Technical Brief ■

Webcasting Videoconferences Over IP: A Synchronous Communication Experiment

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A b s t r a c t A multipoint videoconference was webcast live to an audience who could communicate with conference panelists and each other via chat. The videoconference, webcast, and chat were done entirely over the Internet. Seven panelists at four conference sites that had Internet2 connectivity and were located in different time zones within the continental United States discussed the topic of "Evaluating Health Professions Education and Information Resources on the Web." This discussion was broadcast to individuals and groups at various U.S. locations who had expressed an interest in the topic and had sufficient connectivity for receiving the video stream. Webcast recipients could log on a chat server and type questions and comments to the panelists and other viewers. The experiment's rationale, procedures, and outcomes are described, and issues associated with the use of the technologies are identified.

A multipoint videoconference on "Evaluating Health Professions Education and Information Resources on the Web" was simultaneously webcast in June 2001. Webcasting is the delivery of audio or video over the Internet, either live or on demand, by streaming the data so it can be presented as it downloads. The goals of the webcast/videoconference experiment were to: (1) determine whether it was feasible to conduct an IP videoconference using desktop technology at a small number of sites and simultaneously stream it via IP to a larger audience; (2) explore how other online communications mechanisms such as chat could be used for two-way communication between people viewing the stream and participants in the conference; (3) assess the practicality of offering learning and discussion experiences that marry networked videoconferencing, streaming, and chat technology; and (4) identify issues associated with offering programs that use a combination of synchronous network technologies. The undertaking was motivated by NGI, Internet2, and other initiatives that make it increasingly possible to employ videoconferencing, streaming, and other higher-bandwidth applications to support synchronous distance learning experiences that can complement the asynchronous communication currently dominating the Internet.

Issues associated with the use of synchronous or asynchronous communication in distance learning include the benefits of written communication[1-3] versus real time interaction;[4] the degree to which learning approaches stress problem solving, teamwork, cooperation, and community building can be realized when communication is not immediate;[5] and the degree to which the consistent finding in distance education research that students' value of the presence of a learning group should be accommodated.[6,7] The extent to which classroom learning environments can be replicated at a distance is unknown.[8] Most online synchronous communication currently is equated with messaging and chat,[9,10] whereas more

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robust forms of conferencing and collaboration often are discussed in reference to the future.[11,12] These broader educational issues, however, frame the more modest goals of the current effort in addressing how synchronous learning might be realized using a combination of online video technologies.

Method

Both the videoconference and webcast were done over IP. The videoconference used standard h.323 desktop videoconferencing technology that allows encoding of audio at 48, 56, or 64 kbps (optionally at rates as low as 16 and 8 kbps) and of video at rates from 64 kbps to 30 times greater. The standard also supports the common intermediate format (CIF) and quarter common intermediate format (QCIF) for video. CIF allows individual video pictures (frames) to be sent at rates up to 30 per second (full motion) in a 352×288 pixel window, whereas QCIF has the same frame rate but in a window one-fourth as large. The standard allows varied ways of transmitting data, but the most common is the user datagram protocol (UDP). It is similar to the Internet's TCP/IP protocol but without packet loss checks and retransmission in order to increase the data transfer rate. The h.323 compression standard can be implemented entirely in software, but the use of computer add-in boards, add-on universal serial port devices, or stand-alone systems (videoconferencing appliances) is preferred because software implementations are usually inferior and less consistent. Add-in boards (Escort 25s, the low-end h.323 compliant board from the VCON product line) used in the experiment could automatically adjust bandwidth in the presence of network congestion by dropping frames and preserving the audio. Participating conference sites were able to send data at rates up to 350 kbps, of which 64 kbps was audio, over 100 mbps LANs connected to the Internet2 backbone.

Each site connected to a multipoint conferencing unit (MCU) at the National Library of Medicine that reflected the incoming audio and video from each site to all sites and to a computer that reencoded the audio and video into a streaming format for webcast. Multipoint conferencing, such as the encoding and decoding at the source and destination sites, can be accomplished with hardware or software. A software MCU was used in the experiment running on a computer with dual four hundred megahertz processors and a gigabyte of RAM. Early tests indicated the MCU's performance was comparable to hardware
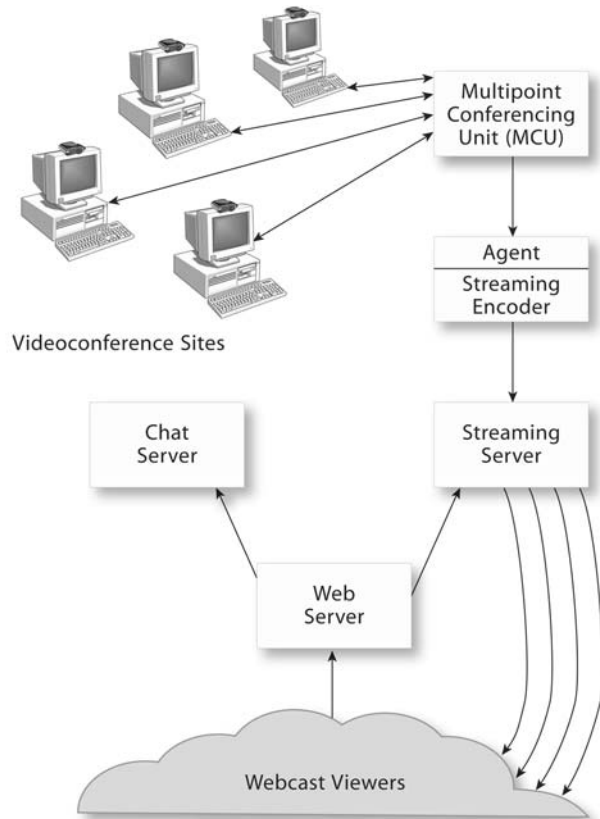

F i g u r e 1 . Webcast technology.

devices. It could be set for voice-activated switching, in which only the site from which audio is being received is reflected, or continuous presence, in which transmissions from all sites are reflected at all times in quadrants of the video window. In the experiment, the MCU was set for continuous presence, a conferencing mode preferred by many because of its similarities to face-to-face meetings. The number of the people in each quadrant ranged from one to three, depending on the site.

"Agent" software installed on a computer with a single 500-megahertz processor and a gigabyte of RAM directed the audio and video from the MCU to streaming encoder software that sent its output to a streaming server. The server had dual 400 megahertz processors, a gigabyte of RAM, and the capacity to unicast up to 60 simultaneous video streams. The videoconference window had to be reduced to 320×240 pixels, and the webcast encoded at 80 kbps for the videoconference and streaming technology to work together. A chat server was used for viewers to communicate and was installed on still another machine, although it did not require much process-

Webcast Questionnaire

1. Did you test your connectivity and chat access in advance of the webcast?
2. Were you able to access the test webcasts or the actual one?
3. Did you participate in the webcast?
   If the answer to question 3 is no, stop.
4. How many other people viewed the webcast with you?
5. Did you encounter any problems other than the audio artifacts that occurred?
6. Please add any comments/criticisms/suggestions that you may have about the webcast.
   If you don't mind being called for follow up, indicate your phone number.
7. Would you be interested in participating in future webcasts and/or conferences?
   If so, what topics and speakers would you suggest?

Questionnaire Results

Total sites responding to questionnaire of the 35 initially participating = 25 (71%)

Number of responding sites testing connectivity in advance = 20 (80%)

Number of responding sites that viewed webcast = 19 (76%)

Number of 19 viewing sites testing in advance = 17 (89%)

Number of 19 viewing sites having more than one viewer = 8 (42%)

Number of viewers at sites with additional viewers = 31 (range from 1 to 9)

Total number of viewers = 42

Number of 19 viewing sites reporting technical difficulties = 4 (21%)

Number of 19 viewing sites commenting on audio/video quality = 8 (42%)

Number of 19 viewing sites indicating future participation = 17 (89%)

Total suggest topics = 17; handheld computers = 5; online evaluation/technology based assessment tools = 4; electronic resource sharing/repositories =3; instructional design and development for online learning = 2; other = 4

ing power. A web server was employed as a portal to the event. Viewers could access a web page and click on different links to download the client software needed to view the webcast, to access chat, and to view the program. The webcast link activated the client that received the stream, and the chat link opened a chat window in a browser. The technologies configured for the experiment are shown in Figure 1.

Thirty-five viewing sites with sufficient connectivity to view the 80-kbps webcast were chosen initially from the 60 responding to the call for participation posted to the American Association of Medical College's MED-ED listserv. The four conference sites tested the videoconferencing and streaming technologies intermittently 1 month in advance. Test webcasts were conducted for the 35 viewing sites in the three days before the webcast. Some sites had difficulty with connecting and others cancelled, reducing the final number of viewing sites to 21 (60% of the 35). All 35 sites originally agreeing to participate were e-mailed an evaluation form (Table 1). Twenty-five returned the questionnaire (71%), including some that did not participate. When sites had more than one participant, the individual organizing the webcast's viewing completed the questionnaire. The results are shown in Table 2.

Results

It is technically feasible to simultaneously stream videoconferences to larger audiences and expand participation by chat, but whether the resulting communication is "synchronous" is debatable. Participants in the conference could communicate in real time, but the webcast stream was subject to a two-minute delay. Webcast viewers did not notice the delay, but it was obvious to conference panelists, especially when they requested audience input. Panelists could compensate by returning to previously covered topics and elaborating on topics while waiting for a response.

There were dramatic differences in the quality of service experienced by those in the conference and those viewing the webcast. Not only was the webcast subject to latency, its frame rate (1–2 frames per second) was much lower than that of the videoconference (15–30 frames per second). Consequently, some webcast viewers reported that it was often difficult to determine who was speaking. While the low frame rate may have been adequate for the panel discussion in the experiment, it is insufficient for other content. Disparities inherent in the videoconferencing and streaming formats may need to be taken into account. Videoconferences tend to be informal exchanges among colleagues, whereas webcasts tend to be more formal, with production qualities similar to television broadcasts. Webcast (and broadcast) viewers are more accustomed to seeing one image that fills the screen at a time, not the "Hollywood Squares" effect that resulted from the use of continuous presence. Voice-activated switching may be a preferable videoconference mode when combined with webcasts and would have helped viewers determine who was speaking. Placards and other production devices may have added formality.

There was a remarkable tolerance for technical problems. Failure of some sites to access the test webcast, initially ascribed to possible bandwidth limitations at receiving sites, actually was caused by the coincidental implementation of a firewall at NLM during the week of the webcast. A combination of the protocols used by the streaming server to transmit data when firewalls are encountered and the way in which local networks were configured to receive streams made it possible for some to access the webcast, whereas others could not. Although some viewing sites noticed differences in picture quality from the conference site using a higher-quality camera, only 21% of those viewing the actual webcast reported technical problems (mostly related to video and audio artifacts). This tolerance may have been due to generally low expectations for video quality over the Internet, the fact that webcast viewers were not aware of the discrepancy between the quality of the conference and the webcast stream, or the fact that they understood the webcast was an experiment.

There was more management overhead than expected. The time required to control access and obtain audience feedback was anticipated, but the time needed to screen applicants who misunderstood the technical requirements and to troubleshoot problems was not. The cognitive load experienced by panelists, who had to manage desktop conferencing technology and attend to the lagging chat dialog while also participating in the discussion, also was unforeseen.

Discussion

The experiment demonstrates that webcasting and chat can be used in conjunction with videoconferences over IP to expand participation in online events and distance learning experiences with some latency in synchronicity. The quality of the webcast is sufficient for panel discussion, but might be improved by changing the videoconference format to a voice-activated format more compatible with webcasts, upgrading camera and microphone quality on desktop videoconferencing units, and other factors in the conferencing environment. Distributing responsibility for attending to the technology and chat (e.g., by assigning it to some one who is not a panelist) and using a moderator to intersperse questions and comments from webcast viewers into those generated by conference participants would reduce cognitive load and mask some of the latency effects.

Streaming and videoconferencing over IP are becoming routine, but it is not possible to determine from the experiment whether conjunctive use of the two technologies is robust enough for others to adopt. The fact that 17 of the 19 participating webcast sites said that they would participate in future webcasts and went so far as to suggest possible discussion topics indicates at least an interest in further investigation of combined use.

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