International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-2 Issue-1, October 2012

Impact of Mobility and Node Speed on Multicast Routing In Wireless MANETs

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Abstract— Mobile Ad-hoc networks are characterized as networks without any physical connections. In these networks there is no fixed topology due to the mobility of nodes, interference, multi-path propagation and path loss. One particularly challenging environment for multicast is a mobile ad-hoc network (MANET), where the network topology can change randomly and rapidly, at unpredictable times. As a result, several specific multicast routing protocols for MANET have been proposed. This paper evaluates well known multicast routing protocols, like on-demand multicast routing protocol (ODMRP), protocol independent protocol- dense mode (PIM-DM) and multicast open shortest path first (MOSPF) under various ranges of MANET scenarios based on mobility and node speed. The simulation environment is Qualnet-5.0.

Index Terms— Computer Network, Routing Protocols, Path loss Models

I. INTRODUCTION

An ad-hoc network is a collection of nodes forming a temporary network without the aid of any additional infrastructure and no centralized control. The nodes in an ad-hoc network [12] can be a laptop, PDA, or any other device capable of transmitting and receiving information. Nodes act both as an end system (transmitting and receiving data) and as a router (allowing traffic to pass through) resulting in multi-hop routing. Network is temporary as nodes are generally mobile and may go out of range of other nodes in the network.

In this paper, authors describe PIM (Protocol Independent Multicast) capable of supporting sparse mode (SM) and dense mode (DM) operations. In sparse mode, PIM can use shared trees (RPT) or shortest path trees (SPT) to deliver data packets [1].

In this paper, authors have developed a multicast routing architecture that efficiently establishes distribution trees across wide area internets, where many groups will be sparsely represented. Efficiency is measured in terms of the router state, control message processing, and data packet processing, required across the entire network in order to deliver data packets to the members of the group [2].

In this paper, authors describe that a number of different routing protocols proposed for use in multi-hop wireless ad hoc networks are based in whole or in part on what can be described as on-demand behavior [3].

In this paper, authors investigate the performance of multicast routing protocols in wireless mobile ad hoc networks [4].

This paper presents different approaches of providing multicast traffic for mobile hosts. Mobile IPv6 is used for mobility support. The network employs Protocol Independent Multicast Dense Mode (PIM-DM) for multicast routing and Multicast Listener Discovery (MLD) to collect multicast group membership information [5].

This paper describes an IP multicast implementation based on Multicast Extensions to Open Shortest Path First (MOSPFP). The MOSPF Forwarding Model presented in this study is used to forward multicast datagram. The Forwarding Model has focused on interaction between MOSPF and OSPF in terms of group-membership-Link-State-Advertisement (type-6 LSA) as well as developing Multicast Routing Table (MRT) and Multicast Forwarding Cache (MFC). The MRT has been organized as a Patricia-based tree while the MFC has been maintained as hash-table data structures. The MFC entries are built from the local group database and the shortest path (SPF) tree calculation. [6]

In this paper, authors describe that multicasting is the ability of a communication network to accept a single message from an application and to deliver copies of the message to multiple recipients at different locations [7].

In this paper, authors describe an important issue in reliable multicasting in ad hoc networks that is busty packet loss that arises when a link breaks due to node mobility [8].

In this paper, authors describe the On-Demand Multicast Routing Protocol for mobile ad hoc networks (ODMRP). ODMRP is a mesh-based, rather than conventional tree based, multicast scheme and uses a forwarding group concept [only a subset of nodes forwards the multicast packets via scoped flooding). It applies on-demand procedures to dynamically build routes and maintain multicast group membership [9]. In this paper authors propose a new multicast protocol for Mobile Ad Hoc networks, called the Multicast routing protocol based on Zone Routing (MZR). MZR is a source-initiated on demand protocol, in which a multicast delivery tree is created using a concept called the zone routing mechanism [10]. In this paper, authors present a performance study of three multicast protocols: ODMRP, ADMR, and SRMP. Multicast Routing in Mobile Ad hoc NETworks (MANETs) is a recent research topic. Source Routing-based Multicast Protocol, (SRMP) is a new on-demand multicast routing protocol that applies a source routing mechanism and constructs a mesh to connect group members [11]. In this paper, authors focus on one critical issue in Mobile Ad hoc Networks (MANETs) that is multicast routing. In fact, optimal routes, stable links, power conservation, loop freedom, and reduced channel overhead are the main features to be addressed in a more efficient multicast mechanism [12]. In this paper, the authors describe the reliability of the On-Demand Multicast Routing Protocol (ODMRP) in terms of the delivery of data packets in response to the important role that multicasting plays in wireless mobile multi hop ad hoc networks.

Manuscript published on 30 October 2012.
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Using GloMoSim 2.0, the simulation results have shown that using ODMRP, the average miss ratio does not always increase with increasing the speeds of mobility of the mobile hosts in the ad hoc network. Instead, there is a "sweet spot" of values of the mobility speeds of the mobile hosts. In addition, the averages miss ratio decreases with increasing the number of multicast group members, which indicates that ODMRP has more packet delivery capabilities for denser multicast groups. [13] In this paper, authors present a comparative performance evaluation of three general-purpose on demand multicast protocols, namely ADMR, MAODV, and ODMRP, focusing on the effects of changes such as increasing number of multicast receivers or sources, application sending pattern, and increasing number of nodes in the network [14]. In this paper, authors analyze the performance of multicast routing protocol PIM-SM to provide suggestions of improving this protocol. PIM-SM is preferred among the current intra domain multicast routing protocols. But it is not widely deployed in Internet till now [15].

II. PROBLEM FORMULATION

The overall goal of this simulation study is to evaluate and analyze the performance of three existing multicast routing protocols; they are: MOSPF, ODMRP AND PIM-DM over mobile ad hoc networks. Protocol performances are observed in several network configurations where some parameters evolve in order to measure the impact of these parameters on the protocol. The experiments are executed to study the effect of the node mobility and speed in the network.

III. MULTICAST ROUTING PROTOCOLS

3.1 On-demand Multicast Routing Protocol (ODMRP)

The On-Demand Multicast Routing Protocol (ODMRP) falls into the category of on-demand protocols since group membership and multicast routes are established and updated by the source whenever it has data to send. Unlike conventional multicast protocols which build a multicast tree, ODMRP is mesh based. It uses a subset of nodes, or forwarding group, to forward packets via scoped flooding. ODMRP consists of a request phase and a reply phase . When a multicast source has data to send but no route or group membership information is known, it piggybacks the data in a Join-Query packet. When a neighbor node receives a unique Join-Query, it records the upstream node ID in its message cache, which is used as the node's routing table, and re-broadcasts the packet. The side effect of this process is to build the reverse path to the source. When a Join-Query packet reaches the multicast receiver, it generates a Join-Table packet that is broadcast to its neighbors. The Join-Table packet contains the multicast group address, sequence of pairs, and a count of the number of pairs. When a node receives a Join-Table, it checks if the next node address of one of the entries matches its own address. If it does, the node realizes that it is on the path to the source and thus becomes a part of the forwarding group for that source by setting its forwarding group flag. It then broadcasts its own Join-Table, which contains matched entries. The next hop IP address can be obtained from the message cache. This process constructs the routes from sources to receivers and builds the forwarding group. Membership and route information is updated by periodically sending Join-Query packets.

Nodes only forward (non-duplicate) data packet if they belong to the forwarding group or if they are multicast group members. The forwarding group nodes flood data packets, ODMRP is more immune to link/node failures (e.g., due to node mobility). This is in fact an advantage of mesh-based protocols.

3.2 Multicast Extensions to Open Shortest Path First (MOSPF)

MOSPF is an enhancement of the unicast routing protocol OSPF. OSPF is a link-state routing protocol in which the routers advertise the state of their directly attached links, and based on these advertisements, each router builds up a link-state database. The OSPF link-state database provides a complete picture of the topology of an Autonomous System (AS). In order to support multicast routing, a new type of link-state advertisement, referred to as the group-membership-LSA (Link State Advertisement), has been added to OSPF. These advertisements help to pinpoint the locations of all multicast group members in the database. The path of a multicast data packet can then be calculated by building a shortest-path tree rooted at the source of the data packet. Each router in the domain has the complete description of the topology and the membership information, and each one of them uses exactly the same algorithm to computer the shortest-path tree rooted at the same node. Thus every router ends up computing the same tree and creating the corresponding forwarding entries for each group. The shortest path trees are built on demand (that is, when the first packet arrives), and the results of this computation are cached for use by subsequent packets having the same source and destination.

3.3 PIM-DM

This is PIM operating in dense mode (PIMDM), but the differences from PIM sparse mode (PIM-SM) are profound enough to consider the two modes separately. PIM also supports sparse-dense mode, with mixed sparse and dense groups, but there is no special notation for that operational mode. In contrast to MOSPF, PIM-DM allows a router to use any unicast routing protocol and performs RPF checks using the unicast routing table. PIM-DM has an implicit join message, so routers use the flood and prune method to deliver traffic everywhere and then determine where the uninterested receivers are. PIM-DM uses source-based distribution trees in the form (S, G), as do all dense-mode protocols.

IV. WORKDONE

The network size is 1500m × 1500m area for scenario simulation. There is no network partitioning throughout the entire simulation. The data transmission rate (unicast and multicast) and data transmission rate for broadcast is 2Mbits/s. The physical layer PHY 802.11b and at MAC layer MAC 802.11s are used. The simulation time for each experiment is 300 seconds. Multiple runs with different seed numbers are conducted for each scenario and collected data is averaged over those runs. The three random based mobility models such as Random waypoint, Random walk and Random directions are to be used. The main traffic source in the simulation is Multicast Constant Bit Rate (MCBR) traffic. Each multicast group has one sender for each protocol every time but the number of receivers is different for different number of nodes.

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The number of receivers is 3, 6, 9 for 25 nodes, 50 nodes and 75 nodes respectively. The sender transmits multicast traffic at a rate from 10 to 60 packets/sec. The senders and receivers are chosen randomly among multicast members. A member joins the multicast session at the beginning of the simulation and remains as a member throughout the simulation. In the simulation, initial 10s is kept to perform this task. Once joining the multicast group, we let the source to transmit data for 300s simulation time. The packet size without header is 512 bytes. The length of the queue at every node is 50 Kbytes where all the packets are scheduled on a first-in-first-out (FIFO) basis. The parameters are summarized in Table 1.

Table 1 Summary of simulation environment

Parameters	**Values**
Network Size	1500m × 1500m
Path loss model	Two ray propagation model
Fading model	None
Simulation time	300 seconds
Physical layer protocol	PHY 802.11b
Data link layer protocol	MAC 802.11s
Data rate	2 Mbps
Shadowing model	Constant
Channel frequency	2.4 GHz
Pause time	30 seconds
Simulation time	300 seconds
Number of source	1
Traffic model	Multicast constant bit rate (MCBR)
Multicast routing protocol	MOSPF, ODMRP, PIM-DM

To evaluate the performance of routing protocols, both qualitative and quantitative metrics are needed. Most of the routing protocols ensure the qualitative metrics. Therefore, three different quantitative metrics are used to compare the performance. They are,

1) Packet Delivery Ratio (PDR): The ratio of the number of data packets received by the receivers verses the number of data packets supposed to be received. This number presents the effectiveness of a protocol.
2) Average End-to-end delay: End-to-end delay indicates how long it took for a packet to travel from the source to the receiver.
3) Throughput: The throughput is defined as the total amount of data a receiver actually receives from the sender divided by the time between receiving the first packet and last packet.

V. RESULT AND DISCUSSION

The performance of MOSPF, ODMRP and PIM-DM are investigated and analyzed based on the results obtained from the simulation. A number of experiments are performed to explore the performance of these protocols with respect to mobility and speed .

In this paper we evaluated well known multicast routing protocols, namely On Demand Multicast Routing protocol (ODMRP), Protocol Independent Protocol- Dense Mode (PIM-DM) and Multicast Open Shortest Path First (MOSPF) under a wide range of network conditions and realistic scenarios.All the simulations are performed over mobile ad hoc networks (MANETs). The simulation environment is QualNet5.0. MOSPF is selected as the representative of proactive multicast routing protocols. On the other hand, PIM-DM is selected as the representative of tree-based and ODMRP as the representative of mesh-based multicast routing protocols. ODMRP is reactive multicast routing protocol.

Fig.1.1.1 to 1.1.6 shows that how does mobility affect the performance of MOSPF, ODMRP and PIM-DM. Fig. 1.1.1 shows the variation in no. of bytes received at server with change in mobility model. For MOSPF and ODMRP, the received bytes are higher for random way point mobility than group mobility but reverse for PIM-DM.

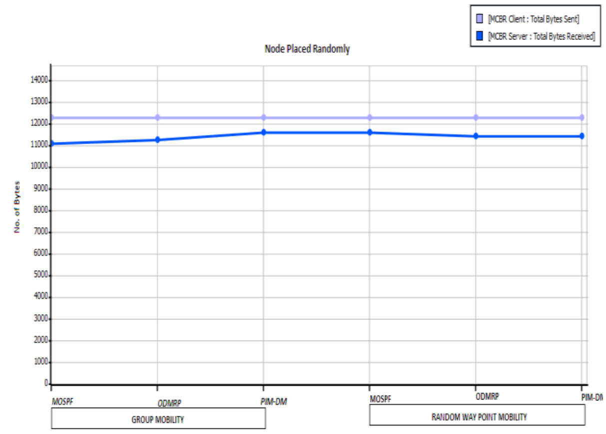

Fig. 1.1.1 Total Bytes Received Vs. Mobility

Fig. 1.1.2 shows that change in mobility model does not affect so much the average ETED for all three protocols. ODMRP has highest ETED for both models. MOSPF and PIM-DM have almost same average ETED for both models.

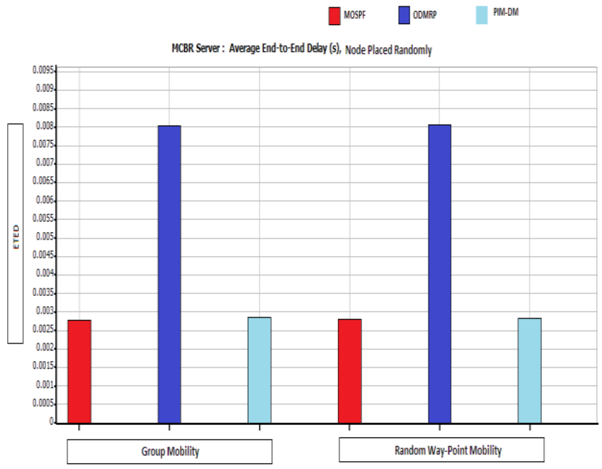

Fig. 1.1.2 Average ETED Vs. Mobility

Fig. 1.1.3 shows that first packet sent from client is received at server almost at same time for all three protocols and for both mobility models. So chances of packet loss are negligible due to zero delay.

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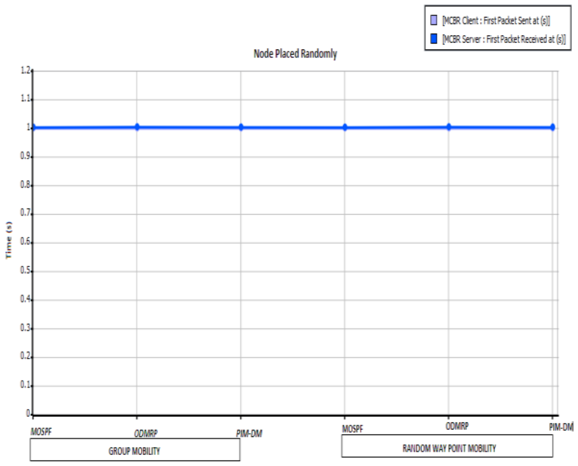

Fig. 1.1.3 First Packet Delay Vs. Mobility

Fig. 1.1.4 shows that delay between last packet sent and received is almost zero for all protocols except ODMRP for group mobility. For random way point mobility, the delay is almost zero except for PIM-DM.

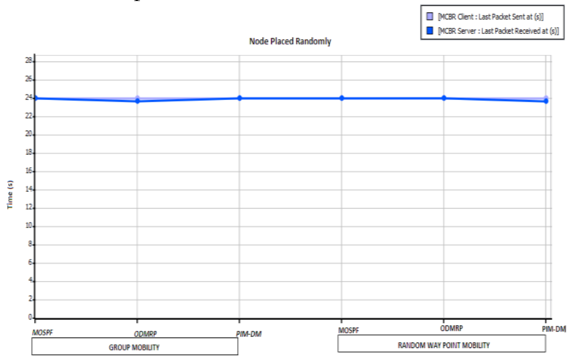

Fig. 1.1.4 Last Packet Delay Vs. Mobility

Fig. 1.1.5 shows that PDR is highest for PIM-DM and lowest for MOSPF for group mobility model. In case of random way point, PDR is highest for MOSPF and almost same for ODMRP and PIM-DM.

Fig. 1.1.6 shows that throughput is highest for PIM-DM and lowest for ODMRP for group mobility model. In case of random way point mobility, throughput is lowest for PIM-DM and almost same for MOSPF and ODMRP.

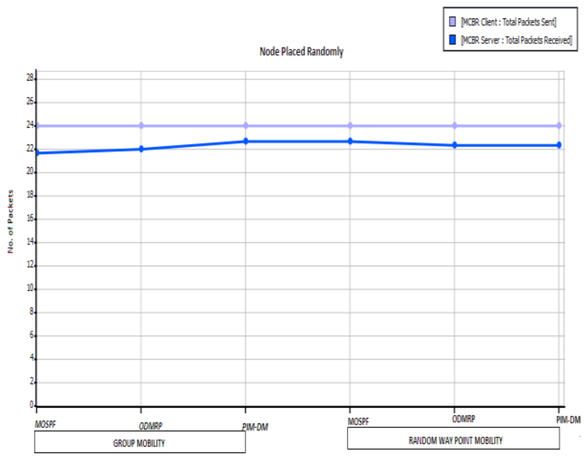

Fig. 1.1.5 PDR Vs. Mobility

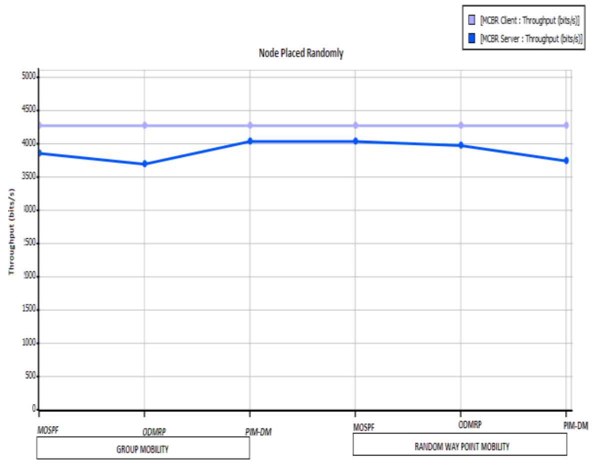

Fig. 1.1.6 Throughput Vs. Mobility

Fig. 1.2.1 to 1.2.6 shows that how does node speed affect the performance of MOSPF, ODMRP and PIM-DM. The no. of bytes received increase as speed increase from 10 to 20mps but decrease sharply for 30mps. PIM-DM has received highest bytes and ODMRP has received lowest bytes for 10 and 20mps speed. For 30mps, PIM-DM has lowest no. of bytes.

Fig. 1.2.2 shows that average ETED increase for all protocol as speed increases from 10 to 20mps but decrease gradually for 30mps. At 30mps speed, ETED is highest for ODMRP.

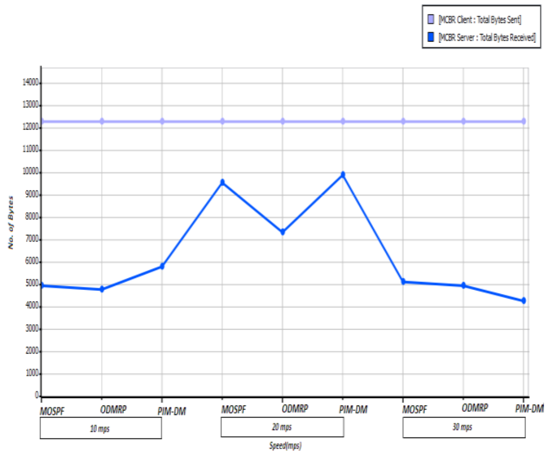

Fig.1.2.1 Total Bytes Received Vs. Speed

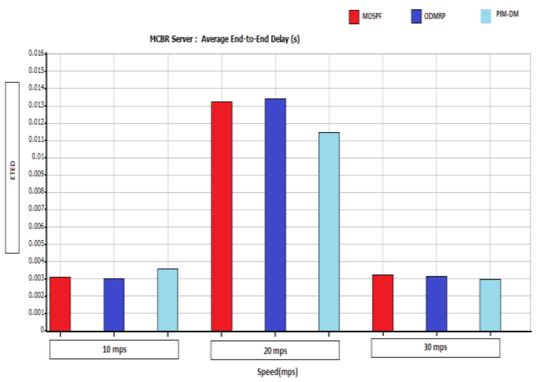

Fig. 1.2.2 Average ETED Vs. Speed

Fig. 1.2.3 shows that first packet delay is highest for PIM-DM and lowest for ODMRP for 10mps speed. But for 20mps, delay decreases and remains same for all of three. For 30mps, delay again increases and is highest for MOSPF and lowest for ODMRP.

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Fig. 1.2.4 shows that last packet delay is highest for PIM-DM at 10mps and 20mps speed. Delay is lowest for ODMRP at 20mps. The delay increases with speed from 10 to 20mps and decreases at speed 30mps.

Fig. 1.2.5 shows that PDR is highest for PIM-DM and lowest for ODMRP at 10 and 20mps speed. At 30mps speed, PDR is lowest for PIM-DM and highest for MOSPF. PDR increases with speed from 10 to 20mps but decreases at 30mps speed.

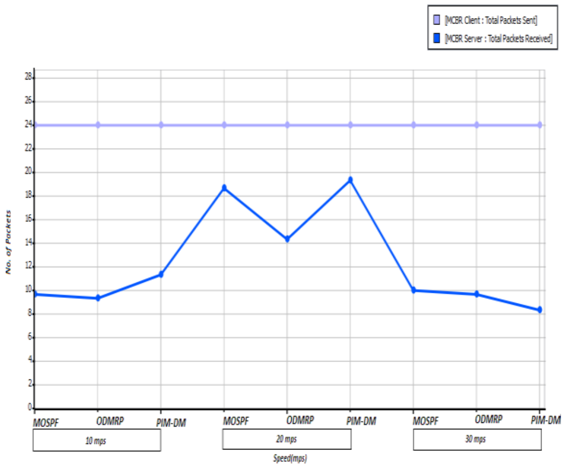

Fig. 1.2.3 First Packet Delay Vs. Speed

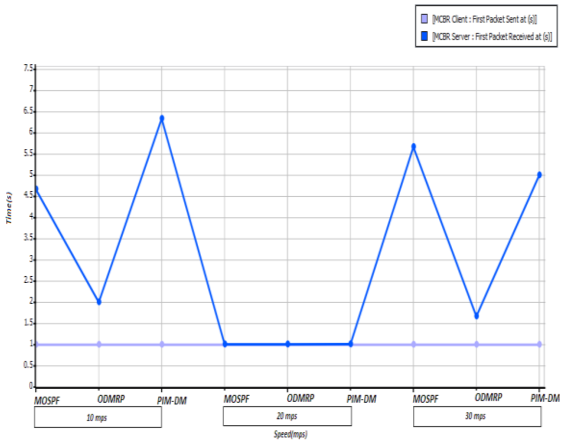

Fig. 1.2.4 Last Packet Delay Vs. Speed

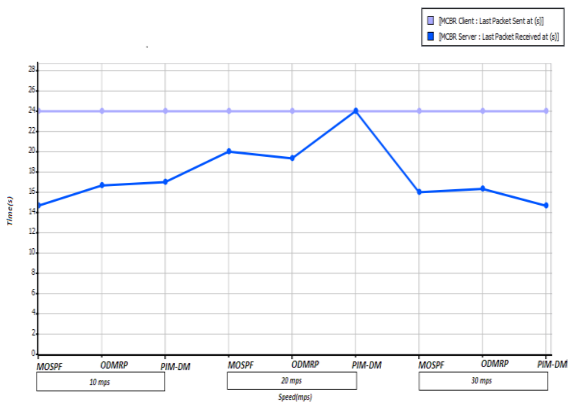

Fig. 1.2.5 PDR Vs. Speed

Fig. 1.2.6 shows that throughput increases with speed from 10 to 20mps but decreases at 30mps speed. ODMRP has highest throughput for 10 and 30mps speed and lowest for 20mps. PIM-DM has lowest throughput at 10 and 30mps speed and highest at 30mps speed.

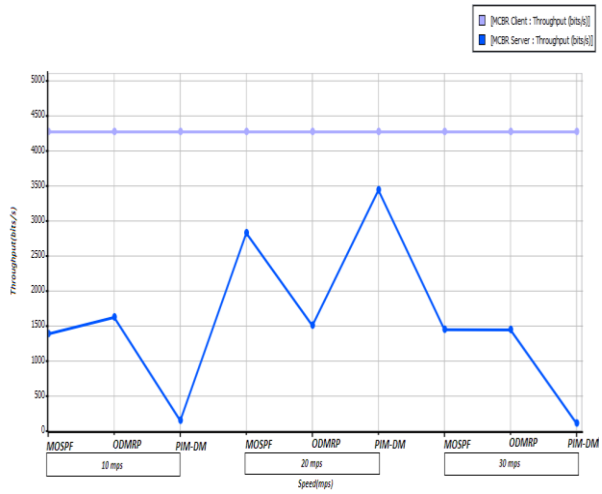

Fig.1.2.6 Throughput Vs. Speed

VI. CONCLUSION

From the investigation, it can be concluded that proactive multicast routing protocols are not suitable for mobile ad hoc networks (MANETs), because of their huge routing overheads. Among the other two reactive routing protocols, mesh based (ODMRP) shows better performance than tree based (PIM-DM) routing protocol. ODMRP has low packet loss, high packet delivery ratio (PDR), less average end to end delay (ETED) high throughput as compared to MOSPF and PIM-DM.

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