H.323 Applications In the Classroom:
Use and Implementation Issues

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Abstract

H.323 is the standard that enables audio, video and data communications across IP-based networks, of which the Internet is the largest. The driving force behind this International Telecommunications Union (ITU) standard is to provide the before mentioned services with products from any mix of vendors without concern for compatibility. These products may be hardware or software.

Of primary concern in this paper is the integration of products such as desktop cameras and microphones with applications such as Microsoft's NetMeeting to facilitate distance education. Several aspects that are usually not clear to the new user with such implementations are the techniques for connecting multiple users, getting the data through firewalls and making the most of available bandwidth, all of which this paper discusses.

This paper will also present the user with several implementation options for two-way video desktop conferencing over the Internet using hardware devices such as Coders/Decoders (CODECS), software applications such as NetMeeting and conferencing sites such as Internet Locator Servers (ILS servers).

I. Introduction
H.323 is an International Telecommunications Union (ITU) standard for multimedia applications with connectivity over Local Area Networks using the Internet Protocol (IP)[1]. It is designed to provide interoperability between software applications and hardware from vendors whose products comply to the standard. Hardware and software that comply to this standard provide the user with an extremely powerful set of tools to allow audio/video conferencing and even application sharing.

The purpose of this paper is to discuss how this technology can be used in the classroom with emphasis given to distance education. In addition to distance education topics, this technology can be easily adapted to provide instructors with many other benefits such as virtual office hours.

II. What is H.323
H.323 provides a single standard for audio and video communications over the Internet. Realizing that the Internet has no guarantee of Quality of Service (QoS) it would be considered a

best effort protocol, but as Internet bandwidth becomes cheaper and speeds continue to increase, the quality of this service can be expected to dramatically improve.

H.323 hardware and software applications provide a means for two or more participants to communicate audibly and visually using computers. There are several ways to deploy H.323 communications with the simplest being point-to-point (2 participants). Multipoint teleconferences (more than two participants) can also be created, but there are usually additional steps that must be followed.

III. H.323 Classroom Applications
This is an extremely cheap technology to use. In it's simplest form, the only cost associated other than the purchasing of a camera and microphone is the monthly service charge for Internet service. Since most users already have Internet service, there should be no cost impact. Here are some of the possibilities for this technology:

     A. Courses delivered to remote sites via two-way video can easily be adapted to also be sent live via the Internet.
     B. With the addition of a few pieces of hardware, an instructor can deliver a class live over the Internet from any location with an Internet connection.
     C. Office/contact hours can be expanded to the concept that the instructor does not have to physically be in his/her office. The contact can occur between student and instructor live over the Internet.
     D. Project groups can be set up to collaborate via the Internet. Project meetings, status reports, etc. can occur with students from several different remote sites.
     E. Application and computer sharing can occur via this technology. This means that a computer can be remotely controlled (with some caution).
     F. Through the use of Gateways, users can connect to conferences using different communication protocols such as ISDN and the Plain Old Telephone System (POTS). Yes, this means that a person can use a regular telephone to dial-up a connection to participate with an H.323 teleconference audibly.

IV. Point-to-Point Connectivity
This by far is the simplest form of H.323 implementation. This is the type of connectivity between two computers that an instructor could expect when teleconferencing with an individual student. All that is required for this connection is a video camera, a microphone and an H.323 software application such as Microsoft's NetMeeting[2] or CUseeME Networks[3] CUseeMe Pro software. In order for two computers to communicate via this setting, the IP address of each machine needs to known. This is acceptable for machines that have static IP addresses assigned, but what do we do when the addresses are assigned dynamically (DHCP)? Dynamic IP addresses assigned to the computers can change each time we log onto the network, making it impossible for the two machines to find each other. It would be like having your telephone number change each time you picked up the phone. Well, there are a few options here:
     A. The participants determine and exchange the IP addresses of their computers before each call is initiated. The address exchange can occur via a telephone call, e-mail, an on-line chat or use of a messenger utility such as Microsoft's Messenger[4] or AOL's

Instant Messenger[5]. Determining IP addresses assigned dynamically can be found using the utility winipcfg.exe on Windows 98 systems.

B. Use an Internet Locator Server (ILS server). To use an ILS server, you usually log onto the server and when someone wants to interact with you, then they can click on your login name and if the hardware is configured properly, a teleconference is automatically created. A word of warning about using ILS servers. These sites are usually open for anyone to access and you may find that you get a lot of undesirables wanting to talk to you. It's kind of like having your telephone number published world wide for anyone to call. To combat this problem, you should find an ILS server that allows private/group conferencing. Many of these services are free and some charge monthly or yearly membership dues. For a comprehensive listing of ILS servers visit URL http://www.netmeeting-zone.com/. You may even want to set-up your own ILS server, but that is beyond the scope of this paper. ILS servers usually specify the software application required for communicating between the two parties.

C. Another method for establishing an H.323 teleconference is to use a utility such as Microsoft's Messenger. When you log onto the Internet, this application runs in the background and when anyone you've identified as being someone you would like to teleconference with is logged on, their username appears in the messenger window. You can use that information to initiate a teleconference. This method requires each person to use the same software applications and to have previously signed up for the membership services which are usually free.

To improve throughput efficiency over that of software only solutions, the use of devices like Coders/Decoders (CODECS) can be used. CODECS perform the video and audio compression in firmware on a PC card. This frees up the computer's CPU to process all other operations. These devices are usually cards that plug into the PC, but are also now available as stand-alone internet appliances. These cards and appliances usually still require the use of ILS servers for connecting users if the IP addresses of the machines are not known. Normally, a CODEC also uses a separate connection to the Internet than the standard Network Interface Card (NIC) used for normal Internet and Local Area Network traffic.

IV. Multi-Point Connectivity

Of more interest to the education foundation is how we can use H.323 to connect more than one user at a time to observe live video and audio data streams. Utilities like Microsoft's NetMeeting and Intel's ProShare[6] only allow two users to participate in a conference when used in a standalone environment. So how do we connect more than one user in an H.323 teleconference? Again, there are several ways that this can be achieved.

A. When more than two users desire to participate in a video conference, a Multipoint Control Unit (MCU) is required. What usually occurs with the MCU is that each participant in the video conference sends their video and audio data stream to the MCU based on its IP address. The MCU then decides how to distribute each video and audio stream it receives based on the capabilities of each end point (an end point is the hardware/software connection of a user). In a classroom environment, the instructor's audio and video can be multi-cast (sent to each remote user). Multi-cast means that only one video and audio stream is

sent out on the network, addressed to each end-user. The MCU manages this data flow and helps save on the required network bandwidth. The MCU can be a software application or a hardware device such as Cisco's IP/VC 3510 Videoconferencing MCU[7]. With Cisco's solution, the video conference can be set up such that the audio from each user is mixed and redistributed back to all participants. The video can be set up to be voice activated. In this scenario, all participants see the person who is speaking. When someone else starts to speak, the video is switched to that person. This is not an optimal situation for a classroom environment. The real benefit of the MCU is that it is configurable and can be set-up so that one individual (the session manager) can control all data flow. This means that the session manager decides which users are allowed to heard and seen.

B. CUseeMe networks has a product called CUseeMe Pro and CUseeMe Conference Server[8]. These products work together to allow multiple users to connect to a single video conference via the Internet. This product is interoperable with NetMeeting and several other H.323 applications. CUseeMe Pro allows up to twelve separate video windows to appear on your computer desktop. One aspect that we encounter with conference servers is that the IT manager can control the amount of network bandwidth that gets dedicated to the teleconference. This helps ensure that the network is not brought to its knees when a teleconference takes place.

C. Ezenia has a product called NetServer[9]. This product runs on a Windows NT server and allows multiple users to connect to a video conference in process. The Encounter 3000 NetServer allows up to 64 H.323 voice/video connections. This product also acts as a gateway which means that there can be connectivity to POTS phones (up to 23) and connectivity to ISDN users (up to 28).

V. H.323 and Firewalls

A major obstacle for performing H.323 video conferencing is getting the audio and video streams through firewalls. H.323 uses dynamic ports and with at least two of the connections using TCP (Transmission Control Protocol) and up to four different UDP (User Datagram Protocol) connections for a simple audio-only conference[10]. All of these connections except for one use dynamic ports. Firewalls are usually set up to prevent the use of dynamic ports. There are several different styles of firewalls that can be in use. In order to use H.323 communications, check with you IT manager and see if H.323 connections are allowed. The styles of firewalls typically used are:

A. Packet Filtering Router
B. Circuit Gateway
C. Address Translating Firewall
D. Application Proxy

The packet filtering router would be the least desirable of firewall solutions for using H.323 conferencing. This is because the only way for this firewall to work is to open up all UDP and

TCP ports above 1024 entering and exiting the firewall. This makes the firewall protected network susceptible to invalid H.323 traffic, minimizing the firewalls effectiveness.

The circuit gateway is similar to the packet filtering router except only the ports required by the H.323 connection are opened. The firewall is dynamically opened in this mode. The firewall must be able to disassemble the control stream packets to determine which ports to open. Many of the firewall products of this type cannot perform this function.

The address translating firewall performs very similar to the circuit gateway except that it also must translate the address of the internal users. Again, this must be a function of the firewall product.

The application proxy is the implementation where the firewall participates in the application. In this scenario the internal clients connect to the proxy server and the proxy sends valid data to the external MCU or endpoints. This system also performs address translation between the internal users and the external network (hides the IP address of the internal addresses).

VI. The Future of H.323
There are several key factors that will affect the future of H.323 implementations. Of most importance is the ability of the Internet to develop Quality of Service (QoS). QoS means that we can have reliable data transfer over a specified time frame. New technologies such as Multi-Protocol Label Switching (MPLS) are being developed by the Internet Engineering Task Force (IETF) that have the goal of providing QoS and traffic engineering to the datagram forwarding techniques of the Internet Protocol. As these standards come on line, we can expect to see a dramatic increase in the quality of H.323 service.

Another obvious plus for H.323 services are the increase in speeds and available bandwidth available to Internet users. High speed Internet access through cable modems and Digital Subscriber Lines (DSL) are becoming very inexpensive for most users. The higher the data rate, the better the quality you can expect from H.323.

There are also new products that follow the H.323 standards being developed daily. Microsoft has decided that this is a technology that it is willing to encapsulate in all of its current operating systems.

VII. Conclusions
H.323 is an inexpensive technology that enables audio and video teleconferences. This technology is available to anyone with an Internet connection. As such, users located anywhere in the world can participate in these teleconferences. This is a great technology that can be easily adapted to the classroom environment for instruction, collaboration and advisement.

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Biography

Scott Baldwin (baldwis@okstate.edu) received his B.S. in Electrical Engineering Technology and his M.S. in Electrical Engineering from Oklahoma State University in 1988 and 1998 respectively. He worked as a Project Engineer for Frontier Electronic Systems Corporation and Raytheon Systems Corporation before coming to Oklahoma State University where he has taught in Electrical Engineering Technology since 1999. His primary teaching emphasis is in the area of electronic project design.