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Behavioral Analysis of Routing Protocols in VANET

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Abstract- The vehicular ad-hoc network (VANET) plays a prominent role in the driver safety through inter-vehicular communication (V2V). Routing is one of the aspects through which vehicle communication have performed through message passing. IEEE 802.11p with the help DSRC supports communication among vehicles (V2V) and in between vehicle to infrastructure (V2I) communication. VANET is basically different from the conventional wireless ad-hoc networks with respect to the speed of the vehicle, fast changes in the topology, fixed movement pattern and frequent disconnection in the links. Thus, developing a routing protocol is a tedious task in the VANET environment. The objective is to verify the behavioral performance analysis of the topological routing protocols in the VANET. The paper consist of the description of the topological routing protocols such as AODV DSDV and AOMDV routing protocols. The simulation is conducted for the topological routing protocols using various scenarios. The parameter analyzed are the average end to end delay, packet delivery ratio, normalized routing load and throughput.

***Keywords*—**VANET, DSRC, Routing Protocols, AODV, DSDV

I. Introduction

VANET is a technology enables Intelligent Transportation System applications to be smarter. It performs communication between vehicular nodes. VANET is a dynamic network of vehicles without fixed infrastructure such as base station. The vehicular node follows the restricted pattern for the movement between the vehicles due to velocity and acceleration of the vehicles. The way used for the communication is multi-hop through intermediate nodes [1] [3].

The physical, data link and network layer play a significant role in the communication inside VANET. At the physical and data link layer, the DSRC standard helps to achieve V2V and V2I communication. The Road Side Unit (RSU) acts as an infrastructure. The transmission range decides whether to forward the packet to the RSU or to the nearest RSU of the vehicle. DSRC operates at 5.9 Mhz. [5]. The functionality of the MAC layer achieved with the help of IEEE 802.11p MAC. Routing is performed at the network layer. The routing is applicable in several applications such as transport, the safety of the vehicles. The application layer consists of Wireless Access Vehicular Environment (WAVE). The WAVE enables minimum latency with the high acceleration of the vehicles [3].

The paper comprises five sections. Section I presents the introduction to the VANET. Related work explains the working of the topological routing protocol, discussed in section II. Section III describes the behavioral analysis of the topological routing protocol. Section IV discusses the simulation results. The last section highlights conclusion.

II. Related work

The routing is an intelligent task determines the route in between the source and target vehicular node. Routing in the VANET relies on several factors such as speed of the vehicle, amount of vehicular nodes and direction of the movement of the vehicles. The routing protocols in VANET are classified based on the topological routing protocols, transmission strategies and position-oriented routing protocols.

A. Topological routing protocol

The decision of a route depends upon topology information and the communication channels. Topology-based routing considers a way to select a route to send information between a source and the destination. These protocols are proactive and reactive in nature [2]. The classifications have shown in Figure 1.

The proactive routing maintains topology information about all nodes whether they have participated in the communication. It incurs the increased overhead of joining new nodes in the network. It uses extra bandwidth to support routing information. Some examples of proactive routing protocols are DSDV, OLSR [4].

The reactive routing has on-demand information related to the routing. It has further classified as hop by hop routing as well as source routing. The reactive routing is superior in a number of delivered packets and delay. The examples are AODV and DSR [7].

The hybrid routing is a combination of a reactive and proactive routing rule. The local region of every node uses the proactive approach and reactive routing used in regions called as zones. It reduces the control packets and relives the network load. It is useful for large and scalable networks. e.g. Zone routing protocol (ZRP). In ZRP, the local neighbourhood of a node is termed a routing zone which is the minimum hop distance. It is less than the zone radius. A node retains paths to entire destinations in the routing zone. To set up a routing zone, the node must recognize close members away from a reaching distance [7].

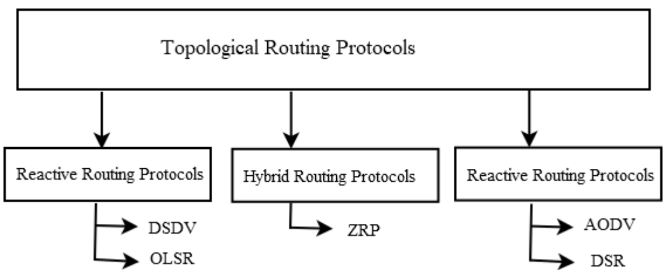

Figure 1- Topological Routing Protocols in VANET

B. Overview of Routing Protocols Under Study

DSDV routing

The Bellman-Ford routing algorithm is the basis for the DSDV routing protocol [6]. Every vehicular node associates a table comprising a route. Each routing table holds a list of destinations with the shortest distance. Routing table also comprises a starting node through the shorter route to remaining nodes in the topology. All entries have labeled by a sequence number initiated through the target node. Routing updates can either be periodic or event-driven. The node in the DSDV advertises own routing table to its present adjacent nodes. The periodic transmission of updates related to the routing tables keeps the information of the network topology. If there is new routing information, the updates are communicated instantly. The neighbouring nodes can be aware of any changes that have present in the network because of the node movement.

Thus the DSDV incurs extra routing load proportionate to the nodes in the network. It is not scalable due to the limited bandwidth and highly dynamic topologies.

AODV routing

AODV is a kind of a reactive routing protocol. In AODV, the route is established whenever needed by the originating node for transmitting packets. It does not preserve routes at any time as long as packets are sent. The source and its neighbors store the information about the next node related to every flow for data packet transmission. The usage of the destination sequence number (DestSeqNum) is the uniqueness in the AODV protocol, determines an updated path to the destination. If the received packet's DestSeqNum is larger as compared to the recent DestSeqNum stored on a node, a node updates the path information [6].

If a node A requests to destine a packet to the destination F. It observes the routing table of A to decide whether it has a present route to its destination or not. If so, it forwards the packet to next hop of the route. If not, it starts a route detection process

The node A transmits a route request (RREQ) to its neighbors, the node receiving RREQ sent it to its neighbors. Sequence numbers used to evade the chance of forwarding the same packet again & to guarantee the freshness of routes.

The route reply (RREP) message is used to answer the request when there is a route to the target. If the route does not exist, the neighbors retransmit the route query packet until some of the packets reach to the target. The intermediate node can also send the RREP packet, provided that it knows a latest path than the one previously known to the node A. The RREP packet is received by the intermediary node. The source node may initiate data transfer after receiving the first RREP.

The route maintenance phase has initiated when a link failure occurs. When the node doesn’t have a HELLO message from its intermediate node in a specific amount of time, a line break event happens. The Route error (RERR) message is generated to disseminate information about link breakage [7].

Figure 2 describes the working of AODV routing with the help of the messages.

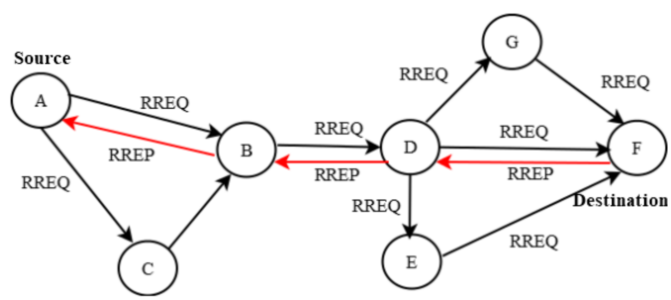

Figure 2- AODV Routing Messages

AOMDV routing

AOMDV is an enhanced version of AODV routing protocol. The use of the distance vector with the hop-by-hop routing approach is the basis for AOMDV. It determines various routes among the source and the target in every route discovery. The loop-free and disjoint routes are determined by using a route update rule. Every destination comprises a list of next hops and respective hop counts in the routing table. The next hop uses the same sequence number to keep track of the route. At the destination each node preserves a promoted hop count known as the maximum hop count for all the routes. Another path to the target is established by a node if there is a minimum hop count as compared to the advertised hop count for the target destination.

A source propagates RREQ to establish multiple reverse routes at the intermediate node and the destination. Various RREP navigates reverse routes back to establish many routes towards the target at the source and intermediary nodes. Intermediary nodes have alternative paths helps to reduce the frequency of the route discovery [13] [14].

III.BEHAVIORAL ANALYSIS

The behavioral analysis is the scientific investigation of the standards of learning and behavior. Experimental behavior analysis involves fundamental research intended to gain knowledge about phenomena that control and influence behavior. The simulation is conducted to observe the behavioral performance of routing protocols in the VANET for city traffic. Table 1 lists the various simulation parameters.

Table 1. Simulation Parameters

Parameter	Simulation Value
Network Simulator	NS-2.35
Transmission range	250 meters
Antenna	Omni-directional
MAC Type	IEEE MAC 802.11
Interface Queue	Droptail, priority queue
Radio Propagation	Two Ray Ground
Protocols	AODV, DSDV and AOMDV
Simulation area	4707m * 3002m
Number of Vehicle (nodes)	20,40, 50,60,80,100
The speed of the vehicle	Up to 50 m/s
Mobility model	Random Waypoint Model
Simulation Time	100ms
Traffic simulator	SUMO

The real city map of Karad, Maharashtra, India have generated with the help of SUMO, a tool for Simulation of Urban Mobility as well as OpenStreetMap (OSM) [11]. The microscopic traffic simulations of the map are tested using SUMO. OSM is a map of the world offers xml based file for the selected area. The map generated using OSM converted into configuration file by using netconvert and polyconvert commands. The configuration files are used to store information and settings. Trace files are generated using trace exporter in SUMO. The trace files are used as an input to the NS 2.35. The setdest utility generates the scenarios using Random Waypoint (RWP) model [10]. The scenario consists of information about the position of each node and their pattern of the movement. The scenarios for the simulation have developed for 20, 40, 50, 60, 80 and 100 nodes. The simulation is executed using NS2.35 on UBUNTU 14.04 [11] [12]. Transmission range used is 250 meters. The vehicle speed varies in between 0-50 m/s. The TCP with File Transfer Protocol (FTP) traffic has used in the environment.

IV.RESULTS

AODV, DSDV and AOMDV routing protocols are simulated. The performance factors such as the packet delivery ratio, normalized routing load, average end-to-end-delay and throughput are used to analyze the behavior of the routing protocols.

A. Average end to end delay (E2ED)

E2ED is the average time taken to reach data packets at the target, measured in milliseconds (ms). Table 2 shows the E2ED for the various scenarios. Figure 3 shows that if the node increases, the E2ED decreases linearly in AODV. The unusual behavior is observed in the scenario comprising 40 nodes in DSDV, scenario comprising 80 nodes in AODV and scenario comprising 60 nodes in AOMDV.
It is observed that the AOMDV and DSDV protocol produces minimum delay as compared to the AODV routing protocol because of its reactive nature [8].

Table 2. E2ED

Protocol/ Nodes	E2ED (ms)					
	20	*40*	*50*	*60*	*80*	*100*
AODV	273.38	188.22	164.17	196.07	355.67	156.24
DSDV	99.68	250.87	160.59	131.85	242.59	145.64
AOMDV	112.96	130.52	135.8	107.2	218.5	201.25

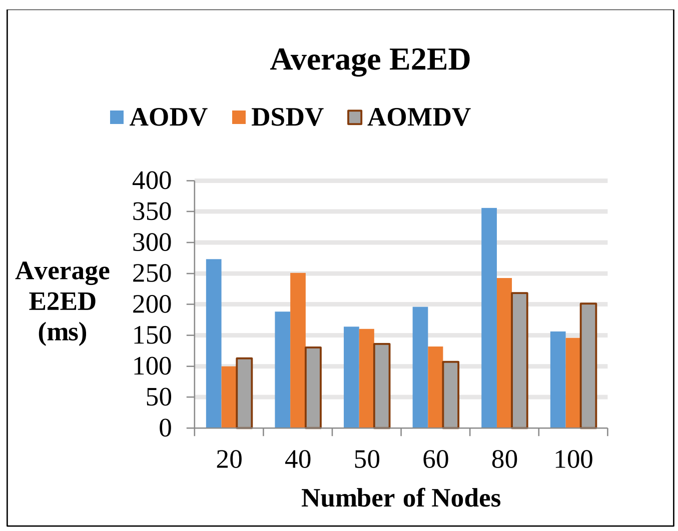

Figure 3- Average E2ED

B. The packet delivery ratio (PDR)

The percentage of the received packets to the sent packets in the network is termed as PDR. Table 3 illustrates the PDR results for varying densities.

Table 3. PDR

Protocol/ Nodes	PDR (%)					
	20	*40*	*50*	*60*	*80*	*100*
AODV	97.99	97.62	97.14	98.32	98.25	99.14
DSDV	97.45	97.37	98.12	98.30	98.99	99.62
AOMDV	97.91	97.93	97.01	98.84	99.12	99.53

Table 4. NRL

Protocol/ Nodes	NRL (%)					
	20	*40*	*50*	*60*	*80*	*100*
AODV	0.16	0.34	0.55	0.58	0.27	0.28
DSDV	0.12	0.22	0.92	1.05	0.21	0.29
AOMDV	0.54	1.29	1.68	1.38	1.46	2.02

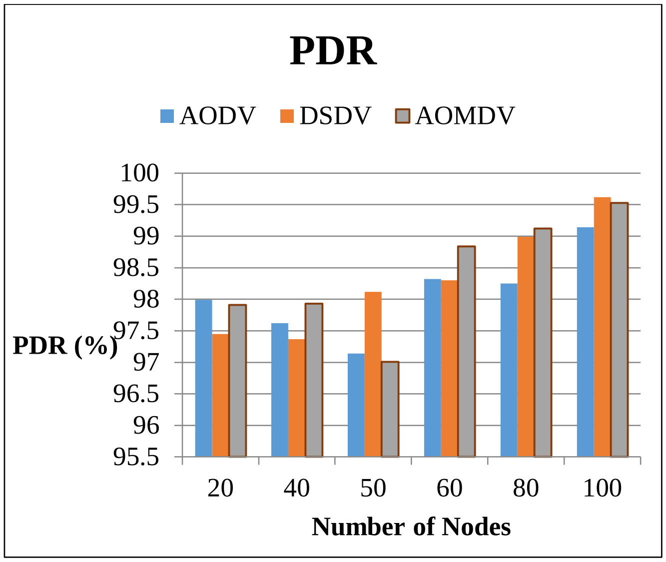

Figure 4- Packet Delivery Ratio

An enhancement is observed in the PDR if the size of the network topology gets increased in both DSDV, AODV and AOMDV. In DSDV and AOMDV, PDR increases linearly with increasing node density [9]. For the scenario comprising 50 nodes shows unusual behavior in AOMDV. When there are more vehicles around, there are additional chances for the packets in buffer to be delivered. Thus, AOMDV has better PDR ratio as compared to AODV and DSDV. The results representing behavior of PDR in AODV, DSDV and AOMDV is as shown in the Figure 4.

C. *Normalized Routing Load (NRL)*

The entire quantity of routing packets to the entire quantity of delivered data packets is termed as NRL. Table 4 shows results related to NRL. For the smaller network topology, the NRL increases both in AODV and DSDV. The NRL decreases if the number of node increases. There is an unusual behavior observed in the DSDV for the scenario comprising 50 and 60 nodes. Thus, AODV is having lower NRL as compared to DSDV and AOMDV [9]. AOMDV uses more route reply and route error for multiroute detection. The use of additional fields in the control packets produces more overhead than AODV. The results are represented graphically in Figure 5.

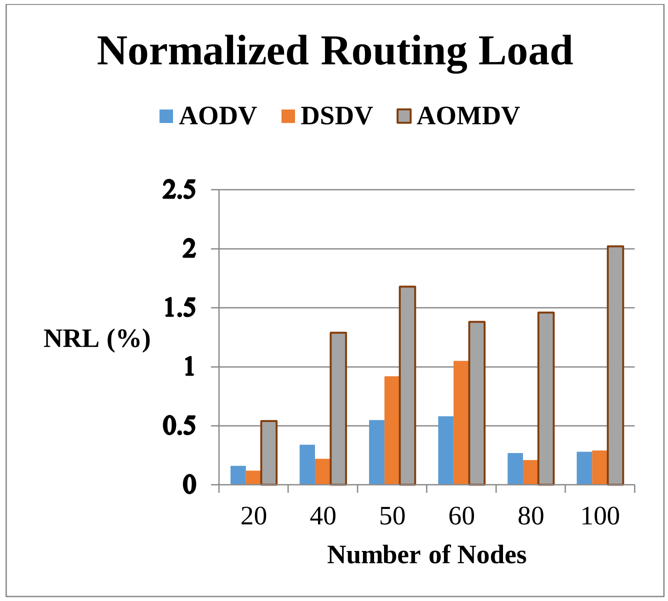

Figure 5 – Normalized Routing Overhead

D. *Average Throughput*

The volume of actual data transferred successfully in between the nodes in a given time period is called a throughput. Table 5 indicates the observation of average throughput. When node density are high then there is better average throughput observed in both protocols. DSDV performs better when there is high density due to proactive nature [6] [9]. Figure 6 shows the average throughput in a graphical manner.

Table 5. Average Throughput

Protocol/ Nodes	Average Throughput (kbps)					
	20	*40*	*50*	*60*	*80*	*100*
AODV	406.12	356.06	430.37	353.97	394.69	524.38
DSDV	280.89	250.87	668.66	574.03	525.65	643.08
AOMDV	393.28	331.07	295.56	406.3	480.6	436.55

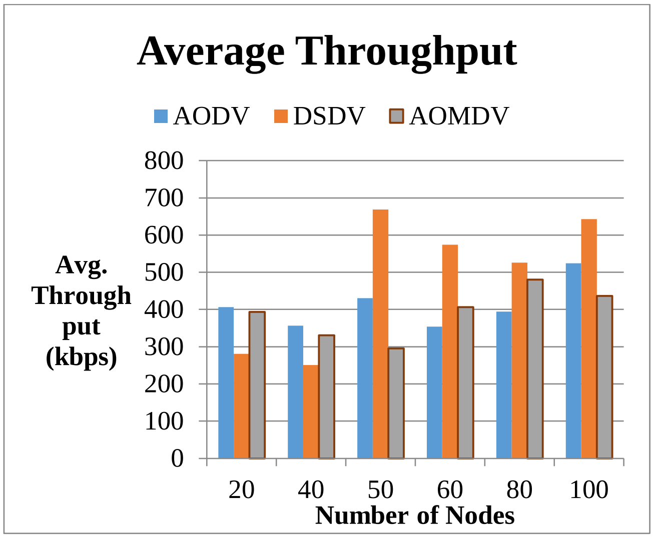

Figure 6 –Average Throughput

VI. Conclusion and Future Direction

The vehicular ad-hoc network achieves V2V and V2I communication with the help of IEEE802.11p DSRC standard. The paper comprises the classification of topological routing protocols in VANET. The behavioral analysis of AODV, DSDV and AOMDV routing protocol were evaluated through simulations on various scenarios created in SUMO and NS 2.35. The parameters used are E2ED, PDR, NRL and average throughput. In AODV, the E2ED decreases as the node increases. For a smaller number of nodes, E2ED was observed less in DSDV. The enhancement was observed in the PDR with increasing node density. AOMDV produces better PDR as compared to both protocols. All protocol produces higher average throughput and less NRL except AOMDV for more number of nodes. The unusual behavior was observed for some of the scenarios related to E2ED, NRL and average throughput.

In future, it is aimed to assess the influence of the various propagation model on the performance of the routing protocol.

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