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Implementation and Performance Analysis of AODV Routing Protocol in VANETs

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Abstract— Vehicular Ad Hoc Network (VANET) is a sub class of Mobile Ad Hoc Networks (MANET). VANET provides wireless communication among vehicles and vehicle to road side equipments. The communication between vehicles is used for comfort, safety and for entertainment as well. The performance of communication depends on how better the routing takes place in the network. There are many routing protocols that have been proposed and assessed to improve the efficiency of VANET. In this paper, simulation of AODV routing protocol is done on simulators SUMO, MOVE and NS2. MOVE tool is an open source micro-traffic simulator which used along with SUMO to generate real world mobility models for VANET. Based on the simulation results performance of AODV is analyzed with respect to various parameters like Throughput, Packet drops etc. and graphs were plotted using MATLAB for evaluation.

Index Terms— AODV, MOVE, SUMO, NS-2, MATLAB

I. INTRODUCTION

A Vehicular Ad-Hoc Network or VANET is a technology that **uses moving vehicles as nodes in a network to create a mobile network.** VANET turns every participating vehicle into wireless router or node, allowing vehicles approximately 100 to 300 meters of each other to connect and create a network with wide range. Fig. 1 shows a view of Vehicular Ad Hoc Network. As vehicles fall out of the signal range and drop out of the network, others vehicles can join in, connecting vehicles to one another so that a mobile Internet is created. It is estimated that the first systems that will integrate this technology are police and fire vehicles to communicate with each other for safety purposes [1].VANET deploy the concept of continuously varying vehicular motion.

Vehicular ad-hoc networks are currently attracting the extensive attention of research in the field of wireless networking as well as automotive industries. Communication in mobile ad hoc wireless networks bolsters various distributed applications among mobile nodes in infrastructure-free environments. Characterized by relatively high mobility, communication in VANETs exhibits stronger challenges than that in other general MANETs. Infrastructure-free environments and higher dynamic network topology cause frequent network partition. Moreover, vehicular ad hoc wireless networks is often deployed by the constraint of roadways where trees, Buildings and other assorted obstacles influence the practical transmission effects as compared to generic open fields.

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VANETs are one of the most promising application areas of MANETs. VANET communication is normally accomplished through special electronic devices placed inside each vehicle so that an ad hoc network of the vehicles is formed on the road. A vehicle equipped with a VANET device should be able to receive and relay messages to other VANET device equipped vehicles in its neighborhood. VANET applications can be broadly classified into two categories: safety applications and comfort applications [2]. An example of a safety application is on-board active safety systems to assist drivers with information (like accidents, road surface conditions, intersections, highway entries and etc) about the road ahead. Comfort applications are those applications that can provide noncritical services like weather information, gas station or restaurant locations, mobile e-commerce, Internet access, music downloads and etc.

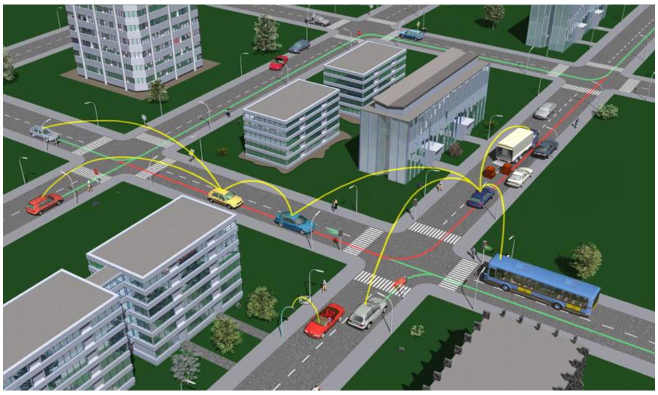

Fig. 1: Vehicular Ad Hoc Network

There are many routing protocols that have been proposed and estimate to improve the efficiency of VANET. In this paper, we are trying to analyze the performance of one of the routing protocols AODV with respect to various parameters like Throughput of sending, receiving and dropping packets. The performance analysis of proposed protocol has been done using simulation tools Network Simulator (NS) and Mobility model generator for Vehicular networks (MOVE) over Simulation of Urban Mobility (SUMO). The rest of the paper is organized as follows: section 2 presents classification of routing protocols for VANET and AODV is explained in detail. Section 3 presents simulation model used for carrying out the experiment. Section 4 shows the analysis and results and section 5 covers the conclusion and future scope.

II. ROUTING PROTOCOLS

A routing protocol generally decides the way of exchanging information in two communication entities. It includes the procedure in establishing a route, forwarding decision and maintaining or recovering from routing failure. The main task for routing protocol is to provide optimal paths between network nodes via minimum overhead. High mobility of nodes in VANET system make design a routing protocol challenging issue and also responsible to compute and maintain efficiently routing paths among the vehicles. So far several routing protocols have been developed, adapted and improved from algorithms that proposed in the past of MANET. But for VANET scenario they are not able to guarantee the same level of efficiency yet. These can be classified in many ways, according to different aspects, such as: protocols characteristics, routing information, techniques used, quality of service, routing algorithms, network structures, and so on [3]. These papers mainly focus on topology-based and graphic-based routing as shown in Fig. 2.

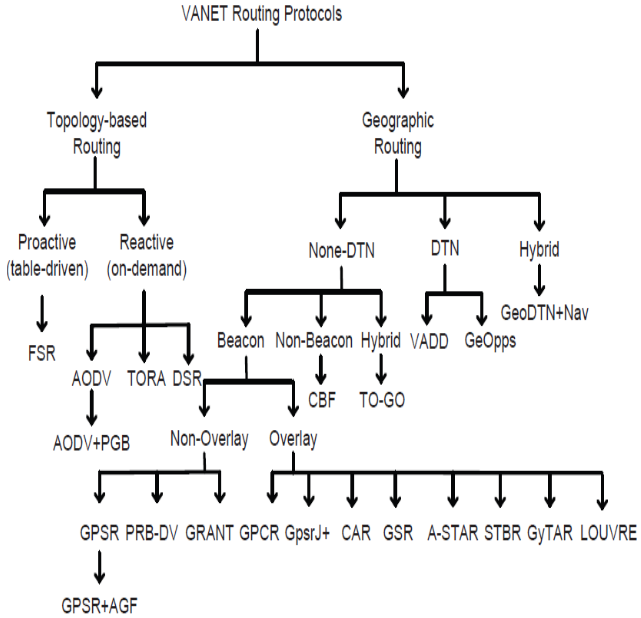

Fig. 2: Classification of routing protocols in VANET

Topology-based routing protocol usually a traditional MANET routing protocol, it uses link's information which stored in the routing table as a basis to forward packets from source node to destination node whereas geographic routing uses the destination node location to forward the packet. Topology-based routing protocols can be classified as proactive (periodic), reactive (on-demand) and hybrid. Proactive protocols allows a network node to use the routing table to store routes information for all other nodes, each entry in the table contains the next hop node used in the path to the destination, regardless of whether the route is actually needed or not. The table must be updated frequently to indicate the network topology changes, and should be broadcast periodically to the neighbors. This scheme may cause more overhead especially in the high mobility network. However, routes to destination will always be available when needed [4]. Whenever reactive routing protocols (also called on-demand) reduce the network overhead; by maintaining routes only when needed, that the source node starts a route discovery process, if it needs a non existing route to a destination. Reactive routing protocols are applicable to the large size of mobile ad hoc networks which are highly mobility and frequently topology changes. And we have used on of the reactive routing protocol for analysis.

A. Ad-hoc on Demand Distance (AODV)

An ad hoc network is the cooperative engagement of a collection of mobile nodes without the required intervention of any centralized access point or existing infrastructure. AODV is a novel algorithm for the operation of such ad hoc networks. Proactive based routing protocols is not suitable for the nodes (vehicles) having high mobility in VANET. Proactive routing protocols may fails in VANET due to the large table information and consumption of more bandwidth. AODV is a reactive routing protocol, so a route is created when a node wants to send a packet. AODV provides loop-free routes even while repairing broken links. Because the protocol does not require global periodic routing advertisements, AODV uses symmetric links between neighboring nodes. It does not attempt to follow paths between nodes when one off the nodes cannot hear the other one. Nodes do not lie on active paths; they neither maintain any routing information nor participate in any periodic routing table exchanges. Further, a node does not have to discover and maintain a route to another node until the two needs to communicate unless the former node is offering its services as an intermediate forwarding station to maintain connectivity between two other nodes [5]. When the local connectivity of the mobile node is of interest, each mobile node can become aware of the others nodes in its neighborhood by the use of several techniques, including local (not system wide) broadcasts known as Hello messages. The routing tables of the nodes within the neighborhood are organized to optimize response time to local movements and provide quick response time for requests for establishment for new routes.

The algorithm's primary objectives are as following:

- To broadcast discovery packets only when needed.
- To distinguish between local connectivity management neighborhood detection and general topology maintenance.
- To disseminate information about changes in local connectivity to those neighboring mobile nodes those are likely to need the information

B. AODV Path Discovery

AODV path discovery process is originated whenever a source node needs to communicate with another node for which it has no routing information in its table. Every node maintains two separate counters: a node sequence number and a broadcast ID. The source node initiates path discovery by broadcasting a Route Request (RREQ) packet to its neighbors (Fig.3a). The broadcast RREQ contains addresses of source and destination, their sequence numbers, broadcast ID and a counter, which counts how many times a RREQ, has been generated from a specific node. Each neighbor either satisfies the RREQ by sending a Route Reply (RREP) back to the source (Fig. 3b), or broadcasts the RREQ to its own neighbors after increment in the hop counter. A node may receive multiple copies of the same route broadcast packet from various neighbors. When an intermediate node receives an RREQ, if it has already received an RREQ with the same broadcast ID and source address, it drops the redundant RREQ and does not rebroadcast to make communication loop free. If a node cannot satisfy the RREQ, it keeps track of the destination IP address, source IP address, broadcast IP address, expiration time for reverse-path route entry and source node's

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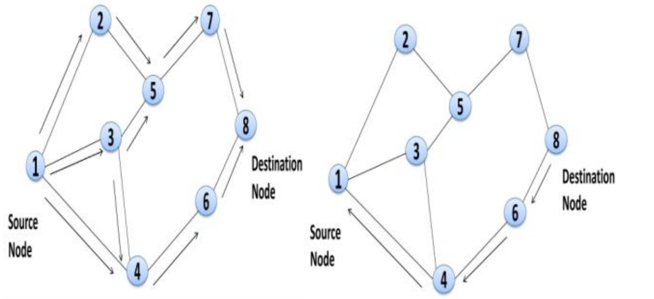
sequence number to implement the reverse-path setup as well as the forward-path setup that will accompany the transmission of the eventual RREP.



(a) RREQ Propagation (b) RREP path to the source
Fig. 3: AODV path discovery

C. AODV Reverse Path Setup

There are two sequence numbers included in an RREQ: the source sequence number and the destination sequence number known to the source. The source sequence number is used to maintain freshness information about the reverse route to the source, and the destination sequence number specifies how fresh a route to the destination must be before it can be accepted by the source. As the RREQ travels from a source to various destinations, it automatically sets up the reverse path from all nodes back to the source. To set up a reverse path, a node records the address of the neighbor from which it received the first copy of the RREQ. These reverse-path route entries are maintained for at least enough time for the RREQ to traverse the network and produce a reply to the sender.

D. AODV Forward Path Setup

Finally, an RREQ will arrive at a node (possibly the destination itself) that possesses a current route to the destination. The receiving node first checks that the RREQ was received over a bidirectional link. If an intermediate node has a route entry for the desired destination, it determines whether the route is current by comparing the destination sequence number in its own route entry to the destination sequence number in the RREQ. If the RREQ's sequence number for the destination is greater than that recorded by the intermediate node, the intermediate node must not use its recorded route to respond to the RREQ [6]. Instead, the intermediate node rebroadcasts the RREQ. The intermediate node can reply only when it has a route with a sequence number that is greater than or equal to that contained in the RREQ. If it does have a current route to the destination and if the RREQ has not been processed previously, the node then unicasts a route reply packet (RREP) back to its neighbor from which it received the RREQ. An RREP contains the source address, destination address, destination sequence, hop count and lifetime. By the time a broadcast packet arrives at a node that can supply a route to the destination, a reverse path has been established to the source of the RREQ. As the RREP travels back to the source, each node along the path sets up a forward pointer to the node from which the RREP came, updates its timeout information for route entries to the source and destination, and records the latest destination sequence number for the requested destination. The forward path setup as the RREP travels from the destination D to the source node S. Nodes that are not along the path determined by the RREP will time out after active route time (3000 milliseconds) and will delete the reverse pointers.

A node receiving an RREP propagates the first RREP for a given source node toward that source. If it receives further RREPs, it updates its routing information and propagates the RREP only if the RREP contains either a greater destination sequence number than the previous RREP or the same destination sequence number with a smaller hop count. It suppresses all other RREPs it receives. This decreases the number of RREPs propagating toward the source while also ensuring the quickest and most up-to-date routing information. The source node can begin data transmission as soon as the first RREP is received and can later update its routing information if it learns of a better route.

E. AODV Route Table Management

Routing table entries associated with reverse-path entries is a timer "route request expiration timer". The purpose of this timer is to avoid reverse-path routing entries from those nodes that do not exist on the path from the source to the destination. The expiration time depends upon the size of the ad hoc network. Another important parameter associated with routing entries is the route-caching timeout, or the time after which the route is considered to be invalid. In each routing table entry, the address of active neighbors through which packets for the given destination are received is also maintained. A neighbor is considered active for that destination if it originates or relays at least one packet for that destination within the most recent active timeout period. This information is maintained so that all active source nodes can be notified when a link along a path to the destination breaks.

F. AODV Path Maintenance

Movement of nodes not lying along an active path does not affect the routing to that path's destination. If the source node moves during an active session, it can re initiate the route discovery procedure to establish a new route to the destination. When either the destination or some intermediate node moves, a special RREP is sent to the affected source nodes. Periodic Hello messages can be used to ensure symmetric links, as well as to detect link failures. Alternatively, When the node does not receive any packets from a neighbor during a few seconds, it assumes a link break to the neighbor such failures could be detected by using link layer acknowledgments (LLACKs). A link failure is also indicated if attempts to forward a packet to the next hop fail [7]. Once the next hop becomes unreachable, the node upstream of the break propagates an unsolicited RREP with a fresh sequence number, that is, a sequence number that is one greater than the previously known sequence number and hop count of all active upstream neighbors. Those nodes subsequently relay that message to their active neighbors and so on. This process continues until all active source nodes are notified; it terminates because AODV maintains only loop-free routes, and there are only a finite number of nodes in the ad hoc network.

III. SIMULATION MODEL

In this, section we will discuss various tools used for simulation which can produce realistic mobility model, Performance metric and simulation parameters.

A. Simulation tools

Implementation and performance analysis of AODV routing protocol in VANET can be done using three simulation tools.

1) Network Simulator 2: Network Simulator (Version 2), widely known as NS2, is simply an event-driven simulation tool that has proved useful in studying the dynamic nature of communication networks. Simulation of wired as well as wireless network functions and protocols (e.g., routing algorithms, TCP, UDP) can be done using NS2 [7]. In general, NS2 provides users with a way of specifying such network protocols and simulating their corresponding behaviors. Due to its flexibility and modulator nature, NS2 has gained constant popularity in the networking research community since its birth in 1989. We are using Network Simulator NS2 for simulations of protocols. It provides substantial support for simulation of TCP, routing and multi cast protocols over wired and wireless networks. NS2 code is written in C++ and OTCL interpreter, thus generating an output file for NAM (Network animator) [8]. It then plots the nodes in a position defined by the code script and exhibits the output of the nodes communicating with each other. It consists of two tools. The network simulator (NS) contains all commonly used IP protocols. The network animator (NAM) is use to visualize the simulations.

2) Simulation of Urban Mobility (SUMO): SUMO is an open source, highly portable, Microscopic, multi-modal road traffic simulation package designed to handle large road networks. Fig.4 shows SUMO-GUI visualization.

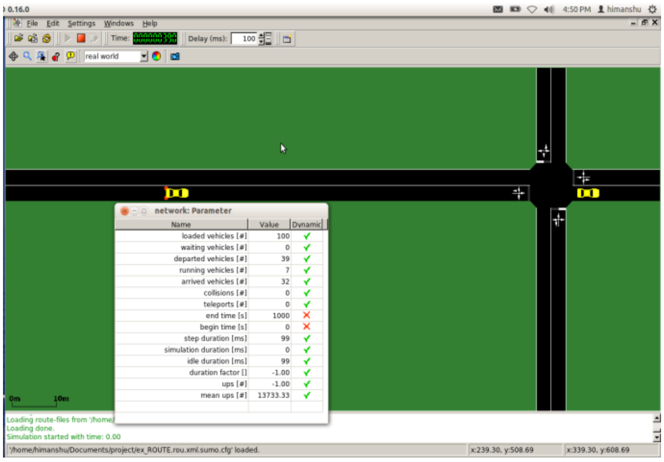


Fig. 4: SUMO-GUI visualization

It is mainly developed by employees of the Institute of Transportation System at the German Aerospace Center. SUMO is licensed under the GPL. It allows the user to build a customized road topology, in addition to the import of different ready-made map formats of many cities and towns of the world [9].

3) Mobility model generator for vehicular networks (MOVE): Mobility model generator for vehicular networks tool is used to facilitate users to rapidly generate realistic mobility models for VANET simulations. Fig. 5 shows MOVE visualization.

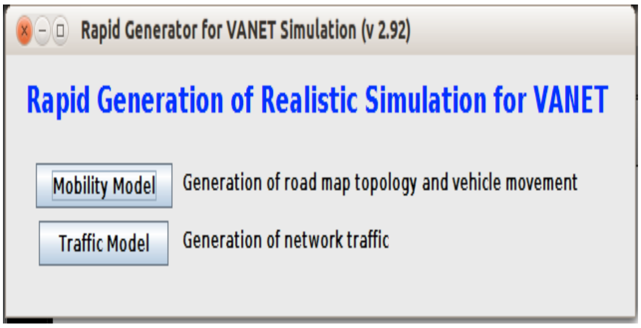


Fig. 5: MOVE visualization

In VANET it's important to use real world mobility model so that the results from the simulation correctly reflect the real world, MOVE allows the user to quickly generate realistic simulation scenarios without the hassle of writing simulation scripts as well as learning about the internal details of the simulator. MOVE is currently implemented in Java and is built on top of an open source micro-traffic simulator SUMO. By providing a set of Graphical User Interface that automate the simulation script generation, It can be run in every operation system, with the requirement that a JVM (Java Virtual Machine) has been already installed [10, 11]. The output of MOVE is a mobility trace file that contains information about realistic vehicle movements which can be immediately used by popular simulation tools such as NS2.

B. Performance Metric

Various parameters used to evaluate performance of AODV are as following:

1) Throughput of sending/receiving packets: It is the amount of data that is delivered from one node to another via a communication link per time unit. The throughput is measured in Packets per unit Time Interval Length or bits per Time Interval Length. More is the throughput of sending and receiving packets better is the performance. Lesser is the throughput of dropping packets better is the performance.

2) Average Throughput of packets: Average throughput of packets is also measured in Packets per unit TIL or bits per TIL where TIL is Time Interval Length. It is the average of total throughput.

3) Data Packets Drop: It shows total number of data packets that could not reach destination successfully. Packets drop may arise due to congestion in network, hardware fault and queue overflow etc. protocol performance will be higher as the lowest packets drop rate.

4) Data Packets Size: Size of packets in bytes.

C. Simulation Parameters

The following are the configuration parameters assumed for simulation:

TABLE 1: SIMULATION SETUP

Parameter	value
Channel type	Wireless
Network Interface type	Physical Wireless
Routing Protocol	AODV
Interface Queue type	Priority Queue
Queue Length	50 packets

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Number of nodes in topography	100
X and Y Dimensions of topography	652*752 sq.m
Time of Simulation End	1000 simulation seconds
Traffic type	TCP
Number of Road Lanes	2
Speed	10 m/s
Radio Propagation model	Two Ray Ground
MAC Protocol	IEEE 802.11

IV. PERFORMANCE EVALUATION

We have divided this section into two Subsections simulation details, results and discussion.

A. Simulation Details

Most of the simulation is done using MOVE for movement of vehicles in a particular road map. At the final stage of MOVE we get a (.tcl) file named (ex_NS2.tcl) that can be used for further analysis. We can either run the NS-2 script in own shell or using the program's NS-2 script runner (by choosing the Run NS-2 button from the traffic model main menu of MOVE). Finally, we can call the NAM trace runner from the main menu. We can play NAM and see the actual movements of vehicles as shown in fig. 6.

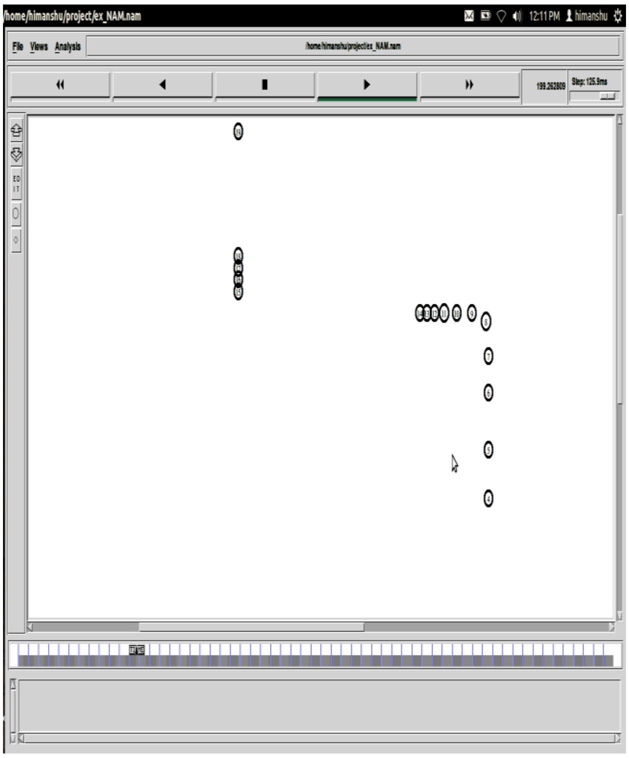

Fig.6: Network Animator Visualization

B. Results & discussion

1) Throughput of sending packets: Figure 7 showing the graph for sending packets throughput. This graph is showing that throughput increases to 9000 packets/TIL in just 1 sec. In the beginning and then suddenly it goes down to 4000 packets/TIL with little variation about 1.3 sec then it keeps on giving an average throughput of 4000 packets/TIL approx,for rest of the simulation time. This can be understood as the number of packets sent per unit time decreases. The packets sent are largest in the beginning because in the initial stage of VANET, the nodes are sending beacons in order to setup the network.

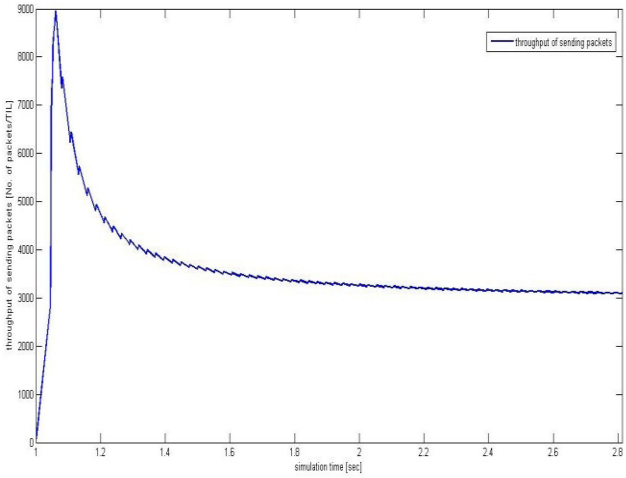

Fig.7: Throughput of sending packets

2) Throughput of receiving packets: Throughput for receiving packets is shown in fig.8 This graph is showing that throughput peaks to 16000 packets/TIL at 10 sec approx. but then drops to 9000 packets/TIL in just 0.2 sec then it gives an average throughput 8500 packets/TIL for rest of the simulation

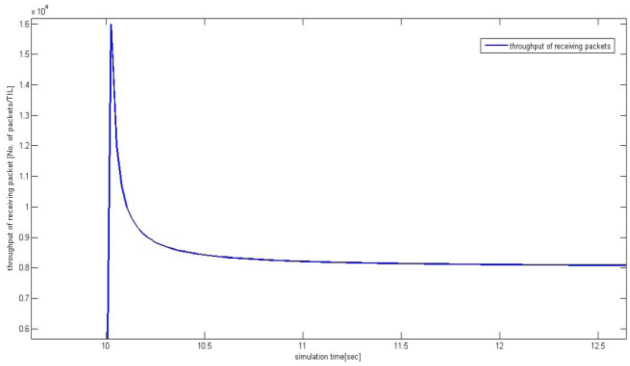

Fig.8: Throughput of receiving packets

3) Throughput of dropping packets: Throughput of drops packets is as shown in Fig. 9. Here from this graph it can be easily analyzed that number of packets dropped has increase constantly for 0.30 sec (72.45-72.75)

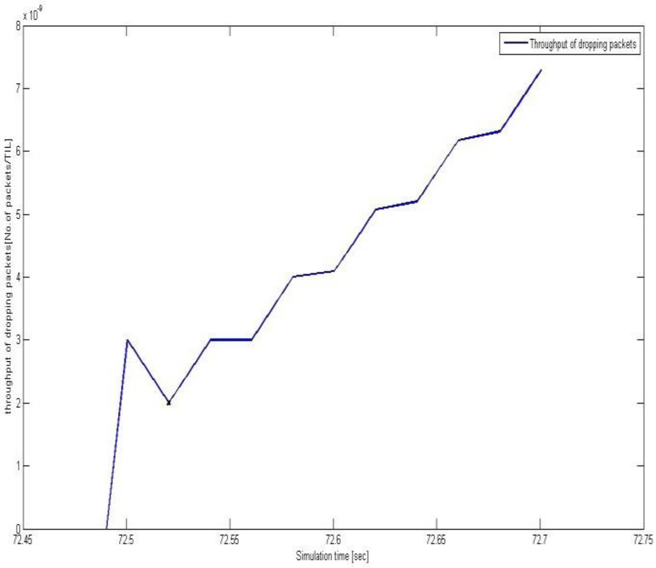

Fig.9: Throughput of dropping packets

V. CONCLUSION & FUTURE SCOPE

In this Project, MOVE is used along with SUMO and NS2 to simulate AODV routing protocol with realistic mobility model for VANET. Then graphs are plotted using MATLAB for evaluation. The performance of AODV's is analyzed for 100 nodes with respect to various parameters like throughput of sending packets, throughput of receiving packets, throughput of dropping packets etc. the simulation results for various cases can be summarized as below:

- Throughput of sending packets: Results shows that for 100 nodes, throughput of sending packets is almost uniform.
- Throughput of receiving packets: Results shows that throughput of receiving packets becomes more uniform with increase in number of nodes.
- Throughput of dropping packets: Results shows that number of packet dropped in initial few seconds is more in a network where numbers of nodes are more.

In future, it can be simulated and analyzed for higher number of nodes. It would be interesting to see how AODV performs in high node density network. Here it has been implemented for single mobility model and manually generated maps. In future performance can be compared for different mobility models. And also its performance can be analyzed for random maps, and map of any city of the world imported from TIGER database, open street maps etc. In future, the comparison of the above mention parameters can be done for different flow of traffic.

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REFERENCES

1. M. Abolhasan, T. Wysocki and E. Dutkiewicz,"A review of routing protocols for mobile ad hoc networks,"Ad Hoc Networks, vol.2, no.1, pp.1-22, Jan.2004.
2. Kapil Bhagchandani, Yatendra Mohan Sharma, "Exploration of VANET Mobility Models with New Cluster Based Routing Protocol",International Journal of Soft Computing and Engineering (IJSCE), ISSN: 2231-2307, Volume-2, Issue-6, January 2013.
3. Marwa Altayeb,Imad mahgoub,"A Survey of Vehicular Ad hoc Networks Routing Protocols", International Journal of Innovation and Applied Studies, ISSN 2028-9324, Vol. 3,No.3, pp.829-846, July 2013.
4. Lee, Kevin C.,Uichin Lee, and Mario Gerla.,"Servey of Routing Protocols in Vehicular Ad Hoc Networks,"Advances in Vehicular Ad-Hoc Networks: Developments and challenges references, IGI Global, 2010, pp.149-170, 25 Mar 2013.
5. Subir Kumar Sarkar, T.G Basavaraju, C Puttamadappa, Ad Mobile Wireless Networks, 2008.
6. C.perkins, E. Royer " Ad hoc on demand Distance vector routing"IETF, RFC 3561, 2003
7. Abolfazl,Akbari,Mehdi soruri and Khosrozadeh "A New AODV routing protocol in Moile Adhoc Networks" World Applied Sciences Journal 19 (4): 478-485, ISSN 1818-4952,2012
8. NS2. Network simulator - ns-2. Available at http://nsnam.isi.edu/nsnam/index.php/Main_Page}, 2013.
9. SUMO. Simulation of urban mobility. Available at http://sumo.sourceforge.net/, 2013.
10. Feliz Kristianto Karnadi, Zhi Hai Mo,Kun-chan Lan "Rapid Generation of Realistic Mobility Models for VANET" Available at:http://www.csie.ncku.edu.tw/~klan/data/paper/pdf/Rapid%20Generation%20of%20Realis%20Mobility%20 Models%20for%20VANET.pdf
11. MOVE. Mobility model generator for vehicular networks. Available at http://sourceforge.net/apps/mediawiki/move, 2013.

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