

Evaluative Comparison of Routing Protocols with Effective Performance Metrics in Heterogeneous VANET Configuration

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ABSTRACT: Vehicular Ad Hoc Networks (VANETs) have emerged as a new influential technology with a purpose to provide vehicle, road and public safety. VANET is a well coordinated network that provides continuous connectivity between vehicle and RSUs through efficient vehicle-to-vehicle or vehicle-to-infrastructure communication. In this paper, we compare performances of reactive and proactive routing protocols named Dynamic Source Routing (DSR), Dynamic MANET On-Demand (DYMO), Destination Sequenced Distance Vector (DSDV) and Optimized Link State Routing Protocol (OLSR) in VANET using OMNET++ and INET framework. The protocols are compared in heterogeneous configuration in terms of SNIR, end to end delay, throughput, number of collisions and loss rate based on different vehicle density.

KEYWORDS: DSR, DYMO, DSDV, OLSR, VANET, OMNET++ and INET.

I. INTRODUCTION

Vehicular Ad hoc Network (VANET) is considered as a special type of Mobile Ad hoc Network (MANET), in which vehicles act as nodes and each vehicle is equipped with transmission capabilities and act as router to exchange information between vehicles and road side units. The essential part of VANET is to improve road and public safety, to increase the comfort level of passengers and to reduce the congestion of traffic. VANET has unique characteristics like high mobility modeling with vehicle predictions, extreme dynamic topology, low power issues, unbounded network size, infrastructure support and high computing power that differentiate it from MANET. These networks are used in traffic control applications, collision avoidance, accident alert services, safety applications, driver assistance and location based services [1-3]. Due to the highly dynamic nature and inherent characteristics of VANET, Many researchers have concentrated on proposing the suitable routing protocols.

II. RELATED WORK

Several studies and papers have been published comparing and surveying the different routing protocols using different mobility models and performance metrics. One of the widespread studies was done by the J. Broch et al [4] in which the results of a detailed packet-level simulation of DSDV, TORA, DSR, and AODV protocols using NS-2. A paper by Das et al. [5] evaluates several routing protocols for ad hoc networks via packet level simulations. Evaluation of on demand and distance vector protocols are performed with respect to fraction of packets delivered end-to-end delay and routing load for a given traffic and mobility model. In a study [6], authors developed a realistic mobility model and evaluate the performance of AODV, DSR, FSR and TORA in freeway traffic scenarios. Routing in Vehicular Ad Hoc Networks Survey [7] presents the research prospective of routing in VANETs and survey routing protocols and mobility models for VANETs. Another study [8] observes the behavior of routing protocols (AODV and GPSR) in VANETs by using microscopic vehicular traffic simulator in terms of packet delivery ratio. A study by R.A. Santos et al [9] compare both position-based and non-position-based routing strategies in different traffic scenarios with performance metrics as average Route Discovery (RD) time, End-to-End Delay (EED), Routing Load, Routing Overhead, and Delivery Ratio. Another study [10] investigates different routing schemes that have been developed for

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VANET and defines the current trends and challenges for efficient routing. A lot of projects related to VANET are practically implemented in countries such as FleetNet [11], PReVENT [12], SeVeCom [13], Network on Wheels (NOW) [14], Car talk 2000 [15] etc.

III. ROUTING PROTOCOLS

PROACTIVE PROTOCOLS

The proactive protocols are also recognized as table driven routing protocols. Proactive protocols allow a node to use the routing table to store the routing information of all other nodes. The table is updated periodically by exchanging the knowledge of topology changes among all the nodes of the network. Proactive schemes maintain new lists of destinations and their routes will be chosen using shortest path algorithms.

Destination Sequence Distance Vector (DSDV): In DSDV protocol, each vehicle advertises its own routing table to all its neighbors. The routing table contains the list of addresses of all other nodes in network which may change dynamically with time, so advertisement must be sent by each vehicle frequently to locate the other vehicles. DSDV is a proactive routing protocol which maintains the route to the destination using destination sequence numbers. The two routing tables are maintained at each node namely routing table and setting time table which contains the address of next hop, route metric, destination sequence number, time for update advertisement etc. DSDV ensures loop free routes. The DSDV mechanism incurs large volume of traffic in highly dynamic networks due to which more bandwidth is consumed. In order to overcome the mentioned shortcoming, two update strategy in proposed: full dump and incremental update. In full dump, the full routing table is send to the neighbors where as in incremental update, only the entries which changes from the last update are sent [16].

Optimized Link State Routing (OLSR) : OLSR protocol employ link state strategy ; it maintains a routing table which has information about all possible routes to network. Once the network topology changed each vehicle send the modified information to some selective nodes which further retransmit the updated information to other selective nodes. However the nodes which are not in the selected list can only read and process the packet. OLSR is a proactive routing strategy which involves periodic flooding of control information using special nodes that act as Multi Point Relays (MPRs). In this scheme, the status of the links is immediately updated which allow the hosts to identify the network routes earlier. OLSR routing protocol has simple done procedure which allows it to integrate in different operating systems. OLSR is appropriate for high density networks, dynamic topology and applications with short transmission delays (safety warning applications) [17].

REACTIVE PROTOCOLS

These protocols are recognized as on-demand routing protocols as they periodically update the routing table only when a vehicle have some data to be send. These protocols help in reducing the burden in the network. But these protocols use flooding process for route discovery, which causes more routing overhead.

Dynamic Source Routing Protocol (DSR): It is a multi-hop reactive routing protocol which store the whole path from source to destination in the routing table [18]. The RREQ and RREP are used to perform the route discovery and delivering the reply message. This protocol applies source routing for route discovery and maintains active route. In DSR protocol, if the node receiving the RREQ message does not have the destination address in its routing table, the RREQ message is rebroadcast to other vehicles. In case of link breakage, a cache route mechanism is used in this protocol. If there is a link failure in a particular path due to the vehicle's movement then the source vehicle looks in its cache route for another route to destination which enhances the data transmission. On receiving the RERR message by the source vehicle, the new route discovery procedure will be initiated. The RERR message will be sent to the source by the very first node which is closer to the source than others. Then the source apply piggyback strategy based on the RERR message received and the new RREQ message will be broadcasted to all the nodes . The size of the packets in the DSR routing protocol increases due to additional node specifications into packet header specially when the number of nodes are more. Another drawback is that node is unaware of neighbor list

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or their link status since there is no periodic updating of packet exchanged between nodes. So applying cache route mechanism in DSR may cause failure due to invalid or expired links.

Dynamic MANET on Demand Routing Protocol (DYMO): DYMO is a new reactive routing protocol that specially designed for use in multi-hop wireless network by IETF's MANET working group. DYMO aims at a simpler design and easy protocol implementation, helping to reduce the system requirements of working nodes. DYMO retains mechanisms of earlier routing protocols like implementing sequence numbers and some better features like internet gateway, implementing path accumulation. A node will not have route information about the destination but will also receive additional information about all transitional nodes of a newly recognized path. DYMO also involves Route Discovery and Route Maintenance as its basic operations [19].

IV. EXPERIMENTAL SETUP AND RESULTS

The simulation set up consists of variable number of nodes between source and destination in heterogeneous configuration in which the vehicles are moving with different speeds (15-25 mps). We prefer to execute the simulation of the network with OMNET++ with INET framework as OMNeT++ is an open, modular, testbed-based on C++ which provides support for sensor networks, wireless ad hoc networks, Internet protocols, network modeling, photonic networks etc with excellent graphical runtime environment and INET Framework extension provides OMNeT++ modules that represents Internet protocol suite, models for wireless and mobile communication, MAC protocols with mobility framework. we evaluate the performance of proactive protocols (DSDV and OLSR) and reactive protocols (DSR and DYMO) in heterogeneous configuration by investigating the performance parameters such as SNIR, average throughput, End to End Delay, loss rate and number of collisions based on varying vehicle density.

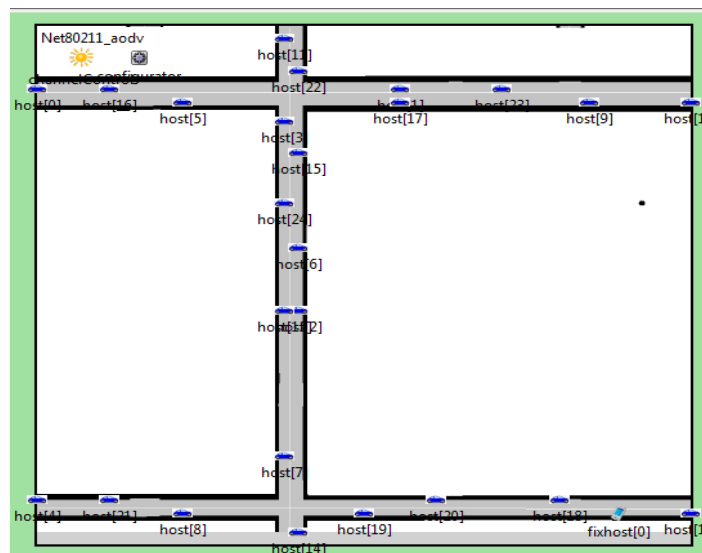


Fig. 1 Simulation Model

Signal-to-Noise plus Interference Ratio (SNIR): Signal-to-noise plus interference (SNIR) is defined as the ratio of signal power to the combined noise and interference power. Figure 2 shows the comparable characteristics for each of four protocols in terms of mean time-averaged values of SNIR for 5 vehicles. It is understood, that a higher SNIR value is advantageous, as signal power must be larger with respect to the noise and interference power. Figure 3 shows the variation in the SNIR metric of all the four protocols when the number of vehicles increases between source and destination. The SNIR values of all protocols are closer to each other in case of 5 vehicles but OLSR seems to be better than other protocols. With increase in number of vehicles the DYMO is seen to lower than other protocols while

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the DSR and DSDV have almost same SNIR value variations. But OLSR have best SNIR values at different vehicle densities.

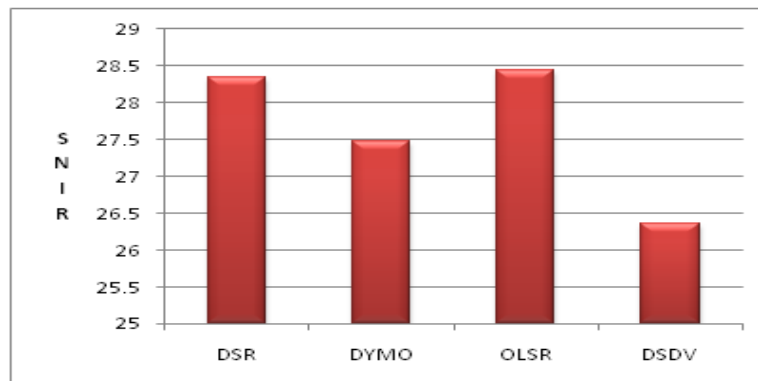


Fig. 2 Comparison of different protocols in terms of SNIR

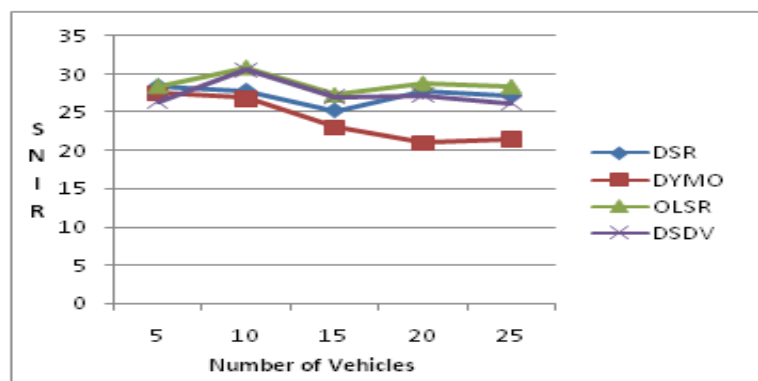


Fig. 3 Variations in SNIR of protocols with varying vehicle density

Average End-to-End Delay: The time taken by the packets to be delivered from source to destination is known as Average End-to-End Delay. The Average End-to-End delay value implies the time consumed for all possible delays caused by buffering procedure, performing route discovery process, the retransmission procedure, propagation and transfer times. Initially in case of 5 vehicles, the DSR have highest end to end delay as shown in figure 4 but after particular number of nodes defined between source and destination the performance of DSR protocol in terms of end to end delay shows better results. DYMO have highest end to end delay while OLSR have lowest value in almost different vehicle density shown in figure 5.

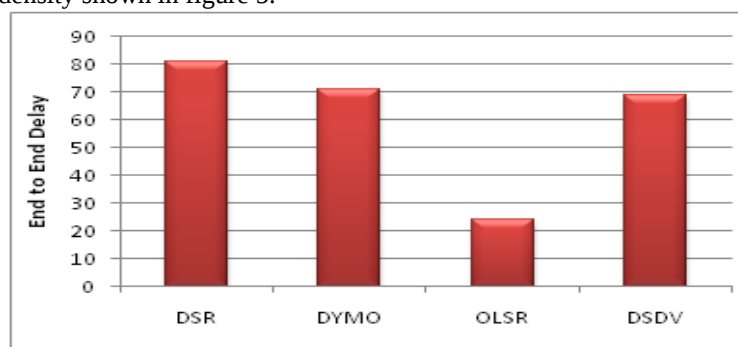


Fig. 4 Comparison of different protocols in terms of End to End Delay

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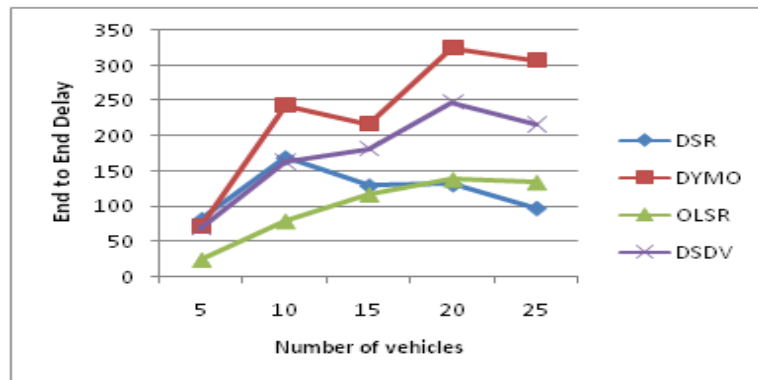


Fig. 5 Variations in End to End Delay of protocols with varying vehicle density

Average Loss Rate: The loss rate is calculated as a fraction of packets lost at the MAC layer. Certain conditions may cause packet loss like corrupted packets, buffer overloading, link failure, inadequate bandwidth and some security issues. This is an important performance metric for the networks where packet loss is not acceptable. Figure 6 and figure 7 represent the related diagrams of loss rate (time averaged) for 5 vehicles and different vehicle densities associated with four routing protocols, respectively. OLSR has the lowest loss rate while DYMO has highest loss rate.

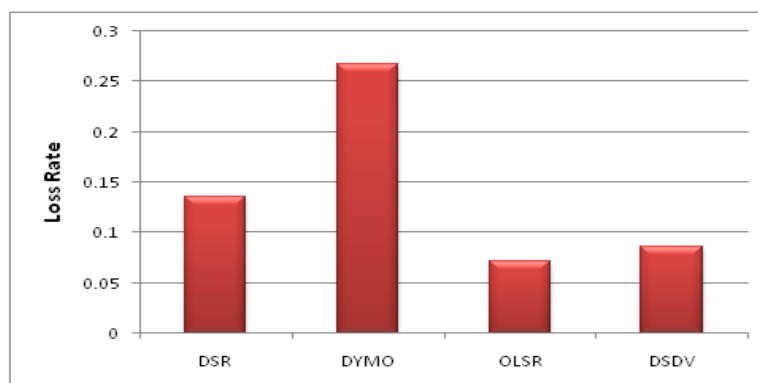


Fig. 6 Comparison of different protocols in terms of Loss Rate

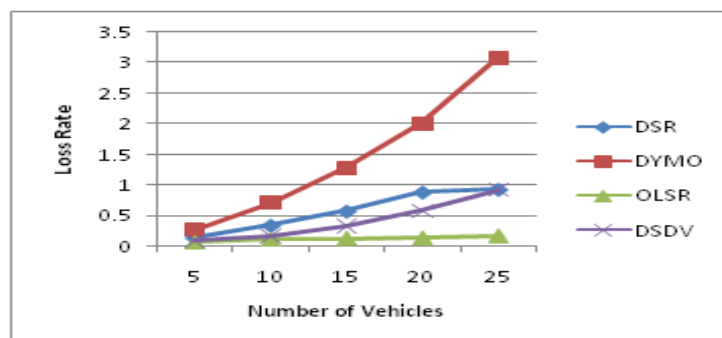


Fig. 7 Variations in Loss Rate of protocols with varying vehicle density

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Number of Collisions: When two or more packets enter the same path at the same time, it causes interference which may damage one or either of the packets and make it unusable. The number of collisions defines the number of packets lost or corrupted during the transmission due to the mutual interference. If the number of packet collisions is low the network will have enhanced performance. Figure 8 and figure 9 shows statistics related to the number of collisions in the network of all four protocols for 5 vehicles and different vehicle densities respectively. Initially DSR has the highest number of collisions, but as the number of vehicles increases the number of collisions decreases due to efficient source routing procedure while DSDV have highest number of collisions. However OLSR has the lowest number of collisions.

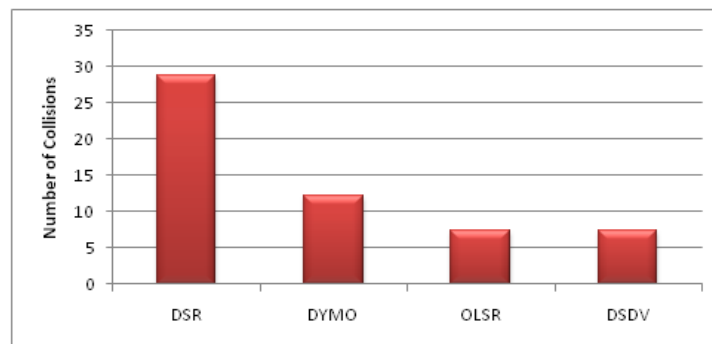


Fig. 8 Comparison of different protocols in terms of Number of Collisions

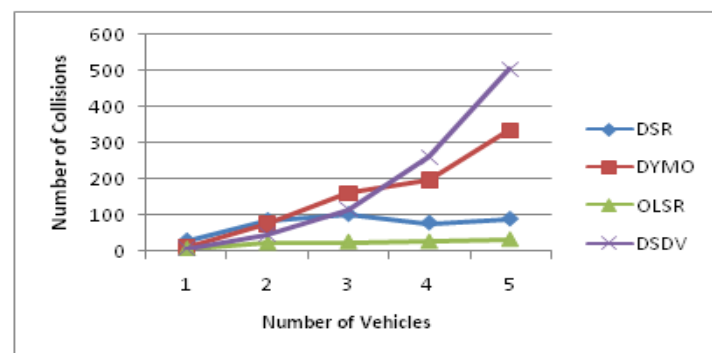


Fig. 9 Variations in Number of Collisions of protocols with varying vehicle density

Average Throughput: It is defined as the sum of data to all the nodes in the system during a period. Throughput reflects the successful delivery of data over communication channel. Throughput may be affected due to change in topology, bandwidth etc. As shown in figure 10 and 11, the OLSR has highest throughput while DYMO has lowest. The proactive protocols (DSDV and OLSR) have higher throughput values than reactive protocols (DSR and DYMO).

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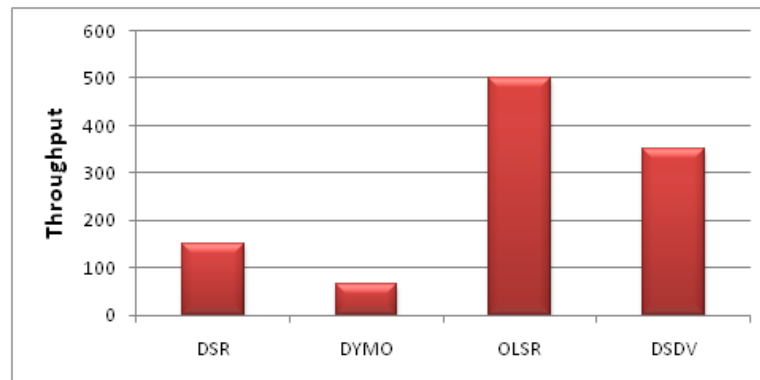


Fig. 10 Comparison of different protocols in terms of Throughput

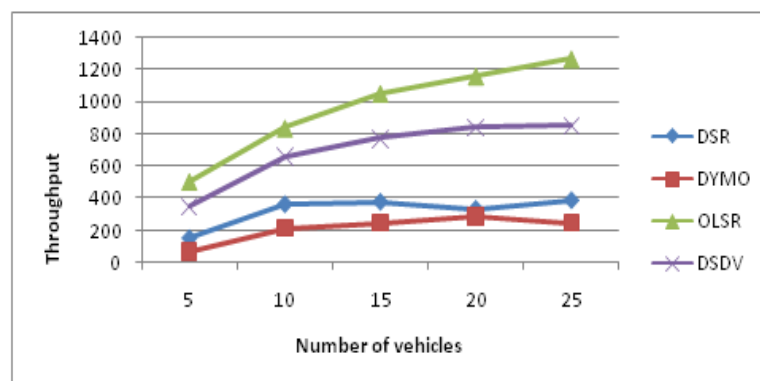


Fig. 11 Variations in Throughput of protocols with varying vehicle density

V. CONCLUSION

The performance of reactive routing protocols [Dynamic Source Routing (DSR), Dynamic MANET On-Demand (DYMO)] and proactive routing protocols [Destination Sequenced Distance Vector (DSDV) and Optimized Link State Routing Protocol (OLSR)] in heterogeneous VANET Configuration has been compared. These protocols are compared in terms of Signal to Noise plus Interference Ratio (SNIR), end to end delay, throughput, number of collisions and loss rate by varying vehicle density. DYMO protocol is seen to have lowest SNIR value, high end to end delay, high loss rate and minimum throughput. We concluded that OLSR achieve best results in terms of all the performance parameters considered i.e. high SNIR value, lowest end to end delay, maximum throughput, less number of collisions and low loss rate among all the protocols.

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