

A Review of Multicasting in Network Communication

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ABSTRACT : 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.

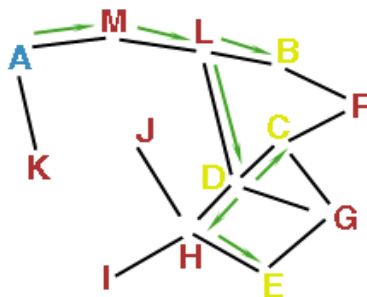
Keywords- Communication, Multicast Routing Algorithm, Multicast Protocol.

I. INTRODUCTION

Multicast is one of those networking concepts that's relatively simple, though hard to explain without some background. But let me assure you, it's worth the effort to understand. 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.

Old Way

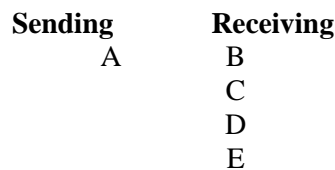
Multicast way

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.

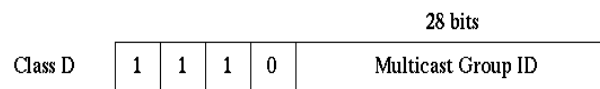


Finally, we come to Ethernet's multicast addresses. Here, the sending machine sends out a stream of packets addressed to a multicast address, and receivers program their Ethernet cards to listen for these addresses. This allows one to keep many computers abreast of something with only one stream of packets.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



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 ore 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. The thing I like is that when no one is listening (subscribing), the traffic doesn't even enter the Internet, it just stays on the LAN. 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.



II. MULTICASTING ROUTING ALGORITHM

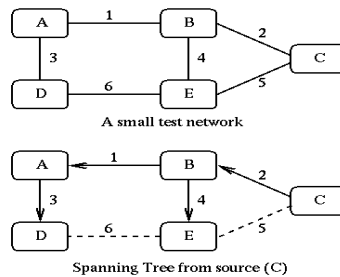
Several algorithms have been proposed for building multicast trees through which the multicast packets can be delivered to the destination nodes. These algorithms can be potentially used in implementing the multicast routing protocols. In this section, we start with reviewing two simpler algorithms called 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.

2.1. Flooding

The Flooding algorithm which has been already used in protocols such as OSPF is the simplest technique for delivering the multicast datagrams 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.

2.2 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. The spanning tree from source node (C) is shown in Figure 2.1.1

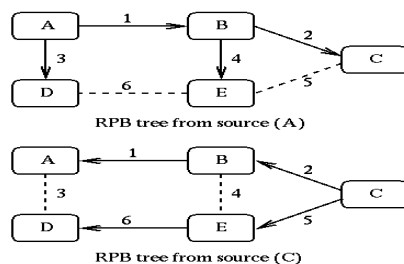


2.1.1 Fig : Spanning Tree

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.

2.3 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. 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



2.3.1 Fig: RPB Tree

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 neighbor, 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.

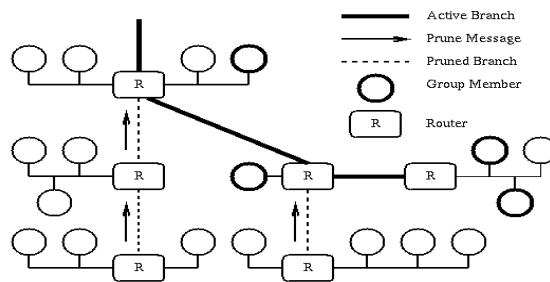
2.4 Truncated Reverse Path Broadcasting (TRPB)

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.

2.5 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

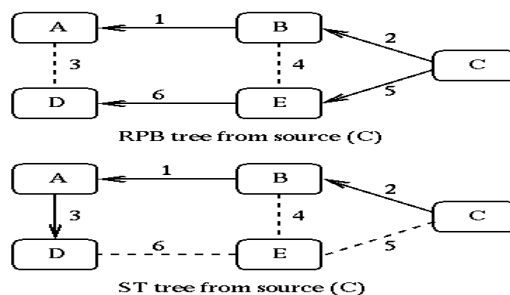
subnetworks along the shortest path to subnetworks with group members. The RPM tree can be pruned such that the multicast packets are forwarded along links which lead to members of the destination group. For a given pair of (source, group) the first multicast packet is forwarded based on the TRPB algorithm. 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. 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).



2.5.1 Fig : RPM Tree

2.6 Steiner Trees (ST)

In the RPB family of algorithms (RPB, TRPB, and RPM) the shortest path between the source node and each destination node is used for delivering multicast packets, guaranteeing that multicast packets are delivered as fast as possible. However, none of these algorithms try to minimize the use of network resources. In Figure 2.6.1 the RPB tree and another delivery for our test network are shown assuming that C is the source and A and D are the recipients. It can be easily observed that the second tree uses less number of links. Although, this tree is slower than the RPB tree (because packets need to pass three hops for reaching D instead of 2 hops required in RPB tree), it uses fewer links.



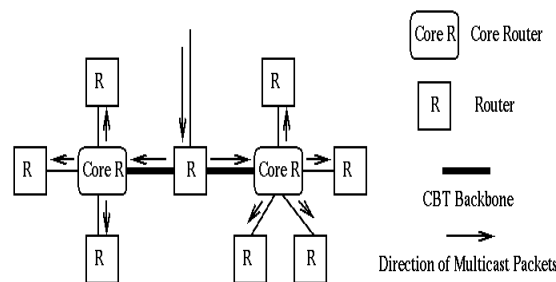
2.6.1 Fig : Steiner Tree

This type of tree is called Steiner tree. Although Steiner trees minimize the number of links used for constructing a delivery tree, difficulties in computing these trees has made these trees of little practical importance. Since the form of ST changes with a node joining or leaving the multicast group, Steiner trees are also very unstable.

2.7 Core-Based Trees (CBT)

The latest algorithm proposed for constructing multicast delivery trees is called Core-Based Tree (CBT) algorithm. Unlike other algorithms discussed earlier, CBT creates a single delivery tree for each group. In other

words, the tree used for forwarding multicast messages of a particular group, is a single tree regardless of the location of the source node. A single router, or a set of routers, are chosen to be the "core" router of a delivery tree. All messages to a particular group are forwarded as unicast messages toward the core router until they reach a router which belongs to the corresponding delivery tree. Then, the packet is forwarded to all ongoing interfaces which are part of the delivery tree except the incoming interface. This has been illustrated in Fig. 2.7.1. Since CBT constructs only one delivery tree for each multicast group, multicast routers are required to keep less information in comparison to the requirements of other routing algorithms. CBT conserves network bandwidth too because, it does not require flooding of any multicast packet over the internetwork. However, using a single tree for each group may lead to traffic concentration and bottlenecks around the core routers. Having only one delivery tree may also result in non-optimal routes and therefore delay in delivering messages. single delivery tree for each group. In other words, the tree used for forwarding multicast messages of a particular group, is a single tree regardless of the location of the source node. the packet is forwarded to all ongoing interfaces. This has been illustrated in Fig. 2.7.1



2.7.1 Fig : Core-Based Tree

III. Multicast Routing Protocols

In the previous chapter, 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.

3.1 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.

Table 1: TTL Scope Control Values

TTL	Scope
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Threshold	
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

3.2 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.

3.3 Protocol-Independent Multicast (PIM)

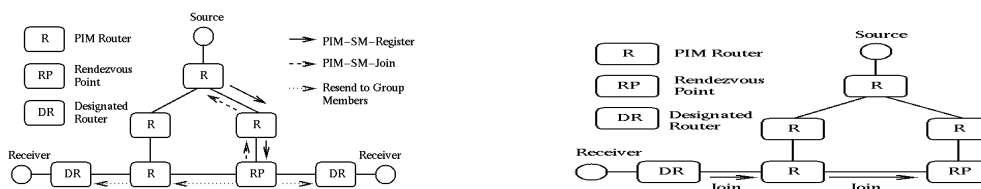
The Protocol Independent Multicast (PIM) routing protocols are being developed by the Inter-Domain Multicast Routing (IDMR) working group of the IETF. IDMR is planned to develop a set of multicast routing protocols which independent of any particular unicast routing protocol can provide scalable Internet-wide 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.

3.4 Protocol-Independent Multicast - Dense Mode (PIM-DM)

PIM-DM is very similar to DVMRP and uses the RPM algorithm for forming delivery trees. However, there are major differences between these two algorithms. Although PIM-DM requires the presence of a unicast routing protocol for finding routes back to the source node, PIM-DM is independent of the mechanisms employed by any specific unicast routing protocol. DVMRP uses RIP-like exchange messages to build its unicast routing table.

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

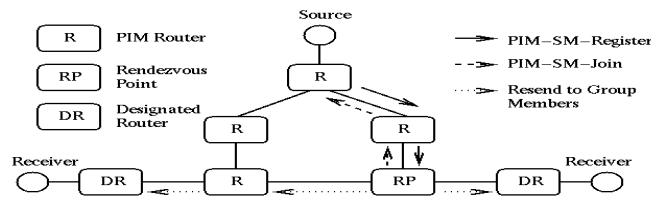
PIM-SM which is defined in [RFC 2117](#), has two key differences with existing dense-mode protocols (DVMRP, MOSPF, and PIM-DM). In PIM-SM protocol routers need to explicitly announce their will for receiving multicast messages of multicast groups, while dense-mode protocols assumes that all routers 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. When a source sends a message to a certain group, the DR of that source encapsulates the first message in a PIM-SM-Register packet and sends it to the RP of that group as a unicast message. 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.



3.5.1 Fig : Host joins a multicast group

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. tables, all multicast messages will be forwarded as encapsulated unicast messages.

3.5.2 Fig : Source sends to a multicast group



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 its 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.

IV. MBONE

4.1 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.

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.

4.2 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 (mrouter). 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 mrouter in the chain.

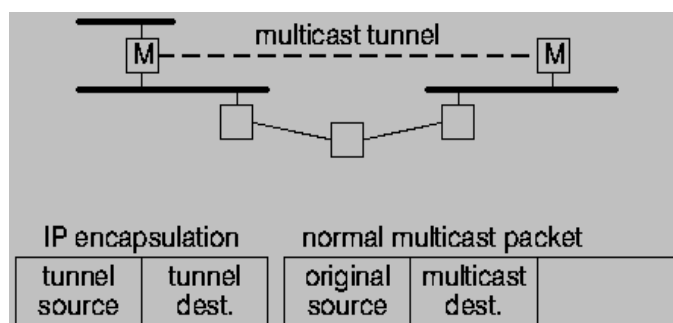


Figure 4.2.1 Encapsulating multicast packets in normal IP datagrams.

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.

4.3 Applications on the Mbone

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

4.3.1 Audio tools

4.3.2 Video tools

4.3.3 Session control

4.3.4 Other applications

V. 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 .

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