Node Disjoint Split Multipath Multicast Ad-hoc on-demand Distance Vector Routing Protocol (NDSM-MAODV)

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ABSTRACT
In Manets the design issues are critical and challenging for the development of efficient routing protocols which provides high quality communication for each data and especially in the presence of a large amount of data. Several routing protocols have already been proposed. In MANETs efficient dynamic multicast routing is an important research challenge. In multicast environment on-demand routing is widely developed in bandwidth constrained mobile wireless ad hoc networks because of its effectiveness and efficiency. In multicast routing protocols most of them focus only on single path routing and do not provide the possibility to convey the load during the route establishment and therefore cannot balance the load on different routes. In this paper we propose a novel routing protocol NDSM-MAODV. According to the group discovery again it is divided into NDSM-MAODV-ran, NDSM-MAODV- seq, NDSM-MAODV- opt. The simulation result shows that the NDSM-MAODV protocol reduces the end-to-end delay and increases the packet delivery ratio, throughput as compared to the MAODV protocol.

Keywords
Manets, Multicast, Multipath QoS

1. INTRODUCTION
Mobile Ad hoc Networks (MANETs) consists of either fixed or mobile nodes which are connected wirelessly without the support of any fixed infrastructure or central administration [1, 3, 6, 7, 8]. The nodes are self-organized and can be deployed "on the fly" anywhere, any time to support a particular purpose or situation. Transmission techniques in MANETs are Unicast, Multicast and Broadcast. Multicasting is the transmission of datagrams to a group of hosts identified by a single destination address. Multicasting plays a crucial role in MANETs to support several applications.

In the multicast [9], any node in the network can join or leave a multicast group at any time and any node in the network can send data to any multicast group. The multicast sources need not to know who are the receivers but it needs the multicast group address. Multicast is usually a separate from unicast for efficiency reasons. The goal of an efficient multicast routing protocol is to deliver a copy of each packet to each multicast receiver by duplicating the packet in the network as few times as possible. The use of multicasting in MANETs has many benefits. It can reduce the cost of communication and improve the efficiency of the wireless channel when sending multiple copies of the same data. Instead of sending data through multiple Unicast, multicasting minimizes channel capacity consumption in the sender and router processing, energy consumption, and delivery delay, which are to be considered important factors of MANET. In addition, multicasting provides robust communication method whereby a receiver's individual address remains unknown to the transmitter or changeable in a transparent manner by the transmitter [10, 11]. In a wireless medium, it is even more crucial to reduce the transmission overhead and end-to-end delay. Multicasting can improve the efficiency of the wireless link when sending multiple copies of messages.

The rest of the paper is organized as follows section 2 describes the Related work of the proposed protocol, section 3 describes the Phases of the proposed protocol, section 4 describes the Performance evaluation of the protocol, section 5 describes the Simulation, section 6 describes the Simulation results and section 7 Conclusions.

2. RELATED WORK
In this work we have compared two tree based routing protocols i.e., MAODV and ADMR. MAODV has more packet delivery ratio and less end to end delay because the ADMR needs large amount of state information which is to be maintained at every node for every group source. Joining a group is very difficult. A receiver initially sends the request and each source must reply to the new receiver. The receiver must send a confirmation to every source. If the tree breaks often even the receiver is repeatedly trying to join the group. Finally, the protocol indicates how the source moves to flooding mode for high mobility, but does not indicate how it moves back when mobility is reduced. However the main drawbacks of MAODV are long delays, low packet delivery ratio and high overheads associated with fixing broken links in conditions of high mobility and traffic load as it depends on AODV. Finally it suffers from a single point of failure which is the multicast group leader.

To improve the performance of MAODV we use the concept of Multipath routing protocols [2] i.e., Split Multipath and Node Disjoint Multipath routing protocols. In the present work routing protocol consists of three main mechanisms: (a) Route discovery (b) Transmitting data or Load distribution and (c) Route maintenance.

2.1 Route Discovery Mechanism
The proposed Multiple Path Discovery algorithm [5] is an on demand source routing protocol that builds multiple routes between the source and the destination using the route request and route reply packets. When the source node needs a route to

the destination but no information is known, it floods the route request message to the entire network. Because this packet is flooded several duplicates that traversed through different routes to reach the destination. The destination node finds multiple node disjoint routes by using the MPD algorithm [5], after that grouping the paths by using Group Discovery algorithm [12] and sends route reply packets back to the source through the selected routes. The intermediate nodes are not allowed to send RREPs back to the source even if they have route information to the destination. If the intermediate nodes are allowed to reply, it becomes difficult for the destination node to compute the maximally node disjoint multiple routes because all the RREQ packets are flooded by the source node which will not reach the destination and the destination node does not know the routing information provided by the intermediate nodes.

2.1.1. Route Request (RREQ)

In MANETs every node maintains the complete route information about the available routes in its routing table. When a source node wants to send a packet to destination it checks its routing table to find whether it has any available route to the destination. If no route is found the source node initiates the route discovery procedure by broadcasting a RREQ message to its neighbors. This RREQ message contains the address of the source and destination nodes, unique identification number generated by the source node and a route record which records the address of the intermediate nodes corresponding to that path. By receiving the route request every intermediate node checks whether its own address is included in the route record of the route request (RREQ) message or not. If not, it appends its own address in the route record and rebroadcasts the route request to its neighbors. In this way the destination node receives several route request messages from its neighbors.

2.1.2. Route Reply (RREP)

When the source node floods the RREQ packet it travels through different possible routes and reaches the destination. When the destination node receives the first route request it appends its own address to the route record and returns it to the source node with route reply (RREP) message. This automatically becomes the shortest path for the source. From the remaining received route requests the destination node computes the maximally node disjoint paths using the proposed algorithm [5], and returns back to the source through the specified path. Now the source node divides the paths into number of groups using the proposed Group Discovery algorithm [12]. In each group the source node uses the shortest delayed path as primary path and uses it for the transmission of data packets and remaining paths are selected as backup paths. If the primary path fails in the group then the source node uses the alternate path

2.2 Transmitting Data or Load Distribution

When the source receives RREPs, it can transmit data packets through the discovered routes. Our protocol uses hop-by-hop method for forwarding data. Source node divides the data according to the number of groups. It consists of three mechanisms i.e., 1. Random 2. Equal 3. Segmentation. Random means source node divides the data by using the random function. Equal means source node divides the data equally according to the number of groups. Segmentation means source node divides the data into 512 bytes. After dividing the data source node distributes the data into each group. In each group every node that receives data packets sends them to the next hops according to the RREPs. Each intermediate node that receives data packets sends them to the next hops according to their RREPs in their Route Table. This process causes that all the discovered routes are used and data packets are distributed across all the paths simultaneously.

2.3. Route Maintenance

In the present work Route Maintenance is carried out through route error (RERR) messages and acknowledgment messages. In MANETs if there is an acknowledgement between the nodes in a path then the route is said to be used. If a node does not receive the acknowledgement from the upstream then the link failure occurs, there by it creates a route error (RERR) message and send it to the source node. The RERR contains the address of the node that has detected the RERR and the address of the next hop which is unreachable. When the source node receives a RERR message, it removes all routes from its cache that have the address of the node in error. If the route is primary path then source node starts using the backup path that is stored in its secondary cache without any rediscovery of a route. If the failed route is a backup path, then only the source node has to reinitiates the route discovery process. In addition to route error (RERR) message, acknowledgements are also used by the intermediate nodes to verify the continuity of the links.

2.3.1. Route Error (RERR)

In the present work when a node fails to deliver the data packet to the next hop of the route or not receiving passive acknowledgements, it considers the link to be disconnected and sends a RERR packet to the upstream direction of the route. The RERR message contains the route to the source and the immediate upstream and downstream nodes of the broken link. Upon receiving this RERR packet the source removes every entry in its route table that uses the broken link and continues the data packet transmission through the backup path. Source will reinitiate a new route discovery only if both the path fails.

3. PHASES OF THE PROPOSED PROTOCOL

In the proposed protocol i.e., NDSM-MAODV, it consists of three phases. (1) Discover multiple paths (2) Select a path or Grouping the selected paths (3) Distribute the load

3.1. Discover Multiple Paths

To discover multiple paths from source to destination, the basic route discovery mechanisms used in DSR and AODV protocols needs to be modified. However one of the major reasons for using multi path routing is to discover multiple paths which should be node-disjointed or link-disjointed. In the node-disjointed paths, nodes on the paths should not be same. In the link-disjointed paths, links on the paths should not be same. Therefore the route discovery mechanisms of the existing routing protocols requires to be modified to discover a maximum number of node- disjointed or link-disjointed paths. After finding all node-disjointed or link-disjointed paths we find the multiple paths by using the proposed Multiple Path Discovery algorithm [5].

3.2. Select a Path or Grouping the Selected Paths

After multiple paths are discovered, a multi path routing protocol should decide to find a path for sending data packets. Whenever if few paths are used, the performance of a multi path routing protocol should be similar to shortest path routing protocol. If all paths are used, there is a chance of selecting an excessively long path which may affect the performance of a multi path routing protocol. To overcome this we proposed Group Discovery algorithm [12].

3.2.1 Computation of Group Discovery in MANETs

In this paper the group discovery of multiple paths we suggested three methods i.e.,

1. Paths can be selected as Random
2. Paths can be selected as Sequential
3. Paths can be selected as Balanced.

A – Source node D – Destination node

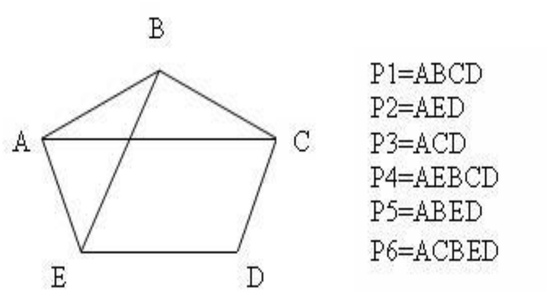

Fig 1: example of ad hoc network

In the above example we got 6 multiple paths i.e., P2, P1, P3, P5, P4 and P6 as been proposed in MPD algorithm [5].

Note: Here we assumed numbers of groups are two.

Case 1: Paths can be selected as Random: From the above example numbers of multiple paths are six. Hence Six paths can be divided into two groups by using the random function.

Case 2: Paths can be selected as Sequential: From the above example numbers of multiple paths are six. i.e. P2, P1, P3, P5, P4 and P6. Six paths can be divided into two groups by using the sequential method.

For Group 1, number 1 is selected
For Group 2, number 2 is selected

P2,	P1,	P3,	P5,	P4,	P6
1	2	1	2	1	2

Now P2, P3, P4 are placed in 1st group. P1, P5, P6 are place in 2nd group.

Case 3: Paths can be selected as Balanced.

A- Source node, D- Destination node

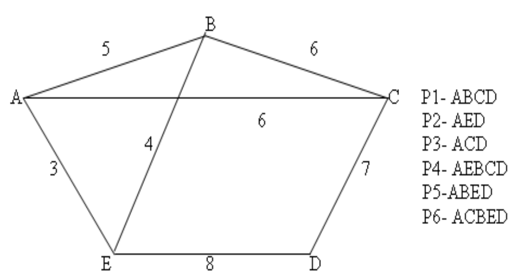

Fig 2: example of ad hoc network

P1- ABCD = 5, 6, 7	=	5
P2- AED = 3, 8	=	3
P3- ACD = 6, 7	=	6
P4- AEBCD = 3, 4, 6, 7	=	3
P5-ABED = 5, 4, 8	=	4
P6- ACBED = 6, 6, 4, 8	=	4
		25

Here the numbers of groups are two. So 25 is divided into two parts, means group1 has to take 12 and group2 has to take 13 or vice versa.

For group1:
3 + 6 + 3 = 12 or 5 + 4 + 3 = 12
G1 = P2, P3, P4 or P1, P5, P4

For group2:
5 + 4 + 4 = 13 or 6 + 3 + 4 = 13
G2 = P1, P5, P6 or P3, P2, P4

G1 & G2 = P2, P3, P4 & P1, P5, P6
or
G1 & G2 = P1, P5, P4 & P3, P2, P4

After the computation of Groups, paths in the groups are used in two ways:

1. One path is selected as a primary and all the rest are alternate paths. Only the primary path is used to transmit packets. Alternate paths are used only when the primary path fails.
2. If all the paths are used at the same time then packets are split among the paths.

The multi-path routing needs a set of paths from source S to destination D so that the total volume of data may be divided and communicated through selected multiple paths, which would perform load balancing and it reduces the congestion and end-to-end-delay if multiple routes are used simultaneously. On the other hand multiple paths can be used one at a time. In this way multi-path routing protocols have greater ability to reduce the route discovery frequency than single path protocols. On-demand multi-path protocols discover multiple paths between the source and the destination in a single route discovery. So, a new route discovery is needed only when all these paths fail. In contrast, a single path protocol has to invoke a new route discovery whenever only the path from the source to the destination fails. On-demand multi-path protocols cause fewer interruptions to the application data when routes fail. They also have a lower routing overhead because of the fewer route discovery operations that needs to be performed.

3.3. Load Balancing

After the group discovery, source node divides the data according to the number of groups. It consists of three mechanisms i.e. (1) Random (2) Equal (3) Segmentation. As explained in the section 2 above.

4. PERFORMANCE EVALUATION

The parameters used in calculating the performance of the protocols are Packet Delivery Ratio, Throughput, and End-to-End Delay [4]. 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 actually receives from all the senders of the multicast group divided by the time it takes for the receiver to receive the last packet. End - to - End Delay it represents the average time i.e. it takes for a data packet to be transmitted from one forwarding node to another.

5. SIMULATION

The routing protocols are simulated by using Network Simulator (NS)[13]. We run simulations with NS2 to analyze and compare the performance of the modified MAODV with MAODV and ADMR

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

6. SIMULATION RESULTS

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

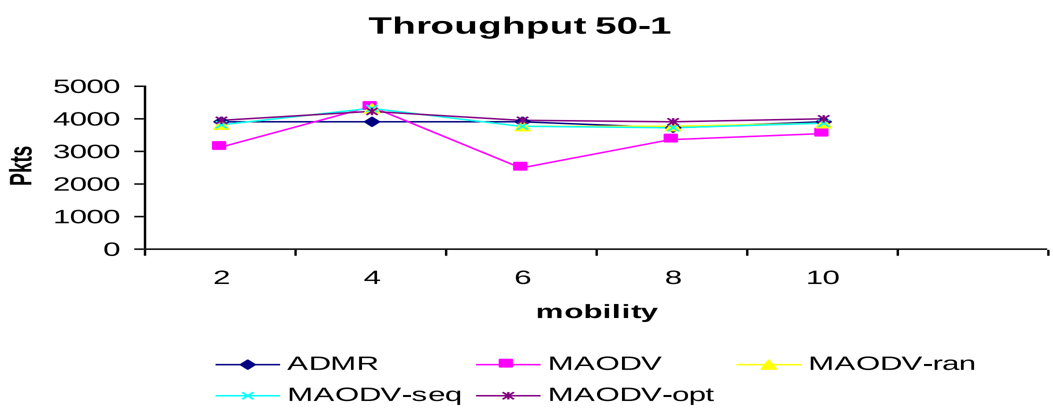

Fig 3: Throughput for 50 nodes with one Group

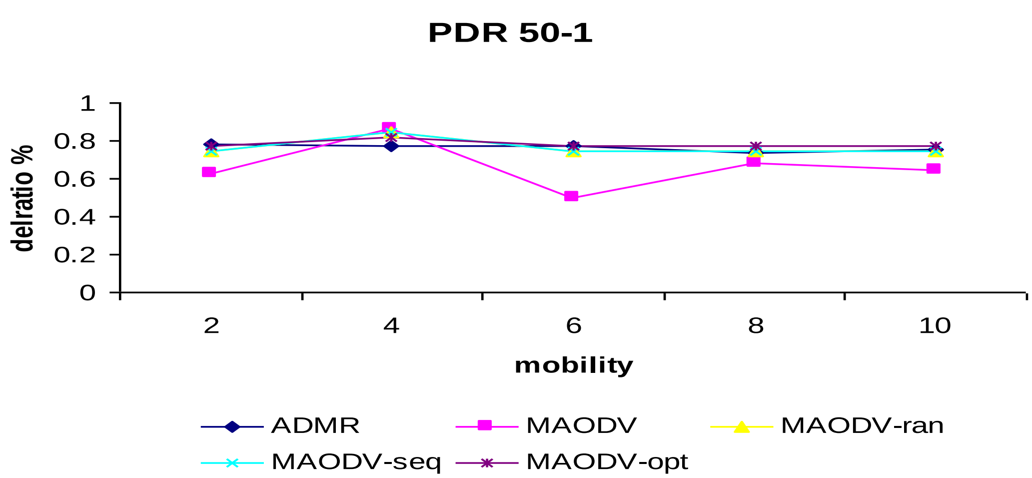

Fig 4: Packet Delivery Ratio for 50 nodes with one Group

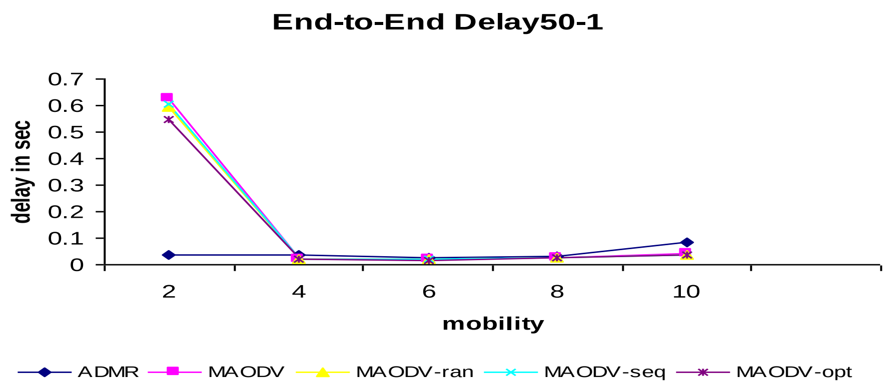

Fig 5: End to End Delay for 50 nodes with one Group

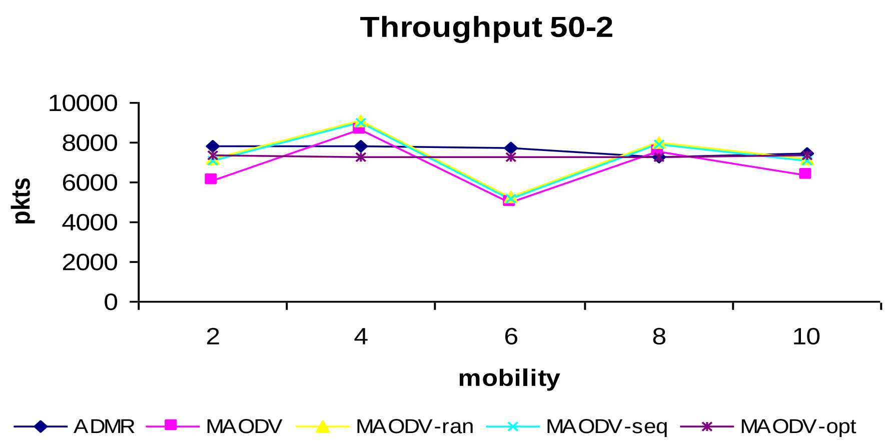

Fig 6: Throughput for 50 nodes with two Groups

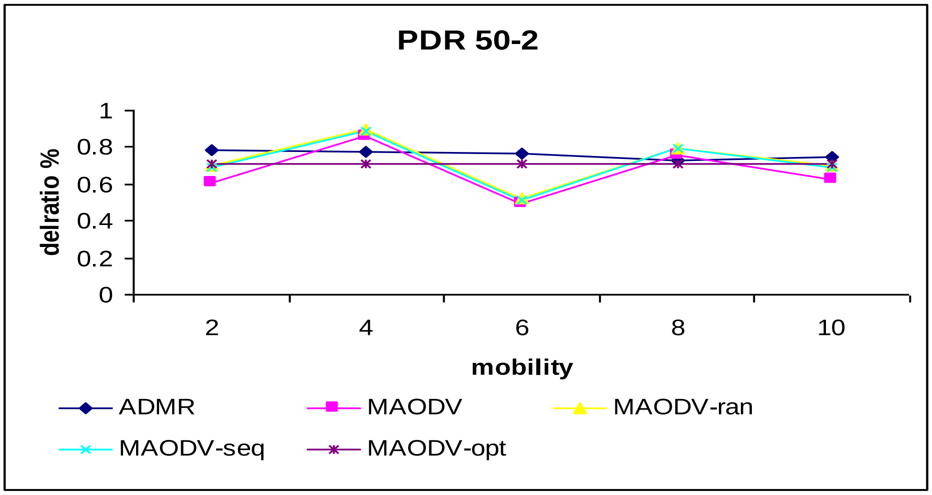

Fig 7: Packet Delivery Ratio for 50 nodes with two Groups

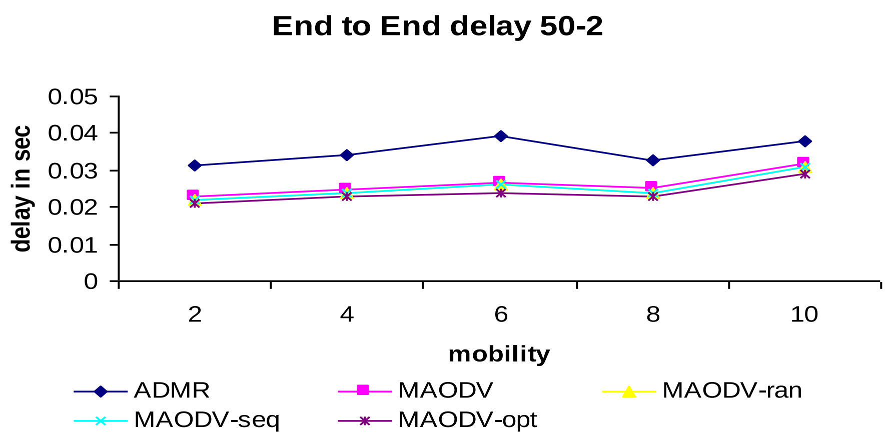

Fig 8: End to End Delay for 50 nodes with two Groups

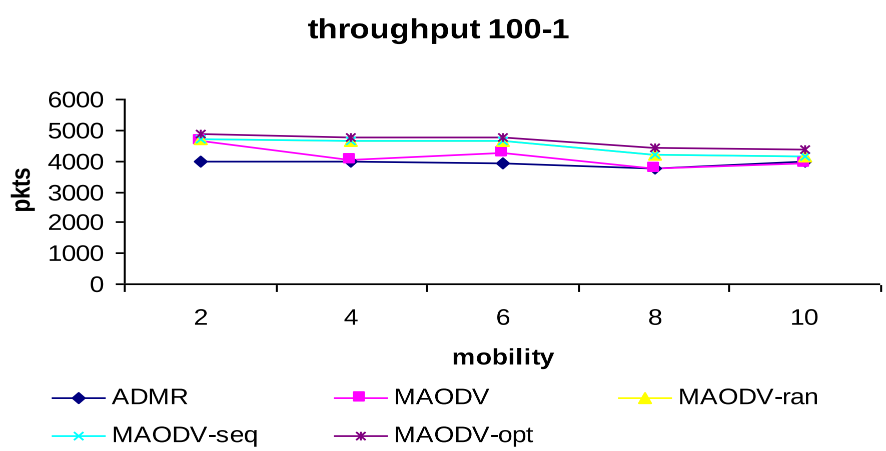

Fig 9: Throughput for 100 nodes with one Group

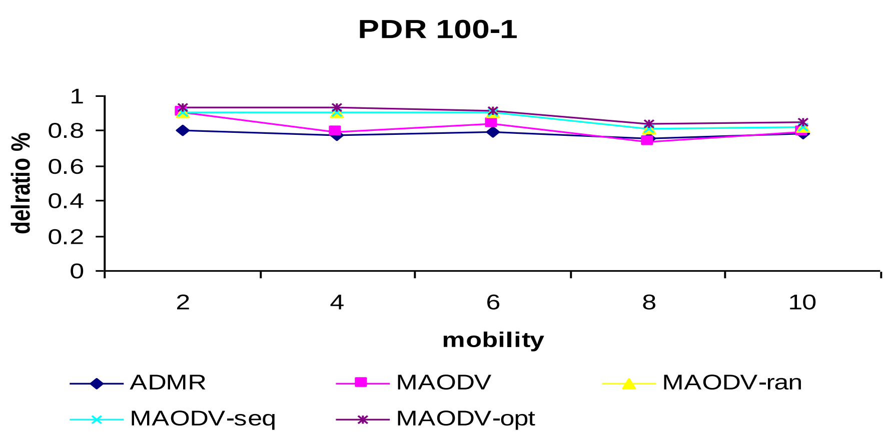

Fig 10: Packet Delivery Ratio for 100 nodes with one Group

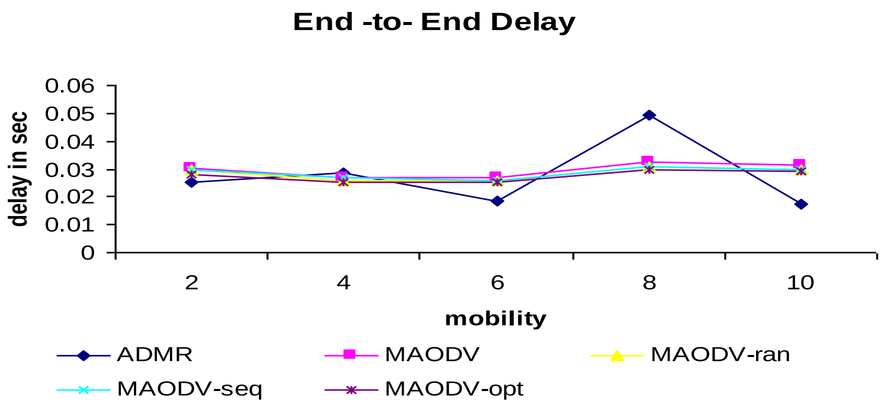

Fig 11: End to End Delay for 100 nodes with one Group

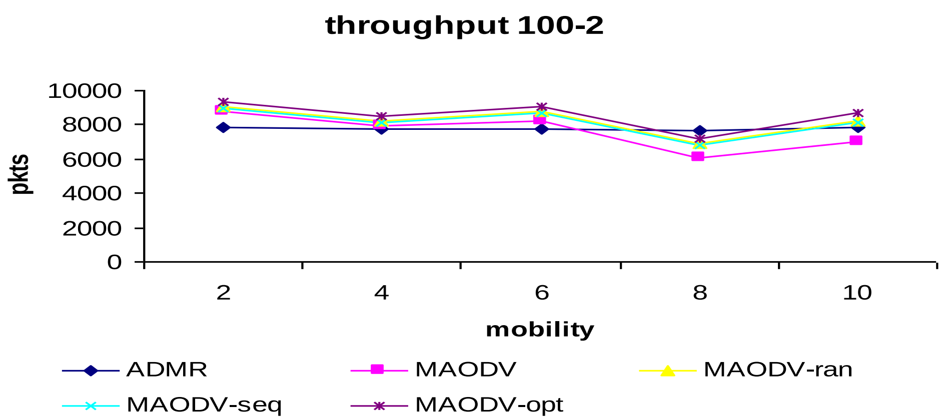

Fig 12: Throughput for 100 nodes with two Groups

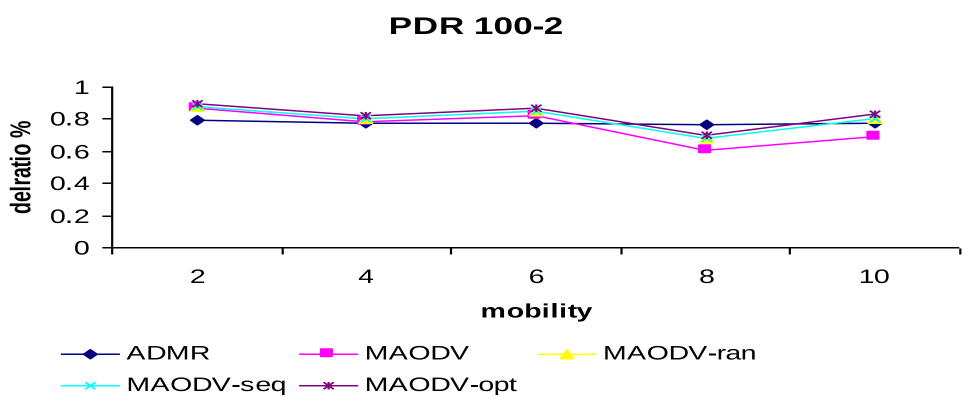

Fig 13: Packet Delivery Ratio for 100 nodes with two Groups

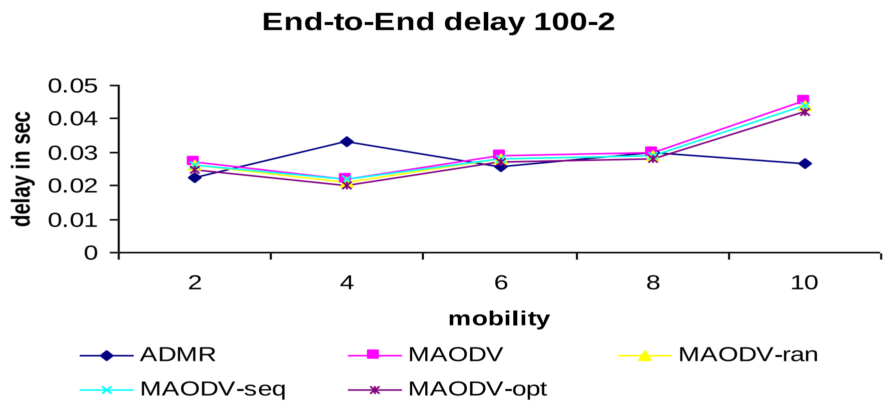

Fig 14: End to End Delay for 100 nodes with two Groups

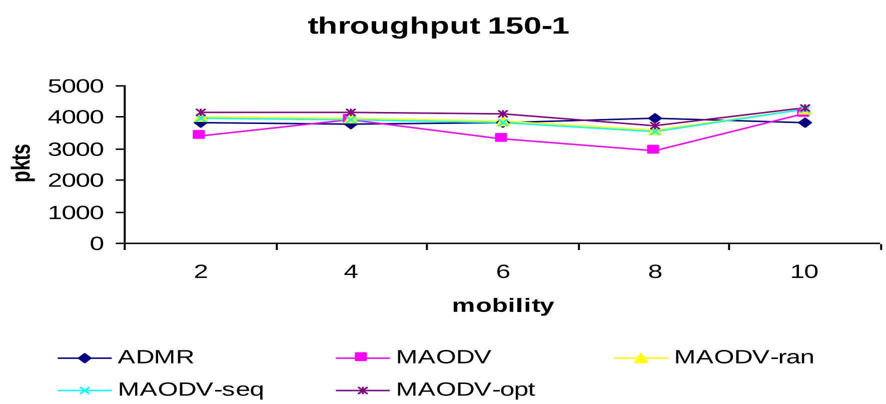

Fig 15: Throughput for 150 nodes with one Group

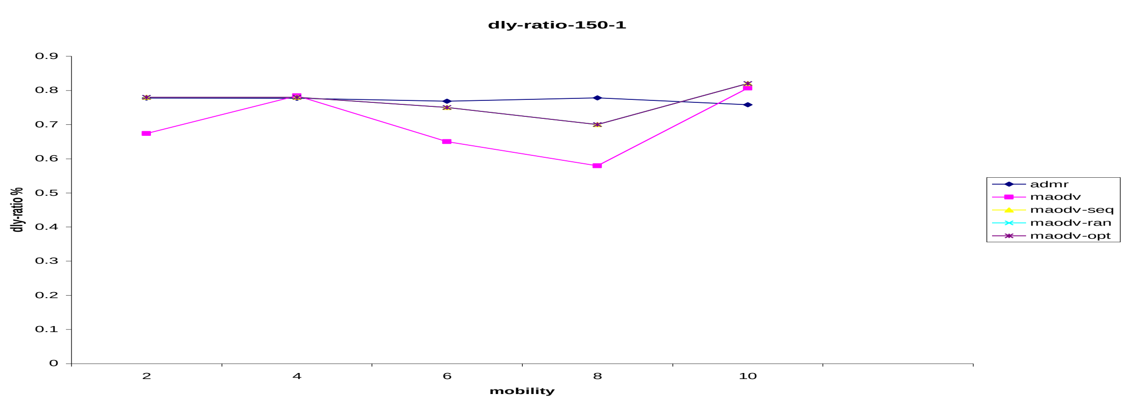

Fig 16: Packet Delivery Ratio for 150 nodes with one Group

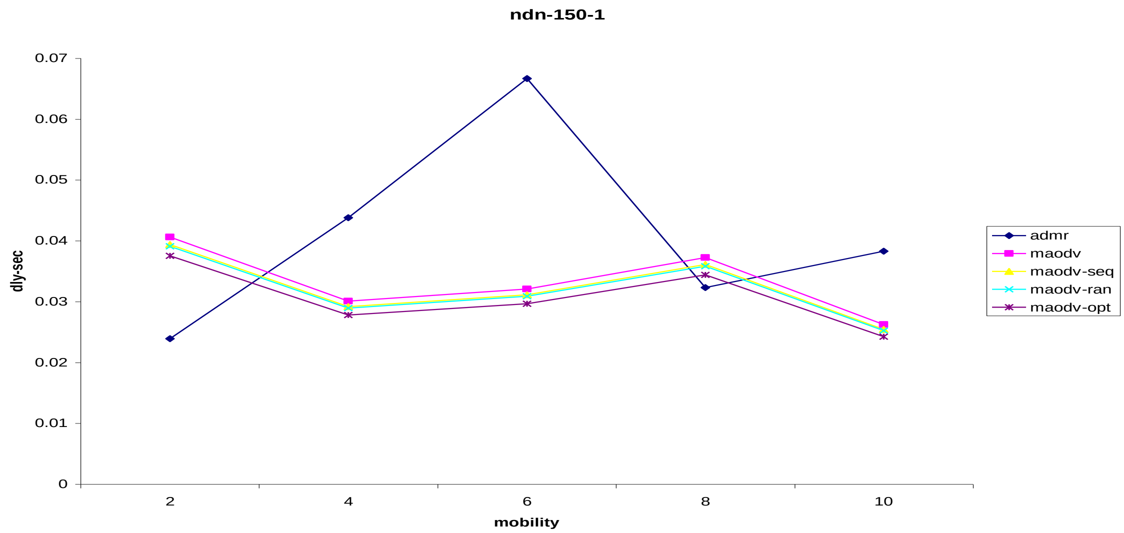

Fig 17: End to End Delay for 150 nodes with one Group

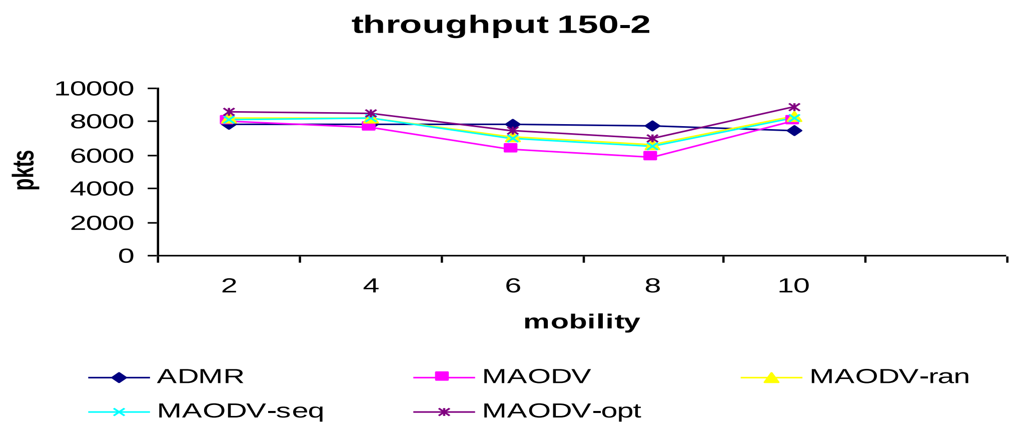

Fig 18: Throughput for 150 nodes with two Groups

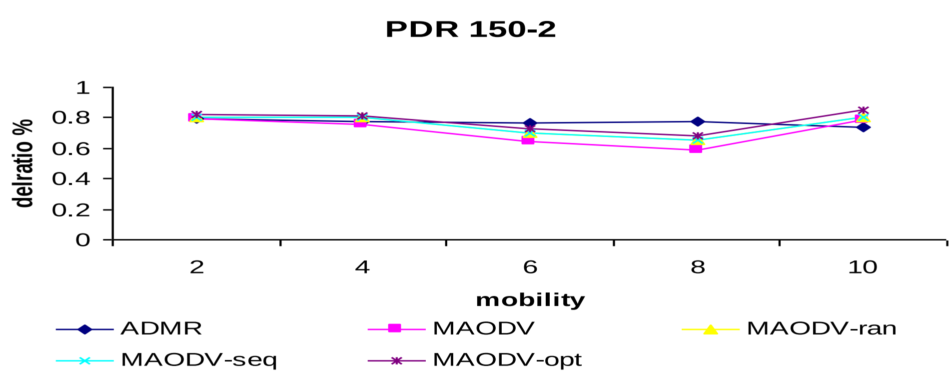

Fig 19: Packet Delivery Ratio for 150 nodes with two Groups

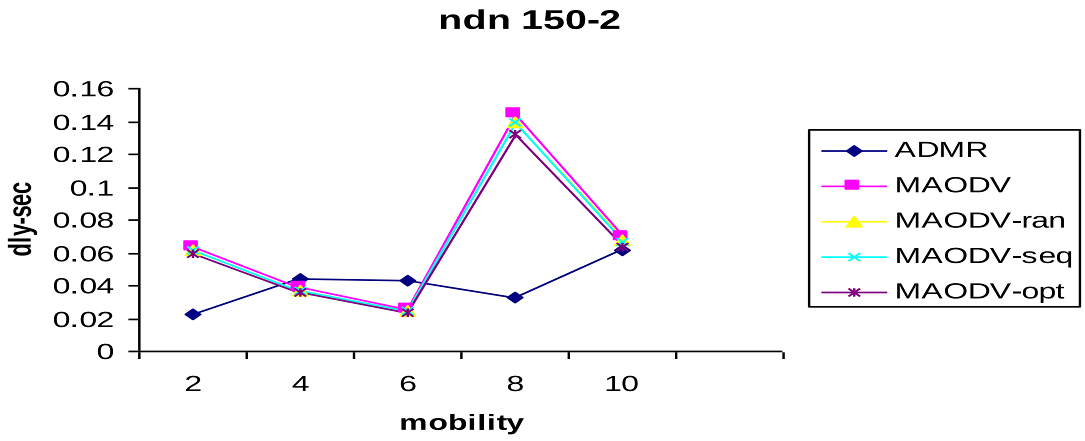

Fig 20: End to End Delay for 150 nodes with two Groups

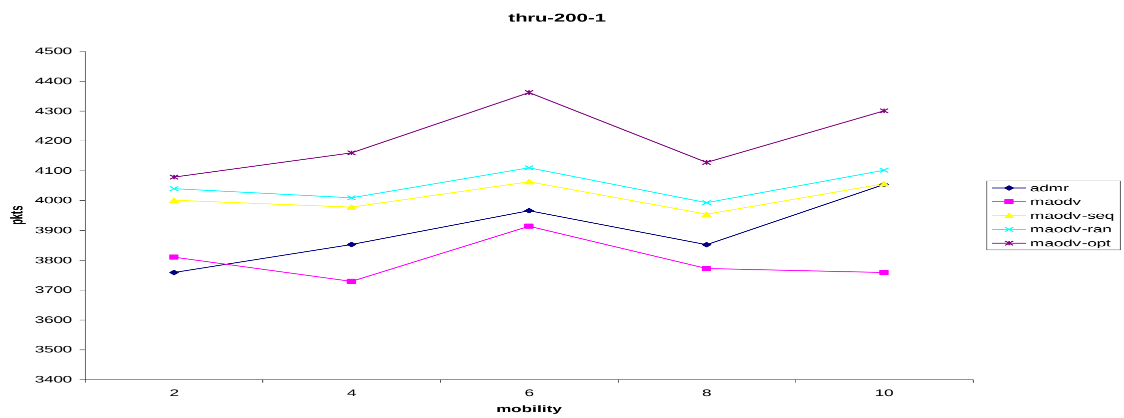

Fig 21: Throughput for 200 nodes with one Group

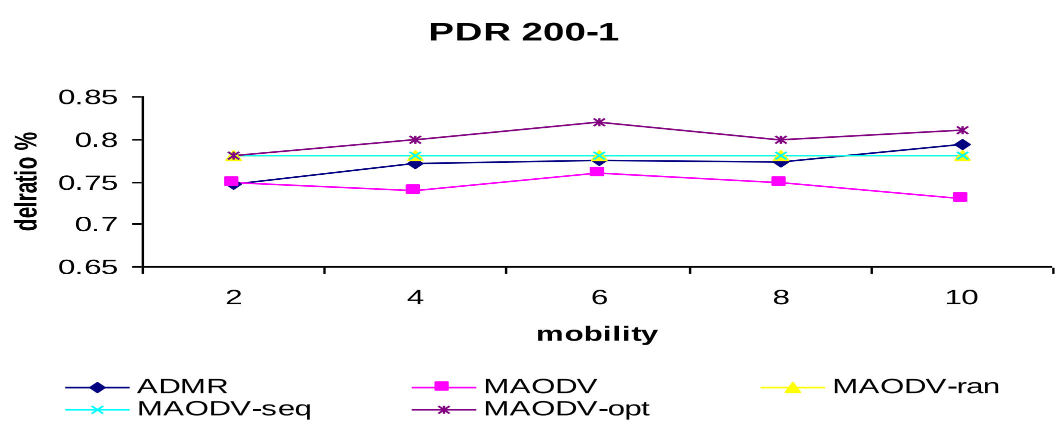

Fig 22: Packet Delivery Ratio for 200 nodes with one Group

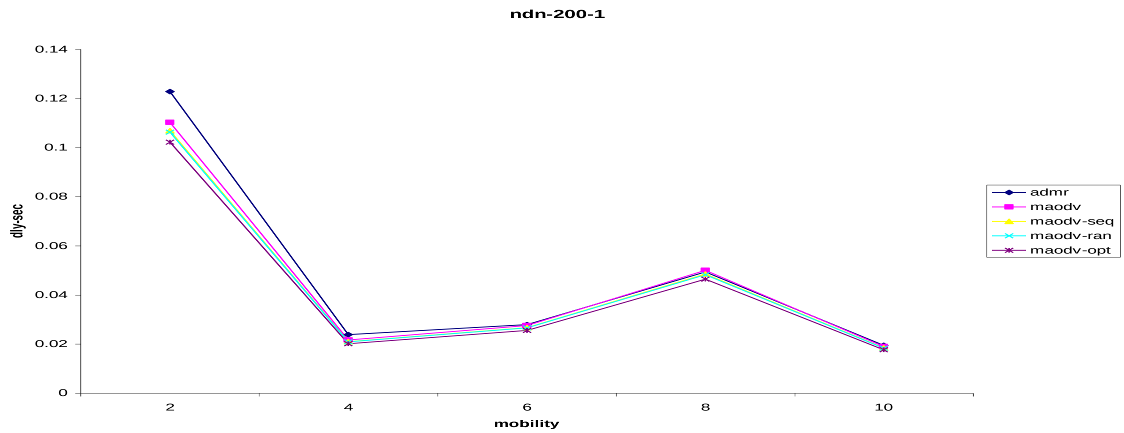

Fig 23: End to End Delay for 200 nodes with one Group

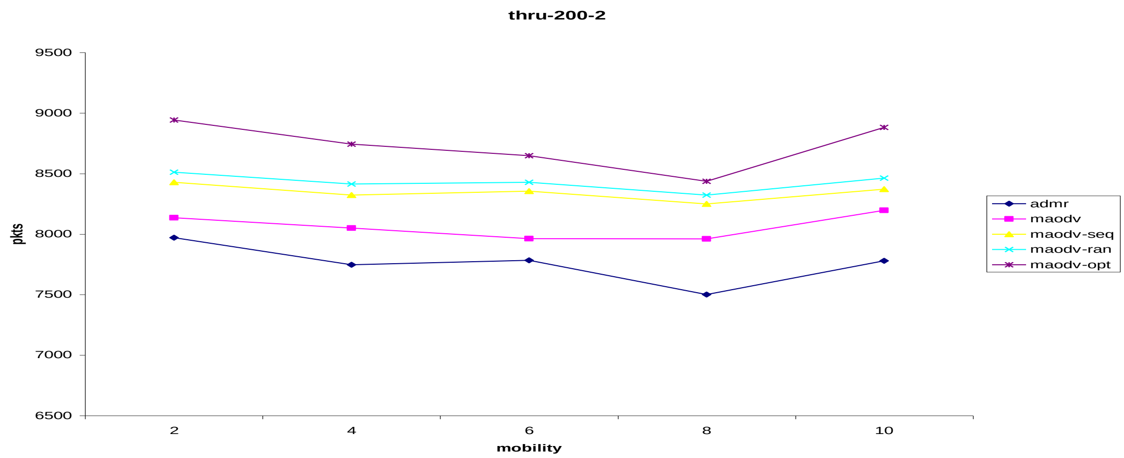

Fig 24: Throughput for 200 nodes with two Groups

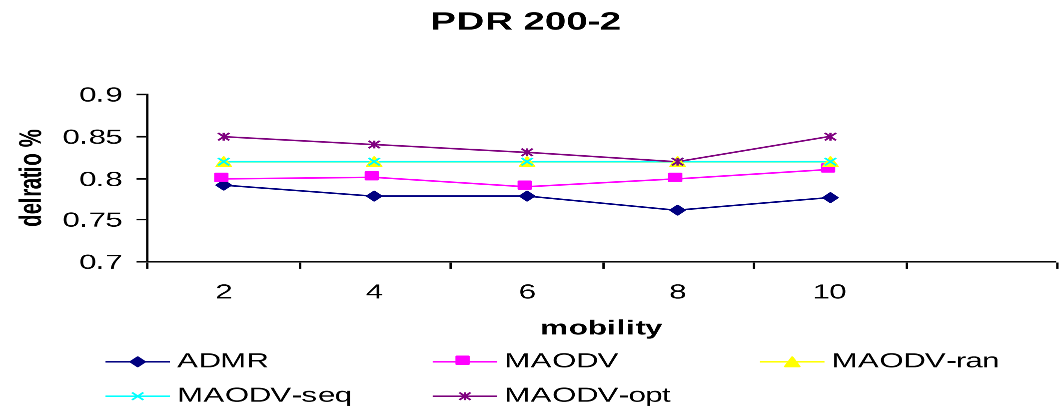

Fig 25: Packet Delivery Ratio for 200 nodes with two Groups

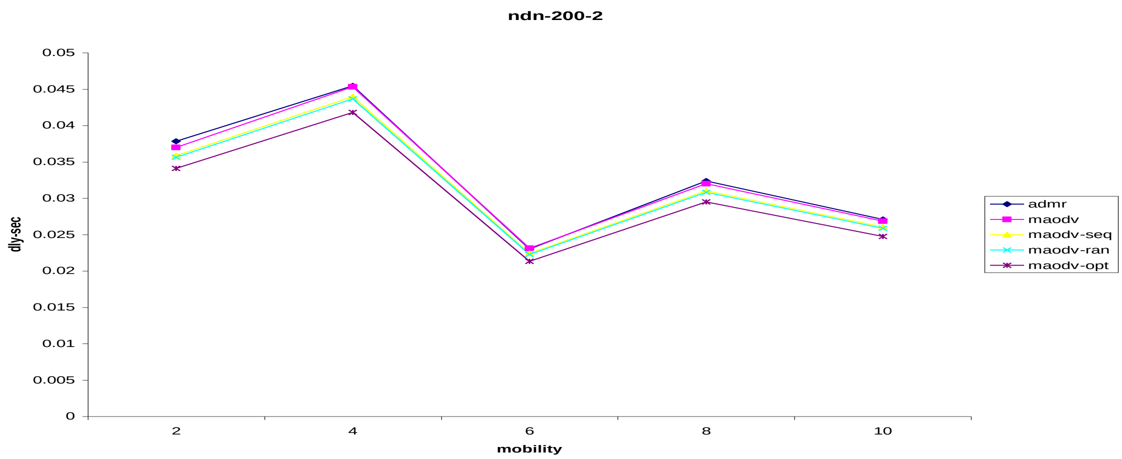

Fig 26: End to End Delay for 200 nodes with two Groups

7. CONCLUSIONS

Observing the MAODV and ADMR, we found MAODV have high packet delivery ratio even the mobility is high. However the main drawbacks of MAODV are long delays, low packet delivery ratio and high overheads associated with fixing broken links in conditions of high mobility and more load. In this paper we proposed a new protocol i.e., NDSM-MAODV routing protocol, in this we propose three mechanisms of Group Discovery algorithm. As per the different mechanisms of Group Discovery algorithm Balancing mechanism has more packet delivery ratio more throughputs and less End to End delay as compared to the random and sequential methods because of the maintenance of the network should be balanced.

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