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Adaptability of MANET Routing Protocols for VANETS

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Abstract: In recent years, co-friendly transportation is becoming more and more important. Vehicular ad hoc networks are emerging as a new class of wireless network spontaneously formed between moving vehicles equipped with wireless interfaces, employing short-range to medium-range communication. One of the most distinguishing features of vehicular ad hoc networks (VANETS) is the increased mobility of the nodes. Many routing protocols for MANETS have been proposed to date. Among them, DSDV is a representative table-driven protocol, while AODV and DSR are two representative on-demand protocols. This paper proposes ns-2 simulation result by comparing these three protocols at different number of nodes and at different mobility. This comparison result helps in checking the adaptability of MANET routing protocol for Vehicular Ad hoc networks. The scenarios used in the simulation experiments take into account a variety of environmental factors that influence protocol performance. The performance of the protocols is compared in terms of their packet delivery ratio, end to end delay and routing overhead.

Keywords: VANETS, MANETS, AODV, DSDV, DSR, performance analysis and routing protocol.

I. INTRODUCTION

With the emergence of mobile ad hoc networks, researchers have conceptualized the idea of communing vehicles, giving rise to vehicular ad hoc networks (VANETs), which are the main focus of engineers yearning to turn cars into intelligent machines that commune for safety and comfort purposes. A VANET is formed by vehicles that are equipped with wireless communication devices, positioning systems, and digital maps. VANETs also allow vehicles to connect to roadside units (RSUs), which are connected to the Internet and may also be connected with each other via a high-capacity mesh network VANETS. Many routing protocols have been proposed for ad hoc networks. The mechanisms they adopt are traditionally categorized as table-driven and on-demand. On-demand routing protocols query a route when there is a real need (demand) for it. In contrast, table-driven routing protocols maintain routing information for all network destinations independently of the traffic to such destinations. Several performances comparisons have been reported for ad hoc routing protocols in the recent past [1], [2], [3] and [4].

This paper compares the Ad hoc On Demand Distance Vector protocol (AODV) and the Dynamic Source Routing protocol (DSR), with the Destination-Sequenced Distance Vector Routing protocol (DSDV). AODV and DSR are the two most popular on-demand protocols to date, while DSDV is a table-driven protocol for ad hoc networks environment. The comparison is made in terms of packet delivery ratio, end-to-end-delay and routing overhead using the NS-2 simulation environment [8].

Section II reviews the key features of the three routing protocols under study. Section III presents the results of the simulation study. The performance of the protocols is compared in terms of their packet delivery ratio, end to end delay and routing overhead. The simulation results show that AODV achieves better performance than DSR and DSDV in the case of packet delivery ratio and routing overhead regardless of number of nodes at low pause times. In the case of end-to-end-delay, at low number of nodes i.e., up to 100 nodes at low pause times the AODV outperformed both DSR and DSDV. It is observed that as the number of nodes increases, the end-to-end-delay and the routing overhead are proportionally increases. Also, it is observed that in the case of packet delivery ratio, end-to-end-delay, routing overhead as the number of nodes increases, the performance of AODV gradually degrades, but still it is better than DSR and DSDV at low pause times. Section IV presents conclusion and future work.

II. ROUTING PROTOCOLS:

*Table-driven***:** In table-driven routing protocols each node maintains one or more tables containing routing

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information to every other node in the network. All nodes update these tables so as to maintain a consistent and up-to-date view of the network. When the network topology changes the nodes propagate update messages throughout the network in order to maintain consistent and up-to-date routing information about the whole network. These routing protocols differ in the method by which the topology change information is distributed across the network and the number of necessary routing-related tables.

On-demand: These protocols take a lazy approach to routing. In contrast to table-driven routing protocols all up-to-date routes are not maintained at every node, instead the routes are created as and when required. When a source wants to send to a destination, it invokes the route discovery mechanisms to find the path to the destination. The route remains valid till the destination is reachable or until the route is no longer needed. This section discusses a few on demand routing protocols.

A. DSDV

Packets are transmitted between the stations of the network by using routing tables, which are stored at each station of the network. Each routing table, at each of the stations, lists all available destinations, and the number of hops to each. Each route table entry is tagged with a sequence number, which is originated by the destination station. To maintain the consistency of routing tables in a dynamically varying topology, each station periodically transmits updates, and transmits updates immediately when significant new information is available. Routing information is advertised by broadcasting or multicasting the packets which are transmitted periodically and incrementally as topological changes are detected.

B. AODV

Ad hoc On-demand Distance Vector Routing (AODV) is an improvement on the DSDV. AODV minimizes the number of broadcasts by creating routes on-demand as opposed to DSDV that maintains the list of all the routes. To find a path to the destination, the source broadcasts a route request packet. The neighbours in turn broadcast the packet to their neighbours till it reaches an intermediate node that has recent route information about the destination or till it reaches the destination. A node discards a route request packet that it has already seen. The route request packet uses sequence numbers to ensure that the routes are loop free and to make sure that if the intermediate nodes reply to route requests, they reply with the latest information only. When a node forwards a route request packet to its neighbours, it also records in its tables the node from which the first copy of the request came. This information is used to construct the reverse path for the route reply packet.

C. DSR

The Dynamic Source Routing Protocol is a source routed on-demand routing protocol. The key distinguishing feature of DSR is the use of source routing. That is, the sender knows the complete hop-by-hop route to the destination. These routes are stored in a route cache. The data packets carry the source route in the packet header. When a node in the ad hoc network attempts to send a data packet to a destination for which it does not already know the route, it uses a route discovery process to dynamically determine such a route. Route discovery works by flooding the network with route request (RREQ) packets. Each node receiving an RREQ rebroadcasts it, unless it is the destination or it has a route to the destination in its route cache. Such a node replies to the RREQ with a route reply (RREP) packet that is routed back to the original source. RREQ and RREP packets are also source routed.

The RREQ builds up the path traversed across the network. The RREP routes itself back to the source by traversing the path backward. The route carried back by the RREP packet is cached at the source for future use. If any link on a source route is broken, the source node is notified using a route error (RERR) packet. The source removes any route using this link from its cache. A new route discovery process must be initiated by the source if this route is still needed. DSR makes very aggressive use of source routing and route caching. No special mechanism to detect routing loops is needed. Also, any forwarding node caches the source route in a packet it forwards for possible future use. The data structure DSR uses to store routing information is route cache, with each cache entry storing one specific route from the source to a destination. DSR makes very aggressive use of the source routing information. Every intermediate node caches the source route carried in a data packet it forwards, and the following optimization rules to DSR have also been proposed:

1. *Salvaging:* If an intermediate node discovers that the next hop in the source route is unreachable, it can replace the source route in the data packets with a route from its own cache.

2. *Gratuitous Route Repair:* A source node notified error of the packets it originates propagates the error notification to its neighbours by piggy-backing it on its next route request. This helps clean up the caches of other nodes in the network that may have the failed link in one of the cached source routes.

3. *Promiscuous Listening:* When a node overhears a packet that is addressed to another node, it adds the source route information into its own route caches. The node also checks if the packet could be routed via itself to gain a shorter route.

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III. EXPERIMENT AND RESULT ANALYSIS

The simulation study is conducted in the Network Simulator (ns2) [8] environment and uses the ad-hoc networking extensions provided by CMU. NS-2 is a discrete event simulator developed by the University of California at Berkeley. It provides substantial support for simulating TCP and other protocols over conventional networks. CMU Monarch project extends NS-2 to allow accurate simulation of mobile wireless networks by providing wireless physical and MAC layer support. They provide the fundamental platform to enable users developing networks layer simulations.

A. Related Work

There are some researches on VANET routing protocols doing the similar experiments as the work in this paper. Reference [5] presents a survey of existing approaches for secure ad-hoc routing and their applicability to VANETS. They compared solutions with respect to applied security mechanisms and performance criteria. Reference [6] presents DOA: DSR over AODV routing for mobile ad hoc networks. They compared DSR and AODV routing protocols. In contrast, we have taken DSDV, AODV and DSR protocols and tested the metrics at high number of nodes i.e., up to 200 nodes in ns2 simulation environment.

B. Communication Model

Continuous bit rate (CBR) traffic sources are used. Only 512-byte data packets are used. The number of source-destination pairs and the packet sending rate in each pair is varied to change the offered load in the network.
All communication patterns were peer-to-peer, and connections are started at times uniformly distributed between 0 and 100 seconds.
TCP sources was avoided because TCP offers a conforming load to the network, meaning that it changes the times at which it sends packets based on its perception of the networks ability to carry packets.

C. Mobility Model

The source-destination pairs are spread randomly over the network. The mobility model uses the random waypoint model. The random waypoint model is a frequently used mobility model in ad hoc networking research. According to this model, a node randomly chooses a destination point in the given area and moves at constant speed in a straight line to this point. The node then rests for a certain time period (pause time), chooses a new destination and speed, and moves with constant speed to this destination, and so on. The field configurations used is: 500m x 500m field with 50 nodes, 100 nodes and 200 nodes. Here, each packet starts its journey from a random location to a random destination with a randomly chosen speed (uniformly distributed between 0-20 m/s). Once the destination is reached, another random destination is targeted after a pause. The pause time, which affects the relative speeds of the mobiles, is varied. We ran the simulations for 100 simulated seconds. Identical mobility and traffic scenarios are used across protocols to gather fair results. In our simulations, we varied the "pause time" between 0 and 100 seconds. A "pause time" of 0 seconds corresponds to continuous motion, and a pause time of 100 seconds corresponds to no motion when the simulation time is 100 seconds.

D. Performance Metrics

The following performance metrics are evaluated:
Packet delivery ratio: The ratio of the data packets delivered to the destinations to those generated by the CBR sources. Packet delivery ratio (%) = (received packets/sent packets)*100 Received packets and sent packets number could be easily obtained from the first element of each line of the trace file.

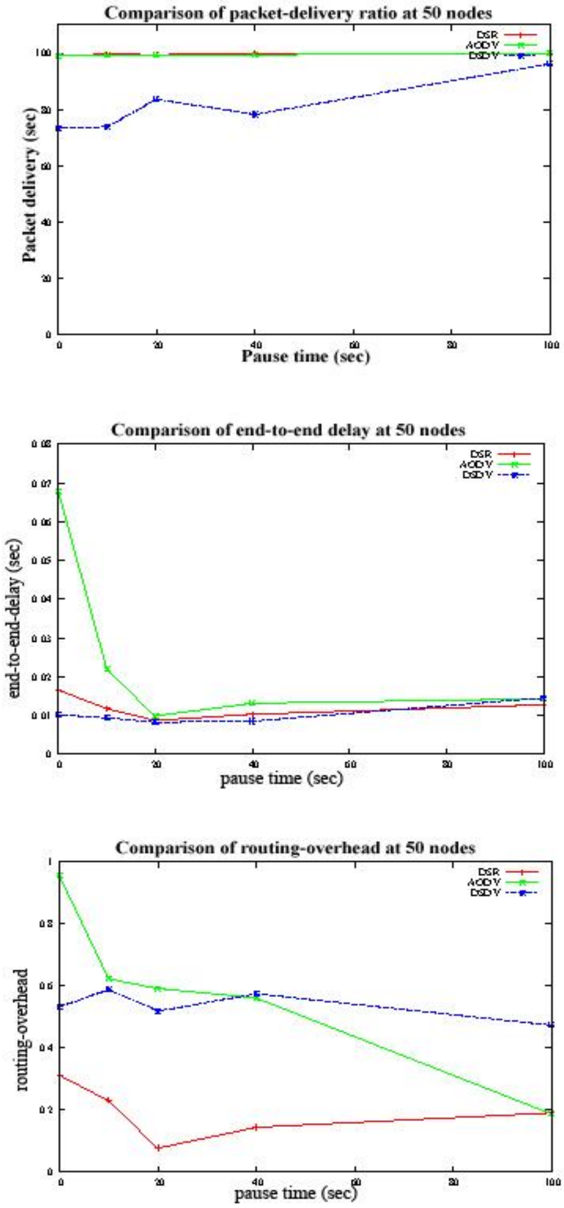

Fig. 1 Comparison of packet delivery ratio, end to end delay and routing overhead at 50 nodes scenario.

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Average end-to-end delay: This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times.

For each packet with id (*Ii*) of trace level (*AGT*) and type (*cbr*), we can calculate the send (*s*) time (t) and the receive (*r*) time (t) and average it.

Routing overhead: It is the ratio of the routing packets sent and the total packets sent. Each hop-wise transmission of a routing packet is counted as one transmission.

Calculation of the routing overhead:
routing overhead = routing packets sent / total packets sent

E. Results and Discussion

For all the simulations, the same movement models were used, the number of traffic sources was fixed at 50, 100 and at 200 nodes, the maximum speed of the nodes is set to 20m/s and the pause time is varied as 0s, 10s, 20s, 40s and 100s. Fig. 1, shows the relative performance test result of the three routing protocols at 50 nodes. All of the protocols deliver a greater percentage of the originated data packets when there is little node mobility, converging to 100% delivery ratio when there is no node motion. The On-demand protocols, AODV and DSR performed particularly well, delivering over 95% of the data packets irrespective of mobility rate. But, DSDV could not achieve good packet delivery ratio when moving more frequently. The reason being invalid route reconstruction is in case of link breakage.

In the case of end-to-end-delay comparison of the three protocols, DSDV performed pretty stable and the delay kept about 0.01seconds when pause time increased from 0 seconds to 100 second. The reason is that it is a table driven protocol, so a node does not need to find a route before transmitting packets and no additional latency would be introduced when proactive protocols were used. So the delay is quite stable. . But, the end-to-end-delay in case of AODV is more as it incurs additional delay due to its route discovery procedure.

In the case of routing overhead from the fig. 1, DSR performed pretty well, because in this routing protocol, the routing packets will be sent on demand. We observed a peak in the case of AODV graph at low pause times. This is due to its inefficient route discovery and route maintenance methods at high mobility.

This routing overhead gradually decreases with increase of pause times. DSR also an on-demand protocol and due to its efficient route discovery and route maintenance methods, it takes less routing overhead than AODV.

Since, DSDV is a table-driven protocol, it maintains relatively constant routing overhead.

In fig. 2, we ran the simulations for the same scenarios except the nodes are increased to 100. In the case of packet delivery ratio, we found that DSR performed well. In the case of end-to-end-delay, DSDV outperformed DSR and AODV. In the case of routing overhead, DSR outperformed DSDV and AODV.

We observed large peaks for AODV at lower pause times. This is due to topology changes at low pause times, inefficient route discovery and route maintenance methods used in AODV at high speeds.

In fig. 3, we ran the simulations for the same scenarios, except the increase of nodes to 200. From these simulations, we observed that in the case of packet delivery ratio, DSR still outperformed both DSDV and AODV. Here, we observed that as the number of nodes increases, the performance of AODV in the case of packet delivery ratio gradually degrades, but is good at low pause times i.e. at high speed.

In the case of end-to-end-delay, the DSR outperformed both DSDV and AODV. In the case of routing overhead, we observed that with increase of number of nodes, the overhead proportionally increases for all the routing protocols.

The shape of the moving space would affect the mobility pattern of the nodes, square and rectangle with the similar area are expected to cause the routing protocols to work differently. The nodes in a square site can move more freely around each other. On the other hand, the nodes in a rectangular site cannot move freely. We also ran the simulations in the rectangular scenario. Fig. 4 shows the simulations under the rectangular scenario.

We have chosen area of 600m x 400m. In these simulations, in the case of packet delivery for DSR and DSDV, the ratio is comparable with that of square scenario. But, in the case of DSDV, the packet delivery ratio is reduced up to 60% at the pause time of 20. In the case of end-to-end-delay, DSDV performance is comparable with that of square scenario as in fig. 1. But in the case of DSR and AODV, the delay is increased at lower pause times.

In the case of routing overhead, at pause time 20, all routing protocols have more routing overhead, in comparison with the square scenario. Finally with little enhancement in AODV protocol, this protocol can be used for VANETS.

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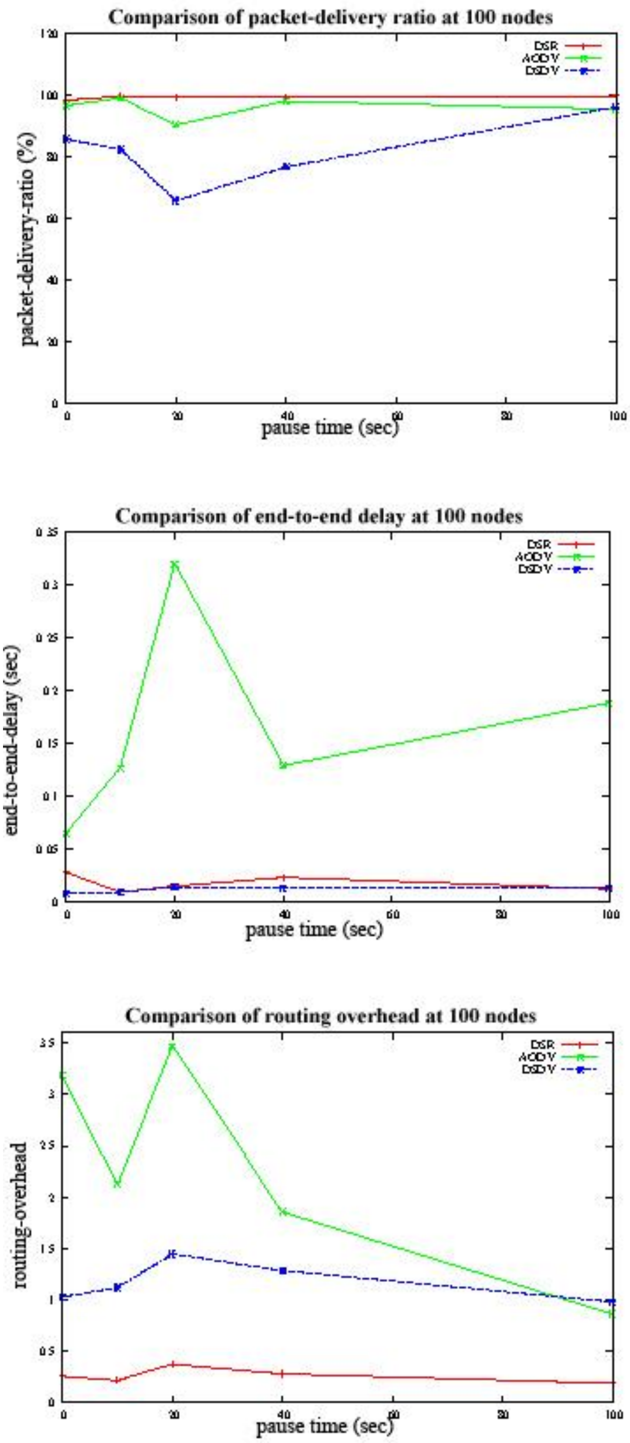

Fig. 2. Comparison of packet delivery ratio, end to end delay and routing overhead at 100 nodes scenario.

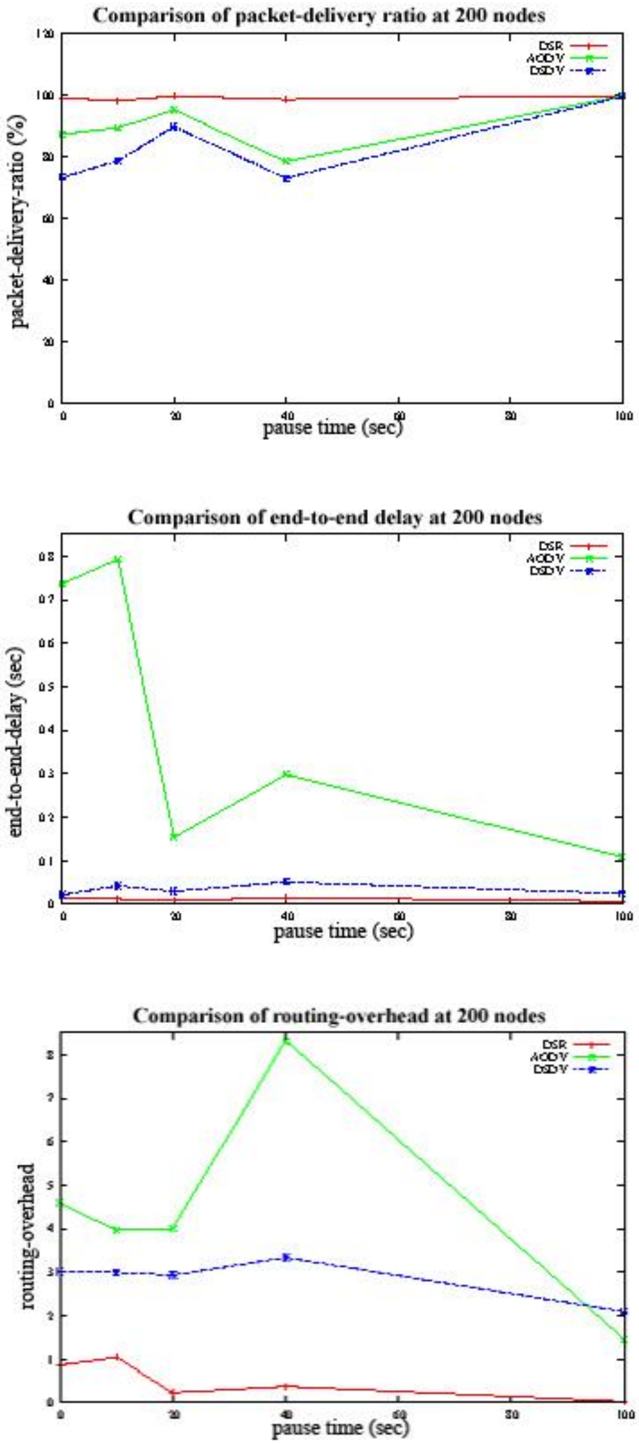

Fig. 3. Comparison of packet delivery ratio, end to end delay and routing overhead at 200 nodes scenario.

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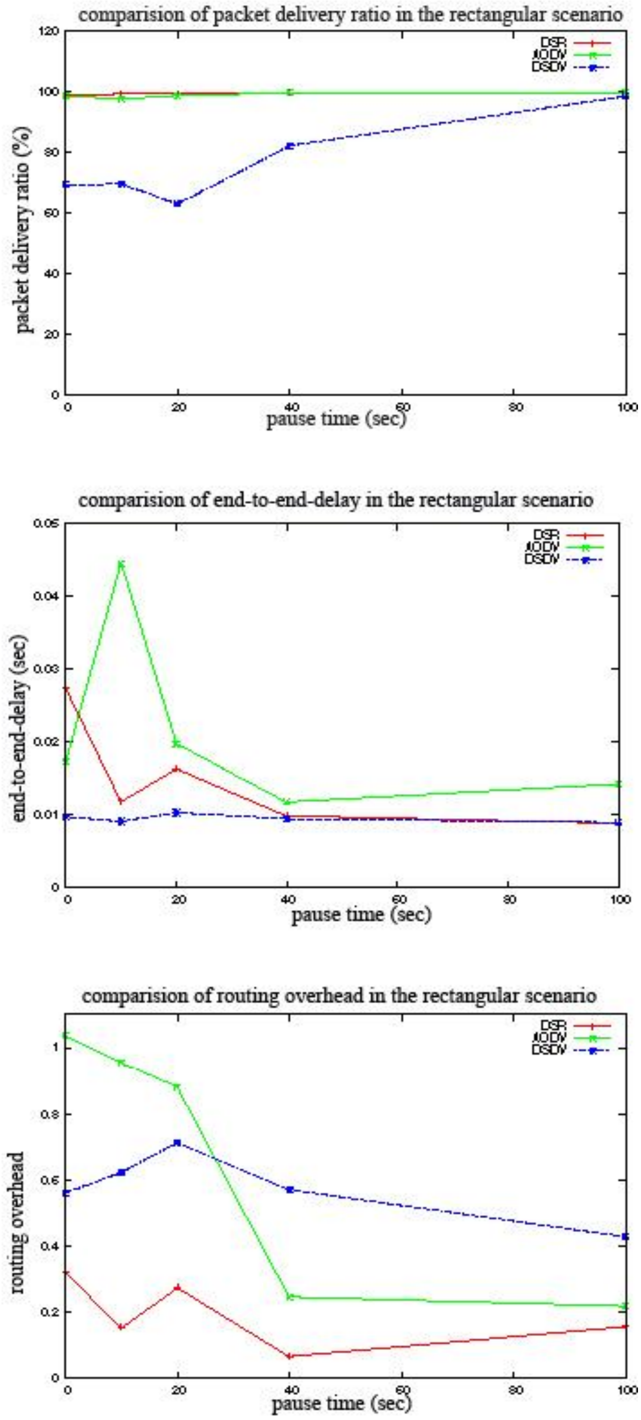

Fig. 4. Comparison of packet delivery ratio, end to end delay and routing overhead in the 600m x 400m rectangular scenario at 50 nodes.

IV. CONCLUSION AND FUTURE WORK

In this paper, we investigated the related topics on MANET, especially for routing protocols of ad hoc networks and checked the adaptability of these protocols for VANETS. On ns-2 simulator, we compared the performance of routing protocols AODV, DSDV and DSR. On-demand driven protocols such as AODV and DSR, performed well for packet delivery with fast movement and mobility rate. But they require more routing overhead for dynamic routing decision. In the case of packet delivery ratio, as the number of nodes increases, the performance of AODV and DSDV gradually degrades while DSR maintains constant ratio irrespective of the number of nodes.

In the case of end-to-end-delay, it is observed that at lower number of nodes DSDV outperformed DSR and at higher number of nodes DSR outperformed DSDV. As the mobility increases i.e. as the speed increases AODV with enhancement can be used for VANET protocols. The routing overhead proportionally increases for all routing protocols mentioned in this paper.

Our future work involves: Firstly, implementing enhanced AODV routing protocol to improve the performance and taking other existing protocols to analyse the performance. Secondly, evaluating routing protocols with different metrics and compare their performance. Lastly we will design a smart city framework for VANETs that include intelligent traffic lights (ITLs) that transmit warning messages and traffic statistics. We will design a VANET routing protocol that considers those statistics in its operation.

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