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Performance Evaluation of LAR protocol using real dataset on Highway and City Scenario

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Abstract

Vehicular ad-hoc networks have gained immense popularity as a research domain as more and more vehicles interact with each other to communicate information. This paper is aimed at evaluating the performance of Location Aided routing protocol (LAR) for Vehicular Ad-hoc networks (VANETs) using NS2 and SUMO. This protocol is evaluated under highway and city scenarios obtained from Open Street Map (OSM) and Bologna Ringway dataset respectively. The performance metrics considered for these scenarios are throughput, packet delivery ratio (PDR), routing overhead. The above mentioned parameters are calculated by varying the simulation time and number of vehicles. The results obtained are graphically plotted and analyzed.

Keywords

LAR;
VANETs;
routing protocols;
city scenario;
real dataset;
highway scenario;
open-street map

1. Introduction

Vehicular Ad-hoc network (VANET) is an extension of Mobile ad-hoc network (MANET) wherein vehicular nodes communicate with each other as opposed to mobile devices communicating with each other in MANETs. In VANETs vehicles communicate in either of the two modes: vehicle-to-vehicle (V2V) or vehicle-to-infrastructure (V2I) [1]. These networks are characterized by high vehicular density and highly dynamic nature of vehicles wherein vehicles keep moving in and out of the network. Based on their modes of communication VANETs find wide applicability in several safety related applications wherein a driver can be notified prior to occurrence of some crash or other hazardous road related conditions. A large number of entertainment and comfort applications such as gaming, advertisements to attract customers to their stores or announcements like petrol pumps, highways restaurants to announce their services to the drivers within communication range are also supported by these networks [2].

In this paper a position based location-Aided Routing *(LAR)* protocol is used for analyzing the performance of VANETs. This protocol relies on location information of the nodes in order to discover routes from source node to the destination node by confining the search to a smaller request zone [3]. It leads to a considerable reduction in the routing overhead as opposed to certain topology-based routing protocols like AODV and DSR. LAR works under two schemes, as per scheme 1 the sender knows in advance the location of the destination at certain time instance and the speed with which it is moving. The sender makes use of this meta-data and begins the discovery of route up to the destination for the current time instance. RREQ packets forwarded by sender to any node not lying within the request zone are rejected by them. As per scheme 2, source node has prior information about the destination's location based on which it computes its distance up to the destination node. The computed distance and location of the destination node are forwarded to the intermediate nodes which decide whether to forward it to the next nodes or to discard it based on its own distance from the destination.

LAR scheme is evaluated by using the following performance metrics: Throughput, Packet delivery ratio and routing overhead. Rest of the paper is organized as: Section 2 is about related work, In Section 3 we present the simulation framework, Section 4 comprises experimental results and finally Section 5 presents the conclusion followed by references.

2. Related Work

In paper [4] vehicular interaction is analyzed for a road map of JNU. The whole network is partitioned into smaller sub regions. The selection of path by drivers in real time is incorporated to ensure vehicular communication. They have evaluated the performance of AODV routing protocol in terms of Delivery ratio, Packet loss and Router dropfor the above scenario. In paper [1] the performance of AODV, DSR and DSDV is evaluated for the highway scenario of China. Routing metrics such as: delivery of packet quotient, end to end delay and routing load has been measured. It was seen that these protocols could not find their suitability in such dynamic networks.

In [5] an analysis is presented for three algorithms i.e. AODV, DSR, LAR and based on the traffic situation it is decided as to which routing protocol to opt for. It is observed that LAR protocol outperforms the other two protocols in terms of all the performance metrics considered. DSR shows worst performance amongst them. In [6] a performance evaluation scheme is presented to monitor the traffic conditions in the city of Rome. The location of taxis moving around in the city are captured and analyzed for the bottleneck caused by them. They compare the results with classic mobility models and observe the effect on information exchange by both the models.

In [7] an extension to the existing LAR protocol is provided which is a direction based strategy. This protocol improves the performance of routing by applying the concept of selective forwarding of packets. For this purpose, a specific area is selected beforehand in which the packets will be forwarded and also the node sender of such a packet will be selected a priori. This scheme works well for highly populated environment. In [8] performance evaluation of urban environment is presented with respect to different routing protocols namely GPSR, AODV, OLSR, DSDV and DSR. In the urban scenarios a lot of commotion is observed due to high rise towers which leads to a significant drop in the messages delivered across different vehicles. It is observed that most of the protocols mentioned above fail to produce the desired results for this scenario due to the interference caused by obstacles. The GPSR protocol however produces better results than other protocols.

3. Simulation Framework

We have conducted the simulation for analyzing the performance of LAR protocol under two different environment scenarios. The first scenario which is a highway region is obtained from Open Street Map (OSM) as depicted in Figure 1. We have taken the highways around Delhi, in particular NH-24, NH-34, NH-9, and NH-44. The traffic is randomly generated on this network with the help of randomTrips tool present in the traffic simulator SUMO. Second we take a real world data set of the city of Bologna wherein the network is already present and there exists a predefined route and communication link between vehicles. The traces of traffic for Bologna city are obtained from the peak hour traffic i.e. between 8 am to 9pm [9]. The traffic flows for both the scenario can be visualized using GUI of SUMO as depicted in Figure 2 (a) and Figure 2 (b) respectively. Further Figure 3 presents the working flow of our implementation.

Figure 1. Extracted image of Delhi highway from OSM

Figure 2(a). SUMO visualization Delhi highway map

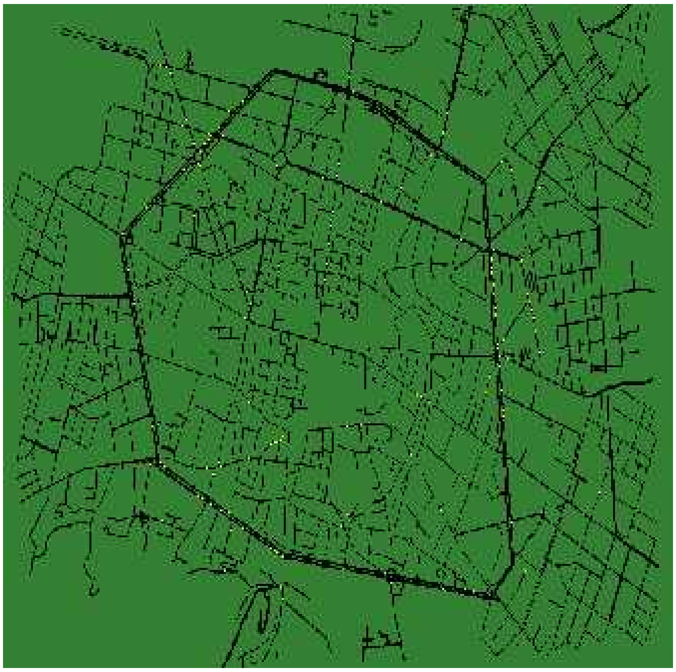

Figure 2(b). SUMO visualization of Bologna city dataset

The process begins by capturing the map from OSM or obtaining the real dataset from Bologna. For the OSM map the network and routes are created and vehicles are randomly deployed. Once the route and network are developed then mobility traces are generated for both the scenarios. The LAR protocol is then run on the mobility traces obtained in the previous steps with the help of NS2. The trace file thus generated is run with the awk scripts to measure the rate of throughput, packet delivery ratio and overhead produced while these vehicles communicate.

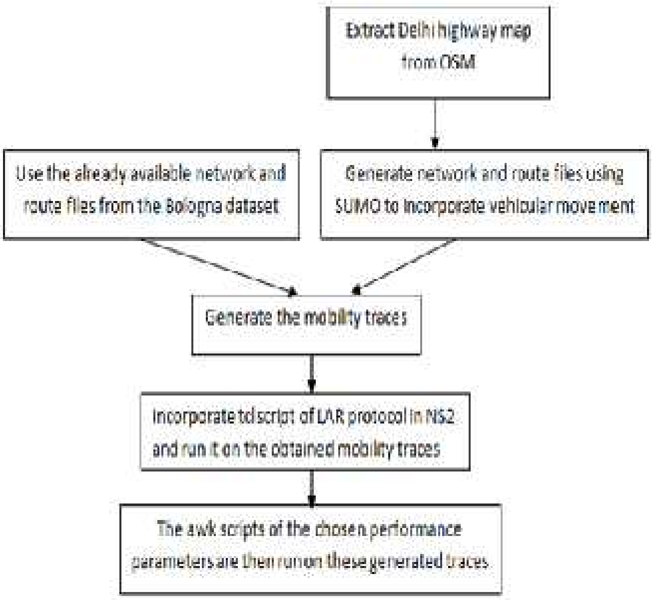

Figure 3. Working flow of the implementation

4. Simulation Framework

The experiments have been performed using the traffic simulator SUMO-0.31.0 and a network simulator NS2.32. These have been opted considering their compatibility with Ubuntu 11.04. Python 3.6 is used to generate random trips for the Delhi highway map extracted via OSM. The experiment has been carried out considering two cases under each of the chosen scenario with Table 1 providing a complete set of details for the chosen simulation parameters.

Table1. Simulation Parameters

Parameter	**Specification**
MAC protocol	IEEE 802.11 DCF
Data Type	Constant Bit Rate (CBR)
Radio Propagation Model	Two-Ray ground reflection model
Channel Type	Wireless
Antenna Model	Omni
Routing Protocol	LAR
Data Packet Size	512 Kbps
Bandwidth	2 Mbps
Simulation Time (seconds)	500,1000,1500,2000, 25000 (Highway scenario) 200,400,600,800,1000 (City scenario)
Number of vehicles	100~500

Next we discuss the metrics that have been considered for monitoring the performance of LAR protocol. Following are the metrics considered:

Throughput– it is defined as the ratio of number of packets transmitted per unit time. In our experiment the unit of throughput is considered to be kbps [10].

Packet delivery ratio- it is defined as the ratio of number of bits transferred by the sender to that received by the receiver. Congestion in the network tends to increase the value of this ratio [11].

Overhead – it is defined as the amount of extra packets that have to send during the transmission of actual information during routing [12].

For the highway scenario an average of five iterations for each set of nodes ranging from 100~500 has been considered to determine each of the metric. The graphical results thus obtained for each of the metric by varying the simulation time in the range 500~2500 (seconds) and plotting it against the average of results obtained for each of the performance metric, considering all the iterations of 100 and 500 nodes lie under case one. They are depicted in Figure 4(a), Figure 4 (b), Figure 4(c).

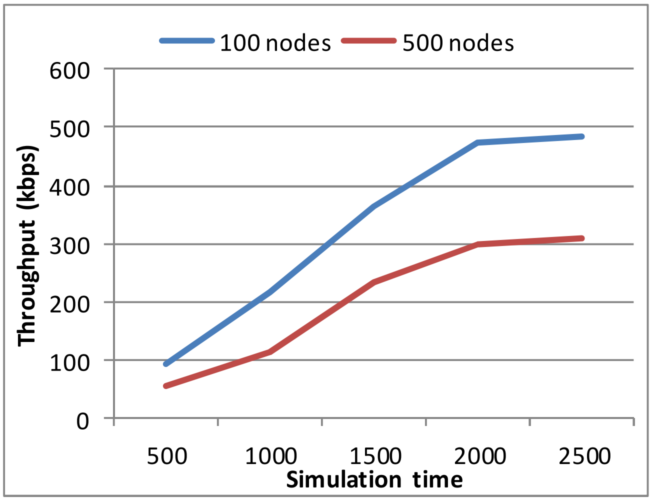

Figure 4(a). Throughput 100 and 500 nodes against the variability in simulation time

As per Figure 4 (a), it can be seen that the average throughput shows a sharp increase with the increase in simulation time till the time reaches nearly 2000 (close to the peak maximum time chosen) beyond which the throughput shows a considerably linear increase with increase in time for both the sets of 100 and 500 nodes.

In Figure 4 (b) average packet delivery ratio for the set of 100 nodes is seen to show a sharp decrease till simulation time reaches1000 seconds beyond which a linear increase till the maximum time instance i.e. 2500 seconds is observed. For the set of 500 nodesa constant increase is seen till 1000 seconds with a sharp drop beyond this value till it is increased beyond 1500 seconds. Any further increase in the simulation time till the maximum chose time instance shows a linear decrease in the PDR.

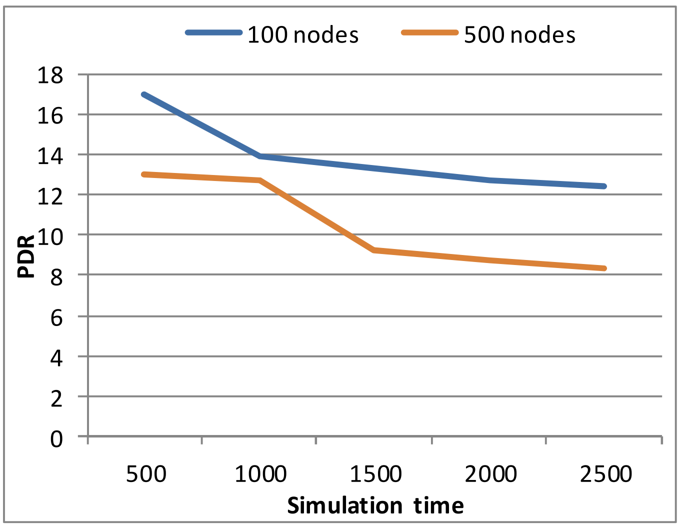

Figure 4 (b). PDR of 100 and 500 nodes against the variability in simulation time

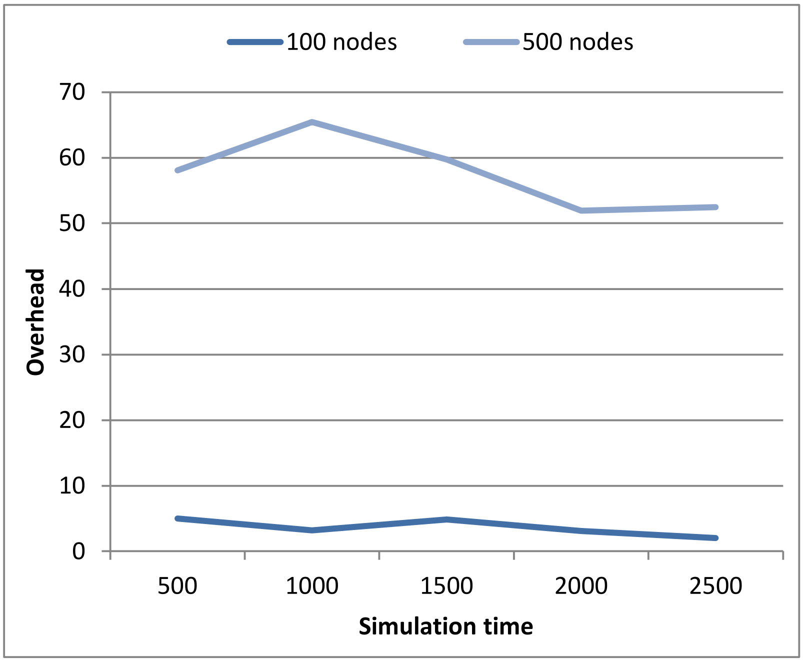

Figure 4(c).Overhead of 100 and 500 nodes against the variability in simulation time

As per Figure 4 (c) we can see that for a set of 100 nodes against all the time instances the overhead is shows a sharp increase in its values till 1000 seconds, beyond which a drastic decease in the value can be observed on further increasing the time instance till 2000 seconds. a further increase in the time up till the already set maximum allowable limit shows a linear increase in its value.

On the contrary for the set of 500 nodes, a relatively gradual decrease in values till 1000 seconds followed by a gradual increase and then a linear decrease can be seen. A smoother zigzag curve can be seen in this case.

In Figure 5 (a) the average throughput for the all the sets of nodes ranging from 100~500 for the 1000 time instance shows a very sharp decrease in its value on increasing the number of vehicles from 100 to 200. A further increase in the vehicle count shows an approximately linear increase in the throughput values.

For the 2000 time instance the throughput values are seen to show a considerable decrease on increasing the number of vehicles, followed by a sharp increase till the number of nodes are increased till 400 and till it reaches the chosen maximum set of nodes i.e. 500 a drastic decrease can be seen as opposed to a linear decrease for 1000 time instance.

An increase in number of nodes for a fixed chosen area leads to a very high chance of increase in collisions amongst these nodes thereby leading to a decrease in throughput values.

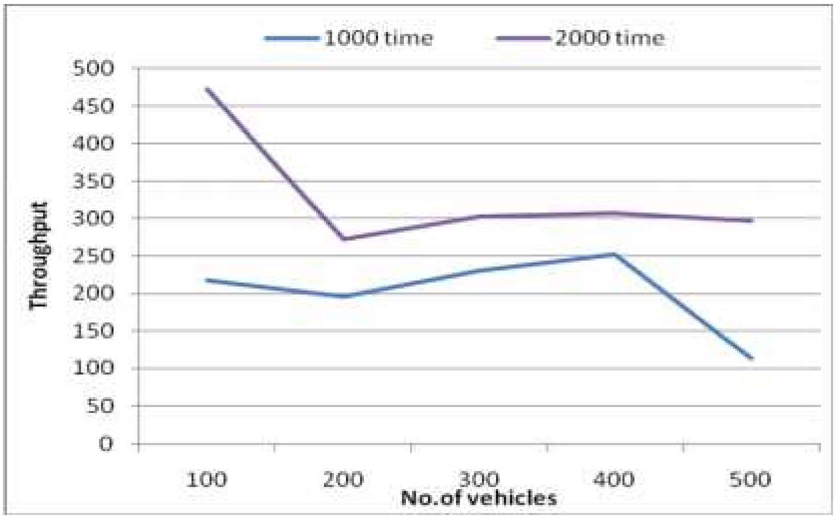

Figure 5 (a). Throughput for 1000 and 2000 time instances against the variability in number of vehicles

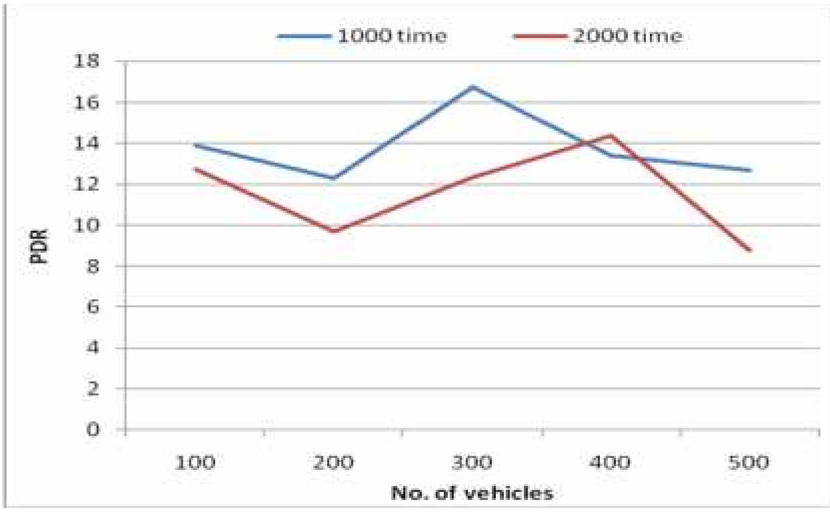

Figure 5 (b). PDR for 1000 and 2000 time instances against the variability in number of vehicles

In Figure 5 (b) the average PDR for all the five iterations of vehicles against 1000 and 2000 time instance is seen to show a sharp decrease for till 200 vehicles. On further increasing the number of vehicles we can observe a drastic increase in the PDR value till number of vehicles reach to 300 for the 1000 time instance and for 2000 time instance increase persists till 400 numbers of vehicles.

Further increase in number of vehicles leads to strong decrease in the PDR value for the 1000 time instance till vehicle count becomes 400. Increase in the vehicle count beyond this leads to a less sharper decrease in PDR values. For the 2000 time instance a severe decrease in PDR value persists as long as numbers of vehicles are increased till they reach the maximum chosen value i.e. 500.

Figure 5 (c) depicts that graphs follow a similar trend for both 1000 and 2000 time instance. An increase in a number of vehicles is represented by a sharp increase in average overhead values till the count of vehicles reach 300. Further increase in vehicle count up to 400 is observed to show a considerably smooth decrease in the average overhead values. This is followed by a sharp increase in average overhead values for an increase in vehicle count till the maximum chosen values i.e. 500.

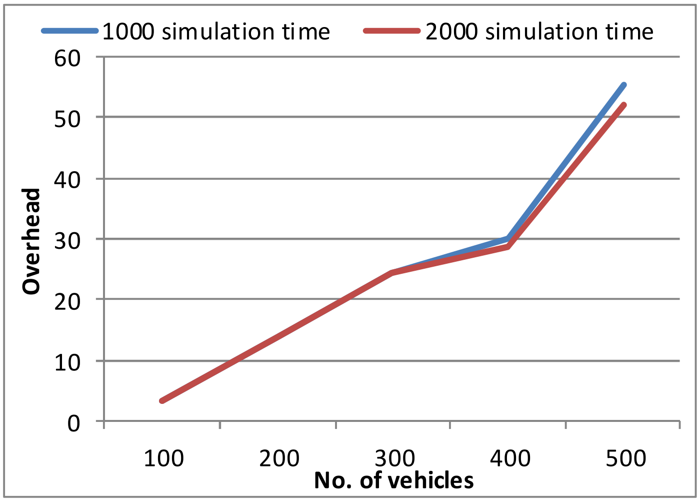

Figure 5 (c). Overhead for 1000 and 2000 time instances against the variability in number of vehicles

For the real world dataset of the Bologna city [9] scenario same cases have been considered. Case one comprises five iterations for each set of nodes ranging from 100~500. The graphical results thus obtained for each of the metric by varying the simulation time in the range 200~1000 (seconds) and plotting it against the results obtained for each of the performance metrics are depicted in Figure 6 (a), Figure 6 (b), Figure 6 (c). Case two comprises visualization of results for the values obtained by varying the number of vehicles/nodes in the range 100~500 for both two fixed time instances 200 and 1000.

Thus similar to the highway scenario case one depicts variability in terms of simulation time for two sets of nodes 100 and 500 and case two accounts of variation in number of vehicles moving in the chosen area for two fixed instances 200 and 1000 sec. The obtained results for case two are shown in Figure 7 (a), Figure 7 (b) and Figure 7 (c). Low initial simulation time for this scenario in comparison to the highway scenario is done to ensure faster execution of LAR protocol, proceeding for larger values lead to a considerable increase in the time complexity.

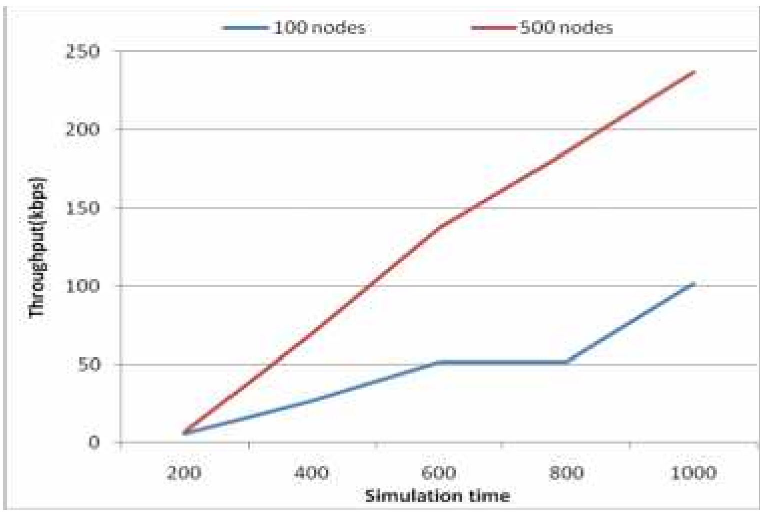

Figure 6 (a). Throughput 100 and 500 nodes against the variability in simulation time

In fig 6(a) it can be observed that as the time increases the throughput increase almost linearly for 500 nodes. For 100 nodes the increase is not exactly linear. Also it is observed that for the same time instances the throughput achieved by 500 nodes is more than that of 100 nodes because more number of packets is delivered by 500 nodes during a simulation time. In fig 6 (b) it is observed that packet delivery ratio drops considerably for 500 nodes and with a less margin for 100 nodes. Also the packet delivery ratio is less for 100 nodes as compared to 500 nodes for same simulation time. In fig 6 (c) we observe that for 500 nodes, overhead increases as the simulation time increases. The increase however is not sharp it is rather slow. For 100 nodes the overhead is very low and nearly remains constant all throughout.

In fig 7 (a) it is observed that the throughput initially increases as the number of nodes increase but gradually its starts falling as more nodes are added. This happens because as the number of vehicles increase the number of collisions also increases therefore less number of packets will be exchanged.

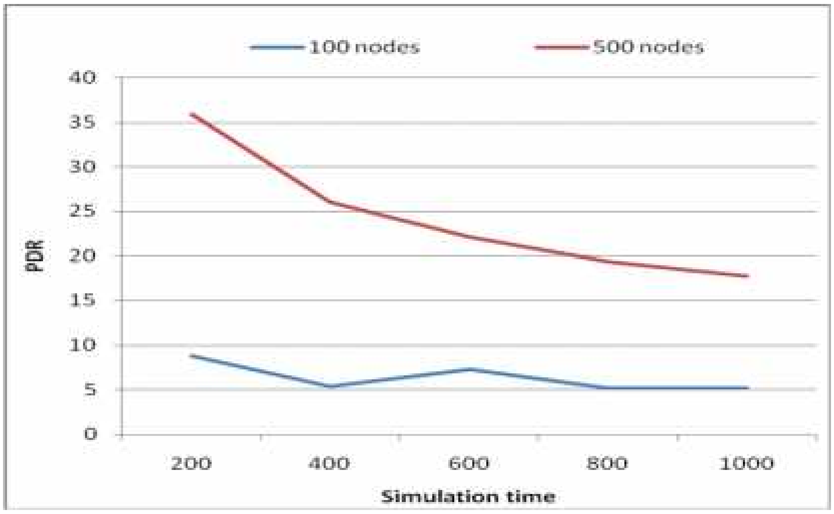

Figure 6 (b). PDR 100 and 500 nodes against the variability in simulation time

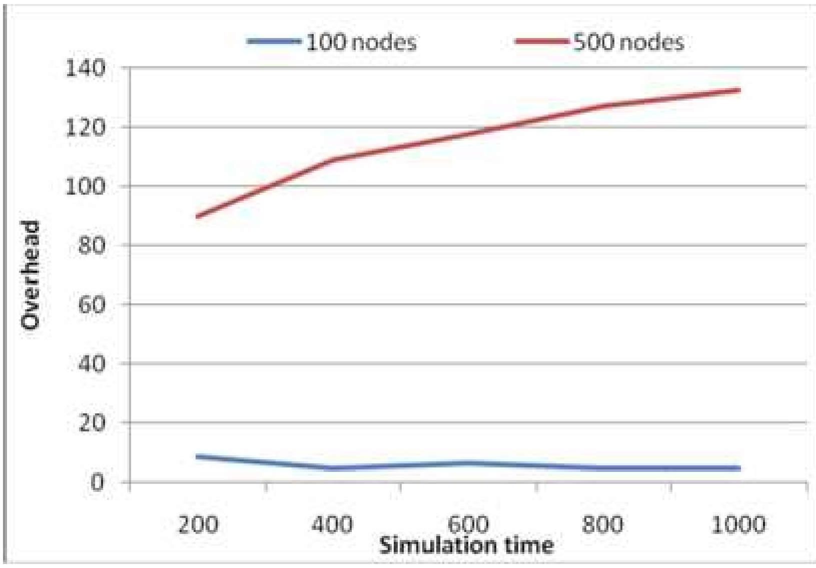

Figure 6 (c). Overhead 100 and 500 nodes against the variability in simulation time

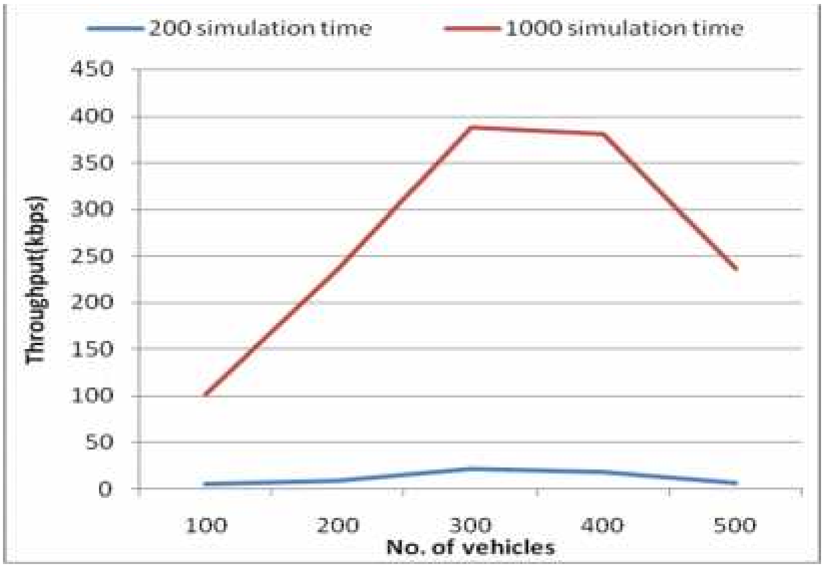

Figure 7 (a). Throughput for 200 and 2000 time instances against the variability in number of vehicles

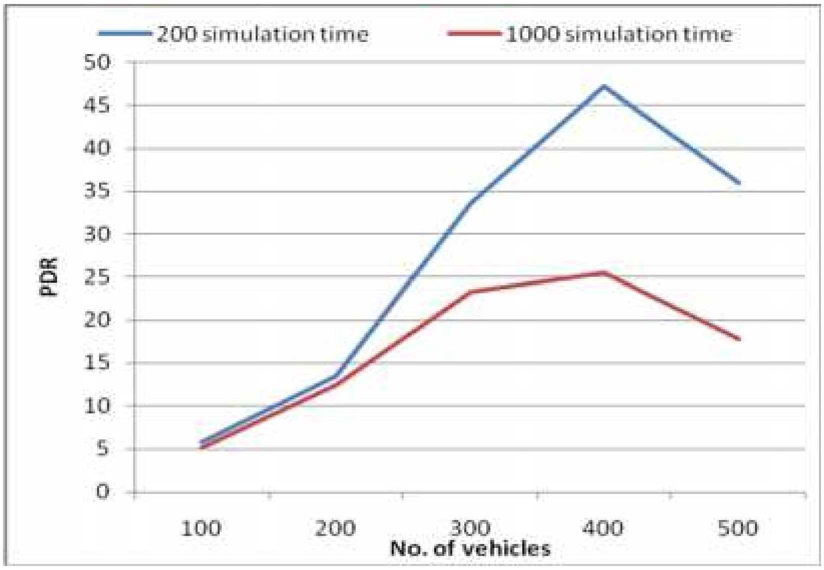

Figure 7 (b). PDR for 200 and 2000 time instances against the variability in number of vehicles

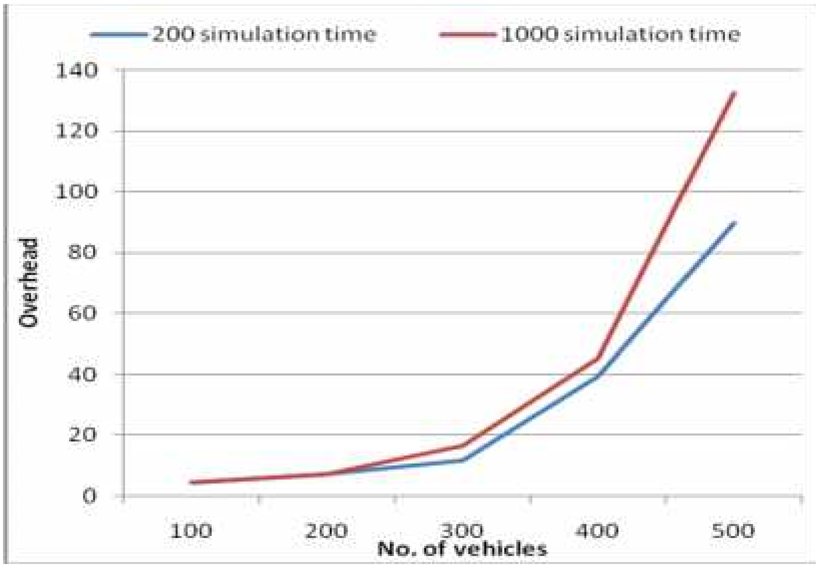

Figure 7 (c). Overhead for 200 and 2000 time instances against the variability in number of vehicles

In fig 7 (b) we observe that the packet delivery ratio increases rapidly with increase in the number of vehicles but after reaching 400 vehicles which is the highest point of increase , the packet delivery ratio starts to fall.

In fig 7 (c) it is observed that the overhead increases exponentially with the increase in the number of vehicles. The overhead is more for a higher simulation time and comparatively less for a lower simulation time.

5. Conclusion

In this work we have evaluated the performance of Location Aided Routing protocol (LAR) for Vehicular Ad-hoc Networks (VANETs) in terms of throughput, packet delivery ratio and routing overhead. We have considered two scenarios namely highway and city scenario. For highway we have taken Delhi highway data from OSM map and for city scenario we have taken real traces of Bologna Ringway dataset. For each of these scenarios the performance is evaluated by considering variation in terms of number of vehicles and simulation time.

We observe that with the increase in simulation time the throughput increases for both highway and city scenario. The packet delivery ratio and overhead tend to decrease with increase in simulation time.

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Ms. Amrit Kaur Saggu has done B.Tech from ABES-EC and her master's from JIIT (Noida) with major interests in the field of Networks. She is currently working as Assistant professor in CSE Department, KIET Group of Institutions. She has attended several workshops and conferences. She has also published in reputed journals.

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