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Design and Simulation of Vehicular Adhoc Network using SUMO and NS2

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Abstract

Imagine a situation in which a vehicle shares its beacon information such as position, speed, direction, etc. in addition safety message such as traffic, slippery, road condition etc with other nearby vehicles so that nearby vehicle can know the status of traffic, accident information, road conditions etc. before reaching or facing it. Thereby, we can reduce road accidents, decrease the waiting at traffic signals, save the life of people. We are initiated to design and analysis of the transmitter of a vehicle node which communicates the in high dynamic environment and frequent connectivity change situation. We analyzed the average packet success ratio and throughput of VANET in Real Traffic environments for various routing protocols. Our proposed design and analysis proved that transmitter is suitable for vehicle to vehicle communication and performs better result in real traffic conditions and high dynamic environment.

Keywords: IEEE 802.11p, NS2, On-board Unit (OBU), Road Side Unit(RSU), SUMO, Vehicle to RSU Communication, Vehicle to Vehicle Communication, WAVE.

1. INTRODUCTION

Advances in ad hoc wireless technology and enhancement in intelligence of human thought process, give rise to the emergence of special and unique category of wireless technology called Vehicular adhoc network (VANET) and also Institute of Electrical and Electronics Engineers (IEEE) standards for Wireless Access in Vehicular Environment (WAVE) is presently represented as the most advanced and emerging technology for vehicular wireless networks. It goal is to support inter vehicle communication, reliable & safe communication in a transport or vehicular environment. Vehicular adhoc network (VANET) is subset of wireless adhoc communication in which vehicles acts as node. Every vehicle is able to communicate with other nearby vehicle by forming adhoc network. VANET is uniquely differentiated based on two special & unique characteristics of wireless networks such as high dynamic connectivity in network and frequently change of network topology. These two properties separate the VANET from other networks such as MANET etc. the increased utilization of vehicles on roads, also increases the road accidents, unsafe journeys and polluted environment etc. and these things motivated us to initiate this work. To assure the safe journey of passengers, drivers and provide the comfortable & easy driving environment, different messages for different requirement are communicated to nearby vehicles called the inter-vehicle communications.

Every vehicle in these networks is integrated with VANET transceivers or OBU to communicate with other vehicles to form a special class of wireless adhoc networks, known as vehicular ad hoc networks or VANETs [1]. Every vehicle node is equipped with an network interface unit called on-board unit (OBU) which consists of communication module, processing module and display unit. With the help of communication module in OBU, each vehicle node able to communicate with other nearby vehicle node (OBU). Vehicular communication system is specially characterized by its high speed of vehicular nodes, wide range of relative speeds among vehicles nodes and frequently changes in network topology. In VANETs, vehicle nodes tend to move in an organized and pre specified mobility (such as streets lane, four road junction etc.), thus, low level technical issues like energy utilization and an design of antenna etc. are not significant technical issues [2] in these types of networks. Vehicular system may consist of Road Side Unit (RSU) in addition to OBU, which is a network interface device located in the moving vehicles and connected to both in adhoc mode and infrastructure mode. In adhoc mode, every vehicle node or OBU is able to communicate with other vehicle node or OBU. In infrastructure mode, every vehicle node or OBU is communicate with Road Side Unit (RSU), which can be described as a device installed in the road infrastructure (such as. Light pole and road signs) that able connect to the moving vehicle to collect vehicle messages at base level which in turn is connected to the core network [3] to share and store data. Vehicular network have two main types of communications. One main type of communication is vehicle to vehicle or OBU to OBU and second is Vehicle to RSU or OBU to RSU communication as shown in Figure 1.

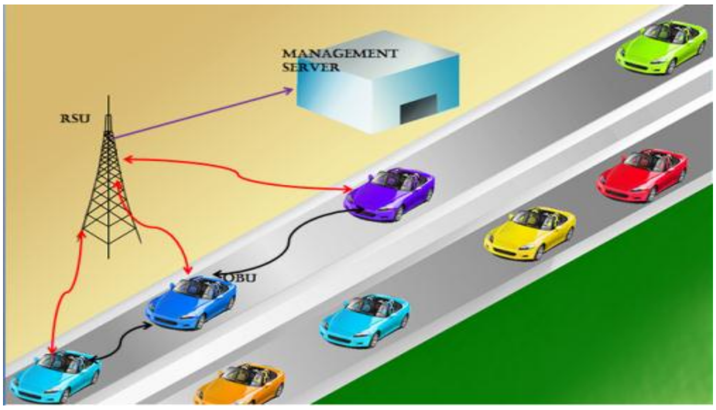

Fig. 1. Vehicular Adhoc Network (OBU-OBU & OBU-RSU)

Figure 1 shows the vehicular network formed among the OBUs or vehicle nodes, OBU to RSU and RSU to RSU. One OBU. In this paper, we provide two key contributions pertaining to multi-channel VANETs. First, we generated the mobility data from real time GPS OpenStreetMap with help of traffic generator. Second, we integrated real time traffics generated from SUMO into ns2 simulator.

2. RELATED WORK

Authors in [3] and [4] utilized the real maps imported from Google maps, and vehicle mobility patterns are constrained or restricted to a real road topology from maps, but the source node and destination nodes are random generated. In practical or real situations, the city's traffic flow will be adapted with respect to time i.e during office hours, during odd timings and special events etc. and it is not completely generated by random. A real traffic generator has been used in [5], but it does not provide the traffic lights, road maximum speed and other details. Authors in [6] integrate VISSIM with NS2 and achieve an agreement under real traffic conditions, but VISSIM is not open source, so this method is not widely used.

The remainder of this paper is organized as follows. Section 2 summarizes the existing work done or related work in VANET. Real time traffic generation and simulation using SUMO is presented in Section 3. VANET simulation using NS2 simulator and methodology used is summarized in Section 4. Simulation results are described in section 5. Section 6 concludes the paper.

3. REAL TIME TRAFFIC GENERATION

As modeling & simulation approaches plays a two important & increasingly significant roles in VANET research in current situations, many efforts have been taken to dedicated to the network simulation of real vehicle traffic scenarios. Deployment of hardware to form network scenario requires minimum of five nodes and become expensive in developing countries like India. We initiated implementation of VANET network with real time traffic. As we said above, this traffic was generated from OpenStreetMap which contains latitude, longitude or position of vehicle etc. and step by step process is given below.

Real Traffic Generator (SUMO)[8]

To design and implementation of VANET in urban environment, we downloaded the Visakhapatnam city OSM file from OpenStreetMap [10] and created a real time road traffic scenario using SUMO 0.22 simulator with a real traffic as shown in below figure 2 and detailed view of communication is shown figure 3. The mobility of traffic data is generated in SUMO trace exporter, that will be exported to NS2 simulator which is used as vehicular network simulator for analyzing the VANET performance.

By using sumo commands such as netconvert and polyconvert, we are able to convert the open street map OSM data into configuration (cfg) file. These configuration files are used to store information and settings. we can also generate trace files which is a very important step in order to create a network scenario for the network simulator which is NS 2 in our case. Generation of trace files can be done in different ways such as using sumo trace exporter, & using MOVES etc. Because SUMO has an inbuilt utility to generate trace files that comes in the default package in sumo itself (any extra software components not required), we preferred the SUMO trace exporter. The sumo package contains tools directory which contains exporter. We can use this either by using the newer command - Python Script or by using the traditional –jar file.

It is a two-step process.

Step1: Use SUMO, to create a traffic trace file using fcd output attribute as shown below:

```
sumo -c My-scenario.sumo.cfg --fcd-output sumoTrace.xml.
```

Step2: Convert the traffic data file into actual/destination trace file format. In our case, it is tcl script which is NS2 trace file. There will be three output files: mobility file, activity file and config file.

C:/traceExporter.py –fcd-input=smpleTrace.xml –ns2mobility-output=mobility.tcl

C:/traceExporter.py –fcd-input=smpleTrace.xml –ns2activity-output=activity.tcl

C/traceExporter.py –fcd-input=smpleTrace.xml –ns2config-output=config.tcl

The above procedure shows creation of traffic files (tcl format) and was integrated into Ns2 simulator

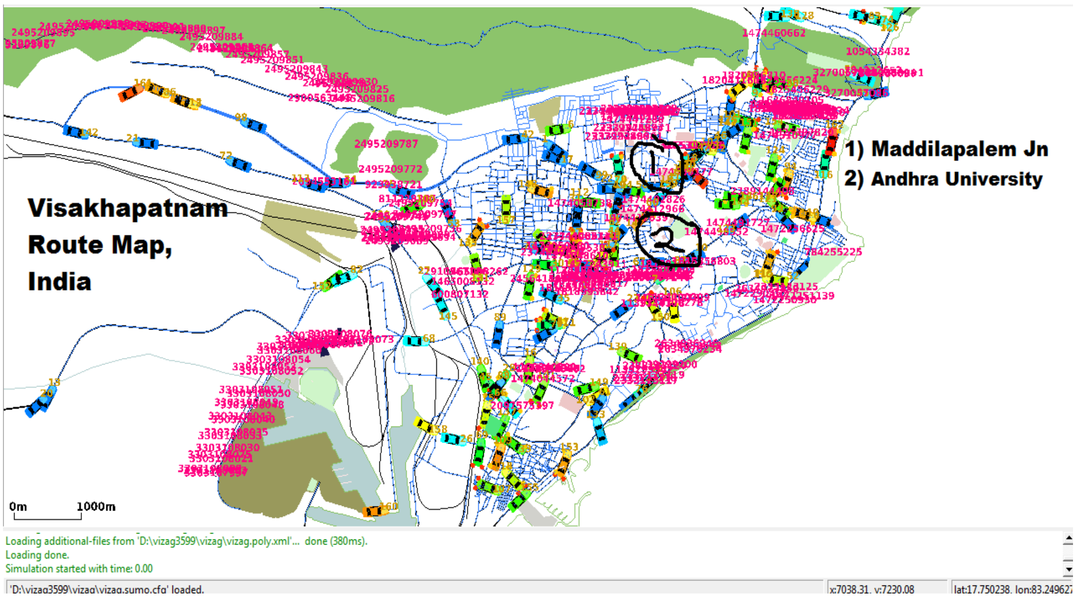

Fig. 2. Visakhapatnam Traffic Simulation in SUMO 0.22

The SUMO simulator is an open source and real time traffic simulation package including net import and demand modeling components. SUMO helps to investigate several research topics in networks e.g. route analysis and traffic light methods and simulating vehicular networks [1] Therefore the framework is used in different projects to simulate automatic driving or traffic management strategies. Few features of SUMO has, space-continuous and time-discrete vehicle movement, different vehicle types, multi-lane streets with lane changing, different right-of-way rules, traffic lights, a fast open GL graphical user interface, manages networks with several edges, fast execution speed, interoperability with other application at run-time, network-wide, edge-based, vehicle-based, and detector-based outputs, supports person-based inter-modal trips, high portability and high interoperability. Hence SUMO is more suitable and convenient for simulation of vehicular communication.

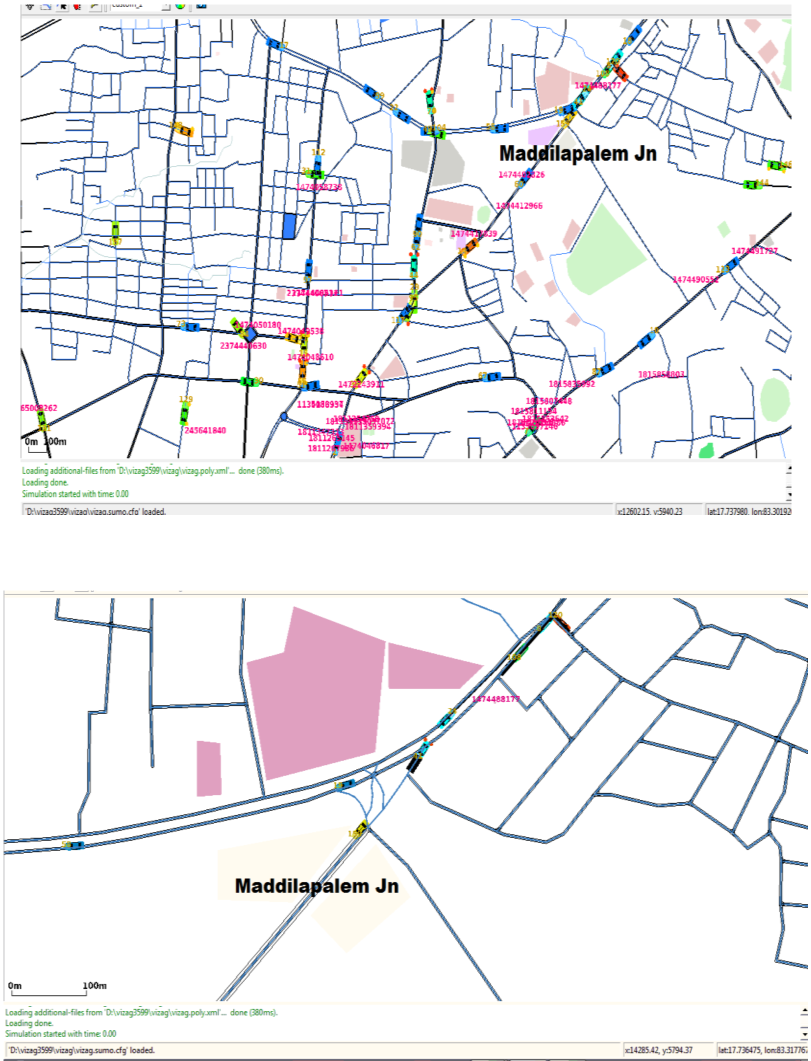

Fig. 3 Traffic at Maddilapalem junction in Visakhapatnam city.

An experiment is conducted to implement and simulation of VANET. Experiment can be of two types' outdoor experiment and experiment using simulators. Before the implementation of VANET in real World, Series of experiments should be carried out to test it. These experiments can be expensive and highly complex to inherit all kinds of situation. For this purpose software simulations can be implemented to eradicate such factors. In VANET, two types of simulation are required for smooth functioning, Network simulation and Traffic simulation. Network simulators such as NS2 [9] are used to evaluate the network protocols or say routing protocols for issues related to the communication among vehicles, and application in a variety of conditions whereas traffic simulators are used for Traffic engineering and transportation.

4. SUMO AND NS2 INTEGRATION FOR VANET SIMULATION

Network Simulator 2 (NS2) is a event based discrete network scenario simulation software for various protocols in Internet systems and targeted primarily for research and educational use [1]. NS2 is a research community accepted network simulator. Comparing with other well-known network simulation tools, NS2 has several advantages. The first & foremost one is, its code is open source, research community accepted and openness facilitates to modify the existing mechanism as per our requirements. The second one is its extendibility and stability. NS2 can support large simulation scenario where the number of nodes can be up to 20000, making the simulation results more realistic. The sequence of steps in integration of traffic simulator and network simulator is shown below figure 4.

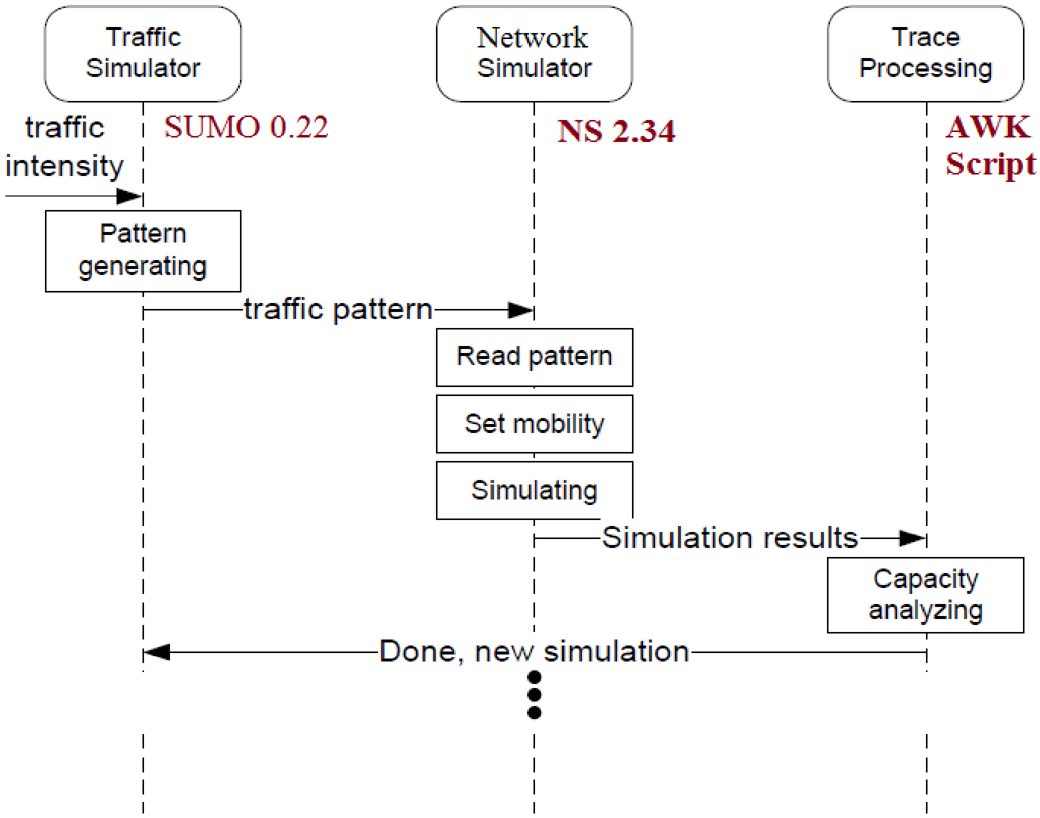

Fig 4. Sequence diagram of flow of execution of VANET application

Simulation Setup and its Results

Table 1: VANET Simulation Parameters

Parameter	Value
Network Simulator	NS 2.34
Traffic Simulator	SUMO v0.22
Map Model	OSM (Visakhapatnam city)
Routing Protocol	AODV,DSDV,DSR
Transport Protocol	UDP,TCP
Number of Vehicles	10-100
Minimum Speed	1 km/h
Maximum Speed	60 km/h
Propagation Model	Two ray ground, Nakagami
Simulation time	50,100,150,200 s
Modulation	BPSK,QPSK,16QAM,64 QAM
Data Rates	3-27 Mbps
Packet Size	500,900 bytes
Application Type	CBR
Code rate	½, 2/3

Simulation of VANETs with various parameters as shown in table 1, was experimented and observed behavior of network in different scenarios. For the performance evaluation in IEEE 802.11p protocols with network density of 50 vehicle nodes in smart city environment, we created a road traffic scenario in SUMO v0.22 (Simulation of Urban Mobility) with a traffic of 10 to 100 vehicles and integrated SUMO 0.22 with NS2 as shown in Figure 5. The traffic files are generated in SUMO trace exporter, will be exported to NS2 2.34 [11] which is a network simulator for analyzing the VANET performance using pre built-in or standard topology based routing protocols such as Adhoc On Demand Distance Vector (AODV), Distance Source Routing (DSR), Destination-Sequenced Distance-Vector Routing (DSDV) as shown in Figure 5. The output of sumo simulator (traffic scenario) file is loaded in ns2 simulator to real time traffic simulation.

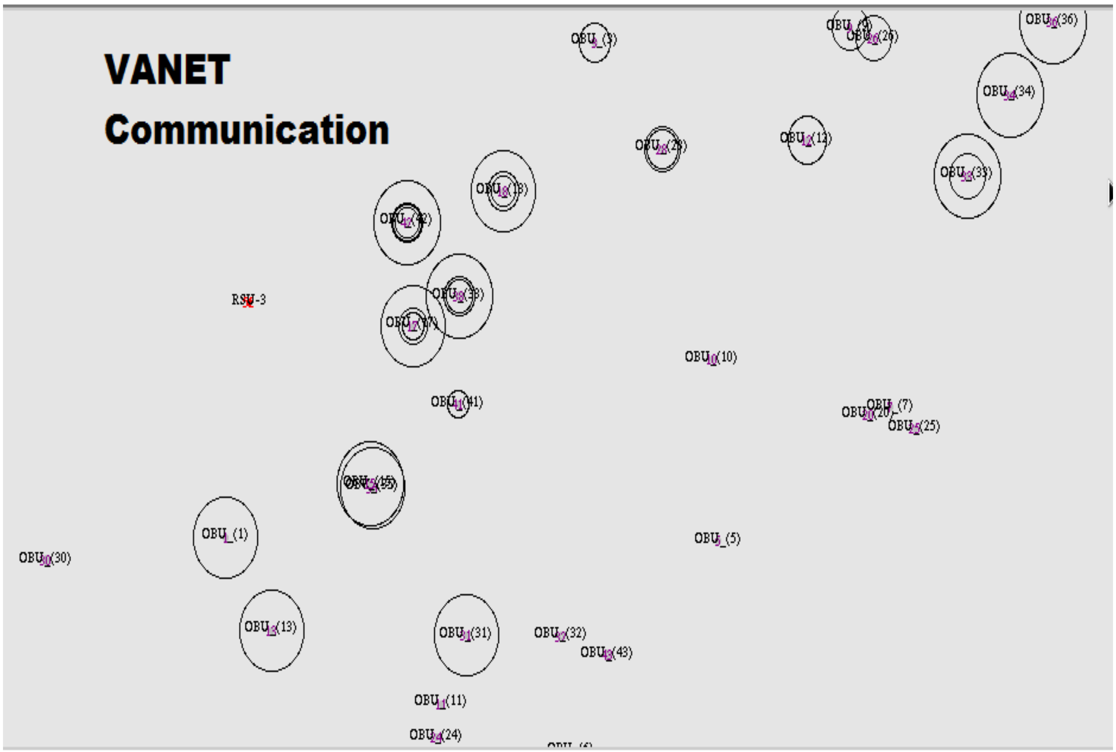

Fig. 5. Visakhapatnam Traffic Simulation in NS2

Figure 5 shows the OBU nodes and RSU formed in vehicular network. Circle around the each nodes indicates that the communication range of a node, a message passed to nearby OBU or RSU nodes. Even though OBU and RSU are differentiated in terms of computation power, we considered both a same. In real time scenarios, RSU is more computation power than the OBU.

5. PERFORMANCE EVALUATION AND RESULTS

The behavior or performance of VANET in various scenarios measured or performance metrics considered, in terms of average packet delivery ration, average throughput and average end to end delay. The packet delivery ratio (PDR) is calculated as the ratio of the number of data packets transmitted to the destination successfully is given by equation 1.

$$\text{pdr}=\frac{\sum Pr}{\sum Ps} \qquad \text{Equation 1}$$

Where pdr indicates packet delivery ratio, Ps is the total number of packets sent between one source and one destination node and Pr is the total number of packet received sucussfully. Network behavior or performance is determined by averaging the packet delivery ratio among all nodes in the network and calculated as the following equation 2.

$$\text{Avg(PDR)} = \sum_{i=1}^{n}\sum_{j=1}^{n} PDRij \qquad \text{where } i \neq j$$

Equation 2

PDRij is the packet delivery ration between source node i to destination node j (computed based on equation1) and Avg(PDR) is sum of all PDRs in network divided by n where n is total number of node in VANET network gives the actual PDR of VANET. Equation 2 is used to compute the average packet delivery ration of VANET.

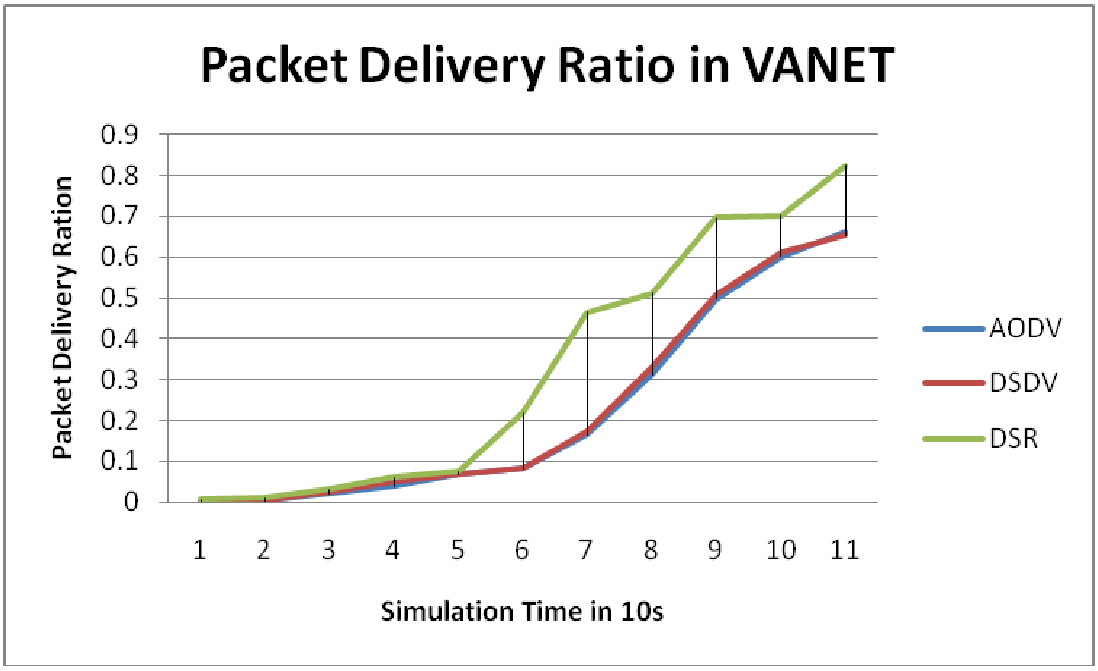

Fig. 6. Packet Delivery Ratio in VANET

Throughput of VANET is a measure of the amount of data transmitted from the source vehicle to the destination vehicle in the Vehicular network in a unit period of time (second) given by equation 3.

$$Thr = \frac{\sum_{i=1}^{n} Nbi}{Ti}$$

Equation 3

where Thr is the throughput of the node i, Nb is the number of bits transmitted from source to destination and t is the time taken for transmission.

$$\text{Avg(Throughput)} = \sum_{i=1}^{n} \text{Thri} \quad \text{where i indicate vehicle node number}$$

Equation 4

Average throughput of VANET is computed as sum of throughputs of all vehicle nodes successfully transmitted divided by n where n is total number vehicle nodes in network. Equation 4 is used to computed the average throughput of VANET

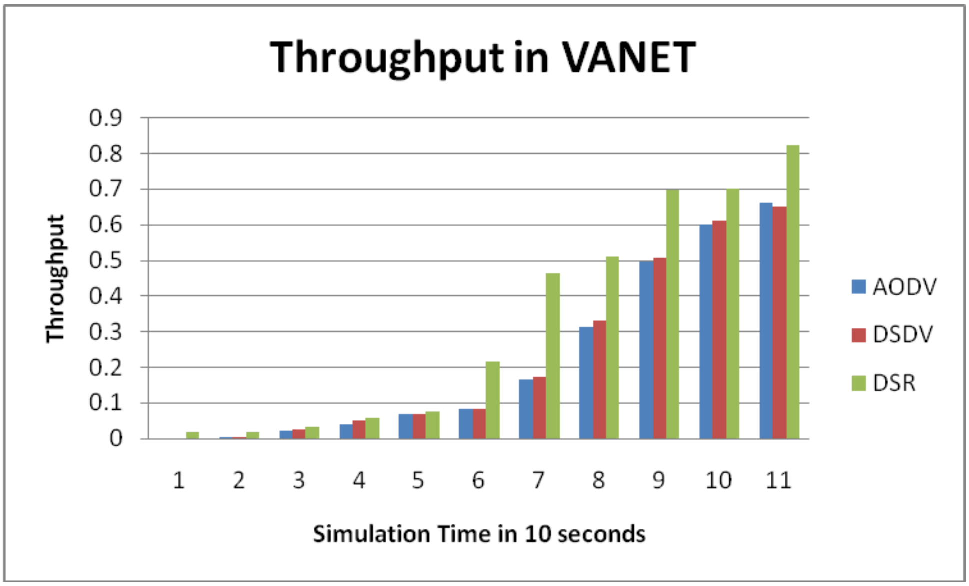

Fig. 7. Throughput in VANET

End-to-end Delay is determined by the average time taken by a data packet to arrive in the destination in network and given by equation .

$$Dee = \frac{\sum(at - st)}{\sum Nc}$$

Equation 5

where eed is the end to end delay, at is the arrival time of the data packet, st is the sent time of the data packet and nc is the number of connections.

Figure 6 and Figure 7 shows the packet delivery ratio and throughput respectively of vehicular network.

6. CONCLUSION

The overall objective of this paper is to evaluate behavior the vehicular network in different scenario. A detailed study made of the structure of the WAVE architecture for VANETs. We subsequently created a set up with real traffic scenario of Visakhapatnam city of various node densities which will help us to analyze the performance metrics of the VANET (throughput, End to end delay, and packet delivery). This scenario is implemented and evaluated using ns-2 network simulator and SUMO traffic simulator. One of the most important points in the vehicular communication simulation is that the nature of vehicular communication is based on the movement, so it is necessary to implement a realistic vehicular movement in the simulation. In other words, all of the important parameters should be implemented accurately in the VANET simulation. The main novelty of this paper is to implement the key parameters of 802.11p standard in ns-2, and prepare the realistic vehicular mobility model by SUMO. Our analysis results shows that DSR routing protocol performing the better in real time and dynamic environment as simulation time increases. Our future work is to provide security routing protocol in realistic and dynamic connection of VANET

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