MBONE, the Multicast Backbone

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Introduction

Changes are being made to the network components all the time, but people want to use the new features without having to wait for all systems to be upgraded. To do this a virtual network is established on top of existing IPv4 Internet using tunnels. If two or more hosts support multicasting, multicast applications can be run on all these hosts and made to communicate with each other. To connect this LAN to some other LAN that also has multicast-capable hosts the mbone tunnel is configured.

MBONE stands for Multicast Backbone, a virtual network that has been in existence for about three years. The network originated from an effort to multicast audio and video from the Internet Engineering Task Force (IETF) meetings. MBONE today is used by several hundred researchers for developing protocols and applications for group communication. Multicast is used because it provides one-to-many and many-to-many network delivery services for applications such as videoconferencing and audio that need to communicate with several other hosts simultaneously. Scalable video conferencing must send large number of large messages to a large number of sites; hence savings in kernel calls and network messages is particularly important.

Background

Multicasting has existed for several years on local area networks such at Ethernet and FDDI. However, with Internet Protocol (IP) multicast addressing at the network layer the service group communication can be established across the Internet. Categorized officially as an IP Class D address, an IP multicast address is mapped to the underlying hardware multicast services of a local area network.

The reason that MBONE is a virtual network is that it shares the same physical media as the Internet, though it must use a parallel system of routers that can support multicast (e.g. dedicated workstations running with modified kernels and multiple interfaces) augmented with "tunnels". Tunneling is a scheme to forward multicast packets among the islands of MBONE subnets through

Internet IP routers which typically do not support IP multicast. This is done by encapsulating the multicast packets inside regular IP packets.

Bandwidth

The key to understanding the constraints of MBONE is thinking about bandwidth. The reason why a multicast stream is bandwidth-efficient is that one packet can touch all workstations on a network. Thus a 125 Kbps video stream (1 frame/second) uses the same bandwidth whether it is received by one workstation or twenty. That is good. However that same multicast packet is prevented from crossing network boundaries such as routers or bridges. Thus the MBONE scheme encapsulates multicast streams into unicast packets which can be passed as regular Internet protocol packets along a virtual network of dedicated multicast routers (mrouters) until they reach the various destination local area networks. The use of dedicated mrouters segregates MBONE packet delivery, protecting standard network communications such as mail and telnet from MBONE experiments and failures. Once properly established, an mrouter needs little or no attention.

Network Multicast

One of the reasons the Kernel layer supports multicasting, is to make a single kernel call to multicast a message to a process group; and if it is supported in the network layer, then it may be sufficient to send a single message along a network link to multicast the message to multiple processes connected by the link. For this reason MBone (Multicast backbone) provides network-level support for multicast.

The saving in kernel calls and network messages is particularly important for scalable video conferencing, which must send large number of large messages to a large number of sites. MBone has been designed for such applications and includes an interesting set of applications for making distributed presentations including audio and conferencing tools and a whiteboard application. All of these tools are scalable in that they have been used by hundreds of users.

Reliability in scalable multicasts can be a tricky issue. In many reliable unicast protocols such as TCP/IP, the sender is responsible for ensuring that the message is delivered to the receiver by waiting for a positive acknowledge latter. This is not a good approach in scalable multicast, since it puts an undue burden on the sending site, which must wait for a large number of positive acknowledge. It is better to use to make each receiver responsible for ensuring reliability by sending negative acknowledge in case messages are lost.

Working details

When a host on an MBONE-equipped subnet establishes or joins a group it announces that event via the Internet Group Management Protocol (IGMP). Groups are disestablished when everyone leaves, freeing the IP multicast address for reuse. The routers occasionally poll hosts on the subnets to determine if any are still group members. If there is no reply by a host, the router stops advertising that hosts group membership to the other multicast routers.

Most MBONE routers employ the Distance Vector Multicast Routing Protocol (DVMRP) which is commonly considered inadequate for rapidly changing network topologies because routing information propagates too slowly. A multicast extension to the Open Shortest Path (MOSPF) link-state protocol has been proposed by John Moy of Proteon Inc. that addresses this problem. However, with both protocols each router must compute a source tree for each participant in a multicast group. MBONE is currently small enough that this restriction is not a problem. However, for a large network with constantly changing group memberships such routing techniques are expected to be computationally inefficient.

Topology and Scheduling

The MBONE topology and the scheduling of multicast sessions must be actively managed by the MBONE community to minimize congestion. Approximately 400 sites worldwide are currently MBONE members. MBONE protocol developers are currently experimenting with automatically pruning and grafting subtrees, but for the most part uses truncated broadcasts to the leaf routers. The truncation is based on the setting for the time-to-live (ttl) field in a packet which is decremented each time the packet passes though a router. A ttl value of 16 would limit multicast to a campus, as opposed to a value of 100 which might send it to every subnet on the entire MBONE (about thirteen countries). These issues can have a major impact on network performance. For example, a default video stream consumes about 128 Kbps (kilobits per second) of bandwidth, which is almost 10 percent of a T1 line (a common site-to-site link on the Internet). Several simultaneous high-bandwidth sessions might easily saturate network links and routers. This problem is compounded by the fact that general purpose workstation routers typically used by the MBONE are normally not as fast or as robust as the dedicated hardware routers used in most of the Internet.

Protocols

The magic of MBONE is that teleconferencing can be done in the hostile world of the Internet where variable packet delivery delays and limited bandwidth play havoc with applications that require some real-time guarantees. In addition to the multicast protocols, MBONE applications are using the Real Time Protocol (RTP) on top of User Datagram Protocol (UDP) and IP. RTP is being developed by the Audio-Video Transport Working Group within the IETF. RTP provides timing and sequencing services; permitting the application to adapt and smooth out network-induced latencies and errors. The end result is that even with a time-critical application like an audio tool, participants normally perceive conversations as if they are in real-time, even though there is actually a small buffering delay to synchronize and sequence the arriving voice packets. Protocol development continues. Although operation is usually robust, many aspects of MBONE are still considered experimental.

Data Compression

Another aspect of this research is the need to compress a variety of media and to provide privacy through encryption. Several techniques to reduce bandwidth include Joint Photographic Experts Group (JPEG) compression and the ISO standard H.261 for video. Visually this translates to velocity compression: rapidly changing screen blocks are updated much more frequently than slowly changing blocks. Encodings for audio include Pulse Coded Modulation (PCM) and GSM. Outside of the concerns for real-time delivery, audio is a difficult media for the MBONE and teleconferencing in general because of the need to balance signal levels for all the parties who may have different audio processing hardware (e.g. microphones and amplifiers). Audio also generates lots of relatively small packets, which are the bane of network routers.

Events

Many of the most exciting events on the Internet appear first on MBONE. Perhaps the most popular is NASA Select, the NASA in-house cable channel broadcast during space shuttle missions. Conferences on supercomputing, Internet Engineering Task Force, scientific visualization and many other topics have appeared, often accompanied by directions on how to download PostScript copies of presented papers and slides from anonymous ftp sites. Radio Free VAT is a community radio station whose DJ's sign up for air time via an automated server (vat-radio-request@elxr.jpl.nasa.gov).

Participation

To participate in an MBONE session you need a few things :

1. A multicast capable kernel.
2. Your subnet needs to be on the MBONE. In other words, multicast packets need to be being forwarded to your machine.
3. The multicast videoconferencing applications. You need a minimum of sdr, vic, and vat (or rat). It is also nice to have wb on hand.

- Sdr provides you with a session directory and video conference launching tool.
- Vic is the video tool; vat and rat are audio tools.
- wb is a whiteboard application that is sometimes used to send slides or for feedback.

4. Multicast debugging tools are also helpful in diagnosing problems. the primary tools available are mtrace, mrinfo, and rtpmon.

Caveats

Some problems still exist and a lot of work is still in progress. The audio interface takes coaching and practice. Leaving your microphone on by mistake may override everyone else since only one person can talk at a time. You will need a video capture board in your workstation to transmit video, but no special hardware is needed to receive video. One frame per second video seems pretty slow (standard video is 30 frames per second), but in practice it is surprisingly effective when combined with phone-quality voice. One user blasting a high-bandwidth video signal (greater than 125 Kbps) can cause severe and widespread network problems. Controls on access to tools are rudimentary and security is minimal; for example, a local user might figure out how to listen through your workstation mike (unless you unplug it). Audio broadcast preparations are often just as involved as video broadcast preparations. Network monitoring tools are not yet convenient to use. Internet bandwidth is still inadequate for MBONE in many countries. On one occasion a local topology change at our school caused a feedback loop that overrode the NASA Select audio track.

Conclusion

It is not every day that someone says to you "Here is a multimedia television station that you can use to broadcast from your desktop to the world." These are powerful concepts and powerful tools that tremendously extend our ability to communicate and collaborate. These tools are already changing the way people work and interact on the net. See you later!

References

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