COMPARISON OF ROUTING PROTOCOLS IN VANET

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ABSTRACT

A Vehicular Ad-hoc Network (VANET) is a system of vehicles (i.e. nodes) that are being connected with each other by wireless technologies. Usually the nodes are moving with very high speeds and, thus, the topology is unpredictable and frequently changing. Such networks can be stand alone and making paths along vehicles or may be connected by an infrastructure internet.

In a vehicular ad hoc network (VANET) environment, an efficient ad hoc routing protocol plays a very important role to enhance the safety of passengers. In this project we present the simulation model of three mobile ad hoc routing protocols: Destination-Sequenced Distance-Vector protocol (DSDV), Dynamic Source Routing (DSR) and ad-hoc On Demand distance Vector (AODV). The performance of three protocols on the basis of varying number of vehicles (nodes) and compared with respect to average throughput, end to end delay, packet loss and packet delivery ratio during communication.

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1.INTRODUCTION

1.1 What is VANET?

VANETs are considered as a special type of MANETs, in which each node is a vehicle (i.e. car,bus,truck). This kind of networks have to face new challenges. They are characterized by very high node mobility and topology changing that depends by means of wireless technologies. These features make VANETs very prone to transmission errors, topology changes and intermittent connectivity. This is an effect of high moving speed of nodes and highly dynamic operating environments. So the main goals for VANETs are to achieve high packet delivery rates and low packet latency.

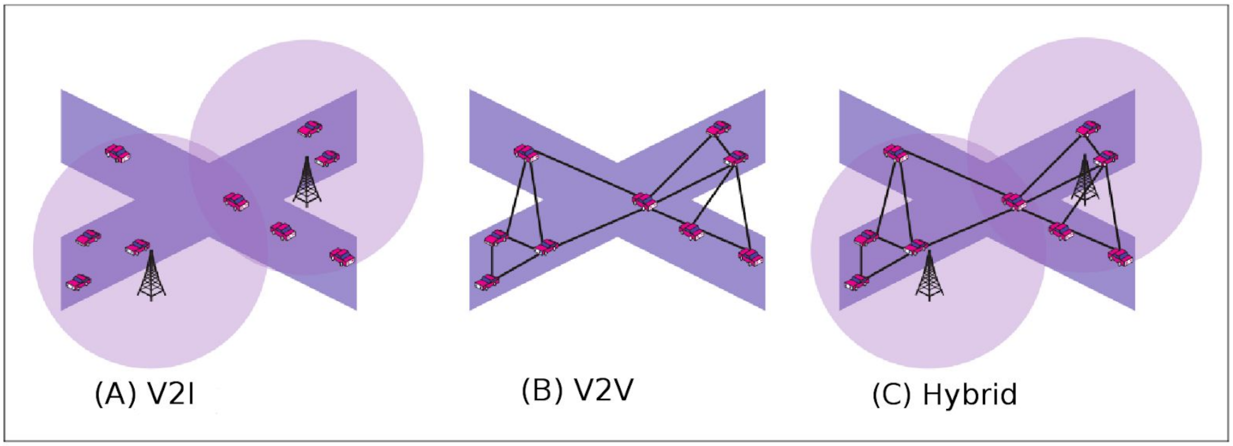
Despite of the difficult challenges VANETs represent an emerging wireless technology, allowing efficient communication among vehicles and fixed devices positioned along the street with a very promising area of safety, traffic control and user applications. Ongoing research is exploring novel protocol stacks and network architectures to efficiently afford these challenging issues.

The area of ad-hoc networks consists for many years and has a large variety of technologies (e.g. MANETs). Although VANET has some distinguishing feature which make it more challenging from other technologies being summarized as following.

- High dynamic topology: Since the high speeds of vehicles and the large area that its cover the topology is very frequently changing.
- Frequently disconnected network: The often topology changes has the result that a node is become frequently out of range of the networks. This problem is also caused by node density changing.
- Unlimited battery power and storage: Every node is a vehicle so the power of every device is being provided by fuels of the car.
- On board sensors: Nodes consists of sophisticated sensors which provide very useful information such as GPS which gives location informations.

1.1.1 Types of communication in VANETs

There are three possible types of communication that could be established within a VANET: Vehicle to Infrastructure (V2I), Vehicle to Vehicle (V2V) and a hybrid combination of them.



A. V2V

V2V is an ad-hoc network among vehicles (car, bus, track etc) which allow vehicles to send data to each other. Using V2V communication, a vehicle can detect the position and movement of other vehicles up to a quarter of a mile away. Vehicles being equipped with a simple antenna, a computer chip and GPS technology; they will know the position of other vehicles and will communicate directly with them. In this way vehicles could share informations about blind spots, car accidents and road condition. Thus vehicles can anticipate and react to dangerously driving situations informing drivers. If the driver does not respond to the alerts, the vehicle could act itself and stop to a safe point avoiding a collision.

B. V2I

Vehicle-to-infrastructure (V2I or v2i) is a communication model that allows vehicles to share information with the components that support a country's highway system. Such components include overhead RFID readers and cameras, traffic lights, lane markers, streetlights, signage and parking meters. V2I communication is typically wireless and bi-directional: data from infrastructure components can be delivered to the vehicle over an ad hoc network and vice versa. Similar to vehicle-to-vehicle (V2V) communication, V2I uses dedicated short range communication (DSRC) frequencies to transfer data.

C. HYBRID ARCHITECTURE

Hybrid architecture consists of both infrastructure networks and ad-hoc networks. That means that vehicles have the ability to make a connection and exchange data and informations with a roadside base (access point) or vehicle which also might be connected with other vehicles or bases. In this way VANET could take the benefits from both V2V and V2I.

1.2 Routing Protocols

Because of the high mobility of nodes into a VANET system to design a routing protocol able to compute and maintain efficiently routing paths among vehicles, represents nowadays a challenging research issue. So far several routing protocols have been developed, some of them have been obtained, adapted and improved from algorithms that proposed in the past for MANETs.

These routing protocols are divided into two major classes based on the underlying routing information update mechanism employed, reactive (on-demand) or proactive (table-driven). Destination Sequenced Distance-Vector protocol (DSDV) is selected as an example for table-driven protocols, while both Dynamic Source Routing (DSR) and Ad-hoc On-Demand distance Vector (AODV) protocol are selected as examples for on-demand protocols.

A. DSDV

DSDV is based on Bellman-Ford algorithm which can effectively solve routing loop problem [9]. Each node has a routing table, which contains the shortest path to every other node in the network. Each entry in the routing table contains a sequence number. The number is generated by the destination. If a node receives new information, it consults the routing table and uses the latest sequence number to forward. If the sequence number is the same as the already one existed the table, the route with the better metric is used. Stale entries are deleted by regular update of its routing tables. DSDV is quite suitable for creating a small-scale ad hoc network. However, it is not suitable for highly dynamic networks

B. DSR

DSR uses source routing instead of hop-by-hop packet routing in comparison with DSDV, and has two major phases which are route discovery and route maintenance [10]. Route discovery is used to set up a route from source node to destination one by sending Route Request packet in the source node. If a node in the path moves away and breaks wireless communication, route maintenance will rebuild a route from source node to destination one by sending RouteError packet in the node adjacent to broken link. Each data packet carries corresponding routing information. Thus, it eliminates the need to periodically flood the network with table update messages which are required in a table-driven approach. However, DSR does not locally repair a broken link. The connection setup delay is higher than those of table-driven protocols.

C. AODV

AODV is very similar to DSR [11]. It set up a route to the destination by sending a RouteRequest message. The source node and the intermediate nodes store the next hop information corresponding to each flow for data packet transmission. The major difference between AODV and other reactive routing protocols is that it uses a destination sequence number (Des SeqNum) to find the latest route to the destination. A node updates its path destination only if the DesSeqNum of the current packet received is greater than the last Des SeqNum stored at the node. However, AODV requires more time to set up a connection than some other approaches.

1.3 About The Project

In this project, we compared three mobile ad hoc routing protocols Destination Sequenced Distance Vector protocol (DSDV), Dynamic Source Routing (DSR) and ad-hoc On-Demand Distance Vector (AODV) on the Indian roadways. For this, we selected the Kathipara Bridge of Chennai to create a simulated environment of that area in SUMO. The map is shown in Fig. 1. We analyzed the above protocols on the basis of various parameter which are - average throughput, end to end delay, packet loss and packet delivery ratio during communication by varying the vehicular traffic in the area. It helped us in analyzing the best protocol in Indian scenario.

Fig. 1 : Kathipara Bridge, Chennai

2. SOFTWARE USED

2.1 SUMO (Software for Urban MObility)

SUMO is an open source, highly portable, microscopic road traffic simulation package designed to handle large road networks. It is mainly developed by employees of the Institute of Transportation Systems at the German Aerospace Center. SUMO is licensed under the GPL [37]. The most significant features are being listed above.

- SUMO includes all applications needed to prepare and perform a traffic simulation (network and routes import, DUA, simulation).
- Simulations has:
  – space-continuous and time-discrete vehicle movement,
  – different vehicle types,
  – multi-lane streets with lane changing,
  – different right-of-way rules, traffic lights,
  – a fast openGL graphical user interface,
  – manages networks with several 10.000 edges (streets),
  – fast execution speed (up to 100.000 vehicle updates/s on a 1GHz machine),
  – network-wide, edge-based, vehicle-based, and detector-based outputs,
- Network import is possible from other tools:
  – imports VISUM, Vissim, Shapefiles, OSM, RoboCup, MATsim, openDRIVE, and XML-Descriptions,
  – missing values are determined via heuristics.
- Routing facilities:
  – microscopic routes - each vehicle has an own one,
  – different Dynamic algorithms.
- High portability:
  – only standard c++ and portable libraries are used,
  – packages for MS Windows and main Linux distributions exist.
- Open source(GPL).
- Its available for below operations systems:
  – MS Windows
  – Linux
  – Mac OS

2.2 NS 2.34 (Network Simulator 2.34)

Network Simulator 2 (NS2) is a event based discrete network scenario simulation software for various protocols in Internet systems and targeted primarily for research and educational use. NS2 is a research community accepted network simulator. Comparing with other well-known network simulation tools, NS2 has several advantages.

- The first & foremost one is, its code is open source, research community accepted and openness facilitates to modify the existing mechanism as per our requirements.
- The second one is its extendibility and stability. NS2 can support large simulation scenario where the number of nodes can be up to 20000, making the simulation results more realistic.

3. METHODOLOGY

3.1 Creating the scenario in SUMO

First we need to download the map of Kathipara Bridge from Openstreetmap available online. To create a simulate the map of Kathipara bridge in SUMO (Simulation of Urban MObility), the following steps were taken -

- Node (.nod.xml) and Edge file (.edg.xml) is to be created for road map.
- Transformed into a Network file(net.xml) with the help of NETCONVERT
- Command of NETCONVERT

  netconvert --node-files=MyNodes.nod.xml –edge files=MyEdges.edg.xml \ --output-file=MySUMONet.net.xml
- Now, Create Route file (rou.xml) to define the path followed by the vehicles to reach from one place to the destination.
- At last network file and route files are combined to make the configuration file.

3.2 Working on NS 2.34

Now we have simulated the scenario in SUMO. So now will move on to NS 2.34 to perform the same simulation as it allows us to establish communication between the vehicles using the protocols as mentioned earlier. We did simulation in SUMO in order to generate a real life like situation and generate vehicles with random mobility. We now use the same movements which were saved in a file to simulate in NS 2.34

The NS 2.34 is chosen because it is an open source simulator and event driven based simulation environment used both C++ and tcl scripts. For data transmission in MAC layer, protocol IEEE 802.11. The following parameter have been set on our network -

Parameters	Value Used
Simulator	NS 2.34
Simulation Time	150 sec
Antenna Model	Omni Directional Antenna
Radio Propagation Model	Two Ray Ground

Queue Type	Priority Queue
Routing Protocols	AODV, DSDV & DSR
Area	3000*4000
No. of Vehicles	10, 20, 30, 40, 50, 60, 70

3.3 Analyzing the results through graphs

Now that we are done with our simulation which we can confirm it through the network animator, we will analyze the results obtained. The results from the above simulation is stored as a trace file which contains the information regarding the packets of information shared while communication.

We will now analyze that trace file based on the following performance metric -

1. **Packet Delivery Ratio :** The ratio of data packets received by the destination node to the data packet sent by the source node is defined as the packet delivery ratio.

   PDR = (Packets received/Packets sent by source node)*100 %

2. **Average Throughput :** This is the measure of the rate at which data being successfully delivered over a communication channel. It is usually measured in bits per second (kilobits/sec or kbps).

   Throughput = (Number of received packets * Packet size)/Total simulation time

3. **Average end to end delay :** When a data packet is sent by the source node to the destination, then the time taken by the data packet to reach the destination from source node is known as end to end delay. The average end to end delay for all successfully delivered packets is calculated by taking its mean value.

End to End Delay = (∑(Reception Time - Sending Time)/Number of Packets successfully delivered) * 100

4. **Packet Loss :** This metrics measure the number of data packets created by the source node but never been reached to the destination node.

Packet Loss = ((Number of Sent Packets - Number of Received Packets) /Number of Sent Packets) * 100 %

Now we defined our metrics, we need to calculate it for each protocol by varying the vehicular traffic. In this way, we can plot the graph for each of the protocol and do a comparative analysis.

4. Results

Below are the results that we get for each parameter after simulation of the map of the bridge in Kathipara in NS2.

4.1 Packet Delivery Ratio

We analyzed the packet delivery ratio for each of the routing protocol - AODV, DSDV and DSR by varying the traffic that is the number of vehicles on the roads. From our analysis we have the following results -

Number of Vehicles	AODV	DSDV	DSR
10	97.22	98.76	99.16
20	96.61	98.64	44.44
30	95.08	97.91	43.59
40	96.62	98.78	76.33
50	95.78	98.37	37.29
60	93.89	97.53	27.45
70	93.70	96.32	26.98

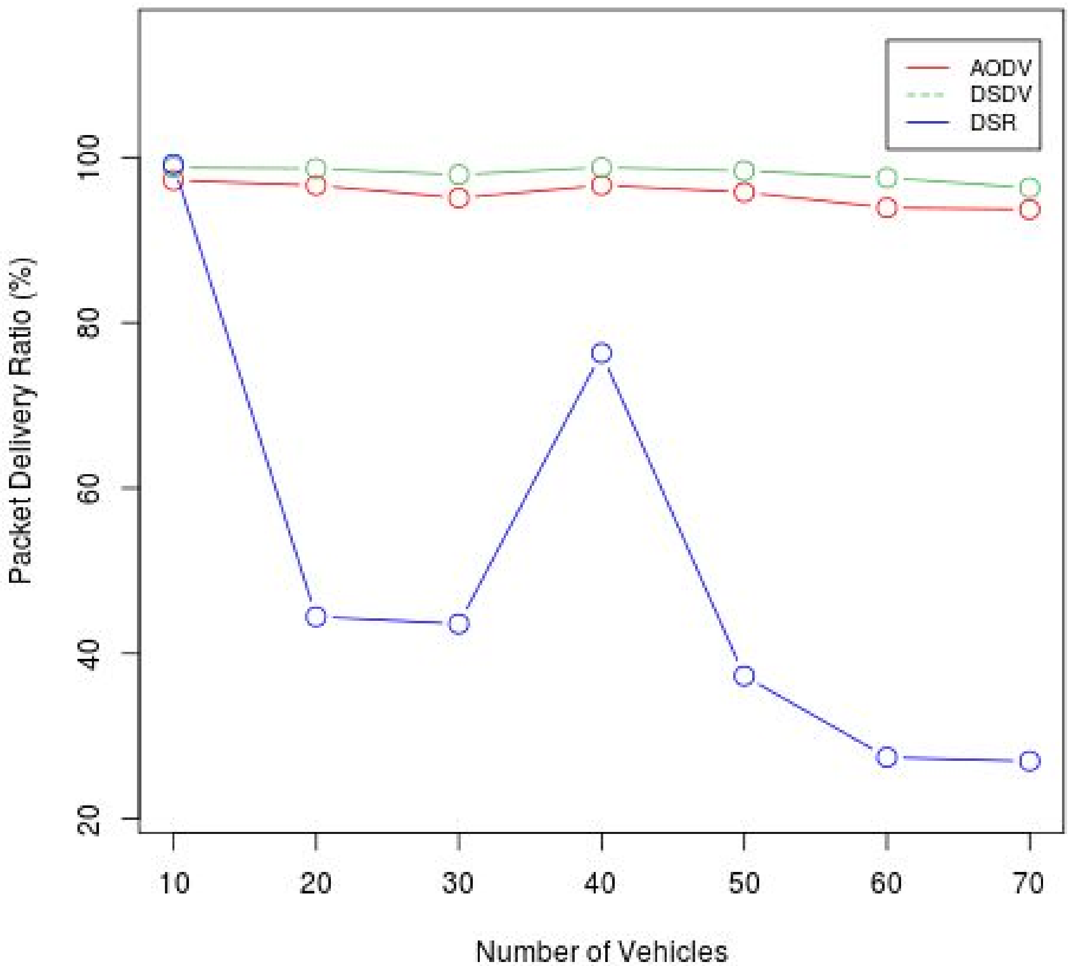


Fig. 2: Packet delivery ratio (%)

From the graph in Fig. 1, it can be clearly observed that the packet delivery ratio of AODV and DSDV protocols is much higher (between 95 to 100) than that of DSR. This shows that the two protocols are efficient for communication among the vehicles. But we also observe that in low traffic DSR also has a good ratio.

4.2 Average Throughput (kbps)

Now we analyzed the average throughput which is in kilobits per second for each of the protocols by varying the vehicular traffic which will help us to determine which protocol will help us to determine which protocol will be efficient in communication. From our simulation we have the following results -

Number of Vehicles	AODV	DSDV	DSR
10	192.45	507.41	477.90
20	401.45	592.19	5.01
30	467.73	576.06	6.56
40	702.62	603.43	81.87
50	561.98	770.58	7.53
60	422.21	551.80	5.80
70	400.50	562.69	5.49

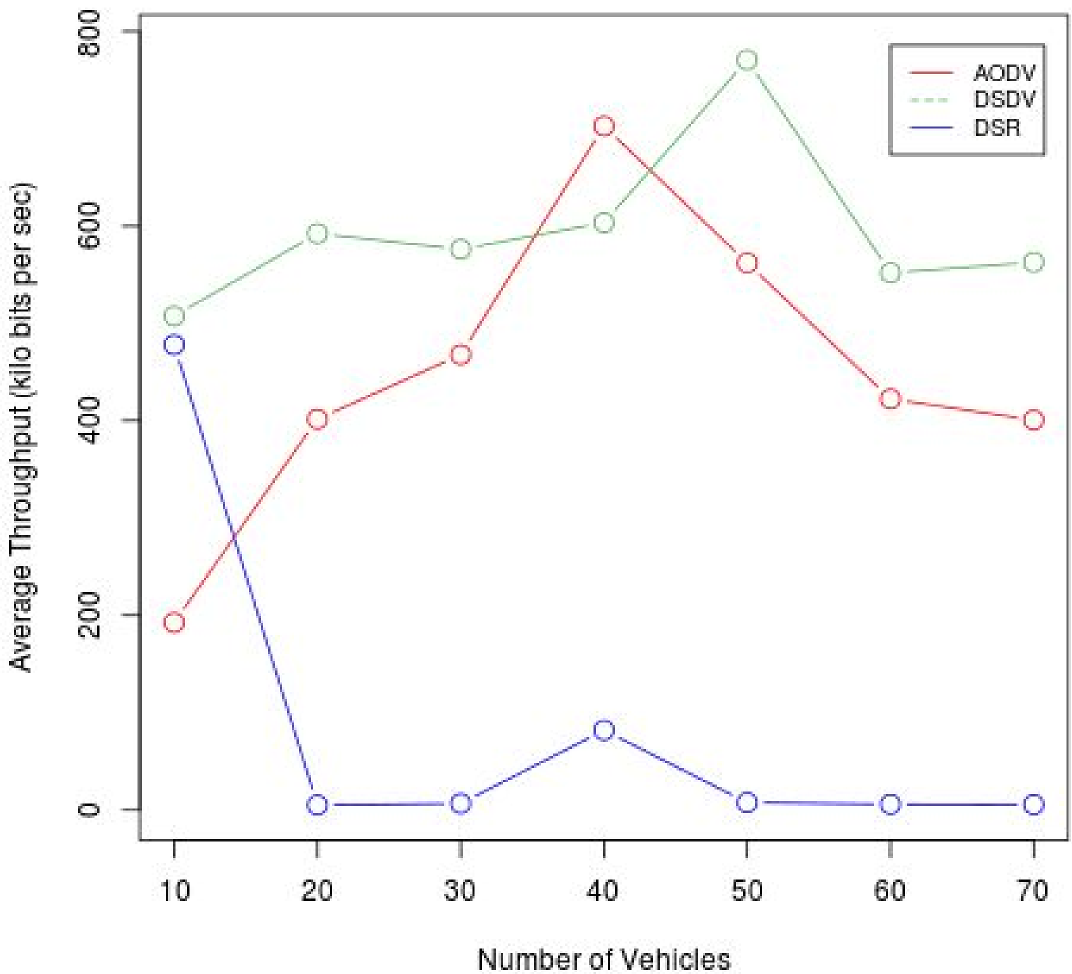


Fig. 3: Average throughput (kbps)

From Fig. 2, it is clear that the average throughput for AODV and DSDV are mostly higher than that of DSR. We also observe that the increase in the throughput for all the three protocols when the traffic is moderate which seems like a common trend for the protocols. The throughput for DSR seems to be high initially but is decreasing with increasing traffic.

4.3 End to End delay (milliseconds)

Our third parameter is also a game changer as it has a very keen role to play in determine which protocol is faster in communication. We analyze all the protocols based on the parameter and varying the traffic and we get the following results -

Number of Vehicles	AODV	DSDV	DSR
10	132.399	114.245	157.134
20	364.747	243.297	11.6301
30	377.703	286.514	28.6103
40	216.224	147.665	108.792
50	619.489	312.593	20.1062
60	566.704	328.919	9.41084
70	940.062	704.174	50.4192

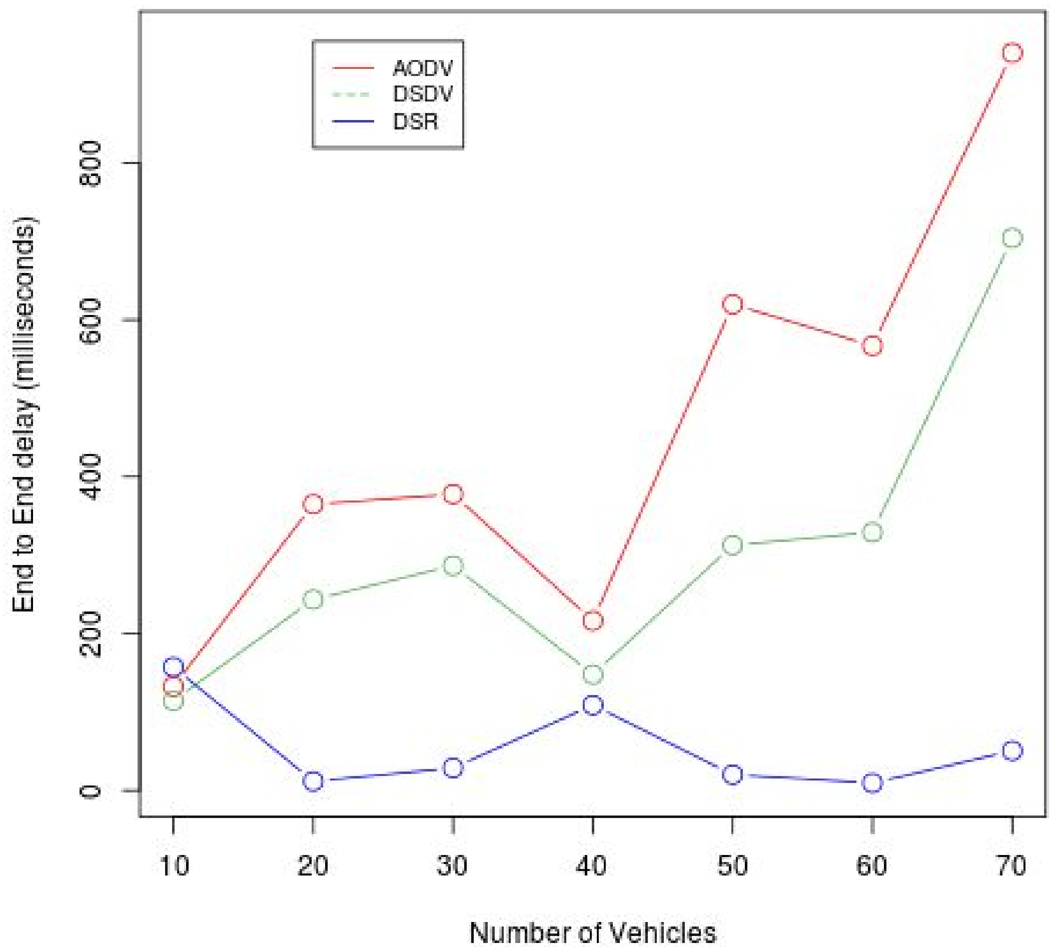


Fig. 4: End to end delay (milliseconds)

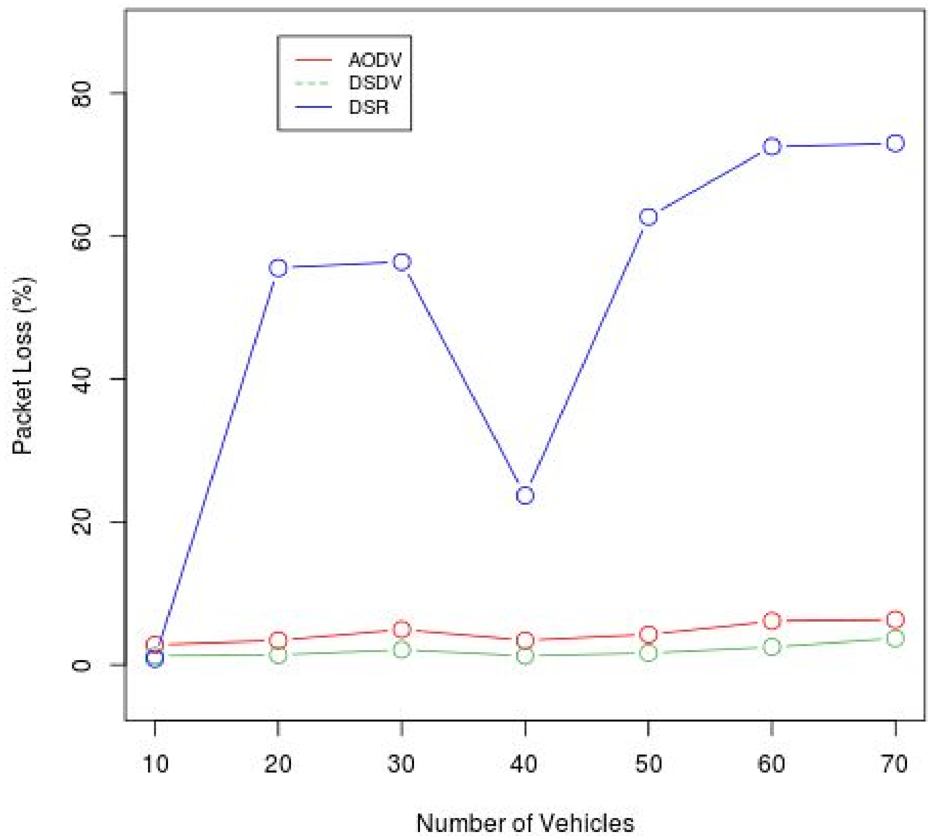
From the Fig. 3, it is evident that the delay for the DSR protocols seems to be the lowest as compared to other. In fact, the delay for the other two protocols - AODV and DSDV is increasing with increase in the vehicular traffic. This might make it difficult for the vehicles to communicate using these two protocols in heavy traffic.

4.4 Packet Loss (%)

Our fourth parameter is crucial in determining which protocols efficiently delivers all the message packets. This parameter might seem to be similar to the packet delivery ratio but it rather points out more loss of the protocols, so might prove to be good in analyzing. Our results are as follows -

Number of Vehicles	AODV	DSDV	DSR
10	2.78	1.24	0.84
20	3.39	1.36	55.56
30	4.92	2.09	56.41
40	3.38	1.22	23.67
50	4.22	1.63	62.71
60	6.11	2.47	72.55
70	6.30	3.68	73.02

Fig. 5: Packet loss (%)



We observe from Fig. 4 that the percentage of loss of packets of information is very low for the protocols AODV and DSDV where the loss for DSR is much higher as compared and is increasing with the increase in the vehicular traffic. In case of the AODV and DSDV protocols, the loss is quite constant.

5. Conclusion

Topology based routing protocols are widely used in vehicular communication. In this project, we have analyzed AODV, DSDV and DSR protocols based on different performance metrics as mentioned in Section 4.3 by varying the vehicular traffic for our Indian road. We chose area of Kathipara bridge and the simulation was successfully done on SUMO(Simulation of Urban MObility) with NS(Network Simulator) 2.34 for the selected region. The simulation results show that the end to end delays for the DSR was very low as compared to other two whereas in case of other metrics the DSR seemed to show very poor performance. So it seems that the DSR was fast enough in communication but seemed to lack in efficiency. Although the end to end delay for DSDV and AODV seemed to quite high, the two protocols still have very good efficiency as compared to the DSR. Among the two, the DSDV seemed to have more efficiency most of the time as compared to AODV.

This brings us to the conclusion that the DSDV had a very good throughput and Packet delivery ratio as compared to the other two at different traffic levels for the chosen area. So, it seems to be the efficient protocol for communication with a drawback that the end to end delay seemed to quite high and increasing with increase in traffic. The other option which is the DSR protocol might seem to be a good option to have a fast communication but compromising with the efficiency of communication. The AODV protocol stands in between the both. So depending on the significance of parameters in particular scenario, specific routing protocol can be selected.

6. Future Prospects

Recent developments in the field of trafficking have opened a new dimension for the application of VANET. The goal of the project completed can find uses in different fields and in near future we will to explore a new ourselves. These goals are as follows -

1. Security - If implemented successfully the security of vehicles can be assured using VANET.
2. Traffic Monitoring - Traffic can be monitored in a much efficient way using VANET.

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