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Analysing and Evaluation of Routing Protocols in VANET

Bilal Saoud
University of Bouira

Tahar Zireg
University of Bouira

Idir Bouaoud
University of Bouira

Smail Medjedoub
University of Bouira

Abstract: Among the application of Ad Hoc network we have Vehicular Ad Hoc Network (VANET), which is an important data research domain today. VANET can improve the traffic road efficiency in order to overcome many problems and offer more services to customer. For instance, VANET can lead to reduce traffic jam or improve road safety by minimizing vehicles' accident. Like any wireless network without infrastructure, the routing task is the most difficult task especially when nodes are mobile. The mobility of nodes, which are vehicles in VANET, causes a rapid change of network topology and leads to bread connection between source and destination nodes. In this paper, we will analyze some routing protocols in order to evaluate their performances. In this study we have proposed some scenarios of VANET routing protocols. The simulation has been done on NS3 simulator and SUMO. Simulation proves that routing protocols have a huge impact on VANET network performances.

Keywords: VANET, NS3, SUMO, AODV, DSDV, GPSR, OLSR

Introduction

Today wireless communication is very important and it can be used in different areas. Wireless communication has the ability to solve many problems and overcome different issues because of its flexibility and mobility. MaNet (Mobile Ad Hoc Network) (Hui et al., 2022) is an example of wiles communication without exiting of infrastructure. Many studies have been done around Ad Hoc networks. Among application of Ad Hoc networks we can find Vehicular Ad Hoc Network (VANET) (Babu & Raj Kumar, 2022). VANET has been gained a lot of attention by scientists in the last decades. VANET can allow communication and data transmission between vehicles, which allow sharing different kind of information about the state of vehicles, roads, traffic, etc**.**

VANET could be seen as a set of mobile nodes, which are vehicles, and some fixed unites (like roadside). These mobile nodes cooperate together in order to ensure communication and data transmission between source node and destination node. Among the areas of VANET communications we have Vehicle to Vehicle (V2V) communication, Vehicle-to-Infrastructure (V2I) communication, Intra-Infrastructure communication (I2I), Vehicle-to-Sensor communication (V2S), Vehicle-to-Personal Device communication (V2PD), Vehicle-to-Cellular Network infrastructure communication (V2CN). In addition, we can find also Vehicle to Everything communications (V2X) based on emergence of cellular networks. VANET has been used to ensure different services such as infotainment applications, driver assistance, video on demand, etc. Furthermore, VANET

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improves significantly safety by warning messages in order to avoid accident. Figure 1 shows the communication between nodes in VANET network.

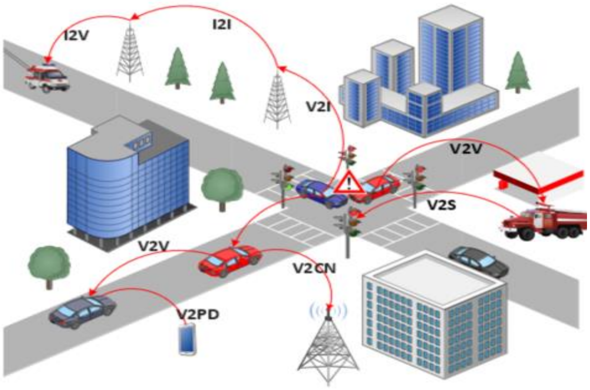

Figure 1. Communication between nodes in VANET network

Routing is a difficult task and is very important to ensure the transmission of data. Data can be sent from node source to destination nodes through many intermediate nodes. The establishment of roads between source node and destination nodes has huge impact on VANET performances such as packet received, errors, link breaks, etc. In this study, some routing protocols for VANET has been studied, analyzed and evaluated in different VANET scenarios. We organize the rest of the paper as follows. Section 2 the architecture of VANET. Section 3 discusses VANET routing protocols. Section 4 discusses simulation and results. Finally, section 5 concludes our paper.

VANET Architecture

VANET offers a wireless communication between mobile vehicles. Communication can be assured based on different standards such as Dedicated Short Range Communication (DSRC), Wireless Access in Vehicular Environments (WAVE). Furthermore, in VANET we have three basic units, which are AU: application unit, OBU: on board unit and RSU: Road side unit. AU unit is a device,which is integrated to vehicle (it can be separated). AU runs applications that communicate with OBU. In generally, AU and OBU are connected through wired or wireless connection. OBU receives, processes and manages data generated from vehicle. OBU unit of each vehicle communicates between each other. Communication between these units is assured by employing a standard of communication like IEEE 802.11 (Szott et al., 2022). RSU is fixed unit, which sends and receives data from OBU units. RSU communicates also with a central center, which is managed generally by government. It is worth to mention that RSU units are fixed in order to provide reliable coverage of network. The VANET architecture is briefly described in Figure 2.

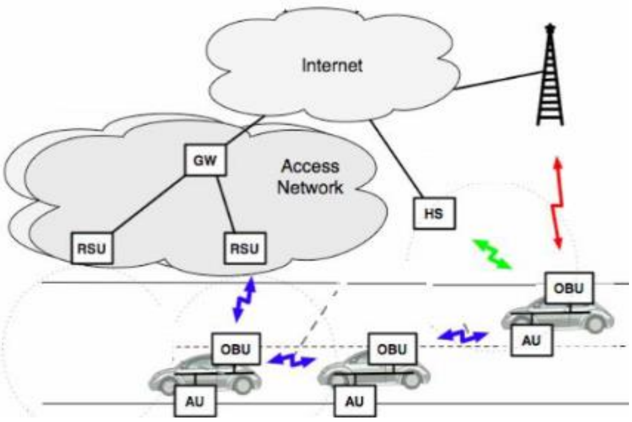

Figure 2. VANET architecture

Routing Protocols in Vanet

Data communication between nodes in VANET is assured based on routing protocols, which means that routing is very important and essential (Poonia, 2017). Among the features of VANET, we find the mobility of nodes.

This feature leads to frequently change of topology. By changing network topology link disruption can appears and keeping communication between nodes becomes a challenge task. VANET routing protocols are classified into topology, position, cluster, broadcast and geocast protocols (Babu & Raj Kumar, 2022). Figure 3 presents the classification of routing protocols in VANET.

Distance-to-Destination Dynamic Dequenced Vector (DSDV)

DSDV is a proactive routing protocol, node periodically transmit its routing tables to its neighbors. A node also transmits their routing table if there is any significant change occurred in their routing table from the last update sent (He, 2002). So each node has a route for any destination node in the network at all-time even the path unused currently.

Optimized Link State Routing Protocol (OLSR)

OLSR is a link state routing protocol (Clausen & Jacquet, 2003). It uses a multi-point relays (MPR) concept. MPR reduces network load when broadcasting the same messages through different nodes.

Routing with Distance-to-Demand Vector (AEDV)

AODV () (Perkins & Royer, 1999), is a reactive protocol. It has been proposed based distance vector strategy. AODV is designed by taking in consideration DSDV and DSR protocol. AODV has two procedures to discovery and maintenance routes ”Route Discovery” and ”Route Maintenance” like the protocol DSR. Routes between nodes update based on sequence numbers. This protocol is very used due to all its characteristics. It is one of the main protocols within the MANET research group.

Greedy Perimeter Stateless Routing (GPSR)

GPSR is a position-based routing protocol, which uses the geographic position of nodes to make the routing decisions(Karp & Kung, 2000). Nodes know their own geographical locations by using global positioning systems (GPS).

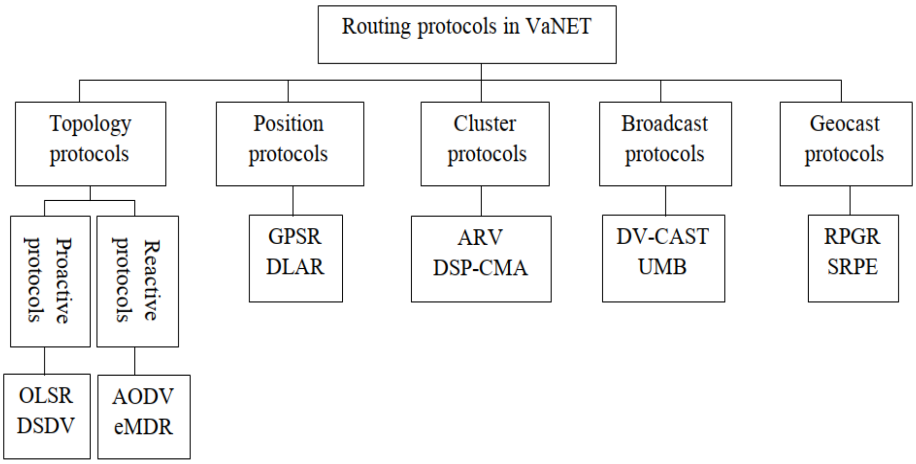

Figure 3. Routing protocols in VANET classification

Simulation and Results

In this section, we present the simulation setup and results. Our simulations were conducted using the NS3 simulator in conjunction with SUMO. We designed a scenario representing Bouira city in Algeria using SUMO. To evaluate the performance, we compared four routing protocols: AODV, DSDV, OLSR, and GPSR. The simulation parameters are detailed in Table 1.

In order to compare these routing protocols we have used some test metrics. Basic safety message packet delivery ratio (BSM_PDR) has been used. BSM_PDR is estimated based on(Pak & Kumar, 2018):

$$BSM\_PDR = \frac{\text{BSM packet reveived}}{\text{BSM packet transmitted}} \qquad (1)$$

In our simulation each node transmits 10 basics safety message of 200 KB every second. If BSM_PDR is high, this means that communication in the network is reliable. MAC/PHY overhead has been used also to compare routing protocols. It is defined as follows(Pak & Kumar, 2018):

$$MAC/PHY = \frac{\text{PHY bytes} - \text{App bytes}}{\text{PHY bytes}} \qquad (2)$$

Average Goodput is used, which is calculated based on useful data transmitted from source to destination node per time unit.

Table 1. Simulation parameters

Parameter	Value
Simulation tool	NS3
Path loss model	Friis model
Trasmission power	10 dBm
MAC layer	802.11p
Channel	Wifi (5.9 GHZ)
Trasmission mas delay	10 ms
Routing protocol	AODV, DSDV,OLSR, GPSR
Simulation area	1000 x 1050 m2
Number of vehicles	30, 50
Vehicle speed	10 m/s
Simulation time	30 s

Scenario 1

In the first scenario, vehicle speed was set at 10 m/s, and a total of 30 vehicles were deployed. Figure 4 displays the results of BSM_PDR for all protocols. It is evident from this figure that GPSR achieved a notably high BSM_PDR value.

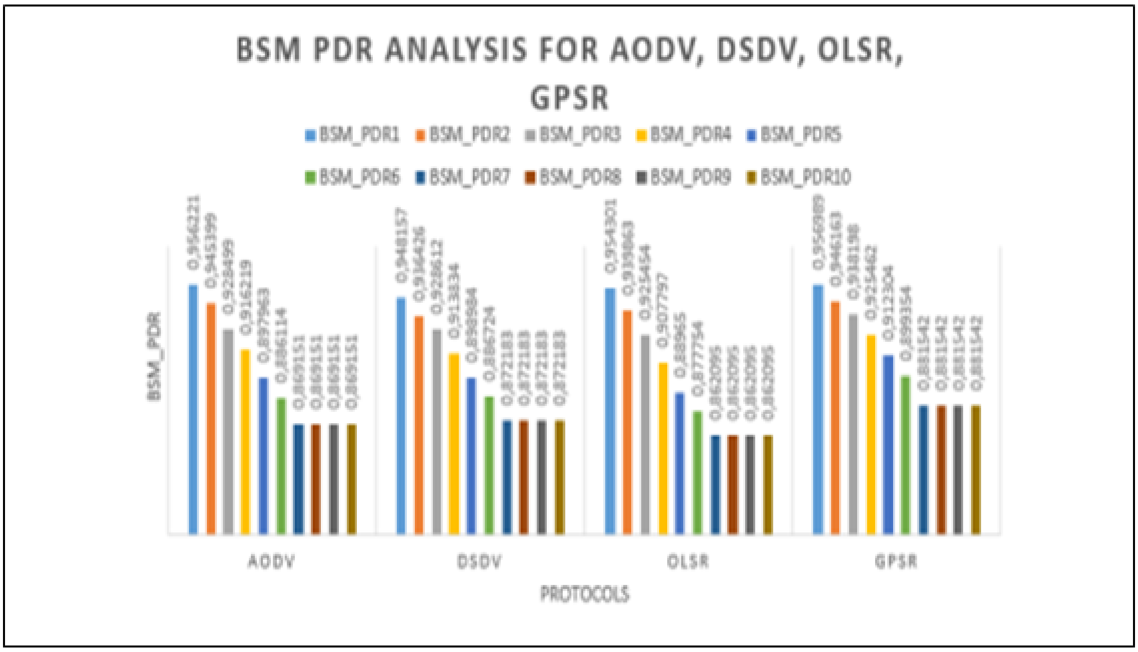

Figure 4. BSM_PDR analysis with 30 vehicles andspeed= 10m/s

Figure 5 presents an analysis of MAC/PHY Overhead. In this context, a lower value of this metric indicates greater network efficiency. As observed in Figure 5, GPSR achieves the lowest value after 15 seconds of simulation, indicating its efficiency. In contrast, AODV records the highest value, primarily due to its periodic use of hello message.

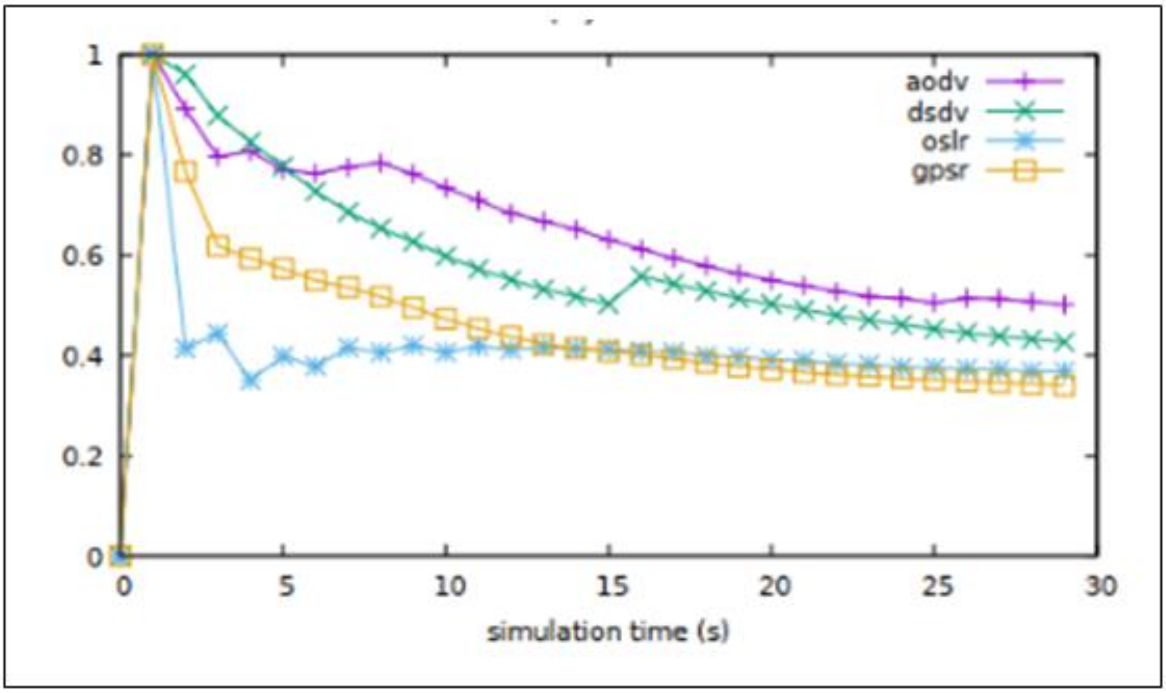

Figure 5. MAC/PHY overhead for 30 vehicles and speed = 10m/s

Regarding to goodput analysis, AODV stands out with the highest value among the compared protocols. This superior performance can be linked to AODV's frequent utilization of 'Hello' messages, which provides a detailed insight into the network topology. Conversely, GPSR registers the lowest goodput value. Figure 6 vividly illustrates these observations. However, both DSDV and OLSR exhibit similar goodput performance results.

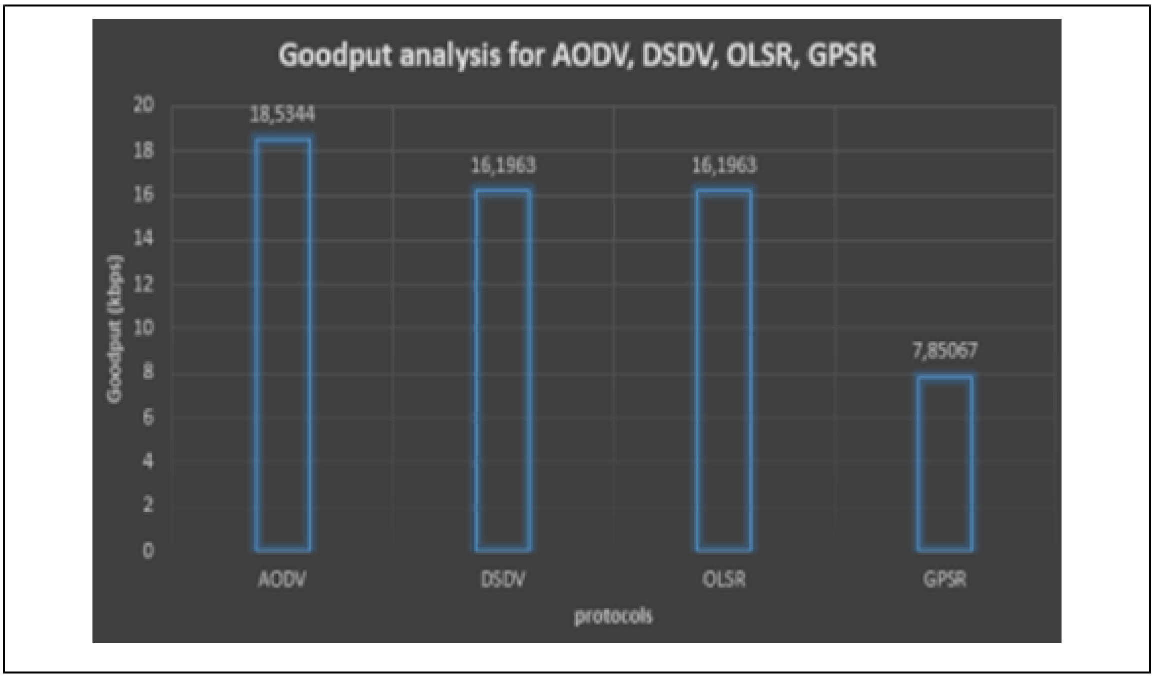

Figure 6. Goodput analysis for 30 vehicles and speed = 10m/s

Scenario 2

In our second simulation, we increased the number of nodes (50 vehicles) and we kept the same speed of vehicles (10 m/s) and the same simulation time (30 seconds). For the analysis of BSM_PDR in the case of 50 vehicles it was noted that OLSR gave the best results compared to other protocols. Because OLSR protocol uses MRP, which is a good strategy to find best routes between source and destination nodes. However, AODV is the protocol that gave the lowest values in this scenario. Figure 7 illustrates this result.

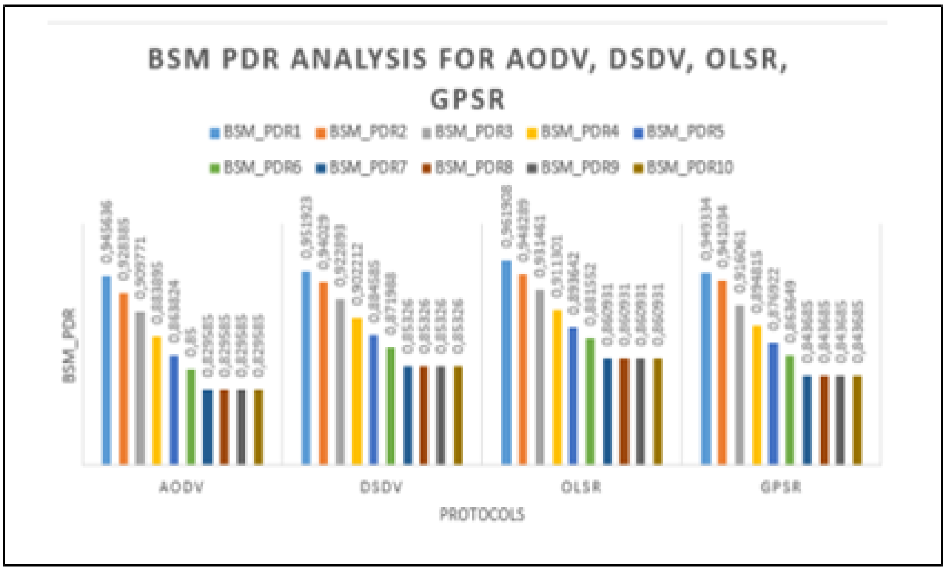

Figure 7. BSM_PDR Analysis with 50 vehicles and speed= 10m/s

In Figure 8, the MAC/PHY Overhead is graphically presented. Similar to the previous results, GPSR stands out as the most efficient protocol when evaluating the MAC/PHY overhead metric, outperforming all other protocols. GPSR excels in terms of both BSM_PDR and MAC/PHY Overhead metrics. However, it's worth noting that it yields the lowest MAC/PHY Overhead performance among the protocols examined.

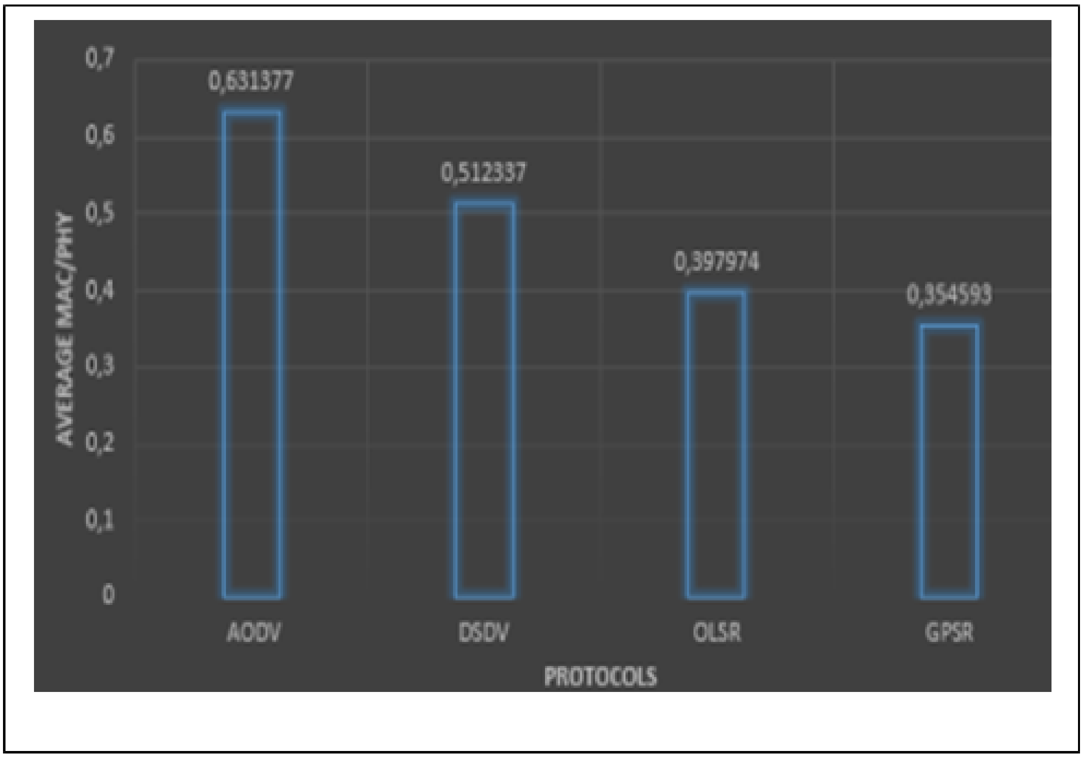

Figure 8. MAC/PHY overhead for 50 vehicles and speed = 10m/s

Figure 9 illustrates a graph depicting the goodput metric calculated for different routing protocols. The graph highlights that, at a vehicle density of 50, DSDV outperforms the other protocols. However, it's worth noting that DSDV exhibits lower goodput compared to AODV in scenarios with lower vehicle density (30 vehicles). However, OLSR demonstrates consistent goodput performance, closely resembling that of the best-performing protocol, across both high and low vehicle density scenarios. Notably, GPSR stands out as it consistently exhibits the lowest goodput performance among all the examined protocols, irrespective of the vehicle density.

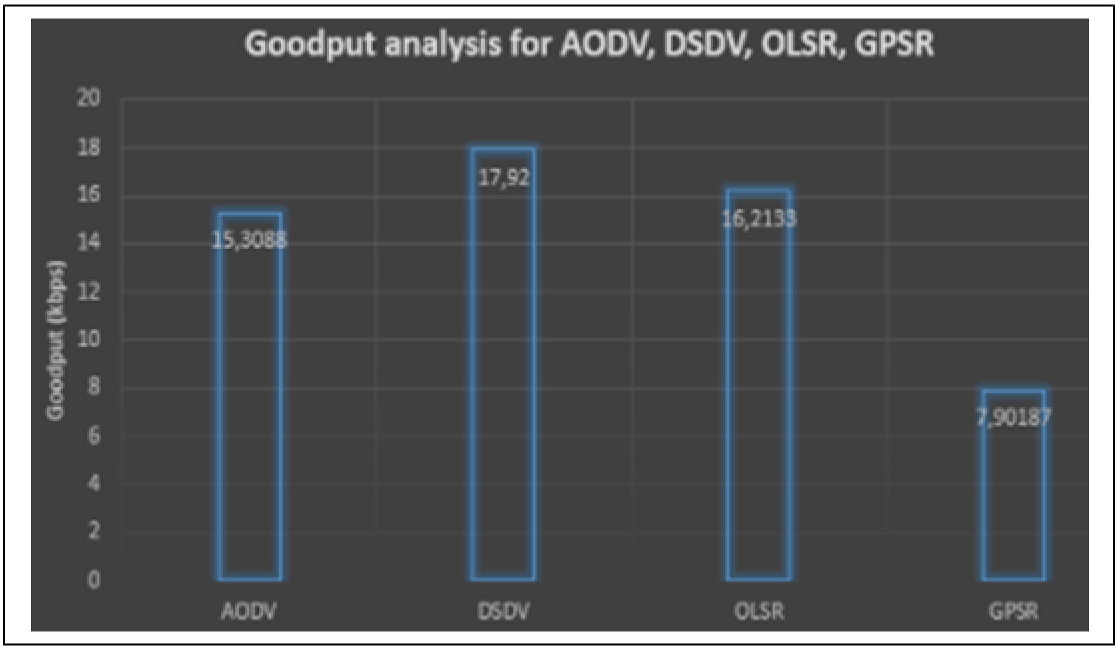

Figure 9. Goodput analysis for 50 vehicles and speed = 10m/s

Conclusion

In VANET networks, vehicles are mobile and can enter or leave the network at any moment, leading to frequent topology changes. Therefore, routing protocols must carefully consider this aspect and establish stable routes between source and destination nodes. This paper has investigated various routing protocols in VANET and proposed two simulation scenarios using NS3 and SUMO simulators. Several metrics were selected to evaluate and compare these routing protocols. The simulation results demonstrate that routing protocols significantly influence VANET performance, making it challenging to identify the best one. While compromise solutions can be proposed to improve the performance of the VANET network.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

Acknowledgements or Notes

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Author Information

Bilal Saoud
Department of Electrical Engineering, Sciences and Applied Sciences Faculty, University of Bouira, Bouira 1000, Algeria
Contact e-mail: *bilal340@gmail.com*

Tahar Zireg
Department of Electrical Engineering, Sciences and Applied Sciences Faculty, University of Bouira, Bouira 1000, Algeria

Idir Bouaoud
Department of Electrical Engineering, Sciences and Applied Sciences Faculty, University of Bouira, Bouira 1000, Algeria

Smail Medjedoub
Department of Electrical Engineering, Sciences and Applied Sciences Faculty, University of Bouira, Bouira 1000, Algeria

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