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Performance Analysis of Synthetic Mobility Models and Mobile Ad Hoc Routing Protocols

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Abstract: Routing protocols heavily influenced by the node motion applied. Many performance analyses are already done with a lot of flaws. But, they do not look to all influenced constraints. Sometimes, they evaluate routing protocols without taken into consideration mobility models. They often analyze them using one routing protocol. Whereas, Simulation time employed is too short. It mainly impacts performance metrics of many mobility models. Or usually, simulation area used is small. It influences the number of packets received. In this study, we aim to summarize all these several parameters into 90 different scenarios with an average of 1350 simulated files. We will combine some well-known mobility models with the most prominent mobile Ad hoc routing protocols in order to analyze their accurate behaviors in one experimental synthesis paper. That shows results of three performance metrics combined with five mobile ad hoc routing protocols under three synthetic mobility models. All these parameters are applied to two dissimilar simulation areas, a small one with (220 m×220 m) and a large one with (1020 m×1020 m). Basing on one exhaustive analysis with all these details like this paper; leads to well understand the accurate behaviors of routing protocols and mobility models used. By displaying the ability of every routing protocol to deal with some topology changes, as well as to ensure network performances.

Keywords: MANET, Routing protocols, Mobility models, NS2, Boonmotion, Performance analysis.

1. Introduction

For almost two decades, mobile communication has become a major field of research and scientific discoveries. Mobile Ad hoc Network (MANET) has achieved a huge improvement due to its flexibility, easier maintenance, the non-existence of centralized control or fixed and static infrastructure as well as self-administration and self-configuration abilities. Therefore, MANET [1] has become an integral portion of the mobile wireless Network. This kind of wireless network can be established anytime and anywhere, with two or more mobile nodes. If they are in the same radio range, they are directly connected one another. So, they must play the roles of both routers and hosts.

Several mobility models have been proposed to overcome these situations with the aim of imitating human beings' real-life. Wireless communications display many problems related to nodes density, traffic load, autonomous energy, and mobility. Routing within this network suffers from frequent topology's updates and unconnected actives routes between mobile nodes. The main challenge of MANETs routing is to develop a dynamic routing protocol expeditiously able to find a route between mobile nodes. The choice of a mobility model (MM) can favorite some designs over others. It must be efficiently readapted to every change occurring in the network topology [2]. The performance of mobile ad hoc networks can vary significantly under different mobility models. Sometimes, they evaluate routing protocols without taken into consideration mobility models. They often analyze them using one routing protocol. Whereas, Simulation time employed is too short. It mainly impacts performance metrics of many mobility models. Or usually, simulation area used is small. It influences the number of packets received. Their optimal implementation requires a deep study of the routing protocols. Researchers find meaningful to explore mobility model decisions and metrics in modeling their wireless communication where mobile nodes move from a place to another with no fixed infrastructure.

Synthetic Mobility models [3] imitate the movement of real mobile nodes that change speed, position, and direction with time. They can be done by making prevision, mobiles move from one place to another at a given moment under varied network restrictions. They represent precisely motion characteristics of mobile nodes. They are amongst key parameters that influence performance features of the mobile network in order to judge which protocol is useful in a special scenario. Nodes' mobility needs to be analyzed to explore dependency and topology requirements.

This paper will propose an intensive performance analysis of some synthetic mobility model under a mobile ad hoc network. In order to describe mobility issue of various wireless communication scenarios that heavily impacts mobile routing protocols. The entire document is divided into three principal sections. Firstly, we present briefly related works where are used in the simulation. Secondly, we present the parameters of simulation; and also, we interpret the simulation results. And finally, we discuss the conclusion.

2. Related Works

Many ways are proposed to classify synthetic mobility models [4].

Firstly, the 'Entity mobility model' where every node is independent of each other. This class has been classified into the following areas: random mobility models, models with temporal dependency, models with spatial dependency and models with geographic restrictions. For random mobility models, nodes travel freely and without obstructions. Direction, speed, and destination are selected randomly and independently of prior selection. That assesses these models to be generally without a memory, e.g.: Random Waypoint Mobility Model (RWMM) [5]. Secondly, models with temporal dependency, devices are governed by motion's physical laws when its present movement depends on its movement's history, for example, Gauss-Markov mobility model [6]. Whereas, patterns with spatial dependency. On many cases, it has been observed that node's waypoint (destination) is probabilistically subordinate its current location, e.g., Probabilistic Random Walk Mobility Model [7]. However, models with geographic restriction, node's movements are not often random or have a temporal/spatial dependency. But, it can be obstructed in a bounded area, guided by paths or restricted into a building, e.g., Manhattan Grid Mobility Model (MGMM) [8]. All previous patterns are considered as 'entity synthetic MM'. Secondly the 'correlated or group based mobility model', where the device node's movement is dependent on others. In this subclass, nodes move by following a leader node in the group. That is to say, each group is governed by one leader which can be a pre-defined or a logical node, e.g., Reference Point Group Mobility Model (RPGMMM) [9].

Thirdly, the 'human or social based mobility model' where nodes are driven by socializing human behaviors, e.g., Self-Similar Least Action Walk [10].

And fourthly, vehicular mobility models emulate vehicle movement with changing speed, moving in queues along highway/street and stopping at traffic signals [11]. That follows the shortest trajectory from a given source to a destination.

However, vehicular communication becomes an important portion of the intelligent transport system.

3. Simulation Parameters and Results

3.1. Simulation Models' Description

Different scenarios have been considered in order to evaluate mobility nodes and traffic load [12-14]. Both of routing protocols and mobility models are impacted by various criterions during simulation. For instance, we can mention: the 'Traffic Generation Model' [15] which is used to investigate systematically traffic load effect. Many application traffics can be generated in such wireless communication. In our case, we use a random traffic load as Continuous Bit Rate (CBR) between mobile nodes.

And also, they are impacted by the 'Radio propagation model' [16] adopted. It predicts propagation features like received signal power of every packet, antenna features and distance of covered zone applied. At the physical layer, there has a receiving threshold for each mobile node. If, its signal power does not below to receiving threshold that leads to being dropped by the MAC layer. Mainly, there are three propagation models which are Free Space model, Two-Ray Ground reflection model, and Shadowing model. According to Free Space model. It considers propagation conditions as ideal. Where between the transmitter and receiver is direct with only one clear line-of-sight path. Although, Shadowing model is more realistic. At a specific distance, the received power is a random variable caused by multipath propagation effects. In our simulation, we use 'Two-Ray Ground reflection model' that considers a ground reflection path in addition to the direct path.

We find also, 'Mobility Generation Model' which is used to explore nodes mobility effect of total network performances. Movement scenario files used for each simulation are characterized by the pause time. If this latter equals 100 seconds there will be almost no movement. However, if it equals zero second that corresponds to continuous motion without stopping.

To study the effect of mobility, a set of movement scenarios correspond to different mobility strategies are generated by Boonmotion Tool [17] in our simulation. There exist many designed tools to generate mobility traces [4].

3.2. Configuration Parameters

This paper shows results of three performance metrics which are Packet Delivery Ratio (PDR), average end-to-end delay and throughput under different scenarios.

We combine five mobile ad hoc routing protocols which two of them are proactive, two are reactive and hybrid one. With three synthetic mobility models which are: RWMM is a random entity synthetic MM, MGMM is an entity synthetic MM with restriction geographic MM and RPGMM is group based MM. All these parameters are applied under two simulation areas; a small one with (220 m×220 m) and a large one with (1020 m×1020 m). So, our results will represent 90 different scenarios with an average of 1350 simulated files. We combine all these details in order to well understand the accurate behaviors of routing protocols and mobility models used. Simulation settings used for experiments are depicted in Table 1.

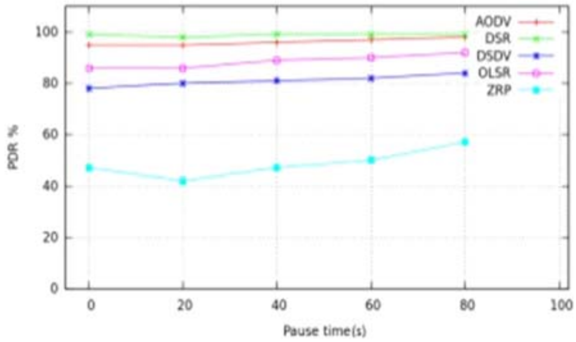
Table 1. Simulation parameters.

Parameters	Values
Propagation model	TwoRawGround model
Bandwidth	10 Mb/s
Number of nodes	50
Packet size	512 bytes/s
Traffic sources	CBR
Pause time (s)	0, 20, 40, 60, 80
Routing protocols	DSDV, OLSR, AODV, DSR, and ZRP
Mobility models	RWMM, MGMM and RPGMM
Performance metrics	PDR, Average e-e delay and Throughput
Area	220 × 220, 1020 × 1020
Simulation time	1000 s
Recursion	15 times

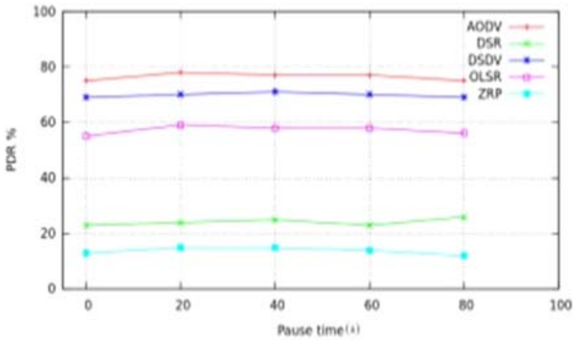
3.3. Configuration Parameters

To evaluate routing protocols, a wide range of performance metrics have been considered to catch characteristics of different mobility models. Our results aim to analyze their performance impacts on routing protocols over MANET [18]. So, different metrics have been used to compare and evaluate them against nodes' mobility, as follows.

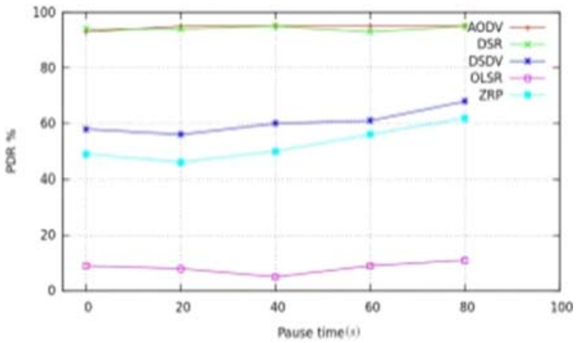
Firstly, we start with Packet Delivery Ratio (PDR) or Fraction (PDF). It represents the ratio of data packets delivered to destinations, those generated by CBR application sources. According to this metric, simulation results are shown in Fig. 1 and Fig. 2.



(a) RWMM



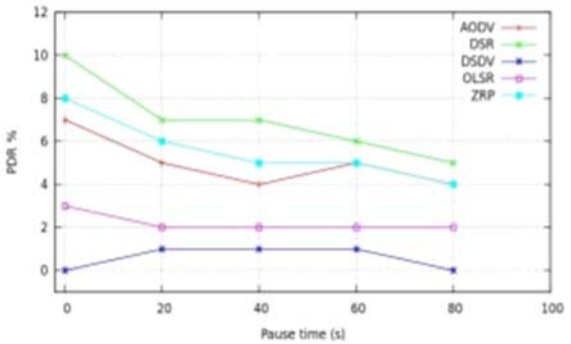
(b) MGMM



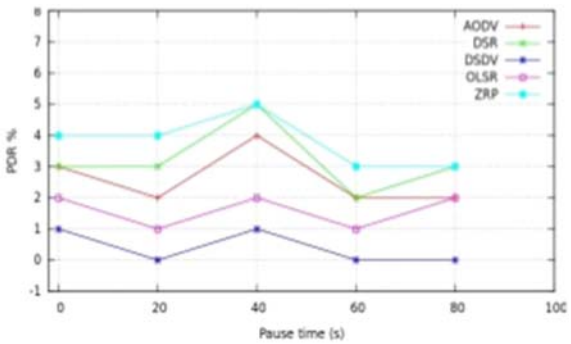
(c) RPGMM

Fig. 1. PDR of routing protocols under various mobility models - Small area. (a) Random Waypoint Mobility Model, (b) Manhattan Grid Mobility Model, (c) Reference Point Group Mobility Model.

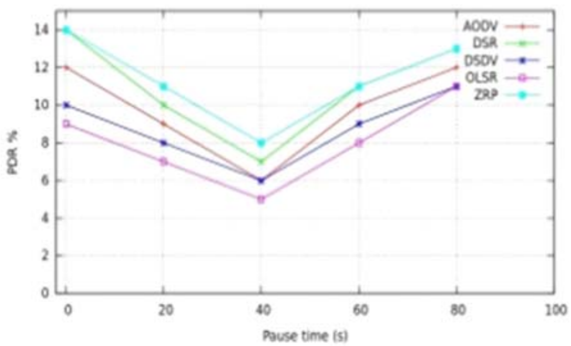
Fig. 1 is applied in the small area. From Fig. 1(a) and Fig. 1(c), the PDR of AODV and DSR present best results in both RWMM and RPGMM in which they reach approximately 100 %. Due to their reactive strategy, routes are sure which are searched on demand. But, AODV represents the best routing protocol in MGMM of Fig. 1(b). However, in RWMM and MGMM, ZRP gives the worst results in this metric, by dint of zone network used by this protocol. DSDV and OLSR in RWMM and MGMM offer acceptable outcomes, thanks to continuously update their routing table. OLSR is the worst in RPGMM.



(a) RWMM



(b) MGMM



(c) RPGMM

Fig. 2. PDR of routing protocols under various mobility models - Large area. (a) Random Waypoint Mobility Model, (b) Manhattan Grid Mobility Model, (c) Reference Point Group Mobility Model.

As a result of, OLSR is based on routing by cluster heads. And, RPGMM has their own groups' leader.

So, the same strategy applied for routing and mobility respectively. The coordination between clusters and leader nodes is tough in this case. In general, we notice that AODV offers best results at the PDR for all mobility used in the small area.

Fig. 2 is applied in the large area. From Fig. 2(a), (b) and (c), the DSR and ZRP offer the best PDR percentage. Due to the hidden routing table of DSR which often has an available route to the destination even in a wide field. And zone based protocol applied by ZRP which it allows to be suitable to the large area. Although, the proactive protocols OLSR and DSDV are the worst in all mobility models. Proactive protocols generally offer bad results in large simulation field. We observe that ZRP is the best in the PDR in this area. As a result of dividing spacious simulation area in a small zone which will be easier to verify transmitted packets.

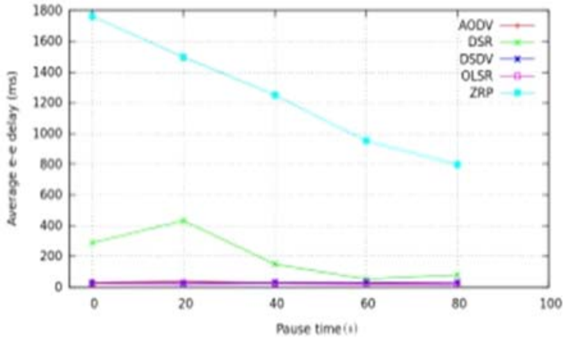
Secondly, we analyze the 'Average End-to-End Delay'. It represents total time spends between application source to destination one. The simulation results are shown in Fig. 3 and Fig. 4.

Fig. 3 is applied in a small area. From Fig. 3(a), (b) and (c), the Average end-to-end delay of DSR and ZRP are the worst in this three mobility models simulated. Due to their zone approach of ZRP and useless routes saved by DSR. However, we notice that in the small area, this metric is best with AODV, OLSR, and DSDV. Thanks to their on demand or continuous proactive strategy adopted by these routing protocols.

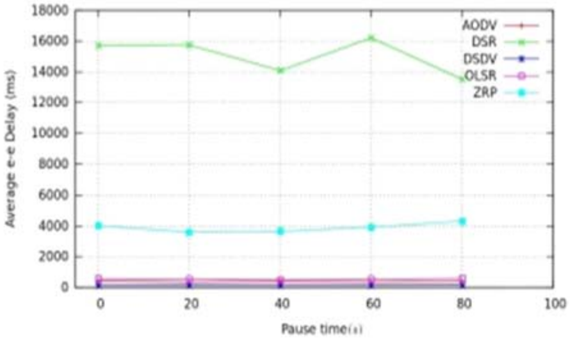
Fig. 4 is applied in a wide area. From Fig. 4(a), (b) and (c) like the small one, the average end-to-end delay of DSR and ZRP are the worst in these three mobility models simulated of Fig. 4(a), (b) and (c). Due to their zone approach of ZRP and useless routes saved by DSR. So, sometimes, they borrow prolonged routes to reach the destination. However, AODV has acceptable results. Thanks to the reactive methodology which send to one neighbor without total knowledge of a correct path to the destination. We notice that average end-to-end delay of proactive protocols OLSR and DSDV are not influenced by simulation field adopted. It offers best outcomes, thanks to their continuous proactive strategy.

Thirdly, we assess the Throughput which is the sum of data rates which are delivered to all mobile nodes, indicating bits or packets received per second. The simulation results are shown in Fig. 5 and Fig. 6.

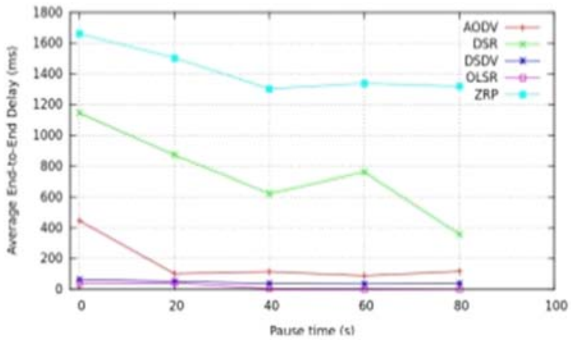
Fig. 5 is applied in a small area. From Fig. 5(a) and (c), reactive protocols AODV and DSR show best results in RWMM and RPGMM. These protocols are suitable for small areas. But from Fig. 5(b), AODV outperforms than others at MGMM due to the reliable path used. However, ZRP is the worst in RWMM and MGMM. And, it is admissible in RPGMM. Although, DSDV and OLSR offer permissible outcomes in RWMM and MGMM.



(a) RWMM

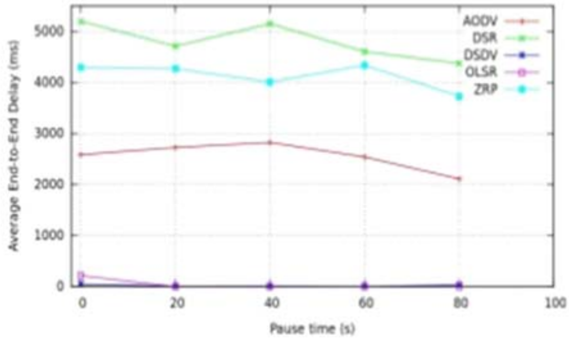


(b) MGMM

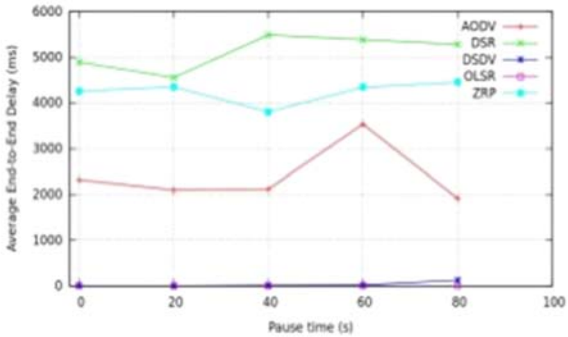


(c) RPGMM

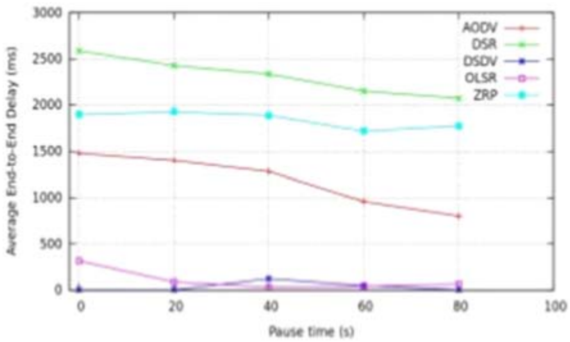
Fig. 3. End-to-End Delay of routing protocols under various mobility models - Small area. (a) Random Waypoint Mobility Model, (b) Manhattan Grid Mobility Model, (c) Reference Point Group Mobility Model.



(a) RWMM



(b) MGMM



(c) RPGMM

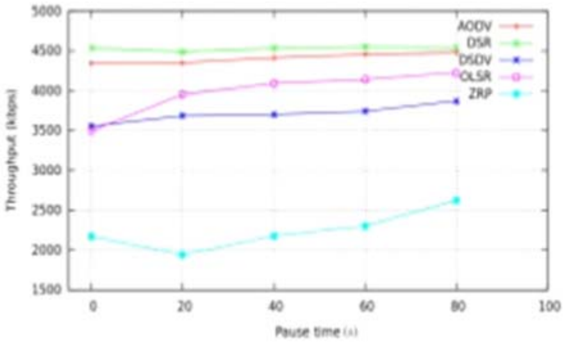
Fig. 4. End-to-End Delay of routing protocols under various mobility models - Large area. (a) Random Waypoint Mobility Model, (b) Manhattan Grid Mobility Model, (c) Reference Point Group Mobility Model.

But, OLSR is the worst in RPGMM due to its cluster routing process. We conclude that AODV is the most suitable for all these mobility models simulated in a small field.

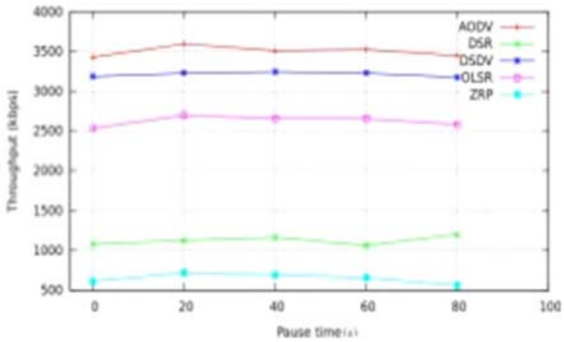
Fig. 6 is applied in a large area. From this figure, we remark that ZRP, AODV, and DSR give best results on the throughput. Furthermore, ZRP is the best according to this metric. But, OLSR and DSDV are the worst at all models experimented. We conclude that proactive protocols are bad. And, ZRP is the best one in large areas.

After simulating 1350 files of 90 different scenarios. Our results will be summarized in Table 2. When we have combined some routing protocols with synthetic mobility models. We obtain best outcomes which are displayed with green cells 1-2. And worst results with red color 4-5.

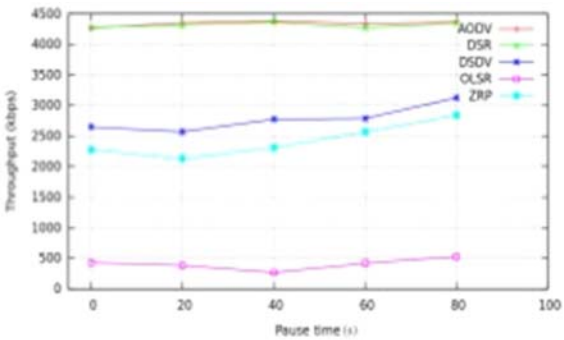
We result from that the Packet delivery ratio and Throughput in a small area. AODV achieve best outcomes as a result of on-demand concept based on route request RREQ and route reply RREP leads to possesses exactly the correct path. But, the worst one is represented by ZRP because it explores information of Intra-zone Routing Protocol (IARP) and Inter-zone Routing Protocol (IERP) which will be tedious to coordinate between them in a small one.



(a) RWMM

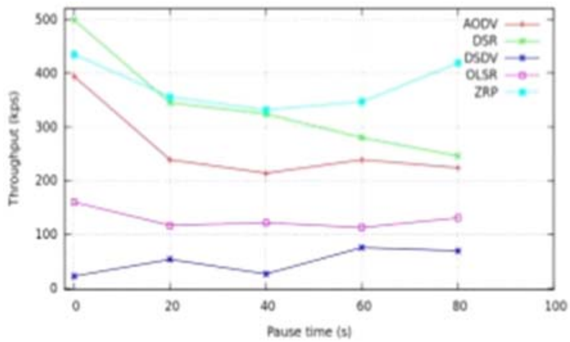


(b) MGMM

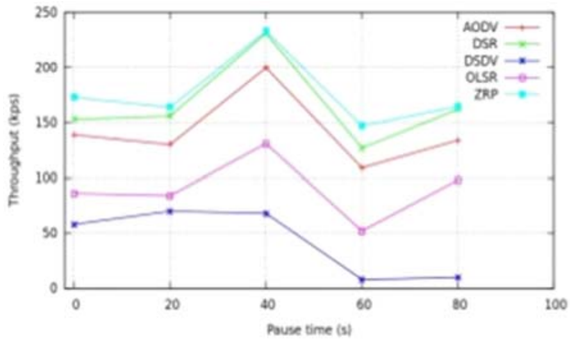


(c) RPGMM

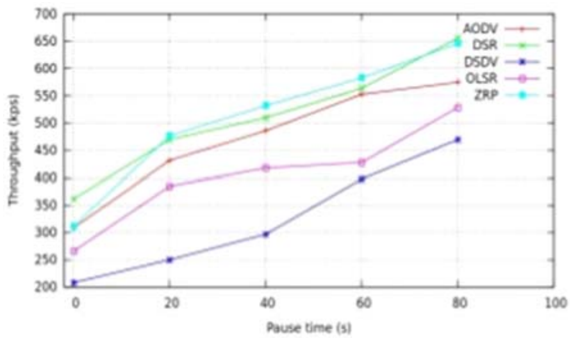
Fig. 5. Throughput of routing protocols under various mobility models - Small area. (a) Random Waypoint Mobility Model, (b) Manhattan Grid Mobility Model, (c) Reference Point Group Mobility Model.



(a) RWMM



(b) MGMM



(c) RPGMM

Fig. 6. Throughput of routing protocols under various mobility models - Large area. (a) Random Waypoint Mobility Model, (b) Manhattan Grid Mobility Model, (c) Reference Point Group Mobility Model.

For the large area, we acquire best results with DSR due to the available path to a destination node, even if in a wide area. And ZRP as a result of dividing spacious simulation area in a small zone which will be easier to verify transmitted packets.

However, for the average end-to-end delay in the two areas, we have best results with proactive protocols DSDV and OLSR, due to their researches in advance and continuous updates or routing tables. So, all the time, they possess correct paths to a destination. But, the worst are obtained with DSR as a result of hidden table without any strategy to erase it, and ZRP due to speed occupied to locate the destination in a specific zone in simulation field.

4. Conclusions

As a reaction to the huge research directed towards mobility models, the principal goal is to analyze performance for any kind of mobile network which is conceived to revivify the real-life scenarios better for applications. Many mobility models have been used to study the mobile ad hoc network performances and evaluate various parameters that can be suitable. This paper aimed to summarize several performance evaluation scenarios of MANET routing protocols under different mobility models.

Table 2. Experimental synthesis results.

Performance metrics	Routing protocols	Mobility models					
		Small area			LARGE area		
		RWMM	MGMM	RPGMM	RWMM	MGMM	RPGMM
PDR	AODV	2	1	1	3	3	3
	DSR	1	4	2	1	2	2
	DSDV	4	2	3	5	5	4
	OLSR	3	3	5	4	4	5
	ZRP	5	5	4	2	1	1
Average end-to-end delay	AODV	3	3	3	3	3	3
	DSR	4	5	4	5	5	5
	DSDV	2	1	2	1	2	1
	OLSR	1	2	1	2	1	2
	ZRP	5	4	5	4	4	4
Throughput	AODV	2	1	1	3	3	3
	DSR	1	4	2	2	2	2
	DSDV	4	2	3	5	5	5
	OLSR	3	3	5	4	4	4
	ZRP	5	5	4	1	1	1

Three mobility models have been applied in order to study the impact of changed metrics as average end-to-end delay, throughput, and the packet delivery ratio. We conclude that AODV offers best results in the small area. It is usually moderate or better for all ninety divers' scenarios. It represents an adaptable routing protocol under varied mobility models for the small and large area. Due to reactive routing approach which leads it to own correct path according to packets transmitted. However, ZRP is the worst. But, it is the best in the large one. And proactive protocols are the worst in this field. Three tracks in mobility modeling are allowed which we achieve the first one in this paper. Basing on one itemized analysis with all these details; leads to well understand the accurate behaviors of routing protocols and mobility models used. Our future work will focus on modeling a human trace mobility model applied in a real world scenario. That will be interesting for mobile P2P application and suitable to a crowded area.

Acknowledgements

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References

[1]. Jonathan Loo, Jaime Lloret Mauri, Jesùs Hamilton Ortiz, Mobile ad hoc networks: current status and future trends, *CRC Press*, 2016.

[2]. Ashish Srivastava, Atul Mishra, Bikash Upadhyay, Akhilesh Kumar Yadav, Survey and overview of Mobile Ad-Hoc Network routing protocols, in *Proceedings of the IEEE International Conference on Advances in Engineering and Technology Research (ICAETR)*, 2014, pp. 1-6.

[3]. S. Umamaheswaran, Naresh Kumar, P. K. Biswas, A survey of routing protocol design patterns for mobile ad hoc networks, in *Proceedings of the IEEE 2nd International Conference on Emerging Technology Trends in Electronics, Communication and Networking (ET2ECN)*, 2014, pp. 1-6.

[4]. Suvadip Batabyal, Parama Bhaumik, Mobility models, traces and impact of mobility on opportunistic routing algorithms: A survey, *IEEE Communications Surveys & Tutorials*, Vol. 17, No. 3, 2015, pp. 1679–1707.

[5]. Guangjie Han, Jinfang Jiang, Chenyu Zhang, Trung Duong, Mohsen Guizani, George Karagiannidis, A survey on mobile anchor node assisted localization in wireless sensor networks, *IEEE Communications Surveys & Tutorials*, Vol. 18, No. 3, 2016, pp. 2220-2243.

[6]. Vinícius F. S. Mota, Felipe D. Cunha, Daniel F. Macedo, José M. S. Nogueira, Antonio A. F. Loureiro, Protocols, mobility models and tools in opportunistic networks: A survey, *Computer Communications*, Vol. 48, 2014, pp. 5-19.

[7]. Youssef Saadi, Said El Kafhali, Abdelkrim Haqiq, Bouchaib Nassereddine, Simulation analysis of routing protocols using Manhattan grid mobility model in MANET, *International Journal of Computer Applications*, 45, No. 23, 2012, pp. 24-30.

[8]. Francisco J. Martinez, Manuel F-ogue, Chai-Keong Toh, Juan-Carlos Cano, Carlos T. Calafate, Pietro Manzoni, Computer simulations of VANETS using realistic city topologies, *Wireless Personal Communications*, Vol. 69, No. 2, 2013, pp. 639-663.

[9]. Qian Dong, Waltenegus Dargie, A survey on mobility and mobility-aware mac protocols in wireless sensor networks, *IEEE Communications Surveys & Tutorials*, Vol. 15, No. 1, 2013, pp. 88-100.

[10]. Daniel Hiranandani, Katia Obraczka, J. J. Garcia-Luna-Aceves, MANET protocol simulations considered harmful: the case for benchmarking, *IEEE Wireless Communications*, Vol. 20, No. 4, 2013, pp. 82-90.

[11]. Saif Al-Sultan, Moath M. Al-Doori, Ali H. Al-Bayatti, Hussien Zedan, A comprehensive survey on vehicular

ad hoc network, *Journal of Network and Computer Applications*, Vol. 37, 2014, pp. 380-392.

[12]. Fahim Maan, Nauman Mazhar, MANET routing protocols vs mobility models: A performance evaluation, in *Proceedings of the 3rd IEEE International Conference on Ubiquitous and Future Networks (ICUFN)*, 2011, pp. 179-184.

[13]. Ola Alsaqour, Raed Alsaqour, Tariq Alahdal, Rashid Saeed, Mohammed Al-Hubaishi, A comparative study of simulation based performance evaluation of routing protocol for ad-hoc networks, in *Innovations and Advances in Computing, Informatics, Systems Sciences, Networking and Engineering, Springer*, 2015, pp. 215-221.

[14]. Arvind Kumar Shukla, C. K. Jha, Rajeev Arya, A simulation study with mobility models based on routing protocol, in *Proceedings of the 5th International Conference on Soft Computing for Problem Solving, Springer*, 2016, pp. 867-875.

[15]. Jogendra Kumar, Broadcasting traffic load performance analysis of 802.11 mac in mobile ad hoc networks (MANET) using random waypoint model (RWM), *International Journal of Information and Network Security*, Vol. 1, No. 3, 2012, pp. 223-227.

[16]. Caleb Phillips, Douglas Sicker, Dirk Grunwald, A survey of wireless path loss prediction and coverage mapping methods, *IEEE Communications Surveys & Tutorials*, Vol. 15, No. 1, 2013, pp. 255-270.

[17]. N. Aschenbruck, R. Gerhards-Padilla, E. Schwamborn, Bonn Motion. A mobility scenario generation and analysis tool, Documentation, Version July 8, 2013, Osnabruck, Germany, 2013.

[18]. Ibadah N., Minaoui K., Rziza M., Oumsis M., Experimental Synthesis of Routing Protocols and Synthetic Mobility Modeling for MANET, in *Proceedings of the 6th International Conference on Sensor Networks (SENSORNETS'17)*, 2017, pp. 168-173.