

## Performance Evaluation of MANET Based Routing Protocols for VANETs in Urban Scenarios.

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**Abstract.** Vehicular Ad hoc NETWORKS (VANETs) are self-organizing ad hoc networks that are specifically designed for communication among vehicles where vehicles are themselves the nodes. Although routing protocols have already been analyzed and compared in the past for Mobile Ad hoc Networks (MANETs), simulations and comparisons of routing protocols for VANETs have almost always been done considering random motions with non-urban specific parameters. This paper studies the performance of Ad hoc On-Demand Distance Vector (AODV) and Destination Sequenced Distance Vector (DSDV) which are popular routing protocols in MANETS for routing among vehicular nodes in VANETs. The effects of urban motions on the simulation parameters, their consequences on routing performance are compared between the two protocols in this study. The VANET simulations showed that on-demand based protocol AODV performs better than the table-driven based DSDV protocol for two performance metrics for vehicular nodes moving in urban scenarios.

**Keywords:** Mobile Ad hoc Networks, Vehicular Ad hoc Networks, Manhattan Mobility Model, Routing.

### 1. Introduction

Vehicles on the roads can form a Vehicular Ad hoc NETWORK (VANET) using wireless technology to communicate with each other without any predeployed infrastructure. VANETs are a special case of Mobile Ad hoc NETWORKS (MANETs), where the mobile nodes are vehicles. High speeds of vehicles, mobility constraints on a straight road and driver behavior are some factors due to which VANETs possess very different characteristics from the typical MANET models. The results of such characteristics are rapid topology changes, frequent fragmentation of the network and small effective network diameter. MANET routing protocols are grouped into on-demand based and table-driven based protocols. Several studies have shown that on-demand based protocols are suitable for highly dynamic mobile environments.

In this paper, our aim is to evaluate the performance of AODV which is an on-demand based routing protocol and DSDV which is a table-driven based routing protocol in realistic urban traffic environments for routing in VANETs. In order to model realistic vehicular motion patterns, we make use of the BonnMotion framework [1]. This model is able to closely reflect spatial and temporal correlations between cars, and between cars and urban obstacles. The tool illustrates clustering effects obtained at intersections and drastic speed decays. Accordingly, it becomes possible to more realistically evaluate ad hoc routing performances for vehicular networks. We configure the Manhattan Mobility Model to model an urban environment, and evaluate the performance of AODV and DSDV in terms of (i) Packet Delivery Ratio (PDR) (ii) Normalized Routing Load (NRL), and (iii) End to End Delay (EED). We test AODV and DSDV under three different conditions (i) variable velocity (ii) variable node density (iii) variable data traffic rate, following which we compare the simulations and graphs and show how AODV is able to outperform DSDV in any condition and for almost all metrics.

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## 2. Related Work

Several studies have been conducted for comparing the routing protocols AODV and DSDV along with other protocols such as DSR or TORA for MANETs. The first endeavour towards such a comparison was made by the Monarch project [8]. AODV, DSDV, DSR and TORA were compared for general wireless ad-hoc networks. In our paper, we have varied the number of nodes and based our study entirely on VANETs.

Sven et al. [9] evaluated the performances of AODV, DSR, FSR and TORA for the Manhattan mobility model and concluded that TORA is completely unsuitable for vehicular environments, whereas FSR, DSR and AODV show promising results in city scenarios. The parameters used for comparison are different from those used in our study. Jerome et al. [10] studied VANETs using Vanet MobiSim and evaluated AODV in urban scenarios.

## 3. Routing Protocols

### 3.1 Ad hoc On-Demand Distance Vector (AODV)

AODV [2] is a reactive routing protocol for MANETs. It operates in two phases namely route discovery and route maintenance. Route discovery is one of the most important characteristics of any protocol in wireless communication. AODV uses route discovery by broadcasting RREQ to all its neighbouring nodes. Sequence numbers help avoid the possibility of forwarding the same packet more than once. An RREQ arrives at a node that possesses a current route to the destination. If an intermediate node has a route entry for the desired destination, it determines whether the route is current by comparing the destination sequence number in its own route entry to the destination sequence number in the RREQ. If the RREQ's sequence number for the destination is greater than that recorded by the intermediate node the intermediate node must not use its recorded route to respond to the RREQ. Instead the intermediate node rebroadcasts the RREQ. Route Maintenance in AODV comes into play when a link or a node fails. RERR (Route Error) is initiated by the node upstream (closer to the source) of the break. It is propagated to all the affected destinations. RERR lists all the nodes affected by the link failure. When a node receives an RERR, it marks its route to the destination as invalid, setting distance to the destination as infinity in the route table. When a source node receives an RRER, it can reinitiate route discovery.

### 3.2. Destination Sequence Distance Vector (DSDV)

DSDV [3] is a hop-by-hop distance vector routing protocol requiring each node to periodically broadcast routing updates. Each node in the network maintains routing information in a routing table. Each routing table entry contains a destination node, the next hop to the destination, a metric and the sequence number. The sequence number is an important feature of DSDV using which it avoids routing loops by eliminating stale entries. The frequent changes in the network need to be updated in the routing tables of the nodes. Any node that detects changes in the network modifies the metric to 1 and broadcasts or multicasts update packets to its neighbours which update their routing tables. They increment the metric by one and rebroadcast the update packets to their one-hop neighbours. This process repeats until all nodes in the network receive the update with the corresponding metric. Before updating its routing table and retransmitting the update packet, each node waits for the best route to the destination to arrive. If multiple updates for the same destination arrive, the update with the most recent sequence number is chosen. In case all the updates have the same sequence number, the one with the smallest metric is chosen and the corresponding previous entry in the routing table is marked as a less preferable route or discarded. Then the update packet with this sequence number is flooded in the network.

## 4. Experimental Setup

### 4.1. Vehicular Mobility Model

Mobility models are the movement patterns of nodes communicating wirelessly. They play a vital role in the simulation-based evaluation of VANETs. Vehicular mobility models are generally classified as either microscopic or macroscopic [4]. When focusing on a macroscopic point of view, motion constraints such as roads, streets, crossroads, and traffic lights are considered. Also, the generation of vehicular traffic such as

traffic density, traffic flows, and initial vehicle distributions are defined. The microscopic approach, instead, focuses on the movement of each vehicle and on the vehicle behaviour with respect to other vehicles.

The work in this paper has focused on urban environments where the speeds of nodes are variable owing to constraints such as buildings, traffic signals and stop signs, Manhattan (grid) Mobility Model has been chosen. The Manhattan Mobility Model uses a grid road topology; it was first introduced in the IMPORTANT framework [5] and is also implemented in the BonnMotion framework [1]. The BonnMotion tool was used in the study conducted for this paper. It is a Java software which creates and analyzes mobility scenarios which can be exported to network simulators such as ns-2, QualNet and others. It includes a myriad of mobility models such as Manhattan grid, Chain model, and Reference Point Group Mobility model (RPGM).

The native format in which BonnMotion saves the movement traces is node-by-line waypoint based. This means that there is one line for each node. This line contains all the waypoints. A waypoint is a position at which the movement of a node (e.g. direction, velocity) changes. It consists of the simulation time in seconds at which the waypoint is reached by the node and the x and y coordinates of the position of the waypoint. The NSFfile application is used to convert the mobility scenario files into an ns-2 compatible format that can be integrated into a TCL script to start an ns-2 simulation.

The Manhattan Mobility Model uses a grid road topology. This mobility model was mainly proposed for the movement in urban areas, where the streets are in an organized manner. In this mobility model, the mobile nodes move in horizontal or vertical direction on an urban map. The Manhattan Mobility Model employs a probabilistic approach in the selection of node movements, since, at each intersection, a vehicle chooses to keep moving in the same direction. Although this model provides flexibility for the nodes to change the direction, it imposes geographic restrictions on node mobility.

## 4.2. Simulation Environment

The ns-2 simulator [6] is used for the experiments. It is a discrete event simulator developed by the University of California at Berkeley. The BonnMotion mobility generator is used to generate ns-2 compatible mobility traces for the Manhattan Grid model. Mobility file parameters such as the number of nodes, mean speed, duration of simulation, number of x and y blocks were varied for the generation of vehicular mobility traces for the experiments.

The mean speed (V-max) was varied from 10 m/s (36 kph or 22 mph) to 80 m/s (288 kph or 178 mph) in steps of 20 m/s. The other parameters such as minimum and maximum speed are automatically defined by Bonn Motion. Random traffic connections of TCP and CBR can be setup between mobile nodes using a traffic-scenario generator script called cbrgen.tcl available under `~ns/indep-utils/cmu-scen-gen` in ns-2. In order to create a traffic-connection file, we define parameters such as the type of traffic connection (CBR or TCP), the number of nodes and maximum number of connections to be setup between them, a random seed and in case of CBR connections, a rate whose inverse value is used to compute the interval time between the CBR packets. For each simulation experiment, the mobility trace file and the corresponding traffic connections file are given as inputs to a tcl file in ns-2. Table 1 specifies the parameters for network simulation. Simulation process in ns-2 can be visualized using NAM (Network Animator). Figure 1 represents a snapshot of the simulation process conducted.

The trace file obtained from the ns-2 simulation was fed as input to an AWK script (parser) which filters out the performance metrics, described in section 4. For better visualization of the simulated VANET, the iNSpect tool [7] was used. The iNSpect program produces a visual display of the nodes in a wireless scenario based on Cartesian (x,y) coordinates used by ns-2. Unlike NAM, iNSpect shows the wireless routes and the success or failure of a packet transmission. The transmissions are displayed with route lines and colour coded nodes. The initiating node of a transmission attempt turns blue to indicate it is sending. The receiving node turns red until the packet is successfully received, then it turns green or blue. If the receiving node is the packet's final destination it turns green. If the receiving node is not the final destination, it turns blue to show the next forwarding transmission attempt, and the route line is extended to show the forwarding of the packet. A snapshot of the visualization obtained for our experiments is shown in figure 2.

Table 3: Network simulation parameters

Parameter	Value(s)
Channel	Channel/WirelessChannel
Propagation model	Propagation/TwoRayGround
Network Interface	Phy/WirelessPhy
Mac Layer	Mac/802_11
Interface Queue	Queue/Droptail/PriQueue
Link Layer	LL
Antenna	Antenna/OmniAntenna
X dimension of topography	500
Y dimension of topography	500
Number of nodes	20 or 30 or 40
Seed	3.0
Simulation time	1000s
Routing Protocol	AODV or DSDV

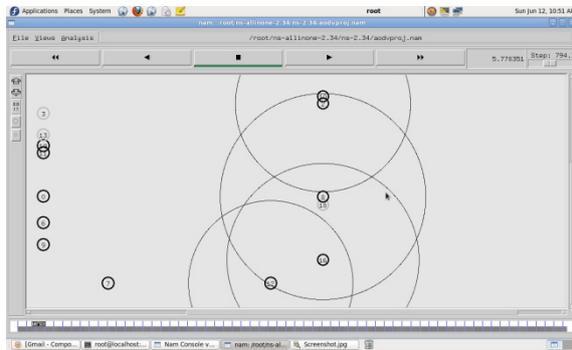


Fig. 1: Wireless connections among the nodes

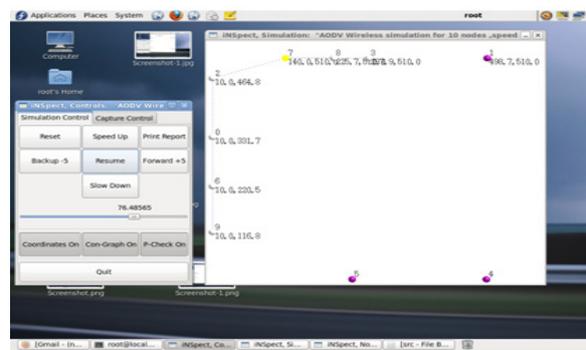


Fig. 2: Forwarding and non-participating nodes

## 5. Simulation Results

The different metrics chosen in this study to evaluate and compare the performances of AODV and DSDV are Packet Delivery Ratio (PDR), defined as the ratio of the number of data packets received at the destination to the number of data packets sent by the source, Normalized Routing Load (NRL), which is defined as the number of “routing” packets transmitted per “data” packet delivered at the destination and End-to-End Delay (EED), which is the delay incurred from the time at which the data packet is generated at the source to the time at which it is received by the destination.

Simulations were conducted by keeping the number of nodes constant and varying the maximum velocity of the nodes. The PDR obtained for 20, 30 and 40 nodes are depicted in figures 3 and 4. As we can observe, AODV performs consistently better than DSDV for increasing number of nodes and also that the PDR of DSDV reduces as the number of nodes in the VANET increases. Another set of simulations were performed by varying the number of nodes, keeping the maximum velocity of the nodes constant. The PDR obtained for V-max = 10, 30 and 50 m/s are shown in figures 5, 6 and 7 respectively. We can notice that, again, AODV provides a better PDR in most cases. Thus, reactive routing can be trusted to provide reliable delivery of packets for varying number of nodes. Figure 8 indicates the %improvement of PDR obtained by using AODV. Though it is not a large improvement, even a slight increase in the PDR would mean an increase in throughput.

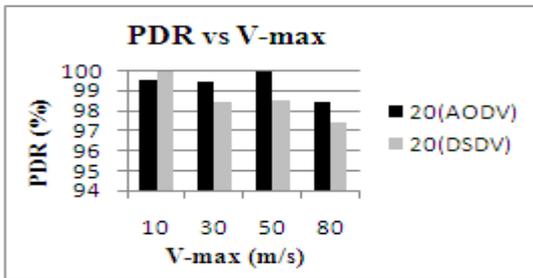


Fig. 3: PDR for 20 nodes

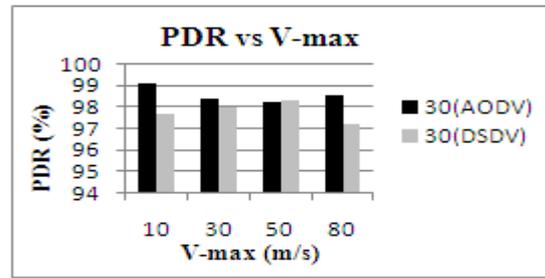


Fig. 4: PDR for 30 nodes

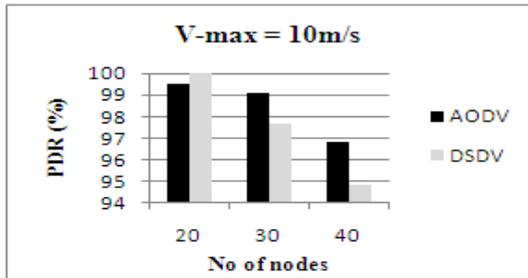


Fig. 5: PDR for Vmax = 10 m/s

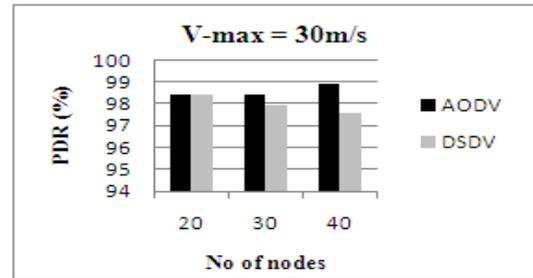


Fig. 6: PDR for Vmax = 30 m/s

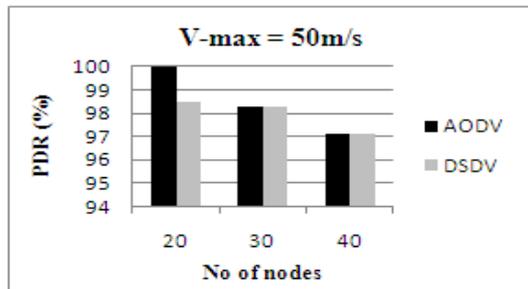


Fig. 7: PDR for Vmax = 50 m/s

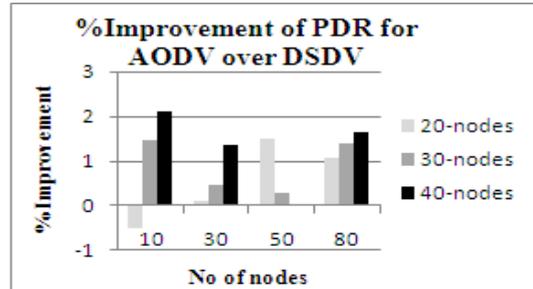


Fig. 8: % Improvement of PDR for AODV over DSDV

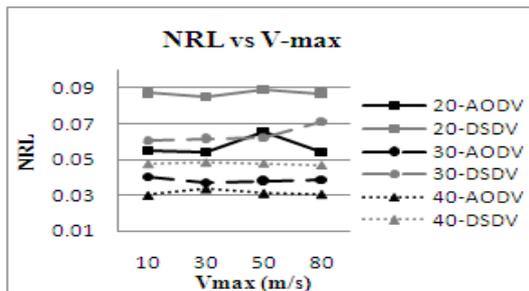


Fig. 9: NRL for 20, 30 and 40 nodes

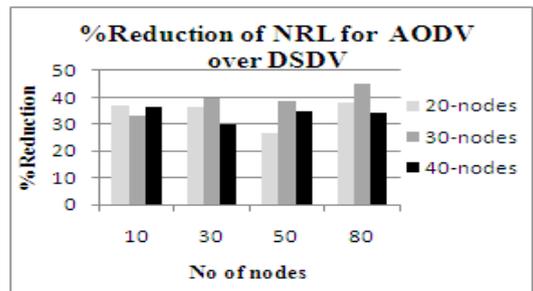


Fig. 10: %Reduction of NRL for AODV over DSDV

It is evident from figure 11 that AODV incurs greater delays when compared to DSDV. Consequently, AODV routing would require a greater amount of time to route the same number of packets as compared to DSDV. Figure 12 depicts the %increase in EED obtained for AODV when compared to DSDV. It averages over 10% which is not quite significant when compared to the large reductions of NRL obtained.

## 6. Conclusion

The study in this work focused on evaluating the performance of MANET routing protocols AODV and DSDV for routing in VANETs in urban scenarios. Results of VANET simulations show that two performance metrics PDR and NRL are better for the on-demand based AODV when compared to the table-driven based DSDV. DSDV had lower EED as compared to AODV. Our future work will be to devise methods for modifying AODV to lessen the EED so that the modified AODV protocol can be shown successful for routing in VANETs under all constraints.

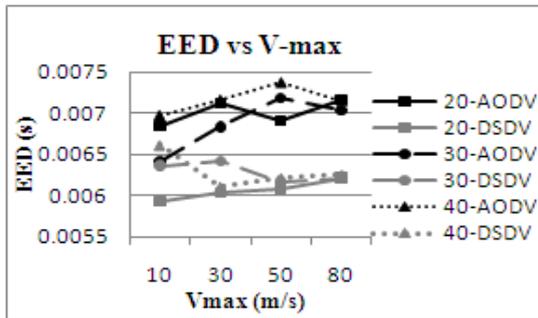


Fig. 11: EED for 20, 30 and 40 nodes

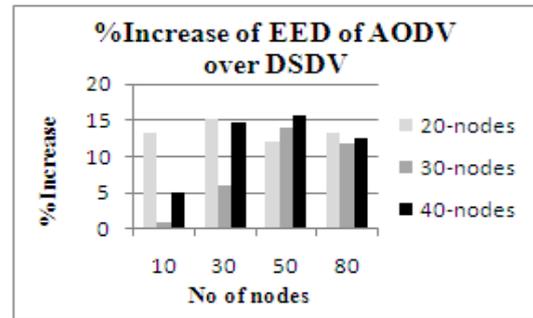


Fig. 12: %Increase of EED of AODV over DSDV

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