Setting Up A MBone Node For Distance Learning Purposes

Claudio G. Mello, Gustavo H. M. B. Carneiro, Paulo R. Lira Gondim
Department of Systems Engineering
Military Institute of Engineering (IME)
Rio de Janeiro, RJ 22290-270 Brasil

Abstract *- In this paper, we present an important step to enable research for the Virtual University (VU) project, that has been initiated at the "Military Institute of Engineering" (IME). It consists in setting up a MBone (a Virtual Multicast Backbone) node for Electronic Distance Learning (EDL) purposes. We initially present the motivation for the use of MBone, and compare broadcasting and multicasting strategies for distribution of information. We follow presenting the particularities of addressing mechanisms on the Internet. The characteristics of some real-time protocols are then discussed, and our experience during setting up a MBone node at IME is described. At end, a brief description of the VU project and our main conclusions are outlined.*

Introduction

Electronic Distance Learning represents a new paradigm on engineering education. In this work, we describe an important phase during the development of the Virtual University project that has been initiated at the "Military Institute of Engineering" (IME), involving the connection to the "Virtual Multicast Backbone on the Internet" (MBone) for long distance learning experiencing purposes.

MBone is an IP ("Internet Protocol") multicasting technology that uses the "User Datagram Protocol " (UDP) of the Internet. UDP doesn't guarantee the order of packet receiving (thus demanding the resequencing of packets at the end node), but is faster than the "Transport Control Protocol" (TCP) also available at Internet. The IP multicast addresses are class D and packets have a "Time to Live" (TTL) that limits the distance the packet can reach on the Internet, avoiding network congestion and enabling private conferences at local area networks.

MBone uses network bandwidth in a efficient way, so multimedia applications that delivers video, audio and data becomes feasible. Some videoconferencing, audio and text applications are used as long distance education tools. Document sharing applications like whiteboard are also experienced. UNIX (Sun Solaris) and Microsoft Windows NT based plataforms are used in this work, providing alternative ways of delivering presentations to geographically distributed audience, and avoiding to concentrate people physically in a special location. Audience can easily join and leave conferences without moving around.

With the MBone node implemented at IME, electronic distance learning solutions can now be experienced, and new tools can be developed. The Virtual University project will proceed in order to offer non-presential courses for several organizations.

This paper is organized as follows. First, the electronic distance learning concept is explained and some examples are provided. Then, an overview of MBone structure and its protocols, services and multicast group management is detailed. Setting up difficulties, multicast router configuration, hardware and software diversities and references are also provided. At end, benefits are discussed and some multimedia tools are analised as distance learning solutions.

Electronic Distance Learning

Recent advances in communication technology created a new generation of multimedia applications, and education is starting to deserve its benefits. "Electronic Distance Learning" (EDL) refers to a situation where learner and teacher are separated, in space or time. Now it is possible for the student to have on-line access to a great variety of multimedia instruction material involving text, image, audio, animation and video. It's still useful for universities collaborate themselves in research and education [1].

The main goals of EDL are: improve and complement instruction materials, intensify and enriching the diffuson of knowledge, development of education applications using networked multimedia, reducing travel between participants and enable interactive seminars using network advances, like the MBone over Internet. There is some different scenarios we can identify in EDL as in [2]:

- <u>Remote lecture room</u>: "the student is required to be present either in the local or in one of the remote lecture rooms available, wich are connected by a high-speed network. Both places are equipped with modern equipments to audio and video services. This scenario is similar to virtual class rooms, although geographically separated. Remote students can interact asking questions".

- <u>Remote interactive seminar</u>: "students and teachers interact individually in seminar style with videoconferencing systems in high-speed work-places".

- <u>Interactive Home-Learning</u>: "the learning student is at home, and usually has a low bandwidth access to the Internet, with a 28.8 Kb modem, for

example. The remote seminar will be transmitted to virtual classrooms and to these home-PC students".

- Tele-tutoring: "students are instructed and supervisioned by teachers via computer. Students make exercices of the course in laboratories with computers and receive a well-directed help by the teacher".

- Offline learning: "students access servers with digitalized and recorded courses [3]. They can revise course materials, or read it in order to prepare for examinations".

One of the most recent technologies in today's Internet is the MBone. MBone is a virtual multicast backbone and provides the infrastructure for efficient multipoint packet delivery in the Internet. The MBone can be used for a variety of multimedia applications over the Internet, like videoconference systems, to enable EDL.

MBone

MBone means "Multicast BackbONE", a virtual network above the Internet layer to support routing of IP multicast [4]. It's an application independent multicast mechanism that was implemented to afford multicast audio and video from the IETF ("Internet Engineering Task Force") meetings.

Broadcasting vs. Multicasting

Broadcasting means distribution of information from one source to any destiny that can be reached, as an example, TV and radio broadcast. Multicasting stands for propagation from one source to a subset of recipients (figure 1). There are quite a few things that must be done before a user receives multicast packets. The destiny must be reachable by network and the user must join the multicast group.

Basically, there are two options to develop a multicast functionality, by multiple point-to-point connections and by mechanism internal to the network [5].
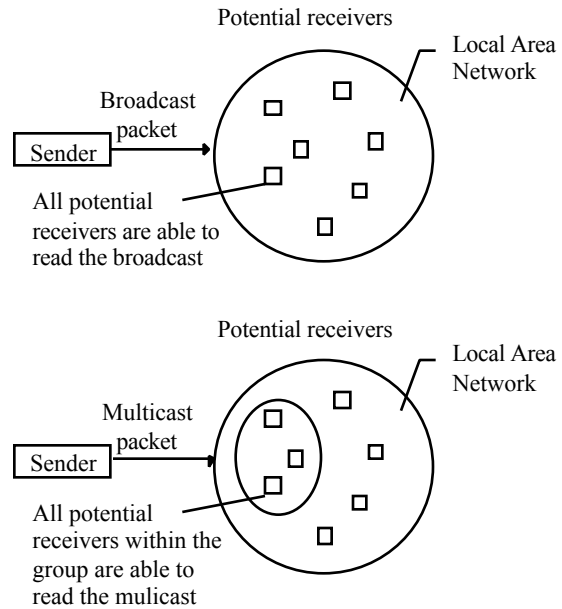

Figure 1 - Broadcast vs. multicast

A point-to-point (figure 2), also called biparty, connection is implemented between each destiny with the source. That is, the information is replicated for each member of the group. As a result the same information will be passing through the network for each attendant placing an unnecessary overload. Therefore this is not the best way to implement multicast due to its high price.

An internal network service – multiparty - offers a better way to implement multicast because a single stream of information is necessary to reach all potential recipients. It's not necessary to replicate data for each participant. Though, there are some places in the network that replication is necessary as illustrated in figure 3.
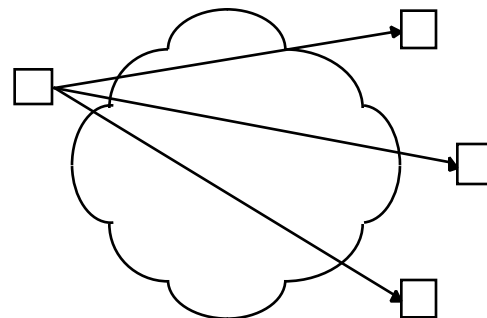

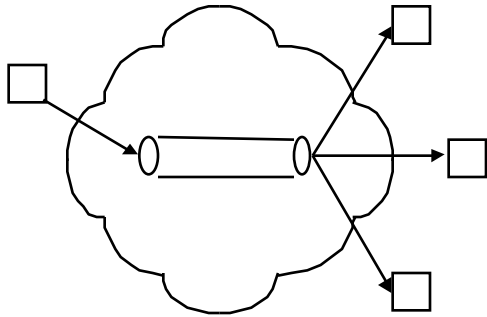*Figure 2 - Multicasting using point-to-point connection*

Figure 3 - Multicasting using internal network service

Multicasting on the Internet

On the Internet, IP ("Internet Protocol") multicast addressing became a standard developed by Steve Deering ("Request for Comments" RFC-1112) and is supported by a number of vendors. Some kinds of services are available, like: it is not necessary to have a central authority to coordinate a multicast group, the members of a conference can be spread all over the world, a host can join more than one group and is able to choose whether it will send, receive or send and receive information.

The Internet addresses are divided in two parts, the former is the net ID and the latter is the host ID [6]. There can be five classes of addresses, A, B, C, D and E. Classes A, B and C are used to identify hosts. Class D is reserved for multicast and class E is for future use. The range of multicast address is from 224.0.0.0 to 239.255.255.255.

If a host is intended to join a multicast group, it must send the network its request. Therefore, the process of entering in a group is initiated from the receiver. One can leave by the same way, that is, it is necessary to send a message containing its request to leave the group.

Each multicast packet has a field called TTL ("Time To Live") that contains a number between 0 and 255 which determines how far the packet is able to travel through the Internet. If it has a little number (below 16), probably it will not be able to traverse the LAN. On the other hand, a great number means a further way to go.

Multimedia on the Internet

Multimedia stands for a combination of various kinds of media, like text, sound, video, pictures, etc. There a lot of problems concerning multimedia over a network. Multimedia information to be transmitted has the following properties: may be composed of discrete and/or continuous parts, temporal relationship may exist between these elements. Basically two mechanisms of synchronism are necessary to support networked multimedia, restoration of the temporal relationships within each stream carrying continuous multimedia information and restoration of the temporal relationships between the various streams or elements which compose the multimedia information [7]. Besides this, it is extremely important to implement data compression in order to reduce the volume of data, which is usually large in multimedia flows.

Joining the MBone

As explained above, MBone supports multicast over the Internet. It uses class D addresses providing multiparty connection between each attendant of a multicast group. As a result it offers a good scalability because as the number of participants grows up, the need for bandwidth does not grow at the same rate, on the contrary, it grows up slower.

Since multicast over the Internet was established recently, it is not common to find a router that is capable to route class D packets (multicast packet), therefore if a multicast packet achieves an old router, probably it will be discarded. In order to resolve this problem, a program called *Mrouted* is able to handle multicast routing on UNIX systems. It also handles multicast tunneling that can arrange to tunnel a multicast datagram between routers that don't participate in multicast routing.
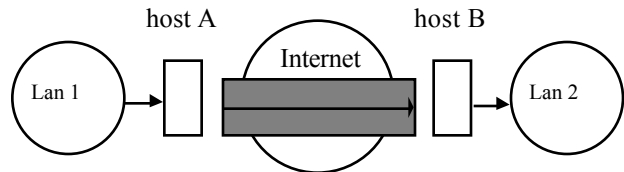

Figure 4 – Tunneling

The figure 4 examplifies how a tunnel functions between LANs ("Local Area Networks"). LAN 1 is sending multicast packets to LAN 2, but there is no guarantee that all the routers through the Internet are able to recognize class D packets, therefore, in order to avoid discarding of packets, a tunnel is established between hosts A and B (both can route class D packets). After setting up a tunnel, a multicast packet reaching host A is encapsulated into a unicast packet which is sent like a regular packet (class A, B or C) through the Internet. Host B, after receiving the packet, shall recognize that it is a multicast packet encapsulated, as a result it will send this packet for all participants of the multicast group in LAN 2.

MBone also consists of tools to announce audio or video programs and to help users in joining groups and launching applications on their systems.

Some goals were achieved with MBone, like enabling efficient multimedia distribution beyond the Internet (using multicast), no additional costs for participants because all the necessary programs to join a MBone conference are available for free on the Internet. On the other hand, there is no quality of service (QoS), so the behavior of a conference may

change dramatically during its existence because of temporary overload on the Internet.

MBone uses the UDP ("User Datagram Protocol") through end-to-end connection, which is an unreliable connectionless delivery service using IP to transport messages between machines. As a result, UDP messages can be lost, duplicated, or arrive out of order. Furthermore, packets can arrive faster than the recipient can process them. However this protocol increase the scalability of the system compared to TCP ("Transmission Control Protocol") because it does not add any overhead to the message to achieve a reliable connection.

MBone throughput:
sound: 36 Kbps (ADPCM), 13 Kbps (GSM), 9 Kbps (LPC).
video: 125 - 128 Kbps.
text and picture: 5 Kbps - 6 Kbps

The following phases to joining the MBone [8] [http://www.mbone.com] can be devised as a set of guidelines:

1. Read the main guide to getting connected to MBone before trying to set up a node [9], as well as FAQs ("Frequently Asked Questions") in [10].
2. Make sure that your ISP ("Internet Service Provider") can supply a multicast feed or a MBone tunneling capability.
3. Subscribe to the MBone mailing list by sending a message to MBone-request@isi.edu and asked to be added to the list.
4. Configure the desktop machine for IP multicast (nowadays most computers and operating systems get shipped from the factory with IP multicast).
5. Turn IP multicast ON (using native multicast packet routing or between your LAN and the ISP's network).
6. And finally, get MBone application software. Below there are some examples of software available for free on the Internet.

A lot of debugging software is available, like tcpdump, netstat, mrdebug, multicast ping, mapbone, etc. There are also available some application software, such as: SDR, as shown in figure 5 (where the conferences are announced and the media available are detailed – figure 6), VIC [11] (that supports transmission/reception of video streams), VAT and RAT (that support transmission/reception of audio streams), WB (whiteboard - supports transmission/reception of data through a whiteboard) , NT (supports transmission/reception of text).
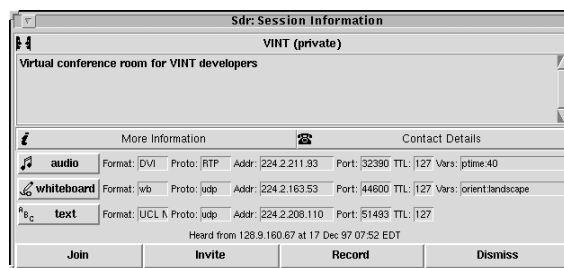

Figure 5 – Session directory for UNIX

Figure 6 – Available media for a session

New real-time protocols

A number of new protocols have been proposed to enhance Internet architecture and to support multimedia requirements. Multimedia applications like audio, video and interative multimedia conference can tolerate missing data better than delays caused by retransmissions of TCP/IP [12]. Some real-time protocols well indicated for IP multicasting are [13]:

RTPv2 *("Real-Time Transport Protocol version 2")* – is a real-time protocol that provides end-to-end delivery services to support multimedia applications like audio and video, over unicast and multicast network services. RTP includes media identification, sequence numbering and time stamping for time synchronization. In fact, RTP runs over UDP to use its multiplexing and checksum (for error detection) services.

RTCP *("Real-Time Control Protocol")* – is the control protocol that works with RTP. RTCP packets are periodically transmitted by each user in a RTP session to all the other participants. This feedback information can be used to control performance and for diagnostic purposes. RTCP performs information to the application (number of packets lost, jitter, etc), identify RTP source, control RTCP transmission interval and, optionally, can carry user's personal informations like the name.

RTSP *("Real-Time Streaming Protocol")* – provides a robust protocol for streaming multimedia in one-to-many applications over unicast and multicast network services. Streaming breaks data

into many packets sized appropriately for the bandwidth available between the client and the server. When the client has received enough packets, the application can be playing one packet, descompressing another and receiving a third. The user can begin listening immediately without having to wait the entire data. RTSP is designed to work on top of RTP to both control and deliver real-time data.

RSVP ("Resource Reservation Protocol") – is used to guarantee QoS for a session. RSVP reservation request consists of a specification for an end-to-end desired QoS like peak/average bandwidth or delay bounds. For multicast, a host sends IGMP messages to join a host group and then sends RSVP messages to reserve resources along the delivery path of that group. The hosts in the path reserve system resources such as bandwidth, CPU and memory buffers to satisfy the QoS request.

Setting up a MBone Node at IME

The environment available at IME is briefly described below. The project was to run on a network composed of workstations (most of them shipped with Intel Pentium) installed with Microsoft Windows NT 4.0 operating system. *Mrouted* program was installed on a Sun Sparc Workstation shipped with Sun Solaris 2.4 operating system at another network composed only with UNIX machines. These two networks are linked by a switch as stated in the figure 7.
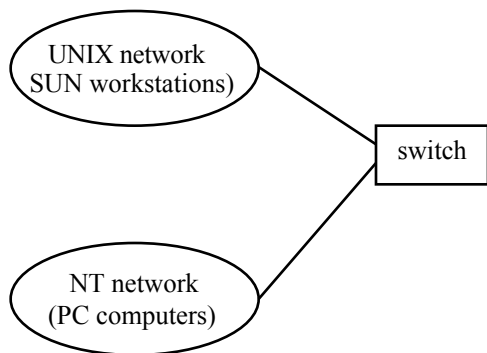

Figure 7 – Diversity of networks

First Step - Multicast Support

The first thing to do is verifying the native multicast support. At the PCs installed with Microsoft Windows NT, it can be stated by testing a program available at Microsoft's site [14] (ftp.microsoft.com/bussys/WinSock/ms-ext/party.exe).

Normally, this program will not present any problem. To verify multicast support on UNIX machines one can install Mrouted program, if any problem takes places during the installation, an error message will be presented and in case that this message shows a problem of lack of multicast

support, there are a some steps to follow in order to fix this flaw.

At IME there wasn't any problem with the NT workstations network, but the UNIX machines did not present multicast support, so it was necessary to find a program on the Internet that offered this support.

Second Step - Multicast Router

At this phase, a tunnel was implemented between IME and the nearest organization that had already joined the MBone, that was *Rede Rio* [15] situated at UFRJ [16] ("Federal Univesity of Rio de Janeiro") on Fundão Island.

The program found to establish the tunnel was Solaris_mc35.2.4.tar at sun's site:

playground.sun.com/pub/ipmulti

which, that besides implementing the tunnel, also provides a multicast support.

After installed, the mrouted.conf file was configured with the values determined by Rede Rio, which were: tunnel [IME IP ADDRESS] [REDE RIO IP ADDRESS] metric 1 threshold 16 rate_limit 500.

Verifying that Tunnel was Working Properly

After above steps, it was necessary to verify that our network was receiving multicast packets. The easiest way to do this is by running SDR which is able to receive the sessions announcements around the world. At IME there was no problem in receiving the multicast packets of MBone. After that, some softwares were acquired to assure the functionality. Since all of them, after running, were capable to receive/send multicast information of video, audio, text, etc., IME was sure joining the MBone.

All the functionality described above was placed at UNIX machines, however it was necessary to verify the same functionality at the NT workstations. In order to accomplish this issue, a NT workstation was installed at UNIX network and all applications available to Windows NT machines were acquired on the Internet.

Some programs worked as described on the origin site, but other presented some problems. For example, all the programs acquired to send/receive announcements of sessions presented some kind of problem except SD from Arlie Davis available on the web site : http://www.research.microsoft.com/research/BARC/MBone.

The same problem occurred for audio flow and the only program that worked correctly was RAT ("Robust Audio Tool"). And for transmission/reception of video streams the program vic (figure 8) found on the web site: http://www.cs.ucl.ac.uk/staff/kouvelas/vic/#download presented the best behavior. Some other softwares were copied in order to test functionality, like NT and whiteboard.

IME Virtual University Project

IME has initiated the Virtual University project in October, 1997. This project has the following main objectives: explore new applications of technology for the teaching/learning process, delivery credit and non-credit programs to the university's students and to others, examine what exist in today's EDL projects and enable internal and external videoconferences for EDL purposes.

The setting up of a MBone node at IME was the first step to enable research and development of multimedia applications, like videoconferencing systems, in the Virtual University project.

Conclusions

Electronic Distance Learning (EDL) is a new paradigm in teaching and learning processes. New advances in network technology created a new demand for multimedia applications. The use of text, image, animation, audio and video in a integrated way can speed the teaching and learning processes.

MBone is a recent technology that enables IP multicasting over Internet. So, EDL can use its benefits to delivery "education in packets", it means use the Internet backbone to run new applications, like audio and video conferences to remote students, improving and enriching the diffusion of knowledge.

In this work, we detailed the setting up process of a MBone node at IME. When all the ISPs support IP multicasting, this process will be certainly easily accomplished, and no tunnels configurations will be necessary. When connected to MBone, we could evaluate some existing multimedia tools that exists in the MBone community.

Several applications softwares were tested: with NT, we chated with other students, all over the world, in a multicast text delivery; with RAT, we've listened music from various MBone public radios, and we also generated and received our own voice. Using VIC, we participated of remote seminars in Berkeley, assisted the NASA TV and also generated our own laboratory images.

MBone uses efficiently network bandwidth, so EDL research area can use its benefits to create multimedia real-time applications. With the MBone node at IME, research and development of new EDL applications for the Virtual University project is now feasible.

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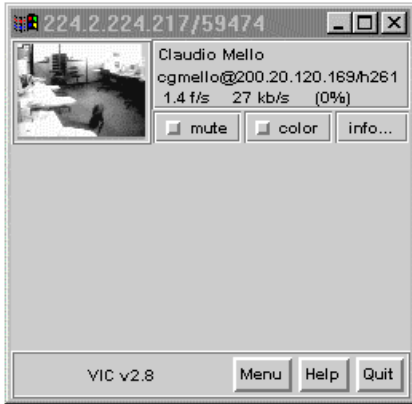[16] RAVEL Lab, "High-Speed Networks" (COPPE/UFRJ), **Error! Bookmark not defined.**

Figure 8 – VIC ("Videoconferencing tool")