Android-based System for Intelligent Traffic Signal Control and Emergency Call Functionality

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Abstract

The aim of the system was to utilize technology to save lives in India by addressing the challenge of transporting patients during emergencies on congested roads. To tackle this problem, we developed two mobile apps - one for users and one for ambulance drivers. The user app requires signup and retrieves their address and location. Similarly, the ambulance driver app also retrieves their location. When the user presses the emergency button, a notification is sent to the ambulance driver via the app. The app then displays the shortest path, and traffic signals along the route are adjusted to facilitate a faster route to the hospital. Overall, our apps were created to aid accident victims in reaching the hospital promptly

Keywords: Intelligent Traffic; Android; Smart System

1. Introduction

Technology has undoubtedly enhanced the quality of life, yet the Android emergency call app stands out in its ability to save lives. By granting rapid access to assistance, the app provides a vital lifeline to individuals who may find themselves stranded in traffic, a growing issue due to increased cars on the road and a cultural preference for driving[1]. These factors increase the risk to people, particularly during times of emergency, when ambulances must navigate congested roads. Fixed traffic light timings exacerbate the problem, creating bottlenecks that impede the progress of emergency vehicles. To address these challenges, governments should explore methods such as promoting public transportation and imposing taxes on personal vehicles, a policy already in place in some Asian countries. Additionally, improving infrastructure by incorporating embedded controllers at junctions could also prove beneficial. One potential solution involves using a system of traffic poles connected to a server via a Raspberry Pi and WIFI module, which could alert emergency vehicles and grant them priority status[2]. By using latitude and longitude to locate the closest ambulance, the server could provide real-time location data to both the ambulance driver and the patient. Finally, traffic poles in the vicinity would be notified of the situation, allowing them to adjust traffic flow accordingly.

2. Existing System

2.1 General Traffic Management System

A standard traffic management system often requires manual intervention by deploying traffic police officers at each intersection to manage traffic flow. The officers supervise the traffic movement and use hand signals to indicate when vehicles can move or stop, thereby enabling drivers to react to

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emergency situations. The presence of human intervention is crucial in facilitating the movement of emergency vehicles[6]. The efficiency of the system hinges on the capability and dedication of the personnel involved.

2.2 Fixed Time Control

The term "electro-mechanical signal controllers" pertains to traffic control signal controllers of the conventional type that utilize movable parts like cams, knobs, and shafts, and relays to manage signals that are directly wired to them. These controllers differ from computerised signal controllers. Electro-mechanical signal controllers operate through dial timers that contain pre-set intersection time plans, featuring small gears that dictate the cycle length of signalised intersections[8]. These cycle gears generally last between 35 and 120 seconds and can be replaced if they malfunction. However, these controllers are only capable of managing phases at a signalised intersection in a single manner, as they have just one signalised intersection time plan. While electro-mechanical signal controllers are still in use at older signalised junctions, they are not suitable for intersections where the dominant flows change during the day, necessitating adjustments to signal timing. They perform satisfactorily in one-way grids where lights can be synchronized with the posted speed limit[3].

2.3 Traffic Light System

Traffic light controllers are usually kept in cabinets and older models use electro-mechanical controls. Modern controllers, however, are solid state and include a power panel, detector interface panel, detector amplifiers, conflict monitor unit, and other components. The conflict monitor unit is required for fail-safe operation and ensures that the traffic lights function properly by detecting conflicting signals and switching the intersection to flashing mode to avoid potential hazards[5].

Traffic preemption devices can be implemented in various ways, such as train transportation network management systems, motor vehicles, or remotely controlled from a stationary point like a fire station. A traffic preemption signal must be received by traffic lights for the system to work, and it can be used in emergency vehicles or other situations where right-of-way is needed[4].

Train transportation network systems can also control nearby traffic intersections to prevent excessive traffic and grant right-of-way to possible obstructions. Battery backups can be added to LED traffic light systems to increase safety and reduce energy use during power outages[7]. The California Energy Commission recommended upgrading to LED traffic lights with battery backups, which can operate with full functionality for two hours after power outages and flash red lights for an additional two hours.

2.4 Sequence Of Events When An Accident Occurs

Emergency Response Centre (ERC) call taker receives emergency report, gathers info (incl. location) & sends appropriate aid (ambulance, police, fire) to reach scene within 18mins. Patients treated en route to hospital in equipped ambulances[9]. However, delayed traffic can prevent timely hospital arrival, leading to fatalities. We propose effective strategy to reduce ambulance transport time from accident to hospital.

2.4.1 Challenges Of Existing System

- Operator

To ensure prompt emergency response, patients are transported in specialized ambulances. However, due to heavy traffic, the ambulance often fails to reach the hospital in time, leading to fatal outcomes. In order to mitigate this issue, we propose a practical approach to minimize the time taken by the ambulance to reach the hospital from the accident site [10].

- Location Accuracy

Frequently, the information about the caller's whereabouts relayed to the operator is incorrect, resulting in potential delays. To mitigate this, the caller can identify a recognizable landmark to assist the operator in locating them. Furthermore, the ambulance driver may not be acquainted with the most efficient route to navigate through traffic to reach the designated destination or hospital [11].

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- Managing Large Group of Callers

When the number of callers increases in an environment where the focus is on the operators, it becomes difficult for them to respond to every call. This can result in a decrease in the efficiency of the system, as fewer clients are being attended to, thereby reducing the overall performance of the system [12].

- Report Generation and Analysis

As the current system relies on paper-based documentation, generating interactive weekly or monthly reports would require significant effort and time from personnel. This poses a difficulty in analyzing the reports and improving efficiency. Furthermore, since there is no provision for data backup, any potential disasters could result in irretrievable data loss [13].

3. Proposed Method

In today's world, the traffic flow is consistently high, and it's crucial to maintain traffic signals properly to prevent accidents. However, there are emergency situations where ambulances can get caught in traffic signals, resulting in severe consequences. To prevent such scenarios, traffic signals should be managed by considering all relevant statistics. A real-time system has been proposed for this purpose, which could be highly beneficial in saving lives during daily commutes.

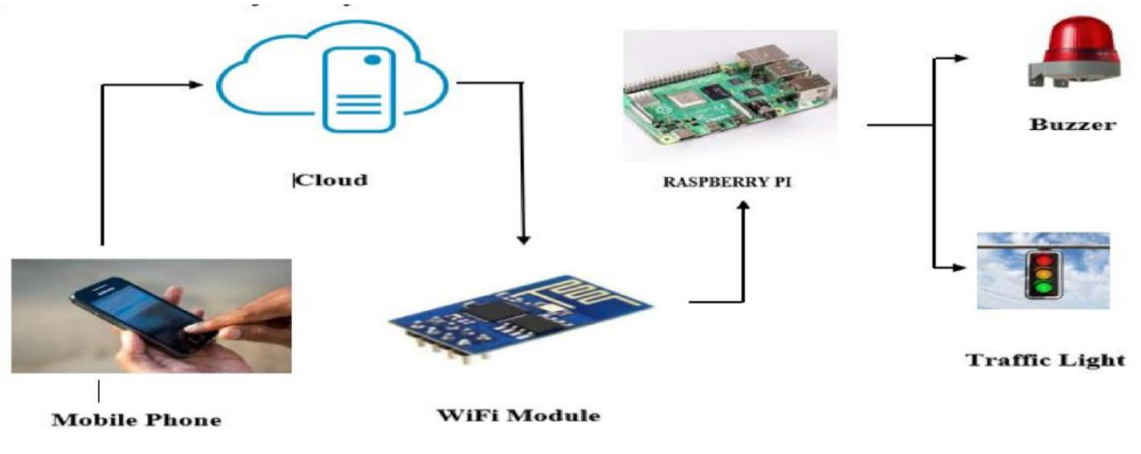

Figure 1: Systematic diagram of proposed system

As A Result, The Project Comprises Of Two Mobile Applications - One For Users And Another For Ambulance Drivers - With Simple Yet Effective Features. To Use The User Application, The User Needs To Sign Up And Grant Authorization For The Programme To Access Their Location And Address Details, Similar To The Ambulance Driver Application. The Emergency Process Starts When The User Taps The Emergency Button, Which Alerts The Ambulance Driver Via Their Mobile App And An Ambulance Alarm Signal. The Driver's App Will Then Display The Quickest Route To The User's Location. Additionally, When The Ambulance Approaches A Traffic Light Within 500 Meters, The Signal Will Automatically Turn Green From Red.

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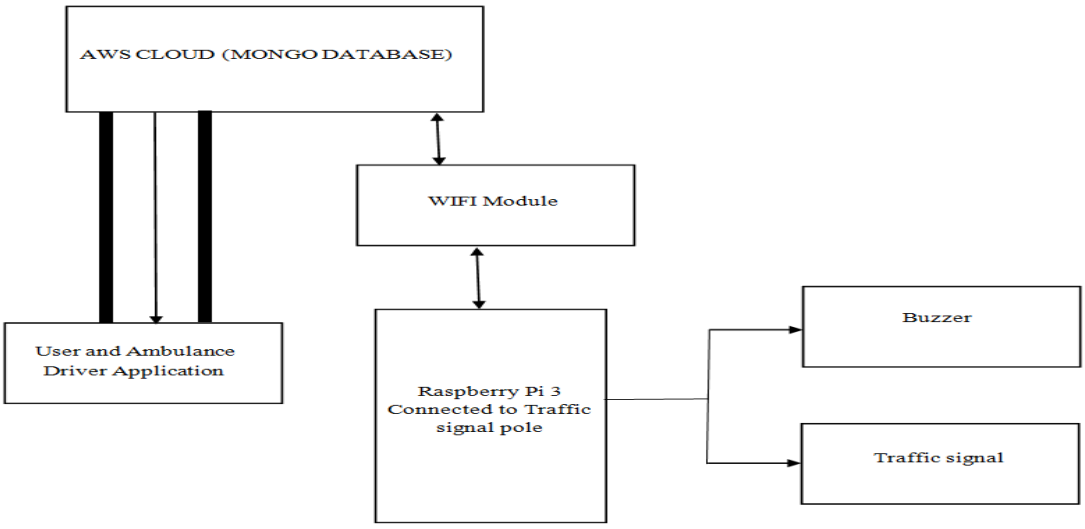

Figure 2: Flow Chart of user module

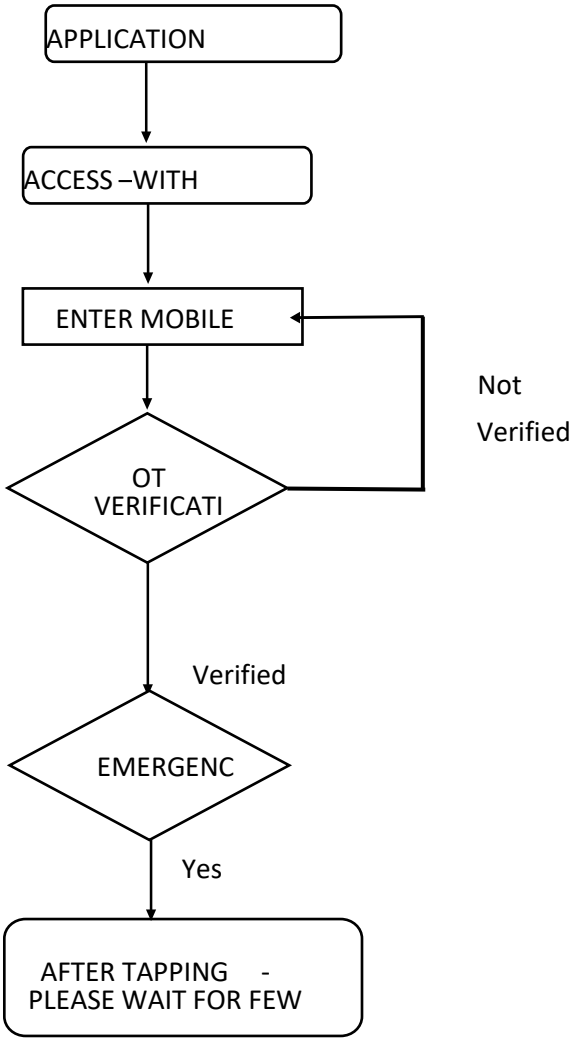

Figure 3: Block diagram of Proposed System

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3.2.2 Flow Chart of Ambulance Module

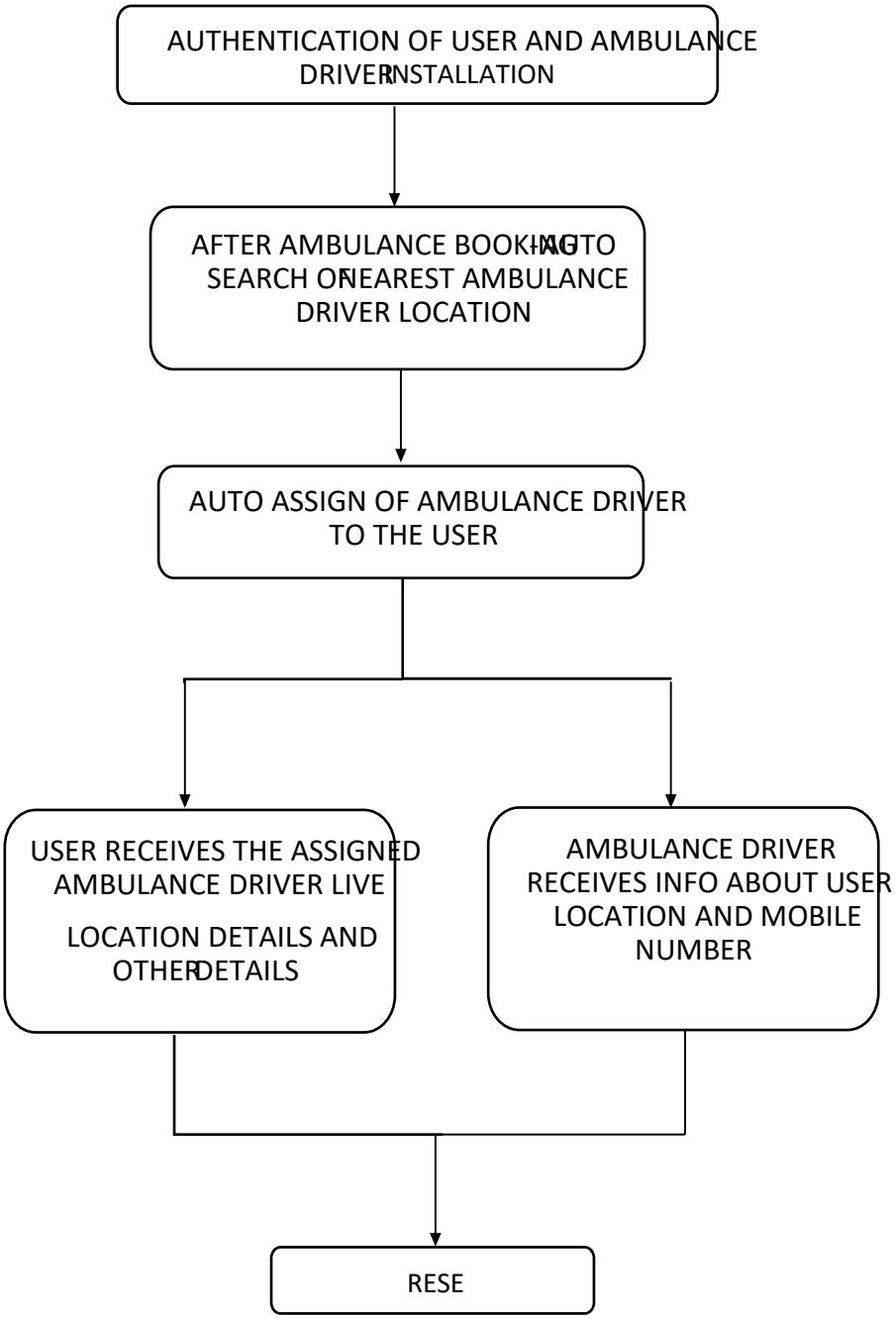

Figure 4: Flow Chart of Ambulance Module

3.3 Working

The system has two parts: a software module with an Android app, and a hardware module for traffic signals.

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MODULE 1:

This Module has 2 main applications.

3.3.1 User End Application

To use the user application, the user is required to sign up using their mobile number and allow GPS access. By using the API, the application will obtain the user's current location, which includes their latitude and longitude [14-16].

Once the location is acquired, the application will direct the user to a new screen that has an emergency button at the center. In this scenario, the user plays a crucial role as they are responsible for pressing the button or tapping the screen. Upon activation, the program will run in the background and send the user's location, along with a customized message, to the server [17].

The server will receive the user's request and then search for an ambulance that is close to the user's location. After a few minutes, the user will receive a personalized message from the server. Our program is capable of tracking the driver's information and the ambulance's location [18].

3.3.2 Ambulance Driver End Application

The program has four buttons that correspond to four different directions. The ambulance driver will select the appropriate button based on the route and send a signal indicating their choice. The server is informed of the ambulance's current location and direction of travel, which is determined through a GPS device that provides a pair of values for latitude and longitude. A compass is used to determine the ambulance's direction of travel based on its degree, which is transmitted to the server via a POST request, executed using the Retrofit API. For instance, if the ambulance is moving between 45 and 135 degrees, it is heading east [19-24].

3.3.3 Proposed Model Of Traffic Light System

To locate the closest signal for an ambulance based on its location, the server employs the shortest distance method. A Junction Unit, consisting of a transceiver and a microcontroller, is installed at the traffic signal post. The Ambulance Unit sends GPS coordinates to the server, which are used by the Junction Unit's microcontroller software to determine the location at a particular distance from the signal, where the ambulance must pass to turn the traffic light green. An LED panel shows a warning message to drivers to yield to the ambulance [25]. The distance between the signal and the location can be customized as needed based on the traffic conditions. The signal remains green long enough to allow the ambulance to pass through the intersection safely. In a four-lane intersection, priority is given to the first arriving ambulance, and if an ambulance is present in multiple lanes, the one that arrived first is prioritized. As the ambulance passes by, a deactivate order is sent to the signal, and it returns to normal operation [26-30].

4. Hardware Implementations

4.1 Raspberry Pi 3

The Raspberry Pi Foundation in the UK designed the Raspberry Pi as a series of small, single-board computers to support the teaching of fundamental computer science in classrooms and underdeveloped nations. One such model is the Pi 3 Model B+, which boasts a processor speed ranging from 700 MHz to 1.4 GHz, and up to 1 GB of RAM. The operating system and program memory are stored on SD cards, while the board includes USB ports, HDMI and composite video output, and an audio jack. It also features GPIO pins, I2C protocols, Ethernet, and built-in Wi-Fi and Bluetooth. The latest model, the Model B, has even more GPIO pins and USB ports, Micro SD slots, better audio, and lower power consumption. To get started with a Raspberry Pi 3 Model B, one would need a power supply, micro USB cable, keyboard and mouse, HDMI cable, display device, and micro SD card [31].

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4.2 ESP-01 Wi-Fi Module

The ESP-01 Wi-Fi module has ten integrated clocks that can support different frequencies and features such as RTOS and built-in Wi-Fi. It enables adding networking modules to existing devices using IEEE 802.11 protocol and creating a separate network controller. The ESP8266 is a wireless SOC for mobile platforms with limited space and power, offering an affordable Wi-Fi integration solution with minimal area requirements. The ESP8266EX has an independent option to offload Wi-Fi networking tasks and includes an ultra-low power 32-bit MCU, supports RTOS, integrated Wi-Fi MAC/BB/RF/PA/LNA, and on-board antenna. The ESP8266EX can also host Wi-Fi networking functionalities of another application processor, providing a fully self-contained Wi-Fi networking solution. Simple connectivity interfaces such as SPI/SDIO or I2C/UART can add wireless internet access to any microcontroller-based architecture [32-35].

5. Software Implementations

5.1. Server

[36] A server is a system that handles data, services, or programs. To act as a server, a device must be network-connected and capable of receiving client requests. The server is like the brain, and AWS Server is the specific server being used. All the modules communicate through this server.

5.1.1 Aws Ec2 Instance

[37] The Amazon EC2 online service provides secure and scalable cloud computing capabilities. Its aim is to simplify web-scale computing for developers, giving them full control over their computing resources while utilizing Amazon's reliable platform.

5.2. Mongo Database

[38] MongoDB is an open-source database system that uses documents and collections to store large amounts of data. It's a NoSQL application that can also function as a file system called GridFS, with load balancing and data spread across multiple workstations. Key-value pairs form the basic data unit in MongoDB, known as documents, which can be used to save user information such as phone numbers, addresses, and geographic coordinates.

5.3. Google Maps Api

[39] The Google Maps API allows external developers to easily integrate Google Maps into their websites through a simple JavaScript interface. Our apps utilize various APIs, including the Javascript and Directions APIs. Once assigned, the ambulance requests quick navigation to reach its destination.

API, short for application programming interface, is a programming system used for software components to manage computer operations and input/output. It enables various functionalities, such as locating items, searching for addresses, obtaining directions, and more. Google API is a well-known example of an API on the internet, often used for mashups, which combine data or functionality from multiple sources. The term API can refer to different types, including hardware APIs or Java APIs, among others [40].

5.3.1 Aspects / Functions Of Google Api

Google's API has multiple functions for map overlay operations using latitude and longitude coordinates. There are different types of overlays available on Google Maps, such as Markers (for single locations) and Polylines (for straight lines). Markers can even display custom icons.

5.3.2 Polyline

A polyline is a sequence of points that connect with line segments. It shows the shortest distance between the ambulance and user locations, calculated by the server using their latitude and longitude coordinates. The map displays this new path.

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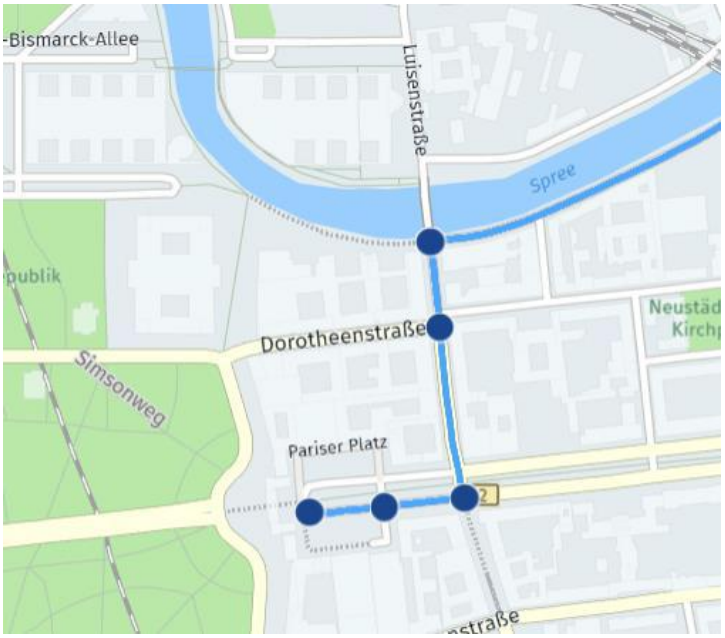

Figure 5: Polyline

6. RESULTS & DISCUSSIONS

6.1 USER APPLICATION

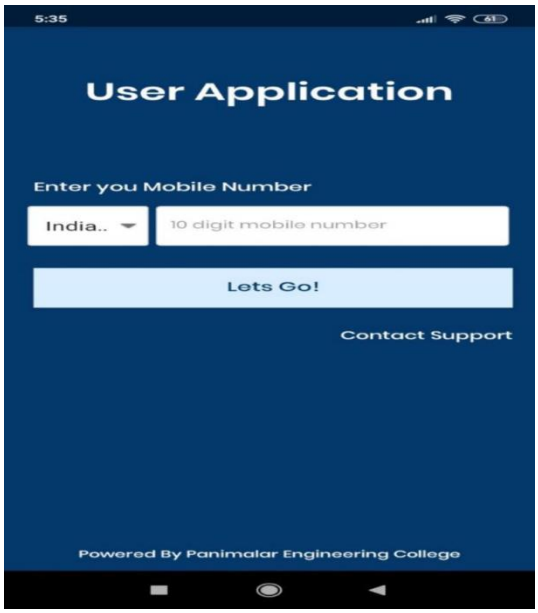

Figure 6: Signup screen

Figure 7.1 shows the signup screen for the user app where a mobile number must be entered in a field with a 10-digit limit. Upon form submission, user credentials are stored in a mongo database and the user proceeds to the next step.

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6.2 SINGLE STEP REGISTRATION SYSTEM

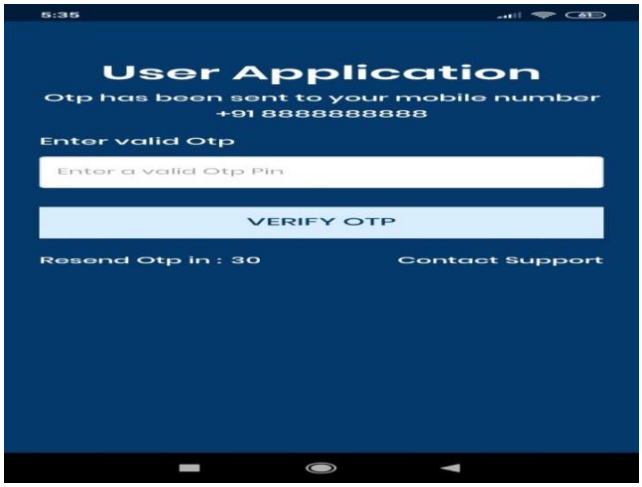

Figure 7: OTP Screen

Mobile number authentication is taking place now. In Figure 7.2, users are prompted to input the four-digit OTP that was sent to their previously provided mobile number. Here's how OTP is generated:

- User's credentials will be saved in the database once they enter their mobile number.
- The third-party API URL provided by msg91 panel will have the user's mobile number and country code attached to it.
- The msg91 panel will process the server's request.
- Lastly, a new four-digit number will be sent to the user's mobile number.

6.3 OTP VALIDATION

MSG91 Panel

MSG91 is a cloud-based communication platform that enables businesses to connect with their clients through SMS and various other API channels.

Figure 8: MSG 91 panel

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6.4. ACTIVATE EMERGENCY SCREEN

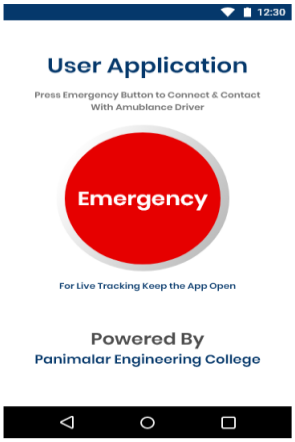

Figure 9: Activate Emergency screen

After logging in, users will see the emergency button in the center of the screen. If they are in an emergency, they can tap it. The system will ask for confirmation to ensure it is a real emergency. The user's location and mobile number will appear on the screen, and they will be asked to verify their address. If Google Maps retrieves an incorrect address, the user can manually update it. Once confirmed, the user's current address and mobile number will be sent to the server.

6.5 SERVER-SIDE PROCESS

The server receives the user's request and follows these steps:

- Check if user's credentials are in the database. If not, create a new document with user details (mobile number, user id, address, current latitude/longitude, and emergency status).
- If user's mobile number is already in the database, create a new array with the same details.
- Check if a similar request from the same user was processed recently. If yes, throw an error.
- Search for available ambulance drivers in the same city.
- Filter the results to find the nearest ambulance driver to the user's location, based on their respective latitude and longitude.
- Get the ambulance driver's ID from the database and schedule them for the user's request.
- Calculate the distance between the user and the ambulance driver using their latitude and longitude.

6.6 AMBULANCE DRIVER APPLICATION

6.6.1 SIGN UP AND OTP VERIFICATION

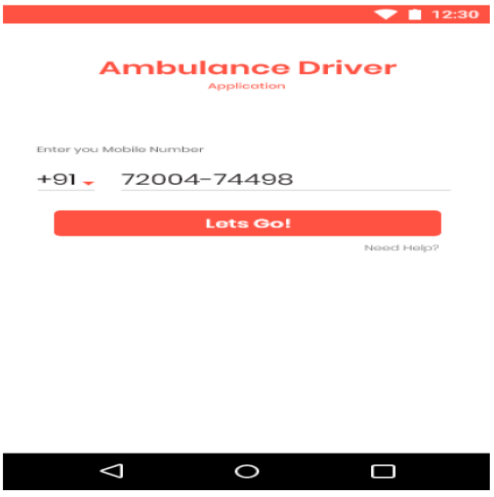

Figure 10: Sign up screen

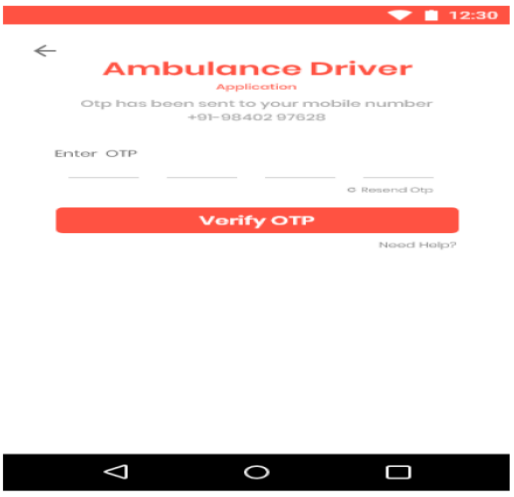

Figure 11: OTP screen

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Figures 765 and 6.6 depict the ambulance driver registering with their mobile number and verifying it with an OTP. These steps are comparable to the ones taken by the user during application.

6.6.2 BOOKED USER DETAILS

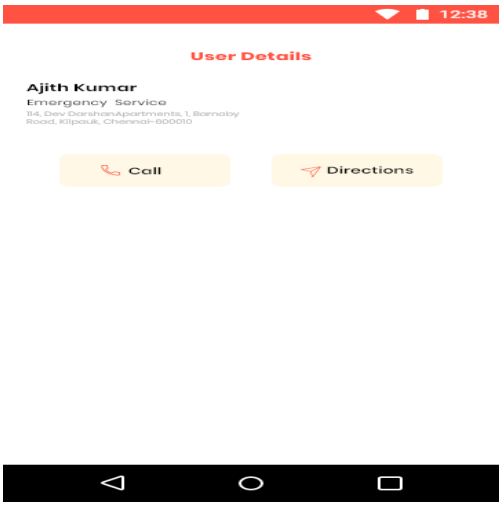

Figure 12: Booked User details Screen

Figure 7.7 shows user information for ambulance drivers, including the user's name, address, and call details. Tapping the call button in the app directs the driver to the call function, which automatically displays the user's mobile number. Tapping the direction button in the app takes the user to the map screen.

6.6.3 NAVIGATION SCREEN

Figure 13: Navigation screen

Figure 6.8 displays the ambulance location on Google Maps in our android app. GPS provides latitude and longitude data to show the location. The app shows the shortest route between the ambulance and user when the driver taps navigate.

Global Positioning System:

Device location is automatically updated while moving and recorded in the cloud. GPS is a satellite system providing location and time information in any weather conditions, where three or more satellites are visible. A basic GPS tracking device combines location and communication

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technologies, enabling centralized tracking without explicit relay of information. This allows real-time monitoring of multiple vehicles or people. An application allows ambulance drivers to select and navigate routes.

ANDROID LOCATION API

These are the Location API classes for getting user location information:

- Location Manager: provides access to location service and helps to get the best location provider based on criteria.
- Location Provider: an abstract class for location providers that report the device's location periodically.
- Location Listener: a class with callback methods triggered when location changes, and it needs to be registered with the location manager.
- Criteria: a class for choosing a suitable location provider based on its properties. Android also offers a Google Maps API that can display desired locations on the map using location APIs.

4. CONCLUSION

The system offers a novel method of managing traffic with improved resource allocation. Real-time ambulance traffic monitoring data can be employed by traffic control authorities to identify hazardous situations and respond swiftly. The paper primary objective is to reduce fatalities among critical patients by ensuring timely transportation to hospitals. The system is precise and has the significant benefit of saving time.

Human life is precious and safety must be a top priority. The application is crucial in all aspects and can fulfill emergency needs with ease. It has the potential to revolutionize the emergency field and upgrade ambulances to be equivalent to hospitals. The upgraded version of the present model is easy to implement and will be available quickly once ready for use.

This paper demonstrates an intelligent traffic signal control system and emergency call application using Android. Patients in emergencies can quickly request an ambulance through a user application, and the ambulance driver can receive accurate location details. Real-time communication with traffic signal poles allows for automatic signal changes, which enables ambulances to bypass traffic signals and reach hospitals quickly, potentially saving lives.

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