JOURNAL OF MECHANICS OF CONTINUA AND MATHEMATICAL SCIENCES
www.journalimcms.org

ISSN (Online) : 2454 -7190 Vol.-19, No.-8, August (2024) pp 41-59 ISSN (Print) 0973-8975

PERFORMANCE EVALUATION OF HANDOVER TECHNIQUES IN VEHICULAR NETWORKS

Rafid Najm Abdullah Alsaadi

University of Information Technology and Communications, Baghdad, Iraq.

Email: rafdnjm4@gmail.com

https://doi.org/10.26782/jmcms.2024.08.00004

(Received: May 22, 2024; Revised: July 10, 2024; Accepted: July 27, 2024)

Abstract

The VANET customized vehicle network's versatility, cost-effectiveness, accurate sensing, and potential to open up new and exciting remote sensing applications make it an intriguing subject of study. VANET, short for Vehicular Ad Hoc Network, is a network designed to build an automobile network for a specific purpose. VANETs are being developed as reliable networks used by automobiles to prevent road accidents and ensure passenger safety. They also allow automobiles to communicate, sending emergency alerts and entertainment updates on highways and in cities. VANET is a mobile network that predicts and assists drivers and others in life-threatening and road safety-related circumstances. Despite their many benefits, these networks face many challenges due to their nature. Random movement patterns and high-speed mobility change network structure, resulting in frequent deliveries. This issue is especially important in dedicated vehicle networks, which we will discuss here. This article investigates the possibility of transitioning from VANET to the incorporation of LTE, SDN, and ultimately 5G to establish performance.

Keywords: Automobile network**,** Remote Sensing Applications, Road Accidents Vehicular Ad Hoc Network

I. Introduction

The growth of wireless networks and the increasing number of wireless devices, such as remote controls, personal digital assistants, laptops, mobile phones, and automated control technologies, have facilitated their utilization by a growing population and expansion. Given the increasing number of traffic accidents and the growing complexity of road networks, there is an urgent need for a technology that may both prevent accidents and enhance the well-being of road commuters. Vehicular Ad Hoc Networks (VANETs), a novel form of mobile network, were introduced [I-XI]. Figure 1 illustrates the wireless Ad-hoc networks and their components, with VANET networks being a specific category under the broader classification of MANET (Mobile Ad-hoc Network).

A VANET network is a distinct variant of a MANET network. These networks are decentralized and self-organized. The network comprises numerous mobile trucks and communication towers known as RSUs (Road Side Units), which are situated alongside the roads [XII-XV].

Potential advancements in driver and passenger safety and comfort can be achieved by developing new technologies that utilize wireless communication devices between mobile cars on road networks. This network was constructed specifically for Intelligent Transportation Systems (ITS) to enhance transportation efficiency [X-XXVI]. These networks facilitate communication and coordination among cars in order to prevent accidents, notify road users about traffic accidents, prevent traffic congestion, regulate vehicle speed, ensure the smooth passage of emergency vehicles, and prevent unlawful obstructions.

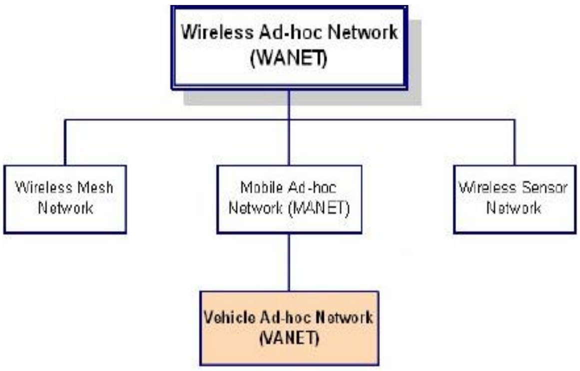

Fig. 1. Wireless Ad-hoc networks. [X]

The structure of this paper is as follows. Section I provides a comprehensive definition of VANET networks and elucidates their advantages. Section II provides an analysis of the communication technologies that can be incorporated into VANET networks along, with an exploration of the handover concept. Moving on to Section III it offers an overview of existing studies related to VANET networks and their improvement. In Section IV we will detail the suggested approach, including the tools to be used for the determination of Measure Metrics and the definition of four work scenarios. Section V will showcase the results of the proposed methodology. Offer an analysis. As for Section VI, covers the conclusion and potential future endeavors. Lastly, Section VII includes all references cited in this research.

II. Background

This part provides an overview of communication technologies that can be incorporated into VANET networks along, with an introduction, to the idea of handover.

Long-Term Evolution (LTE)

LTE, also known as 4G LTE is a wireless communication standard that represents an advancement, in mobile technology. It was developed to meet the growing demand for data transfer, reduced latency, and enhanced connectivity in a society dependent on mobile devices and data usage. Compared to its forerunner 3G (Third Generation) LTE presents an improvement, with higher data speeds and overall efficiency [L-LX].

LTE stands out for its IP (Internet Protocol) architecture facilitating data transfer, over mobile networks and the web. The device operates on frequency bands, including unlicensed ones providing adaptable connectivity, in urban, suburban, and rural areas. LTE uses multiple antenna strategies, like MIMO (Multiple Input, Multiple Output) and efficient spectrum management techniques to enhance data speed making it ideal for tasks that require a lot of bandwidth, such, as streaming multimedia content, high-definition video calls, online gaming and more.

LTE stands out for its latency, which is crucial, for time-sensitive tasks like voice calls, online gaming, and IoT devices. The decrease, in latency, is achieved through a network structure and by minimizing delays related to packet switching. Figure 2 provides an overview of the applications of LTE technology.

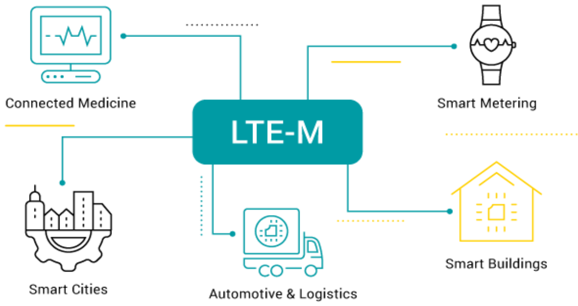

Fig. 2. Applications of LTE

A. Software-Defined Networking (SDN)

Software Defined Networking (SDN) stands for an approach, to network design, management, and operation that marks a departure from traditional methods. In network setups devices like routers and switches handle both control and data forwarding functions within a hardware unit. This integrated setup can pose challenges when adapting to changing network requirements and services due, to its inflexibility. SDN addresses these limitations by separating the control logic from the data forwarding process resulting in a customizable and agile network infrastructure [L-LX].

Software-defined networking (SDN) revolutionizes networking by dividing the control and data planes, enabling centralized network management powered by software. This technique provides more flexibility, scalability, and adaptability in network operations, making it an essential facilitator for contemporary, dynamic, and responsive network infrastructures. SDN continues to lead the way in innovation as network demands grow, enabling enterprises to fully utilize their networks to meet the dynamic requirements of the digital age. Figure 3 illustrates the SDN method.

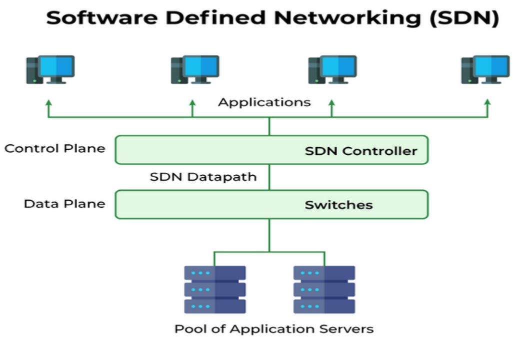

Fig. 3. SDN method.

B. Fifth Generation of Mobile Networks (5G)

5G, the fifth generation of mobile networks, signifies a significant advancement in wireless technology that has the potential to transform the way we connect, communicate, and engage with the digital realm. 5G represents a substantial improvement over its predecessor, 4G LTE, in terms of speed, capacity, latency, and connectivity. This technology heralds a new era of interconnectedness that will have a major influence on multiple businesses and our everyday existence [I-LX].

5G is a revolutionary advancement in mobile technology that provides quicker speeds, less delay, increased capacity, and improved connectivity. It also enables the development of innovative apps and services in several industries. The influence of this technology extends beyond the enhancement of our smartphones. It has the capacity to completely transform our way of life, work, and engagement with the digital realm. This will bring about a new era of unparalleled connectedness and technical progress. Figure 4 represents the concept of a 5G network.

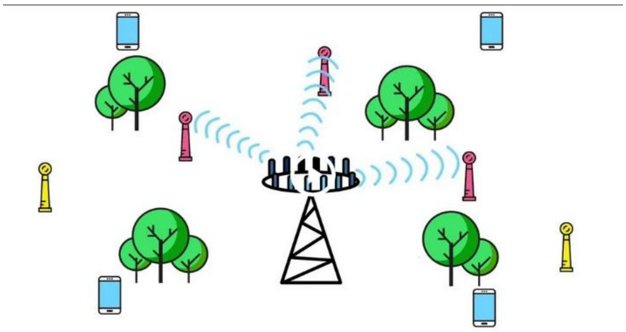

Fig. 4. 5G network.

C. Handover

Handover is the act of moving a mobile device from one cell to another and establishing a connection with the new base station [XLVI-LX]. The handover is essential to guarantee the uninterrupted connection between the devices during their physical separation. Handover can take various forms, with horizontal Handover and vertical Handover being the most significant.

Horizontal handover is the act of transferring a connection between two devices that are either identical or have comparable characteristics. Conversely, vertical handover refers to the process of transferring a connection between two devices that possess separate or varied features. Deliveries can be categorized according to many attributes, including flexible handover, fixed handover, and reactive handover [XVIII].

The handover primarily occurs as a result of the deterioration of signal strength in the service cell. When the User Equipment (UE) moves beyond the coverage area of the cell. To ensure a consistent connection, a user equipment (UE) may transition its connection to a neighbouring cell that has superior signal quality compared to the present service cell. Several key factors are taken into account while defining the Handover, such as high population density, coverage of the mobile network, movement patterns, allocation of resources within the network, protocols, and analysis of network topology and its related parameters.

III. Related Work

The researchers improved system efficiency by developing a fuzzy approach based on demand time, download, and upload time to manage network resources, as described in the research [X-L]. In a separate study [XLVIII], a fuzzy system was used to dynamically regulate the transmission force required to hold the car. The paper [XLIX] describes a fuzzy system that efficiently transmits information in VANET networks. In this system, a node rebroadcasts the information, and the fuzzy system relies on many input parameters, including communication, transmission, and node coverage.

The study [L] suggested including a fuzzy approach to describe the dependability and security of in-vehicle networks. This involved measuring the reliability of each node as it communicated with another node. In another research project [LI], the dependability value was determined by considering factors such as the quantity of packets, the rate at which packets are repeated, and the similarity of nodes. This analysis was conducted using a neural fuzzy controller. Paper [LII] contains a collaborative learning method was employed to enhance the precision of the vehicle's positioning during navigation when the GPS signal is unavailable.

A study [LIII] introduces a learning algorithm that utilizes (MABs) to optimize data publication through prefetching in the vehicle cloud system. The learning algorithm is employed to ascertain the success rate of the unidentified network, therefore enabling the construction of an optimal binary decision matrix for determining the approach to data prefetching from the data center. In their study [LIV], researchers effectively managed data congestion by categorizing messages based on message type, size, and validity. By utilizing the K-mean algorithm, they were able to significantly enhance the transfer rate, reduce latency, and minimize packet loss. The research [55] introduces a reinforcement learning technique that enhances the RSU access scheduling by considering the limitations of a power source (rechargeable battery). This algorithm leads to improvements in the RSU throughput and other Qos metrics.

The study [LVI] improved the forecasting of road safety in VANET through the use of an analysis-incorporated network known as FMCNN. Furthermore, they applied a network to anticipate road safety by integrating feature interactions gathered during the pre-training phase. In a study [LVII], researchers introduced a faceted optimization framework tailored to tackle the challenge of selecting mobile gateways, in VANET networks. This optimization strategy is geared towards enhancing the connectivity of consumer vehicles and ensuring load distribution.

IV. Method

A. Tools

NS 3, also known as Network Simulator 3 is a software platform used to design and analyze computer network simulations. It employs a discrete event approach to accurately model and simulate the behavior of computer networks. This tool is widely used for research and development, in network protocols, communication systems, and related applications. Ns 3 is an open-source network simulation framework mainly used for research purposes. It operates on an event-driven basis allowing researchers, engineers, and developers to create models of network scenarios, experiment, with network protocols and configurations, and evaluate different networking technologies' effectiveness.

B. Measure Metrics

Throughput: The speed at which data is effectively sent or received on a communication channel, network, or system is known as throughput. Throughput measures the amount of data that can be moved across a network and is essential, for evaluating the effectiveness of network functions.

Packet Loss Ratio: measuring the percentage of data packets that don't make it to where they're supposed to go when sent through a network or communication channel. This measurement is usually expressed as a percentage or fraction showing how many packets were lost out of the number sent. When there's a rate of loss it can lead to performance issues, more retransmissions, and lower service quality. Keeping an eye on the number of lost packets helps assess how well a network is doing overall and spot any issues.

Received Delivery Packet: Successful reception and delivery of data packets, within a network or communication system are essential for assessing data transmission effectiveness analyzing delivery efficiency, and identifying loss or network issues. Monitoring the number of received delivery packets is key, to evaluating these aspects.

C. Scenarios of Work

This paper discusses how four types of handover scenarios are carried out in settings. The scenarios are displayed in Table 1.

Table 1: Scenarios of work.

No.	Information about Scenario
Scenario 1	Implement handover in VANET.
Scenario 2	Implement handover in VANET with LTE.
Scenario 3	Implement handover in VANET with SDN.
Scenario 4	Implement handover in VANET with 5G.

i. Scenario 1

In this scenario, we employ handover in VANET by utilizing a variety of VANET protocols. Three VANET protocols will be utilized during the handoff process, followed by the calculation of throughput, which refers to the rate at which data packets are received successfully at their intended destinations. Figure 5 depicts the throughput during a handover scenario for each protocol type. The protocols can be described as the following;

a. AODV (Ad hoc On-Demand Distance Vector) is a routing system that establishes routes between nodes only when necessary, minimizing overhead by maintaining active routes. However, the efficiency of this protocol can lead to delays in route discovery and setup compared to proactive protocols like OLSR and DSDV.

b. OLSR is a proactive routing technique that keeps routing information up-to-date using a table-driven approach. It uses control messages to continuously update routing tables, reducing route-finding time but increasing the number of control messages sent.

c. DSDV (Destination-Sequenced Distance Vector) is a proactive routing technique that maintains a comprehensive list of destinations in its routing table. It uses sequential numbers and a distance-vector algorithm to ensure up-to-date routes without loops.

However, frequent updates in dynamic networks like VANETs result in increased overhead.

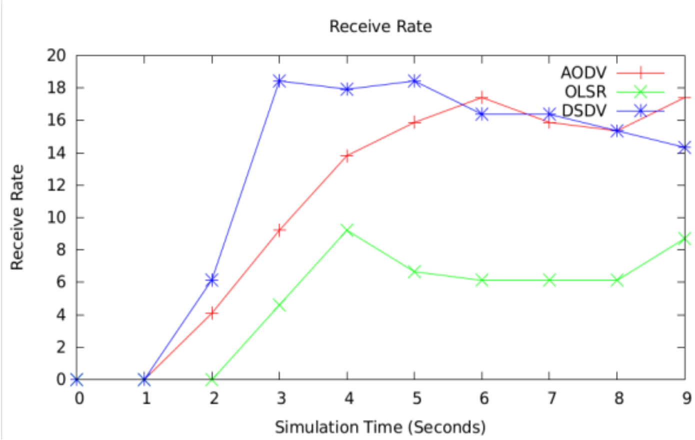

Fig. 5. Throughput during the handover scenario.

Figure 5 indicates that the throughput is significantly higher when utilizing AODV. However, it should be noted that AODV's on-demand approach, while it may have faster route setup times, could lead to more frequent route discoveries. This can have an impact on the received rate during the formation of routes.

After determining that AODV is the most effective routing protocol for handover, we implemented AODV as shown in Figure 6. Subsequently, we performed a handover and measured the throughput during the handover process.

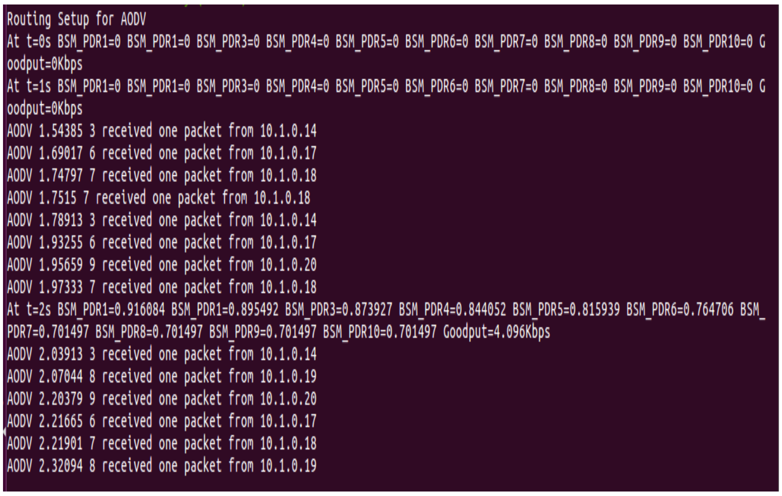

Fig. 6. Handover under only AODV.

Figure 7 displays the result that was obtained from the calculation of throughput. It was found the handover process made the throughput increase.

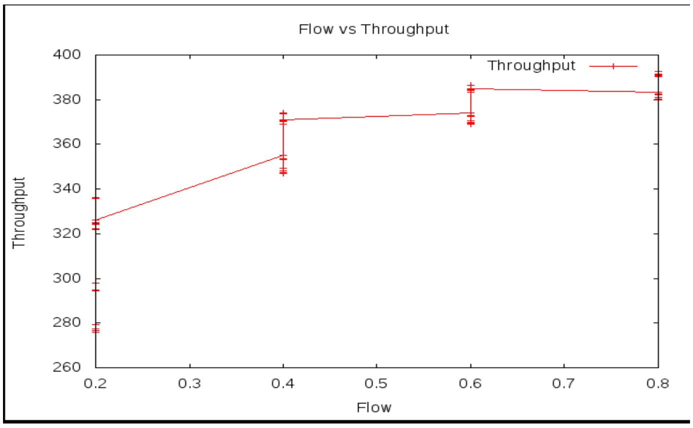

Fig. 7. Throughput under handover.

Next, we determine the packet loss rate and the packet delivery rate for successful packets. Figure 8 illustrates the metrics values in VANET.

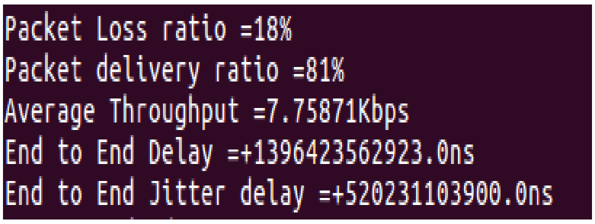

Fig. 8. Metrics in VANET.

ii. Scenario 2

In the field of LTE (Long-Term Evolution) and cellular networks, a "handover," also referred to as a "handoff," is the procedure of shifting an ongoing communication session or data connection from one cell or base station to another as a mobile device (such as a smartphone or tablet) or user equipment (UE) moves throughout the network. Handovers are an essential component of cellular communication systems and have a critical function in guaranteeing uninterrupted connectivity for mobile users.

The integration of VANETs with LTE can enhance the handover process, making it more fluid and efficient. The VANET system incorporates LTE (Long-Term Evolution) cellular technology, enabling vehicles to establish connections with both RSUs (Roadside Units) and LTE base stations. Handovers between RSUs and LTE base stations can be efficiently handled by optimizing characteristics such as signal strength, load, and available bandwidth. The utilization of LTE-V2X (Vehicle-to-Everything) communication protocols can be implemented to improve connectivity.

The handover result in the Vehicular Ad Hoc Network (VANET) with Long-Term Evolution (LTE) is depicted in Figure 9.

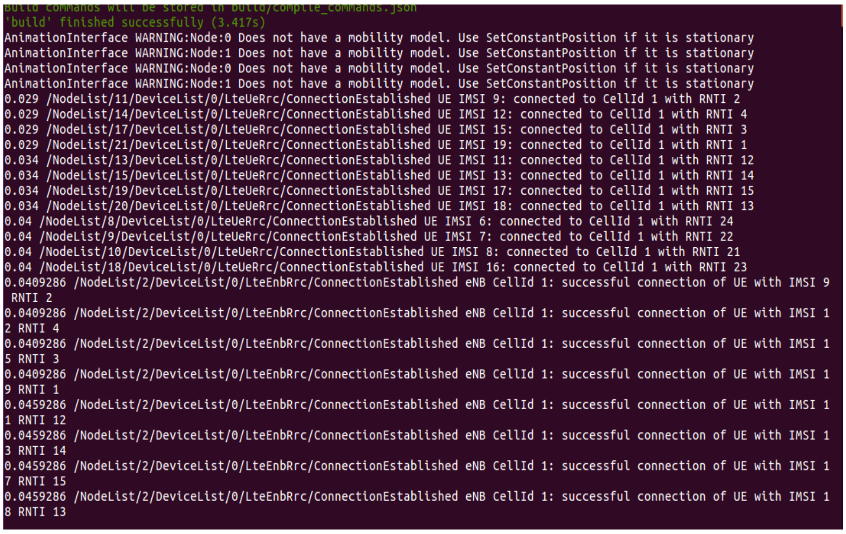

Fig. 9. Handover in VANET with LTE.

Figure 9 displays log entries that signify handover events. Log entries may contain situations where a User Equipment (UE) is initially connected to one eNodeB (eNB) and subsequently establishes a successful connection with another eNB. Handovers occur when User Equipment (UEs) migrate between cells, ensuring uninterrupted communication.

Upon completing the handover, proceed to calculate the metrics. Figure 10 illustrates the metrics values in LTE VANET.

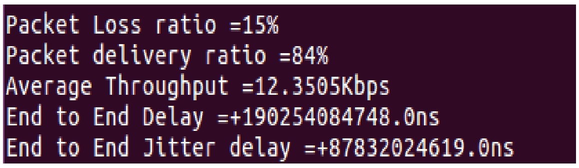

Fig. 10. Metrics in LTE VANET.

iii. Scenario 3

In the area of Software-Defined Networking (SDN), "handover" denotes the act of shifting authority or supervision of network resources and traffic from one network controller or domain to another. Handovers in Software-Defined Networking (SDN) commonly occur when there is a requirement to smoothly transfer or distribute network control between several SDN controllers, domains, or administrative organizations.

Software-defined networking (SDN) in Vehicular Ad Hoc Networks (VANETs) brings about a heightened degree of adaptability and authority in managing the network. SDN controllers effectively oversee and control network resources and the movement of data. The SDN controller can coordinate handovers by making real-time choices using information about network conditions, traffic patterns, and QoS needs. Software-defined networking (SDN) has the capability to enhance handover decisions, resulting in enhanced performance and more efficient utilization of resources. After incorporating SDN architecture into the above situation to improve performance, the handover outcome is depicted in Figure 11.

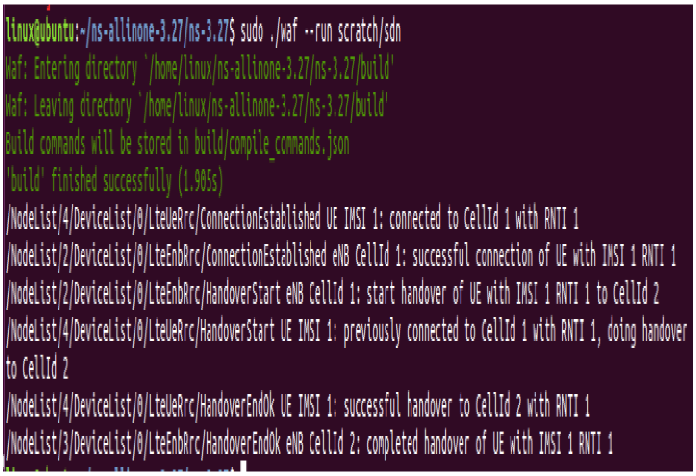

Fig. 11. Handover in VANET with SDN.

Figure 11 illustrates the effective implementation of a handover procedure in an LTE network with SDN, showcasing the advantages of SDN in overseeing and enhancing network operations, such as handovers, to enhance user satisfaction and network efficiency. Figure 12 illustrates the metrics values in SDN VANET.

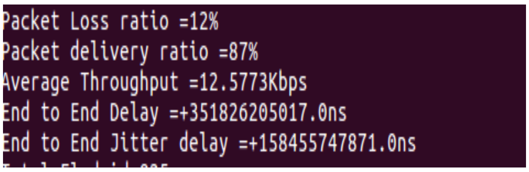

Fig. 12. Metrics in SDN VANET.

iv. Scenario 4

In 5G (Fifth Generation) wireless networks, a "handover," also referred to as a "handoff", is the procedure of transferring an ongoing communication session or data transmission from one cell or base station (eNodeB or gNodeB) to another, while ensuring uninterrupted continuity of the session. Handovers are crucial for ensuring uninterrupted and consistent connectivity of mobile devices as they transition within the network's service area or encounter variations in signal strength and quality.

Handovers are essential for facilitating movement and ensuring uninterrupted connectivity in 5G networks. They serve a wide range of applications, including voice conversations, video streaming, Internet of Things (IoT), and vital services. The 5G standard incorporates sophisticated handover techniques to optimize efficiency, minimize latency, and enhance the overall user experience in a dynamic and continuously changing wireless environment. Figure 13 illustrates the metrics values in 5G VANET.

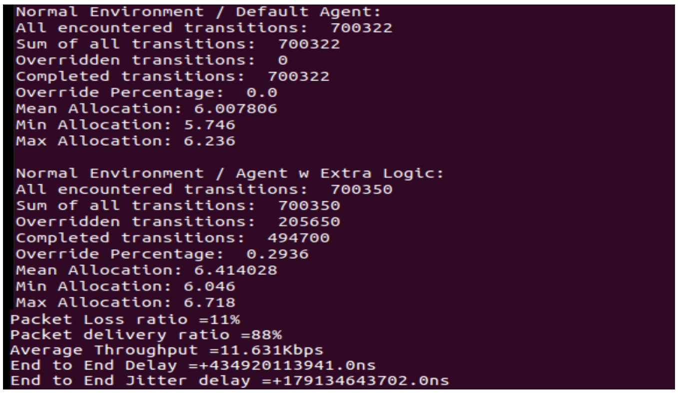

Fig. 13. Metrics in SDN VANET.

Vehicular ad hoc networks (VANETs) that are combined with 5G technology get advantages from the fast data transfer speeds, little delay, and extensive device connection provided by 5G networks. Handoffs between 5G base stations are anticipated to be exceptionally rapid and effective. 5G NR and C-V2X technologies facilitate sophisticated vehicular communication and support autonomous car applications. The network slicing capabilities of 5G enable the creation of unique slices for various VANET services, each with customized Quality of Service (QoS) needs.

V. Results and Discussion

In a traditional VANET scenario, where vehicles connect with each other directly in an ad-hoc way, the 18% packet loss rate poses a substantial obstacle to sustaining dependable communication. Such a high amount of packet loss can cause interruptions in the transfer of data, which can have a negative impact on applications like vehicle-to-vehicle (V2V) communication and safety-critical communications. In each scenario, Figure 14 illustrates the rate of loss.

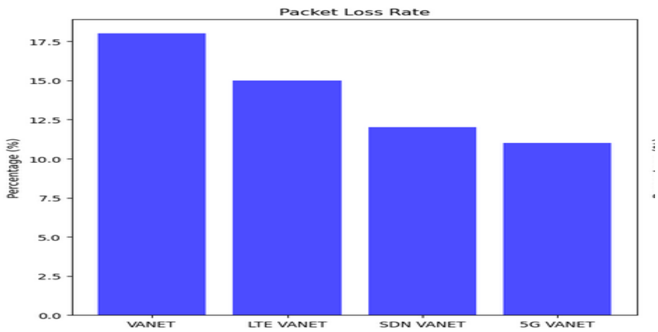

Fig. 14. Rate of packet loss.

The integration of Long Term Evolution (LTE) technology, in Vehicular Ad Hoc Networks (VANETs) aims to improve connectivity and reduce data loss when compared to VANETs. However, a 15% packet loss rate suggests that there is room for improvement. Term Evolution (LTE) Vehicle Ad Hoc Networks (VANETs) could offer reliability and lower latency, than VANETs without LTE integration.

In the SDN VANET scenario, there is a decrease, in the number of lost packets with a rate of 12%. This indicates that integrating Software Defined Networking (SDN) enhances the reliability of delivering packets. SDN enables networks to be managed dynamically and resources to be allocated efficiently. As a result it can reduce loss. Enhance communication, within vehicular ad hoc networks (VANETs).

The scenario involving 5G VANET showcases performance boasting an 11% packet loss rate. When 5G technology is integrated into VANETs there is an enhancement, in the reliability of delivering packets. The 11% packet loss rate illustrates the capability of the 5G VANET environment to reduce data packet losses particularly when encountering challenges like mobility, varying signal conditions, and the need for quick communication. The advanced features of 5G, such as reliable low latency communication (URLLC) and network slicing play a pivotal role in achieving this outstanding packet loss rate. The infrequent instances of loss in "5G VANET" offer advantages, for applications requiring immediate data exchange, including autonomous driving, traffic management, and critical safety communication. In each scenario, Figure 15 illustrates the rate of packet delivery.

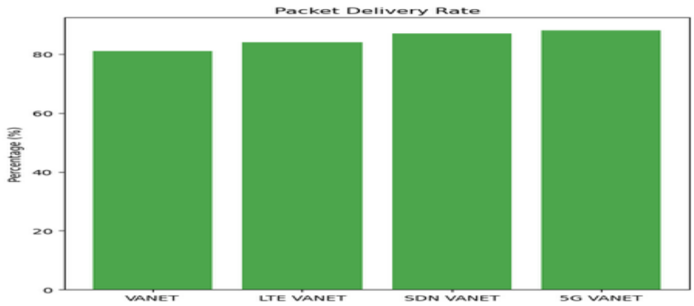

Fig. 15. Rate of packet delivery.

In a VANET environment the delivery success rate, for packets stands at 81%. This statistic shows that a significant amount of data packets manage to reach their destinations within the VANET system with challenges, like movement and changing signal conditions.

The scenario involving "LTE VANET" showcases an improvement, in the success rate of delivering packets reaching 84%. The integration of LTE technology enhances the reliability of transmitting data packets, in VANETs.

In "SDN VANET" scenario, the delivery speed of packets goes, up to 87%. The utilization of Software Defined Networking (SDN) improves the delivery process and communication resulting in a packet delivery rate.

In the scenario involving "5G VANET," it achieves a delivery rate of 88% as mentioned before. This underscores the effectiveness of 5G technology, in ensuring data packet transmission, within VANETs.
In essence, the findings indicate that "5G VANET" excels, in minimizing loss and achieving a rate of packet delivery. This technology is well suited for critical communication needs in vehicles focusing on reliability and swift communication, with delays. The incorporation of sophisticated technology is ongoing, thereby improving the capabilities of vehicle networks and their capacity to facilitate various applications. The integration of Internet of Things (IoT) devices, microstrip devices like antennas and filters, and cybersecurity plays a crucial role in enhancing handover techniques in vehicular networks. IoT devices provide real-time data and connectivity for vehicles, enabling seamless communication and information exchange. Microstrip devices, such as antennas and filters, help improve signal reception and transmission, which is

essential for reliable communication between vehicles and infrastructure. Additionally, cybersecurity measures are vital to protect the integrity and privacy of data exchanged in vehicular networks, ensuring secure handover processes and preventing potential cyber threats [II, XV, XXV, XXVII, XXIX, XLI, LIX, LXII-LXIV, LXX, LXXII].

VI. Conclusion and Future Work

In this research, we studied VANET networks under several scenarios to reveal the significant impact of advanced technologies in redefining vehicular communications and preparing the delivery process in them.

This research addresses the development from traditional VANET to the integration of LTE, SDN, and eventually 5G and the impact of this development on the significant advances in performance metrics for packet loss rate and packet delivery rate as they are fundamental factors that affect the effectiveness of the handover process, which is very important in vehicular networks.

Among the studied scenarios, the “5G VANET” scenario, in which we see an exceptional achievement with an 11% lower packet loss rate, was the best. The result we have achieved with 5G VANET networks ensures connectivity through a seamless transmission process, as vehicles move between cells or base stations. 5G VANET providing fast connectivity and reducing packet loss is very important in many tasks such as driving and traffic control.

It has been observed that the use of “VANET”, “LTE VANET”, and “SDN VANET” greatly affects the handover process, as it helps in improving the reliability of handover transfers, which reduces the chances of service interruption during network switching. While using 5G VANET, it involves improvements in loss rates and handover rates resulting in an efficient and effective handover process.

Improving the delivery phase provides opportunities to enhance road safety, enhance traffic management, and improve the operation of self-driving cars. By incorporating cutting-edge technologies, such as 5G, we can ensure optimization while enabling decision-making during deliveries, leading to a better user experience.

In the realm of cutting-edge networks, upcoming studies need to concentrate on creating environments that are completely independent, safe, and eco-friendly. These environments should empower vehicles to communicate collectively enhance routes and enhance road safety.

This forthcoming effort should include integrating edge computing to facilitate decision-making enforcing security protocols embracing hybrid network structures for seamless connectivity designing innovative interfaces, for human vehicle engagement, and incorporating sustainable energy alternatives.

Furthermore, it is crucial for researchers to play a role, in shaping frameworks, legislation, and ethical standards to ensure accountable execution and emphasize the societal benefits. The objective is to convert vehicular networks into robust, disaster-prepared systems that enhance the safety, intelligence, and sustainability of transportation, addressing the expanding requirements of a swiftly changing world.

Conflict of interest:

The author declares that there was no conflict of interest regarding this paper.

References

I. Ahmed, A., Merghem-Boulahia, L. and Gaiti, D. (2011) 'An intelligent agent-based scheme for vertical handover management across heterogeneous networks', *Annals of Telecommunications*, pp.583–602.

II. A. R. Azeez, "UWB tapered-slot patch antenna with reconfigurable dual band-notches characteristics," J. Mech. Contin. Math. Sci., vol. 19, no. 3, 2024.

III. Ahmed, A., Boulahia, L.M. and Gaiti, D. (2013) 'Enabling vertical handover decisions in heterogeneous wireless networks: a state-of-the-art and a classification', *IEEE Communications Surveys and Tutorials*, Vol. 16, No. 2, pp.776–211.

IV. Alexey Vinel, A new routing protocol for the reconfigurable wireless networks, in: Universal Personal Communications Record, 1997, Conference Record, 1997 IEEE 6th International Conference, 2012, pp. 562–566.

V. Araniti, G., Campolo, C., Condoluci, M., Iera, A. and Molinaro, A. (2013) 'LTE for vehicular networking: a survey', *IEEE Communications Magazine*, pp.148–157.

VI. Azzali, F., Ghazali, O. and Omar, M. (2011) 'Performance analysis of vertical handover in vehicular ad-hoc network using media independent handover services', *Journal of Telecommunication, Electronic and Computer Engineering*, Vol. 9, No. 2, pp.13–18.

VII. Azzali, F., Ghazali, O. and Omar, M.H. (2017) 'Fuzzy logic-based intelligent scheme for enhancing Qos of vertical handover decision in vehicular ad-hoc networks', *Proceedings of the International Research and Innovation Summit (IRIS'17), IOP Conference Series: Materials Science and Engineering*, Doi: 10.1088/1757-899X/226/1/012081.

VIII. Banda, L., Mzyece, M. and Noel, G. (2013) 'Fast handover management in IP-based vehicular networks', *Proceedings of the IEEE International Conference on Industrial Technology (ICIT'13)*, IEEE, South Africa, pp.1279–1284.

IX. Bhoi, S and Khilar, p. ―*Vehicular communication: a survey". IET Commun* , 2014, Vol. 3, Iss. 3, pp. 204–217.

X. Bi, Y., Tian, L., Liu, M., Liu, Z. and Chen, W. (2016) 'Research on joint handoff algorithm in vehicles networks', *Hindawi Chinese Journal of Engineering*. Doi: 10.1155/2016/3190264.

XI. B. K. Chaurasia, S. Verma, et al., "Infrastructure based authentication in VANETs", *International Journal of Multimedia and Ubiquitous Engineering*, vol. 6, no. 2, pp. 41–54, April, 2011.

XII. Deb, R., & Roy, S. (2022). A comprehensive survey of vulnerability and information security in SDN. Computer Networks, 206, 108802.

XIII. E. Limouchi, I. Mahgoub, and A. Alwakeel, "Fuzzy Logic-based Broadcast in Vehicular Ad hoc Networks," *2016 IEEE 84th Veh. Technol. Conf.*, pp. 1–5, 2016.

XIV. F. Aadil, S. Rizwan and A. Akram, "Vehicular Ad Hoc Networks (VANETs), Past Present and Future: A survey," *In HET-NETs, The Seventh International Working*, England, UK, 2013.

XV. F. Abayaje et al., "A miniaturization of the UWB monopole antenna for wireless baseband transmission," *Periodicals of Engineering and Natural Sciences*, vol. 8, no. 1, pp. 256–262, 2020.

XVI. F. D. da Cunha, L. Villas, et al., "Data communication in VANETs: Survey, applications and challenges", *Ad-Hoc Networks*, vol. 44, pp. 90–103, 2016. Elsevier.

XVII. G. G. Md. Nawaz Ali and E. Chan, "Co-operative load balancing in multiple road side units (RSUs)- based vehicular ad hoc networks (VANETs)", *International Journal of Wireless Networks and Broadband Technologies*, vol. 1, no. 4, pp. 1–21, 2011.

XVIII. Hakak, S., Gadekallu, T. R., Maddikunta, P. K. R., Ramu, S. P., Parimala, M., De Alwis, C., & Liyanage, M. (2022). Autonomous Vehicles in 5G and beyond: A Survey. Vehicular Communications, 100551.

XIX. Handover management in dense cellular networks: A stochastic geometry approach," in Proc. IEEE Int'l Conference on Communications (ICC), 2016, pp.

XX. HASBULLAH, H. SOOMRO, I. and MANAN, J. ―*Denial of Service (DOS) Attack and Its Possible Solutions in VANET*," International Science, Vol.4, No.5, 2010, 348-352.

XXI. H. Hartenstein and K. P. Laberteaux, *VANETs: Vehicular Applications and Inter-Networking Technologies*, Wiley, UK, 2010.

XXII. H. Zhao, T. Mao, J. Duan, Y. Wang, and H. Zhu, "FMCNN : A Factorization Machine Combined Neural Network for Driving Safety Prediction in Vehicular Communication," *IEEE Access*, vol. 7, pp. 11698–11706, 2019.

XXIII. Isaac, J. Zeadally, S and Camara, J. ―*Security attacks and solutions for vehicular ad hoc networks*‖. IET Commun., 2010, Vol. 4, Iss. 7, pp. 894–903.

XXIV. Jain, A and Sharma, D. ―*Approaches to Reduce the Impact of DOS and DDOSn Attacks in VANET*‖. International Journal of Computer Science (IIJCS), Volume 4, Issue 4, April 2016,1-5.

XXV. H. A. Hussein, Y. S. Mezaal, and B. M. Alameri, "Miniaturized microstrip diplexer based on FR4 substrate for wireless communications," Elektron. Ir Elektrotech., 2021.

XXVI. J. Li, N. Song, G. Yang, M. Li, and Q. Cai, "Improving positioning accuracy of vehicular navigation system during GPS outages utilizing ensemble learning algorithm," *Inf. Fusion*, vol. 35, pp. 1–10, 2017.

XXVII. J. K. Ali and Y. S. Miz'el, "A new miniature Peano fractal-based bandpass filter design with 2nd harmonic suppression," in *2009 3rd IEEE International Symposium on Microwave, Antenna, Propagation and EMC Technologies for Wireless Communications*, 2009.

XXVIII. J. Mo, B. Huang, and X. Cheng, “Improving security and stability of ad hoc on-demand distance vector with fuzzy neural network in vehicular ad hoc network,” *Int. J. Distrib. Sens. Networks*, vol. 14, no. 10, pp. 1–15, 2018.

XXIX. K. M. Arrad et al., “Cybercrime Challenges in Iraqi Academia: Creating Digital Awareness for Preventing Cybercrimes,” International Journal of Cyber Criminology, vol. 16, pp. 15–31, 2022.

XXX. Kabir, H. ―*Research Issues on Vehicular Ad hoc Network*‖. International Journal of Engineering Trends and Technology (IJETT), Volume 6 Number 4- Dec 2013,174-179.

XXXI. Kumar, V. Mishra, S and Chand, N. ― *Applications of VANETs: Present & Future*‖ Communications and Network, 2013, 5, 12-15.

XXXII. Kaur, H and SupreetKaur, M. ―*Security mechanism for Collision Avoidance and Attack Prevention Formants*‖. International Journal of Computer Trends and Technology (IJCTT) – volume 23 Number 2 – May 2015, 72-75.

XXXIII. LA, V, H. and CAVALLI, A. ―*SECURITY ATTACKS AND SOLUTIONS IN VEHICULAR AD HOC NETWORKS: A SURVEY*‖. International Journal on AdHoc Networking Systems (IJANS), Vol. 4, No. 2, April 2014, 1-20.

XXXIV. Mahi, M. J. N., Chaki, S., Ahmed, S., Biswas, M., Kaiser, M. S., Islam, M. S., ... & Whaiduzzaman, M. (2022). A review on VANET research: Perspective of recent emerging technologies. IEEE Access, 10, 65760-65783.

XXXV. Mahmoud Hashem Eiza, VADD: Vehicle-assisted data delivery in vehicular ad hoc networks, IEEE Trans. Veh. Technol. 57 (3) (2012) 1910–1922.

XXXVI. M. S. Jameel, Y. S. Mezaal, and D. C. Atilla, “Miniaturized coplanar waveguide-fed UWB antenna for wireless applications,” *Symmetry (Basel)*, vol. 15, no. 3, p. 633, 2023.

XXXVII. M. Q. Mohammed, S. Yaqeen, and S. K. Mezaal, *Harnessing cloud of thing and fog computing in Iraq: administrative informatics sustainability*, Journal of Mechanics of continua and mathematical sciences, vol.19, no.2, pp. pp 66-78, 2024.

XXXVIII. Mahmoud Hashem Eiza, Routing in vehicular ad hoc networks, A survey, IEEE Veh. Technol. Mag. 2 (2) (2013) 12–22.

XXXIX. Martinez, F. Toh, CH. Cano, J and Calafate, C. ―*A survey and comparative study of simulators for vehicular ad hoc networks (VANETs)*‖. WIRELESS COMMUNICATIONS AND MOBILE COMPUTING ,Wirel. Commun. Mob. Comput. (2009).

XL. Mobarhan, M. A., & Salamah, M. (2023). REPS-AKA5: A robust group-based authentication protocol for IoT applications in LTE system. Internet of Things, 100700.

XLI. M. S. Shareef *et al.*, "Cloud of Things and Fog computing in Iraq: Potential applications and sustainability," *Heritage and Sustainable Development*, vol. 5, no. 2, pp. 339–350, 2023.

XLII. M. Petracca, P. Pagano, R. Pelliccia, et al., "On board unit hardware and soft-ware design for vehicular ad-hoc Networks", *Roadside Networks for Vehicular Communications: Architectures, Applications and Test Fields* (Eds. R. Daher, A. Vinel), pp. 38–56. IGI Global, 2013).

XLIII. M. Fahad, F. Aadil, S. Ejaz, and A. Ali, "Implementation of Evolutionary Algorithms in Vehicular Ad-Hoc Network for Cluster Optimization," *2017 Intell. Syst. Conf.*, pp. 137–141, 2017.

XLIV. MOKHTAR, B. and AZAB, M. "*Overview of security issues in Vehicular Ad-hoc Networks* ", Alexandria Engineering Journal, Vol. 54, No. 4, December 2015, 1115-1126.

XLV. N. Taherkhani and S. Pierre, "Centralized and Localized Data Congestion Control Strategy for Vehicular Ad Hoc Networks Using a Machine Learning Clustering Algorithm," *IEEE Trans. Intell. Transp. Syst.*, vol. 17, no. 11, pp. 3275–3285, 2016.

XLVI. PATHRE, A. AGRAWAL, CH. and GAIN, A. ‗*A Novel Defense Scheme against DDoS Attack in VANET*'' Tenth International Conference of Wireless and Optical Communications Networks (WOCN), , IEEE 2013.

XLVII. Piran, M. Murthy, G and Babu, G. ―*VEHICULAR AD HOC AND SENSOR NETWORKS; PRINCIPLES AND CHALLENGES*‖. International Journal of Ad hoc, Sensor & Ubiquitous Computing (IJASUC) Vol.2, No.2, June 2011,38-49.

XLVIII. QIAN, Y. LU, K and MOAYERI, N, ―*A SECURE VANET MAC PROTOCOLFOR DSRC APPLICATIONS*‖, Global Telecommunications Conference, 30 Nov.- 4 Dec. 2008.

XLIX. Qian, Y. LU, K and Moayeri, N. ―*A SECURE VANET MAC PROTOCOL FOR DSRC APPLICATIONS*‖, IEEE "GLOBECOM" 2008.

L. Qian, Y and Moayeri, N. *"DESIGN SECURE AND APPLICATION ORIENTED VANET", IEEE* Vehicular Technology Conference, 2008. VTC Spring 2008.

LI. Raya, M and Hubaux ,J. ―*The Security of Vehicular Ad Hoc Networks*‖. SASN'05, November 7, 2005, Alexandria, Virginia, USA.

LII. R. Kim, H. Lim, and B. Krishnamachari, "Prefetching-Based Data Dissemination in Vehicular Cloud Systems," *IEEE Trans. Veh. Technol.*, vol. 65, no. 1, pp. 292–306, 2016.

LIII. R. F. Atallah, C. M. Assi, and J. Y. Yu, "A Reinforcement Learning Technique for Optimizing Downlink Scheduling in an Energy- Limited Vehicular Network," *IEEE Trans. Veh. Technol.*, vol. 66, no. 6, pp. 4592–4601, 2017.

LIV. R. Nirmala and R. Sudha, "A relativity cram between MANET and VANET background along routing protocol", *International Journal of Advanced Information Science and Technology(IJAIST)*, vol. 26, no. 26, pp. 153–157, June 2014.

LV. Selvan, T. Subramanian, K and Rajendiran, R. —*A Holistic Protocol for Secure Data Transmission in VANET*‖. International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 6, December 2013.4840- 4846.

LVI. Stampoulis, A and Chai, Z. *"A Survey of Security in Vehicular Networks***".**

LVII. S. A. Soleymani, A. H. Abdullah, M. Zareei, M. H. Anisi, C. Vargas-Rosales, M. K. Khan, and S. Goudarzi, "A Secure Trust Model Based on Fuzzy Logic in Vehicular Ad Hoc Networks With Fog Computing," *IEEE Access*, vol. 5, pp. 15619–15629, 2017.

LVIII. S. P. Godse and P. N. Mahalle, "Intelligent authentication and message forwarding in VANET". *International Journal of Smart Vehicles and Smart Transportation (IJSVST)*, vol. 3, no. 1, pp. 1–20, 2020. doi:10.4018/IJSVST.2020010101.

LIX. S. Roshani, "Filtering Power Divider Design Using Resonant LC Branches for 5G Low-Band Applications," *Sustainability*, vol. 14, no. 19, 2022.

LX. S. Retal and A. Idrissi, "A multi-objective optimization system for mobile gateways selection in vehicular Ad-Hoc networks," *Comput. Electr. Eng.*, vol. 73, pp. 289–303, 2019.

LXI. S. Sulistyo and S. Alam, "SINR and Throughput Improvement for VANET using Fuzzy Power Control," *Int. J. Commun. Syst.*, vol. 31, no. 10, pp. 1–14, 2018.

LXII. S. Roshani et al., "Design of a compact quad-channel microstrip diplexer for L and S band applications," Micromachines (Basel), vol. 14, no. 3, 2023.

LXIII. S. I. Yahya et al., "A New Design method for class-E power amplifiers using artificial intelligence modeling for wireless power transfer applications," Electronics (Basel), vol. 11, no. 21, p. 3608, 2022.

LXIV. S. A. Abdulameer et al., "Cyber Security Readiness in Iraq: Role of the Human Rights Activists," International Journal of Cyber Criminology, vol. 16, pp. 1–14, 2022.

LXV. Tanveer, J., Haider, A., Ali, R., & Kim, A. (2022). An overview of reinforcement learning algorithms for handover management in 5G ultra-dense small cell networks. Applied Sciences, 12(1), 426

LXVI. Tulika. Garg, D and Gore, M. —*A Publish/Subscribe Communication Infrastructure for VANET Applications*‖. IEEE, 2011 Workshops of International Conference on Advanced Information Networking and Applications.

LXVII. X. Li and H. Li, "A survey on data dissemination in VANETs", *Chinese Science Bulletin*, vol. 59, no. 32, p. 4190, 2014.

LXVIII. Xu, Q. Mak, T. Sengupta,R and Ko, j, —*Vehicle-to-Vehicle Safety Messaging inDSRC".* Proceedings of the 1st ACM international workshop on Vehicular ad hoc networks, Philadelphia, PA, USA — October 01 - 01, 2004. Pages: 19-28.

LXIX. Yan, G. Rawat, D and Bista, B. ―*Provisioning Vehicular Ad hoc Networks with Quality of Service*‖. 2010 International Conference on Broadband, Wireless Computing, Communication and Applications, 102-107.

LXX. Y. S. Mezaal and S. F. Abdulkareem, "New microstrip antenna based on quasi-fractal geometry for recent wireless systems," in *2018 26th Signal Processing and Communications Applications Conference (SIU)*, 2018.

LXXI. Y. S. Mezaal, L. N. Yousif, Z. J. Abdulkareem, H. A. Hussein, and S. K. Khaleel, "Review about effects of IOT and Nano-technology techniques in the development of IONT in wireless systems (2018)," International Journal of Engineering and Technology, vol. 7, no. 4, 2018.

LXXII. Y. S. Mezaal, H. H. Saleh, and H. Al-saedi, "New compact microstrip filters based on quasi fractal resonator," *Adv. Electromagn.*, vol. 7, no. 4, pp. 93–102, 2018.

LXXIII. Yousefi, M. Mousavi, M and Fathy, M. ―*Vehicular Ad Hoc Networks (VANETs): Challenges and Perspectives*‖. 6th International Conference on ITS Telecommunications. , 2006.

LXXIV. Zeadally, SH. Hunt, R and Chen, Y. ―*Vehicular ad hoc networks (VANETS): status, results, and challenges*‖. Springer Science+Business Media, LLC 2010.

LXXV. Zeadally, SH. Hunt, R. Chen, Y. Irwin, A and Hassan, A. ―*Vehicular ad hoc networks (VANETS): status, results, and challenges*‖. Springer Science+Business Media, LLC ,2010.

LXXVI. Z. Haitao, Z. Yuting, Z. Hongbo, and L. Dapeng, "Resource Management in Vehicular Ad Hoc Networks: Multi-parameter Fuzzy Optimization Scheme," *Procedia Comput. Sci.*, vol. 129, pp. 443–448, 2018.

LXXVII. Zhu, J and Roy, S, ―*MAC for Dedicated Short Range Communications in Intelligent Transport System*‖. IEEE Communications Magazine • December 2003.