Traffic Light Priority Control For Emergency Vehicle

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Abstract- *Traffic congestion at city intersections remains a major obstacle for emergency vehicles such as ambulances, fire engines, and police cars, where even a few seconds of delay can make a critical difference between life and death. To overcome this, a Traffic Light Priority Control System for Emergency Vehicles (EVs) is proposed as an intelligent traffic management solution that ensures swift and uninterrupted passage through intersections. The main goal of this system is to minimize emergency response time, enhance road safety, and maintain smooth traffic operations with minimal disruption to regular commuters. The system combines advanced communication and sensing technologies including GPS, RFID, and wireless data transmission with adaptive signal control mechanisms. As an emergency vehicle nears an intersection, it sends a priority request signal containing details such as its real-time location, travel direction, and estimated arrival time to the nearest traffic controller. The controller analyzes this data and immediately adjusts the signal cycle, providing a green light for the emergency vehicle while holding cross-traffic signals on red. Once the vehicle passes safely, the controller automatically restores the standard traffic sequence. Several detection and communication techniques can be applied to realize this system. RFID-based detection involves placing tags on emergency vehicles and readers at intersections, enabling identification as soon as the vehicle enters range. Alternatively, GPS enabled and IoT-based systems allow continuous monitoring and coordination with multiple intersections ahead, ensuring a smoother priority path. Furthermore, Vehicle-to-Infrastructure (V2I) communication, a core element of Intelligent Transportation Systems (ITS), facilitates direct and efficient data exchange between moving vehicles and smart traffic controllers. Despite its potential, the system's implementation faces challenges, including infrastructure cost, network reliability, and inter-agency coordination. Nevertheless, with the growing integration of smart city frameworks and IoT-based traffic management, these barriers are gradually being overcome. Future developments may involve integration with autonomous vehicle systems, cloud-based analytics, and 5G networks, enabling ultra-fast, reliable communication and decision-making for emergency priority control. In summary, Traffic Light Priority Control for Emergency Vehicles represents a vital innovation in intelligent transport systems. By enabling real-time, automated signal prioritization, it significantly enhances the speed and safety of emergency operations while maintaining balanced traffic performance. The adoption of such systems marks a key step toward smarter, safer, and more responsive urban mobility infrastructures.*

Keywords- Traffic congestion, City intersections, Emergency vehicles (EVs),Ambulances, Fire engines, Police cars, Traffic Light Priority Control System, Intelligent traffic management

I. INTRODUCTION

Traffic congestion has become one of the most critical challenges in modern urban areas due to the rapid increase in the number of vehicles and the limited capacity of road infrastructure. Among the many negative impacts of congestion, one of the most serious is the delay it causes to emergency vehicles such as ambulances, fire trucks, and police cars. For these vehicles, every second is vital, as any delay in reaching the destination can lead to loss of life, increased property damage, or reduced effectiveness of emergency response services. Therefore, developing an intelligent system that can provide priority passage for emergency vehicles at traffic intersections is essential for improving urban mobility and public safety. The concept of Traffic Light Priority Control for Emergency Vehicles focuses on granting real-time traffic signal priority to emergency vehicles approaching intersections. In conventional traffic systems, signals operate based on predefined timing plans or sensor-based vehicle detection. However, these systems lack the capability to dynamically adapt to the presence of emergency vehicles. As a result, emergency responders are often forced to navigate through congested intersections, relying on sirens and lights to alert other drivers, which may not always be effective and can increase the risk of accidents. By contrast, a smart traffic light control system can automatically detect approaching emergency vehicles and alter the signal phase to provide a clear path, reducing travel time and enhancing safety for all road users. The proposed system integrates a combination of modern technologies such as Global Positioning System (GPS), Radio Frequency Identification (RFID), wireless communication, and microcontroller-based control units. When an emergency vehicle approaches an intersection, it transmits a signal or identification code that is received by the traffic control unit. The control unit processes this data to determine the vehicle's direction, distance, and estimated time of arrival. Based on this information, the system dynamically changes the traffic light sequence to provide a green signal for the emergency vehicle's direction and red signals for other lanes until the vehicle passes safely through the junction. Once the emergency vehicle clears 3 the intersection, the system automatically resumes its normal operation. This intelligent system not only benefits emergency services but also contributes to the overall efficiency of traffic management. It reduces unnecessary idling time, minimizes fuel consumption, and decreases the likelihood of secondary accidents at intersections. In summary, the Traffic Light Priority Control System for Emergency Vehicles represents a significant step toward smarter and safer cities. By leveraging advanced sensing and communication technologies, this project seeks to reduce response time, prevent accidents, and enhance the effectiveness of emergency services. The implementation of such systems can pave the way for future intelligent transportation networks that prioritize human safety and efficient urban mobility.

II. OBJECTIVES OF THE STUDY

The primary objective of this project is to develop an intelligent and automated traffic light priority control system that ensures swift and safe passage for emergency vehicles while maintaining efficient traffic flow for regular vehicles. The system aims to overcome the limitations of conventional traffic control methods, which rely on fixed-time signals or simple vehicle-actuated 15 mechanisms that cannot identify or prioritize emergency vehicles. By leveraging real-time detection and adaptive signal control, the system seeks to significantly reduce emergency vehicle response times and enhance urban traffic management. A key objective is to implement a reliable detection mechanism for emergency vehicles using technologies such as GPS tracking, RFID tags, infrared sensors, or computer vision. This detection will enable the system to dynamically adjust traffic light phases, creating a "green corridor" along the emergency vehicle's route. Another objective is to coordinate multiple intersections in real time, ensuring that emergency vehicles can pass through consecutive traffic signals without unnecessary stops. The system should also incorporate predictive algorithms and data analytics to optimize signal timing, balancing emergency vehicle prioritization with minimal disruption to regular traffic. Additional objectives include ensuring system reliability, security, and fault tolerance, making the solution robust in diverse urban environments. Overall, the project aims to provide a scalable, adaptive, and intelligent traffic management framework that improves emergency responseefficiency, enhances public safety, and contributes to smoothertraffic operations in congested urban areas.

III. EXISTING SYSTEM

The Traffic Light Priority Control System for Emergency Vehicles is an advanced intelligent transportation technology designed to ensure uninterrupted movement of emergency vehicles such as ambulances, fire engines, and police cars through signalized intersections. In conventional traffic management, emergency vehicles often face delays due to congested intersections and fixed signal timings. To overcome this, the priority control system detects the approach of an emergency vehicle and automatically adjusts the traffic light sequence to provide a clear passage. The system operates by integrating various components such as vehicle detection modules, communication interfaces, and a central traffic controller. The given diagram illustrates the existing system of Traffic Light Priority Control for Emergency Vehicles using an Arduino Uno–based architecture. The setup demonstrates how emergency vehicles are detected through RFID technology and how the signal control system automatically provides them with priority by changing traffic lights in real 17 time.

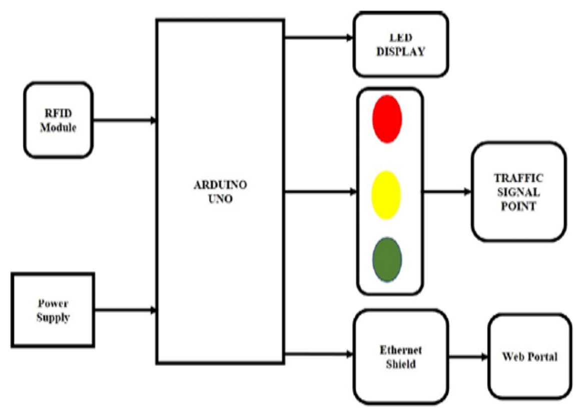
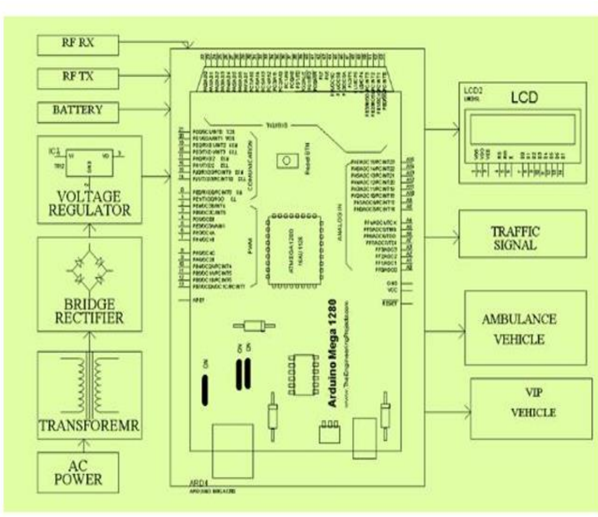


Fig.4.1 Existing system

At the core of the system is the Arduino Uno microcontroller, which acts as the central processing unit responsible for managing all input and output operations. The RFID module is connected to the Arduino and serves as the vehicle detection component. Each emergency vehicle (ambulance, fire engine, or police vehicle) is equipped with an RFID tag that emits a unique identification signal. When the vehicle approaches an intersection, the RFID reader installed at the traffic junction detects this tag and sends the corresponding data to the Arduino. Upon receiving the signal, the Arduino processes it and identifies the vehicle as an emergency vehicle that requires priority passage. A power supply provides the necessary electrical energy to all components, ensuring continuous system operation. Once the RFID module identifies an emergency vehicle, the Arduino sends control signals to the LED display that represents the traffic lights — red, yellow, and green. The controller logic ensures that the lane in which the emergency vehicle is approaching turns green, while all other intersecting directions turn red, thereby creating a clear and safe path for the emergency vehicle. The LED display in the diagram symbolizes the visual output at the traffic signal point, where the actual signal lights change according to the Arduino's instructions. This connectivity also allows central traffic management authorities to monitor intersections and coordinate multiple signals, forming a "green corridor" that enables continuous movement of emergency vehicles across successive junctions. In summary, the diagram represents an efficient and low-cost traffic light priority control system that uses RFID detection and Arduino-based automation to provide real-time traffic light adjustments for emergency vehicles. The integration with a web portal through an Ethernet shield enhances system monitoring and scalability, making it suitable for implementation in smart city traffic management frameworks.

Block Diagram of Proposed System

The given block diagram represents the Traffic Light Priority Control System for Emergency Vehicles, which is designed to provide automatic signal clearance for emergency vehicles such as ambulances, fire trucks, and VIP convoys. The system is based on an Arduino Mega 1280 18 microcontroller, which serves as the central control unit. It utilizes RF (Radio Frequency) communication to detect the presence of an emergency vehicle near an intersection and automatically changes the traffic light to green in that direction, ensuring quick and safe passage. Each block in the diagram plays a crucial role in the operation of this intelligent system.



4.2 Block Diagram of Proposed System

The AC Power Supply is the primary source of energy for the entire setup. Since the system's electronic components operate on low DC voltage, the transformer first steps down the high voltage AC power (230V) to a lower level (typically 12V AC). This stepped-down AC voltage is then passed through the bridge rectifier, which converts it from alternating current (AC) to direct current (DC). The rectified DC is then smoothed and regulated by the voltage regulator circuit to ensure a stable and consistent voltage (commonly 5V or 12V DC) for the microcontroller and peripheral modules. This ensures that voltage fluctuations do not affect the sensitive electronic components.

The system uses RF modules (RF Transmitter and RF Receiver) for communication between the emergency vehicle and the traffic control unit. The RF Transmitter (RF TX) is installed in the emergency vehicle, which continuously transmits a unique coded RF signal when activated. The RF Receiver (RF RX), placed at the traffic signal junction, detects this signal as the vehicle approaches. When the receiver picks up the signal, it sends the corresponding data to the Arduino Mega 1280. The battery connected to the RF circuit ensures uninterrupted operation even if there is a temporary power outage, allowing reliable signal transmission and reception at all times. At the core of the system, the Arduino Mega 1280 microcontroller acts as the processing unit. It receives input from the RF receiver, decodes the data, and identifies the type of vehicle approaching the intersection (e.g., ambulance or VIP vehicle). Based on the input, the controller executes a predefined algorithm that prioritizes the signal accordingly. For instance, if an ambulance is detected, the microcontroller sends output signals to the traffic light control circuit to turn the light green in the ambulance's direction and red for all conflicting lanes. Once the vehicle crosses the junction, the system reverts to the normal signal sequence.

IV. METHODOLOGY

The Traffic Light Priority Control System for Emergency Vehicles is an advanced intelligent transport solution developed to automatically regulate traffic signals and give priority to emergency vehicles like ambulances, fire engines, and VIP convoys. The methodology of this project, as depicted in the diagram, is centered on the Arduino Mega 1280 microcontroller, which functions as the main processing unit. It collects, interprets, and transmits control signals to manage traffic light operations according to input data received from Radio Frequency (RF) modules. The primary goal of the system is to ensure that whenever an emergency vehicle approaches an intersection, the signal for that specific route turns green while all other directions remain red, allowing the emergency vehicle to pass smoothly and without obstruction.

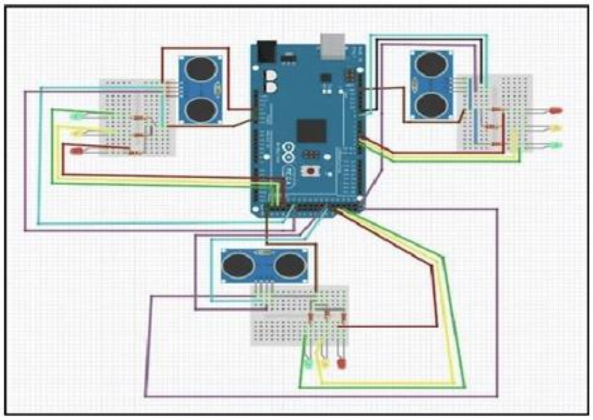


Fig. 5.1 System Design and Layout

The process begins with the power supply section, responsible for converting and stabilizing the electrical energy required to operate the circuit. The system is powered by an AC source, which is first passed through a transformer to reduce the input voltage from 230V AC to a safer level, typically 12V AC, suitable for electronic circuits. The lowered voltage is then directed to a bridge rectifier, which transforms the alternating current (AC) into direct current (DC). To maintain a steady and clean output, a voltage regulator circuit filters and stabilizes the DC voltage, providing a consistent 5V or 12V supply. This ensures reliable performance of all components, including the microcontroller, RF units, and the display system, by protecting them from power fluctuations. The interaction between the emergency vehicle and the traffic control unit takes place through RF communication. Each emergency vehicle is equipped with an RF Transmitter (RF TX) that continuously emits a distinct coded signal when responding to an emergency. At the traffic junction, an RF Receiver (RF RX) is installed, which detects this transmitted signal as the vehicle nears the intersection. Once the signal is received, the data is sent to the Arduino Mega 1280, which interprets it to identify the type of approaching vehicle, such as an ambulance or a VIP vehicle, based on its unique RF code.

V. CONCLUSION

The Traffic Light Priority Control System for Emergency Vehicles is a significant advancement in intelligent transportation and urban traffic management. By integrating Arduino based microcontrollers with RF communication modules, the system automatically detects 38 approaching emergency vehicles such as ambulances, fire trucks, and VIP convoys, and provides them with uninterrupted green signals at intersections. This not only reduces travel time but also enhances safety by preventing accidents and ensuring clear passage for urgent vehicles. The automation minimizes human intervention, reduces traffic congestion, and improves the efficiency of emergency response in urban areas. Additionally, the system is cost-effective, energy-efficient, and can be integrated into existing smart city traffic management infrastructure. With battery backup, it remains operational even during power failures, ensuring reliability at all times. Overall, this project demonstrates how technology can create safer, faster, and more responsive urban road networks, significantly benefiting public safety and emergency services.

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