

Design and Implementation of an Emergency Traffic Clearance System Using Smart Indicators

Trisha Indurkar¹, Payal Burde², Ojasvi Rathod³, Pavitra Baghele⁴.

Department of Civil Engineering

G H Raison College of Engineering and Management, Nagpur – 440016, India

Abstract

Rapid urbanization and the continuous increase in vehicular density have intensified traffic congestion in major cities, leading to significant delays in the movement of emergency vehicles such as ambulances and fire services. These delays can critically affect emergency response outcomes and, in severe cases, result in loss of life. Conventional siren-based alert systems are often insufficient in dense traffic conditions due to limited audibility and delayed driver reaction. To address this issue, this study proposes a simple and cost-effective emergency traffic clearance system based on an indicator-driven alert mechanism that provides early warning to road users and facilitates timely lane clearance.

The proposed system utilizes a manually operated electronic setup consisting of a switch, power source, and audible alert device to notify surrounding vehicles and pedestrians about the approaching emergency vehicle. Traffic volume observations at selected urban intersections were analyzed to understand congestion patterns and evaluate the system's effectiveness. The findings suggest that the implementation of such an alert mechanism can significantly reduce response time by improving traffic flow and enabling higher movement speeds for emergency vehicles. The system is easy to implement, economical, and adaptable to existing infrastructure, making it a practical solution for improving emergency traffic management, with potential for future integration into advanced intelligent transportation systems.

Keywords

Traffic congestion, Emergency vehicles, Smart traffic system, Traffic indicator, Green corridor, Traffic management.

I. Introduction

Rapid urbanization and population growth have significantly increased vehicular traffic in major cities such as Mumbai, Nagpur, Pune, and Chennai, leading to frequent congestion characterized by reduced speeds, longer travel times, and extended vehicle queues. This situation has become a critical issue in urban transportation, particularly affecting emergency services. Vehicles such as ambulances and fire units require immediate and unobstructed routes to respond effectively; however, heavy traffic conditions often delay their movement. Such delays can have serious consequences, including reduced chances of survival in medical emergencies and decreased efficiency in handling critical situations.

Conventional traffic management systems primarily rely on sirens and visual signals to alert drivers, but these methods are often ineffective in dense and noisy traffic environments where timely driver response is uncertain. Additionally, the rapid increase in privately owned vehicles has placed excessive strain on existing road infrastructure, which is not adequately designed to handle current traffic demands. To overcome these challenges, this paper proposes a simple and cost-effective emergency traffic clearance system based on an indicator-driven alert mechanism. The system provides early warning to road users, enabling them to clear a path for approaching emergency vehicles. This approach aims to improve response time, enhance traffic flow, and offer a practical solution that can be easily implemented and further developed into advanced traffic management systems.

II. Problem Statement

Urban transportation systems are increasingly challenged by severe traffic congestion due to rapid population growth and a continuous rise in the number of vehicles. This congestion leads to reduced travel speeds, longer delays, and inefficient utilization of road infrastructure. A critical consequence of this situation is the obstruction faced by emergency vehicles such as ambulances and fire services, which require immediate and uninterrupted access to reach their destinations. In many cases, the inability to navigate through dense traffic results in

delayed response times, adversely affecting emergency operations and increasing the risk of fatal outcomes.

Existing traffic management approaches are largely dependent on conventional alert mechanisms, including sirens and flashing lights, to signal the presence of emergency vehicles. However, these methods are often ineffective in high-density traffic conditions due to environmental noise, lack of driver awareness, and limited space for maneuvering. Drivers may fail to respond promptly or may be unable to provide a clear path, especially at congested intersections and narrow road sections. As a result, emergency vehicles remain trapped in traffic, reducing the overall efficiency of emergency response systems.

Advanced traffic control solutions, such as intelligent transportation systems, automated signal control, and IoT-based communication technologies, have been proposed to address these issues. While these systems offer improved performance, their implementation requires significant investment, complex infrastructure, and technical expertise. This makes them less feasible for immediate deployment in many developing urban areas where resource constraints and infrastructural limitations are prevalent.

Therefore, there is a need for a simple, reliable, and cost-effective solution that can facilitate rapid traffic clearance for emergency vehicles without requiring major modifications to existing infrastructure. The problem addressed in this study is to design and develop an efficient alert-based system that enhances driver awareness and enables timely lane clearance, thereby reducing delays and improving the overall effectiveness of emergency response in congested urban environments.

III. Methodology

A. System Design

The system is structured around a basic electrical circuit consisting of a switch (input unit), a power source, connecting wires, and an output device in the form of a buzzer. The switch acts as the control mechanism, which can be operated by traffic personnel upon identifying an approaching

emergency vehicle. Once activated, the circuit is completed, allowing current to flow from the battery to the buzzer, which then emits a distinct sound signal. This sound serves as an immediate alert to drivers and pedestrians in the vicinity, prompting them to clear a designated path for the emergency vehicle.

B. Component parts

- **Buzzer:** Produces an audible alert signal.
- **Switch/Button:** Used to activate the system.
- **Battery:** Provides power supply.
- **Connecting Wires:** Facilitate electrical connections.

1) Buzzer

A buzzer is an audio signaling device commonly used to generate warning sounds in various applications, including alarm systems and alert mechanisms. In the proposed system, the buzzer functions as a primary alert unit to notify road users about the presence of an approaching emergency vehicle, thereby facilitating timely traffic clearance.

- It operates on electrical energy and produces a distinct audible signal when activated through a switch.
- The alert sound is designed to be easily distinguishable from regular traffic noise, ensuring effective communication with drivers.
- It assists in creating awareness among road users, prompting them to clear a path for emergency vehicles such as ambulances.
- The mechanism reduces response delay by enabling quicker movement through congested traffic conditions.
- It also enhances safety by minimizing the risk of collisions between emergency vehicles and other road users.

2) Switch Button

- An electromechanical device used to open or close an electrical circuit.
- Acts as the input component in the proposed system.
- Activated manually by traffic personnel.
- Completes the circuit to trigger the buzzer alert.

- Enables quick and immediate response during emergency situations.
- Simple, reliable, and suitable for real-time traffic control.

3) Battery

A battery serves as the primary source of electrical energy in the proposed system, enabling the operation of the alert mechanism. It supplies the necessary power to activate the circuit and ensure continuous functioning of the buzzer during emergency situations.

- It provides direct current (DC) required for operating the electronic components of the system.
- It ensures reliable and uninterrupted power supply during system activation.
- It is compact, portable, and easy to integrate into the circuit design.
- It supports quick response by instantly powering the buzzer when the switch is activated.
- It can be replaced or recharged as needed, making the system efficient and reusable.

4) Connecting Wires

Connecting wires are essential components that enable the flow of electrical current between different parts of the system. In the proposed setup, they form the conductive path that links the power source, switch, and buzzer, ensuring proper functioning of the alert mechanism.

- They are typically made of conductive materials such as copper or aluminum for efficient current transmission.
- They provide a secure electrical connection between all circuit components.
- Insulated coatings are used to prevent electrical leakage and ensure safety.
- They help maintain circuit continuity, allowing smooth operation when the system is activated.
- Proper selection of wire thickness (gauge) ensures reliable performance without overheating or power loss.

C. Working Procedure:

The proposed system operates on a simple alert- based mechanism designed to provide immediate

notification to road users about the presence of an approaching emergency vehicle. The system is activated manually by authorized personnel at a traffic control point or intersection when an emergency situation is identified. Upon activation, the electrical circuit is completed, allowing current to flow from the power source to the buzzer, which generates a distinct audible signal. This signal acts as an early warning, alerting drivers and pedestrians in the surrounding area.

The emitted sound prompts road users to respond by clearing a designated lane, thereby creating an unobstructed path for the emergency vehicle. As vehicles move aside in response to the alert, congestion at the intersection is reduced, enabling smoother and faster movement. Once the emergency vehicle has successfully passed through the traffic zone, the system is deactivated, and normal traffic flow resumes. This procedure ensures minimal delay in emergency response while maintaining a simple and efficient method for traffic clearance.

D. Traffic Volume Study and Analysis

Traffic studies were conducted at key intersections to understand congestion levels.

Observed Location:

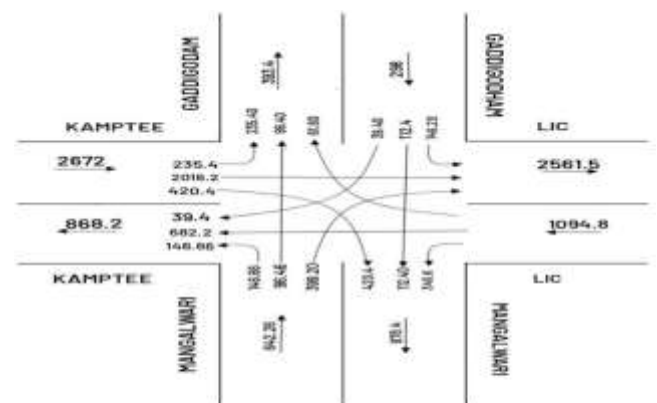
- Gaddigodam Square, Nagpur.
- LIC Square, Nagpur.

Time Intervals:

- Morning (10:00–11:00 AM)
- Afternoon (1:00–2:00 PM)
- Evening (4:00–5:00 PM)

Reports:

- GADDIGODAM SQUARE (10:00 to 11:00 am)
- LIC SQUARE (10:00 to 11:00 am)



- dur evening hours.
- Emergency vehicles face significant delays due to lane blockage

Performance Comparision

Condition	Average Speed	Time to Reach Destination
Without System	30 km/h	High Delay
With System	70–80 km/h	Reduced Delay

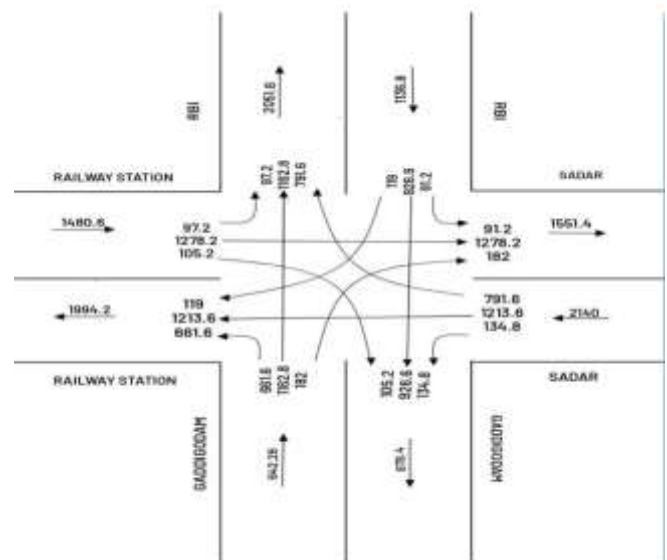
IV. esults and Analysis

Observations were carried out at key locations during peak and non-peak hours, and the number of vehicles passing through the intersections was recorded systematically over fixed time periods.

The collected data indicated that traffic congestion was significantly higher during peak hours, particularly in the morning and evening periods. Increased vehicular density during these intervals resulted in longer waiting times, reduced speeds, and difficulty in lane clearance. Emergency vehicles were observed to experience considerable delays due to lack of coordination among road users and absence of an effective alert mechanism. The analysis highlights that conventional traffic conditions do not support the smooth passage of emergency vehicles, thereby emphasizing the need for an improved system.

A comparative assessment suggests that the implementation of an alert-based mechanism can enhance traffic flow by encouraging timely driver response and organized lane movement. By providing early warning to road users, the system can reduce congestion at critical points and improve the average speed of emergency vehicles. The study demonstrates that even a basic traffic control intervention, when applied effectively, can lead to noticeable improvements in emergency response time and overall traffic management efficiency.

R



V. Future Scope

The proposed emergency traffic clearance system provides a foundational approach for improving the movement of emergency vehicles; however, it can be further enhanced through the integration of advanced technologies and intelligent systems. Future developments can focus on automating the alert mechanism using sensors, GPS tracking, and wireless communication to eliminate the need for manual intervention. By incorporating real-time vehicle tracking, the system can automatically detect the location of an approaching emergency vehicle and activate alerts at upcoming intersections, ensuring timely traffic clearance.

Additionally, the system can be integrated with smart traffic signal control to provide dynamic signal prioritization for emergency vehicles. This would allow traffic lights to automatically switch to green along the route of the emergency vehicle, creating a continuous and unobstructed path. The use of Internet of Things (IoT) technology and centralized traffic monitoring systems can further enhance coordination between different traffic points, improving overall efficiency. Mobile applications and in-vehicle notification systems can also be developed to directly inform drivers, increasing awareness and response speed.

In the long term, the proposed system can be incorporated into smart city infrastructure, where data-driven traffic management and artificial intelligence can optimize traffic flow in real time. The adoption of such advanced solutions can not only improve emergency response time but also contribute to reducing congestion, enhancing road safety, and promoting sustainable urban transportation systems.

Potential Implementation Locations:

1. **Urban Areas:** Implement our advanced traffic clearance techniques in densely populated urban areas to manage congestion, reduce delays, and improve the overall flow of traffic. This can lead to reduced pollution and improved quality of life for city residents.
2. **Highways and Expressways:** Deploy the project on highways and expressways to clear traffic incidents quickly, preventing long backups and improving highway safety.
3. **Airports:** Airports often face traffic congestion, especially during peak travel times. Our system can be applied to clear traffic efficiently and ensure smooth airport operations.

4. **Tunnels and Bridges:** Highways, tunnels, and bridges are critical transportation infrastructure. Implement our project to manage traffic incidents in these areas effectively, reducing disruptions and enhancing safety.

5. **Smart Cities:** In smart cities that prioritize technology and data-driven decision-making, our advanced traffic clearance techniques can be integrated into the broader smart city infrastructure for a seamless and efficient traffic management system.

6. **Tourist Destinations:** Locations with heavy tourist traffic can benefit from advanced traffic clearance techniques to ensure a positive visitor experience and minimize congestion in popular destinations.

7. **Industrial Zones:** Areas with high industrial traffic may experience congestion and traffic incidents. Implement our project to keep traffic flowing smoothly in these zones.

VI. Conclusion

This study presents a simple and effective approach for improving the movement of emergency vehicles in congested urban traffic conditions. The proposed indicator-based alert system provides an early warning to road users, enabling timely lane clearance and reducing delays faced by emergency services. By utilizing basic electronic components and a straightforward working mechanism, the system offers a cost-effective and easily implementable solution without requiring major modifications to existing infrastructure.

The analysis of traffic conditions highlights the challenges faced by emergency vehicles in dense traffic environments and demonstrates the potential of the proposed system to enhance response efficiency. Although the current design relies on manual operation, it establishes a practical framework that can significantly improve traffic management during emergency situations. With further development and integration of advanced technologies, the system can be expanded into a more automated and intelligent solution, contributing to safer and more efficient urban transportation systems.

VII. References

- [1] S. Kumar and R. Singh, "Smart Traffic Management System for Emergency Vehicles Using IoT," *International Journal of Engineering Research & Technology (IJERT)*, vol. 9, no. 6, pp. 120–124, 2020.
- [2] A. Sharma and P. Verma, "RFID-Based Intelligent Traffic Control System for Emergency Vehicle Clearance," in *Proc. IEEE Int. Conf. on Intelligent Transportation Systems*, 2019, pp. 45–49.
- [3] P. Singh, "Analysis of Traffic Congestion and Its Impact on Urban Mobility," *Journal of Civil Engineering and Environmental Technology*, vol. 8, no. 3, pp. 210–215, 2021.
- [4] World Health Organization, "Global Status Report on Road Safety," Geneva, Switzerland, 2022.
- [5] Ministry of Road Transport and Highways, Government of India, "Road Accidents in India – Annual Report," New Delhi, India, 2023.
- [6] R. Gupta and M. Patel, "Emergency Vehicle Priority System Using Wireless Communication," *International Journal of Scientific Research and Development (IJSRD)*, vol. 8, no. 5, pp. 300–304, 2020.
- [7] M. Patel, "Urban Traffic Flow Optimization Techniques," *International Research Journal of Engineering and Technology (IRJET)*, vol. 8, no. 7, pp. 1500–1504, 2021.
- [8] N. Verma and S. Kulkarni, "Smart City Traffic Management Using Intelligent Systems," *International Journal of Advanced Research in Engineering and Technology*, vol. 13, no. 2, pp. 95–101, 2022.
- [9] K. Mehta and D. Shah, "Design of Low-Cost Traffic Alert Systems for Developing Cities," *International Journal of Innovative Research in Technology*, vol. 7, no. 9, pp. 50–55, 2021.
- [10] L. Chen et al., "Intelligent Transportation Systems: A Review of Current Trends and Future Directions," *IEEE Access*, vol. 8, pp. 12345–12360, 2020.