CLEAR – Controlled Lane Emergency Access Routing

Keerthy N[1], Preethi P H[2], Kavya J[3], Prajwal Oddodagi[4], Pooja A[5]
[1,2,3,4,5]Department. Of Electronics and Communication Global Academy of Technology Bengaluru,Karnataka,India

***Abstract*—This project presents an RF module-based traffic signal prioritization system designed to facilitate the swift passage of emergency vehicles through congested intersections. When an emergency vehicle activates a directional switch, the traffic signals dynamically change from red to green exclusively in the requested direction, ensuring an unobstructed path. The system employs microcontroller-based controllers integrated with RF wireless communication to detect and respond to emergency vehicle signals in real-time. Additionally, the project incorporates real-time updates from nearby hospitals through the Adafruit IoT platform, enhancing coordination between traffic management and healthcare facilities. This integration enables timely response to emergencies, reduces delay for emergency services, and improves overall traffic flow without compromising regular traffic. By combining wireless communication technology with IoT-based hospital updates, this system aims to optimize emergency vehicle routing and elevate urban traffic management efficiency.**

***Index Terms*—RF Module, Traffic Signal Control, Emergency Vehicle Priority, Real-time Traffic Management, Arduino Microcontroller, Wireless Communication, Adafruit IoT Integration, Hospital Emergency Updates**

I. INTRODUCTION

Traffic congestion in urban areas often results in significant delays for emergency vehicles such as ambulances, fire engines, and police cars, which can critically impact emergency response times and patient outcomes. Traditional fixed-timing traffic signals do not account for the urgent passage of these vehicles, leading to slowdowns in their mobility and compromised emergency services. To overcome this challenge, this project proposes an intelligent traffic signal control system that leverages RF (Radio Frequency) communication modules to dynamically change traffic signal states. When an emergency vehicle approaches and activates the RF switch corresponding to its travel direction, the traffic signals will immediately turn green in that direction, allowing an unhindered route while the other directions remain red.

This system not only helps in prioritizing emergency vehicles but also enhances overall traffic flow by reducing unnecessary stops. Furthermore, the project integrates Realtime updates from nearby hospitals through the Adafruit IoT platform. This feature provides vital health facility status information and emergency alerts that can aid in more efficient traffic and healthcare service coordination. The integration of RF-based traffic control and cloud-based hospitalization data creates a comprehensive emergency management system, aimed at saving lives by cutting down delays and improving communication between traffic authorities and medical facilities.

II. LITERATURE SURVEY

The literature survey presented in the document highlights various recent research efforts focused on improving emergency response through advanced traffic management and healthcare integration. One key study discussed is the “RF and IoT-Driven Automated Lane Clearance System for Enhanced Emergency Response,” which employs RF and IoT technologies to automate ambulance lane clearance by controlling traffic signals and facilitating vehicle communication in real-time. This system is noted for its low cost, scalability, and suitability for smart city applications. Another notable contribution is the “Smart Ambulance
System using IoT,” which focuses on real-time health monitoring and GPS navigation to enhance

coordination between ambulances and hospitals, thereby reducing emergency response times.

Overall, the literature converges on the theme of integrating RF communication, IoT platforms, GPS tracking, and real-time data sharing to create smarter, responsive emergency vehicle priority systems. These systems not only clear traffic lanes efficiently but also coordinate with healthcare facilities to optimize patient care, making them highly relevant and supportive of the objectives of the current project.

III. METHODOLOGY

The methodology of this project centers around using RF communication modules and microcontrollers to enable emergency vehicle priority at traffic intersections. The emergency vehicle is equipped with an RF transmitter that sends a coded signal when emergency mode is active. This signal is received by an RF receiver integrated with the traffic signal controller's microcontroller, such as an Arduino. Upon receiving and decoding the signal, the microcontroller interrupts the normal fixed traffic light sequence and immediately switches the signal to green for the direction from which the emergency vehicle is approaching, while turning others red. This ensures a clear and safe path for the emergency vehicle to pass through the intersection without delay.

A Monitoring System

1.Ardunio Uno:

The Arduino Uno is a widely used microcontroller development board based on the ATmega328P microcontroller. It serves as the "brain" of many electronic projects and is designed to make programming and prototyping simple for beginners and professionals alike. The board operates at 5 volts and can be powered either through a USB cable or an external power supply of 7 to 12 volts. It contains 14 digital input/output pins as shown in figure 3.1, out of which 6 can be used as PWM outputs, and 6 analog input pins for reading sensor data. Communication with a computer is established through the USB interface, which also allows code uploading via the Arduino IDE. Due to its low cost, ease of use, and open-source nature, the Arduino Uno is extensively used in embedded systems, robotics, home automation, and IoT applications, making it one of the most popular platforms for developing and testing innovative electronic projects.

Figure 3.1 Ardunio Uno

2.(a) RF Transmitter Module:

The transmitter module has three main pins as shown in figure 3.2: VCC (power supply, typically 3V to 12V), Data Input (DIN), and Ground. The data input receives encoded serial data from an encoder IC (like HT12E), which converts parallel directional commands (from switches pressed in the emergency vehicle) into a serial stream. The transmitter modulates this data using Amplitude Shift Keying (ASK) and broadcasts it via an antenna at 433 MHz

(b) RF Receiver Module:

The receiver module has four pins as shown in figure 3.2:

VCC (regulated 5V supply), Data Output (DOUT), Linear Output (can be tied to DOUT), and Ground. The receiver picks up the modulated RF signals on the same 433 MHz frequency. It demodulates the ASK signals and outputs the original serial data via DOUT to a decoder IC (like HT12D).

Figure 3.2 RF Transmitter and Receiver

3.LCD Display

The LCD (Liquid Crystal Display) is an electronic display module that is widely used in various embedded systems and electronic projects to display text, numbers, symbols, or messages. It works on the principle of light modulation — liquid crystals do not emit light directly but use a backlight or reflector to produce visible images. One of the most commonly used LCDs in microcontroller-based projects is the 16x2 LCD as shown in figure 3.3, which can display 16 characters per line on 2 lines

The LCD module typically has 16 pins, which include power pins (VCC and GND), a contrast control pin (VEE), data pins (D0–D7), and control pins (RS, RW, and EN

Figure 3.3 LCD Display

4.Push Buttons:

A push button is a simple electromechanical switch used to control the flow of electricity in a circuit. In this way, a push button acts as a digital input device that sends HIGH (1) or LOW (0) signals to a microcontroller such as an Arduino Uno.

A typical push button has four terminals (pins) as shown in figure 3.4, though in most cases only two are used — one connected to the input pin of the microcontroller and the other to ground (GND) or VCC, depending on the circuit

Figure 3.4 Push button switch

5.ESP32

Figure 3.5 shows the ESP32 is a powerful and low-cost microcontroller developed by Express if Systems, featuring built-in Wi-Fi and Bluetooth for wireless communication. It has a dual-core 32-bit processor running up to 240 MHz, with 520 KB SRAM and flash memory for program storage. The board operates at 3.3V and includes multiple GPIO pins, ADC, DAC, PWM, I2C, SPI, and UART interfaces for connecting sensors and modules.

Figure 3.5 ESP32 Wi fi module

6.LED:

A LED (Light Emitting Diode) is a semiconductor device that emits light when an electric current flows through it in the forward direction. It has two terminals as shown in figure 3.6: anode (+) and cathode (−). In microcontroller projects like

Arduino, LEDs are used as indicators for status, signals, or alerts, usually with a current-limiting resistor to prevent damage.

Figure 3.6 LED Light emitting diode

7.Temperature Sensor:

A temperature sensor is an electronic device used to measure the temperature of an object, environment, or body. It works by converting heat energy into an electrical signal that can be read by a microcontroller or display system.

Common types of temperature sensors include thermistors, thermocouples, RTDs (Resistance Temperature Detectors), and semiconductor sensors like LM35 and TMP36. The LM35 sensor, for example, gives a linear voltage output proportional to temperature. Temperature sensors can be either contact type(directly touch the object) or non-contact type (use infrared technology) as shown in figure 3.7.

Figure 3.7 Temperature Sensor

8.Pulse Sensor:

A pulse sensor is an electronic device used to measure the heart rate of a person by sensing changes in blood flow. It usually consists of an LED that emits light and a photodiode that detects the reflected light from the skin as shown in figure

3.8. When the heart beats, the volume of blood in the fingertip or earlobe changes, which alters the amount of reflected light. These variations are converted into electrical signals that represent the pulse. Pulse sensors are small, low-cost, and easy to use, making them ideal for wearable health devices like fitness bands and smartwatches. They are also used in medical monitoring systems to track heart health in real time.

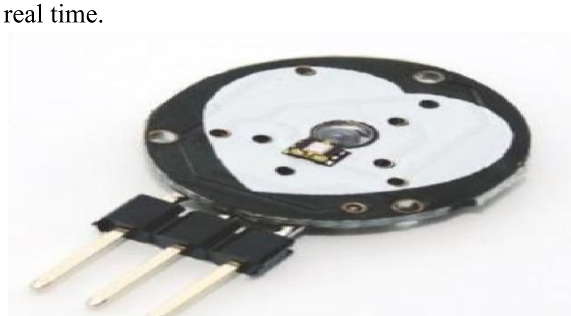

Figure 3.8 Pulse Sensor

B. Software Workflow:

1.Ardunio IDE:

The Arduino IDE (Integrated Development Environment) is the official software used to write, compile, and upload programs to Arduino boards like the Arduino Uno. It provides a user-friendly platform for beginners and developers to easily create and test embedded system applications. The IDE uses a simplified version of C/C++ programming language, making it easier to control hardware components such as LEDs, sensors, and motors.

The IDE consists of a code editor, toolbar, and output console as shown figure 3.9. In the code editor, users write programs called sketches, which typically include two main functions: setup () and loop (). The setup () function is executed once to initialize settings like pin modes or serial communication, while the loop () function runs continuously to perform the main program logic.

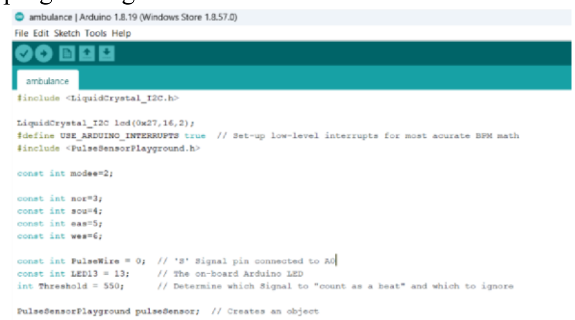

Figure 3.9 Arduino IDE Software tool

2.Adafruit IO:

Adafruit IO is a cloud-based Internet of Things (IoT) platform developed by Adafruit Industries that provides a simple and efficient way to connect, monitor, and control devices over the internet. It allows users to send data from sensors, devices, or microcontrollers like Arduino, ESP32, Raspberry Pi, or other compatible hardware to the cloud, where it can be stored, analyzed, and visualized in real time.

The platform uses feeds to represent individual streams of data, such as temperature readings, humidity levels, switch states, or any sensor output as shown in figure 3.10. Users can organize these feeds into dashboards, which provide visualizations using charts, graphs, gauges, maps, or buttons to monitor and interact with their devices.

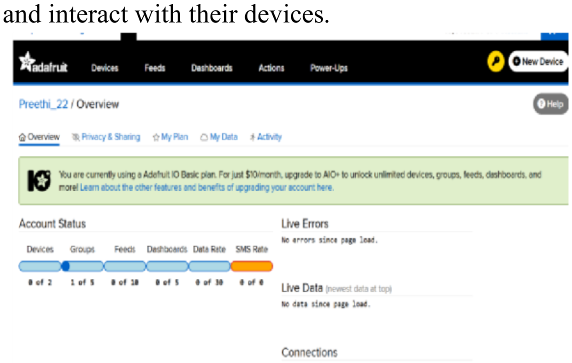

Figure 3.10 Adafruit IO

C. Block Diagram:

Ambulance:

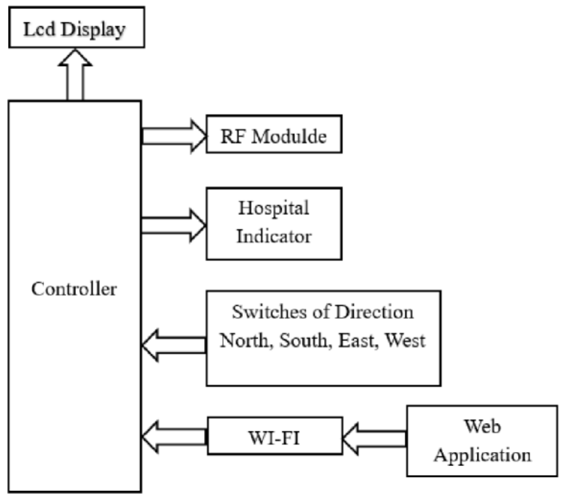

Figure 3.11 Block diagram of ambulance

The flow as shown in figure 3.11 in the ambulance for the RF-based automatic traffic signal control system begins when the ambulance is dispatched on an emergency call. The onboard microcontroller activates the RF transmitter, which encodes and sends a priority signal to traffic signals ahead via radio frequency communication. As the ambulance moves towards intersections, the RF signals are received by the RF receivers installed at traffic signals. These signals are decoded and processed by the traffic signal controllers to switch the lights to green in the ambulance's direction, clearing the path.

Traffic:

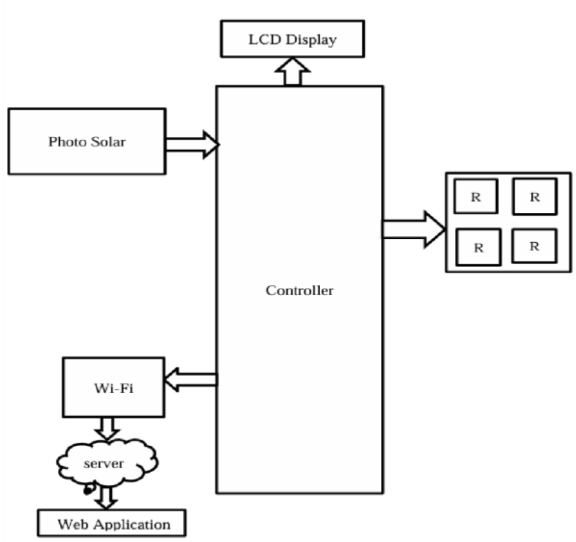

Figure 3.12 Block diagram of Traffic signal

Emergency vehicle traffic signal priority systems are designed to grant emergency vehicles such as ambulances priority at intersections by temporarily modifying traffic light patterns. When an emergency vehicle approaches, it sends a wireless signal detected by the traffic signal controller as shown in figure 3.12. The controller then overrides normal operation to switch the light green in the vehicle's direction, holding other lights red to clear the way

IV. RESULT

The system successfully provided automatic green light priority as shown in figure 4.1 for emergency vehicles using RF communication, allowing them to move quickly through traffic. Along with traffic control, it also offered live patient updates such as body temperature and pulse rate through the Adafruit IoT platform as shown in figure 4.3, which were shared instantly with hospitals.

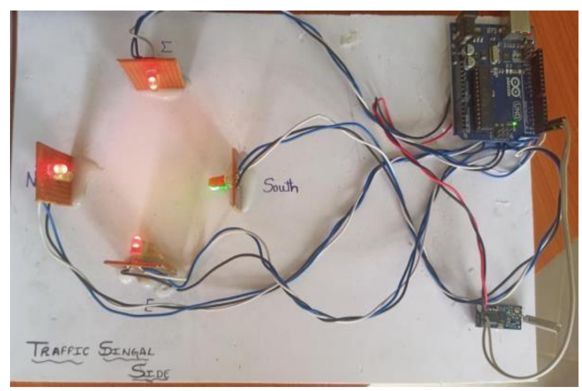

Figure 4.1 Result of Traffic signal from red to green

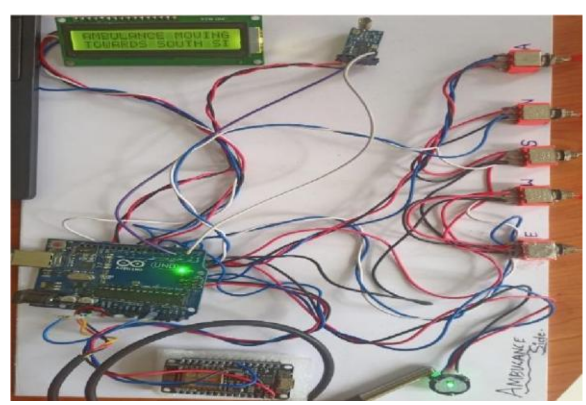

Figure 4.2 Result of Ambulance side

Figure 4.3 Adafruit IO live update of patient

V. CONCLUSION

The conclusion of this RF module-based automatic traffic signal control project is that the system effectively prioritizes emergency vehicles by clearing their route through traffic signals using RF communication. The project demonstrates a practical, cost-effective solution that can be easily implemented with commonly available components like microcontrollers, RF transmitter and receiver modules, encoders, and decoders. It improves road safety by reducing traffic congestion and minimizing the risk of accidents during emergency situations Overall, the project contributes to smarter traffic management, saves lives by enabling quicker emergency responses, and enhances the efficiency of urban transportation systems.

VI. FUTURE SCOPE

The future scope of this RF module-based automatic traffic signal control system includes several promising enhancements. Integration with advanced AI and machine learning algorithms can enable real-time adaptive traffic signal optimization, improving emergency vehicle routing dynamically based on traffic conditions. Incorporating GPS and V2X (vehicle-to-everything) communication can allow seamless interaction between emergency vehicles and traffic infrastructure, creating predictive green corridors well in advance.

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