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Modeling and Analysis of Multicast Protocols Over IPv6

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Abstract: Business and multimedia entertainment applications require sending simultaneously to multiple users or specific groups. IP multicast is an efficient and scalable network layer delivering method for multimedia content to a large number of receivers across the Internet. It has the mechanism that offers bandwidth optimization and reduces the time required for forwarding data to multiple destinations. In traditional IP networks, packets are sent to single destination (unicast). Now a days, the demand of multimedia communication has increase in many fields; especially multimedia applications such as video conferencing (video and audio), distance learning and entertainment. Furthermore, application requires sending packets in the same time to multiple users or specific groups. Unicast protocol has a number of problems preventing its successful deployment of these applications. These problems include inefficient bandwidth, high cost, congestion and more collision in the networks. Thus, multicast protocols over IPv6 were developed to overcome these problems. There are already exist a few protocols implementing multicast transmission in real networks like PIM-SM and PIM-DM. In this study, simulation was done using NS-2 simulator to evaluate the performance of each those protocols based on packet loss variable receivers. The study consists of one main scenario; that consists of network topology with a few numbers of receivers with three sources, seven receivers and seventeen intermediate nodes. Simulation shows that, the PIM-SM has the better result in term of the packet lost. Hence, this results show that, the PIM-SM protocols are more suitable to be used in WAN environments.

Key words: PIM-SM, PIM-DM, IPV6, NS-2, environments

INTRODUCTION

An Internet Protocol (IP) (Sharp, 1994) is a set of rules which end points in network utilize for communication. Protocols occur at several layers in the communication model, i.e., OSI reference model (Perlman, 2000). In this model, every layer determines a protocol to communicate with its peer layer at the other side of the network. The protocol must possess a mechanism which makes sure that the reception of messages is in the same order as it was transmitted and must pledge that the packets are not lost, duplicated or destroy in crossing through communication. In addition, the protocol must realize the technique for data exchange, flow control, error detection and correction, etc. Normal IP communication is among one sender and one receiver. However, for many applications, it is indispensable for a operation to send data to large number of receivers together. In addition, some examples are data updating, distributed data bases, video conferencing, etc.

Internet Protocol (IP) supports multicasting in which effort are made to deliver the data to all of the members of the set addressed. A group is number of receivers, who share the same address called multicast address. No guarantees are given which all the members of the group will receive data. Original IP multicast routing model, proposed via. Deering (1991) focused on many to-many communication services. This communication model called Any Source Multicast (ASM) has number of technical and marketing problems (Diot *et al*., 2000) such as address allocation, inefficient handling of multicast sources and protecting multicast groups from unauthorized senders, that limit its wide scale deployment. There is another model which supports one to many and many to many communications. This one-to-many and many-to-many communication service model is called Source Specific Multicast (SSM) (Bhattacharyya, 2003) and has been considered as a feasible model to deploy multicast service in the Internet. This service model is based on application joining the channels which are

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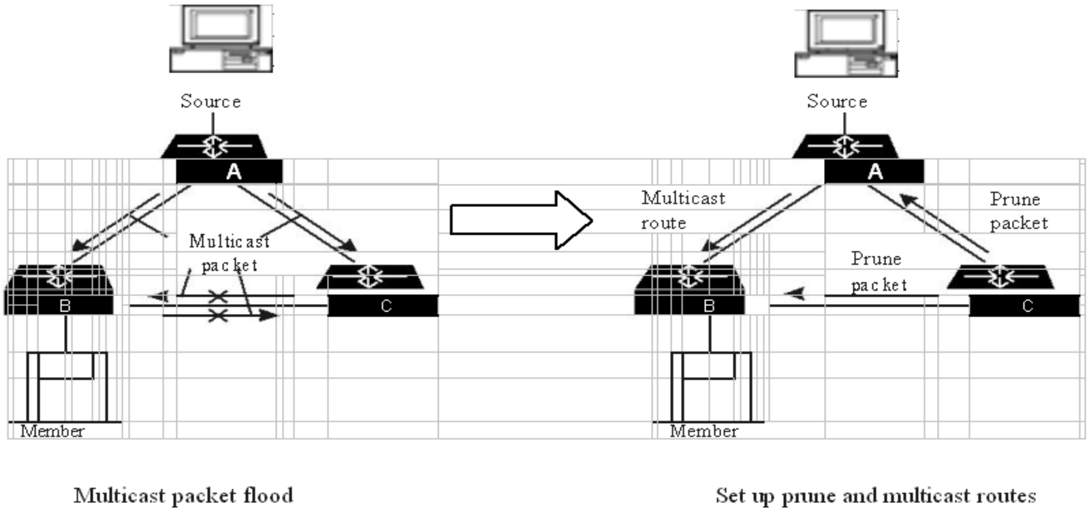

Fig. 1: Flood and prune process in PIM-DM

identified by the tuple (S, G), where S is unicast source address and G is multicast group address. Internet Protocol version 4 (IPv4) was introduced (Postel, 1981) and forms the backbone in the current inter-network with huge number of computers all over the world. The number of computers is increasing rapidly day by day and has resulted in the depletion of IPv4 addresses. In addition, behest for newer Internet Protocol version started in 1995 (Mankin and Bradner, 1995) to provide more flexible, efficient and secure version of IP called internet protocol plus and later designated as IPv6.

Recent the demand of multimedia data has increased many folds in the last few years. Typical multimedia applications are mainly distance learning, conference tools (audio and video), multiplayer gaming etc. These applications requirements efficient distribution of data to large group of receivers that are dispersed over enormous geographical distances. With the increase in demand of these applications, the requirement to deliver such media through multicast rather than unicast has also increased. Network applications where mass distribution is necessary cannot use unicast because of the high cost involved. Multicast protocols over IPV6 is the best solution for servicing multimedia applications. Many applications such as video conferencing, real time multimedia applications and distributed interactive simulations have emerged that are designed to derive maximum benefit from multicasting of data. These applications are focused on use certain inherited characters of a multicast protocol to deliver the desired QoS. The performance evaluation of the multicast protocol is relatively a complex job. For the performance evaluation of multicast protocols there are various programs available to aid the user in simulating for network applications. Besides, in this project the implementation of a given scenario has covered the performance of the analysis multicast routing protocols PIM-SM and PIM-DM Over IPV6 also answered the question of which is the best routing protocol the performance metrics which are the packet loss utilize the simulator NS-2.

Intra-domain multicast routing protocols: Similar to unicast routes, multicast routes are classified as intra-domain or inter-domain. Intra-domain multicast routing protocols have become quite sophisticated. Among the many intra-domain routing protocols. In this study has been used two multicast routing protocols: Protocol Independent Multicast-Dense Mode (PIM-DM) and Protocol Independent Multicast-Sparse Mode (PIM-SM).

PIM-Dense Mode (PIM-DM): In a PIM-DM domain, routers enabled with PIM-DM periodically send Hello messages to discover adjacent PIM routers and determine leaf networks and leaf routers. PIM-DM routers are also responsible to electing a Designated Router (DR) on a multi-access network (Fig. 1).

PIM-DM is developed under the assumption that when a multicast source sends data, all network nodes in the domain require to receive the data. Packets are forwarded in the flood and prune method. When the source sends data, all interfaces on the router forward the data, except the RPF interface that corresponds to the source. As a result, all network nodes in the PIM-DM domain receive the multicast packets. To forward the multicast packets, intermediate routers need to create multicast entries (S, G) for multicast group G and multicast source S. Multicast entries (S, G) cover multicast source address, group address, inbound interface, list of outbound interfaces, timer and flag. If no multicast group member exists in a certain area, routers in the area send prune messages to temporarily prune away or suspend the interface that directs multicast packets to the area. When the interface enters the pruned state, a timeout timer starts. When the timer expires, the state of the interface changes from pruned to forwarding again. In addition, the Prune message contains information about the multicast source and group. If a novel multicast group member is detected in the pruned area, the downstream device does not wait for the pruned state to expire. The device voluntarily sends a graft message to the upstream device to alteration the pruned state to the forwarding state and decrease response time.

At first, the information sent via the multicast source is flooded across the network. Routers perform the RPF check when forwarding packets. As a result, the flooded packets sent by routers B and C to together are rejected due to the RPF check failed. Because the area where router C resides has no multicast group member, router C sends a Prune message to routers A and B. As a result, routers A and B set corresponding interfaces to the pruned state and the multicast packets are sent to all group members along the correct paths.

PIM-Sparse Mode (PIM-SM): PIM SM protocol functions to perform efficient routing to multicast groups that may span wide-area and interdomain Internet. The approach is mentioned to as Protocol Independent Multicast-Sparse Mode (PIM-SM) as it is not dependent on any particular unicast routing protocol and because it is designed to support sparse groups.

PIM protocol depends on a Multicast Routing Information Base (MRIB) to fetch the next hop router to a destination subnet (Fenner *et al*., 2006). MRIB is populated with all the existing routes in the topology via routing protocols such as MBGP.MRIB determines the next hop router to which Join\Prune messages were sent. Information is sent in the reverse direction of Join message. Rendezvous Point (RP) is the root node of the distribution tree for a multicast group. This address is obtained automatically over a bootstrap mechanism or over static configuration (Estrin *et al*., 1999). The phase one of the protocol formulates a distribution tree to multicast. The receivers give the consent for receiving multicast traffic via means of IGMP or MLD messages. The receiver designates one local router as a designated Router (DR) for its contained subnet. All the DR's sent JOIN messages towards the RP for multicast transmissions. This Join message is known as a (*, G) Join since it joins group G for all sources to that group. As the (*, G) is traversed hop by hop, it instantiates multicast tree state of that group. Ultimately it reaches either RP or a router that has the Join state entry for which group. When many receivers join the group, their join messages converge at the Preforming 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 information to the group over the DR. The DR unicast encapsulates the data and directs them for the RP. This process is called Registering. The encapsulated packets are called PIM Register Packets. RP decapsulated the information and forwards them to the intended shared tree. The packets then follow the (*, G) multicast tree state in the routers on the RP Tree, being replicated wherever the RP Tree branches and eventually reaching all the receivers to which multicast group (Fenner *et al*., 2006) . The second phase of PIM-SM operation is the Register STOP operation.

Encapsulation and decapsulation process at the router may be expensive. In addition, the journey back and forth among a RP and common tree may take long. Furthermore, 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. Also, RP is in the process of joining source specific packets, information 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 optimisation of the forwarding paths. This is done to achieve low latency and an efficient bandwidth utilisation. The route over RP may not always be appreciable. It may cause important delays via detouring of paths. DR may initiate a transfer from shared tree to source specific SPT via usage an (S, G) join message. Information 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 instantiates a state indicating which the traffic from S for G should not be propagated in that direction. Thus the shortest path tree is formed (Fig. 2).

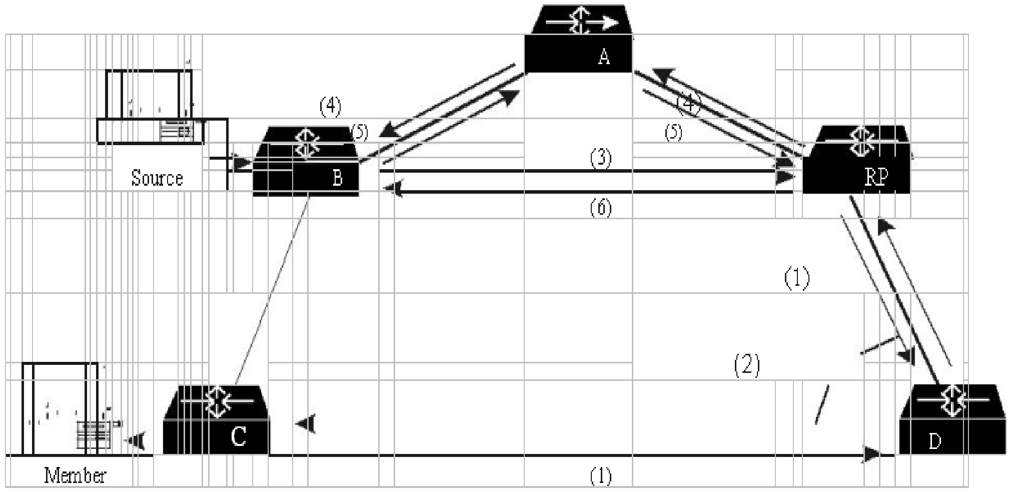

Fig. 2: Example of working process of PIM-SM

MATERIALS AND METHODS

Simulation tools: In this study, simulation is done using NS-2 simulator. To evaluate and analysis the performance of the two protocols, PIM-SM and PIM-DM multicasting routing protocols for WAN environment over IPv6. The performance will calculate using variable receivers. In addition, the simulation is carried out through node densities 27.

Simulation scenario: The overall goal of this simulation study is to analyze the performance of different multicast routing protocols in Mobile WAN environment over IPV6. In addition, the scenario presented in two cases. In the first case the multicast network was configured and three multicast groups were created with one source and the few numbers of receivers for each group with arbitrary topology that we can represented in NS-2. Table 1 represents the multicast distribution used in our simulation.

The network is consisting of 27 nodes: 3 source (S1-S3), 7 receivers (R1-R7) and 17 intermediate nodes (N0-N16). The rendezvous point (RP) is required only in networks running PIM-SM. In PIM-SM, only network segments with active receivers that have explicitly requested multicast data will be forwarded the traffic. This method of delivering multicast data is in contrast to the PIM-DM model. In PIM-DM, multicast traffic is initially flooded to all segments of the network. Routers that have no downstream neighbours or directly connected receivers prune back the unwanted traffic. An RP acts as the meeting place for sources and receivers of multicast data. In a PIM-SM network, sources must send their traffic to the RP. This traffic is then forwarded to receivers down a shared distribution tree. By default, when the first hop router of the receiver learns about the source, it will send a join message directly to the source, creating a source-based distribution tree from the source to the receiver. This source tree does not include the RP unless the RP is located within the shortest path between the source and receiver. In most cases, the placement of the RP in the network is a complex decision. By default, the RP is needed only to start new sessions with sources and receivers.

Table 1: Multicast group description used in the simulation

Multicast groups	Sources	Receivers
0	23	11,19,22
1	20	24,26
2	17	21,25

In this study, used the RTP (Real-time Transport Protocol) to provide end-to-end delivery services for data with real-time characteristics. RTP defines a standardized packet format for delivering audio and video over the Internet. It is designed for end-to-end, real-time, transfer of multimedia data. The protocol provides facility for jitter compensation and detection of out of sequence arrival in data, that are common during transmissions on an IP network. RTP supports data transfer to multiple destinations through multicast. RTP is regarded as the primary standard for audio/video transport in IP networks. Real-time multimedia streaming applications require timely delivery of information and can tolerate some packet loss to achieve this goal (Fig. 3).

Simulation parameters: The simulation parameters used in this scenario to develop the network are listed in (Table 2).

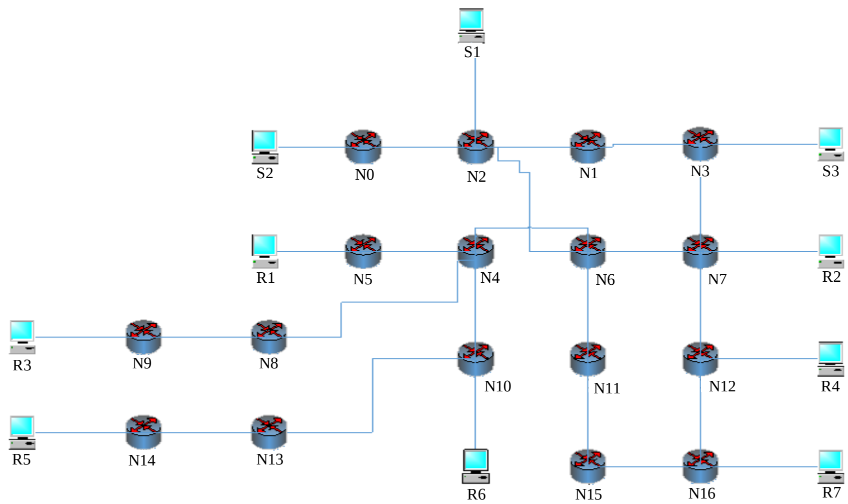

Fig. 3: Network topology for the simulation

Table 2: Simulation parameters

Components	Type
Multicast routing protocols	PIM-SM, PIM-DM
Simulation time	5 sec
Bandwidth	1.5 Mbps
Mean delay	10 msec
Packet size	210 bytes
No. of nodes	27
Traffic type	CBR (Constant Bit Rates)
No. of source	3
No. of intermediate nodes	17
N0. of receivers	7
Simulation name	NS-2

Constant bit rate: The Continuous Bit Rate (CBR) application was used and a variable bit rate. CBR is a term used in telecommunications, relating to the quality of service. It is useful for streaming multimedia content on limited capacity channels. It guarantees bandwidth for real-time voice and video.

All node use DropTail queue: It is a simple queue management algorithm used by Internet routers to decide when to drop packets. In contrast to the more complex algorithms like RED and WRED, in DropTail all the traffic is not differentiated. Each packet is treated identically. With DropTail, when the queue is filled to its maximum capacity, the newly arriving packets are dropped until the queue has enough room to accept incoming traffic.

RESULTS AND DISCUSSION

The results for these experiments were gathered from output files generated by NS-2 simulator. It is the time taken for a packet to be transmitted across a network from source to destination. Figure 4 shows the performance of both the multicast routing protocols PIM-SM and PIM-DM for packet loss. The PIM-SM protocol has less

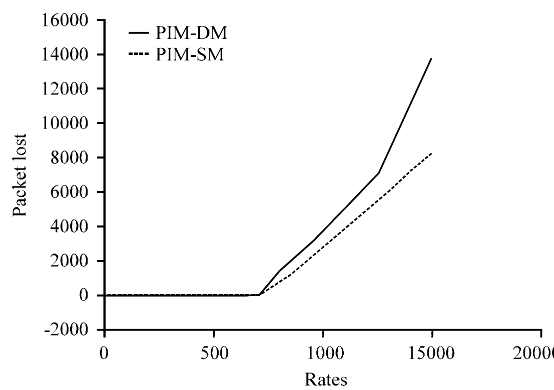

Fig. 4: Packet lost in PIM-SM and PIM-DM environments in the simulation

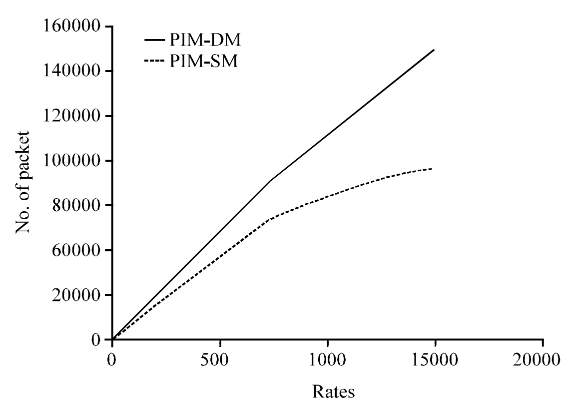

Fig. 5: No of packets with different rate in PIM-SM and PIM-DM environments in simulation

packet loss than PIM-DM protocol in different experiment. In Fig. 5 are shown the simulation results of packet loss vs. data rate.

This loss of data can occur during a data transmutation from sources to receiver's due excess flow for a specific link. In the 500 rate we can see a superiority percentage among PIM-SM and PIM-DM is equal but in the 1000 rate was superiority percentage for PIM-SM is 37.5%. On the one hand, we note that the packet loss increases with the rate where in 1500 was superiority percentage is 42.8%.

Further more, the number of packet that produced by PIM-DM (source tree) is so high comparing to PIM-SM (shared tree). By analyzing Fig. 5 represents the number of packets produced by PIM-SM and PIM-DM in the simulation, the centralized source (source tree) forwarded more multicast data, since they had more connection links. PIM-DM is suitable for implementation of multicast where the additional control is not needed and where occasional "accidental" flooding would not be very harmful. PIM-SM scales rather well because packets only go where they are needed and because it creates state in routers only as needed.

CONCLUSION

In this study, in this study, the performance comparison and analysis of two multicast routing protocol PIM-SM (RPT multicast) over IPV6 in different number of packet sent in different experiments using NS-2 simulator. The simulator result shows that the RPT multicast gets the lower packet lost comparing to the SPT multicast in the specific data rate. The RTP is suited for the WAN networks and QoS will be better for multimedia applications.

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