THE REALISTIC MOBILITY EVALUATION OF VEHICULAR AD-HOC NETWORK FOR INDIAN AUTOMOTIVE NETWORKS

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ABSTRACT

In recent years, continuous progress in wireless communication has opened a new research field in computer networks. Now a day's wireless ad-hoc networking is an emerging research technology that needs attention of the industry people and the academicians. A vehicular ad-hoc network uses vehicles as mobile nodes to create mobility in a network.

It's a challenge to generate realistic mobility for Indian networks as no TIGER or Shapefile map is available for Indian Automotive Networks.

This paper simulates the realistic mobility of the Vehicular Ad-hoc Networks (VANETs). The key feature of this work is the realistic mobility generation for the Indian Automotive Intelligent Transport System (ITS) and also to analyze the throughput, packet delivery fraction (PDF) and packet loss for realistic scenario. The experimental analysis helps in providing effective communication for safety to the driver and passengers.

KEYWORDS

Ad-hoc Networks, VANETs, V2V, V2I, ITS, Throughput, PDF, Packet Loss

1. INTRODUCTION

The wireless network is the seamless integration of all types of networks. Network special purpose Vehicular Ad-hoc Networks (VANETs) is sub category of Mobile Ad-hoc Networks (MANETs) [1]. It contributes a lot to the Inter Vehicle Communication (IVC). IVC shows very different characteristics from other MANET network. Specifically, the constraints on the movement of vehicles, the behaviour of variable driver, and cause high mobility topology changes quickly, frequent network fragmentation, a small effective diameter of the network, and limited usefulness of redundancy network [2].

In VANETs vehicles serving as nodes and offers some intelligent activities. It is an intelligent network of vehicles, called Intelligent Transportation System (ITS). It is used to ensure the security services of driver assistance and comfort to road users. Intelligent Transportation Systems (ITS) include all types of communications in vehicles, between Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I). They also include the use of Information Technology and Communication (ICT) for Indian railway and air transport, including navigation systems. All types of Intelligent Transport System (ITS) depend on the services of radio communication and the use of specialized technologies [2].

DOI : 10.5121/ijasuc.2014.5201

The traffic is the main component of mobility research. Traffic research is broadly categorized into four classes of traffic flow models. They are distinguished by the level of detail of the simulation. They are listed below:

- Macroscopic Models: In this traffic flow is the basic entity, which formulates the relationship among traffic flow characteristics like density, flow, speed etc.

- Microscopic Models: It simulates the movement of each vehicle on the road most of the time considering that the behaviour of the vehicle depends on both the physical capabilities of the vehicle and the behaviour of the driver.

- Mesoscopic Model: It is located at the boundary between the microscopic and macroscopic simulations. In this, the movement of vehicles is mainly simulated using queue approaches and single vehicles are moved between queues.

- Sub Microscopic Models: It considers simple vehicles as microscopic, but extends them by dividing into new structures that describe the rotational speed of the motor with respect to the vehicle speed or switching speed of the preferred shares of the drive. This allows more detailed compared to simple microscopic simulation calculations. However, this model requires longer computation time [3].

According to the available data at [4], the Indian Automotive Road Network is about 33 Lakh km, which is second in the world. The number of vehicles has increased at an average rate of 10.16% per annum over the past five years. As the number of vehicles is growing at rapid speed, the need for the driver and passenger safety is also increasing. Because of this, it is necessary to develop an Intelligent Transportation System (ITS) for the Indian Automotive Networks.

The rest of the paper is organized as follows: Section 2 review the literature available for the generation of realistic mobility. Section 3 describes the research methodology for the Indian Automotive Networks; Section 4 presents the configuration and realistic scenario simulation of the mobility for the different regions. Finally, Section 5 concludes the paper with the main points of this research.

2. RELATED WORK

VANET is a type of Mobile Ad-hoc Networks (MANET) which consists of number of vehicles with the ability to communicate with each other. The main objective of VANET research is to make a quick and cost effective data transmission for the safety and benefit of the driver and passengers [5]. The required solution is not possible by direct experimentation, due to cost and complexity. Thus, simulation becomes the tool of choice to evaluate these quality solutions. This simulation depends on the mobility model, which represents the flow diagram of mobile users, including its location, speed and acceleration over time. A mobility model should be a realistic mobility model that takes into account the characteristics of real-world region [6]. The realistic mobility can be achieved by two different ways:

- A real world map obtained from TIGER (Topologically Integrated Geographic Encoding and Referencing) database from the U.S. Census Bureau [7], Clustered Voronoi Graph [8] and Shapefile Map [9].

- A real world map organizes satellite images from google earth for realistic simulation of the networks [10].

Nidhi et. al. generated a real world map of JNU, Delhi using google earth and the existing GIS tools [5]. Authors have collected the traffic data for a limited area of the road map to capture the realistic mobility. In this work, the whole region has been divided into several small roads. Realistic mobility model used here considers the choice of route driver at run time. It also examines the effect of consolidation caused by the traffic lights at the intersection used to regulate the flow of vehicles in different directions. Finally, the performance of VANETs is evaluated in terms of average packet delivery ratio, packet loss, and routers drop those statistical measures for the choice of the route of the driver with the traffic light scenario.

The paper [6] describes the generation of an urban vehicle trace of the large-scale mobility. The data set is obtained by considering the realistic road topology, the microscopic and macroscopic mobility flows. A comparison with traces employed showed that incomplete representations of mobility can lead to significantly different network topologies, may seek performance evaluation protocols and architectures. Their mobility traces of vehicles are available at [11]. However, the author's notes that they are still far from complete realism.

Haerri et. al. [8], generated a realistic vehicular movement traces for telecommunication networks simulators. They provide the description of VanetMobiSim mobility, which was validated by comparing its traces with TSIS-CORSIM. It is a traffic generator industry benchmark. VanetMobiSim is one of the few vehicles oriented mobility simulator fully validated and freely available to the research community on vehicular networks. Paper [12] presents VanetMobiSim, an extension of Canu-MobiSim capable of producing realistic mobility traces of vehicles for several network simulators. VanetMobiSim-1.0 extensions made by both the macro and micro mobility were also demonstrated by the authors.

In paper [13], the authors proposed the so-called MOVE, a VANETs mobility model that uses as compiler SUMO [3], which is a realistic vehicular traffic simulation model. In the article [14], Kun chan Lan et. al. first introduce a tool MOVE that allows users to quickly generate realistic mobility models for VANET simulations. MOVE built on top of an open source micro-traffic simulator SUMO. The output motion is a realistic model of mobility and can be used immediately by Simulators popular networks such as NS2 and QualNet. Authors evaluated the effects of retail mobility models in three simulation studies VANET case (in particular, the existence of traffic lights, choice of route driver and car overtaking behaviour) and show that the selection sufficient level of detail in the simulation is essential for VANET protocol design.

The main challenges in the field of vehicular ad-hoc network are the realistic simulation of Inter Vehicle Communication (IVC) protocols. To provide income for the meaningful evaluation of IVC protocols, accurate modelling of traffic movement and to know the exact position of the vehicles involved is very important. In [15], the authors provide study of different mobility models with a different methodology. The necessary bidirectional coupling of network and traffic simulation and the use of a new hybrid location-based Ad-hoc routing protocol instead of DYMO in the bidirectional coupling of SUMO and OMNeT++ (veins) is proposed.

Article [16], proposed a more realistic scenario, the city section mobility model and the radio propagation model with obstacles. The performance of the routing protocol was simulated in the traditional scenario and new one. Then the performance of DSR and AODV is simulated and analyzed in the new scenario. The result showed that in the more realistic scenario AODV is more suitable for VANET. The article has simulated VANET more realistically.

Different simulation software are available as an open-source program and can be extended to meet the own researcher and also be used as a reference test bench for new traffic patterns needs. The few traffic simulators are used for generation of realistic mobility: SUMO, MOVE CanuMobiSim, VanetMobiSim-1.0 and VanetMobiSim-2.0 etc. Each simulator has its own way to generate mobility and traffic assessment. In our research, we used the VanetMobiSim-2.0 for generation and evaluation of the mobility and traffic respectively. It provides a platform to perform all the steps of single mobility simulation.

3. SIMULATION METHODOLOGY

It is necessary to prepare a methodology for the realistic evaluation of Indian Automotive Networks. As it provides the clear reflection of the research involved. It can conclude from the previous section that the simulation is a concern for Indian Networks. So selecting the suitable methodology is necessary, as it will improve the research. The methodology involved is shown below:

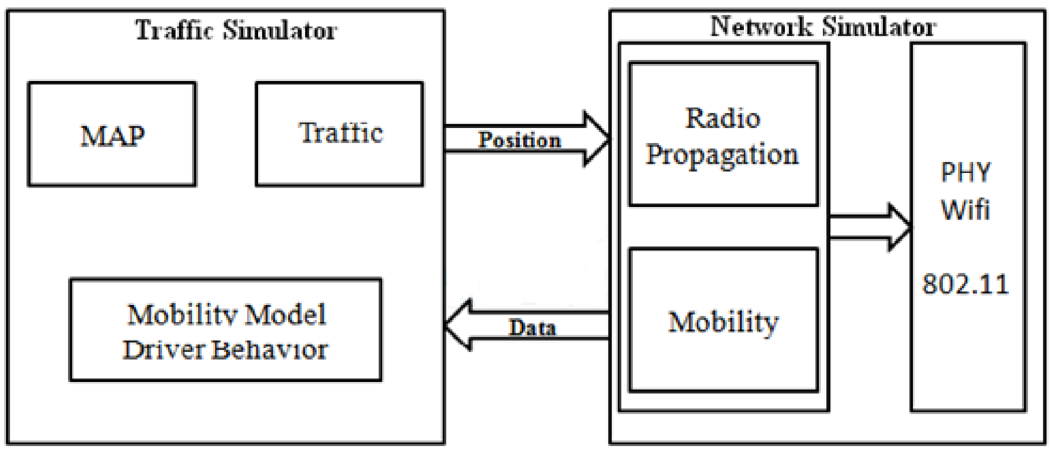

Figure 1. Methodology Adopted

The figure 1 shows the research methodology adopted for the realistic simulation and the evaluation. As the coupling simulators is used for the work. They are traffic and network simulators respectively. Traffic simulator helps in generating the realistic mobility for the different region. These regions are captured from the realistic map, which is available for the Indian automotive networks. Mobility traces is provided to the network simulator, where the appropriate propagation model and short range communication standards is provided to get the desired output traces for the realistic evaluation of the Indian automotive networks.

4. EVALUATION

In this section, work is analyzed by simulating the performance of VANET for Indian Automotive Networks. Section 4.1 introduces the simulation platform and the main parameters used in the evaluation. Then section 4.2 performs the realistic scenario simulation of VANET for Indian Intelligent Transport System. Finally section 4.3 analyzes their performance.

4.1. Simulation Platform and Scenario

To evaluate the performance of VANET, it is necessary to deploy a real network scenario with all possible parameters of vehicle simulation, such as simulation time, traffic flows, maximum and minimum traffic delay etc. The evaluation is carried out by simulation, using VanetMobiSim-2.0 and NS2/NS3. Experiment was conducted by taking into account two real VANET regions.

Table 1. Simulation Parameters

Parameters	Value
Propagation	TwoRayGround Model
IEEE Standards	DSRC (MAC/802_11p)
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IEEE Standards	DSRC (MAC/802_11p)
Channel	Wireless
Wireless Layer	Phy/WirelessPhy
Antenna	OmniAntenna
Type of Flow	Constant Bit Rate (CBR)
Ad Hoc Routing	AODV
Coverage	100 m
Packet Size	512KB
Max IFQ Packet	50
Max Traffic Light	10
Minstay / Maxstay	2 / 6s
Min Speed/ Max Speed	10 / 20 miles/hr
Node Type	Car / Truck
No. of Nodes	50, 100, 150, 250, 500
Simulation Time	500 s, 1000 s
Simulation Region (Urban)	8049 m **X** 4315 m
Simulation Region (Rural)	6691 m **X** 6766 m

The table 1 summarizes the main parameters of the simulations. It provides the basic parameters such as propagation model used, which IEEE standards and layer is involved etc. The PHY/MAC layer parameters of the simulated nodes are based on the specification of the IEEE 802.11.

For the evaluation, two respective scenarios for the urban and rural region of Jaipur, Rajasthan, India is taken. The regions are:

- Urban Scenario - B2 Bypass, Jaipur, Rajasthan, India and
- Rural Scenario - JNU Jagatpura, Jaipur, Rajasthan, India.

4.2. Realistic Scenario Simulation

The first step for realistic simulation is to produce a map for the network scenario. VanetMobiSim2.0 is capable of generating a map from OpenStreetMap. OpenStreetMap is a map of the world, created by people and free to use under an open license. It emphasizes local knowledge. Their contributors use aerial imagery, GPS devices, and low-tech field maps to verify that OSM is accurate and up to date. OpenStreetMap has been integrated into the VanetmobiSim2.0. The two experimental regions are generated from the same. The two experimental region maps are shown in figure 2 and 3 respectively

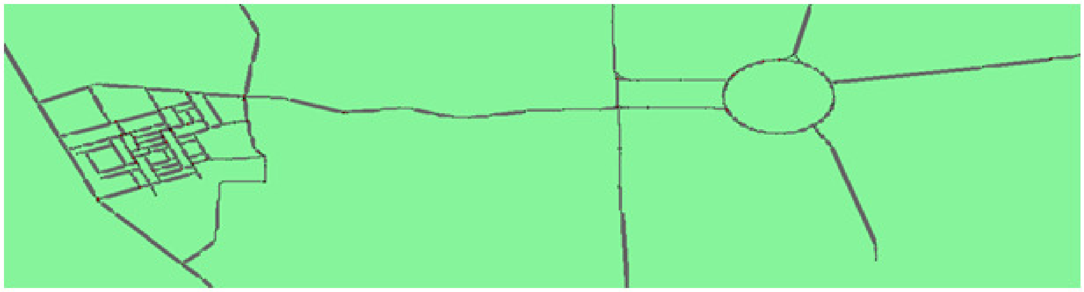

Figure 2: B2 Bypass, Jaipur map (Urban Region)

Figure 3: JNU Jagatpura, Jaipur map (Rural Region)

Once the map is generated, their xml file is created. The simulation parameters are provided to the experimental mobility file for both the regions. The source file path (.xml) and the target/output file (.tr) are also provided in the mobility file.

The output file from the traffic simulator is provided to the NS2 for their network simulation. Here simulation is performed for urban and rural region based on their simulation time and number of nodes. As mentioned in table 1, the simulation is performed for 1000 and 500 seconds respectively for 50, 100,150, 250 and 500 nodes of both the regions. Each region has their respective simulation area and uses the AODV routing protocols with Constant Bit Rate (CBR) flow. Wireless channel is used and packet size is of 512 KB.

This realistic evaluation involves the calculation of matrices for each simulation region. They include the throughput, PDF and packet loss percentage. It considered packet loss because of packet being dropped due to its waiting time exceeding its maximum latency or packet error due to wireless transmission channel in our simulation. Following matrices are used for calculating the performance of Indian Automotive Networks.

Throughput is the rate of successful message delivery over a communication channel. It is calculated by the given mentioned equation:

*Throughput = ((received packet*pkt_size)/total simulation time)/1024* (1)

PDF, the packet delivery fraction is the fraction of the data packets originated by an application that each routing protocol delivers i.e.

*PDF = (received packet /sent packet)*100* (2)

Packet Loss occurs when one or more packets of data travelling across a communication channel fail to reach their destination. It is generally calculated in percent. The equation to find packet loss percent in motioned below:

*Packet Loss % = (sent packet – received packet)*100)/sent packet* (3)

4.2.1 Urban Region

The simulation is performed by analyzing the impact of matrices required for evaluating the performance of the VANETs for urban region

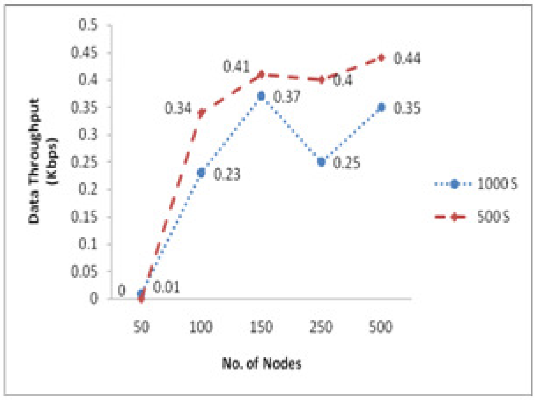

Figure 4: Urban Region Throughput

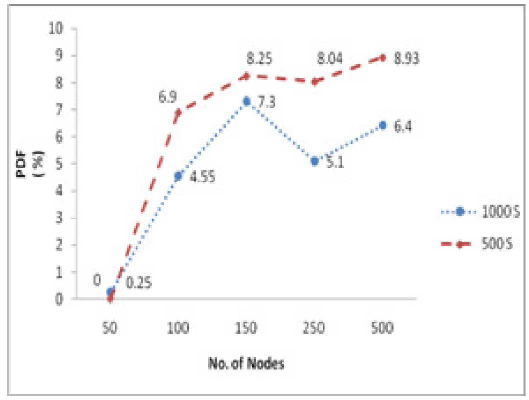

Figure 5: Urban Region PDF

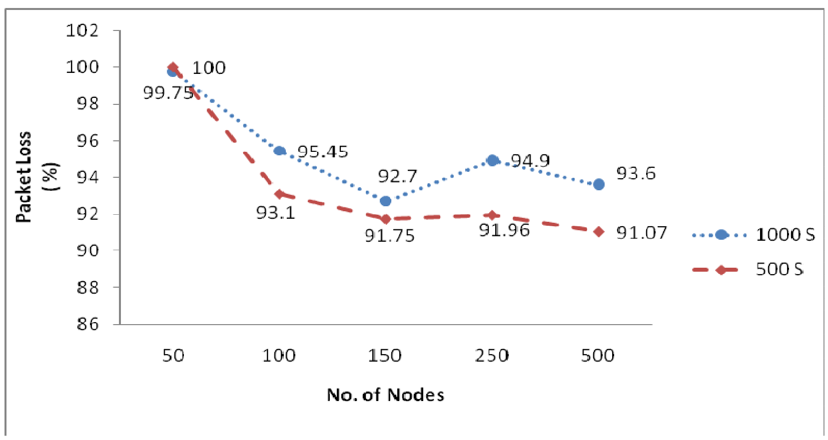

Figure 6: Urban Region Packet Loss

The figure 4 and 5 shows the throughput and packet delivery fractions for different number of nodes respectively for the region. The simulation is compared for 1000 and 500 seconds. When number of nodes increases, results show the trend of increased throughput as well as PDF. Figure 6 depicts the relationship between the packet loss percent for different simulation time. It can be observed that as the number of nodes increases, the packet loss decreases.

4.2.2 Rural Region

In this simulation is performed by analyzing the impact of matrices required for evaluating the performance of the VANETs for rural region.

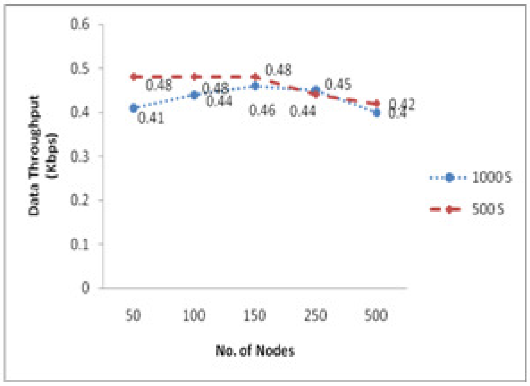

Figure 7: Rural Region Throughput

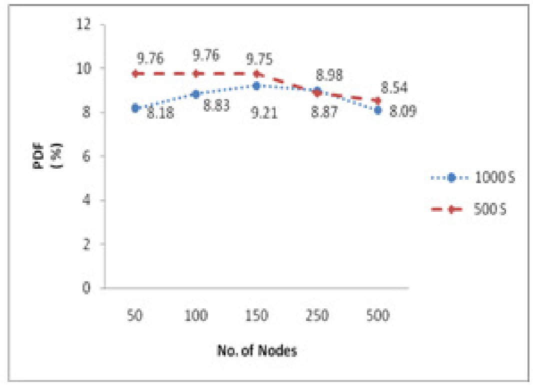

Figure 8: Rural Region PDF

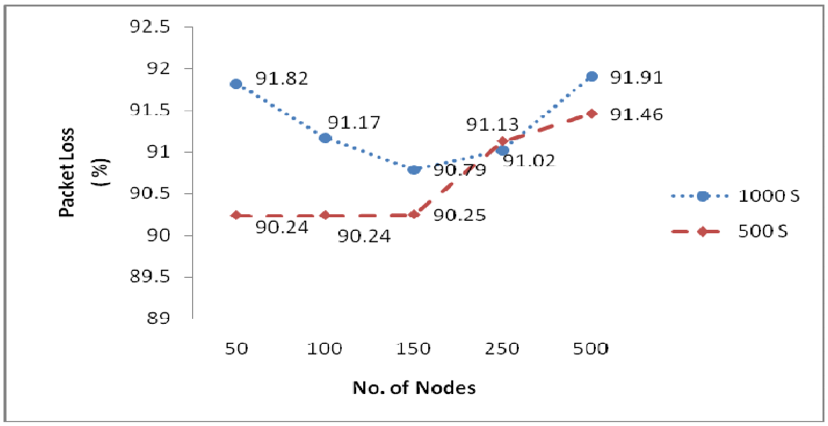

Figure 9: Rural Region Packet Loss

The figure 7 and 8, the throughput and packet delivery fraction for different number of nodes was all most same. It shows a minor change with respect to simulation time. In case of packet loss percent, Figure 9 shows the packet loss percent decreases to some extent, and then shows the trend of increase as the number of nodes changes from 150 to 250 and than 500.

However, it is clear from Figure 6 and 9; the packet loss percent in this research is lower for rural region as compared to urban region. Their realistic simulation is best suited for the rural region with respect to number of nodes and simulation time.

4.3. Analysis of VANET performance with Mobility

Section 4.2 provides the realistic simulation and their performance evaluation. Based on their result, it analyzes the realistic simulation with respect to the region, simulation time and number of nodes respectively. The analysis is performed to understand the percent gain of different matrices for respective region. This is evaluated on the basis of results obtained for the 50 number of nodes.

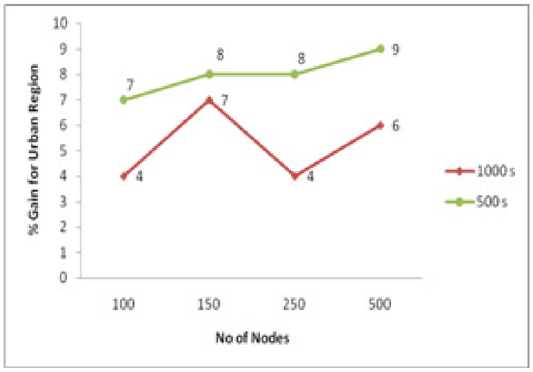

Figure 10: Gain % for Urban Region

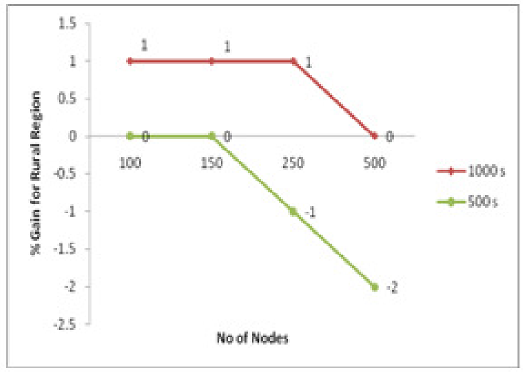

Figure 11: Gain % for Rural Region

The figure 10 & 11 provide the main characteristics of the respective Urban and Rural regions. Figure 10 shows that in urban region higher nodes mobility leads to higher gain. It also highlights that the less simulation time leads to more percent gain. Figure 11 analyze the rural region. In this the change is almost constant or varies minutely with respect to nodes mobility. However when simulation is performed for less time period, higher mobility nodes leads to loss in respect to their throughput and packet delivery fraction.

5. CONCLUSIONS

In this paper, author evaluated the realistic mobility for Indian Automotive Region. It has considered two different regions for realistic evaluation. Their research can effectively and efficiently evaluate the two different regions based on their simulation parameters.

Table 2: Evaluation of VANET for Urban and Rural

Region	Simulation Time	No of Nodes	%Gain (Matrices)
Urban	1000	100	4
		150	7
		250	4
		500	6
	500	100	7
		150	8
		250	8
		500	9
Rural	1000	100	1
		150	1
		250	1
		500	No Change
	500	100	No Change
		150	No Change
		250	-1
		500	-2

It was found in table 2 that the rural region shows almost constant growth with respect to nodes mobility and simulation time. But as the region changes to urban, it shows gain as the number of nodes mobility increases. But less simulation time provide more gain in throughput and packet delivery fraction. It also shows the decrease in packet loss.

The study also highlights that there is vast scope for Indian Automotive Networks to be evaluated for realistic simulation, and need to improve existing models and routing protocols for Indian Automotive Networks. The future work will be on realistic evaluation for different models for improving the packet throughput. So that packet loss can be reduced to large extent. It will also further exploit existing routing protocols for more realistic evaluation to Indian Automotive Networks.

ACKNOWLEDGEMENTS

Thank you all mighty god for your kind blessings. We also thank our friends and family for their support!

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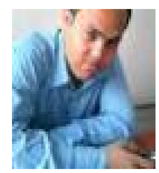

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