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Videoconferences in Physics

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After a brief introduction on videoconferences, the applications to physics are considered. I will describe the various videoconferencing systems, in particular the Internet systems.

1. Introduction

Videoconferences allow many people in different locations to communicate quickly and directly, saving time, money and travel. They also allow for regular contacts. For these reasons videoconferences are becoming increasingly popular.

In the following I will discuss the use of videoconferences in physics and I will describe the different solutions available. I will in particular discuss videoconferencing over the Internet; we are trying to use this solution for the OPAL Collaboration at CERN. I will end with some conclusions and an outlook.

2. Use in Physics

Large collaborations have regular meetings held in various locations around the world. To bring the people together requires extensive travel. With the funding cuts that many Universities and Research Institutes are experiencing, travel has become more difficult, and even with unlimited travel funds, it is difficult to keep regular contacts. For these reasons many Scientific Organizations are adopting various videoconferencing systems.

A scheduled session would enable technicians to answer questions from a number of users simultaneously and could demonstrate to participants how to perform upgrades, installations, etc.

With videoconferences one can:
- collaborate with colleagues regularly and directly in real-time;
- hear and see live lectures from famous scientists, with the possibility of interacting;
- attend seminars and presentations without leaving the home Institute;
- "Distance Education" (taking courses without being on campus) for students and other users;
- "Chat" in real time with other users connected.

For example the very large CERN LHC collaborations CMS and ATLAS, consisting each of more than 1000 physicists and more than 120 Institutions in different continents, require regular plenary and working group meetings, to be held in various locations around the world. They have adopted the videoconference solution for many of these meetings.

3. Videoconferencing systems

Basically there are two ways to do professional videoconferencing:
1) using ISDN;
2) over the Internet.

With ISDN one buys and uses a complete hardware and software system. With Internet one uses free software taken directly on the Internet.

3.1. ISDN

I recall that ISDN stands for Integrated Services Digital Network and is the new digital telephone system. During an ISDN communication the whole telephone line is allocated and the bandwidth is guaranteed (the bandwidth is a measure of how much information can be transmitted between two points at a given time).

An ISDN videoconferencing system consists

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of a complete hardware and software system that works reliably, is user friendly and gives high quality audio and video communications. The CERN has equipped two multimedia ISDN rooms, now regularly used for about 20 conferences per month.

The problems concerning the ISDN solutions are:
- the cost of the full equipment;
- the hourly fee to telecommunication companies (more than twice the price of an analog telephone bill);
- for multi-point communications there is a need for another expensive piece of hardware or rent a specific line (at a cost of ~100 Sfr/h to be added to the bill).

3.2. Videoconferences on the Internet

Internet is the world's largest computer network with "free" access. Videoconferencing over Internet normally uses software only solutions on Unix, Windows and Macintosh operating systems. If the home Institute is directly connected to the Internet, one has free use of the line.

A complete hardware and software videoconferencing system, like an ISDN solution, may be too expensive for people outside a well funded organization. As workstation speed increases, real-time processing of multimedia streams on general purpose computer CPU, has become more feasible. A software-only solution is especially attractive since it can be quickly installed on a workstation of an Institute without the expenses involved in replacing hardware. This solution is particularly attractive for small videoconferences.

The problems concerning the Internet solutions are:
- the bandwidth is not guaranteed;
- they share the Internet with other applications;
- the quality is presently worse than that of ISDN systems.

4. MBone

MBone stands for Multicast Backbone; it has been in existence since early 1992. It was originated from an effort to distribute audio and video from meetings of the Internet Engineering Task Force (IETF). MBone shares the same physical network as the Internet, and for that reason is called a virtual network. Mbone is an internet on the Internet. The size of the MBone, compared to the Internet as a whole, is relatively small. It is something like 3.5% of the whole Internet.

Internet was originally organized to send information to one person at a time. One computer is sending the information, and only a second one is receiving it. MBone implements the Multicasting over the Internet. Multicast provides one-to-many and many-to-many network delivery for applications such as videoconferencing. The sender doesn't need to know who is receiving the transmission. A video transmission uses the same bandwidth whether it is received by one workstation or 100 (this is true only if the network is well organized).

MBone uses a network of routers (called mrouters) that can support multicast. A router is a device that connects computers or networks to other sites around the world. The mrouters are either upgraded commercial routers, or dedicated workstations running with modified kernels. For older routers MBone uses the *tunneling method*, encapsulating multicast packets inside regular IP (Internet Protocol) packets. Fig.1 shows a sketch of unicast, multicast and broadcast transmissions.

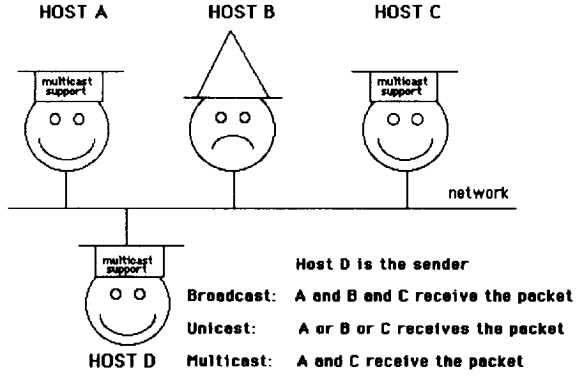

Figure 1. Sketch of unicast, multicast and broadcast transmissions.

The MBone community controls the topology and the scheduling of multicast sessions to minimize congestion an to optimize the efficiency. No single person or entity is in charge of managing MBone. Everything is controlled via electronic mailing lists or similar electronics methods. MBone is controlled by the users, not by telecommunication companies.

The cost of the hardware equipment for MBone is often relatively low, because it needs only a Unix workstation (normally easy to find in every Scientific Institution) with audio and video support.

In order to use the MBone applications efficiently, it is important to have fast connections to the Internet.

In the following will be described some MBone applications.

4.1. NV

NV (Net Video) is an Internet video conferencing tool. NV allows users to receive video in a standard X11 window and can transmit windows on the monitor without additional hardware. It requires only a basic "frame grabber" to transmit video from an external source (like a video camera or a video recorder).

NV takes advantage of both the similarity between consecutive frames and of the similarity between neighboring pixels. It provides typical compression ratios of 20:1 for data information. It takes few tens of milliseconds on any workstation to compress or decompress a frame. The default sending bandwidth is 128 Kbps, while the receiving one is dynamical. To control the bandwidth, the sender can choose the pixel resolution and the amount of colors. There is a slider which allows to choose the maximum bandwidth.

A refresh video of 3-5 frames per second (fps) is obtained with a typical workstation and the standard bandwidth. Resolutions up to 640*512 pixels in 256 colors are possible, which is comparable to the PAL tv system. All stationary portions of the image are periodically updated with high resolution (this is important when showing a graph or a picture). NV, as all the other MBone applications discussed below, can be used both for multi-point (multicast) and point-to-point (unicast) communications.

4.2. VIC

VIC (VIdeo Conference) is a real-time, multimedia application for video conferencing over MBone. The video quality is similar to that of NV; VIC is backward compatible and can interoperate with NV. VIC video encoder achieves better compressions; frame rates are typically 2-4 times that of NV. VIC dynamically adapts the bandwidth and gives information about the amount of lost packets.

VIC allows even to configure the viewing windows to "follow the speaker". Using cues from VAT (see below), VIC will switch the viewing window to whoever is speaking.

CERN used NV for some years, but now there is a preference for VIC.

4.3. VAT

VAT (Visual Audio Tool)is an Internet audio conferencing tool. The default bandwidth is 64 Kbps for both receiving and transmitting; a variety of data compression formats are available to reduce the bandwidth occupancy.

4.4. Whiteboard

The Whiteboard (Wb) is a network conferencing software tool that provides a *distributed whiteboard*. Its drawing capabilities are limited; Wb is intended to be a shared whiteboard, not a general purpose drawing tool.

The drawings are separated into pages; one can make new pages while the old pages remain easily accessible. Wb may be used to send or receive PostScript files. One can use the Wb features on these files to make comments or underlyings.

The typical maximum bandwidth of Wb is 64 Kbps.

4.5. SD

SD stands for Session Directory and is only an interface that starts the applications needed for the selected videoconference. SD announces MBone session availability and dynamically displays active multicast transmissions. Clicking on a session name gives information about the session, such as time and date of transmission.

4.6. Other Mbone applications

IMM (Image Multicaster Client) is a low-bandwidth image server; it typically provides at half hour intervals live images of Earth from various geostationary satellites.

IVS (INRIA Videoconference System) is a complete videoconference system with better video compression than NV, but the audio quality is worst than VAT.

NEVOT (Network Voice Terminal) provides multiple party audio conferences.

MMCC (MultiMedia Conference Control) is a session orchestration tool and multimedia conference control program (it is comparable to SD).

4.7. Present MBone problems

As already stated the actual quality of Internet videoconferences is worse than for ISDN systems. The software is still under development, and the available one is not completely stable, and not so user-friendly.

One of the main problems with MBone is that the transmission of a high-bandwidth video signal can cause severe and widespread network problems (the presently available Internet bandwidth is still inadequate for Mbone). MBone applications work better when used for unicast videoconferences because they use directly Internet.

If the network is saturated, many packets may be lost in an MBone transmission (and the audio will be almost un-understandable). In our tests we have seen that videoconferences from Italy to the USA are not yet usable, since a lot of packets are lost, leading to major audio problems; from CERN to the USA there is a better situation.

4.8. Other Internet videoconferencing tools. CU-SeeMe and Reflector

CU-SeeMe is a desktop videoconferencing software product for person-to-person or group conferencing on the Internet; CU-SeeMe supports only the Windows and Macintosh operating systems. The minimum hardware requests are:

- PC 386 with at least 4 MB;
- Macintosh 68020 with at least 4 MB.

This application is targeted for low-bandwidth connections with at least a 28.8 Kbps connection; at this speed it takes 6-7 seconds per frame.

The video window supports only 16 greyscale images at a maximum pixel resolutions of 320 * 240 pixels.

The Video quality of CU-SeeMe is still inadequate for true videoconferencing, and the audio is not really full-duplex. Now is available an enhanced version of CU-SeeMe supporting colors, higher resolutions and a whiteboard, but it is not free.

The Reflector is a UNIX-based application which allows CU- SeeMe and NV+VAT clients to have group conferences.

5. Conclusions

Videoconferencing is gaining interest in Physics for fast and easy real-time communication. Both ISDN and Internet systems are being used.

ISDN systems work better, but are more expensive and need advance organization. Several scientific organizations are planning to adopt MBone as a low-cost communication tool for small meetings.

The freeware CU-SeeMe version system is at present comparable to a simple videotelephone.

We have tested the MBone applications for videoconferencing from Bologna to CERN in the context of the OPAL Collaboration at LEP: all worked well and an easier system is in preparation.

In the near future new fast lines will connect the Internet with larger bandwidths; this will surely improve the quality of Internet videoconferencing.

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