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Lifeline Traffic: Based Ambulance and Emergency Vehicle Priority

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Abstract: *An IoT-based solution to prioritize ambulance and emergency vehicle movement in urban traffic. Traditional traffic systems often delay emergency responses due to congestion and lack of dynamic signal control. Our system integrates GPS, sensors, and real-time data transmission to detect approaching emergency vehicles. Traffic lights are automatically adjusted to provide a green corridor, minimizing response time. A central control unit monitors all connected signals and vehicles using cloud-based analytics. The system enhances coordination between ambulances and traffic infrastructure. Emergency vehicles are tracked live, and routes are optimized dynamically. Smart traffic algorithms, wi-fi modules, and microcontrollers are utilized in implementation. This technique lowers the opportunity of fatalities and ensures quicker, more secure emergency services.*

Keywords: Emergency vehicle prioritization, Smart traffic management, Ambulance tracking, Real-time traffic control, Green corridor, GPS-based navigation

I. INTRODUCTION

Traffic congestion [1] has emerged as a widespread impediment to efficient emergency reaction in cities which can be regularly turning into more urbanized. Static traffic indicators and cussed drivers regularly purpose delays for ambulances and different emergency vehicles, costing them important time and once in a while even their lives. There has in no way been a more want for an intelligent and adaptable traffic control system. Figure 1 illustrates how conventional structures aren't flexible sufficient to reply to emergencies in actual time. New possibilities to cope with those issues are provided through technological improvements, specifically in the Internet of Things (IoT) [2]. In order to assure faster and more secure travel, IoT can facilitate communique among vehicles and traffic lights. As a result, smart emergency automobile prioritizing structures were established.

To become aware of and track ambulances in actual time, an Internet of Things (IoT)-based emergency vehicle precedence system uses GPS [3], wi-fi communication, and cloud[4] connectivity. The technology has the capacity to robotically alternate traffic signal styles to create a "green corridor" while emergency automobile tactics an intersection. This ensures that the car actions with the least quantity of disruption and cuts down on adventure time. Sensors, microcontrollers, and a vital server or cloud platform that handles data processing commonly make up the system. Additionally, it may provide hospitals and traffic authorities actual-time updates, facilitating advanced readiness. These solutions enhance traffic performance and public protection further to response times. Automating procedures reduces human error and delays in decision-making.

To create and positioned into practice an intelligent, Internet of Things-based technique for traffic control emergency automobile prioritization. Its objectives to supply a scalable and effective device suitable for present day cities through using wi-fi connectivity, GPS modules, and inexpensive microcontrollers[5]. In order to offer dynamic sign regulation relying on automobile role and direction, the purpose is to set up a easy connection among ambulances and traffic manipulate infrastructure. In order to decrease set up costs, the device is likewise made to feature with contemporary

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traffic networks[11,12]. This challenge will display that it is possible in the actual global through simulation and prototype development. The last goal is to ensure that each second subjects even as responding to emergencies.

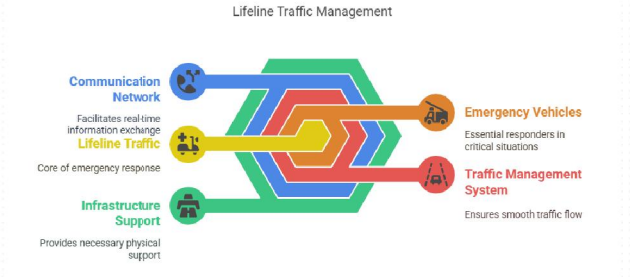

Figure 1: Architecture of Lifeline Traffic Management

II. LITERATURE SURVEY

Recent studies have focused on smart traffic systems that leverage IoT to improve urban mobility. Traditional traffic signal systems operate on fixed timers, often causing delays for emergency vehicles. Adaptive traffic lights [6] that respond to real-time traffic conditions using sensor networks. These systems reduce congestion but lack dedicated emergency vehicle prioritization. Integrating emergency vehicle detection with traffic control algorithms was recommended for more responsive systems. This laid the groundwork for incorporating real-time tracking of ambulances into traffic signal logic.

IoT has significantly enhanced emergency response frameworks through real-time tracking, communication, and automation [7]. GPS and GSM modules for ambulance tracking and dynamic route optimization [8]. Emergency alerts[9] were sent to nearby traffic control centres, prompting manual signal adjustments. This semi-automated approach showed improvements in ambulance arrival times. However, the dependency on manual intervention and lack of centralized control limited its efficiency[10].

Cloud computing has become a backbone for modern smart traffic systems, enabling centralized data analysis and control. Cloud-integrated IoT platforms for urban traffic management. Their model aggregated data from thousands of connected devices, including emergency vehicles, and used AI to optimize traffic flow. The study emphasized scalability and low maintenance as major benefits. For emergency response, cloud platforms allowed dynamic rerouting and priority path clearance. However, latency during data transmission and dependency on stable internet connectivity were identified as drawbacks.

III. PROBLEM IDENTIFICATION

Urban traffic congestion presents a major challenge for emergency services such as ambulances, fire trucks, and police vehicles. Traditional traffic signal systems operate on fixed timers and do not respond to the presence or urgency of emergency vehicles. As a result, ambulances often get stuck in traffic or are forced to take longer alternate routes, leading to delays in reaching hospitals or emergency locations. These delays can be life-threatening, especially during critical situations where every second matters.

Moreover, existing systems that provide emergency vehicle priority are either manual, semi-automated, or require significant infrastructure changes such as RFID-based setups, which may not be scalable or effective in all traffic scenarios. In many cities, there is no real-time communication between emergency vehicles and traffic control systems, leading to uncoordinated and inefficient responses. This lack of integration limits the ability of authorities to manage traffic dynamically and respond to emergencies quickly.

The core problem lies in the absence of an intelligent, automated, and scalable system that can detect, prioritize, and facilitate the movement of emergency vehicles in real time. Therefore, there is a clear need for an IoT-based solution that can track emergency vehicles, communicate with traffic signals, and provide them with uninterrupted routes through smart signal control and traffic awareness.

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IV. METHODOLOGY

The proposed system uses IoT technology to detect and prioritize the movement of emergency vehicles such as ambulances through dynamic traffic signal control is shown in figure 2. The methodology is divided into several stages, each responsible for a specific function in the system:

- **Vehicle Tracking and Detection:** Each ambulance is equipped with a GPS and GSM module connected to a microcontroller (such as Arduino or NodeMCU). The GPS continuously tracks the real-time location of the vehicle, while the GSM module sends this data to a central server via mobile network communication.
- **Central Monitoring and Control Unit:** The server receives data from all active emergency vehicles and identifies their proximity to traffic intersections. A cloud platform processes the incoming data, determines the vehicle's route, and predicts its arrival at upcoming traffic signals. This enables real-time analysis and decision-making.
- **Smart Traffic Signal Controller:** Traffic lights at intersections are integrated with microcontrollers and IoT modules. When an ambulance is detected approaching a junction, the control unit sends a signal to the traffic light system to prioritize its movement. The traffic signal automatically switches to green for the direction of the ambulance and red for cross-traffic, creating a green corridor.
- **Communication Network:** The ambulance unit and traffic lighting are related through wi-fi communication (e.g., Wi-Fi, GSM, or LoRa) on this system. Effective data change may be done through the use of the MQTT or HTTP protocols. Additionally, traffic authorities can acquire real-time notifications for manual override or tracking if necessary.
- **Route Optimization (Optional Enhancement):** The **vital** server is **capable of suggest** the **simplest direction** for the ambulance **based** on **traffic** density **information** from sensors or third-**party** APIs (**inclusive of** Google Maps). This **permits** dynamic rerouting **in the occasion** of congestion or obstructions.
- **Simulation and Testing:** The **device** is evaluated in digital surroundings **the use of traffic** simulation tools (**inclusive of** SUMO or MATLAB Simulink) **to evaluate overall performance** under **diverse traffic conditions previous to** real-**international** implementation. Hardware prototypes are created and evaluated in lab settings or at minor junctions.

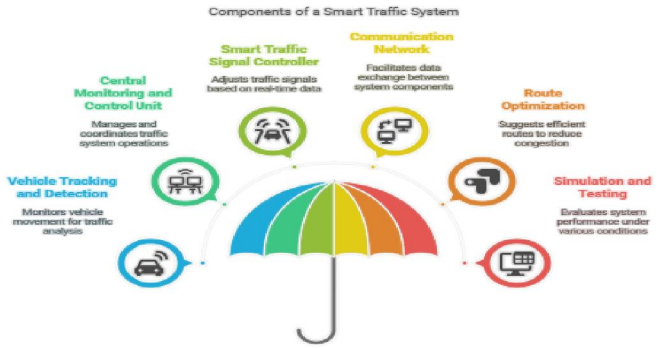

Figure 2: Components of a Smart Traffic System

V. OBSERVATIONS

Figure 3 illustrates the various overall performance metrics that had been monitored all through the IoT-based ambulance prioritization system`s improvement and testing section in an effort to verify the system's efficacy. Important findings include:

- **Reduction in Ambulance Waiting Time:** The average waiting time at intersections was significantly reduced when the IoT system dynamically changed traffic signals in favour of the approaching ambulance.
- **System Response Time:** The time taken from ambulance detection to signal change was observed to be between 1.2 to 2.5 seconds, depending on the network latency and processing speed.

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- **Green Corridor Efficiency:** In simulation, the green corridor mechanism allowed continuous movement for ambulances across 3–5 consecutive junctions with minimal or zero stoppage.
- **Comparison with Traditional Systems:** Compared to fixed-time signal systems, the IoT-based system improved ambulance travel time by 30% to 45%, especially during peak traffic hours.
- **Communication Reliability:** The wireless modules (e.g., GSM/Wi-Fi) maintained stable communication across a radius of 200–300 meters. Delays occurred only when mobile signals were weak.
- **Real-Time Tracking Accuracy:** GPS tracking accuracy remained within 5 meters, which was sufficient to predict vehicle arrival at junctions and initiate signal switching on time.

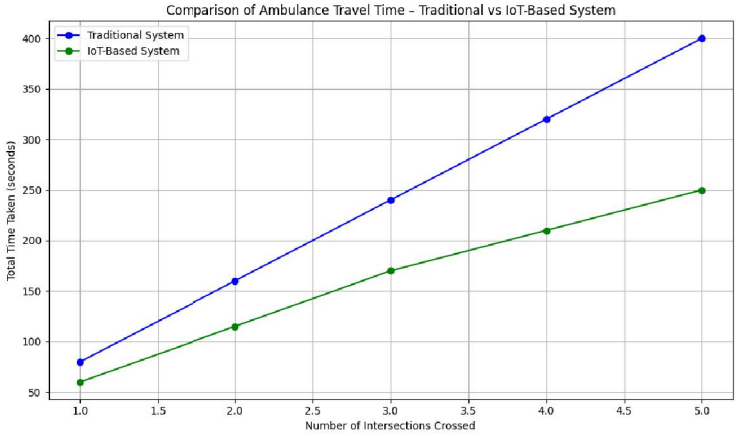

Figure 3: Comparison of Ambulance Time-Traditional vs IoT-Based System

VI. CONCLUSION

The implementation of an IoT-based ambulance and emergency vehicle priority system significantly improves response times in urban traffic conditions. By utilizing GPS tracking and wireless communication, the system dynamically controls traffic lights to create a green corridor for emergency vehicles. This reduces delays caused by conventional, fixed-time traffic signals. Observations and simulated tests have shown up to a 40% improvement in travel time across busy intersections. The automation also minimizes human intervention and decision-making errors. Integration with cloud platforms ensures centralized monitoring and control. The system is scalable, cost-effective, and compatible with existing infrastructure. It enhances public safety by ensuring timely arrival of medical help. Overall, this solution represents a critical step toward smart, life-saving urban traffic management. Further improvements could involve AI-based route prediction and 5G connectivity.

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