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Performance Analysis of Cluster Based Protocols in VANET

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ABSTRACT

Clustering is a technique used in network routing to enhance the performance and conserve the network sources. This paper presents analysis between cluster-based routing protocols for VANET in urban scenario. The simulation results allow us to reach a conclusion as to which protocol among AODV, DSDV, and GPSR can be better implemented on the basis of Packet Delivery Ratio, Packet Delay, Frame Collision Rate and Signaling Rate in our scenario.

Keywords: - Vanet, INET, Veins, Sumo, Routing protocol, Delay, Ad-hoc network, AODV, DSDV, GPSR.

I. INTRODUCTION

With the development of vehicles and mobile Ad Hoc network technology, the Vehicle Ad-hoc Network (VANET) has become an emerging field of study. Many potentially useful applications have been envisioned in vehicular networks [8] [9]. It is a challenging problem for searching and maintaining an effective route for transporting some data information. Some modern vehicular applications that aim at improving the users' safety e.g. emergency remote control [10] require a video data throughput of up to 4 Mbit/s and a control packet delay in the order of milliseconds. Among all the proposed routing protocols, we chose to compare Ad-hoc Online Distance Vector (AODV), Destination- Sequenced Distance-Vector Routing (DSDV), and Greedy Perimeter Stateless Routing (GPSR) because they are the best-known protocols belonging to their own categories: reactive, proactive table-driven and proactive position-based protocols, respectively [11].

II. LEVEL OFCOMMUNICATION

A. RSU TO RSU

Each VANET node is typically attached to an On-Board communication Unit (OBU) which stays in the duty of providing communication with other nodes and/or Road-Side communication Unites (RSUs)Maintaining the Integrity of the Specifications

RSU-RSU (infrastructure level communications). The first allows the vehicles to locally communicate in an ad-hoc manner and forward network traffic to each other. The second provides communication between the vehicles and RSUs to report network data such as lane traffic, road safety and/or congestionstatus.

III. HARDWARE/SOFTWARE

OMNeT++ (Objective Modular Network Testbed in C++) is a modular, component-based C++ simulation library and framework, primarily for building network simulators.

OMNeT++ can be used for free for non- commercial simulations like at academic institutions and for teaching. OMNEST is an extended version of OMNeT++ for commercial use cases.OMNeT++ itself is a simulation framework without models for network protocols like IP or HTTP. The main computer network simulation models are available in several external frameworks.

A. INET

INET is built around the concept of modules that communicate by message passing. Agents and network protocols are represented by components, which can be freely combined to form hosts, routers, switches, and other networking devices. New components can be programmed by the user, and existing components have been written so that they are easy to understand and modify.

INET benefits from the infrastructure provided by OMNeT++. Beyond making use of the services provided by the OMNeT++ simulation kernel and library (component model, parameterization, result recording, etc.), this also means that models may be developed, assembled, parameterized, run, and their results evaluated from the comfort of the OMNeT++ Simulation IDE, or from the commandline.

B. Veins

Veins, an open-source model library for (and a toolbox around) OMNeT++, which supports researchers conducting simulations involving communicating road vehicles—either as the main focus of a study or as a component. Veins already includes a full stack of simulation models for investigating cars and infrastructure communicating via IEEE 802.11p based technologies in simulations of Vehicular Ad Hoc Networks (VANETs) and Intelligent Transportation Systems (ITS). Thanks to its modularity, though, it can equally well be used as the basis for modeling other mobile nodes(like bikes or pedestrians) and communication technologies (from mobile broadband to visible light). Serving as the basis for hundreds of publications and university courses since its beginnings in the year 2006, today Veins is both one of the most mature and established tools in this domain.

Working Process of VEINS:

The network simulation in Veins is performed by OMNeT++ along with the physical layer modeling.
Both the simulators are bi-directional that can be coupled.
Simulations are then performed on the basis of domain specific models for vehicular networking.
There is WDM deployment in the local exchange of networks. There is universal personal networking.
Furthermore, there are optical networking trends and evolution.
Performance of probabilistic caching and cache replacement policies for Content-Centric Networks.
Green Networking With Packet Processing Engines: Modeling and Optimization.

Veins answer the question why we still don't know how to simulate networks in contemporary fashion.
It is a compound document framework for multimedia networking and has Information-centric networks for parallel processing in data center.

C. SUMO

SUMO is a free and open source traffic simulation suite. It is available since 2001 and allows modeling of intermodal traffic systems - including road vehicles, public transport and pedestrians. Included with SUMO is a wealth of supporting tools which automate core tasks for the creation, the execution and evaluation of traffic simulations, such as network import, route calculations, and visualization and emission calculation. OSM is used to generate a scenario of Amravati city area by selection various parameters. The view of selected Shegaon Square from Amravati can be seen in the figure 1 below as can be viewed on the Sumo-GUI.

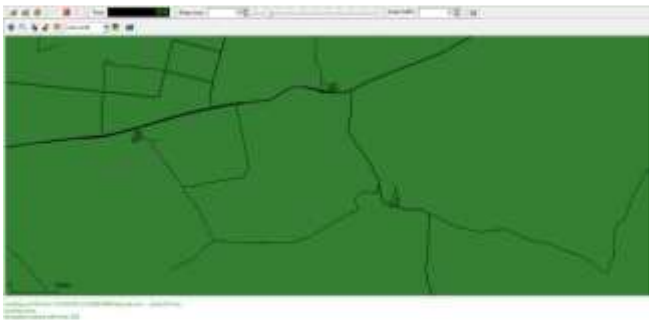

Figure 1: View of Selected Shegaon Square in Sumo simulator

IV. CLUSTER BASED ROUTINGPROTOCOL

Due to the random node mobility, a major challenge is how to route data packets in anurban areas and similar scenarios of communication, particularly when the source and the destination are out of the DSRC transmission range. Maintaining a routing table, as in proactive methods, is not an optimal solution, and repetitive path finding before each packet delivery, as in reactive routing, can also be exhaustive. Therefore, specific routing solutions are needed. A routing strategy only based on the location information of the nodes can satisfy the requirements of VANETs in anurban area.

4.1 Routing within aCluster

When a cluster member needs to establish a link, it sends a request to the CH. The CH after receiving the request verifies whether the intended vehicle is a member of the cluster or not. In case both vehicles are in the same cluster, the CH finds from its storage the location information of the source and the destination vehicle, then starts the process of best route selection depending on the destination and source locations.

For better understanding of the proposed inter-cluster routing protocol, we assume five vehicles, as follows. V1 is the source vehicle located at the coordinates (xV1, yV1).
Both V2 and V3 are two vehicles in between the source and the destination with (xV2, yV2) and (xV3, yV3) coordinates, respectively. V4 is the destination vehicle located at (xV4, yV4) coordinates, as shown in Figure 2.

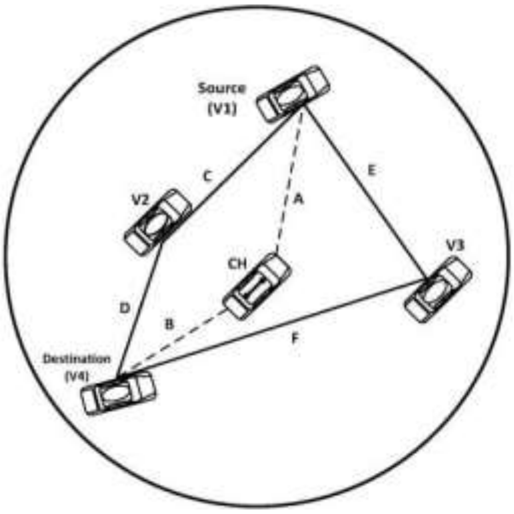

Figure 2. Routing within a cluster.

The CH selects the best route according to:

$L \geq \sqrt{(xi-xj)^2+(yi-yj)^2}$——————————————(1)

$A \geq \sqrt{(xch-xV1)^2+(ych-yV1)^2}$——————————(2)

$B \geq \sqrt{(xch-xV4)^2+(ych-yV4)^2}$——————————(3)

$C \geq \sqrt{(xV1-xV2)^2+(yV1-yV2)^2}$——————————(4)

$D \geq \sqrt{xV2-xV4)^2+(yV2-yV4)^2}$——————————(5)

$E \geq \sqrt{(xV1-xV3)^2+(yV1-yV3)^2}$——————————(6)

$F \geq \sqrt{(xV3-xV4)^2+(yV3-yV4)^2}$——————————(7)

If C + D ≤ A + B, hence, the route C, D is the best one and the next hop is V2. The CH notifies V1 about the best route, which decreases the risk and burden on the CH.
If A + B < C + D, this means that the best route will be through the CH, which will forward the packet to V4. That is to say, besides being responsible for the route selection, the CH may also participate in the packet forwarding process. The route E, F will be stored as a backup. The overall procedure flowchart is described in Figure 3.

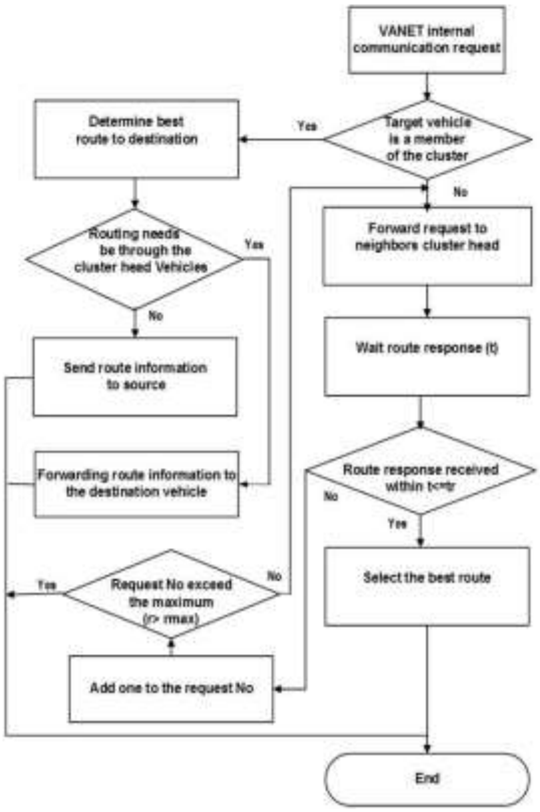

Figure 3. Routing Algorithm within cluster.

4.2 Routing betweenClusters

When the CH does not find the needed information in its internal storage, it requests the closest CHs for the destination information and waits for a routing response. If the waiting time exceeds the threshold tr and the route response has not yet been received, re-request message (*RREQ*) is resent. If the retransmission exceeds the maximum retransmission limit ($rmax$), the route search process is terminated. To reduce network congestion, not all of the neighboring CHs receiving *RREQ* will respond. Only those located on the route towards the destination having the ability to serve will participate in the routing process. As shown in Figure 4, only *CH*1 and *CH*2 participate in the routing process.

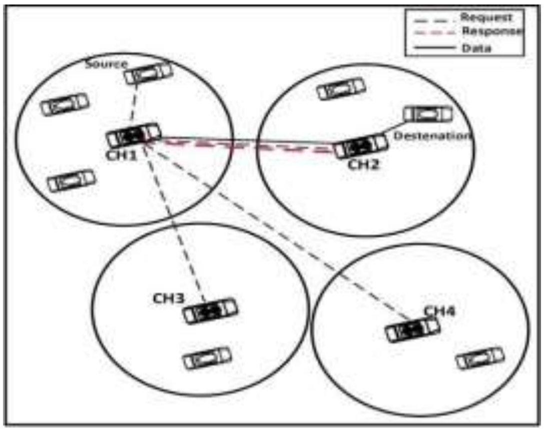

Figure 4.Routing within Cluster.

1. If the CH receives more than one route response, then it chooses the vehicle with the fewest numbers of routing hops and the minimum distance to the destination and adds its own msg to the (REEP msg) message; then, it forwards this message to the previous hop CH vehicle at the same time, saving other routes as backups. If the routing requestfails, probably due to the destination cluster, which is far away from the source cluster, and the routing communication request cannot be established through the VANET or through neighbor vehicles, the CH may establish a connection via satellite or mobile communication.

2. In some situations and according to the CHE process, the CH may have no satellite or mobile equipment to communicate with the far away CHs; in this case, the CH searches for one of its cluster members, which is equipped with satellite or mobile communication, to forward the request to the neighboringCHs.

3. If still not be able to establish the connection and routing through satellite or mobile communication, then it sends the notification REER to the source vehicle, indicating routing failure. The flowchart of the procedure of routing between vehicles located in different clusters is shown in Figure 5.

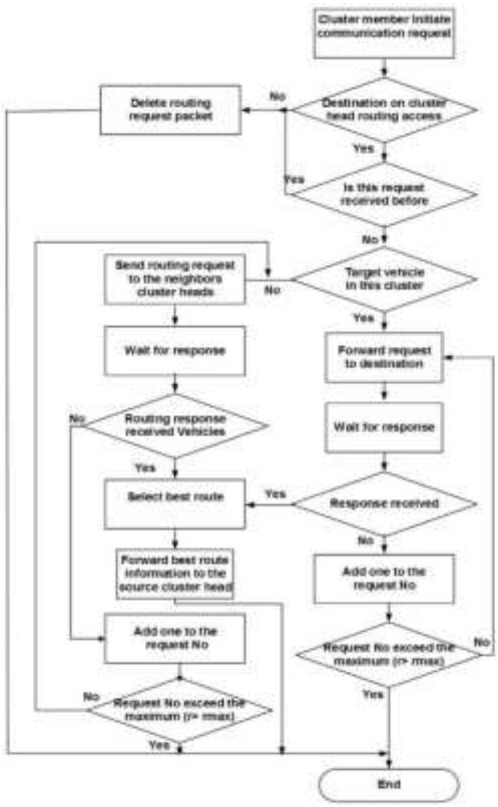

Figure 5. Routing algorithm for public networks and between clusters.

4.3 Cluster Member's Communication with thePublic Networks

In normal situations, only vehicle types V_m, V_S and V_{ms} can communicate with the outside networks. Vehicles always prefer using the VANET, but if the destination is out of the VANET coverage or they need to communicate with public networks and the destination is unreachable through the multi-hop VANET, in such cases, the source CH firstly searches its cluster members to find a member that is equipped with an appropriate communication link to communicate with the public network. If no cluster members are equipped with suitable equipment to communicate with the public network, then it forwards the request to the neighboring CH, which is equipped with the appropriate communication link, as shown in Figure 6.

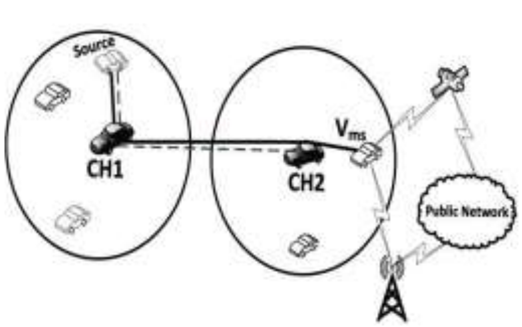

Figure 6. Communication to the public network using cluster member type Vms.

V. ROUTING PROTOCOLS

1. AD HOC ON-DEMAND DISTANCE VECTOR (AODV) ROUTINGPROTOCOL

The AODV routing protocol is a reactive routing protocol. A reactive routing hunts for routes when data needs to be sent by a node. Hence, routes are formed when needed. The AODV routing protocol consists of four control packets: hello messages, route replies (RREPs), route error messages (RERRs), and route requests (RREQs). These control packets are used in two protocol mechanisms, route maintenance and route discovery. All nodes in the AODV protocol maintain a routing table to store

2. Greedy Perimeter Stateless Routing(GPSR)

GPSR is a geographical routing protocol. Such protocols utilize position-based routing, where a node must know where its immediate neighbor is located. GPSR routing protocols use periodic beaconing to maintain updated geographical locationinformation of neighboring nodes within their transmission range. Greedy forwarding decisions are made by GPSR with the information of the router's instant neighbors in the network topology. When a packet reaches where greedy forwarding is not possible, the packet is forwarded around the perimeter of the region, keeping status information of local topology. GPSR scales best than the shortest path and ad hoc routing protocols as the number of network destinations nodes grows.

3. Destination-Sequenced Distance-Vector Routing(DSDV) Operation—DSDV [4] is a proactive table-driven routing algorithm for MANETs. Each mobile node periodically broadcasts information about viable routes to reach every other destination node in the network to their one-hop neighbors. In particular, the distributed information is a set of route entries, each of them associated with the distance in number of hops (or any other metric) between the sender and the route destination, accompanied by a sequence number. This data structure is referred to as the distance vector (DV). The sequence number is needed to maintain only the freshest route entry received by a node, and to guarantee that the computed routes are loop-free.

VI . METHODOLOGY

We performed the simulations of various protocols on scenario generated for Shegaon Square, Amravati, Maharashtra, India. We computed our results for different vehicular densities by fixing the maximum vehicular speed and topology.—our scenario features a single data flow from the data-source vehicle to the data-destination vehicle, respectively located at the top-left and bottom-right corners of the simulation scenario. The implementations of mentioned protocols are based on INET library. The vehicular mobility was simulated using SUMO [1], and the protocols were simulated with OMNeT++ [3]. These two tools communicated through a TraCI interface wrapped by Veins INET [2]. The below table contains the parameters taken into consideration while simulating the three protocols.

Parameter	Value
Protocols	AODV, DSDV, GPSR
Number of vehicles	10-200
Simulation Time	600 s
Traffic	CBR
Amravati Grid	600m x 600m
Vehicular density	20-100 vehicles/km^2
Vehicle speed	30-50 km/hr
Bitrate	2 Mbps
MAC Layer protocol	IEEE 802.11p
Packet Interval	12 ms
Packet Size	1000

VII. IMPLEMENTATION

Figure 7: Zoomed in view of Shegaon square, Amravati,

India in Sumo-GUI.

Route Maintenance: [7] Fig 7 shows the zoomed in area of Shegaon square taken into consideration.Due to vehicle's movement, the established route may be lost. Consequently, the communication will temporarily disconnect. At the same time, the vehicle will store the destination routing information for a while and try to resend the request. If it succeeds in sending a new route request to the intended destination, it means that the route has been recovered. If it fails to send the request, then it will search its backup routing information and try to use one of the best backup routes. If it fails to send the message, it will start a new route finding procedure.

The performance of the AODV is evaluated against DSDV, and GPSR in terms of Frame collision versus time, packet delivery ratio (PDR),average end-to-end delay (AD) and Signaling Rate. The PDR isdefined as the percentage of packets that is successfully received by the destination nodes to the packets sent by source nodes and can be calculated according to Equation (8).

$$\text{Packet Delivery Ratio} = \frac{\Sigma(\text{Total packets received by all destination nodes})}{\Sigma(\text{Total packets send by all source node})} \quad (8)$$

D is defined as the average time between a packet being sent and being received and can be calculated according to Equation (9)

D = (1/n) n Σi=1(Tri - Tsi) * 1000 [ms]----------------- (9)

Where

D = Average E2E Delay i = packet identifier

Tri = Reception time Tsi = Send time

n = Number of packets successfully delivered

Packet Loss(PL) is the ratio of the number of packets that never reached the destination to the number of packets originated by the source. Mathematically it can be shown as equation (10).

PL=(nSentPackets- nReceivedPackets)/ nSentPackets--(10)

Where

nReceivedPackets = Number of received packets

nSentPackets = Number of sent packets

Average Throughput is the average of the total throughput. It is also measured in packets per unit TIL. TIL is Time Interval Length. Mathematically it can be shown as equation (11).

Average Throughput =

(recvdSize/(stopTime - startTime))*(8/1000) ---------------- (11)

Where

recvdSize = Store received packet's

size stopTime = Simulation stop time

startTime = Simulation start time

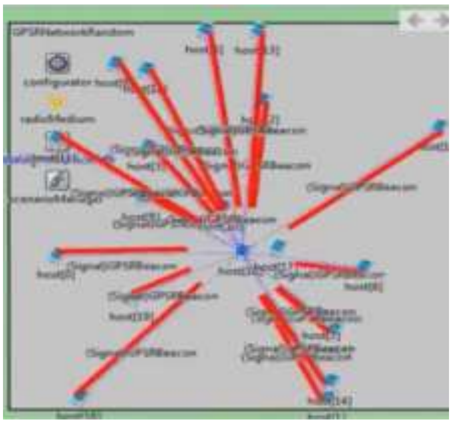

Figure 8: Implementation of GPSR in INET.

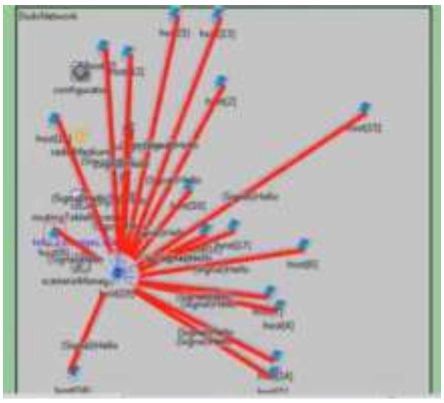

Figure 9: Implementation of DSDV in INET.

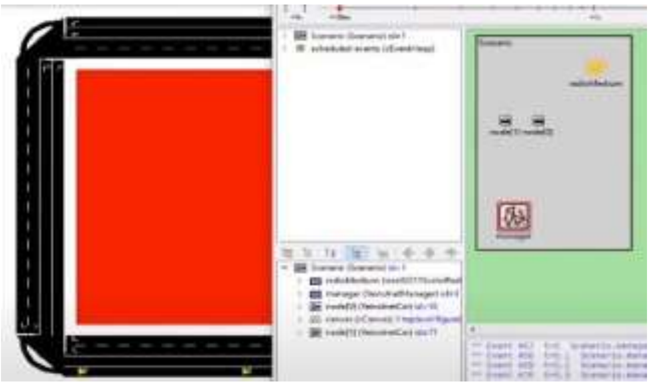

Fig 10: Implementation of AODV with INET and Veins.

VIII. RESULTS AND DISCUSSION

During simulation, we realized that the main problem of the three protocols is that they have a limitation when used in desert environments to connect the source and destination located in different clusters, and there is no direct connection between them. As these protocols are originally designed for MANETs rather than VANETs, they have been utilized in VANETs in urban and highways scenarios.

FIGURE 11, 11.1, 11.2 and 11.3 shows comparison between AODV, DSDV and GPSR protocols in terms of PDR, End-to-end-delay, Packet Loss and Average Throughput respectively.. It is observed that PDR of AODV remains high while increasing the number of vehicles. The increase of the number of vehicles did not affect the PDR because of the high efficiency and cluster structure stability of the routing algorithm. The PDR of DSDV and GPSR is less than that obtained by AODV, because the source node and the intermediate nodes store the next hop information corresponding to each flow for data packet transmission, but DSDV and GPSR use source routing in which a data packet carries the complete path to be traversed. The use of RM increases the packet delivery ratio, saves route rediscovery flooding traffic and reduces overall route acquisition delay. The PDR is too low in the beginning of the curves due to the random initiation of the simulation program.

AODV requires more time to establish a connection, and the initial communication required for finding a route is dense; however, it has no extra traffic for communication along existing links. For that reason, it has more advantage over GPSR and DSDV.

Moreover, its packet delay decreases with time. Other protocols had a longer delay because the route finding process takes more time, as every intermediate node tries to extract information before forwarding the reply, while the protocol tries to search for a new route.

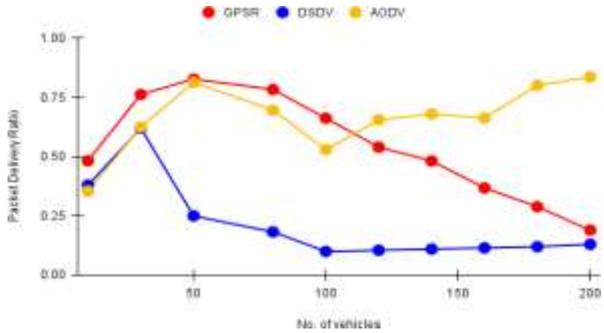

Figure 11: Packet Delivery Ratio (PDR) vs. Number of vehicles for AODV, DSDV and GPSR

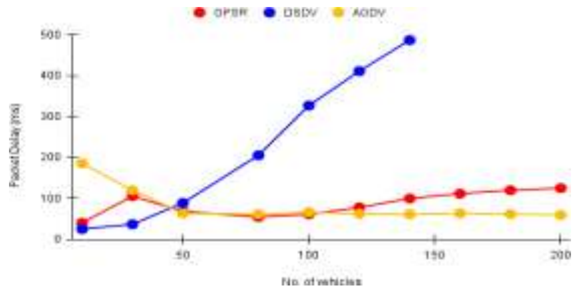

Figure 11.1: End-to-end delay vs. Number of vehicles for AODV, DSDV and GPSR

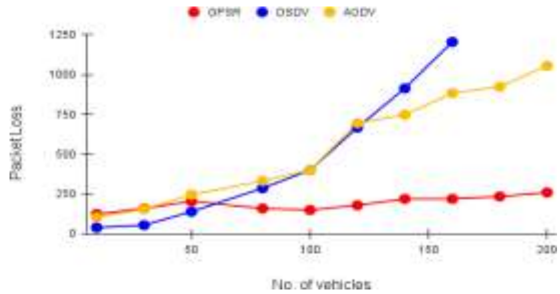

Figure 11.2: Packet Loss vs. Number of vehicles for AODV, DSDV and GPSR

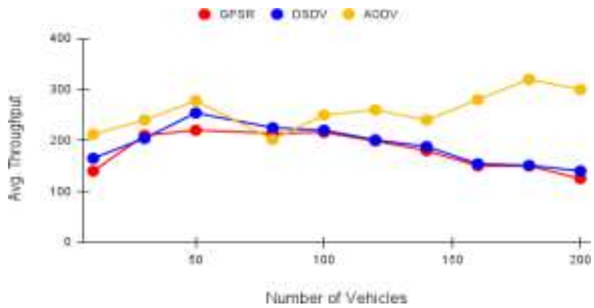

Figure 11.3: Average Throughput vs. Number of vehicles for AODV, DSDV and GPSR

IX. CONCLUSION

In this paper, we have discussed recent results for data dissemination in VANETs. It is evidently hard for a single protocol to maintain a constant performance behavior against such dynamic network.
VANETs exhibit dynamically changing topology. It is quite a demanding work to route the communications to their last target. Clustering is a most efficient approach to manage and stabilize such systems.

With this study, we observed that reactive protocols provide a higher PDR and throughput compared to proactive protocols, as claimed in some of the previous works [5, 6]. In this paper we also observed that proactive protocols provide the best packet delay, as stated by the majority of the cited previous works. In the proposed single-flow scenario, AODV outperformed the proactive protocols.

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