Design and Performance Analysis of Reference Point Group Mobility Model for Mobile Ad hoc Network

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***Abstract* — A Mobile Adhoc Network is a network which is made up numerous mobile nodes, that are wireless in nature and they self-organize themselves to form an environment with an arbitrary and ever-changing topology. These networks do not have any pre-established infrastructure and they do not require some central management. Each of the mobile station in MANET can work as source, receiver and router then they have no restrictions to move anywhere in the network. MANETs can be uses in various civilian and military applications such as classrooms, battlefields and tragedy management activities. In such scenarios, we find correlated movement among the nodes. The Reference Point Group Mobility (RPGM) model is based on correlated node mobility. This work demonstrates design and performance analysis of RPGM model, with the help of the reactive routing protocols (RPs) like AODV which is Ad hoc On-demand Distance Vector and AOMDV which is Ad hoc On demand Multipath Distance Vector. The network simulator NS2 has been used to perform the simulations.**

Keywords— MANET, routing protocols, Mobility model, RPGM, NS2.

I. INTRODUCTION

The networks with wireless communications can be categorized into two types: infrastructure wireless systems and ad hoc systems. The fixed infrastructure networks consist of base station that helps in connection establishment between various mobile nodes. The ad hoc networks do not have such centralized control mechanism. Each of the nodes communicates directly with other nodes without base stations. When the nodes are not directly connected, then the intermediate nodes forward the traffic between those nodes, as each of the node works like a router [1].

The topology of MANETs is highly dynamic and random. There are various attractive features of MANETs such as establishing communication between mobile devices without need of central controller, less expensive, flexible nature etc. With minimum configuration and rapid installation capabilities, the MANETs can be effectively used in desert places, forests and in emergency conditions similar to military conflicts, disaster relief assistance, medical urgencies etc. They can also be used in small networks for communication between attendee groups in exhibitions or meetings and even in classroom for students [1], [3].

Path routing and selection of protocol are of prime importance for designing any wireless network. The RPs chooses the route between the communicating nodes, on which packets are to be sent. The RPs that are available for MANET include proactive, reactive and hybrid RPs. The reactive RPs, also called as on-demand RPs, discover the routes only when the source has packets to be delivered to the destination. Neither do they maintain routing tables, nor do they keep information about the network topology. AODV and AOMDV are the conventions that are grouped into this class. AODV is a unipath while AOMDV is a multipath RP.

The RPGM model is a group mobility model, where arbitrary move of a group and every node inside a group is represented. Here, every group has a reasonable centre or group frontrunner and this group frontrunner decides the group’s motion behavior. In lots of significant applications like soldier effort in battleground, movement of attendee clusters in an exhibition etc., there is a strong correlation among the nodes and they are allowed to move in some restricted areas only. This can be well represented by RPGM.

The remaining paper is arranged as follows. Section II describes about the related work. Section III presents methodology and designing of network with RPGM model. Section IV contains the simulation outcomes and analysis. The decision of the paper is presented in Section V.

II. RELATED WORK

In [1], wireless ad hoc systems have been studied, along with MAC sub layer and physical layer features of IEEE 802.11, individual of the primary tools for MANET implementation .The topology based, table-driven, on demand and position based RPs have been described. The authors [2] have described various RPs in MANET. For assessment of protocol performance, various performance metrics have also been mentioned in [2].

Based on different parameters, the authors in [3] have compared performance of on-demand RPs and have also analyzed about features of protocol that cause finer performance in MANET. The authors [3] concluded that, as compared to DSR i.e. Dynamic Source Routing, AODV incur less routing overhead. AODV has an advantage to familiarize himself to highly changing and varied environments. The writers [4] have suggested the design of Vehicular Ad hoc Network with the use of Multiple Input Multiple Output and Adaptive Modulation Coding techniques. These techniques result in greater throughput, data rate and better efficiency in network and also improve Quality of Service (QoS). The authors [5] have also used the same techniques described in [4] and have found AOMDV performing better than AODV, DSR, and DSDV in terms of QoS. In [7], the authors have suggested a outline to study the influence of dissimilar mobility models on performance of MANET and they have found that different mobility scenarios result in different performance ranking of protocols. Out of various mobility models which they have studied RPGM, Manhattan, Freeway, RPGM model with the use of DSDV, DSR and AODV protocols attain greatest throughput and least overhead. The writers [8] have concluded that AODV and AOMDV are well suited for applications requiring less delay, examples include, earthquake rescue, avalanche rescue. The authors have also found that the link conditions of the mobility model are affected by the node speed variations, which also affects the performance of RPs, depending whether traffic is CBR or TCP. They found that as the node velocity growths, link constancy of RPGM is the finest, due to its cluster movement design.

The results in [9] show that correlated node movements outcome in much effective delay throughput tradeoff, as compared to autonomous node movements. The authors [10] found that correlated node movements result in better performance than independent node movements. The authors [11] have devised a applied limited arbitrary mobility model and have found that they provide flat tradeoff among throughput and delay in MANET by monitoring the node flexibility pattern. Similar results are obtained in [12]. The authors [13] have shown that the super-diffusive properties affect the performance of RPs and make an impact on network performance also. They have found that the message delivery ratio becomes higher, when the nodes diffuse at faster rate. The less diffusive behavior in Brownian motion results in decreased message delivery ratio.

The Zone RP (ZRP) implemented on haphazard nodes degrades the performance of network, as associated to ZRP used on static nodes. The average throughput and packet delivery ratio decrease when network with random nodes is used with ZRP [14]. The authors [15] have surveyed various mobility models and studied their characteristics such as chronological dependency of speed, spatial dependency of speed and geographic limitations. The authors [16], [17] have presented Proactive, Reactive and Hybrid RPs. Various routing methods have been used and overhead incurred in each method have been compared here.

Our study focuses on design and assessment of performance of RPGM with the help of performance metrics like average throughput; energy used and average end to end delay by making use of AODV and AOMDV with the help of NS2 simulation software.

III. METHODOLOGY

A. *Mobility model*

The mobility model is used to represent the movement of mobile nodes and it also describes how the node's location, speed and acceleration changes over time. The mobility pattern of mobile nodes has a vigorous part in calculating the system performance and hence the mobility models must describe the movement design of actual life applications correctly.

Mobility models are classified as:

a. Random models
b. Temporal dependency models
c. Spatial dependency models
d. Geographic restriction models

Limits of Random mobility patters: In the random-based mobility patterns, there is no restriction on the movement of mobile nodes. Their speed, direction etc. can be selected arbitrarily and autonomously of other nodes. But, these mobility models have the limitation that, they cannot represent the important mobility characteristics like time-based addiction, spatial addiction and geographic restriction.

a) Temporal addiction of speed: The measure of amount of likeness of speeds of a node at two parts that are not too distant is called temporal dependency of velocity. In arbitrary mobility models, the speed of mobile node at current time instant is independent of the previous time instant. However, in real life situations, the rapidity of vehicles and people walking on road will not change suddenly, it will be dependent on their previous speed.

b) Spatial dependeny of velocity: The measure of amount of similarities of velocities of two nodes that are not too distant from each other is called spatial dependency of speed. In arbitrary mobility patterns, the movement of particular node is independent that of that of the other node. But, in some scenarios like soldiers moving in battlefield or attendee groups moving in an exhibition, their movement is dependent on the 'leader' of the group.

c) Geographic restrictions: In random mobility models, the nodes can transfer freely wherever in the given simulatiuon zone. However, in the real scenarios, the mobile nodes may face obstacles like buildings, trees, towers etc on their way.

d) The random mobility models like Arbitrary Waypoint pattern and its alternatives are not able to represent these above mobility features.

e) RPGM: The RPGM model consists of groups, where each cluster has a reasonable centre or a group leader. This group frontrunner defines the motion of the cluster. The nodes in the cluster are arbitrarily placed around the group leader. At each instant, the speed and track of the node are calculated by arbitrarily differing from that of the group frontrunner. The group frontrunner and the cluster members can be described as:

f) Group leader: The motion vector Vtgroup , represents the drive of group frontrunner, at time t. It also determines the motion trend of full cluster. The motion of other nodes can be determined by deviating from this

Vtgroup by some degree. The Vtgroup is chosen randomly or designed on definite predefined routes.

g) Cluster members: The movement of cluster leader affects the movement of cluster followers. A certain reference point is set and mobile points are located randomly in the neighborhood of this predefined reference point. The motion vector Vit , for a cluster fellow i at time t can be written as:

$$Vit = Vtgroup + RMit \quad (1)$$

The vector RMit is an autonomous identically disseminated arbitrary process with the length consistently dispersed in the intermission [0,r] and with the way consistently dispersed in the intermission [0,2π) [15].

The SDR and ADR are here to regulator the nonconformity of the speed of cluster associates from that of the group leaders [7].

The RPGM pattern is based on the correlated node mobility and therefore it is found to be useful in various practical applications like fighter movement in battleground, where soldiers follow the commander movement. Other application is crusade of tragedy respite people group, where they follow certain pattern of movement, doing different tasks.

B. *Performance Parameters*

To evaluate the outcomes of RPs using the RPGM model, we have used numerous outcome metrics.

1) Average Throughput: The fraction of overall quantity of data forwarded from the transmitting node to the receiving node to the entire duration of time occupied by it is called as average throughput, which is measured in bytes per second or bits per second.

2) Energy consumption: The overall energy utilize in MANET is because of energy spent by all nodes for transmission of packets (in transmitter side), reception of packets (in receiver side) and when nodes are idle (but carrier sensing is going on) in given simulation time. The mobile nodes are battery operated with limited battery. Hence energy consumption should be as low as possible [18], [19].

3) Average End to end Delay: The overall time duration engaged for process of data package transmission in the network from sender node to the receiver node is called as average end to end delay. The average end to end delay contains transmission delay, propagation time, processing delay and queuing delay.

C. *Designing of Mobile Ad hoc Network*

Table I describes the simulation parameters and their corresponding values which have been considered for designing the network with static nodes and for network with RPGM model. We have simulated the RPGM model using the Bonnmotion version-3.0.1 [20].

TABLE I. Simulation parameters and their corresponding values

Parameters	Network with static nodes	Network using RPGM model
Frequency (GHz)	2.4	2.4
Bandwidth (MHz)	20	20
RP	AODV, AOMDV	AODV, AOMDV
MAC protocol	IEEE 802.11	IEEE 802.11
Channel type	Wireless	Wireless
Antenna	Omni-directional	Omni-directional
Propagation model	Two ray ground	Two ray ground
Number of nodes	100	100 (10 groups with 10 nodes in each group)
Packet size (Bytes)	1000	1000
Packet interval time (sec)	0.35	0.35
Type of traffic	UDP/CBR	UDP/CBR
Simulation area	1500m X 1500m	1500m X 1500m
Simulation times	30 sec to 100 sec	30 sec to 100 sec

IV. SIMULATION RESULTS AND ANALYSIS

The detailed analysis for the performance assessment of RPGM has been done by using NS2 simulation software. At first the simulation atmosphere consists of 100 static nodes in the area of 1500m X 1500m, using AODV and AOMDV protocols and with different simulation times starting from 30 sec up to 100 sec. The same parameters are then used to perform simulation for RPGM model with 100 mobile nodes (with 10 groups and each group having 10 nodes). Later running the tcl scripts in NS2, the trace files are generated. These generated trace files along with awk scripts help in computing the values of various performance parameters.

Figure 1 and figure 2 illustrate graphs for comparative analysis of average throughput using static nodes and using RPGM model. For figure 1, AODV is used, while AOMDV is used in figure 2. Similarly, figure 3 and figure 4 show graphs for energy consumption. Finally, figure 5 and figure 6 depict graphs for average end to end delay.

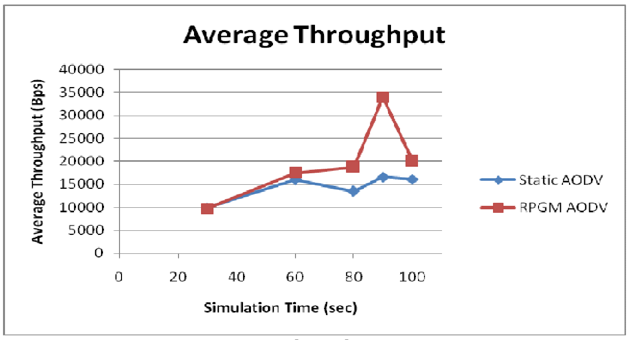

Fig. 1. Average throughput using AODV

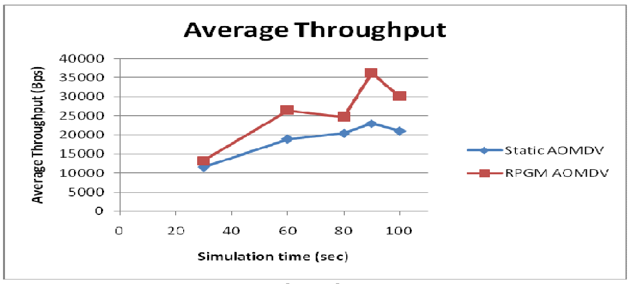

Fig. 2. Average throughput using AOMDV

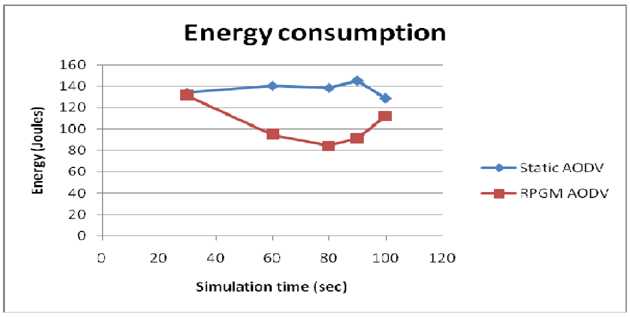

Fig. 3. Energy consumption using AODV

As seen from the results in figure 1 and figure 2, the values of average throughput are found to be higher for RPGM model than the static nodes network, in both cases, that is for AODV protocol and AOMDV protocol. From the figure 3 and figure 4, we observe that for both AODV and AOMDV, the energy consumption is lower, when RPGM model is used. The average end to end delay values are lower in RPGM model, than the network with static nodes.

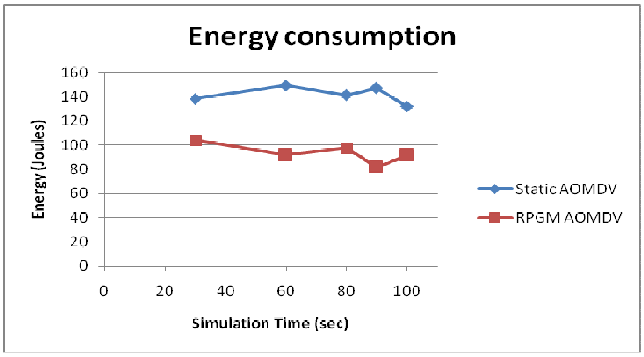

Fig. 4. Energy consumption using AOMDV

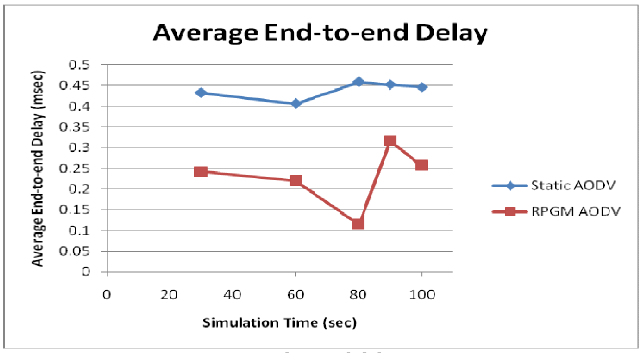

Fig. 5. Average End-to-end delay using AODV

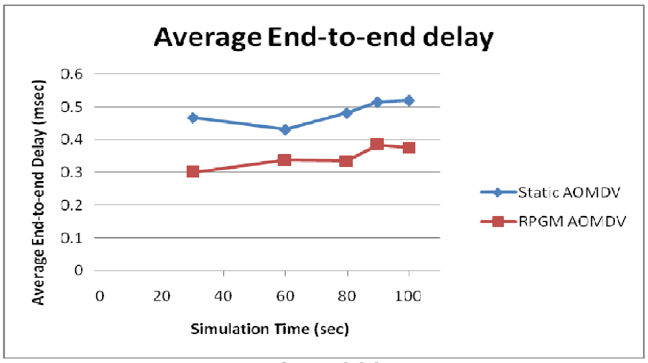

Fig. 6. Average End-to-end delay using AOMDV

Table II illustrates overall analysis of performance of network with static nodes and network with RPGM model with various performance factors and with protocols AODV and AOMDV.

TABLE II: Overall performance of network with static nodes and network with RPGM model

Parameters	Static AODV	RPGM AODV	Static AOMDV	RPGM AOMDV
Average Throughput (Bps)	14435	20004	18986	26115
Energy (Joules)	137.44	102.8	141.76	93.42
Average End to end Delay (msec)	0.44	0.23	0.48	0.35

V. Conclusion

In this paper we have designed the RPGM model and investigated its performance using reactive RPs like AODV and AOMDV. On the basis of the obtained results, we can infer that, RPGM model excels in performance than that of the network with static nodes. The high average throughput, low energy consumption and low average end to end delay are desirable in any wireless networks, such advantageous results are given by RPGM model. As we can see from figure 1 to figure 6, RPGM has high average throughput, low energy consumption and low average end to end delay. RPGM has correlated node movements because of which two nearby nodes have similar velocities, which lead to higher link duration and higher path duration between them. As the path is more stable, packets do not get dropped and ultimately the average throughput is higher [7].

Finally from table 1, we can deduce that RPGM model, used with AOMDV protocol gives higher average throughput than with RPGM model and AODV protocol. This is because, when a particular route fails, AOMDV has already alternate routes searched in previous route discovery attempt and hence throughput increases. This is not in the case of AODV, as it is unipath protocol. We also conclude that RPGM used with AOMDV consumes less energy than used with AODV, because after link breakage AODV starts new route discovery process whereas AOMDV has already routes discovered. This conserves energy and hence RPGM used with AOMDV has less energy consumption. Lower average end to end delay is obtained for RPGM with AODV. There are many stale routes, because of multipath in

AOMDV, that adds up to get more delay than AODV. Also, in case of path failure, AOMDV has alternate paths available, while AODV does not have alternate paths, so the packet will not reach to the destination, resulting in packets getting dropped. Hence, the average end to end delay of AODV is less than AOMDV protocol. From our findings, we conclude that we can use RPGM model with AOMDV protocol, for the applications that require higher throughput and lower energy consumption. For the applications which need less delay like search and rescue operations, disaster relief management etc., the RPGM mobility model with AODV protocol can be used.

VI. Future Work

In the upcoming year we would like to investigate about other cluster mobility replicas such as locality based mobility pattern, group force mobility model, column mobility model etc. and find out which mobility pattern is suitable for which type of application. In our study we have used only two RPs: AODV and AOMDV. Further, we would like to make use of other RPs such as geographic RPs and multicast RPs.

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