A Multi-University Internet-Based (H.323) Graduate Course in Turbulence, Part II: Technical Description

Lisa Stephens[1], **Elizabeth Fellendorf**[2], **James Whitlock**[3]
Honglu Wang[4], **Hui Meng**[5], **and William K. George**[6]

[1] *Millard Fillmore College, State University of New York at Buffalo, Buffalo, NY, USA http://www.mfc.buffalo.edu*
Tel: 716-645-6522, fax: 716-645-7983 stephens@buffalo.edu [2]*Tel: 716-645-6347, eof@buffalo.edu*
[3] *Computing and Information Technology, State University of New York at Buffalo, Buffalo, NY, USA http://www.wings.buffalo.edu/~whitlock*
Tel: 716-645-3060, whitlock@buffalo.edu
[4] *Post Doctoral Associate, State University of New York at Buffalo, Buffalo, NY, hw4@eng.buffalo.edu, 716-645-2593, ext. 2322*
[5] *Mechanical and Aerospace Engineering, State University of New York at Buffalo, Buffalo, NY USA*
Tel: 716 645-2593 ext. 2300 huimeng@eng.buffalo.edu [6] *Tel: 716 645-2593 ext. 2323 trlbill@eng.buffalo.edu*

Dan Dullea[7] **and Mark N. Glauser**[8]
Clarkson University, Potsdam, NY USA
[7] *Tel: 315-268-2292 ded@clarkson.edu,* [8] *Tel: 315-268-6683 glauser@clarkson.edu*

Evelyn Smith[9], **William Hayes**[10] **and Luciano Castillo**[11]
Rensselaer Polytechnic University, Troy, NY, USA http://www.rpi.edu
[9] *Tel:518-276-8461 smithe2@rpi.edu,* [10] *Tel:518-276-8472 hayesw2@rpi.edu,* [11] *Tel: 518-276-4892*

Sharon Hoshida[12] **and Peter Koritschan**[13]
University of California at Santa Barbara, Santa Barbara, CA, USA http://www.ucsb.edu
[12] *Tel 805-893-8694 hoshida@id.ucsb.edu* [13] *peter@umail.ucsb.edu*

David Shurtleff[14] **and Ricke Casterlin**[15]
State University of New York at Binghamton, Binghamton, NY USA http://www.binghamton.edu
14 Tel 607-777-6954 shurtlef@binghamton.edu, 15 Tel: 607-777-6958 rcaster@binghamton.edu

Daniel Ewing[16]
McMaster University, Hamilton, ON, Canada http://www.mcmaster.ca
Tel905-525-9440 ext: 27476 ewingd@mcmaster.ca

Abstract: This paper summarizes our experiences regarding the academic, technological and professional support involved in teaching a multi-university graduate course on the fundamentals of turbulent flow. Particular features of interest include the manner in which an Internet-2 (H.323) high performance videoconference link was incorporated with an ISDN (H.320) videoconferencing link. The course was a cooperative effort with faculty and professional support staff from five participating institutions. This paper describes pre-production planning, the utilization of Internet 2 as a solution to incompatible ISDN networks, a description of necessary hardware, cost-benefit issues and student reaction. The academic and pedagogical details of this innovative class are described in a paper at this conference by Wang, et al [1].

Keywords: distance learning, students and teachers mobility, applications of new communication and information technologies in teaching and learning, turbulence

1. Introduction

This paper, together with the companion paper by Wang et al., describes a multi-university Internet-based (H.323) graduate course in turbulence involving five institutions. The paper by Wang et al. focuses on the pedagogical issues, while this paper summarizes our experiences in technical planning and supporting this course.

2. Description of the Problem:

SUNY at Buffalo Professor William K. George accepted a semester-long research invitation to the NSF sponsored Institute for Theoretical Physics (ITP) at the University of California Santa Barbara. In order to minimize disruption to his department's teaching needs, he approached the authors about the possibility of teaching his Turbulence class via videoconferencing technology back to his home students in Buffalo, as well to students at other universities in an experimental co-teaching format. By prior arrangement with faculty at the other institutions, it was determined that we would need to accommodate two live classroom hours per week, with a third hour being taught locally at participating institutions.

3. Pre-Production Planning

The first pre-production planning tasks included coordination of facility and personnel schedules, Y2K compliance and equipment compatibility testing between five universities. This in and of itself was a time consuming process, and it was important to convey as much information as possible up front. This included relevant course start, end and vacation dates; as well as support personnel contact phone numbers (pagers, email, cell phones) and site contact information (ISDN numbers, conference room phone and fax numbers). Gathering this information early became very useful as the project progressed. When contingency plans needed to be implemented, valuable time was not wasted chasing down contact information.

Initially it was expected that all sites would be connected using H.320 ISDN default standard connections. SUNY participates in a state contract with AT&T that enables discount ISDN rates for PRI (Primary Rate Interface) telephone connections and usage. In order to achieve the most cost-effective rates, each site was required to connect through the AT&T digital network. Though UB is not constrained to a PRI private network due to an innovative design change by co-author Whitlock, in practical terms, this network is most easily identified by a 700 number area code in the dial string.

UB does not own an H.320 ISDN bridge, so we typically sub-contract with SUNY Binghamton to provide bridging and technical support services. Test connections were intentionally delayed until after the beginning of the year due to Y2K compliance concerns. Initial testing revealed no difficulty originating ISDN connections from Binghamton's bridge to RPI, UB and Clarkson. The first difficulty encountered was when we realized that just as SUNY enjoyed discount rates with AT&T, so too did UCSB with MCI. This presented an incompatibility problem where UCSB could not communicate directly with the Binghamton bridge, nor could the bridge initiate a direct call into UCSB. Several phone calls later, two independent commercial telecommunications vendors provided quotes for gateway services that would interconnect network data between MCI and AT&T solving the incompatibility issue, but unfortunately, the cost was prohibitive and the project was in danger of not moving forward unless another solution could be found.

4. The Internet 2 Solution

During December 1999, UB was actively conducting high performance H.323 videoconferencing tests with Stanford University utilizing a point-to-point Internet 2 connection in preparation for a comparative literature class. The general vision was to establish a connection that would allow for file sharing if necessary, yet maintain the integrity of a connection nominally equivalent in quality to a 384 Kbps ISDN connection. Initial testing, using industrial grade television production equipment contained in rolling carts at both sites, proved promising. The advantage of this approach is the ability to videoconference from nearly any classroom to any other site(s) by plugging into a data port without the capital and recurring costs of ISDN lines in dedicated distance learning classrooms.

Hundreds of personnel hours were invested in testing an Internet 2 solution by a resident group of developers at UB headed by Jim Whitlock. It would be beyond the scope of this paper to detail all of the steps and coordination necessary to resolve network engineering issues, however we will describe the solution of what worked in a production application. People interested in a more detailed account of the Western New York High Performance Networked Video Initiative spearheaded by Whitlock are encouraged to contact him directly at whitlock@buffalo.edu.

In order to take advantage of the I2 network solution, it was necessary to first diagnose path impairments between UB and UCSB. NetTach software, one of the most effective path impairment measurement tools, was provided by PictureTel and installed on both the UB PC and Professor George's laptop to determine whether the transmission would be within acceptable standards. Once the path was found to be acceptable, an outboard PC with

the necessary hardware was used as a telecommunications coupling device between the sites. UB and UCSB were linked through Internet 2 using the ITU H.323 standard. A scan converter on the output of the H.323 PC translated Professor George's signal into a regular composite video signal which was routed through the UB distance learning control room to a switcher, monitors, recording decks and a VTEL TC2000 ISDN CODEC. The switcher, a relatively inexpensive Panasonic MX-50 enabled us to record Professor George picture-in-picture with the receive sites. This enabled archiving the entire class experience to videotape, rather than Professor George's transmission alone. Clarkson or RPI were received by Binghamton's bridge through voice activation, triggering the bridge to automatically switch to the site where participants were talking. Typically all sites kept their microphones muted until a natural pause in the lecture, when Professor George would ask each site if they had any questions. If a spontaneous question arose, a facilitator (student or faculty member) at that site would un-mute their microphone and ask the question, though the system delay in audio would cause some initial confusion (see figure 1).

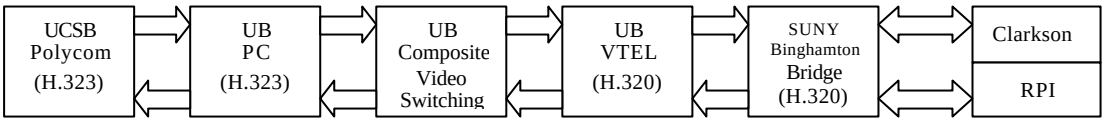

Fig. 1, Communications connection pathway between UCSB, UB, Binghamton, Clarkson and RPI

5. PC Hardware Required for IP Transmission

The heart of the PC that enables these connections is the H.323 CODEC card, in this case a Zydacron Z-340. Zydacron builds and distributes original equipment manufacture (OEM) parts to several high quality videoconference manufacturers (http://www.zydacron.com). It moves all of the videoconference compression and decompression processing power to the board, freeing the rest of the host computer resources (processor, memory, etc.) available for file exchange. The bulk of Jim Whitlock's early investigative efforts in creating a low-cost videoconference desktop solution were spent testing how "off the shelf" components would reliably interface with the CODEC. Given that most of his development efforts were targeted toward telemedicine applications, reliability and user interface issues were a priority concern. The guiding principle became that when specifying computer components for in-house assembly, use only the "best of breed, highest market penetration boards with no OEM variations." This principle is more critical than general hardware processing speed specifications, etc. from commonly purchased computer manufactures. This meant that nearly any Pentium class computer running Windows NT with Intel motherboards and network interface cards would reliably work with the Z-340 CODEC. A Western Digital hard drive and ATI graphics card with 8 Mb RAM minimum is also recommended along with a CD ROM. Whitlock produced a second stand-by pre-formatted removable hard drive with mirrored configurations as part of our contingency plan to be kept near the PC in case of system corruption or gross hard drive failure. The cost of this PC system with the Zydacron board (excluding SVGA monitor) was approximately $3,000 USD. This of course did not include the cost of any of the fixed distance learning classroom hardware such as microphones, cameras and distribution hardware. Our system designs are now available through ViewCommunications, a long-standing supporter of Whitlock's development efforts (http://www.viewcom.com).

At UCSB, Sharon Hoshida had access to a Polycom 512. Polycom is arguably the current leader in videoconferencing appliances. The difference between an appliance and a PC solution is that an appliance can not accommodate application sharing, file sharing, or ancillary supportive PC-based applications in the same system. This was not an issue, however, as none of these functions were required between Professor George and the remote sites. The Polycom is a small television-top unit with built-in camera and remote control. There are also several auxiliary ports available for plugging in outboard devices such as a VCR, laptop for PowerPoint presentations or a graphics camera or tablet. Since UCSB had already migrated most of their campus over to Internet 2, we had immediate success when connecting point-to-point with Professor George. For more information on Polycom products, see: http://www.polycom.com.

6. Discussion of Support Issues

Compared with supporting other distance learning classes, the process of integrating H.320 with H.323 transmissions was at times both exciting and frustrating. It's quite possible that once the hardware and scheduling issues were resolved the entire project may still have fallen apart had it not been for the unique set of dedicated personalities that were committed to the project.

From the perspective of the technical staff supporting the effort, the first problem encountered was a constant "whooshing" sound in the audio. We later determined that the H.323 signal from UCSB was being re-entered through UB's internal path, causing a low-level feedback loop. We thought that this was contributing to the bridge behaving erratically, as participants at Clarkson were frequently reporting seeing RPI instead of Professor George during his lecture. This problem was confounding in nature, as it was intermittent and did not reliably replicate during subsequent testing. Dave Shurtleff narrowed the problem to a bridge voice activation issue caused by software incompatibility between PictureTel videoconference units and the VTEL manufactured bridge. Individually muted sites were being received and interpreted by the bridge as active, causing the last muted site to remain the active site sent to the H.320 connected sites. A software patch resolved that very distracting problem, yet it was unrelated to the H.323 link and was speculated to have been a minor Y2K glitch.

There were several occasions when the H.323 link mysteriously dropped, but was quickly re-established in Buffalo. On one occasion, the entire UCSB campus network was experiencing problems which led to Professor Castillo delivering the lecture at the last minute. On another occasion, software and hardware changes made over the spring break in the Buffalo control room led to an operator interface error, resulting in loss of audio from UCSB, which was corrected after more in-depth troubleshooting during the class. During that incident, Professor Glauser was able to lecture the content using Professor George's notes as a guide, demonstrating the merits of having contingency plans for all anticipated failures when the unexpected occurs. Problems notwithstanding, the quality of the H.323 connection was comparable to that on the H.320 ISDN link. It is critical to recognize that the majority of technical failures were not the result of any specific single point of technology failure, but rather a combination of human error, random events, and overall system complexity. There were no equipment failures within the fixed distance learning classroom infrastructure, which reinforced that the main classroom design was robust and flexible enough to handle the complexity imposed on it with this project. For more information about distance learning classroom design and support by Audio Video Corporation, see: http://www.audiovideocorp.com/

Figure 1 illustrates the send and return path of the transmission with Professor George as the host content originator. This is not entirely accurate where the Binghamton bridge is concerned. If for a moment, UCSB is ignored --UB, Clarkson and RPI would all be connected and interacting through the Binghamton bridge. Part of basic bridge design is that an active (voice activated) site never sees themselves on the return path. For example: UB students never see themselves reflected back in the television monitor from the bridge, nor do Clarkson students ever see themselves, etc. As far as the bridge is concerned, it never directly "sees" UCSB, it only receives whatever is being fed to it from the UB control room. UCSB is treated as an external feed into the UB control room, much like any other external selectable source: a VCR, graphics camera, computer or auxiliary camera feed. This presented a fundamental handicap for Professor George. He always saw the return ISDN feed from Clarkson or RPI as if he were a UB student in their local classroom. Thus, he never saw his UB students. The switcher enabled us to feed a picture-in-picture of Professor George and the UB students to the remote sites as a selectable source, so RPI and Clarkson students recognized the UB classroom whenever they are selected by Beth Fellendorf during the class. A sub-switcher on the return path would have resolved this difficulty. However, Professor George claimed he was familiar enough with his home base of graduate students and was able to recognize their voices most of the time. Overall it was not a major handicap, but it would have been a problem had the students in Buffalo ever been required to visually present material back to Professor George. In this event, an alternative contingency plan was formed to add an another UB distance learning classroom to the bridge, but was never implemented in order to save bridging costs.

The only major operational flaw was the audio path being looped through Buffalo back to remote sites during a question and answer period. This is a configuration problem due to lack of additional equipment. In order to capture the comments from both sides of the transmission on to a single tape, it was necessary to always leave the audio path open from all sites. When a remote site activated their microphones, they heard their own comments coming back with a delay, causing some confusion.

7. Cost – Benefit Considerations

The advantages of student access to fellow students and a variety of professors, including interviews with visiting researchers from the Institute of Theoretical Physics are obvious. Networking and establishing relationships is an important part of academic development. When examining the cost/benefit ratio of this experimental class, a tight set of criteria needs to be developed in order to evaluate whether the expense and effort is beneficial. Any tuition

generated was retained by the participating institution. The ISDN telecommunications and bridging costs were shared equally between the three New York sites. Professor George was responsible for expenses incurred at UCSB (approximately $1,300) and each remote site was responsible for their own technical support personnel and facility charges. If this class had been conducted through a commercial teleconference provider, the bridging and telecommunications costs would be an estimated $5,200-7,000 USD. Though at the time of this writing the Binghamton bridge invoice has not been received, the total estimated costs of conferencing through the SUNY bridge for line charges and technical support are estimated at less than $2,500. On that measure the course is a bargain, albeit based on marginal costs that presume use of existing infrastructure and personnel. If UB had their own H.320 bridge, the usage costs would be less, but the capital expense would not likely justify the investment at this point, as it is anticipated that newly developed hardware will soon be able to bridge both H.323 and H.320 signals effectively within a year.

8. Student Feedback and Evaluation

Of the students who both participated in Professor George's experimental turbulence class and attended the 1,000 Islands Regional Fluids Conference (http://www.mech.mcmaster.ca/~ewingd/1000_islands), all filled out short surveys and participated in a panel discussion that was recorded for later qualitative analysis. This free-form discussion among fellow students and faculty who did not participate in the class provided a surprising amount of lively discussion, generating valuable feedback both formally and informally.

All of the students present at the conference expressed being pleased with the class experience in spite of the occasional technical glitches. Many of the concerns expressed had less to do with the technology than with concerns about material distribution and understanding how to best prepare for each lecture. Many of the suggestions were insightful and meritorious, such as establishing the connection 15 minutes in advance of the scheduled class start time (thereby minimizing any time loss to the students if connection difficulties occurred). This unfortunately was not possible due to room use at UCSB prior to the start of each turbulence class. In the thirty question survey, none of the students characterized technical problems as "frequent" (choosing instead "occasional" or "rare") and all of the students indicated that as the semester progressed the quality of the technology "got better" (rather than "got worse" or "was neutral"). The students appeared to have an appreciation of the magnitude of what was accomplished in consideration of the minimal amount of preparation opportunity for both the instructors and technical support personnel.

9. Summary and Conclusions

Distance learning technology, regardless of the transmission modality, offers students and faculty expanded pedagogical opportunities. In the synchronous format of this class, aided by asynchronous web pages from RPI, the benefits to both the faculty and students are a qualitative and quantitative advantage. One of the more memorable comments made during the course evaluation was by a faculty member who said, "forget about the fancy technology, the reality is that we had some good old fashioned cross-university competition going on. The quality of the work that students submitted from the beginning of the semester toward the end of the semester showed the largest quality of student work gains that I've ever seen." What is impressive about that comment from an administrative support point of view is that the technology was transparent enough to allow affective communication to flourish in spite of the geographic dispersion of the participants. The final observation is that just as academic networking is necessary to advance scholarly research, it is an equal imperative that professional support staff have the opportunity to engage in these types of multi-institutional activities to expand their knowledge and expertise.

10. Acknowledgements

We gratefully acknowledge the willingness of the students and faculty members to work closely and constructively with the technical support staff members at each of our respective institutions. One point that everyone agreed upon was that this class succeeded in large measure because of the dedicated attitude each professional brought to the project. We also acknowledge the early adopter efforts by the Western New York High Performance Video Initiative. This class could not have been realized without the on-campus expertise acquired as the result of that initiative.

[1] Honglu Wang, et al, "A Multi-University Internet-Based (H.323) Graduate Course in Turbulence, Part I: Academic Description", ICEE 2000, Taipei, Taiwan, August, 2000