 66.9%



We designed this question to determine if this video over the Internet technology would benefit certain majors more then others. The responses show that 66.9% of the sample group felt as if this technology would not benefit certain majors more then others. While 33.1% felt as if certain majors would benefit from this technology more then others.

Question #12; Part 2 If you answered yes, which majors would the benefit most?

Sample Size: 86

	% of Responses		% of Responses
Computer Science	**44.2%**	**Chemistry**	**5.8%**
Electrical Engineering	**18.6%**	**Math**	**5.8%**
Technical majors	**16.3%**	**MG**	**5.8%**
Biology	**15.1%**	**MIS**	**5.8%**
Humanities and Arts	**8.1%**	**Physics**	**5.8%**
Mechanical Engineering	**6.9%**	**Other**	**6.9%**

We asked the students this question to find out which majors they felt would benefit most from having this technology available at WPI. Over 44.0% of the respondents stated that CS majors would benefit most, while 18.6% thought that EE majors would. 16.3% percent of those surveyed stated that the more technical majors

would benefit most from the use of this technology. BB, HU, and ME majors followed as those which would benefit the most from this technology.

Question #13 What is your major?

Sample Size: 292

	% of Responses		% of Responses
Computer Science	**29.8%**	**MIS**	**7.2%**
Mechanical Engineering	**14.4%**	**Chemistry**	**5.5%**
Biology	**14.0%**	**Civil Engineering**	**3.8%**
Electrical Engineering	**13.3%**	**Other**	**12.0%**

Once again we devised this question to help us determine the characteristics of the sample group. Looking at the results we see that over 29.0% of the respondents were computer science majors. Biology, mechanical, and electrical engineering individually accounted for over ten percent of the sample group. So from these numbers we see that in this sample group there was an overrepresentation of computer science majors. This is due in part to the fact that the majority of people who would check their mail over a one week period would be computer science students, since they spend the most time on a computer.

Question #14 What is your current year at WPI?

Sample Size: 300

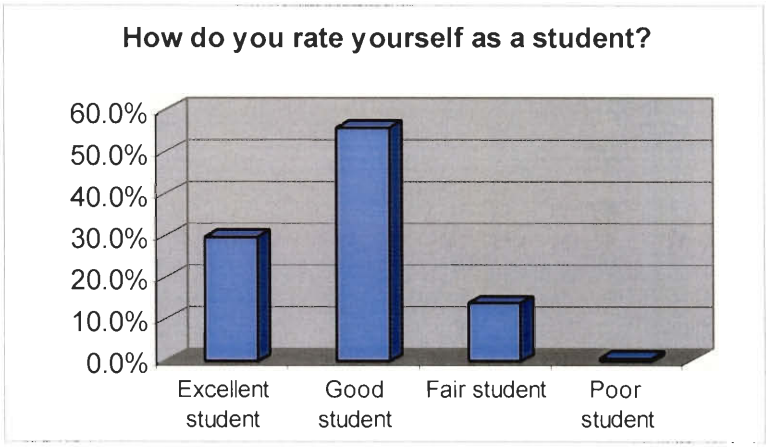
2nd year Graduate	**5.7%**
1st year Graduate	**6.3%**
4th year Undergraduate/Senior	**34.7%**
3rd year Undergraduate/Junior	**22.7%**
2nd year Undergraduate/Sophomore	**29.0%**
1st year Undergraduate/Freshman	**1.7%**

We asked the respondents this question in order to help us determine the characteristics of the sample group. Looking at the figures above we see that the numbers are evenly distributed throughout the class years with the exception of the freshman class. Therefore the freshman class was underrepresented in this sample. The number of graduate students is smaller then the others due to the fact that the number of graduate students on campus are substantially less then the number of undergraduate students.

Question #15 How do you rate yourself as a student?

Sample Size: 303

Excellent student	**29.7%**
Good student	**55.8%**
Fair student	**13.9%**
Poor student	**0.7%**



We asked this question to find out on average how the students in the sample group rated themselves as students. These numbers seem to reasonably represent the student body at WPI. Over 58.0% of those sampled rated themselves as good students, while 29.7% rated themselves as excellent students. These numbers seem reasonable other then the extremely low number of poor students, which was below one percent.

Summary of Survey Findings

Since the survey was conducted during the summer when the majority of the faculty members are not present, there was not a large enough sample group to perform statistical analysis of. So instead we will summarize the responses of those faculty members who did complete the survey, and compare their views with those of the student sample group. The responses of those faculty members who did complete the survey, are extremely important to us since they are all we have in terms of feedback from professors. So in this section we will express the views of the faculty respondents as accurately as possible.

Comparing the results of the student body and faculty, we see that there are a few distinct differences between the two sample groups. One being that the group of students sampled spent a greater amount of time on a computer in comparison to the faculty sample group. Nearly half of the students surveyed spend over twenty hours a week on the Internet, in comparison to less then ten percent for the faculty sample group. While one out of four faculty members have never viewed video over the Internet, more then 90% of the student sample group has. Video clarity and download time were the most common problems encountered by faculty members viewing video over the Internet. This holds true for the student sample group also.

Both groups had similar views in regards to learning in the classroom. The majority of both groups felt that students learned about as much in-class as they did outside the classroom. Of the two groups sampled, a larger percentage of the students felt viewing video over the Internet would substantially improve learning in the classroom, although half of the faculty members felt the same. The majority of both groups felt as if

this would be a viable technology for students at Worcester Polytechnic Institute. The majority of the faculty members surveyed stated that they would be willing to take extra time to record their lectures and learn about additional uses for technology. Half of the faculty sample group stated that they would incorporate this technology into their teaching curriculum at WPI if it were to be available. Four out of five faculty members believed that students would use this technology if it were available to them. Both sample groups strongly agreed that this technology would not benefit certain majors more then others.

The majority of the student and faculty sample groups strongly agreed that this would be a viable technology for students at WPI. Both sample groups were similar in their responses when stating the possible uses for this technology, including advertising to prospective students and employees, distance learning, and communication between project centers. Other suggestions from the student sample group included broadcasting social and sporting events, maintaining an archive of MQP presentations, broadcasting guest speakers and seminars to the WPI campus, and broadcasting lab demonstrations. After viewing and analyzing the results of the survey, we can assume that there is a substantial amount of interest for this technology at WPI. Both students and faculty members agreed that this technology would be helpful to students, and would improve learning in the classroom.

Both sample groups also voiced their concerns, about the current problems they encountered while viewing video over the Internet. These problems include video download time, video clarity, system compatibility, synchronization of audio and video, and problems with the video stopping in mid stream. We conclude from these results that

if WPI took measures to deal with these technical obstacles, the implementation of such a system would prove to be beneficial to both the students and faculty of Worcester Polytechnic Institute.

Project Findings and Conclusions

As we stated before the scope of our project was to access the cost and benefits of accessing a video streaming system at Worcester Polytechnic Institute. We researched and analyzed three popular systems on the quality of video displayed, ease of implementation to an existing infrastructure, administrative capabilities, support and documentation, and basic ownership cost of the system. We detailed the strengths and weaknesses of each system and showcased three educational institutions that have implemented such technology. Through our research and analysis we concluded that a video streaming system is feasible to implement at WPI and is very cost efficient in terms of dollars, support and maintenance.

The next phase of our project focused on conducting web surveys to access positive and negative feedback for the implementation of a proposed system. The responses from our web surveys strongly suggest that students and faculty are interested in incorporating video streams and other learning essentials over the schools intranet. Also students are willing to pay the monetary costs associated with the full implementation and launch of such a system.

The only problems that can hinder this technology's usefulness is the current connection speeds that don't allow full-featured 100% uninterrupted video broadcast capability. Although this is the prevalent problem with video streaming systems today, vendors like RealNetworks, SGI, and Vxtreme are making alliances and advancing their own systems to rapidly address this problem. And as network speed and scalability improve so will a video streaming systems broadcast capability.

Glossary of Terms

Add-on - Software that is designed to enhance or expand the capabilities of other software.

Application - Software designed for a particular purpose (i.e., word processing, creating streaming content or browsing the Internet).

Archive - Information or content that has been stored in a retrievable format.

Auto Update - A feature introduced in RealPlayer G2 that allows it to automatically download plugins and update the player software without having to open a Web browser or restart itself.

Bandwidth - The amount of data, typically expressed as Kilobits per second (Kbps), that can pass through a network connection.

Binary – the code that the computer understands

Bit - Short for "binary digit", a bit has either a value of one or zero and is the smallest unit of measure of data in a computer.

Bit rate - A measure of bandwidth, expressed as the number of bits transmitted per second.

Broadcast - To deliver a presentation, whether live or prerecorded, in which all viewers join the presentation in progress.

Browser - The program that finds and displays Web pages. Microsoft Internet Explorer and Netscape Navigator are browsers.

Buffering - The process by which streaming media that is entering the user's computer at a faster rate than can be played, is saved as memory without backing up or overloading the Player.

Byte - Short for "binary term", a byte is a unit of memory made of eight bits, about the amount needed by a computer to store a typed number or letter.

Cache - The term for the computer memory that stores information that is most frequently used. Usually stored in a special section of the main memory or in a separate device, this data can be retrieved much faster than if the computer has to find it on the hard drive.

Client - A software application that receives data from a server.

Clip - A media file within a presentation.

Clip art - Images, illustrations or photos collected, owned and copyrighted by companies that license usage to individuals and businesses.

Codec - Coder/decoder. Codecs convert data between uncompressed and compressed formats, reducing the bandwidth a clip consumes.

Compression - By compressing data, your computer uses less memory to store information. When data is compressed and sent over the Web, it takes up less bandwidth and allows faster and more efficient downloading.

Content - Here, content refers to the audio, video or any other media assembled and produced for broadcast, webcast, or other form of distribution.

Data – Information the form of words, numbers, or images that has been transcribed into bits. The information can then be read by a computer and stored as memory or sent over the Internet.

Deploy - To use for an intended purpose or end.

Download - The software that is literally loaded or installed onto your computer from the Web, as opposed to installation via CD-ROM or other physical storage device.

DSL (Digital Subscriber Lines) High speed Internet access lines for connections directly from a telephone switching station to a home or office, avoiding the slowdown between switching stations. DSL offers download rates many times faster than a 56K modem.

Enable - To make happen, make possible.

Encoding - The act of rewriting or transferring media sources from one format to another.

Extension An add-on or tool designed to enhance or extend the capabilities and functions of a particular application or product.

Flash - Refers to Web animation software created by Macromedia Inc., which has become an industry standard for Web page development.

Format - Different programs and devices store information in a variety of ways. The specific arrangements of information a program or device requires is called its format. Some types of formatting are VHS, DVD.

Function - The part of a program that performs a particular action. For example, hitting the reload button on your browser is using the reload function.

GIF (Graphics Interchange Format) - A graphics format in which images are constructed of tiny dots, also called pixels, each one colored to correspond to the specific area of the image they represent. This format can be compressed to require fewer memory resources, which is useful in adding images to Web pages.

Graphics The pictures, borders, illustrations—everything on a Web page that is not text-based—are graphics. Anything that is produced using a graphics program, even a text title, is considered a graphical element, because it is formatted differently than the plain text that follows it.

Host - The computer on the other end of a network connection from your computer that contains the information you are trying to access.

HTML (HyperText Markup Language) - The simple, tag-based language used to create World Wide Web pages.

HTTP - a type of network protocal.

Image - The visual representation of illustrations, photos, pretty much anything graphic in nature.

Information - Here, information usually goes hand in hand with the word data, which defines anything, input or output by a computer. One way to think about it is this: When it's in your head, it's information. It becomes data when you type it into a computer.

Interface - the front-end of an application. What the user interacts with.

Intranet - The internal communications network used by corporations and businesses for data sharing, presentations or other business applications.

ISP (Internet Service Provider) - A company that provides personal or business access to the Internet.

JPEG (Joint Photographic Experts Group) - A compression technique for photos that reduces them to a small percentage of the original file size.

Language - Like human languages, programming languages involve sets of rules and syntax that computers understand, allowing computers to carry out the tasks set by the program. Language can refer to many different types and levels of programming languages, each with particular capabilities and shortfalls.

Media - This is the blanket term used when referring to audio, video or images such as photos, as well as the ways they are used to reach the viewer (i.e., streaming media).

Megabytes – unit of measurement for bytes. 1000 bytes

Memory - The actual amount of data a computer can store either on a disk or on a chip. Disk memory is a more archival form of storage because it can be saved even when the computer is off. Chip memory is more immediately accessible, but requires electric current to actively remember information.

Modem - device that allows access to the internet.

MP3 (MPEG, audio layer 3) - A format used for the compression and reproduction of CD-quality audio, which can be downloaded and listened to on a computer or handheld device.

MPEG-1 – A format used for the compression and reproduction of quality video, which can be downloaded seen on a computer.

Network - A group of computers linked together, usually by phone lines that can share information and resources. When you are connected to the Internet, your computer is part of a network.

On-demand - Archived or stored content that viewers can access whenever they want, as opposed to live or one-time-only broadcast events.

PDF (Portable Document Format) - Developed by Adobe Systems, PDF documents are usually used to present longer or technical information because they open in a window outside of the page they are linked from. This saves space on Web pages while keeping the information handy.

Platform - Often used to define the operating system your computer runs on (i.e., Windows, Macintosh, Linux), but platform can also refer to your computer hardware (i.e., Macintosh or PC).

Player window - The window in RealPlayer or Microsoft media player where you can watch streaming media content.

Plug-in - A type of software that adds a specific capability to a program already on your computer. For instance, your browser probably requires a plug-in to see certain types of animation.

PNG (Portable Network Graphics) - A pixel-based graphics format similar to GIF. PNG was approved to replace GIF because GIF is a patented process, while PNG is completely patent- and license-free.

PowerPoint - Microsoft Office software that lets you create slide- and narration-enhanced business presentations.

Presentation - Refers to a slide- and/or narration-based business meeting aid.

Program - The set of instructions that tell the computer how to perform a certain task. Software are programs, each one written to enable the computer to understand what, when, how and/or any other variable and apply the set of instructions to them to fulfill a set task.

RealAudio - The file format developed by RealNetworks that is used to stream audio over the Internet.

RealG2 with Flash - A RealSystem G2 file type for streaming Shockwave Flash animation along with a RealAudio soundtrack.

RealPix - A RealSystem format (file extension .rp) for streaming still images over a network.

RealPlayer - RealNetworks software that lets you play multimedia presentations streamed by RealServer or a Web server.

Real time - The actual time an event takes place. For example, real time can refer to a live broadcast or an active exchange between a host and user.

RealServer - RealNetworks server software used to stream multimedia clips to RealPlayer.

RealText A RealSystem format (file extension .rt) for streaming text over a network. It uses a mark-up language for formatting text.

RealVideo - The file format developed by RealNetworks that is used to stream video over the Internet.

Resolution - Described in dots per inch (dpi), resolution refers to the clarity and detail of an image. On a 15-inch monitor there are usually 680 pixelsof width, times 480 lines of height. This multiplies to a total of around 300,000 pixels, or a resolution of around 50 dpi. The higher the dpi, the more clear and precise the image will appear.

Resources - The term used to describe anything you draw upon and need for a particular task. For example, emailing a large file requires network resources, which include the size of the server, the speed of connection, scalability and so on.

SDK (Software Development Kit) A SDK is a group of products and/or software that helps a programmer develop applications for a specific platform.

Server - 1.A software application, such as a Web server or RealServer G2, that sends clips over a network.

2.A computer that runs server software.

Signal - When you send an email, for example, it is delivered via a signal—a bundle of information containing your message that travels over the phone lines. A television signal

on the other hand, is data that is transmitted over the airwaves which tells your television what colors to show and which sounds to produce.

Software – any program or application that runs on a computer is software.

Storage device - Here, storage device refers to many kinds of hardware used to save data. These all come with an amount of memory, which is available on either a portable disk, a hard-drive disk or digital tape.

Streaming media - An Internet data transfer technique that allows the user to see and hear audio and video files without lengthy download times. The host or source "streams" small packets of information over the Internet to the user, who can access the content as it is received.

Stream - A flow of a single type of data, measured in Kilobits per second (Kbps). A RealVideo clip's soundtrack is one stream, for example.

SureStream - A technology that allows switching between higher and lower bandwidth streams in a single RealAudio or RealVideo file to compensate for network congestion.

Switching station - The phone company location that takes in-coming and out-going signals and routes them along to the proper destination.

Tag - A programming language tool that contains formatting directions.

TCP - a network protocal

Transmit/transmission - Used in the context of both television-style broadcasting, as well as in reference to digital communication over phone or cable lines between computers.

UDP – a network protocal

URL (Universal Resource Locator) - A location description that lets a Web browser or RealPlayer receive a clip stored on a Web server or RealServer.

VBR (Variable Bit Rate) - This refers to the ability to maintain a quality broadcast without interruption from fluctuating bandwidth or other network load problems.

Vector graphics - Refers to graphics based on mathematical algorithms. As opposed to GIF or PNG pixel-based graphics, vector graphics can be resized infinitely without losing clarity.

W3C - World Wide Web Consortium, an Internet standards body.

Webcast - The broadcasting of streaming content over the Internet. Typically refers to a live broadcast.

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Appendices

Appendix 1A

Survey of the Student Body of Worcester Polytechnic Institute

Video Over the Internet Survey

This survey is being conducted for an IQP done by Ekwan Steele and Manuel Velho, and advised by Prof. Huong Higgins. The data gathered from this survey will be extremely helpful in evaluating the costs and benefits of implementing a Streaming Media System that enables students to view lectures and other learning materials over the Internet in a high quality synchronized audio and video format. The results of this survey will be used to determine the demand for such a technology at Worcester Polytechnic Institute. All results from this survey will remain anonymous. If desired, we will inform you of the results after the survey study has been completed. Thank you for your time.

If you are viewing this message in telnet, you must first open a web browser and then type in the URL in order to access the website. To take the Video Over the Internet Survey, please go to the following website:

http://www.busreslab.com/student.htm

Appendix 1B

Survey of the Faculty of Worcester Polytechnic Institute

Video Over the Internet Survey

This survey is being conducted for an IQP done by Ekwan Steele and Manuel Velho, and advised by Prof. Huong Higgins. The data gathered from this survey will be extremely helpful in evaluating the costs and benefits of implementing a Streaming Media System that enables students to view lectures and other learning materials over the Internet in a high quality synchronized audio and video format. The results of this survey will be used to determine the demand for such a technology at Worcester Polytechnic Institute. All results from this survey will remain anonymous. If desired, we will inform you of the results after the survey study has been completed. Thank you for your time.

If you are viewing this message in telnet, you must first open a web browser and then type in the URL in order to access the website. To take the Video Over the Internet Survey, please go to the following website:

http://www.busreslab.com/faculty.htm

Appendix 2A

Survey of the Student Body at Worcester Polytechnic Institute

Video over the Internet Survey

Please answer this survey completely. The data gathered from this survey will be used to evaluate the costs and benefits of implementing a Streaming Media System that enables students to view lectures and other learning materials over the Internet in a high quality synchronized audio and video format. The results of this survey will be used to determine the demand for such a technology at Worcester Polytechnic Institute. All results from this survey will remain anonymous. If desired we will inform you of the results, after the survey has been completed.

How many hours a week do you spend on a computer?

- ○ 0 - 10
- ○ 11 - 20
- ○ 21 - 30
- ○ 31 and over

How many hours a week do you spend on the Internet?

- ○ 0 - 10
- ○ 11 - 20
- ○ 21 - 30
- ○ 31 and over

Have you ever viewed video over the Internet?

- ○ Yes
- ○ No

If yes, please rank in order the most common problems you have encountered while viewing video over the Internet, with 1 being the most common, and 5 being the least. If you have never encountered one or more of the problems listed, please leave that response blank.

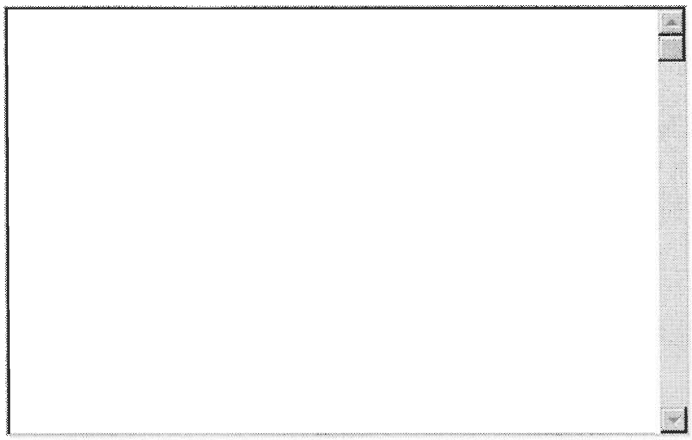
Problem	Rank
Video is unclear	
Audio is unclear	

Video download time ☐

Video stops in mid stream ☐

Video doesn't load ☐

Please list any other problems you may have encountered.



Do you feel that the majority of your learning comes during class lectures or outside class lectures?

- ○ In class
- ○ Fairly the same
- ○ Outside class

When searching materials outside of the classroom, how would you rate the following resources?

	Great Resource	Good Resource	No Preference	I don't know
Web documents	○	○	○	○
Periodicals	○	○	○	○
Books (not the textbook but recommended by the professor)	○	○	○	○
Books (not the textbook and not recommended by the professor)	○	○	○	○

Please state your level of agreement with the following statements.

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
I feel that viewing learning materials, such as lectures, on the Internet	○	○	○	○	○

would substantially improve learning in the classroom					
I believe a system that would allow students to view live or prerecorded lectures is a viable technology for students at WPI	○	○	○	○	○

How much of an increase in annual tuition would you be willing to tolerate in order to have this technology available at WPI?

- ○ Less than $10
- ○ $10 - $30
- ○ $31 - $50
- ○ $51 - $75
- ○ $76 - $100
- ○ $100 or more

If this technology were to be available to students, would you incorporate it as a learning tool?

- ○ Yes
- ○ No

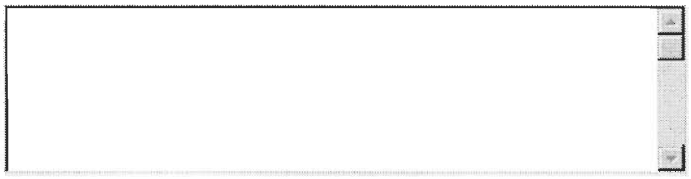
Besides using video for class supplement, what other uses do you think WPI could use this technology for?

Do you feel that this technology would benefit certain majors more then others?

- ○ Yes
- ○ No

If you answered yes, which majors would benefit most?

What is your major?



What is your current year at WPI?

- ○ 2nd year Graduate
- ○ 1st year Graduate
- ○ 4th year Undergraduate/Senior
- ○ 3rd year Undergraduate/Junior
- ○ 2nd year Undergraduate/Sophmore
- ○ 1st year Undergraduate/Freshman

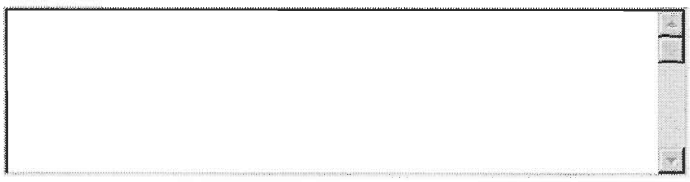
How do you rate yourself as a student?

- ○ Excellent student
- ○ Good student
- ○ Fair student
- ○ Poor student

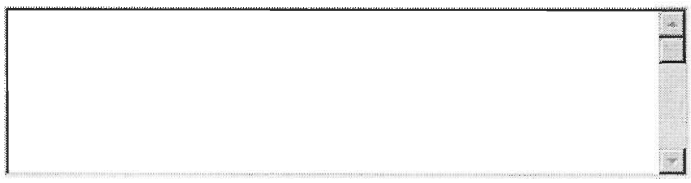
Would you like to be informed of the results of this survey after it has been completed?

- ○ Yes
- ○ No

If you would like to be informed of the results of this survey, please enter your email address in the space below.



If you have any additional comments about video streaming, please enter them here.



Thank you for taking the time to complete this survey. Select Submit Survey now to send your responses.

Submit Survey | Clear All Answers

Appendix 2B

Survey of the Faculty of Worcester Polytechnic Institute

Video over the Internet Survey

Please answer this survey completely. The data gathered from this survey will be used to evaluate the costs and benefits of implementing a Streaming Media System that enables students to view lectures and other learning materials over the Internet in a high quality synchronized audio and video format. The results of this survey will be used to determine the demand for such a technology at Worcester Polytechnic Institute. All results from this survey will remain anonymous. If desired, we will inform you of the results after the survey has been completed.

How many hours a week do you spend on a computer?

- ○ 0 - 10
- ○ 11 - 20
- ○ 21 - 30
- ○ 31 and over

How many hours a week do you spend on a the Internet?

- ○ 0 - 10
- ○ 11 - 20
- ○ 21 - 30
- ○ 31 and over

Have you ever viewed video over the Internet?

- ○ Yes
- ○ No

If yes, please rank in order the most common problems you have encountered while viewing video over the Internet, with 1 being the most common, and 5 being the least. If you have never encountered one or more of the problems listed, please leave that response blank.

Problem	Rank
Video is unclear	
Audio is unclear	
Video download time	

Video stops in mid stream ☐

Video doesn't load ☐

Please list any other problems you may have encountered.

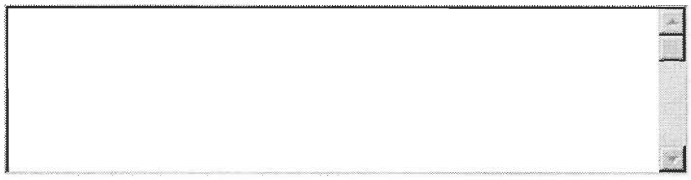
Do you feel that the majority of your students' learning comes during class lectures or outside class lectures?

- ○ In class
- ○ Fairly the same
- ○ Outside class

Please state your level of agreement with the following statements.

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
Viewing learning materials, such as lectures, on the Internet would substantially improve learning in the classroom	○	○	○	○	○
A system that would allow students to view live or prerecorded lectures is a viable technology for students at WPI	○	○	○	○	○
I would be willing to take extra time to learn how to utilize this technology and video tape my lectures	○	○	○	○	○
I would incorporate this video technology into my teaching curriculum at WPI	○	○	○	○	○
If this technology were to be made available to students, I feel they would use it	○	○	○	○	○

Besides using video for class supplement, what other uses do you think WPI could use this technology for?

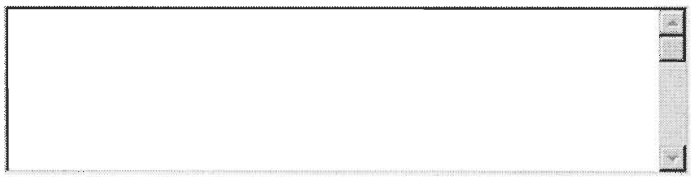


Do you feel that this technology would benefit certain majors more then others?

- ○ Yes
- ○ No

If you answered yes, which majors would benefit most?

What department do you teach in at WPI?



Would you like to be informed of the results of this survey after it has been completed?

- ○ Yes
- ○ No

If you would like to be informed of the results of this survey, please enter your email address in the space below.

If you have any additional comments about video streaming, please enter them here.

Thank you for taking the time to complete this survey. Select Submit Survey now to send your responses.

Submit Survey | Clear All Answers

Appendix 3A

Student sample group results

How many hours a week do you spend on a computer?	
Sample Size	303
0 to 10	7.6%
11 to 20	19.8%
21 to 30	22.1%
31 and over	50.5%

How many hours a week do you spend on the Internet?	
Sample Size	303
0 to 10	26.7%
11 to 20	28.4%
21 to 30	21.1%
31 and over	23.8%

Have you ever viewed video over the Internet?	
Sample Size	303
Yes	92.1%
No	7.9%

Please rank in order the most common problems you have encountered while viewing video over the Internet, with 1 being the most common, and 5 being the least

Video is unclear	
Sample Size	268
Average	2.64
1	24.3%
2	24.3%
3	25.0%
4	16.4%
5	10.1%

Audio is unclear	
Sample Size	264
Average	3.42
1	9.5%
2	14.8%
3	23.1%
4	29.5%
5	23.1%

Video download time	
Sample Size	271

Average	2.46
1	32.5%
2	23.6%
3	19.2%
4	14.4%
5	10.3%

Video stops in mid stream

Sample Size	265
Average	2.43
1	33.2%
2	24.9%
3	18.5%
4	12.8%
5	10.6%

Video doesn't load

Sample Size	264
Average	3.34
1	12.9%
2	17.8%
3	18.9%
4	14.0%
5	34.5%

Do you feel that the majority of your learning comes during class lectures or outside class lectures?

Sample Size	302
In class	19.5%
Fairly the same	52.6%
Outside class	27.8%

When searching materials outside of the classroom, how would you rate the following resources?

Web documents

Sample Size	301
Average	1.64
Great Resource	45.5%
Good Resource	45.5%
Books (not the textbook, but recommended by the professor)	8.6%
Books (not the textbook and not recommended by the professor)	0.3%

Periodicals

Sample Size	300
Average	2.43
Great Resource	12.0%
Good Resource	41.7%

Books (not the textbook, but recommended by the professor)	37.3%
Books (not the textbook and not recommended by the professor)	9.0%

Books (not the textbook but recommended by the professor)

Sample Size	301
Average	2.22
Great Resource	23.3%
Good Resource	44.2%
Books (not the textbook, but recommended by the professor)	19.6%
Books (not the textbook and not recommended by the professor)	13.0%

Books (not the textbook and not recommended by the professor)

Sample Size	300
Average	2.51
Great Resource	12.7%
Good Resource	41.0%
Books (not the textbook, but recommended by the professor)	29.3%
Books (not the textbook and not recommended by the professor)	17.0%

I feel that viewing learning materials, such as lectures, on the Internet would substantially improve learning in the classroom

Sample Size	300
Average	2.39
Strongly agree	31.3%
Agree	32.7%
No opinion	11.7%
Disagree	14.3%
Strongly disagree	10.0%

I believe a system that would allow students to view live or prerecorded lectures is a viable technology for students at WPI

Sample Size	300
Average	1.94
Strongly agree	48.0%
Agree	30.0%
No opinion	6.7%
Disagree	10.3%
Strongly disagree	5.0%

How much of an increase in annual tuition would you be willing to tolerate in order to have this technology available at WPI?

Sample Size	303
Less than $10	37.0%
$10 - $30	14.5%
$31 - $50	12.5%
$51 - $75	8.3%
$76 - $100	15.5%
$100 or more	12.2%

If this technology were to be available to students, would you incorporate it as a learning tool?

Sample Size	305
Yes	83.0%
No	16.7%

Do you feel that this technology would benefit certain majors more then others?

Sample Size	299
Yes	33.1%
No	66.9%

What is your current year at WPI?

Sample Size	300
2nd year Graduate	5.7%
1st year Graduate	6.3%
4th year Undergraduate/Senior	34.7%
3rd year Undergraduate/Junior	22.7%
2nd year Undergraduate/Sophmore	29.0%
1st year Undergraduate/Freshman	1.7%

How do you rate yourself as a student?

Sample Size	303
Excellent student	29.7%
Good student	55.8%
Fair student	13.9%
Poor student	0.7%

Would you like to be informed of the results of this survey after it has been completed?

Sample Size	298
Yes	53.7%
No	46.3%