Comparative Analysis of Dense, Centralized and BST Mode of Multicast Routing Strategies in Wired Networks

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Abstract This paper shows the comparative analysis of the DM (Protocol Independent Multicast – Dense Mode), DVMRP (Distance Vector Routing Protocol), CTR (Centralized Tree) and BST (Bidirectional Shared Tree) protocols on the basis of various performance metrics such as number of packets sent, average jitter, average delay, packet delivery ratio (PDR) with the varying number of receivers. The results show that PIM-DM is better in case of packet delivery ratio (PDR) and numbers of packets send as compared to others. BST works well in case of average jitter. And DVMRP is good in terms of average end-to-end delay.

Keywords: PIM-DM; DVMRP; CTR; BST; Multicasting.

1. Introduction

Nowadays, with the increasing popularity of the group-oriented communication and applications like multiplayer online gaming, audio/video conferencing, net meeting, streaming media, etc., it is imperative to find out the best method to provide these services. Multicasting [8, 9] is an efficient way which supports group communication, as it permits the transmission of packets to all the receivers which belong to a multicast group with fewer network resources. Multicasting also decreases the communication cost and uses the available bandwidth efficiently.

Steeve Deering [3] in 1986 introduced the concept of multicasting. The initial support of multicast is: MRouters (Multicast-capable routers) and Dedicated Tunnels. The MRouter encapsulate and decapsulate each multicast packet and send it through the tunnel to another MRouter. This set of MRouters is known as the MBone (Multicast Backbone) [7]. There are various multicast routing protocols, which are based on the multicast routing strategies.

1.1. *Multicast routing strategies*

It is the mechanism which computes the multicast distribution tree in the simulation. NS [5] supports four multicast routing strategies: dense mode (DM), shared tree mode (ST), centralized tree mode (CTR) and bidirectional shared tree mode (BST).

1.1.1. *Dense mode (DM)*

It activates in two modes depending upon the value of DM class variable CacheMissMode: PIM-DM and DVMRP. The main difference between two modes is that dvmrp keeps parent-child relationships among hops to decrease the number of connections over which data packets are broadcast. The two modes are described as follows:

(1) **Protocol Independent Multicast – Dense mode (PIM-DM):** PIM-DM [1, 2] is a source-established tree routing protocol that practices RPF and pruning and grafting schemes for multicasting. Its procedure is like that of DVMRP; however, unlike DVMRP, it does not depend on a particular unicasting protocol. It imagines that the independent system is employing a unicast protocol and each router has a table to discover the outgoing interface that has an optimal path to a target. This unicast protocol can be a link state protocol, or distance vector protocol. It is visualized that PIM-DM will be deployed in resource-rich surroundings, such as a campus LAN where group membership is comparatively dense and bandwidth is readily obtainable. PIM-DM protocol acts in ***two phases***:

In the maiden phase, the entire network is flooded with multicast data and this is done by propagation of packet on all interfaces exclude on the upstream interface. This phase is extremely ineffective because it directs to extreme network resource usage because of its network overflowing technique.

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

There is a significant message that is periodically exchanged between PIM-DM routers are Hello packets. It aids routers learn regarding the presence of PIM DM-capable neighbor routers in the network.

(2) **Distance Vector Multicast Routing Protocol (DVMRP):** DVMRP [11] depends upon the distance vector routing protocol. It uses the Reverse Path Multicasting (RPM) algorithm to onward multicast packets. It creates a multicast tree for each source and target host group. It is a source based routing protocol, based on Routing Information Protocol (RIP). It uses a unicast routing protocol because the router never actually creates a routing table.

When a router receives a multicast packet it onwards (broadcast) it. DVMRP employs a Broadcast & Prune mechanism. That is, a broadcast tree is made from a source by interchanging routing information. Then this broadcast tree is altered to multicast tree by employing a pruning technique. More specifically, originally multicast datagram's are broadcast to all nodes on the tree. Those leaves that do not have any group members transmit prune messages to the upstream router, noticing the absence of a group.

The upstream router keeps a prune state for this group for the given transmitter. A prune state is old out afterward a given configurable interval, permitting multicasts to resume. Pruned branches are restored to a multicast tree by transmitting graft messages towards the upstream router. Graft messages begin at the leaf node and travel up the tree, first transmitting the message to its neighbor upstream router. Thus, it acts on broadcasting, pruning and grafting process.

1.1.2. *Centralized multicast (CM)*

It is similar to Protocol Independent Multicast – Sparse Mode (PIM-SM) or Core Based Tree (CBT). It is sparse mode implementation of multicast. In this a Rendezvous Point (RP) rooted shared tree is made for a multicast group. The real sending of prune, join messages, etc. to set up at the hops is not simulated. A centralized computation agent is used to calculate the forwarding tree and set up multicast forwarding state, <S, G> at the relevant hops as new destinations join a group. Data packets from the senders to a group are unicast to the RP.

1.1.3. *Shared tree mode*

It is a simplified sparse mode and an implementation of a shared-tree (with RP) multicast protocol.

1.1.4. *Bidirectional shared tree mode (BST)*

It is an implementation of the bidirectional shared tree protocol. The difference from shared tree mode is that it has a bidirectional capability. BST is a multicasting protocol implemented in NS2 is in research manner. In BST, multicast data can move in both the direction of a tree for each receiver. When receivers are distributed throughout the network it yields the improved result than another. Bidirectional trees provide bettered routing optimality by being capable to forward data in both directions while retaining a minimum quantity of state information. RP employed in this system is employed to keep the routing table for the upstream and downstream receivers. All the data are transmitted to the RP and RP then onwards is to the receivers employing the minimal path.

2. Related Work

There are enormous works on modes of multicasting routing strategies with performance parameters such as a packet delivery ratio, throughput, end-to-end delay and drop ratio.

Ankur Dubey and Akhilesh Kosta compare the Centralized, Dense and BST mode of multicast routing strategies in MANET on the basis of various performance metrics such as packet delivery ratio (PDR), average end-to-end delay, and drop ratio. They concluded that dense mode and BST mode have similar behavior in most cases. Dense mode is better than both BST mode and CTR mode [4].

Manish Kumar Tiwari and S.S. Gautam discussed about the multicast routing protocols in wired networks. They have discussed the strengths and weaknesses, trade-offs and properties of multicast routing protocols. They concluded that the selection of the multicast routing protocol depends upon the nature of application [6].

Shalu Sraw and Gupreet Singh compare the different multicasting modes (DM, CTR and BST) on the basis of different performance parameters such as throughput, average jitter, number of packets send, average path, average end-to-end delay and average jitter. They concluded that BST has high throughput value, better in terms of number of packets sent and good in terms of average path. And CTR is good in terms of average jitter and average delay [10] [12] [13].

In this paper, we presented the Comparative Analysis and Performance Evaluation of Dense (PIM-DM, DVMRP), Centralized and BST mode of multicast routing strategies.

3. Simulation Settings and Results

The simulation settings and simulation results are described as below.

3.1. *Simulation Settings*

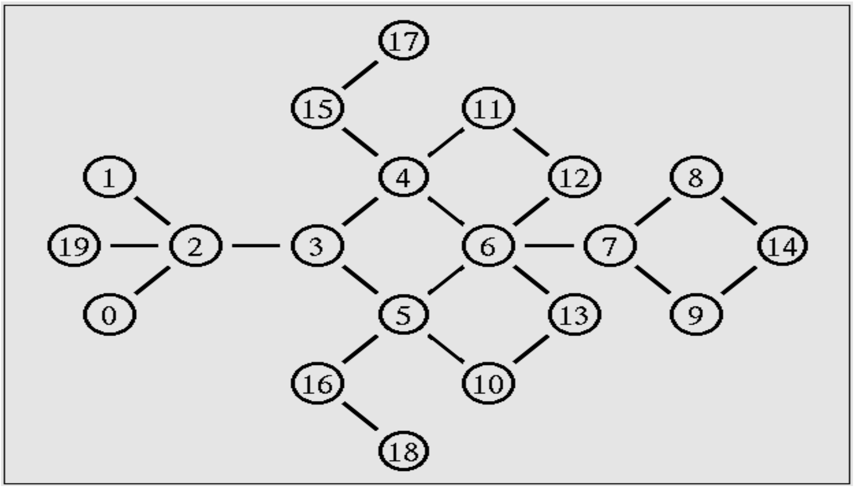

Fig. 1. Common Network Topology Design

NS-2.35 version of NS2 simulation tool is used to conduct the experiments. A network of 20 nodes is formed and constant Bit Rate (CBR) is used as a traffic pattern. We have created four scenario i.e. Number of receivers (4, 8, 12, 16). Node 1 is considered as source node. From this node packets are transmitted to specific group hops. PIM-DM and DVMRP are simple routing protocols. But central point i.e. Rendezvous point (RP) is required in case of CTR and BST. Node 3 is RP for both CTR and BST. Simulation time is 5.0 sec.

3.2. *Simulation Results*

Table 1. Simulation Results of PIM-DM, DVMRP, CTR, BST

Performance Metrics	**Multicast Modes** / **No. of Receivers**	PIM-DM	DVMRP	CTR	BST
No. of Packets Send	4	2272	2367	1194	1185
	8	8457	7018	5424	5412
	12	13827	11997	10126	10137
	16	23840	21372	21673	20077
Packet Delivery Ratio (PDR)	4	47	47	35	39
	8	104	99	82	89
	12	153	146	128	137
	16	229	226	224	219
Average Jitter	4	1.653642	1.341502	1.855391	0.021518
	8	1.524783	1.265580	1.750924	0.037804
	12	1.273309	1.106645	1.702190	0.050487
	16	1.220607	0.970510	1.702178	0.068937
Average End-to-End Delay	4	2.571254	2.476453	2.556001	2.767067
	8	2.610633	2.587850	2.607574	2.770503
	12	2.480717	2.519566	2.638537	2.769033
	16	2.455685	2.491028	2.642019	2.766587

This table is created by using NS2 simulation tool. For this, we ran the simulator for 20 nodes for 5.0 sec and for different protocols such as PIM-DM, DVMRP, CTR, and BST. The results obtained in form of values for different metrics. After analyzing these values we concluded that dense mode of multicast routing strategies outperforms all these metrics. These values are plotted in the form of line graphs in section 4.

4. Performance Evaluation

With the help of NS2, we have measured and compared the different performance metrics of multicast routing strategies i.e. PIM-DM, DVMRP, CTR and BST in wired network and eventually plotted the bar graphs. Performance metrics used for comparison are:

(1) **Number of Packets Send:** It is simply the sum of number of packets delivered by source node.

Number of packets send = ∑ (Number of delivered packets)

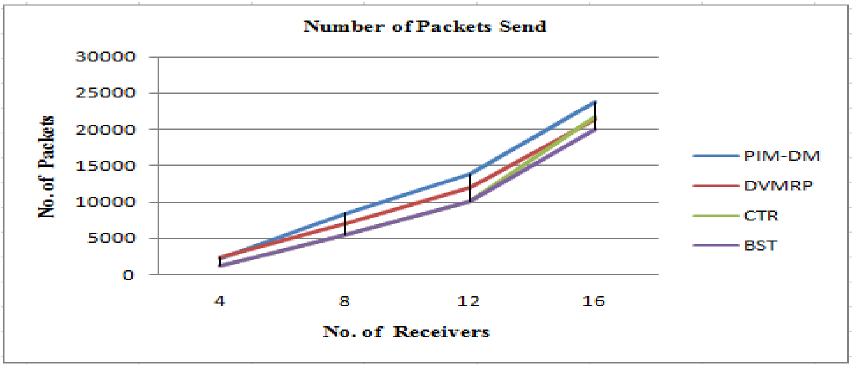

Fig. 2. Numbers of Packets Send with different no. of receivers.

Fig. 2 shows the number of packets sends with varying number of receivers by discussed protocols. This shows that number of packets send are increases with increase in number of receivers in case of all protocols. PIM-DM has a higher number of packets send as compared to others. On the other hand, BST has lower number of packets send.

(2) **Packet Delivery Ratio (PDR):** PDR is defined as the ratio of received data packets to the delivered data packets.

PDR % = (∑ (No. of received packets) / ∑ (No. of delivered packets)) * 100

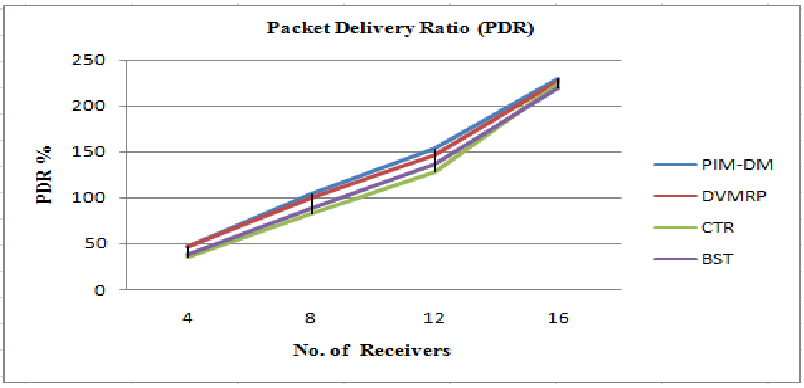

Fig. 3. Packet Delivery Ratio with different no. of receivers.

Fig. 3 shows the packet delivery ratio (PDR) with varying number of receivers by discussed protocols. This shows that PDR increases with increase in number of receivers in case of all protocols. PIM-DM has better PDR as compared to others. BST has lowest PDR value.

(3) **Average Jitter:** Average Jitter is defined as the variation in delay of received packets with respect to some definition time or rate.

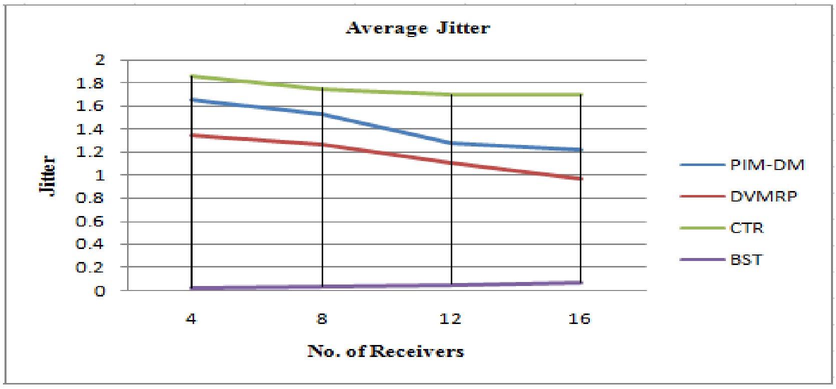

Fig. 4. Average Jitter with different no. of receivers.

Fig. 4 shows the average jitter with varying number of receivers by discussed protocols. This shows that average jitter decreases with increase in number of receivers in case of PIM-DM, DVMRP and CTR. But in case of BST, it slightly increases with increase in number of receivers. BST has lower (better) average jitter as compared to others. CTR has higher (worst) average jitter.

(4) **Average End-to-End Delay:** The average end-to-end delay is the average time required to transmit data packets from source node to destination node, including transmission, propagation and queuing delay.

Average End-to-End Delay = ∑ (Time when packets enter in the queue) - ∑ (Time when packets is received)

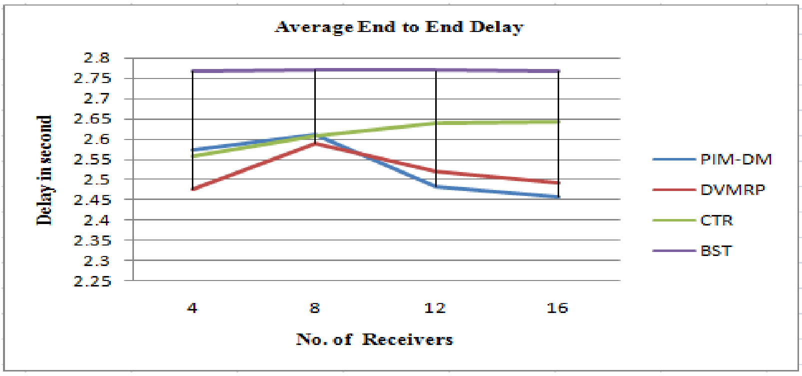

Fig. 5. Average End-to-End Delay with different no. of receivers.

Fig. 5 shows the average end-to-end delay with varying number of receivers by discussed protocols. This shows that average end-to-end delay decreases with increase in receivers in case of PIM-DM and DVMRP. In BST, THE average delay remains almost constant. DVMRP has lower (better) average end-to-end delay as compared to others. On the other hand, BST has higher (worst) average end-to-end delay.

7. Conclusion

This paper compares the multicasting protocols on the basis of different performance metrics as number of packets sent, average jitter, average delay, packet delivery ratio (PDR). Simulations were performed using the NS2 simulation tool with same networks and implementing different protocols with different number of receivers.

(1) Number of packets sends increases as the number of receivers are increasing. PIM-DM has a higher number of packets sends as compared to others. BST has lower number of packets sends.

(2) Packet Delivery Ratio (PDR) increases as the numbers of receivers are increasing. PIM-DM has a better PDR as compared to DVMRP, CTR and BST. BST has lower PDR.

(3) Average Jitter decreases with increase in receivers. BST has lower (better) average jitter value as compared to others. CTR has higher (worst) average jitter value.

(4) Average End-to-End Delay does not affect with the number of receivers. DVMRP has lower (better) average end-to-end delay as compared to PIM-DM, CTR and BST. BST has higher (worst) average end-to-end delay.

The result shows that PIM-DM and DVMRP performs better than CTR and BST. So, dense mode of multicasting routing strategies performs well as compared to CTR and BST.

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