Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

Velocity Based Performance Analysis of GreedLea Routing Protocol in Internet of Vehicle (IoV)

Normaliza Omar[1,2,*], Naimah Yaakob[1,2], Mohamed Elshaikh Elobaid Said Ahmed[1,2], Zulkifli Husin[1,2], Iszaidy Ismail[1,2], Alaa KY Dafhalla[3]

[1] Faculty of Electronic Engineering & Technology, Universiti Malaysia Perlis, Arau, 02600 Perlis, Malaysia
[2] Centre of Excellence for Advanced Computing (AdvComp), Universiti Malaysia Perlis, Arau, 02600 Perlis, Malaysia
[3] Department of Computer Engineering, College of Computer Science and engineering, University of Ha'il, Saudi Arabia

ARTICLE INFO

Article history:
Received 12 January 2023
Received in revised form 29 September 2023
Accepted 28 February 2024
Available online 26 March 2024

ABSTRACT

Intelligent routing protocols for IoV have also been made possible by the convergence of IoT and machine learning algorithm. In order to make informed routing decisions, these intelligent routing protocols examine data gathered from IoT devices like vehicle sensors and traffic monitoring systems using machine learning algorithms. Moreover, as the number of vehicles increases and road networks become more complex, traditional routing protocols for ad hoc networks are being replaced by more advanced and efficient protocols. The purpose of this study is to concentrate on these unique qualities of IoVs network scenario. A combined routing method has been developed to construct periodic connectivity and find routes on-demand in order to save route data as graphs. The simulation's findings show that GreedLea routing protocol outperforms GPSR and AODV routing protocols in terms of delay and packet delivery ratio (PDR). The results demonstrate that the average AODV latency is significantly higher when there are fewer vehicles on the network. This is due to the fact that connections are frequently lost at higher speeds and lower densities, and re-establishing new channels takes a lot of time. As the number of vehicles rises, efficiency improves and the wait gets shorter. The average latency, yet, keeps increasing as vehicle density increases due to the additional overheads related with routing.

Keywords:
GreedLea; AODV; GPSR; Velocity; IoV

1. Introduction

The transportation sector is suffering a paradigm revolution in the way of a more connected and effective future with the introduction of the Internet of Vehicles (IoV). The practise of robust routing protocols in the context of IoV networks is one of the fundamental elements of this revolution. According to Contreras-Castillo *et al.*, [9] , these routing protocols are crucial for enabling seamless and effective data exchange between roadside infrastructure, vehicles, and service providers, which ultimately enhanced traffic management and transportation efficiency. The integration of machine

---

[*] *Corresponding author.*
E-mail address: normaliza@unimap.edu.my

https://doi.org/10.37934/araset.42.1.199214

learning algorithms and Internet of Things (IoT) technology has also enhanced the capabilities of routing protocols in IoV.

Routing protocols might dynamically adapt to optimizing route planning, exchanging traffic conditions, and enable real-time decision-making by utilizing machine learning algorithms and IoT data. As a result, routing protocols have drawn a lot of attention in the field of IoV research, with a focus on developing clever and reliable solutions that can effectively manage the specific problems that IoV networks present.

It's possible to think of IoV as a superset of IoT. It increases the scale, architecture, and applications of the IoT. Its objectives are to deliver travel accessibility, produce real-time traffic information easily, and improve trip comfort. IoV, which is an important component of the IoT, is mostly employed in urban traffic environments to offer drivers, passengers, and traffic management professionals with network connectivity. The IoV environment combines the network environment with the driving conditions [8]. IoV implementation presents a number of difficulties that must be overcome in real life. First and foremost, it is essential to provide quick, accurate, and effective communications to all vehicles, trains, and embedded sensors.

However, moving objects or vehicles in IoVs frequently travel across large distances, implying that they are involved in a variety of network topologies and scenarios. A routing method that can handle a variety of network circumstances and topologies is required as a result of the adhered behaviour of IoV nodes. IoV is the combination of three networks recognised as Intra-vehicle; Inter-vehicle; and Vehicular mobile internet. IoV is also a combined network aimed at taking care of traffic management, intelligent dynamic information service and intelligent vehicle control. The main goals of IoV are being to exchange information between the vehicle’s driver to avoid unpleasant traffic situations, enhance traffic management and offer infotainment services. IoV can provide road safety in means of intersection collision warning, emergency warning between vehicles, road condition information exchange between vehicles, and post-crash estimation systems [6].

The growth of the traditional transportation system is motivated by the problem of the low road efficiency brought on by traffic accidents and congestion. An unfavourable picture of increasing traffic accidents was created by the rise in automobile ownership. Road efficiency must be promoted while keeping in mind that traffic safety is always the primary factor to be taken into account [18]. The majority of communication in the IoV is composed of vehicle to vehicle (V2V) and vehicle to infrastructure (V2I), both referred to as vehicle to everything (V2X). In order to link the IoV to the core or other networks, the Road-Side-Unit (RSU) serves as an access point and is a crucial part of V2X communication [13].

One of the primary obstacles facing IoV is the execution of message dissemination. IoV's network architecture changes more quickly, which frequently leads to packet loss, network fragmentation, and route failure. The reliability of human transportation systems has been enhanced by IoV applications, but there are still substantial challenges and development issues that need to be resolved before IoV applications can be employed in a variety of real-time applications (Abdelsamee, Alsaleh, and Algarni). Reliability, connection, packet loss, and delay are significant Quality-of-Service (QoS) characteristics that still have unresolved research problems. For instance, maintaining a connection to a vehicle node presents difficulties due to mobility, changes in network architecture, and frequent changes in traffic circumstances that affect how well the network functions. This divergence could make the network less effective. Thus, minimising the effects of these issues is crucial in real life. Getting a consistent level of performance in terms of high throughput, minimal packet loss, and fewer connection failures is another challenging aspect of IoV. Practically speaking, long distances are commonly travelled by vehicles. A vehicle may therefore connect to different network topologies and scenarios as a result. This unique IoV behaviour highlights the requirement for a strong routing protocol architecture. A vehicle using the same routing protocol, for instance, must satisfy certain network topology requirements when it travels from one geographical area to another. This affects how well the routing protocol performs. The network's performance suffers as a result. Routing in IoV faces serious challenges as the movement of vehicles keeps changing the network topology. Thus, it is essential to provide a routing protocol that can transport data packets with the least amount of delay and packet loss in order to increase user satisfaction and vehicle safety [14].

These innovations have made it possible to create sophisticated, dependable routing systems that can dynamically adjust to shifting traffic conditions and enhance route planning. In the context of an IoV network, these intelligent routing protocols are essential for streamlining traffic management and raising overall travel efficiency. As researchers try to create clever and reliable solutions that can effectively solve the particular issues of IoV networks, these developments in routing protocols have become a prominent area of concentration in the IoV field. Additionally, there are now more options for the creation of intelligent routing protocols in the IoV because to the convergence of machine learning algorithms and IoT technology. By utilizing real-time data and sophisticated algorithms to optimize routes, decrease traffic, shorten travel times, and increase overall transportation efficiency, these intelligent routing protocols have the potential to transform the way vehicles navigate across road networks.

2. Research Scope

The development and improvement of a new IoV routing protocol is the aim of this work. The protocol's goal is to provide information about vehicular traffic to vehicles moving toward the problematic area rather than those leaving it. The research-designed technique will be more effective, dependable, and robust with topology change. This study aims on the design and development of mobility model and routing algorithm for inter-vehicular communications in city and highway environments. The scope of this study comprises the following goals:

i. Reviews and comparisons of existing routing protocols with/ without integrated algorithms for the development of reliable and robust IoV routing mechanism.
ii. The study focused on the integration of reinforcement learning (RL) method and GPSR routing protocol.
iii. The study considered the traffic management for the network scenario.
iv. Analyse and evaluate the performance of proposed integrated IoV routing protocols with a network simulator.

3. Internet of Vehicle (IoV)

The evolution of the IoT has extended its influence into the realm of transportation, giving rise to the IoV, a revolutionary concept that seamlessly integrates vehicles, infrastructure, and advanced communications technologies. One of the core elements underpinning the success of IoV is the efficient exchange of data and information through routing protocols. This study provides a thorough and in-depth review of routing protocols in the context of IoV, thoroughly examining their difficulties, advantages, and effectiveness. By categorizing existing routing protocols, examining their operational mechanisms, and rigorously evaluating performance metrics, this paper not only uncovers trends but also identifies critical research gaps that deserve attention in the field of IoV routing.

In an era where connectivity and data sharing are paramount, IoV represents a breakthrough paradigm that brings vehicles together to form a dynamic network. Central to the operation of the IoV are routing protocols that govern the paths over which data flows in this complex network scenario. This study provides a comprehensive analysis of different routing protocols in the IoV context, highlighting their central role in promoting seamless communication and optimized data transmission has been provided. The intricacy of IoV routing protocols must be understood using an organized approach. Vehicular Ad Hoc Network (VANET) protocols, Cellular Vehicle-to-Everything (C-V2X) protocols, and hybrid protocols that combine the VANET and C-V2X paradigms make up the three categories into which these protocols have been divided. Each class is thoroughly analysed to show its unique traits, benefits, and potential drawbacks. Decision-makers can choose the best protocol for particular IoV network scenarios by attending to these details.

When a vehicle is integrated with Internet connectivity and cutting-edge communication technology, it is referred to as the IoV. Vehicles can communicate with one another, with infrastructure systems, and with other electronic devices or networks thanks to the IoV, which improves ease, effectiveness, and safety. IoV technology consists of a number of elements, including:

i. Vehicle-to-vehicle communication (V2V): In order to avoid collisions, drive cooperatively, and control traffic, vehicles communicate with one another about their speeds, positions, and directions of movement.
ii. Vehicle-to-Infrastructure Communication (V2I): To gather real-time data and improve traffic efficiency, vehicles communicate with roadside infrastructure such traffic lights, road sensors, and toll systems.
iii. Vehicle-to-Cloud communications (V2C): Vehicles can link to cloud-based services to access data, update software, and employ cutting-edge capabilities like navigation, remote diagnosis, and customized services.
iv. Vehicle-to-Pedestrian communication (V2P): To improve safety and prevent accidents, vehicles interact with pedestrians, cyclists, and other vulnerable road users.
v. Vehicle-to-Grid communication (V2G): To enable two-way energy exchange, electric vehicles (EVs) communicate with the power grid. Since they can store energy, EVs can help with load management and grid stability.

Improved traffic safety, lessened congestion, effective transportation systems, a better driving experience, and environmental sustainability are a few advantages of IoV. It has the ability to completely transform transportation by providing smart and networked mobility solutions.

IoV applications are constantly evolving, with continuous advances in autonomous vehicles, connected vehicle platforms, smart infrastructure and data analytics. The ultimate goal is to create a seamless and intelligent transportation network that optimizes mobility, increases safety and improves the overall quality of life.

4. Related Work

This section discusses related work on IoV routing and accentuates the differences with the study reported in the study. The work on this study proposed an improvement to GPSR routing protocols by integrating it with RL algorithm. Each IoV vehicle uses a routing protocol to determine the best route to take while transmitting messages to a certain location. The aforementioned behaviour highlights how the routing protocol affects IoV performance. The proposed GreedLea routing protocol is stateless, does not require flooding, and adapts quickly to changing network topology. To route packets to their destination, it uses a perimeter forwarding technique and a greedy forwarding structure. GreedLea routing protocol stipulates that the vehicles must be fitted with a GPS gadget or other location-based system so they can obtain their own geographic data.

One of the most effective AI tools, machine learning (ML), has been widely applied to address the aforementioned issues. Using deep reinforcement learning (DRL) and machine learning algorithms for the IoV, a critical analysis of analytical modelling for offloading mobile edge computing decisions was conducted by Ali *et al*., [2]. As part of the Quality of Experience (QoE) optimization, several recent studies and methodologies have been analysed, compared, and discussed in the paper's researchers' focus on buffer and energy. An agent learns from its surroundings using the model-free technique of RL to determine the optimal path of behaviour. For effective selection of the cluster head (CH) for handling the network's resources while taking into account the noisy nature of the IoV network scenario, Sharif *et al*., [26] provided an actor-critic-based deep reinforcement learning framework (AC-DRL)-based experience-based technique. The experimental outcomes show gains of 28% and 15% in terms of fulfilling the SLA requirements as compared to the static and DQN techniques as well as improvements of 35% and 14% in throughput.

Duduku *et al*., [11] applied position data and a clustering technique utilising GPS to develop the Secured Minimum Delay Routing Protocol (SMDRP). The results show that SMDRP was economical with respect to packet delivery ratio, throughput, and end-to-end delay. Nazari *et al*., [19] presented an end-to-end framework for the Vehicle Routing Problem (VRP) utilizing DRL. This technique relies solely on a single model that is instructed to recognise reward signals and adhere to feasibility requirements in order to provide nearly optimum solutions for issue instances that are experimented from a given distribution. With more improvements, the proposed architecture has a significant chance of being applied to real-world issues. Despite the fact that the provided algorithm can only be utilised for TSP or VRP problems, it can be applied to other combinatorial optimization issues. Nazari *et al*., [19] provided an end-to-end framework for employing RL algorithm to solve the VRP. In this approach, writers direct a single model that, using only reward signals and feasibility restrictions, produces nearly optimum solutions for problem situations sampled from a given distribution. This approach is quite interesting because it simply needs a verifier to find workable solutions and a reward signal to show how effectively the process is functioning.

In a research by Rana *et al*., [24], an enhanced directional LAR routing system was put out that detects the proper next hop forwarder node in the forward area and minimizes pointless communications. For choosing the best next-hop forwarder node and for data packet forwarding in the network, two strategies were put forth. The position-based routing protocol called ID-LAR that is being developed is substantially more suitable for identifying the forward region and selecting the best node to be the next forwarder node in a network. Datta [10] offerred a reliable and effective routing method for the VANET scenario in smart cities. The outcomes show that the innovative approach reduces latency and boosts packet transmission throughput. However, the vehicular network's features are not assessed for precise and efficient routing. Bannan [5] came across the idea of using a RL algorithm to solve the problem of routing in a driverless vehicle. A recommended framework uses cutting-edge artificial intelligence techniques to plan a route while taking into account many factors that a driver is not typically aware of.

Attia *et al*., [4] proposed an Advanced Greedy Hybrid Bio-Inspired (AGHBI) routing protocol uses an enhanced hybrid routing scheme with the help of a bee colony optimization to select the route with the highest quality of service and obtain the path with the least amount of overflow in order to enhance IoV performance. According to simulation results that show how effectively it handles both vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) situations, the suggested protocol has a considerable impact on improving packet delivery ratio and delay while achieving acceptable overhead and number of hops. According to Pandey *et al.*, [20], an IoV-based route optimization procedure for combat vehicles was offered to offer a helpful comparison of different methods and algorithms and to determine which ones are suitable for a particular application. For this reason, the authors discuss how these strategies will be created and developed to offer dependable connectivity for a networking scenario that will completely automate 3D route models in the future. Moreover, Husnain *et al.*, [15] suggested a method for creating and assessing the best cluster head (CH) based on Harris Hawks' Optimization for Intelligent Route Clustering in order to enable the most effective route discovery in IoV networks. Additional testing was done to examine Packet Delivery Ratio (PDR), bandwidth use, and latency, which demonstrate superiority over alternative strategies already in use. Additionally, statistical research reveals an increase in cluster stability (by 90.6 R-squared) and cluster optimization (by 80%).

Punia and Kumar [22] proposed a novel EK-PGRP (Extended Kalman filter- Predictive Geographic Routing Protocol) routing approach to choose the most advantageous neighbour for forwarding packets from the source to the destination vehicle using an extended Kalman filter for real-time V2V communication in both urban and highway vehicular environments. The findings demonstrate that EK-PGRP performs better than the majority of simulated instances and achieves the lowest location error while improving the vehicle's prediction accuracy in the vehicular environment. It is contrasted with GPSR (Greedy Perimeter Stateless Routing), PGRP (Predictive Geographic Routing Protocol), and K-PGRP (Kalman filter- Predictive Geographic Routing Protocol). The simulations were carried out using the traffic simulator SUMO and MATLAB R2018a. In order to improve cluster stability and lower communication overhead, Senouci *et al.*, [25] described a novel Efficient Weight-based Clustering Algorithm for IoV (WECA-MR) that uses Mobility Report. This research suggests that the unavailability of CH can be decreased if the main chunk CH and another backup CH (BCH) are selected. The authors used the network simulator NS-2 and the integrated environment VanetMobiSim to compare the performance of the proposed system to that of the MOSIC protocol.

Mazouzi *et al.*, [17] initially suggested a unique lightweight location service based on intelligent mobile agents to find all geographic routes between two vehicles. A reactive geographic routing protocol based on agents is the second idea put out by the ARGENT developers, and it incorporates a brand-new, lightweight location service into the routing procedure. Performance studies shows significant increases in query success rate, data packet delivery, and end-to-end delay in addition to significant decreases in communication issues and overhead. According to Chen *et al.*, [7], an urban IoV traffic-aware and link quality sensitive routing protocol (TLRP) is proposed by the authors. They create a new routing metrics called Link Transmission Quality (LTQ) to account for the impact of the number, quality, and relative placements of communication links along a routing path on network performance. A number of simulations show that in terms of packet delivery ratio and average transmission delay, the presented protocol greatly beats the cutting-edge protocol MM-GPSR, the normal intersection-based scheme E-GyTAR, and the conventional connectivity-based routing iCAR.

Despite the obvious advantages (such as reducing CO2 emissions, reducing traffic congestion, and saving money, time, and energy), the usage of location data raises privacy issues. Atmaca *et al.*, [3] created a privacy-compliant approach for exchanging vehicle locations (such as positioning) for cloud-based automobiles as a result. The novel feature of this work is the transformation of vehicle geographical data into graph-structured data for improved applicability in the road network, development of a real-time application, and empirical examination of the best privacy efficacy. To further reduce the effect of traffic signals on connectivity between vehicles along a path, some researchers suggested the Traffic Sensitive Connectivity-Aware Geocast Routing (TS - CAGR) protocol. Packet delivery ratio, routing overhead, end-to-end delay, and throughput are performance factors taken into account when assessing TS-CAGR's performance in a vehicle urban context. The comparative performance evaluation demonstrates the superiority of the TS-CAGR protocol over the other protocols. Data must be delivered fast across the network for effective network operation, which calls for minimal compute and bandwidth overhead. However, because nodes move very frequently in automotive environments, there are significant obstacles to effective data distribution. Group'n Route (GnR), an effective method of message routing, and a novel clustering algorithm at the network's edge are proposed by Magaia *et al*., [16] to handle this kind of issue. The performance assessment demonstrates that the clustering method produces consistent results under various road circumstances, making it a suggested strategy for mobile IoV nodes. In addition, as compared to conventional routing protocols, the developed routing protocol achieves two orders of magnitude lower overhead and nearly twice the delivery ratio. This demonstrates that the combination of the two clustering and routing techniques we've suggested is a viable option for supporting IoV communication in real-world settings.

The revolution in communication and information technologies enabled smart devices (RSU and OBU) to gain access for a verity of information such as digital maps and position information systems. This information utilized to improvise the search for a path in GRP routing mechanisms. Consequently, GRP protocols are classified based-on their awareness of this information into greedy and stateless, Street, infrastructure, connectivity and real-time aware routing protocols. Greedy and stateless protocols exploit the position information of vehicles to estimate the geographical distance between two nodes, and then find the shortest path with respect to distance as in the greedy mode of GPRS. Advantages of these protocols include: less considering topological information that reduces protocol overhead, and efficiently handles the scalability in IoV. In contrast, most of these protocols are designed for specific scenarios (urban, rural or highway) which reduce their robustness to vehicles frequent relocation. Bio-inspired routing mechanisms are more efficient in large-scale network as they mimic a collaborative behaviour of large group species (Ants Colony and Bees Colony). Further, the adaptability of these algorithms to varieties in conditions and requirements considered a promising solution for the dynamicity in IoV. Additionally, the simplicity of these algorithms in term of computation makes them an implementable and easy to integrate solution for IoV routing protocols.

5. GreedLea Routing Protocol

The operational framework, formulation of the research issues, formulation of the research design, and performance evaluation are the main components of the research methodology that are reviewed in this section. One of the most important aspects of this study is its design and development, which comprise of two steps—the routing algorithm and the mobility model. Utilizing accurate synthetic and real mobility traces in a high mobility and significant obstacle environment, an effective mobility model has been created (urban areas). The IoVs routing protocol was developed in the next stage employing geographic data to manage highly dynamic topology, various communication settings (such as cities, highways, etc.), and strict latency requirements. In order to accomplish the goals of this study, the operational framework provides a direction. The process to determine the effectiveness of the proposed network system is then outlined. The routing protocol was created to take network mobility, latency, and loss into account while maintaining application requirements. The next subsections contain a presentation of the aforementioned procedures.

5.1 Mobility Model

Designing network protocols for vehicular networks heavily relies on mobility. It is important to note that a realistic mobility model is crucial for predicting the network efficiency, capacity, and infrastructure needs in metropolitan regions. Detailed synthetic and real mobility traces were used to study mobility in urban areas during the first phase of this project. The accurate mobility traces and a precise urban map, which contains information on building shape and height, street direction and lane description, stop signs, traffic lights, and their timing, were used to conduct the large-scale network simulations. This study focused on examining how those design space factors affected protocol performance across a range of network situations.

5.2 Routing Algorithm

Numerous routing algorithms for Ad Hoc networks exist in the scientific literature, but none of them have yet found the perfect balance between control traffic overhead, convergence speed, and algorithm dependability. Proactive protocols, reactive protocols, position-driven protocols, and numerous protocol families have all been introduced. Unfortunately, none of the existing protocols are able to handle vehicular networks' high node mobility and typical urban propagation conditions efficiently. This study has developed an IoVs routing protocol that can adapt to changing network conditions by including real-time data on vehicle traffic, route stability by using road-based routes, and geographic forwarding. To find routes, an integrated routing protocol has been developed.

5.3 Research Design & Procedure

The RL algorithm is a sort of learning that engages with its surroundings by creating actions and assessing successes or failures. This method makes it possible for software agents and robots to regularly manage the desired behaviour contained by a certain situation with the intention of increase the network performance. In machine learning, the environment is normally expressed as a Markov decision process (MDP) as various RL algorithms apply dynamic programming method. Protocols for Greedy perimeter Stateless Routing (GPSR) have been incorporated with this technique. In order to optimize a particular performance measure, each protocol is initially created for two alternative IoV situations (City and Highway) in terms of its routing parameters. Additionally, the chosen protocols are updated to automatically adjust the values of their routing parameters to the state of the network. In this study, four measures (throughput, latency, packet delivery ratio, and overhead) were chosen as a target for enhancing network performance. There are four steps in the procedure:

i. Routing parameter selection
ii. Initialization
iii. GreedLea design and implementation
iv. Result and evaluation

By determining the best parameter tuning for the current running network and storing them as routing profiles on the host (RSU) side, the GreedLea routing protocol is proposed to lessen the impact of the frequent topology changes and enable routing protocol to reconfigure its routing parameters for running network scenario. GreedLea routing protocol enable vehicles (OBU) to acquire the network profile from the closest host (RSU). GreedLea routing protocol applied initialization process to determine the optimal fine tunes values of routing protocol parameters for a target network scenario which is highway and city. GreedLea routing protocol enable the routing protocol to change its running profile when the vehicle (OBU) changes its surrounding network. For example, when a vehicle (OBU) moved to a city, it starts by contacting the closest host (RSU) to acquire the optimal routing profile that suits the current network and once the vehicle (OBU) move to the new geographical area (highway), it repeats the same procedure to acquire the new routing profile. This method is integrated with the routing protocol by adding two processes (initialization and switching process). Initialization process enabled the host (RSU) to obtain the optimal routing profile while switching process describe the procedure of obtaining the routing profile by the vehicle (OBU). In the initialization process, RL is used then being integrated with GPSR routing protocol. The process started by initializing the routing protocol parameter for specified scenario and performance metric. The initialization process's objective is to determine the optimal fine-tuned values for a set of routing protocols that optimize one of the network performance metrics (throughput, end-to-end delay, PDR, overhead). The optimal solution obtained in initialization process is used as initial condition to find a single solution for all network performance metrics. The initialization process results in a set of parameter fine-tuned values of a routing protocol in IoV scenario. The initialization results are used to design and implement GreedLea routing protocol.

The first phase focused on determining the probable protocol parameters that need to be adjusted during initialization. Based on the adjustable protocols, routing settings are chosen. After the parameters were chosen, each protocol underwent a simulated performance analysis to figure out how each parameter would affect network performance. Three inner-parameters were listed as a result of this stage for the initialization stage to fine-tune.

In the initialization process, network has been divided into part which are vehicle (OBU) and host (RSU). Each part has their own function. The second stage is the Route Selection (RouteSel) process, where GreedLea routing first determines the distance between the location of the last destination and the current node before calculating the shortest path from a neighbour’s table. Then in the third stage which is Route Beaconing (RouteBea). In RouteBea process, the beacon is used for the beaconing process where each node is required to periodically transmit a beacon that includes a node's location and identify to its close neighbours. The next stage is GreedLea process which is the last part of the development and will take place in the OBU nodes. The following sub title will describe in detail each process involved in this study. The GreedLea routing protocol's flow diagram is depicted in Figure 1. In addition, the RL and GPSR will be integrated as profiles that are mapped to the desired IoV scenario. A routing protocol will then be utilized to find the best profile for the active profile.

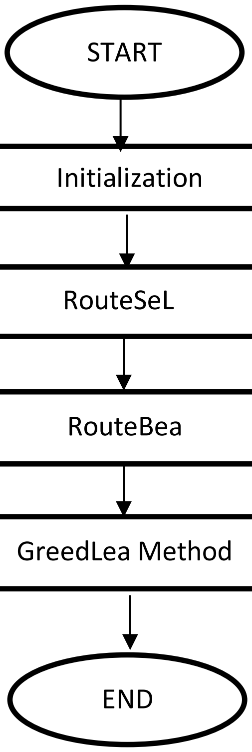


Fig. 1. GreedLea Routing Flow Diagram

Routing protocols perform a significant responsibility in the performances of IoV. The common network routing is GPSR for the geographical routing. This protocol is selected to integrate the RL-method for its merits and features.

5.4. Initialization Process

The initialization process evaluates the initial configuration for a network scenario and stored it as routing profile in the host (RSU). The switching process added to the vehicle (OBU) for adopting the optimal routing profile based on the current attached network. In GreedLea routing protocol, host (RSU) is responsible to find the optimal configuration profile and stored it. The vehicle (OBU) selects the nearest host (RSU) as its parent RSU. The nearest RSU is chosen based on the distance. Moreover, vehicles (OBUs) obtain the better configuration profile from their parent by sending a profile request message. Host (RSU) responses to the profile request message with the fresh profile stored. Initialization process applied two initial condition which is 0 and 1. This initial condition is used to identify the route selection process whether the vehicle (OBU) need to change the route or remain the same route based on certain requirement condition. RL process aimed at fine tuning the routing parameter of a routing protocol that results in highest network performance for a running network situation.

Finding a set of values for the protocol's routing parameter that preserves the optimum network performance for a certain IoV scenario is the major objective of the initialization process in this work. Two IoV scenario (highway and city) are defined for road and traffic. Four performance metrics (throughput, delay, PDR, overhead) are defined as a goal of the initialization problem. Accordingly, two initialization problem can be formulated:

i. For the highway scenario finds a set of a value for inner parameter of GreedLea protocol that
    - maximize the network throughput
    - maximize PDR
    - minimize delay
    - minimize overhead

ii. For the city scenario find a set of a value for inner parameter of GreedLea protocol that
    - maximize the network throughput
    - maximize PDR
    - minimize delay
    - minimize overhead

6. Result and Discussion

The aim of the investigation is to evaluate the GreedLea routing protocol in the IoV network environment. To do this, three performance indicators such as path loss, packet delivery ratio (PDR), and latency have been investigated at different vehicle speeds and travel distances.

6.1 Distance of 100 Meter

The packet delivery ratio, often known as PDR, or the ratio of total sent and received packets, indicates how effectively a network can transmit data. Additionally, the network's packet loss ratio is evaluated using the inverse PDR. Figure 2 contrasts the PDR results for the GreedLea, GPSR, and AODV routing protocols across a distance of 100 meters for varying vehicle velocities. It shows that the average PDR for the GreedLea routing protocol is 99.71 percent for a velocity of 50 mps and 99.83 percent for a speed of 200 mps. When compared to the AODV, the PDR for speeds of 50 mps and 200 mps is 88.93 percent and 89.16 percent, respectively. Given that GreedLea's average PDR for all velocities settings is 99.88 percent and its packet loss is less than 0.1 percent, it can be said to be superior to other existing routing protocols.

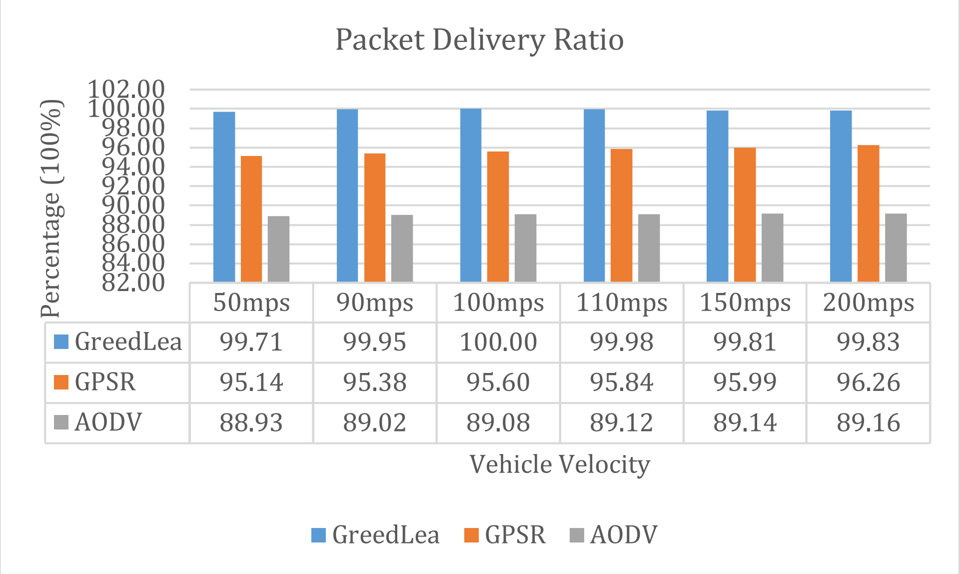
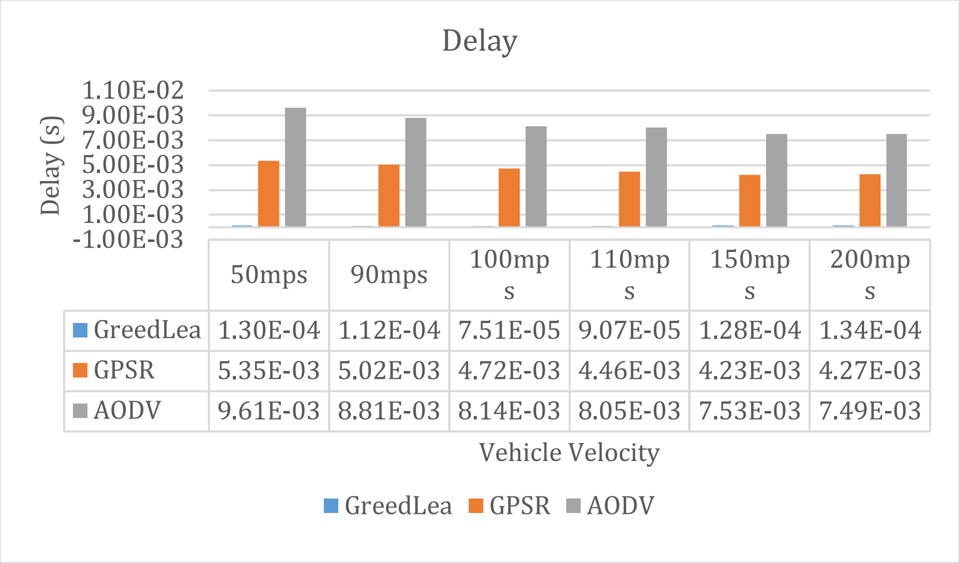


Fig. 2. PDR vs Vehicle Velocity

The overall time required by this method to transmit a packet of information to its intended destination is referred to as the delay. The second serves as the unit of delay. Figure 3 compares the average delay results for the GreedLea routing protocol, GPSR routing protocol, and AODV routing system across a distance of 100 meters for various vehicle or vehicle velocities. It demonstrates that the GreedLea routing protocol has an average delay of 1.30 x 10-4 seconds for 50 mps and 1.34 x 10-4 seconds for 200 mps. In contrast, the GPSR routing protocol has an average delay of 4.27 ms for 200 mps and 5.35 ms for 50 mps. The average latency for the AODV routing protocol is 9.61 ms for 50 mps and 7.49 ms for 200 mps. As a result, GreedLea routing protocol is considered to have a reduced average delay than AODV and GPSR routing protocols.



	50mps	90mps	100mps	110mps	150mps	200mps
GreedLea	1.30E-04	1.12E-04	7.51E-05	9.07E-05	1.28E-04	1.34E-04
GPSR	5.35E-03	5.02E-03	4.72E-03	4.46E-03	4.23E-03	4.27E-03
AODV	9.61E-03	8.81E-03	8.14E-03	8.05E-03	7.53E-03	7.49E-03

Fig. 3. Delay vs Vehicle Velocity

6.2 Distance of 1000 Meter

In Figure 4, the PDR results for the GreedLea, GPSR, and AODV routing protocols are compared at different vehicle velocities over a distance of 1000 metres. It demonstrates that using GreedLea routing protocol, the average PDR for the velocity of 50 mps is 99.90% while it is 100% for the velocity of 200 mps. The PDR is 77.03 percent for a speed of 50 mps and 81.11 percent for a speed of 200 mps when compared to the AODV. As a result, the GreedLea routing protocol's average PDR for all velocities settings is 99.99 percent, which is superior than other existing routing protocols because it results in less than 0.1 percent packet loss. For the GPSR and AODV protocols, the performance of the PDR routing protocols reduces with increasing distance. Additionally, the output starts to suffer from routing overhead brought on by more vehicles as the journey distance increases. The GPSR routing protocol and the AODV routing protocol both have more intermediate vehicles available, hence the path loss value keeps rising as the journey distance increases.

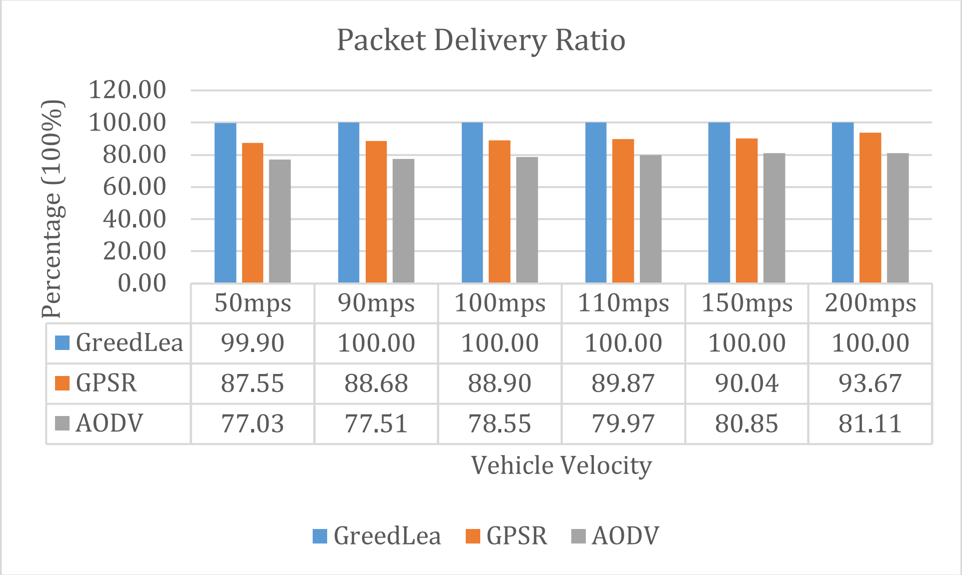


Fig. 4. PDR vs Vehicle Velocity

Figure 5 compares the average delay results for the GreedLea routing protocol, GPSR routing protocol, and AODV routing protocol for various vehicle or vehicle speeds at a distance of 1000 meters. The results demonstrate that the average AODV latency is significantly higher when there are fewer vehicles on the network. This is due to the fact that connections are frequently lost at higher speeds and lower densities, and re-establishing new channels takes a lot of time. As the number of vehicles rises, efficiency improves and the wait gets shorter. The average latency, however, keeps rising as automobile density rises because of the additional overheads associated with routing. On the other hand, there hasn't been much of a change in the typical wait for GreedLea. In GreedLea, overhead from hello beacons is the cause of a little increase in average delay. Since the shortest path in GPSR is determined packet-by-packet and can disseminate with less delay, GreedLea outperforms GPSR and AODV. The outcome indicates that the GreedLea routing protocol has an average latency of 0.929 seconds compared to GPSR's average delay of 0.12 milliseconds and AODV's average delay of 0.19 milliseconds.

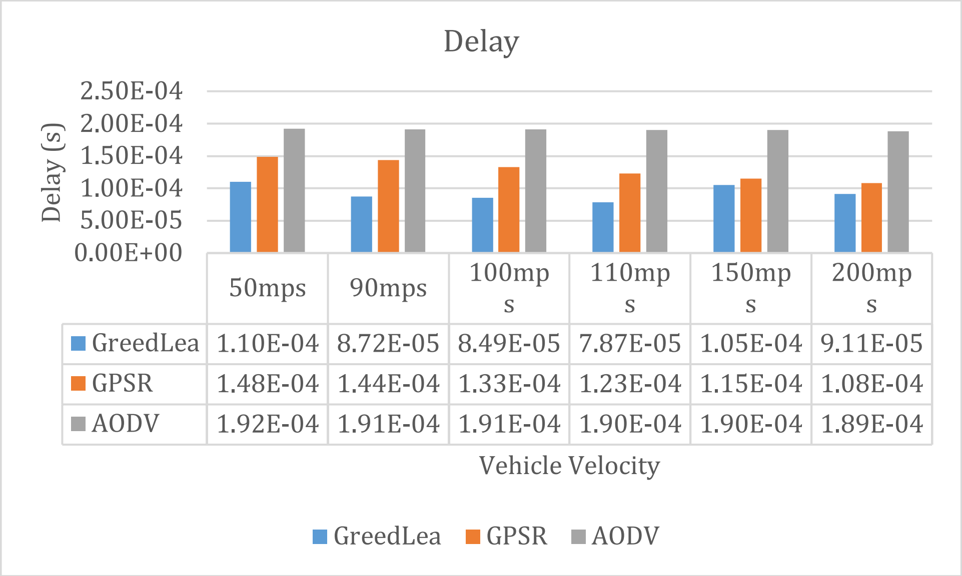


Fig. 5. Delay vs Vehicle Velocity

7. Conclusion

The important channels that enable communication within the IoV and encourage seamless data interchange to increase traffic safety and efficiency are routing protocols. The analysis of current IoV routing protocols that this paper concludes with looks deeply into their difficulties, operational processes, performance benchmarks, and security issues. By painting a vivid picture of their strengths and limitations, this work lays the foundation for future research, innovation, and progress in IoV routing. GreedLea's routing protocol ought to be capable of coping with a fragmented network and quick topology changes. But the current ad hoc routing techniques cannot satisfy these particular requirements. Though the stateless spatial forwarding of these protocols prohibits them from anticipating topological holes (network fragmentation) in route. The difficulties of creating dependable routing protocols for usage in IoV and the difficulty of dynamic network topology are examined in this paper. Routing protocol has grown difficult due to IoV's network partitioning, high mobility, and inconsistent connectivity. For instance, maintaining a connection to a vehicle node presents difficulties due to mobility, changes in network architecture, and frequent changes in traffic circumstances that affect how well the network functions. This divergence could make the network less effective. Getting a consistent level of performance in terms of high throughput, minimal packet loss, and fewer connection failures is another challenging aspect of IoV. To track traffic conditions and congestion, the GreedLea routing system was developed. The results show that when compared to GPSR and AODV routing protocols, the GreedLea routing protocol outperformed existing routing protocols in terms of average delay, packet loss, and path loss. The network performance has been studied based on various vehicle distances and velocities. The outcome indicated that the average delay decreased as vehicle speed increased. GreedLea's performance improves in the PDR, with less than 0.1 percent packet loss and a 20–60% reduction in protocol overhead as vehicle speed increases for beaconing intervals between 1-3 seconds. On the other hand, there hasn't been much of a change in the typical wait for GreedLea. In GreedLea, overhead from hello beacons is the cause of a little increase in average delay. Since the shortest path in GPSR is determined packet-by-packet and can disseminate with less delay, GreedLea outperforms GPSR and AODV.

Acknowledgement

This research was not funded by any grant.

References

[1] Abdelsamee, Nagwan M., Shuroog S. Alsaleh, and Abeer Algarni. "On Simulating Internet of Vehicles." In *2018 21st Saudi Computer Society National Computer Conference (NCC)*, pp. 1-9. IEEE, 2018. https://doi.org/10.1109/NCG.2018.8593142

[2] Ali, Elmustafa Sayed, Mohammad Kamrul Hasan, Rosilah Hassan, Rashid A. Saeed, Mona Bakri Hassan, Shayla Islam, Nazmus Shaker Nafi, and Savitri Bevinakoppa. "Machine learning technologies for secure vehicular communication in internet of vehicles: recent advances and applications." *Security and Communication Networks* 2021 (2021): 1-23. https://doi.org/10.1155/2021/8868355

[3] Atmaca, Ugur Ilker, Carsten Maple, Gregory Epiphaniou, and Mehrdad Dianati. "A privacy-preserving route planning scheme for the Internet of Vehicles." *Ad Hoc Networks* 123 (2021): 102680. https://doi.org/10.1016/j.adhoc.2021.102680

[4] Attia, Radwa, Abeer Hassaan, and Rawya Rizk. "Advanced greedy hybrid bio-inspired routing protocol to improve IoV." *IEEE Access* 9 (2021): 131260-131272. https://doi.org/10.1109/ACCESS.2021.3114646

[5] Bannan, Mark. “Reinforcement Learning for Autonomous Driving and Re-Routing.” 2017.

[6] Bujari, Armir, Jordan Gottardo, Claudio E. Palazzi, and Daniele Ronzani. "Message dissemination in urban IoV." In *2019 IEEE/ACM 23rd International Symposium on Distributed Simulation and Real Time Applications (DS-RT)*, pp. 1-4. IEEE, 2019. https://doi.org/10.1109/DS-RT47707.2019.8958708

[7] Chen, Chen, Lei Liu, Tie Qiu, Jiange Jiang, Qingqi Pei, and Houbing Song. "Routing with traffic awareness and link preference in internet of vehicles." *IEEE Transactions on Intelligent Transportation Systems* 23, no. 1 (2020): 200-214. https://doi.org/10.1109/TITS.2020.3009455

[8] Cheng, JiuJun, JunLu Cheng, MengChu Zhou, FuQiang Liu, ShangCe Gao, and Cong Liu. "Routing in internet of vehicles: A review." *IEEE Transactions on Intelligent Transportation Systems* 16, no. 5 (2015): 2339-2352. https://doi.org/10.1109/TITS.2015.2423667

[9] Contreras-Castillo, Juan, Sherali Zeadally, and Juan Antonio Guerrero-Ibañez. "Internet of vehicles: architecture, protocols, and security." *IEEE internet of things Journal* 5, no. 5 (2017): 3701-3709. https://doi.org/10.1109/JIOT.2017.2690902

[10] Datta, Atreyee. "Modified Ant-AODV-VANET routing protocol for vehicular adhoc network." In *2017 1st International Conference on Electronics, Materials Engineering and Nano-Technology (IEMENTech)*, pp. 1-6. IEEE, 2017. https://doi.org/10.1109/IEMENTECH.2017.8076998

[11] Duduku, V. Viswacheda, Ali Chekima, and Jamal Ahmed Dargham. "Performance Evaluation of Proposed Secured Minimum Delay Routing Protocol (SMDRP) in Vehicular Adhoc Network." In *Proceedings of the Eighth International Conference on Soft Computing and Pattern Recognition (SoCPaR 2016)*, pp. 322-329. Springer International Publishing, 2018. https://doi.org/10.1007/978-3-319-60618-7_32

[12] Genc, Yasin, Nilay Aytas, Ahmet Akkoc, Erkan Afacan, and Erdem Yazgan. "ELCPAS: A new efficient lightweight certificateless conditional privacy preserving authentication scheme for IoV." *Vehicular Communications* 39 (2023): 100549. https://doi.org/10.1016/j.vehcom.2022.100549

[13] Hai-Tao, Zhao, Du Ai-Qian, Zhu Hong-Bo, Li Dapeng, and Liu Nan-Jie. "Research on Q-learning based channel access control algorithm for internet of vehicles." In *2016 International Computer Symposium (ICS)*, pp. 491-496. IEEE, 2016. https://doi.org/10.1109/ICS.2016.0104

[14] Hassan, Abeer, Radwa Attia, and Rawya Rizk. "Internet of vehicles and intelligent routing: A survey-based study." In *International Conference on Advanced Machine Learning Technologies and Applications*, pp. 517-531. Cham: Springer International Publishing, 2022. https://doi.org/10.1007/978-3-031-03918-8_43

[15] Husnain, Ghassan, Shahzad Anwar, and Fahim Shahzad. "An Enhanced AI-Enabled Routing Optimization Algorithm for Internet of Vehicles (IoV)." *Wireless Personal Communications* 130, no. 4 (2023): 2623-2643. https://doi.org/10.1007/s11277-023-10394-4

[16] Magaia, Naercio, Pedro Ferreira, Paulo Rogério Pereira, Khan Muhammad, Javier Del Ser, and Victor Hugo C. de Albuquerque. "Group'n route: An edge learning-based clustering and efficient routing scheme leveraging social strength for the internet of vehicles." *IEEE Transactions on Intelligent Transportation Systems* 23, no. 10 (2022): 19589-19601. https://doi.org/10.1109/TITS.2022.3171978

[17] Mazouzi, Mohamed, Khaleel Mershad, Omar Cheikhrouhou, and Monia Hamdi. "Agent-Based Reactive Geographic Routing Protocol for Internet of Vehicles." *IEEE Access* (2023). https://doi.org/10.1109/ACCESS.2023.3299230

[18] Merdrignac, Pierre, Oyunchimeg Shagdar, and Fawzi Nashashibi. "Fusion of perception and v2p communication systems for the safety of vulnerable road users." *IEEE Transactions on Intelligent Transportation Systems* 18, no. 7 (2016): 1740-1751. https://doi.org/10.1109/TITS.2016.2627014

[19] Nazari, Mohammadreza, Afshin Oroojlooy, Lawrence Snyder, and Martin Takác. "Reinforcement learning for solving the vehicle routing problem." *Advances in neural information processing systems* 31 (2018).

[20] Pandey, Alok Nath, Piyush Agarwal, and Sachin Sharma. "IoV Enabled Route Optimization Technique for Combat Vehicles." In *2022 4th International Conference on Inventive Research in Computing Applications (ICIRCA)*, pp. 310-317. IEEE, 2022. https://doi.org/10.1109/ICIRCA54612.2022.9985649

[21] Kumar, Sushil, Rishi Pal Singh, Arvind Kumar, Ritesh Yaduwanshi, and Durga Prasad Dora. "TS-CAGR: Traffic sensitive connectivity-aware geocast routing protocol in internet of vehicles." *Ad Hoc Networks* 147 (2023): 103210. https://doi.org/10.1016/j.adhoc.2023.103210

[22] Punia, Divya, and Rajender Kumar. "A novel extended Kalman filter-based optimized routing approach for IoV environment." *Advances in Engineering Software* 173 (2022): 103250. https://doi.org/10.1016/j.advengsoft.2022.103250

[23] Qureshi, Kashif Naseer, Muhammad Ahmed, Gwanggil Jeon, and Francesco Piccialli. "An enhanced multi-hop intersection-based geographical routing protocol for the internet of connected vehicles network." *IEEE Transactions on Intelligent Transportation Systems* 22, no. 6 (2021): 3850-3858. https://doi.org/10.1109/TITS.2021.3049429

[24] Rana, Kamlesh Kumar, Sachin Tripathi, and Ram Shringar Raw. "Analytical analysis of improved directional location added routing protocol for VANETS." *Wireless Personal Communications* 98 (2018): 2403-2426. https://doi.org/10.1007/s11277-017-4980-y

[25] Senouci, Oussama, Saad Harous, and Zibouda Aliouat. "An efficient weight-based clustering algorithm using mobility report for IoV." In *2018 9th IEEE Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON)*, pp. 614-620. IEEE, 2018. https://doi.org/10.1109/UEMCON.2018.8796619

[26] Sharif, Abida, Jian Ping Li, Muhammad Asim Saleem, Gunasekaran Manogran, Seifedine Kadry, Abdul Basit, and Muhammad Attique Khan. "A dynamic clustering technique based on deep reinforcement learning for Internet of vehicles." *Journal of Intelligent Manufacturing* 32 (2021): 757-768. https://doi.org/10.1007/s10845-020-01722-7