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Study the Effect of Mobility Model on Various Parameters by Varying Node Density in VANETs for TCP and CBR Applications

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Abstract— In this paper, experiments have been performed to analyze the performance of on demand OLSR and reactive AODV Routing Protocols for random waypoint mobility model and mobility model generated through SUMO tool showing realistic vehicular movement on the basis of various parameters by varying node density for TCP and CBR applications by Network Simulator (NS-3.19). The results shows that for both TCP and CBR applications, random waypoint mobility model gives better result than SUMO generated mobility model for both of the two AODV and OLSR protocols.

Keywords— VANETs, NS-3.19, SUMO, AODV, OLSR, TCP, CBR

I. INTRODUCTION

VANET (Vehicular ad hoc networks) is a sub-class of MANET, having characteristics of high node mobility and fast changing topology [1]. VANETs are used for wide variety of services ranging from safety related to entertainment applications. A wide variety of routing protocols can be used for VANETs. The routing protocols for VANETs can be classified broadly on the basis of routing information and transmission strategy [2]. One protocol cannot be used for all the applications, we have to consider the pros and cons of the routing protocols [3].

The most important parameter for evaluating any protocol for VANETs is the mobility model that must represent the realistic and constrained vehicular movement [4]. The performance of protocols has been analysed by various researchers on the basis of various parameters as AODV, DSDV and OLSR are analysed in VANET for CBR applications using the mobility model generated using SUMO tool [5]. Also in [6], AODV and DSR protocols are analysed by varying pause time in VANET. However in this paper, we analyse the performance for TCP and CBR applications by varying node density for mobility model generated using SUMO tool and random waypoint mobility model whose characteristics are set according to VANET environment for AODV and OLSR routing protocols using NS-3.19 network simulator.

Rest of the paper consists: Section 2 presents the protocols used in simulation. Section 3, presents methodology used for simulation and, in Section 4, simulation results are shown. Finally, in section 5, we draw conclusions from the work done.

II. ROUTING PROTOCOLS IN VANETS

In this section, we describe AODV and OLSR routing protocols which we used in our simulations. Routing protocols can be broadly categorized as topology based protocols and position based protocols. Topology based routing protocol uses link's information stored in the routing table as a basis to forward packets from source node to destination node. They are further divided into Proactive and Reactive. Position or geographic routing protocol uses physical/geographical positions rather than the network address of nodes to perform data routing from source node to destination node assuming each node has knowledge of physical/ geographic position by GPS or by some other position determining services. In this article, we focused on AODV as reactive protocol and OLSR as proactive protocol.

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

AODV routing protocol is a reactive routing protocol [7]. When a source node wants to send data packets it starts route discovery. Node broadcasts a route request message to its neighbours including the last known sequence number for that destination. If a node does not know the route it again forwards the route request message to its neighbours and creates a reverse route for itself back to the source node. If a node knows the route to the destination node that node generates a route reply message to the source that contains the number of hops necessary to reach destination and the latest sequence number of destination most recently seen by the node generating the reply. It is hop-by-hop state routing or source routing therefore each node remembers only the next hop and not the entire route.

B. Optimized Link State Routing (OLSR)

OLSR is a table driven, proactive protocol based on the concept of Multi point Relays (MPR) [8]. The MPR set is selected in such a way that it covers all nodes that are two hops away in the network. OLSR uses hello to find and topology control (TC) messages to disseminate link state information throughout the network. In route calculation, the MPRs are used to form the route from a given node to any destination in the network. Furthermore, the protocol uses the MPRs to facilitate efficient flooding of control messages in the network.

III. PROPOSED WORK & METHODOLOGY

A. Performance Metrics

In this paper, the performance of routing protocols AODV and OLSR is evaluated and compared in terms of throughput, Packet Delivery Ratio (PDR), end-to-end delay and Packet Loss Ratio (PLR) by varying node density for random waypoint mobility model and mobility model designed for VANET using SUMO Tool for TCP and CBR applications.

1) *Throughput:* It is defined as the number of bits delivered successfully per second to the destination. It is represented in kilo bits per second (kbps).

$$\text{Throughput} = \frac{\Sigma NumberofBitsRecieved(1sec.)}{1024}$$

Higher value of throughput means better performance of protocol.

2) *Packet Delivery Ratio (PDR):* It is defined as the ratio of the number of data packets delivered to destination to the total number of data packets sent by the source

$$\text{PDR} = \frac{\Sigma Number\ of\ Data\ Packets\ Delivered}{\Sigma Number\ of\ Data\ Packets\ Sent}$$

Higher value of packet delivery ratio means better performance of protocol.

3) *End-to-End Delay:* The average time period taken by a data packet delivered successfully during transmission from source to destination. Lower value of end to end delay means better performance of protocol.

4) *Packet Loss Ratio (PLR):* Packet loss is the ratio of the number of data packets dropped to the total number of data packets generated.

$$\text{PLR} = \frac{\Sigma Number\ of\ Dtat\ Packets\ Dropped}{\Sigma Number\ of\ Data\ Packets\ Generated}$$

Lower value of packet loss ratio means better performance of protocol.

B. Simulation Parameters

To evaluate the performance of routing protocols by varying mobility models and number of nodes, we used a network simulator NS-3.19 [9]. For simulation purpose we used random waypoint mobility model and mobility model generated using SUMO tool as explained below. In our simulation, the node density is changed with constant pause time of 10s. Initial 50s of simulation are used as setup time after which nodes start sending data packets. Except mobility model all other network parameters are kept same during simulation as shown in the Table I.

Table I Various parameters used in the simulation of routing protocols

Simulation Parameters	Value
Network Simulator	NS-3.19
Routing Protocols	AODV, OLSR
Propagation Loss Model	Friis Propagation Loss Model
Propagation Delay Model	Constant Speed Propagation Delay Model
MAC Protocol	IEEE802.11
Number of Nodes	12, 24, 36, 48, 60
Simulation Area	1700m x 1000m
Simulation Time	300 sec.
Connection Type	UDP (for CBR applications) and TCP
Packet Size	512
Data Rate	1 Mbps

C. Mobility Models

1) *Random Waypoint Mobility Model:* Random Waypoint mobility model is used as a benchmark mobility model to evaluate the performance of MANET routing protocols [10]. In this model, a node chooses a random point in the simulation field as its destination and starts moving towards that with a velocity chosen randomly from [0, V_{max}] and after reaching to that point it waits for T_{pause} time and then again chooses other random point as its destination. In our simulation, we set V_{max} to and T_{pause} to 0 so that topology becomes highly dynamic as required for VANET.

2) *Mobility Model Generated using SUMO:* A mobility model showing realistic vehicular movement is generated using SUMO (Simulation of Urban Mobility) traffic simulator [11]. In the mobility model, a Road Map is generated with Vehicular Traffic flow of five different types (Cars A, B, C and D and Bus). The speed of the traffic varies from 6 m/sec to 14 m/sec. The road map includes four origins and four destinations with all signalized intersections. Each vehicle goes to destination point which is farthest from its point of origin using different paths. Each road has three lanes and all drivers are 50% perfect in driving is assumed.

IV. SIMULATION RESULTS AND PERFORMANCE ANALYSIS

A. For TCP Applications

In this work the performance analysis is done for a vehicular ad hoc network by varying number of nodes and using random waypoint mobility model and mobility model generated using SUMO tool, while keeping other network parameters constant. On basis of various performance metrics defined above two protocols i.e. AODV and OLSR are analysed for TCP applications.

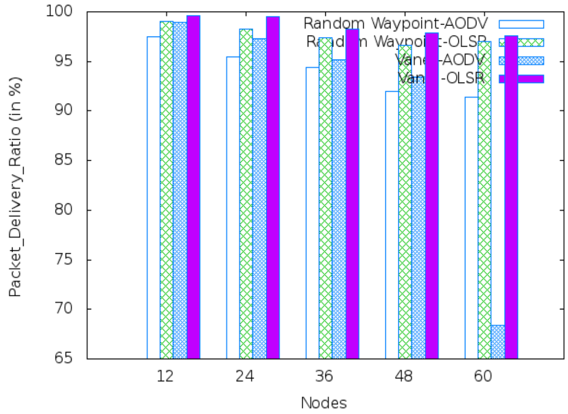

Fig.1. Effect of node density on Packet Delivery Ratio.

In Figure 1, the packet delivery ratio (in %) during simulations time versus the number of nodes is shown. The OLSR outperforms AODV protocol for both the mobility models. As the number of nodes increases i.e. 12, 24, 36, 48, 60 the packet delivery ratio in all protocols changes slightly. AODV packet delivery ratio decreases steeply for VANET mobility model generated using SUMO as the node density increases because there is increment in the collision caused by higher node density especially at the intersections in this mobility model.

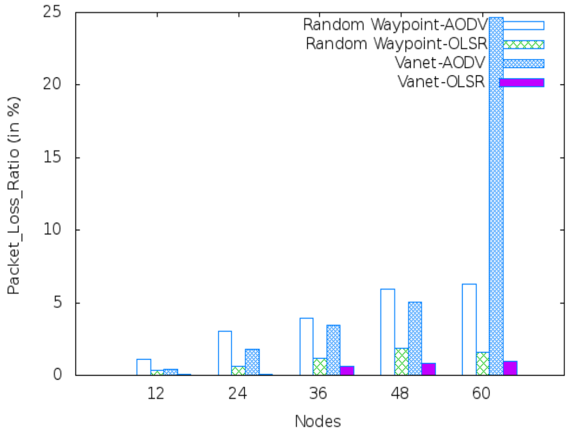

Fig.2. Effect of node density on Packet Loss Ratio.

As node density increases, the number of collisions and packet loss ratio (in %) also increases as shown in figure 2. OLSR has the lowest packet loss ratio for both mobility models.

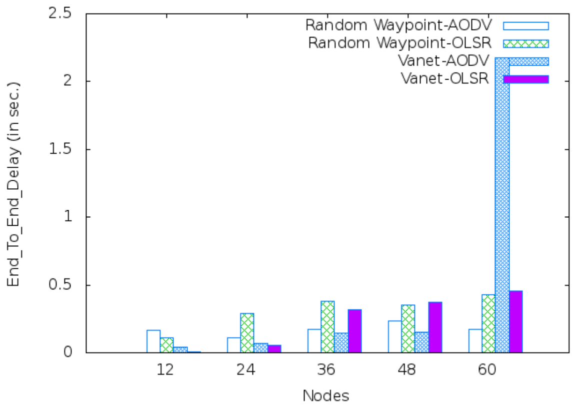

Fig.3. Effect of node density on End to End Delay.

Figure 3 shows the average end to end delay (in sec.) by varying node density. Average end to end delay increases with increase in the number of nodes for both protocols. But AODV has less end to end delay up to 48 nodes as node density becomes 60, AODV end to end delay goes up speedily for VANET mobility model.

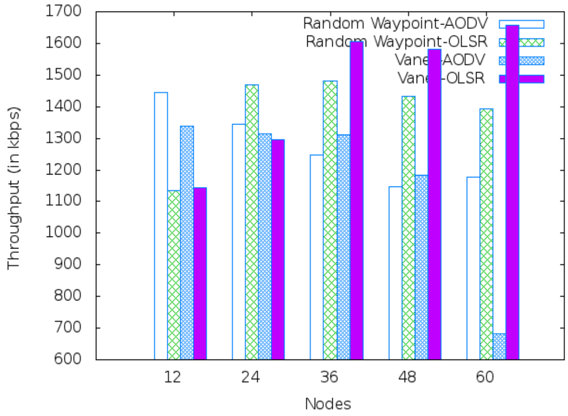

Fig.4. Effect of node density on Throughput.

Figure 4 shows Throughput (in Kbps) of protocols with varying number of nodes. AODV has higher throughput in comparison with OLSR protocol for small number of nodes but as node density increases OLSR throughput increases and becomes more than AODV. OLSR shows higher throughput because its routing overhead is more than AODV. But AODV performs better for Random waypoint mobility and OLSR performance changes as node density changes.

B. For CBR Applications

In this work the performance analysis is done for a vehicular ad hoc network by varying number of nodes and using random waypoint mobility model and mobility model generated using SUMO tool, while keeping other network parameters constant. On basis of various performance metrics defined above two protocols i.e. AODV and OLSR are analysed for CBR applications.

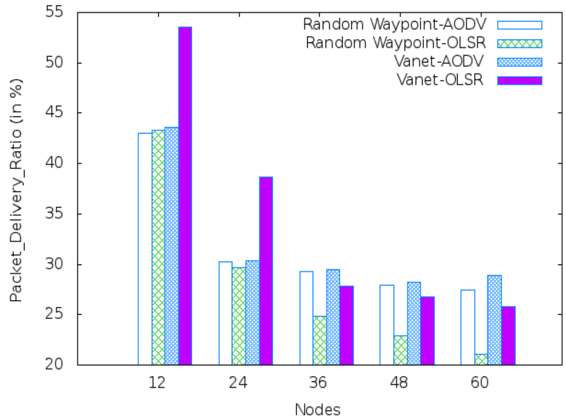

Fig.5. Effect of node density on Packet Delivery Ratio.

In Figure 5, the packet delivery ratio (in %) versus the number of nodes changes during simulation time is shown. The OLSR outperforms AODV protocol for small number of nodes but AODV performance is better as node density increases. Both protocols perform better for VANET mobility model than random waypoint mobility model.

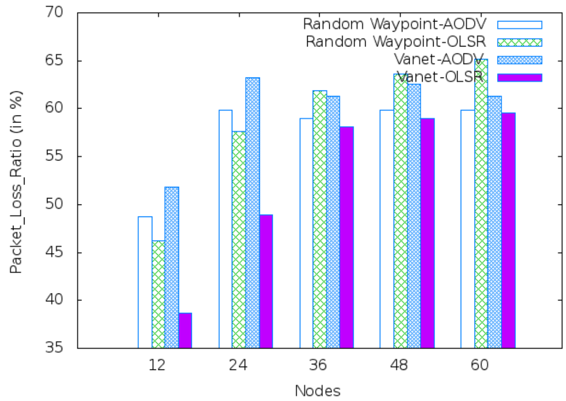

Fig.6. Effect of node density on Packet Loss Ratio.

Packet loss ratio (in %) as shown in Figure 6 by varying node density. For random waypoint mobility model AODV and for VANET mobility model generated using SUMO OLSR has lowest packet loss ratio at higher node density.

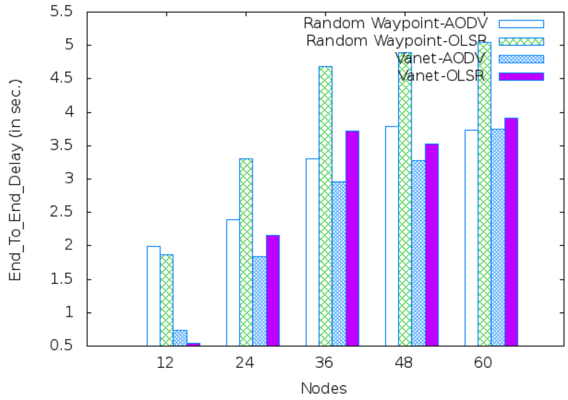

Fig.7. Effect of node density on End to End Delay.

Figure 7 shows the variation of the average end to end delay (in sec.) by varying node density. Average end to end delay increase with increase in the number of nodes for both protocols. AODV and OLSR perform better for VANET mobility model in terms of end to end delay in results.

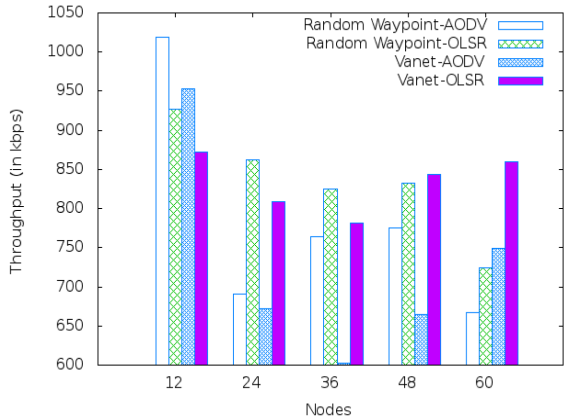

Fig.8. Effect of node density on Throughput.

Figure 8 shows Throughput (in Kbps) of protocols by varying number of nodes. However throughput first decreases and then increases with increase in node density. AODV and OLSR throughput for random waypoint mobility model is more than VANET mobility model but as node density becomes 60 it decreases steeply.

V. CONCLUSIONS

In this paper, performance of two routing protocols AODV and OLSR is evaluated for random waypoint mobility model and mobility model generated using SUMO by varying node density for TCP and CBR applications against various metrics using the simulation tool NS-3.19. The results show that both protocols performance is good if overall node density change is considered for random waypoint mobility model than VANET mobility model generated using SUMO tool for both TCP and CBR applications. Therefore, we can say that topology based routing algorithms are not good choice for VANETs.

For future work, we can evaluate the performance of position based routing protocols as they are more suitable in vehicular traffic environment.

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