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Multicast Routing and Its Protocols

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Abstract: **In the age of multimedia and high-speed networks, multicast is one of the mechanisms by which the power of the Internet can be further harnessed in an efficient manner. When more than one receiver is interested in receiving a transmission from a single or a set of senders, multicast is the most efficient and viable mechanism. In the protocol stack of the network, multicast is best implemented in the network layer in the form of a multicast routing protocol to select the best path for the transmission. The other layers of the protocol stack provide additional features for multicast. Group communication and network multimedia applications are becoming more and more popular. These applications set new demands on the quality of network resources such as bandwidth or latency. While these resources are usually very limited, good multicast routing will be more and more important as networks and the number of users continues to grow. In this paper, we discuss about the multicast routing that provide more quality. First, an overview of routing and its design considerations, discussing several key features in routing. Multicasting, as it is an important topic to cover, is explained stating definitions, requirements and applications. Differences between general multicast trees, functional overview are highlighted. Also some well-known multicast routing protocols are covered.**

***Keywords*: DVMRP: Distance Vector Multicast Routing Protocol, IGMP: Internet Group Management Protocol, LAN local area network, MOSP: multicast extension to the OSPF routing protocol, OSPF open shortest path first, PIM Protocol-Independent Multicast, and RPF reverse path forwarding.**

I.INTRODUCTION

Data communication in the Internet can be performed by any of the following mechanisms: unicast, broadcast, and multicast. Unicast is point-to-point communication. Broadcast is when data is forwarded to all the hosts in the network. Anycast is when data is to be transmitted to any one of the members selected to be part a group. Multicast is when data is to be transferred to only a group of hosts on a network. In the age of multimedia and high speed networks, multicast is one of the viable mechanisms by which the power of the Internet can be further harnessed in an efficient manner. Steve Deering first suggested IP multicast in his PhD dissertation in 1988[1]. The first usage of multicast on a wide scale was during an ―audiocast‖ at the March 1992 IETF meeting in San Diego. There have been a number of techniques proposed to implement multicast in the Internet and intranet. Both unicast and broadcast traffic are easy for networks to implement; data packets will either be delivered to a single unique destination, or they will be propagated throughout the network for all end users. Supporting multicast traffic is considerably more complex because participants must be identified, and traffic must be sent to their specific locations. The network should also refrain from sending traffic to unnecessary destinations to avoid wasting valuable bandwidth. Large service providers are concerned about the effects of multicast traffic on their networks. Service providers do not support broadcast traffic. However, multicast traffic is increasing over the Internet. Applications such as data casting (news, stock tickers, etc.), video and audio transmissions, training, seminars, etc all depend on multicast technology. These applications are designed to deliver identical packets to a large number of receivers. Multicasting is not connection-oriented. A multicast datagram is delivered to destination group members with the same "best-effort" reliability as a standard unicast IP datagram

II. MULTICAST ROUTING

Routing is the process of selecting paths in a network along which to send network Traffic. Routing is performed for many kinds of networks, including the telephone network, electronic data networks (such as the Internet), and transportation networks. In packet switching networks, routing directs packet forwarding, the transit of logically addressed packets from their source toward their ultimate destination through intermediate nodes; typically hardware devices called routers, bridges, gateways, firewalls, or switches. *Multicast* (delivers a message to a group of nodes that have expressed interest in receiving the message). With a multicast design, applications can send one copy of each packet and address it to the group of computers that want to receive it. This technique addresses packets to a group of receivers rather than to a single receiver, and it depends on the network to forward the packets to only the networks that need to receive them. Path selection involves applying a routing metric to multiple routes, in order to select the best route. In the case of computer networking, the metric is computed by a routing algorithm, and can cover such information as bandwidth, network delay, hop count, path cost, load, reliability, and communication cost.

There are several parameters that the network layer must define in order to support multicast communications:

a) *Addressing*: There must be a network-layer address that is used to communicate with a group of receivers rather than a single receiver. In addition, there must be a mechanism for mapping this address onto data-link layer multicast addresses where they exist.

b) *Dynamic registration*. : There must be a mechanism for the computer to communicate to the network that it is a member of a particular group. Without this ability, the network cannot know which networks need to receive traffic for each group.

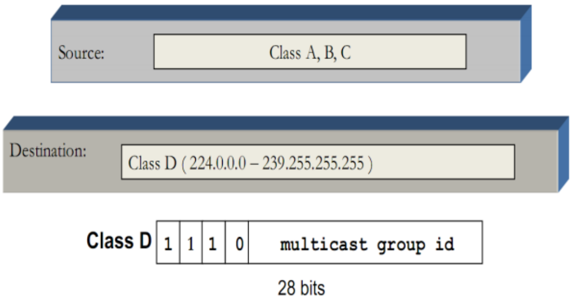

Fig 1: Data packet format for Multicast Routing

The network must be able to build packet distribution trees that allow sources to send packets to all receivers. A primary goal of these packet distribution tree is to ensure that each packet exists only one time on any given network .When the number of sender and receiver involved in a data communication is one-to- many or many-to-many or many-to-one, multicast is used as the means of data communication. The sender(s) and receivers are assumed to be part of a group.

The features of a multicast group are described below:

1. A host can be a member of any number of multicast groups.
2. The membership to a multicast group is dynamic, the sender(s) and receivers can join or leave the group at any time. For scalability, the join and leave operation has to be simple without any side effects.
3. To be a sender of a group, it is not necessary that the host is a member of the group. Each group is identified by a Class D address in IPv4 networks.
4. Data communication is done using User Datagram Protocol (UDP). This is to avoid the overhead of reliability and flow control that is associated with Transmission Control Protocol (TCP).

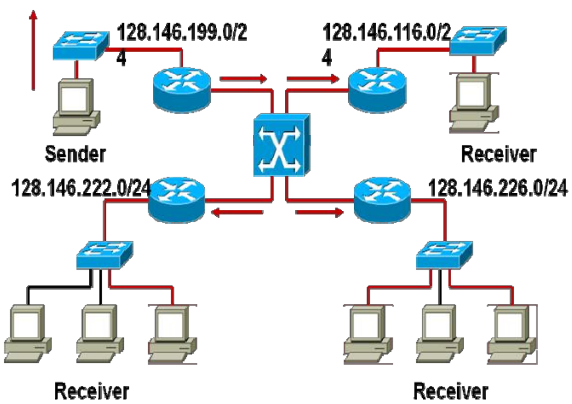

Fig 2: Multicast Routing

The multicast groups can be classified either as permanent or transient groups. The transient groups remain in existence as long as there are members in the group. However permanent groups remain in existence even when the number of members in the group is zero. Apart from this, the multicast groups can be classified either as dense or sparse groups based on the distribution of the group members in the network.

Functional overview:

The two important benefits of multicast routing are:

1. When an application must send the same information to more than one destination, multicasting is more efficient than unicasting: it reduces the transmission overhead on the sender and the network, and it reduces the time it takes for all destinations to receive the information.
2. When an application must locate, query, or send information to one or more hosts whose addresses are unknown or changeable, multicasting serves as a simple, robust alternative to configuration files, name servers, or other binding mechanisms.

III.INTERNET GROUP MANAGEMENTPROTOCOL(IGMP)

The Internet Group Management Protocol, IGMP version 2[RFC 2236], operates between a host and its directly attached router (informally, think of the directly attached router as the ―first-hop‖ router that a host would see on a path to any other host outside its own local network, or the ―last-hop‖ router on any path to that host), as shown in Figure 3. Figure 3 shows three first-hop multicast routers, each connected to its attached hosts via one outgoing local interface. IGMP provides the means for a host to inform its attached router that an application running on the host wants to join a specific multicast group

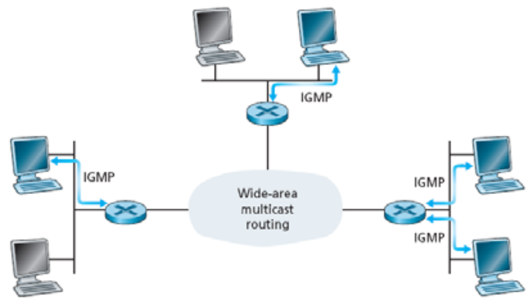

Fig 3: IGMP

Given that the scope of IGMP interaction is limited to a host and its attached router, another protocol is clearly required to coordinate the multicast routers (including the attached routers) throughout the Internet, so that multicast datagram are routed to their final destinations. IGMP version 2 [RFC 2236] has only three message types, as shown in Table 1. A general membership query message is sent by a router to all hosts on an attached interface (for example, to all hosts on a local area network) to determine the set of all multicast groups that have been joined by the hosts on that interface. A router can also determine whether a specific multicast group has been joined by hosts on an attached interface using a specific membership query. The specific query includes the multicast address of the group being queried in the multicast group address field of the IGMP membership query message, as shown in Figure 4.

8	16	32
Type	Max .resp .time	Check sum
Multicast group address		

Fig 4: IGMP Message format

IGMP thus provides an explicit mechanism aimed at decreasing the number of membership report messages generated when multiple attached hosts belong to the same multicast group Specifically, each membership query message sent by a router also includes a ―maximum response time‖ field, as shown in Figure 4.After receiving a membership query message and before sending a membership report message for a given multicast group, a host waits a random amount of time between zero and the maximum response time value. If the host observes a membership report message from some *other* attached host for that given multicast group, it *suppresses* (discards) its own pending membership report message, since the host now knows that the attached router already knows that one or more hosts are joined to that multicast group. The final type of IGMP message is the leave group message. Interestingly, this message is optional router infers that no hosts are joined to a given multicast group when no host responds to a membership query message with the given group address

IV. MULTICAST ROUTING PROTOCOLS

There are several different multicast routing protocols, and each one has its own unique technological solution. The Distance Vector Multicast Routing Protocol (DVMRP) is the earliest protocol for multicast routing. A key concept introduced by DVMRP is the use of separate forwarding trees for each multicast group; this fundamental principle continues to be used in the newer multicast routing protocols. The next incarnation of multicast routing was an extension of the popular OSPF protocol called MOPSF. OSPF is designed explicitly to be an interior gateway protocol, meaning that it resides within a single autonomous system. Hence, any extensions to OSPF, such as MOSPF, would also reside within the confines of one autonomous system. A new breed of multicast routing protocols was developed in the late 1990s. This family of protocols is collectively known as Protocol Independent Multicast (PIM). The name PIM is derived from the fact that these multicast forwarding protocols are not dependent upon any one specific routing protocol.

4.1. DVMRP

DVMRP is a distance vector style algorithm that builds source based multicast trees. When a DVMRP router receives a multicast packet, it sends the packet to all attached routers and waits for a response. Routers with no group members return a ―prune‖ message, which eventually prevents further multicast messages for that group from reaching the router. The prune state is soft, that is, it will time-out within a set time interval. If after sending a prune and before the state can time-out, the host wants to join the group, it has to send a ―graft‖ message upstream. DVMRP is inefficient when the number of receivers in the group is sparsely distributed. DVMRP builds its own routing table instead of reusing the existing unicast routing table for RPF checking of incoming packets. DVMRP has been used to build the MBONE—a multicast backbone across the public Internet—by building tunnels between DVMRP-capable machines. The MBONE is used widely in the research community to transmit the proceedings of various conferences and to permit desktop conferencing. A packet is assumed to have arrived on the RPF interface if a router receives it on an interface that it uses to send unicast packets to the source. If the packet arrives on the RPF interface, then router forwards it out the interfaces that are present in the outgoing interface list of a multicast routing table entry.

IGMP Message Types	*Sent by*	*Purpose*
Membership query:general	*router*	*Query multicast groupsjoined by attached nodes*
Membership query:specific	*router*	*Query if specificmulticast group joined by attached hosts*
Membership report	*host*	*Report host wants tojoin or joined to given multicast group.*
Leave group	*host*	*Report leaving givenmulticast group*

Table 1: IGMP version2 Type

The advantage of RPF is that it does not require the router to know about spanning trees. This way, multicast adapts automatically and only is sent where it is wanted. RPF checking cannot be used to check the validity of a path in case of asymmetric paths.DVMRP will periodically reflow in order to reach any new hosts that want to receive a particular group. There is a direct relationship between the time it takes for a new receiver to get the data stream and the frequency of flooding. DVMRP implements its own unicast routing protocol in order to determine which interface leads back to the source of the data stream. This unicast routing protocol is very like RIP and is based purely on hop counts. As a result, the path that the multicast traffic follows may not be the same as the path that the unicast traffic follows. DVMRP has significant scaling problems because of the necessity to flood frequently. This limitation is exacerbated by the fact that early implementations of DVMRP did not implement pruning.

4.2 MOSPF

MOSPF is a multicast extension to the OSPF routing protocol. MOSPF is a link state routing protocol that builds the map of the network topology, including location of domains and tunnels. It selects the best path to the required receivers using Djikstra’s shortest path algorithm. It is meant to be in use within an Autonomous System (AS). (source, subtree, (group, link-ttls), (group, link-ttls)),

When there are multiple sources or many groups, it is CPU intensive. It is best used when relatively few sources or groups are active at any given time. It does not work well in presence of unstable links, as it leads to frequent state update and the associated computations.

MOSPF does not support tunneling. It constructs source based multicast trees. It can also be considered as a QoS routing algorithm that minimizes delay. It is one of the dense mode protocols that requires explicit join from the receivers.

MOSPF provides an effective means for a single corporation, university, or other organization to support multicast routing, but it cannot support wide-scale applications that require the use of the Internet. MOSPF is used sporadically for some specialized applications, but it is not prevalent. MOSPF works only in internetworks that are using OSPF. MOSPF is best suited for environments that have relatively few source/group pairs active at any given time. It will work less well in environments that have many active sources or environments that have unstable links.

4.3 PIM

P1rotocol-Independent Multicast (PIM) works with all existing unicast routing protocols. PIM supports two different types of multipoint traffic distribution patterns: dense and sparse.

Dense mode is most useful when:

a) Senders and receivers are in close proximity to one another.

b) There are few senders and many receivers.

c) The volume of multicast traffic is high and the stream of multicast traffic is constant.

Dense-mode PIM uses Reverse Path Forwarding and looks a lot like DVMRP. The most significant difference between DVMRP and dense-mode PIM is that PIM works with whatever unicast protocol is being used; PIM does not require any particular unicast protocol.

Sparse multicast is most useful when:

a) There are few receivers in a group.

b) Senders and receivers are separated by WAN links.

c) The type of traffic is intermittent.

Sparse-mode PIM is optimized for environments where there are many multipoint data streams. Each data stream goes to a relatively small number of the LANs in the internetwork. For these types of groups, Reverse Path Forwarding techniques waste bandwidth. Sparse-mode PIM works by defining a Rendezvous Point. When a sender wants to send data, it first sends to the Rendezvous Point. When a receiver wants to receive data, it registers with the Rendezvous Point. Once the data stream begins to flow from sender to Rendezvous Point to receiver, the routers in the path will optimize the path automatically to remove any unnecessary hops.

V. ADVANTAGES & DISADVANTAGES

The Multicast Routing has many more advantages over other two routing mechanisms.

1. Better bandwidth utilization: Any form of network communication involving the transmission of information to multiple recipients can benefit from the bandwidth efficiency of multicast technology.
2. Besides the support of distributed applications, multicast also provides optimized network performance, resource reduction, scalability, and reduced network load. These benefits provide for a better working more efficient network.
3. Multicast provides for an optimized network performance because of decreasing the amount of flow replications. Multicast avoids these flow replications because of a better architecture to distribute the data.
4. Scalability is another benefit of multicast. By effectively using the network resources by not wasting resources on unnecessary unicast statements, it reduces the traffic load of the sender.
5. Less host/router processing.
6. Server load: single sender can support arbitrary number of receivers.
7. User latency: receivers get data in ―parallel‖ rather than serially.
8. The cost is minimal since the current infrastructure already supports multicasting.

Multicast Routing has the following disadvantages,

1. A multicast routing protocol has to handle a number of issues like state collection and updating, handling of dynamic topology and membership changes, tree maintenance and scalability. QoS further complicates the protocol design process.

2. The multicast packets must be periodically broadcast across every router in the internetwork, onto every leaf subnet work. This "broadcasting" is wasteful of bandwidth.

3. Excessive processing of control information.

4. Poor response to network congestion.

5. Inability to handle high-priority traffic.

VI. CONCLUSION

Multicast applications are catching on. The Internet already supports many large multicast applications such as news bureaus and financial services. Tens of thousands of small multicast groups exist at any given time to support two or three users participating in small conferences. As these applications further proliferate, multicast traffic will significantly increase over the Internet. The term ―multicast‖ has many different connotations. It encompasses a dozen different protocols, each of which has its own specific purpose. Currently, the most common protocols are IGMP versions 2 and 3, MLD versions 1 and 2, and PIM-SM. As multicast technology continues to mature, the protocols will further evolve. The implications of increased multicast traffic for networks and routers are unknown. Extensive network and device testing is absolutely critical to understanding the effects of the expanding and changing multicast space.

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