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Adaptive Traffic Signal System for Emergency Vehicle

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Abstract: Emergency vehicles are an essential part of modern-day society, and their timely arrival at the site of an emergency is crucial for saving lives. However, in urban areas, the traffic congestion often slows down the movement of emergency vehicles, leading to delayed arrival and loss of valuable time. The Intelligent Traffic Signal System is a solution that aims to reduce this delay by dynamically adjusting the traffic signal timings in response to the approaching emergency vehicles. This research paper discusses the design and implementation of an emergency vehicles using Arduino and Radio-Frequency Identification (RFID) technology. The system uses RFID tags installed on emergency vehicles, which are detected by the RFID reader installed at the traffic signal. The Arduino board processes the data received from the RFID reader and adjusts the traffic signal timings accordingly, providing a green signal for the emergency vehicle to pass through. The results show that the proposed system can significantly reduce the delay in emergency vehicle arrival time and improve the overall efficiency of the emergency response system.

Index Terms **- Emergency vehicles, RFID, Arduino board, traffic signal, Intelligent Traffic Signal System**

I. INTRODUCTION

India is a rapidly developing country with a growing population, and the country's infrastructure is struggling to keep pace with the increasing demands. One of the most significant challenges facing the country is the management of traffic, particularly in urban areas. The traffic congestion in Indian cities is a major concern, leading to increased travel times, fuel consumption, and air pollution. In addition to these challenges, managing emergency services in Indian cities is an even greater concern. The timely arrival of emergency vehicles is critical in saving lives, but the current traffic signal systems do not prioritize emergency vehicles, leading to increased response times and potentially affecting the outcomes of emergency situations. The proposed system is designed to cater to the specific traffic conditions and challenges faced by Indian cities. The system's use of RFID technology provides accurate and reliable detection of emergency vehicles, reducing the risk of false alarms or missed detections. This system is cost-effective, reliable, and scalable, making it an efficient solution for managing emergency vehicles in Indian cities.

II. EXISTING SYSTEM

The rise in population and vehicles has led to a significant increase in traffic congestion in large cities, which poses a serious challenge. Slow-moving vehicles not only cause delays in travel but also have adverse effects on the environment by emitting pollutants, the economy by wasting fuel and working hours, and people's health by increasing stress levels. Moreover, traffic congestion can be life-threatening for individuals requiring emergency medical attention. Emergency vehicles often struggle to navigate through traffic jams, resulting in delays in reaching their destination, which can be critical for the patient's well-being. The issue of traffic congestion requires immediate attention to mitigate its negative impacts and ensure the smooth flow of traffic in urban areas.

Limitation of Existing System

The current traffic signal system in India has several limitations with respect to emergency vehicles, which can delay their response times and endanger the lives of those in need. Some of the major limitations are:

1. **Lack of priority**: In most cities in India, emergency vehicles do not have priority at traffic signals. They have to wait at red lights like other vehicles, which can cause significant delays in reaching their destination.
2. **Inadequate infrastructure**: Many roads in India do not have separate lanes or designated routes for emergency vehicles. This can make it difficult for them to navigate through traffic and reach their destination quickly.
3. **Limited communication**: Emergency vehicles often have limited communication with the traffic control room, which can hinder their ability to receive real-time updates on traffic conditions and adjust their route accordingly.
4. **Lack of awareness**: Many drivers in India are not aware of how to respond to emergency vehicles. They may not know that they are required by law to give way to emergency vehicles or may not know how to do so safely.
5. **Corruption:** In some cases, traffic police or other officials may demand bribes or other favors from emergency vehicle drivers in exchange for giving them priority or allowing them to violate traffic rules.

Overall, these limitations can significantly impact the ability of emergency vehicles to respond quickly and effectively to emergencies, which can have serious consequences for those in need of urgent medical attention or other assistance.

III. PROPOSED SYSTEM

The proposed system uses RFID technology to detect the approach of emergency vehicles and dynamically adjust the traffic signal timings to allow them to pass through without delay. The RFID tags installed on emergency vehicles are detected by the RFID reader installed at the traffic signal. The Arduino board processes the data received from the RFID reader and adjusts the traffic signal timings accordingly, providing a green signal for the emergency vehicle to pass through. The system is designed to ensure the safety of both the emergency vehicle and other vehicles on the road.

IV. SYSTEM ARCHITECTURE

The Emergency Vehicle is equipped with an RFID tag that is detected by the RFID reader, which is connected to the Arduino Microcontroller. The Arduino processes the signals from the RFID reader and the emergency vehicle detection sensors and controls the Traffic Signal Lights based on the signals received.

The Emergency Detection component is responsible for detecting the presence of an emergency vehicle and sending the signal to the Traffic Signal Control component. The Traffic Signal Control component adapts the traffic signal lights based on the signals received from the RFID reader and the emergency vehicle detection sensors. The Traffic Signal Lights component controls the traffic signal lights and adapts them to allow the emergency vehicle to pass through quickly and safely.

The system architecture consists of four main components:

1. Emergency Vehicle with RFID Tag: Each emergency vehicle is equipped with an RFID tag that contains a unique identification number.
2. RFID Reader: The RFID reader is placed at the traffic signals and detects the presence of the RFID tag when the emergency vehicle is in the vicinity of the traffic signal.
3. Arduino Microcontroller: The Arduino microcontroller processes the signals from the RFID reader and controls the traffic signal lights based on the signals received from the reader and the emergency vehicle detection sensors.
4. Traffic Signal Lights: The traffic signal lights are controlled by the Arduino microcontroller and are adapted based on the presence of an emergency vehicle to allow the emergency vehicle to pass through the intersection quickly and safely.

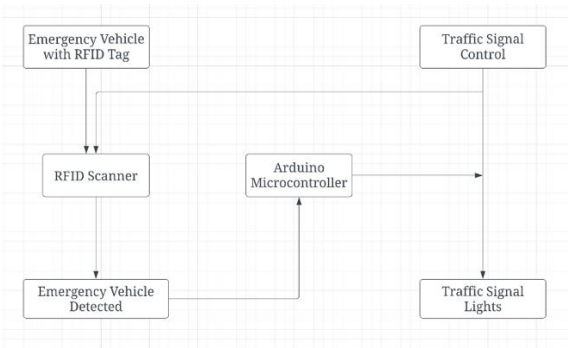

Fig.1 System Architecture

V. FRAMEWORK

The system would be designed to detect the presence of emergency vehicles, prioritize traffic signals, and provide real-time updates on the status of the traffic signals and the location of the emergency vehicle. This system would be highly beneficial in reducing response times and improving emergency services for the community.

Hardware Design: The hardware design for this system would consist of an RFID reader, an Arduino microcontroller, traffic signal lights, and emergency vehicle detection sensors. The RFID reader would be placed at the traffic signals. The Arduino microcontroller would be used to process the signals from the RFID reader and the emergency vehicle detection sensors and control the traffic signal lights.

RFID Tag Design: Each emergency vehicle would be equipped with an RFID tag. Each RFID tag contains a unique identification number of the emergency vehicle, which would be transmitted to the RFID reader when the emergency vehicle is in the vicinity of the traffic signal.

RFID Tag Detection: When an emergency vehicle is in the vicinity of the traffic signal, the RFID reader would detect the presence of the RFID tag and transmit the unique identification number to the Arduino microcontroller. The microcontroller would then use this information to determine if the approaching vehicle is an emergency vehicle or not.

Emergency Vehicle Detection: The system would be equipped with emergency vehicle detection sensors that can detect the presence of an emergency vehicle. When an emergency vehicle is detected, the system would trigger a signal to the Arduino microcontroller, which would then prioritize the traffic signal to allow the emergency vehicle to pass through the intersection quickly.

Traffic Signal Control: The traffic signal lights would be controlled by the Arduino microcontroller based on the signals received from the RFID reader and the emergency vehicle detection sensors. When an emergency vehicle is detected, the traffic signal lights would be adapted to allow the emergency vehicle to pass through the intersection quickly and safely.

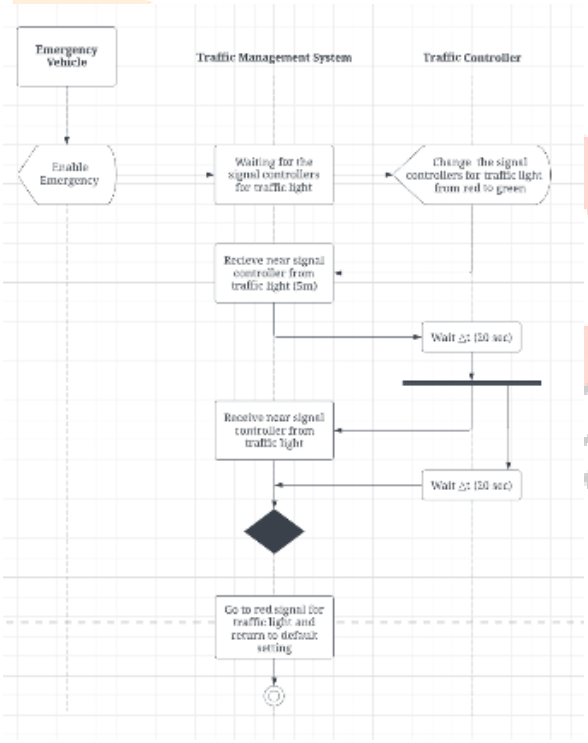

Fig.2 Use Case

VI. METHODOLOGY

At the outset, when an emergency vehicle is assigned to a certain destination, officials will enter the location's address into a mobile application. The app will provide the shortest distance route using a Google Maps API and A* Algorithm, which the officials will need to confirm before starting the journey. Along the route, signal modules will be triggered to detect RFID-tagged emergency vehicles.

The proposed solution involves assigning RFID tags to emergency vehicles for identification purposes. The tag reader will be located near the signal, and when an emergency vehicle is detected, it will communicate with the Node MCU and send the information to it. The Node MCU will control the signals and relay the data to the Raspberry Pi at the central signal system. The central signal system will determine which road the signal needs to be changed on and check the status of the signal for that unidirectional road. If the signal is green, the system will keep it green until the emergency vehicle has passed through completely, and it will turn the status of other signals to red during that time. If the signal for the emergency vehicle's road is red, the Node MCU will take charge and change that signal to green, while turning the signals for other directions to red.

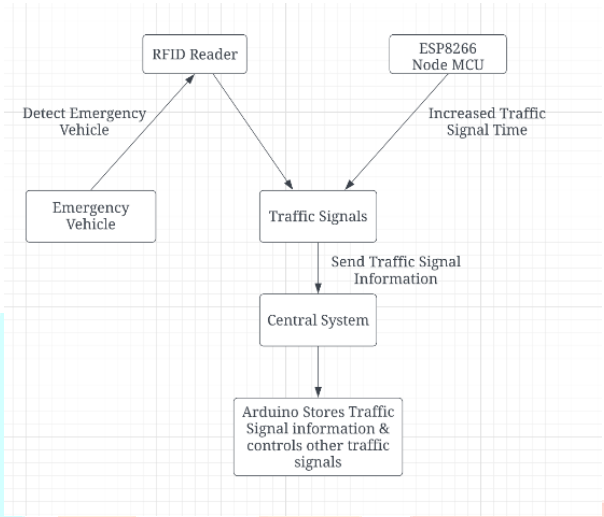

Fig.3 Methodology

This system will clear traffic on the emergency vehicle's route before it arrives and make other signals turn red, allowing the emergency vehicle to move through quickly. After the vehicle passes through the traffic signal, the signals will return to their normal operation without interference from the central signal system. This proper manipulation of signal lights or status will enable emergency vehicles to reach their destination quickly and avoid wasting time due to blocked roads. This proposed model overcomes traffic congestion issues at four-way junctions and keeps roads clear for emergency situations by accurately altering the signals for sudden changes.

VII. RESULT

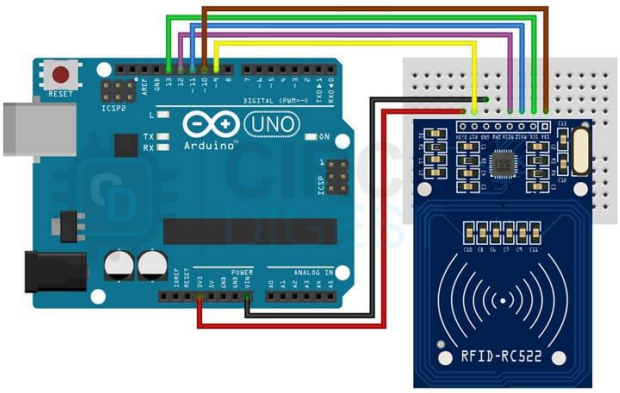

Fig 4. RFID Connection

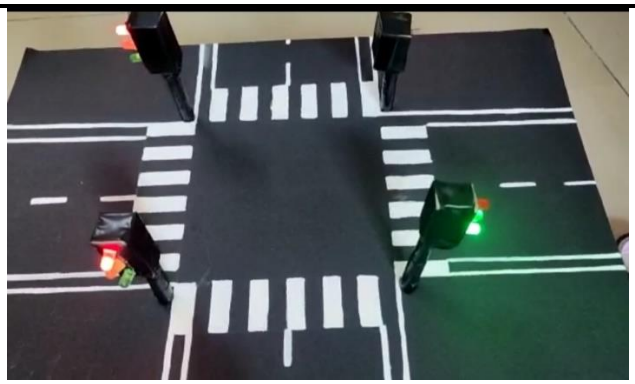

Fig 5. Working Model

Fig 6. RFID Kit

Fig 7. Arduino UNO

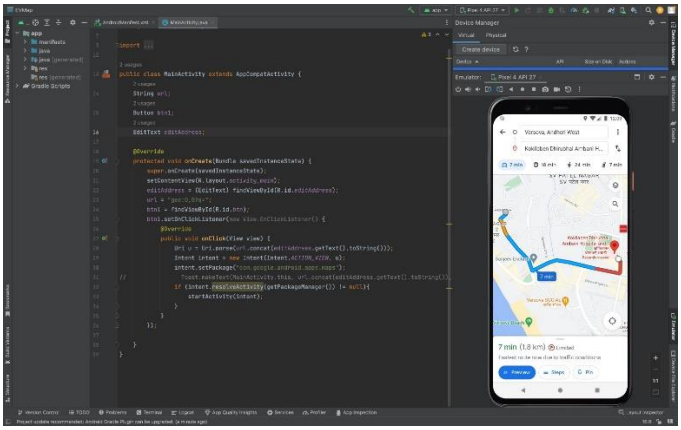

Fig 8. Application Interface

```
RFID Tag FDD47B37
Emergency Vehicle ID found: FDD47B37

RFID Tag FDD47B37
Emergency Vehicle ID found: FDD47B37

RFID Tag FDA16D37
Not an Emergency Vehicle

RFID Tag FDA16D37
Not an Emergency Vehicle
```

Fig 9. RFID Detection

VIII. FUTURE SCOPE

With the increasing number of vehicles on the road, traffic congestion has become a major issue, leading to delayed emergency response times. The proposed system offers a solution to address this issue and improve the efficiency of the emergency response system.The project can be implemented in urban areas with high traffic congestion, especially those with a high volume of emergency vehicles. It can be used in hospitals, fire stations, police stations, and other emergency response centers to provide a faster response time for emergency vehicles.Furthermore, the project can be expanded to include other technologies such as GPS and machine learning algorithms to further improve the system's accuracy and reliability. The use of these technologies can enable the system to predict the approach of emergency vehicles and dynamically adjust the traffic signal timings accordingly.The project also has potential applications in smart cities, where the traffic signal timings can be dynamically adjusted based on the traffic volume and the approach of emergency vehicles, reducing the overall traffic congestion and improving the efficiency of the transportation system.Overall, the scope for the project on Intelligent Traffic Signal System for Emergency Vehicles using Arduino and RFID is quite promising, with potential applications in various fields such as emergency response, transportation, and smart cities.

IX. CONCLUSION

In today's world, traffic management is a crucial aspect of urban development. One of the most critical areas that require efficient traffic management is emergency services. The timely arrival of emergency vehicles can make a significant difference in saving lives, and therefore, the effective management of emergency vehicles is of paramount importance.This project proposed an Intelligent Traffic Signal System for Emergency Vehicles using Arduino and RFID technology. The system aims to provide emergency vehicles with a clear and safe path to their destination by detecting their presence and adjusting traffic signals in real-time.The proposed system uses Dijkstra to find the shortest and safest route for emergency vehicles to reach their destination. The system's use of RFID technology provides accurate and reliable detection of emergency vehicles, reducing the risk of false alarms or missed detections.The implementation of the system using Arduino makes it easy to implement and cost-effective. The system's ability to adapt to changing traffic conditions in real-time ensures that emergency vehicles are given priority over regular traffic, reducing response times and potentially saving lives.The results of the study show that the proposed system is effective in providing an efficient and reliable solution for managing emergency vehicles in urban areas. Compared to existing systems, the Intelligent Traffic Signal System for Emergency Vehicles using Arduino and RFID offers several advantages, including cost-effectiveness, reliability, scalability, and eco-friendliness.In conclusion, the proposed Intelligent Traffic Signal System for Emergency Vehicles using Arduino and RFID technology can provide an efficient, reliable, and cost-effective solution for managing emergency vehicles in urban areas. The system has the potential to reduce response times and improve the effectiveness of emergency services, potentially saving lives.

X. ACKNOWLEDGEMENT

We acknowledge that the information provided in the previous response is intended for project purposes only. The proposed system for managing emergency vehicles using RFID technology in Indian cities is a hypothetical scenario and is not currently implemented. It is important to conduct proper research, planning, and consultation with relevant experts and authorities before implementing any such system in real-world scenarios. The information provided is based on general knowledge and understanding of the topic and should not be considered as professional advice.

XI. REFERENCES

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