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# A Simulation of AODV and GPSR Routing Protocols in VANET Based on Multimetrices

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**Abstract**
*Vehicular Ad hoc Networks (VANETs), a subsection of Mobile Ad hoc Networks (MANETs), have strong future application prospects. Because topology structures are rapidly changing, determining a route that can guarantee a good Quality of Service (QoS) is a critical issue in VANETs. Routing is a critical component that must be addressed in order to utilize effective communication among vehicles. The purpose obtained from this study is to compare the AODV and GPSR performance in terms of Packet Delivery Ratio, Packet Drop Ratio, Throughput, and End-to-End Delay by applying three scenarios, the first scenario focuses on studying these protocols in terms of QoS while changing the number of vehicles at a constant speed of 40Km/h, and for the second scenario changing the speed value while keeping a constant number of vehicles which is 100, the third involves changing the communication range at a constant speed and vehicle number. This study represents a foundation for researchers to help elaborate on the strength and weaknesses of these two protocols. OMNeT++ in conjunction with SUMO is used for simulation.*

**KEYWORDS: AODV, GPSR, OMNeT++, QoS, SUMO, VANET.**

## I. INTRODUCTION

With the increasing number of vehicles on the road, traffic congestion and accidents have become major global challenges. Road traffic accidents are among the top ten causes of death worldwide, based on the World Health Organization, with losses estimated at more than one and a quarter million lives and fifty million nonfatal injuries each year [1], and these statistics are expected to rise unless a prevention mechanism is implemented. Meanwhile, congested traffic reduces transportation efficiency and impedes economic progress.

Given the aforementioned, vehicular ad hoc networks were attracting increased interest from governments, academic groups, and vehicle manufacturers in order to evolve as the heart of the ongoing development of the intelligent transportation system.

Vehicular Ad hoc Networks (VANETs), a subsection of Mobile Ad hoc Networks (MANETs). Mobile nodes in VANETs are vehicles equipped with advanced equipment on board that travels on restricted routes (such as roads and lanes) to communicate with each other to exchange messages, via Vehicle-to-Vehicle (V2V) communication, as well as between vehicles and fixed roadside infrastructure Vehicle-to-Infrastructure (V2I) communications [2-6]. The WAVE and IEEE 802.11p standards are used in the

Dedicated Short Range Communication (DSRC) protocol to allow low latency and high speed in V2I and V2V communications [7-9].

Vehicles in VANETs are able to communicate in the range of 100–1000m. As a result, the design of these networks includes two communication units: (a) An onboard unit (OBU) (b) a roadside unit (RSU), OBUs are installed within vehicles, whereas RSUs are stationary nodes positioned near a street intersection or traffic signal. To spread messages, RSUs serve as an access point, while vehicles serve as a router, source, or destination [10].

VANETs [11, 12] are made up of a wireless network of vehicles that can exchange messages with one another to assist the application [13, 14] of novel traffic services ranging from commercial applications, and traffic management to entertainment and safety.

To improve the efficiency and reliability of routing in VANET, many routing protocols have been suggested. These protocols are designed to improve throughput while minimizing packet loss. However, due to the extreme mobility of nodes, which makes the network topology dynamic and causes link disconnections frequently, routing protocols in VANET is a complex and not easy task. In this situation, the features of the network heavily influence the routing protocol selection. As a result, a single routing

protocol is insufficient to address the needs of all network types.

VANETs have numerous issues, including routing protocols, security, connectivity, privacy, and service quality. This research will examine two famous routing protocols in VANETs AODV (Ad hoc On-demand Distance Vector) and GPSR (Greedy Perimeter Stateless Routing) by using OMNeT ++ network simulation and two frameworks INET, Veins, and the traffic simulator SUMO for realistic simulation scenarios.

The rest of this work is structured as follows. Section II demonstrates the related work, section III briefly clarifies the VANET routing protocol and its classification. While section IV demonstrates the simulation environment. As in section V dive into the detailed result concerning the three scenarios and discuss each parameter apart. Lastly, section VI shows the conclusion and future work.

## II. RELATED WORK

Many researchers have proposed and examined a variety of topology and position-based routing protocols. AODV protocol has been presented in [15] using SUMO, MOVE, and NS2 simulators, the result is analyzed using diverse parameters like Network Routing Load, Throughput, Packet Drop Rate, Jitter, and Average End-to-End Delay. While in [16] the AOVD is put in comparison with DSDV and OLSR using network simulator NS3, the simulation shows that AODV outperforms both DSDV and OLSR. In addition, in [17], the paper investigates the performance of various protocols to demonstrate this research paper reveals the routing technique that has greater performance in VANET's high mobility environment is a clustering routing protocol, which is proper for VANET.

In [18] authors investigate and study AODV and DSR routing protocols. Based on the simulation results, they concluded that a significant amount of work is required to achieve high-quality video streaming on VANET, and AODV has once again proven to be superior for video applications. Lastly, [19] makes a performance examination of the AODV and GPSR, the network simulation is split into three different scenarios, which are packet delivery ratio, delay of the first data packet, and normalized routing load for the city, and highway scenarios.

## III. VANET ROUTING PROTOCOLS

A routing protocol is a mechanism that organizes communication between two nodes for the exchange of information, which includes route creation, redirection decisions, and recovery from routing failures. Numerous routing protocols have been utilized to meet the needs of VANET routing [20-23]. These routing protocols are categorized as showing in Fig.1.

This paper focuses on two types of routing protocols: (i) Topology-based routing and (ii) Position-based routing.
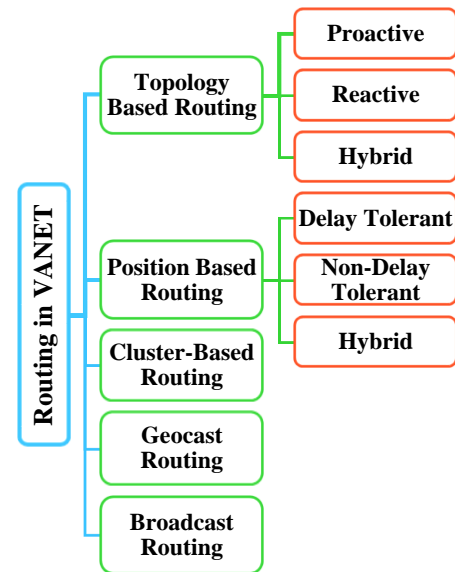


Fig. 1: A Brief Taxonomy for VANET Routing Protocols.

### A. Ad hoc On-demand Distance Vector (AODV)

AODV is one of the extremely essential and broadly used on-demand routing protocols, and it is organized as a reactive protocol. When it is necessary, a route is built in this protocol. It keeps routes open for as long as the sources want them to [24, 25]. The AODV method is summarized as a source node sending Route Request (RREQ) messages to surrounding nodes. The node responds to the sender node with Route Reply (RREP). If an error happens during transmission, a Route Error (RERR) message is returned to the sender node. If there is a node that needs to send data using the RREQ packet sent by the source, the route to the destination is identified. If there is an active route to the destination, the receiver will respond with an RREP packet [26, 27]. Figure 2 shows AODV messaging. The AODV uses sequence numbers to prevent the same packet from being forwarded more than once.
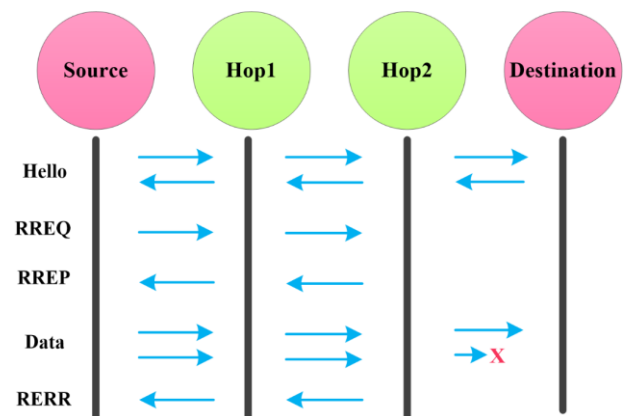


Fig. 2: AODV Protocol Mechanism.

### B. *Greedy Perimeter Stateless Routing (GPSR)*

GPSR is a non-delay tolerant position-based routing protocol that uses the geographic position of the nodes to determine routing decisions. It is expected that every node be informed of its own geographical location via global positioning systems (GPS).

GPSR employs greedy forwarding and perimeter forwarding to move packets from source to destination. To share coordinates, the node sends a message to its neighbor node if they are inside the transmission range this is called greedy mode.

If no greedy forwarding route exists, the perimeter method is employed, and the situation is known as Local Maximum, the right-hand rule is used to forward the message to the nearest node on the right [28-31]. Figure 3 demonstrate the state-transition modes in GPSR protocol.
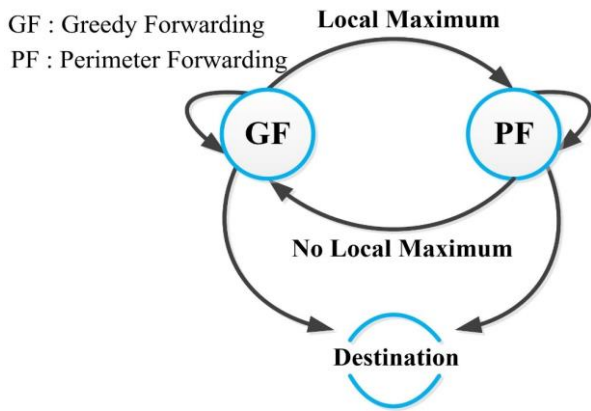


Fig. 3: State-Transition Modes in GPSR protocol.

### IV SIMULATION ENVIRONMENT

To examine the performance of the vehicular network, the following VANET environment is considered:

1.  The scenario is implemented in a 3x6 Manhattan grid, with real-time integration of OMNeT++ and SUMO in urban streets.
2.  The simulation is implemented without taking into account any barriers or distortion in signal transmission over a wireless channel while driving.
3.  Veins will employ a TCP link and Python scripts to make SUMO operate as a mobility model in the OMNeT++ simulation as shown in Figs. 4 and 5. As a result, the nodes can freely connect with the simulation of flowing road traffic.
4.  Two frameworks are employed in this simulation INET and Veins.
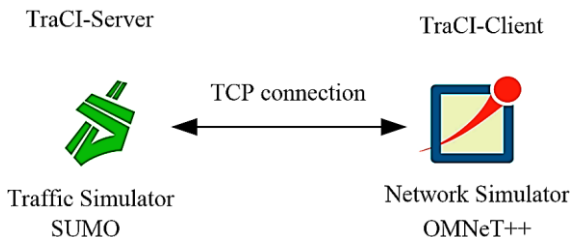
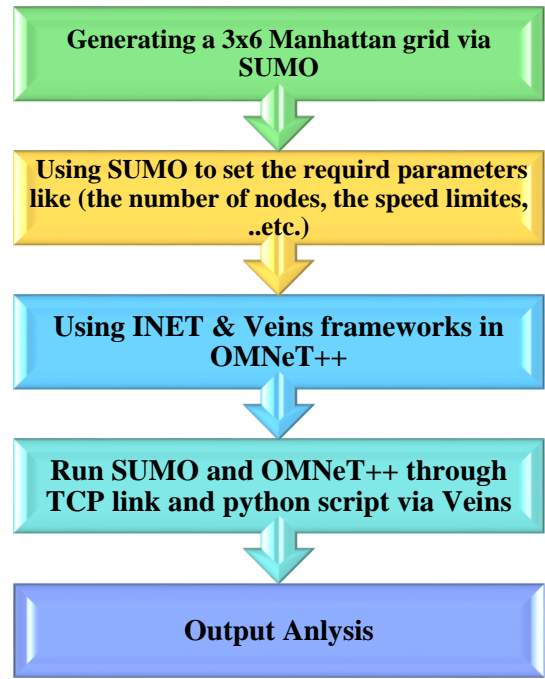

Fig. 4: TCP Connection of OMNeT++ with SUMO.



Fig. 5: A Typical Design of a Network Simulator in OMNeT++ and SUMO for VANET Environment.

Table 1 provides a summary of traffic and simulation characteristics in an urban environment.

TABLE 1
Simulation Parameters.

| Parameter | Value |
|---|---|
| Simulation Area | 2500m x 2500m |
| Simulation Time | 600 sec |
| Vehicle Number | 100,200,300,400,500 |
| Vehicle Speed | (20,40,60,80,100) km/h |
| Transmission Range | 250m |
| Physical Layer | IEEE802.11p |
| Transmission Power | 20mW |
| Packet Type | UDP |
| Routing Protocol | GPSR, AODV |
| Beacon Interval | 1 sec |
| Hello Messages | 1 sec |

In Table 2, a brief comparison between two famous mobility generators MOVE and SUMO is summarized. From the table it is noticed why SUMO was chosen for this study; the reason behind is because of its continuous development.

Also, Table 3 shows why the network simulator OMNeT++ was chosen instead of another simulator like NS2.

TABLE 2
A Features Comparison of the Various Types of
Mobility Generators.

|                          | SUMO | MOVE |
|--------------------------|:----:|:----:|
| **Open-source**          | ✓    | ✓    |
| **GUI**                  | ✓    | ✓    |
| **Real maps**            | ✓    | ✓    |
| **Continuous development** | ✓  | ✗    |
| **Available examples**   | ✓    | ✓    |

TABLE 3
A Comparison of the Network Simulators.

|                              | OMNeT++     | NS2           |
|------------------------------|-------------|---------------|
| **Language supported**       | C++         | C++ and OTCL  |
| **GUI Support**              | Good        | Poor          |
| **Ease of Use**              | Moderate    | Hard          |
| **Time is taken for installation** | Moderate | Moderate   |
| **License Type**             | Open-source | Open-source   |

## V. SIMULATION RESULTS

This section describes the findings produced in an urban situation by employing the AODV and GPSR routing protocols.

### A. The Impact of Changing the Number of Vehicles.

The AODV and GPSR performance can be described here with different numbers of nodes while maintaining a constant speed. The node speed is set at 40km/h in this case.

Fig. 6(a) shows that the lower packet delivery ratio in AODV is due to a shortage of pass on nodes; most packets are missed and do not reach their destination; nevertheless, as node density increases, so performs in terms of packet delivery ratio so the AODV is better than GPSR.

In the case of GPSR, the packet delivery ratio is low with lower node density due to the increased potential of network splitting and the increased number of void zones. Because more intermediate nodes become available as the number of nodes grows, the packet delivery ratio value grows as well. AODV outperforms GPSR because the average value of the packet delivery ratio in AODV is greater than that of GPSR.

According to Fig. 6(b), as the number of nodes increases, the packet drop ratio decreases. This is due to the number of relay nodes increases, which greatly improves the process of packet delivery to the destination. Because the average value of the Packet Drop Ratio in AODV is less than that of GPSR, it outperforms GPSR.

Fig. 6(c) shows that as the number of nodes (vehicles) increases, so does the throughput in both the AODV and GPSR, but in terms of compassion, the GPSR outperforms the AODV. As seen in Fig. 6(d), GPSR outperforms AODV in terms of end-to-end delay. In the case of AODV, as the vehicle's density increases, so does its end-to-end latency. The route discovery process that heads every data transmission to an unfamiliar destination is the cause of AODV's poor performance. In the case of GPSR betters AODV because the shortest path is chosen on a hop-by-hop basis in GPSR and can deliver at a lower latency.

### B. The Impact of Changing the Vehicles Speed.

The AODV and GPSR performance can be determined by varying the speed of the vehicle while maintaining a constant number of nodes (vehicles). The vehicles were held at 100 in this case.

According to the results in Fig. 7(a), the GPSR exceeds the AODV, and increasing speed has a negative influence on PDR. This is since, in AODV, increasing the speed will lead to increasing the probability of connection failure, which also leads to packet loss. The performance of GPSR is further affected due to the increasing node mobility, as there are fewer surrounding nodes at higher speeds. In addition, as the speed of the node increases, the performance of GPSR reduces due to the network disconnection and path instability. Vehicle speed influences the accuracy with which nodes receive geographical information, hence affecting GPSR performance.

In Fig. 7(b), the packet drop ratio in GPSR is lower than AODV as the vehicle speed increase.

In Fig. 7(c), the GPSR outperforms the AODV in terms of throughput. However, as the speed increases, the value of the throughput decreases because the link failure and nodes become out of range more quickly.

Figure 7(d) shows that GPSR outperforms AODV in terms of E2ED because GPSR has a lower E2ED than AODV. The effect of speed variation can be explained by stating that at lower speeds and fixed node density, AODV does not operate well due to congestion. The broken links resulting from increased speeds can easily explain this. On the other hand, at lower speeds, the end-to-end delay for GPSR is quite low, but as speed grows, it increases due to the existence of more possibilities of void zones, therefore the packet goes in perimeter forwarding mode. The right-hand rule is used to choose the next-hop neighbor in perimeter forwarding, which can result in inaccurate and long route selection.

### C. The Impact of Changing the Communication Range.

The AODV and GPSR performance can be determined by varying the communication range value (100, 150, 200, 250, and 300) m, at a constant speed of 40km/h and putting the number of vehicles to 100 during the examination. Figure 8(a) shows the packet delivery ratio in both protocols, as noticed as the communication range value increase so as the packet delivery ratio for both AODV and GPSR, but it seems that AODV takes the leads in a small amount. Figure 8(b) demonstrate the end-to-end delay in AODV and GPSR protocols, which shows with increasing the value of communication range result in decreasing the delay because the probability of the neighboring node is high in both protocols, even though the GPSR outperform the AODV in the end-to-end delay.
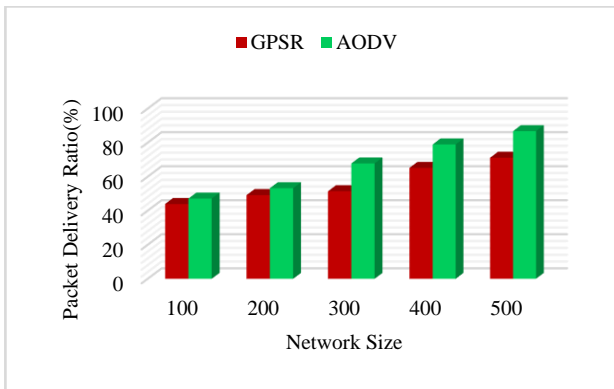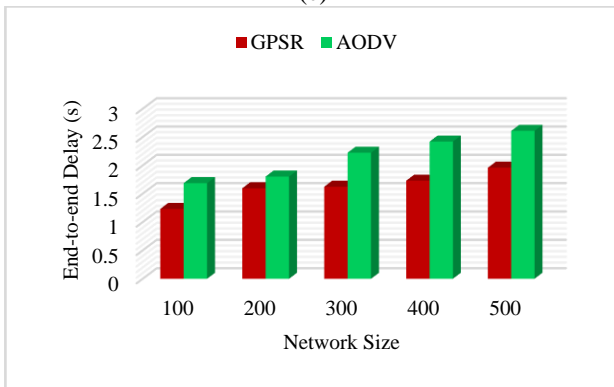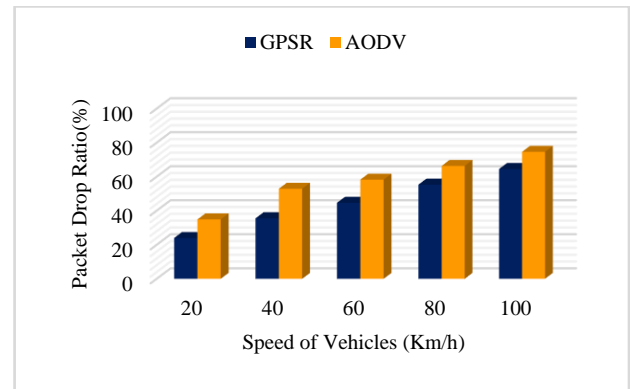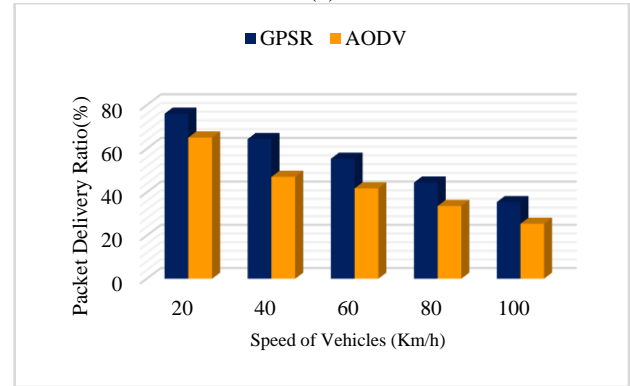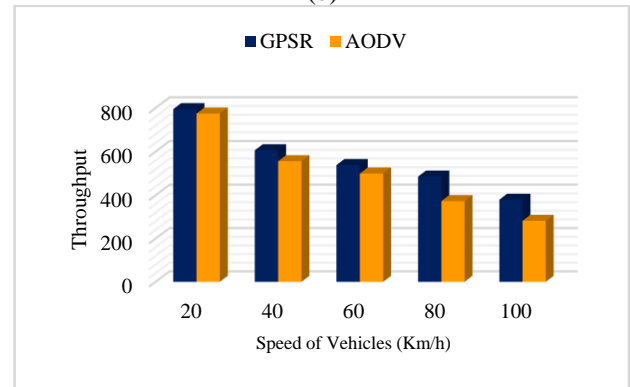
(a)
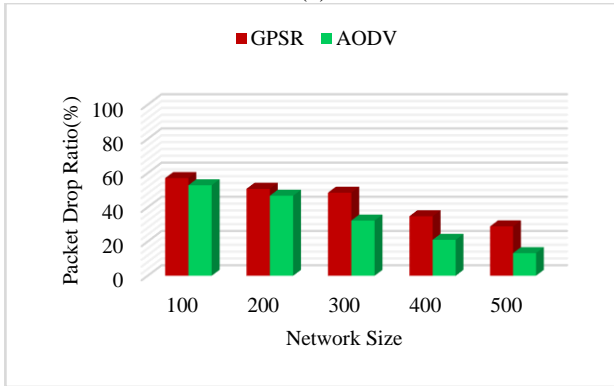


(b)
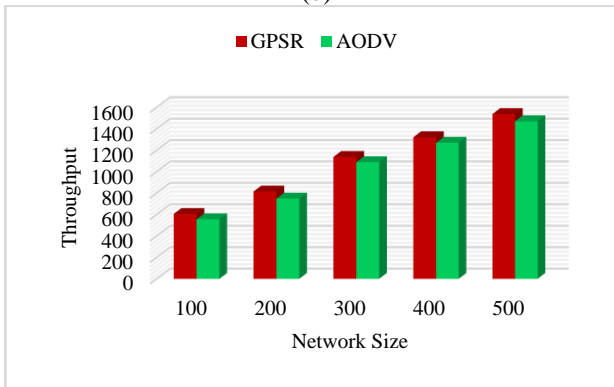


(c)



(d)

Fig. 6: The Impact of Network Size (a) Packet Delivery Ratio (b) Packet Drop Ratio (c) Throughput (d) End-to-End Delay.



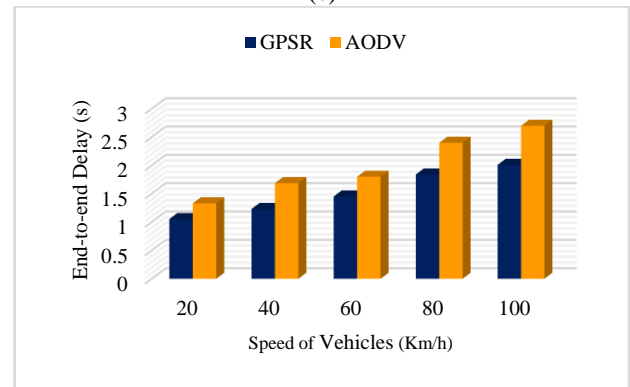(a)



(b)



(c)



(d)

Fig. 7: The Impact of Speed of Vehicles (Km/h) (a) Packet Delivery Ratio (b) Packet Drop Ratio (c) Throughput (d) End-to-End Delay.
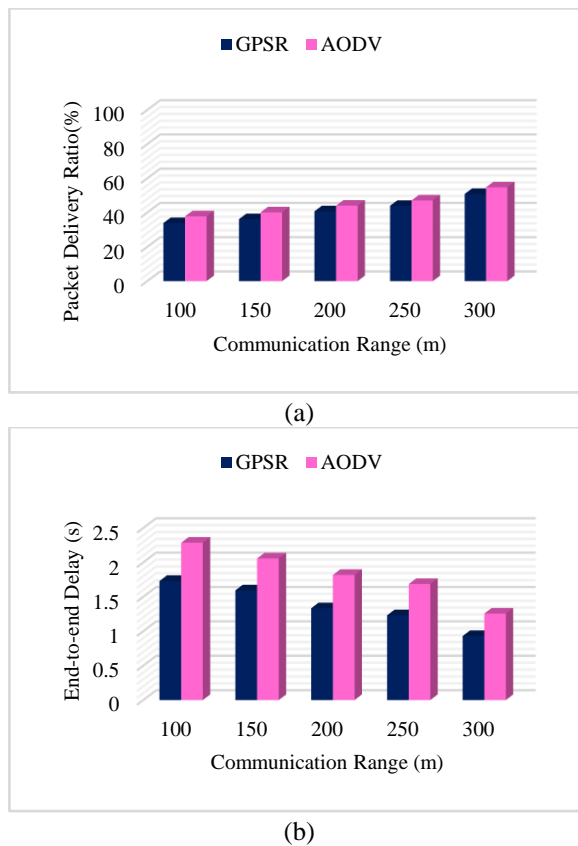
(a)



(b)

Fig. 8: The Impact of Communication range (a) Packet (b) End-to-End Delay

## VI. CONCLUSION AND FUTURE WORK

The performance of the AODV and GPSR was investigated in three scenarios.

(A) The first scenario involves varying the number of nodes (100, 200, 300, 400, and 500) at a constant speed of 40km/h in this situation; the AODV outperforms GPSR concerning the packet delivery ratio, whereas GPSR outperforms AODV in terms of E2ED. Since the association of a significant number of radio barriers in an urban environment, greedy forwarding is limited, resulting in a lower packet delivery ratio value for GPSR. The cause for superior E2ED is due to intermediate nodes has faster processing due to GPSR's proactive character as opposed to AODV's reactive nature.

(B) The second scenario involves varying the speed (20, 40, 60, 80, and 100) km/h at a constant vehicle value of 100. In this situation, the GPSR routing protocol outperforms the AODV about the packet delivery ratio and E2ED. Furthermore, as compared to AODV, the performance of GPSR is less vulnerable to increasing the number of nodes and speed, demonstrating its strength for scalability and mobility. GPSR is more beneficial for real-time communications because of its lower E2ED.

(C) The third scenario involves varying the communication range (100, 150, 200, 250, and 300) in [m], at a constant vehicle value of 100, and speed of 40km/h. In this term, the GPSR outperforms the AODV in terms of E2ED, because there is a high probability of nodes in the neighborhood as the communication range increases, leading

to the greedy forwarding mode is possible, and vehicles do not have to enter in the perimeter mode.

As for future work, this study is established a very good foundation for selecting the proper protocol for development and enhancement in an intelligent way to extract a good QoS and better performance. The intelligent methods may involve fuzzy systems, a Genetic Algorithm (GA), or any bio-inspired algorithms.

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