Location and Non-Location Based Ad-Hoc Routing Protocols under Various Mobility Models: A Comparative Study

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Abstract: *In this paper we present a performance evaluation study of three fundamentally different Ad-hoc routing protocols using different mobility patterns with special focus on three well-known performance metrics, namely the throughput, the end-to-end delay, and the packet loss. Simulations study is carried out in a standard simulator that provides the scalable simulation environment for wireless network systems. The comparative study entails three different protocols, namely the Dynamic Source Routing (DSR), the Location-Aided Routing (LAR), and the Wireless Routing Protocol (WRP). The mobility models employed in this study include the Random Way Point (RWP) mobility model, the Reference Point Group (RPG) mobility model, the Manhattan Grid (MG) mobility model, and the Gauss-Markov (GM) mobility model. The results shows that the performance metrics of Ad-hoc routing protocols vary significantly with the node mobility pattern. It confirms that the speed, with which the node changes its position, considerably affect the network performance. Furthermore, it has been observed that a location-based routing protocol shows quite a good performance with various mobility patterns.*

Keywords: *MANET, routing protocol, mobility model.*

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1. Introduction

A Mobile Ad-hoc Network (MANET) is a collection of mobile nodes where nodes are connected with one another wirelessly. A typical MANET lacks proper infrastructure and a given node in the network receives its data from the source node in a multi-hop fashion. The main advantages of such type of networks are their ease of deployment, popularity, improved flexibility, and reduced costs [4]. Mobile nodes in the network have the ability to self-organize and self-configure as the topology of the network changes. Since MANETs are infrastructure-less, each mobile node performs the functionality of a host as well as a router, to forward data to/from other nodes in the network [16]. That is why there is always a possibility that the target node may go outside the range of the source node transmitting the packets. A routing process plays an important role in finding the path, from the source to the target node, through which to properly forward the data packets within the network [20]. Many routing protocols have been proposed in the literature and a variety of comparative studies have been carried out on these protocols. Almost all comparative studies evaluate network performance using the metrics like, packet delivery ratio, end-to-end delay, packet loss, and energy consumption. But, in reality, the performance of mobile Ad-hoc networks depends on many other things, among which the mobility model isconsiderably important-others include factors like traffic pattern, network topology, radio interference and obstacle positions. It is very difficult to cover all these factors in a single comparative study of Ad-hoc routing protocols [5]*. For the sake of simplicity, many comparative studies have employed only one mobility model, i.e., the Random Way Point (RWP) mobility model, to evaluate the performance of Ad-hoc routing protocols [3, 8]. However, it is generally observed that mobility patterns play an important role in performance of Ad-hoc routing protocols. From the analysis of [5], it is evident that various mobility patterns can lead to completely different performances with the same protocol very differently.

In this paper we present a comparative study of location and non-location based routing protocols. Most of the comparative studies, available to-date, are based only on the RWP mobility model, which shows unrealistic behavior in many scenarios. Simulations study is carried out in Global Mobile Information System Simulator (GloMoSim) which provides the scalable simulation environment for wireless network systems [33]. The comparative study entails Dynamic Source Routing (DSR) [15], Location-Aided Routing (LAR) [18], and Wireless Routing Protocol (WRP) [26]. DSR is a non location based reactive routing protocol working on the principle of source routing. LAR is location based reactive routing protocol

* For a considerable part on the theoretical foundations in this paper, the authors are relying on reference [5].

utilizing location information. WRP which is non location based and employs proactive routing strategy. The Simulations have been carried out using four different mobility models, namely the RWP, the Reference Point Group (RPG) mobility model, the Manhattan Grid (MG) mobility model, and the Gauss-Markov (GM) mobility model. The metrics of throughput, end-to-end delay, and packet loss ratio have been employed for the comparison.

The remainder of this paper is organized as follows. Section 2 gives an overview of the concepts essential for the understanding of this work. This is followed by section 3 which briefly discusses previously conducted comparative studies related to our work and outlines differences with the current study. Section 4 provides an overview of the simulation setup and the performance metrics. Section 5 presents simulation results and performance analysis while section 6 concludes the paper.

2. Background Concepts

Due to the frequent and unpredictable movement of the mobile nodes in the network, routing is a key challenge in MANETs. The challenge is frequent change in topology resulting in partitions in the network due to mobility [4]. To study the performance of networks under different mobility patterns, different mobility models are proposed by the researchers.

2.1. Mobility Models

The mobility model is used to describe the mobility pattern of a node in mobile Ad-hoc networks. It also shows how speed and direction of a node is changed over the time according to a given pattern of mobility [10]. There are two main types of mobility models, i.e., trace based mobility model and synthetic mobility models. The trace based mobility model is used to obtain the deterministic data from the real environment while the synthetic mobility model is an imaginative mobility model. Statistics is used by this mobility model. Statistic model describes the movement behavior of the node in real environment [30]. RWP mobility model, MG, RPGM, and Gauss Markov (GM) mobility models lies in the category of synthetic mobility models. The detail of these mobility models is given below.

RWP is a simple and one of the most commonly used mobility model in MANET protocols for the evaluation of performance metrics in the research community. In this model each mobile node, from the network, moves randomly and freely from the other nodes. The parameters that are used in RWP model are the minimum speed (V_{min}), the maximum speed (V_{max}) and the pause time. Pause time is the time it takes to change the speed and/or direction of a mobile node in the network [25].

The GM mobility model was employed, in the beginning, for the simulation of a Personal Communication Service (PCS) [21]. Nowadays, however, the simulation of MANET protocols also uses this mobility model [4]. Tuning parameter α is used in this mobility model to adapt different levels of randomness. By setting α=0, totally random values are obtained and by setting α=0 linear motion is obtained. By setting the value of α between 0 and 1 intermediate levels of randomness can be obtained. Current speed and direction is assigned to each mobile node at the initial step of simulation. Speed and direction of each mobile node are updated after a fixed interval of time, when n movements occur in the network. The new speed and direction at the n^{th} instance is calculated based upon the value of a random variable d and speed and direction at the $(n-1)^{th}$ instance.

RPG [11] is a mobility pattern that represents the random movement of a group of mobile nodes, as well as the individual random movement of each node within the group, in the network. Movement of a group is based upon the path travelled by a logical centre for the group. With the help of a group motion, vector group movement is calculated by the logical centre for that group. The group centre movement is completely characterized by the movement of its corresponding group of mobile nodes, also including their directions and speeds. Depending on the group movement, each individual mobile node of the network, randomly move about their own predefined reference points. Locations are updated according to the group's logical centre, as the individual reference points move from time t to t+1 [11].

The MG model uses the mobility pattern of mobile nodes on streets defined by maps [2]. The maps are a combination of a number of horizontal and vertical blocks. North and South direction are used for vertical blocks and East and West are used for horizontal blocks. Mobile nodes are allowed to move along the grids of vertical and horizontal blocks on the map. At an intersection point of a horizontal and a vertical block, each mobile node in the network field decide to turn left, right or go straight with certain probability. The probability of moving on the same street is 0.5, the probability of turning left is 0.25 and the probability of turning right is 0.25. The velocity of a mobile node at a time slot is dependent on its velocity at the previous time slot.

2.2. Ad-Hoc Routing Protocols

Ad-hoc routing protocols can fall in two categories, viz. proactive and reactive. Of the protocols, tested in this work, only WRP is proactive and the other two (DSR, LAR1) are reactive in nature. WRP update route information periodically, while in DSR and LAR1 approaches, the routing procedure is based on the demand of source and the routes are established only when needed. Following is a summary of routing protocols evaluated in this paper. The authors of LAR have proposed two Location-Aided Routing algorithms [18] which are the first LAR scheme LAR1 and the second LAR scheme LAR2. The Flooding Algorithm [23] provides the basis for the route discovery procedure. The Algorithm can be improved with the help of location information. In this research work only the LAR1 Algorithm is tested for the selected metrics under different mobility model. In this work, we only consider LAR1. In the first LAR scheme [18], before initiating a route discovery process, the source node calculates the expected zone and defines a request zone in its request packets. During the route discovery process, when an ordinary node receives the route request packet, it forwards the request packet only if it lies in the request zone; otherwise it will discard this packet. When the request packet reaches its final destination, then the destination node replies with a route reply packet that contains its current location, time and average speed. The mobility pattern of the destination node plays an important role in the adjustment of the size of a request zone. The size of the request zone is small in the case of the low speed of the destination node. On the contrary, in the case of fast moving destination node, the size of request zone will be large.

WRP [26], a proactive routing scheme, maintains four types of routing tables at each node. These tables are routing table, distance table, message retransmission list and link cost table. Routing table contains the information about the entries like final destination node's ID and shortest distance to the destination node. For the detection of loop and preventing the counting-to-infinity problem in the networks, the preceding and the succeeding nodes of the shortest path, a tag is used to identify the state of the path, i.e., whether it is a simple path, a loop, or invalid path. In the distance table, a mobile node decides to update its routing table after detecting a change in its link status of the neighboring nodes or receiving an update message from the neighboring nodes and sends acknowledgment ACK back to the node in case of receiving more than one updating messages. The message retransmission list contains information about that neighboring node which has not sent the ACK in response to an update message. The link cost table contains the information about all the neighboring nodes in its table. These update messages can be sent either periodically or in the case of any change in link state. The cost of a failed link is considered to be infinity, and the cost of a normal link is considered to be unity.

DSR [15] is a reactive and on-demand unicast routing protocol in wireless Ad-hoc networks. The topology of the network, in DSR protocol, is completely self-configuring and self-organizing, i.e., no administration is required to maintain the topology of the network. Nodes cooperate with one another to forward packets to reach their final destination in multi-hop fashion. DSR uses dynamic procedure, of route discovery, for the transformation of data from a source route to the destination over multiple hops in Ad-hoc network. Each data packet contains the complete path, from the source to the destination, in its data header. No periodic messages are broadcasted within the network.

3. Related Work

The literature is replete with the comparative studies of various Ad-hoc routing protocols and many of those are very detailed treatments. One such comprehensive evaluation can be found in [4] where the authors present the results of a detailed performance evaluation on two location based routing protocols: LAR and Distance Routing Effect Algorithm for Mobility (DREAM). They then compare the performance of these two protocols with two non-location based routing protocols: the DSR protocol and a minimum standard (i.e., a protocol that floods all data packets). The emphasis has been on the protocols evaluation with high data load during both low and high speeds. NS-2 simulation environment was used for this analysis and only RWP model has been employed. Our comparative study, in contrast, entails DSR, LAR and WRP, with the simulations being carried out using four different mobility models, namely the RWP, RPG, MG and GM mobility models.

In [3], the authors compared four Ad-hoc routing protocols including DSR, Ad-hoc On-demand Distance Vector (AODV), Destination-Sequenced Distance-Vector routing (DSDV), and Temporally Ordered Routing Algorithm (TORA) focusing on packet delivery ratio, routing overhead, and path optimality. NS-2 simulation environment is used for the implementation of these routing protocols. This work provides detailed performance analysis on Ad-hoc routing protocols but only the RWP mobility model was used to check the performance of these routing protocols. Two on-demand routing protocols (DSR, AODV) are selected in [13] for comparison. This comparative study is focusing on packet delivery fraction, normalize routing load, average delay, and normalize medium access load by varying number of nodes, speed, and connection rate. NS-2 simulation environment is used for the implementation of these routing protocols using only MG mobility model. In [14], a similar approach has been adopted with the RWP model.

Das *et al*. [6, 7], present the evaluation of several routing protocols for MANET through packet-level simulations. Maryland Routing Simulator (MaRS) was used for these comparative performance evaluations. The protocol suite includes several routing protocols specifically designed for Ad-hoc routing, as well as for

link state and distance vector protocols, used for dynamic networks. The authors observe that the new generation of on-demand routing protocols use much lower routing load, especially with small number of peer-to-peer conversations. But generally the distance vector and link state protocols provide better packet delivery and end-to-end delay performance.

The Urban Mobility Model (UMM) was proposed in [24] for a realistic city-like scenario whereby it models users' motions, and radio signals' propagation. The authors study the effects of realistic network simulation on routing performance by employing DSR. From the analysis of the results authors observed that a realistic scenario with roads and buildings has a significant impact on the performance of routing protocol.

In [17] the authors present an overview of the broadcasting techniques in mobile Ad-hoc networks and then implement the simple flooding algorithm and probability based flooding algorithm with respect to normalized routing load. A survey can be found in [32] that classify existing broadcasting schemes into categories and then compares the sample protocols from each category. The comparison is simulation based and is designed to test the protocols under specific conditions of increasing neighbor density, traffic rates and node mobility. Each simulation study allows the authors to identify the deficiencies that are relevant to MANETs, e.g., bandwidth congestion and dynamic topologies in the protocols, and propose solutions to correct for specific problems.

Two multipath techniques for the DSR protocol which use disjoint paths have been proposed in [27]. For this purpose authors develop an analytical modeling framework to evaluate the performance advantage of these multipath techniques. The modeling framework is also useful for performance evaluation of on-demand routing protocols regardless of the use of multiple paths. The authors evaluate the performance of one of the two proposed multipath routing protocols using simulations in order to confirm the validity of analytical model.

A simulation based analysis of Ad-hoc network performance at three layers (physical layer, network layer, and transport layer) using four different mobility models, with AODV being the routing protocol and TCP as the transport protocol, is presented in [9]. The authors identify some counterintuitive results, which they justify by correlating the behavior measured at the three layers. An energy-based performance comparison of some well-known routing protocols (AODV, DSR, TORA, and DSDV) is carried out in [5]. These protocols are simulated and compared using three different mobility models, namely the RWP, the RPG, and the MG, by using the NS-2 simulator with various scenarios. The results show significant energy conservation difference among the mobility models employed. An analysis from a quite different angle can be found in [28] which focuses on the performance evaluation of location update schemes for MANET based on Markov chains.

The impact of the mobility model on the performance of a specific network protocol is investigated in [11]. For this purpose they have applied their own RPG model to two different network protocol scenarios, clustering and routing. In addition, they check the performance of the network under different mobility patterns, i.e., random mobility model, in-place model, overlap model and the convention model for different protocol implementations, i.e., DSDV, AODV, and Hierarchical State Routing (HSR) [12]. Their results show that different mobility patterns affect various protocols in different ways. They observe that the ranking of routing algorithms is also influenced by the choice of the mobility pattern. The performance comparison of AODV under four different mobility models, including random walk, RWP, random direction and boundless simulation area mobility models has been studied in [1] under Scalable Wireless Ad-hoc Network Simulator (SWANS). For comparative results, the authors employ a variety of simulation settings and parameters under these mobility models. Two Ad-hoc routing protocols unicast DSR and Broadcast Routing (BCAST) [19] protocol are selected in [8]. These protocols are selected over a group oriented communication system based on the metrics of packet delivery ratio, packet latency, normalized routing load, normalized MAC load, and throughput. NS-2 simulation environment is used for the implementation of these routing protocols. This work analyzes the detailed performance analysis on Ad-hoc routing protocols but under a single mobility model, i.e., RWP.

In [22], the authors first implement a tool for generating a special trace mobility model which is called ant mobility model. Using this mobility model, DSDV, DSR, and AODV are selected to check the performance of these protocols focusing on the metrics like throughput, network latency, and controls overhead messages. NS-2 simulator is used for this purpose. In order to check the feasibility of ant mobility model authors also compare the result of Ant mobility model with RWP mobility model based upon the same protocols and performance metrics and using the same network simulator. The effect of the different mobile node movement pattern is analyzed by the authors in [29]. For this purpose, they use the RWP mobility model, Random Walk Mobility Model (RW) and Random Direction Mobility Model (RD) over AODV focusing on the routing overhead, throughput, and packet delivery ratio. This comparison was conducted by using the discrete-event simulator OMNeT++. From the analysis of the above literature review, we conclude that a lot of comparative studies have been carried out based on one or more mobility models in MANETs, but few of these have addressed the evaluation of these performance metrics in such a in perspective. Our work is touching upon the issue with a previously unused mélange of mobility models that includes RWP, MG, GM, and RPGM. This investigation study is, hence, based upon different category of Ad-hoc routing protocols using four different mobility patterns under the GloMoSim simulator.

4. The Simulation Setup

4.1. Performance Metrics

The performance metrics that were employed for this comparative study entails the throughput, the end-to-end delay, and the packet loss ratio [31]. Throughput is the ratio of the number of packets received by the destination node to the number of packets originated at the CBR source. It is usually expressed as a percentage. End-to-end delay is assumed to be the average amount of time that a packet takes to reach its final destination. Finally, the packet loss is the difference between the number packets delivered to that node over the number of packets generated by CBR and the successfully packets received by the destination node [31].

4.2. The Simulation Tool

The GloMoSim simulator [33] is used for the comparative study of Ad-hoc routing protocols using the four mobility models. All nodes use 802.11 based wireless radios with the transmission range of the nodes set to 50m and a nominal transmission rate of 2 Mbps. All simulations are performed with 100 mobile nodes in a rectangular area of 1500m x900m. The length of each simulation is 200 seconds. All network layer operations of the wireless network interfaces are logged which is used in post-simulation analysis.

4.3. Mobility and Traffic Scenario Generation

BonnMotion* is used to generate movement patterns for all of the four mobility models: MG, RWP, GM, and RPGM. In each model, nodes move in patterns as described in the given parameter tables. To see the speed impact on the network performance, we change the node mobility by varying the maximum speed in each mobility scenario. There are four speed levels: 5m/s, 10m/s, 15m/s, 20m/sec. To provide traffic load to the Ad-hoc network, 10 Constant Bit Rate (CBR) traffic streams are set up for each simulation. Each CBR traffic source sends 10 packets per second with packet size of 512 bytes. The traffic sources and destinations are chosen uniformly from all mobile nodes. All analyses were performed over the average diverse category of Ad-hoc routing protocols (location and non location based) as has been done in the work value of the 3 cases. For the fairness of protocol comparison, each Ad-hoc routing protocol is run on the same set of scenarios. We choose a set of reasonable parameters for each model, measuring the performance of these metrics, as defined in [9].

4.4. Simulation Parameters

The simulation parameters that are used in this comparative study, for different mobility models, are listed in Table 1.

Table 1. Simulation parameters for the selected mobility models.

S/no	Model	Simulation Parameters	Values used in Simulation
1	RWP	a. Pause time	0 sec
		b. Max Speed	5,10,15,20m/sec
		c. Min speed	0 m/s
2	MG	a. Min speed	0 m/sec
		b. Pause probability	0.1
		c. Update distance	10m
		d. Speed change probability	0.1
		e. Mean speed	5, 10, 15, 20 m/sec
		f. Turn probability	0.3
		g. No of blocks along y-axis	2
		h. No of blocks along x-axis	10
3	RPGM	a. Max speed	5, 10, 15, 20 m/sec
		b. Average no of nodes per group	5
		c. Group change probability	0.3
		d. Max distance to group centre	5m
4	GM	a. Max speed	5, 10, 15, 20 m/sec
		b. Angle standard deviation	45degree
		c. Speed standard deviation	0.5 m/sec
		d. Speed, angle update frequency	10 sec

5. Simulation Results

The results of the simulation based on the throughput, end-to-end delay, and packet loss analysis, for various speeds, are being discussed in the following paragraphs.

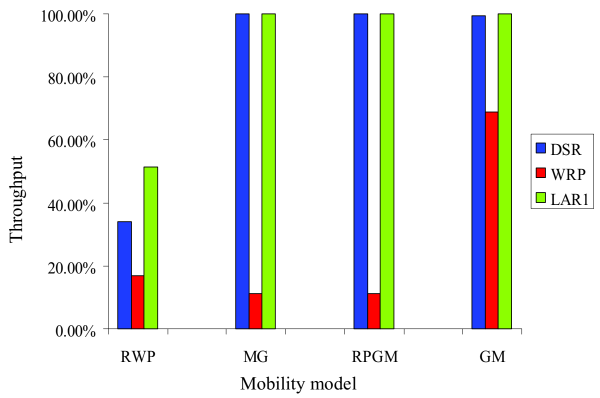
5.1. Throughput Evaluation

DSR, LAR1, and WRP were analyzed under different mobility models. The network load was kept constant at 10 packets/second networks load and the speed of nodes is varied and fixed at 5, 10, 15, and 20m/s. Results exhibit that LAR1 protocol under RWP, MG, RPGM, and GM mobility model outperforms DSR and WRP in terms of throughput. Simulation results are given in Figure 1. These figures clearly show that for

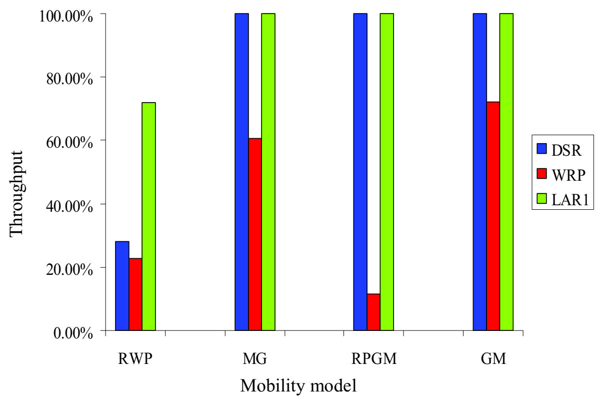
* http://net.cs.uni-bonn.de/wg/cs/applications/bonnmotion/

LAR1 protocol, throughput is highest in case of all mobility models at different speeds of graphs.

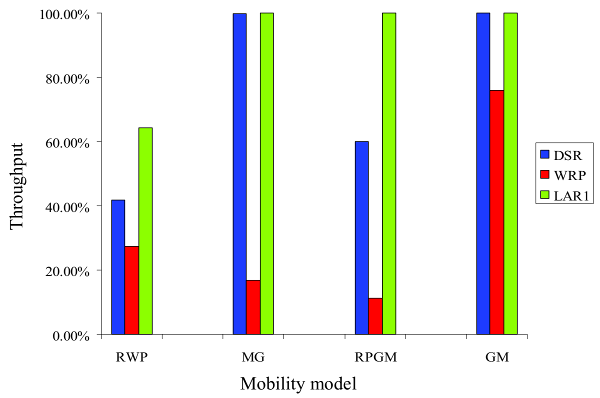
Throughput metric is almost equal to 100% for these three mobility models. But in the case of random way point mobility model, LAR1 exhibits poor performance as compared to the rest of the three mobility models. The reason for this may be the high speeds in the case of the RWP Mobility Models that causes more link breakage and as a result the throughput decreases drastically. But as compared to the other two protocols the throughput of LAR1 is still higher under this model. The throughput for WRP is less than both DSR and LAR1 in all cases. The reason may be due to its proactive nature and periodically update the routing tables in the network will decrease the average throughput level in the networks in case of WRP.



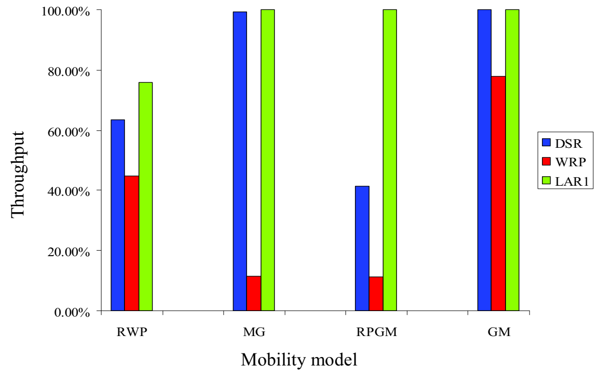
a) 20 m/sec.



b) 15 m/sec.



c) 10 m/sec.

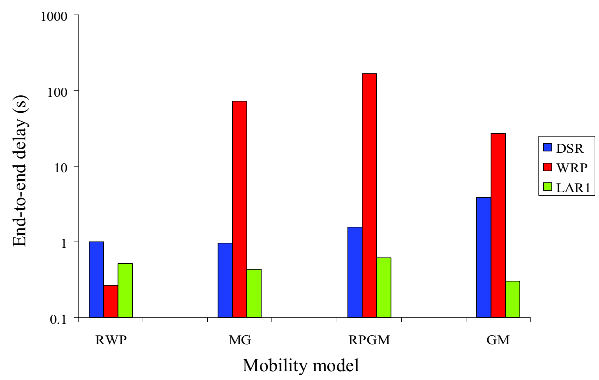


d) 5 m/sec.

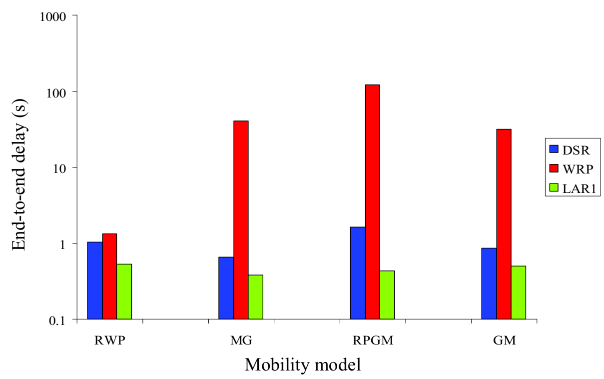
Figure 1. Average throughput with 10 packets per second payload at various speeds.

5.2. Evaluation Based on End-to-End Delay

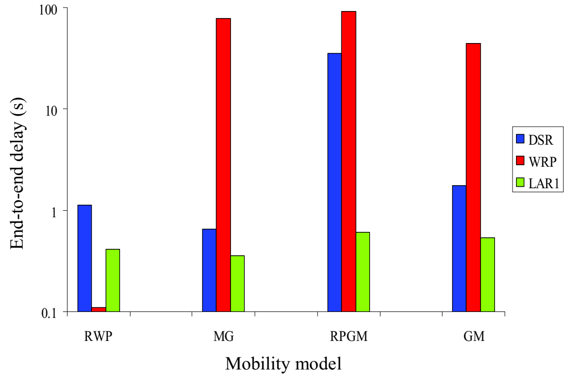
Figure 2 shows the performance of DSR, LAR1, and WRP protocols in terms of end-to-end delay under different mobility models with 10 packets/second networks load. The speeds of nodes are 5, 10, 15, and 20m/s respectively. The LAR1 protocol exhibits lowest end-to-end delay as compared to other two protocols under all mobility models at different node speeds. The end-to-end delay is at its maximum at the speed of 20m/sec which was expected as the speed increases, connectivity decreases and hence higher delays are incurred. The end-to-end delay for WRP is worse than both DSR and LAR1 in all the cases. This may be due to its proactive nature and the periodic updates of the routing tables in the network will increases the end-to-end delay in the networks.



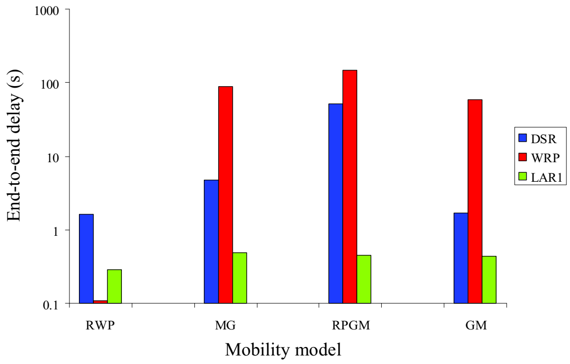
a) 20 m/sec.



(b) 15 m/sec.



c) 10 m/sec.

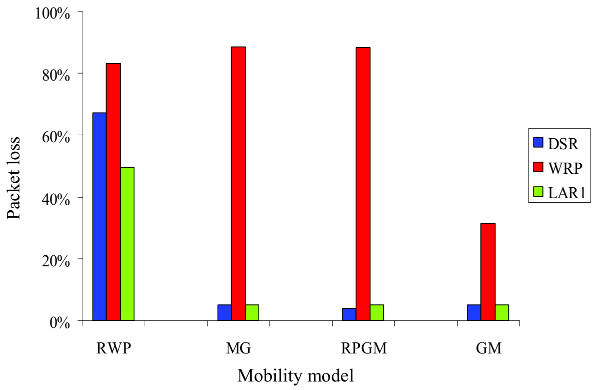


d) 5 m/sec.

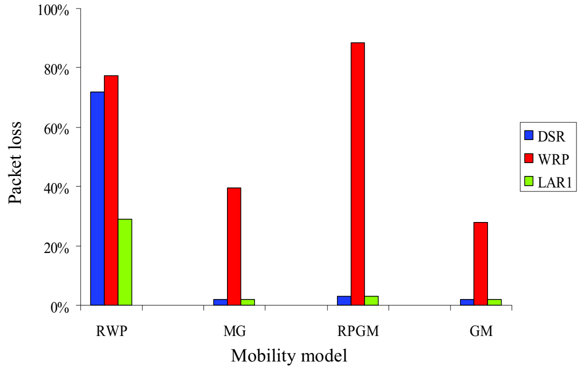
Figure 2. Average end-to-end delay with 10 packets per second payload at various speeds.

5.3. Packet Loss Evaluation

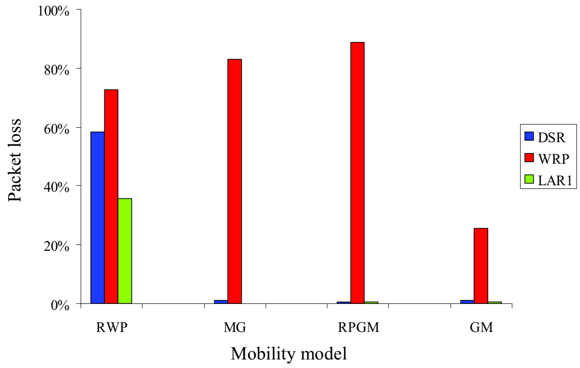
Figure 3 shows the packet loss ratio for the three protocols with respect to the four different mobility models. LAR1 incurs least packet loss with respect to all mobility models under different node speeds (5-20 meter/second). For the RWP mobility model, packet loss is on the higher side as compared to the other three mobility models under different node speeds. Packet loss for WRP is greater as compared to DSR and LAR1 under all the mobility models. Thus simulation results suggest that LAR1 protocol performs better in terms of lower packet loss at different speeds under MG, RPGM, GM mobility models.



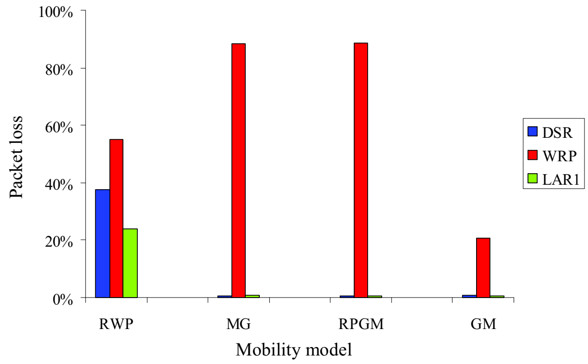
a) 20 m/sec.



b) 15 m/sec.



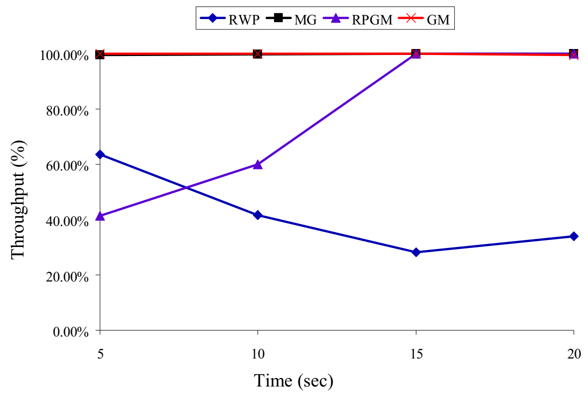
c) 10 m/sec.



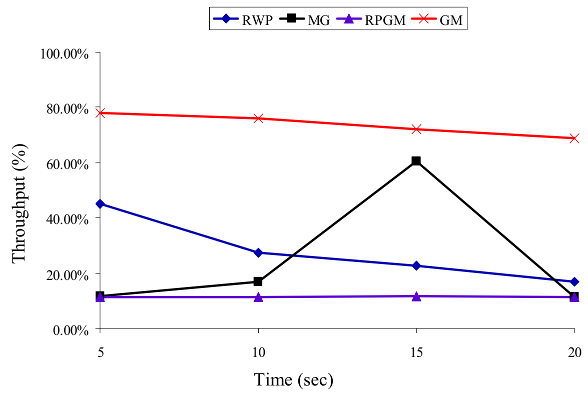
d) 5 m/sec.

Figure 3. Average packet loss with 10 packets per second payload at various speeds.

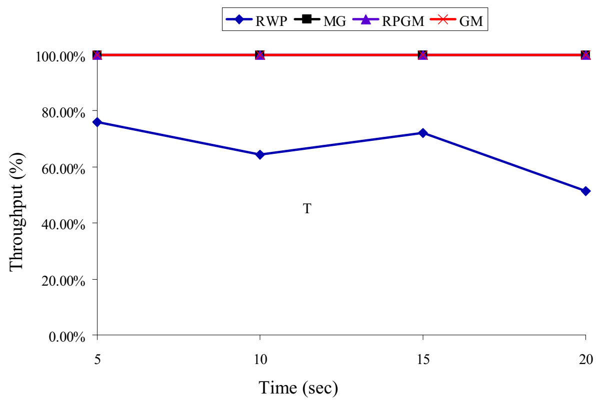
To compare the four mobility models under a given protocol, out of the three, we are relying on the throughput ratio at various network speeds, as shown in Figure 4, Figure 4-a shows the throughput of DSR protocol with respect to different mobility models. It is evident from the figure that the throughput of under DSR is affected by the mobility model used. For instance in the case of GM and MG mobility model, the throughput for DSR is always greater than 95% for different speeds (5-20 meter/second). On the other hand, for RPGM, throughput decreases rapidly as the speed increases. At a speed of 5 m/sec, the throughput is almost 100% which rapidly decreases to 40% at a speed of 20 meter/second. For RWP mobility model, at 5 meter/second speed, the throughput is 62% and it also gradually decreases to 40% at 20 meter/second speed. So RWP and RPGM mobility models severely affect the performance of the DSR in terms of throughput. Figure 4-b plots the throughput of WRP protocol with respect to different mobility models. It can be seen from the figure that throughput of WRP is effected by the mobility model used. For instance, in the case of GM mobility model, throughput for WRP almost remains constant ranging between 75 and 80% with respect to different speeds of nodes. On the other hand, throughput has the minimum values for RPGM mobility model and MG mobility model. Figure 4-c shows time dependent throughput of LAR1 protocol with respect to different mobility models. It can be seen from the figure that throughput of LAR almost remains above 95% for GM, RPGM, and MG mobility models at different speeds of nodes. On the other hand, for the RWP mobility model, the throughput fluctuates between 80 and 60% for different node speeds.



a) DSR.



b) WRP.



c) LAR1.

Figure 4. Speed dependent variation in throughput for various protocols under the three mobility models.

6. Conclusions

This research has been analyzed and confirmed with the help of simulations based routing protocol. It has a very good performance for throughput end to end delay and packet loss using four different mobility models when compared with non location based routing protocols. The analysis of the throughput suggests that LAR1 with MG performs almost 100% due to the restricted mobility area which is in grid form according to selected parameters of this mobility model. The GM mobility model exhibits the best performance in terms of the selected metrics due to the reason that the nodes move in this model according to their previous position. The LAR1 mobile node predicts its new location due to a localization scheme before sending the actual data. LAR1 exhibits the best performance on RPGM, thanks probably to what is called a group leader which serves as the logical center of its respective group. The member nodes of a group are almost evenly distributed around their leader who is responsible for the group's mobility; the members are however random in their motion both in directions and speed. The extra robustness of the RWP model, in the case of LAR1, as compared to non location based routing protocols due to its localization scheme. This may be attributed to the fact that the RWP model tends to distribute the nodes in such a way that they can move freely/randomly and independently in the network without considering the previous position of node the result will be the maximum amount of path breakage. The better performance of LAR1 as compared to other two protocols may also be due to the former's localization scheme.

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