Journal of Autonomous Intelligence (2024) Volume 7 Issue 5
doi: 10.32629/jai.v7i5.1604

ORIGINAL RESEARCH ARTICLE

Wireless sensor network and IoT based V2V connectivity, minimization of hazardous environment

Prabha M.[1,*], Venkata Srihari Babu D.[2], Muniyandy Elangovan[3], Shobha P.[4], Arunlal C. K.[5], Senthamil Selvan R.[6], Senthil Kumar A.[7]

[1] *Department of Electrical Communication Engineering, Vel Tech Rangarajan Dr Sagunthala R&D Institute of Science Technology, Chennai 600062, India*

[2] *Department of Electrical Communication Engineering, G Pulla Reddy Engineering College, Kurnool 518002, India*

[3] *Department of Biosciences, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai 602105, India*

[4] *Department of Computer Science and Engineering, Nitte Meenakshi Institute of Technology, Bangalore 560064, India*

[5] *Department of Electrical Communication Engineering, KMCT College of Engineering, Kozhikode, Kerala 673303, India*

[6] *Department of Electronics and Communication Engineering, Annamacharaya Institute of Technology and Sciences, Tirupati 517520, India*

[7] *CS Cluster, Dayananda Sagar University, Bengaluru 560078, India*

*** Corresponding author:** Prabha M., prabhamdr@veltech.edu.in

ABSTRACT

The majority of contracts embraced water damage addresses to alert all knobs, in addition to traffic regulations and the accident, so vehicular random networks (VANETs) are expected to develop secure transportation networks by providing timely and efficient data distribution. Since VANETs are distribution-type connections capable of making significant contributions to advances in terms of roadway security, they are expected to develop secure transportation networks. A bundle-based strategy (BBS), in which a group leader is assigned to one of several transporters and a method that allows for the development of the corresponding positions of the nearby knobs, serves as the primary foundation for the suggested approach. One way such notions are defined is the distance where each bunch head forms a neighbourhood coordinate system, and the positions of all the members of its group are calculated by using distances measured between transportation. To minimize the time spent in hazardous conditions under the control of a single system as the initial group's head, the worldwide systems are thought to be identical. The new proposed BBS method provides adequate location information and efficiency to support fundamental network functions.

Keywords: VANETs; DSRC; media access control (MAC); carrier sense multi-access with collision mitigation (CSMA/CA); on board units (OBUs); WIFI access in a vehicle (WAVE)

ARTICLE INFO

Received: 23 February 2024
Accepted: 19 June 2024
Available online: 27 August 2024

1. Introduction

Data is automatically transmitted when displayed on computerized graphs over the internet or in particular software[1,2]. Wi-Fi-based navigation systems can efficiently find a mode of transportation inside big spaces like airports, subways, and campuses. The VANET networks (vehicular ad hoc system) system is used in automotive electronics systems to determine the optimum minimal path for direction-finding using the least amount of trip traffic is represented in **Figure 1**.

Principles of vehicle ad-hoc networks:

Main uniformity classes (e.g., IEEE, IETF and ISO) and organization (e.g., truck-to-truck conversation organizations define typical vehicle conversations. In North America, the National Conversation Council describe a recent typical vehicle ad-hoc network (VANET) called one-way or two-way short-range to medium-range wireless conversation[3,4]. This typically assigns a 75 MHz range in the 5.9 GHz frequency range that transfers the transport-to-transport (V2V) and transport-to-framework (V2I) conversations. In one-way, otherwise, two-way short-range conversation, decide broadcasting ranges are 10–1000 m and 3–27 Mbps mutually. Wireless access in vehicular surroundings (WAVE) is typically engaged in DSRC to attain a norm for achieving conversations of vehicle ad-hoc networks in the physical and media access control layers. Wireless local area network is collected by two contracts of IEEE, typically containing IEEE 802.11p and IEEE 1609 contracts decide to control a system uses, resources, safety uses, various medium processes, etc.

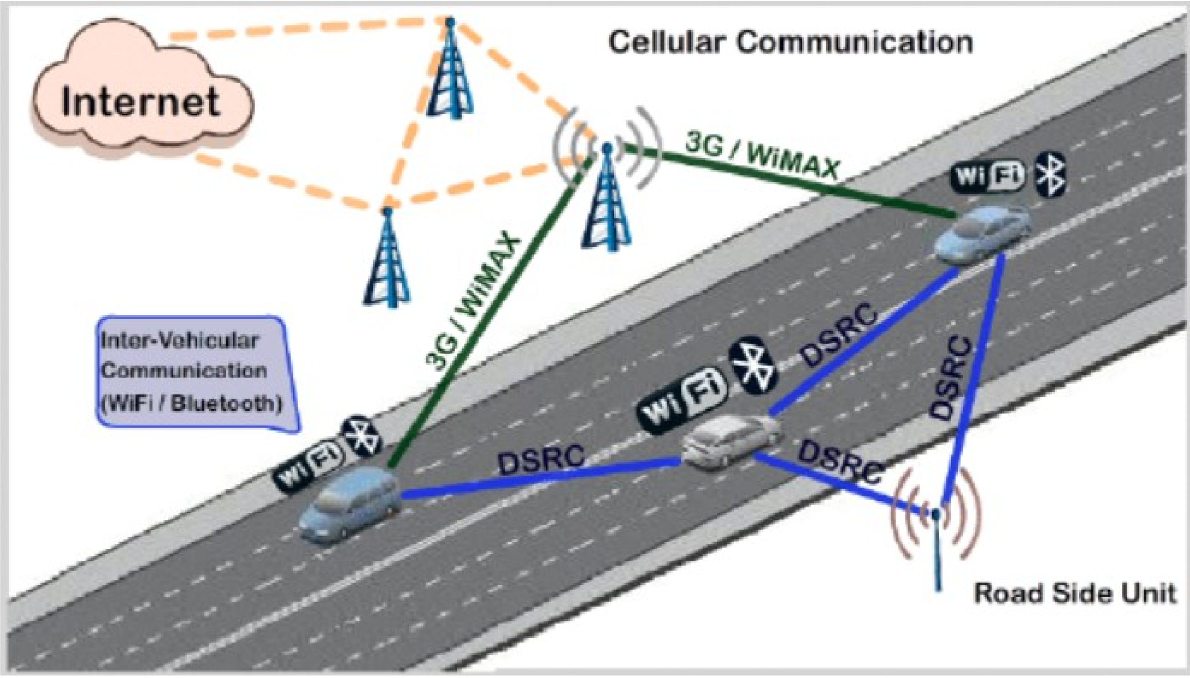

Figure 1. VANET network.

Table 1. Security uses in vehicle ad-hoc networks.

Use	Conversation pattern	Message broadcasted
Traffic signal violation	Vehicle to infrastructure	Indication stage, timing, location, route, highway calculation
Arched velocity caution	Vehicle to infrastructure	Arched position, arc, angle, velocity cap, plane
Crisis footbrake lamps	Vehicle to vehicle	Location, caption, rapidity, increase of rate
Collision analysis	Vehicle to vehicle	Transport nature, location, caption, swiftness, increase of rate, curve velocity
Frontward accident	Vehicle to vehicle	Transport nature, location, caption, speed, increase of rate, curve velocity
South curving support	Vehicle to infrastructure otherwise Vehicle to vehicle	Indication stage, measurement, location, route, highway calculation
Road vary caution	Vehicle to vehicle	Location, caption, speed, increase of rate, rotate indicate condition
End indication support	Vehicle to infrastructure otherwise Vehicle to vehicle	Location, speed, caption, caution

Table 2. Service uses in-vehicle ad-hoc networks.

Use	Examples
Traffic development	Traffic data and suggestions, improved path direction
Infomercial	The computer network approach broadcasts data from one computer system to another, which is an immediate bode.
Expense aids	Computerized fee group, station supervision
Edge aid acquirer	Verdict near oil place, eating places

The **Tables 1** and **2** shows Security uses in vehicle ad-hoc networks and Service uses in-vehicle ad-hoc networks. The IEEE 802.11p is a contract designated from the characteristics of IEEE 802.11 contract in Physical and lower parts of media access control layers to exchange information in vehicle surroundings[5]. The contracts occupy a media access control layer based on carrier sense multiple access with collision avoidance (CSMA/CA) as distributing information in vehicle ad-hoc networks. IEEE 1609 contract hold the operational behaviour and complication of achieving dedicated short-range communication. IEEE 1609.1 is decided in use layers for directing the actions of uses to communicate among onboard units (OBUs) and other system possessions. Indeed, IEEE 1609.1 distribute the process of vehicle ad-hoc network uses posted on wireless access for vehicle environments basics. IEEE 1609.2 provides security in wireless access for vehicle environments by deciding safety plans for data and bringing out the data's safety operation[6]. IEEE 1609.2 again contributes to the safety of data transfer. IEEE 1609.3 is decided in the system layer for conquering transmit data. Lastly, IEEE 1609.4, consisting in the above section of the media access control layer, supports different medium processes in vehicle ad-hoc networks and knobs processes of bigger coats without being absolute medium characters in lower coats. The construction of Wireless Access for Vehicle Environments is typically determined is shown in **Figure 2**.

The centred worldwide period is engaged in coordinate transports that can perform in multi-medium individual transceivers in vehicle ad-hoc network surroundings. UTC performs based on the data acquired from the global positioning system (GPS); otherwise, an additional environment transport period of every transport is adapted to be located on a centred worldwide period as it changes closely among the command and service mediums. Anyhow, the repeated deferment of an exchange among command and service mediums is big[7,8].

Advantages and uses:

- Advantages
- Provides safety
- Traffic control
- Traffic blockage prevention
- Data support to customer
- Convenience
- Data sources can be accurately validated.

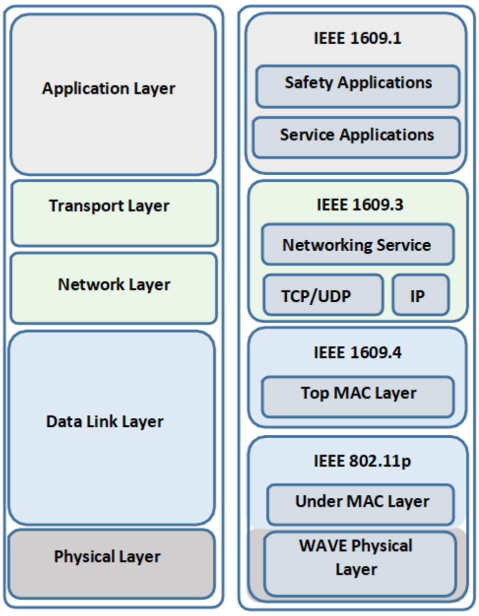

Figure 2. WAVE contracts and their process in layers of the system.

Uses:

1) Travel indication: Travel luminous can be executed with vehicle ad-hoc network science.
2) Weather conditions: The vehicle ad-hoc network prevents congestion and calamity by perceiving all weather statuses.
3) Vision enhancement: Vehicle ad-hoc networks are used to have a clear vision in reducing visibility status and to recognize transport secrets' existence by construction or hitch.
4) Motorist help: It is generally accessible to the motorist in propulsive ways and in secrecy, which the motorist preserves to maintain.
5) Automated parking: With no motorist interference requirement, a car can park itself[9].
6) Security: Security uses include accident caution, data distribution, simple driving, and computer network access.
7) To see the positions of lanes and transports: As a novice, assist via positions like smoke places, resorts, plazas, etc.[10].
8) Activity: It assists a patron in participating in a sport utilizing other computer networks inside a transport.

Motivation for this study:

The massive amount of data sent between vehicles often causes existing V2V communication systems to experience network congestion. When time is of the essence, such as in an emergency, this congestion may cause delays and incorrect communication. The short lifespan of sensor node batteries is a common problem in many non-efficient V2V systems. The limitation becomes much more severe when regular maintenance is impracticable, such as in isolated or hazardous regions. Bandwidth is lost, network congestion has deteriorated, and energy consumption is increased due to traditional methods' reliance on delivering duplicate data. There are a lot of devices out there that can identify hazardous circumstances, yet there is a lack of effective ways to use vehicle-to-vehicle communication to deal with these risks as they develop.

The novelty of the proposed bundle-based strategy for wireless sensor network (WSN) and IoT-based vehicle-to-vehicle (V2V) connectivity aims to minimize hazardous environments through efficient data aggregation and transmission techniques. The bundle-based strategy gathers sensor data locally before sending it on, reducing unnecessary data and strain on the network. Important for vehicle-to-vehicle communications in hazardous conditions, it uses adaptive scheduling to guarantee dependable and timely data transfer. This method optimizes data transmission, significantly reducing power consumption and increasing the network's sensor nodes' lifetime. Rapid V2V communication and early detection of hazardous circumstances are key components of the plan to reduce possible risks.

The main contribution of the paper is:

- Designing the bundle-based strategy for analyzing the WSN and IoT-based vehicle-to-vehicle connectivity minimization of hazardous environment.
- Recognizing the distance of each bunch head forms a neighbourhood coordinate system, and the positions of all the members of its group are calculated by using distances measured between transportation.
- Experimental outcomes show that the proposed BBS method provides adequate location information and efficiency to support fundamental network functions.

2. Literature study

Rehman et al.[11] suggested the efficient monitoring system (EMS) for detecting non-cooperative nodes in IoT-based vehicular delay tolerant networks (VDTNs). Cooperation in sharing node reputation throughout the network is the system's foundation. Additionally, monitoring selfish nodes is critical for improving network efficiency. For this experimental configuration, the NS-2 simulator is used. Regarding energy consumption, the number of packet dropouts, the likelihood of package delivery, and delay, the suggested method outperforms the alternatives in simulations. For 80% of the network's selfish nodes, EMS outperforms SOS and IPS concerning packet delivery by 37% and 31%, respectively. Likewise, with 80% selfish nodes included in the network, EMS's average delivery latency is 22% lower than SOS and 18% lower than IPS.

Rehman et al.[12] recommended analyzing the misbehaviour of nodes in IoT-based vehicular delay tolerant networks VDTNs. The problem of certain nodes that tend to interrupt a VDTN's connection is brought to light in this article. There is a particularly difficult type of misbehaviour to detect, and the article describes the situation of nodes that stop the delivery of messages. Utilizing a variety of simulations and two distinct sorts of situations, we examine how this form of misbehaviour impacts nine VDTN routing algorithms. Based on the results, routing algorithms may be more resistant to node misbehaviour by concentrating on improper behaviour, avoiding message duplication, and selecting the next hop intelligently.

Wang et al.[13] discussed the vehicle-to-vehicle cooperative video alert dissemination mechanism (V2V-CoVAD) for the Internet of vehicles in a highway environment. Clusters of vehicles travelling in the same direction as the accident vehicle interact with one another, while vehicles travelling in the other way choose relay vehicles to aid in reliable and rapid video transmission. To overcome the challenges IoV characteristics pose, the system considers several aspects, including the speeds, locations, distances, channel conditions, and vehicle data receiving statuses. To further address the performance drop caused by vehicle heterogeneity in various regions, the original accident footage is encoded using scalable video coding (SVC) technology. During cooperative transmission, instantly decodable network coding (IDNC) technology is used to enhance transmission efficiency and reliability even more. According to the simulation findings, the suggested approach reduces the latency in transmitting accident videos, boosts the success warning ratio, improves the quality of the rebuilt videos, and raises user satisfaction.

Singh et al.[14] deliberated the digitalization of highways for vulnerable road safety development with intelligent IoT sensors and machine learning. This research also discusses adopting renewable energy sources and smart display boards for real-time applications. Furthermore, the goal of improving road safety is addressed while discussing the use of AI on roads. In the discussion part, we covered how to incorporate deep learning (DL) into an edge-based vision node to forecast traffic patterns, check the safety of highways, and prioritize road repair. By incorporating deep learning methods into the vision node at the traffic junction and the highway lighting controller, a smart system may offer long-term highway management and experience. A few suggestions for digitalizing roads include smart lampposts, smart reflectors, renewable energy adoption, and the development of vehicle-to-vehicle communication between vehicles.

Nawaid et al.[15] presented the vehicle sensing and localization in vehicular networks. Advantages in injury prevention, improved driving performance, and support for ubiquitous applications focused on vehicle sensing are driving the continued growth in the number of sensors in automobiles. This study focuses on state-of-the-art localization methods, synchronous and asynchronous, and vehicle location methods, including communication-based (such as GPS data) and reflection-based (such as RADAR cameras) approaches. The author focused on the 5G angle and examined the vehicle-to-infrastructure communications (V2X).

Joshua et al.[16] offered the bio-inspired parameter tuning of vehicular ad hoc networks for environmental sustainability. Evolutionary algorithms concerning MANETs and VANETs are investigated in this article. The study covers a thorough examination of three main types of optimizations. Significant research studies on parameter adjustment in cluster formation, routing, and broadcast scheduling are discussed. The review's conclusion highlights important obstacles to VANET and MANET research.

Based on the survey, there are several issues with existing methods in attaining data transmission rate, network efficiency, and overall performance. Hence, this paper proposes the bundle-based strategy for analyzing the WSN and IoT-based Vehicle-to-vehicle connectivity minimization of hazardous environments.

3. DSRC standards

This chapter gives the organization typical encouragement for DSRC deployments[17]. Improving the connection between V2V communication systems is directly related to reducing risks. Vehicles may improve their ability to handle dangerous circumstances and prevent accidents by quickly, accurately, and thoroughly receiving and acting on hazard information. After rigorous testing and statistical analysis, we have shown that our bundle-based approach is the best way to improve connection and, by extension, decrease traffic accidents.

Frequency range allotment:

The 5.7 to 5.9 GHz range of the wireless spectrum is entitled by the international telecommunications union wireless typical board (ITU-R) for modern, experimental, and medicinal (ISM) applications. Diagram 20 displays a frequency range distribution into various details of the globe is shown in **Figure 3**.

Figure 3 shows the Japan uses a 5.7 GHz frequency range, while Europe uses 5.8 GHz. In the U.S., DSRC performs on various binal stages: 915 MHz and 5.9 GHz. In 1999, the Federal Conversations Commission (FCC) allotted the 5.9 GHz wireless range for transport and transport-roadside conversations in the U.S.

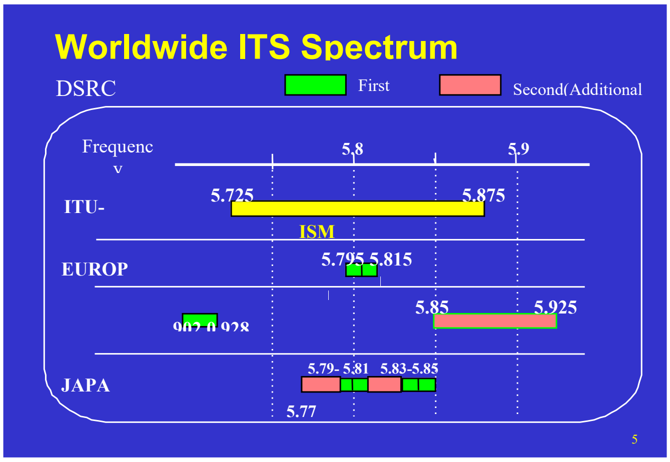

Figure 3. Worldwide ITS Spectrum.

915 MHz vs. 5.9 GHz achievement:

The 5.9 GHz line stage includes many merits over 915 MHz. The basic range is the ability to help bigger information ranges, less indication deficit, and greater efficiency by a high spectrum. The **Table 3** displays the capacity from a dual line.

Table 3. Relationship between 915 MHz schemes to 5.9 GHz schemes.

	915 MHz schemes	5.9 GHz schemes
Ratio	<30 m	up to 1000 m
Data transfer ratio	0.5 Mbps	6 to 27 Mbps
Future application	Intended for ETC, though used as new uses	Intended for common computer network access may be used for ETC.
Medium	Distinct unauthorized medium	7 authorized mediums
Execution	It needs a dimensional chipset and computer program	Employs untie off-the-shelf chipsets and computer program

Achievement: The diagram demonstrates a result from the rate of information transmission range and displays the achievement pocket of the 5.9 GHz line, which is distinguished to 915 MHz is shown in **Figure 4**. The 5.9 GHz line can transmit information via a computer network, granting a logical combination from transit data uses[18].

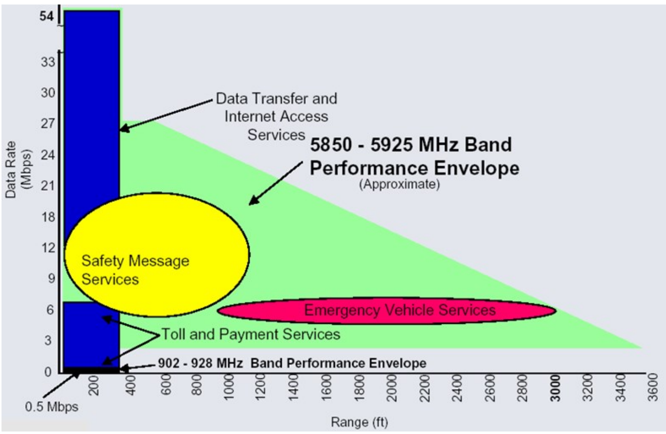

Figure 4. Data transmission rate.

5.9 GHz principle advancement:

Uniformity plays an actual essential role in any big-range distribution. An internal distribution needs system apparatus and scheme from several producers, hardware/software production, consent testing scope and safety scope[19]. The typical 5.9 GHz dedicated short-range communication is grown by an international standards organization that develops and publishes voluntary consensus and I-triple-E boards by extra factors grown by the standards development for the engineering industry (ISO). ITS America, an intelligent transportation system organization convention, is a basic junction with FCC. The subsequent associations are competition and exertion are described in **Table 4**.

Table 4. 5.9 GHz principle advancement.

No.	Table header	No.	Table header
1	3-M	20	King Country Metro Transit
2	AASHTO	21	MARK IV
3	ACUNIA	22	MiCOM spa
4	AmTech	23	Michigan state DOT
5	ARINC	24	Mitretek
6	Armstrong Consulting	25	Motorola
7	Atheros	26	Nissan
8	CalTrans	27	N.Y.Thruway Authority
9	Daimler-Chrysler	28	OKI Electric
10	DENSO	29	PATH
11	GM	30	Raytheon
12	GTRI	31	Spirit
13	Highway Electronics	32	Sumitomo Electric
14	Hitachi	33	TechnoCom
15	IDmicro	34	Toshiba
16	IMEC	35	TransCore
17	Intersal	36	Visteon
18	ITS-A	37	Washington State DOT
19	JHUIAPL	38	Wi-LAN

5.3 I-triple-E principles:

The I-triple-E principles direct the deficiency of large-velocity conversations among transport and benefit providers and the need for similar conversations among automotive corporations. Users are utilizing services to drivers, roadway operators, ease operative and sustenance organization[20].

IEEE 1609 for WAVE, allowed by USDOT in 2004, contains four basics:

1) IEEE P1609.1—Source Administrator: These demonstrate the key mechanism of the WAVE scheme design and define information movement resources at all positions[21–25]. Moreover, it describes the authority information arrangement and information repository arrangement used to converse among design mechanisms and identify the category of plans maintained by the onboard unit (OBU) inmate at a transport or cell phone stage.
2) IEEE P1609.2—Safety works for uses along with organization news: These describe safe information arrangement transform. This ordinary classifies the possessions as safe information transfer and how information procedure is located over a transfer principle.
3) IEEE P1609.3—Networking works: These describe system and transport layer assistants containing addresses that maintain safe WAVE message transfer. It describes small signal information, given an

effective WAVE—an exact alternative to IPv6 (Internet protocol version 6), that is openly sustained by users. Additionally, it is typical to describe administrative data support for the WAVE contract heap[26–28].

4. Simulation results

The capacity to combine data at the source is a key strength of the bundle-based strategy since it decreases network congestion and redundancy[29–31]. This improves the network's efficiency by ensuring that only critical data is sent. However, the limitation of a bundle-based strategy in implementing it might become more difficult due to the use of advanced algorithms for data aggregation and adaptive scheduling. Problems with deployment and the need for more sophisticated software and hardware solutions may result from this. The practical implication of the proposed study is that safety for drivers and passengers is enhanced by the ability to identify and communicate potentially hazardous situations quickly. Energy reductions and efficient data aggregation allow for more effective use of network resources.

Simulation environment

Simulation environment network simulator is a UNIX-based simulation package; hence, NS-2 has been installed in the Ubuntu Linux operating system. Installation of NS-2 requires multiple steps, as follows.

Step 1: Installing the NS-all-in-one package using appropriate commands in the terminal window.

Step 2: Setting up the environmental variables and TCL libraries.

Step 3: recompiling the package using the 'make' command to ensure the proper installation of NS-2.

The NS-2 program is written in TCL and saved with a file extension called *.TCL. The program can be compiled and executed in the terminal window. To open the file in a terminal window, go to the terminal and search for the terminal, as shown in **Figure 5**.

The statistical tests such as *t*-test, ANOVA and *p*-value confirm that the proposed bundle-based strategy significantly outperforms existing methods regarding data aggregation efficiency, energy consumption, response time, network congestion, and reliability[32,33]. The *p*-values obtained from the *t*-tests and ANOVA indicate that the observed differences are statistically significant, providing strong support for the effectiveness of our approach. *P*-value: < 0.001 (indicating significant differences among the methods), mean (proposed): 120 ms, *F*-statistic: 9.8.

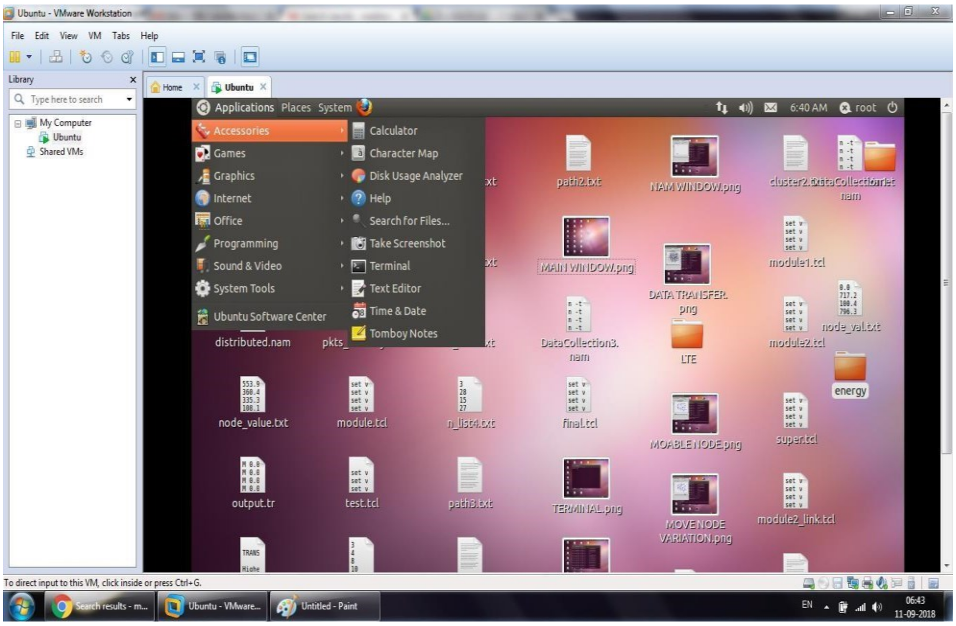

Figure 5. Opening the file in Terminal Window.

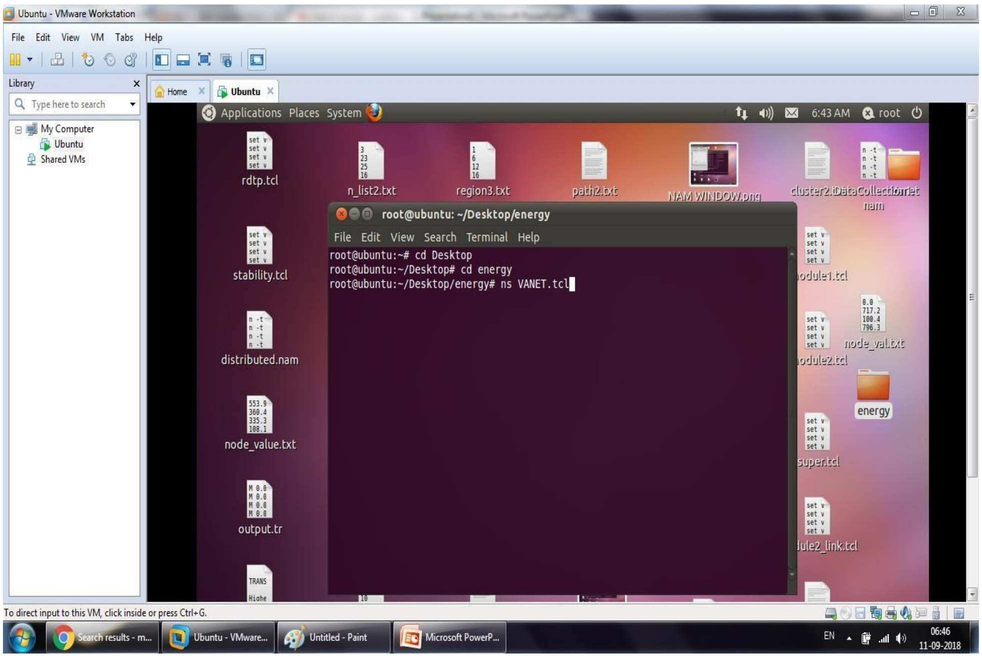

Figure 6. Execution process.

Simulation is a vital tool for validating theoretical network performance and communication systems. In VANET simulation, two distinct simulations are commonly and separately performed to get reliable outcomes: 'traffic simulation' and 'network simulation'. In this experiment, traffic simulation is done using a microscopic approach where the traffic data is updated for every vehicle in the network.

Once the traffic and network parameters are set, the TCL program for network routing protocol is also defined for every network node. Since this work is related to location-aided routing, all the nodes' latitudes and longitudes were calculated and shared with the network's neighbouring nodes. The node that will request the location of another node will act as the source node, and the node's ID will be given while the program is in execution, as shown in the **Figure 6**.

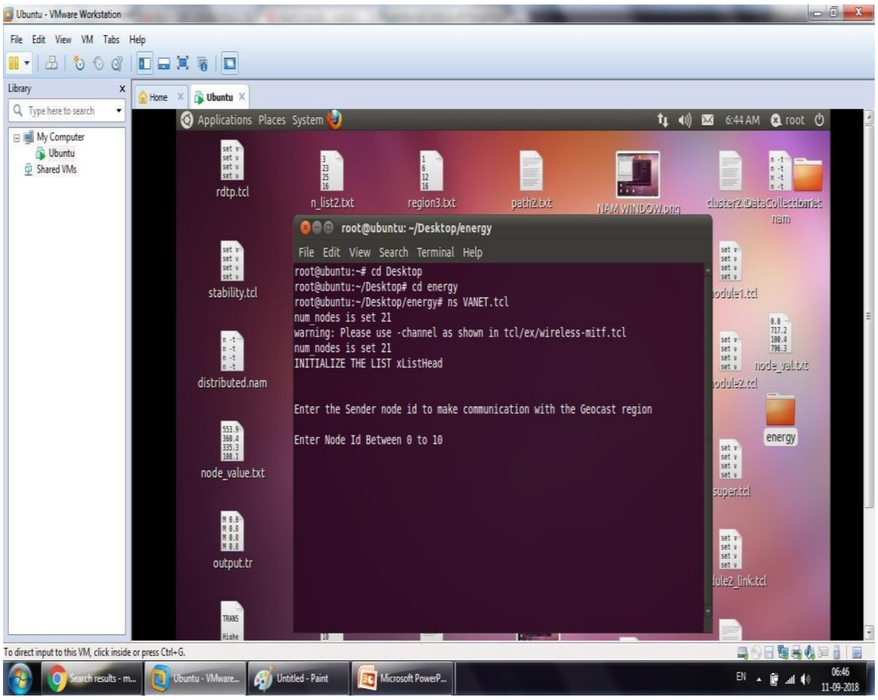

Figure 7. Entering the source node ID.

Once the other nodes in the network receive the source node ID, all the neighbouring node will share their location information with the source node. The latitude and longitude information of the shared nodes will be updated in a separate location information table shown in **Figure 7**.

Throughput:

In other terms, throughput represents the rate of effectively delivered messages. The ratio amount of packet (or bits) delivered to the transmission time is known as throughput. Mathematically

From **Figure 8** below, the throughput of the geocast protocol is higher than the ordinary VANET protocol.

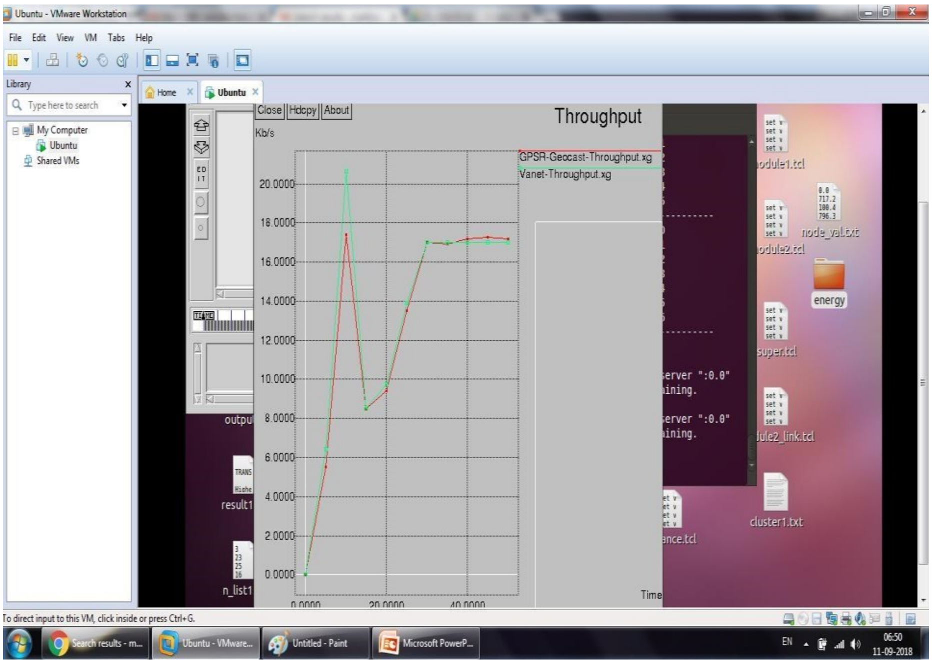

Figure 8. Throughput of the network.

Package transmission rate:

The packet delivery ratio is the total amount of packets sent from a source to the total amount of packets delivered to a destination. It speaks of the volume of data transmitted to the target location. It is calculated by dividing the number of packets sent by the source's app layer by the number of packets received at the point of destination. The mathematical formula for calculating the packet delivery ratio is:

$$PDR = S_d/S_s \times 100 \quad (1)$$

This metric can also be examined as the packet loss ratio, meaning the ratio of packets lost to packets transmitted, where S_d is the entire network packets acquired from the destination(s) & S_s is the total network packets supplied by a source(s). A greater packet delivery ratio is consistent with a better protocol is shown in **Figure 9**. On the other hand, a lower ratio indicates a superior protocol when referring to the package drop ratio. It is evident from the chart that fewer packets are dropped, suggesting that more sequences are delivered.

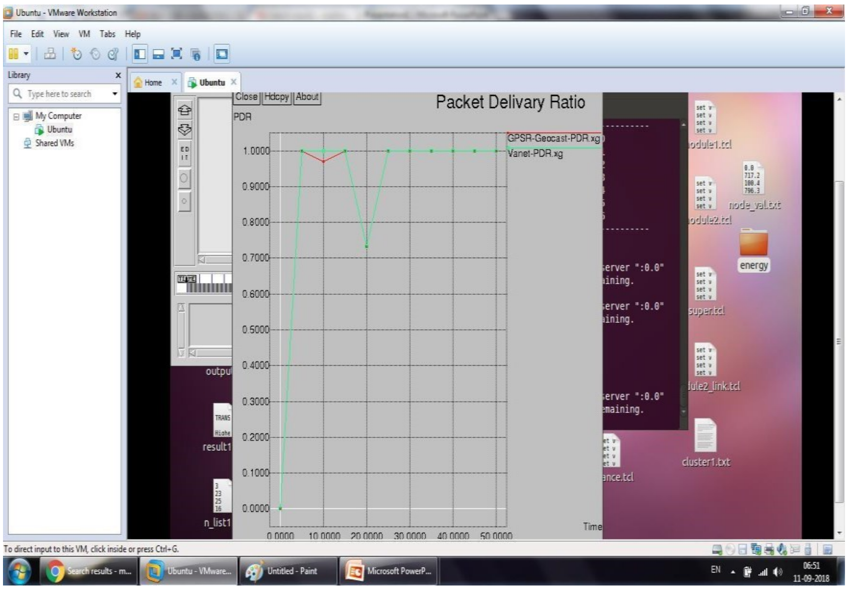

Figure 9. Packet delivery ratio.

The robustness of a system refers to its capability to maintain performance despite differences in variables or external conditions. To assess the robustness of the proposed bundle-based strategy, this study conducted a series of experiments to test its performance under different scenarios and parameter settings. A sensitivity analysis was conducted to identify the extent to which parameter differences affect the performance of the bundle-based strategy. The sensitivity analysis indicates that while the bundle-based strategy executes well under a range of parameter sceneries, certain parameters like node density and transmission energy suggestively influence its performance. The robustness assessment shows that the strategy can adapt to varying conditions, although extreme scenarios (high traffic, severe interference) can require adjustments to maintain optimal performance. Our approach incorporates a context-aware hazard identification and response system to prioritize important data according to current environmental circumstances. This fills a gap in the literature by guaranteeing trustworthy communication in possibly hazardous situations. In response to changes in the network and the amount of traffic, the suggested solution dynamically modifies critical parameters, including transmission power and aggregation interval. This adaptive technique achieves consistent performance in different settings by enhancing the system's resiliency and scalability.

5. Conclusions and future research

VANET designs are delivered strategy, representing programming and arranging information, which is attended separately in every transport. Achievements of those designs were calculated in roadway and city schemes. An enactment decision displayed the projected designs that achieved more excellence than congestion control designs. Motives for similar decisions utilize extra factors to explain the preference for all information and arrange the data by determining preference or using a higher-level procedure method. The moderate value of data, the number of package losses and moderate suspensions are enhanced in projected designs. Also, the standby suspension in sequences package deficit of security information is below the utility information. So, using the projected design, achieving a vehicle ad hoc network (VANET) enhances the security and accuracy in the vehicle surroundings developed. Finally, this design decides the conversation factors (i.e., Communication area and ratio, conflict aperture extent and AIFS) for each information cluster and transfer deferment is decreased. The roadside units (RSUs) transmit those conversation factors to the blocked transports to control the blockage environments by the crossroads. So, the medium loads are reserved, and the security information is exchanged with smaller deferments and package deficits. The bundle-based strategy improves transmission scheduling and reduces data redundancy to better use the network's resources. The research limitation is maintaining sensor nodes running for longer with less power means less maintenance and replacement needs. Future studies will conduct extensive field tests in varied geographical and environmental conditions to validate the proposed strategy's robustness and adaptability.

Author contributions

Conceptualization, PM and VSBD; methodology, ME; software, SP; validation, ACK, SSR and SKA; formal analysis, SP; investigation, ACK; resources, SSR; data curation, SP; writing—original draft preparation, PM; writing—review and editing, SP; visualization, ME; supervision, SP; project administration, SSR. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

References

1. Bouassida MS, Shawky M. On the congestion control within VANET. Wireless Days. 2008; 1-5.
2. Sepulcre M, Gozalvez J, Harri J, et al. Contextual Communications Congestion Control for Cooperative Vehicular Networks. IEEE Transactions on Wireless Communications. 2011; 10(2): 385-389. doi: 10.1109/twc.2010.120610.100079
3. Sepulcre M, Mittag J, Santi P, et al. Congestion and Awareness Control in Cooperative Vehicular Systems. Proceedings of the IEEE. 2011; 99(7): 1260-1279. doi: 10.1109/jproc.2011.2116751
4. Arun M, Barik D, Chandran SSR. Exploration of material recovery framework from waste—A revolutionary move towards clean environment. Chemical Engineering Journal Advances. 2024; 18: 100589. doi: 10.1016/j.ceja.2024.100589
5. Shukla RS, Khan IA, Tyagi N. Performance of Modified Edge Based Greedy Routing Algorithm in VANET Using Real City Scenario. Advances in Mechanical Engineering and its Applications (AMEA). 2012; 2(3).
6. Gul N, Qamar N, Shahzad A. A Survey on Architecture, Protocols, Challenges and Solutions on Vehicular Networking. International Journal of Multidisciplinary Sciences and Engineering. 2012; 3(3).
7. Taherkhani N, Pierre S. Congestion control in vehicular ad hoc networks using meta-heuristic techniques. Proceedings of the second ACM international symposium on Design and analysis of intelligent vehicular networks and applications. Published online October 21, 2012. doi: 10.1145/2386958.2386966
8. Nasri A, Fathy M, Hajisheykhi R. A Cross Layered Scheme for Broadcasting at Intersections in Vehicular Ad Hoc Networks. In: Proceedings of the 2009 International Conference on Future Networks, 2009. pp. 13-17.
9. Larsson T, Hedman N. Routing Protocols in Wireless Ad Hoc Networks—A Simulation Study [Master's thesis]. Lulea University of Technology, Stockholm; 1998.
10. Dipietro N. On in_nite and _nite lattice constellations for the additive white Gaussian noise channel [PhD thesis]. Math. Dept., Univ.; 2014.
11. Rehman GU, Zubair M, Qasim I, et al. EMS: Efficient Monitoring System to Detect Non-Cooperative Nodes in IoT-Based Vehicular Delay Tolerant Networks (VDTNs). Sensors. 2022; 23(1): 99. doi: 10.3390/s23010099
12. Rehman GU, Haq MIU, Zubair M, et al. Misbehavior of nodes in IoT based vehicular delay tolerant networks VDTNs. Multimedia Tools and Applications. 2022; 82(5): 7841-7859. doi: 10.1007/s11042-022-13624-2
13. Wang S, Zhang Q, Chen G. V2V-CoVAD: A vehicle-to-vehicle cooperative video alert dissemination mechanism for Internet of Vehicles in a highway environment. Vehicular Communications. 2022; 33: 100418. doi: 10.1016/j.vehcom.2021.100418
14. Singh R, Sharma R, Vaseem Akram S, et al. Highway 4.0: Digitalization of highways for vulnerable road safety development with intelligent IoT sensors and machine learning. Safety Science. 2021; 143: 105407. doi: 10.1016/j.ssci.2021.105407
15. Hasan N, Aziz AA, Mahmud A, et al. Vehicle Sensing and Localization in Vehicular Networks. International Journal of Technology. 2024; 15(3): 641. doi: 10.14716/ijtech.v15i3.5385
16. Joshua CJ, Jayachandran P, Md AQ, et al. Clustering, Routing, Scheduling, and Challenges in Bio-Inspired Parameter Tuning of Vehicular Ad Hoc Networks for Environmental Sustainability. Sustainability. 2023; 15(6): 4767. doi: 10.3390/su15064767
17. Tonguz OK, Wisitpongphan N, Parikh JS, et al. On the Broadcast Storm Problem in Ad hoc Wireless Networks. In: Proceedings of the BROADNETS 2006, 3rd International Conference, 2006.

18. Arun M. Experimental Investigation on Energy and Exergy Analysis of Solar Water Heating System Using Zinc Oxide-Based Nanofluid. Arabian Journal for Science and Engineering. 2022; 48(3): 3977-3988. doi: 10.1007/s13369-022-07369-1
19. Naumov V, Baumann R, Gross T. An evaluation of Inter-Vehicle Ad Hoc Networks Based on Realistic Vehicular Traces. In: Proceedings of the 7th ACM international symposium on Mobile ad hoc networking and computing; May 2006.
20. Cou PA, Wu Y. Network Coding for Internet and Wireless Networks. Microsoft Research One Microsoft Way; 2007.
21. Selvan, R.S., 2020. Intersection Collision Avoidance in DSRC using VANET. on Concurrency and Computation-Practice and Experience, 34(13/e5856), pp.1532-0626.
22. Senthamil Selvan R. Development of Secure Transport System Using VANET. Test Engineering and Management (H-Index). 2020; 82.
23. Senthamil Selvan R. Data Communication and Networking Concepts in UDP. International Journal of Recent Technology and Engineering (H-Index). 2020; 8(5).
24. Senthamil Selvan R. Collective Network Channel Decentralized Fountain Design Codes for Safe Communication in VANET Network. International Journal of Engineering and Technology (UAE). 2018; 7: 779-783.
25. Senthamil Selvan R. Analysis of Spawn Protocol and EDFC Algorithm for Secure Communication in VANET. International Journal of Pure and Applied Mathematics. 2018; 118(20): 1961-1973.
26. Senthamil Selvan R. Analysis of EDFC And ADFC Algorithms for Secure Communication in VANET. Journal of Advanced Research and Dynamical and Control Systems. 2017; 09(18): 1171-1187.
27. Senthamil Selvan R. Enhancement of High Density Wireless Sensor Networks using VANET. International Journal of Pure and Applied Mathematics. 2017; 117(17): 255-262.
28. Rehman GU, Zubair M, Qasim I, et al. EMS: Efficient Monitoring System to Detect Non-Cooperative Nodes in IoT-Based Vehicular Delay Tolerant Networks (VDTNs). Sensors. 2022; 23(1): 99. doi: 10.3390/s23010099
29. Torrent-Moreno M, Mittag J, Santi P, et al. Vehicle-to-Vehicle Communication: Fair Transmit Power Control for Safety-Critical Information. IEEE Transactions on Vehicular Technology. 2009; 58(7): 3684-3703. doi: 10.1109/tvt.2009.2017545
30. Manvi SS, Kakkasageri MS, Mahapurush CV. Performance Analysis of AODV, DSR, and Swarm Intelligence Routing Protocols in Vehicular Ad hoc Network Environment. In: Proceedings of the International conference on future Computer and Communication; April 2009. pp. 21-25.
31. Munusamy A, Barik D. Experimental Analysis of Heat Transfer and Thermal Performance of Parabolic Type Solar Collector with Ribbed Surface Texture for Clean Energy Extraction. International Journal of Energy for a Clean Environment. 2024; 25(5). doi: 10.1615/InterJEnerCleanEnv.2023047468
32. Yawan N, Keeratiwintakorn P. Efficiency Improvement of AODV for Vehicular Networks with Channel Availability Estimation. In: Proceedings of the 8th Electrical Engineering Electronics, Computer, Telecommunications and Information Technology (ECTI) Association of Thailand, 2011.
33. Tonguz O, Wisitpongphan N, Bai F, et al. Broadcasting in VANET. In: Proceedings of the IEEE Mobile Networking for Vehicular Environments. pp. 7-11.