Performance Evaluation of GPSR Routing Protocol for VANETs using Bi-directional Coupling

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Abstract

Routing in Vehicular Adhoc Networks is a challenging task where the nodes themselves are vehicles. The mobility factors such as beacon intervals and vehicles with different velocities may cause inaccuracy in the identification of the vehicle's position. This in turn affects the performance of the position based routing protocols. Further, there is a need to evaluate through simulations performance of the position based routing protocol, especially in urban realistic scenarios for VANETs. The work in this paper evaluates the performance of Greedy Perimeter Stateless Routing protocol (GPSR) for VANETs which is a popular position based protocol especially for routing in MANETs. In order to evaluate realistic simulation environment bi-directional coupling of OMNET++/ INET Framework and SUMO is chosen for Nagarbhavi region in Bengaluru, India. The simulations are done for various scenarios realizing the impact of mobility parameters on routing using GPSR, and performance is measured in terms of packet delivery ratio and throughput.

Keywords: VANET, Bi-directional, GPSR, SUMO, OMNET++.

1. INTRODUCTION

Vehicular Ad hoc Networks (VANETs) are an extension of Mobile ad-hoc networks (MANETs). The nodes in VANETs are the vehicles themselves which communicate with each other using wireless technology, without any pre-deployed infrastructure [1]. IEEE 802.11p standard is being used for the Wireless Access in Vehicular Environments [2]. Various applications of VANETs such as safety related and comfort related have been stated in[3] .The main factors effecting routing performance in VANET's are the speed of the vehicles, mobility constraints on the roads and frequent network breakdown. One of the preliminary tasks is in designing routing protocols which can trace the routes between vehicular nodes efficiently. For the same, realistic simulation scenarios are considered for routing protocols from which reliable results can be obtained.

The objective of the work in this paper is to study the performance of GPSR through simulations for routing among vehicular nodes in VANETs particularly in urban areas. Mobility traces are obtained by the real world traffic simulator, these modelled offline traces will give the influence of road traffic on network traffic, but not vice versa. In order to overcome this problem bi-directional coupling of traffic simulator SUMO [traffic simulator, http://sourceforge.net/projects/sumo/], and OMNET++/ INET Framework [network simulator, http://www.omnetpp.org/] are used for realistic simulation scenarios [4].

The work in this paper evaluates the performance of Greedy Perimeter Stateless Routing (GPSR) protocol for VANETs which is a popular position based protocol especially for routing in MANETs. In order to evaluate realistic simulation environment, bi-directional coupling of OMNET++/ INET Framework and SUMO is chosen for Nagarbhavi region in Bengaluru, India.

An overview of position based routing protocols of VANETs is presented in a tabular form in section 2. The comparative analysis is given in Section 3. And the Section 4 discusses on the methodology, simulation setup and its scenarios. Section 5 gives the evaluation metrics as well as an illustration of the acquired results. Further, Section 6 concludes the paper.

2. LITERATURE REVIEW

Routing in VANETs is a challenging task because of the high speed of the nodes (vehicles), frequent topology changes and predictable mobility (constrained by the road topology and traffic regulations). Previous studies showed that the position based routing protocols outperforms non-position based protocols [5][6][7] as modern vehicles are equipped with GPS receivers, digital maps and navigation systems. The position based routing protocols use the geographical information of nodes to route the data packet towards the destination, by beacon packets. These beacon packets along with the node speed may introduce the inaccuracy for position information in the position based routing protocols [8][9].

Table1 shows the comparative study on different position based routing protocols and their functionalities in VANETs. The parameters chosen for comparison are the routing strategies, maps adopted, simulation scenarios and the different simulation tools. The protocols presented adopt multi-hop techniques to transmit the data from source to destination.

As the GPSR protocol is the basic platform in position based routing protocol, it is considered further to evaluate its performance in Indian road network scenarios. GPSR makes greedy forwarding using the immediate neighbour's position information in the network. It consists of two methods for forwarding the data packets. They are greedy forwarding and perimeter forwarding. It works well in a highway scenario because of evenly distributed nodes. GPSR may increase the possibility of getting the local maximum and link breakage because of the high mobility of vehicles and the road specifics in urban areas. It also suffers from link breakage with some stale neighbour nodes in the greedy mode because of the rapidly changing network topology. Packet loss and delay time may occur because the number of hops increases in perimeter mode forwarding.

TABLE 1: Comparison and analysis of different position based routing protocols for VANETs.

Routing protocol	Forwarding Strategy	Digital Map	Traffic-aware	Scenario	Recovery Strategy	Intersection Based	Mobility Model	Simulation Tool
GPSR	Greedy	No	No	Highway	Perimeter Forwarding	No	Random Way Point	NS2
GyTAR	Improved Greedy	Yes	Yes	Urban	Carry and Forward	Yes	Realistic Mobility Model	QualNet

GSR	Greedy	Yes	No	Urban	Carry and Forward	Yes	Obtacle Model	Daimler Chrysler
GPSR-L	Greedy	No	No	Highway	Perimeter Forwarding	No	Manhatta n	NS2
CAR	Advanced Greedy	Yes	No	Urban& Highway	Node Awareness	Yes	MTS	NS2
A-STAR	Greedy	Yes	Yes	Urban	Recompute d Anchor Path	Yes	M-Grid	NS2
SAR	Greedy	Yes	No	Urban	Flooding	No	RWP	NS2
GPCR	Greedy	No	No	Urban	Right hand rule	Yes	Obstacle Model	Vanet Mobisim
MDBG	Greedy	Yes	No	Urban	Carry & Forward	Yes	MOVE	NS2
JBGR	Greedy	Yes	Yes	Urban	Carry & Forward	Yes	Vanet Mobisim	Vanet Mobisim
IBRP	Greedy	yes	No	Urban	Carry & Forward	Yes	Manhatta n	NS2
GTLBR	Greedy	Yes	Yes	Urban	Carry & Forward	Yes	SUMO	NS2/SU MO
E-GyTAR	Greedy	Yes	Yes	Urban	Carry& Forward	Yes	Vanet Mobisim	GLOMO SIM
BACRP	Trajectory	Yes	Yes	Urban	Carry & Forward	No	Manhatta n	NS2
IBGRP	Greedy	Yes	No	Urban	-unknown-	Yes	- unknown-	MatLab/ SIMULIN K

3. COMPARATIVE ANALYSIS

Alsaqour et. al. analyzed the effect of position information inaccuracy caused by node speed and beacon packet interval time. Their work also identified that the network performance metrics can be affected by position information inaccuracy in GPSR routing protocol, in terms of end-to-end delay and routing loop in MANETs [26]. Yongjin et. al. and Shah et.al had also identified that the location errors degrade the performance of perimeter forwarding strategy in terms of data packet drop, optimal route and routing loop rate in dense networks and may lead to power consumption of nodes due to sub-optimal path [27,28]. Further, the link connection problem with neighboring nodes and routing loop due to inaccurate location information are also identified as shown in [29, 30].

4. SIMULATION ENVIRONMENT

In the present study, analysis is carried out for network performance metrics, affected by position information inaccuracy in GPSR routing protocols, in term of PDR and Throughput. The speed of vehicular nodes and beacon packet interval time are the two main mobility parameters, which causes the position information inaccuracy in VANETs. Inaccurate location information caused by node mobility is also shown.

4.1 Simulation Model

Network topology and route information on Nagarbhavi region in Bengaluru covering an area of 25 km^2 are selected and downscaled from Open Street Map for the study. The information of network topology (net.xml) and Route files (rou.xml) are obtained using Net converter and Duarouter in SUMO. In a real time scenario, inter vehicle communication is necessary among the vehicle's for the distribution of the information on traffic, where the vehicles position depends on the received information. In order to handle such interactions, bi-directional coupling is required. Therefore, a TCP connection is used between Traffic and Network simulators to communicate bi-directionally using Traffic Control Interface (TraCI) [10], as shown in the figure 1. The bi-directional communication is initiated by sending the synchronization message and simulation results (vehicles position) to each other (figure 3).

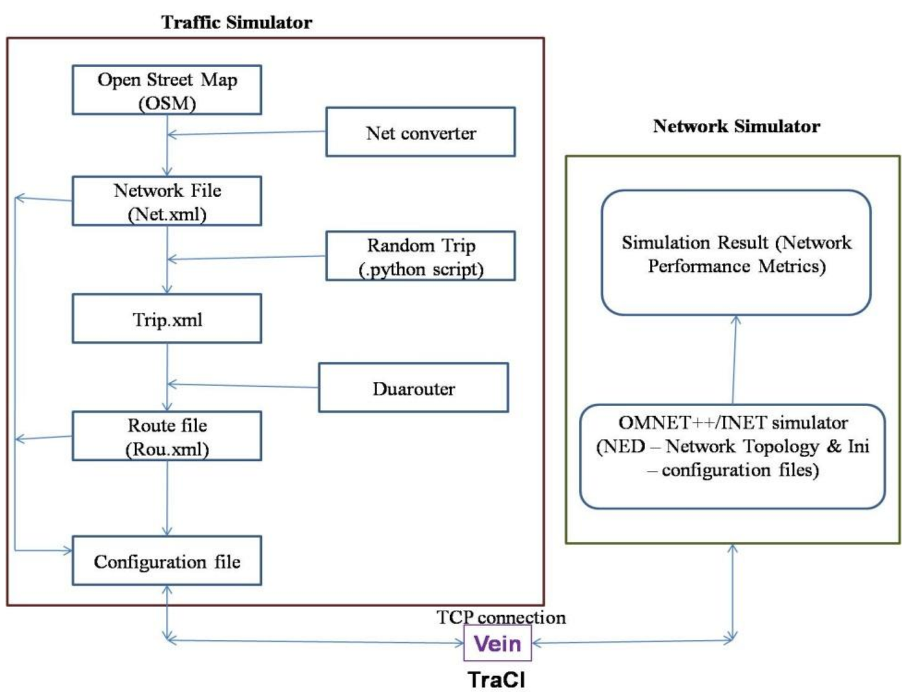

FIGURE 1: Methodology for calculating the Network performance metrics.

By considering the urban scenario, vehicle speed (m/s) [in rou.xml] is modified during the generation of trace files in traffic simulator, which will be used further in network simulator. The beacon intervals in seconds and number of traffic sources [in .ini file] is varied for the communication between nodes. The moving vehicles on the obtained road network are given in figure 2a &b.

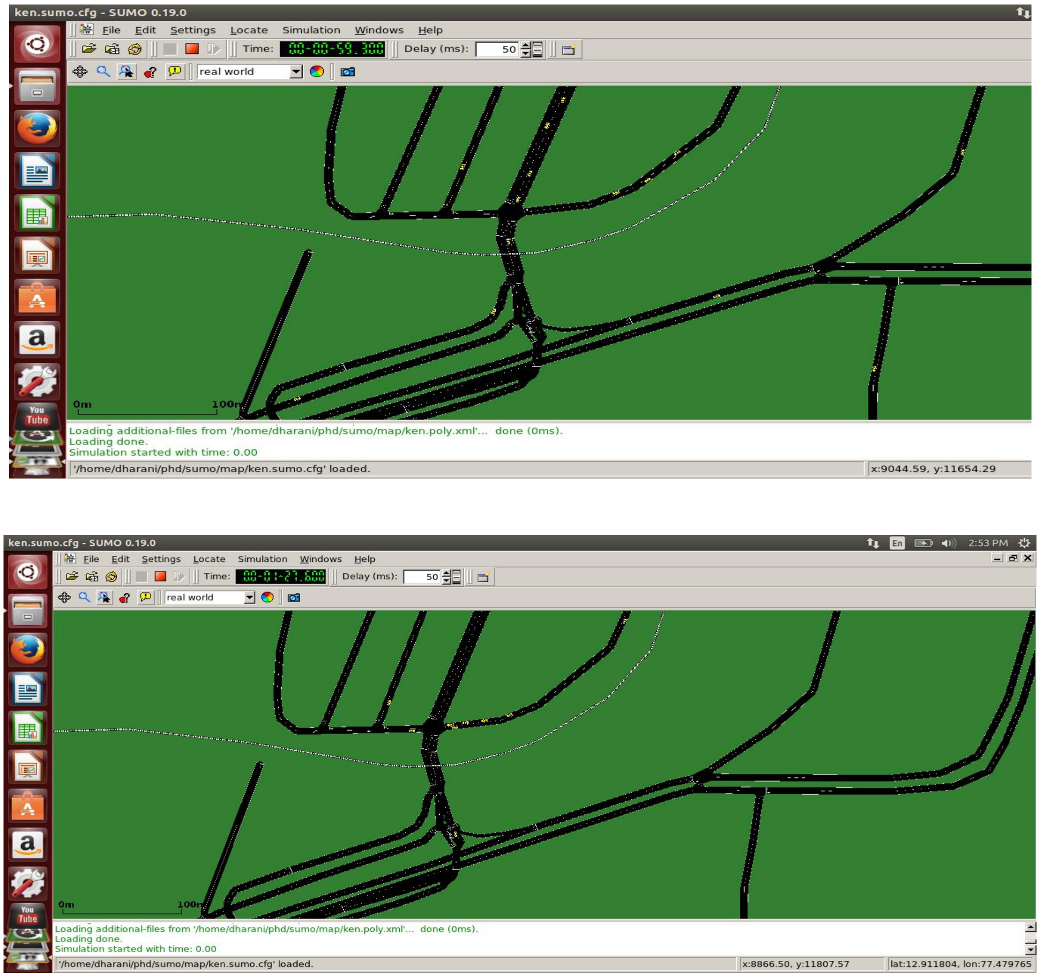

FIGURE 2 a & b: Road network of Nagarbhavi [urban area] showing the simulation of Nodes in SUMO [Traffic simulator].

The vehicular mobility is controlled by SUMO and Vehicular nodes by OMNET++/INET, where IEEE 8011p is used for the communication. The position and radio wave transmissions between the vehicular nodes are shown in the figure 3.

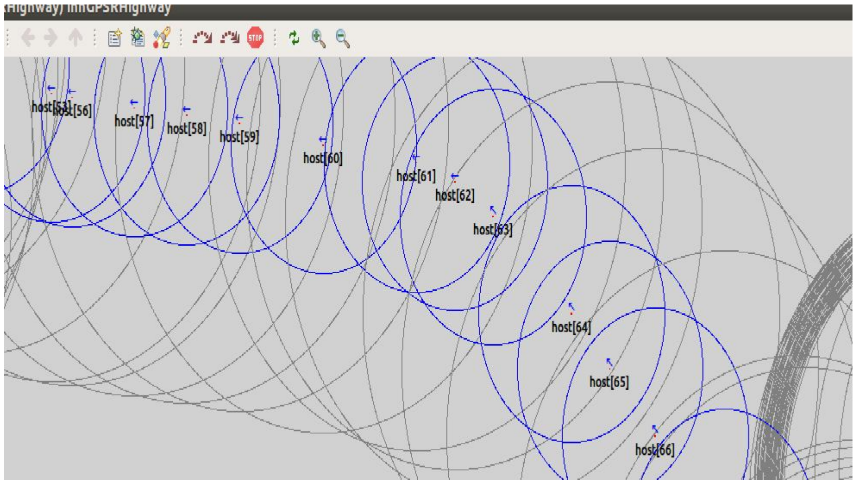

FIGURE 3: Communication among the vehicles in motion [OMNET++/INET].

Table 2 indicates the parameters used for network operation, where the parameters of Physical and MAC layers are configured to IEEE 802.11p.

TABLE 2: Configuration parameters used in the simulation process.

Parameter(s)	**Value(s)**
Simulation Area	5000m*5000m
Simulation Time	300s,600s
Number of traffic Sources	10,20,50,70,100
Vehicle Speed	5m/s,10m/s,15m/s,20m/s
Data Packet Length	512 Byte
Vehicle Beacon Interval	1s,2s,3s,4s,5s
Carrier Frequency	5.8GHz
Transmission Range	250m
Physical Layer	IEEE802.11p
Data Bitrates	27Mbps
Transmission Power	10mW
Packet Type	UDP
Mobility Model	TraCIMobility
Routing Protocol	GPSR

5. RESULTS AND DISCUSSION

The performance of chosen GPSR routing protocol is evaluated for different parameters which includes beacon intervals, vehicles with different velocities and numerous traffic sources. The PDR and throughput are the two different network performance metrics evaluated for the comparison of GPSR protocol performance. Packet Delivery Ratio (PDR) gives the ratio of the number of data packets received at the destination vehicle to the number of data packets sent by the source vehicle. The throughput is the total number of bits delivered successfully from the source to the destination every second. The results obtained through simulation are discussed below.

5.1 Varying Beacon Packet Interval

Figure 4 show the simulation results on the effect of using different beacon intervals. It shows the performance metrics, PDR and Throughput of GPSR routing protocol for Beacon packet intervals varying from 1 second to 6 seconds keeping the maximum velocity of a vehicle as constant to 5m/s. The result indicates the degradation of the protocol performance when the time gap for beacon packet increases. The result also shows an inverse relation between PDR, Throughput and Beacon Packet Intervals due to the inaccuracy on the delivery of position information of neighbors.

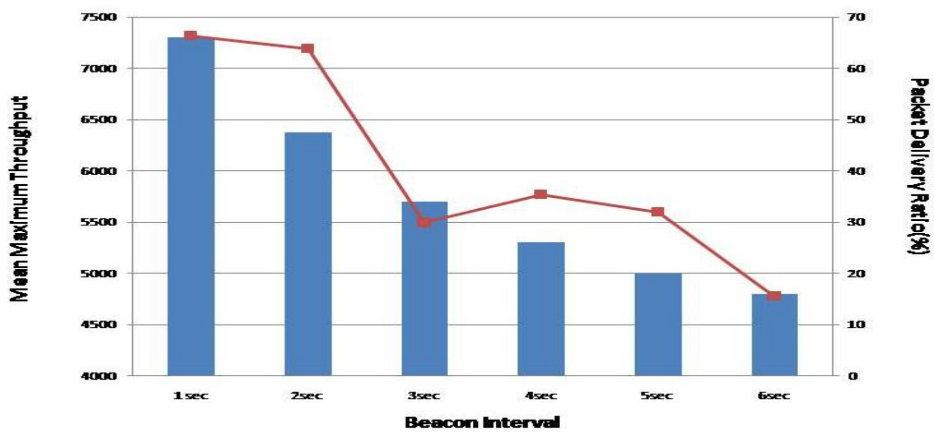

FIGURE 4: The relationship between PDR, Throughput and Beacon Intervals.

5.2 Vehicles with Varying Velocities

Figure 5 shows the effect of node speed on the performance of GPSR routing protocol in term of PDR and Throughput for node velocities starting from 5m/s to 20m/s in steps of 5m/s. The beacon interval is set as 1.5 second in network simulator. Due to the network disconnection and path instability the performance of GPSR decreases as the speed of the node increases. Vehicle speed influences the accuracy in receiving the geographical information of nodes which effect the performance of GPSR.

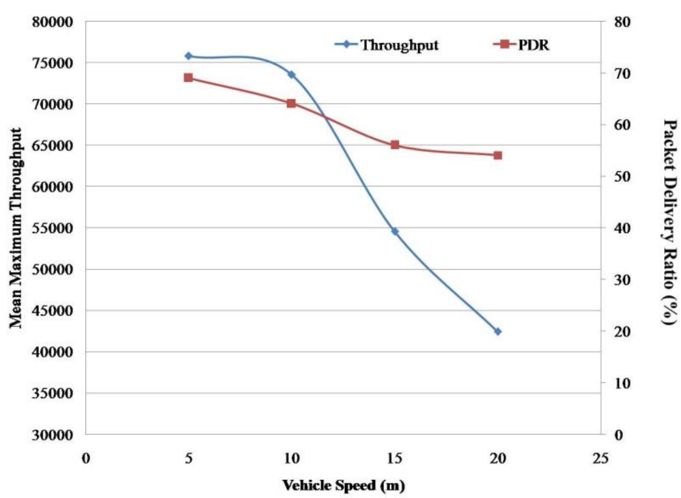

FIGURE 5: The impact of vehicle Speed on PDR and Throughput.

5.3 Traffic sources (nodes transferring the data packets)

The levels of Throughput and PDR relies on the number of traffic sources. As the traffic sources increases, the throughput increases because of the increase in transmission rate of data packets. This helps in the improvement of connectivity between traffic sources. In the meantime, the PDR decreases as there is a lack of scalability. Also, drastic changes can be observed in PDR due to node buffer overflow, as shown in the figure 6.

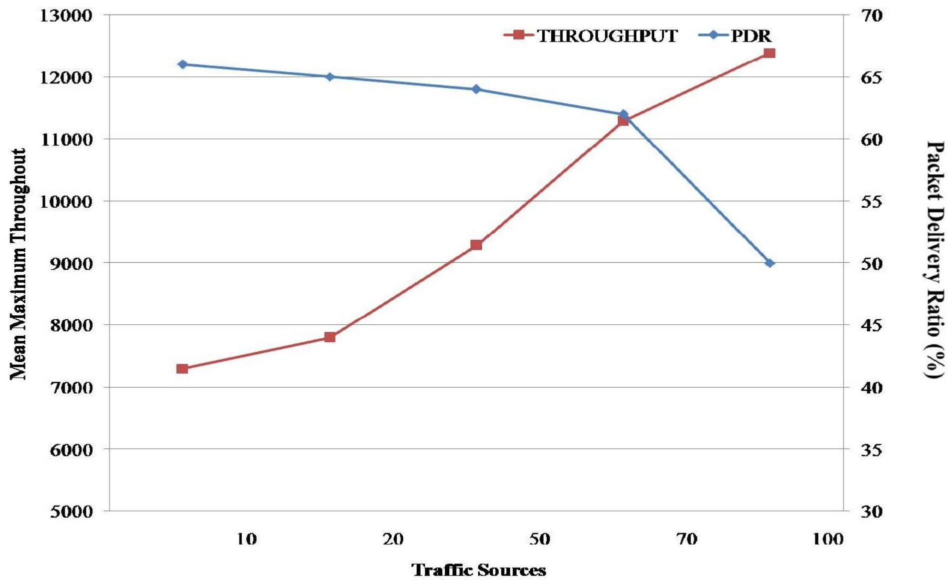

FIGURE 6: Influence of Traffic Sources on PDR and Throughput.

6. CONCLUSION

In this paper, an attempt has been made to study the effect of node speed and beacon intervals on GPSR protocol performance. Network topology and route information about Nagarbhavi region, Bengaluru urban area is obtained using OpenStreetMap (http://www.openstreetmap.org/). The bi-directional coupling of OMNET++/INET and SUMO had been used to create a realistic scenario. The results indicate that:

- The levels in beacon intervals have an impact on the delivery of position information degrading the performance of GPSR.
- High mobility of vehicles causing network disconnection and path stability problem influences the network performance metrics.
- As the number of traffic sources increase the PDR decreases due to scalability issue in GPSR.

The present study on the performance of GPSR routing protocol indicates the potential to improve the performance for VANETs in urban scenarios considering the real time parameters such as vehicles velocity, direction and vehicle density for further work.

7. ACKNOWLEDGEMENT

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9. ANNEXURE

1. Greedy Perimeter Stateless Routing Protocol (GPSR) [11]
2. Improved Greedy Traffic Aware Routing Protocol (GyTAR) [12]
3. Geographic Source Routing (GSR) [13]
4. Greedy Perimeter Stateless Routing with Lifetime (GPSR-L) [14]
5. Connectivity-Aware Routing (CAR) [15]
6. Anchor-based Street and Traffic Aware Routing (A-STAR) [16]
7. Spatially Aware packet Routing (SAR) [17]
8. Greedy Perimeter Coordinator Routing (GPCR) [18]
9. Moving Direction Based Greedy Routing (MDBG) [19]
10. Junction-Based Geographic Routing (JBGR) [20]
11. Intersection-Based Routing Protocol (IBRP) [21]
12. Geographic and Traffic Load Based Routing Strategy (GTLBR) [22]
13. Enhanced GyTAR (E- GyTAR)[23]
14. Bus Assisted Connectionless Routing Protocol (BACRP)[24]
15 Intersection-Based Geographical Routing Protocol (IBGRP)[25]