# Impact of Mobility Models on the Performance of Routing Protocols in Mobile Ad Hoc Networks

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## Abstract

Mobile ad hoc network consists of wireless mobile nodes, where nodes convey message to each other without any pre-established infrastructure or centralized control. The wireless ad hoc network eradicates the complications which may arise while setting up the infrastructure. The mobility model is crucial when evaluating routing protocols exhibition in mobile ad hoc networks. Two parameters are very important when dealing with mobility behavior of mobile nodes: pause time and maximum speed. In this paper, we investigate the effect of mobility model on state of art proactive and reactive routing protocols for mobile ad hoc networks. The Reference Point Group Mobility model and the Random Way Point Mobility model represent the group and an entity mobility model used in this simulation to compare and analyze the performance of the routing protocols. In this study the performance analysis and comparison of the routing protocols under different mobility scenarios are evaluated in Network Simulator 2. Four important performance metrics of ad hoc networks including average end-to-end delay, packet delivery ratio, normalized routing load or overhead and average number of hops are considered. Based on the empirical study, both propagation models cause different impact on the AODV and DSDV routing protocol. Where, AODV performs better with the RPGM than the RWPM with respect to end-to end-delay, normalized routing load and average number of hops. However, in delivery ratio AODV performs better with the RWPM than the RPGM. On the other hand, AODV and DSDV protocols have similar results in delivery ratio and average number of hops and DSDV performed better than AODV in normalized routing and end-to-end delay. Finally, it can be concluded that no protocol significantly outperforms the other in all scenarios and matrics considered.

*Keywords:*Destination-Sequenced Distance Vector (DSDV), MANET, Reference Point Group Mobility model (RPGM), Ad Hoc on Demand Distance Vector (AODV), Mobility model, Random Way Point Mobility model (RWPM), Network Simulator (NS-2), Routing protocols.

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## 1. Introduction

Mobile ad hoc network (MANET) is a wireless network which communicates through the electromagnetic wave. It comprises of wireless mobile nodes. These wireless nodes convey message to each other without any pre-established infrastructure or centralized control. The wireless ad hoc network eradicates the complications which may arise while setting up the infrastructure. It transmits and receives the packets through the transmission medium. When an available mobile node in network broadcast information; all other nodes within the network will receive the message. MANET communication has been through node to node communication for nodes that are close to each other [1] or by one node serving as a router or host to aid communication for the nodes that are not close to each other [2]. The MANET has a dynamic environment in the sense that the mobile nodes can easily leave the network anytime they want as well to join whenever pleases it.

During the analysis and design of a routing protocol of MANETs, it has been of great importance to fully understand the mobility characteristics. The mobility model is crucial when evaluating the performance and study of a MANET; it creates a realistic moving behaviour for mobile nodes. The mobility behaviour of each mobile node in MANET and how the directions and speeds of each mobile node changes with time is always represented in the mobility model. There are two parameters which are very important when dealing with mobility behaviour of mobile nodes, they are: maximum speed and pause time [3]. In a situation where maximum speed is small and pause time is large, the stability of network topology is assured while in the reverse case there is always dynamic network topology. In MANET, routing protocol development has really gained a huge significant advancement. The way mobile nodes move is very essential in mobile wireless networks design and configuration because the mobility models helps in mobile wireless network performance analysis.

The routing protocol development has really gained a huge significant advancement because the design of a good and the dependable routing strategy continues to be a challenging problem. As a result of resource limitation in MANET, there is compelling need for dependable routing protocols that are able to effectively manage these scarce resources and thus make communicating agents in MANET to adapt to variations in network conditions [4]. Previously, numerous researches proposed a lot of routing protocols which are categorized or classified into two broad groups namely reactive and proactive. Usually in MANET, routing from one node to another is done by the use of the reactive routing protocol and the reactive routing protocols are known as on-demand basis. A number of research works done using AODV on-demand routing protocol [5,7,9,10], this protocol generates routing information whenever interested station initiates the transmission. The proactive routing protocols keep route information to all nodes including route information for the route immediately needed and those that may be needed for use at some other times. It is however worthy to point out that the list is always amenable to topology changes even though the traffic among the disparate MANET agents may or may not be affected by this dynamism [6].

The reference point group mobility model and random way point mobility model represent the group and non-group model, which are used in simulating the protocols in order to compare and study the behaviour of the routing protocols. The non-group model is also known as entity mobility model. The RWPM has been the most mobility model frequently used by most experimenters in the simulation study of MANET in order to examine in contrast and analyze the behaviour routing protocols. In RWPM, when the nodes finally get to a point where it becomes stable, they always revolve around the center region with almost none around the boundaries. Also the mobile nodes always pause for a specify period called pause time but in RPGM the mobile nodes in the group pause at the same time.

This paper presents an examination of the RPGM and RWPM mobility models impact regarding performance of MANETs AODV and DSDV routing protocol using a NS-2. Performance metrics that we employed for our evaluations includes routing load, packet delivery fraction, end-to-end delay and average hop count for the simulations.

The rest of the paper is organized as follows. Section 2 presents a short overview of mobility models of MANETs. Section 3 describes the experimental environment and the experimental results and analysis are presented in Section 4. Section 5 concludes the paper with a summary of obtained results.

## 2. A short overview of Mobility Models

In Random Way Point Mobility Model (RWPM), the mobile nodes are at first spread indiscriminately all over the simulation range and this has nothing to do with the way the mobile nodes choose to distribute it when moving. The RWPM is a very easy mobility model which is based on random speeds and direction, with which each mobile node generates its speed and direction. This mobility model makes the use of pause time [14]; this pause time is a specified period of time mobile node must stay in some location when it arrived before starting the process again. When a mobile node gets to its maximum speed it becomes stationary for a while according to the pause time specified. After this precise period of time, the mobile node will randomly choose its speed again. It will also choose its next destination to which it will move based on the chosen random speed; this next destination it must choose though must be within the simulation area. The mobile nodes will keep repeating this process until the end of simulation time. Some problems associated with the use of the RWPM the incidence of sudden stops and sharp turns by the mobile node.

The Reference Point Group Mobility (RPGM) is a group mobility model in which the mobile hosts are arranged in group, this group arrangement depends on their logical relationships. There is a logical center in all groups in the RPGM model, the movement of the entire group such as speed, acceleration, location and direction depends on the center's motion. The RPGM model [15] has to do with the way mobile nodes in the group move irregularly according to the path travelled by a logical center to the group. Also it represents each distinctive mobile node random motion in their group with the help of their reference point [11]. In RPGM nodes are distributed uniformly within the area of the group. A path for the center must be provided in order to determine the path for the group.

Table 1. Communication model parameters

| Parameters | Values |
|---|---|
| Traffic Source | CBR |
| Maximum connection | 8 |
| Data packet size | 512 Bytes |
| Sending rate | 2 Packets/seconds |

Table 2. Simulation parameters

| Simulation Parameters | Values |
|---|---|
| Chanel type | Wireless channel |
| Radio propagation model | Two ray round |
| Network interface type | Wireless physical |
| Interface queue type | Priority queue |
| Sending rate | 2 Packets/seconds |
| Link layer type | Link layer |
| Antenna | Omni Antenna |
| Maximum packet interface queue | 50 |
| X and Y coordinates | 1000 x 1000 $m^2$ |
| Number of nodes | 10- 70 |
| Source type | TCP |
| Routing protocols | AODV, DSDV |
| Mobility models | RWPM, RPGM |
| Simulation time | 1000 seconds |

## 3. Modeling of MANETs in NS/2 and Simulation Setup

In this paper, network simulator 2 is used in simulating DSDV [8] and AODV with RWPM and RPGM. The motion of the nodes in this simulation depends on these two mobility models. In RWPM, at the beginning of simulation, all nodes randomly placed in the network area. All the nodes have a speed either uniform and random with [0,Vmax], where the parameter Vmax is the maximum allowable velocity for every mobile node [18]. The velocity and direction of a node are chosen independently of other nodes. Upon reaching the destination, the node stops for a duration defined by the 'pause time' parameter T pause. If T pause=0, this leads to continuous mobility. After this duration, it again chooses another random destination in the simulation field and moves towards it. The whole process is repeated again and again until the simulation ends. The network characteristics can be defined by the value of pause time. A network with greater pause time is considered as a stable network and vice versa. On the other hand, in RPGM model, each group has a center that either a group leader node or a logical center. The movement of group leader at time (t) can be represented by motion vector (Vt) group. Not only does it define the motion of group leader itself, but also it provides the general motion trend of the whole group. Each member of this group deviates from this general motion vector Vt group by some degree. The motion vector Vt group can be randomly chosen or carefully designed based on certain predefined paths. We assume for the simplicity that the center is the group leader. Therefore, each group is composed of one leader and a number of members. The movement of group members is significantly affected by the movement of its group leader. For each node, mobility is assigned with a reference point that follows the group movement. Upon this predefined reference point, each mobile node could be randomly placed in the neighbourhood. The mobility behaviour is determined by the movement of the group leader of the entire group.

Table 3.Parameters for Random Way Point Mobility model (RWPM)

| Parameters | Values |
|---|---|
| Maximum speed | 1.5m/s |
| Pause time | 60 seconds |
| X coordinate | 1000m |
| Y coordinate | 1000m |

In our experimental part, the traffic source used in communication model is CBR (constant bit rate). For both RWPM and RPGM we configured different scenarios by varying the number of nodes. The Random way point movement scenario is generated using setdest tool in NS-2 [16], while the scenario of reference point group mobility model is generated using the code from [11] in NS-2 and different communication scenarios are also generated using cbrgen.tcl of NS-2 [16].

A number of simulation parameters used in the simulation is presented in Tables 1-4. Each simulation runs including one communication scenario file, one movement scenario file, and protocol to be simulated along with the tcl script. The same communication model is used for both group mobility model and non-group mobility model according to the number of nodes to be simulated. Trace file is generated for each simulation run and awk script [17] is used to get the simulation results. The protocol's performance is evaluated and shown according to the average results of simulations.

Table 4.Parameters for Reference Point Group Mobility model (RPGM)

| Parameters | Values |
|---|---|
| Maximum speed | 1.5m/s |
| Number of groups | 2 to 14, it varies according to the number of nodes being simulated |
| Pause time | 60 seconds |
| X coordinate | 1000m |
| Nodes separation | 3 |
| Y coordinate | 1000m |

## 4. Experimental Results and Analysis

This section presents the experimental results along with the analysis. In subsection 4.1 and 4.2 demonstrate the performance of AODV and DSDV protocol for RWPM and RPGM mobility model, respectively. A detail impact of RWPM and RPGM mobility model on AODV and DSDV is depicted in subsection 4.3 and 4.4, respectively.

### *4.1. Investigation of AODV with respect to RWPM and RPGM*

Here the performance analysis of ad-hoc on demand distance vector routing protocol with respect to RWPM and RPGM is presented for numerous performance metrics. The result is the average of three simulation results with the same parameters for each number of nodes used.

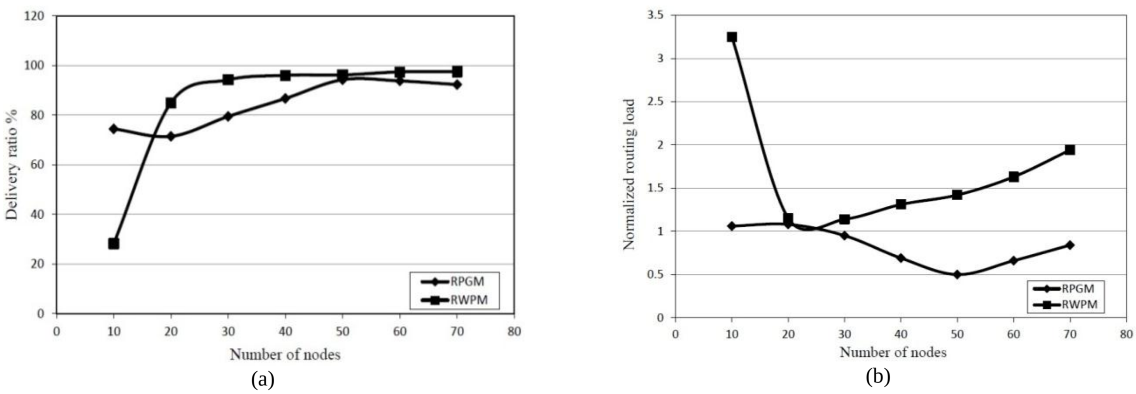
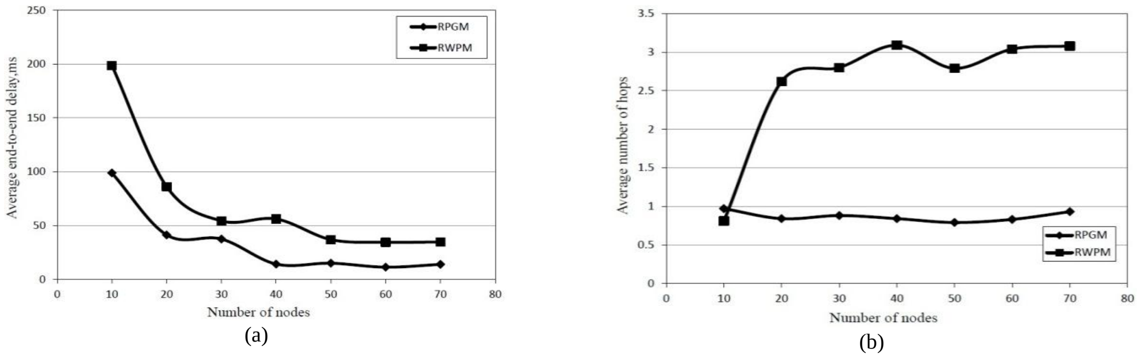



Fig.1. (a) Delivery ratio versus number of nodes; (b)Normalized routing load versus number of nodes- for AODV protocol with respect to RWPM and RPGM mobility models

According to the Fig. 1(a), the data delivery ratio of AODV with respect to these two mobility models follow a similar characteristics curve. It only exhibit slight variations has slight difference when the number of nodes was between 20 and 70; however, significant difference was experienced for the number of nodes was between 10 and 20. When the number of nodes was 10, the RWPM performs very poor compared to the performance of RPGM by exhibiting very lower packet delivery ratio. For both mobility models the packet delivery ratio gradually reaches up to maximum average 93% and 97% for RWPM and RPGM, respectively. Where, the delivery ratio of these two mobility increases with the increments in number of nodes.

In Fig. 1(b), the result of normalized routing load of AODV with respect to the RWPM and the RPGM under different numbers of nodes is presented. When the number of nodes was 10, the normalized routing load of RWPM has experienced much higher compare to that of the RPGM. The RWPM and the RPGM figures on normalized routing load for AODV protocol are clearly different. The values are obtained with RPGM is comparatively lower with the result of RWPM. This is because in RPGM all the mobile nodes in the group pause at the same time when they reach their destination unlike RWPM; where the mobile nodes in the network pause differently when they get to destination before they chose another speed and destination. This simply shows that the AODV performs better with RPGM on normalized routing load compare to the RWPM. On the other hand, RWPM experiences much more graceful degradation of its normalized routing load than RWPM between 10 and 20 nodes which may suggest a benefit derived from its nodes pausing at different times. The different pause times may have allow the network to better adjust to changing dynamism and reconfiguration.




(a) (b)

Fig. 2. (a) End-to-end delay versus number of nodes; (b) Average number of hops versus number of nodes- for AODV protocol with RWPM

Fig. 2(a) demonstrates the behaviour of AODV for these two mobility models. The RWPM has experienced a greater delay compare to the RPGM for various number of nodes. More specifically, both mobility models experienced a higher delay when the number of nodes was 10 and the RPGM outperform RWPM in end-to-end delay. According to the Fig. 2(b), the RPGM outperforms over RWPM with the numerous numbers of nodes. The average hop count is different for the two mobility models; a lot of hop count was involved with the RWPM. This is because the movement of mobile nodes in RPGM depends on its reference point or motion centre, the nodes move in group unlike RWPM, where individual node moves separately while they choose their speed and pause time differently. This increases the delay because they pause different in the RWPM. In RPGM, the nodes in a group move with the same speed and have the same pause time.

*4.2. Investigation of DSDV with respect to RWPM and RPGM*

This section presents the performance analysis of destination sequenced distance vector routing protocol with RWPM and RPGM. According to the Fig. 3(a), the delivery ratio of RWPM increases with the increments in number of nodes, but that is not the case for RPGM. For RPGM, the delivery ratio increase with increasing number of nodes from 10 to 40, it starts fluctuating from 50 to 70. The delivery ratio of RWPM is very low when the number of nodes was 10. This is simply showing that the mobility model has an effect on the behaviour of DSDV protocol. The pause time of mobile nodes when the number of nodes was 10 was too high in the RWPM. The RPGM performs better than DSDV when the number of nodes was 30 as shown in Fig. 3(a). However, in general, the DSDV protocol slightly performs better for RPGM with respect to delivery ratio.

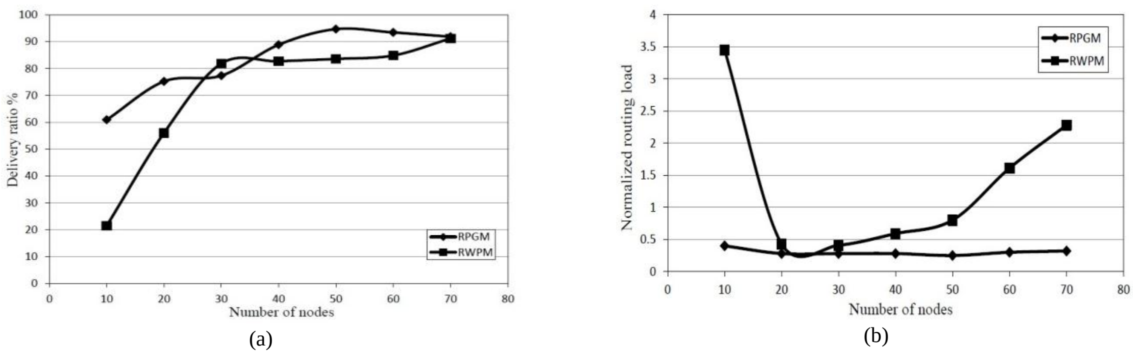
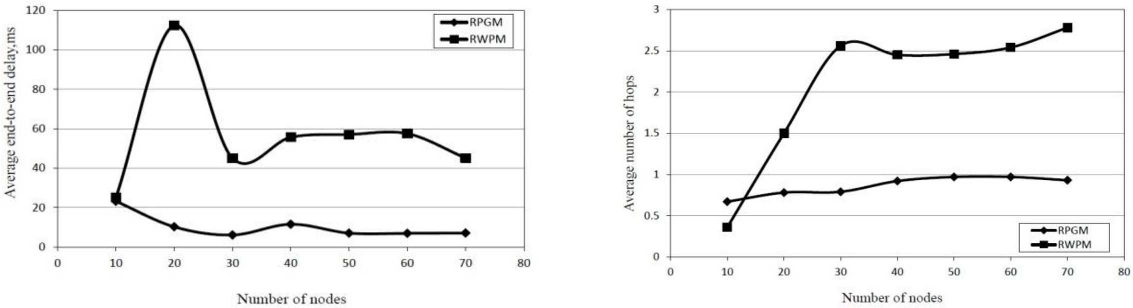



Fig. 3.(a) Delivery ratio versus number of nodes; (b)Normalized routing load versus number of nodes- for DSDV protocol with RWPM and RPGM mobility models

The Fig. 3(b) shows that the normalized routing load of DSDV with RPGM was generally low compared with that of the RWPM. The RWPM has a high normalized routing load with DSDV. In RWPM, individual nodes randomly select their speed and direction. In addition, they also select their pause randomly unlike in RPGM where nodes in the group move with a common speed along with a common pause time. In the RWPM, when the number of nodes was 10 the normalized routing load was too high, this is as a result of the speed and pause time of individual nodes. Based on the normalized routing load the DSDV performs better with RPGM.




(a) (b)

Fig. 4.(a) End-to-end delay versus number of nodes; (b) Average number of hops versus numbers of nodes- for DSDV protocol with RWPM and RPGM mobility models

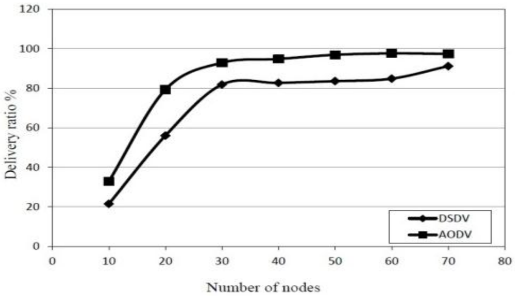
As depicted in Fig. 4(a), the RWPM has a very high delay with DSDV than those of the RPGM. The RWPM has experienced a large delay when the number of nodes was 20. This is due to the pause time is involved in RWPM. There is a huge difference in the performance of DSDV with RWPM and RPGM for numerous amounts of nodes. From the result, the RPGM model outperforms compare to the RWPM model with respect to the average end-to-end delay. Fig. 4(b) shows that the RWPM performs well only for 10 nodes, but the RPGM performs better than the RWPM with increased number of nodes with respect to average number of hop. A lot of hop count was involved with the RWPM due to the randomness of pause time of individual node.

### *4.3. Investigation of AODV and DSDV with respect to RWPM*

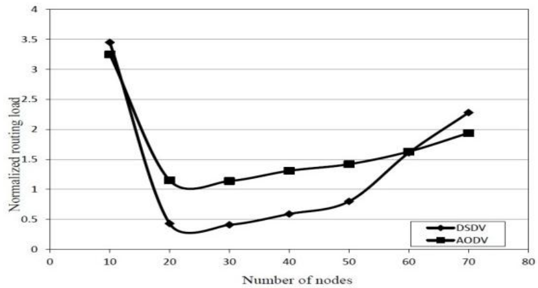
Fig. 5(a) shows that the delivery ratio of the protocols increases when the number of nodes increases. Although both protocols exhibit almost similar characteristics curves, the AODV slightly performs better than the DSDV with respect to delivery ratio for RWPM by experiencing higher delivery ratio as shown in Fig. 5(a).

Fig. 5(b) shows that the AODV performs better than the DSDV when the number of nodes between 10 and 70. However, the DSDV performs better than the AODV for node population ranging between 20 and 60. This is because, in DSDV the route to destination of all the nodes in the network are stored in the routing table before start up. This is not similar to the AODV which finds route when needed.

According to the Fig. 6(a), the end-to-end delay of AODV has experienced much higher when the number of nodes was 10 while for DSDV it was for 20 nodes. The delay of the two protocols was follow almost similar characteristics curve and the value of delay gradually decreases with the increments of number of nodes. However, for different scenarios the AODV slightly performs better than the DSDV. This is because routes to the destination are provided whenever the source node shows interest to transfer a packet to the terminal. The average hop count graph is also exhibited similar characteristic curves where for both protocols the number of hop count gradually increases with the increment of number of nodes. However, the DSDV performs better than the AODV in average number of hops metric with RWPM.

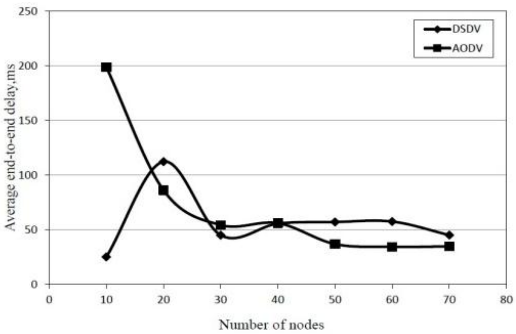



(a)

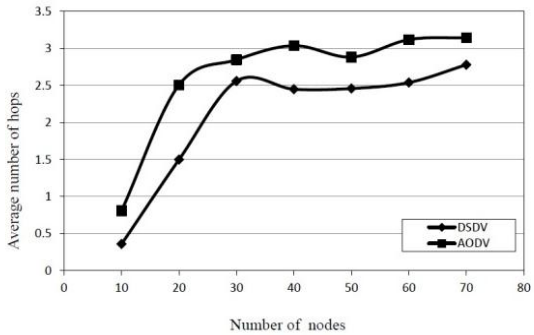



(b)

Fig. 5.(a) Delivery ratio versus number of nodes for AODV and DSDV protocols with RWPM mobility model; (b) normalized routing load versus number of nodes for AODV and DSDV protocols with RWPM mobility model




(a)

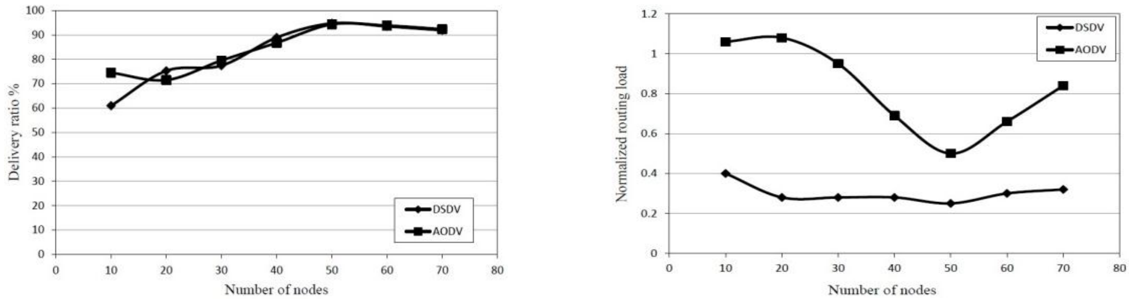



(b)

Fig. 6.(a) End-to-end delay versus number of nodes for AODV and DSDV protocols; (b) Average number of hops versus number of nodes for AODV and DSDV protocols- with RWPM mobility model

### *4.4. Investigation of AODV and DSDV with respect to RPGM*

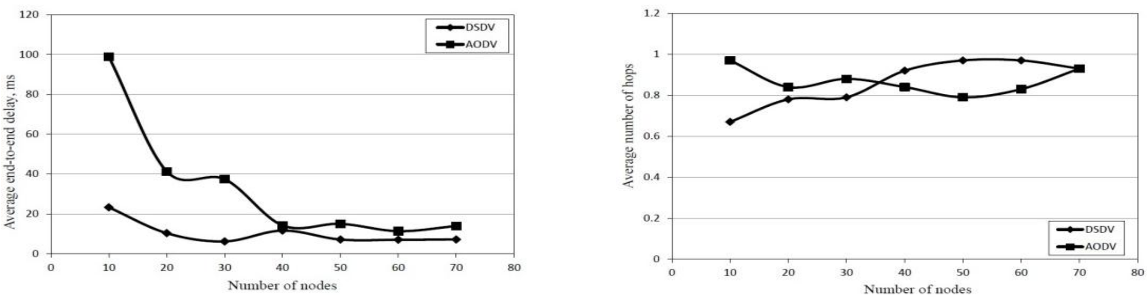
The delivery ratio of the two protocols exhibit almost similar characteristic curves as depicted Fig. 7(a). Where, the amount of packet delivery ratio gradually increases little bit with the increment of number of nodes. The Fig. 7(b) demonstrates the normalized routing load where, the DSDV has lower normalized routing load than that of AODV. This is because in DSDV all routes are stored in the routing table before the start up. This makes it easy for the source node in the network that wants to send packet to the destination node to easily retrieve the route to destination node and send their packets without much delay. This reduces the overheads encountered in finding the route to destination and each time the initiator wants to transfer a packet as experienced for AODV protocol. Therefore, the DSDV clearly performed better than the AODV in normalized routing load metric with RPGM.




(a) (b)

Fig. 7. (a) Delivery ratio versus number of nodes; (b) Normalized routing load versus number of nodes- for AODV and DSDV protocols with RPGM mobility model

As presented in Fig. 8(a), although the end-to-end delay of AODV gradually decreases as the number of nodes increases, the AODV has experienced greater delay compare to the delay of DSDV. This is as a result of its on-demand basis. As the DSDV has lower delay in RPGM and thus, it performs better than the AODV. With respect to average hop count both protocols demonstrate mixed characteristics curve for RPGM model as illustrated in Fig. 8(b); where none of these protocols outperforms each other. Both protocols perform better in some cases while in some other case not.




(a) (b)

Fig. 8. (a) End-to-end delay versus number of nodes; (b)Average number of hops versus number of nodes- for AODV and DSDV protocols with RPGM mobility model

## 5. Conclusion

This paper examines the impact of RPGM and RWPM mobility models on the performance of AODV and DSDV MANET routing protocol using a simulator NS-2. In order to do performance analysis, we consider different network metrics such as routing load, packet delivery fraction, end-to-end delay and average hop count for the scenarios of state of art protocols. The results show that the propagation models causes different impacts on the AODV and DSDV. The AODV performs better with the RPGM than the RWPM with respect to end-to end-delay, normalized routing load and average number of hops. Also in delivery ratio AODV performs better with the RWPM than the RPGM. Conclusively, the RPGM overall performs better than the RWPM for AODV protocol. For DSDV, the experimental result shows that both propagation models demonstrate alternating benefits and demerits leading to hybrid performance for considered performance metrics. Overall result suggests that no protocol performs outstandingly better than the other as each of the protocols performs well on some of the performance metrics and lacks significant performance benefits on other considered metrics. None of these protocols outperform each other in deliver ratio and average number of hops as their performance was similar. In addition, in some scenarios, the DSDV performed better than AODV considering the normalized routing and end-to-end delay. Finally, based on the results presented in different sections, we can conclude that different routing protocols show different performances under different mobility models, and no protocol outperforms than other in all scenarios for state of art performance metrics.

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