VEHICLE TO EVERYTHING(V2X) COMMUNICATION USING ZIGBEE

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*Abstract*—Vehicle-to-Everything (V2X) Communication is a rapidly advancing technology in the modern automotive industry. This evolving technology offers numerous advantages in terms of providing real-time information during driving. Many on-road incidents and accidents stem from inadequate traffic path information, distracted drivers, and poor driving patterns. This paper explores the efficient utilization of Vehicle-to-Everything communication, employing On-Board Units (OBUs) and Roadside Units (RSUs). The OBU and RSU collaboratively share information not only between themselves but also with other OBU-equipped systems, utilizing Zigbee technology an IEEE standard (1609 family) that facilitates low-cost, low-power wireless Machine-to-Machine communication. This approach aims to significantly reduce risks to human life and minimize damage to public assets. The paper provides a detailed explanation of the design and functionality of the device incorporating OBUs and RSUs with Zigbee standards.

Keywords—V2X, OBU, RSU and ZigBee.

# Introduction

In an era marked by the relentless pursuit of innovation, the automotive industry finds itself at the crossroads of a revolution that promises to redefine the way we navigate the world's roadways. The catalyst for this transformative journey is none other than Vehicle-to-Everything (V2X) Communication, an avant-garde technology that transcends the limits of conventional vehicular interaction. This paper embarks on an exploration of this promising frontier, emboldening itself with the alliance of On-Board Units (OBUs) and Roadside Units (RSUs). But this is no ordinary partnership; it is a symphony orchestrated with the finesse of Zigbee technology, firmly rooted in the IEEE standard (1609 family). Zigbee, the unsung hero of low-cost, low-power wireless Machine-to-Machine communication, becomes the thread weaving this narrative of transformation. This paper defines the data sharing between infrastructure and vehicle and then between two vehicles with the change in controls of the vehicle which will be more useful in road safety and traffic management.

# LITERATURE REVIEW

In order to increase the reliability of the vehicle to everything (V2X) communication many researchers are going with various technology. In this survey, proposed a new method to implement the vehicle to everything (V2X) communication based on Distance Short Range Communication (DSRC) [1]. In that survey they shown the test result of V2X communication based on DSRC. In the result of the line-of-sight (LOS) test the packet reception rate (PRR) is high when the distance was 720 meters at 5dBm, and 1035 meters at 11dBm. In the Non-LOS (NLOS) shadowing test, more of PRR was up to 175 meters at 5 dBm and 520 meters at 11dBm. We know that DSRC used for the vehicle to everything(V2X) communication a vehicular wireless standard protocol is to be used for V2X.Wireless Access in Vehicular Environment (WAVE) and this covered under the IEEE 802.11P standard. The design and implementation of DSRC\WAVE described and functioning of the device mechanics using WAVE standard is explained with a live project using vehicle mounted unit (OBU) and road side mounted unit RSU in the survey [2]. In the survey [3] collect the data from the sensors on the public transportations and it is collected in a units mounted on the road side. This units are called On-Board Units (OBU). This units are transferred the signals using communication protocols. The unit includes the sensors for urban mobility and environmental data. Road Side Units (RSU) [4] assisted for the cluster head selection and backup protocol to tackle the traffic information problems. This protocol simply the cluster-based protocols with the help of road side unit. In this survey the vehicle movement with the mathematical way and validate the feasibility of that protocol through extensive simulations. This result increases the data reception rate and the cluster head backup accuracy is high. The India’s first electric tractors uses the intelligent lane control system using ZigBee IoT [5]. It uses a sophisticated microcontroller based embedded system to manage various aspects of the vehicle like speed, battery and GPS navigation with the help of ZigBee wireless sensors and IoT maps. In this survey it includes a simulation using embedded-c firmware code to evaluate how well the system works under predefined constraints.

Vehicle-to-X (V2X) communication system has been created to enhance safety for both vehicles and pedestrians [6]. In this survey system combines IEEE 802.11p and Wi-Fi protocols in an on-board unit (OBU) for vehicles. Extensive testing demonstrates that the OBU ensures reliable communication for vehicle-to-vehicle (V2V) and vehicle-to-pedestrian (V2P) interactions in terms of packet delivery and delay. Two safety applications have been developed: one provides driving information and collision warnings in vehicles. The applications can adapt their alerts based on the pedestrian's smartphone usage, and experiments show they effectively prevent intersection accidents and provide context-aware alerts to pedestrians. Among the urgent problems in inter-vehicular communication, in particular Vehicle to Everything(V2X) connectivity, can solve autonomous transportation networks and self-driving cars. A lot of work is being done to create a dependable V2X communication architecture using multiple wireless technologies, including Zigbee, LTE, 5G, and Long Range (LoRa) communication. V2X communication dependencies on communication architecture and related wireless technology are critical to its reliability and effectiveness. According to testing and research, a car using the suggested design can depend connect with roadside infrastructures at speeds ranging from 10 to 30 miles per hour (MPH) [7]. In the survey [8] LTE and 5G’s role in efficient V2X(vehicle-to-everything) communications. It begins by explaining why cellular-based V2X communications are important. Then, it outlines the LTE V2X architecture and its scenarios. The paper explains the challenges within LTE for supporting V2X, covering aspects like the physical layer, synchronization, multimedia services, resource allocation, and security. It also provides the solutions for these challenges. In V2X(vehicle-to-everything) it has comprehensive look at the ecosystem [9]. It covers the main security and privacy concerns, ongoing standardization efforts, and existing defense mechanisms within the V2X domain. In that it also points out where there may be gaps in the current security solutions and suggests potential areas of concern that need further exploration. Potential DSRC and cellular interworking options for effective V2X communications are examined in the survey [10]. It goes over possible DSRC-cellular hybrid architectures as well as the primary interworking problems put on by vehicle mobility, including issues with network selection and vertical handover. In an effort to connect academic research with automotive industry activities, they offer an overview of the global DSRC standards, the V2X products already adopted and deployed in vehicles by auto manufacturers, and the current V2X research and development platforms.

The main elements of V2X are, Vehicle to Vehicle(V2V) communication and Vehicle to Infrastructure (V2I). These are enabling the vehicles to transmits the signals between one another and road side units. In this survey they describe the hardware implementation and to explore the inner working of these technologies [11]. The vehicle can communicate with each other with the infrastructure, pedestrian, network or any other devices to exchange information that is used for in various applications that can be aid intelligent transportation. This article discuss how V2X can emerge as a solution for various challenges in the communications [12].Variable delays and packet losses in data are examples of imperfect communication conditions that the control system is built to handle. To address this, the survey [13] introduces a packet dropout compensator to mitigate the loss of V2X information. With Hardware-In-the-Loop testing, the authors show that this controller is stable under a range of driving conditions. The outcomes demonstrate that the suggested control system can be used for vehicle platoon control even in situations where V2X communication is not optimal because it still performs well in vehicle-following tasks.

The initial designs and results of the prototype of a vehicle-to-vehicle communication system using light fidelity (Li-Fi) technology [14]. The proposed use of Li-Fi technology in this article comprises mainly light emitting diode (LED) as means of connectivity by sending data through light spectrum as an optical wireless medium for signal propagation. The usage of LED eliminates the need of complex wireless networks and protocols. In this survey [15] the intersection of safety service using vehicle-to vehicle communication. In this survey [15] suggested model uses wireless access in vehicular environment (WAVE) proposed by IEEE WG 802.11 and P1609 as the V2V communication protocol. This protocol provides the GPS information of the vehicles. Through this model, the host vehicle recognizes the other vehicles. The 5G New Radio frame structure using mm wave communication technology to provide the low latency and high data rate information. In this survey field test results prove that data rate of 2.8 Gbps within 500ms latency in mobile vehicle communication. Vehicle -to-vehicle safety communications requirements are systematically studied. Safety message and the corresponding communication requirement are designed. In this survey [17] is used to guide designation of vehicle-to-vehicle safety communication protocols.

# PROBLEM STATEMENT

Despite the considerable advancements in V2X communication technology, a number of obstacles stand in the way of its seamless implementation and realization of its benefits. The integration of V2X with legacy infrastructure, pose significant hurdles to achieving its full potential in reducing accidents and minimizing risks to both drivers and pedestrians. Resolving these challenges is critical to ensuring that V2X communication realizes its potential in creating safer and more secure transportation environments. In order to tackling these challenges is essential to harness the full potential of V2X communication in revolutionizing road safety, reducing traffic congestion, and enhancing overall transportation efficiency.

OBJECTIVES

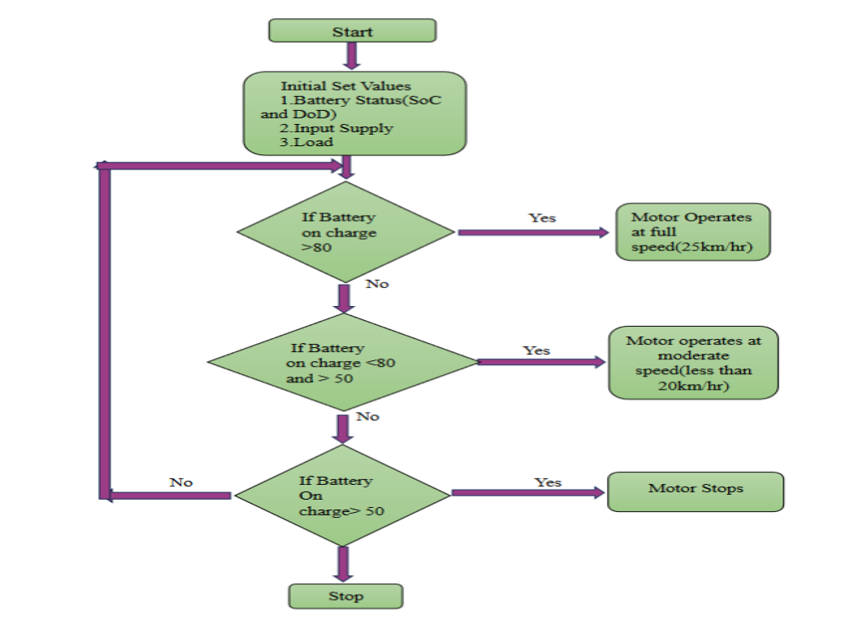
* To update the driver about driving conditions and environment by the means of notifications, images and audio commands.
* Guidance assistance for drivers through Road Side Unit (RSU) about traffic routes and congested driving areas.
* Transferring important information between vehicles through On-Board Unit (OBUs).
* To alert driver with speed control warnings in accordance with the area or road of driving.
* To operate controls of vehicles using monitored data.

PROPOSED METHODOLOGY

The work proposed in this paper presents a less complicated yet highly efficient method to reduce road accidents caused by reckless drivers and poor driving patterns. In order to minimize the loss of life and property resulting from road accidents, this paper leverages Vehicle-to-Everything (V2X) communication technology.V2X communication technology plays a pivotal role in reducing the aforementioned adversities to a significant extent. To implement V2X communication, the system proposed here utilizes ZigBee technology for information transfer between the infrastructure and vehicles, as well as between vehicles themselves. Information is transmitted from the infrastructure to vehicles using two key components: the On-Board Unit (OBU) within the vehicle and the Road Side Unit (RSU) installed in the infrastructure. Information exchange between vehicles is facilitated through the OBUs of the vehicles involved.

The shared data from both the infrastructure and other vehicles is harnessed in real-time to enhance vehicle control. With access to sufficient information, it becomes possible to adjust vehicle speed, provide drivers with zone-specific information, offer traffic updates for congested and less crowded routes through notifications on the infotainment system, and prevent accidents by enabling communication between the OBUs of different vehicles. Figure 1 illustrates the workflow for reducing vehicle speed based on its battery percentage.

The algorithm adopted here is, if the battery charge is above 80 % the vehicle runs at the full speed. If the battery is between the 50% to 80% vehicle runs at its moderate speed but if the battery charge is below 50% the vehicle will automatically stop with a prior alert.



**Fig 1: First Part of Proposed Methodology**

# PRELIMINARY RESULT

The result here is the speed control of the vehicle with respect to its battery’s state of charge is tabulated in Table 1. The algorithm involves three cases which are:

Case 1: The vehicle should run at full speed, if the charge of the battery is above 80%.

Case 2: The vehicle should operate at moderate speed, if charge on the battery is between 50% to 80%.

Case 3: The vehicle should be stopped, if the charge on the battery is less than 50%.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Voltage Divider Circuit** | | **Wheel Diameter(mm)** | **Voltage Reading**  **(Volts)** | **RPM** | **Km/**  **hr** |
| **R1(k ohm)** | **R2(k ohm)** |
| 100 | 100 | 8 | 8.02 | 16,500 | 24.8 |
| 100 | 40 | 8 | 4.63 | 4000 | 6.03 |
| 100 | 30 | 8 | 3.47 | 0 | 0 |

**Table 1: Battery Charging & motor Speed characteristics**

Since the battery is 9V, the 80% of 9V will be 7.2V, therefore if the voltage is above than 7.2 vehicle will be running at its full speed(25km/hr). Then 50% of 9V will be 4.5V, if the voltage is between 4.5 to 7.2 than the vehicle will operate at its moderate speed(6km/hr). If the voltage is below 50% the vehicle will be stopped. The Figure 2 represents the graphical

view of the output.

Figure 2: Power output characteristics

CONCLUSION

To sum up, the findings presented in this research underscore the significance of V2X technology in enhancing road safety and traffic efficiency. The proposed design here works in very proficient manner in addition to the data exchange between the infrastructure and vehicles and between two vehicles, this system helps in controlling the vehicles in Realtime to avoid the ill-occurrences. As we bring this research to a close, it is evident that V2X technology, combined with a proficiently designed system, holds the promise of a safer, more efficient, and interconnected future for our roadways. With continued development and widespread adoption, we can look forward to a world where road safety and traffic efficiency are no longer mere goals but a tangible reality, ultimately benefitting society as a whole.

##### FUTURE SCOPE

The paper depicted here have more and more value in the future implementation. As the Vehicle to Everything communication is a rapidly developing technology with many attributes to its core this can also be applied in the safety vehicle such as Ambulances and Fire engines. The V2X communication is only in the level of controlling the vehicle but with the future implantation with the upgraded system it will be possible to alert the driver with the notification for the blind spot so that many accidents can be reduced. The tracking of vehicle and the less crowded routes are also can be shown to the drivers in the time of need..

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DECLARATION

**Conflict of interest:** The authors declare no competing interests.

##### References

1. J. -K. Bae, M. -C. Park, E. -J. Yang and D. -W. Seo, "Implementation and Performance Evaluation for DSRC-Based Vehicular Communication System," in IEEE Access, vol. 9, pp. 6878-6887, 2021, doi: 10.1109/ACCESS.2020.3044358
2. P. Kumar and K. B. Ali, "Intelligent Traffic System using Vehicle to Vehicle (V2V) & Vehicle to Infrastructure (V2I) communication based on Wireless Access in Vehicular Environments (WAVE) Std," *2022 10th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO)*, Noida, India, 2022, pp. 1-5, doi: 10.1109/ICRITO56286.2022.9964590.
3. Jose Santa, Luis Bernal-Escobedo, Ramon Sanchez-Iborra, On-board unit to connect personal mobility vehicles to the IoT, Procedia Computer Science, Volume 175, 2020, Pages 173-180, ISSN 1877-0509, doi:10.1016/j.procs.2020.07.027.
4. L. Sun, Y. Wu, J. Xu and Y. Xu, "An RSU-assisted Cluster Head Selection and Backup Protocol," *2012 26th International Conference on Advanced Information Networking and Applications Workshops*, Fukuoka, Japan, 2012, pp. 581-587, doi: 10.1109/WAINA.2012.61.
5. Arunkumar Palaniappan, Ramaswamy Muthiah, Murugesh Tiruchi Sundaram, ZigBee enabled IoT based intelligent lane control system for autonomous agricultural electric vehicle application, SoftwareX, Volume23,2023,101512,ISSN2352-7110.
6. Liu Zhenyu, Pu Lin, Zhu Konglin, Zhang Lin, Design and evaluation of V2X communication system for vehicle and pedestrian safety, The Journal of China Universities of Posts and Telecommunications, Volume 22, Issue 6, 2015, Pages 18-26, ISSN 1005-8885, doi:10.1016/S1005-8885(15)60689-6.
7. K. F. Haque, A. Abdelgawad, V. P. Yanambaka and K. Yelamarthi, "A LoRa Based Reliable and Low Power Vehicle to Everything (V2X) Communication Architecture," *2020 IEEE International Symposium on Smart Electronic Systems (iSES) (Formerly iNiS)*, Chennai, India, 2020, pp. 177-182, doi: 10.1109/iSES50453.2020.00047.
8. S. Gyawali, S. Xu, Y. Qian and R. Q. Hu, "Challenges and Solutions for Cellular Based V2X Communications," in *IEEE Communications Surveys & Tutorials*, vol. 23, no. 1, pp. 222-255, Firstquarter 2021, doi: 10.1109/COMST.2020.3029723.
9. M. Hasan, S. Mohan, T. Shimizu and H. Lu, "Securing Vehicle-to-Everything (V2X) Communication Platforms," in *IEEE Transactions on Intelligent Vehicles*, vol. 5, no. 4, pp. 693-713, Dec. 2020, doi: 10.1109/TIV.2020.2987430.
10. M. Hasan, S. Mohan, T. Shimizu and H. Lu, "Securing Vehicle-to-Everything (V2X) Communication Platforms," in *IEEE Transactions on Intelligent Vehicles*, vol. 5, no. 4, pp. 693-713, Dec. 2020, doi: 10.1109/TIV.2020.2987430.
11. G. Tewolde and B. Smith, "Small Scale Field Study of Vehicle-to-Vehicle (V2V) Communications for Safety Applications," 2019 IEEE 16th International Conference on Smart Cities: Improving Quality of Life Using ICT & IoT and AI (HONET-ICT), Charlotte, NC, USA, 2019, pp. 059-063, doi: 10.1109/HONET.2019.8908002.
12. .R. Jain, "V2X (Vehicle to Everything) in India," 2023 IEEE International Conference on Electronics, Computing and Communication Technologies (CONECCT), Bangalore, India, 2023, pp. 1-6, doi: 10.1109/CONECCT57959.2023.10234762.
13. J. Liu, Z. Wang and L. Zhang, "Integrated Vehicle-Following Control for Four-Wheel-Independent-Drive Electric Vehicles Against Non-Ideal V2X Communication," in IEEE Transactions on Vehicular Technology, vol. 71, no. 4, pp. 3648-3659, April 2022, doi: 10.1109/TVT.2022.3141732.
14. N. A. Abdulsalam, R. A. Hajri, Z. A. Abri, Z. A. Lawati and M. M. Bait-Suwailam, "Design and implementation of a vehicle to vehicle communication system using Li-Fi technology," 2015 International Conference on Information and Communication Technology Research (ICTRC), Abu Dhabi, United Arab Emirates, 2015, pp. 136-139, doi: 10.1109/ICTRC.2015.7156440.
15. S. -C. Pyo, J. -H. Yoon, J. -W. Lee and S. -S. Lee, "Intersection safety service model using vehicle-to-vehicle communication," 2014 International Conference on Information and Communication Technology Convergence (ICTC), Busan, Korea (South), 2014, pp. 605-606, doi: 10.1109/ICTC.2014.6983223.
16. Q. Zhang, H. Sun, Z. Wei and Z. Feng, "Sensing and Communication Integrated System for Autonomous Driving Vehicles," IEEE INFOCOM 2020 - IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS), Toronto, ON, Canada, 2020, pp. 1278-1279, doi: 10.1109/INFOCOMWKSHPS50562.2020.9162963.
17. C. Wen-Jing and H. Qing-Tian, "Requirements Analysis for Vehicle-to-Vehicle Safety Communication," 2012 International Conference on Industrial Control and Electronics Engineering, Xi'an, China, 2012, pp. 216-218, doi: 10.1109/ICICEE.2012.64.