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Performance Evaluation and Comparative Analysis of Reactive 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 Reference Point Group Mobility model (RPGM) and Manhattan Grid (MG) model. The simulations are carried out using NS2. From the simulation results comparison of these three protocols is presented in a table and represented using KIVIAT diagrams. Contribution in this work is beneficial in deciding which protocol to choose for better QoS.

Keywords
MANET, AODV, DSR, TORA, RPGM, MG.

1. 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].

2. REVIEW OF PREVIOUS WORK
The work in [1] evaluates the performance of AODV, DSR and TORA with identical loads and environmental conditions with respect to two performance metrics such as average End-to-End delay and packet delivery ratio using only one mobility model i.e. Random Waypoint Mobility Model. The work in [3] describes the characteristics of ad hoc routing protocols such as AODV, OLSR, and TORA based on the performance metrics such as packet delivery ratio, end-to-end delay , routing overhead by increasing number of nodes in the network and it proves that AODV and TORA performs well in dense networks than OLSR in terms of packet delivery ratio. The work in [2] analyzes the behavior of MANET routing protocols such as AODV, DSR, DSDV, OLSR and DYMO under three mobility models such as RWP, RPGM, and CMM.

2.1 PRESENT WORK
This work is an extension of the work presented in [11] and is different from the previous work such that it evaluates and compares the performance of three routing protocols such as AODV, DSR and TORA for mobile nodes following group mobility model such as RPGM and Entity mobility model such as MG with respect to six parameters such as Packet Delivery Ratio, Normalized Routing Load, End-to-End Delay, Throughput, Packet Loss and Routing Overhead. The simulations are carried out in three different simulation environments by varying speed of mobile nodes from 2m/s to 30m/s and from 30 m/s to 60 m/s and keeping rest of the parameters same. Then effect of varying speed of mobile nodes on all the parameters are represented in tabular form. Contribution in this work is beneficial in deciding which protocol to select for better QoS. KIVIAT diagrams which are presented in this work represent overall evaluation of these three protocols and help in quick identification of performance evaluation of these three protocols for six performance metrics. The selected six performance metrics are enough to evaluate the performance of any protocol.

3. 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.

Table 1. Simulation Parameters

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			
Protocols	AODV, DSR and TORA			

4. 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

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

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

5. SIMULATION RESULTS AND DICUSSION

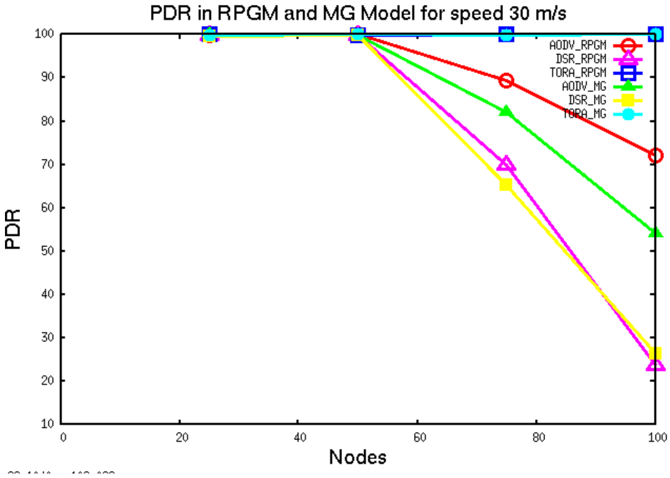

Fig 1 : PDR Vs Nodes

Figure 1 shows that up to 50 nodes PDR in AODV, DSR and TORA remains constant but as the number of nodes goes beyond 50, PDR in DSR and AODV decreases. AODV protocol responds immediately using RREP messages to the changes in the network topology due to mobility of nodes and so the PDR of AODV is greater than that of DSR. From above figure, 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.

Figure 2 show 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.

Figure 3 shows that after 50 nodes as the number of nodes increases delay also increases because of increasedcongestionincreased routing overhead, increased queuing time etc. Also 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.

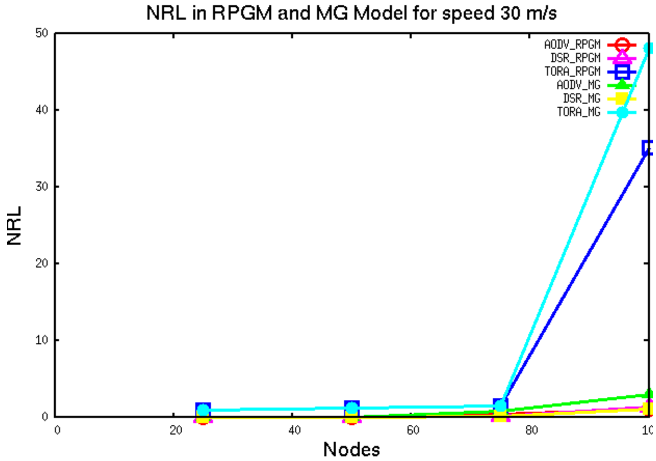

Fig 2 : NRL Vs Nodes

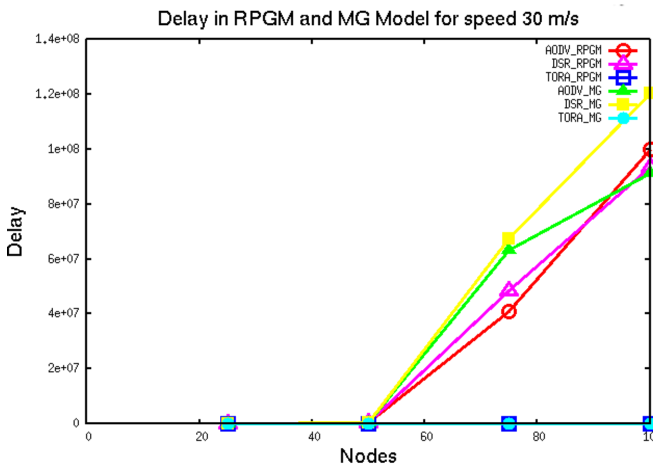

Fig 3: Delay Vs Nodes

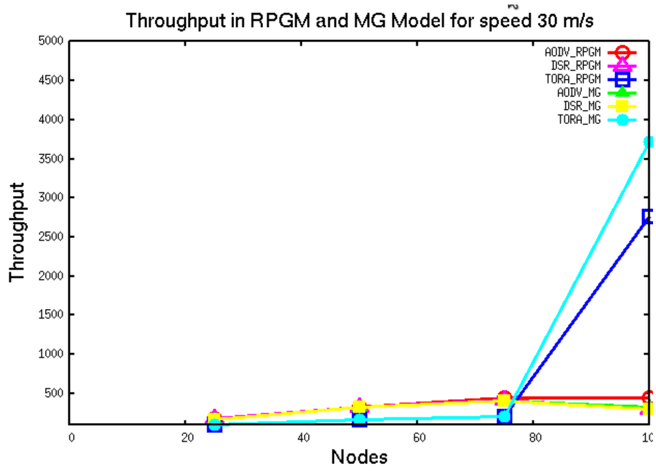

Fig 4: Throughput Vs Nodes

Throughput is defined as successful message delivery over a communication channel. TORA protocol delivers packets successfully as there are multiple routes between source and destination. So as the number of nodes increases and goes beyond 75 nodes, throughput increases in TORA protocol. And figure 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.

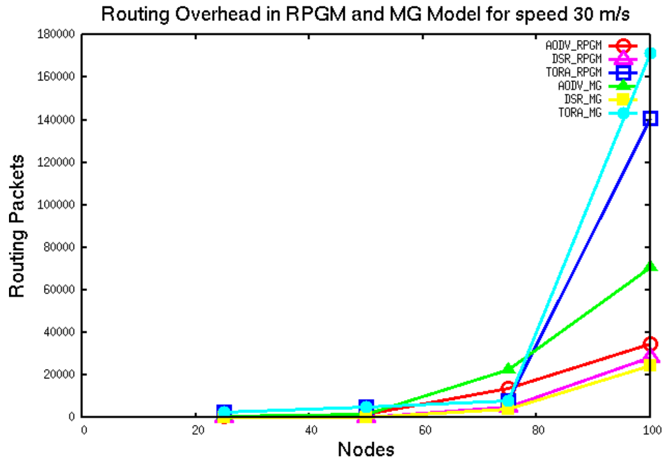

Fig 5: Routing Overhead Vs Nodes

Figure 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. And in TORA in case of all the routes getting lost, new routes are required to be constructed and in that case more routing packets are generated. So routing overhead of TORA protocol is higher than AODV and DSR. The figure also shows that routing overhead of TORA is greater for Manhattan Gris model due to restriction of node movement in MG model and less in RPGM because in RPGM the group leader decides the mobility of the group members.

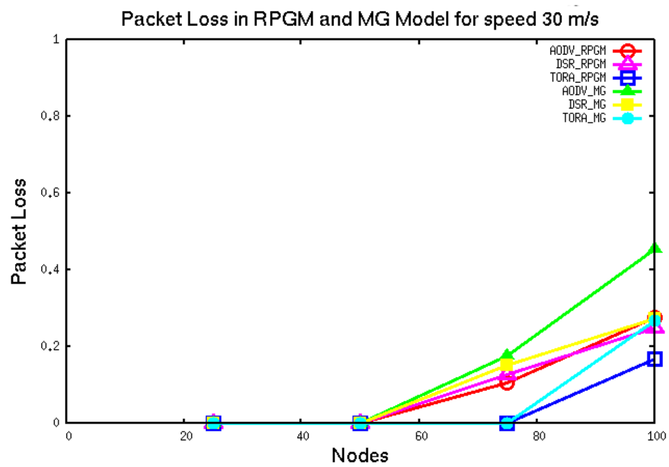

Fig 6 : Packet Loss Vs Nodes

Figure 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.

6. 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.

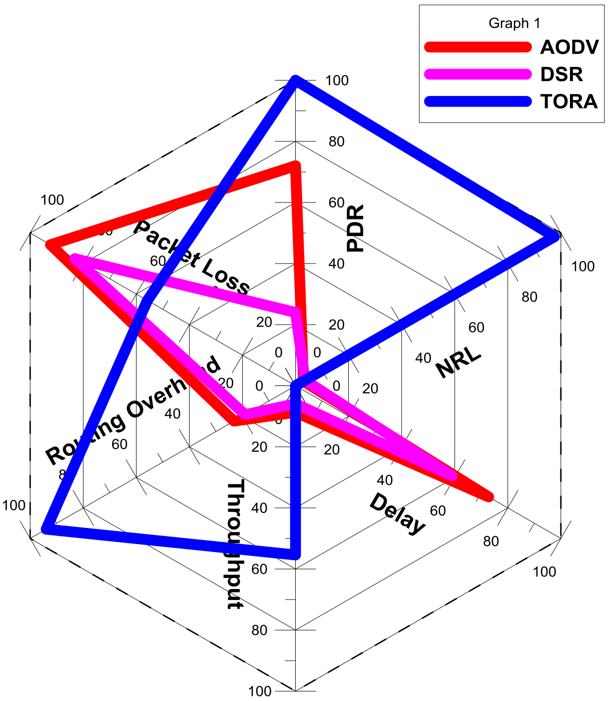

Fig 7: KIVIAT diagram for routing protocol comparison with speed of mobile nodes 30 m/s

The above figure 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.

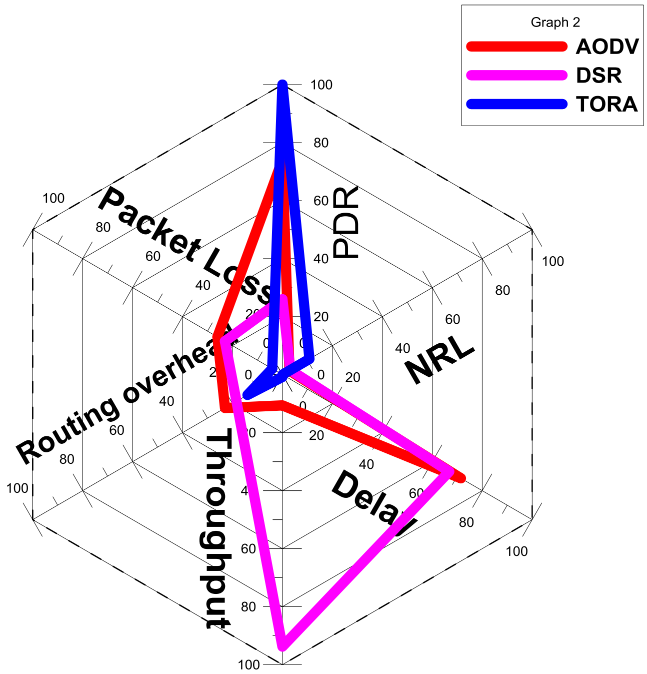

Fig 8 : KIVIAT diagram for routing protocol comparison with speed of mobile nodes 2 m/s

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.

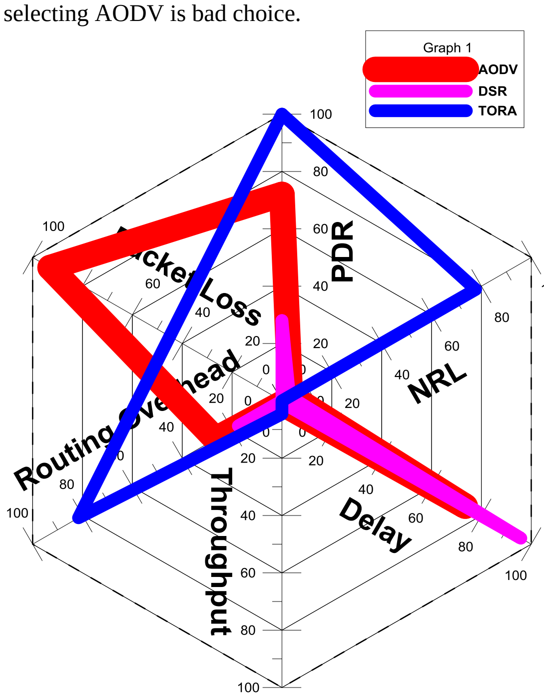

Fig 9 : KIVIAT diagram for routing protocol comparison with speed of mobile nodes 60 m/s

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.

The following tables 2 and 3 shows percentage increase or decrease (- shows decrease) in the values of each parameters for AODV, DSR and TORA when the speed of mobile nodes changes from 2 m/s to 30 m/s and 30 to 60 m/s respectively.

Table 2. Analysis of MANET Routing Protocols for speed change from 2 to 30 m/s

Parameters	speed 2 to 30 m/s		
	AODV	DSR	TORA
PDR	-2%	-2%	0%
NRL	0.20%	0.45%	86.78%
Delay	1.32%	-7.82%	0%
Throughput	-0.2%	-0.5%	47.14%
Routing Overhead	0.17%	0.57%	79.95%
Packet Loss	66.27%	23.03%	51.74%

Table 3. Analysis of MANET Routing Protocols for speed change from 30 to 60 m/s

Parameters	speed 30 to 60 m/s		
	AODV	DSR	TORA
PDR	0%	4%	0%
NRL	0.36%	-0.56%	-19.89%
Delay	0.75%	36.83%	0%
Throughput	-0.04%	0.41%	-9.59%
Routing Overhead	3.49%	-1.47%	-12.35%
Packet Loss	0.70%	0%	-10.83%

In the above tables 2 and 3 value 0% means that value remains constant. When speed increases from 2 to 30 m/s PDR decreases by 2% for AODV and DSR and when it increases from 30 to 60 m/s PDR remains constant for AODV and TORA but for DSR it increases by 4%. In table 2 routing overhead of all the protocols increases but in table 3 except AODV, it decreases. Packet loss increases for all protocols in table 2 but in table 3, for AODV increases and for TORA decreases. In both tables 2 and 3 Delay increases for AODV and remains constant for TORA and for DSR it decreases in table 2 and increases in table 3. Throughput of AODV decreases when speed increases but for TORA in table 2 it increases and in table 3 it decreases and for DSR it decreases in table 2 and increases in table 3. From tables 2 and 3 the observation is that for TORA protocol value of each parameter increases up to some threshold value when the speed increases from 2 to 30 m/s but for speed increases from 30 to 60 m/s the values of all parameters decreases except for PDR and Delay which remains constant. For AODV value of each parameter either keeps on increasing or keeps on decreasing but not like first increase in the speed range 2 to 30 m/s and then decrease in the speed range of 30 to 60 m/s and vice versa. For DSR protocol value of each parameter if it increases in the speed range of 2 to 30 m/s then it decreases in the speed range of 30 to 60 m/s and vice versa.

7. COMPARATIVE 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 4. Comparison of MANET Routing Protocols for speed of mobile nodes 30 m/s (I)

	PDR	NRL	Delay
AODV	2	1	3
DSR	3	2	2
TORA	1	3	1

Table 5. Comparison of MANET Routing Protocols for speed of mobile nodes 30 m/s (II)

	Throughput	Routing Overhead	Packet Loss
AODV	2	2	3
DSR	3	1	2
TORA	1	3	1

8. CONCLUSION

From the above tables the conclusion is that TORA outperforms AODV and DSR when we consider PDR, Delay, Throughput and Packet Loss, DSR outperforms TORA and AODV when we consider Routing Overhead and AODV outperforms DSR and TORA when we consider NRL.AODV has worst performance in Delay and Packet loss and DSR has worst performance in PDR. In a summery we can say that 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 and this work is beneficial in selecting a protocol for better QoS. Also performance of these protocols is better when the nodes follow Reference Point Group Mobility model than Manhattan Grid model.

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