MediNav – Autonomous Ambulance Management System

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Abstract - *With the progression of Transport Systems, nations are distinguished based on their "Roads". India has difficult street and traffic conditions. Conditions of roads crosswise over India are not hidden. In the last 50 years, India's vehicle populace has grown multiple times while road infrastructure has expanded only nine times. Due to all these reasons, the number of road accidents is on an ever increasing rate. The increase in traffic congestion puts forward a major hindrance to ambulance services. This affects the health of the patient, thereby increasing the risk leading to death. In emergency situations, each and every second is valuable in saving a human's life. So, the aim of this proposed paper is to reduce the handover time and give the patient medical attention as fast as possible. In medical science, there is a term called "Golden Hour"- "the first hour after injury will largely determine a critically injured person's chances for survival". This paper focuses on reducing the handover time by utilising the advancement of technologies in the filed of Internet of Things (IoT).*

Key Words: Internet of Things, Golden hour, Traffic control, Patient monitoring.

1.INTRODUCTION

The global status report on road safety benefited from the contribution of WHO in December 2018, highlights that the death from the road traffic crashes have increased to 1.35 million in a year. That is nearly 3700 people aged between 5 to 29 is dying of road accidents every day all over the world. According to R Adam Cowley, "the first hour after injury will largely determine a critically injured person's chances for survival". This is termed as the "Golden Hour". Experience shows that sustainable road safety must be planned to control the traffic congestion thereby reducing the needless death and disability caused by road traffic crashes.To overcome this, we introduce "MEDINAV - AUTONOMOUS AMBULANCE MANAGEMENT SYSTEM". The main aim behind this scheme is to converse a general outline for the design of an autonomous ambulance management system with real time patient monitoring, using IoT. This paper mainly focus on issues like reaching the nearest suitable medical center as fast as possible and monitoring patients status and proving urgent response to the hospital.

The ambulance is controlled by a mobile application which shows all the nearby hospitals on a single click along with the most scant route to the selected destination hospital. The ambulance also contain sensors like blood pressure and temperature sensor for real time monitoring of accident victims and is uploaded to the cloud, so that the doctor at the destination hospital can view the vital parameters of the patient even before the patient reaches the hospital. This minimizes the delay on victims to reach the hospital due to distance and death due to delay in reaching the ambulance to the hospital is minimized. The ambulance can also control the traffic light, helping to reach the hospital in time.

2. RELATED WORK

This section describes some of the related works carried out in ambulance rescue system and traffic control management for ambulance. [5] Devyani Bajaj proposed a system to facilitate the control of traffic congestion using GPS based automatic tracking system. This system will maintain the traffic system by controlling the time duration of red and green light based on traffic flow or by sensing the flow of traffic on the road. This is done using global positioning system which convey the detail of traffic and using that, time slot is given to traffic lights i.e. controlling and managing will work in real time.

In another work proposed by [7] Anita Acha George ensures an emergency ambulance system to treat the accident victim within the golden hour. The structure of emergency system consist of different modules like ambulance registration and authentication, location tracking module and a traffic signal triggering module.

[4] Fatih Alisinanogluin in his work used a blood pressure sensor inside the ambulance system to monitor blood pressure of the accident victim on a real time basis. This helps the doctor or any other medical staffs to know the condition of patient before reaching the hospital. The data is send via cloud and can be collected using any platforms like an android app or PC.

3. SYSTEM DESIGN

The proposed system is intended to ensure that Ambulance services is given higher priority on public traffic using IoT. In this work, all the traffic lights are internet enabled and can be controlled by the proposed system. The existing traffic signaling system is running on the conventional timer system and is independent of the present traffic conditions. It runs on a basic timer system.

The proposed system monitors the ongoing traffic condition and when an ambulance with emergency turned ON comes near a traffic signal point the system automatically senses the presence of the ambulance and the corresponding path is made green so that the ambulance can pass by smoothly avoiding unwanted delay. Before that, the ambulance driver must select the route to the respective hospital in the Mobile application integrated with this system. Throughout the route to destination, all the roads will get cleared when the ambulance reaches 150 meters near to the traffic signal post. After the ambulance clears a traffic junction, the traffic gets restored to the previous state. Added feature is the vital parameters of the patient can be continuously monitored and logged to the cloud system from where the doctor at the hospital can have a real-time information about the patient who is reaching to his hospital. So that the doctor can arrange the facilities required much earlier.

The various modules of this system is explained in detail below.

3.1 MediNav Mobile Application

The mobile app is used by the ambulance driver. This app can either be installed on the infotainment system of the ambulance or on the driver's smartphone. The ambulance driver should register himself and the ambulance with the corresponding ambulance ID. By default the app shows the current location of the ambulance plotted on a map. When the emergency button is turned ON, the app finds all the nearby hospitals and the driver can see all these hospitals plotted on the map. The ambulance driver then selects a particular hospital. The app then sends an alert message or notification to the corresponding hospital's dashboard, the details of the ambulance and the location coordinates of the ambulance, allowing the hospital authorities to be ready with the necessary aids. On selecting a particular hospital, the app navigates the ambulance through the shortest or best possible route by analyzing the live traffic conditions to the destination hospital. The application screenshots are shown in Fig -1.

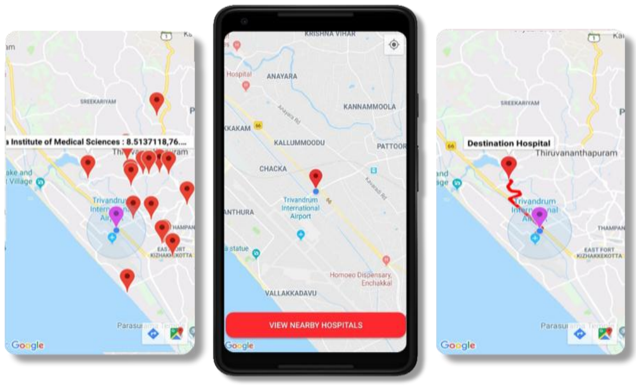

Fig -1: MediNav App Screenshots.

The app plays a major role in controlling the traffic signal lights. The application uses three main API's - Google Maps API, Google Places API and Google Directions API. The Google Maps API is used to load an instance of Google map inside the application, Google Places API is used to find and plot all the nearby hospitals and the Directions API is used to find the shortest and quickest route to the selected hospital. From Google Directions API, the whole turn by turn navigation data between two points (latitude, longitude points) can be retrieved in JSON format. A sample data from the Directions API is as shown in Fig -2.

```
"steps" : [
        {
           "distance" : {
              "text" : "0.9 km",
              "value" : 881
           },
           "duration" : {
              "text" : "3 mins",
              "value" : 153
           },
           "end_location" : {
              "lat" : 8.5584177,
              "lng" : 76.8799657
           },
           "html_instructions" : "At the roundabout, take the \u003cb\u
           "maneuver" : "roundabout-left",
           "polyline" : {
              "points" : "qnfs@s}ftMA?A?A?AAA?A??AA?AAAAAA?AAAAA?A?AAA?
           },
           "start_location" : {
              "lat" : 8.558010500000002,
              "lng" : 76.881697
           },
           "travel_mode" : "DRIVING"
        },
        {
           "distance" : {
              "text" : "0.8 km",
              "value" : 778
           },
           "duration" : {
              "text" : "1 min",
              "value" : 59
           },
           "end_location" : {
              "lat" : 8.550720399999999
              "lng" : 76.8769935
           },
           "html_instructions" : "Turn \u003cb\u003eleft\u003c/b\u003e
           "maneuver" : "turn-left",
           "polyline" : {
              "points" : "qlfs@q|etML?dAAhAALAv@ATANAr@AVAZALAvBKv@Ev@E
           },
```


Fig -2: Route information form Mobile app in JSON format.

On selecting the destination hospital, the app finds out the shortest or the best possible route and navigates the ambulance. At the same time the whole turn by turn navigation data is sent via a REST post to the cloud service and is stored in the database under the corresponding ambulance ID. This data is used by the traffic control system to predict the route of the ambulance and make the corresponding traffic lights on that path green.

With technologies like Android Auto and Apple Carplay coming to flesh, this app can be integrated into the ambulance dashboard as shown in Fig. 3.

Fig -3: Application working on ambulance's dashboard.

3.2 Traffic Control System Architecture

Each ambulance will have a unique ID. As stated earlier, first of all, the ambulance driver should set the destination hospital on the mobile application. The app then navigates the ambulance via the shortest path to the hospital. At the same time the app sends the entire turn by turn route information to the cloud and it is stored in the database as a hash map table under the corresponding ambulance ID. It is stored as a {Key, Value} pair. Here the 'Key' data is the latitude and longitude (lat/lng) value (e.g. 8.4920382, 76.9294004) and the 'Value' is the instruction or maneuver (e.g. Turn Left). A sample table is shown here (Table II).

Table -2: Sample HashMap Table

Sample HashMap	
Lat/Lng	Maneuvers
8.5577396, 76.8763939	roundabout-left
8.55072039, 76.876993	turn-left
8.5139812, 76.9001938	straight

There are two main IoT devices involved in controlling the traffic – RFID (Radio Frequency Identification) Reader Module and the Signal Light Controller as shown in Fig. 4. Both the devices are based on a NodeMCU microcontroller board.

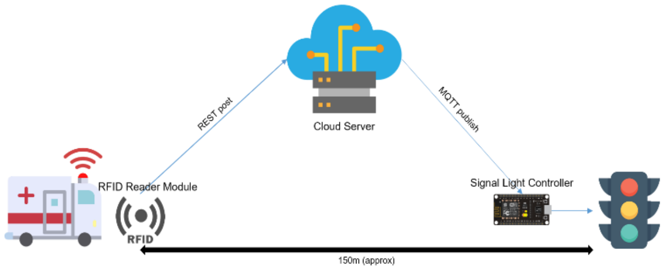

Fig -4: Traffic control system architecture.

RFID reader modules are placed 150m (approx) ahead of every signal point. Each ambulance is equipped with an RFID tag with the ambulance ID hardcoded. The ambulance on passing a RFID reader placed in front of a signal point, the RFID reader reads the 'ambulance ID' of that ambulance and sends it to the cloud along with the latitude and longitude value of the location via a REST post. Now the server logic checks for any active sessions under this ambulance ID. The server finds the previously stored hash map table and looks for a lat/lng value that is equal to the received lat/lng value. If it finds a lat/lng value is within a specified radius of the received value, the corresponding 'Maneuver' field value is send to the device controlling the traffic light. Then the signal light controller will turn the corresponding lights green.

The signal controller device is configured as a MQTT device and is subscribed to a particular topic (means, the device receives all the messages published in that topic).

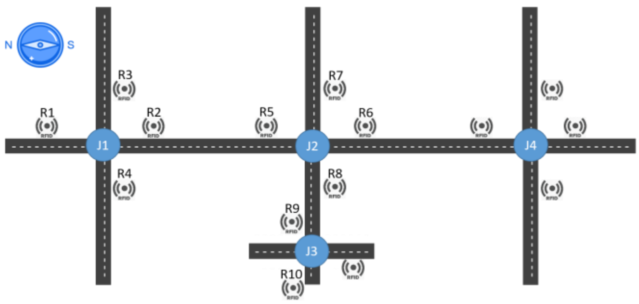

Fig -5: Traffic control flow.

In Fig. 5 shown above, J1, J2, J3, J4 represents junctions and R1, R2, R3, R4, R5, R6, R7, R8, R9, R10 represents RFID reader modules. There are signal controller devices at each junction and each controller is subscribed to a particular topic.

Under normal operation the traffic lights are controlled based on the conventional timer system. Consider an ambulance approaching junction J1 from north and it wants to go straight to J2. Once the ambulance pass RFID reader R1, R1 sends the ambulance ID and the lat/lng value to the cloud. The server logic then checks for the nearest lat/lng value in the route information table (stored earlier) and publishes the corresponding maneuver data to the topic which the signal controller at J1 is subscribed. J1 on receiving the message (e.g. 'straight') overrides the normal operation and turns the corresponding traffic light green, clearing the track for the ambulance to smoothly pass through. Ambulance on passing R2 indicates an exit from junction J1 and the normal operation is restored.

1. **RFID Reader Module**

The RFID Reader module is based on a NodeMCU microcontroller. It consists of an active RFID reader. Each Ambulance is equipped with a RFID tag. As soon as the ambulance passes the RFID reader module, it sends a REST post to the cloud server, which contains the ambulance ID and the latitude and longitude value of the traffic signal light junction ahead of it.

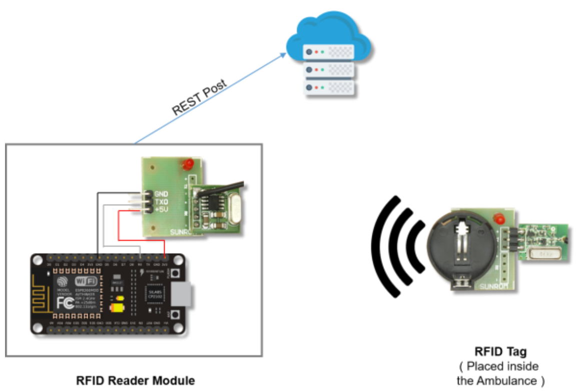

Fig -6: RFID Reader Module Setup.

Fig. 6, shows the setup of RFID Reader module. The RFID reader modules are placed at an approximate distance of about 150m ahead of each signal point in order to avoid any kind of tailgating, so that the ambulance can smoothly pass through a signal point junction without any delay.

2. **Signal Light Controller**

Signal Light Controller is an MQTT device. MQTT is a lightweight, publish – subscribe system where we can publish and receive message like a client. It is a perfect solution for IoT applications.

Signal light controllers are placed at each traffic light junction. It basically controls the functioning of each traffic signal light. Under normal condition, the traffic lights are controlled based on the conventional timer system. Each device is subscribed to a particular topic. The server logic finds out the corresponding maneuver field data and publishes that data onto the respective topic the signal light controller is subscribed.

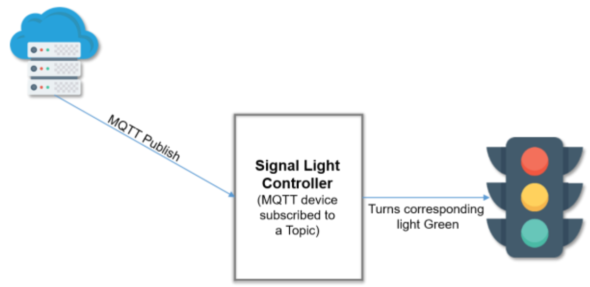

Fig -7: Signal Light Controller Setup.

The signal light controller on receiving a message (for example "turn right") turns the corresponding traffic light green, thereby clearing the track for the ambulance. Fig. 7, shows the setup of the Signal light controller. The Signal light controller is also based on a NodeMCU microcontroller.

3.3 Real Time Patient Monitoring

Inside the ambulance, an IoT device having various biomedical sensors, can be connected to the patient's body for real time monitoring of vital parameters by the doctor via cloud. The device is based on the NodeMCU microcontroller board. A user friendly IoT platform 'Adafruit IO' is used in this project. Adafruit IO libraries are used to send data from NodeMCU to the cloud platform. Biological sensors like blood pressure, temperature and pulse rate sensors are connected to the patient's body. The microcontroller collects the data from these sensors and sends it to the IoT cloud platform. The interfacing of blood pressure sensor and temperature sensor with NodeMCU is shown in Fig. 8 and Fig. 9.

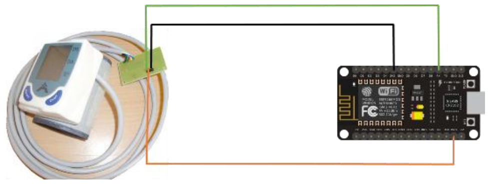

Fig -8: Blood pressure sensor interfacing with NodeMCU.

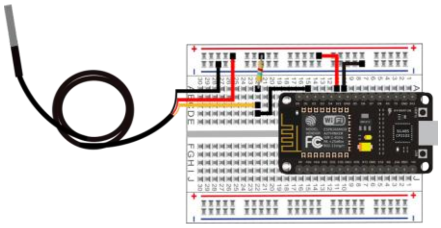

Fig -9: DS18B20 temperature sensor interfacing with NodeMCU.

The blood pressure sensor gives the systolic, diastolic and pulse readings as serial output at 9600 baud rate. It is an easy to use wrist style sensor and it eliminates pumping. It has three pins – TX-OUT - Output serial data of 3V logic level (usually connected to RXD pin of microcontrollers/RS232/USB-UART), VCC – regulated 5V supply input and GND – board common ground.

The temperature sensor used is the DS18B20 Waterproof Temperature Sensor. It has 12 bits of precision from the on-board digital-to-analog converter. They have three pins – Data pin, VCC and GND. These sensors use the one-wire interface, i.e. they require only one digital pin for communication.

These sensors are interfaced with NodeMCU and the sensors connected to the microcontroller can be attached to the patient inside the ambulance and the sensor readings are sent to the cloud using the Adafruit IO libraries. The doctor at the hospital can view these parameters from the Adafruit IO dashboard and can arrange the facilities required even before the patient reaches the hospital. The doctor can even view the patient's vital parameters on his/her smartphone (Fig 11). This ensures that the patient gets medical attention as fast as possible. The Adafruit IO dashboard's screenshot is shown in Fig. 10.

Fig -10: Dashboard of Adafruit IO.

Fig -11: Vital parameters of patient on Smartphone.

4. CONCLUSIONS

With automatic traffic control system along with the shortest route to the nearest hospital gives a way to reduce the traffic density on the life saving vehicles.

The manual exertion with respect to the traffic policeman is spared as the whole framework is automated, it requires less human intercession. With MEDINAV App it's very easy to get to the nearby hospital with a single click with the least traffic route available. On choosing the destination, the application discovers the most brief or the ideal course and explores the emergency vehicle. At a similar time the entire turn by turn route information is sent to the cloud database. This information is utilized by the traffic control framework to foresee the course of the rescue vehicle and make the relating traffic lights on that way green.

Inside the rescue vehicle, an IoT enabled device having different biomedical sensors, can be connected with the patient's body for constant observing of vital parameters by the doctor by means of cloud. Biological sensors like blood pressure, temperature and pulse rate sensors are associated with the patient's body. The microcontroller gathers the information from these sensors and sends it to the IoT cloud platform.

As of now with the actualized automated framework it helps to reduce the handover time and help the patients reach the destination much faster and thereby saving life according to golden hour rule.

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