

# Emergency Response Enhancement: AI-Driven Ambulance Traffic Coordination

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**Abstract** - This project presents an advanced Ambulance Assistance System designed to reduce delays in emergency medical response, particularly within congested urban environments. Unlike conventional approaches that rely heavily on manual communication, the system integrates Artificial Intelligence (AI) and Internet of Things (IoT) technologies enable continuous monitoring and automated coordination between ambulances and traffic management authorities. Using GPS-based tracking and intelligent detection mechanisms, the system identifies situations where an ambulance remains stationary for more than 30 seconds. In such cases, automated alerts are immediately sent to nearby traffic control units to facilitate rapid clearance. The system also supports manual alert activation, allowing ambulance drivers to signal authorities when additional assistance is required. An AI-driven safety feature further strengthens the solution by enabling accident victims or bystanders to initiate an emergency call simply by holding the device's volume button. This action automatically triggers an emergency call and transmits live GPS coordinates to the relevant authorities, helping ensure swift intervention even when direct communication may.

**Keywords:** Artificial Intelligence (AI), GPS-based tracking, Emergency response, IoT monitoring, smart mobility.

## I. INTRODUCTION

Ambulances are essential parts of emergency medical services, where patients' chances of survival depend on how quickly they are transported to medical facilities. However, growing traffic congestion often causes significant delays in ambulance movement in densely populated urban areas, jeopardizing emergency response systems' overall effectiveness. The majority of current systems rely on manual communication, which is slow, inconsistent, and prone to human error, between ambulance drivers and traffic authorities. These drawbacks highlight the necessity of an automated and more intelligent approach to emergency mobility management. This study introduces the Ambulance

Assistance System, a real-time platform that improves coordination between ambulances and traffic authorities. The system automates essential communication, ensuring timely and accurate updates on ambulance movement. Incorporating advanced technologies, it reduces response delays, enhances patient outcomes, and strengthens the reliability of urban emergency healthcare infrastructure.

Additionally, the system provides optional public notifications to increase citizen awareness and cooperation during emergencies. The system uses continuous GPS tracking and intelligent alerts to monitor ambulance movement. If an ambulance remains idle for over 30 seconds or faces unexpected delays, automatic notifications are sent to traffic authorities to initiate rapid interventions, such as adjusting signals or clearing routes. This proactive approach overcomes the shortcomings of traditional methods and supports the development of smart and responsive urban transportation systems.

Furthermore, the Ambulance Assistance System aims to address the broader operational challenges associated with emergency response networks, such as communication delays, lack of situational awareness, and the absence of dynamic traffic coordination. When IoT-enabled communication modules and AI-driven decision support, system establishes a unified digital ecosystem which ambulances, traffic authorities, and, optionally, the public can exchange timely and actionable information. This interoperability is essential for developing resilient emergency infrastructures capable adapting to unpredictable urban traffic patterns. This feature ensures that assistance can be requested even in scenarios verbal communication may be compromised.

## II. LITERATURE REVIEW

Recent advancements between 2023 and 2025 have significantly transformed emergency vehicle mobility systems through GPS based tracking, IoT sensing, VANET communication, and AI driven detection. These developments reflect a growing shift toward intelligent and automated emergency transportation infrastructures capable of operating

in dense, unpredictable urban environments. Edge-computing enabled IoT systems are among the most prominent innovations. Rosayyan *et al.* propose an IoT and edge-processing oriented model that dynamically adjusts traffic light cycles to grant priority to emergency vehicles, demonstrating how distributed computing can reduce intersection delays and enhance real time coordination between ambulances and traffic controllers [1].

Similar work by N. R., Manoj *et al.* introduces an IoT integrated traffic signal controller equipped with embedded sensors capable of recognizing ambulances and modifying signal states autonomously, reinforcing the role of decentralized sensing in emergency response automation [2].

Research on communication centric architectures has also seen extensive development. VANET based designs presented by Bairi, Rao, and Chandra highlight how vehicle-to-infrastructure (V2X) communication enables extremely low latency interaction between ambulances and traffic signals, creating a seamless priority corridor in urban settings [3].

Complementary to communication driven methods, deep learning based detection frameworks—such as the YOLO powered ambulance identification model proposed by Kumar, Verma, and Dinesh—show strong performance in recognizing emergency vehicles through video feeds and automatically executing signal overrides [4].

However, these AI systems require extensive camera networks and are sensitive to obstacles, lighting variations, and environmental constraints.

Alternative sensing techniques have also been explored. RFID-IoT hybrid models, such as the system developed by Swathi *et al.*, demonstrate a low cost approach by enabling RFID tagged ambulances to trigger signal changes upon entering reader zones, though their effectiveness depends on widespread hardware deployment at intersections [5].

Raspberry Pi based intelligent systems integrating GPS, RF, and computer vision have been proposed to support multi sensor decision-making in traffic automation, offering effective prototype level solutions for smaller regions but facing scalability challenges in metropolitan environments [6].

Broader analytical frameworks such as SEVS extend emergency management beyond road coordination by integrating hospital communication, routing analytics, and real-time patient handling predictions, signaling a move toward holistic emergency management ecosystems [7].

In parallel, GIS based emergency routing frameworks—such as the predictive green corridor generation model introduced by Bhardwaj - demonstrate how data driven urban analytics can optimize ambulance dispatching and travel routes, though such systems remain simulation oriented and lack real time operational capabilities [8].

Emerging literature also explores AI enabled priority routing and IoT supported traffic clearance systems. Gupta, Malhotra, and Sharma present an AI driven traffic prediction mechanism capable of forecasting congestion patterns and adjusting emergency pathways, which underscores the growing role of machine learning in proactive emergency mobility planning [9].

Prakash and Gopinath introduce an IoT based smart corridor system designed to automate real time road clearance during medical emergencies, illustrating how integrated sensor infrastructures can support metropolitan ambulance networks [10].

### **III. PROPOSED WORK**

The proposed system introduces an intelligent and real-time ambulance management solution designed to minimize delays during emergency situations. The system integrates modern web technologies with real-time communication to ensure smooth coordination between ambulance drivers and traffic police authorities.

The system is composed of two main modules: the Driver Dashboard and the Police Dashboard System. The Driver Dashboard allows ambulance drivers to initiate a trip using their live location, which marks the beginning of real-time tracking. This ensures that the ambulance's movement is continuously monitored throughout the journey.

Once the trip begins, the system actively tracks the ambulance using GPS-based location updates. If the ambulance remains stationary for a predefined duration, such as 30 seconds, the system identifies it as a potential delay. This delay detection mechanism plays a crucial role in ensuring that issues like traffic congestion or roadblocks are immediately recognized.

Upon detecting such delays, the system generates real-time alerts and sends them to the Police Dashboard using Socket.io. These instant notifications enable traffic police to take quick actions, such as clearing traffic or prioritizing routes for the ambulance. This real-time communication significantly reduces response time and improves coordination.

The Police Dashboard provides a centralized interface where authorities can view incoming ambulance requests, monitor live movements, and respond to alerts efficiently. It enhances situational awareness by allowing police personnel to track ambulances dynamically and make informed decisions to facilitate smoother traffic flow.

The system is developed using a modern technology stack, including React.js for the frontend interface, Node.js and Express for backend services, Socket.io for real-time communication, and MongoDB for data storage. These technologies ensure scalability, performance, and reliability of the system.

So far, the implementation includes the Driver Dashboard with live trip functionality, Police Dashboard for receiving alerts, and real-time notification integration. Future work will focus on integrating advanced features such as Google Maps for route optimization, AI-based traffic prediction, and IoT-based traffic signal automation to further enhance the system's effectiveness.

#### IV. SYSTEM ARCHITECTURE

The proposed system follows a centralized client-server architecture that integrates mobile applications, backend processing, IoT-based ambulance units, and a police monitoring system. The architecture enables real-time ambulance tracking, delay detection, and alert generation to ensure efficient traffic clearance during emergencies.

##### 4.1 Overall System Architecture

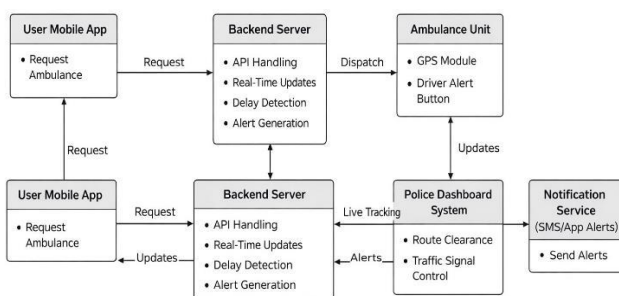


Figure 4.1: Architecture

This architecture enables seamless communication between different components while supporting real-time tracking, delay detection, and alert generation. The system consists of five primary components: the user mobile application, the backend server, the ambulance unit, the police dashboard system, and the notification service.

Users interact with the system through a mobile application, where they can request an ambulance and receive updates regarding its status and estimated arrival time. The

application sends requests to the backend server through API calls, which act as the entry point for all system.

The backend server functions as the central processing unit of the system, handling API requests, managing real-time data exchange, and performing critical operations such as delay detection and alert generation. It continuously receives location updates from the ambulance unit and processes this data to monitor movement.

The backend ensures that all communication between components is synchronized and efficiently managed, enabling real-time updates across the system. The ambulance unit is equipped with a GPS module and a driver alert mechanism, allowing it to transmit live location data and emergency signals to the backend server.

These updates are crucial for tracking the ambulance's movement and identifying any delays during transit. The police dashboard system receives real-time tracking information from the backend and allows traffic authorities to monitor the ambulance's route, perform route clearance, and manage traffic signals to facilitate faster movement.

The system incorporates a notification service that delivers alerts through SMS or mobile applications. When the backend detects abnormal conditions, such as the ambulance being stationary for a prolonged period, it generates alerts that are sent to both the police dashboard and the notification service. This ensures that immediate action can be taken to resolve delays and maintain smooth traffic flow.

##### 4.2 Ambulance Workflow

The activity diagram illustrates the workflow of the Ambulance Traffic Clearance System, beginning with the user requesting an ambulance through the mobile application. The request is sent to the backend server, where availability is checked and the ambulance is dispatched if available.

During the journey, the ambulance continuously sends live GPS data to the backend, which processes and forwards real-time updates to the police dashboard for monitoring and traffic management. The system also detects delays, and if the ambulance stops for a certain time, alerts are generated and sent to authorities through the notification system.

The ambulance reaches the destination, and the system updates the user with the arrival status, ensuring smooth coordination and timely emergency response. This process improves communication between all components of the system. It also helps in reducing delays and enhancing the efficiency of emergency services.

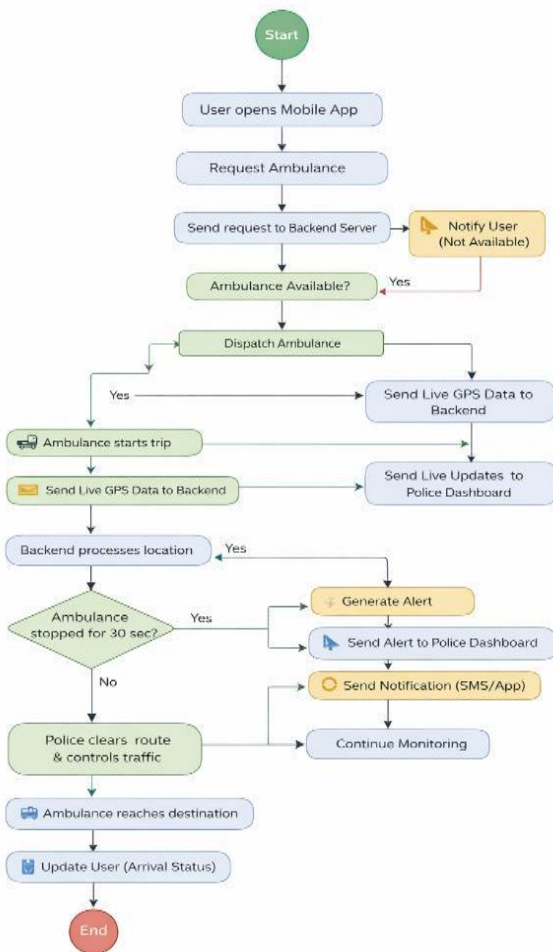


Figure 4.2: Workflow

## V. RESULTS

The proposed Ambulance Traffic Clearance System was successfully developed using a client-server architecture integrating React.js for the frontend and Node.js with Express for the backend. Real-time communication is implemented using Socket.io, enabling low-latency data exchange between system components. The system ensures efficient handling of ambulance requests and status updates.

The system utilizes GPS-based tracking through the browser's Geolocation API to continuously capture and transmit ambulance location data. This data is processed by the backend server and streamed in real time to the police dashboard. The implementation ensures high responsiveness and accurate tracking of ambulance movement.

A key feature of the system is the delay detection mechanism, which analyzes consecutive location updates to identify inactivity or stoppage. If the ambulance remains stationary beyond a predefined threshold, the backend triggers automated alert generation. This event-driven approach improves system intelligence and responsiveness.

The police dashboard is designed to handle real-time data visualization and decision-making. It receives live updates via Web-Socket connections and allows authorities to monitor routes and initiate traffic control measures. This integration enhances coordination between emergency services and traffic management systems.

The system demonstrates a scalable, event-driven architecture capable of handling real-time operations efficiently. It improves emergency response time by reducing delays and ensuring seamless communication between all stakeholders involved.



Figure 5.1: Login Dashboard

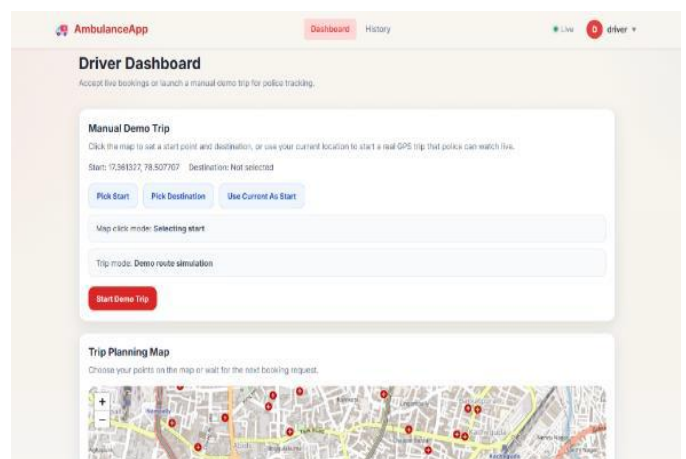


Figure 5.2: Driver Dashboard

The Driver Dashboard provides real-time monitoring and control for ambulance operations, displaying the current location on an interactive map along with nearby points of interest. It allows the driver to start or stop the trip, send emergency alerts, and track system responses such as police coordination. The dashboard continuously updates location data, ensuring accurate tracking.

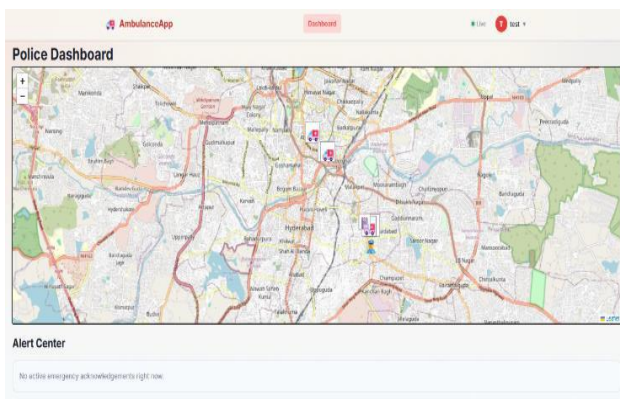


Figure 5.3: Police Dashboard

The Police Dashboard provides real-time monitoring of ambulance locations through an interactive map, enabling traffic authorities to track multiple ambulances simultaneously. It displays emergency alerts, such as ambulance distress signals, and allows quick acknowledgment and response. The system supports efficient decision-making by helping police manage traffic flow.

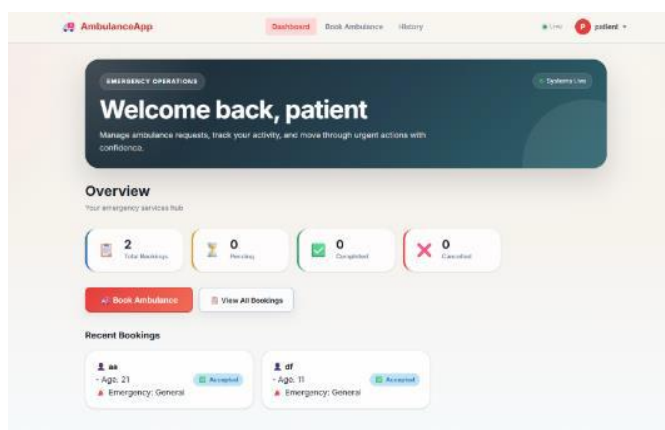


Figure 5.4: User Dashboard

The User Dashboard provides a centralized interface for managing ambulance bookings and tracking service status. It displays key metrics such as total bookings, pending requests, completed trips, and cancellations.

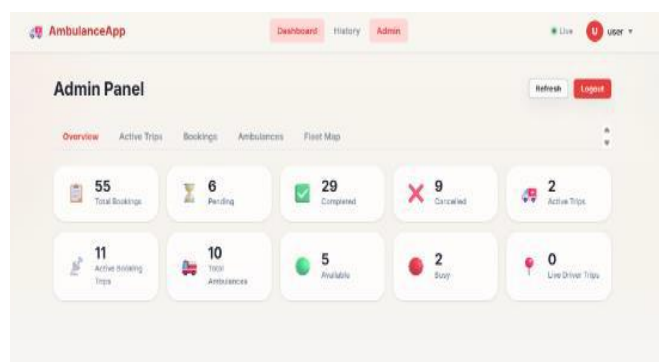


Figure 5.5: Admin Dashboard

The Admin Panel provides a centralized interface for managing the entire ambulance system, offering an overview of key metrics such as total bookings, active trips, available ambulances, and driver status. It allows administrators to monitor system performance, manage bookings and fleet operations, and track real-time activity. This panel ensures efficient system control, better resource management, and smooth coordination across all services.

## VI. DISCUSSIONS

The implementation of the Ambulance Traffic Clearance System demonstrates a significant improvement over traditional emergency response systems by integrating real-time tracking and communication technologies. The system effectively addresses key challenges such as delays in ambulance movement, lack of coordination between stakeholders, and inefficient traffic management.

By leveraging modern web technologies and real-time data exchange, the system enhances overall response efficiency. In conventional emergency systems, there is often limited visibility into ambulance location and status, making it difficult for authorities to take timely action. In contrast, the proposed system provides continuous GPS-based tracking, allowing the backend server to monitor ambulance movement in real time. This ensures that all stakeholders, including police authorities, have accurate and up-to-date information for decision-making.

The use of WebSocket-based communication enables instant data transfer between the ambulance unit, backend server, and police dashboard. This real-time synchronization minimizes latency and ensures that alerts and updates are delivered without delay. As a result, the system improves coordination between ambulance drivers and traffic authorities, leading to faster route clearance.

The police dashboard plays a crucial role in managing traffic flow and ensuring a clear path for ambulances. By providing live tracking and alert notifications, the dashboard enables traffic personnel to take immediate actions such as signal control and route clearance. This integration significantly enhances the effectiveness of emergency traffic management.

The system is designed with scalability and modularity in mind, allowing future enhancements such as IoT-based GPS devices, AI-driven traffic prediction, and automated signal control. Overall, the proposed system offers a reliable, efficient, and technologically advanced solution that improves emergency response time and coordination, ultimately contributing to saving lives.

## VII. CONCLUSION

This study presents the design and implementation of an Ambulance Traffic Clearance System aimed at improving emergency response efficiency through real-time tracking and intelligent alert mechanisms. The system successfully addresses key challenges in traditional emergency services, such as delays in ambulance movement, lack of coordination, and limited visibility of vehicle status. By integrating modern web technologies and real-time communication, these issues are significantly reduced.

The proposed system utilizes a client-server architecture with GPS-based tracking and Web Socket communication to ensure continuous monitoring and instant data exchange. The backend server processes real-time location updates and implements delay detection logic to identify critical situations. Alerts are automatically generated and communicated to the police dashboard and notification services, enabling quick and effective action.

The police dashboard enhances traffic management by providing live tracking and enabling authorities to clear routes and control signals efficiently. This coordination between ambulance drivers, backend systems, and traffic personnel ensures smoother ambulance movement and reduces response time. The system demonstrates improved reliability, scalability, and responsiveness compared to conventional approaches.

Overall, the proposed solution offers an efficient, real-time, and scalable approach to emergency traffic management. It enhances communication between stakeholders and ensures timely intervention during critical situations, ultimately contributing to saving lives. Future enhancements such as IoT-based GPS devices, AI-driven traffic prediction, and automated signal control can further improve the system's performance and effectiveness.

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