Impact of Packet Rate on Routing Protocols In Vehicular Communication System Using realistic movement patterns

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Abstract

Vehicular Ad-hoc Network (VANET) has now been proven as a new emerging technology from the domain of ad-hoc networks that can be used to get better road safety and comfort of the passengers inside the vehicles. However due to mobility constraints and high dynamics, routing the time-critical information is a more challenging task in VANETs. A lot of studies on ad-hoc routing protocols in inter-vehicular environment are available in literature, but most of them were based on randomly generated road topology. Instead of that here we assess the efficacy of various routing protocols in city scenario for the map of city of Arlington, Texas, USA by defining the road topology for generating the realistic movement patterns. In this paper, we have taken OLSR, AOMDV, LAR and DREAM as the candidate protocols. We analyses the impact of the packet rate over these protocols by comparing their performances in terms of average end-to-end delay, throughput, normalized routing load and packet delivery ratio using ns2. We used Intelligent Driver Model (IDM) based tool VanetMobiSim to generate realistic movement patterns.

Keywords: ***Vehicular Ad-Hoc Network (VANET);Topology based routing;Position bsased routing; OLSR; AOMDV; LAR;DREAM.***

1. Introduction

Today's the wireless communication technologies and various advancements in this made possible a very new era of wireless to grow and become popular especially in term of providing the road safety identified as vehicular ad-hoc network (VANET). It is a kind of infrastructure less network like MANET (mobile ad-hoc network) where the vehicles substitute the nodes that are moving across the roads or highways following fixed traffic lanes. Such networks are created to fulfill the aim of providing safety and comfort during journey. Like MANETS, in VANETs the nodes are in motion which organized themselves with no pre-requirement of existing infrastructure. Thus both of these networks can easily and rapidly be installed wherever required in case of emergency or disaster situations.

The structure of Vehicular Ad-hoc Network contains various vehicles as nodes and roadside base stations. There exist two types of communications vehicle to vehicle communication (V2VC) i.e. inter-vehicle communications as well as vehicle to roadside-infrastructure communication (V2RIC) using Dedicated Short-Range Communications (DSRC) [1] operating in the 5.9 GHz band. The nodes in VANET have higher mobility as vehicles running at greater speed this causes the network to face frequent partition and thus the topology is changing regularly.

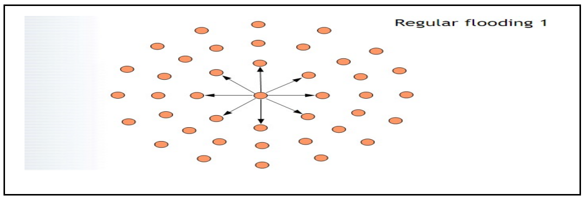
In order to fully utilize all the benefits of such a network the Federal Communications Commission (FCC) allocated a new 75 MHz band DSRC at the 5.9 GHz frequency in 1999 in North America. The IEEE 802.11p standard and WAVE (Wireless Access for Vehicular Environment) suite were recently released for trial use [2]. After establishing these networks we require the alert-messages related information to be exchanged among the nodes. This can be achieved with the help of routing protocols. Routing protocols plays an important role for establishing the communication in VANETs. But because of high mobility of vehicles Routing is the most difficult concern to be handling in VANETs. Routing protocols can be classified into two major categories [3]: The topology-based routing protocols and the geographic position-based routing protocol. In topology-based routing protocols based on the structure of the network for taking any routing actions [4] i.e. it utilizes the topology itself of the network for routing decisions. These protocols can be: proactive or reactive. The proactive one maintains the topology information in advance for each other node in the form of a routing table. So, it reduces the time required for path discovery. Although such protocols maintains all path but at the cost of extra bandwidth need for maintaining tables for all possible routes [4]. The protocols belonging to this class includes DSDV [5], OLSR [6] etc. On the other hand the reactive routing protocol, discover the path as requested only. Therefore, in comparison to proactive one these protocols saves the wastage of bandwidth but requiring path to be invented from sender to receiver. Its examples include AODV [7], DSR[8], AOMDV [9]. On the other hand in position based routing protocols the routing decision is not based on a routing table instead the routing decision is based on real-time geographical positions of the nodes in any network. The position information of nodes (vehicles in VANETs) can easily be obtained by having GPS (Global Positioning System) system. Examples include DREAM and LAR protocols.

In this paper we examine the impact of the packet rate over the performances of OLSR, AOMDV, LAR and DREAM routing protocols. The performance metrics such as packet delivery ratio (PDR), throughput, average end-to-end delay and normalized routing load are considered for the evaluation purpose using NS-2. The Intelligent Driver Model (IDM) based tool VanetMobiSim is being used for generating the realistic vehicular mobility traces. Selecting the road topology is the most important and critical issue in order to map realistic vehicular mobility traces [10]. So having the city scenario, the real world map for city of Arlington, Texas has been followed for mapping the realistic results through simulation and a road topology is generated from this map. The remaining of the paper is structured in four segments. Segment 2 presents brief about the four candidate protocols. In Segment 3 we present simulation method and examine the impact of the packet rate over the performances of these protocols using the simulation results. Finally the achievement of this paper is concluded in segment 5.

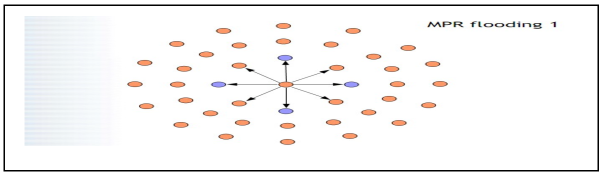
2. SUMMARY OF CANDIDATE ROUTING PROTOCOLS

2.1 OLSR (Optimized Link State Routing)

The OLSR [6] is a type of proactive (table-driven) protocol where the routes are already determined in advance and can be available immediately. It is an advancement of link-state routing algorithms where every node continuously flooded the link- information about its neighbors over the entire network due to which problem of redundancy of messages arises that occupies additional bandwidth. This problem overcomes by OLSR which is based on the concept of MPR (Multipoint Relays). MPR is the important theory behind the working of OLSR. The improved flooding i.e. multipoint-relaying reduces the number of redundant retransmissions of link state information by limiting the set of nodes retransmitting a packet from all nodes of the network called pure flooding to only a subset of all nodes. This subset of nodes is called as MPR set and only those nodes which belong to this MPR set can forward the link information message over the network [6]. While the differentiation between regular or pure flooding and MPR-flooding is shown in the following fig. 1.



(a) Regular or Pure flooding



(b) MPR flooding

Fig.1. Regular flooding versus MPR-flooding, Source: Andreas Tønnesen, Mobile Ad-Hoc Networks

2.2 AOMDV (Ad-hoc On-demand Multipath Distance Vector Routing)

The AOMDV [9] [11] [12] routing protocol is an expansion of AODV. It is a reactive (on-demand) routing protocol as compared to proactive OLSR protocol. It is multi-path routing protocol as compared to single path based AODV protocol. Therefore, it is more appropriate for highly dynamic ad-hoc networks like VANETs where network partitioning and route breakdown occur very frequently [13]. For dealing with such network scenario AOMDV protocol determines multiple paths during the procedure of route discovery. As a consequence in case of link failure every time in the network there is no need to find the new route due to availability of other routes while the AODV protocol require an extra burden of route discovery procedure to be called every time to find the new route. So AOMDV is said to be an improved form of AODV routing protocol. The working of AOMDV protocol involves two parts. First is the computation of multiple loop-free paths and second is the computation of disjoint paths [13].

2.3. DREAM (Distance Routing Effect Algorithm for Mobility) Protocol:

Dream [14] is a direction dependent and restricted flooding type position-based routing protocol [15]. Each node maintain a position table to store the position information of other nodes which belong to the network. Then this position table is flooded into the network frequently in order to bring up to date position information maintained by its neighbors.

DREAM protocol is consists of two algorithms. In first the position information packets are disseminated based on restricted flooding idea. The maximum distance is defined that a position packet can travel in order to have check over flodding. The principle of ‘distance effect’ is used: the closer the node, the more updates will be provided to it. Thus when a node maintains the position information of another node that is far apart, less frequent updates are sent to it. In second algorithm the data packets are disseminated using directional flooding concept where the sender node S forwards the packet only to those one hop neighbors which are in the direction of destination node.

2.4 LAR (Location Aided Routing) Protocol

LAR [16] [17] is a type of reactive routing protocol where the path provided on request of the nodes. LAR is based on the concept of position information to discover and setting up the route between source and the destination and thus saves the time required for route discovery proocess like in other reactive ad-hoc routing approaches: AODV and DSR.

Although, LAR uses the flooding technique like DSR to discover the route but it is restricted to a certain area called “request zone” based on the assumption that every node has information about other nodes’ positions. The necessary condition to be satisfied for a node to forward the route request packet to its neighbors is: the forwarding node must belong to the request zone. Based on the geographical position information a route request packet is flooded for destination only in request zone rather than flooding into the entire network.

3. **SIMULATION METHODOLOGY AND RESULTS**

This section presents the simulation and results for analyzing the impact of packet rate over the performances of OLSR, AOMDV, DREAM and LAR routing protocols. Extensive simulations have been carried out to evaluate and compare the performances of the protocols in VANETs by using the network simulator NS-2 [18]. The movement traces of nodes are generated using VanetMobiSim tool [19]. It is assumed that every vehicle is equipped with GPS and can easily obtain its current geographical location.

3.1 Mobility Model

In simulating mobile systems, it is important to use a realistic mobility model. In order to model realistic vehicular movement Advanced Intelligent Driver Model has been used. It is the extension of Intelligent Driver Model (IDM) and part on VanetMobiSim tool. VanetMobiSim developed by J. Harri et al [20][21], extends IDM and adds two new microscopic mobility models Intelligent Driver Model with Intersection Management (IDM-IM) and Intelligent Driver Model with Lane Changing (IDM-LC).

3.2 System Model

For simulation purpose the selection of the road topology is the most important and critical issue in order to map realistic vehicular mobility traces [10]. In order to have realistic results the real map for city of Arlington, Texas as shown in Fig. 2. is being taken into account and a scene from this map is generated by defining road topology in terms of user-defined graph [22]. We consider a simulation area which is a square of 1000m × 1000m and perform a set of experiments using NS-2.Vehicles communicate with each other using the IEEE 802.11 MAC layer. The simulations are carried out taking the city scenario and varying the packet rate against various performance parameters. The simulation parameters are given in Table 1.

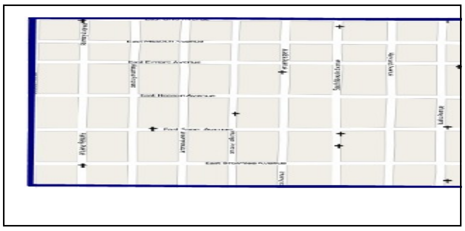


Fig. 2 Real Map– 1000 × 1000m, City of Arlington, Texas for simulation as road topology

TABLE 1: SIMULATION PARAMETERS

Parameter	**Value**
MAC Type	IEEE 802.11 DCF
Channel type	Wireless
Simulation time	1000 seconds
Simulation area	1000m x 1000m
Transmission range	250m
Node speed	40 km/hr
Traffic type	CBR(constant bit rate)
No. of CBR Sources	10 (constant)
Packet rate	Keeps varying between 4 to 20 packets/second
Data Packet Size	512 bytes
Mobility model	IDM
No. of node (vehicles)	50 (constant)
Routing protocol	OLSR ,AOMDV,DREAM and LAR

3.3. Results and Discussion

The protocols are evaluated for throughput, average end-to-end delay, packet delivery ratio, and normalized routing load at varying packet rate from 4 to 20 pckets pr second under IDM model in city scenario where the maximum speed of vehicles is taken as 40 km/hr with transmission range equal to 250 meters and keeping the traffic light period is constant at 10 seconds.

3.3.1 Throughput

It is the total number of bits delivered successfully per second from source to the destination. It is observed from Fig. 3 that generally throughput increases with increasing packet rate. Both LAR and DREAM protocols have shown a continuous increase in throughput with increasing the packet rate. The variation among them is so marginal that their plot of throughput against the packet rate is seems to be overlapping. Overall the throughput has increased with increasing packet rate because more number of packets reach their destination.

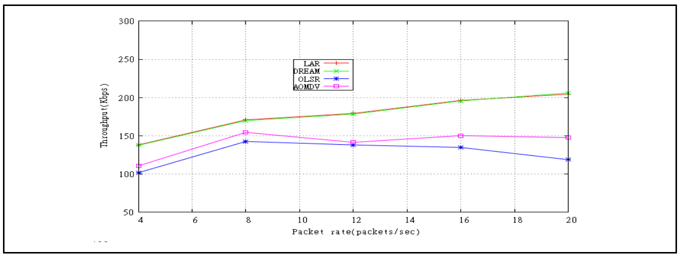


Fig.3. Throughput against packet rate

3.3.2 Average End-to-End Delay

End-to-End delay is the average delay between source and destination node for all such data packets which are delivered successfully This includes all possible delays caused by buffering and queuing at the interface queue during route discovery. Fig. 4. shows average end-to-end delay. At initial stage when packet rate equal to 4 packets/ second AOMDV shown the least delay but as the packet rate increases AOMDV has the much higher delay compared to other protocols and finally turns out to be the worst protocol in this case showing highest delay.

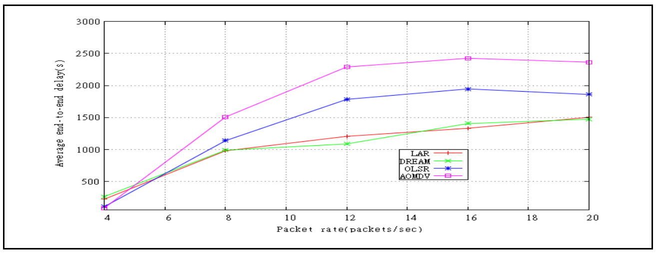


Fig.: 4. Delay against packet rate

This may be explained by the fact that its route discovery process takes a quite long time compared to other protocols. Although at some instance LAR seems better and at another DREAM looks better. But at last DREAM protocol becomes comparatively better than all others when packet rate reached its maximum value having clearly lesser delay than LAR. Finally, it is noticed that average end-to-end delay increases with the increasing the packet rate in all protocols.

3.3.3 Normalized Routing Load

It is the ratio of total number of control packets transmitted by every node in the network and the number of data packets received by the destination nodes. Fig. 5 illustrate that routing load increases with increasing the packet rate in both LAR and DREAM when packet rate varies from 4 to 8 then it continuously dropping with increasing the packet rate. Note the initial sharp reduction in normalized routing load with increase in the packet rate for both OLSR and AOMDV protocols. This is because at low packet rate, more or less all the routes are invalid by the moment they used again. The DREAM protocol has shown the least overhead than other protocols though it is slightly smaller than LAR. Overall in this case the variation in packet rate shows a mix-up impact over the performances of all routing protocols.

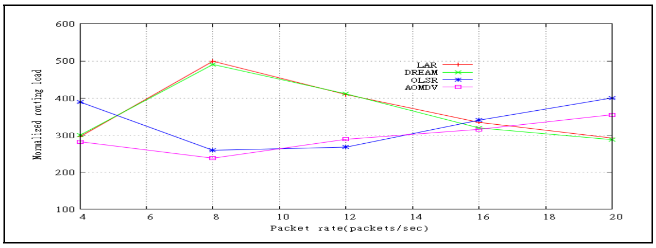


Fig.5. Normalized Routing Load against packet rate

3.3.4 Packet Delivery Ratio (PDR)

PDR is defined as the ratio of those packets that successfully reach the destination. It can be observed that the PDR is continuously dropping with increasing the packet rate. With increased inflow of the packet the network gets more and more congested and as a result more packets fail to reach their destination leading to lower PDR. Overall position-based protocols outperform their topology-based protocols.

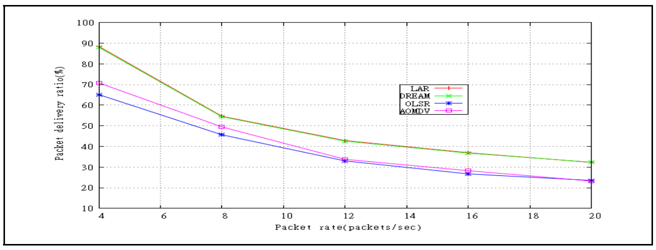


Fig. 6. PDR against packet rate

4. CONCLUSIONS

In this paper we analyzed the impact of packet rate over various protocols by comparing their performances in terms of average end-to-end delay, throughput, normalized routing load and packet delivery ratio using Advanced Intelligent Driver Model (IDM) by considering the city scenario and modeling the real map of city of Arlington, Texas, USA for obtaining the realistic vehicular traces through simulation using NS-2. It is concluded from the simulation results that overall both LAR and DREAM protocols performs better than OLSR and AOMDV protocol i.e. the position based routing protocols outperforms the topology based routing protocols. Overall the throughput and delay has increased with increasing packet rate. The PDR is continuously dropping with increasing the packet rate. While increase in packet rate has shown a combine effect on all the protocols. Therefore we can say that as more and more number of packets is injected into the network it will have a extreme impact on the performances of various routing protocols.

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