Project LIVE: A Classroom for Students on the Go

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Abstract

The classical lecture environment represents one of the most important opportunities to directly interact with students, allowing professors to leverage an array of communication and teaching techniques and to be immediately responsive to students' questions. However, during a lecture students must absorb considerable amounts of new information within a very brief timeframe. As a result, the student who is unclear about a presented topic or misses a lecture may find this educational medium to be a bottleneck to the learning process since the unrealized learning is difficult to recover. With today's mobile technologies, new opportunities now exist to extend access to classroom lectures by making them available via the Internet. This capability addresses two problems. First, students who are unable to physically attend a lecture can virtually attend a 'live-lecture.' Second, students can carefully review the lecture in its entirety or selected parts to gain a better understanding of the materials presented. The Location-Independent Video Education (LIVE) system provides an innovative solution that enhances student-faculty interaction through wireless remote access to live and archived instructional materials. The overall project goals are to integrate, test, and disseminate new and emerging technologies that link the mobile student to the classroom or laboratory. Through a video/audio capture capability installed in the classroom and a network server, lectures can be streamed in real-time or archived for later viewing. Students can have access to these resources using hand-held devices, tablet PC's, or laptops with mobile connectivity. When viewing a live lecture, students will have the ability to interact with the instructor using messaging software. This paper will detail the basic system requirements as well as the technical approach that is currently being used to implement the system in classrooms and laboratories. In addition, the pedagogical aspects of creating a viable learning environment will be addressed. If sufficient network bandwidth and appropriate secure access can be provided, current capabilities of the LIVE system will be demonstrated.

Introduction

The classical classroom lecture is a mainstay of our academic environment and is a well understood forum for most educators. This environment provides one of the most important

opportunities to directly interact with students, allowing professors to leverage an array of communication and teaching techniques and to be immediately responsive to students' questions. However, during a lecture, students must absorb considerable amounts of new information within a very brief timeframe. As a result, the student who misses a lecture may find this learning medium to be a bottleneck in the learning process from which the unrealized learning is difficult to recover. The use of technologies available today provides new opportunities to offer remote access to classroom lectures both synchronously and asynchronously.[1] This capability addresses two problems. First, students who are unable to physically attend a lecture (due to illness, employment, or in the case of distance education reside in a different city) can virtually attend a 'live-lecture'. Second, students can carefully review previous lectures to gain a better understanding of the materials.

Some previous work has been performed to address the issues of cost and support for lecture delivery systems. For example, one option currently in use at Old Dominion University and the University of North Carolina, Charlotte is to provide students with lectures on CD-ROM that include audio and PowerPoint presentations.[2,3] While this system has the advantage of not requiring internet connectivity, it does not allow the instructor to have a video presence during the lecture. It also does not provide students with the ability to participate in a class in real-time. Another option is to digitize the actual lecture and make it available to students. At the 2000 National ASEE Conference, FAMU-FSU presented an Internet delivery system for use in the classroom.[4] However, this system required the instructor to prepare notes in advance and also required the presence of a technician during the lecture to manage the equipment. Although this is a step in the right direction, what is truly needed is a recording system that is economical enough to be permanently placed in all classrooms and simple enough to be activated by the professor through a "one touch" process. Ongoing work within the Electronics and Telecommunications Engineering Technology Programs at Texas A&M University and supported by Hewlett Packard addresses these issues and limitations through development of the Location Independent Video Education (LIVE) system.

The LIVE system is aimed at establishing two complementary technology-oriented capabilities to greatly enhance the learning experience at Texas A&M University. The first involves the implementation of a 'live-lecture' system that produces learning materials for students. The faculty member enters the classroom and, through a secure login, activates the video recording and distribution system installed in the classroom. The second capability provides the resources necessary to process, record, and database all classroom lectures for later retrieval by students. Students can access these recorded video files, use them for purposes related to homework assignments and examination review and, most importantly, enhance their understanding of the concepts and technologies presented by the instructor.

The LIVE system leverages the wireless infrastructure recently established through an equipment grant from Cisco Systems, Inc in the Engineering Technology Department at Texas A&M University[5,6] to create a test bed for the development and evaluation of mobile technologies for enhancing the educational process. A prototype of the system has been developed and will be used by three faculty members teaching to over 80 students in the Spring of 2004. Through surveys, final grades, and anecdotal information, the effectiveness of the new system will be evaluated.

The LIVE System

Objectives

The overall goal of the development process is to create a system, the LIVE system, with the capability of remotely delivering synchronous and asynchronous classroom lectures using the Internet. As a first step to designing the LIVE system, several faculty and students were brought together to brainstorm the objectives and the requirements for the final system. The starting point was considered to be the classical lecture environment. A primary constraint of the brainstorming session was that the "LIVE" classroom had to maintain or augment as many of those original features as possible. With this in mind, the following objectives were defined:

- The system has to provide audio and visual presence of the professor. It was decided that some level of video presence from the professor would help maintain the atmosphere of a traditional lecture and would provided added information such as the lecturer's facial expressions and physical gestures. It was also determined that the instructor's visual presence helped to engage the student and maintain focus on the presented material.
- Any material projected in the classroom has to be accessible remotely. These include presentation tools such as PowerPoint as well as computer-aided engineering tools such as programming environments, circuit simulation software, FPGA design tools, etc. The system should also support presentation of materials prepared by students such as homework or in-class assignments.
- Readability of materials presented on a blackboard has to be supported. In order to make the system ubiquitous, it was decided that all teaching modalities including "blackboard lectures" needed to be supported. This objective is considered separately from the requirement to have a video presence because of additional resolution and bandwidth requirements.
- Some level of two-way interaction with the professor has to be maintained during synchronous activities. It was decided that for the remote system to retain the feel of a classroom, remote students needed the capability to ask and answer questions during a lecture.
- Synchronization of multiple information sources has to be assured. With the possibility of multiple data streams including audio as well as multiple video feeds, the delivery of a cohesive lecture requires time synchronization of all of the data streams.
- The system had to be as low-cost as possible. Most commercial systems reviewed were cost prohibitive. To ensure that the system could be widely deployed in an educational environment, cost was an important constraint. It was decided upfront to use low-cost hardware and to leverage the use of free and/or existing university licensed software tools in this project. No proprietary software should be required on the remote computer. Students should be able to gain access to and participate in the classroom experience or review archived lectures using standard web browsing software such as Internet Explorer or Netscape. A single login to an online or archived lecture should provide activation and synchronization of the multiple sources of video and audio information.

System Overview

Figure 1 shows a block diagram of the LIVE system as developed through the initial brainstorming sessions. The overall system is made up of three separate pieces: the classroom

encoding systems, the streaming and archiving server, and the remote viewing systems. The classroom encoding systems are placed in all of the classrooms and laboratories where remote lecture delivery is needed. These systems are used by the lecturer for in-class presentations and have the capability of encoding the screen output as well as up to two camera inputs and then transferring this information to a server.

The server then receives these data in real-time and handles live streaming requests from remote students. The server also archives all incoming streams for asynchronous remote viewing. Design constraints on the server include processor speed, memory, storage space, and necessary software tools. Finally, the remote viewing systems are used by the student to access both archived and real-time lectures remotely. These systems can either be on or off campus. To maintain maximum flexibility, it was required that these systems be able to operate both in a wired or wireless mode. In addition, the use of handheld devices, tablets, laptop PC's, and desktop systems was considered.

Because most academic institutions (as well as private industry) use security measures to isolate their local intranet from the rest of the world, this also had to be considered. At Texas A&M University all off-campus access as well as on-campus wireless access is secured through the use of a virtual private network system. This system limits the use of on-campus resources to currently enrolled students and employees of the university system. The use of LIVE in conjunction with VPN has been tested and functions satisfactorily. In addition, the VPN system gives first-pass security to the lectures being served by requiring username and passwords from those requesting access. However, it is also possible to make lectures accessible to the general public by serving it through the standard web port (Port 80).

Theory of Operation

The development of the LIVE system is predicated on one underlying assumption dealing with capabilities that were currently available in all classrooms at Texas A&M University, College Station. Each classroom has been previously mediated with an instructor podium that provides a touch screen display connected to a computer with its video output routable to an LCD projector which can select from multiple inputs and project this information to a screen at the front of the classroom. The LIVE development team was able to make use of the some of these resources so that an integrated lecture environment could be created to support the LIVE capability while not disrupting current teaching activities. Reference to these currently installed resources will be made as needed to explain the LIVE system.

The operation of the LIVE system is designed around ease of use by the lecturer and the audience. It is important that the lecturers not have to change from their normal mode of teaching in order to use this tool. A typical lecture would involve the instructor logging into the LIVE system through the normal Windows XP login for one or both of the Compaq EVO N610c classroom computers. Once logged on, a list of icons will be presented that represent the different methods the instructor can utilize to deliver his/her lecture. These methods invoke the tools/peripherals of the LIVE system he/she wishes to use.

For example, one teaching method uses the podium tablet to deliver the entire lecture with a low-resolution camera to capture the presence of the instructor. The LIVE system

captures the screen of the tablet monitor in the podium. The current lecture rooms are equipped with a tablet monitor that allows the functionality of a normal computer monitor along with the added functions of a tablet. This enables the lecturer to use any PC software to deliver the lecture. In the classroom, the same source is used to display a projected image for the in-class audience. This source gives the remote students the same view on their client machines as if they were present in the classroom.

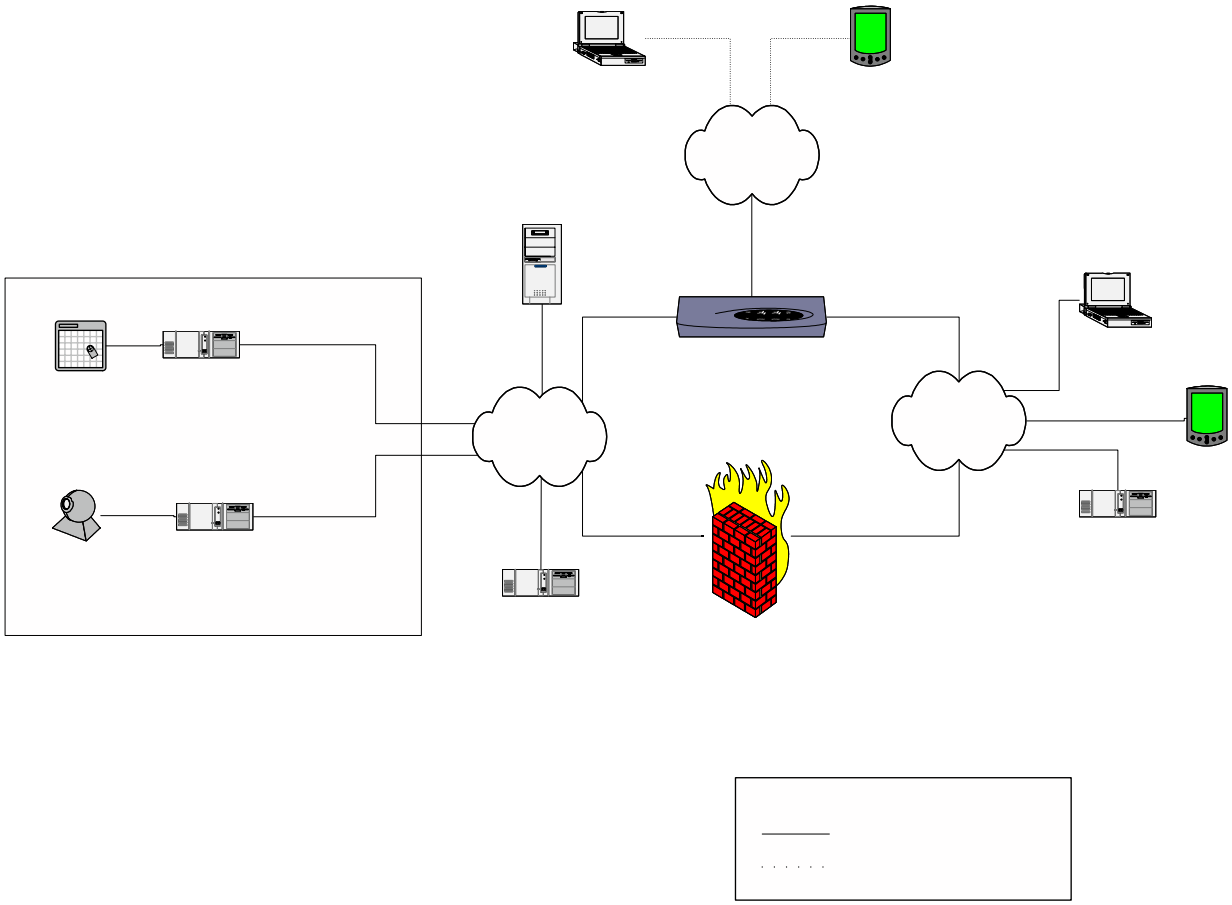

Figure 1 –LIVE System Block Diagram.

Another support method uses a high-resolution camera to capture the lecture given on a chalkboard or similar device. The camera can be used alone or in conjunction with more devices to present the material. Many lecturers still rely on the chalkboard as the primary method for presenting information. In this scenario, a script is run to setup the encoding system on the respective local PC. The encoding software, Windows Media Encoder version 9 (WME9), enables the capture devices, sets the resolution, tests the connection to the streaming server, defines the bandwidth of the stream, and invokes a graphical user interface (GUI) to start and monitor the stream.

The remote student or audience can use a web browser to navigate to the website used to facilitate web streaming for that particular lecture. Although a Pentium-class computer is

recommended for use by the student, the primary constraint for acceptable remote viewing is a high-speed DSL or cable internet connection. The student must log into the website to validate that he/she has privileges for that information. Once the login is successful, the browser is redirected to an html-based GUI for the user to view material and interact with the lecturer. In the last example of dual streams, both of the streams are brought up showing the screen capture of the tablet monitor and the high-resolution camera view using two separate UDP unicast connections to the server. At this point, the student sees everything presented through each view with an approximate 20-second delay and can ask questions or respond via a chat program that supports communication between the student and lecturer. As the lecture progresses, the instructor may require feedback from remote students, and the chat program enables this communication.

Once the live lecture is completed, the instructor terminates the connection with the server through the GUI invoked during the original setup. This informs the publishing point on the server that the stream has ended. The server reacts by archiving the streams for later use and terminating all the active unicast connections to that publishing point. The archived streams are now available to a different publishing point and subsequently available for a browser to access those streams for a post-viewing.

Whether viewing the live lecture or reviewing an archived file, a high-speed internet connection is necessary to support the LIVE throughput requirements. The LIVE system is not intended to support dial-up speeds. In the slower, archived mode, the file is streamed to the media player of the remote computer, not downloaded. This process has been adopted so that the faculty member maintains control of the distribution of his or her lectures. Because most students now have access to high-speed Internet connections in their dorm rooms and apartments, or at least on campus; this requirement is not seen as a major obstacle. Faculty members currently provide access to their PowerPoint slides and their graphical materials via FTP or web sites for direct download. The project will also evaluate extraction of the audio track only from the video stream for downloading with the slides as was done by Old Dominion University and UNC-Charlotte.[2,3]

Lessons Learned

Development of the LIVE system has been accomplished through an iterative process where, based on empirically-determined capabilities and limitations of various hardware and software configurations, the overall features have been refined. With each configuration and test scenario, new information became available to guide the developers in creating an environment that provides ease of use by faculty and students while delivering a cost effective solution that can readily be adapted to a wide range of teaching environments. The lessons learned will continue to be one of the important factors in guiding future development efforts. This section discusses some of the more important lessons that have been extracted from the project to date.

System requirements for such a capability can be expressed in many different formats. One such requirement deals with the equipment necessary to support real-time encoding, transport, synchronization, storage, retrieval, and serving of the LIVE material. The development team has found that a computer with at least a 2 GHz processor is necessary to

accept, encode, and transfer the text/graphic/audio/video information from the classroom to the LIVE Server. Windows Media Encoder has been chosen for the in-class computers based on its free availability from Microsoft. Its associated software package, Windows Media Server 9, is available through typical university licensing and is used on the LIVE video server. These are the primary software packages used to facilitate the LIVE capability and were chosen based on their ease of use and ability for each faculty member to configure the computer display in a way that best presents the teaching materials. This configuration can support an instructor who wishes to use a single camera and computer to capture his presence (talking head) while lecturing to students using computer-based media such as PowerPoint slides or by using a pen-based input device. In this configuration, the classroom computer will generate approximately 100-120 MBytes of information for storage at the LIVE Server each hour. This translates into approximately 250 kbits/s of bandwidth that is needed to support each classroom. Obviously, if two cameras/computers were used in the classroom, the bandwidth requirements would double.

Another important lesson was in the area of camera resolution. For "head shots" of the instructor that keep the student involved in the lecture content, a standard USB Webcam is suitable for capturing real-time video. However, this technology is not adequate for capturing information written on a blackboard. It was empirically determined that a camera with an 800x600 resolution and a high quality glass lens would produce a readable video stream of information as the instructor wrote on a blackboard measuring eight feet in length and four feet in height. The team found that this type of camera is not readily available. There are a number of different vendors producing sub-$100, 640x480, Webcams with a plastic lens, and a smaller number of vendors that are providing higher performance cameras that extend the resolution to 1280x1024 and use C-mount, glass lenses with per unit costs between $1200 and $1500. Research has yet to identify a Webcam-like unit that has a high-quality glass lens, interfaces to a computer using USB or FireWire, and provides an 800x600 video image. The lack of such a camera has had a negative impact on the ability to readily support instructors who prefer to use the blackboard in their classroom for the development of new concepts or mathematical derivations.

During the course of developing LIVE, one of the faculty members became aware of a hearing-impaired student. Although not addressed in the original objectives of the project, the team realized that the capabilities being developed in the LIVE system could augment and improve the learning experience for such a student. Working with this student, the development team equipped him with one of the tablet computers, and through his use of the HP Grant hardware and software, the team received relevant insight into how the LIVE system could assist students in overcoming such roadblocks to learning.

Since the audio portion of the lecture is being broadcasted wirelessly to the encoding computer, students with hearing impairments have the ability to monitor this audio stream in class and listen to it through headphones. Also, because the lecture is archived, these students have access to the lecture outside of the class for later review. Finally, by equipping the student with a tablet PC and Microsoft OneNote software, he or she can digitize his or her handwritten notes during class while synchronously digitizing the audio stream from the instructor. Later, the OneNote software allows the student to playback select pieces of audio that are synchronized to his or her notes. Preliminary evaluation of this use of the LIVE student has been very positive.

In fact, the student in question has requested access to this system again for the Spring 2004 semester.

As work has progressed, more and more EET/TET students have learned of the project and the plan to perform beta testing in up to three separate courses during the Spring 2004 semester. All of the faculty involved in the LIVE System development have been pleased with the acceptance of these new methodologies by the students and the enthusiasm they have demonstrated in participating in the beta testing. Many more students have shown a real interest in having access to recorded lectures that will be available to them literally at anytime, anywhere. They have indicated that by having access to the classroom material in essentially its original format, they will be able to resolve questions and issues as they arise, rather that having to resort to their notes which might be incomplete, inaccurate, or potentially unreadable.

This early user acceptance and demand for server-based instructional information has generated other questions and concerns. For faculty to be interested in using the LIVE System, they will have to be assured that their intellectual property can be accessed by only those enrolled in the class during a particular semester. Controlling this access is something that the faculty members will want to have the ability to assign and change themselves. Faculty will also want to ensure that these students will have access to the information for their use, but not be able to download information as a file that can be saved at a remote computer in any manner. In addition, while not required, some faculty may want to edit their files to remove "dead" spots where there is little to no information content, to correct errors, or to remove content not appropriate for archiving. These issues are being addressed and resolved, but work will continue on these requirements during the beta testing in Spring 2004.

Next Steps

In the Spring of 2004, the LIVE system will be permanently installed in one classroom. Up to three courses will be chosen to test the final system; one sophomore, one junior and one senior level class. By using courses at different points during the Electronics and Telecommunications Engineering Technology curriculum, the effectiveness of the LIVE system can be correlated to the level of the student. In addition, because the courses are taught by different instructors, the system will also be evaluated as to its ability to accommodate different teaching styles. At the time of writing this paper, three instructors have volunteered to use the system, each having a unique teaching style. These three styles include:

- Lecturing with a background PowerPoint presentation.
- Lecturing using a pen input device with imported images and PowerPoint slides.
- Lecturing using a blackboard, and augmented with PowerPoint slides and pen-based annotations.

At the beginning of the semester, the students involved in the test courses will have the opportunity to check out either a laptop or a tablet PC if they do not already have some form of mobile connectivity. The students will then be divided into two groups; those that choose to take the class remotely for the entire semester and those that use the LIVE system to augment their in-class experience. Also, while no student will be prevented from using the LIVE system, it is

anticipated that there will be a group of students that will choose not to access the system at all. Performance data from the three groups, along with data from previous semesters, will be used to evaluate the effect of the LIVE system on student performance.

During the semester, periodic surveys will be used to gather students' impressions of the system as well as quantitative data to indicate how often a particular student accesses the system, when he or she accesses the system, whether he or she uses the system as an aid when doing homework, etc. At the end of the spring semester, it is hoped that the data collected will provide preliminary answers about the effectiveness of the LIVE system including answers to questions such as:

- Do students tend to use the system to replace the lecture or to augment it?
- Does the availability of remote live and archived lectures impact student performance positively or negatively?
- Does the availability of remote live lectures decrease direct participation in the classroom?
- Is the live lecture system seamless, or does it interfere substantially with the normal lecturing environment?

Once this assessment is complete, the LIVE system will be refined and a final system defined. This system will then be deployed in up to six classrooms and two laboratories within the Engineering Technology Department. Also, the LIVE webpage[7] will be updated to disseminate information on the results of testing and on the construction of the system. Finally, through publications such as this one, the authors hope to encourage interested faculty to participate in using the LIVE system in their classrooms.

Summary

Currently, various methodologies for delivering and archiving classroom lectures presently exist including live television broadcasts, video taping, and Internet-based digital video. While these systems have their respective advantages and disadvantages, they all generally involve expensive commercial hardware and software and require substantial infrastructure including personnel to support their operation. Also, these systems are not typically very flexible and require that the lecturer change his or her teaching style to accommodate their limitations. Through an ongoing effort, the authors are currently developing a system to address these problems. The LIVE remote lecture system is designed to be low-cost using standard PC technology and software available through typical university licenses. The final system seeks to address the infrastructure problem by being a permanent (most modern classrooms already have personal computers available), turn-key system that is easily operated by the lecturer through a "one-button" interface.

A prototype of the system has been developed and tested. Initial results have demonstrated that the system works as expected. In addition, when the system was tested in the classroom, student feedback was very positive. In fact, of the students asked, all were enthusiastic to have the system placed permanently in the classroom so that they could have access to archived lectures. The authors are currently evaluating the system for reliability, ease of use, and effect on student performance. Once this evaluation is complete, the system will be

refined and information about system design and performance will be disseminated through web pages and publications.

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