Streaming Media Seminar – Effective Development and Distribution of Streaming Multimedia in Education

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Introduction

Concisely defined, "streaming media" is moving video and/or audio transmitted over the Internet for immediate viewing/listening by an end user. However, at Saint Francis University's Center of Excellence for Remote and Medically Under-Served Areas (CERMUSA), we approach streaming media from a broader perspective. Our working definition includes a wide range of visual electronic multimedia that can be transmitted across the Internet for viewing in real time or saved as a file for later viewing. While downloading and saving a media file for later play is not, strictly speaking, a form of streaming, we include that method in our discussion of multimedia content used in education.

There are numerous media types and within most, multiple hardware and software platforms used to develop and distribute video and audio content across campus or the Internet. Faster, less expensive and more powerful computers and related tools brings the possibility of content creation, editing and distribution into the hands of the content creators. This offers instructors the opportunity to "roll their own" multimedia content. It is important to learn when that is appropriate, and when content creation and production is best turned over to the experts.

The decisions regarding the types and formats of streaming multimedia content must also consider the technical capabilities of the sender, the receiver, and the network connecting them. The focus of distance education research at CERMUSA is the utilization of appropriate technologies to serve remote and technologically under-served populations. The Saint Francis University campus in Loretto, Pennsylvania, is a bright beacon of broadband in a sea of dialup access. As a result, when developing Internet-delivered multimedia content, the limitations of our end-users must be considered. At the same time, it is important to establish reasonable minimum technological requirements so that distant students can access educational materials in a useful and meaningful manner. Campus Information Technology managers must be cognizant of the increasing use of bandwidth-intensive multimedia content. Course developers must be aware of the capabilities and limitations of the available technology and of end-user computer skills.

Media Types

Three companies, each with their own proprietary streaming format, dominate the traditional video streaming environment:

- Windows Media (Microsoft)
- Quick Time (Apple)
- Real (RealNetworks)

Each of these uses to varying extents, the Moving Picture Experts Group (MPEG)-4 standard as the foundation of their latest formats; and codec developers have made cross-platform playback possible in limited circumstances, making easier the choice of which format(s) to use when producing streaming video content (Microsoft, 2002). In general, Windows Media offers the advantage of a broad user base (every Windows-based) PC or laptop that comes equipped with a version of Windows Media Player. Apple's QuickTime offers perhaps the best overall video and audio quality over both Mac and Windows-based platforms, but also requires additional support at the server level, and has the lowest installed user-base of the three. Real has over the years managed to make the most of limited bandwidth, but the company has pursued an aggressive cost-recovery business model at both the developer and end-user levels. A free version of the Real player is still available, although finding the free version on Real's website can be challenging.

As we broaden the working definition of streaming media to encompass any multimedia delivered over a distance, we begin looking into programs such as Macromedia Flash. While strictly speaking, a Flash object downloads its entire payload before playback begins (although Macromedia plans to eventually release a streaming version). The smaller file sizes and close integration with most browsers results in an end-user experience that looks and feels very much like streaming. Originally designed to accommodate low frame-rate animations, the newest version, Flash MX, is increasingly able to effectively handle large frame-rate video files in limited circumstances, again depending on the transport method and available bandwidth from point of origin to destination(s). These alternatives to "traditional" video/audio streaming will continue to grow in value and usage with the continued improvements in computer hardware and software.

One of the newer additions to the video file menagerie is Material Exchange Format (MXF), developed primarily in response to the conversion to digital transmission by the broadcast television industry. Bruce Devlin, principle research engineer at Snell & Wilcox UK and a member of the standards body, the Society of Motion Picture and Television Engineers (SMPTE), describes MXF as "an open file format targeted at the interchange of audio-visual material with associated data and metadata. It has been designed and implemented with the aim of improving file-based interoperability between servers, workstations, and other content creation devices. These improvements should result in improved workflows and result in more efficient working than is possible with today's mixed and proprietary file formats." The proposed standard is now in final SMPTE review (Devlin, 2002).

The MPEG Consortium is also working on new extensions to the MPEG protocols (MPEG-7 and MPEG-21) which also address these issues.

Creation and Playback Software

Over the past five years, video stream content development and delivery has gone from something that only big media powerhouses did regularly to something that anyone with a reasonably recent computer and some extra cash can do. A big part of this evolution came about due to computer-based non-linear video editors and the capabilities therein. A Non-Linear Editor (NLE) allows video, audio, and other elements of a traditional multimedia production to be handled as separate objects. These objects can be manipulated and moved around within a timeline analogous to moving text around in a word-processing document. NLEs can speed the editing process or, more frequently, allow for better use of post-production time by incorporating video effects, audio/video processing and adjustments, and functions for rendering streaming media.

In the mid 1990s NLE systems required dedicated graphics workstations and were tools available only to the major Hollywood film production companies. Now, consumer-oriented laptops often include a movie editor as part of the basic software bundle. Consumer level editing equipment and software generally does a few things quite well, and may be a reasonable solution for an instructor seeking to create and develop multimedia content. Figure 1 offers a sample of popular consumer-level NLE software packages currently in the marketplace. This list is not inclusive. Companies and computer home brewers are adding products and add-ins daily. Additionally, all of these NLE systems will save the movie that is created into an MPEG file, which is the universally accepted file for conversion into the many different flavors of streaming media. One item of note: many digital video cameras now include software that allows you to input the video, edit with software, and finally, output the edited video to tape or file.

Figure 1
Consumer Level Video Editing Tools

Name of Software:	System Requirements:	Cost:
iMovie	Mac OS X	Bundled with Macintosh systems
Windows Movie Maker	Windows XP	Bundled with many Windows XP systems. Also available as a freeware download
Avid Free DV	Mac OS X 10.3.2 & up Windows XP	Freeware
MuVee autoProducer	Windows 98 & up	$50 to $70
Pinnacle Studio 9	Windows 98 SE & up	$100
Roxio VideoWave 5 Power Edition	Windows 98 SE & up	$100
Sony ScreenBlast Movie Studio 3.0	Windows 98 SE & up	$100
Ulead VideoStudio	Windows 98 & up	$100
Canopus Let'sEDIT	Windows 2000 & up Mac OS 9 & up	$150
Final Cut Express 2	Mac OS X 10.2.5	$300
Adobe Premiere Pro	Windows XP	$700

Professional level systems, not including the video decks and monitors (typically considered a separate purchase), start around $12,000 for a basic turnkey system, including a computer, memory, video/audio inputs and outputs, and media storage for projects. Customization, add-ons, bigger hard disk space, system upgrades, and product upgrades can push a purchase like that above $50,000. Just as we've seen across the technology environment, each year delivers hardware and software improvements and lower (especially per byte) prices.

CERMUSA currently uses a dpsVelocity 8.2 NLE system running on a dual Pentium III system running Windows 2000, with 512 MB of RAM, a 36 GB editing disk (for making graphics, effects, A/V work, and streaming storage), and a 130 GB off-deck media storage. The NLE suite includes a Panasonic DVCPro AJ-D450 Video Tape Recorder (VTR) and an input selector from an A/V routing system that incorporates all video resources within the production facility known as the Distance Learning Prototype Lab (DLPL.) Outputs include both a Serial Digital (SDI) and component into the aforementioned DVCPro VTR, as well as a component output into the video routing system. One of its main uses is the production of streaming media, with encoders for QuickTime, Real, and Windows Media.

The use of a fairly specialized system is a result of the multifunctional capabilities of the DLPL and the wide range of uses for a variety of multimedia across the research and administrative environments of CERMUSA. While some of our needs could be met by any of the NLE packages listed in Figure 1, much of our output consists of highly demanding work that necessitates a professional-grade solution. In addition, our recording format of choice is DVCPro stock, which is a pro-level stock, and the integration of the NLE into our studio makes for the necessity of a professional-grade NLE. That is not to say, however, that we don't use desktop-style programs for streaming. The Clinical Pharmacology courses for which CERMUSA produces streams, is directly recorded live, edited, and converted to streaming files on a studio laptop using Sonic Foundry's SoundForge 6. In the time that it takes for the mid-class break, the preceding lecture can be wrapped with meta-data and posted for student use.

Figure 2
Primary Streaming Formats

Name:	Common Extension(s):	Platform:	Player Cost:
QuickTime	mov, mpg, mpeg	Windows, Mac	Free download; Pro version $25. Bundled on Macs.
Real	rm, ram, mpg	Windows only	$9.95 for the RealOne player. Free version available
Windows Media	wmv, wma, avi, asf, mpg, mpeg	Windows 98 SE & up. Support for Mac OS 10 and higher.	Free. Bundled on Windows PCs

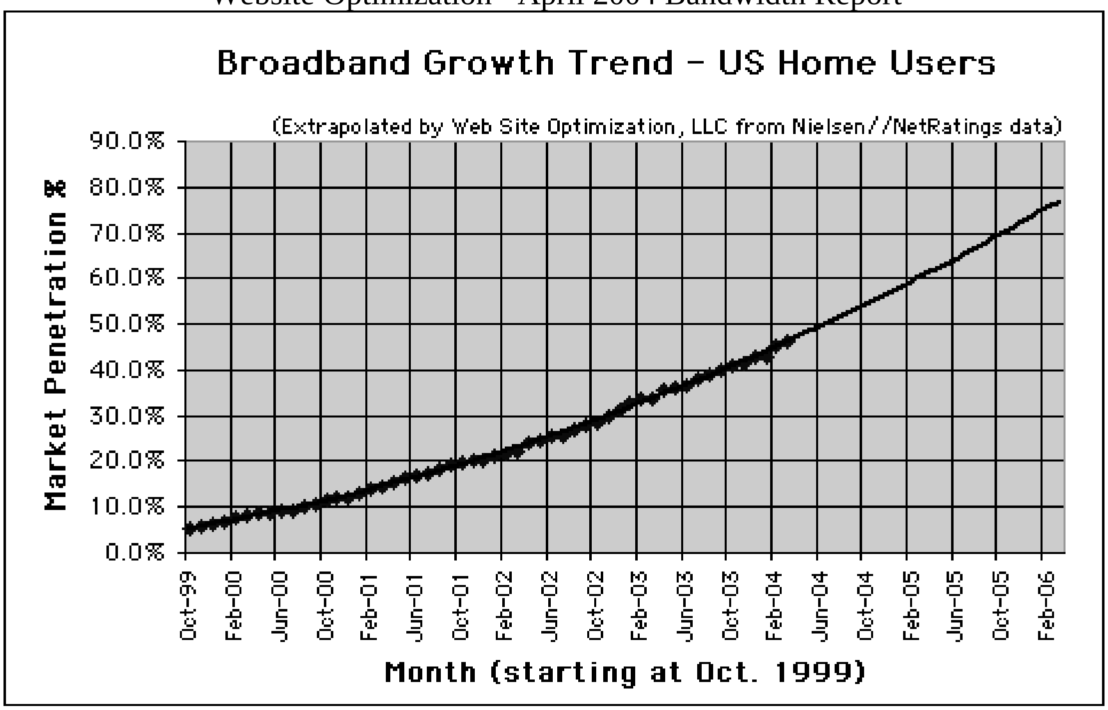
As stated earlier, the principle streaming playback viewers are QuickTime, Real, and Windows Media. Figure 2 breaks down the differences between the three. These players can be downloaded from the websites listed. Once downloaded, a user can change settings, select defaults, etc., and begin viewing streaming media.

Bandwidth Limitations

As previously mentioned, the effective use of available bandwidth is a primary factor in deciding how to develop streaming multimedia content.

When developing content for streaming, the most important question that must first be answered is "how much bandwidth is available to the end-user?" Our research at CERMUSA has tended to focus on the most rural and remote populations who have no access to broadband technologies. However, broadband access is growing rapidly. The Leichtman Research Group reports in its study, "Broadband Internet Access & Services in the Home 2004," based on a survey of 1,600 households nationwide, that, as of November 2003, 62% of residential households subscribed to an online service at home, and about one-third of this group subscribed to broadband (Leichtman Research Group, (2004). Another new media consulting firm, Website Optimization (WSO), using data from Nielsen/NetRatings and Ipsos-Reid, places broadband penetration in American homes at nearly 46% as of March 2004. As shown in Figure 3, WSO predicts broadband penetration to exceed 50% by July 2004, and reach three-quarters of U.S. homes by the end of 2005.

Figure 3
Website Optimization - April 2004 Bandwidth Report



If your audience is expected to include a significant proportion of the one quarter of Internet-connected homes restricted to (or choosing) narrowband, your streaming options will be accordingly limited (Websiteoptimization.com, 2004).

Applied Streaming Media

When considering "teaching with technology," it is easy to imagine a lecture delivered to a remote campus using interactive television, a multiple-choice test given online, or other cases where new tools are used to enable or enhance existing teaching practices but do not radically change the practices themselves.

However, there is reason to believe that technology is affecting a transformation in teaching and learning, shifting the focus from the teacher to the learner. Technology tends to empower students to direct their own learning, whether it is setting their own pace in an online tutorial, directing their own learning in a fully interactive simulation, or constructing their own knowledge using authoring tools. Technology also encourages decentralized and democratized classes by supporting open discussions, collaborative work, peer reviews, and other communal learning activities (Campbell, p. 24-26, 61).

Such change compels instructors to rethink teaching and learning and examine the educational theories and principles that have long been studied but less often put into practice. Nearly 75 years ago Kurt Lewin discussed the significance of learners playing an active role in discovering knowledge for themselves, of the importance of a cohesive approach to instruction that includes cognitive, affective, and psychomotor activities, and the powerful impact that the social environment of the learner has in supporting change (Stahl, 1999). Yet frequently in distance education courses, students often have a difficult time visualizing concepts and struggle to grasp information that is presented either verbally or in writing. This situation certainly exists in traditional classrooms, but it can become particularly acute in an online environment.

Cognitive research suggests that the addition of multimedia *can* actually improve the learning process if certain methods are employed. By using auditory and visual methods of presenting information, students can process that information more quickly, often fostering an enhanced learning process. Thus, streaming media can play an important role in effective distance education delivery. An excellent example is the Educational Streaming Media Program at Cincinnati Children's Hospital Medical Center where a variety of audio and/or video programs are offered via streaming media. Examples include nursing and pediatric lectures that are worth continuing education credits once the participant completes the online post-test.

A CERMUSA research study was initiated in 2001 into the use of multimedia-rich, web-delivered case studies. This practicum in pharmacology provided physician assistant students a virtual opportunity to ask questions of a simulated patient, diagnose their ailment, and recommend a course of treatment. This was achieved through the development of a web-based interface, seen in Figure 4, containing streaming video clips of the questions and responses that would be typical of a routine medical examination.

Production of the streaming clips is a straight forward process. Taping takes place in CERMUSA's DLPL using a "green screen" in the background to create a virtual medical exam room. During the post-production of each segment, the background of the doctor's office is inserted in this green area (Griffin, 2001, p. 175-180).

Figure 4
Case Study Screen Shot

After editing is complete the segments are encoded as streaming Windows Media files. When encoding anything, one must take into account a number of variables: Will the students access the data at the same time, or will it be spread over time? How much bandwidth is available at any given time, from server to end-user? Which media player format(s) are available to the end-users? What kind of restrictions will the learning institutions place on content being delivered through their networks? Will any of the students connect via dial-up? The answers to these questions would determine the various encoding processes.

The ultimate goal of encoding streaming media is to have the most number of people be able access the highest quality video or audio possible. Using these parameters and the above questions, we developed a plan for the encoding of video. At the beginning of this project, each clip was encoded at three bandwidth levels, 28 Kbps, 56 Kbps, and 100 Kbps. Doing so allows for a range of connection speeds and accommodates a range of Internet and local network traffic conditions. It soon became apparent that the lowest setting, 28 Kbps provided inadequate image quality, and it was eliminated from the encoding mix.

Other factors that contribute to the overall viewing quality of a streaming file include optimizing for smoother motion or for sharper pictures quality and frame rate. Standard television video in North America contains 30 frames per second (fps.) Streaming video seen on the Internet ranges from only a few fps, up to 30 fps, with 12 to 15 fps being the most commonly seen rates. The process is a matter of compromise, balancing file size against quality. Higher frame rates result in larger file sizes and require additional bandwidth. The pharmacology case study files were encoded at no lower than 15 fps.

In order to compress and decompress the video files, the encoding software makes use of key frames. They can be looked upon as "anchors" or reference points in a video stream. When users fast forward or rewind to selected portions of a video file, they are actually jumping across key frames. Key frames contain far more information than do regular frames and so, an increase in key frames will result in larger file sizes. For this project, the lowest bandwidth files were encoded with one key frame every eight seconds, while the higher quality files contained a key frame every five seconds.

Figure 5
Window Size Comparison

Picture size is a key factor in determining file size. This is measured width by height in pixels, thus a 320 by 240 image is 320 pixels wide by 240 tall. As Figure 5 illustrates, the smaller dimensions result in less information having to be saved, and therefore reducing the overall file size. For the case study project, video clips are encoded at 240 by 180, providing a useful window size within the overall case study web interface.

Internet 2

To this point we have centered on how best to cope with bandwidth limitations. Virtually the opposite is true when considering use of Internet2 for delivery of high quality video content. Internet2 is a consortium led by more than 200 universities working in partnership with industry and government to develop and deploy advanced network applications and technologies, with a focus on bandwidth-intensive applications such as high quality, full motion video, 3-D modeling, and the like (About Us).

If the traditional Internet is described as an information freeway, Internet2 is a toll road. While access is limited, it should be remembered that the original Internet had similar beginnings as a limited access network connecting research institutions and the U.S. Department of Defense.

The lesson to be taken from the emergence of this new communication channel is the continuing evolution in our ability to send and receive bandwidth intensive content. At the same time, we must remain cognizant of the limitations forced upon or chosen by some of our constituents by virtue of their location in relation to the information infrastructure.

Conclusion

In the end, the decision on whether or how to incorporate streaming video or other multimedia into course content contains both technological and pedagogical dimensions. While on the one hand, it is becoming much easier for the average person of modest technological talents to create useful streaming content, to be useful, the consumers at the far end of the information pipeline must be able (and willing) to make use of that content. To that end, we see a generation of students who are increasingly comfortable at the keyboard, navigating the Internet as easily as they stroll through the local mall on a Friday night. They are the ones driving the increasing demand for bandwidth for both recreational and educational purposes. Conversely, non-traditional students make up a growing proportion of higher education's consumers, creating a growing need for nontraditional distribution methods to accommodate their busy schedules. Streaming media and other forms of bandwidth-intensive content will play an increasing role in serving their needs.

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