



Multicast Routing Protocols in Wired Networks: A Comprehensive Study

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Abstract -Multicast routing is a group oriented communication whose objective is to support the propagation of data from a sender to all the receivers of a multicast group while trying to use the available bandwidth efficiently, it also reduces the communication cost and saves the network resources. In this paper, multicast routing protocols in wired networks that was proposed in recent years has been covered and made a comprehensive study on existing multicast routing protocols.

Keywords-Wired Networks, Multicast Routing Protocol, DVMRP, PIMDM, MOSPF, CBT, PIMSM, PGM, BGMP.

I. INTRODUCTION

A. Wired Network: It is a common type of wired configuration which uses physical cables to transfer data between different devices and computer systems. Wired networks, also called Ethernet networks, are the most common type of local area network (LAN) technology. It is simply a collection of two or more computers, printers, and other devices linked by Ethernet cables. In a small wired network, a single router may be used to connect all the computers but larger networks often involve multiple routers or switches that connect to each other.

Wired networks have several salient *characteristics*:

1. Changes in network topology are very rare.
2. Abundant link capacities.
3. Bandwidth has higher magnitude.
4. Use cable to connect computers.
5. Wired networks can also be used as part of other wired and wireless networks.
6. Wired network is within a 2,000-foot-radius.
7. The disadvantage of this is that data transmission over this distance may be slow or nonexistent.
8. Interference is very limited through direct connections.
9. More secure.
10. Can be used in many situations; corporate LANs, school networks and hospitals.
11. The biggest drawback to this type of network is that it must be rewired every time it is moved.
12. The cost for wired networking has become rather inexpensive. Ethernet cables, hubs and switches are very inexpensive
13. Wired LANs offer superior performance
14. Firewalls are the primary security consideration.

B. Type of Transmission:

Broadcast: It is a basic mode of operation in which source transmits message to every other node in the network [19].

Unicast: It is a mechanism in which one source transmits messages or data packets to one destination [20]. This is the most common approach and forms the basis for other type of protocols. Unicast protocols lag when there is a need to send same message or stream of data to multiple destinations.

Multicast: It is a mechanism in which source transmits messages or data packets to several destinations and has desirable routing tree or a mesh from one source to several destinations [21]. These protocols have to keep up with information of joining and leaving of nodes to a multicast group.

C. Multicasting

Multicast [1, 2, 3] is a network addressing method for the delivery of information to a group of destinations simultaneously using the most efficient strategy to deliver the messages over each link of the network only once, creating copies only when the links to the multiple destinations split. It allows saving bandwidth and reducing the traffic load in the network. It also provides seamless and uninterrupted streaming services, and mostly used in streaming media, Internet television, video conferencing and net meeting etc. Multicasting reduces the communication costs for applications that send the same data to multiple recipients. Instead of sending via multiple unicasts, multicasting minimizes the link bandwidth consumption, sender

and router processing, and delivery delay. The Initial Support required for multicasting are: Multicast-capable routers (MRouters), Dedicated Tunnels and Multicast backbone (MBone).

Taxonomy of common multicast routing protocols

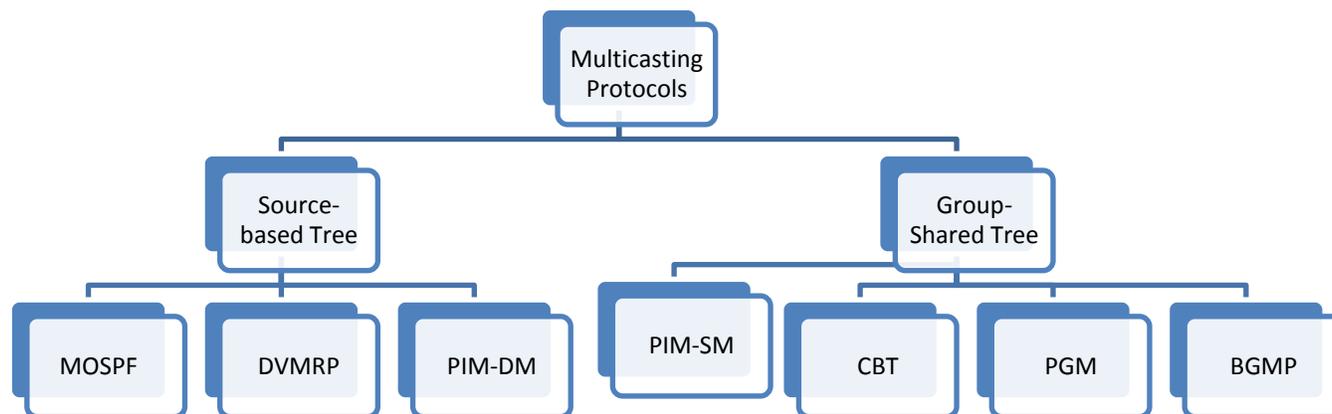


Fig 2: Classification of Multicasting Protocols

D. Two main strategies of Multicasting Protocols are:

Source- Based Tree: In this each router needs to have one shortest path tree for each group. It constructs a separate tree for each source, using the least-cost paths between the source and the members. The shortest path tree for a group defines the next hop for each network that has loyal member(s) for that group.

Group-shared tree: In the group shared tree approach, instead of each route having m shortest path trees, only one designated router, called the centre core, a rendezvous router, takes the responsibility of distributing multicast traffic. The core has m shortest path trees in its routing table. The rest of the routers in the domain have none. If a router receives a multicast packet, it encapsulates the packet in a unicast packet and sends it to the core router. The core router removes the multicast packet from its capsule, and consults its routing table to route the packet.

II. RELATED WORK

Wired networks have gained tremendous focus from researchers and application developers because of the great potential of its network type. In earlier research works [2, 3] several MRPs have been proposed based on wired networks. MRPs basically follow two approaches; source tree-based and group tree –based [22]. In each approach, a tree is setup connecting all the members of the multicast group. The difference between these protocols is in approach of creating and maintaining the tree. All the work in this research will be based on performance comparison and analysis of both types of MRPs.

Wei and Estrin et al. and many more have done a great work in multicast routing protocols in wired networks. They also evaluated the performance of the existing multicast protocols to justify their proposal.

The literature survey has been done to analyze the proposed multicast routing protocol in wired networks. Already a number of eminent researchers carried out some experiments to study the multicast routing protocols such as PIM-DM, DVMRP, BGMP, CBT, PGM, PIM-SM, and MOSPF in wired or static environments. Multicasting plays a crucial role in many applications. They can significantly improve the performance of these networks, the channel capacity and bandwidth etc. In spite of being designed for the same networks, these protocols are based on different design principles and have different functional features when they are applied to the multicast problem.

In the following subsections I am going to explain different multicasting protocols in wired network and then comparison between them.

III. DIFFERENT MULTICAST ROUTING PROTOCOLS

A. Distance Vector Multicast Routing Protocol (DVMRP)

The distance vector multicast routing protocol [4] is an implementation of multicast distance vector routing. DVMRP builds a multicast tree for each source and destination host group. It implements the Reverse Path Multicasting (RPM) algorithm. It is a source based routing protocol, based on RIP, but the router never actually makes a routing table but it uses unicast routing protocol for this purpose. When a router receives a multicast packet it forwards (broadcast) it. DVMRP uses a *Broadcast & Prune mechanism*. That is, a broadcast tree is build from a source by exchanging routing information. Then this broadcast tree is changed to multicast tree by using pruning technique. More specifically, initially multicast datagram's are delivered to all nodes on the tree. Those leaves that do not have any group members send *prune messages* to the upstream router, noting

the absence of a group. The upstream router maintains a prune state for this group for the given sender. A prune state is aged out after a given configurable interval, allowing multicasts to resume. Pruned branches are restored to a multicast tree by sending graft messages towards the upstream router. Graft messages start at the leaf node and travel up the tree, first sending the message to its neighbor upstream router. Thus it works on broadcasting, pruning and grafting process.

B. Protocol Independent Multicast- Dense Mode (PIM-DM)

PIM-DM [5, 6, 7] is a source – based tree routing protocol that uses RPF and pruning and grafting strategies for multicasting. Its operation is like that of DVMRP; however, unlike DVMRP, it does not depend on a specific unicasting protocol. It assumes that the autonomous system is using a unicast protocol and each router has a table that can find the outgoing interface that has an optimal path to a destination. This unicast protocol can be a distance vector protocol or link state protocol.

It is envisioned that PIM-DM will be deployed in resource-rich environments, such as a campus LAN where group membership is relatively dense and bandwidth is readily available.

PIM DM protocol works in two phases:

In the first phase, the whole network is flooded with multicast data and this is done by propagation of packet on all interfaces except on upstream interface. This phase is highly inefficient because it leads to excessive network resource usage because of its network flooding technique.

In the second stage, called a prune phase, cuts out unnecessary branches by means of a *Prune* message. A network device, after reception of a *Prune* packet, terminates further forwarding of multicast traffic on this interface and the interface is set to be in prune state.

There is one important message that is periodically exchanged between PIM DM routers are *Hello* packets. It helps routers learn about the presence of PIM DM-capable neighbor routers in the network.

C. Multicast open shortest path first (MOSPF)

MOSPF [8] protocol is an extension of the OSPF protocol that uses multicast link state routing to create source based trees. The protocol requires a new link state update packet to associate the unicast address of a host with the group address or addresses the host is sponsoring. This packet is called the group membership LSA (link state advertisements). This LSA makes it possible to identify the location of each group member. In this way, we can include in the tree only the hosts that belong to a particular group. In other words we make a tree that contains all the hosts belonging to a group. But we use the unicast address of the host in the calculation. For efficiency, the router calculates the shortest path trees on demand. In addition, the tree can be saved in cache memory for future use by the same source/group pair. MOSPF is data driven protocol; the first time an MOSPF router sees a data gram with a given source and group address, the router constructs the Dijkstra shortest path tree. MOSPF routers maintain a current image of the network topology through the unicast OSPF link-state routing protocol.

D. Core Based Tree (CBT)

CBT [9, 10, 11] was first proposed by Ballardie, Francis, and Crowcroft. It floods the data or the membership information from the multicast group address to a particular unicast address (core address) of a router (Core Router), and build explicit distribution trees centered on this particular router. It has a single Core Tree per group. Working of CBT is as follows:

1. Identification of Core Router: The placement of a group's core reflects that group's characteristics since the core placement helps in optimizing the routes between any sender and group members on the tree. Therefore selection of core should be done carefully. A router could become a core when a host on one of its attached subnets wishes to initiate a group. Or in case of a single sender, the router nearest to it could become a core.

2. Formation of the Tree: After the rendezvous point (core) is selected, every router is informed of the unicast address of the selected router. Each router then sends a unicast join message (similar to a grafting message) to show that it wants to join the group. This message passes through all the routers that are located between the sender and rendezvous router. Each intermediate router extracts the necessary information from the message, such as the unicast address of the sender and the interface through which packet has arrived, and forward the packet to the next router in the path. When the rendezvous router has received all join messages from every member of group, the tree is formed. Now every router knows its upstream router and the downstream router.

If a router wants to leave the group, it sends a leave message to its upstream router; the upstream router removes the link to that router from the tree and forwards the message to its upstream router, and so on.

3. Sending multicast packets: After formation of the tree, any source can send a multicast packet to all members of the group. It simply sends the packets to the rendezvous router; this router distributes the packets to all the members of the group. Note that source host can be any of the hosts inside the shared tree or any host outside the shared tree.

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

PIM-SM [12, 13, 14] is a group-shared tree routing protocol that has a rendezvous point (RP) as the source of the tree. Its operation is like CBT; however, it is simpler because it does not require acknowledgement from a join message. In addition, it creates a backup set of RPs for each region to cover RP failures. PIM-SM creates and maintains unidirectional multicast trees based on explicit Join/Prune protocol messages. It is designed to support sparse groups. PIM-SM creates a shared, RP-routed distribution tree that reaches all group members and it authorizes the receivers to switch from a RP (Rendezvous Point)-routed tree (RPT) to a shortest path tree (SPT).

It works in following phases:

The phase one of the protocol formulates a distribution tree for multicast. The receiver designates one local router as a Designated Router (DR) for its contained subnet. All the DR's sent JOIN messages [in form of (*, G)] towards the RP for multicast transmissions. When many receivers join the group, their join messages converge at the Performing a distribution tree. This is called as RP tree (RPT) and is a shared tree as it is shared by all the sources sending to the group. The Multicast sender sent the multicast data to the group through the DR. The DR Unicast encapsulates the data and sends them to the RP. This process is called Registering. The encapsulated packets are called PIM Register Packets. RP decapsulated the data and forwards them to the intended shared tree and replicates wherever the RP Tree branches, and eventually reaching all the receivers for that multicast group [5].

The second phase of PIM-SM operation is the Register STOP operation. Encapsulation and decapsulation process at the router may be expensive. Hence when the RP receives a register encapsulated data packet from source S on group G, it will normally initiate an (S, G) source specific Join towards S and RP will switch to native forwarding. Eventually the messages reach the subnet S and the packets flow towards the RP. While RP is in the process of joining source specific packets, data packets continue to encapsulate to RP. Thus RP receives packets forwarded natively from S as well as encapsulated packets. RP now begins to discard the encapsulated copy of the packets and sends a Register STOP message to DR of the source S.

The third phase of protocol is the formation of Shortest Path Tree (SPT). The phase results in optimization of the forwarding paths. This is done to achieve low latency and efficient bandwidth utilization. The route through RP may not always be appreciable. It may cause significant delays by detouring of paths. DR may initiate a transfer from shared tree to source specific SPT by using an (S, G) join message. Data packets then flow from S to the receiving nodes following the (S, G) entry. The receiver thus receives two copies of data, one following RPT and other from SPT. When traffic starts arriving from SPT, it sends a PRUNE message towards the RP known as (S, G, rpt) prune. It maintains state indicating that the traffic from S for G should not be propagated in that direction. Thus the shortest path tree is formed.

F. Pragmatic General Multicast (PGM)

PGM [15, 16] is a reliable multicast transport protocol implemented on the sources and on the receivers for applications that require ordered, duplicate-free, multicast data delivery from multiple sources to multiple receivers. It guarantees that a receiver in a multicast group either receives all data packets from transmissions and retransmissions or can detect unrecoverable data packet loss. PGM provides a reliable sequence of packets to multiple recipients simultaneously, making it suitable for applications like multi-receiver file-transfer.

The source maintains a transmit window of outgoing data packets and will resend individual packets when it receives a negative acknowledgment (NAK). The network elements (such as routers) assist in suppressing an implosion of NAKs (when a data packet is dropped) and in efficient forwarding of the re-sent data only to the networks that need it.

PGM allows a receiver to detect missing information in all cases and to request replacement information if the receiver application requires it.

PGM has only a few data packets that are defined:

1. ODATA: original content data
2. NAK: selective negative acknowledgment
3. NCF: NAK confirmation
4. RDATA: retransmission (repair)
5. SPM: source path message

G. Border Gateway Multicast Protocol (BGMP)

Border Gateway Multicast Protocol (BGMP) [17, 18] is a protocol used for inter-domain multicast routing, this is run by the border-routers of a domain, and has inter-domain bidirectional shared trees, constructed by using BGP group routes. Previously it is known as GUM. BGMP builds trees of domains that are similar to CBT trees of routers - they are inter-domain bidirectional shared-trees rooted at a single domain built by sending explicit join messages towards a root domain. In each domain, any multicast routing protocols can be used for intra-domain routing and they are called MIGPs. However BGMP can also build source-specific branches, which are similar in concept to source-specific trees in PIM-SM.

In BGMP, since each domain needs to have a range of multicast addresses to be used by groups rooted in the domain, a hierarchical multicast address allocation scheme is required. This is an important mechanism to support applications such as multimedia teleconferencing, distance learning, data replication and network games, for example.

IV. CONCLUSION

Multicasting protocols in wired network have been well established. In this paper, we have reviewed Shared Tree and Per-Source Tree solutions for wired multicast. From the investigation, it can be concluded that number of multicast routing protocols are able for wired network and all these protocols has low bandwidth requirements. The quality of service and reliability guaranteed by the proposed network is worth mentioning for the superior uses of multimedia and other emerging applications of the era especially by PGM. For each protocol, we have summarized the properties, and reveal the characteristics and trade-offs, describe the operation, and list the strengths and weaknesses. There are other multicast routing protocols that aim at providing reliability, QoS guarantees, security, and so on. The selection of a multicast routing protocol is as much dependent on the nature of application, and different applications have diverse requirements.

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