



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 5, May 2025

Smart Emergency Traffic Management System

Dr. S. Karthigai Lakshmi

Professor and HOD, Department of ECE, SSM Institute of Engineering and Technology, Dindigul, Tamil Nadu, India

M. Muthuvel, R. Naveen Kumar, J.J. Robin, A. Mohamed Sulaiman

UG Students, Department of ECE, SSM Institute of Engineering and Technology, Dindigul, Tamil Nadu, India

ABSTRACT: The project operates at the intersection of intelligent transportation systems (ITS), urban traffic management, and emergency response services. It aims to revolutionize emergency response efficiency by integrating intelligent traffic light control with advanced vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. This system prioritizes emergency vehicles, such as ambulance and fire trucks, by dynamically adjusting traffic lights to ensure they receive green signals, thereby minimizing response times and enhancing overall traffic safety.

I. INTRODUCTION

Emergency vehicles often get delayed at traffic signals due to conventional, fixed-time traffic light systems. These delays can be critical, especially in life-saving situations. To address this problem, our project presents a Smart Emergency Traffic Management System that prioritizes the movement of emergency vehicles at intersections. Using ESP8266 microcontrollers and the ESP-NOW communication protocol, the system enables wireless communication between the emergency vehicle and the traffic controller. When an emergency vehicle approaches an intersection, it broadcasts a signal that is received by traffic controller nodes at each direction. Upon reception, the system dynamically alters the traffic light pattern—giving a **green signal** to the emergency vehicle's path and **red signals** to all others. After the vehicle has passed, the system automatically resumes its normal traffic cycle. Each direction is equipped with addressable LEDs to represent real-time traffic signals and OLED displays on nearby units to alert surrounding drivers. The solution is low-cost, scalable, and does not depend on centralized infrastructure, making it suitable for deployment in developing regions and smart city projects alike. This project ensures faster emergency response times, improves road safety, and demonstrates the potential of embedded systems in solving real-world problems.

II. LITERATURE SURVEY.

Efficient traffic management and emergency vehicle prioritization have been key areas of research in intelligent transportation systems. Various approaches have been proposed in recent years to enhance traffic flow and reduce delays for emergency services.

Conventional Traffic Control Systems: Traditional traffic light systems operate on fixed time intervals, which do not account for real-time traffic conditions or the presence of emergency vehicles. These systems lack flexibility and responsiveness, often leading to traffic congestion and delayed emergency responses.

RFID-Based Systems: Some earlier works have used RFID technology to detect emergency vehicles. In these systems, RFID tags are installed on emergency vehicles and RFID readers are mounted at intersections. When a tagged vehicle approaches, the reader detects it and changes the traffic light accordingly. However, these systems have limited range and require precise alignment, making them less effective in dynamic urban environments.

GPS and GSM-Based Control: A number of studies have explored the use of GPS and GSM modules to track emergency vehicle positions and control traffic signals remotely. While this method offers good range, it depends heavily on mobile networks and cloud servers, leading to potential delays and requiring significant infrastructure.

Camera and Image Processing Techniques: Image processing has been applied to detect emergency vehicles through siren lights or visual patterns. These systems require high-resolution cameras and robust algorithms, and they are often affected by weather conditions, lighting, and occlusions, reducing their reliability.

Wireless Sensor Networks and IoT Approaches: More recent research explores the use of wireless sensor networks (WSNs) and IoT devices for traffic management. ESP8266 modules and protocols like ESP-NOW offer a lightweight and low-latency communication method for real-time signaling between vehicles and intersections without the need for internet access. Most of the existing systems either rely on expensive infrastructure (e.g., cameras, centralized servers) or lack the speed and reliability needed for real-time emergency vehicle prioritization. Our system bridges this gap by using **ESP-NOW communication, embedded controllers, and local decision-making logic** to ensure immediate response to emergency signals, without relying on external networks.

III. METHODOLOGY

The primary goal of this project is to design and implement a **Smart Traffic Control System** that responds dynamically to the presence of emergency vehicles while managing regular traffic flow efficiently. This system leverages wireless communication using the **ESP-NOW protocol** and visual indication through **addressable LEDs** controlled by **ESP8266 D1 Mini boards**.

3.1.1 System Design and Architecture

Develop a **modular architecture** that consists of:

Emergency vehicle units: In this project, the system is designed to enable an emergency vehicle to send a priority signal to a traffic light to ensure quick passage. The emergency vehicle is equipped with an ESP8266 (D1 Mini) microcontroller, programmed to act as a signal transmitter. A button or automatic detection system is used to trigger the emergency signal.

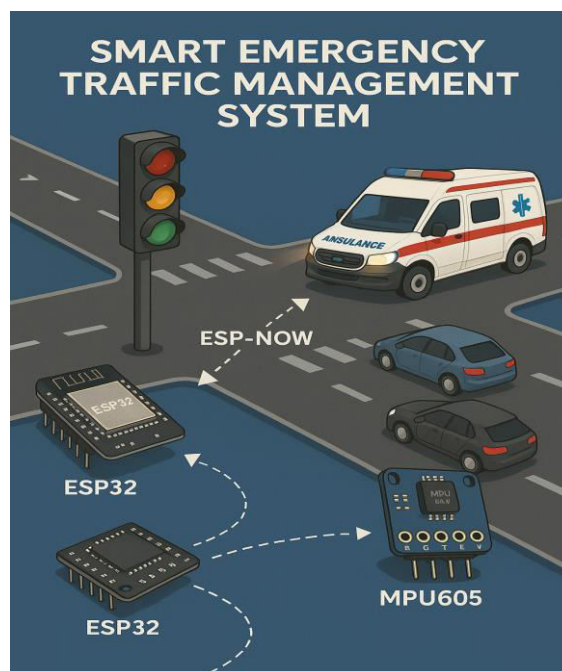


figure 1.

Hardware Components

- **ESP8266 (D1 Mini):** Acts as the main microcontroller for both vehicle and controller nodes due to its low power consumption and built-in Wi-Fi support for ESP-NOW.
- **WS2812 RGB LEDs:** Used to simulate traffic signals for each direction at the intersection.
- **OLED Display :** For real-time status display and debugging purposes.

These direction values are embedded into a data packet for wireless transmission.

Communication Protocol using ESP-NOW, a connectionless peer-to-peer protocol supported by the ESP8266, is utilized for wireless communication between the emergency vehicle and the traffic controller. Key features of the communication setup include:

- One-way broadcast from vehicle to controller.
- Minimal latency and high reliability in signal delivery.
- Pre-registered MAC addresses to ensure secure data transmission.

The directional value from the emergency vehicle is broadcast continuously as it approaches the intersection.

3.1.2 Traffic Signal Control Logic

The traffic light unit at the intersection is also equipped with an ESP8266, programmed to act as a receiver. For communication, the ESP-NOW protocol is used, which allows direct, low-latency, peer-to-peer data transmission without requiring an external Wi-Fi network. When the emergency condition is triggered, the vehicle's ESP8266 forms a data packet and wirelessly broadcasts it using ESP-NOW. The traffic light's ESP8266 listens for incoming packets and receives the emergency alert in real-time.

1. Normal Mode:

Time-based traffic light cycle.

- Each direction receives a Green-Yellow-Red sequence with equal or adaptive timing.

2. Emergency Mode:

- After the emergency vehicle broadcasts the signal, the traffic light unit, equipped with an ESP8266 receiver, continuously monitors incoming data packets using the ESP-NOW protocol.
- Upon receiving a valid emergency signal, the traffic controller immediately overrides the normal traffic light sequence. The system identifies the direction from which the emergency vehicle is approaching and sets the corresponding traffic signal to green, ensuring a clear path for the vehicle.

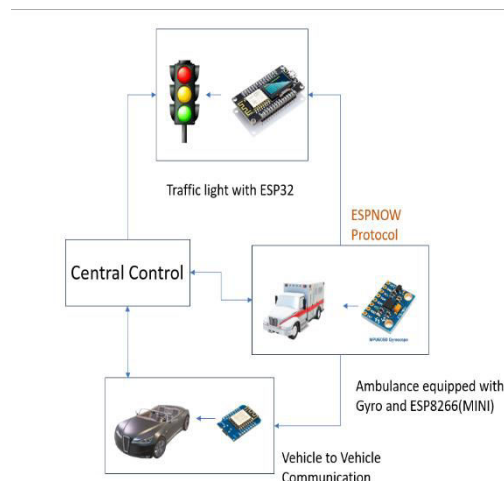


Figure 2.

3.1.3 Software and Firmware Development.

The embedded software is developed using Arduino IDE. Key software modules include:

- ESP-NOW initialization and message broadcasting.
- LED control and timing logic using FastLED or Adafruit NeoPixel library.
- Interrupt handling and failsafe routines for unexpected inputs or communication dropouts.

3.1.4 System Testing and Calibration.

- Test the MPU6050 orientation detection for accuracy and consistency under motion.
- Calibrate signal strength and range of ESP-NOW communication to ensure it functions within urban intersection distances (~50–100m).
- Perform simulations with mock emergency signals to observe and verify traffic light behaviour.

IV. CONCLUSION

This project demonstrates an effective low-cost traffic control system using ESP8266 and ESP-NOW communication. By dynamically adjusting traffic lights based on emergency vehicle proximity and direction, the system minimizes delays in emergency response times. Unlike traditional or infrastructure-heavy systems, this solution operates in a decentralized manner and does not depend on internet access, making it highly scalable and practical for smart cities and developing areas. In future work, the system can be extended to support multiple simultaneous emergency vehicles with varying priority levels. Additional sensors such as GPS and environmental detectors can be incorporated to further refine decision-making. Integration with central traffic management systems can also provide a hybrid decentralized-centralized model.

V. FUTURE WORK

In the future, the proposed Smart Emergency Traffic Management System can be enhanced through several key upgrades. Major enhancement is the implementation of two-way communication between emergency vehicles and traffic controllers using ESP-NOW. This will allow the traffic controller to send acknowledgment messages back to the emergency vehicle, confirming the signal has been received and a green signal has been granted. Additionally, the integration of GPS modules in emergency vehicles will enable real-time location tracking and allow authorities to visualize routes and manage priority access through a centralized dashboard. Another important upgrade involves securing the system against spoofed signals. By assigning unique MAC addresses for all emergency nodes, only authorized vehicles will be allowed to influence the traffic control system, thereby preventing malicious attacks or impersonation. The system can be designed to intelligently handle scenarios involving multiple emergency vehicles arriving from different directions. By evaluating incident severity and vehicle type, the controller can dynamically assign signal priority, ensuring ambulances, fire brigades, and police vehicles are granted access in a fair and effective order. These upgrades collectively enhance the system's robustness, adaptability, and scalability, making it better suited for real-world deployment in smart cities.

REFERENCES

1. M. Al-Saedi, A. Debnath, and E. Chung, "Smart traffic light control system for emergency response vehicles," *IEEE Transactions on Intelligent Transportation Systems*, vol. 21, no. 6, pp. 2434–2443, Jun. 2020.
2. Y. Jeong and H. Oh, "Priority-based traffic signal control for emergency vehicles using connected vehicle technology," *Sensors*, vol. 19, no. 17, pp. 3741–3755, Sep. 2019.
3. Sharma and R. Jain, "Design and implementation of emergency vehicle alert system using IoT," *International Journal of Computer Applications*, vol. 178, no. 11, pp. 1–4, 2019.
4. B. K. Rout and S. Mohapatra, "Smart traffic light control system using microcontroller," *International Journal of Electronics and Communication Engineering & Technology*, vol. 9, no. 2, pp. 1–9, 2018.
5. N. Kumar and S. Singh, "Real-time traffic light control using AI for emergency vehicle management," in *Proc. of the IEEE Int. Conf. on Smart Technologies*, pp. 301–306, 2021.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details