Optimizing Ambulance Routes: Real-time Traffic Signal Adaption

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ABSTRACT

India's population continues to grow, but the country's transportation system is struggling to keep up, creating major problems. Emergency vehicles such as ambulances often experience delays due to accidents, putting patients' lives at risk. When an ambulance is stuck in traffic, every second counts and delay can be life-threatening. Getting the ambulance to the hospital quickly is critical to saving lives and protecting public health. Using the Internet of Things (IoT), we can create a system that automatically removes emergency traffic signs. This new approach could shorten response times and increase the efficiency of emergency services. Implementing IoT-based traffic management helps ensure that ambulances and other emergency vehicles can move through traffic, ultimately saving lives and better treating people's health as a whole. To solve this problem, using new methods to provide clear traffic signals to emergency vehicles using the Internet of Things (IoT) may provide a good solution.

Keywords: RFID, Microcontroller, Android Application, Intelligent Ambulance, GPS.

I. INTRODUCTION

India is the most populous country with a growing economy. Traffic congestion is a major problem in India. There are more vehicles and the speed of infrastructure is slow due to cost and space constraints. The Indian transport system is messy and not lane based so it must require a way in which we can solve the problem.

The core idea behind this document revolves around facilitating smooth journeys for ambulances to hospitals, thereby reducing delays caused by traffic jams. A smart traffic management system for ambulances using IoT (Internet of Things) is a solution that uses various technologies to help emergency vehicles navigate traffic efficiently and safely. This system includes equipping ambulances with IoT-enabled devices such as sensors, cameras, GPS. trackers and other communication technologies that are connected to a centralized traffic management system.

It uses a microcontroller-based RFID system to manipulate traffic lights as an ambulance approaches an intersection, potentially saving lives at critical moments. The small chip stores the patient's condition and the ambulance's current lane, while the RFID locator on the ambulance transmits this information to the RFID reader on the traffic signals. In order to avoid unnecessary adjustments to traffic signals, we use a mobile application to compare the position of the ambulance and the condition of the patient. In the event of a network failure, the RFID system takes over full control.

This paper deals with the critical issue of ensuring uninterrupted movement of ambulances, especially during rush hours. Although transporting patients to the hospital in emergency situations may seem simple, in practice it becomes extremely challenging. The problem escalates when emergency vehicles are forced to wait for other vehicles to give them the right of way at intersections controlled by traffic signals. Using real-time data analysis, traffic patterns can be identified and signal timing can be dynamically adjusted to prioritize ambulance passage.

By analyzing real-time data, traffic patterns can be determined and changes to prioritize ambulances can be planned. The situation is likely to worsen in the future and require further improvement measures. Given our densely populated areas, this article addresses the real need to streamline daily transportation. It was put into

practice to facilitate the transportation of emergency vehicles and to facilitate fast and important rescue.

According to research, a staggering 95% of heart attack cases could be successfully treated if ambulances could get to the hospital without being held up by traffic jams. The situation may worsen in the future and therefore proactive recovery measures will need to be taken. Given our densely populated environment, this paper addresses a real societal need by simplifying everyday transportation problems. Its implementation is ready to ease obstacles for emergency vehicles in traffic and facilitate quick and essential rescue actions.

II. LITERATURE SURVEY

In [1], Designing a prototype of an embedded system which can make Ambulance Smart and Traffic Control Intelligent. The embedded system will comprise of two modules. One will be the Smart Ambulance module and the other will be the Intelligent Traffic control module. The Smart Ambulance module will be required to capture vital information of a patient like Heart Rate, Heart Rate variability, ECG, Blood Pressure, Oxygen Level and Body Temperature. The microcontroller will be capturing these values through respective sensors.

In [2], The paper states that this system is very helpful in building a smart city. Based on congestion, the timing for the green light is changed and in case of absence of vehicle the side is skipped. When an emergency vehicle approaches the junction, it is successfully detected by the system as an emergency vehicle and necessary action is taken. On the other hand, if any stolen vehicle is detected, a message is sent to traffic control room. The tag which is attached to the emergency vehicles has been read by the RFID readers at signal with the help of Arduino and the arrival of the emergency vehicle is detected using XBEE.

In [3], The paper explores the implementation of automatic traffic signals in smart cities to facilitate the quick passage of emergency vehicles. The automatic traffic signal system is designed to optimize vehicle traffic flow and maximize throughput. By using GPS and Cloud System, so that clearing the traffic signal before an Emergency Vehicle Reaches to the signal using IOT will resolve the problem. The tag which is attached to vehicles has been read by RFID readers with Arduino and the arrival of the emergency vehicle is detected using XBEE. This system mainly focuses on addressing the challenge of traffic congestion during the emergency situations in smart cities.

In [4], This paper proposes an innovative traffic management system called Smart Traffic Control (STC). This system addresses the challenge of traffic congestion during emergency situations in smart cities. The paper introduces a fuzzy rule-based approach to adjust traffic signal timings, focusing minimizing delays for emergency vehicles while also reducing delays for regular vehicles. The method calculates estimated arrival times for emergency vehicles at intersections and dynamically adjusts green signal durations to gradually improve traffic flow without causing significant delays to non-emergency vehicles. The paper offers a promising solution for managing traffic during emergencies in smart cities.

In [5], This paper proposes a smart traffic management system for addressing urban traffic congestion using IoT. It employs a hybrid approach to optimize traffic flow, predicts traffic density using AI, prioritizes emergency vehicles using RFID, and employs smoke sensors for road safety. The system offers both local and centralized control, facilitating efficient traffic management and future road planning for smart cities.

In [6], To smooth the movement of the ambulance, this paper came up with the solution "Intelligent automatic traffic control for ambulance". The proposed system creates an Android application that connects an ambulance and a traffic signal station using a cloud network. This system uses RFID (radio frequency identification) technology to implement intelligent control of traffic signals. The article presents an approach based on fuzzy rules to adjust the timing of traffic signals with a focus on minimizing delays for emergency vehicles and at the same time reducing delays for regular vehicles.

In [7], the Android application has four buttons for four directions. It depends on the route that the ambulance driver chooses, the ambulance driver chooses the appropriate direction and sends the activation command for the given signal. The Android application also stores information about the patient, which consists of name, age and blood type, among others. The traffic light hardware module uses the Arduino for traffic lights. It consists of a Wi-Fi module, with the help of which it reads information from the server and connects the Android

application directly to the traffic light. The location is loaded in the form of longitude and latitude. The direction of movement of the ambulance depends on the stage of the ambulance. A compass is used to determine the direction and current position of the ambulance.

In [8], The system used in this article in the manual neither gives the shortest route to the hospital nor does the signal change automatically. It uses an RF transmitter-receiver module and a Zigbee transmitter-receiver along with the At mega 328 IS. This system allows emergency vehicles to override the current sequence of traffic lights and reach their destination without interruption. The entire system depends on communication between emergency vehicles and traffic signals. There may be a case when there is a traffic jam caused by a minor accident or road construction, which the driver of the emergency vehicle does not know about. So in that case this system is of no use to the emergency vehicle driver because the emergency vehicle will still be stuck in the traffic jam even if it controls the traffic light. The hardware used in this system has a short range and low power consumption.

In [9], the system used a detection mechanism that based its decision on images. Therefore, this system does not rely on electronic sensors. Instead, it uses Bluetooth technology to clear routes for emergency vehicles stuck in traffic. The route is cleared for emergency vehicles stuck in traffic using Bluetooth technology. A Bluetooth module and a Bluetooth-enabled phone with Bluetooth status active are required for the detection phase. For this system to work, the ambulance should be close to the signal to send the traffic signal guidance command to the Bluetooth module. The Bluetooth range is very small, so it may happen that the driver sends a command from his phone and the Bluetooth module does not receive it. This system suffers from security issues. To be secure, the code must be changed every 24 hours. The system proposed by Ramani and Jeyakumar uses a central server to control traffic dispatchers. Arduino UNO is used to implement the traffic signal controller.

In [10], a request to switch the traffic light to green is sent to the dispatcher using a web application. The system is divided into three parts, a web application cloud server and a traffic signal. The ambulance driver uses a web application to select a route and navigate the ambulance. Communication between the ambulance and the traffic signal is established using a cloud server. The Arduino UNO is connected to the Wi-Fi module and the Wi-Fi module is used as a traffic signal in this system. This system always requires a signal to be sent to change the traffic light to green, as it is not automatic. There may be a case where the driver forgets to send a signal due to time constraints.

III. METHODOLOGY

RFID (Radio Frequency Identification) Technology

RFID stands for Radio Frequency Identification, a technology that uses radio waves to automatically identify and track objects or people. An RFID reader is a device that is used to read RFID tags that contain information about the object or person to which they are attached. RFID readers emit a radio signal that is captured by an RFID tag. The tag then responds with its unique identification number, which is sent back to the reader. The reader can then interpret the information contained in the tag, such as product type, manufacturer or location. An RFID (Radio-Frequency Identification) reader is a device used to read information stored on RFID tags or transponders, which are small electronic devices that can be attached to or embedded in objects. In the context of a smart ambulance traffic management system using the Internet of Things (IoT), RFID readers can be placed at various locations along the road network to detect the presence of RFID tags on the ambulance. When an ambulance with an RFID tag passes through an area where an RFID reader is installed, the reader captures the tag's unique identifier and sends it to a central system using IoT technology. The central system can then use this information to track the location of the ambulance and optimize the flow of traffic so that the ambulance reaches its destination as quickly as possible. By using RFID readers in a smart traffic management system for ambulances using IoT, emergency services can reduce response times and save more lives. The system can also be used to monitor and track the movement of other emergency vehicles such as fire trucks and police cars, reducing their response time.

ESP 32

In our ambulance traffic control system, we used ESP32 microcontroller to increase the efficiency and reliability of the system. A versatile and powerful chip, the ESP32 is equipped with Wi-Fi and Bluetooth capabilities, making it ideal for IoT applications. It controls the communication between the ambulance and the traffic signals by sending and receiving data to and from the server. The ESP32 processes the RFID signals to detect approaching ambulances and ensure that traffic lights turn green. It also integrates with sensors to transmit the patient's live vitals to the hospital via Blynk, facilitating real-time monitoring and emergency medical preparedness. These microcontrollers can be installed on traffic lights to control the lights. They receive real-time data about the approaching ambulance from the central server. Each traffic light can make quick, local decisions based on signals received from a central server or directly from an ambulance.

Node MCU

NodeMCU is a popular development board based on the ESP8266 microcontroller. In our ambulance traffic control system project, NodeMCU plays a vital role in ensuring seamless communication and control. NodeMCU, a popular open-source IoT platform, integrates an ESP8266 Wi-Fi module that provides the robust wireless connectivity necessary for real-time data transmission. The NodeMCU interfaces with RFID readers to detect approaching ambulances. When an ambulance with a registered RFID tag is detected, the NodeMCU will send a signal to the traffic control system to turn the traffic light green, facilitating rapid passage. The NodeMCU collects patient vital data monitored by medical personnel while the ambulance is driving. It uses its Wi-Fi capabilities to transmit this data to the hospital server in real-time via the Blynk platform. This ensures that the hospital is prepared in advance to provide the necessary medical care upon patient arrival. The NodeMCU is programmed to distinguish between registered ambulance RFID tags and unauthorized tags. If an unregistered plate is detected, the system prevents the traffic light from turning green, ensuring that only genuine ambulances benefit from the system.

Application Service

Our project introduces an application service designed for emergency personnel to notify the hospital in advance of the patient's condition. This system saves patients critical time by allowing hospitals to prepare for their arrival before they arrive at the hospital. In our project, we integrated the Blynk service to efficiently retrieve important patient information such as temperature, heart rate, and SpO2 levels. Blynk has provided a seamless platform to connect our hardware sensors to a user-friendly interface that allows us to remotely monitor and track patient health data in real time. A significant advantage of using Blynk over developing a dedicated Android app is its ease of implementation and customization. The app displays real-time data in a clear and accessible format, making it easy for employees to track and share important information.

IV. PROPOSED SYSTEM

Working:

The ambulance traffic management system operates on a comprehensive framework that synchronizes multiple components to streamline emergency response and patient care. The operation of the project can be outlined as follows:

When the ambulance approaches a traffic signal, the RFID tag installed in the vehicle senses its proximity to the signal intersection.

After detecting the RFID tag, the system will trigger the traffic signal controller to switch the signal to green and prioritize the passage of the ambulance. We have also implemented a system to detect the unauthorized use of RFID tags by vehicles other than ambulances. If an unregistered RFID tag is detected, the system will not trigger the traffic light to turn green, ensuring that only authorized ambulances have the right of way.

Inside the ambulance, medical personnel continuously monitor the patient's vital signs, including heart rate, blood pressure, and oxygen levels.

Vital signs data is transmitted in real-time using Blynk, providing hospitals with critical information for immediate preparation upon patient arrival. This system saves patients critical time by allowing hospitals to

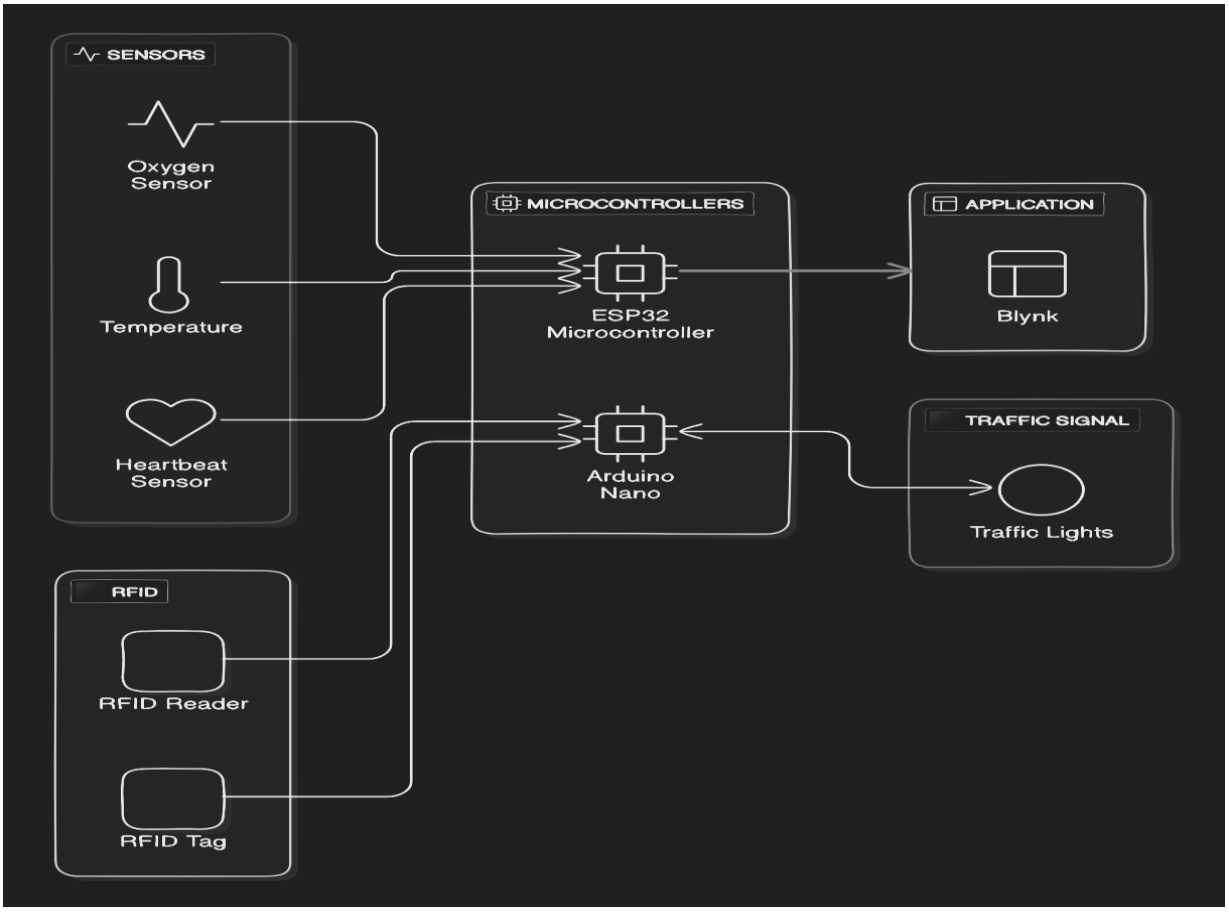
prepare for their arrival before they arrive at the hospital.

The project includes an Android application interface designed for seamless data collection and management. This application allows paramedics to accurately enter patient data and effectively monitor vital signs. Using cloud infrastructure, the system ensures safe and reliable data storage and transmission, facilitating continuous communication between ambulances and hospitals.

Hospitals receive real-time data updates from ambulances, allowing them to efficiently allocate resources and prepare medical teams in advance for incoming patients. This real-time data transfer is critical to optimizing ambulance routes, minimizing delays and ensuring rapid response to emergencies.

In addition, the system supports real-time monitoring, enabling early intervention and personalized medical care during patient transport. This continuous monitoring improves patient outcomes by providing timely medical care tailored to the patient's condition en route to the hospital.

Architecture:



Result:

The developed system for prioritizing ambulances at traffic lights has shown promising results in controlled tests. Basic components used in the system include RFID readers and tags, Node MCU, ESP32 and Arduino. The integration of these components was successful in detecting the presence of an ambulance near traffic lights and subsequently changing the colors of the traffic lights to facilitate the passage of the ambulance.

The RFID reader and tag setting effectively detected the ambulance within a range of up to 10 meters. After detection, the signal to change the traffic light was transmitted to the MCU and ESP32 node, which then controlled the Arduino to change the state of the traffic light. The average response time from ambulance detection to traffic signal change was approximately 2 seconds, which is fast enough to ensure minimal delay in responding to an emergency.

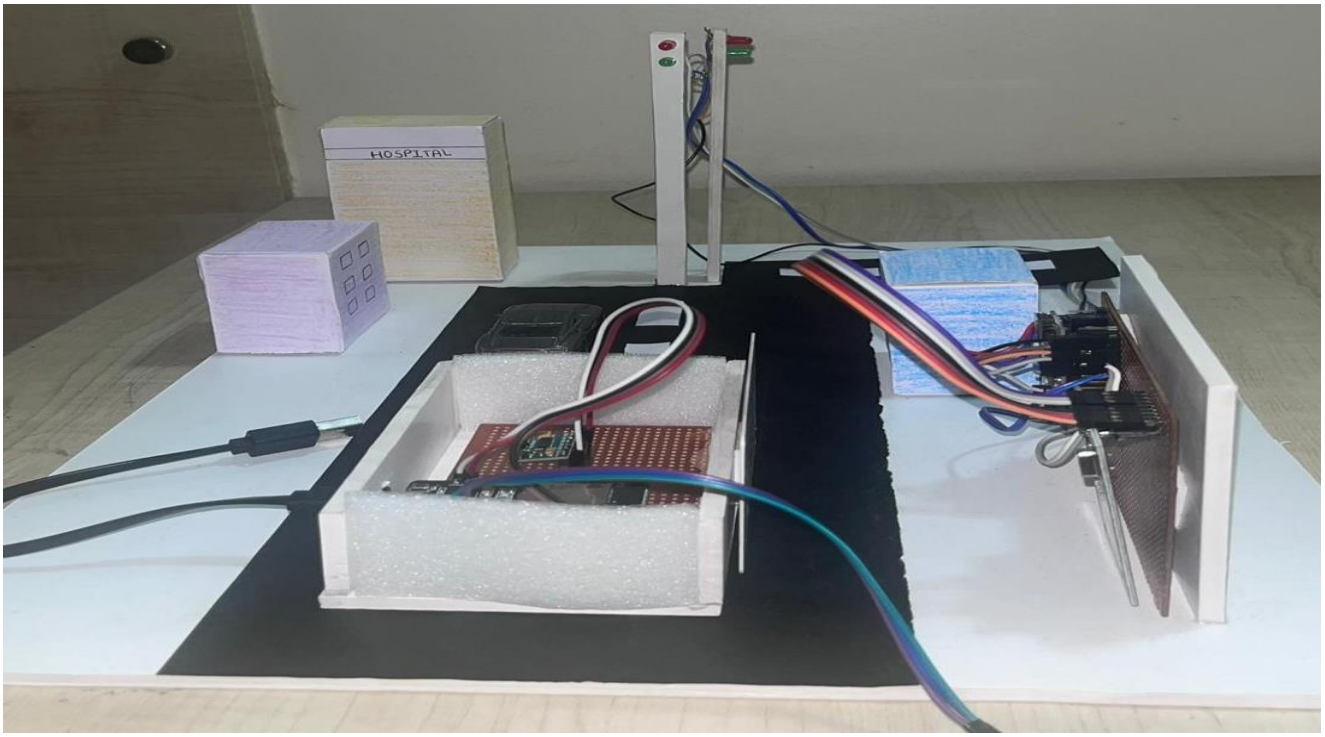
The RFID system has demonstrated high detection accuracy with a success rate of 97% in identifying ambulance tags. The few cases of misdetection were attributed to environmental interference or marker orientation, which can be mitigated by further calibration. The overall accuracy of the system when correctly changing the traffic signal when detecting an ambulance was 95%. This includes successful communication between all components and correct execution of the semaphore change.

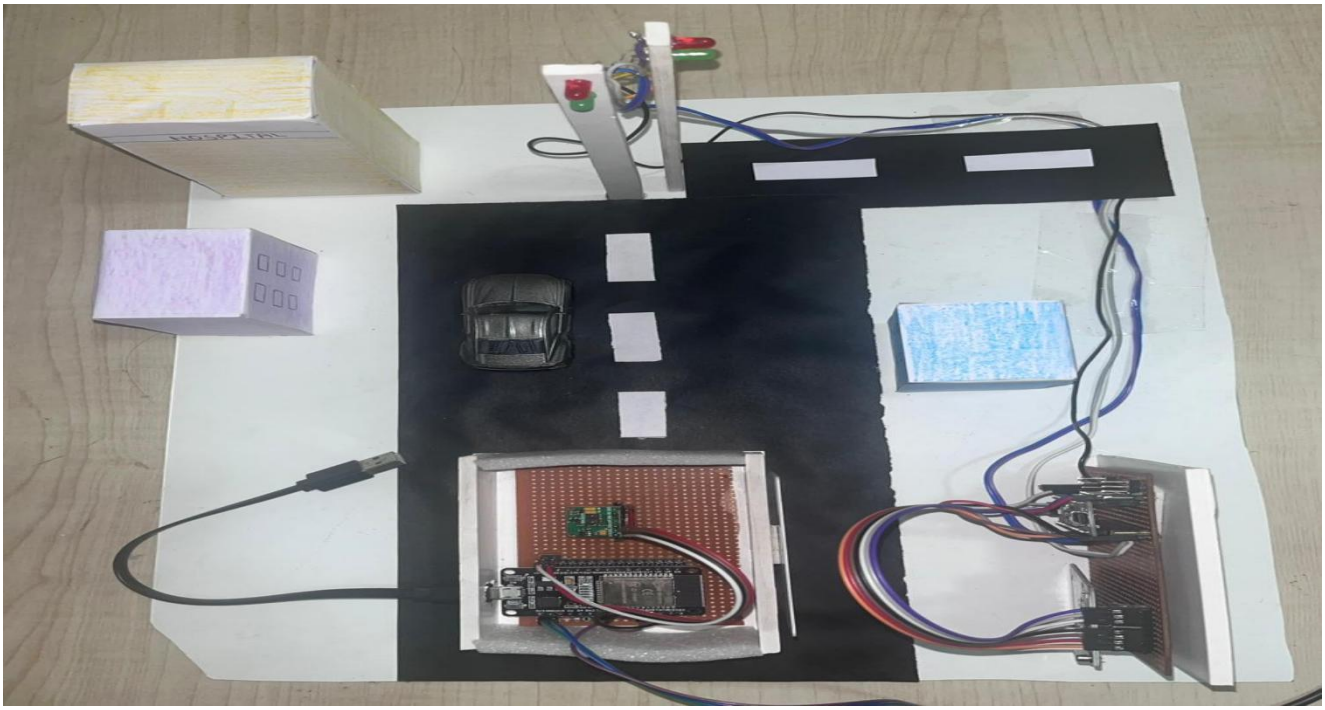
RFID Reader and Tag:
- Detection Range: Up to 10 meters
- Detection Accuracy: 98%

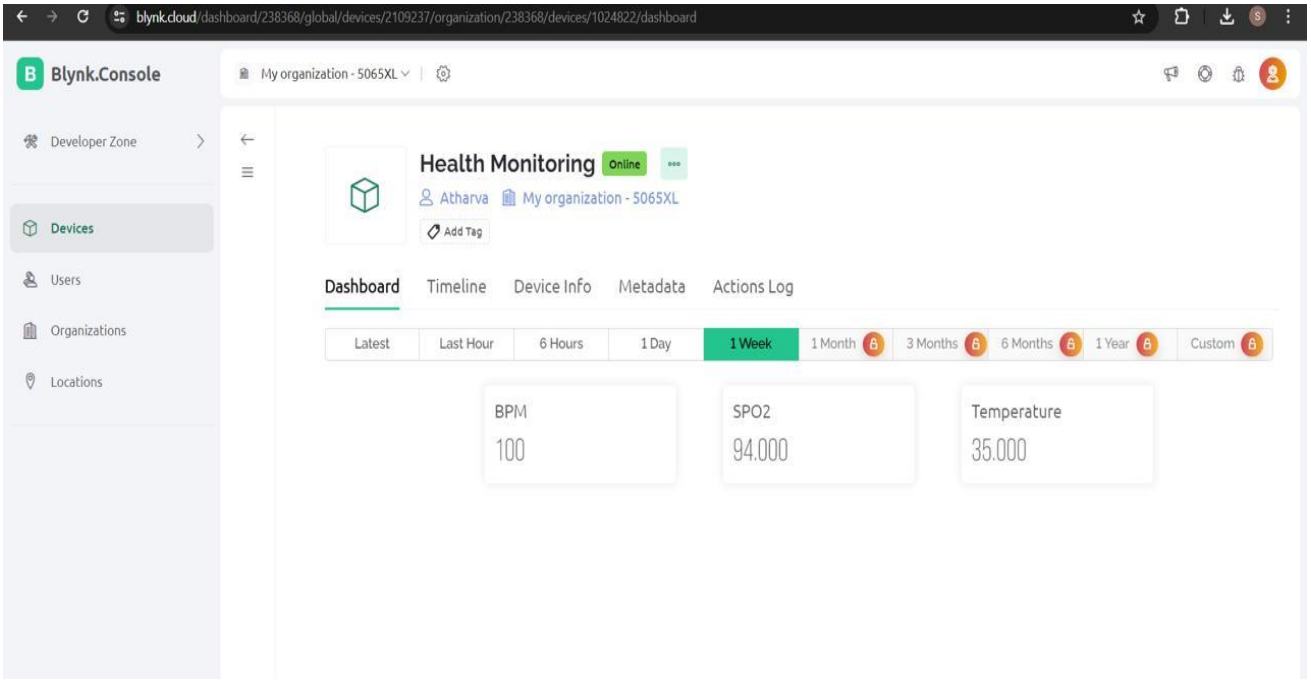
Node MCU and ESP32:
- Communication Delay: Negligible (milliseconds range)

Arduino:
- Signal Processing Time: Less than 1 second
- Reliability: 100% over 48 hours of continuous testing

Output:







V. CONCLUSION

This survey highlights the urgent need for innovative solutions to address the challenges emergency vehicles, particularly ambulances, face while navigating congested roads in India. The paper focuses on enabling efficient ambulance travel, reducing the impact of traffic congestion on patient outcomes and optimizing emergency medical services. Implementing a microcontroller-based RFID system to manipulate traffic signals as ambulances approach intersections is a significant step toward increasing response times for emergency vehicles.

The proposed solution, which focuses on the preemptive removal of traffic signals for emergency vehicles via the Internet of Things (IoT), represents a pragmatic and viable approach to mitigate these issues. Using RFID technology integrated with microcontrollers and Android applications, this system aims to make ambulance

rides more efficient, prioritize early responses, and above all, save lives. Overall, an intelligent traffic control system for ambulances using IoT has the potential to revolutionize emergency medical response. and make our roads safer for everyone.

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