MOVE Mobility Model in GreedLea Routing Protocol for Internet of Vehicle (IoV) Network

Normaliza Omar¹,², Naimah Yaakob¹,³, Mohamed Elshaikh¹,⁴ and Zulkifli Husin¹,⁵

¹Advance Computing, Centre of Excellence, Faculty of Electronic Engineering Technology, Universiti Malaysia Perlis (UniMAP), Perlis, Malaysia

²normaliza@unimap.edu.my  
³naimahyaakob@unimap.edu.my  
⁴elshaikh@unimap.edu.my  
⁵zulhusin@unimap.edu.my

Abstract. Internet of Vehicles (IoV) is a broad variety of mobile transmission purposes for file sharing [1]–[5]. There are still debates on the viability of purposes using end to end multi-hop communication, since the significant number of high mobility nodes involved in the networks. The main issue is the efficiency of IoV routing protocols in cities and highways can meet the ideal delay and throughput for such purposes. In particular, it is not usually a challenge to locate a node to hold a message in urban daytime situations, where vehicles are tightly packed. Since fewer number of vehicles are running in highway scenarios and cities at night, and it might not be possible to set up end-to-end roads. In general, each protocol offered a performance evaluation in contradiction of some other protocols, giving considerable importance to a detailed performance evaluation of each protocol type. After such an assessment, it was found that geocast routing would perform best in urban areas. GreedLea routing protocol is develop to overcome the current routing protocol drawback. The development of GreedLea routing protocol involved Greedy Perimeter Stateless Routing (GPSR) and reinforcement learning method in order to deliver better performance compared to current existing routing protocol. Urban environments without obstacles has been simulated using actual maps for example intersection density. In order to measure efficiency, the metrics are: average delivery rate, average delay, average length of path and overhead. From the analysis, it shows that GreedLea offers better performance compared to GPSR for both city and highway scenario. The first section in your paper

1. Introduction

A group of wireless connections without the necessary interference of central access point or current infrastructure known as ad hoc network. Ad hoc networks hold the main characteristics of been self-healing, self-forming, and in depend on any single node's centralized services [6]. Over the past decade, three major types of ad hoc routing protocols have emerged. Pro-active routing protocols preserve new targets and their routes by frequently allocating network routing tables. The benefit of this protocols is instantly accessible a path to a specific destination [7]. The weakness of the pro-active routing protocol is the creation an excessive routing traffic for used routes.
Reactive routing protocol found a route by drowning the network with Route Request packets when needed. The benefit of reactive protocols is the less routing traffic created as a routing table and will enter the network only when routes is needed. The weakness of this approach is there will be a start-up delay if data requests to be driven to a destination to let the protocol to determine a path.

Hybrid routing protocols combine a benefits of reactive and pro-active routing protocols, for example, allowing usage of reactive routing in restricted areas wherever there are various mobility-related path exchanges. Pro-active routing is formerly applied among more secure nodes and is used to connect ad hoc network clusters that make use of reactive routing.

Two major types of ad hoc networks being studied nowadays, known as mobile ad hoc networks (MANET) and vehicular ad hoc networks (VANETs). Wireless topology might be change rapidly and unpredictably in both forms. IoV is an extended of VANET structure and features. IoVs, however, distinguish features from former types of ad hoc networks, for example highly dynamic topology, often cut off networks, satisfactory storage and energy, different communications environment and limitations of hard delay [8].

2. Data Distribution Models for IoVs
IoVs are emerging as the selected network architecture for intelligent transport systems. IoVs are wireless short-range connectivity among vehicles. Different with infrastructure based networks, IoVs are built on-the-fly and, aside from the wireless network interfaces which is a common characteristic in the next generation of vehicles. In addition, IoVs allow an innovative class of applications requiring time-critical (less than 50 ms) responses or very fast data transfer rates (6-54 Mbps).

Traffic information allocation between vehicles in an accessible way is a significant issue that needs to be addressed in IoVs. Broadcast-based systems are known to have the ability to bootstrap vehicular networks. The aim of the data push communication model is to share information between a collection of moving vehicles on a regular basis (e.g., location, speed) appropriate to allow every vehicle to analysis and evaluate the traffic conditions onward of it. To accomplish this purpose, two main methods could be utilized: flooding and distribution. Every vehicle regularly transmits its personal information inside the flooding mechanism. Every time a vehicle receives a broadcast message, it keeps and transmits it by re-transmitting the message immediately. Because of the huge number of messages drowned through the network, particularly in high traffic density situations, this method is clearly not scalable. Instead in the distribution method, every vehicle transmit its personal information to other vehicles. Whenever a vehicle obtains information transmitted thru other vehicle, it keep informed the stored information consequently and holds the information transferred until the subsequent transmission time, at which point it transmits the up-to-date information.

Since there is constraints in transmitted messages and they do not overwhelm the network, the transmission method is scalable. The distribution method can either transmit information to all vehicles, or conduct a targeted transmission limiting information regarding a vehicle to vehicles behind it. In addition, only vehicles moving in the unchanged direction, vehicles moving in the other direction, or vehicles covering in both directions could be used to relaying communication.

For the VANET environment, authors [9] had studied current offered bio-inspired routing algorithms that support ITS applications applied to VANET routing. In particular, authors describe the main characteristics, limitations and strengths of proposed methods and use different parameters to compare them. In addition, authors suggest a single formal model applied to VANET routing of the bio-inspired multi-modular methods. In reality, bio-inspired approaches have been demonstrated to be more effective aimed at large-scale vehicle networks that distribute low-complexity data packets. This approaches is also stable and flexible, where, amid network interferences and enhanced routing efficiency. After presenting the context and current standards of VANET routing, authors identified the fundamental ideas and processes of newly suggested bio-inspired algorithms.

In VANETs, the topology of the network exchanges rapidly because of irregular vehicle distribution and high mobility, making street connectivity difficult to predict. The street density is considered by traditional routing protocols as a deciding aspect of street connectivity; though, this method neglect the
experience event collected through the vehicle due to traffic lights at the intersections [10]. Authors [11] discovered the impact of traffic lights on the dissemination of vehicles in a street and therefore measure street connectivity according to the dissemination and vehicles’ density in the centre of a street. Lastly, authors suggest a street-centric protocol based on street connectivity, called the traffic-light-aware routing protocol which takes into account the impact of traffic lights on the efficiency of routing and chooses a street according to street connectivity. The finding of the simulation shows that the offered procedure had increase the delivery ratio and decrease the delay from end to end.

In [12], authors presented a qualitative comparative analysis on position-based routing protocols aimed at highways and cities area. In addition, using systematic simulations and comprehensive analysis, authors analyzed the effect of various forwarding methods on the actions of routing protocols. The results show that predictive and directional forwarding methods are outperformed by greedy forwarding and improved greedy forwarding. Dynamic junction selection is also observed to be more suitable for routing in the city environment. Therefore, junctions need to be chosen by given destination’s distance, vehicular traffic, and another significant features. In addition, dynamic junction selection systems are very suited for the design of protocols aimed at the climate of the region.

In VANETs, position-based routing is believed to be the furthermore important solution. In [13], authors suggested an overview of the relevant position-based unicast routing protocols in the urban environment aimed at vehicle to vehicle communications. For the exchange of information between vehicular nodes, authors provide them with their working characteristics. Authors defined the benefits and drawback of them. Authors furthermore offered a contrast of routing protocols based on vehicle to vehicle contact. The proportional analysis is focused on particular important variables, for example traffic intensity, mobility, the approach used to deal with an ideal local condition, forwarding methods and the selection process for junction approaches. It moreover offers a simulation based analysis of current routing protocols for dynamic junction selection and a routing protocol for static junction selection. This paper offers a detailed understanding hooked on the routing methods and the most useful solutions for advancing VANETs suggested in this field.

VANET is an evolving tools for wireless communications which can improve driving safety and speed by sharing information on real-time transport. The carry-and-forward method has been implemented in VANETs to address unequal vehicle distribution. When the subsequently located vehicle remains in the transmission radius, therefore the packets are forwarded by the vehicle; if not, the packets are carried before the meeting. Correspondingly, due to queuing delays, the dense state may have long delays. In different vehicle densities, the suggested intersection-based routing protocol [14] discovered a minimum delay routing route. In addition, vehicles redirect each packet at each intersection corresponding to the routing of the packets at the intersections and real-time road conditions depends on the path of travel for the subsequent vehicle. Lastly, the finding shows that there is low end-to-end.

In [15], authors presented an improvement to GPRS routing protocol which uses information on node interchange (location, speed and direction) to improve network efficiency by predicting the future position of all vehicles. Thus, different geographical routing protocols have been suggested for this reason in order to face several challenges. The nodes utilize the neighbours' existing position information surrounded by their destination's location and the transmission limit range. This information is necessary in order to choose the appropriate subsequent hop used for data transmission. There are, however, some situations where this GPRS strategy is not sufficient. An improvement of GPRS known as GPRS+PRedict is presented in this paper. This enhancement is established thru approximating the upcoming location of all nodes involved. The results show the GPRS+PRedict method had ability to solve the problem studied and increase the conventional GPRS's general performance. GPRS+PRedict has been presented to attain a low end-to-end latency, a higher packet transmission ratio, a high throughput and a low routing cost compared to the other protocols. In the highway situation, the simulation is carried out by applying NS-2 and VanetMobiSim simulators.

In [16], authors represented the worldwide opinion of the mobility models and the ad hoc vehicle network to discovery the problems within VANETs and to concentrate on the mobility model of the city area. The mutual network characteristics of VANETs, with the description of VANETs and the
important principles of VANET routing, were also presented. Therefore authors divided the protocols for ad hoc routing into three; protocols for active routing, protocols for reactive routing and protocols for hybrid routing. A cluster-based method was tested to define the clustering route mechanism in VANETs and to categorize the creation of the cluster into two different types; connectivity-based and identity-based. In addition, authors selected the important metrics to evaluate the proposed method in both ACO and AODV routing protocol.

3. Mobility Model

In the design of IoV network protocols, flexibility plays a key role. It should be noted that, in order to estimate network efficiency, capability and system requirements, a practical mobility model for urban areas is necessary. Mobility in urban areas has been analyzed with the use of comprehensive synthetic and real mobility traces during the initial part of this study. A vehicular traffic has been built based on lane-changing models and car-following models for collision avoidance. The primary purpose of these mobility models is to allow a vehicle to be drive at the optimum safe speed to ensure that no collision with the previous vehicle occurs. The car-following model has the capability to switch smoothly among deceleration and acceleration. The proposed mobility model provide traffic lights at road intersections as well as bidirectional and multi-lane traffic, since highway and city scenarios are aimed. The large-scale network simulations has been performed using detailed mobility traces composed with a precise urban map that involves lane definition and street direction, traffic lights, stop signs, and building height and shape. The goal of this study is to evaluate the impact of some parameters in the design space, thereby improving the efficiency of the protocol under different network conditions.

3.1. MOVE Mobility Model

MOVE mobility model is proposed to distribute information effectively using the locations and speeds of vehicles. For standard highway scenarios, MOVE mobility model offers an almost 100 percent success rate inside the radio range and 10-15 percent increase outside the radio range up to 400 m. There is almost 100 percent transmission rate in data transmission inside the radio range and a half increase in output beyond the radio range, reflecting the single way that defines the important performance. In the highway, MOVE mobility model divided into virtual cells. In the highway, the nodes are organized into two hierarchical levels which is all of the nodes in a cell are take in the first level; the second level is represented as the host, where a few nodes typically located close to the geographical core of cell. The host serves as a base station (cluster head) for a certain period of time, handling path interval which is carried important messages from member of the same cell or its closest neighboring. In addition, path interval coming from it’s neighboring. The host acts as an intermediary node and determines which will be the first to be forwarded. Figure 1 shows the flow chart for MOVE mobility model. Path interval is used to define the route selection for each vehicle.
4. Routing Protocol in IoVs

The topology of IoVs is often changing because of the high velocity of moving vehicles. Finding and managing the routes in the complex existence of mobile nodes in the network is a difficult task. Like VANETs, IoVs also do not rely on a fixed communication system. Several researches have been made recently in IoVs to develop successful routing protocols[7], [17], [18].

4.1. GreedLea Routing Protocol

GreedLea always forwarded the packet to the node which is closest to its destination. However, if there is no node in the destination of the node direction, the perimeter forwarding method is used as a recovery
method. The first planarization algorithm in the perimeter forwarding method allows a neighboring exchange of the connectivity graph hooked on a planarized graph. In a free open space scenario (e.g. on highways), GreedLea performs well in contrast to Greedy Perimeter Stateless Routing (GPSR) [18]. However, the greedy forwarding algorithm of GPSR does not function properly in the city because direct contact between vehicles may be limited because of high mobility environments and large obstacles (for example, traffic signals, trees, buildings etc). In order to construct a planarized graph to build a routing topology and run a greedy forwarding algorithm, data packets must be travel in a long distance with high delays.

4.2. Cluster based Routing Protocol
A virtual block known as cluster-based routing can be created between vehicles travelling in the same road direction. In cluster-based routing, the virtual network architecture is designed to provide scalability by vehicle clustering. The secret to generating this routing protocol is the stable clustering of vehicles. Most of this kind of node structure happens on highways where cars appear to drive in blocks of consecutive gaps. In VANETs, several cluster-based routing protocols have been proposed [16], [19]–[22]. However, clustering is done in different ways than prevailing VANET models because of differentiating structures of IoVs for example highly dynamic topology, driver behavior, often disconnected network, etc. To provide scalability with low overhead communication, the clusters generated in VANETs are too short-lived. Therefore, in IoVs, current clustering strategies in VANETs cannot be used.

5. Result and Discussion
An IoV routing protocol has been built in this study to adapt network conditions by integrative real-time vehicle traffic information and road stability within geographic forwarding and road-based path. To discover paths, hybrid routing protocols has been built. The reactive protocol defines on-demand routes and informs them back to the source, where contains in the packet headers (i.e., source routing). Similarly, proactive routing protocol can create periodic communication packets that visit and keep the produce graph in linked road segments. This map is then distributed to all network nodes and used to determine the shortest paths to destinations.

5.1. Scenario 1: Without Obstacle
Data has been sent to vehicles in an obstacle-free scenario to assess the performance of the mobility model and routing protocols. This experiment has been carried out using the area of 1000m x 1000m. Bi-directional traffic with two lanes in each direction has been built on each route. Obstacles would not be used in this scenario to test the protocols in the light of improved network congestion. In this technique, the data transmission rate would result in a significant increase in the network performance. Next, it has been built according to the lane-changing and car-following models. Figure 2 display PDR with respect to the host number under the routing protocol of GPSR and GreedLea respectively. It is shown here that PDR is a bit poor for both GPSR and GreedLea on lower host density. Due to the lack of relaying hosts in the lower PDR using GPSR, most of the packets are fell and do not arrive the destination. However as the host density increases, efficiency also improves in PDR terms. In addition, the output begins to degrade at higher host density due to routing overhead induced by higher host numbers. In the case of GreedLea, due to the greater probability of network splitting and a greater number of void regions, PDR is low at a lower host density. Due to the availability of more intermediate hosts, the PDR value continues to increase as the number of hosts increases. From the result it shows that GreedLea provide 97.48% of average PDR which is the loss of the packet is less than 0.3%.
Figure 2. PDR vs Host without obstacle

Figure 3 display average delay over number of hosts under the routing protocol of GPSR and GreedLea. The results indicate that the average latency for GPSR is much greater with a lower number of hosts on the network. This is because connections are often broken at lower density and greater speed. Moreover, much of the time is spent on re-establishing new routes. There is a boost in efficiency as the number of host increases, the delay is decreased. However with an advance rise in host density due to the routing overheads incurred, the average latency continues to increase. On the other hand, in the case of GreedLea, the shift in average delays is mild. In GreedLea, a slight increase in average delay is due to overhead owing to hello beacons. GreedLea exceeds GPSR since the shortest path is chosen on a packet-by-packet basis in GPSR and can distribute at lower delays. From the result it shows that GreedLea routing protocol having 25µs of delay compared to GPSR which is having 0.3ms of delay.

Figure 3. Delay vs Host without obstacle

5.2. Scenario 2: Highway
National highways and rural areas has been used in this scenario to assess the performance of the proposed IoV routing protocol. In particular, sharp edges and slopes on rural single-carriage roads, where driver visibility is very low has been investigated. Figure 4 display PDR with respect to the host number under the routing protocol of GPSR and GreedLea respectively. It is shown here that PDR is very poor for GPSR on lower host density. Due to the lack of relaying hosts in the lower PDR using GPSR, most of the packets are fell and do not arrive the destination. However as the host density increases, efficiency also improves in PDR terms. In addition, the output begins to degrade at higher host density due to routing overhead induced by higher host numbers. In the case of GreedLea, due to the greater probability of network splitting and a greater number of void regions, PDR is low at a lower host density. Due to the availability of more intermediate hosts, the PDR value continues to increase as
the number of hosts increases. From the result it shows that GreedLea provide 99.14% of average PDR which is the loss of the packet is less than 0.1%.

![PDR vs Host (Highway Scenario)](image)

**Figure 4.** PDR vs Host for highway scenario

Figure 5 display average delay over number of hosts under the routing protocol of GPSR and GreedLea. The results indicate that the average latency for GPSR is much greater with a lower number of hosts on the network. This is because connections are often broken at lower density and greater speed. Moreover, much of the time is spent on re-establishing new routes. There is a boost in efficiency as the number of host increases, the delay is decreased. However with an advance rise in host density, due to the routing overheads incurred, the average latency continues to increase. On the other hand, in the case of GreedLea, the shift in average delays is mild. In GreedLea, a slight increase in average delay is due to overhead due to hello beacons. GreedLea exceeds GPSR since the shortest path is chosen on a packet-by-packet basis in GPSR and can distribute at lower delays. From the result it shows that GreedLea routing protocol having 4.12µs of delay compared to GPSR which is having 0.14ms of delay.

![Delay vs Host (Highway Scenario)](image)

**Figure 5.** Delay vs Host for highway scenario

Table 1 shows the comparison results for city without obstacle and highway scenario for packet delivery ratio.

| Host   | GPSR  (Highway) | GreedLea (Highway) | GPSR (Without Obstacle) | GreedLea (Without Obstacle) |
|--------|-----------------|--------------------|--------------------------|-----------------------------|
| Host 1  | 93.10           | 98.61              | 96.19                    | 96.51                       |
| Host 2  | 94.50           | 98.62              | 96.21                    | 96.77                       |

Table 1. Packet delivery ratio
Table 2 shows the comparison results for city without obstacle and highway scenario for delay.

| Host | GPSR (Highway) | GreedLea (Highway) | GPSR (Without Obstacle) | GreedLea (Without Obstacle) |
|------|----------------|-------------------|-------------------------|-----------------------------|
| Host 1 | 0.195ms | 0.212µs | 0.376ms | 0.415µs |
| Host 2 | 0.185ms | 0.106µs | 0.371ms | 0.356µs |
| Host 3 | 0.177ms | 7.07µs | 0.359ms | 0.328µs |
| Host 4 | 0.170ms | 5.30µs | 0.338ms | 0.307µs |
| Host 5 | 0.165ms | 4.24µs | 0.326ms | 0.271µs |
| Host 6 | 0.161ms | 3.54µs | 0.312ms | 0.238µs |
| Host 7 | 0.154ms | 3.03µs | 0.296ms | 0.210µs |
| Host 8 | 0.148ms | 2.65µs | 0.283ms | 0.184µs |
| Host 9 | 0.143ms | 2.36µs | 0.271ms | 0.163µs |
| Host 10 | 0.137ms | 2.12µs | 0.26ms | 0.147µs |
| Host 11 | 0.132ms | 1.93µs | 0.25ms | 0.134µs |
| Host 12 | 0.127ms | 1.77µs | - | - |
| Host 13 | 0.122ms | 1.63µs | - | - |
| Host 14 | 0.118ms | 1.52µs | - | - |
| Host 15 | 0.113ms | 1.41µs | - | - |
| Host 16 | 0.108ms | 1.33µs | - | - |
| Host 17 | 0.103ms | 1.25µs | - | - |
| Host 18 | 0.988µs | 1.18µs | - | - |

6. Conclusion
This was a long-standing process with the goal of understanding IoV network. A comparative analysis is carried out to reveal the strengths and shortcomings of the existing models and methods that contributed to the creation of the research proposal method in IoV network. There are still debates on the viability of purposes using end to end multi-hop communication, since the significant number of high mobility nodes involved in the networks. The main issue is the efficiency of IoV routing protocols in cities and highways can meet the ideal delay and throughput for such purposes. In particular, it is not
usually a challenge to locate a node to hold a message in urban daytime situations, where vehicles are tightly packed. Since fewer number of vehicles are running in highway scenarios and cities at night, it might not be possible to set up end-to-end roads. Designing an effective routing algorithm for vehicular networks is the main focus of this study. The research problems of routing and data dissemination in IoVs are addressed. Associated mobility models and current routing protocols for IoVs are studied. In particular, different IoV routing protocols and their future technology implementations are addressed in order to adopt several of the design issues involved. In general, each protocol offered a performance evaluation in contradiction of some other protocols, giving considerable importance to a detailed performance evaluation of each protocol type. After such an assessment, it was found that geocast routing would perform best in urban areas. GreedLea routing protocol is developed to overcome the current routing protocol drawback. The development of GreedLea routing protocol involved Greedy Perimeter Stateless Routing (GPSR) and reinforcement learning method in order to deliver better performance compared to current existing routing protocol. Urban environments without obstacles has been simulated using actual maps for example intersection density. In order to measure efficiency, the metrics are: average delivery rate, average delay, average length of path and overhead. From the analysis, it shows that GreedLea offers better performance compared to GPSR for both city and highway scenario.

References
[1] D. Kombate and Wanglina, “The Internet of Vehicles Based on 5G Communications,” Proc. - 2016 IEEE Int. Conf. Internet Things; IEEE Green Comput. Commun. IEEE Cyber, Phys. Soc. Comput. IEEE Smart Data, iThings-GreenCom-CPSCCom-Smart Data 2016, pp. 445–448, 2017.
[2] W. Xu et al., “Internet of vehicles in big data era,” IEE/CAC J. Autom. Sin., vol. 5, no. 1, pp. 19–35, 2018.
[3] Z. Fantian, L. Chunxiao, Z. Anran, and H. Xuelong, “Review of the key technologies and applications in internet of vehicle,” 2017.
[4] T. T. Dandala, V. Krishnamurthy, and R. Alwan, “Internet of Vehicles (IoV) for traffic management,” Int. Conf. Comput. Commun. Signal Process. Spec. Focus IoT, ICCTSP 2017, no. 10 V, 2017.
[5] S. Yu, J. Lee, K. Park, A. K. Das, and Y. Park, “IoV-SMAP: Secure and Efficient Message Authentication Protocol for IoV in Smart City Environment,” IEEE Access, vol. 8, pp. 167875–167886, 2020.
[6] D. Johnson, “Evaluation of a single radio rural mesh network in South Africa,” 2007 Int. Conf. Inf. Commun. Technol. Dev. ICTD 2007, 2007.
[7] J. Cheng, J. Cheng, M. Zhou, F. Liu, S. Gao, and C. Liu, “Routing in internet of vehicles: A review,” IEEE Trans. Intell. Transp. Syst., vol. 16, no. 5, pp. 2339–2352, 2015.
[8] N. Sharma, N. Chauhan, and N. Chand, “Smart logistics vehicle management system based on internet of vehicles,” 2016 4th Int. Conf. Parallel, Distrib. Grid Comput. PDGC 2016, vol. 1, pp. 495–499, 2016.
[9] S. Bitam, A. Mellouk, and S. Zeadally, “Bio-inspired routing algorithms survey for vehicular ad hoc networks,” IEEE Commun. Surv. Tutorials, vol. 17, no. 2, pp. 843–867, 2015.
[10] J.-J. Chang, Y.-H. Li, W. Liao, and I.-C. Chang, “Intersection-Based Routing for Urban Vehicular Communications with Traffic Light Considerations,” Ieee Wirel. Commun., no. February, pp. 82–88, 2012.
[11] Q. Ding, B. Sun, and X. Zhang, “A Traffic-Light-Aware Routing Protocol Based on Street Connectivity for Urban Vehicular Ad Hoc Networks,” IEEE Commun. Lett., vol. 20, no. 8, pp. 1635–1638, 2016.
[12] S. M. Bilal, A. ur R. Khan, and S. Ali, “Review and Performance Analysis of Position Based Routing in VANETs,” Wirel. Pers. Commun., vol. 94, no. 3, pp. 559–578, 2017.
[13] I. Abbasi and A. Shahid Khan, “A Review of Vehicle to Vehicle Communication Protocols for VANETs in the Urban Environment,” *Futur. Internet*, vol. 10, no. 2, p. 14, 2018.

[14] L. Der Chou, J. Y. Yang, Y. C. Hsieh, D. C. Chang, and C. F. Tung, “Intersection-based routing protocol for VANETs,” *Wirel. Pers. Commun.*, vol. 60, no. 1, pp. 105–124, 2011.

[15] Z. S. Houssaini, I. Zaimi, M. Oumsis, and S. El Alaoui Ouatik, “Improvement of GPSR protocol by using future position estimation of participating nodes in vehicular ad-hoc Networks,” *Proc. - 2016 Int. Conf. Wirel. Networks Mob. Commun. WINCOM 2016 Green Commun. Netw.*, pp. 87–94, 2016.

[16] K. Youneng, S. Sulistyvo, and I. Wayan Mustika, “A Comparative Study Cluster-Based Routing Protocols in VANETs for City Environment,” *2019 2nd Int. Semin. Res. Inf. Technol. Intell. Syst. ISRITI 2019*, pp. 409–413, 2019.

[17] K. C. Lee, J. Häerri, U. Lee, and M. Gerla, “Enhanced perimeter routing for geographic forwarding protocols in urban vehicular scenarios,” *GLOBECOM - IEEE Glob. Telecommun. Conf.*, no. 01, 2007.

[18] B. Karp and H. Kung, “GPSR: Greedy Perimeter Stateless Routing for wireless networks,” *ACM MobiCom*, no. MobiCom, pp. 243–254, 2000.

[19] R. R. Sahoo, R. Panda, D. K. Behera, and M. K. Naskar, “A trust based clustering with Ant Colony Routing in VANET,” *2012 3rd Int. Conf. Comput. Commun. Netw. Technol. ICCCNT 2012*, no. July, 2012.

[20] Venkatesh, A. Indra, and R. Murali, “Routing Protocols for Vehicular Adhoc Networks (VANETs): A Review,” *J. Emerg. Trends Comput. Inf. Sci.*, vol. 5, no. 1, p. 56, 2014.

[21] H. P. WU Zhen-hua, “Analysis on VANET routing protocols,” *J. Commun.*, vol. 36, pp. 76–84, 2015.

[22] M. Balakrishnan and M. Karthigha, “A Cluster Based OLSR Routing to Overcome the Routing Issues in Ad Hoc Networks: A Review,” in *International Conference on Electronics, Communication and Aerospace Technology*, 2017, pp. 673–678.