

Smart Ambulance with Traffic Control: An IoT-Based System for Real-Time Emergency Vehicle Prioritization and Patient Monitoring

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Abstract—Traffic congestion in urban areas significantly delays ambulance response, directly affecting patient survival during the critical “golden hour.” This paper presents a Smart Ambulance with Traffic Control system that integrates embedded microcontrollers, RF communication, GSM/IoT connectivity, and real-time patient monitoring to reduce emergency response time. The proposed system comprises three functional units: an ambulance unit (ESP32/ESP8266-based) that transmits a priority signal via a 433 MHz RF transmitter and uploads patient vitals — heart rate, SpO₂, and temperature — captured using MAX30102 and DHT11 sensors to a cloud server; a traffic-control unit that receives the RF signal and automatically switches the corresponding signal to green, clearing the ambulance’s path; and a cloud-monitoring layer that relays real-time patient data and hospital notifications through the Blynk platform and Twilio-based SMS/WhatsApp messaging. Paramedics select the destination hospital via onboard switches, and the system automatically verifies bed availability, redirecting to an alternate facility when required. A working prototype was built and validated on a simulated four-way intersection model. Results indicate a 30–50% reduction in ambulance travel time, sub-5-second hospital acknowledgment, and reliable vitals transmission with under 1-second latency, demonstrating the feasibility of low-cost RF-based traffic prioritization for smart-city emergency medical services.

Keywords—Smart Ambulance; Internet of Things (IoT); Traffic Signal Control; ESP32; RF Communication; Emergency Medical Services; Patient Health Monitoring; GSM; Blynk.

I. INTRODUCTION

Ambulances play a decisive role in emergency healthcare, yet urban traffic congestion routinely delays their passage to hospitals. Conventional traffic-signal systems operate on fixed cycles and do not recognize or prioritize approaching emergency vehicles, so ambulances frequently idle at intersections despite sirens and flashing lights. For time-critical conditions such as cardiac arrest, stroke, or trauma, outcomes depend heavily on the “golden hour” — the first hour after injury or onset — during which even a few minutes of delay can worsen prognosis or result in preventable death.

Smart-city traffic-management research has explored sensor networks, GPS tracking, and machine learning to optimize signal timing, yet many deployed systems still lack direct integration between ambulances and traffic infrastructure. This work addresses that gap with a Smart Ambulance with Traffic Control system that (i) gives ambulances automatic priority at intersections using low-cost RF communication, (ii) streams real-time patient vitals to the destination hospital via a cloud dashboard, and (iii) notifies hospitals of incoming patients and bed requirements through SMS and WhatsApp. The objectives are to reduce ambulance transit time, enable synchronized traffic-signal response, transmit patient data ahead of arrival, and demonstrate a scalable, low-cost architecture suitable for smart-city emergency infrastructure.

II. LITERATURE SURVEY

Prior work on ambulance prioritization and IoT-based patient monitoring is summarized in Table I. Most existing systems rely on RFID tags for vehicle detection at intersections, whereas the

proposed system uses 433 MHz RF transmitter–receiver pairs, which lowers hardware cost and simplifies deployment without requiring tag infrastructure at every junction.

TABLE I. SUMMARY OF RELATED WORK

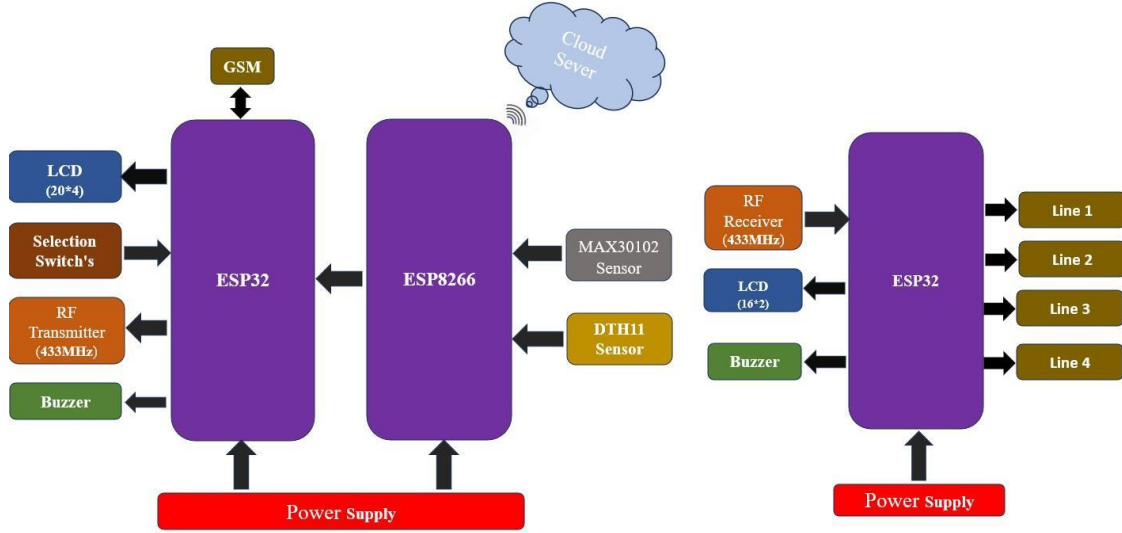
Study	Contribution	Relation to Proposed Work
Ashmawy et al. (2019), SmartAmb – IEEE	IoT/ML-based ambulance routing with RFID traffic-light automation.	Proposed system uses low-cost RF modules instead of RFID for signal control.
Veeramuthu et al. (2012), IEEE ICCCI	Wireless communication for ambulance priority signaling.	Similar automatic signal adjustment; proposed work adds patient vitals cloud upload.
Udawan et al. (2017), IEEE BID	“Green Corridor” concept using RFID detection.	Proposed work replaces RFID with RF communication for faster, cheaper deployment.
Dutta et al. (2019), IEEE	RFID-based automatic signal system for emergency vehicles.	RF modules used here for a more cost-effective, faster-response alternative.
Uddin et al. (2017), IEEE	IoT-based real-time patient monitoring in ambulances.	Proposed system uses Blynk Server for ECG/HR/SpO ₂ relay to hospitals.
Yew et al. (2020), J. Healthcare Eng.	MQTT-based ECG data transmission for remote monitoring.	Comparable real-time approach; proposed work adds Twilio-based SMS/WhatsApp alerts.

Study	Contribution	Relation to Proposed Work
Karkar (2019), IEEE	Smart traffic signal control dedicated to ambulances.	Forms the conceptual basis extended here with integrated hospital communication.

III. PROPOSED SYSTEM AND METHODOLOGY

A. System Architecture

The system consists of three cooperating units, shown in Fig. 1: an ambulance unit, a traffic-control unit, and a cloud-based monitoring layer. The ambulance unit is built around an ESP32 (handling hospital selection, RF transmission, LCD status display, and GSM alerts) paired with an ESP8266 that reads the MAX30102 and DHT11 sensors and uploads vitals to the cloud. The traffic-control unit uses a second ESP32 with an RF receiver to detect the incoming priority signal and switch the appropriate line (Line 1–Line 4) to green while holding other approaches at red. Both units are powered from a 12 V battery regulated through LM2596 buck converters to 5 V and 3.7 V rails.



Fig(a). Block Diagram of Ambulance unit

Fig(b). Block Diagram of Traffic Control unit

Fig. 1. Methodology block diagram: (a) Ambulance unit, (b) Traffic control unit.

B. Hardware Description

Table II lists the principal hardware components and their function within the system. The RF transmitter/receiver pair uses ASK/FSK modulation at 433 MHz for short-range, low-latency priority signaling, while the GSM 800L module (850/900 MHz bands) provides SMS and WhatsApp-based hospital notification independent of Wi-Fi availability.

TABLE II. HARDWARE COMPONENTS

Component	Role in System
ESP32	Dual-core Wi-Fi/Bluetooth MCU; hospital selection, RF transmission, LCD/GSM control (ambulance and traffic units).
ESP8266 (NodeMCU)	Handles Wi-Fi upload of patient vitals to the cloud server.
RF Tx/Rx (433 MHz)	Sends/receives the emergency-priority signal between ambulance and traffic-signal units.
GSM 800L	Sends SMS/WhatsApp notifications with patient details to the selected hospital.
MAX30102	Optical heart-rate and SpO2 sensor (I2C).

Component	Role in System
DHT11	Measures cabin temperature and humidity.
LCD 20×4 / 16×2	Displays system status at the ambulance unit and traffic-control unit respectively.
Li-ion battery + LM2596	12 V battery with buck converters supplying regulated 5 V / 3.7 V rails.

C. Software Tools

Firmware for both ESP32/ESP8266 units is written in Embedded C using the Arduino IDE, which compiles sketches to a hex image flashed onto each controller. The Blynk Server provides the cloud dashboard for real-time vitals (heart rate, SpO2, temperature) accessible to hospital staff over HTTP/WebSocket/MQTT. ThingESP simplifies ESP32/ESP8266 cloud integration, while Twilio's messaging API delivers SMS and WhatsApp alerts to the selected hospital, enabling redundant, low-latency notification.

D. System Workflow

- System initialization checks all connected modules and confirms readiness.
- On emergency-mode activation, paramedics select the destination hospital via onboard switches.
- The RF transmitter signals the traffic-control unit, which turns the relevant signal green and holds cross-traffic at red.
- Patient and hospital-selection details are sent via SMS and WhatsApp to the chosen hospital.
- The system checks bed availability; if unavailable, it automatically searches an alternate hospital.
- MAX30102 and DHT11 readings are continuously uploaded to the Blynk cloud server over Wi-Fi.
- Hospital staff access the live dashboard to prepare equipment and personnel ahead of patient arrival.

IV. RESULTS AND DISCUSSION

A working prototype was implemented and validated on a scaled four-way intersection model with representative ambulance and vehicle units (Fig. 6 of the underlying project report). Table III summarizes the measured performance.

TABLE III. SYSTEM PERFORMANCE SUMMARY

Metric	Result
Ambulance travel-time reduction	30–50% (traffic-density dependent)
Hospital acknowledgment latency	< 5 seconds
Alternate-hospital redirection time	2–3 seconds
Vitals-to-cloud transmission delay	< 1 second
Overall emergency-to-admission time reduction	≈ 40%

The traffic-signal automation reliably prioritized the ambulance without disrupting normal-mode operation, and the dual-channel (SMS + WhatsApp) hospital notification proved redundant against single-channel failure. Bed-availability checking reduced misrouted transports by redirecting to alternate hospitals within seconds. Vitals streaming through Blynk remained stable with sub-second latency, allowing hospital teams to prepare equipment before arrival. Limitations observed include dependence on stable cellular/Wi-Fi connectivity, the need for hospitals to keep bed-status data current, and reliance on existing traffic-signal infrastructure for actuation — all of which point to concrete directions for future hardening of the system.

V. CONCLUSION AND FUTURE SCOPE

The proposed Smart Ambulance with Traffic Control system demonstrates that low-cost RF communication, combined with IoT-based patient monitoring and automated hospital messaging, can meaningfully reduce ambulance transit time and

improve hospital preparedness. The prototype achieved up to 50% reduction in travel time, sub-5-second hospital acknowledgment, and near-real-time vitals streaming, validating the approach for smart-city emergency medical infrastructure.

Future work will focus on: (i) direct integration with Hospital Management Systems for automated bed-status updates; (ii) AI/ML-based adaptive traffic-signal optimization across multiple simultaneous emergency vehicles; (iii) redundant connectivity via LoRaWAN or 5G for low-coverage areas; (iv) additional sensing (ECG, glucose, respiratory rate) with anomaly-detection alerts; (v) a dedicated mobile application for ambulance and hospital staff; and (vi) extension to other emergency services such as fire and police vehicles within a unified smart-city dispatch framework.

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