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Vehicle to Vehicle Communication using Zigbee

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ABSTRACT: Road traffic accidents, a leading cause of global fatalities, often stem from delayed reactions to sudden hazards. This project addresses this critical issue by proposing an in expensive vehicle communication system designed to provide drivers with early warnings of impending collisions. The system's primary objective is to overcome the limitations of conventional technologies, such as Wi-Fi and Bluetooth, which are ill-suited for this task due to their short operational range and high-power consumption. The proposed system is architected around Zigbee, selected as its foundational communication technology for its optimal balance of critical attributes: sufficient operational range, exceptional power efficiency, and robust performance in radiofrequency hostile environments.

I. INTRODUCTION

The growing complexity of road traffic systems and the increasing density of vehicles demand advanced technological solutions to enhance safety and reduce accidents. Vehicle-to-Vehicle (V2V) communication is a critical enabler for advanced driver assistance systems (ADAS), aiming to reduce accident rates by facilitating the exchange of kinematic data. While Dedicated Short-Range Communication (DSRC) and Cellular-V2X (C-V2X) are prominent standards, their cost and complexity motivate the exploration of alternative technologies for specific safety applications.

This project proposes a cost effective V2V architecture utilizing Zigbee (IEEE 802.15.4), chosen for its ultra-low power consumption, low latency, and inherent mesh networking capabilities, which are advantageous in dense traffic scenarios. This reliable, low-power connection weaves a secure network between vehicles that operates completely independently of cell towers. The outcome is a web of awareness on the road, giving every driver a sixth sense for potential hazards up ahead.

This project is motivated by the alarming number of road accidents globally and the necessity for enhanced safety measures in modern transportation systems. Most accidents occur due to a severe communication breakdown: vehicles fail to warn each other about impending dangers like sudden braking or road obstacles. Often, by the time you see a hazard on the road, there's not enough time to react. That split-second delay is where most accidents start, and the problem gets worse in heavy traffic or bad weather, when you need a warning system you can count on without question.

II. LITERATURE SURVEY

This chapter provides a summary of the reviewed literature, forming the foundation for this project. on Zigbee-based Vehicle-to-Vehicle (V2V) communication systems. The focus is on identifying the gaps in existing technologies and highlighting the advantages of Zigbee for enhancing road safety and accident prevention.

1. **Kim et al. (2012)** Investigated the application of visible light communication(VLC). for inter- vehicle communication. While VLC was shown to have potential for high-speed data exchange, it was significantly limited by its dependence on lineof- sight communication, which is impractical in many real-world scenarios, such as during adverse weather conditions [2].

2. **Santos and Ferraz (2015)** investigated VLC in vehicle networks and compared it with RF- based technologies. The study concluded that RF technologies like Zigbee offer a more robust solution for non-line-of-sight communication, essential for modern vehicular systems [3]. Zigbee's low-power and low-latency capabilities have been highlighted in several studies as ideal for vehicular applications. Sarkaret al. (2018) demonstrated the effectiveness of Zigbee in a smart communication system. Their research highlighted Zigbee's energy efficiency and its suitability for short-range, reliable communication [4].

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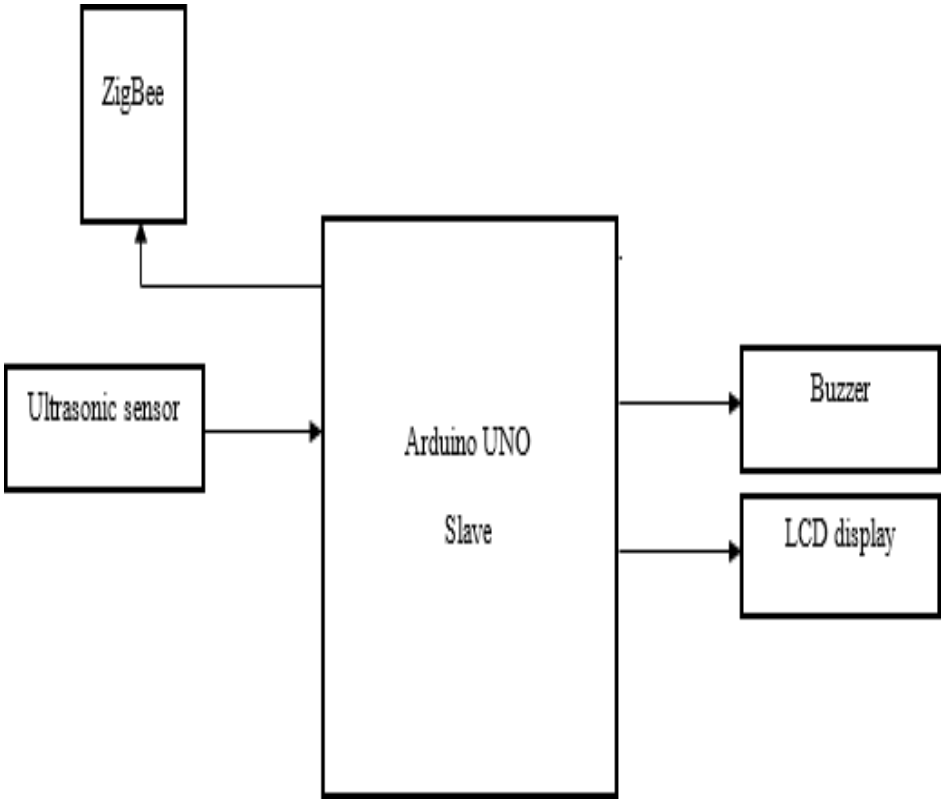
3. **Elhoseny and Shankar (2019)** proposed a A framework for securely transmitting data on mobile ad hoc networks, utilizing signcryption techniques to ensure data confidentiality and integrity. While the model significantly enhanced the security aspect—an essential requirement for V2V communication—it also introduced considerable computational overhead, which may limit its practicality in real-time applications

4. **Takai et al. (2018)** highlighted the benefits of integrating GPS with vehicular communication systems for precise location tracking. Their research laid the groundwork for combining Zigbee and GPS in this project to enhance real-time hazard alerts [8].

III. METHODOLOGY

The Master node designed using various sensors, such as HC05 and ultrasonic sensors, a GPS module, an accelerometer, and components like a motor driver, DC motor, buzzer, and LCD display. This node continuously monitors environmental and vehicle data, using Zigbee to communicate potential hazards to the Slave node. The Slave node, containing similar components (ultrasonic sensor, GPS, buzzer, and LCD display),receives data from the Master node to respond to alerts like collision risks or sudden proximity changes. The Zigbee module facilitates this reliable, low-power communication between nodes, allowing real-time alerts for drivers and helping them respond promptly to potential dangers on the road. This setup offers an efficient and scalable way to reduce accidents, enhance traffic management, and improve overall safety on the roads The development of the Zigbee-based Vehicle-to-Vehicle (V2V) communication system follows a structured approach to ensure reliability, scalability, and efficiency.



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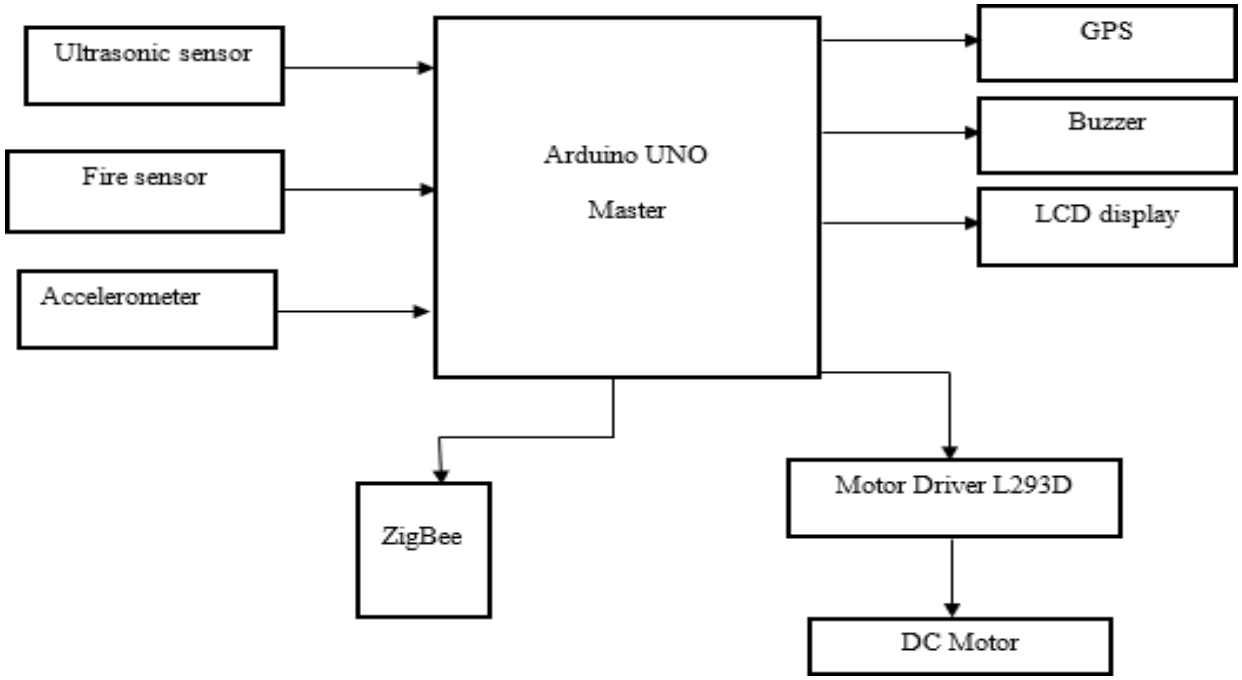

Fig.1 Block diagram of the proposed system

The system's block diagram of the Zigbee-based Vehicle-to-Vehicle (V2V) communication system demonstrates a setup that enhances road safety through real-time data exchange. The system features a Master node and a Slave node, each centered around an Arduino UNO. The Master node designed using various sensors, such as HC05 and ultrasonic sensors, a GPS module, an accelerometer, and components like a motor driver,DC motor, buzzer, and LCD display.

ARDUINO UNO

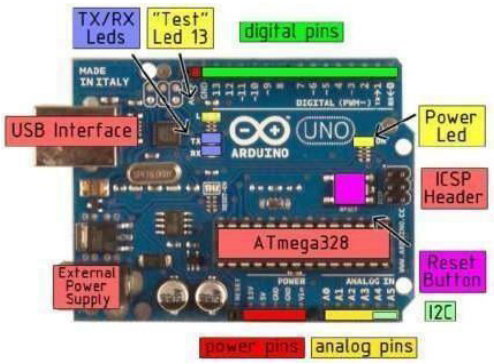

Fig.2 Arduino Uno

The Arduino Uno is one of the most popular microcontroller boards, built around the ATmega328 chip. It can be powered either through a USB connection or an external power source, such as a battery or an AC-to-DC adapter.The board automatically selects the appropriate power source, with a recommended input voltage range of 7–12V for stable operation (although it can technically work between 6 V and 20 V). Supplying less than 7V may cause instability, while going above 12 V can overheat the voltage regulator[4].

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NEO-6M GPS MODULE

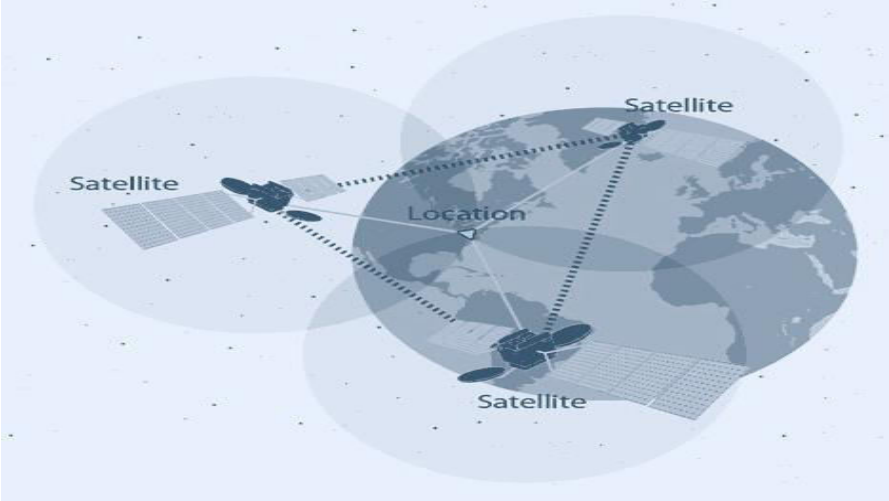

Fig.3 NEO-6M Gps Module

The Global Positioning System (GPS) is made up of over 30 navigation satellites orbiting the Earth. These satellites continuously broadcast radio signals containing their exact location and the precise time the message was sent. GPS receivers on the ground use this information to determine their position by calculating how long the signals take to reach them. By measuring distances from at least three satellites, the receiver can pinpoint its location using a method called trilateration. This process involves analysing the signal travel time from multiple satellites to the receiver, allowing it to calculate an accurate

ZIGBEE

Fig.4 ZIGBEE

Many collisions stem from a critical communication gap: vehicles cannot share real-time the warnings about immediate dangers like sudden braking or road hazards. Since drivers must rely solely on visual cues, they often identify threats too late to react safely—a delay that becomes especially perilous in dense traffic or poor weather. While technologies like Wi-Fi and Bluetooth have been explored, their high power consumption, limited range, and latency make them unsuitable for the instant, reliable communication required for collision avoidance. Zigbee technology, in contrast, is specifically designed to overcome these limitations, offering a low- power, robust solution for the instantaneous data exchange that vehicular safety demands.

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SOFTWARE

The Arduino UNO can be instructed using the Arduino IDE software (Integrated Development Environment), which provides an easy-to-use interface for writing programs, compiling, and uploading code. The system's firmware was developed and uploaded using the Arduino Integrated Development Environment (IDE). The Arduino Uno board's preinstalled bootloader, which implements the STK500 protocol, facilitated direct programming via the USB port, streamlining the development process.

Fig.5 Arduino IDE

IV. RESULTS & DISCUSSIONS

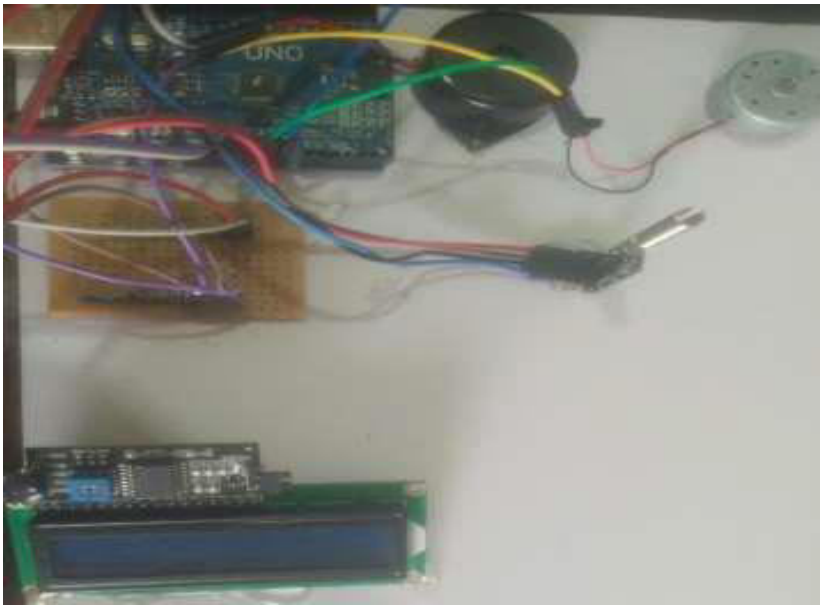

Fig.6 Result Analysis

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The design and implementation of a Zigbee-based Vehicle-to-Vehicle (V2V) communication system proved successful, with the Arduino UNO serving as the effective central controller. The hardware integration of ultrasonic sensors, a GPS module, a DC motor, a buzzer, and an LCD display created a functional prototype that was rigorously tested under various scenarios. These tests confirmed the system's core capability to detect potential collision risks and provide real-time alerts. The prototype system was rigorously tested to evaluate its core functionalities: collision warning, accident detection, and V2V communication. The ultrasonic sensor provided consistent distance measurements with an average accuracy of ±2 cm within a 4-meter range.

V. CONCLUSION

Vehicle-to-Vehicle (V2V) communication powered by Zigbee technology provides a dependable and efficient means to enhance road safety and manage traffic effectively. Through real-time data sharing between vehicles, the system improves collision prevention, congestion control, and hazard detection. Zigbee's low power requirements, affordability, and scalability make it well- suited for V2V applications, enabling energy-efficient and reliable connectivity. When integrated with sensors, GPS, and alert systems, it delivers timely warnings about potential threats—such as sudden braking or accidents—thereby lowering collision risks and improving driver awareness. This approach supports the development of smarter, safer roads And establishes the groundwork for intelligent transportation systems, that cater to both conventional and autonomous vehicles.

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