

# Performance Evaluation of Tree - Based Multicast Routing Protocols in MANETs

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## Abstract

Multicasting plays a crucial role in many applications of MANETs. It can significantly improve the performance of the networks. This paper proposes the comparison of MAODV and ADMR protocol. MAODV improves the QoS parameters like throughput, delivery ratio, end-to-end delay as compared to the ADMR.

## Keywords

MANET, multicast, throughput, delivery ratio, end-to-end delay, latency.

## I. Introduction

The objective of a multicast routing protocol for mobile ad hoc networks (MANETs) is to support the dissemination of information from a sender to all the receivers of a multicast group, while trying to use the available bandwidth efficiently in the presence of frequent topology changes. Several multicast routing protocols have been proposed for MANETs [1, 2, 4, 8-13]. According to the topology Multicast routing protocols can be classified into tree-based and mesh-based. These protocols are differing in terms of the redundancy of the paths between senders and receivers. Whereas tree-based protocols provide only a single path between senders and receivers, mesh-based protocols provide multiple paths. Examples of tree-based protocols are MAODV and ADMR. The rest of this paper is organized as follows. section II describes about the MAODV protocol, section III describes about the ADMR protocol, section IV provides the simulation of NS, section V provides the performance evaluation of two protocols and section VI provides results of two protocols.

## II. MAODV protocol

MAODV [1,7] – Multicast Ad-hoc On Demand Distance Vector Routing protocol is intended for use by mobile nodes in an ad hoc network which is one of the best network-layer, tree-based multicast routing protocols for MANETs. It is dynamic, self-starting, multihop routing protocol between the mobile nodes wishing to join or participate in a multicast group within an ad hoc network. MAODV creates a shared tree between the multicast sources and receivers for a multicast group. The root of each group tree is a multicast source or receiver for the group that has been designated as a group leader. The multicast group leader is responsible for the maintenance and dissemination of the multicast group sequence number, a variable that is used to ensure the freshness of the routing information.

MAODV uses a unique sequence number to identify multicast group. Each multicast group has its own sequence number, which is initialized by the multicast group leader and incremented periodically using a timer. Using these sequence numbers it ensures that the routes to multicast groups are always the most current ones. This means that if a node that requests routes to the multicast group has two routes, then it always selects the one with greatest sequence number i.e., the fresher one.

Each multicast group is organized by using a tree structure, composed of the group members and several routers, which are

not group members but have to exist in the tree to connect the group members and the sources. The group member that first constructs the tree is the group leader for that tree and is responsible for maintaining the group tree by periodically broadcasting Group-Hello (GRPH) message in the whole network. The group leader also maintains the group sequence number, which is propagated through the GRPH. GRPH contains extensions that indicate the multicast group IP address and sequence numbers (incremented every Group Hello) of all multicast groups for which the node is the group leader. Each node may maintain three tables

1. Unicast Route Table
2. Multicast Route Table
3. Group Leader Table

Unicast Route Table is used to record the next hop for routes to other destination for unicast communication. Multicast Route Table is used to list the next hops for the tree structure for each multicast group. Every node that belongs to that group tree should maintain such entries, with its own unique ID as group leader, group member, or router. Every next hop is associated with direction either downstream or upstream with respect to the root. Group Leader Table is used to record the currently-known multicast group address with its group leader address and next hop towards that group leader when the node receives a periodic GRPH message.

MAODV is a successor of the most popular unicast protocol, Ad-hoc On-demand Distance Vector (AODV). It discovers multicast routes on-demand using a broadcast route discovery mechanism employing route request (RREQ) and route reply (RREP) messages that exist in the unicast AODV protocol. As long as the multicast group members remain connected within a 'multicast tree', MAODV need not do any maintenance. When a source node wants to join or participate in a multicast group and which is not a member of that group, it follows the following steps:

### A. Generating Route Request (RREQ)

A node sends a RREQ either when it determines that it should be part of a multicast group, which is not already a member of that group, or when it has a new message to send to the multicast group but does not have a route to that group [1]. If the node wishes to join the multicast group, it sets the "J" flag in the RREQ. The destination address of RREQ is always set to the multicast group address. If the node knows the group leader and has a route to it, the node may place the group leader's address in the multicast group leader extension, and unicast the RREQ via its neighbors to the destination; Otherwise, if the node does not have a route to the group leader, or if it does not know who the multicast group leader is, it broadcasts the RREQ and does not include the multicast group leader extension field.

After transmitting RREQ, the node waits to receive a route reply packet (RREP) for specific amount of time. If RREP is not received in time, the node may resend RREQ up to RREQ\_RETRIES number of times. If a RREP is not received after RREQ\_RETRIES additional requests, the node may assume that there are no other members of that particular group within the connected portion

of the network. If it wanted to join the multicast group, it then becomes the multicast group leader for that multicast group.

### B. Receiving Route Request (RREQ)

When a node receives a RREQ, the node checks whether the 'J' flag is set. If so, the node can only respond if it is a member of the indicated group, and if it has the multicast group sequence number with at least as great as that contained in the received RREQ. If the 'J' flag is not set, the node can respond if it has an unexpired state of route to the multicast group and the multicast group sequence number is at least as great as the one given in received RREQ. If the node does not meet either of these two conditions, it replaces the IP address in the IP header of the original RREQ, updates the Destination Sequence Number to the maximum existing Destination Sequence Number in the RREQ and rebroadcasts this new RREQ among the whole network [1]. This node creates and updates the route table entry for the source node. It also creates a next hop entry for the multicast group in its multicast route table.

### C. Generating Route Reply (RREP)

If a node receives a join RREQ for a multicast group, and if it is already a member of the group, the node updates its multicast route table and generates RREP message. The Source and Destination IP Addresses in RREP contains the current sequence number for the multicast group and the IP address of the group leader. It unicasts the RREP back to the node indicated by the Source IP Address field of the received RREQ. A node can respond to a join RREQ only if it is a member of the specific multicast tree. If the node receives a multicast route request that is not a join message, it can reply if it has a current route to the multicast tree else it continues with forwarding the request packet.

### D. Forwarding Route Reply (RREP)

If an intermediate node receives a RREP in response to a RREQ that it has transmitted, it creates a multicast group next hop entry for the node from which it has received the RREP. The direction of this next hop is UPSTREAM, and the Activated Flag of RREP is unset. When the node receives more than one RREP for the same RREQ, it saves the route information with the greatest sequence number, and beyond that the lowest hop count. It discards all other RREPs with duplicate sequence numbers and with higher hop counts.

### E. Route Activation

When a node broadcasts a RREQ message, it may receive more than one reply since any node in the multicast tree can respond to the specific RREQ. The RREP message sets up route pointers as it travels back to the source node. If the request is a join request, these route pointers will build a branch onto the multicast tree. Due to the broadcast nature of wireless network, the route to the multicast tree must be explicitly selected and only one of the routes created by the RREP messages. The RREP containing the largest destination sequence number is chosen to be the branch added to the multicast tree, or the path to the multicast tree if the request was a non-join request. If the node received more than one RREP with the same largest sequence number, it selects the first one with the smallest hop count, with the shortest distance to a member of the multicast tree [1].

By sending Multicast Activation (MACT) message, the node selects the route it wishes to use as its link to the multicast tree. The node unicasts this MACT message to the selected next hop, effectively activating the route. It then sets the Activated flag in the next hop Multicast Route Table entry associated with that

node. After receiving this message, the node to which the MACT was sent activates the route entry for the link in its multicast route table, thereby finalizing the creation of the tree branch and adding a new node to the existing tree. When the node receives a MACT selecting it as the next hop, it unicasts its own MACT to the node it has chosen as its next hop, and so on up the tree, until a node which is a member of the multicast tree is reached [1, 2].

## III. ADMR protocol

ADMR [5] (Adaptive Demand-Driven Multicast Routing protocol) supports receivers to receive multicast packets sent by any sender, as well as receivers may join a multicast group only for specific senders [12]. The multicast sources do not need to know who are the receivers and in which network they are located. The receivers do not need to know who the sources are or in which network they are located. ADMR can work with the nodes which may move at any time in the whole network, and that any packet may be lost in the whole network.

### A. Multicast State Setup

A node S receives a multicast packet from a group G. If S is not currently a source for it, then ADMR attaches an ADMR header to the packet and floods the packet in the whole network. When R (receiver) for G receives this packet, it unicasts a RECEIVER JOIN packet back to S. This packet will set up forwarding state for S and G through which it is forwarded. When node R first issues a join request for group G, ADMR floods a MULTICAST SOLICITATION packet in the whole network. Each source for G responds to the solicitation by unicasting a UNICAST KEEPALIVE packet to R back, R then responds with a RECEIVER JOIN, which sets up forwarding state. The multicast forwarding state for a given group G and sender S in ADMR forms a source-based multicast forwarding mesh. In general, ADMR does not create redundant states.

### B. Multicast Packet Forwarding

There are two techniques to forward packets namely, network flood and mesh flood. In network flood any packet with a broadcast destination address containing an ADMR header will be sent via all the nodes in the network. In mesh flood any packet with a multicast destination address containing an ADMR header will only be sent via the nodes with multicast forwarding state for the source and group indicated in the packet. When a node receives a packet from S with a multicast destination address G and an ADMR header with it, it checks its Membership Table entry for source S and group G to decide whether it should forward the packet. Even if the packet is forwarded or not, the receiving node compares the hop count in the packet's header to the hop count in the Node Table entry for S. If the new hop count is less than that of the Node Table entry, the node may update the entry with the new hop count and set the previous hop address in the entry to the MAC layer source address from which the packet was received. If the packet has a payload, the node checks its Membership Table to check if it is a receiver for S and G. If so, it passes the packet up to the above layers to allow the packet to be processed as a received multicast packet. Since each node in the multicast source mesh forwards every packet that is mesh flooded without regard to whom it is transmitted, each packet will flow within the mesh to the group receivers without being restricted to follow any specific links, and will be able to automatically be forwarded around temporarily broken links.

### C. Multicast State Maintenance

Multicast state maintenance in ADMR is on-demand i.e., performed only when one or more receivers are disconnected from the mesh. The repair works for reconnecting the mesh with out duplicating the previous structure. Multicast mesh repair is performed with respect to the source-rooted tree traced out by the most recently forwarded multicast packet. Each multicast packet originated by node S contains an ADMR header, with number of fields used by the protocol in forwarding the packet and for maintaining the multicast forwarding mesh for S and G.

### IV. Performance Evaluation

The parameters [6] used in calculating the performance of protocols are Packet Delivery Ratio, Throughput, End-to-End Delay, Latency, no. of sent packets. Packet Delivery Ratio is the ratio of the data packets delivered to the destination. Throughput is defined as the total amount of data a receiver R actually receives from all the senders of the multicast group divided by the time it takes for R to receive the last packet. End – to- End Delay this represents the average time it takes for a data packet to be transmitted from one forwarding node to another.

### V. Simulation

The routing protocols are simulated by using Network Simulator (NS) [3]. We run simulations with NS2 to analyze and compare the performance of the MAODV and ADMR

1. Propagation: Two Ray Ground
2. Channel: Wireless Channel
3. Medium Access Control (MAC) protocol: IEEE 802\_11
4. Antenna: Omni Antenna
5. Simulation area: 1100 m × 1100 m
6. Traffic pattern: 50 CBR/UDP
7. Number of nodes: 50, 100, 150, 200
8. Pause time: 10s
9. Max speed: 2, 4, 6, 8, 10 m/s
10. Transmission range 250 m
11. Number of senders 5
12. Number of receivers 20
13. Simulation time 100 s
14. Packet size 1460
15. Maximum no. of packets: 1000000
16. Mobility Model: Random Way point
17. Number of groups: 1, 2

### VI. Simulation results

Simulation results of ADMR and MAODV protocol for group one and group two

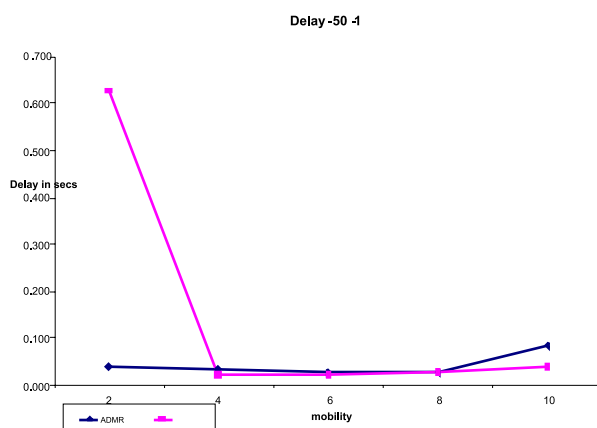


Fig.1 : Delay for 50 nodes with 1 group

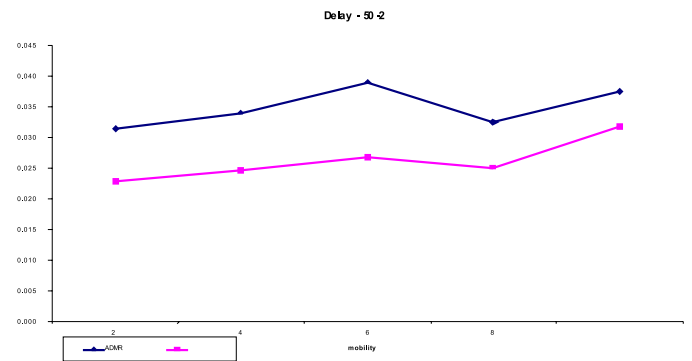


Fig. 2 : Delay for 50 nodes with 2 groups

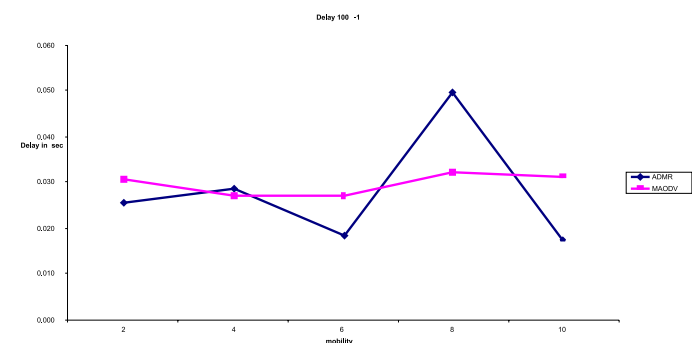


Fig. 3 : Delay for 100 nodes with 1 group

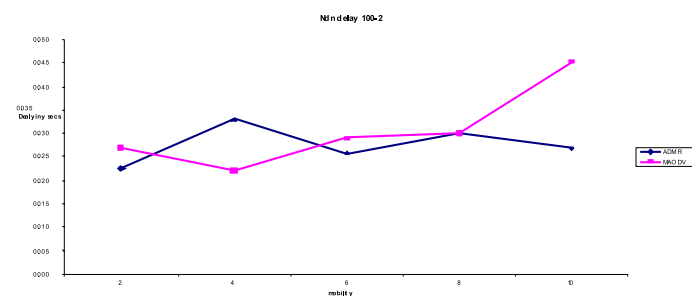


Fig 4 : Delay for 100 nodes with 2 groups

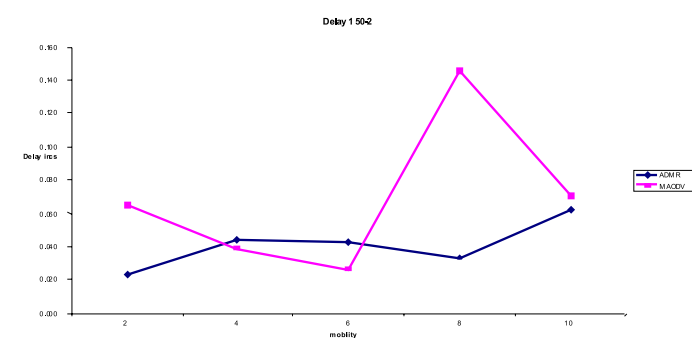


Fig. 5 : Delay for 150 nodes with 2 groups

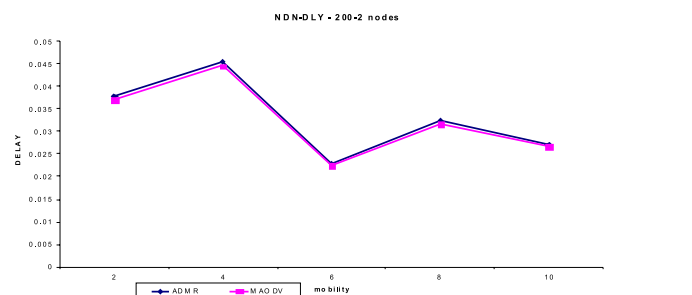


Fig. 6 : Delay for 200 nodes with 2 groups

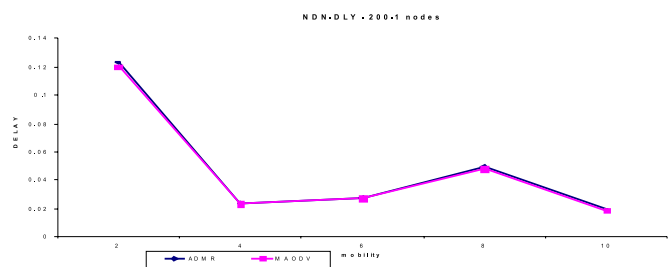


Fig. 7 : Delay for 200 nodes with 1 group

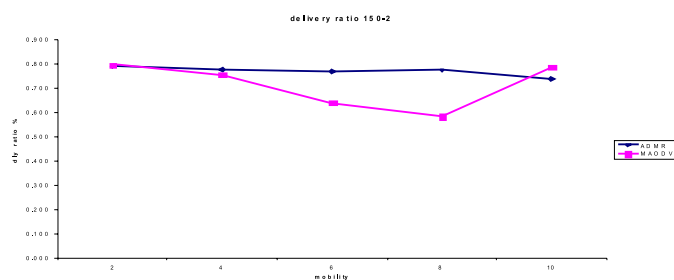


Fig. 13 : Delivery ratio for 150 nodes with 2 groups

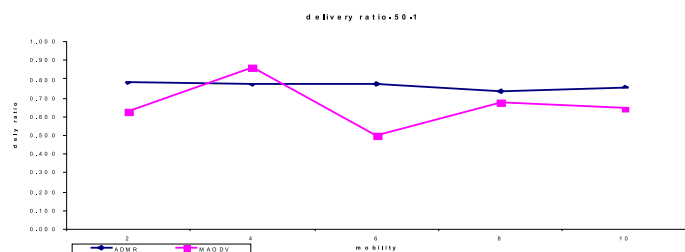


Fig. 8 : Delivery ratio for 50 nodes with 1 group

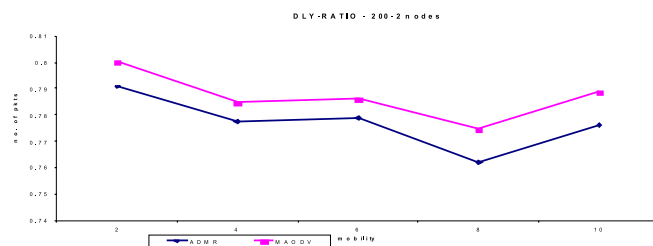


Fig. 14 : Delivery ratio for 200 nodes with 2 groups

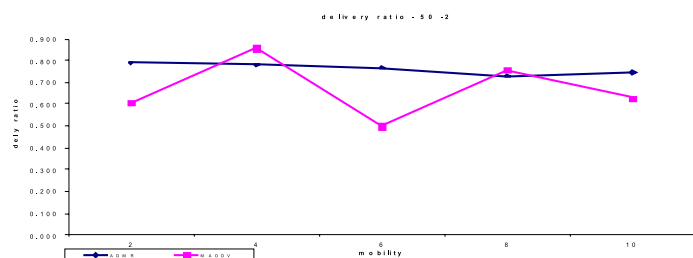


Fig. 9 : Delivery ratio for 50 nodes with 2 groups

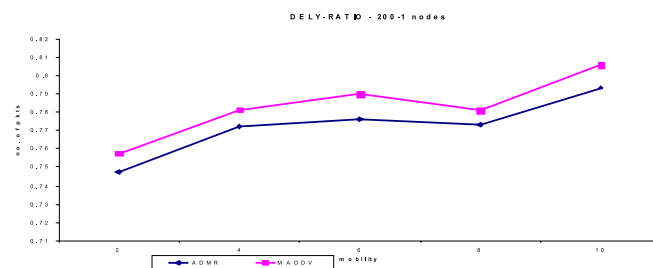


Fig. 15 : Delivery ratio for 200 nodes with 2 groups

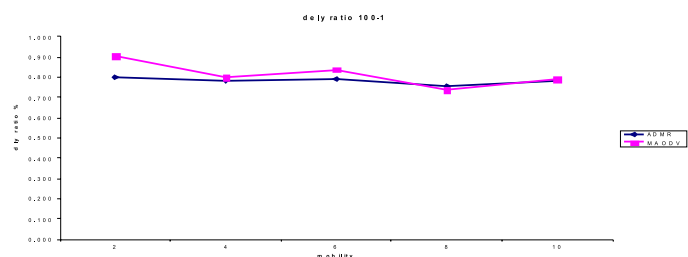


Fig. 10 : Delivery ratio for 100 nodes with 1 group

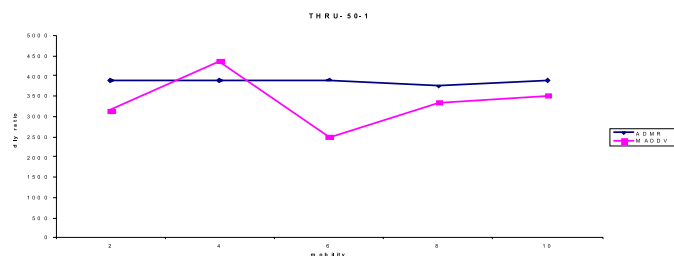


Fig. 16 : Throughput for 50 nodes with 1 group

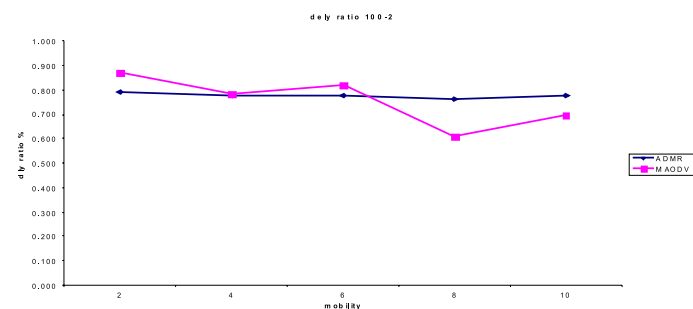


Fig. 11 : Delivery ratio for 100 nodes with 2 groups

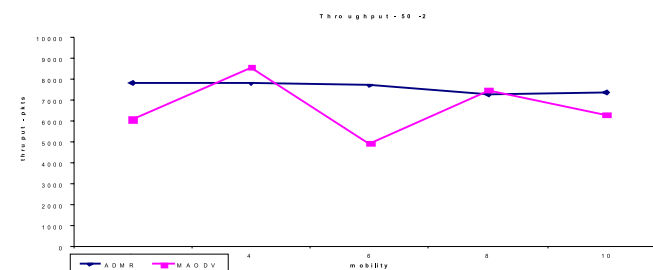


Fig. 17 : Throughput for 50 nodes with 2 groups

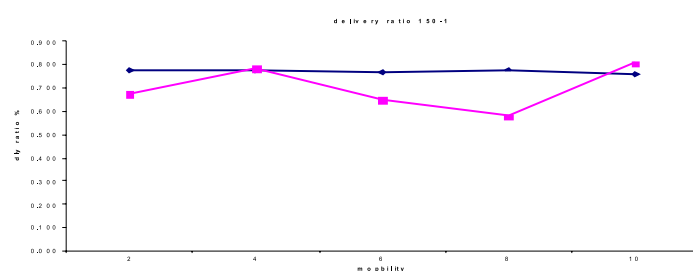


Fig. 12 : Delivery ratio for 150 nodes with 1 group

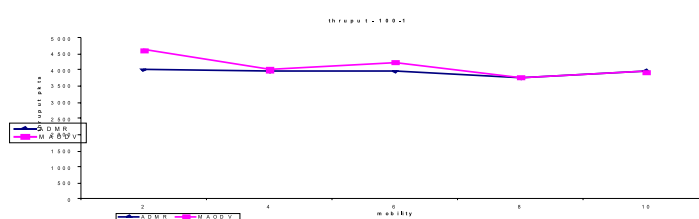


Fig. 18 : Throughput for 100 nodes with 1 group

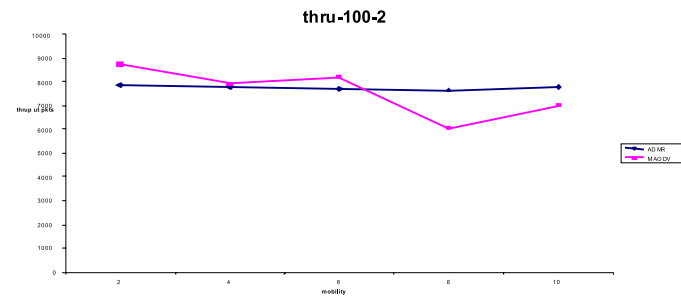


Fig. 19 : Throughput for 100 nodes with 2 groups

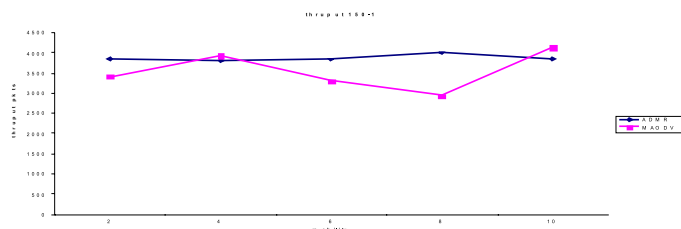


Fig. 20 : Throughput for 150 nodes with 1 group

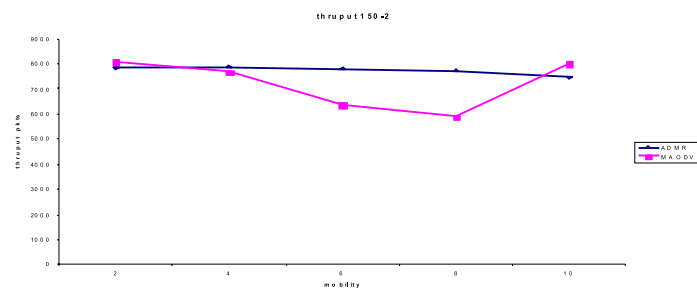


Fig. 21 : Throughput for 150 nodes with 2 groups

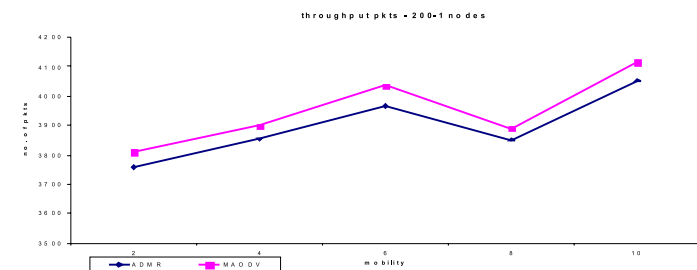


Fig. 22 : Throughput for 200 nodes with 1 group

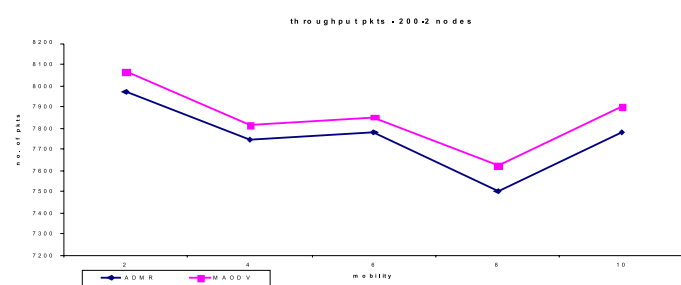


Fig. 23 : Throughput for 200 nodes with 2 groups

## VII. Conclusions

There have many routing protocol are developed for improving the Quality of Service of routing protocol. Example of MANET reactive routing protocol MAODV also improves the performance i.e. it reduces the delay metric and improves the throughput and packet delivery ratio as compared to the ADMR by varying the mobility.

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