# VANET – Vehicular Ad-Hoc Networks

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***Abstract*—Vehicular Ad-Hoc Networks (VANETs) are a type of network that enables communication between vehicles and infrastructure. This project develops a low-cost VANET system using ESP32, sensors, and ESP-NOW protocol for real-time communication. It helps in accident detection, traffic management, and road safety improvement.**

***Index Terms*—VANET, ESP32, Vehicle-to-Vehicle Communication, Real-Time Alerts, Wireless Sensor Network.**

## I. INTRODUCTION

With the increasing number of vehicles, issues such as traffic congestion, road accidents, and safety challenges have become major concerns. Vehicular Ad-Hoc Networks (VANETs), a subclass of Mobile Ad-Hoc Networks (MANETs), provide a solution by enabling communication between vehicles and infrastructure. These networks allow vehicles to share real-time information such as traffic conditions, hazards, and emergency alerts.

VANETs use technologies such as Wi-Fi, DSRC, 5G, and IoT devices to create dynamic communication networks. This project focuses on developing a low-cost VANET system using ESP32 microcontrollers integrated with sensors like GPS, accelerometers, and ultrasonic sensors. The system demonstrates how real-time communication can improve road safety, reduce accidents, and support intelligent transportation systems.

Additionally, VANET applications include traffic management, navigation assistance, congestion control, and emergency response systems. Integration with advanced technologies such as Artificial Intelligence (AI) and Cloud Computing further enhances the capabilities of VANETs, making them essential for future smart city infrastructure

## II. RELATED WORK

VANETs play a significant role in Intelligent Transportation Systems by enabling real-time communication between vehicles and infrastructure. Previous research has focused on accident detection, traffic monitoring, and safety enhancement using VANET technology. Communication protocols such as DSRC and IEEE 802.11p have been widely used for reliable data transmission.

Researchers have also explored the integration of cloud computing and IoT with VANETs to improve data storage and accessibility. Sensor-based systems using GPS, accelerometers, and ultrasonic sensors have been proposed for detecting crashes and monitoring vehicle movement.

Recent advancements include the use of Artificial Intelligence and Machine Learning to predict traffic patterns and improve decision-making. Blockchain technology has also been introduced to enhance security and data integrity in vehicular communication. Despite these advancements, challenges such as scalability, security, and energy efficiency remain areas of active research.

## III. METHODOLOGY

The proposed system uses ESP32 microcontrollers as the core processing unit due to their built-in Wi-Fi and Bluetooth capabilities. The system integrates sensors such as MPU6050 (accelerometer and gyroscope), ultrasonic sensors, and optional GPS modules to monitor vehicle movement and detect potential hazards.

Communication between vehicles is achieved using the ESP-NOW protocol, which enables fast and connectionless data transmission without requiring internet connectivity. The system continuously monitors sensor data to detect events such as sudden braking, collisions, or unsafe distances between vehicles.

## IV. SYSTEM ARCHITECTURE

The system architecture consists of vehicle units equipped with ESP32 microcontrollers and sensors, communication modules, and receiver units. Each vehicle collects real-time data such as speed, distance, and movement patterns using sensors.

This data is transmitted through wireless communication channels, enabling both Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication. The receiver unit processes the incoming data, performs analysis, and generates alerts if necessary.

The system also includes data logging and storage components to maintain records for future analysis. Alerts are displayed using visual and audio indicators, ensuring timely notification to drivers. The architecture supports scalability, allowing multiple vehicles to communicate within a network for cooperative safety.

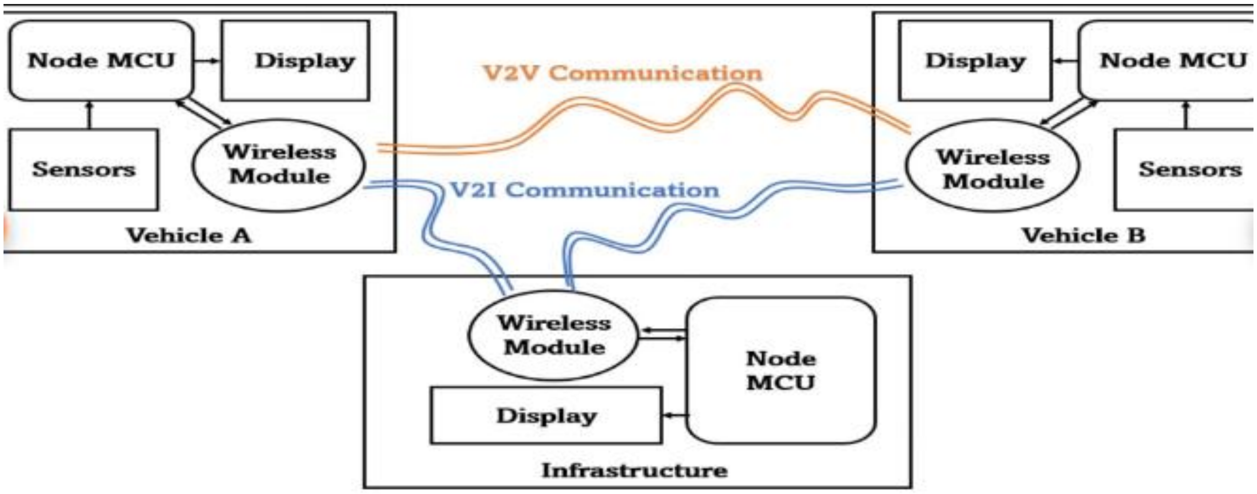


Fig. 1: System Architecture

## V. MODELING AND ANALYSIS

*The system is divided into three main modules:*

1. Vehicle Unit Module:

This module detects crashes and monitors nearby vehicles using sensors. It sends alerts to surrounding vehicles and displays status information.

2. Nearby Vehicle Alert Module:

This module receives alerts from other vehicles and provides real-time warnings to the driver using visual and audio indicators.

3. Receiver Tower (Base Station):

This module collects data from vehicles, including crash information and location details. It stores and displays critical information for monitoring and analysis.

The overall system ensures efficient communication and coordination between vehicles, helping to reduce accidents and improve traffic safety.

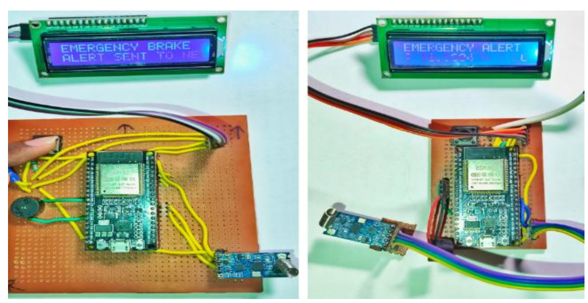


Fig. 2: Hardware Setup

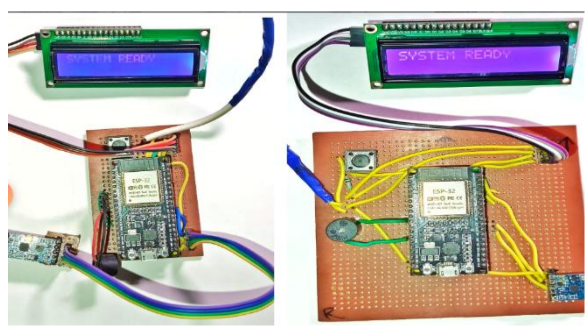


Fig. 3: Communication Flow

## VI. ABBREVIATIONS AND ACRONYMS

1) VANET – Vehicular Ad-Hoc Network
2) MANET – Mobile Ad-Hoc Network
3) V2V – Vehicle-to-Vehicle Communication
4) V2I – Vehicle-to-Infrastructure Communication
5) ESP32 – Microcontroller with Wi-Fi and Bluetooth
6) GPS – Global Positioning System
7) MPU6050 – Motion Processing Unit (Accelerometer + Gyroscope)
8) IoT – Internet of Things
9) DSRC – Dedicated Short Range Communication
10) AI – Artificial Intelligence
11) ML – Machine Learning
12) PDR – Packet Delivery Ratio
13) ITS – Intelligent Transportation System
14) Wi-Fi – Wireless Fidelity

## VII. RESULTS AND DISCUSSION

The proposed VANET system was successfully implemented and tested under various conditions. The results show that the system enables real-time communication between vehicles, improving road safety and traffic management.

The system demonstrated low latency and high reliability in data transmission. Alerts were generated efficiently during critical situations such as collision detection and unsafe distance monitoring. The performance remained stable even under dynamic conditions.

Overall, the system proved effective in enhancing vehicular communication and reducing accident risks.

## VIII. CONCLUSION

This project presents the design and implementation of a cost-effective Vehicular Ad-Hoc Network (VANET) system aimed at improving road safety and traffic management. By enabling real-time communication between vehicles and infrastructure, the system helps in early detection of accidents and hazardous situations.

The integration of ESP32 microcontrollers with sensors such as MPU6050 and ultrasonic sensors ensures accurate monitoring of vehicle movement and surroundings. The use of the ESP-NOW communication protocol allows fast and reliable data exchange without the need for internet connectivity.

The experimental results demonstrate that the proposed system achieves low latency, high reliability, and efficient communication even in dynamic traffic conditions. It effectively generates timely alerts, thereby reducing the risk of collisions and improving driver awareness.

In future, the system can be enhanced by integrating advanced technologies such as Artificial Intelligence, cloud computing, and 5G communication to support large-scale deployment and smart city applications. Overall, the proposed VANET system provides a promising solution for intelligent transportation and safer road environments.

## IX. APPENDIX

The appendix includes additional details related to the implementation of the proposed VANET system. The system utilizes ESP32 microcontrollers integrated with sensors such as MPU6050 and ultrasonic sensors for data collection and communication.

The ESP-NOW protocol is used for wireless data transmission between vehicle units, ensuring low latency and efficient communication. Additional configurations and sensor connections are implemented to support real-time monitoring and alert generation.

These supporting components enhance the functionality of the system and contribute to the overall performance of the proposed model.

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