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A Comparative Approach to Establishing Vehicle-2-Vehicle (V-2-V) Communication using Kali Linux and Pre-existing Technique



Abstract: - This research aims to study the implementation of Vehicular-to-Vehicular (V2V) communication using Kali Linux. This initiative will largely cover the protocols and standards of the V2V messages, such as Dedicated Short-Range Communications, all while exploring their practical application, particularly, in the context of packet relaying. The work consists of several steps such as installing Kali Linux, activating the Virtual Private Network and launching the virtual machine with software like Virtual Box. As the implications will be focused on the relaying aspects of V2V message protocols and standards, this will provide substantial insight into their technical and performance aspects. Firstly, one should install Kali Linux, a distribution based on designed for digital forensics and pretesting. The system offers a wide spectrum of possibilities to test multiple networking protocols and techniques, which makes it a Perfect Environment for the experience of V2V. The next part describes the importance of the VPN activation on Kali Linux to secure the communication. VPN is necessary for V2V as they exchange sensitive up-to-date information about traffic and warnings of possible accidents. Also, the third point in this installation scenario is the laboratory setup, which is done using virtual machines. The virtual machine helps create real-life V2V scenarios in a controlled laboratory environment. It is essential for experimenting with different types of protocols and standards in different conditions and traffic simulations to prove the usage and effectiveness of the standards. The protocol and standards part describes the V2V protocols, focusing on DSRC. DSRC is positioned as a base for many protocols and V2V safety applications. Using DSRC, V2I applications are made through the support of roadway infrastructure. DSRC-based V2I possibility is the gateway to a more intelligent national surface system. Finally, the overall performance of the relay activity is tested by running packet delivery ratios for the experiments on the same street and the street cutting the first one at a T-junction. The results are proving the point of protocol and importance. Thus, the present research describes the experience of V2V communication application and performance with the help of Kali Linux possibilities. The research shows that Vehicular-to-Vehicular communication holds many opportunities and perspectives, which will be developed and maintained over time with the help of new technologies.

Keywords: V2V communication, LTE, Kali-Linux, Pre-existing techniques, Proposed technique, VANET Approaches

I. INTRODUCTION

A. VANET Fundamentals

LTE is popularly known as 4G LTE this a significant advancement in the category of wireless communications. It was mainly conceived for use in mobile broadband data communication requirements and covers most of the VANETs' domain. [2].

Vehicular Ad hoc Networks (VANETs) are a subset of Mobile Ad hoc Networks (MANETs) in which vehicles and roadside units (RSUs) form the communication topology. VANETs' ultimate objective is to provide V2V and V2I communications to improve road safety, traffic control [1] and entertainment and comfort of drivers and passengers and the cooperation among vehicles is key to their functionality.

B. The Role of LTE in VANETs

LTE is popularly known as 4G LTE this a significant advancement in the category of wireless communications. It was mainly conceived for use in mobile broadband data communication requirements and covers most of the VANETs' domain. [2].

- **Ubiquitous Connectivity:** LTE offers almost everywhere connectivity in most of the urban and suburban regions which makes [2] it a good candidate for VANETs. This connectivity lets vehicles remain connected to one another and also with such objects as traffic signals, road signs, and a central traffic control center.

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- *High Data Rates:* They claimed that LTE can sustain high data rates, which enable the system to send the required amount of data in the shortest time possible. This is very important in VANETs where the communication delay and throughput significantly impact the forward collision warning, lane change advisories traffic signal information, etc., and infotainment [3].
- *Quality of Service (QoS):* LTE includes QoS protocols that can allow safety relevant information to be superior to non-precious data for instance an emergency brake signal.
- *Low Latency:* Due to the nature of VANETs communication delay is a major constraint where timely decision has major consequences on road safety. This LTE technology is correct to reduce the communication delay, and therefore it is right for real time applications in VANETs.

II. PRE-EXISTING TECHNIQUES

Vehicular hoc networks (VANETs) have attracted significant attention to communications and resources sharing techniques and protocols have been proposed profusely to meet the dynamic nature of vehicular environments. In this section, we focus in on a thorough literature survey of the various techniques as well as protocols that are applied in VANETs and how they can be characterized in terms of performance and weakness.

A. IEEE 802.11p (WAVE)

The IEEE 802.11p Wireless Access for Vehicular Environments (WAVE) was one of the first standards initially developed for VANETs. It is deployed in the 5.9 GHz band and is designed for use in vehicle-to-vehicle (V2V) communication and vehicle to infrastructure (V2I) [4].

Key characteristics and considerations include:

- *Dedicated Frequency Band:* 802.11p operates in a dedicated frequency band, reducing interference from other wireless technologies and ensuring reliable communication.
- *Short Range:* The technology is primarily designed for short-range communications, making it suitable for safety-critical applications such as collision warnings.
- *Low Latency:* 802.11p offers low-latency communication, making it suitable for time-sensitive safety applications.
- *Limited Scalability:* One limitation is its limited scalability in terms of the number of concurrent users and communication range.

B. Dedicated Short Range Communications (DSRC)

DSRC is a communication standard found in use in the United States and which is based on the IEEE 802.11p standard [5]. They are used in Intelligent Transportation Systems (ITS) where they are applied in attacks like electronic toll collection and vehicle to roadside infrastructure communication.

- *ITS Applications:* It will be also necessary to note that DSRC is already used in such applications as ETC and V2I in traffic control [6].
- *Limited Global Adoption:* Most of its application is implemented in the United States, and this causes problems whenever cars move to another country which uses a different system of communication.

C. IEEE 1609 WAVE Standards

While the 802.11p and DSRC are developed for vehicle communication, the IEEE 1609 standards provide a more set of protocols related to this topic. These standards target both the lower protocols which include the physical and data link layers and the higher protocols the networking and transport layers [7].

- *Full-Stack Solution:* The IEEE 1609 standards contain all the facets of the V2V/WAVE technology that guarantee consonance and compatibility of to-do from different manufactures.
- *Security Mechanisms:* These standards include security mechanisms to protect communication and the privacy of users.

- *Interoperability:* The standards emphasize interoperability and compatibility, allowing for seamless communication among different vendors' equipment.

D. *Geo Networking (ETSI EN 302 636)*

Geo Networking is an ETSI standard aimed to provide means for cooperative vehicular communication system. It is mostly applied together with IEEE 1609 standards [8].

- *Geographic Routing:* Geo Networking emphasizes geographic routing, where messages are forwarded based on their geographic location rather than traditional IP addresses.
- *Efficient Multicast:* The standard supports efficient multicast communications, enabling the dissemination of information to a specific geographical area [9].
- *Scalability:* Geo Networking is known for its scalability and the ability to efficiently handle large numbers of vehicles.

E. *Cellular-Based Approaches*

Apart from these vehicle-centric communication standards, mobile-network dependent solutions have also tended to become fashionable in VANET leveraging the increased adoption of LTE and 5G. [10].

- *Cellular V2X (C-V2X):* Cellular V2X is a system that builds upon LTE technology to allow direct car-to-car and car-to-infrastructure communication and provides low end-to-end latency with high data rate. It incorporates Vehicle to Everything communication (V2X) and device to device communication (D2D).
- *Advantages:* The cellular-based approach has huge advantages because of the large coverage of the networks and is ideal to be implemented in both the developed and the developing worlds. They can be used to deliver rather essential messages or other classified and relevant non-safety related information to passengers such as movies, TV shows, etc.
- *Challenges:* However, Davenport and Wright's system faces challenges using commercial cellular networks such as congestion, handovers, and subscription costs.

VANETs, as dynamic and complex vehicular environments, present certain challenges and needs that may make it difficult to achieve efficient communication and share resources effectively. Of most importance in the formulation of sound protocols and techniques to handle such incidents is to appreciate such challenges as these. In this part of the paper, we highlight the major issues and minimum prerequisites based on the integration of VANETs and LTE. In this section, we discuss the primary challenges and essential requirements in the context of VANETs and LTE integration.

III. CHALLENGES AND REQUIREMENTS OF PRE-EXISTING TECHNIQUES

A. *Concept of VANETs is high mobility of vehicles.*

- *Frequent Handovers:* Cars are in constant motion with expectations for handover from one base station to another, more often. There should be smooth handover methods such that there are no gaps in communication.
- *Dynamic Network Topology:* Unlike fixed wired network, the topology of VANETs alters frequently because of vehicular mobility. Connectivity, therefore, requires these protocols to change to remain integrated.

B. *Varying Network Conditions*

VANETs work under varying conditions in city roads, intercity motorways, and much more. This varying network condition I have described poses issues:

- *Urban Congestion:* In densely populated areas, the network can be congested which would slow down the running of the networks and therefore the reliability of communications.

- *Rural and Remote Areas:* A few places may not have network coverage or may have a limited coverage making the solutions to be implemented to cover such places.

C. *Low Latency*

Low-latency communication is critical in VANETs, particularly for safety-critical applications:

- *Collision Avoidance:* Some services such as collision avoidance involve warning and response that needs to be transmitted in the shortest time [11].
- *Traffic Management:* Real-time traffic control and congestion alerts require low latency in data communications to be successful.

D. *Scalability*

Scalability is a fundamental requirement for VANETs, as they must accommodate a growing number of vehicles:

- *Concurrent Users:* A major requirement that the network must meet is related to the number of users that are able to communicate simultaneously at any one time.
- *Resource Allocation:* There is a problem with the management of resources when the number of users is large, and there are scarce resources in the network.

E. *Security and Privacy*

Security and privacy are paramount in VANETs, where the reliability of safety-critical messages and the confidentiality of user data is crucial:

- *Secure Communication:* There are certain aspects of secure communication and message integrity that need to be taken to avoid critical attacks [12].
- *User Privacy:* The privacy-preserving technique will be needed since the users of such systems and their data cannot be identified.

F. *Resource Management*

Efficient resource management is vital for optimizing communication in VANETs:

- *Spectrum Utilization:* Preventing interference and congestion in the net can be one of the solutions if the wireless spectrum is well coordinated.
- *Quality of Service (QoS):* QoS mechanisms have become important to want to prioritize safety-sensitive messages over those which are not as critical on time.

G. *Connectivity Across Regions*

As VANETs are not limited to being established within a nation's geographical boundary, the connections need to be smooth when cars move to different zones that use different communication protocols:

- *International Roaming:* Vehicles require communication to occur even when they enter other countries that may use a unique communication standard.
- *Interoperability:* The integration standards and protocols necessary for vehicles to be able to communicate to each other are even pivotal if not more so of the vehicle's origin or destination.

H. *Environmental Considerations*

Environmental factors such as weather conditions can impact communication in VANETs:

- *Harsh Weather:* Domingo noted that Wireless communication is affected by weather conditions such as the rains or snow.

- *Physical Obstructions:* There can always be other barriers to signal reception such as buildings or even more complicated man-made structures such as tall buildings.

IV. PROPOSED TECHNIQUE FOR ESTABLISHING V2V COMMUNICATION

Optimal vehicular networking and common resource pool implementation in Vehicular hoc networks (VANETs) by Long-Term Evolution (LTE) are required to harness the potential of present-day transportation framework [13]. In this section, the reader is introduced to a few advanced and promising ideas and methods that have been considered for VANETs, having regard to its particularities and demands.

A. Cooperative Awareness Messaging (CAM)

Cooperative Awareness Messaging or CAM is one of the cornerstones of the European approach to VANETs. It allows vehicles to share status, location and other safety relevant information with adjacent vehicles [14].

1) *CAM Functionality:* Digital CAM messages include speed, heading and positional information, transmitted from one vehicle to another. These messages form the foundation of several safety applications in the car, such as collision avoidance and control of traffic. CAM messages are performed with low and therefore fast latency times.

2) *Decentralized Resource Sharing:* Decentralized resource sharing solutions are designed to enhance utilization of the network resources and the accomplishment of communication in VANETs. It is noteworthy that these approaches can be subdivided into a few types.

a) *Adaptive Spectrum Allocation:* Compared to dedicated spectrum, this approach efficiently load-balances spectrum depending on traffic conditions and density of vehicles, thus reducing interference, and improving spectrum usage.

b) *Cognitive Radio Networks:* Intelligent access of frequency bands used in the communication by the vehicle means that communication can occur even in evolving environment through the use of cognitive radio technology.

c) *Dynamic Channel Assignment:* According to the communication requirements and traffic patterns, the dynamic channel assignment schemes are used to assign the communication channels to the vehicles.

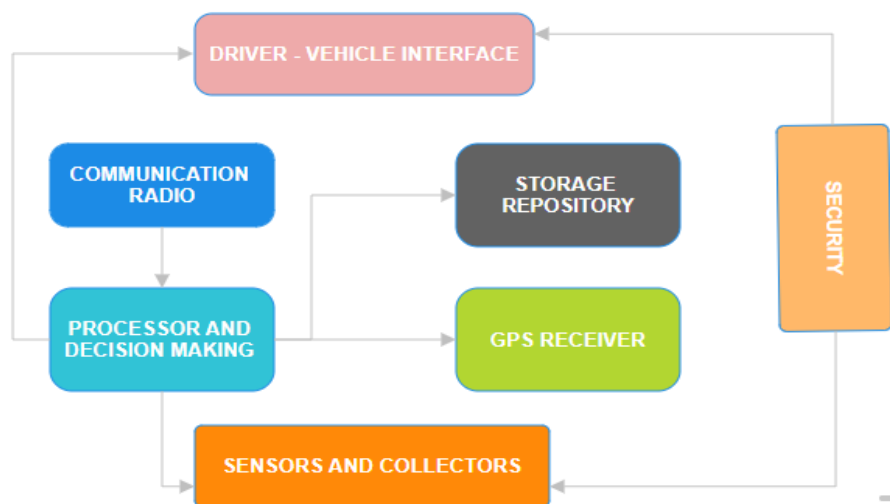


Fig. 1 V2V Communication mode

B. *Geo graphic and Cluster-Based Routing*

Geo graphic and cluster-based routing protocols are designed to enhance the routing mechanism and to minimize overhead in VANETs. These protocols employ the location information to give a path through which to route data [15]. GPSR (Greedy Perimeter Stateless Routing) algorithm which employs geographic routing to spread the messages. Inter cluster-based protocols organize the entire network into clusters, where each of them has a cluster head. This hierarchical approach saves many overheads of route updates and could deliver additional scalability.

C. *Quality of Service (QoS) Mechanisms*

The quality of services required in VANETs varies differently and thus the need to maintain the quality of service for all the types of communication:

- *Message Prioritization:* QoS mechanisms addresses the issue of timing nonetheless differentiates between important messages like warnings and less critical data.
- *Bandwidth Allocation:* This is very important because it assigns bandwidth in proportion to the need of communication for different applications in the available resources.

D. *Security and Privacy Enhancements*

Applying the most recent security and privacy enhancement techniques is crucial to maintaining communication confidentiality in VANETs [16]. Other features such as the digital signature and message authentication code (MAC) make sure that the messages are not intertwined in any ugly ways by somebody.

E. *Multi-Channel Communication*

Portable communications are a method that can make use of many-channel to enable a vehicle to communicate through more than one channel:

- *Load Balancing:* In multi-channel communication, the process implies that the communication load can be divided in that it does not overload any of the channels.
- *Spectrum Diversity:* The use of multiple channels increases spectrum diversity and hence reliability of messages under different network environments.

F. *Fog and Edge Computing*

Fog and edge computing consequent computation near the data source supposes several benefits in VANETs:

- *Low Latency:* data processing at network edge minis latency and leads to the real-time decision which is crucial in safety-related applications.
- *Edge-Based Security:* Security measures that are implemented at this software network level can be able to detect and respond to threats faster.

G. *Machine Learning and Artificial Intelligence (AI)*

To improve the VANET systems and the decision-making Machine learning and AI technique has to be implemented:

- *Traffic Prediction:* Some of the functions include traffic flow predictions, wherein the models learned from them ensure directions of vehicles can switch and speeds adjusted.
- *Anomaly Detection:* The AI algorithms can detect the emerging of curt behaviors in the network, thus making the system secure.

V. COMPARATIVE ANALYSIS

In our case of studying the domain of communication and resource sharing in VANET using LTE, it is imperative to evaluate the current technique and protocols performance over the proposed approaches. Here, we carry out the evaluation and assessment of the performance and efficiency in opposition to each other based on various parameters.

A. Performance Metrics

In order to perform more comprehensive comparative analysis, we choose such indicators of its performance. For that reason, the following measures are central to evaluating the effectiveness of these approaches and procedures

- *Latency:* Reliability and low delay are the two critical factors in VANETs, and more so for safety relevant applications such as collision avoidance. The amount of delay which is introduced by each of the solutions has to be measured.
- *Throughput:* This is usually the measure of the amount of data that can be carried in the network at any one time. Hence, the key performance indicator for VANETs is high throughput due to the requirement of applications like real time traffic information and infotainment.
- *Scalability:* Another parameter is scalability and particularly in the areas where concentration of people traffic is high. It decides whether a solution can scale for accommodating increasing numbers of vehicles.
- *Security:* Some of the security parameters are the capability to maintain confidentiality, integrity of messages, as well as confidentiality of the user's data. To this end, strong security measures, which can be easily adapted to an environment created by intelligent vehicles, need to be in place.
- *Resource Efficiency:* Resource management and the call admission control technique of available spectrum and bandwidths are essential to avoid network traffic congestion and from utilization of available resources.

Table 1 Comparative enhancement of proposed technology

Technology/Protocol	Advantages	Limitations
IEEE 802.11p(WAVE)	-Low latency communication -Short range communication -Dedicated frequency band	-Limited scalability -Security vulnerabilities
Dedicated Short Range Communication (DSRC)	-Widely used in ITS applications -Support for V2I communication -Position as a base for many protocols	-Limited global adoption -Challenges with international roaming
IEEE 1609 WAVE Standards	-Full stack solution for vehicular network -Enhanced interoperability -Security mechanisms included	-Necessitates significant infrastructure -Requires adoption by manufactures
Geo Networking (ETSI EN 302636)	-Geographic routing for efficient forwarding -Efficient multicast -Scalability	-Reliance on geographic info can be challenging
Cellular-Based Approaches	-Extensive network coverage -High throughput -Support for diverse applications	-Network congestion
Proposed Techniques/Protocols	-Improved low latency for safety applications	-Implementation complexity -Security concerns

	-Improved scalability -Resource efficiency	
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B. Applications Developed for V2V Communication Systems from Existing Systems

VANET (Vehicular Ad-Hoc Networks) structure, share a fundamental basis but may vary in terms of certification, hierarchy, and communication rules.

1) On Board Unit (OBU)

- a) Modules installed on vehicles.
- b) Responsible for communication within the vehicle and with other vehicles, RSUs, and server units.
- c) Executes various applications and protocols designed for VANET systems.

2) Roadside Unit (RSU)

- a) Modules installed on the infrastructure or road units.
- b) Facilitates communication between vehicles and the infrastructure.
- c) Provides services such as traffic information, road condition updates, and safety warnings to vehicles.

3) Server Unit (SU)

- a) Units located on general servers.
- b) Centralized units that manage and coordinate communication within the VANET system.
- c) Handle tasks such as authentication, data storage, and overall system management.

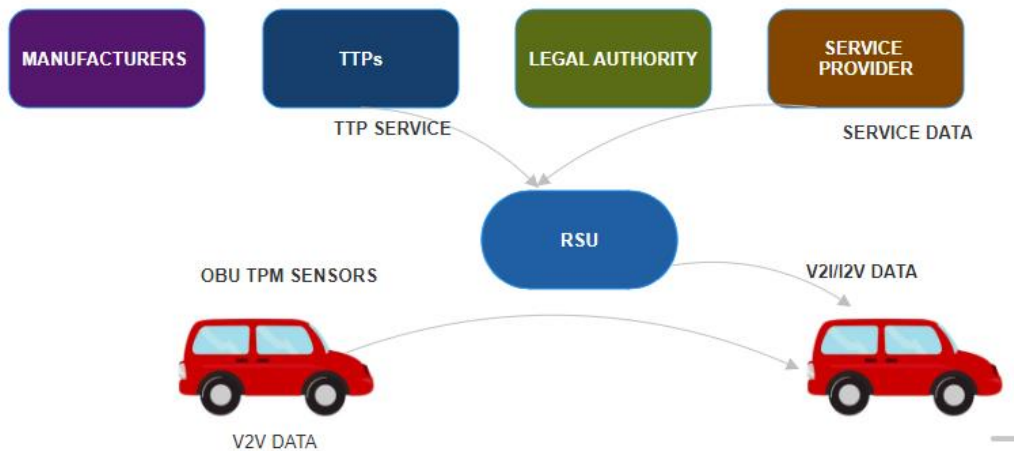


Fig. 2 Applications Developed for V2V Communication Systems from Existing System

VI. PERFORMANCES OF EXISTING TECHNIQUES AND DEVELOPED PROTOCOL

In our comparative analysis, we first evaluate the performance of existing techniques and protocols.

A. IEEE 802.11p (WAVE)

- **Latency:** 802.11p also has low latency, so it can be used for safety-related messages.
- **Throughput:** However, it is designed for near field communication and therefore is not very effective through put for applications that entail a lot of data transfer.
- **Scalability:** 802.11p has issues of scalability hence it's not very efficient in a highly built populated area.

- *Security:* Security was designed to work on the lower layers of the OSI model for the 802.11p system, as a result of which secure connection established on these protocols is vulnerable.

B. *Dedicated Short Range Communications (DSRC)*

- *Performance:* DSRC takes a lot from 802.11p and has related advantages and drawbacks.
- *Regional Variation:* With its regional usage especially in America, it presents problems of international roaming.

C. *IEEE 1609 WAVE Standards*

- *Full-Stack Solution:* The IEEE 1609 standards provide full package with higher level of integration and security integration than the current standards.
- *Latency and Throughput:* The standards declare that safety-essential use cases require low latency and high throughput for exchanging information.
- *Scalability:* IEEE 1609 standards have advantage in scalability than other standards due to their design nature.

D. *Geo Networking (ETSI EN 302 636)*

- *Geographic Routing:* Geo Networking's geographic routing improves routing efficiency in VANETs.
- *Scalability:* It is known for its scalability and efficient handling of a large number of vehicles.
- *Challenges:* Its reliance on geographic information can face challenges in dynamic environments.

E. *Cellular-Based Approaches*

- *Cellular V2X (C-V2X):* C-V2X offers low-latency, high-throughput communication, especially in urban areas.
- *Coverage:* Its reliance on commercial cellular networks ensures coverage in urban and remote areas.
- *Challenges:* Network congestion and subscription costs can pose challenges.

VII. PROPOSED TECHNIQUES AND PROTOCOLS

A. *Proposed Protocols*

VANET (Vehicular Ad-Hoc Networks) structure, share a fundamental basis but may vary in terms of certification, hierarchy, and communication rules.

1) *Cooperative Awareness Messaging (CAM)*

- a) *Performance:* CAM excels in low-latency communication for safety-critical applications.
- b) *Scalability:* It is designed to handle many vehicles effectively [17].
- c) *Security:* Security mechanisms are crucial to protect the integrity of CAM messages.

2) *Decentralized Resource Sharing*

- a) *Adaptive Spectrum Allocation:* These approaches enhance the use of available spectrum to allow for better utilization with little or no interference as well as congestion.
- b) *Cognitive Radio Networks:* Technology in cognitive radio provides means to improve efficiency and utilization of the spectrum.
- c) *Dynamic Channel Assignment:* It also means that the resource is allocated in the best way to give a fair and effective way of using data.

3) *Geographic and Cluster-Based Routing*

- a) *Geographic Routing:* Geographic routing enhances the routing function and is favorable where traffic is random, and the geographical location is open.

b) *Cluster-Based Routing*: as observed in [18], hierarchical clustering cuts across some costs, which leads to scalability.

4) *Quality of Service (QoS) Mechanisms*

a) *Message Prioritization*: QoS mechanisms enhance the safety-critical messages and makes sure that they are delivered within the shortest time possible.

b) *Bandwidth Allocation*: Optimizing on the use of bandwidth is achieved through efficient allocation of the resources.

5) *Security and Privacy Enhancements*

a) *Message Authentication*: Other form of security such as digital signatures that enable the messages to be authentic in their communications.

b) *Pseudonym Management*: Privacy maintaining techniques serve to ensure that user identities are kept confidential.

6) *Multi-Channel Communication*

a) *Load Balancing*: The examination of multi-channel communication shows that it can diffuse the communication load so that no channel overloads [19].

b) *Spectrum Diversity*: Thus, the use of the different means of communication increases the reliability of the communication.

7) *Fog and Edge Computing*

a) *Low Latency*: Real-time decisions can be achieved through fog and edge computing decreasing the latency level.

b) *Edge-Based Security*: Measures of security provided at the edge make it easy to detect and contain threats [20].

8) *Machine Learning and Artificial Intelligence (AI)*

a) *Traffic Prediction*: Several traffic forecasts can be obtained through machine learning models to enable adjustments of the selected route and speed.

b) *Anomaly Detection*: Abnormality is recognized through the AI algorithms with the ability to correct them hence improving security [21].

B. *Comparative Assessment*

A comparative assessment of existing techniques and protocols with proposed solutions reveals several critical points:

- Current standards such as IEEE 802.11p, and DSRC provide low latency, but they are not scalable to many numbers, and their security may also be inadequate.
- Resulting IEEE 1609 standards offer a more solid solution whilst offering better scalability and security.
- The combined cellular-based approaches like the C-V2X have capability to provide a ubiquitous coverage but challenges related to network traffic and subscription can occur.
- Various requirements have been listed such as low latency, scalability, resource utilization, security, and privacy.
- The selection of technique or protocol must, therefore, depend on certain basic parameters of VANET that is to be deployed [22].

Table 2 Performance based table with proposed techniques

Performance Metrics	Existing Techniques	Proposed techniques
Latency	Low latency	Improved Low latency
Throughput	Limited throughput	High throughput

Scalability	Limited Scalability	Improved Scalability
Security	Limited Security	Enhanced Security
Resource Efficiency	Varies	Optimized

C. Algorithm to Developed Protocol for Establishing V2V Communication using Kali Linux

1) Understanding V2V Communication:

a) V2V communication involves wireless signals exchanged between vehicles to share information about accidents, weather conditions, roadblocks, and traffic as u can see in fig 3.

b) Unlike traditional Original Equipment Manufacturer (OEM) embedded systems that rely on sensors and cameras, V2V communication provides more effective real-time data exchange1.

2) Steps to Set Up V2V Communication Using Kali Linux:

a) Install Kali Linux:

I)If you haven't already, download and install Kali Linux on your system.

b) Enable VPN (Virtual Private Network):

II)Kali Linux does not come with VPN pre-installed.

III)Download Open VPN configuration files (.ovpn) from a VPN provider's website.

IV)Install Open VPN on Kali Linux.

V)Configure Open VPN using the downloaded .ovpn files2.

c) Create a Virtual Machine (VM):

I)Use virtualization software like Virtual Box to create a Kali Linux VM.

II)This allows you to run Kali Linux as a separate environment, interact with other VMs, and take snapshots for easy rollback3.

3) Explore V2V Protocols and Standards:

a) DSRC (Dedicated Short-Range Communications):

I)DSRC technology supports V2V safety applications.

II)It enables communication between vehicles and infrastructure (V2I) when combined with roadway infrastructure.

III)DSRC-based V2I communications serve as a gateway for broader intelligent transportation systems.

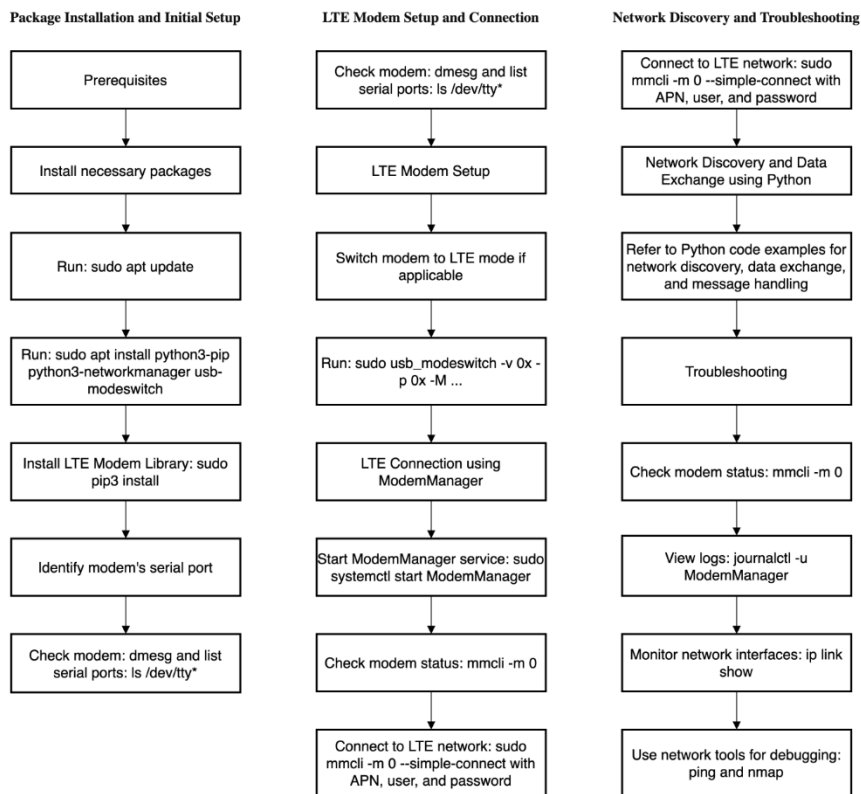


Fig. 3 LTE Modem Setup and Network Management on Linux

VIII. PERFORMANCE EVALUATION USING RELAYING AND KALI LINUX FOR V2V COMMUNICATION

Comparing the tagging accuracy of the R1 on Tagged Vehicles based on the two orientations of the street, as shown in table 3. The machine produced a tagging accuracy of 0.85 on the same oriented street and 0.78 on the perpendicularly oriented street. Tagged Vehicle R2 had a slightly higher accuracy on the same street it scored a 0.91 while on the perpendicular street; it scored 0.82. Thus, the obtained results show a significant dependence of the tags performance on the street orientation and reveal the impact of environmental factors on vehicle Detection Street. As depicted similarly in fig 4. Tagged Vehicle R2 demonstrated higher accuracy on the same street with a score of 0.91, compared to 0.82 on the perpendicular street. These results indicate a notable difference in tagging effectiveness based on street orientation, highlighting the influence of environmental factors on vehicle detection.

Table 3 Performance Evaluation- Packet Delivery Ratio

Scenario	Same Street	Perpendicular Street
Tagged Vehicle R1	0.85	0.78
Tagged Vehicle R2	0.91	0.82

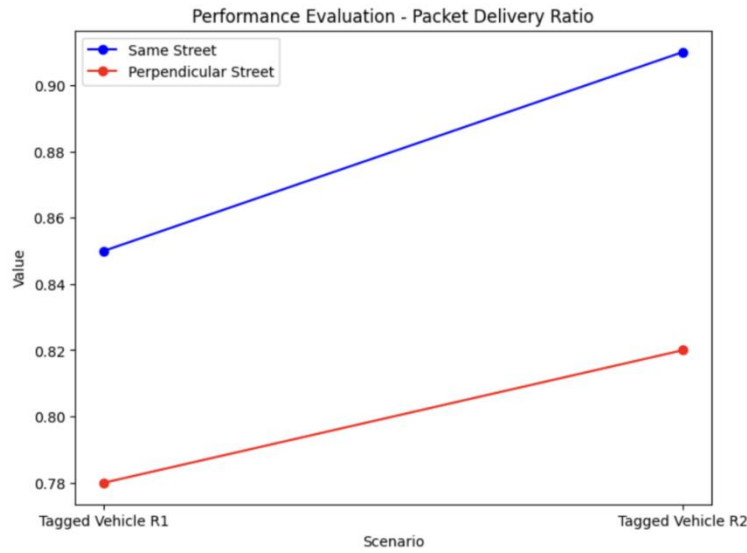


Fig. 4 Performance Evaluation- Packet Delivery Ratio Comparison of Relaying Techniques Over Time

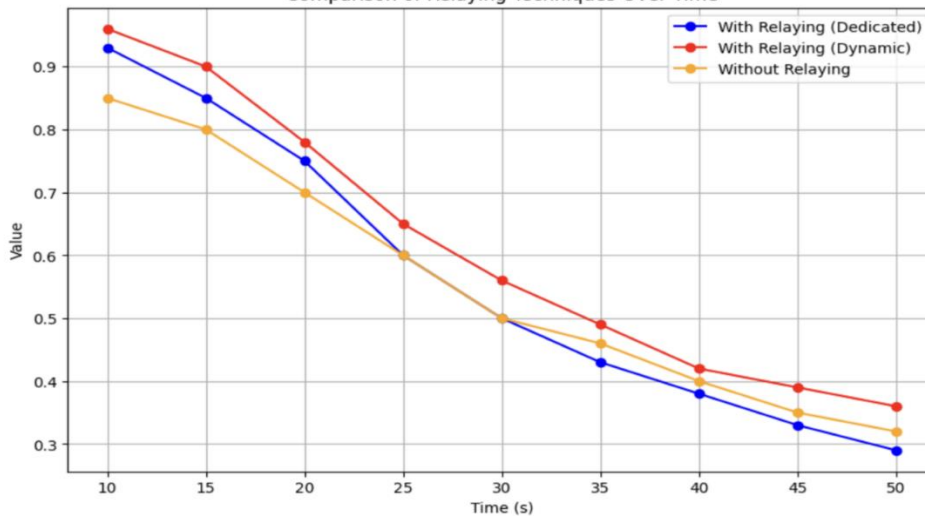


Fig. 5 Packet Delivery Ratio (PDR) Presentation Comparison When Tagged Vehicle R1 in Same Street

The investigation of data transmission over time shows that both relaying methods (dedicated and dynamic) performed higher than the non-relaying approach in all trials based on Table 4. It was observed that dynamic relaying performs slightly better than dedicated relaying over all time periods, although the greatest difference is at short times only. As shown in fig 5. All the methods were found to reduce their transmission efficiency as time went on and the difference between the two methods became less and less apparent. Relaying approach dynamic relaying showed slightly higher performance than dedicated relaying across all time intervals, with the most significant differences observed at shorter times. Over time, all methods experienced a decline in transmission efficiency, with the gap between the approaches narrowing as time increased.

Table 4 Comparison of relaying technique in Same Street

Time	With Relaying (Dedicated)	With Relaying (Dynamic)	Without Relaying
10	0.93	0.96	0.85
15	0.85	0.9	0.8
20	0.75	0.78	0.7
25	0.6	0.65	0.6
30	0.5	0.56	0.5
35	0.43	0.49	0.46
40	0.38	0.42	0.4
45	0.33	0.39	0.35
50	0.29	0.36	0.32

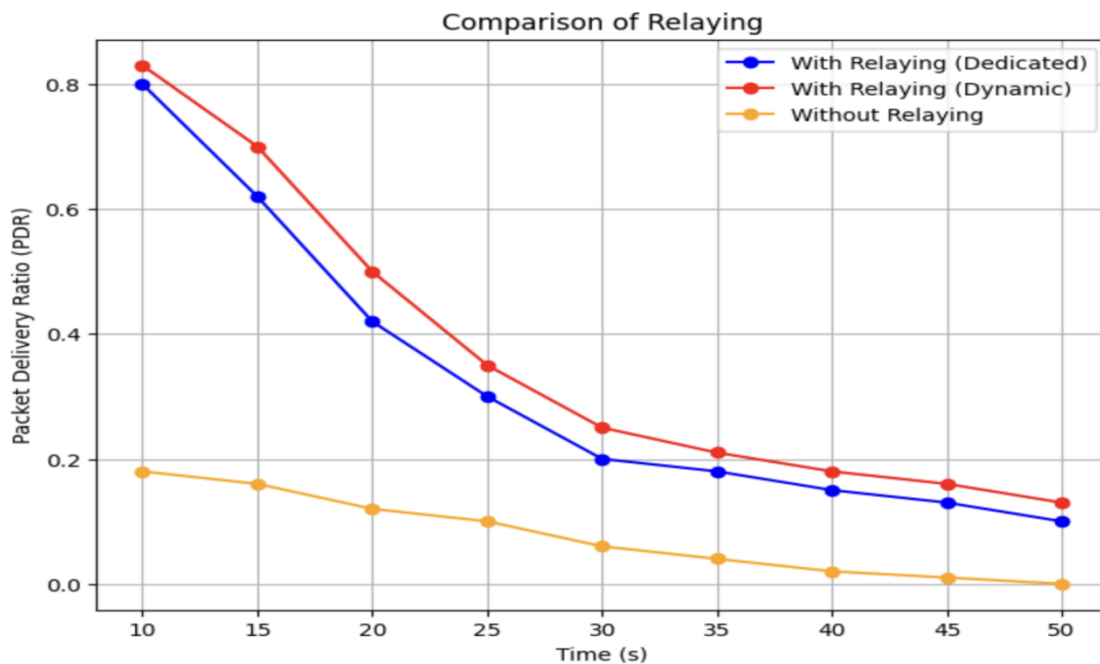


Fig. 6 Packet Delivery Ratio (PDR) Presentation Comparison When Tagged Vehicle R1 in Perpendicular Street

In accordance with the data, both the fully dedicated and dynamic methods of relaying maximize the results as according to Table 5. Compared to non-relaying varieties in each of the scenarios, dynamic relaying is seen to outdo dedicated relaying notably at time intervals which are earlier. However, if relaying does not take place, performance is substantially below this level and declines to a rate of zero during the 50th minute. All methods demonstrate a decrement in the efficiency as some or all the factors making up the time parameter evolve with

time interval efficiently improve performance compared to the non-relaying approach. Dynamic relaying consistently outperforms dedicated relaying, particularly at earlier time intervals. Without relaying performance remains notably low, dropping to zero by the 50-minute mark. All methods show a gradual decline in efficiency as time progresses as depict in fig 6.

Table 5 Comparison of relaying technique in Perpendicular Street

Time	With Relaying (Dedicated)	With Relaying (Dynamic)	Without Relaying
10	0.8	0.83	0.18
15	0.62	0.7	0.16
20	0.42	0.5	0.12
25	0.3	0.35	0.1
30	0.2	0.25	0.06
35	0.18	0.21	0.04
40	0.15	0.18	0.02
45	0.13	0.16	0.01
50	0.1	0.13	0

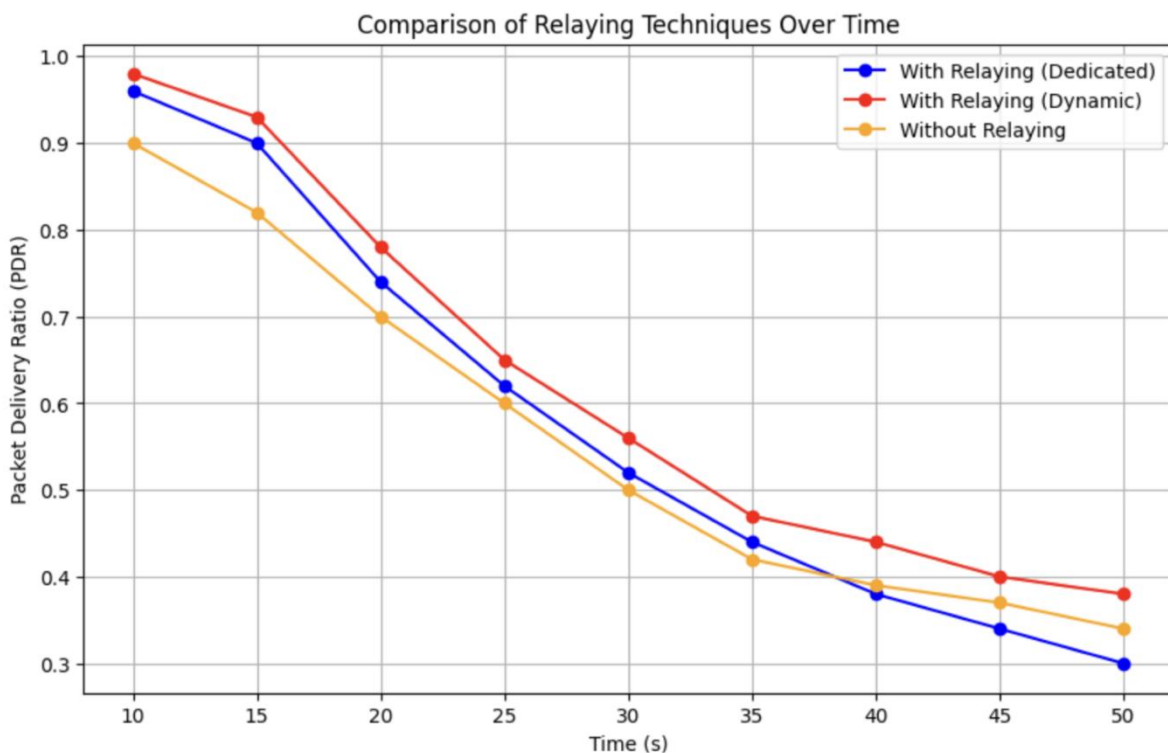


Fig. 7 Packet Delivery Ratio (PDR) Presentation Comparison When Tagged Vehicle R2 in Same Street

The evaluation of relaying methods highlights that both, dedicated and dynamic types provide higher performance than non-relaying, while dynamic type reveals higher result in all time intervals. Fig 7 the overall efficiency of all methods weakens with time, while dynamic relaying continues to stay slightly ahead of the others. The non-relaying method shows the least proficiency in overall percentage of learning at the end of twenty minutes, and progressively declines thereafter dynamic relaying yielding slightly higher performance across all time intervals. Performance gradually declines over time for all methods, but dynamic relaying consistently maintains a marginal

advantage. Table 6 the non-relaying method demonstrates the lowest overall efficiency, especially as time progresses beyond 20 minutes.

Table 6 Comparison of relaying technique of over time with relaying and without relaying in same street

Time	With Relaying (Dedicated)	With Relaying (Dynamic)	Without Relaying
10	0.96	0.98	0.9
15	0.9	0.93	0.82
20	0.74	0.78	0.7
25	0.62	0.65	0.6
30	0.52	0.56	0.5
35	0.44	0.47	0.42
40	0.38	0.44	0.39
45	0.34	0.4	0.37
50	0.3	0.38	0.34

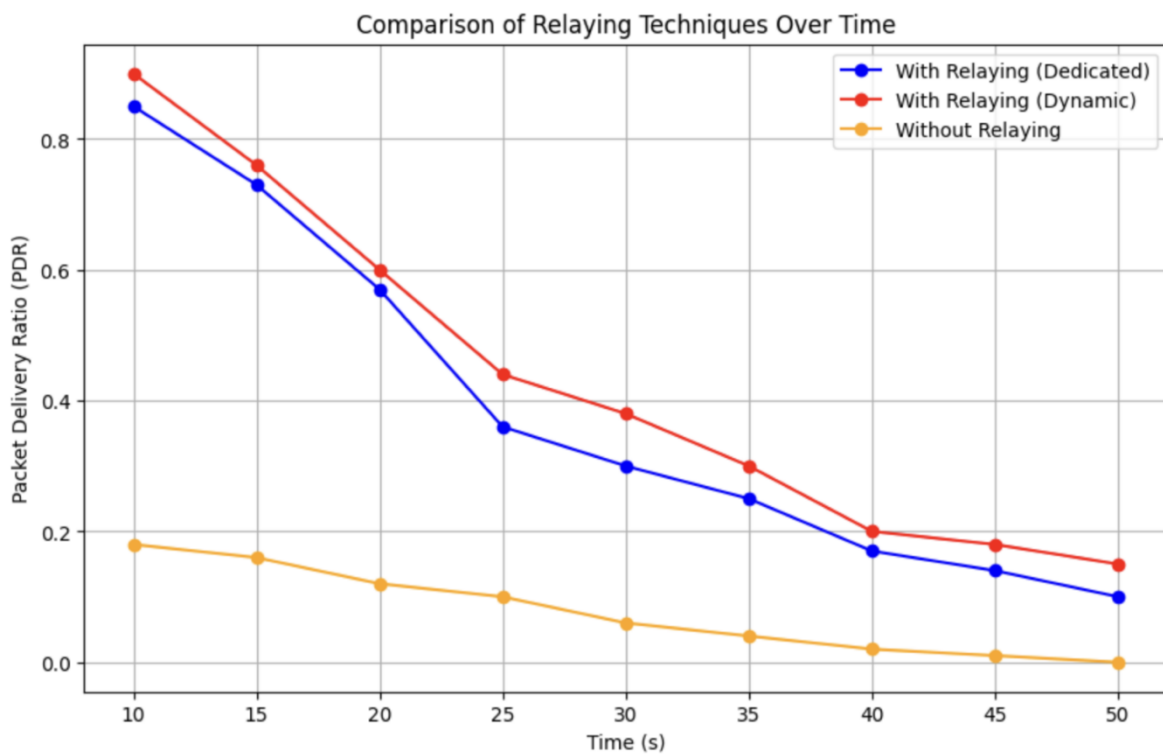


Fig. 8 Packet Delivery Ratio (PDR) Presentation Comparison When Tagged Vehicle R2 in Perpendicular Street

These findings confirmed the benefits of relaying methods by showing that the two forms of relaying; dedicated and dynamic relaying yielded better results than the non-relaying. Comparing the performance of dynamic and dedicated relaying for each time slot, we identify that dynamic relaying performs better than the dedicated relaying. As shown in fig 8 this is seen where relaying has not occurred, performance decreases dramatically all the way to zero at 50 minutes. All methods degrade as time goes on, but relaying is still significantly behind non-relaying in terms of efficiency approach. Dynamic relaying consistently shows better performance than dedicated relaying across all time intervals. In contrast, without relaying, performance is significantly lower, dropping to

zero by 50 minutes. As depend upon Table 7 time progresses, all methods experience a decline in efficiency, but the gap between relaying and non-relaying remains substantial.

Table 7 Comparison of relaying technique of over time with relaying and without relaying in Perpendicular Street

Time	With Relaying (Dedicated)	With Relaying (Dynamic)	Without Relaying
10	0.85	0.9	0.18
15	0.73	0.76	0.16
20	0.57	0.6	0.12
25	0.36	0.44	0.1
30	0.3	0.38	0.06
35	0.25	0.3	0.04
40	0.17	0.2	0.02
45	0.14	0.18	0.01
50	0.1	0.15	0

CONCLUSION

In conclusion, this study offers a thorough insight into the establishment of Vehicular-to-Vehicular communication (V2V) via Kali Linux, implementing its protocols and standards such as Dedicated Short-Range Communications (DSRC). The study shows how the creation of a virtual machine is necessary for simulating real environment establishment of V2V communication for the purpose of testing their implementations under different network conditions and traffic conditions. It is notable that implementing this platform on Kali Linux is highly secure which requires VPN setup to ensure a secure exchange of sensitive messages (traffic update and collision warning) between two cars. Interestingly, Kali Linux proved effective in the observation of the functioning and performance evaluation DSRC. Notably, DSRC technology is crucial to the support of V2V safety applications and V2I communication and enables the interaction between vehicles and infrastructure. V2I served the role of a gateway for generalized intelligent transportation system, crucial in road safety and traffic flow coordination. Performance evaluation of relaying scenarios demonstrates the performance of the V2V protocol and computation of PDR was reliable and such performance experimentation gives hopes for the technology improvement for future developments and installations. Therefore, it provides hope for a safer transportation industry. Consequently, V2V communication via Kali Linux has the potential to revolutionize the transport industry as it is safer and more efficient. In addition, millions of lives have been claimed while others are left forever disabled. If the transportation industry, both water, and road will embrace this technology, more lives will be saved and less accidents will be reported.

FUTURE SCOPE

As we look to the future, several key directions are set to shape the evolution of VANETs. The rollout of 5G and the advancement of Vehicle-to-Everything (V2X) communication will unlock new applications, including support for autonomous vehicles and augmented reality in-vehicle displays. The integration of VANETs into smart city initiatives will enhance traffic management and reduce congestion. Edge and fog computing will enable real-time data processing, while data analytics and machine learning will drive data-driven decision-making.

CONFLICT OF INTEREST

Competing Interests: The authors declare no conflicts of interest.

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- Author contribution: All authors contributed equally.
- Research Involving Human and /or Animals: No Human and /or Animals used in research

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REFERENCES

- [1] Ali, G.G.M.N.; Sadat, M.N.; Miah, M.S.; Sharief, S.A.; Wang, Y. A Comprehensive Study and Analysis of the Third Generation Partnership Project's 5G New Radio for Vehicle-to-Everything Communication. *Future Internet* 2024, 16, 21. <https://doi.org/10.3390/fi16010021>.
- [2] X. Qi, A. Hu and Z. Zhang, "Data-and-Channel-Independent Radio Frequency Fingerprint Extraction for LTE-V2X," in *IEEE Transactions on Cognitive Communications and Networking*, doi: 10.1109/TCCN.2024.3360508.
- [3] L. Lusvarghi, C. A. Grazia, M. Klapez, M. Casoni and M. L. Merani, "Awareness Messages by Vulnerable Road Users and Vehicles: Field Tests via LTE-V2X," in *IEEE Transactions on Intelligent Vehicles*, vol. 8, no. 10, pp. 4418-4433, Oct. 2023, doi: 10.1109/TIV.2023.3280744.
- [4] Rehman, A.; Valentini, R.; Cinque, E.; Di Marco, P.; Santucci, F. On the Impact of Multiple Access Interference in LTE-V2X and NR-V2X Side link Communications. *Sensors* 2023, 23, 4901. <https://doi.org/10.3390/s23104901>
- [5] N keneyeye, L.; Naik, R.P.; Jang, J.-W.; Chung, W.-Y. Software-Defined Small Cell-Linked Vehicular Networks: Architecture and Evaluation. *Electronics* 2023, 12, 304. <https://doi.org/10.3390/electronics12020304>.
- [6] Tahir, M.N.; Leviäkangas, P.; Katz, M. Connected Vehicles: V2V and V2I Road Weather and Traffic Communication Using Cellular Technologies. *Sensors* 2022, 22, 1142. <https://doi.org/10.3390/s22031142>
- [7] Albattah, W.; Habib, S.; Alsharekh, M.F.; Islam, M.; Albahli, S.; Dewi, D.A. An Overview of the Current Challenges, Trends, and Protocols in the Field of Vehicular Communication. *Electronics* 2022, 11, 3581. <https://doi.org/10.3390/electronics11213581>.
- [8] Lazar, R.-G.; Pauca, O.; Maxim, A.; Caruntu, C.-F. Control Architecture for Connected Vehicle Platoons: From Sensor Data to Controller Design Using Vehicle-to-Everything Communication. *Sensors* 2023, 23, 7576. <https://doi.org/10.3390/s23177576>.
- [9] Tahir, M.N.; Mäenpää, K.; Sukuvaara, T.; Leviäkangas, P. Deployment and Analysis of Cooperative Intelligent Transport System Pilot Service Alerts in Real Environment. *IEEE Open J.Intell. Transp. Syst.*2021, 2, 140–148.
- [10] Shinde, S., Wadhwa, L., Rawan dale, S., Sherje, N., Jadhav, S., Biswas, A., & Gupta, K. (2023). Advanced adaptive cruise control and vehicle to vehicle communication using LiDAR. *Multidisciplinary Science Journal*, 6(3), 2024022. <https://doi.org/10.31893/multiscience.2024022>
- [11] Tahir, M.N.; Katz, M. C-ITS Communications using Heterogeneous Wireless Technologies. In *Proceeding soft he IEEE INFO COM 2021 IEEE Conference on Computer Communications Workshops (INFOCOMWKSHPS)*, Vancouver, BC,Canada, 10–13 May2021.
- [12] Do D.-T.; Nguyen, T.-T.T.; Le, C.-B.; Lee, J.W. Two-Way Transmission for Low-Latency and High-Reliability 5 G Cellular V2X Communications. *Sensors* 2020, 20, 386. <https://doi.org/10.3390/s20020386>.
- [13] Abolfazl, Hajisami., Ralf, Weber., Jim, Misener., Vishnu, Vardhan, Chetlur., Michael, Ruder., Shuping, Chen. (2023). 3. A Tutorial on V2I Communication: Evaluating the LTE-V2X for Day-1 V2I and V2V Integration in Congested Scenarios. *SAE international journal of connected and automated vehicles*, Available from: 10.4271/12-06-04-0027.
- [14] Tahir, M.N.; Katz, M. Heterogeneous (ITS-G5 and 5G) vehicular pilot road weather service platform in a realistic operational environment. *Sensors* 2021, 21, 1676.
- [15] Joseph, Clancy., Dara, Molloy., Sean, Hassett., James, Leahy., Enda, Peter, Ward., Patrick, Eoghan, Denny., Edward, Jones., Martin, Glavin., Brian, Deegan. (2024). 1. Evaluating the Feasibility of Intelligent Blind Road Junction V2I Deployments. *Smart cities*, Available from: 10.3390/smartcities7030041
- [16] Saraereh, O.A.; Ali, A.; Khan, I.; Rabie, K. Interference Analysis for Vehicle-to-Vehicle Communications at 28 GHz. *Electronics* 2020, 9, 262. <https://doi.org/10.3390/electronics9020262>
- [17] Mintsis, E.; Vlahogianni, E.I.; Ozkul, S. Enhanced speed advice for connected vehicles in the proximity of signalized intersections. *Eur. Transp. Res. Rev.*2021,13, 2.
- [18] Tahir, M.N.; Katz, M.; Pouttu, A. VANET (ITS-G5 & 5G Test Network) with Drone-assisted Communication Using Road Weather Information. In *Proceedings of the 2021 17th International Conference on Wireless and Mobile Computing, Networking and Communications (WI Mob)*, Bologna, Italy,11–13October2021.

- [19] Tahir, M.N.; Katz, M.; Rashid, U. Analysis of collaborative wireless vehicular technologies under realistic conditions. *J. Eng.* 2021, 2022, 123–248.
- [20] Tahir, M.N.; Rashid, U. Demo: Intelligent Transport System (ITS) Assisted Road Weather & Traffic Services. In *Proceedings of the 2020 IEEE Vehicular Networking Conference (VNC)*, Newyork, NY, USA, 16–18 December 2020; pp.1–2.
- [21] Tahir, M.N.; Katz, M.; Rashid, U. Analysis of VANET Wireless Networking Technologies in Realistic Environments. In *Proceedings of the 2021 IEEE Radio and Wireless Symposium (RWS)*, SanDiego, CA, USA, 17–22 January2021; pp. 123–125.
- [22] J. Blum, A. Eskandarian, and L. J. Hoffman, "Challenges of intervehicle ad hoc networks," *IEEE Trans. Intelligent Transportation Systems*, vol. 5, no.4, pp. 347-351, Dec. 2004. [23] C. M. Krishna and K. G. Shin, *Real-Time Systems*, McGraw-Hill, New York, 1997. [24] S. Eichler, "Performance evaluation of the IEEE 802.11p WAVE communication standard," in *Proc. IEEE Vehicular Technology Conf.*, Baltimore, MD, US, Oct. 2007, pp. 2199-2203.
- [23] N. Choi et al., "A solicitation-based IEEE 802.11p MAC protocol for roadside to vehicular networks," in *Proc. Work. on Mobile Networking for Vehicular Environments*, Anchorage, AK, US, May 2007, pp. 91-96.
- [24] C. Suthaputchakun and A. Ganz, "Priority based inter-vehicle communication in vehicular ad-hoc networks using IEEE 802.11e," in *Proc. IEEE Vehicular Technology Conf.*, Dublin, Ireland, Apr. 2007, pp. 2595-2599
- [25] Vansha, Kher. (2022). 5. Analysis of Modulation Techniques for Short Range V2V Communication. Available from: 10.1007/978-981-19-1844-5_5.