MBone Virtual Classroom for Engineering Distance Education

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Abstract - *The College of Engineering has completed a pilot project to deliver courses to remote sites via the Internet Multicast Backbone (MBone). The MBone was officially established by the Internet Engineering Task Force (IETF) in July, 1992, as a vehicle for developing real-time multimedia standards for the Internet. The basis of the MBone is the IP-Multicast protocol, which allows the establishment of group sessions with any number of participants. Content is effectively broadcast to all members of the group session simultaneously, creating the effect of a multimedia "party-line" in which all participants are virtually co-located. A good source of background information about the MBone is the "MBone Information Web" [1].*

MBone Features for Distance Education

There are several compelling features of the MBone for delivery of distance education:

Content richness. MBone-based delivery provides the capability to take advantage of the full multimedia capabilities of the computer; delivering audio, video, and data simultaneously. This allows much greater possibilities for content; e.g., shared whiteboards and other applications, than does traditional video.

Interactivity. The MBone is a peer-oriented network. Each participant has equal ability to send and receive content. This allows for a much higher degree of

interactivity than broadcast delivery mechanisms, which are essentially one-way.

Efficiency. In traditional video-based distance education, very high quality video transmission is required so that the detail of graphical information is preserved. The NC-REN video network, for example, transmits broadcast-quality video using a bandwidth of 40Mb/s. Through compression techniques such as MPEG-2 this can be reduced to about 6-8Mb/s. MBone, however, allows computer-generated text and graphical information to be delivered in its canonical form, thus requiring orders of magnitude less bandwidth. A typical MBone session uses less than 150Kb/s of network bandwidth.

On-demand access. Access to traditional videoconference or broadcast networks typically requires scheduling well in advance. This does not lend itself well to educational workflows, which often require short term scheduling ("I'm going to hold a special help session tonight for those of you who are having difficulty applying Kirchoff's laws...") or even spontaneous conferences among class participants. MBone is suitable not only for lecture delivery, but also for office hours, help sessions, one-on-one conferences, and group meetings.

Low cost. Participating in an MBone session requires a multimedia computer and facility with a network connection of T-1 grade or better. (A lower speed connection is satisfactory if there is no other traffic on the network, but this is not the typical case.) This is in contrast to traditional videoconferencing systems, which cost upwards of $50,000.

Sparse delivery. Delivery of specialized courses (in our case, discipline-specific engineering courses) often result in a sparsely distributed audience. There may be only one or two students in each of several remote locations who wish to subscribe to a particular course needed to complete a degree program. Broadcast systems (e.g., satellite, ITFS, or cable) are well suited for delivery to large sparsely distributed populations, but not for small populations. IP-multicast is much more practical in this situation, since bandwidth is consumed only on those segments of the network which interconnect the participants.

Extensibility. A good number of MBone applications have been developed for a variety of platforms (see http://www.mbone.com/mbone/mc-soft.html). Because the system is software based, it is relatively straightforward to extend or adapt the MBone applications to individual program needs.

NC State MBone Pilot Project

Under sponsorship of NSF through the Southern University and College Coalition for Engineering Education (SUCCEED), NC State has been experimenting with computer-based conferencing technologies for the delivery of distance education. A number of commercial and non-commercial tools, both Internet-based and ISDN-based, have been evaluated. It was found that for the purpose of delivering live courses, a combination of tools from the MBone application suite was most satisfactory. These include *sdr* (the MBone session directory), *vic* (videoconference tool), *vat* (visual audio tool), *wb* (shared whiteboard), and WBIMPORT (the whiteboard import tool). For multi-point delivery, IP-multicast was found to be more satisfactory than ISDN-based conferencing, which requires the use of a special multi-conferencing unit (MCU) for multi-point conferences. In addition, the excellent network infrastructure in North Carolina (NC-REN and NCIH) tilted the scales in favor of IP-multicast. Details of the setup and initial experiments can be found in Chapter 4 of Leigh Anne Rettinger's master's thesis [2].
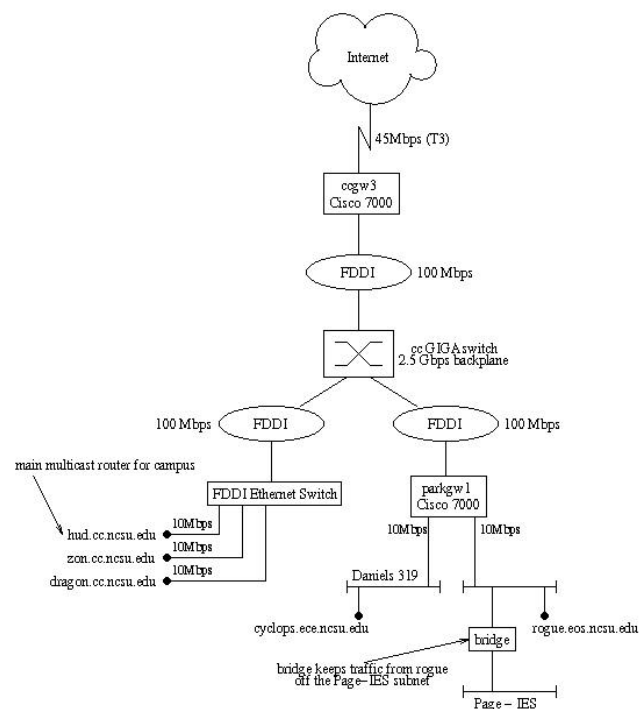

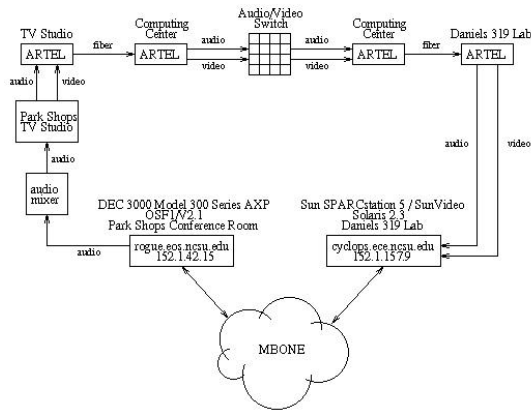*Figure 1. NC State MBone connection topology.*

Figure 2. Audio/video data flow for NC State MBone pilot projects.

During the Fall 1996 semester, the MBone was used to deliver two courses originating from NC State to students at UNC-Asheville [3]. The two courses were ECE 212, a sophomore level electrical and computer engineering course, and IE 544, a graduate level industrial engineering course. Lectures in ECE 212 were delivered to Asheville students with traditional broadcast quality video over the NC-REN video network, with office hours for the remote students held on the MBone. Students in ECE 212 were participants in the 2+2 engineering degree program, a highly successful joint program between UNC-A and NC State in which students complete the first two years of a four year engineering degree at UNC-A and transfer to NC State to finish the degree. IE 544 was delivered to Asheville students entirely via the MBone, and to an additional group of distance students by videotape. Both courses were delivered live to students at NC State.

Figure 3. Mbone videoconference tool (vic) with Professor Mirka at NC State and students at UNC-A.

In addition to using MBone for live interaction, both courses were set up with "course lockers" (shared file space) on the College of Engineering's Eos computer network. All materials for the courses were kept in their respective course lockers, thus were equally accessible to the students at Asheville and NC State. In addition, the lecture notes were placed in the course locker before each lecture so that the students could preview or print them. The MBone whiteboard has an import facility so that the lecture notes could be loaded onto the whiteboard and used like a "slide show" during the course of the lecture. The instructor can access the slides in sequence or randomly. In addition, the instructor can mark on the slides as they are being discussed, or ask a student to do so. The combination of the whiteboard tool (*wb*) and the audio tool (*vat*) turned out to be the most important components of lecture delivery.

Figure 4. The Mbone Whiteboard (wb)

The response of both the students and faculty to MBone delivery was very positive with a few exceptions. Equipment failures caused delays on several occasions. Also, IE 544 is an ergonomics course in which the instructor often has demonstrations or "labs" where certain motions are demonstrated. The low resolution, low frame rate video was sometimes a problem when rapid motion demonstrations were involved. In spite of these difficulties, students at UNC-A overwhelmingly preferred this interactive mode of delivery to the videotaped lectures which they were accustomed to. A complete evaluation of both the educational effectiveness and the qualitative perceptions of both faculty and students in the pilot project is found in [4].

Ongoing Activities

Funding was obtained from the North Carolina State legislature to initiate two additional 2+2 programs modeled after the program at UNC-A. The funding included a significant distance education component, which is being used to develop an MBone classroom at NC State which will be used to deliver courses to the three 2+2 sites. Workstations will be set up at the remote sites as extensions of NC State's Eos network so that students at the remote sites can access course materials and other university information, and communicate with faculty, staff and other students by e-mail just as if they were resident on campus.

A graduate level distance education facility is also being developed for NC State's new Engineering Graduate Research Center (EGRC). This facility will also be set up for MBone course delivery as well as traditional video classes.

Two senior design projects in electrical and computer engineering were set up to work on system enhancements deemed highly desirable in the first phase of the pilot project. These include a system for "electronic hand raising" to directly address recommendation #4 in Dr. Brawner's evaluation report, and interfacing a touch-sensitive physical whiteboard to the MBone electronic whiteboard to allow instructors to teach on the MBone in the traditional manner to which they are accustomed while retaining the benefits afforded by the networked electronic media. These capabilities and other enhancements have been incorporated into DETA, the "Distance Education Teaching Assistant."

DETA was developed to provide a "wizard" style front end to the set up of an MBone session for classes and office hours. With DETA, a teacher or student with very little knowledge of the MBone tools can establish and run a session with ease.

As of the spring 98 semester, a total of seven courses (four undergraduate, three graduate) have been delivered to students in Asheville using the MBone Virtual Classroom. The two new 2+2 sites will come on line in the fall 98 semester. In addition, a new BS degree program in mechatronics has been established at NC State, which will be delivered to students in Asheville using a combination of MBone and other technologies.

Future Work

The first phase of the Mbone pilot project has clearly indicated the potential for this technology to be a highly effective means of synchronous distance education. The MBone tools can wholly or partially satisfy many needs of the college-level education workflow, including lecture delivery, faculty office hours, conferences and help sessions, and student group collaborations. However, the pilot project has also identified shortcomings of the technology which must be addressed. These and other issues for future work are outlined below.

Quality of Service. As discussed above, the two most significant negative aspects of the pilot project from the perspective of the remote students were equipment failures and limitations on video quality during certain demonstrations. These can both be considered user-level quality of service issues. Robustness of the hardware, software, and network will be critical importance if this technology is expected to work at the scale of multiple courses delivered concurrently to many remote sites. The issue of video quality translates directly into network QoS paradigms. A network infrastructure model which supports definable levels of audio and video quality to meet the particular needs of the material being presented will be required for a successful NBE system.

Transparency. The human/machine interface must be such that the machine is as transparent as possible, thus allowing the humans to communicate in an unencumbered fashion. It is clear from the pilot project that this is an area for considerable improvement. It is somewhat unnatural for an instructor to try and draw with the mouse on the MBone whiteboard while explaining a concept, for example. Although Dr. Mirka was able to largely overcome this distraction with some practice, it will be difficult for many teachers to master. The correct approach is not to force the human to adapt to the technology, but rather to adapt the technology to

the human. (This is the philosophy behind one of the senior design projects mentioned above.) The DETA interface described above was designed to match the needs of the teacher and student during an MBone session and to hide the complexity of the MBone tools. It has proven to be a very significant step in the direction of transparency.

Issues of Scale. Although multicast technology has been employed in this project, most of the interaction has been point-to-point. As such, it has been possible to have continuous bi-directional video streams at all times. This will not be feasible, however, when more than two or three sites are included in the session. NC State's long term distance education plans include expansion to a number of community colleges to provide broad geographic coverage and enhanced educational opportunities for students in remote areas. Work must be done to look at the human factors involved when communicating over a large number of sites. The human factors must be translated into a set of parameters for the network and software to natural interactions under these conditions.

Laboratories. NC State's long-term plans for distance education include the delivery of complete BS degree programs to remote students. One of the most difficult technical barriers to overcome will be the provision of laboratory courses to the distant students. Both of the courses delivered thus far in the pilot project have had some type of laboratory component. It is clear that this is one aspect of the education workflow that does not translate easily to a distance mode of delivery. On-site facilities and personnel can solve the problem, but this may not be practical for a sparsely distributed population of students. Other approaches must be investigated. Interactive networked multimedia combined with virtual reality technologies hold some promise. For these approaches, issues of network QoS requirements as well as the human/machine interface need to be studied.

References

[1] Kumar, Vinay, "The MBone Information Web," **Error! Bookmark not defined.**

[2] Rettinger, Leigh Anne, *Desktop Videoconferencing: Technology and Use for Remote Seminar Delivery*. Master's Thesis, North Carolina State University, 1995. **Error! Bookmark not defined.**

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[4] Brawner, Catherine E*., North Carolina State – Fujitsu Network Based Education Project: Course*

Evaluation Report. Technical Report, North Carolina State University, 1997. **Error! Bookmark not defined.**