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Review Article

REVIEW PAPER ON MULTICAST ROUTING ALGORITHM

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A B S T R A C T

Multicasting is fundamental communication paradigm for supporting one to many communications. A better way to transmit data from one source to many destinations is to provide a multicast transport service. With a multicast transport service one node can send data to many destinations' by making just a single call on the transport service.

Thus for those applications which involves a single node sending to many recipients, a multicast facility is clearly a more natural programming paradigm than unicast (point to point).

Many underlying transmission media provide support for multicast and broadcast at hardware and media access level. When a multicast service is implemented over such a network, there is a huge improvement in performance. If hardware supports multicast, a packet which is destined for N recipients can be sent as just a single packet.

IP MULTICAST PROTOCOL (RFC 1112) was adapted by Internet Engineering Task Force (IETF) in march 1992 as a standard protocol for building multicast applications on the internet.

INTRODUCTION

Multicasting is a technical term that means that you can send a piece of data (a *packet*) to multiple sites at the same time.

The three types of communication between hosts (or computers) on a network are unicast, where a host talks directly to another computer; broadcast, in which a computer can talk to *all* computers; and multicast, where one computer can communicate with a select group of others.

To illustrate, let's apply these concepts to an Ethernet network. In traditional Ethernet, each computer on a network has an Ethernet card, which acts as a transmitter. When a computer has packets or data to send, it hands them to the Ethernet card, and the card then transmits them on the network. The Ethernet card also listens to all packets sent by everyone, looking for packets that are addressed to the card's unique Ethernet address. When the card encounters a packet addressed to itself, it interrupts the processor and hands the packet off to the operating system for processing (the operating system then processes the packet, which mostly means handing the data to an application program). This is unicasting, or host-to-host communication. The problem with unicasting is that if one wants to keep multiple computers abreast of something, say stock-ticker quotes, one needs to send the information stream multiple times, each time to a separate address. This can chew up bandwidth fast, especially if it involves something that is already high bandwidth, such as audio or video.

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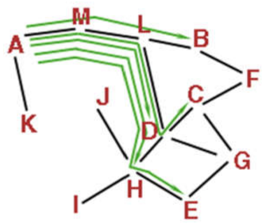


Fig Traditional Way of Data Routing

Ethernet also allows broadcasting using a special address called the "broadcast" address. When packets are addressed to this address, every Ethernet card picks up the packet, interrupts its processor, and hands the packet to the operating system for processing. It's a win if one has to send data out to everyone, or nearly everyone. The downside is that often not everyone is interested.

Finally, we come to Ethernet's multicast addresses. Here, the sending machine sends out a stream of packets addressed to a multicast address, and receivers program their Ethernet cards to listen for these addresses. This allows one to keep many computers abreast of something with only one stream of packets. It also avoids interrupting hosts that aren't interested.

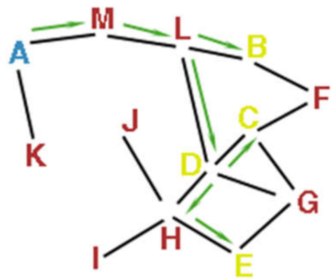


Fig Multicast way

Sending Receiving

Sending	Receiving
A	B
	C
	D
	E

When we examine how these concepts work on the Internet, one mostly sees unicast communication - that is, communication from one host to another.

On the Internet, broadcast communication isn't used; as a network gets more and more hosts, there are fewer things the great majority of hosts are all interested in, and the power to interrupt every computer on the Internet is a dangerous thing. In IP, the ability to broadcast is generally relegated to the subnet or LAN (local area network) level.

While large-scale broadcasting isn't that useful, multicasting over a WAN (wide area network) is. That is, it is useful to be able to send data over the network to a group of subscriber hosts whereby a) the data goes over a link once (consuming only the bandwidth necessary), and b) it only goes to parts of the network where it is needed.

IP multicast is implemented using a special range of IP addresses, called Class D addresses (224.0.0.0 - 239.255.255.255). These addresses are special because, unlike other IP addresses, they don't refer to specific hosts - they refer instead to groups.

					28 bits
Class D	1	1	1	0	Multicast Group ID

Multicast Routing Algorithms

Several algorithms have been proposed for building multicast trees through which the multicast packets can be delivered to the destination nodes. These algorithms can be potentially used in implementing the multicast routing protocols. In this section, we start with reviewing two simpler algorithms called Flooding and Spanning Trees. Then, we discuss more sophisticated algorithms such as Reverse Path Forwarding (RPF), Truncated Reverse Path Forwarding (TRPF), Steiner Trees (ST), and Core-Based Trees (CBT). In the next section, we will see how some of these algorithms have been used to develop the multicast routing protocols.

Flooding

The Flooding algorithm which has been already used in protocols such as OSPF is the simplest technique for delivering the multicast datagram to the routers of an internetwork. In this algorithm, when a router receives a multicast packet it will first check whether it has seen this particular packet earlier or this is the first time that this packet has reached this router. If this is the first time, the router will forward the packet on all interfaces, except the one from which the packet has been received. Otherwise, the router will simply discard the packet. This way we make sure that all routers in the internetwork will receive at least one copy of the packet.

Although this algorithm is pretty simple, it has some major disadvantages. The flooding algorithm generates a large number of duplicated packets and waste the network bandwidth. Furthermore, since each router needs to keep track of the packets it has received in order to find out whether this is the first time that a particular packet has been seen or not, it needs to maintain a distinct entry in its table for each recently seen packet. Therefore, the Flooding algorithm makes inefficient use of router memory resources.

Spanning Trees

A better algorithm than Flooding is the Spanning Tree algorithm. This algorithm which has been already used by IEEE-802 MAC bridges is powerful and easy to implement. In this algorithm, a subset of internetwork links are selected to define a tree structure (loop-less graph) such that there is only one active path between any two routers. Since this tree spans to all nodes in the internetwork it is called spanning tree. Whenever a router receives a multicast packet, it forwards the packet on all the links which belong to the spanning tree except the one on which the packet has arrived, guaranteeing that the multicast packet reaches all the routers in the internetwork. Obviously, the only information a router needs to keep is a boolean variable per network interface indicating whether the link belongs to the spanning tree or not. We use a small network with five nodes and six links to show different trees. For simplicity sake, we do not differentiate between hosts and routers, subnets and links. We also assume that links are symmetric and their costs are shown next to the links. The spanning tree from source node (C) is shown in Figure 2.1.1

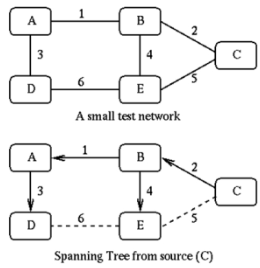


Figure Spanning Tree

The spanning tree algorithm has two drawbacks: It centralizes all the traffic on a small set of links and it does not consider the group membership.

Reverse Path Broadcasting (RPB)

The RPB algorithm which is currently being used in the MBone (Multicast Backbone), is a modification of the Spanning Tree algorithm. In this algorithm, instead of building a network-wide spanning tree, an implicit spanning tree is constructed for each source. Based on this algorithm whenever a router receives a multicast packet on link "L" and from source "S", the router will check and see if the link L belongs to the shortest path toward S.

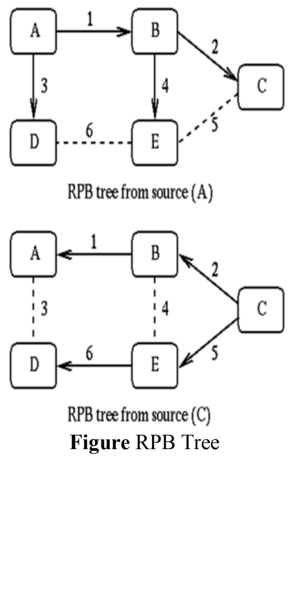


Figure RPB Tree

If this is the case the packet is forwarded on all links except L. Otherwise, the packet is discarded. Three Multicast trees from two sources of our test network are shown in Figure. 2.3.1

The RPB algorithm can be easily improved by considering the fact the if the local router is not on the shortest path between the source node and a neighbour the packet will be discarded at the neighboring router. Therefore, if this is the case there is no need to forward the message to that neighbor. This information can be easily obtained if a link-state routing protocol is being used. If a distance-vector routing protocol is being used, a neighbor can either advertise its previous hop for the source as part of its routing update messages or "poison-reverse" the route.

This algorithm is efficient and easy to implement. Furthermore since the packets are forwarded through the shortest path from the source to the destination nodes, it is very fast. The RPB algorithm does not need any mechanism to stop the forwarding process. The routers do not need to know about the entire spanning tree and since the packets are delivered through different spanning trees (and not a unique spanning tree) traffic is distributed over multiple tress and network is better utilized. Nevertheless, the RPB algorithm suffer from a major deficiency: it does not take into account the information about multicast group membership for constructing the distribution trees.

Truncated Reverse Path Broadcasting (TRPB)

The TRPB algorithm has been proposed to overcome some of the limitations of the RPB algorithm. We earlier mentioned that by using IGMP protocol, a router can determine whether members of a given multicast group are present on the router subnetwork or not. If this subnetwork is a leaf subnetwork (it doesn't have any other router connected to it) the router will truncate the spanning tree. It should be noted here that TRPB similar to RPB won't forward the message to a neighbor router if the local router is not on the shortest path from the neighbor router to the source node.

Although, multicast group membership is used in the TRPB algorithm and the leaf subnets are truncated from the spanning trees but, it does not eliminate unnecessary traffics on non-leaf subnetworks which do not have group member.

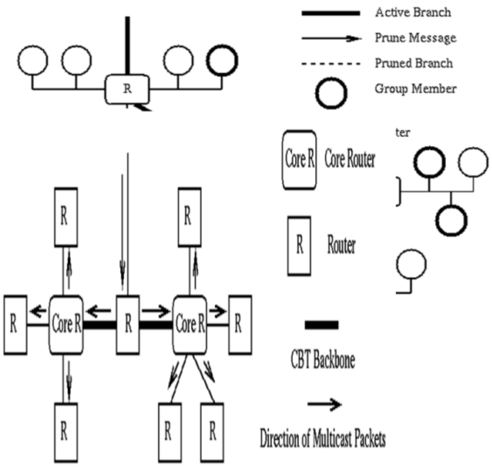
Reverse Path Multicasting (RPM)

The RPM algorithm (also known as RPB with prunes) is an enhancement to the RPB and TRPB algorithms. RPM constructs a delivery tree that spans only: *1) subnetworks with group members, and 2) routers and subnetworks along the shortest path to subnetworks with group members*. The RPM tree can be pruned such that the multicast packets are forwarded along links which lead to members of the destination group.

For a given pair of (source, group) the first multicast packet is forwarded based on the TRPB algorithm. The routers which do not have any downstream router in the TRPB tree are called leaf routers. If a leaf router receives a multicast packet for a (source, group) pair and it does not have any group member on its subnetworks, it will send a "prune" message to the router from which it has received the multicast packet. The prune message indicates that the multicast packets of that particular (source, group) pair should not be forwarded on the link from which the prune message has been received. It is important to note that prune messages are only sent one hop back towards the source. The upstream router is required to record the prune information in its memory. On the other hand, if the upstream router does not have any local recipient and receives prune messages from all of its children in the TRPB tree, the upstream router will send a prune message itself to its parent in the TRPB tree indicating that the multicast packets for the (source, group) pair need not be forwarded to it. The cascaded prune messages will truncate the original TRPB tree such that the multicast packets will be forwarded only on those links that will lead to a destination node (multicast group member). For showing the tree obtained after the exchange of prune messages in a network, we need to use a more complicated network. Figure 2.5.1 illustrates pruning and the obtained RPM tree.

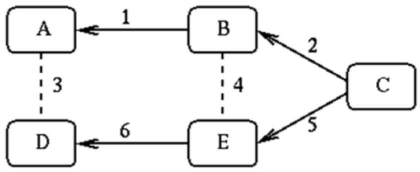
Group membership and network topology can dynamically change and the prune state of delivery trees should be refreshes at regular intervals. Therefore, in RPM algorithm the prune information in routers is removed periodically and the next packet for a (source, group) is forwarded to all leaf routers. This is essentially the first drawback of RPM.

Relatively big memory space required for maintaining state information for all (source, group) pairs is another drawback which makes this algorithm not scalable (and therefore, not suitable for very large internetworks).

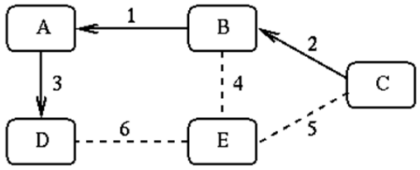


Multicast Routing Protocols

In the discussion, we reviewed some algorithms that can potentially be used in multicast routing protocols. Similar to unicast routing protocols (such as Routing Information Protocol (RIP) and Open Shortest Path First (OSPF) protocol), there should be multicast routing protocols such that multicast routers can determine where to forward multicast messages. In this section, we discuss existing multicast protocols and see how these protocols use some of the algorithms discussed in the previous section for exchanging the multicast routing information. We first review three routing protocols (Distance Vector Multicast Routing Protocol (DVMRP), Multicast Extensions to OSPF (MOSPF) protocol, and Protocol Independent Multicast - Dense Mode (PIM-DM) protocol) which are more efficient in situations where multicast group members are densely distributed over the network. Then, we discuss the Protocol Independent Multicast - Sparse Mode (PIM-SM) protocol which performs better when group members are sparsely distributed.



RPB tree from source (C)



ST tree from source (C)

Distance Vector Multicast Routing Protocol (DVMRP)

The Distance Vector Multicast Routing Protocol (DVMRP) which was originally defined in RFC 1075 was driven from Routing Information Protocol (RIP) with the difference being that RIP forwards the unicast packets based on the information about the next-hop toward a destination, while DVMRP constructs delivery trees based on the information on the previous-hop back to the source. The earlier version of this distance-vector routing algorithm constructs delivery trees based on TRPB algorithm. Later on, DVMRP was enhanced to use RPM. Standardization of the latest version of DVMRP is being conducted by the Internet Engineering Task Force (IETF) Inter-Domain Multicast Routing (IDMR) working group.

DVMRP as mentioned earlier implements the RPM algorithm. The first packet of multicast messages sent from a particular source to a particular multicast group is flooded across the internetwork. Then, prune messages are used to truncate the branches which do not lead to a group member. Furthermore, a new type of messages is used to quickly "graft" back a previously pruned branch of a delivery tree in case a new host on that branch joins the multicast group. Similar to prune messages which are forwarded hop by hop, graft messages are sent back one hop at a time until they reach a node which is on the multicast delivery tree. Similar to RPM, DVMRP still implements the flooding of packets periodically.

In cases where more than one router are present in a subnetwork, the one which is closer to the source of a multicast message is elected to be in charge of forwarding multicast messages. All other routers will simply discard the multicast messages sent from that source. If there are more than one router on the subnetwork with the same distance from the source, the router with lowest IP address is elected. DVMRP support tunnel interfaces (i.e. interfaces connecting two multicast routers through one or more multicast-unaware routers). More specifically, each tunnel interface should explicitly configured with the IP address of the local router's tunnel interface and the IP address of the remote router interface. The scope of an IP multicast can be limited by using the TTL field in the IP header. The following table lists the conventional TTL values used to limit the scope of multicast packets.

Table 1 TTL Scope Control Values

TTL Threshold	Scope
0	Restricted to the same host
1	Restricted to the same subnetwork
15	Restricted to the same site
63	Restricted to the same region
127	Worldwide
191	Worldwide; limited bandwidth
255	Unrestricted in scope

Multicast Extensions to OSPF (MOSPF)

The Multicast Extensions to OSPF (MOSPF) defined in RFC 1584 are built on top of Open Shortest Path First (OSPF) Version 2 (RFC 1583). MOSPF uses the group membership information obtained through IGMP and with the help of OSPF database builds multicast delivery trees. These trees are shortest-path trees constructed (on demand) for each (source, group) pair. Although MOSPF does not support tunnels it can coexist and interoperate with non-MOSPF routers.

MOSPF supports hierarchical routing. All hosts in the Internet are partitioned into some "Autonomous Systems" (AS). Each AS is further divided into subgroups called "areas". In the next three sections we investigate how MOSPF performs multicast routing in these three levels.

Intra-Area Routing

OSPF is a link-state routing protocol which allows a AS to be split into areas.The OSPF link state database provides the complete map of an area at each router. By adding a new type of link state advertisement "Group-Membership-LSA" (Group-Membership Link State Advertisement) the information about the location of members of multicast groups can be obtained and put in the database. From OSPF link state information, shortest-path delivery trees rooted at the source nodes are constructed using Dijkstra algorithm. Then, group membership information is used to prune those links which don't end up to a group member. Since all area routers have the complete information about the topology of the area (a property of link-state routing protocols) and group memberships, all the routers will come up with the same delivery tree for a given (source, group) pair as long as source and all group members are in the same area. It should be noted here that delivery trees are constructed on demand. In other words, when a router receives the first multicast datagram of a (source, group) pair, it will build the delivery tree. Based on a delivery tree, a router easily knows from which interface it should expect to receive multicast messages (of a particular (source, group) pair) and to which interface(s) it should forward them. At each router the "forwarding cache" is created. There will be a separate forwarding cache entry for each (source, group) pair, containing these information: 1) on which interface the packets are expected to be received ,and 2) on which interfaces the packets should be forwarded. Unlike DVMRP, the first packet need not to be flooded in an area.

Protocol-Independent Multicast (PIM)

The Protocol Independent Multicast (PIM) routing protocols are being developed by the Inter-Domain Multicast Routing (IDMR) working group of the IETF. IDMR is planned to develop a set of multicast routing protocols which independent of any particular unicast routing protocol can provide scalable Internet-wide multicast routing. Of course, PIM requires the existence of a unicast routing protocol. The major proposed (and used) multicast protocols perform well if group members are densely packed and bandwidth is not a problem. However, the fact that DVMRP periodically floods the network and the fact that MOSPF sends group membership information over the links, make these protocols not efficient in cases where group members are sparsely distributed among regions and the bandwidth is not plentiful.

To address these issues, PIM contains two protocols: PIM - Dense Mode (PIM-DM) which is more efficient when the group members are densely distributed, and PIM - Sparse Mode (PIM-SM) which performs better in cases where group members are sparsely distributed. Although these two algorithms belong to PIM and they share similar control messages, they are essentially two different protocols. These two protocols are reviewed in the next two sections.

Protocol-Independent Multicast - Sparse Mode (PIM-SM)

PIM-SM which is defined in RFC 2117, has two key differences with existing dense-mode protocols (DVMRP, MOSPF, and PIM-DM). In PIM-SM protocol routers need to explicitly announce their will for receiving multicast messages of multicast groups, while dense-mode protocols assumes that all routers need to receive multicast messages unless they explicitly send a prune message. The other key difference is the concept of "core" or "rendezvous point" (RP) which have been employed in PIM-SM protocol.

Each sparse-mode domain has a set of routers acting as RPs (RP-set). Furthermore, each group has a single RP at any given time. Every router which want to receive multicast messages from a certain group needs to send a join message to the RP of that group (Fig. 9). Each host has a Designated Router (DR) which is the router connected to the same sub network with the highest IP address. When a DR receives an IGMP message indicating the membership of a host to a certain group, the DR finds the RP of that group by performing a deterministic hash function over the sparse-mode region's RP-set and forwards a unicast PIM-Join message to the RP. The DR and intermediate routers create an entry in their multicast forwarding table for the (*, group) pair (* means any source) such that they can know how to forward multicast messages coming from the RP of that multicast group to the DR and group members.

When a source sends a message to a certain group, the DR of that source encapsulates the first message in a PIM-SM-Register 3.5.1 packet and sends it to the RP of that group as a unicast message.

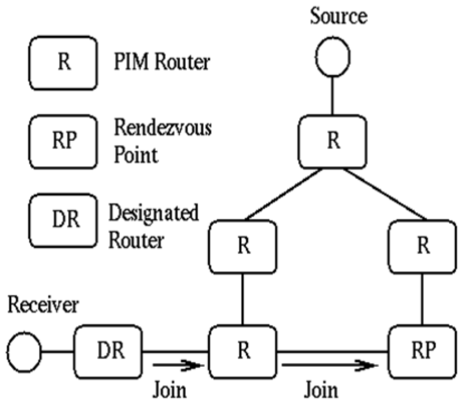


Figure Host joins a multicast group

After receiving this message, the RP sends back a PIM-Join message to the DR of the source. This exchange has been illustrated in Figure 3.5.1.

While this message is being forwarded to the DR, all intermediate routers add a new entry in their multicast forwarding tables for the new (source, group) pair. This way, next multicast messages of this source can be forwarded to the RP easily. Obviously, RP will be responsible for forwarding these multicast messages to the members of the group. It should be noted that until these entries have been added in all intermediate routers' tables, all multicast messages will be forwarded as encapsulated unicast messages.

Although forwarding multicast messages through a shared RP-tree is sufficient, if the number of participants (or messages being transmitted through this shared tree) increases, using the same shared tree may not be very desirable. PIM-SM provides a method for using shortest-path trees for some or all of the receivers. PIM-SM routers can continue using the RP-tree, but have the option of using source-based shortest-path trees on behalf of their attached receiver(s). In these situations, the PIM-SM router sends a Join message to the source node. After the source-based shortest-path delivery tree is constructed, the router can send a prune message to the RP, removing the router from the RP-tree. Figure 3.5.2 illustrates both RP-tree and shortest-path trees of our simple network.

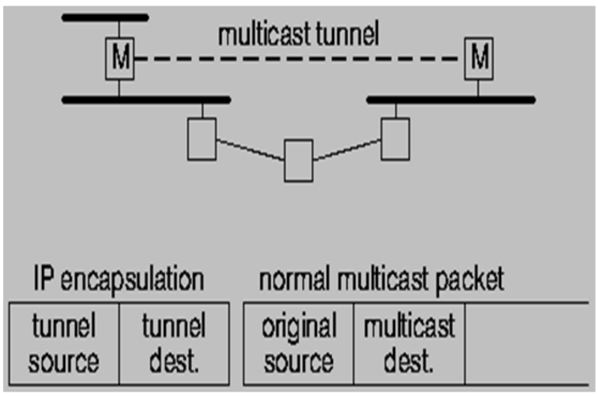
Thus we have studied different Multicast Routing Protocols. Also we observed the advantages and disadvantages of these protocols. The use of each protocol is decided by considering it's properties and application for which it is to be used .These multicast routing protocols are such that multicast routers can determine where to forward multicast messages. These protocols also use some of the algorithms discussed in the previous chapter for exchanging the multicast routing information.

MBONE

Introduction

The IP Multicast Protocol (RFC 1112) was adopted by the Internet Engineering Task Force (*IETF*) in March of 1992 as the standard protocol for building multicast applications on the Internet.

The Virtual Internet Backbone for Multicast IP, or *MBone*, is an experimental system which is acting as a testbed for multicast application and protocol design and refinement. It is an outgrowth of the first two experimental ``audiocasts" which were run by the IETF in 1992, and its purpose is to support continued experimentation between IETF meetings.



The MBone is currently a co-operative voluntary effort, consisting of Internet service providers who route multicast traffic over their networks, and end users who install multicast routers at their sites. In spite of this, the MBone has experienced exponential growth in the number of participating sites since its inception in 1992.

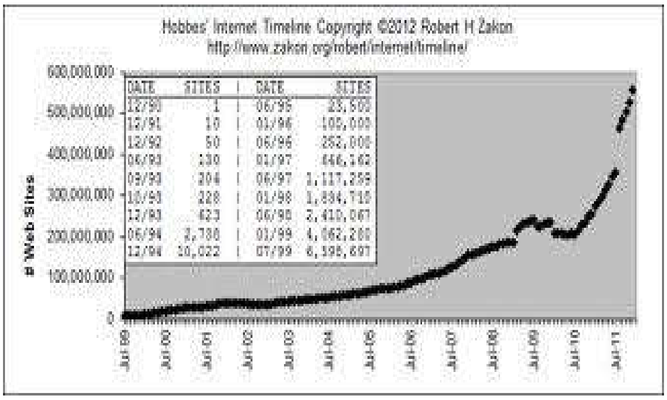


Figure 4.1.1 Growth in the MBone by year

At the moment, the MBone spans several continents; there are a few intercontinental links in place, but most activity takes place within continental (and, more specifically, national) boundaries. For all that, the MBone still represents a tiny disjoint fragment of the entire Internet. With the current growth in popularity of multimedia applications and the work being done on moving multicast support into IPng, though, it seems reasonable to expect that the size of the multicast user community relative to the size of the Internet as a whole will continue to grow for the foreseeable future.

Structure

The MBone is based around the use of the IP Multicast Protocol and the use of *tunnels*. At the moment, sections of the MBone form a virtual network of ``islands", interconnected using tunnels over the physical Internet. Ordinary routers along a tunnel know nothing about the multicast IP packets they carry, as they are encapsulated in ordinary IP packets; multicast packets are transmitted point-to-point between multicast routers (*mrouters*). Once an mrouter receives a multicast packet, it plucks out the encapsulated packet and processes it as appropriate. This may involve using native LAN technology (such as Ethernet or FDDI) to multicast or broadcast the packet locally, and perhaps also re-encapsulating the packet to send it on to several more mrouters in the chain.

Since the current applications of the MBone do not need reliable delivery or flow control, TCP is not used to transmit data. Instead, the Real-Time Transport Protocol (*RTP*) is used. RTP provides sequenced datagram delivery, but makes no guarantees about delivery, and does not provide flow control. The idea is that applications should generate as much data as their clients need ``on the fly", and that clients should be adaptable to varying degrees of network lag.

Applications on the MBone

At present, most MBone applications are oriented towards group communication and productivity.

1. Audio tools
2. Video tools
3. Session control
4. Other applications

CONCLUSION

Today, the MBONE is a critical piece of the technology that's needed to make multiple-person data, voice, and video conferencing on the Internet -- in fact, sharing any digital information -- cheap and convenient.

Internet researcher John December says, "MBONE is truly the start of mass-communication that may supplant television. Used well, it could become an important component of mass communication."

Also the IEEE and other such organizations are publishing the papers on the topic of “Multicasting & Mbone”.

So in the future this technology is going to work in combination. With the peer to peer technology to fulfil the requirements of the Networking basics.

References

MBone: Multicasting Tomorrow’s Internet
A book about the multicasting backbone and the future of multimedia on the Internet Copyright 1996, 1998 by Kevin Savetz, Neil Randall, and Yves Lepage

Web Links

1. "Unicast and Multicast Addressing and Routing Introductions," http://www.ipmulticast.com/community/links-routing.html
2. A list of links on IP multicast routing. "Current Internet-Drafts relating to IP Multicast," http://www.ipmulticast.com/community/rcdrafts.html
3. A list of related Internet Drafts and a short description for each of them. "IP Infrastructure and Multicasting References," http://skynet.gsfc.nasa.gov/transition/ip-infra/Multicast-refs.html

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