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5G -Based Intelligent Vehicle Communication Using Lightweight Blockchain for Accident Detection and Emergency Alert.

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Abstract - Road accidents require timely detection, dependable emergency notification, and reliable handling of incident records. This paper presents a prototype-oriented approach combining an embedded accident-alert unit, a cloud-connected hospital portal, a hash-linked database audit mechanism, and a separate MATLAB-based 5G link simulation. The hardware prototype uses an ESP32-S3 EC200U development board and an MPU6050 inertial sensor. SOS button and cancel SOS button is provided user needs to press any one of the buttons, after a detected event, a 30-second cancellation window allows a false alarm to be cancelled, the system submits event information to Supabase over Wi-Fi and sends SMS alerts through the cellular module. The hospital portal provides staff authentication, role-based access, accident-status management, notifications, and a PostgreSQL/Supabase hash-linked audit trail with chain-verification functions. Separately, MATLAB with 5G Toolbox is used to simulate an example communication link; the simulated alert data are not streamed from the physical hardware. The reported audit test returned "CHAIN AND CHECKPOINTS VERIFIED." The supplied BER/BLER values are illustrative and are not treated as reproducible measured performance. The work therefore demonstrates integration of an accident-alert prototype live accident location GPS coordinates, cloud-based incident management, database audit verification, and an independent 5G simulation.

Key words - Accident detection, GPS coordinates, ESP32, MPU6050, emergency notification, Supabase, hash-linked audit trail, MATLAB, 5G Toolbox, BER, BLER.

I. INTRODUCTION

Intelligent transportation systems use sensing, communication, and information services to improve transportation safety and operational awareness. When a road accident occurs, delays in reporting the event or sharing its details may complicate emergency response. An embedded system can monitor motion-related sensor data and initiate an alert when measurements satisfy a defined trigger condition. A cloud service can then make incident information available to authorized hospital personnel, while an audit mechanism can help reveal later changes to stored records. These functions introduce several engineering challenges. Motion thresholds must be selected and evaluated carefully because sudden movement does not always mean a crash. Cellular or internet connectivity may be unavailable or intermittent. Accident records also require access controls and an auditable history.

In addition, a simulated 5G link can help study communication behavior under defined channel conditions, but simulation results must not be confused with measurements from a physical 5G deployment. This project addresses these issues through three distinct components:

(1) A sensor-based hardware accident-alert prototype,

(2) A Supabase hospital portal with a hash-linked audit mechanism,

(3) A separate MATLAB 5G communication simulation.

II. PROBLEM STATEMENT AND OBJECTIVES

The engineering problem is to prototype a system that detects a possible vehicle accident from inertial sensor thresholds, notifies emergency contacts, makes incident records available to authorized hospital staff, and checks the integrity of the stored record history. A separate simulation is used to explore a 5G-style communication link without claiming that the physical hardware uses a real 5G connection.

The objectives of the implemented work are:

- Build and test a hardware prototype using an ESP32-S3 EC200U board, MPU6050 sensor, SOS button, and cancellation button.

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- Use threshold-based motion detection and a 30-second cancellation window before alert escalation.
- Submit accident data to Supabase over Wi-Fi and send SMS alerts through the cellular module.
- Provide hospital staff login, role-based access, incident-status updates, and notifications.
- Implement and verify a database hash-linked audit trail and checkpoints in PostgreSQL/Supabase.
- Develop a separate MATLAB 5G link simulation and clearly distinguish simulated data from physical hardware observations.

III. RELATED WORK

Research on IoT-based accident detection commonly explores sensors, embedded controllers, wireless connectivity, and automated emergency notification. Such systems are relevant because they establish the general design pattern of detecting an event locally and transmitting a report to a remote service.

For this project, the most relevant comparisons should examine the sensor type, trigger method, false-alarm handling, communication path, and whether the reported location is obtained from a live positioning module or supplied as test data. [1].

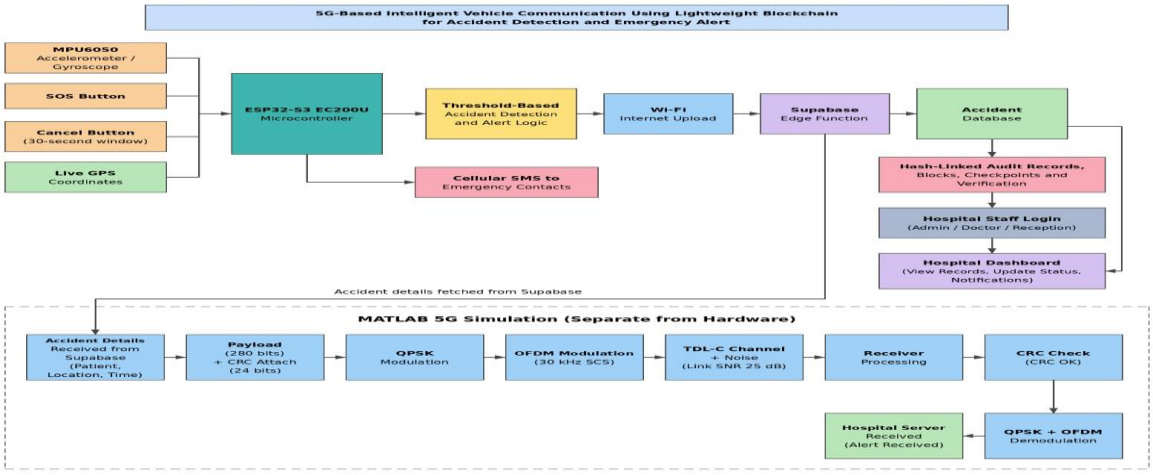
A second relevant research area is tamper-evident audit logging. Hash-linked records can make changes detectable when verification recomputes hashes from the protected history. However, a hash chain is not equivalent to a decentralized blockchain. The present work uses a database-based, blockchain-inspired audit mechanism in Supabase/PostgreSQL. [2], [3].

The third area is link-level wireless simulation. MATLAB with 5G Toolbox can be used to model signal processing and channel effects under defined assumptions. For a meaningful comparison, the paper should specify the waveform, modulation, channel model, coding and CRC configuration, number of transmitted bits or blocks, and the procedure used to estimate BER and BLER. The literature survey should be completed with publisher-verified papers and exact bibliographic metadata before submission.

IV.RESEARCH GAP AND ACTUAL CONTRIBUTION

The project materials support an implementation-focused contribution rather than a claim that a new or decentralized-blockchain algorithm has been developed. The work brings together a tested sensor-threshold alert prototype, a cloud hospital workflow with access controls, a database hash-linked audit trail, and an independent MATLAB 5G link simulation. The available evidence does not establish that this combination is novel relative to prior research. A defensible contribution claim should therefore be limited to the implemented prototype and its demonstrated functional checks. A stronger research gap can be stated only after a documented comparison of verified papers identifies a limitation that the present work address.

V.SYSTEM ARCHITECTURE



The hospital path authenticates staff, applies role-based access controls, displays incident records and statuses, generates notifications, and records changes in a hash-linked audit history. No live data link between the physical hardware and the MATLAB simulation only connected supabase edge function can directly send the message to claim.

A. Hardware Components

The prototype uses an ESP32-S3 EC200U 4G LTE Cat-1

Wi-Fi/Bluetooth/GNSS development board, an MPU6050 accelerometer/gyroscope, an SOS button, a cancellation button, breadboard connections, and jumper wires. The cellular module is used for SMS alerts, while Wi-Fi is used to submit event data to Supabase. In the reported hardware test, Live GPS coordinates were used; live GNSS-based accident location is therefore claimed

B. Threshold-Based Event Trigger

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Accident detection is based on programmed sensor thresholds. The reported thresholds are approximately 2.8 g total acceleration and 2.5 g on the Y/Z axes, according to the implementation notes. These values must be described as code-configured trigger thresholds, not as universally validated crash-detection limits. The paper should explain how the resultant acceleration is calculated and under what conditions the axis thresholds trigger an event.

C. **Cancellation and Alerting**

After an accident is detected, the system provides a 30-second cancellation window. If the alert is not cancelled, the prototype escalates the event by submitting data to Supabase over Wi-Fi and sending SMS messages to emergency contacts using the cellular connection. Hardware and cellular/SMS tests have been performed.

VII. HOSPITAL PORTAL AND HASH-LINKED AUDIT MECHANISM

The cloud component uses Supabase, including a database and an Edge Function for accident submissions. Hospital staff can log in, and role-based access with Row Level Security (RLS) policies is intended to restrict staff to records associated with their hospital. The dashboard displays accident records and supports pending, in-progress, dispatched and resolved statuses. Dashboard notifications are implemented.

A PostgreSQL/Supabase audit mechanism links record-change events using hashes and stores checkpoints. Verification functions check the chain and checkpoint state. In one reported test output, the audit system showed 19 total blocks, 6 inserts, 12 updates, 1 delete, 9 checkpoints, latest block 19, latest checkpoint 19, and the statuses "CHAIN VERIFIED" and "CHAIN AND CHECKPOINTS VERIFIED". The mechanism is described as a database-based, blockchain-inspired audit trail. It is not a deployed public or decentralized blockchain and does not use Ethereum, Hyperledger, or a consensus network. Hash-chain verification can help detect unauthorized changes, but it does not automatically prevent all attacks or protect against an attacker who can modify the data, hashes, and verification state together.

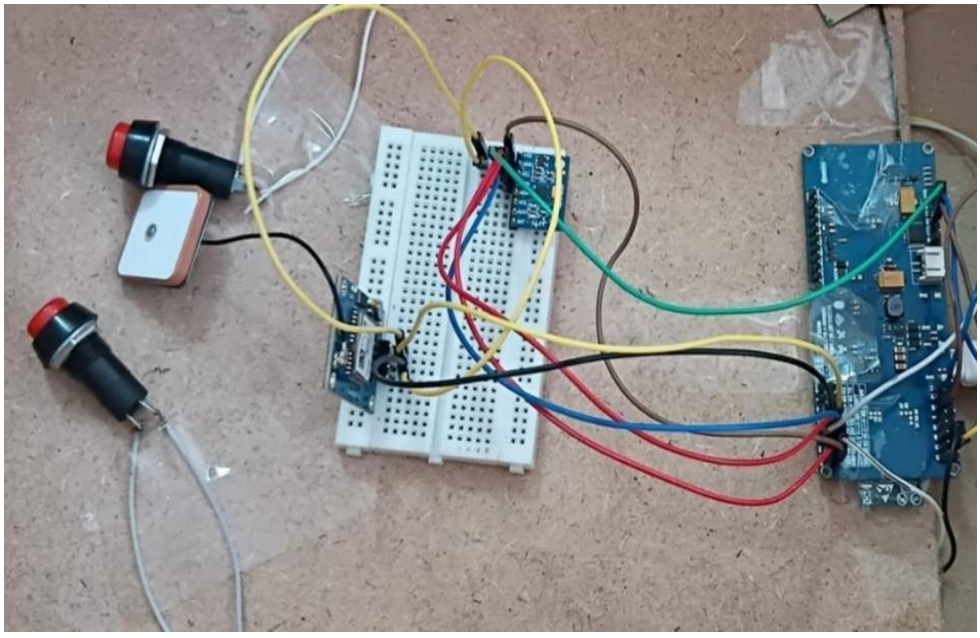
VIII. MATLAB 5G SIMULATION LINKED WITH SUPABASE

The system stores patient and accident details, including patient name, age, blood group, mobile number, Live GPS coordinates, accident time, and destination hospital, in the Supabase cloud database. MATLAB automatically retrieves the latest accident record through the Supabase REST API, eliminating manual data entry. The retrieved information is converted into a binary alert packet, and CRC-24A is added for error detection. The alert packet is transmitted through a simulated 5G New Radio (NR) communication link using QPSK modulation, OFDM, and a TDL-C multipath fading channel. At the receiving end, the hospital server checks the received packet and requests retransmission if an error is detected. Finally, the system evaluates communication performance by analyzing latency, Bit Error Rate (BER), packet delivery ratio, packet loss, and retransmissions. The results are displayed through transmitted and received waveforms, latency graphs, BER-VERSUS-SNR curves, and packet transmission logs.

IX .EXPERIMENTAL SETUP AND RESULTS

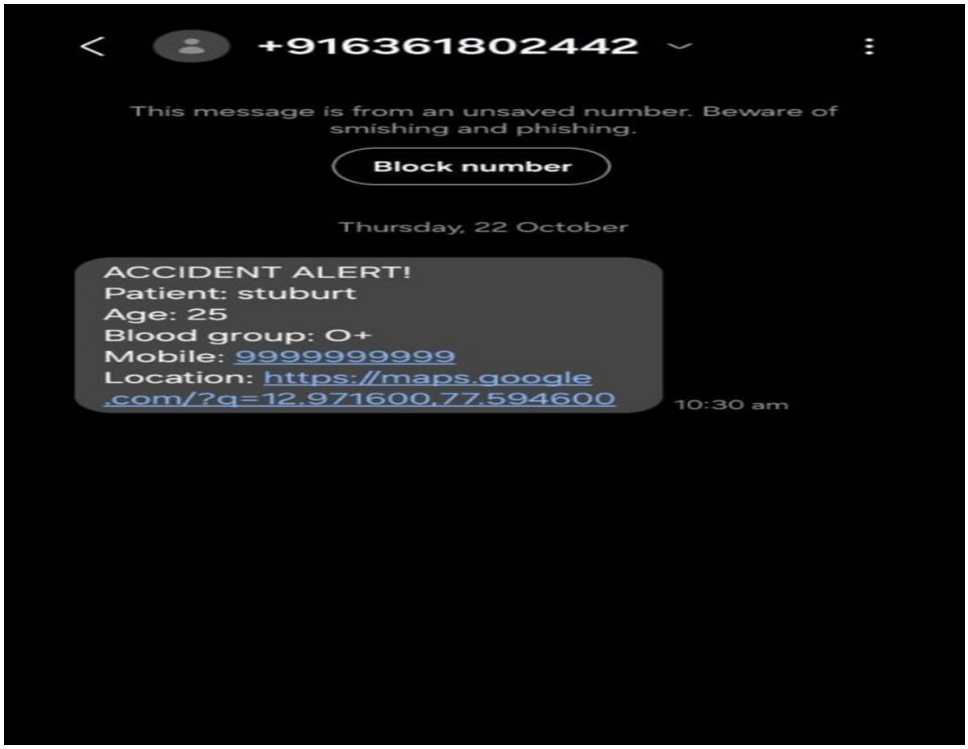
A. Hardware and Cloud Tests

The available implementation notes state that hardware and cellular/SMS tests were performed, and that the Supabase portal, notifications, audit chain, and verification functions were implemented.

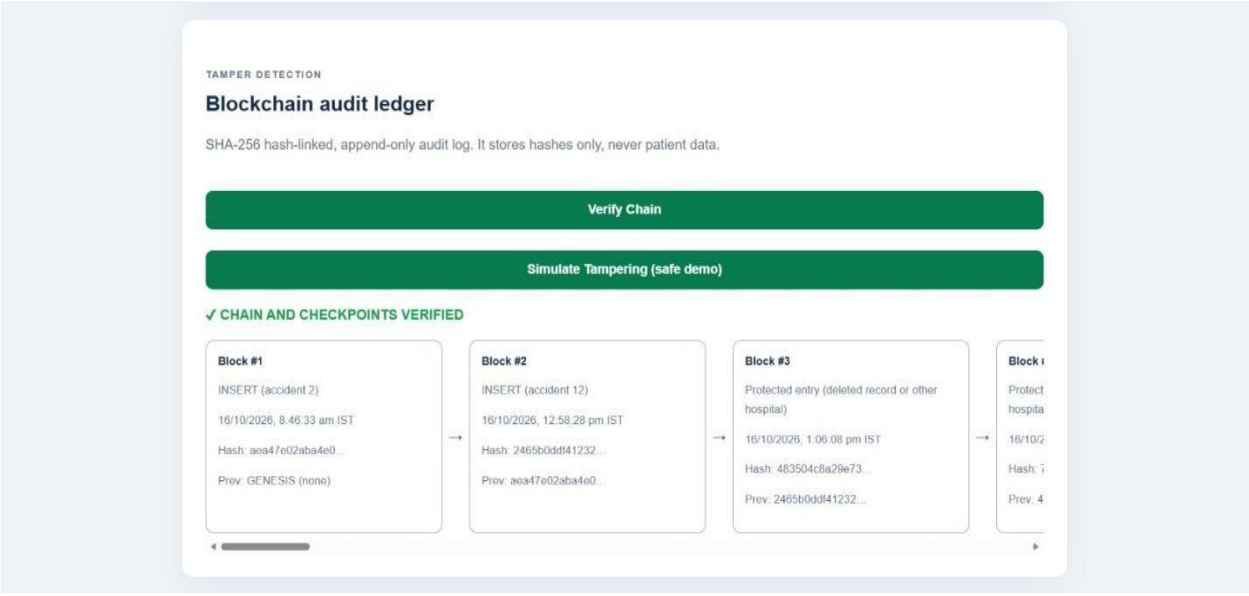


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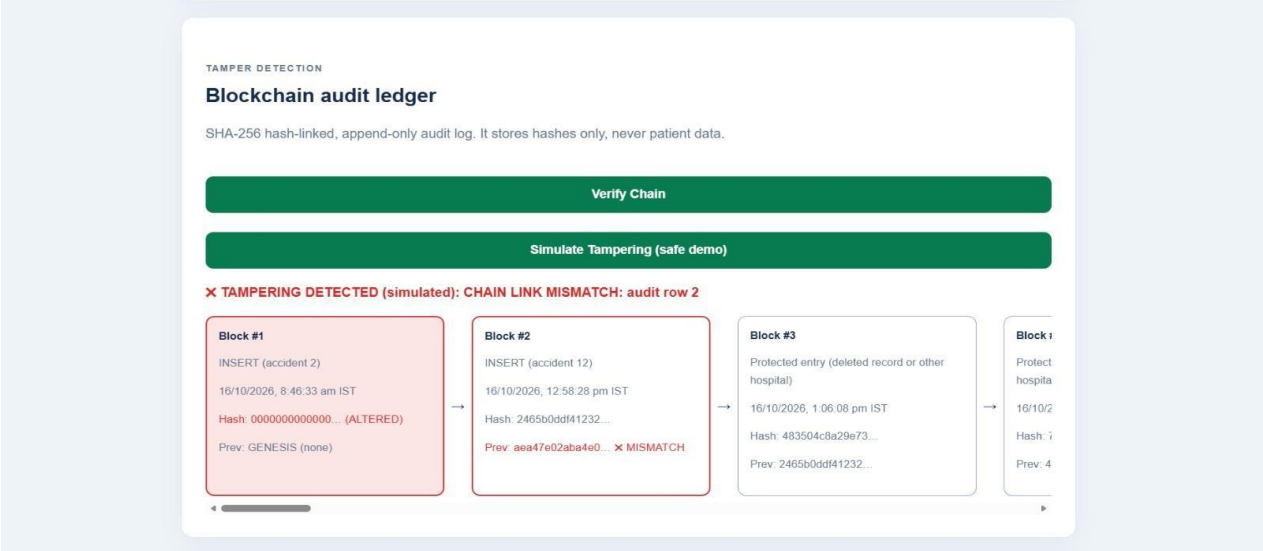


B. Audit Verification Output



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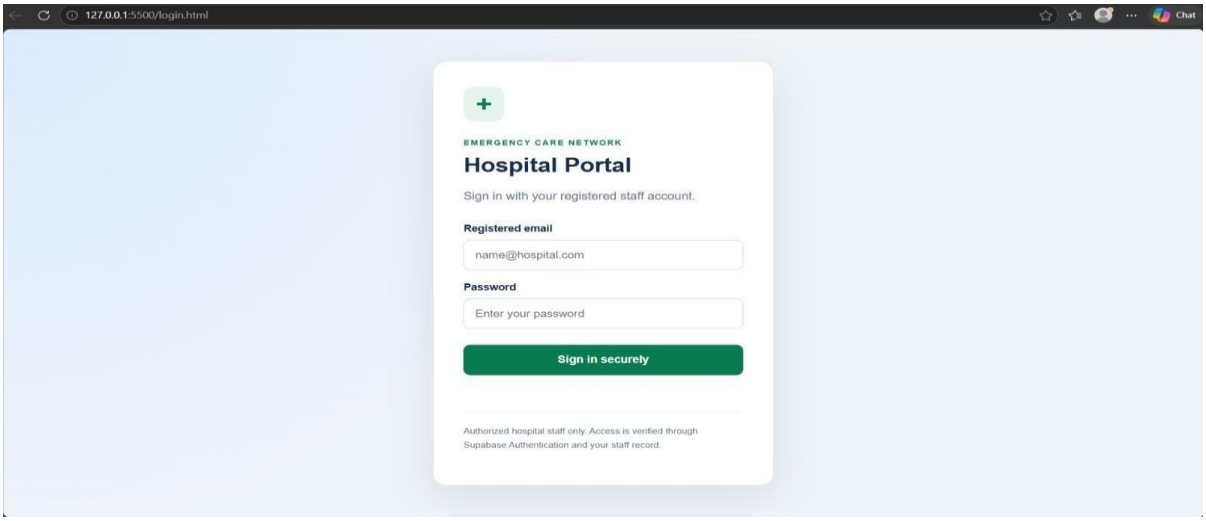
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Reported item	Value from one test output
Total blocks	19
Inserts / updates / deletes	6 / 12 / 1
Checkpoints	9
Latest block / checkpoint	19 / 19
Verification status	CHAIN AND CHECKPOINTS VERIFIED

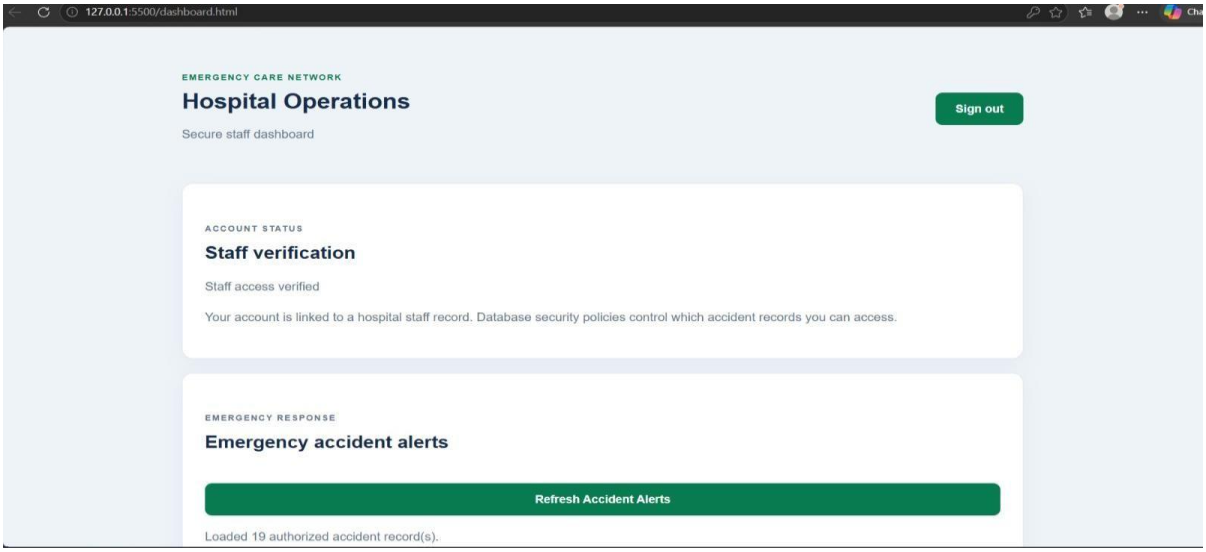
These values are an example verification output, not a performance benchmark.

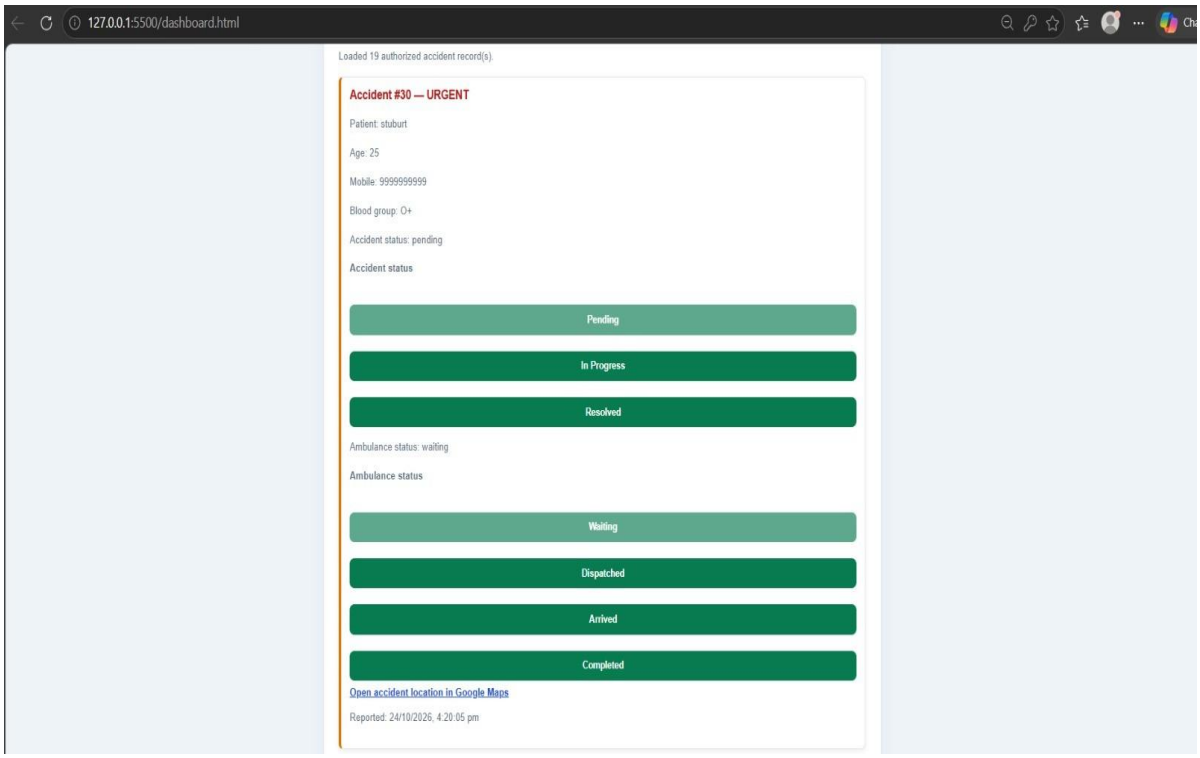
C. Hospital Portal



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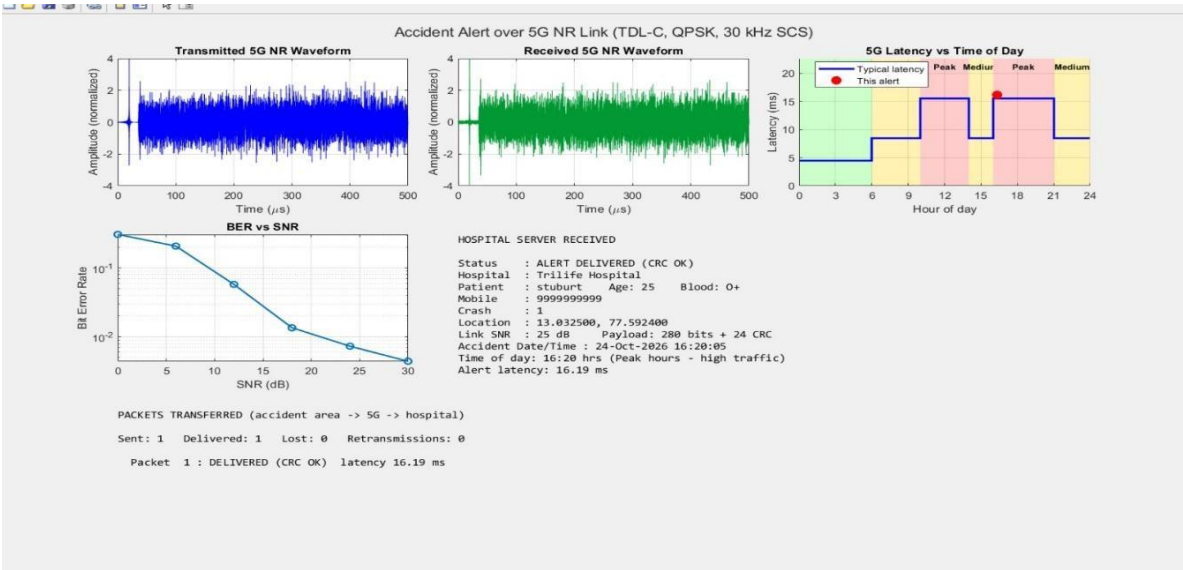




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D. Illustrative BER/BLER Values



The following values were supplied as illustrative values and were not verified as results from a reproducible MATLAB.

Parameter	Result	Explanation
Link SNR	25 dB	Indicates the signal strength relative to noise.
Alert latency	16.19 ms	Time taken for the alert to be delivered in the simulation.
Packets sent	1	One accident-alert packet was transmitted.
Packets delivered	1	The packet reached the receiving server.
Packets lost	0	No packet was lost in this simulation run.
Retransmissions	0	The packet did not require retransmission.
Packet delivery ratio	100%	All transmitted packets were delivered.
CRC status	Successful	The received packet passed the error-checking test.

X. Discussion and Limitations

The prototype demonstrates a threshold-based accident-alert path, cloud incident management, and a database audit mechanism, while the MATLAB component demonstrates a separate simulated wireless-5G link example.

The main strength of this arrangement is that the hardware, cloud portal, and communication simulation can be tested independently.

- Accident classification uses fixed thresholds.
- The physical hardware does not transmit accident messages through a real 5G network in the reported tests.
- The hardware test uses live GPS coordinates; live GNSS tracking is established.
- The supplied BER/BLER table is illustrative and needs replacement with reproducible simulation results.

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- The hash-linked audit mechanism is not a decentralized blockchain and cannot guarantee protection against every privileged or coordinated attack.

XI. CONCLUSION AND FUTURE WORK

IoT-based vehicle accident detection and emergency alert prototype integrated with cloud-based hospital management and a hash-linked audit mechanism. The system uses an ESP32-S3 EC200U development board and MPU6050 sensor to detect possible accidents through predefined acceleration thresholds. A 30-second cancellation mechanism helps reduce unnecessary emergency alerts. Accident information is submitted to Supabase through Wi-Fi, while SMS notifications are sent through the cellular module. The hospital portal enables authorized staff to access accident information, manage Accident status, and receive notifications. The hash-linked audit mechanism provides verification of database changes and checkpoints. Additionally, MATLAB with 5G Toolbox is used to simulate an independent 5G communication link for emergency alert transmission. The reported audit test demonstrated successful chain verification. Further hardware integration, repeated communication experiments, and security testing are required to improve the system. The proposed work provides a foundation for developing intelligent accident detection and emergency response systems using IoT, cloud computing, secure data management, and next-generation communication technologies.

XII. REFERENCES

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