Performance Evaluation and Statistical Analysis of MANET routing Protocols for RPGM and MG

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***Abstract*—Mobile Ad Hoc Network is a collection of mobile nodes forming temporary network. In MANET routing protocols are classified as Proactive, Reactive and Hybrid. The work presented here evaluates performance of three Reactive routing protocols such as AODV, DSR and TORA under six performance metrics such as packet delivery ratio, routing overhead, packet loss, normalized routing load, throughput and end to end delay The nodes follow two realistic mobility models such as Reference Point Group Mobility model (RPGM) and Manhattan Grid (MG) model. This work also presents the statistical analysis of AODV, DSR and TORA in Manhattan Grid (MG) model and Reference Point Group Mobility (RPGM) model in low load with low speed, average load with average speed, high load with high speed and very high load with high speed. Contribution in this work is beneficial in deciding which protocol to choose for better QoS.**

***Keywords*— MANET; AODV; DSR; TORA; RPGM; MG.**

I. INTRODUCTION

In MANET as the nodes are moving, the topology of the network changes dynamically. Also when packets are forwarded from source to destination, before the packets reach to the destination many routes break and many new routes are constructed dynamically. So an efficient routing algorithm is required to be used [4]. In MANET the routing algorithms are classified as On Demand i.e. Reactive, Table Driven i.e. Proactive and combination of both as Hybrid. AODV, DSR and TORA are Reactive, DSDV and OLSR are Proactive and ZRP is Hybrid routing algorithms. This work evaluates performance of only Reactive routing algorithms for nodes following Reference Point Group Mobility Model (RPGM) and Manhattan Grid Model (MG).

Mobility models are categorized as Entity Mobility e.g. Manhattan Grid and Group Mobility e.g. RPGM and define the pattern in which the nodes are moving. In Manhattan Grid the area is divides into rows and columns. Nodes can move only horizontally along the rows and vertically along the columns. Nodes can choose a random destination and move towards this destination with a predefined speed range upon reaching to the destination pause for some time and again repeat the same process. Whereas in RPGM nodes form groups and move in a coordinated manner. The logical center of the group is the group leader. Group leader determines the group member's speed and direction [8].

II. SIMULATION MODEL

Bonnmotion which is a mobility generator tool is used to generate the scenarios for RPGM and MG [9]. Network traffic is generated by network traffic generating tool supported by ns2 which is in $NS2_HOME/indep-utils/cmu-scen-gen/cbrgen.tcl [11]. The simulation is carried out by increasing the number of nodes in the network as well as by increasing the speed of mobile nodes. And effect of these two factors i.e. network scalability and speed of mobile nodes on above mentioned six performance parameters is observed. The different simulation parameters are explained in Table 1 below.

III. PERFORMANCE PARAMETERS

Following performance parameters were used for evaluation of Reactive routing protocols.

1) Packet Delivery ratio i.e. PDR is defined as total packets received by constant bit sources (CBR) divided by total number of packets sent by CBR sink at destination.

2) Normalized Routing Load is defined as total routing control packets transmitted divided by total received data packets.

3) The packet End-to-End Delay is the average time that packets take to traverse the network. This is the time from the transmission of the packet by the sender up to their reception at the destination's application layer.

4) Throughput is defined as total delivered data packets divided by simulation time. Throughput is the successful message delivery over the communication channel.

5) Packet Loss is defined as total number of dropped packets divided by total number of data packets transmitted by sources.

6) Routing overhead is defined as total routing control packets generated during the simulation time.

TABLE I. SIMULATION PARAMETRS

Parameter	**Number of nodes**			
	25	***50***	***75***	***100***
Simulation area	500*500	700*700	1000*1000	1200*1200
Traffic Nodes	15	30	50	75
Nodes per group	5	10	15	20
Simulation time	300 sec			
Speed	2 m/s, 30 m/s, 60 m/s			
Pause	10 sec			
Traffic rate	2.5 Mbps			
Traffic type	Constant Bit Rate (CBR)			
Mobility models	RPGM, MG			

IV. SIMULATION RESULTS AND DICUSSION

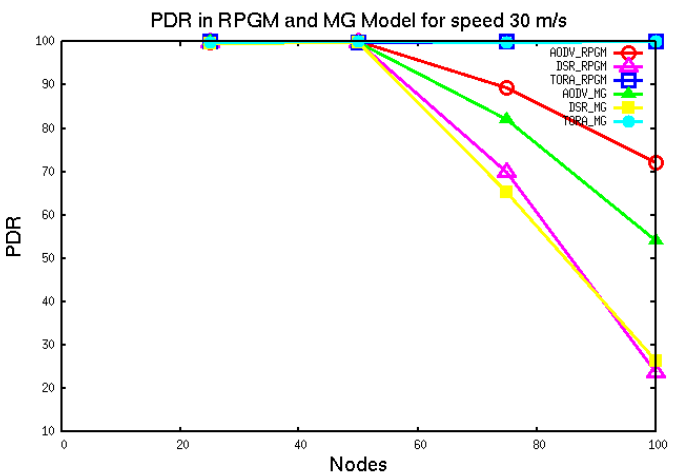

Fig. 1. PDR Vs Nodes

From Fig. 1, it is observed that PDR in TORA is highest among AODV, DSR and TORA because TORA protocol finds multiple paths from source to destination. So even if the network topology changes frequently due to mobility of nodes, TORA does not react at all. And therefore PDR in TORA is highest as compared to AODV and DSR.

Fig. 2 shows that NRL of DSR is the least because of route cache which is available at each DSR node. In case of route failure the DSR node refers to this cache for selecting new route and the probability of route discovery is reduced so routing overhead is reduced.

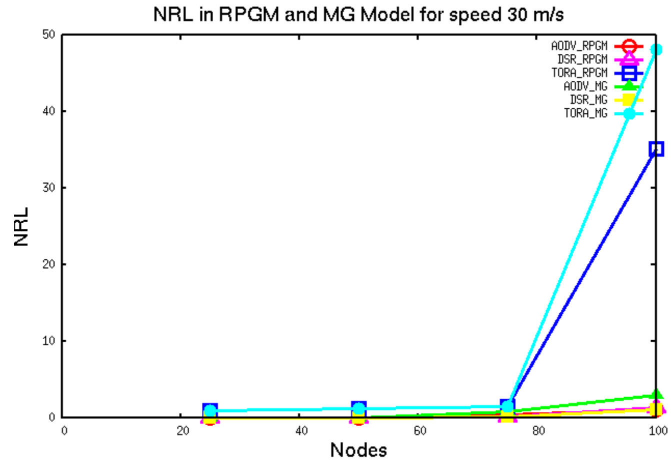

Fig. 2. NRL Vs Nodes

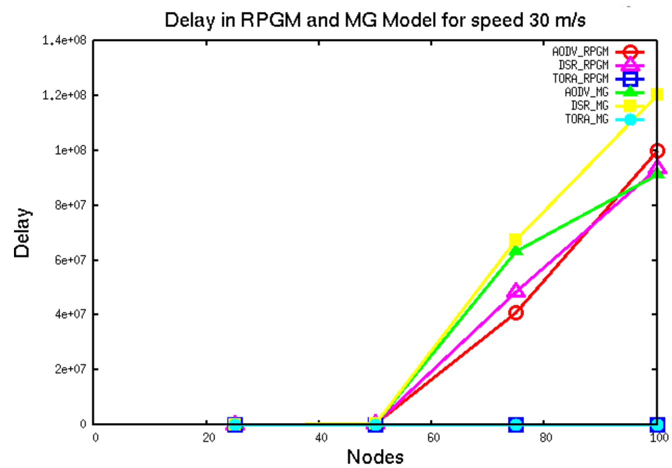

Fig. 3. Delay Vs Nodes

From Fig. 3 it is observed that delay of DSR protocol is greater in Manhattan Grid model because there is restriction on node movement as nodes can move only in four directions like left, right, top and down. And speed of node is restricted by preceding node in the same route.

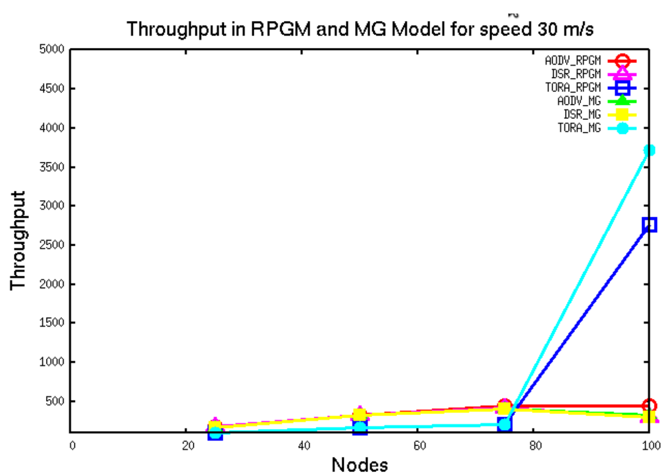

Fig. 4. Throughput Vs Nodes

Fig. 4 shows that throughput of TORA protocol is higher than AODV and DSR. Figure 4 shows that up to 75 nodes throughput of TORA protocol for RPGM and MG both is approximately same but after 75 nodes as the nodes increases throughput in Manhattan Grid is higher than RPGM because of increased number of nodes, the group size increases, congestion in the network increases and the probability of successful message delivery decreases so it is less in RPGM.

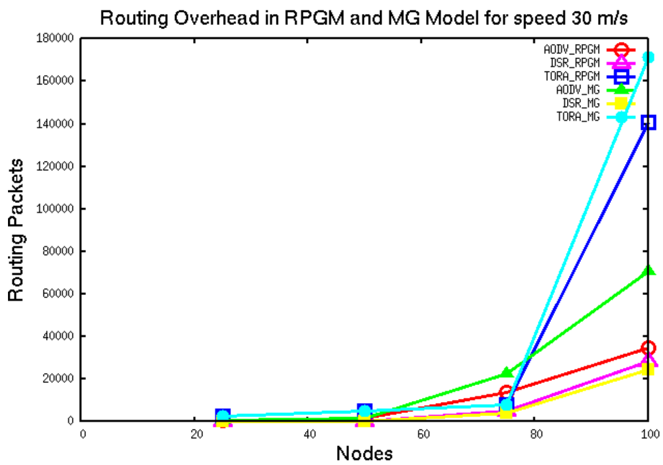

Fig. 5. Routing Overhead Vs Nodes

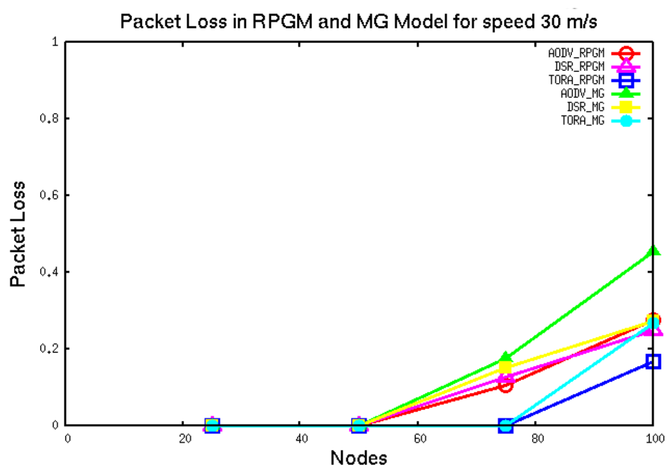

Fig. 6. Packet Loss Vs Nodes

Fig. 5 shows that routing overhead is least in DSR protocol because each node has its own route cache which it refers in case of route failure because of mobility of nodes. So less routing packets are generated in DSR.

Fig. 6 shows that as the number of nodes increases and goes beyond 50, packet loss increases because congestion increases and also because of node mobility probability of routes breaking frequently increases so packet loss increases. Packet loss of AODV is higher than DSR and TORA because there is no route cache as DSR also there are no multiple routes as TORA. Also figure shows that in Manhattan Grid model as there is restriction on node movement packet loss in higher. And as RPGM is group mobility model and group leader determines the group motion behavior and each member of the group is uniformly distributed in the neighborhood of the group leader and each node deviates its speed and direction from that of the group leader. So Packet loss is less in RPGM as compared to MG.

V. PERFORMANCE ANALYSIS

The following KIVIAT diagrams in figure 7, 8 and 9 present the overall performance of AODV, DSR and TORA for 100 nodes and speed of mobile nodes as 30 m/s, 2 m/s and 60 m/s respectively. These diagrams help in quick identification of performance evaluation under the six performance metrics such as PDR, NRL, Delay, Throughput, Routing Overhead and Packet Loss. Each axis represents one parameter as shown in the figure.

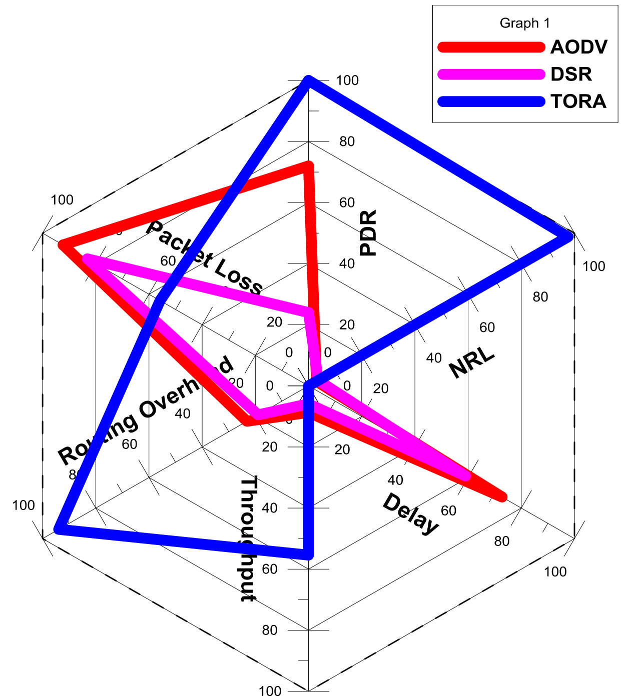

Fig. 7. KIVIAT diagram for routing protocol comparison with speed of mobile nodes 30 m/s

The above fig. 7 shows that for speed 30m/s TORA protocol performs well for PDR, Throughput, Packet Loss and Delay and performs badly for NRL and Routing Overhead. AODV performs average for PDR, Throughput and Routing Overhead but performs badly for Packet Loss and Delay. Whereas DSR performs average for NRL, Delay and Packet Loss and performs badly for throughput and PDR.

For speed of mobile nodes 2 m/s TORA protocol performs well for PDR, Packet Loss, Delay, and Routing Overhead. But it performs badly for NRL, Throughput. So selecting TORA is good choice. DSR performs good for Throughput, performs average for Delay, Routing Overhead, Packet Loss, NRL and PDR. So selecting DSR is average choice. AODV performs badly for Delay, Routing Overhead, and Packet Loss and performs average for PDR, NRL and Throughput. So selecting AODV is bad choice.

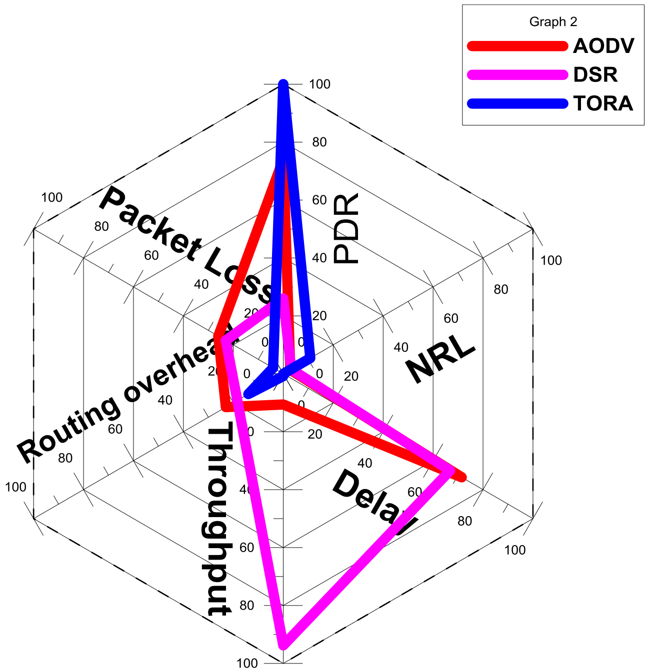

Fig. 8. KIVIAT diagram for routing protocol comparison with speed of mobile nodes 2 m/s

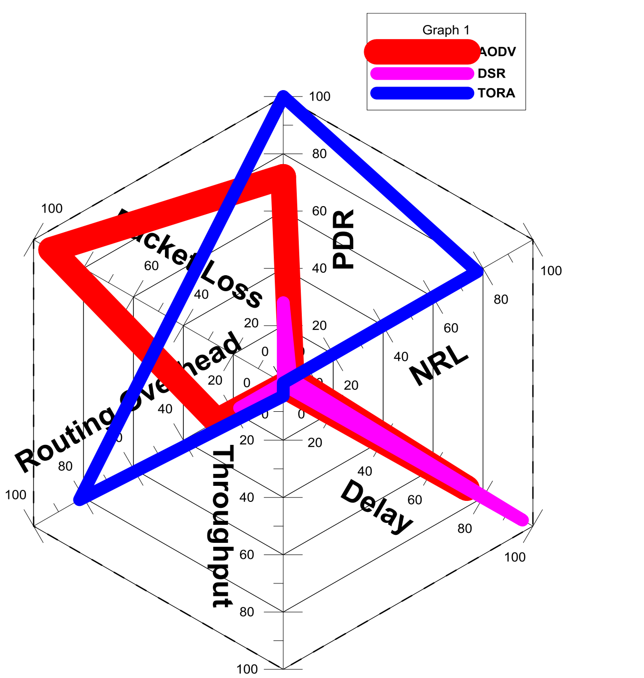

Fig. 9. KIVIAT diagram for routing protocol comparison with speed of mobile nodes 60 m/s

For speed of mobile nodes 60 m/s TORA performs well for PDR, Delay, and Throughput and performs badly for Routing overhead and NRL and performs average for Packet Loss. So selecting TORA is good choice. DSR performs good for Packet Loss, NRL and Routing Overhead, performs badly for PDR, Delay and Throughput. So selecting DSR is bad choice.

AODV performs badly for Packet Loss and performs average for Delay, Routing Overhead, PDR, NRL, and Throughput. So selecting AODV is average choice.

VI. Comparitive Analysis

Comparison of AODV, DSR and TORA for speed of mobile nodes 30 m/s can be presented in the following table. Value '1' represents the good choice, '2' represents average choice and '3' represents bad choice.

TABLE II. Comparison of MANET Routing Protocols for speed of mobile nodes 30 m/s

	AODV	DSR	TORA
PDR	2	3	1
NRL	1	2	3
Delay	3	2	1
Throughput	2	3	1
Routing Overhead	2	1	3
Packet Loss	3	2	1

VII. Statistical ANalysis

The number of nodes and speed of mobile nodes in low load with low speed, average load with average speed, high load with high speed and very high load are 25 and 2 m/s, 50 and 30 m/s, 75 and 60 m/s and 100 and 60 m/s respectively.

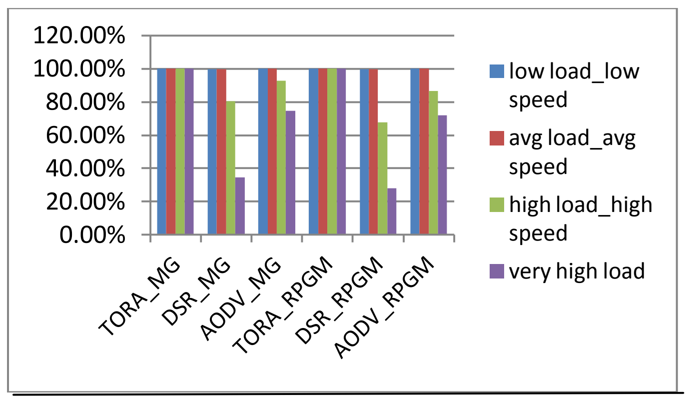

Fig. 10. PDR in low, average, high and very high load and speed.

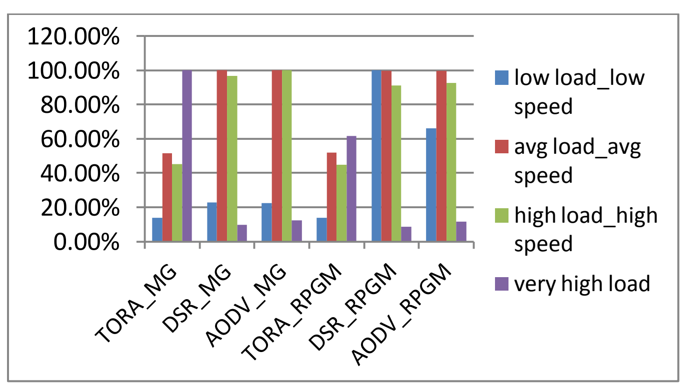

Fig. 11. Throughput in low, average, high and very high load and speed.

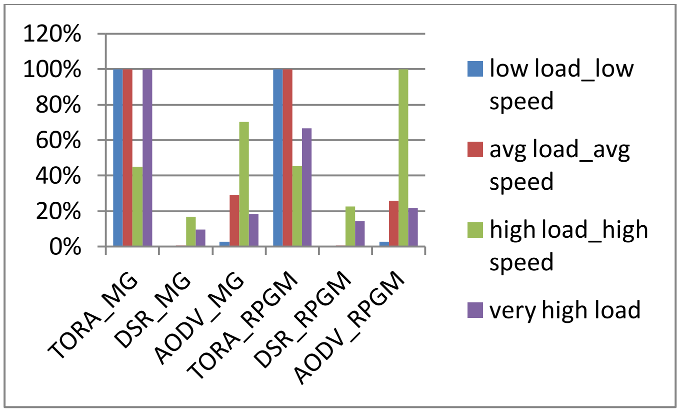

Fig. 12. Routing Overhead in low, average, high and very high load and speed.

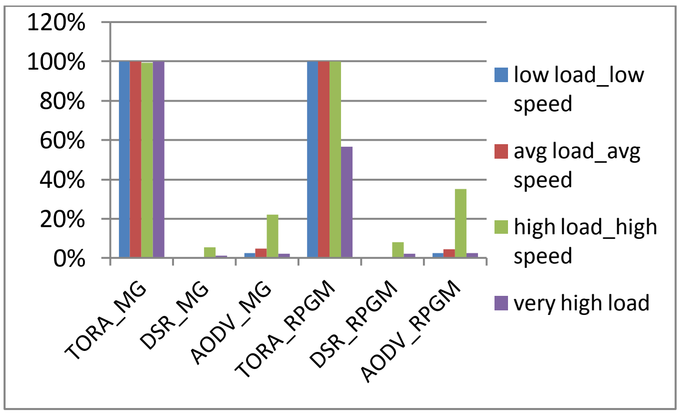

Fig. 13. NRL in low, average, high and very high load and speed.

PDR is observed to be maximum in low load and low speed and average load and average speed and least in very high load from fig. 10. PDR of DSR in Manhattan Grid and RPGM model is dropped by 20 % and 33 % respectively in high load and high speed and it is dropped by nearly 66 % and 73 % respectively in very high load because as the speed of mobile nodes increases the probability of link breaking increases, congestion also increases with increased load.

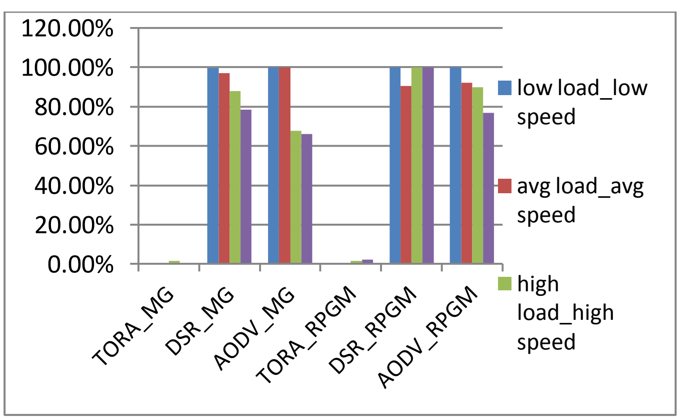

Fig. 14. Delay in low, average, high and very high load and speed.

From the fig. 11 it is observed that in low load and low speed DSR in RPGM model has maximum throughput and it is dropped by 9 % and 92 % in high load with high speed and very high load respectively. AODV has maximum throughput in average load with average speed and high load with high speed and it is dropped by 78 % and 88 % in low load with low speed and very high load with high speed respectively because the packets delivered in low load are always lesser than that in average load and high load but further in very high load as the network becomes very congested and at high speed because of frequent topological changes throughput of the protocol is dropped.

Routing overhead of TORA is observed to be maximum in low load with low speed, average load with average speed and very high load from fig. 12. It is observed to be least of DSR in low load with low speed and average load with average speed and it is increased by 9 % and by 16 % in very high load and high load with high speed respectively because with increasing speed and increasing load the probability of topology changes increases with frequently route breakings and the routing control packets required for route discovery and route creations also increases resulting in increased routing overhead.

From fig. 13, NRL of TORA is observed to be highest in both MG and RPGM models and it is observed to be least in DSR. NRL of DSR is increased by 5 % in high load with high speed and NRL of AODV is increased by 2 % and 20 % in average load with average speed and high load with high speed because the NRL increases with increasing speed and load as routing packets are increased and it increases up to a threshold value in high load but after that it is again decreased in very high load.

From fig. 14 it is observed that Delay is least in TORA protocol in both RPGM and MG models and it is observed to be maximum in AODV in low load with low speed and average load with average speed. Delay of AODV in MG model is increased by 9 % and 19 % in high load with high speed and low load with low speed respectively because the nodes are moving with speed of 2 m/s in low load with low speed. Also in high load, high speed there is more congestion, more queuing delays and time consumed in route discovery and route creation so delay of DSR increases with increased load.

VIII. CONCLUSION

TORA outperforms AODV and DSR in PDR, Delay, Throughput and Packet Loss; DSR outperforms the other protocols in Routing Overhead and AODV outperforms the rest protocols in NRL. AODV has the worst performance in Delay and Packet loss and DSR has worst performance in PDR. The overall performance of these protocols is better when the nodes follow Reference Point Group Mobility model than Manhattan Grid model.

Our simulations do provide a link between the theoretical concepts associated with ad hoc routing protocols and the expected performance in practical implementations.

From this work, the conclusion is that among the protocols considered, there is no single one with an overall superior performance. One protocol may be superior in terms of routing overhead while others may be superior in terms of packet delivery ratio, packet end-to-end delay or throughput etc. The choice of a particular routing protocol will depend on the intended use of the network. The work in this paper is beneficial in selecting the protocol for better QoS.

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