

Webcasting From Challenging Locations

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Abstract—This paper will discuss the issues associated with webcasting from remote and challenging locations using open source software. Issues discussed will include the pros and cons of point-to-point versus multicasting, the use of commercial software versus open source, website design criteria, and some of the technical issues (network bandwidth requirements, chat room and webpage configuration). The authors have experience in setting up and conducting webcasts of astronomical events which have been broadcast from nine different countries as part of the Sun Earth Moon system (SEMs) project - a public outreach and informal learning project developed at the University of North Dakota (UND). The system developed is also being used to evaluate an unmanned aircraft system in support of Defense Support of Civil Authorities.

Keywords-webcast; solar and lunar eclipses; social media.

I. INTRODUCTION

The scientific community has long been concerned with the gap between advances in natural sciences, particularly in physics and astronomy, and the level of public awareness and involvement [1-3]. Additionally, if young generations do not acquire knowledge of basic scientific concepts, the knowledge gap will continue to widen. Contrary, if young people are equipped with the underlying scientific principles, it is easier for them to stay connected with the growth of scientific knowledge throughout their lives [4]. Therefore, scientists should not only focus on research but also on bridging the gap between science and the public by means of informal science education [5-8]. Hence, the scientific community is currently looking for innovative ways of encouraging informal science learning [9].

Sun Earth Moon system (SEMs) [10] is a public outreach project conceived by the authors to bring live coverage of rare astronomical events to the public using the Internet as a way to encourage informal science learning [11]. Scientists determine beforehand from what geographical location these celestial events can be best observed; then a UND team travels to the location, sets up equipment, and shares the event with SEMs visitors in real time.

SEMs webcasts began with the June 8, 2004 Venus transit that was webcast from Delhi, India. The webcast was very successful with 37,000 visitors to the website occurring

during the six hour webcast. This was encouraging as webcasting was still in its early development stage with an adoption rate of only 7% [12]. The second SEMs webcast was the October 28, 2004 lunar eclipse that was webcast from Grand Forks. Unfortunately, it was cloudy. However, the website had over 159,000 visitors in just two hours; which increased the load on the server to the point where the system administrator could not login to place a notice on the website that it was cloudy and that there would be no webcast! It was quickly realized that if the team planned to continue webcasting astronomical events that a better understanding of webcasting methodologies, the current server and software environment, and usage patterns would have to be developed.

For the first two webcasts, accounts and disk space on the UND School of Medicine's MacroMedia Breeze server were obtained. While this software is very capable and easy to use, it limits the number of concurrent viewers (as determined by the site license). Given the problems encountered with the October 28, 2004 lunar eclipse webcast, alternative webcast techniques / packages were explored.

The SEMs webcasts have some unique requirements which drove our decision making process. First and foremost is the tremendous number of visitors that can be expected over a short time period coupled with finite network bandwidth. The second is that the team must be able to broadcast from remote locations – locations were one must make do with whatever Internet connection can be obtained and with whatever equipment can be brought (due to weight and customs restrictions). Therefore, it is mandatory to be able to send a single stream from our remote site to a server located at UND and have that server provide the multitude of public streams. The third is that it is the goal of the SEMs project to give viewers the feeling of being there and to instill the excitement of being part of a global community witnessing a rare event. The fourth is to have the ability to record and store for playback (at the viewer's convenience) the video and audio. As a result, experiments with the use of the media to make the event as life-like as possible for the viewers have been continuously conducted. Unlike the other eclipse webcasts, the SEMs webcasts use streaming color video, audio and have a chat room. It was discovered that having viewers post questions

on the chat room and our answering via audio was very popular. However, such amenities require bandwidth and flexible software/systems.

The remainder of this paper will review the techniques and software that are available and provide a discussion of the techniques/software that have been adopted and developed.

II. BACKGROUND

Webcasting refers to the delivery of audio and video content over the web [13]. Ha and Ganahl [14] point out that “there are many different applications of webcasting in both the nonprofit and the commercial sector” where the web is used as a delivery medium, such as informational, instructional, marketing, and entertainment. Webcasting options can be broken down into two categories: the network protocol and the software used [15, 16]. The network protocol options can be further divided into two sub-categories:

1) *Point-to-point*: This is the most common protocol used by commercial webcast systems as it gives the software a mechanism to track/limit the number of viewers. Furthermore, point-to-point commonly uses HTTP port 80 which is rarely blocked by Internet Service Providers (ISPs). Unfortunately, every viewer creates/requires a separate and redundant connection to the server. Therefore, the number of viewers possible is also limited by the server site’s bandwidth.

2) *Multicast*: With multicast a single stream is broadcast by the server and is replicated by all network routers encountered and therefore sent to everyone on the network (whether they want it or not). As a result, multicast consumes a massive amount of network bandwidth and therefore, many ISPs block all multicast signals. Thus, multicast is akin to AM/FM radio where anyone knowing the channel can tune in, thus multicast is not commonly supported by commercial webcast systems. Finally, to webcast over multicast, one needs a multicast address [17], and one must set the time-to-live on the packets such that the appropriate number of routers is crossed to reach the desired audience.

The software options can also be divided into two sub-categories:

1) *Commercial Software*: Commercial packages typically provide support for many cameras and microphones and provide useful features such as chat rooms, the ability to show presentation slides, have remote feed capability and have web browser interfaces. The drawbacks to using commercial packages include the price, the lack of support of multicast, license restrictions limiting the number of viewers, and the need to install web browser plug-ins.

2) *Open source*: Open source packages range widely in capability and few support chat rooms, the ability to show presentation slides, or remote feeds. We have also found

camera and microphone support spotty in these packages. However, free packages have no license restrictions and more likely to support multicast.

One can also consider a push or pull strategy. The “pull” strategy requires the receiver to initiate a message transfer by explicitly contacting the sender; therefore, a website using the “pull” model only allows users to retrieve information. In the “push” model, the sender knows the identity of the receiver in advance and pushes messages in an asynchronous manner to the receiver [18, 19]. For the purposes of creating the utmost, life-like experience of being part of a global community witnessing a rare astronomical event, the “pull” strategy was found to be most effective. In addition, the nature of the webcasts and network bandwidth has limited our ability to support the “push” model.

III. UND/SEMS WEBCAST SYSTEM

Given our requirements and limited funding, we were fortunate to realize that we could develop a system that would meet our needs using open source software. Hence, the UND/SEMs webcast system relies heavily on open source software. The chat room and website are hosted on a Linux server running the High Performance Internet Relay Chat software [20] and the Apache web server [21]. The multimedia (audio and video) streams are served by three Windows XP servers each running the VLC media player [22]. All servers are located at UND. A webcam connected to a laptop computer is used to capture and forward the multimedia stream from the remote site to one of the VLC servers using a User Datagram Protocol (UDP) connection. Two copies of the VLC media player (version 8.6i) are executed on the laptop computer. The first is used to acquire the multimedia data from connected devices (webcam, microphone, etc.), to make a high quality recording on the laptop, and to stream the multimedia data to the loopback network connection (127.0.0.1). The second receives the multimedia data from the loopback network connection, transcodes the multimedia stream to reduce its bandwidth, and streams the transcoded multimedia data to UND using the UDP connection. At UND, the multimedia stream is received by the first VLC server which provides two multimedia streams, a webcast/HTTP stream and a multicast/UDP stream (the North Dakota Higher Education Computer Network possesses a block of multicast addresses). Both of these multimedia streams use the same codec as was employed by the laptop. The second VLC server receives the multicast stream and transcodes it producing a Microsoft MediaPlayer compatible webcast multimedia stream. The third VLC server receives the multicast stream and transcodes it producing a MPEG4 Real Time Streaming Protocol (RTSP) multimedia stream compatible with many mobile devices (e.g., smartphones). Experience has shown that when serving N unique (different codecs) video streams it is best to use N unique IP addresses

on N unique servers for stability. Hence, two video streams require two servers, each sending a uniquely encoded stream. Even a dual processor server with dual network interface cards has proven to be unstable when used for this purpose. However, multiple streams using the same codec

has proven to be stable when served from a single computer with multiple network interfaces. Figure 1 depicts the webcasting system.

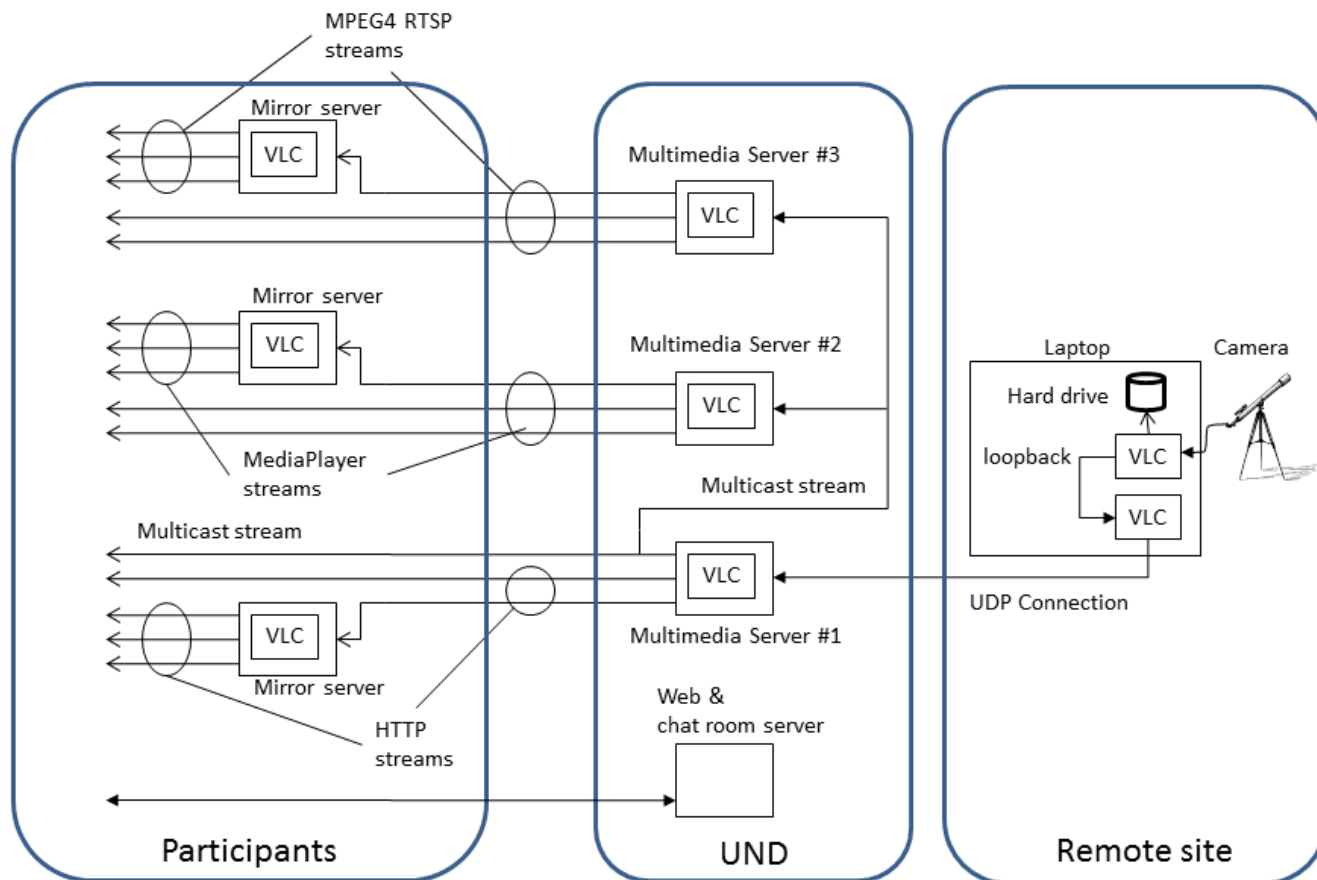


Figure 1. UND/SEMS webcast system

Fortunately, VLC can be easily configured (via command line options or a startup script) to allow mirror sites. Thus, in order to reduce bandwidth requirements at UND, a mirroring scheme has been employed. To date, the SEMs webcasts have been mirrored by Pennsylvania State University (main campus at University Park, and Wilkes-Barre campus), High Performance Computing Research Department at Lawrence Berkley National Laboratory, and Williston North Dakota School District in the United States; Universidad de Sonora in Mexico; and the University of Barcelona in Spain.

Unfortunately, VLC does not provide support for a chat room, presentation slides, has relatively poor web browser support, spotty camera and microphone support and requires unique web browser plug-ins. However, due to its popularity, a lot of people not associated with the VLC project have developed components to extend its capability. For example, JavaScript applications have been written that

allow VLC streams to be viewed on a web browser (IE and FireFox).

To support social interaction [23, 24] and solicit feedback within an open environment like SEMs, the site integrates an online chat room supported by open source JavaScript code. The integration of a chat room provides visitors with an opportunity to become engaged in discussions with UND scientists and fellow viewers at a time of an event. The inclusion of a real-time discussion turned out to be very popular. Therefore, with a little development, the SEMs team was able to create a website with nearly the same look and feel as a commercial package, but that provided the non-commercial features required.

The presence of the blog is another important factor for a website's success. Originally, the SEMs project weblog consisted of postings of daily activities, trials and tribulations of fieldwork, links to local Internet-radio stations and webcams, as well as information about local cultures. The current site design allows readers to comment

on the project blog. The commenting feature was implemented during the August 1, 2008 total solar eclipse webcast that was broadcasted from Xi'an, China. According to Du and Wagner [25], factors that determine the success of a blog include content, the technology used to support the blog, and its social value. The content is the information (written or media) provided. The technology used to support the weblog should be interactive and should be able to present and organize content facilitating social interaction among bloggers [26]. Research has also shown that users prefer blogs that are commented on by other visitors and support social interaction [27, 28].

Once you have arrived and successfully "setup shop" you have to determine how much bandwidth you have. Or more importantly, what is the bandwidth back to the server. While local bandwidth may be very high, there may be a low bandwidth link somewhere between you and your servers. One tool that has proven useful is Speedtest.net (www.speedtest.net) and/or other similar sites (as long as they have a server near your servers). However, the only reliable way to verify what bandwidth you have is to test the stream and to adjust the video and audio data rates (VLC provides this capability) to obtain the best quality of service possible. It helps to have someone monitoring the stream from a location at or near the server and to have them communicate to you regarding the stream quality (the chat room works nicely for this). Unfortunately, there is no obvious formula for determining the best combination of codecs, frame rates, and bit rates. Given the many variables, trial and error is the only real solution.

IV. SCRIPTS

We have developed a set of scripts that allow our system to be used by others, those scripts are listed below:

A. Laptop VLC Script #1

This MS Windows 7 script starts VLC instructing it to accept connect to a Vimicro USB PC Camera and the default audio device. The script then sets the video size to 320x240 with a frame rate of 6 frames per second. The script then transcodes the stream into a mpeg4 (video and audio) stream, sets the bit rates, duplicates the stream for local display, for local storage (filename: "test.mp4"), and broadcasts the stream over the loopback network connection (http port 80).

```
C:\Progra~2\VideoLAN\VLC\vlc.exe -vvv dshow://
:dshow-vdev="Vimicro USB PC Camera (ZC0301PL)"
:dshow-adev="" :dshow-size="320x240" :dshow-
caching=200 :dshow-fps=6.000000 :sout=#transcode
{vcodec=mp4v,vb=3072,scale=1,acodec=mp4a,ab=192,
channels=2}:duplicate{dst=display,dst=std
{access=file,mux=mp4,dst="C:\Users\rmarsh\Desktop\te
st.mp4"},dst=std{access=http,mux=ts,dst=127.0.0.1:80}
}
```

B. Laptop VLC Script #2

This MS Windows 7 script starts VLC instructing it to accept the stream on the loopback network connection and to transcode the stream into a reduced bit rate DivX3 stream. The stream is then displayed locally and forwards it via UDP to UND VLC server #1 (bbbb.cs.und.edu).

```
C:\Progra~2\VideoLAN\VLC\vlc.exe -vvv
http://127.0.0.1:80 :sout=#transcode{vcodec=DIV3,
vb=256,scale=1,acodec=mp3,ab=192,channels=2}
:duplicate{dst=display,dst=std{access=udp,mux=ts,
dst=bbbb.cs.und.edu:1235}}
```

C. UND VLC Server #1 script

This MS Windows XP script terminates any running version of VLC (taskkill) and restarts VLC instructing it to accept a UDP stream addressed to it on port 1235 and to rebroadcast it over multicast (UDP) on IP xxx.xxx.xxx.xxx port 1234 and over http on IP/host name bbbb.cs.und.edu port 80 with a time-to-live of 200. Note that the host name of this machine would be bbbb.cs.und.edu.

```
taskkill /f /im vlc.*
```

```
C:\Progra~1\VideoLAN\VLC\vlc.exe -vvv
udp://@:1235
:sout=#duplicate{dst=std{access=udp,mux=ts,dst=xxx.
xxx.xxx.xxx:1234},dst=std{access=http,mux=ts,dst=bbb
b.cs.und.edu:80}} --ttl 200
```

D. UND VLC Server #2 script

This MS Windows XP script terminates any running version of VLC (taskkill) and restarts VLC instructing it to accept the multicast (UDP) stream produced by server #1 on port 1234 and to transcode and rebroadcast it over mmsh (media player) on IP/host name cccc.cs.und.edu port 80 with a time-to-live of 200. Note that the host name of this machine would be cccc.cs.und.edu.

```
taskkill /f /im vlc.*
```

```
C:\Progra~1\VideoLAN\VLC\vlc.exe -vvv
udp://@xxx.xxx.xxx.xxx:1234
:sout=#duplicate{dst=std{access=mmsh,mux=asf,
dst=cccc.cs.und.edu:80}} --ttl 200
```

E. UND VLC Server #3 script

Like the previous MS Windows XP scripts, this script terminates any running version of VLC (taskkill) and restarts VLC instructing it to accept the multicast (UDP) stream produced by server #1 on port 1234. This script then transcodes the stream into mpeg4 (video and audio) and rebroadcasts it as a Real Time Streaming Protocol (RTSP) on IP/host name dddd.cs.und.edu port 554 with a time-to-live of 200. Note that the host name of this machine would be dddd.cs.und.edu. Finally, we chose not to include this

script at this time as we are still debugging and testing it on the different cell phone provider's systems and their smart phones available.

Note that to use any of these scripts one will need to copy and paste the text into Notepad and save it as a DOS batch file.

V. CONCLUSION

By using a combination of open source software, our own scripts, and a combination of point-to-point and multicast webcast technologies a hierarchical webcasting system that allows many more viewers than would be possible with any single approach has been achieved. A multicast stream over Internet2, primarily for university viewers, and multiple point-to-point streams, for home viewers via the SEMs site and mirror sites, is provided. A similar webcast system could easily be developed by anyone else wanting to produce such live events.

The latest development/usage is for Defense Support of Civil Authorities. For this project video acquired by a UND operated (<http://www.uasresearch.com/home.aspx>) Insitu ScanEagle unmanned aircraft is captured by a computer located in the mobile command center [29-32]. Two instances of VLC are again used to make a high quality local recording and a lower quality transcoded version for streaming. Using a cell phone, the transcoded video stream is then sent to the VLC servers at UND using a User Datagram Protocol (UDP) connection. From there emergency management personnel have access to the video stream via a dedicated website. We have also achieved some success in streaming that video to smart phones (iPhone, Android, etc.) using the Real Time Streaming Protocol (RTSP).

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