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Energy and Mobility Models based Performance Evaluation in MANET

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Abstract— Mobile ad hoc networks are constituted with randomly moving nodes and movement of these nodes is depended upon moving model used in the network. Performance of the network directly depends on the movements and energy consumed in a specific time period by the nodes. Also performance of the protocol used for communication depends on the type of mobility model used by that specific protocol. In this paper, performance of AODV (Ad hoc On demand Distance Vector) routing protocol have been evaluated in respect of five mobility models Random Way Point Mobility Model, Manhattan Grid Mobility Model, Gauss Markov Mobility Model, Random Direction Mobility Model, RPGM (Reference Point Group Mobility)). Performance metrics are considered as: average energy consumption and average residual energy. By varying the network connections, speed of the nodes, and node densities, in different scenarios, routing protocol has been simulated in network simulator 2. Simulation results show that reference point group mobility model is best suitable model as compared to other mobility models for AODV protocol in terms of energy consumption.

Keywords- mobility models; transmission energy; energy consumption; residual energy; idle energy.

I. INTRODUCTION

Performance of the routing protocol in mobile ad hoc network depends upon the remaining energy and consumed energy of the nodes. During communication, if energy of the node is low, active participation of the node is suspicious and chances of the data loss will be more. Therefore, we should have an idea about exact requirement of the energy for nodes for smooth conduction of communication. Nodes participating in data communication in the mobile ad hoc networks have a limited energy. Time and speed are two important factors which directly effects on the energy consumption rate in the networks. Also the energy consumption rate is varied upon mobility models used. Different routing protocols have different energy consumption rate. Energy consumption and mobility model both have the significant impact on the performance of AODV routing protocol. In literature, generally routing protocols have been evaluated with random way point mobility model. Some authors worked with random way point and Manhattan mobility models. Some inventors evaluated routing protocols by considering speed and node density with random mobility model. Mostly energy parameter is ignored during evaluating the performance of routing protocols.

Our main objective in this paper is to analyse the impact of mobility and energy consumption by the nodes, on the performance of the AODV routing protocol. In this research work, energy consumption is verified and evaluated for AODV routing protocol in different mobility models: Random way pint, Manhattan grid model, Gauss Markov model, Random Direction model, and Reference Point Group Mobility model.

A.AODV:

AODV (Ad hoc on demand distance vector) routing protocol is basically a mobile ad hoc network (MANET) protocol. It comes under reactive routing protocol category. Due to its loop-free feature, AODV is most likely used in mobile ad hoc networks. Each node maintains its own routing table which has three mandatory fields named as: address of next hop mobile node, hop count, and sequence number. During communication, AODV maintains three messages: Route Request (RREQ), Route Reply (RREP), and Route Error (RERR). Performance of AODV is excellent as compared to DSR and DSDV routing protocol, when speed of the nodes is high in the MANET. But, AODV have no any proper security mechanism integrated into it. Performance of AODV is affected upon the mobility model used in the network.

B.Mobility Models:

Different mobility models are used in different wireless networks. Movements of the nodes in the network is directly depends upon the mobility model used. Researchers are using different mobility models to simulate the networks to implement the algorithms and proposed models. For example, random way point mobility model is generally used by the inventors that is already included in network simulator NS2.

To implement or to generate different mobility scenarios, Bonn motion tool is most likely used tool. Other mobility models like Manhattan Grid mobility, Gauss Markov Mobility, Random Direction mobility, Reference point group mobility are used by configuring different parameters like speed, pause time, network size, number of nodes etc.

Generally all the mobility models comes under five categories named as: random based, temporal dependencies, spatial dependencies, geographic restrictions, and hybrid characteristics. Random way point mobility model and random direction mobility model are also called indoor mobility models while Gauss Markov mobility model comes under outdoor mobility models. Out of above discussed five mobility models, random way point model is simplest mobility model in which pause time facility available when speed/direction is changed. To simulate the group behaviour in the network, reference point group mobility model is generally used. In this model, a central node controls group motion behaviour. Each node can use its own mobility model and provides a reference point to the group. In disaster management and military operations, RPGM model is mostly used [1]. Gauss Markov mobility model was designed especially for simulation of personal communications. Gauss Markov model is purely developed on random simulation area i.e. there is no any concept of fixed area. N this model, each node is authorized to have its own speed/direction and can change it randomly.

Manhattan Grid mobility model is mostly used in VANET and is one type of the urban type of model. Nodes in this mobility model moves only in vertically and the horizontally manner. Grid topology is used in Manhattan mobility model which is not appropriate in highway system. Nodes can change their direction only at intersection points.

In this proposed work, by considering five mobility models and performance parameters as average residual energy and average energy consumption, protocol have been evaluated. By varying the speed of the nodes, number of traffic connections, and node densities, AODV is simulated. Rest of the paper is organized as follows: literature review is conducted in section II. Research methodology with specifications is elaborated in section III. Section IV describes about the implementation outputs with proper justifications. This paper is concluded in section V.

II. RELATED WORK

In [2-3], performance of mobile ad hoc network is analysed by considering different mobility models such as Gauss Markov model and random way point mobility models. To generate mobility model based scenarios, Bonn-motion tool has been used.

Reactive, proactive, and hybrid routing protocols n wireless network have been analysed based on energy consumption during communication [4]. Performance evaluation work is carried out by considering the parameters such as throughput, delay, and packet delivery ratio. Energy consumption for AODV (Ad hoc On-Demand Distance Vector), OLSR (Optimized Link State Routing protocol), and HWMP (Hybrid Wireless Mesh Protocol) has been evaluated and compared by conducting experimental work on NS 3.25 network simulator. HWMP is used in its both states i.e. proactive and reactive modes. Constant Position Mobility and Random way mobility Models have been used in the proposed research work. OLSR is declared as best performer routing protocol in terms of delay and packet delivery ratio.

Performance of reactive, proactive, and flooding schemes has been evaluated based on mobility and energy consumption [5]. Effect of mobility on energy consumption by different routing protocols is analysed by using random direction mobility model (RDMM). Energy consumption is calculated by considering the listening reception, transmission and sleep operating modes. It was concluded that there is very strong relationship among routing scheme, mobility of nodes, traffic conditions, and energy consumption in such an environment.

In [6], Ashish Kumar et al. has been evaluated the energy consumption for AODV, DSR (Dynamic source routing), and DSDV (Destination Sequenced Distance Vector Routing) routing protocol in mobile ad hoc network. Protocol have been analysed based on the metrics like overhead, throughput, and energy consumption during data communication in the network. By considering the parameters sources, pause time, nodes, area, sending rate and mobility speed, different network scenarios have been generated and implementation work is conducted in network simulator. DSDV routing protocol is declared as most efficient protocol in terms of energy consumption in the network. But, at higher mobility rates, DSDV shows very low throughput.

Mohammed Ayad Saad, et al. presented energy consumption based performance evaluation in mobile ad-hoc network [7]. Implementation work was carried out using network simulator NS3. By varying the node densities and intervals, in different network scenarios, simulations were implemented for 500 seconds. It was observed that there is relationship between packets transmitted and energy consumption in the network. It has been also observed that large networks with high node densities is responsible for higher flooding while in small networks, number of collisions will be high.

In [8], MGGR (Multipath Grid-Based Geographic Routing) protocol has been evaluated in three different mobility models in under water wireless sensor network. The performance

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parameters were considered as packet delivery ratio, end to end delay, and energy consumption. The protocol was simulated for 1000 seconds in aqua-sim network simulator. The mobility models were taken as random way point, reference point group mobility model, and meandering current mobility model. Bonn-motion tool was used to generate different mobility scenarios as per particular mobility model. From the simulation work carried out in this research work, it is observed that performance of MGGR is not much more affected in respect of mobility models; but slightly changed as the speed of the nodes is increased. Performance of the MGGR is degraded in Meandering current mobility model as compared to above two mobility models. By varying the node densities, speed of the nodes and packet generation rate performance is observed for MGGR routing protocol in respect of different performance metrics like delay and packet delivery ratio.

In [9], Juan Carlos Cano et al. has conducted a research work for performance of AODV, DSR, DSDV, and TORA routing protocols based on energy consumption in mobile ad hoc networks. Five network scenarios were generated by considering the node density, traffic type, number of traffic sources, network size, and mobility models. Simulation work was conducted in network simulator NS2 for mobile ad hoc network. In terms of energy consumption, DSR and AODV routing protocols were declared as most appropriate protocols as compared to TORA and DSDV routing protocols. TORA routing protocol is identified as worst protocol as it consumes more energy as compared to above routing protocols.

Frederico O. Sales et al. [10] analysed the Low-power and Lossy Network (LLN) routing protocol for lossy networks by considering energy consumption parameter as main performance metric. By considering the tree, circular, and grid topologies, protocol is simulated in Contiki Cooja 3.0 simulator for 600 seconds. Paired observations method was used during the comparison work in respect of evaluation work of topologies. After conduction of implementation work within six different network scenarios, it was observed that circular topology outperforms in terms of managing the node densities. In respect of HOP metric, circular topology consumes very less energy as compared to tree and grid topologies.

Geetha Jayakumar and Gopinath Ganapathi discussed the performance evaluation research work for routing protocols in mobile ad hoc network based on two mobility models: first one is reference point group mobility model and second one is random way point [11]. AODV and DSR routing protocols have been evaluated in above two mobility models by considering the performance metrics like average end to end delay, packet delivery ratio, and normalized routing load. Simulation work at NS2 is conducted in three different network scenarios (varying the mobility, network traffic, and number of nodes in the network). It was concluded that AODV and DSR routing protocols works well with reference point group mobility model especially in terms of throughput. AODV outperforms with RGGM model with small delays.

Based on packet delivery ratio and remaining energy performance parameters, AODV and DSR routing protocols have been analysed in mobile ad hoc networks [12]. By varying the node densities and speed of the nodes, protocols were simulated on network simulator NS-2.35. DSR routing protocol is declared as best performer protocol as it consumes less energy and packet delivery ratio is higher as compared to AODV routing protocol. Random way point mobility model is generally used when researchers are using network simulator NS2 because random way point model is already available in network simulator 2[13][14].

To send data securely and efficiently, so many routing protocols have been proposed in mobile ad hoc networks. Also the evaluation work for these protocols has been conducted since a long time period. In most of the research work, inventors focused on the throughput and end to end delay to analyse the efficiency of various routing protocols in mobile ad hoc networks. a very few research work has been conducted on the performance evaluation of routing protocols by considering energy consumption and mobility models variation.

III. RESEARCH METHODOLOGY

Network simulator version NS2.34 [15] is used for simulating the AODV routing protocol in three different network scenarios. NS2 is an event driven simulator and supports some other tools for calculating the performance parameters. These scenarios have been created by varying the speed, number of traffic connections, and node densities. Bonn motion tool has been used for generating the mobility scenarios for different mobility models. Five mobility models are considered as listed below:

Mobility Models:

1. Random Way Point Mobility Model
2. Manhattan Grid Mobility Model
3. Gauss Markov Mobility Model
4. Random Direction Mobility Model
5. RPGM (Reference Point Group Mobility)

Average residual energy and average consumed energy are considered as the performance metrics for evaluating the performance of AODV routing protocol.

Performance metrics:

1. Average Residual Energy

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2. Average Consumed Energy

Three network scenarios have been created by varying different network parameters. The details for the scenarios are discussed as below:

Network scenario-I (Connections): was generated by varying the number of connections (5, 10, 15, 20, 25, 30, 35, and 40). Total 60 nodes in network topology size as 316m*303m, were simulated for 100 seconds. TCP Traffic connections (5-40 connections) were established. Simulation work was configured with node speed (maximum speed as 20 m/s and minimum speed as 0.5 m/s) and pause time as 20 seconds. All the other parameters were kept as same as shown in table 1.

Scenario-II (Nodes): by varying the node densities from 3 to 60, protocol was simulated for 100 seconds at node minimum speed as 0.5 m/s and node maximum speed as 20 m/s. network topology is settled as 220m*220m. In this scenario two traffic connections (TCP connections) with packet size as 512 bytes have been established. During all the simulation time, pause time was considered as 20 seconds.

Scenario-III (Speed): In this scenario, total 40 TCP connections were established for maximum 60 nodes. Protocol was simulated in network size as 220m*220m. This scenario is generated by varying the speed of nodes from 10 m/s to 35 m/s. In TCP traffic, packet size of 512 bytes is considered. All the other parameters are kept as same as in scenario-I.

Table 1: Simulation Parameters for NS2.34

Simulation parameter	Value
Simulator type and Version	Network simulator NS2.34
Simulation time	100 seconds
Pause time	20 seconds
Speed	10, 15, 20, 25, 30, 35 m/s
Nodes	3, 10, 20, 30, 40, 50, 60
Traffic type	FTP
Connections	5, 10, 15, 20, 25, 30, 35, 40
Interface queue size	100
Network topology size	220m*220m
Mobility Models	Random Way Point Mobility Model, Manhattan Grid Mobility Model, Gauss Markov Mobility Model, Random Direction Mobility Model, RPGM (Reference Point Group Mobility)
Energy Model	EnergyModel
Initial Energy	50 Joules
Transmission Power	0.75 Watts
Receiving Power	0.25 Watts
Idle Power	0.04 Watts
#Sense Power	0.10 Watts
Sleep Power	0.05 Watts
Mac Type	Mac/802_11

IV. RESULTS AND DISCUSSION

Results and discussion part of this research work is partitioned scenario-wise into three categories: Connections versus energy, nodes versus energy, and speed versus energy. For each category, average energy consumption and average residual energy is calculated with respect to mobility models. Simulation results are tabulated and graphically presented by using Xgraph tool.

Connections Versus Energy:

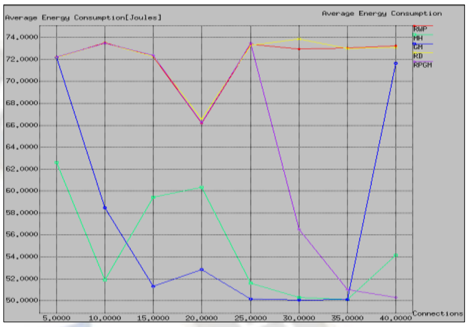

Figure 1: Connections Vs Average Energy Consumption

As shown in figure 1, average energy consumption is studied and analysed by varying the number of traffic connections from 5 to 40. Average energy consumption for AODV routing protocol within four mobility models named as RWP (Random Way Point), MH (Manhattan Mobility Model), GM (Gauss Markov), RD (Random Direction), and RPGM (Reference Point Group Mobility Model) is observed in terms of network traffic loads. Using Manhattan mobility model, energy consumption is very less as compared other above mobility models. Energy consumption for Manhattan and Gauss Markov mobility models is approximately same. Random direction model shows very low performance as energy consumption rate for it is very high. Energy consumption rate for Manhattan Model is 17% while it is 23% for random direction model. Average energy consumption rate is fluctuating as the traffic load is increasing. Performance of AODV is excellent by using Manhattan mobility model (MH) as overall average energy consumption rate is very low i.e. 17%.

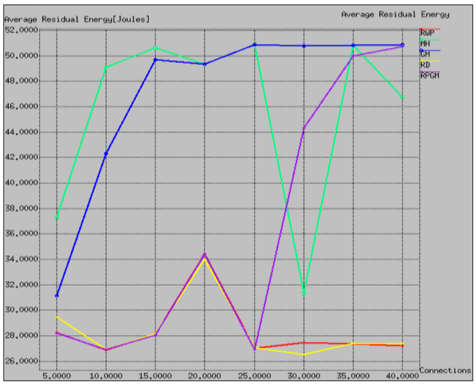

Figure 2: Connections Vs Average Residual Energy

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Figure 2 illustrated the average residual energy in the network for AODV routing protocol in respect of different mobility models. As the numbers of network connections are increased, the average residual energy of the nodes is also fluctuating for all mobility models. At 40 network connections, average residual energy for RWP and RD is approximately same i.e. 27.236 Joules and 27.344 Joules respectively. Using Gauss Markov mobility model (GM), AODV performs well as average residual energy is 25% while in case of Random Way Point and Random Direction mobility models, average residual energy level is least i.e. 15%.

Nodes Versus Energy:

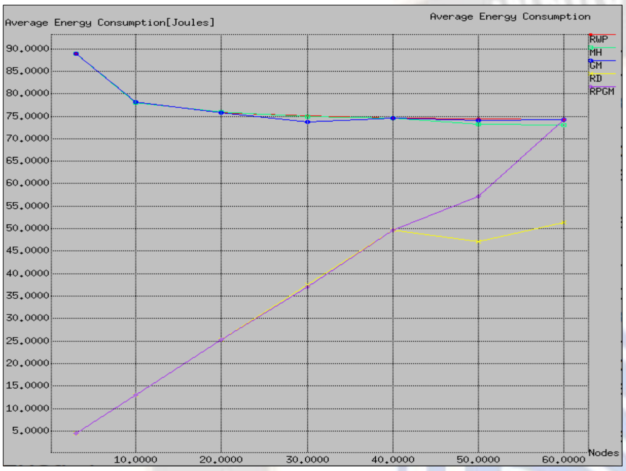

Figure 3: Nodes Vs average Energy Consumption

As shown in figure 3, average energy consumption for AODV routing protocol is analysed using four mobility models in respect of various node densities in the network. In case of random way point model and Manhattan Mobility model, as the node density is increased, average energy consumption rate is decreased, while for random direction mobility model and reference point group mobility model, the case is just opposite i.e. as the node density is increased, the average energy consumption rate is increased. Average energy consumption rate is fluctuating as the node density is increased for Gauss Markov mobility model. The AODV routing protocol shows better performance by using random direction model as average energy consumption rate is very low i.e. 11%. Average energy consumption rate for random way point and Gauss Markov model is approximately same i.e. 77.29 Joules and 77.07 Joules respectively.

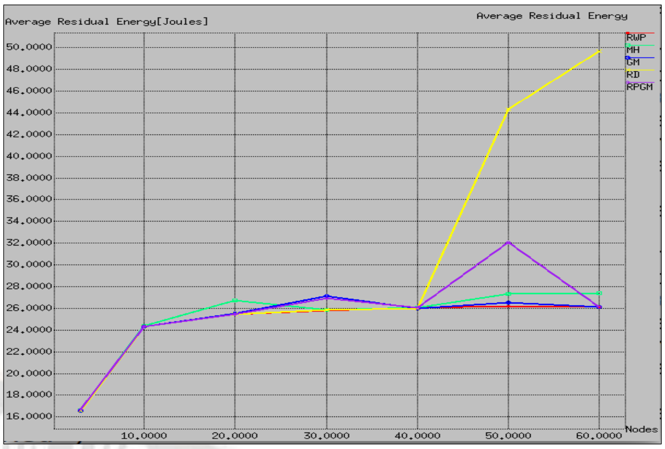

Figure 4: Nodes Vs Average Residual Energy

Average residual energy analysis with respect to node densities is described in figure 4. By varying the node densities from 3 to 60, performance of AODV routing protocol is evaluated within four different mobility models. In case of RWP, RD, as the node densities are increased, the average residual energy rate is increased. Overall average residual energy for RWP and RD is 19% and 23% respectively. In case of MH, GM, RPGM, average residual energy is fluctuating as the node densities are varying. Overall average residual energy for RWP, MH, and GM is same i.e. 19%. Performance of AODV routing protocol is excellent by using the RD mobility model as average residual energy rate for it is 23%. In case of MH model, for node densities from 3 to 20, average residual energy is increasing, but suddenly is decreasing for node density 30. For node densities 40-60, again it is increasing on regular basis. In case of GM, node densities from 3-30, average residual energy is increasing; but suddenly at node density 40, it is decreased.

Speed Versus Energy:

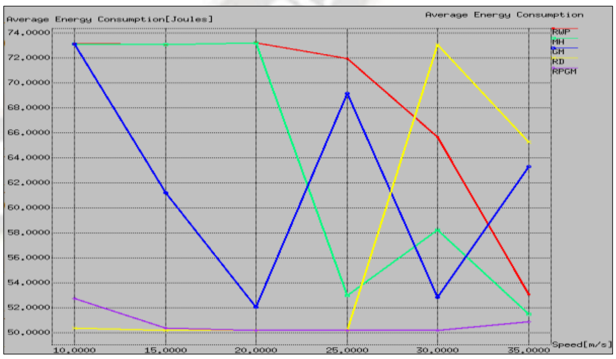

Figure 5: Speed Vs Average Energy Consumption

In figure 5, average energy consumption by the network is presented in terms of speed of the nodes. AODV is evaluated in respect of average energy consumption by using four mobility models. As the speed of the nodes is increasing, average energy consumption for all four mobility models is fluctuating. In case of Random Way Point (RWP), from speed

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10m/s to 15 m/s, average energy consumption rate is decreasing, but suddenly it is increased at speed of 20 m/s. Again, from speed 25m/s-35m/s, average energy consumption rates are decreasing. In case of Random Direction mobility model (RD), average energy consumption rates are approximately same from speed 10m/s-25m/s, but suddenly it is increased at speed 30m/s. in case of Reference Point Group Mobility model (RPGM), average energy consumption at speed 10 m/s is highest i.e. 52.746 Joules, but from speed rates 15m/s-35m/s, it is approximately same. AODV shows better performance by using RPGM mobility model because overall average energy consumption rate is 17% which is least. Overall average energy consumption rate for RWP and MH is same i.e. 23%.

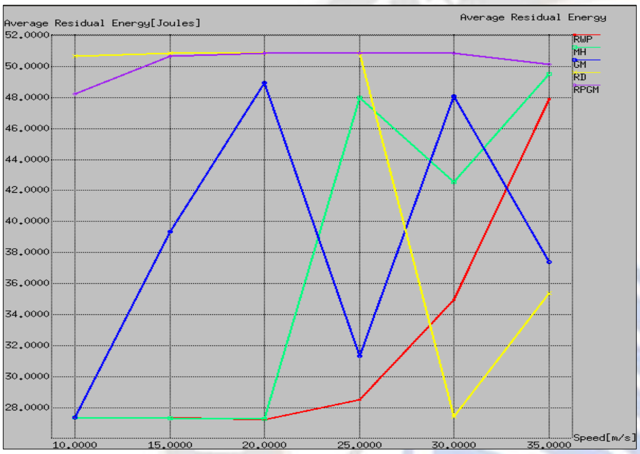

Figure 6: Speed Vs Average Residual Energy

As shown in figure 6, by using RWP, MH, GM, RD, and RPGM mobility models, AODV is evaluated for average residual energy in respect of speed. In case of RWP, from speed rate 10m/s-20m/s, average residual energy is approximately same. But suddenly it is increasing from speed rate 20m/s to 35m/s. in case of Reference Point Group Mobility model (RPGM), at speed 10m/s, average residual energy is lowest i.e. 48.20 Joules; surprisingly, average residual energy rate is approximately same from speed rate 15m/s to 35m/s. in case of Manhattan Mobility model (MH)) and Random Direction (RD), average residual energy is approximately same from speed rate 10 m/s to 20 m/s and afterward it is fluctuating up to speed rate 35 m/s. AODV shows better result by using RPGM mobility model as overall average residual energy rate is maximum i.e. 25%. In other case, performance of AODV comes under worst case when Random Way Point (RWP) mobility model is used.

V. CONCLUSION

Mobile ad hoc networks are the wireless networks in which nodes move randomly with different speed rates. Due to the high speed of the nodes, link breakage happens frequently and as a result performance of the routing protocol in the network is highly affected. In such an environment, mobility models play a great role in respect of performance. Different mobility models have their own specification and rules for movement of the nodes. In this research paper, effect of five mobility models on the performance of AODV has been evaluated by varying the speed, connections, and node densities. In terms of speed, average energy consumption, and average residual energy performance parameters, AODV produces better results with RPGM mobility model as compared to other mobility models. Based on the performance metrics (Average energy consumption and average residual energy), Random Direction mobility model (RD) is most suitable model in terms of node density. In respect of average energy consumption and number of connections, AODV routing protocol shows better result with Manhattan mobility model. Gauss Markov mobility model is best appropriate model used by AODV when performance parameters like connections and average residual energy are considered.

In future, this research work will be extended with some other mobility models and some routing protocols such as TORA (Temporary Ordered Routing Algorithm) and ZRP (Zone Routing Protocol).

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