An Improved Method to Evaluate the Vehicle's Encounter with Events in the VANET with the Approach of Developing Non-Linear Methods

Farzaneh Kaviani[1], Mohammadreza Soltanaghaei[2]
Department of Computer Eng., Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran.
Email: f.kavyani96@gmail.com
Department of Computer Eng., Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran.
Email: soltan@khuisf.ac.ir

ABSTRACT:
Data exchange between vehicles as network nodes, like other ad-hoc networks, due to the lack of stability infrastructure and central management, and the complete distribution of the network platform, have led to attract many parts of today's researches. In this article, an improved method has been presented in order to evaluate the encounter of the vehicle with the incident, and the interaction of data related to the incidents for use in the vehicle ad-hoc networks. The proposed method has been developed based on the basic indicators of evaluating the node's encounter with events in vehicle ad-hoc networks and has been strengthened based on the advantages and capabilities of fuzzy logic, so that the desired and expected result is obtained from the output of the set. In order to evaluate the performance of the proposed method, developments and implements were based on the OPNET simulator and this method was compared with the VESPA and VESPA-DM methods as the most important researches in this field. The simulation results indicated the superiority of the proposed method over past researches.

KEYWORDS: Vehicle Ad Hoc Networks, Evaluation of Vehicle Encounters with Events, Event Sharing Management, Fuzzy Logic.

1. INTRODUCTION

In today's world, vehicles are considered as the most used means of transportation. Unfortunately, the popularity of this widely used tool has come with several issues such as security and environmental issues. Therefore, in order to reduce vehicle accidents, several programs, which are generally related to the intelligent system of vehicles, have been started in Japan, America and some European countries and they have attracted the attention of many scientific and industrial researchers. The result of this research was the introduction of ADAS (advanced driver assistance system) [1 and 2]. Furthermore, wireless networks were expanded and made it possible to establish wireless IVC (Inter-Vehicle Communications) communication between vehicles. The main purpose of these communications was to increase the security of the vehicle network and its management by exchanging information between nearby vehicles [2]. For example, IVC provides the ability to notify vehicle occupants (through nearby vehicle) of an accident that has occurred on the road ahead of them, or to notify them of an incident in the area. Thus, there is a fundamental difference between Advanced Driver Assistance System (ADAS) and IVC. ADAS provides the ability to analyze data based on information stored on an external memory, while IVC supports and implements IVC during movement [3 and 4].

IVC inter-vehicle wireless communication based on standards such as IEEE802.11p or UWB provides the ability to support wireless network communication with a short range (several hundred meters), and a bandwidth of about megabits/second. [5] Based on the use of such wireless communication technology, network nodes are able to share information related to accidents, parking space, traffic level, etc. [4, 6]. While there are networks with a wide range and

Paper type: Research paper
DOI: 10.30486/MJTD.1402.1104122
Received: 22 November 2023; revised: 17 December 2023; accepted: 28 January 2024; published: 1 March 2024
How to cite this paper: F. Kaviani, M. Soltanaghaei, **"An Improved Method to Evaluate the Vehicle's Encounter with Events in the VANET with the Approach of Developing Non-Linear Methods"**, *Majlesi Journal of Telecommunication Devices*, Vol. 13, No. 1, pp. 41-48, 2024.

high throughput such as GPRS, UMTS (mobile phone networks), but these types of networks do not support the dynamic characteristics of nodes in the network [7]. On this basis and for the quick exchange of information between two vehicles, they will not be effective and practical in order to prevent an accident. Often, these types of technologies can be used in applications such as finding different places, etc.

In vehicle ad hoc networks, in very high mobility and the non-uniform and random movement of nodes [8 and 9], information management is considered a very important and big challenge that the some of these challenges related to this topic will be addressed below:

• Is it necessary to report the information to the driver or send a warning to the driver depending on the location of the vehicle in relation to the information exchanged (shared event).

• What necessary information is reported and what information needs to be provided to other vehicles;

• How should the sharing of information related to events be done (what time and place) so that, in addition to being effective, it does not negatively affect network resources.

In relation to these concepts and challenges, the place and time dimension (the vehicle in relation to the published event) is very important, and correct and optimal decision-making in this connection can play a useful and effective role in improving performance. The high importance of this topic in vehicle networks shows the necessity of providing effective research to improve this field.

In this article, an improved method has been introduced based on the basic indicators of evaluating the vehicle's encounter with the event, focusing on the performance of fuzzy sets. The proposed method consists of two stages of evaluating the encounter of the vehicle with the event and re-sharing the event message. Based on these two stages, it is tried to evaluate the encounter and manage the sharing of events in a favorable way in the context of vehicle networks. The proposed method, based on the operational framework of its stages, provides the ability to evaluate the node's encounter with the event with high accuracy and tries to share the received events with other nodes in the network.

The parts of the article are: the second part is related work, the third part is the approach of the article, the fourth part is the introduction of the proposed improved method, the fifth part is the simulation, the experimental results and the efficiency analysis of the proposed method, and finally, in the sixth part, the summary of the article is presented..

2. RELATED WORK

According to what was presented and considering the importance of the subject of evaluating the vehicle confrontation with the event and its sharing in the vehicle networks, so far, several researches have been presented in this basic field. In this part of the article, we will review some of the most important ones. The purpose of this review is to show the importance of the present article in order to improve the open challenges in the field of evaluating the vehicle encounter with the event and its sharing. Most of the presented articles suffered from neglecting the important and basic indicators of evaluating the vehicle confrontation with the event.

In [10 and 11], crash warning assistant systems have been proposed with the aim of improving the problem of outside the line of sight. In this research, an attempt has been made to evaluate the two factors of the time of encountering an accident and the time of preventing an accident. In [12], methods for message propagation with the aim of minimizing packet delivery delay, which is considered essential in the safety applications of vehicle ad hoc networks, have been proposed. The introduced method works in accordance with congestion control policies and based on the release of safety-emergency packets [13]. In [14 and 15], techniques based on multi-hop propagation of packets with the aim of preventing chain accidents have been proposed. In [16], the traffic visibility of vehicles on multi-lane roads has been investigated. In this work, three types of protocols contain propagation by nodes in the same direction, propagation by nodes moving in the opposite direction, and propagation by nodes moving in both agreeing and opposing directions, are used to analyze the rate of receiving data and the average error rate and [17]. In [18], opportunistic methods derived from medical science are proposed, in such a way that information acts like a disease vector and is transmitted to nearby nodes. In [19-21], other opportunistic methods have been proposed. In these methods, time indicators, and the optimal space are taken into consideration. In the following, three classic storm strategies, epidemic strategy, and proximity are examined. In [22], a method for scaled broadcast based on node position, time condition and information condition is proposed. In [23-25], the probability of an accident and encounter of node with the desired accident have been investigated, and a solution has been suggested for how to pass the accident. In this work, fuzzy logic has been used to evaluate the encounter with an accident. In [26], based on the segmentation of the network platform (city), publications are made in an intelligent manner, based on the importance of the message. In method of [27], the network is divided into separate areas, and based on this, network releases are made so that an implicit control is applied on the release. In [4] and [28], methods aimed at classifying events, evaluating the probability of a node encountering an event, and managing its re-release are proposed. These evaluations have been strengthened in [28], focusing on the advantages of using digital maps in order to increase the accuracy of calculations. In [29-30], the issue of places with low density of vehicles and disruptions in sending messages has been discussed.

In [31] addresses these challenges by proposing a decentralized Blockchain based trust management framework (BC-TMF) aiming to compute trust metrics for vehicles. These trust metrics rely on the authenticity of the messages. Periodically each miner aggregates the received trust metrics into global trust metrics, then packs them in a block.

In [32] proposed an Artificial Intelligence (AI)-based Sugeno fuzzy inference system. The proposed Artificial Intelligence (AI)-based Sugeno fuzzy inference system provides network security, reduces end-to-end delay, and increases packet delivery ratio and throughput. S Nagpal el al. 2022 [33] is focusing on assorted assaults on the VANET environment so that a detailed view of vulnerabilities can be analysed. In addition, the assorted security mechanisms and approaches are underlined and explained to guard against the assaults effectively with a higher degree of performance. In year of 2023 [34] quantifies VANETs to improve their reliability and availability, essential for integrating urban advanced mobility (UAM) into urban infrastructures This research is significant for monitoring UAM systems in future cities, presenting a cost-effective framework over traditional methods and advancing VANET reliability and availability in urban mobility contexts. In [35] proposed a security system based on intrusion detection called Detection of Anomalous Behaviour in Smart Conveyance Operations (DAMASCO). They used a statistical approach to detect anomalies in vehicle-to-vehicle communication (V2V). In [36] discussed the detection and a deep analysis of affects of malicious nodes on the network performance as throughput, average latency, and packets drop in the network. They presented an approach to detect malicious data with Artificial Neural Networks as well as malicious nodes with Support Vector Machines in VANETs. In E Al-Ezaly et al. 2023 [37] used vehicular ad-hoc networks (VANETs) for VANET traffic light recognition (VTLR). Information exchange as well as monitoring of the TL status, time remaining before a change, and recommended speeds are supported.

The past researches suffered the lack of evaluating the variety of events, and some limitations such as increasing the error coefficient of linear equations, and the accuracy of calculations. In this article, the focus has been on providing a method based on important indicators in evaluating the node's encounter with the event and its re-release. These indicators are developed based on the performance of multi-level fuzzy logic to improve the disadvantages and problems of linear and threshold-based decision making. Also, an attempt has been made to use other new indicators in order to improve the accuracy of decision-making and the performance of the proposed method based on wider indicator.

3. PROPOSED METHODS

The proposed fuzzy set is a multi-level set and it is based on Mamdani's fuzzy logic, which is based on a series of if and then rules to derive outputs based on inputs (Fig. 1).

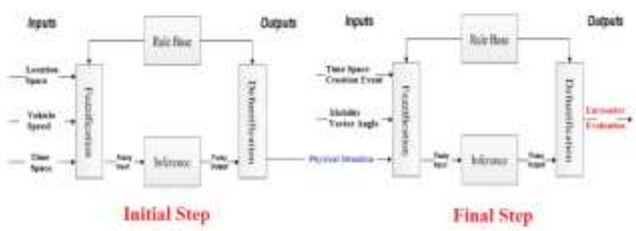

Fig. 1. Overall performance of the proposed multi-level fuzzy set

Finally, based on the function of fuzzy logic, the final result of evaluating the node's encounter with the event is deduced. The final output membership functions are shown in Fig. 2. The higher the output value or encounter probability tends to one (VHigh), the higher the encounter probability.

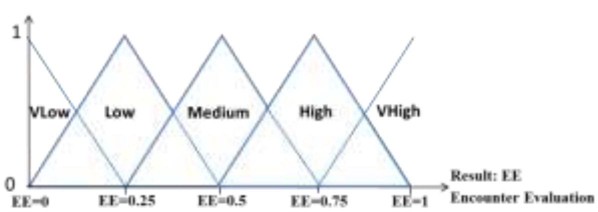

Fig. 2. The final output functions of the proposed fuzzy set.

In relation to the results obtained from the proposed two-stage fuzzy set, if the fuzzy output is obtained in VLow mode, it means that the vehicle will not encounter an event in terms of all the valuable criteria. Therefore, the event message is worthless in this situation, and the desired node ignores its re-broadcast in order to prevent unnecessary traffic injection into the network and to prevent the negative effects of unnecessary message dissemination. The flowchart of the proposed method along with its operational components is shown in Fig. 3.

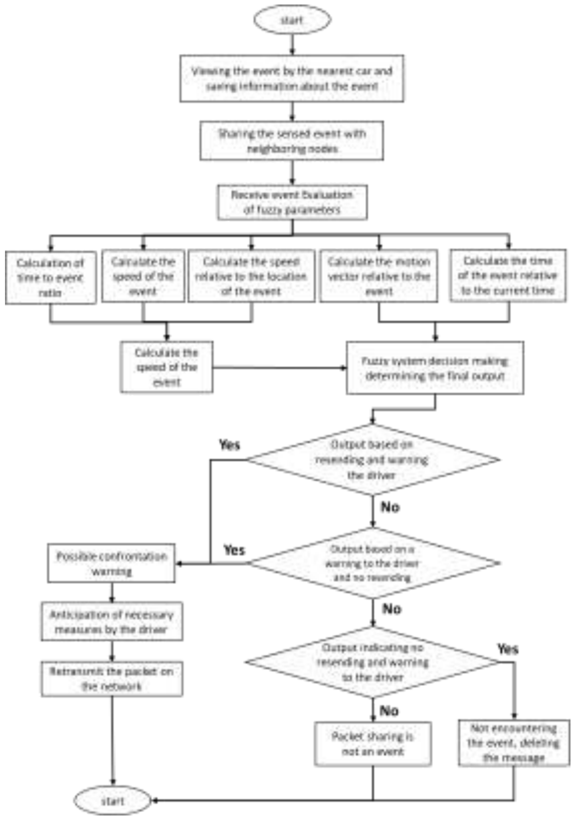

Fig. 3. The flowchart of the proposed method and its operational components.

4. SIMULATION AND EXPERIMENTAL RESULTS

In order to show the effectiveness of the proposed method in the area covered by the article, it has been simulated with the OPNET simulator software. A vehicle ad-hoc network has been designed and simulated using physical layer protocols and MAC (media access control) in IEEE802.11p in the OPNET simulator, and the methods under comparison have been developed based on it. The parameters related to the simulation scenarios are according to the parameters presented in table (1). The proposed method has been compared to VESPA [4] and VESPA-DM [15] for the purpose of comparisons and evaluation.

Table 1. Parameters related t

Parameter	Value
Simulation time	900 s
Start of simulation time	100 s
Vehicle number	100, 150, 200
Network area	10000 m * 10000 m
Vehicle mobility model	Random way point in identified route
The type of traffic sent after the event	Constant Bit Rate (CBR)/UDP
The volume of event packets	1024 byte
Operating mode	802.11p
Transfer rate	27 Mb/s, 6 Mb/s
The speed of node mobility	Randomly between 0-33 m/s (120 km/h)
Create an event	In constant period of time

Fig. 4 shows the rate of receiving published events and Fig. 5 shows the network loading rate in different scenarios. The reception rate is the average number of received event messages and the network loading rate, including the total amount of traffic sent in the network platform for the publication of events. It is reasonable to improve the network resources, including overhead, unnecessary traffic injection, increased calculations and loading, etc. If the compared methods, including the VESPA and VESPA-DM methods have an increase in the error coefficient (error coefficient Astana) and the lack of purposeful decision-making in the accompanying publications, due to the neglect of some important criteria for confrontation evaluation, the use of linear calculations and threshold-based decision-making, which has led to an increase in unnecessary sharing and an increase in network workload and unnecessary traffic injection into the network.

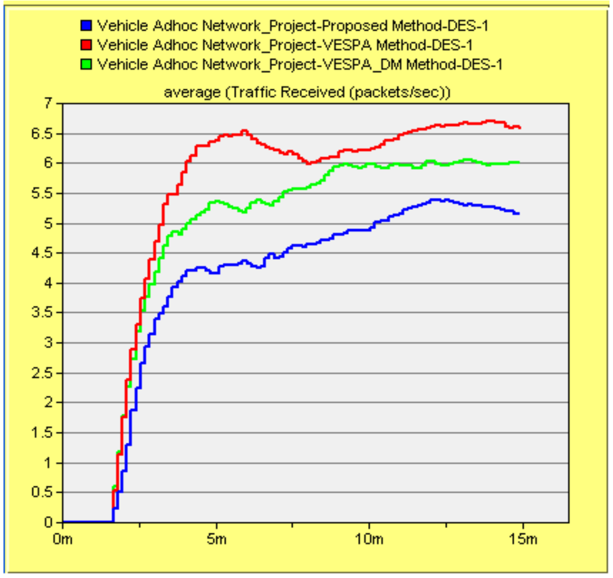

Fig. 4. The rate of receiving published events in the compared methods in different scenarios

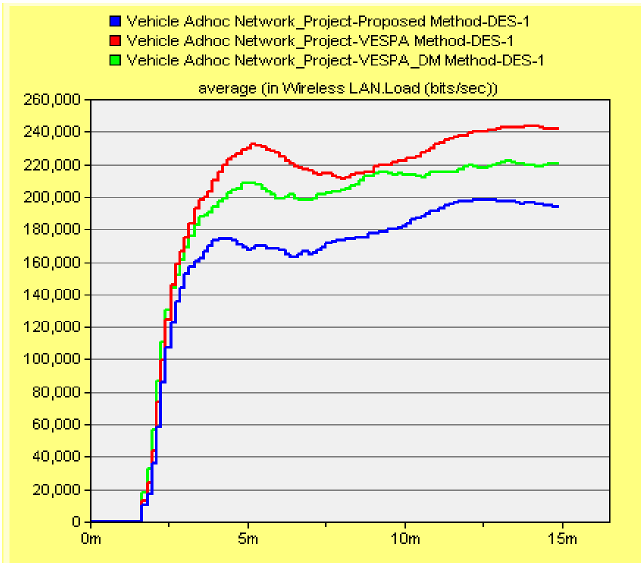

Fig. 5. Network loading rate in the compared methods under different scenarios

Fig. 6 shows the propagation delay and Fig. 7 shows the network efficiency in different scenarios. Event propagation delay is the average delay required to propagate events in the vehicles of the relevant area. The network efficiency includes the evaluation of the correct encounter of the node with the event and the management of the occurrences and will change related to the amount of network load and the propagation delay. These criteria will be improved according to how the methods work in the amount of calculations and the speed of calculations. If the number of releases and updates are optimized and done with higher management, the delay of releases will decrease and the efficiency rate will increase. The performance of the proposed method based on the use of multi-level fuzzy logic and the stated application criteria has increased the speed of decision-making, and has led to the improve and manage the publication of messages related to events at the vehicle network level and optimize sharing of information with the vehicles, which has ultimately reduced the delay and increased the efficiency of the network. In the both VESPA and VESPA-DM methods, due to neglecting some important criteria for confrontation evaluation, and due to the use of applied linear equations in their research, with the lack of optimal sharing and the increase of the error coefficient related to Linear calculations have been associated, which have been associated with increasing delay and decreasing efficiency. On the other hand, the VESPA-DM method, based on the increase in accuracy in performance, based on a digital map, has been more efficient than the VESPA method, especially in relation to moving events, and has been associated with improvement.

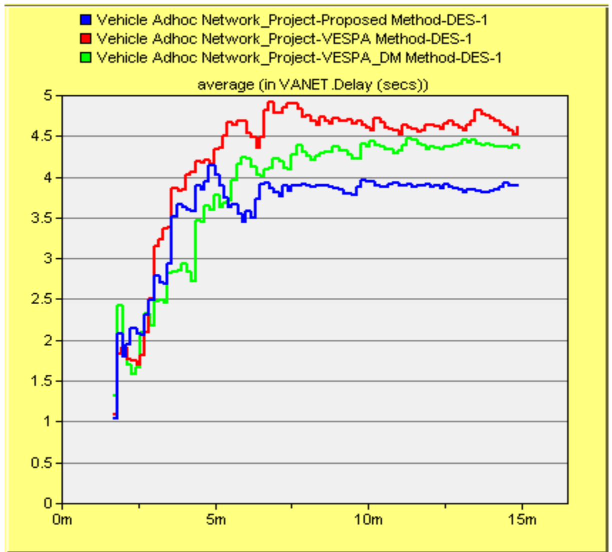

Fig. 6. Delay of sharing and propagation of events in the compared methods in different scenarios.

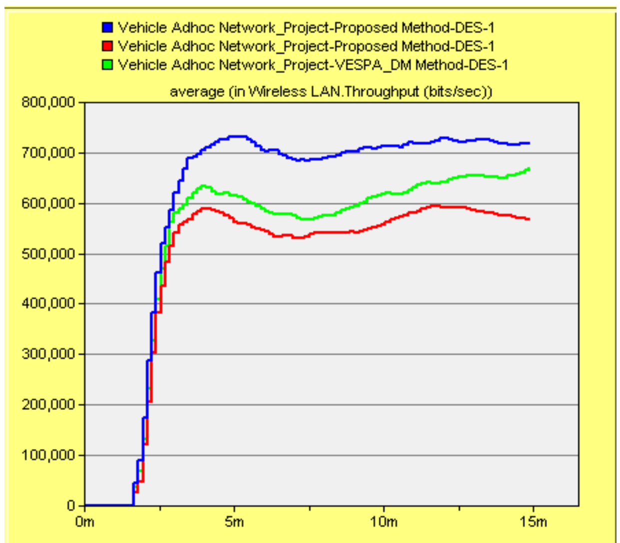

Fig. 7. Network efficiency in the compared methods in different scenarios

5. CONCLUSION AND FUTURE WORK

In this article, a mechanism for assessing the node's encounter with the event and its re-release was introduced with the aim of increasing the accuracy in the calculations of encounter with the published event, and optimizing the exchanges of vehicular networks. The performance of the proposed method has improved the criteria related to the evaluation of the encounter and the exchange management of car networks compared to the previous methods. In the future works, we are trying to make the proposed method more optimal and practical by using predictive criteria such as Markov chain and other criteria related to the evaluation of the vehicle's encounter with the event in the vehicle networks.

REFERENCES

[1] Vadivel, Sharmila, et al. "**Dynamic route discovery using modified grasshopper optimization algorithm in wireless Ad-Hoc visible light communication network**." Electronics 10.10 (2021): 1176.

[2] S Lin, Chia-Hung, et al. "**A survey on deep learning-based vehicular communication applications**." Journal of Signal Processing Systems 93.4 (2021): 369-388.

[3] Wang, Xiaoyan, et al. "**Better platooning toward autonomous driving: Inter-vehicle communications with directional antenna**." China Communications 18.7 (2021): 44-57.

[4] T. Delot, N. Cenerario, and S. Ilarri, "**Vehicular event sharing with a mobile peer-to-peer architecture**," Transportation Research Part C, Vol. 18, pp. 584–598, 2010.

[5] Singh, Pranav Kumar, Sunit Kumar Nandi, and Sukumar Nandi. "**A tutorial survey on vehicular communication state of the art, and future research directions**." Vehicular Communications 18 (2019): 100164.

[6] Yeferny, Taoufik, and Sofian Hamad. "**Vehicular ad-hoc networks: architecture, applications and challenges.**" arXiv preprint arXiv:2101.04539 (2021).

[7] Sharef, Baraa, et al. "**Robust and trust dynamic mobile gateway selection in heterogeneous VANET-UMTS network.**" Vehicular communications 12 (2018): 75-87.

[8] Tian, Jin, and Fudong Meng. "**Comparison Survey of Mobility Models in Vehicular Ad-Hoc Network (VANET)**." 2020 IEEE 3rd International Conference on Automation, Electronics and Electrical Engineering (AUTEEE). IEEE, 2020.

[9] Andrade, Everaldo, et al. "**Analyzing cooperative monitoring and dissemination of critical mobile events by VANETs.**" Wireless Networks 27.3 (2021): 1981-1997.

[10] Madhuri, K., and B. UmaMaheswari. "**Adaptive Steering Control and Driver Alert System for Smart Vehicles**." 2019 3rd International Conference on Computing Methodologies and Communication (ICCMC). IEEE, 2019.

[11] Miller, and Ronald, "**An adaptive peer-to-peer collision warning system,**" In: Vehicular Technology Conference, pp. 317-321, 2002.

[12] X. Yang, J. Liu, F. Zhao, and N. Vaidya, "**A Vehicle-to-Vehicle Communication Protocol for Cooperative Collision Warning**," Mobile and Ubiquitous Systems: Networking and Services, (MOBIQUITOUS), the First Annual International Conference, Vol. 11, pp. 35-43, 2004.

[13] Chehri, Abdellah, et al. "**Realistic 5.9 GHz DSRC vehicle-to-vehicle wireless communication protocols for cooperative collision warning in underground mining**." Smart Transportation Systems 2020. Springer, Singapore, 2020. 133-141.

[14] X. Shouzhi, H. Zhou, C. Li, and Y. Zhao, **"A Multi-Hop V2V Broadcast Protocol for Chain Collision Avoidance on Highways,**" Communications Technology and Applications, (ICCTA'09), Vol. 13, pp. 126-135, 2009.

[15] Urmonov, Odilbek, and HyungWon Kim. "**A multi-hop data dissemination algorithm for vehicular communication**." Computers 9.2 (2020): 25.

[16] T. Nadeem, P. Shankar, and L. Iftode, "**A comparative study of data dissemination models for VANETs,**" In: Third International Conference on Mobile and Ubiquitous Systems (MobiQuitous), pp. 1–10, 2006.

[17] Shahwani, Hamayoun, et al. "**A comprehensive survey on data dissemination in Vehicular Ad Hoc Networks**." Vehicular Communications (2021): 100420.

[18] B. Xu, A.M. Ouksel, and O.Wolfson, "**Opportunistic resource exchange in inter-vehicle ad-hoc networks**," In: Fifth International Conference on Mobile Data Management (MDM), pp. 4–12, 2004.

[19] Azimi Kashani, A., M. Ghanbari, and A. M. Rahmani. "**Improving performance of opportunistic routing protocol using fuzzy logic for vehicular ad-hoc networks in highways**." Journal of AI and Data Minining (2020).

[20] S. Nittel, M. Duckham, and L. Kulik, "**Information dissemination in mobile ad-hoc geosensor networks,**" In: Third International Conference on Geographic Information Science (GIScience), Vol. 3234, pp. 206–222, 2004.

[21] Tomar, Ravi, Hanumat G. Sastry, and Manish Prateek. "**A novel protocol for information dissemination in vehicular networks.**" International Conference on Internet of Vehicles. Springer, Cham, 2019.

[22] Fahad, Muhammad, et al. "**Grey wolf optimization based clustering algorithm for vehicular ad-hoc networks**." Computers & Electrical Engineering 70 (2018): 853-870.

[23] T. Kosch, C. J. Adler, S. Eichler, C. Schroth, and M. Strassberger, "**The scalability problem of vehicular ad hoc networks and how to solve it**," IEEE Wireless Communications, pp. 22–28, 2006.

[24] V. Milanés, J. Pérez, J. Godoy, and E. Onieva, "**A fuzzy aid rear-end collision warning / avoidance system,**" Expert Systems with Applications, Vol. 39, pp.9097-9107, 2012.

[25] Basjaruddin, Noor Cholis, Didin Saefudin, and Anggun Pancawati. "**Hardware Simulation of Rear-End Collision Avoidance System Based on Fuzzy Logic**." Jurnal Rekayasa Elektrika 16.1 (2020).

[26] Rashid, Sami Abduljabbar, et al. "**Prediction Based Efficient Multi-hop Clustering Approach with Adaptive Relay Node Selection for VANET**." J. Commun. 15.4 (2020): 332-344.

[27] J. S. Li, I. Liu, C. Kao and C. Tseng, "**Intelligent Adjustment Forwarding: A compromise between end-to-end and hop-by-hop transmissions in VANET environments**," Journal of Systems Architecture, Vol. 59, pp. 1319-1333, 2013.

[28] T. Delot, S. Ilarri, N. Cenerarioa, and T. Hien, "**Event sharing in vehicular networks using geographic vectors and maps**," Mobile Information Systems, Vol. 7, pp. 21-44, 2011.

[29] K. N. Qureshi, A. H. Abdullah, and J. Lloret, "**Road Perception Based Geographical Routing Protocol for Vehicular Ad Hoc Networks**," International Journal of Distributed Sensor Networks, Vol. 5, pp. 1-17, 2016.

[30] Qureshi, Kashif Naseer, et al. "**Improved road segment-based geographical routing protocol for vehicular ad-hoc networks**." Electronics 9.8 (2020): 1248.

[31] Gazdar T. , Alboqomi O. , et al. (2022). "**A Decentralized Blockchain-Based Trust Management Framework for Vehicular Ad Hoc Networks**", [2624-6511], 5(1):348-363.

[32] Gayathri, M and C Gomathy. "**Ai-Tasfis: An Approach to Secure Vehicle-to-Vehicle Communication**." Applied Artificial Intelligence, vol. 36, no. 1, 2022, p. 2145636.

[33] Nagpal, Shally et al. "**Privacy and Security Issues in Vehicular Ad Hoc Networks with Preventive Mechanisms**." Proceedings of International Conference on Intelligent Cyber-Physical Systems: ICPS 2021, Springer, 2022, pp. 317-329.

[34] Silva, Luis Guilherme et al. "**Urban Advanced Mobility Dependability: A Model-Based Quantification on Vehicular Ad Hoc Networks with Virtual Machine Migration**." Sensors, vol. 23, no. 23, 2023, p. 9485.

[35] Valentini, Edivaldo Pastori et al. "**A Novel Mechanism for Misbehaviour Detection in Vehicular Networks**." IEEE Access, 2023.

[36] Sharan, Bhagwati et al. "**A Novel Approach for Malicious Node Detection in Vehicular Ad-Hoc Network Using Support Vector Machine.**" 2023.

[37] Al-Ezaly, Esraa et al. "**An Innovative Traffic Light Recognition Method Using Vehicular Ad-Hoc Networks**." Scientific reports, vol. 13, no. 1, 2023, p. 4009.