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QUANTITATIVE ANALYSIS OF VANET ROUTING PROTOCOLS IN URBAN AND HIGHWAY SCENARIOS

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***Abstract*— Intelligent Transport System (ITS) is one of the very well-known research area in wireless communication technology, which focuses on transport safety, reliable and secure communication among the vehicles. It is the promising approach of ITS, and sub class of MANET. VANET is the wireless ad-hoc technology which mainly comprehend about traffic monitoring, traffic flow control ,collision prevention and communication among vehicles. Main Characteristics of VANET are dynamic topology, random and high speed movement of nodes. For better communication, an effective routing protocol has to be taken into account, which works profoundly well in VANET environment and it is very challenging task. The main goal of this paper is to evaluate the performance of MANET routing protocols, Ad-hoc On-demand Distance Vector (AODV) and Optimized Link state Routing (OLSR), which are Reactive and Proactive routing protocols, respectively. And examined whether they are suitable for VANET environment, in urban and highway scenario with respect to different number of nodes and seed values. Throughput, Average end-to-end delay, Normalized routing load, Packet delivery ratio are the performance metrics used. For simulation, VanetMobiSim and NS-2 are used as mobility generator and network simulator respectively. Result shows that, according to the characteristics of reactive and proactive routing, scalability and efficiency of protocols depends and in most cases AODVworks better than OLSR**

***Index Terms*— AODV, MANET, NS-2, OLSR, Routing protocols, VANET, VanetMobiSim.**

I. INTRODUCTION

VANET is the emerging area of the wireless ad-hoc network. VANET has attracted many researchers both in terms of academic and scientific research. It mainly focuses on smart transportation, safety measures, communication between drivers and so on [12].

Usually the communication is divided into two types:

Vehicle-to-vehicle (V2V): communication occurs directly between vehicles.

Vehicle-to infrastructure (V2I): communication occurs indirectly with the help of third party (road side units) between vehicles.

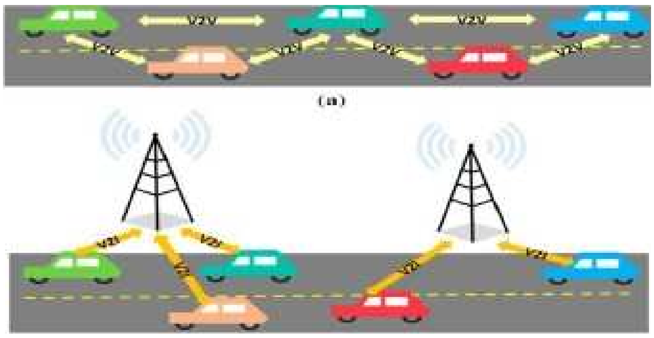

Fig-1 a) Vehicle-to-vehicle b) Vehicle-to-infrastructure

VANET poses many different features than MANET, like vehicles acts as mobile nodes [4], and the network is restrained by predefined roads, speed breakers, traffic control mechanism (eg. traffic lights and stop signs) and congestion in roads [14]. In addition to this, future generation vehicles are equipped with wide range transmission, storage efficiency and processing power, which are not an issue unlike MANET. So this leads to VANET as a very flexible and easy to adapt network, when compared to MANET [13]. Some of the characteristics of the VANET are high mobility of vehicles, distributed network, infrastructure less and dynamic topology [12]. Hence routing protocols for VANET should adapt continuously to these inflexible conditions [2]. Which becomes very challenging task in the development of communication routing protocols.

So in this paper, we will study whether the traditional MANET routing protocols are suitable for VANET environment, does these protocols can be adapted to work profoundly in VANET environment.

II. BACKGROUND

A routing protocol is the procedure to coordinate the communication between two nodes to exchange information which includes the route establishment, forwarding decisions, and the recovering from routing failure [8]. Many MANET routing protocols have been adapted to suit VANETs' characteristics. Routing protocols can be classified into five categories: Topology based, position-based, broadcast based, Geo-cast based, Position based and Cluster based [9]. This paper focused on topology based routing protocols that are OLSR and AODV.

A. *Ad hoc On-demand Distance Vector (AODV)*

AODV routing protocol works completely on demand basis, when it is required by the networks. It consists of two phases: route discovery and route maintenance. It uses route discovery by broadcasting Route Request (RREQ) message to all its neighbouring nodes. The broadcasted RREQ message carries address and sequence numbers of the source and destination node. AODV uses sequence numbers to avoid the eventually of forwarding the same packet more than once and also to maintain recent fresh demanded route information. When an intermediate node receives RREQ and if it knows the route to the demanded destination node, it sends a Route Reply (RREP) packet back to the source node. Route maintenance is needed when a route fails in the network. RERR (Route Error) lists all the nodes affected by the link failure between the nodes. When a source node receives an RRER, it can reinitiate route discovery [3,9].

B. *Optimized Link State Routing (OLSR)*

OLSR works as a table driven protocol that exchanges topology information between neighbour nodes of the network. In OLSR each node constructs and maintains the set of neighbour nodes that can be reached in 1-hop and 2-hops and it also selects a set of its neighbour nodes as multipoint relays (MPR) node to decrease the number of transmissions required. Each MPR will transmit link state information in the network. The number of active relays needed to covered by all 2-hops can be reduced by MPR algorithm. Such relays are called Multipoint Relays. The only packet is forwarded by the node if and only if it is selected as MPR by the sender node. The advantages of OLSR are: is to provide shortest path route from source node to all destinations and the available link-state information can be used to eliminate redundancy. MPRs are also used to establish the route from a given node to any destination node in the network[3,9].

III. RELATED WORKS

Several studies have been examined and studied about the performance evaluation of routing protocols for VANET. Some of the researches are listed in this section. The authors in [12] have discussed about whole concept of VANET in terms of architecture, mobility model, network security, propagation mechanism and its issues. Authors have evaluated the performance of different types routing protocols considering packet delivery ratio, node density, throughput, average end-to-end delay and routing overhead as performance metrics and they have showed that existing protocols are not efficient, a proper designed routing protocols are needed for efficient routing in VANET environment. A large number of research papers have been published about VANET, challenges faced in designing routing protocols, and about simulations for VANET.

In this section, we have discussed a series of papers, which are focused on VANET environment, comparison of routing protocols and so on In [11], authors have listed advantages and disadvantages of various routing protocols for VANET and its applications. They have explained the motivation in designing and traces of the evolution of routing protocols. At the end they have done the tabular comparison of various routing protocols.

In another paper [8], authors have discussed about challenges and features of various routing protocols. They have characterised routing protocols in two categories has transmission strategy and routing information. And explained how do they work, their advantages and disadvantages.

In [3], authors have focused on difficulties faced in designing the routing protocols for VANET as its nature is highly dynamic and frequent disconnection occurs. So this study is about pros and cons of existing protocols and this work can be used for further improvement or development of new routing protocol.

In article "Wireless Communications and Mobile Computing" [1], have done survey on several mobility generators, network simulators, VANET simulators , which in turn helps in developing a realistic simulation tools. And they concluded that VanetMobiSim is better for mobility generator because of good traffic model support. For network simulator, every simulator doesn't reach to the expectations and showed poor scalability. Groovnet and NCTUs are more frequently used for VANET simulation.

Performance analysis of traditional ad-hoc routing protocols like AODV, DSDV and DSR for the highway scenarios have been presented in [17] and the authors proposed that these routing protocols are not suitable for VANET. Their simulation results showed that these conventional routing protocols of MANET increase the routing load on network, and decrease the packet delivery ratio and end to end delay.

In our study for quantitative analysis, we have used two routing protocols AODV and OLSR which are reactive and proactive routing protocols respectively.

IV. METHODOLOGY

The methodology of this work is explained in this section. The very first step is to define XML file in which all the information about traffic mobility is described and this file is executed with the VanetMobiSim jar, which generates the traffic trace file, also called as scenario file. The generated file and network scenario are included in the Tcl file. The simulation is done using network simulator NS-2. Generated files by network simulator are .Nam and .tr files, which are used for visualisation and analysis purpose respectively.

The methodology of this work can be summarized in the below given Figure-2.

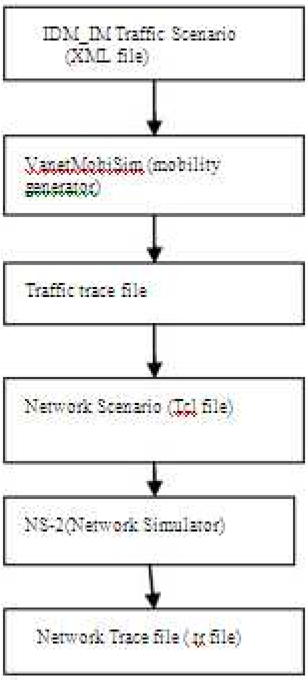

Figure. 2. Methodology flow

A. SIMULATION ENVIRONMENT AND PERFORMANCE METRICS

In this section we have described about the simulation environment, Performance metrics and parameters for both urban and highway scenario used. Simulation Environment In order to evaluate the routing protocols mentioned above, we have used the open network simulator NS-2 and the version is NS-2.35 [2]. In this work, we have considered two scenarios that is Urban and Highway Scenario. The difference between the urban and highway scenario is network topology area, traffic lanes, street lights [15].

The simulation was simulated 60 times for each scenario, with each different seed, for every variation in number of nodes[10]. This is done to both protocols AODV and OLSR. So total number of simulations done are 120 simulations. The results prepared were obtained by calculating the average of the simulation results. The details of the simulation parameters for the urban scenario and highway scenario are showed in Table 1 and Table 2 respectively

TABLE- 1

Number of nodes	15,20,30,40,50 nodes
Simulation time	1000 sec
Map size	1000 × 1000 m
Max speed	13.89 sec
Mobility model	Random Way Point
Traffic type	Constant Bit Rate(CBR)
Packet size	32 bytes
Connection Rate	4 packets/ sec
Traffic Lights	6
-Lanes	2
Mac layer type	IEEE 802.11 p
Seed	5,20,40,60,80,90
Routing Protocols	AODV,OLSR

Parameters of Urban Scenario

TABLE- 2

Number of nodes	15,20,30,40,50 nodes
Simulation time	1000 sec
Map size	4000 × 4000 m
Max speed	20 sec
Mobility model	Random Way Point
Traffic type	Constant Bit Rate(CBR)
Packet size	32 bytes
Connection Rate	4 packets/ sec
Traffic lights	0
Lanes	4
Mac layer type	IEEE 802.11p
Seed	5,20,40,60,80,90
Routing Protocols	AODV,OLSR

Parameters of Highway Scenario

B. Performance Metrics

For the evaluation of the routing protocols the used performance metrics are Packet Delivery Ratio, Average End-To-End Delay, Throughput and Normalized Routing Head [9].

a) Packet Delivery Ratio(PDR) : PDR can be defined as the ratio of total number of packets effectively reached to destination to the total number of packets sent from source. PDR evaluates the efficiency of protocol in sending packets from source to destination. Higher the PDR value, higher the efficiency of routing protocol.

PDR = total received_packets / total sent_packets

b) Throughput : It can be defined as the amount of data transmitted to destination in a specified span of time. Higher the value, more efficient is a protocol. The unit for throughput is bytes per sec. Throughput is effected by many factors like bandwidth, network topology, reliability of communication.

Throughput = recieved_bits / specified time interval

c) Normalized Routing Load (NRL): It can be defined as the total number of data packets delivered to destination node. Usually Normalized Routing Load (NRL) is used to measure the overhead created in the network during the routing operation. Lesser the value means lesser the total number of packets is created by the protocol, which leads to additional network resources available to transmit real data packets.

NRL= ∑(routing_packets_gen) / ∑ (recv_data_packets)

d) Average End-to-End Delay(E2E) : It indicates the delay in reaching the packets from source node to destination. The total delay can be considered as summation of several small delays in the network. Usually delays may be any of the reason like, buffer in route discovery latency, Media Access Control, (MAC) retransmission delays, delays in lining up at the interface, propagation delays, transfer time. The average E2E delay can be calculated by obtaining the time variance between the transmission and response of the packet at a Constant Bit Rate (CBR) and dividing the time difference by the total number of CBR transmissions. Lower E2E delays indicates better performance. A packet with an ID i is sent by source node, the current time is stored in the position i of an array (send_array[i]). If the packet with ID i received by destination node, the current time is stored in second array (receieved_array[i]). The average End-to-End (E2E) delay is given by

E2E=∑(recieved_array[i]-send_array[i])/recieved_packets

V. SIMULATION RESULTS

A. *Urban scenario*

In the urban scenario, we have used a simulation area of 1000* 1000 meters and simulation time of 1000 sec. We have conducted a simulation for different number of nodes i.e 15,20,30,40,50 with each different seed values i.e 5,20,40,60,80,90. So totally 60 simulations are taken and took average of them for each seed value.

a) Packet Delivery Ratio (PDR): Higher the value of Packet Delivery Ratio represents the reliable communication between nodes. OLSR has less PDR compared to AODV. Because in OLSR for every topology change, nodes needs to exchange the updates, that leads to excessive transmission of packets and less availability of resources, which results in many packets loss.

Graph analysis for PDR is shown in Figure-3

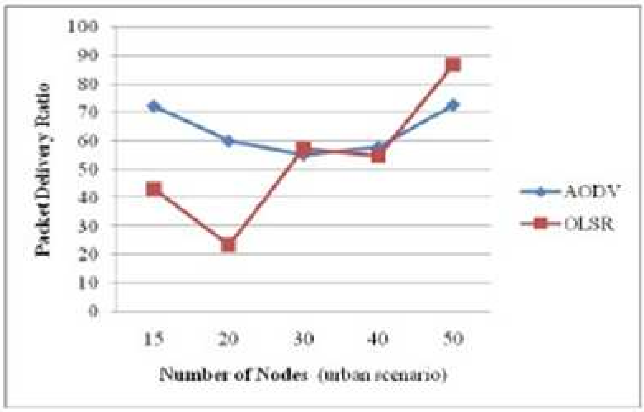

Fig. 3. Packet Delivery Ratio for varying Number of nodes

b) Throughput : The throughput for the AODV routing protocol is higher than for that of OSLR because AODV has lower routing overhead than OLSR since it searches for paths on-demand and does required to depend on the latest routing table. The lower overhead allows more bandwidth to be used for the data packets. OLSR recorded the worst throughput because it consumes a significant amount of network bandwidth because of the frequent need to send updates. Graph analysis is shown in Figure-4.

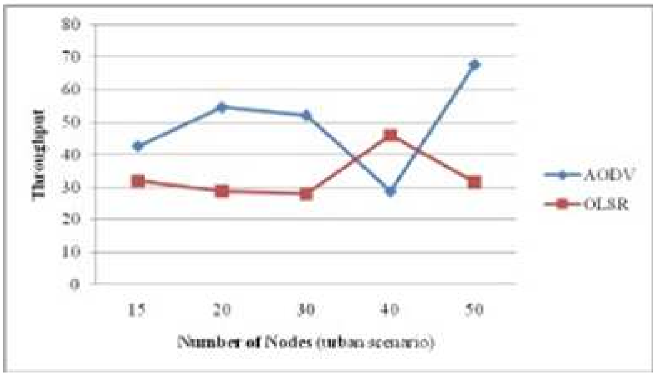

Fig. 4. Throughput for varying Number of nodes

c) Normalized Routing Load : AODV routing protocol has less routing overhead comparison to OLSR. Because AODV only maintains active route information in the network. While OLSR is proactive and each node maintains topology information of other nodes in the network for every topology change. OLSR routing has more packets traffic volume, because of many updates. Graph analysis of normalized routing load is shown in Figure-5.

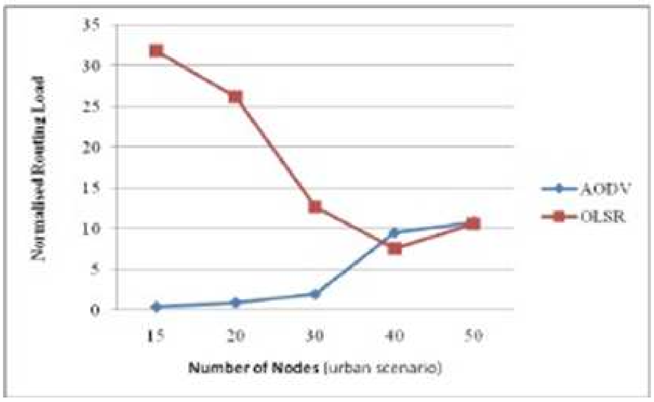

Fig. 5.- Normalized routing load for varying Number of nodes

d) Average End-to-End Delay: Average End-to-End Delay describes the overall delay occurred in the network between source and destination node. OLSR routing is proactive in nature it means all routes are available at all times. While in AODV routes are determined when needed. So OLSR has low delay than AODV. Because AODV takes time to make route. Graph analysis is shown in Figure-6.

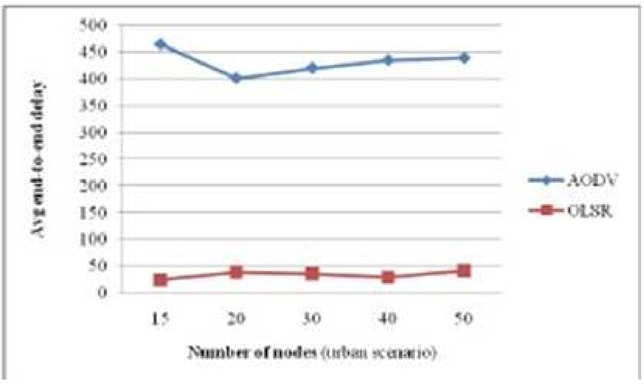

Fig. 6. Average(avg) End-to-End Delay for varying number of nodes

B. *Highway Scenario*

For highway, simulation as conducted same as the urban with different seed values, for every number of nodes. But the difference is in simulation area 4000 * 4000 meters, lanes are 4, and no traffic lights are considered.

a) Packet Delivery Ratio: Figure-7 shows AODV and OLSR protocol route packet delivery ratio, which decreases as the network topology increases that is in Highway scenario. This is because as the network gets wider, the nodes are capable of moving further from each other. Which results, easily breakdown of links between nodes, as mobility of nodes is in wider area. Some nodes could become inaccessible, which reduces packet delivery ratio.

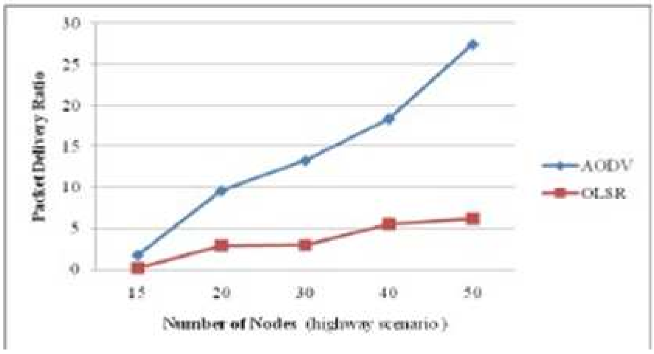

Fig.7. Packet Delivery Ratio for varying Number of Nodes

b) Throughput: It shows that throughput results for both routing protocols decreases as simulation area increases. This is because when network size increases, nodes have greater mobility, which leads to changes in network topology. This makes it more difficult to find a routing path to the destination node, irrespective of the protocol. Some destination nodes may not even be reachable. Graph analysis is shown in Figure-8.

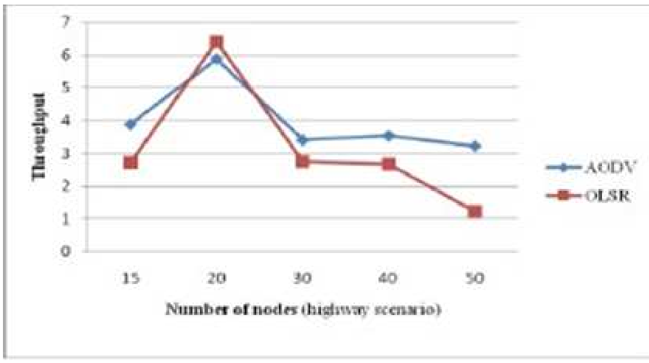

Fig. 8. Throughput for varying Number of nodes

c) Average End-to-End Delay: In the Highway scenario, as the network area increases as a result the average end-to-end delay also increases, which reduces the efficiency of the network. Graph analysis is shown in Figure-9.

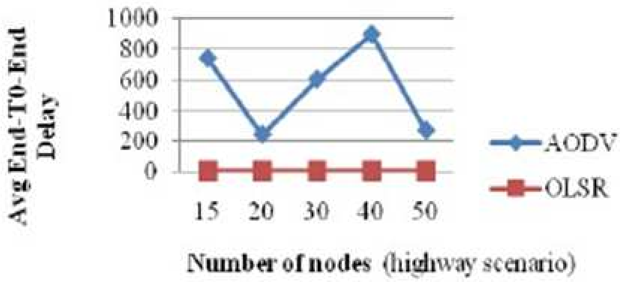

Fig. 9. Average end-to end Delay for varying number of Nodes

d) Normalized routing load : Normalized routing load for OLSR increases as the network topology becomes wider or bigger. Because as the network topology gets larger, the mobility of nodes becomes more random and therefore more update messages need to be created by OLSR to maintain up-to-date routing information. For AODV, the normalized load route slightly grows as the network size increases because more RREP and RREQ messages need to be generated to search for nodes that have moved further away from the source. Graph analysis is shown in Figure-10.

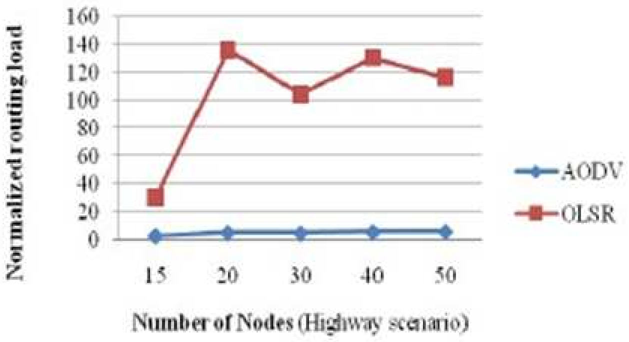

Fig.10. Normalised Routing load for varying number of node

VI. CONCLUSION

In this paper performance analysis of two routing protocols namely AODV and OLSR were studied in both urban and highway scenarios. Packet delivery ratio, Throughput, Average, end-to-end delay and normalized routing load are the performance metrics used. According to the study in terms of Packet delivery ratio, normalized routing load and throughput in both scenarios AODV works better. But when it comes to average end-to-end delay, OLSR is better to adapt.

Both protocols scalability is constrained due to their proactive and reactive characteristics. In the AODV protocol it is because of the on-demand availability of the information of nodes which is challenging in the high mobility networks and in dynamic topology. In the OLSR protocol it is the size of the routing table and topological updates messages. and Both protocol performances depends a lot on the network environment.

As both are traditional MANET routing protocols, these protocols do not fit completely in VANET environment some additional features has to be added to work profoundly well.

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