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September 2007
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Video Screencasting: A Recipe For Automation

Video Screencasting:
A Recipe For Automation
In The Educational Environment

Introduction:

University instructional support services are often understaffed, operate with limited budgets, and lack automated digital content workflow processes. They rely on staff or student operators recording content with digital video cameras and manually uploading that content to the web.

The increasing demand for digital media content cannot be met without finding streamlined solutions to capturing multiple content sources, performing the encoding processes and then delivering it to the web.

In this white paper, we will share our knowledge and research to:

- Identify trends in the rising use of digital media content.
- Identify the presentation elements that are most important to students.
- Explore two designs that deliver hybrid on-line digital media content to accommodate the needs of instructors, end-users and instructional support personnel in a scalable, cost effective way.

A Brief History:

Classroom Support Services' Information Technology Group (CSSITG) designed and implemented two new media pilot programs in October, 2005, that gave students "any time, anywhere" options for reviewing digital audio or video content. These new media pilot programs were designed as a practical response to a problem. The libraries were allocating valuable real estate and equipment so that students could access class lectures recorded on magnetic tapes.

The pilot programs explored two forms of new media delivery solutions. CSSITG developed a scalable, automated podcast solution that captured, uploaded, and delivered digital audio content to the web. CSSITG also modernized classroom video recording operation by taking content recorded with digital video cameras and streaming it over the Internet.

The podcasting pilot program was immediately successful because of its automated capture and content delivery design. Instructors particularly appreciated the "zero configuration" of the technology and it provided students anytime/anywhere access to lecture recordings in a timely, reliable manner. Between October 2005 and June 2007, 146 classes have participated in the podcasting pilot program, resulting in 175,000 digital audio downloads of classroom lectures.

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History, continued:

The video pilot program did not realize the same instantaneous success. University instructional support services are often understaffed, operate with limited budgets, and lack automated digital content workflow processes. They rely on staff or student operators recording content with digital video cameras and manually uploading that content to the web.

Classroom lectures are live performances. The key to successful video recording of live performances is to have plenty of time for equipment setup and testing. Why? Mistakes are often impossible to reverse. Camera operators are dispatched to classrooms with consumer-grade video cameras that must be patched into a lecture hall's PA system during short class breaks. Pressure to have content immediately available for student checkout at the library meant that many classes were recorded directly to DVD media. Incorrect patching, forgetting to monitor the audio track, frequent DVD media writing errors and recording equipment glitches resulted in many lost recordings.

Some recordings were saved in post production. UW Media technicians spent many hours synching audio captured from other PA recording devices to video recordings that had poor or missing audio. This process was time consuming and resulted in lost productivity.

Some lecture recordings were being shot specifically for video streaming. They were recorded on portable DTE recorders which split the video files into multiple segments as a result of file system limitations on their hard drives. These segments had to be stitched together and encoded before they could be uploaded to the Web. These tasks were also time-consuming and did not lend themselves to scalability.

In July 2006, the Internet video site YouTube announced that its users were now watching more than 100 million videos per day. YouTube had the effect of hitting the reset button for the world's on-line video appetite. This phenomenon became immediately apparent at the University of Washington when students began to pressure instructors to offer digital video content to supplement classroom instruction. Equally apparent was the fact that the demand for digital media content could not be met without finding a solution that automated the process of capturing content and delivering it to the web.

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The Current Landscape:

Many new media experts credit the popularity of YouTube with creating the demand for online video consumption by mainstream audiences. The user-generated online video market exploded in 2006 and by the end of the year, user generated videos made up 47% of the total online video market in the US[1].

Web 2.0 technologies that facilitate collaboration and the sharing of content between users have transformed the Internet from a place where information is found into one where the audience creates multimedia content. Students, a key demographic of the Internet audience, are both content creators and content consumers. The result is an "audience" with very definite expectations about the availability of Web-accessible classroom lecture material.

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Student interest in on-line classroom lecture material appears to have surged right along with the popularity of YouTube. In January 2006, a group of University of Washington Biochemistry students petitioned the department's program coordinator to move their class to a location capable of supporting video recording and streaming. Students in other areas of study also began expressing their desire for instructors to offer new media content for classes, with an emphasis on interactive, on-demand digital video lecture recordings.

Students' tastes for rich new media content offerings have reached a level of refinement that can no longer be ignored. Digital video footage of a talking head, without other elements of the presentation is simply not acceptable to them. All information must be conveyed.

It is not possible to meet the increasing demand for digital media production, in terms of volume, and in terms of providing rich content, when instructional support services are understaffed, operate with limited budgets, and lack automated digital content workflow processes. CSSITG has solved this problem by employing a centrally managed, automated approach to capturing, encoding and delivering rich digital video lecture content to the Web.

1 User-generated online video: Competitive review and market outlook, Screen Digest Press, January, 2007.

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Audience:

The key to designing a successful new media solution starts with knowing the expectations of the audience. The University of Washington's Office of Learning Technologies conducted a formal evaluation of how students used digital audio recordings of class lectures. CSSITG collected student feedback and monitored new media consumption patterns for both pilot programs.

CSSITG's assessments of the results lead to the following conclusions:

- Video is preferred over audio-only content if there is a choice.
- The majority of students who view on-demand digital video lecture recordings watch the entire video, often multiple times.
- The ability to easily move forward and backward through a recording is a highly desired feature.
- The instructor's presentation material and narration are the most important elements to convey; including a view of the instructor and the classroom setting is ideal.
- Digital video content must be viewable on multiple operating systems and devices.

Presentation Elements:

Classroom presentations incorporating multiple digital elements and input sources are quickly becoming the norm. An interface capable of providing an enhanced user experience is required to convey all of this information. Classroom presentations typically include the following elements:

- Lecturer.
- Audio, program audio.
- PowerPoint slides, or other presentation software applications.
- Video clips, animations, pictures.
- Web pages, syllabi, assignments.
- Document camera.
- Overhead projector with transparencies, whiteboard, chalkboard.
- Software demonstrations.

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Defining Process Requirements:

An automated solution that meets the growing needs of digital media content capture and delivery must seamlessly perform six operations: video recording, video screen capture, video encoding, image processing, metadata annotation, and posting of the final presentation for distribution to students. The solution should be flexible, simple to use, and work across multiple operating systems and devices.

Video Recording. Video recording, the first operation, is relatively easy to implement. A video conferencing camera with remote controlled pan, tilt and zoom features can be mounted in the classroom or control booth. The audio track can be captured with a patch from the house PA system. The video and audio tracks will then be sent to a video capture server.

Video Screen Capture. Video screen capture of presentation material, often from multiple input sources, presents a small challenge. The solution is to capture the VGA signal sent from the presenters computer display to the classroom's data projector by using a video frame grabber. Frame grabbers can digitize analog video signals from a variety of sources such as a Windows PC, Macintosh OSX, a Linux machine, a document camera, a medical device, or other scientific lab equipment. The results are high-resolution JPEG images.

Video Screen Capture. Video encoding converts analog video to a digital form. It is important to choose an encoding format that is flexible and designed for scalability because an automated video capture and delivery solution may require multiple encoding steps. There are many encoding technologies that create digital file for storage and playback on a range of operating systems and devices. MPEG-2 supports interlaced video and is a good choice for video capture encoding. Adobe flash video is an excellent choice for screencasting because it is installed on more than 700 million computers and devices worldwide and over 96% of Internet-enabled desktops[2].

Screen Capture Image Processing. Screen capture image processing is necessary so that redundant frame grabs can be discarded to reduce file size. The remaining images are saved in several convenient resolutions to accommodate optional viewing preferences.

Metadata Annotation. Metadata annotation is crucial to the success of automation. The most important metadata are the names and timestamps of raw screen grabs that need to be synchronized with the video recording. Other metadata is included to identify class and event names, dates, file destinations and for the creation of chapter markers.

2 Adobe, http://www.adobe.com/products/flash/features/allfeatures/

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Process Requirements, Continued:

Posting. Posting of the final screencast components is the final operation. This operation populates the media server with digital media content for download and consumption by end-users. The increasing demand for digital media content cannot be met without finding streamlined solutions to capturing multiple content sources, performing the encoding processes and then delivering it to the web.

Requirements Summary. To sum up these requirements, an automated solution for digital media content capture and delivery will have to record video using a CCD color camera connected to a capture Server. Audio can be captured with a patch from the house PA system. The analog video must be converted to a digital form using a format that is flexible and scalable. Presentation material, such as power point slides, will be captured with a frame grabber located in the signal path between the input sources and the data projector. The resulting images must be processed to discard redundant frame grabs for file size reduction. Metadata will be added to the image files for the purposes of synchronization and automation of other workflow operations. The final presentation content will then need to be posted on a media server for distribution to students.

The CSSITG Solution:

CSSITG's Automated Video Screencasting models were developed as solutions for cost-effective, flexible, and scalable digital media production in the university environment. They include equipment, software and scripting for automating the video recording, video screen capture, video encoding, image processing, metadata annotation, and web delivery workflow.

The CSSITG models are built around MythTV, an open source application for Linux that transforms a computer into a programmable video recorder. MythTV's architecture allows remotely captured content to be flexibly managed by one or more back-end servers.

Both models were designed to keep overall IT development and maintenance costs to a minimum, yet they are robust enough to respond to future growth. The scalability model utilizes capture servers located in classrooms to record, encode and process images captured by a frame grabber. This model was developed for quick deployment, but due to its modular architecture, the hardware can be repurposed for use in the volume model with complete investment protection.

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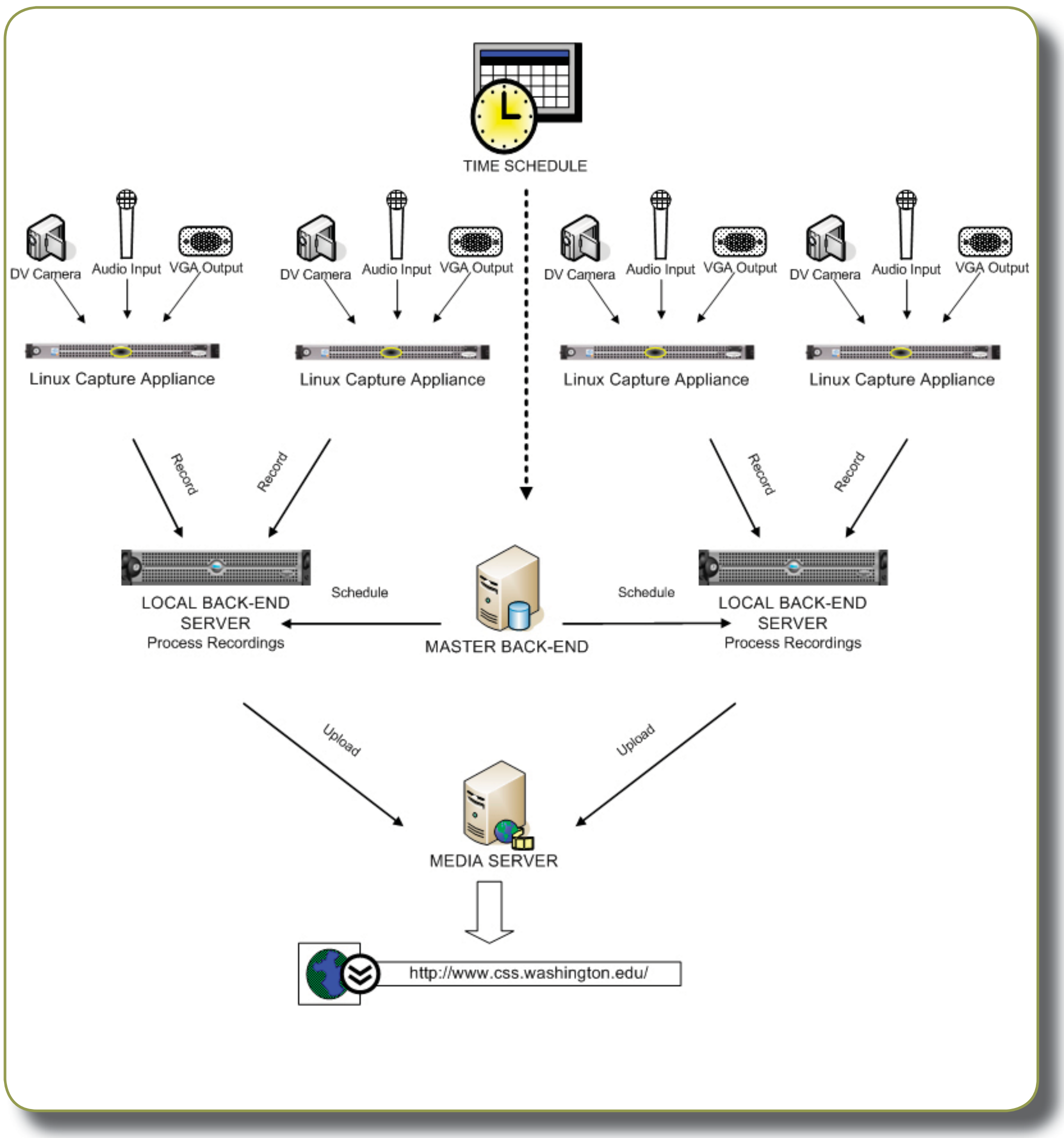
CSSITG Solution Continued:

The volume model uses a combination of solid-state Linux capture appliances and satellite back-end servers to handle the heavy processing requirements of increased production volume. The hardware requirements for the capture appliances are minimal; hard drives, large processors and fans are optional. The back-end servers perform the encoding and screen capture image processing operations for multiple capture appliances. They are centrally managed by a MythTV Master back-end server that contains the schedule for all classroom recordings.

Figure 1: CSSITG Volume Model



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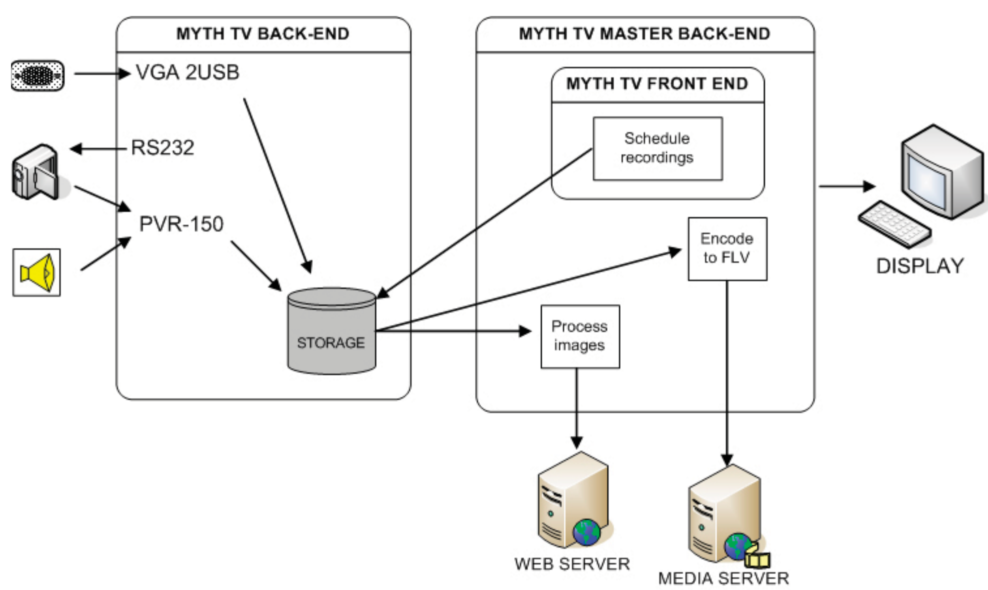
Automated Workflow Descriptions:

The scalability model uses a series of MythTV backend servers that are controlled by a centrally managed master back-end server for the digital video lecture recording process. Classroom events are scheduled on the master back-end server, which starts the recording processes at their respective times. The master back-end server also performs the post processing operations.

Multiple content sources are fed into a MythTV backend server located in the lecture hall's control booth. Audio and video sources are recorded to disk via the server's Hauppauge PVR-150 capture and hardware encoding card; digital presentation material is captured and written to disk with an Epiphan VGA2USB frame grabber. When the lecture recording ends, scripts send the MPEG2 video and JPEG images to the master backend server for re-encoding to FLV and image processing. When post-production is complete, the screencast component files are posted to the Web for delivery to students.

Figure 2: Scalability Model Workflow



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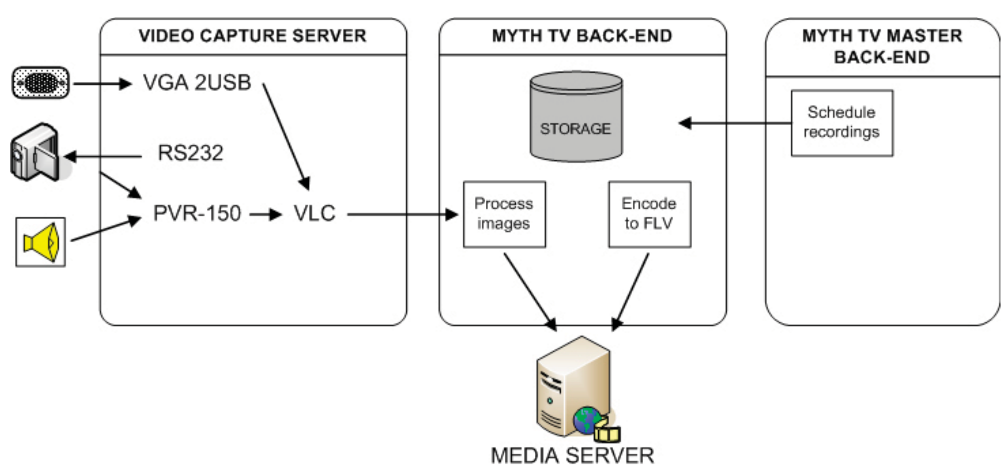
Workflow Descriptions, Continued:

The volume model uses a combination of solid-state Linux capture appliances, satellite back-end servers and a centrally managed master back-end server. Classroom events are still scheduled on the master back-end server, but the master back-end server performs no post processing operations. This job is delegated to the satellite back-end servers which are geographically dispersed throughout the campus. One satellite back-end can serve a building, or a subnet spanning multiple buildings.

Multiple content sources are fed into a Linux capture appliance located in the lecture hall's control booth or equipment closet. Audio and video sources are consecutively captured, encoded and streamed to an assigned satellite back-end server; digital presentation material is captured via frame grabber and also sent to an assigned satellite back-end server. The satellite back-end server performs all post-production operations for the capture appliances that it is assigned to. When the work is complete, it posts the screencast component files to the Web for delivery to students.

Figure 3: Volume Model Workflow



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Summary:

New media content is being created, distributed and experienced faster than ever before. Capturing and delivering that content can now be accomplished with solutions built on open-source platforms and inexpensive hardware. Central management, automation, and scalability play a key role in achieving success.

Next Steps:

CSSITG's automated screencasting solution continues to evolve. Features that would further enhance the system are in the preliminary design stages.

They include:

- Web-based self-recording tool for instructors to use for production of short screencasts as supplemental class material.
- A customized interface that would allow users to change or add bookmarks globally for collaborative interaction with other students.
- Development of Flash or local webserver executable for off-line viewing of presentations.
- Interface modifications to accommodate users with disabilities

For more information about CSSITG's Automated Video Screencasting system, please visit http://www.css.washington.edu/computing/.

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