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SIMULATION-BASED PERFORMANCE EVALUATION OF VANET ROUTING PROTOCOLS UNDER INDIAN TRAFFIC SCENARIOS

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Abstract. *Road accidents are a major cause of causalities, and approximately 0.15 million people died in road accidents in India yearly. An intelligent transportation system must possess and improve the comfort and safety of drivers and pedestrians that VANET can achieve. It has become necessary to implement VANET in India to reduce high casualties and provide a comfortable journey. The relevance of VANET on Indian roads must be tried before execution indeed. Vehicles perform routing functionality to deliver data; therefore, routing algorithms play a crucial role in VANET for message dissemination on time. VANETs routing is one of those challenges which required specialized protocols. The work presented in this paper shows the simulation results of AODV and DSDV routing protocols on important routing metrics such as packet delivery ratio, throughput, and average end-to-end delay. To simulate a real traffic environment, the authors have taken a map of Jaipur city, India, from OpenStreetMap and used the Simulation of Urban MObility as a traffic simulator and network simulator NS-2.35 for AODV and DSDV routing protocols performance evaluation on the realistic city traffic environment.*
Keywords: VANET, Routing protocols, AODV, DSDV, NS-2.35

1. **Introduction.** Due to the large population, most of the roads in India are prone to traffic jams. According to the Ministry of Road Transport and Highways Report, every year, 147,913 people died in road mishaps caused by wrong driving and non-acceptance of traffic rules [1]. Due to the absence of medical treatment at accidental sites, these figures are constantly increasing. If the patients get a life support system treatment within 1 to 2 hours, their lives can be saved. Today's wireless and sensor technology has made incredible progress, due to which the physical health information of the patient can be easily collected and delivered to the desired location or interested person in real time. VANET is the class of ad-hoc networks in which vehicles construct a moving network. VANET can play a significant part in realizing the dream of the Intelligence Transport System (ITS). ITS

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provides an environment with automatic traffic control and the minimum number of traffic deaths. ITS is not possible without the implementation of VANET. VANET may be a very beneficial technology in declining road accidents and traffic fatalities. Many VANET projects like NoW (Network on Wheels) [2], FleetNet [3], and CarTALK [4] are already completed, and some of them are still going on. VANET consists of running vehicles and fixed infrastructure installed at the roadside called Road Side Unit (RSU). These running vehicles are called Mobile Nodes (MN), which share the data packets by IEEE 802.11p standard having 250 to 500 meters of communication range. Vehicles used in VANET are intelligent vehicles embedded with Global Positioning System (GPS), omni-directional antennas, and On-Board Unit (OBU) consisting of many sensors and processing capabilities [5]. RSU works as a gateway between MN and servers and provides more coverage to vehicles in its communication range [6]. VANET uses Vehicle to Vehicle (V2V), Vehicle to Infrastructure (V2I), and Vehicle to Pedestrian (V2P) communications. Various VANET applications have been developed so far to make the long journey comfortable and more convenient. These applications can be categorized into safety applications and comfort applications. Safety application includes traffic signal violation, intersection collision, turn assistance, blind spot warning, pedestrian crossing, lane change warning, forward collision warning, post-crash alert, emergency service vehicle, curve speed warning, etc. Comfort applications include information about the restaurant and parking availability, automatic toll collection, watching a real-time video, route diversion in case of traffic jam and download map for traveling, etc. [7]. VANET can send intermittent and communicated messages, high-need crisis messages, and educational and non-wellbeing application messages to improve traveler security and traffic efficiency [8]. The main contributions of this paper are as follows.

- A critical review is performed on VANET routing protocols based on data dissemination techniques, route update methods, and the suitability of applications.
- Urban city scenarios of Jaipur city are created by utilizing Open Street Map and design a simulation area of 2210 meters × 1020 meters from the available map.
- Finally, the performance of the AODV and DSDV protocol has been compared in terms of packet delivery ratio, throughput, and average end-to-end delay using UDP with CBR packets of 1000 to 4000 bytes size on NS-2.35 network simulation.

The remainder of the paper is composed as follows. Section 2 discusses the routing protocols used in VANET. Section 3 presents the topological routing algorithm. Section 4 describes the simulation parameters used in our experiments. Section 5 presents the experimental results and Section 6 presents the conclusions.

2. **VANET Routing Protocols.** VANET utilizes multi-hop wireless technology for information transmission from one node to another node. Routing protocols process routing information for connection maintenance to find the optimal path and store it into routing tables. Routing for VANET is a research challenge, and a variety of VANET routing protocols have been proposed and evaluated by researchers and academicians so far. VANET routing protocols are mainly classified into Broadcast-Based (BBR), Cluster-Based (CBR), Topology-Based (TBR), Position-Based (PBR), and Geo Cast Based (GBR) routing protocol as per information dissemination technique, path update technique, and suitability of applications [9-13]. Figure 1 shows some examples of different routing approaches used for information dissemination in VANET. BBR protocols use the flooding approaches for the dissemination of information in real time. These protocols are helpful for ITS application like safety messages, road conditions, and weather conditions. BROADCOM, V-TRADE, and DECA are a few examples of BBR protocols. PBR protocols assume vehicles have access to GPS services for calculating their location and destination location information [14]. They use periodic beaconing for one-hop neighbor discovery and collision avoidance. GPSR, GPCR, and A-STAR are examples of PBR

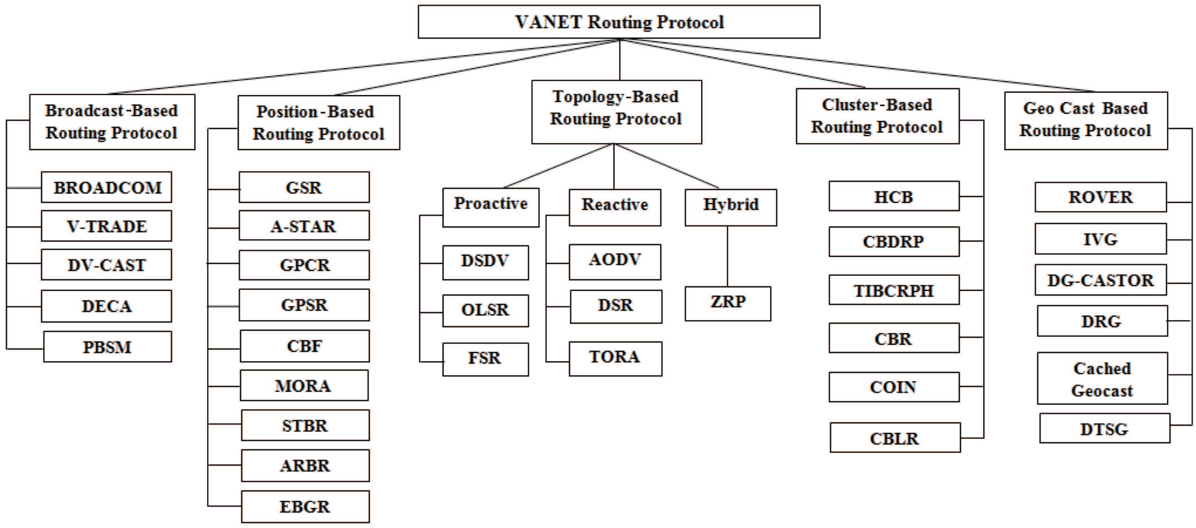

Figure 1. VANET routing protocols

protocols. CBR protocol divided the networks into many clusters. Each cluster consists of member nodes and one cluster head. Cluster size depends on routing techniques based on locations, velocity, and direction of node movement. CBDRP, CBLR, and TIBCRPH are examples of CBR protocols. GBR protocols use multicasting forwarding techniques to deliver data packets to nodes inside a particular geographical area. This area is called the Zone of Relevance (ZOR). ROVER, IVG, and DRG are examples of GBR routing protocols.

3. **Topology-Based Routing Protocols.** Topology-based routing protocols use topological information established in the network for data transmission. These protocols can be classified into three categories: proactive, reactive, and hybrid routing protocols. Proactive routing protocols update and maintain the route information periodically even when the route is not required. They use the shortest path algorithm for route discovery. Destination-Sequenced Distance-Vector (DSDV), Optimized Link State Routing (OLSR), Fisheye State Routing (FSR) are examples of proactive routing protocols. Reactive routing protocols are on-demand routing protocols that maintain only the routing paths that are recently used. These protocols do not update all the routes periodically. This approach saves bandwidth and reduces memory requirements. Ad-hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR) are examples of reactive routing protocol. Hybrid routing protocols exploit the properties of proactive routing protocols and reactive routing protocols. Zone Routing Protocol (ZRP) is an example of a hybrid routing protocol.

3.1. **AODV routing protocol.** AODV is a reactive routing protocol that enables self-starting and multi-hop communication between mobile nodes in ad-hoc networks. It uses destination sequence numbers for loop-free routing. This destination sequence number is formed by the destination which is incorporated alongside any route information it sends to mentioning nodes. If two paths exist for the destination node, the largest sequence number path is selected. It consumes low bandwidth and memory because of its reactive approach. AODV starts route discovery in a request-response fashion. The source node broadcasts a Route Request (RREQ) message to all its one-hop neighbors for route discovery. Neighbor nodes rebroadcast this REEQ message until it reaches the destination. The destination node unicasts the response message called Route Reply (RREP) message along the reverse route of intermediate nodes until it reaches the source node. Route Error (RERR) message is broadcasted by the node which has lost its path to the next hop.

AODV responds reasonably to the topological changes, and the routing table is updated only of such nodes affected by these changes [15].

3.2. **DSDV routing protocol.** DSDV is a Bellman-Ford algorithm-based table-driven routing protocol. Pravin Bhagwat and Charles E. Perkins developed it in 1994 as a MANET routing protocol. All nodes in the network maintain their routing table that contains an entry for destination, required numbers of hops to reach the destination node, and sequence number. The routing table of DSDV has a sequence number that is used in avoiding routing loops. This sequence number is either even or odd based on the link availability. Each node uses either periodic updates or trigger updates methods for routing table updates. Trigger updates are used whenever a node receives a DSDV packet that causes routing table changes. As all route information is already available in DSDV, there is no need for route discovery, causing a lower delay. As in DSDV, all route information is kept in the routing table; if the topology is dynamic because of node speed and network size increase, DSDV consumes more bandwidth [16].

4. **Simulation Methodology.** To determine the performance of proactive and reactive routing protocol in the Indian city scenario, we have chosen open-source discrete event simulator network simulator NS-2.35 [17]. Simulation of wired and wireless network protocol and their functionality can be achieved in NS-2. A more realistic Jaipur city map has been imported from OpenStreetMap (OSM). OpenStreetMap is created by a network of mappers that contribute and keep up information about streets, trails, bistros, and railroad stations everywhere in the world. Simulation of Urban MObility (SUMO) [18] is used as a traffic simulator for generating realistic traffic scenarios. SUMO permits the displaying of multi-purpose traffic frameworks, including street vehicles, public vehicles, and walkers. Traffic files produced by SUMO are handed over to the NS-2.35 simulator. NS-2.35 processes these files and generates trace files. Lastly, we have used Perl scripts to draw results and performance analysis. The results graph is plotted by GNUPLOT. The simulation environment and setup used for performance evaluations of AODV and DSDV protocols are discussed in the following sub-sections.

4.1. **Simulation environment.** Authors have created the Jaipur city road traffic environment by importing the Jaipur map of 2210×1020 meters from OpenStreetMap as depicted in Figure 2. Network traffic is created by SUMO-0.32.0 python script osmwebwizard.py, and vehicle trips are created by randomtrips.py utility. Vehicle density is chosen between 10 to 50 with 5 through traffic factor. We have executed the entire simulation for 500 seconds. SUMO configuration file and NS-2 compatible trace file are created followed by the creation of NS-2 compatible network mobility files using traceexporter.py

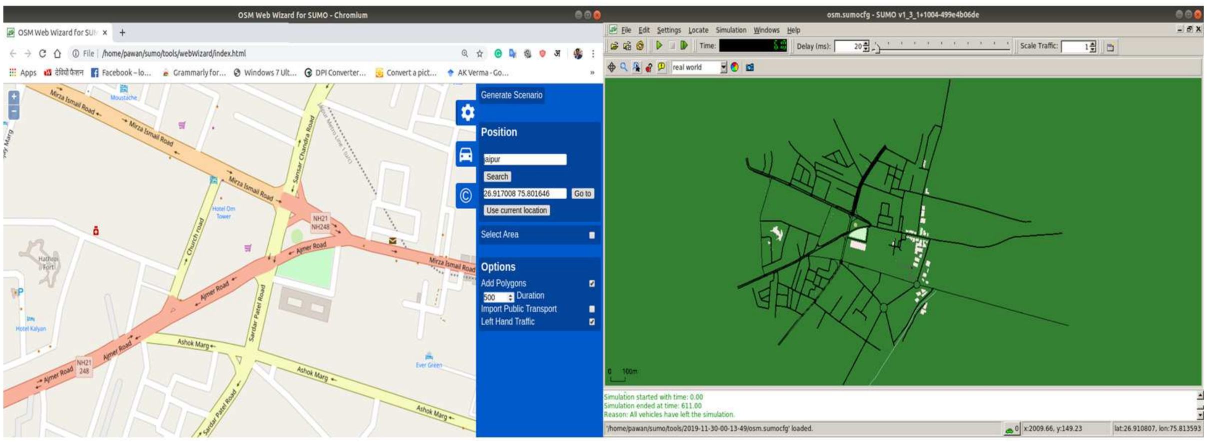

FIGURE 2. OSM and SUMO screenshots of Jaipur city

python utility. The generated NS-2 config.tcl is modified as per the simulation parameters mentioned in Table 1 that create different networking scenarios. UDP with CBR traffic is selected for data exchange between sources to destination vehicle. To investigate the impact of CBR packet size on AODV and DSDV protocols, we have chosen 1000 to 4000 bytes packet size of CBR traffic flows with a 2 Mbps data rate.

4.2. **Simulation setup.** Table 1 represents the simulation parameters used in our experiments for the comparative study of DSDV and AODV routing protocols in Indian traffic conditions. Ubuntu is selected as a platform for running OSM, SUMO, and NS-2.35 because of its wide support and zero cost in experimentation. Our experiments used a wireless channel using IEEE 802.11p standards with two rays ground propagation models, unidirectional antenna, LL layer, and drop tail priority queue.

TABLE 1. Simulation parameters

Parameters	**Values**
Network simulator	NS-2.35
Traffic simulator	SUMO-0.32.0
Scenario map	Jaipur city, INDIA from OSM
Channel data rate	3 Mbps
Radio propagation model	Two-ray Ground
MAC type	IEEE 802.11p
Antenna model	Omni-directional Antenna
Interface queue type	Drop Tail Priority Queue
Routing protocols	AODV and DSDV
Traffic type	UDP/CBR
Number of vehicles	10-50
Speed of vehicles	10-40 km/hr.
Communication range	250 meters
CBR packet size	1000-4000 bytes
Simulation area	2210 m × 1020 m
Number of road lanes	2
Trip type	Random Trips
Performance metrics	Throughput, PDR and AEED
Simulation time	500 sec

5. **Results and Discussion.** In this section, performance analysis of AODV and DSDV routing protocols for VANET is achieved by executing these protocols in NS-2.35 by creating accurate traffic simulation, as mentioned in Section 4. Files with .tcl extensions are executed as per the simulation parameters setting defined in Table 1. Different trace files and network animator files are generated on execution by NS-2.35. Three routing metrics, packet delivery ratio, throughput, and average end-to-end delay, were used for the comparative study on the Indian city environment.

5.1. **Throughput.** It is defined by the ratio of effectively delivered messages over a communication channel. It is measured in Kbps. Throughput can be calculated as

$$Throughput = \frac{Total\ number\ of\ received\ packets}{Simulation\ end\ time} \times Packet\ size \tag{1}$$

Figure 3 represents the throughput versus the number of vehicles and packet sizes for the AODV and DSDV protocols. To measure the impact of vehicular density on throughput, we vary the vehicle density from 10 to 50 vehicles. The vehicles have 250 meters communication range and generate CBR packets of 2000 bytes at the interval of

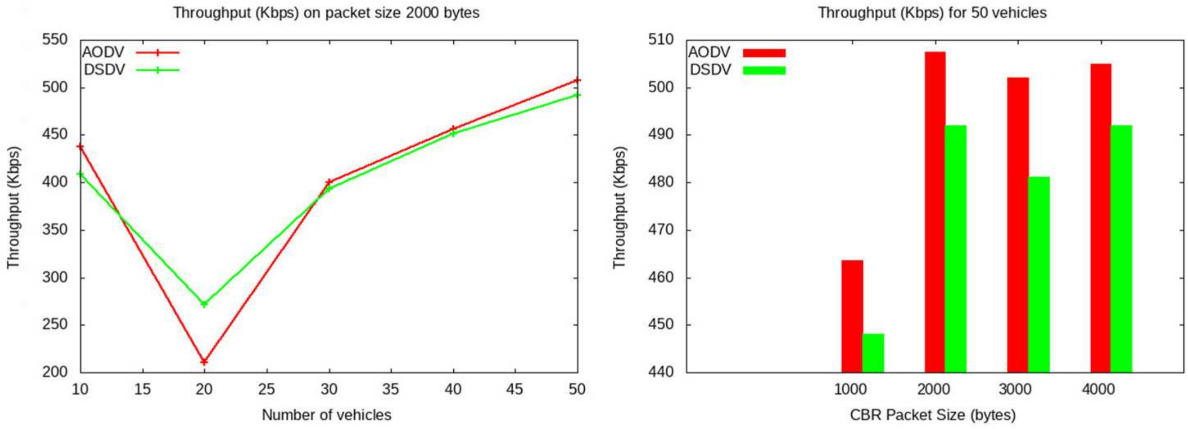

Figure 3. Throughput vs number of vehicles and CBR packet size

.2 seconds. To investigate the impact of packet size on the throughput for state-of-the-art protocols, packet size was varied from 1000 bytes to 4000 bytes with 50 vehicles. It is observed that the AODV shows the maximum throughput in most scenarios than the DSDV protocol when node density is greater than 30. DSDV has a higher throughput than AODV when node density and packet size are low, but its performance is degraded significantly in high density and bulky packet size.

5.2. **Packet Delivery Ratio (PDR).** PDR in this simulation is defined by the ratio of successfully received packets at the CBR sinks to packets transmitted by all the CBR sources. PDR is calculated in percentage and can be calculated as

$$PDR = \left(\sum Pkt_{Ri} \Big/ \sum Pkt_{Sj}\right) \times 100 \tag{2}$$

Here $\sum Pkt_{Ri}$ indicates the total number of packets received by sinks and $\sum Pkt_{Sj}$ indicates the total number of packets sent by all sources. It is observed from Figure 4 that as node density increases, AODV performs better because nodes become more stationary, leading to a more secure route from source to destination, while DSDV efficiency declined as the number of nodes increased as more packets drop because of connection breaks. DSDV protocol presents a high PDR than AODV in the sparse density of the vehicle. As packet size increases, AODV outperforms DSDV in terms of PDR. DSDV sends a periodic control message to the routers, which consumes more bandwidth and causes a decrement in the packet delivery ratio.

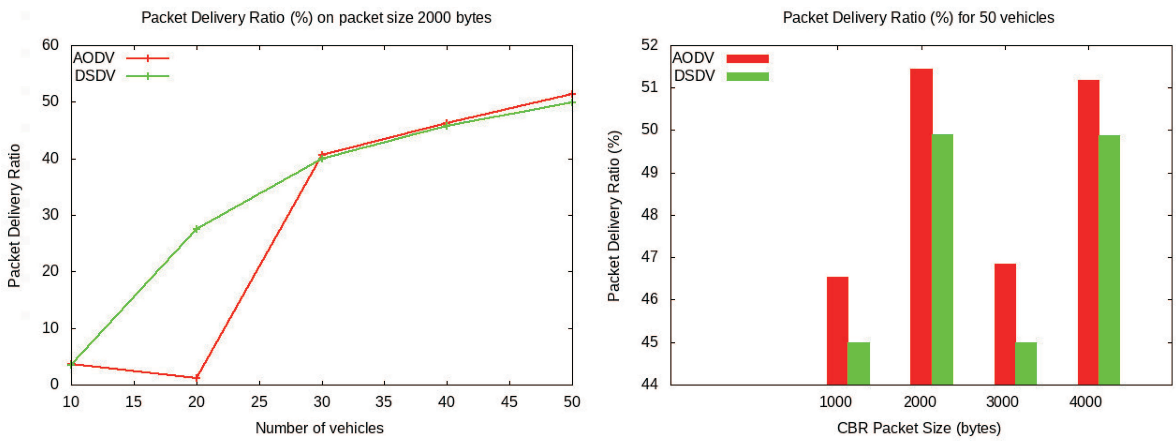

Figure 4. PDR vs number of vehicles and CBR packet size

5.3. **Average End-to-End Delay (AEED).** This metric provides the total waiting time in packet transmission by the application agent at the CBR source node until packet receipt by the application agent at the CBR sink node. Lower AEED represents a better protocol for VANET. The following equation can calculate AEED:

$$AEED = (Time_R - Time_S) \quad (3)$$

Here, $Time_R$ indicates the time at which the packet is received at the sink and $Time_S$ indicates the time the packet is transmitted from the source. It is measured in milliseconds (ms). Figure 5 shows that DSDV provides a lower end-to-end packet delay as compared to the AODV protocol. AODV did not produce much delay even the number of nodes, and packet size increased. DSDV performs better in all scenarios because route information to all destination nodes already exists.

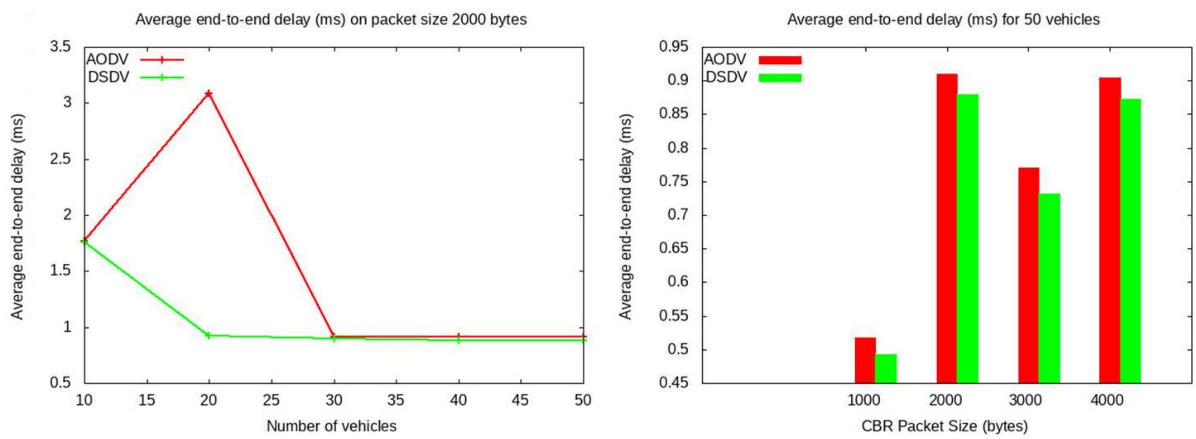

FIGURE 5. AEED vs number of vehicles and CBR packet size

6. **Conclusions.** Due to high mobility and rapid topological changes, designing a suitable routing protocol for VANET is difficult. All quality-of-service metrics cannot be satisfied by any protocol. This paper summarized the VANET communication architecture, topology-based VANET routing protocols, and VANET application areas. We evaluated AODV and DSDV protocol performances in Jaipur city for simulating metro city environments using NS-2.35, SUMO-0.32, and OSM. Our experiment shows that AODV is a better protocol in throughput and packet delivery ratio metrics than DSDV. Results show that in a sparse network, DSDV is well performed than its competitor AODV in average end-to-end delay metrics.

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