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Analyzing the Performance of MAODV, ODMRP, MOSPF and PIM in Mobile Adhoc Networks

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***Abstract*— Mobile adhoc networks are flexible networks consisting of nodes which are mobile and without a wired infrastructure. Due to its dynamic topology, it supports upcoming group applications like spontaneous joint activities and emergency operations. Different multicast routing protocols have been proposed for ad hoc networks each having certain levels of difficulties for routing during mobility of nodes and band-width constraints. Here, a simulation of a set of wireless adhoc multicast protocols is evaluated under various network scenarios. The relative pros, cons, and area of application of each multicast protocol to different situations are analyzed using parameters like throughput, packet delivery ratio and average end-to-end delay. The Multicast routing protocols like ODMRP (On-Demand Multicast Routing Protocol), MAODV (Multicast Adhoc On-Demand Distance Vector), PIM (Protocol Independent Multicast) and MOSPF (Multicast Open Shortest Path First) are considered for the evaluation and the simulation is performed using QUALNET.**

***Index Terms*—Multicast Routing Protocols, ODMRP, MAODV, MOSPF and PIM**

I. INTRODUCTION

THE Mobile adhoc network consists of an autonomous group of wireless nodes that does not dependent on any centralized administration or stable infrastructure. There is no differentiation between host and a router, as a node can act as both source node as well as traffic forwarders. These nodes are free to arrange themselves by moving randomly thus causing the network topology to change quickly and unexpectedly. MANETs may be limited to a local area wireless network or connected to the internet.

A mobile ad-hoc network can be used to provide emergency management applications, like disaster recovery, in which the whole network setup is damaged and rapid restoration of communication is complex.

In contrast with the infrastructure based mobile networks, MANETs need basic changes to typical routing mechanism and protocols for packet forwarding for both peer-to-peer and group communication. A number of routing protocols for multicast networks have been proposed by taking into consideration that communication within a group is one among the important applications in MANET. Proactive and reactive [1] are the two classifications of multicast protocols based on how routing states are maintained. Proactive protocols maintain routing states based on periodic updates and changes in the network, while the reactive protocol acquire routes on demand which reduces the impact of frequent changes in topology.

The main aim of this paper is to explore the performance characteristics of multicast routing protocols. For this in-depth simulation using different scenarios like mobility of nodes, traffic source conditions and multicast group characteristics [2] is carried out. Here the performance of multicast routing protocols like ODMRP [3], which is a mesh-based, is compared against tree-based protocols like PIM [4], MAODV [5] and MOSPF [6].

II. OVERVIEW OF MULTICAST ROUTING PROTOCOLS

Existing multicast protocols can be classified into tree-based or mesh-based according to the nature of multicast topology that is used to forward multicasts packets. Some of the important features of MANETs, like quick setup, make the former suitable for crucial environments like battle field or disaster recovery, where there is a need for reliability and robustness are required. While the latter build a mesh for transmitting multicast data by which it uses path redundancy to addresses the above mention requirements.

A. On Demand Multicast Routing Protocol (ODMRP)

The On-Demand Multicast Routing Protocol (ODMRP) [3, 7] is an on-demand mesh based protocol where a mesh is formed by a group of nodes known as forwarding nodes. These nodes forward the data packets between the source and destinations, and keep a message cache which helps in the detection of duplicate data and control packets.

In the Mesh establishing phase between the source and receivers, a JoinReq [8] control packet is flooded by the sender periodically for the creation of mesh. The receivers respond to the request by sending a JoinReply through the shortest reverse path. Each intermediate node that receives the JoinReq packet stores the upstream node Identity before broadcasting the packet. The JoinReply packet consists of the Source Id and the Next Node ID. An intermediate node on the receipt of a JoinReply packet sets a forwarding flag thus becoming a member of the forwarding group of that multicast group.

Mesh Maintenance is carried out by soft state approach, in which routes are reestablished between the source and destination by the sending of periodic JoinReq packet by the source. This protocol is resistant to link and a node failure since it has a forwarding group which is in fact a merit of mesh-based protocols. The drawback is that it has higher control overhead and multiple transmission of same data packet through the network leads to decrease in efficiency of the multicast group.

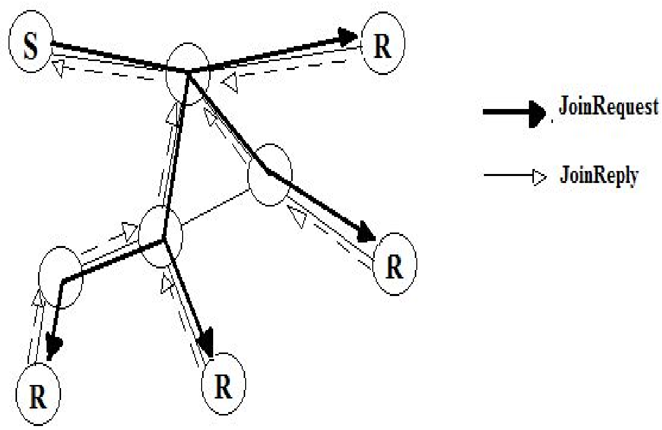

Fig. 1. ODMRP Mesh Formation

B. *Multicast Ad hoc On-Demand Distance Vector (MAODV)*

The working of MAODV [5] is similar to the operation of AODV [11]. The MAODV is a tree based multicast routing protocol in which nodes quickly respond to breakage of links in multicast trees by correcting these periodically. When a network partition occurs, in each partition independent multicast trees are formed, and trees belonging to the same multicast groups are joined when components of a network merge. Multicast routes are discovered when require and to obtain the most recent routes, sequence numbers are used.

Tree establishment in MAODV is made by means of group leader and group sequence number. Each group has a sequence number which is updated by group leader and the change is updated to other nodes by means of group hellos (GRPHs) [8].The first node to join in the group acts as group leader. Nodes can join into a group by sending a unicast route request (RREQ) if they have the address of group leader or a broadcast RREQ packet if group leader is unknown. Members of the multicast group replies its distance from group leader and group sequence number by means of a RREP packet. The node requesting to join sends multicast activation (MACT) [8] message to the nearest member with an updated sequence number. After reception of MACT all the intermediate nodes become the members of the tree.

A prune message is send upstream by a node if it wants to leave a group. Maintenance of network partition is done by means of GRPH message. When a node receives multiple GRPH, it starts a group election protocol which is used to select a single group leader. The route discovery process in MAODV uses information from AODV thus reducing the control overhead.

C. *Multicast Open Shortest Path First (MOSPF)*

MOSPF [6] protocol is a multicast improvement of OSPF (Open Shortest Path First) protocol to provide efficient

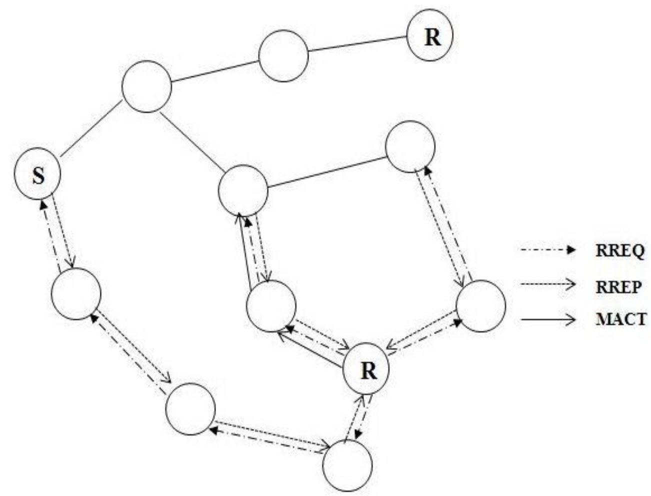

Fig. 2. MAODV Tree Formation

multicasting within a network. MOSPF provides the facility to forward multicast datagrams from one IP network to another. MOSPF forwards a multicast datagram on the basis of both source and destination address of the datagram. MOSPF constructs a distribution tree for each source-group pair and computes a tree for active sources sending to the group. The tree state is cached, and trees must be calculated again when a link state change happens or when the cache has stale data. IGMP (Internet Group Management Protocol) is used in MOSPF routers to examine membership in multicast group by broadcasting IGMP Host Membership Queries and receiving IGMP Host Membership Reports [6]. The group information is then transmitted in the network by flooding of OSPF link state advertisements (LSA). This information is used by the routers to build the shortest path tree where source is the root and multicast receivers are the terminal nodes. A separate shortest path is created for each source destination group pair. Every router in the route of a multicast datagram makes its forwarding decision based on the contents of a data cache called the forwarding cache. A separate forwarding cache entry for each source/destination combination [6] is maintained. Each cache entry designates, for multicast datagrams having matching source and destination, which neighboring node the datagram must be received from (upstream node) and to which interfaces the datagram should then be forwarded out (downstream interfaces).Compared to DVMRP [12], faster network convergence is provided by MOSPF.

D. *Protocol Independent Multicast (PIM)*

PIM [4] is a multicast routing protocol that uses an existing unicast infrastructure. It is termed as protocol independent because it uses routing information provided by other routing protocols such as the Border Gateway Protocol (BGP), Routing Information Protocol, Open Shortest Path First and Multicast Source Discovery Protocol. PIM consist of a group of multicast Routing protocols each of which is dedicated for a different environment. They include PIM Sparse Mode (PIM-SM), PIM Dense Mode (PIM-DM), PIM source specific multicast (PIM-SSM) [9] and Bidirectional PIM.

In sparse mode few receivers are present while dense mode has receivers at most of the location. In sparse groups [10], receiver who wishes to join the group is required to transmit a specific join request to a distinct RP which is selected on the basis on the address of the multicast group. Routers use PIM Join and Prune messages to join and leave multicast distribution trees. By default PIM-SM makes use of shared trees, which are multicast distribution trees rooted at a selected node (Rendezvous Point or RP) and is used by all sources sending to the multicast group. In dense mode, initially source broadcast to every node. A prune message is send to the router by the nodes not intending to receive packets meant for a group. Reverse-path forwarding is used to ensure that no packet loops occur among routers. Sate information is refreshed at the routers by periodic control messages. No explicit teardown mechanism is needed to remove states when a group ceases to exist.

III. Model And Methodology

A. Scenarios

Here three MANET scenarios are considered for the simulations. The scenarios, like multicast group size, number of traffic sources, and mobility are varied over a wide range of values.

B. Metrics

Packet delivery ratio

Packet delivery ratio is calculated as the ratio of total number of unique packets received by the receivers to the number of total packets transmitted by the sources.

Throughput

Throughput is calculated as the total number of successful packet delivered over a period of time

Average End-to-End Delay

Average End-to-End Delay is computed as the average time taken for a packet to reach the destination node from the sender.

All the above metrics are calculated in three different network conditions. They include:

1. *Mobility effects:* In this, the performance of the various multicast protocols are calculated based on different node speeds [13].
2. *Group Size:* Here different density of network is used for the performance comparison of the four routing protocol.
3. *Traffic Sources:* In this condition, the numbers of sources in a multicast group are increased to analyze its effect.

IV. Simulation Results

The multicast protocols, ODMRP, MAODV, MOSPF and PIM are compared under various synthetic scenarios. An in-depth simulation using different scenarios like mobility of nodes, traffic source conditions and multicast group characteristics is performed using Qualnet 5.0.2 [14, 15, 16], a simulation platform from Scalable Network Technologies, inorder to find out the outperforming protocol among these. In the simulations, every node in the adhoc network joins the multicast group at the launch of simulation and continues to be members of the group till the end of the simulation period. Table 1 shows the parameters that have been set for simulation. The parameters like number of nodes, speed of mobility and number of traffic sources differs according to the scenario considered.

Table I
Simulation Parameters

Parameter	Value
Field - Range-x Field-range-y	1500m 1500m
Number of packets Packet size	1000 256 bytes
Simulation time	500s
Node placement	Random
Mobility model Speed	Random waypoint 75mps
MAC Protocol	802.11
Application Traffic	MCBR

Fig. 3 shows the experimental setup of a MANET with 40 nodes as multicast group members. Here node1 is selected as the sender and is assigned with a MCBR application.

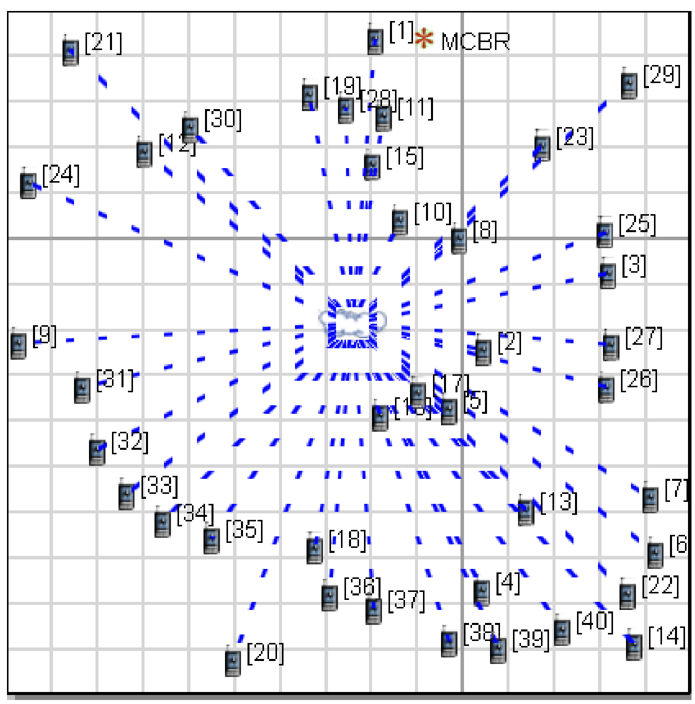

Fig. 3. MANET scenario with 40 nodes

A. Multicast Group Size

For this the effect of group size on performance of multicast routing is analyzed. The number of source nodes was taken as one, 75mps is the node mobility and the group size is varied from 10 to 40 receivers in increments of 10.

Throughput

In the Fig. 4, it shows the effect of change in multicast group size on the throughput of each protocol. It shows that for larger group size, the throughput of MAODV and ODMRP is greater than that of PIM and MOSPF.

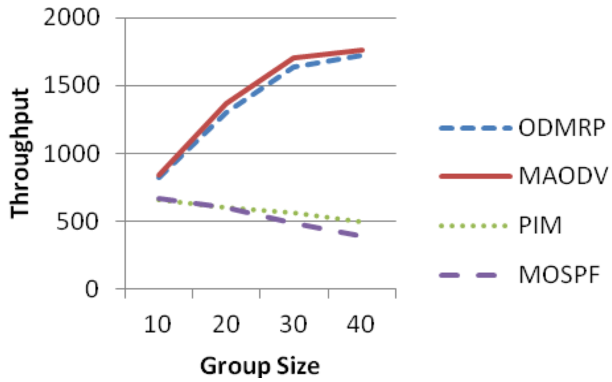

Fig. 4. Throughput as a function of multicast group size

Average End-to-End Delay

The Fig. 5 shows how the end-to end delay varies with increasing group size for each protocol. It can be observed that MAODV shows a higher delay than the other three protocols. While ODMRP shows a linear increase in delay with raise in group size whereas the rest of the two protocols maintains a minor change in delay.

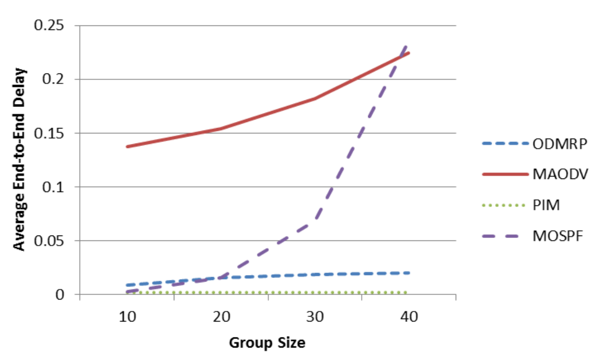

Fig. 5. Average End-to-End Delay as a function of multicast group size

Packet Delivery Ratio

From Fig. 6, it can be inferred that in MAODV and ODMRP the packet delivery ratio increases proportionally with the group size. But there is an inverse effect in PIM and MOSPF.

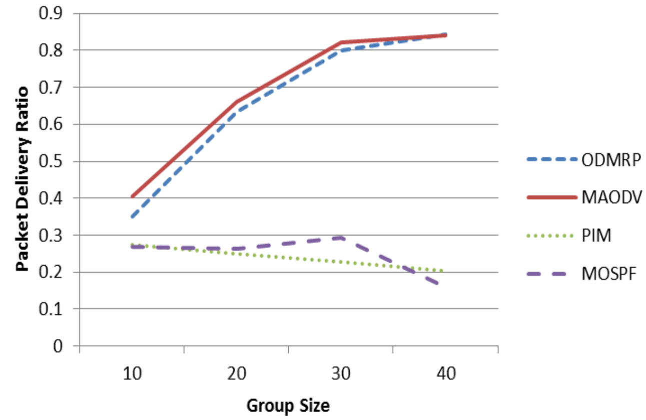

Fig. 6. Packet Delivery Ratio as a function of multicast group size

B. *Mobility*

For this, the effect of change in mobility speed on the performance of multicast routing is analyzed. The number of senders was taken as one in a multicast group of 20 nodes and the speed is varied from 25mps to 150 mps receivers in increments of 25mps.

Throughput

From Fig. 7, it can be deduced that in PIM and MOSPF the throughput tends to decrease with increasing mobility while the ODMRP and MAODV shows good outcome.

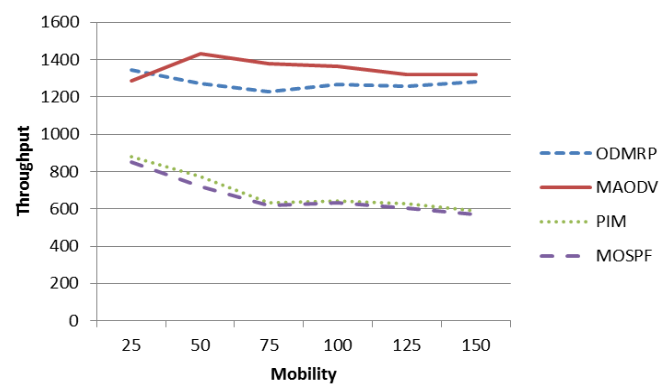

Fig. 7. Throughput as a function of node mobility

Average End-to-End Delay

From Fig. 8 it can be concluded that increase in mobility causes degradation of performance in MAODV while the other three protocols show a convincing outcome.

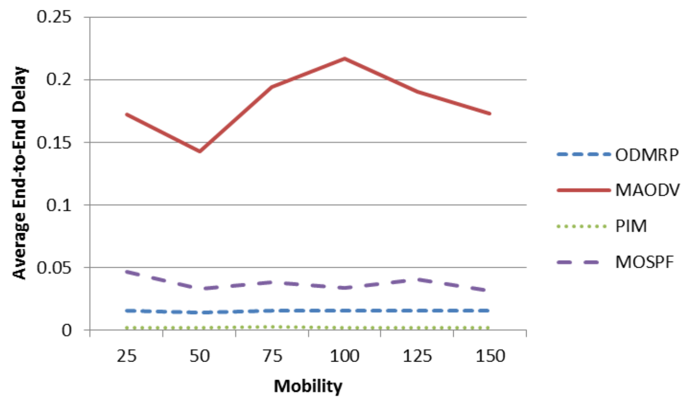

Fig. 8. Average End-to-End Delay as a function of node mobility

Packet Delivery Ratio

Fig. 9 shows the variation of protocol reliability with change in mobility. The trend observed is that MAODV outperforms ODMRP which in turn performs better than PIM and MOSPF.

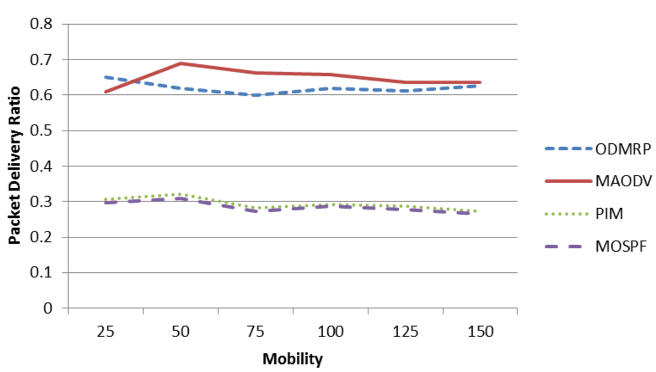

Fig. 9. Packet Delivery Ratio as a function of node mobility

C. Number of Traffic Sources

In this experiment the numbers of traffic sources are varied from 10 to 30 in increments of 10, while maintaining the number of receivers as 30 and the mobility was fixed at 75mps.

Packet Delivery Ratio

From Figure 10, it can be inferred that in MAODV the packet delivery ratio shows an increasing nature at first but then decrease as the traffic sources increase. While MOSPF shows an opposite nature to that of MAODV. ODMRP and PIM have a linear increase in the packet delivery ratio.

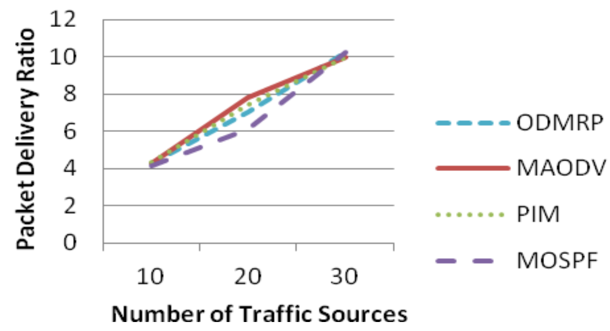

Fig. 10 Packet Delivery Ratio as a function of Number of Traffic Sources

Average End-to-End Delay

The average end to end delay characteristic graph shown in figure 11 implies a common performance of the four protocols.

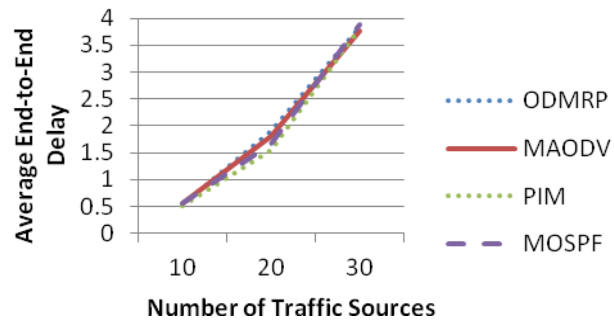

Fig. 11. Average End-to-End Delay as a function of Number of Traffic Sources

Throughput

In the Fig. 12, it shows the effect of change in number of traffic sources on the throughput of each protocol. It can be seen that a common performance variation is exhibited by MOSPF, ODMRP, PIM and MAODV where PIM has a slight higher throughput than others.

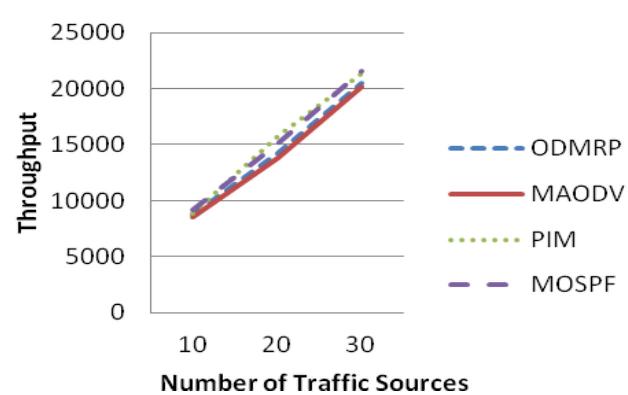

Fig. 12. Throughput as a function of Number of Traffic Sources

V. Conclusion

Here, a set of wireless adhoc multicast protocols are analyzed under network scenarios like multicast group size, number of traffic sources, and mobility by differing the scenario characteristics ,like size of the group, the number of sources and the speed of mobility ,under various ranges respectively. Throughput, Packet delivery ratio and Average end-to-end delay are the parameters considered to measure the relative performance of each protocol in each application scenario.

The simulation results show that MAODV provides better characteristic when compared to the other three but, it is having a higher Average end-to end delay which makes it unsuitable. PIM and MOSPF has lower average end-to-end delay when compared to ODMRP and MAODV but the resultant throughput is very less when compared to others. In case of increasing the number of traffic sources, PIM outperforms the rest of the three. While seeing to the protocol that is showing an average performance characteristic in all the scenarios taken under consideration, it can be concluded that ODMRP, a mesh based protocol, is having a relatively good performance and outperforms the three other protocols.

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