SMART BLOOD BANK MANAGEMENT SYSTEM USING IOT

Pooja Huggi[1], Ankita Birajdar[2], Ashwini Biradar[2], Divya Patil[2], Megha Toran

ABSTRACT

Blood is a vital part of human life and has a crucialrole in supporting modern medical treatments. Every day, thousands of people require blood transfusions due to accidents, surgeries, childbirth complications, anemia, cancer treatments and other medical emergencies. Blood banks often struggle with shortages of specific blood groups, expired or contaminated blood units, inefficient inventory tracking and lack of coordination between multiple blood banks and hospitals. Traditional blood bank management is carried out manually, leading to human errors, delays in data updates and lack of real-time information. To address these issues, a Smart Blood Bank Management System using IoT technology is proposed that integrates smart sensors, cloud connectivity and automated systems to monitor blood storage conditions, inventory levels and transportation in real time. The system uses IoT-enabled hardware including Arduino UNO, DHT11 temperature sensor, weight sensors, GSM and Wi-Fi modules, interfaced with a cloud-based backend and a responsive web frontend. Real-time data collection, automated SMS alerts, and cloud dashboards enable centralized monitoring and timely supply of safe blood. The system demonstrates significant improvements in efficiency, accuracy and emergency responsiveness over existing manual systems.

KEYWORDS: Blood bank management, Internet of Things (IoT), Arduino UNO, DHT11, Weight Sensor, GSM, Wi-Fi, Firebase, Real-Time Monitoring, Inventory Management, Cloud Computing

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INTRODUCTION

Blood is a vital part of human life and has a crucial role in supporting modern medical treatments. Every day, thousands of people require blood transfusions due to accidents, surgeries, childbirth complications, anemia, cancer treatments and other medical emergencies. However, despite the continuous demand, blood banks often struggle with numerous challenges such as the shortage of specific blood groups, expired or contaminated blood units, inefficient inventory tracking and lack of coordination between multiple blood banks and hospitals.

In many traditional systems, blood bank management is carried out manually, leading to human errors, delays in data updates and lack of real-time information. These inefficiencies can result in critical situations where life-saving blood is either unavailable or wasted. In developing countries especially, these problems are more severe due to limited resources and outdated systems.

To address these issues, the integration of Internet of Things (IoT) technology plays an important role in enhancing real-time monitoring and management. IoT enables the use of modern technologies such as smart sensors, cloud connectivity and automated systems that can monitor and manage blood storage conditions, inventory levels and transportation in real time. For example, sensors can monitor the temperature and humidity inside

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blood storage units and provide instant notifications if the environment goes beyond safe thresholds, helping to preserve the quality and usability of stored blood.

An intelligent blood bank management solution that uses IoT technology to monitor, manage and control blood inventory efficiently aims to modernize the existing infrastructure by automating critical tasks and enabling centralized monitoring and control. With real-time data collection and cloud-based dashboards, authorities can track blood stock availability, generate automatic notifications when blood stock levels run low, monitor upcoming expiry dates and connect with other blood banks for hospitals and patients to ensure timely supply of safe blood.

MATERIALS AND METHODS:

Materials

The materials required for the Smart Blood Bank Management System include both hardware and software components. The hardware components consist of computer systems, barcode or QR code scanners, RFID readers, blood storage monitoring sensors, printers, internet connectivity devices, and UPS power backup systems. The software requirements include an operating system such as Windows or Linux, frontend technologies like HTML, CSS, JavaScript, and Bootstrap, backend technologies such as Python, Java, or PHP, and databases like MySQL or PostgreSQL. Development tools such as Visual Studio Code, PyCharm, and Git are also used for coding, database management, and version control. Additional modules include donor registration, blood inventory management, hospital request handling, notification systems, and reporting dashboards.

Methods

The Smart Blood Bank Management System was developed using a structured methodology to automate blood donation, storage, and distribution processes. Initially, requirement analysis was conducted to identify problems in traditional blood bank systems, such as manual record handling and delays in blood availability tracking. The system was then designed using database models, user interface designs, and client-server architecture. Donor information, blood stock details, and hospital requests are stored in a centralized database. Each blood unit is assigned a barcode or QR code for tracking, while FIFO (First In First Out) techniques are used to minimize wastage. The system also performs blood compatibility verification, sends automated alerts for emergencies and blood expiry, and provides secure access through authentication and encryption. Finally, the system is tested using unit, integration, and user acceptance testing before deployment on a local or cloud server.

RESULTS:

The Smart Blood Bank Management System was designed to improve the efficiency, accuracy, and reliability of blood bank operations through automation and real-time monitoring. The system architecture was optimized by integrating donor management, blood inventory tracking, compatibility checking, and notification modules into a centralized database system. Barcode and QR code technologies were incorporated to ensure accurate blood unit identification and tracking, while FIFO (First In First Out) techniques were implemented to reduce blood wastage caused by expired units. The database structure and user interface were optimized to provide faster data retrieval, easy navigation, and secure access for administrators, hospital staff, and donors.

The system was validated through functional testing, integration testing, and user acceptance testing to ensure proper operation of all modules. Experimental evaluation showed that the automated system significantly reduced manual errors in record maintenance and improved the speed of blood request processing compared to traditional methods. Real-time inventory updates enabled efficient monitoring of blood stock levels and expiry dates, reducing delays during emergency situations. The notification module successfully delivered alerts for low blood stock, blood expiry, and donor reminders through SMS and email services.

DISCUSSION:

The results obtained from the Smart Blood Bank Management System demonstrate that the integration of automation and centralized data management significantly improves the overall efficiency of blood bank operations. The reduction in manual record handling minimized human errors and improved the accuracy of donor and blood inventory information. The implementation of barcode and QR code tracking provided reliable monitoring of blood units throughout collection, storage, and distribution processes, which enhanced traceability and reduced the chances of mismanagement. The use of FIFO techniques effectively minimized blood wastage by ensuring that older blood units were utilized before newer stock, thereby improving inventory optimization.

The experimental validation also showed that real-time inventory updates and automated notifications improved communication between blood banks, donors, and hospitals during emergency situations. Faster processing of blood requests reduced response time and increased the availability of compatible blood units when required. Secure authentication and encryption mechanisms ensured the protection of sensitive donor and patient information, improving system reliability and data confidentiality. The optimized database design and user-friendly interface contributed to faster data retrieval and easier management of blood records. Overall, the findings justify that the proposed Smart Blood Bank Management System is a reliable, efficient, and scalable solution that can enhance blood bank services, reduce operational delays, and support effective healthcare management.

CONCLUSIONS:

The Smart Blood Bank Management System successfully improved the efficiency, accuracy, and reliability of blood bank operations through automation and centralized data management. The study demonstrated that the implementation of real-time inventory tracking, barcode and QR code identification, automated notifications, and secure data handling significantly reduced manual errors, minimized blood wastage, and improved response time during emergency blood requests. The findings indicate that the proposed system provides an effective and scalable solution for modern blood bank management by enhancing communication, optimizing blood inventory utilization, and ensuring better accessibility of blood resources for hospitals and patients.

Tables and figures:

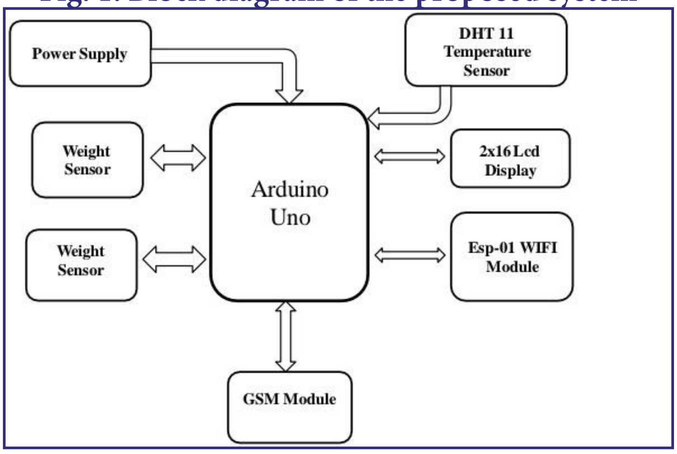
Block Diagram of the Proposed System

The methodology defines the step-by-step approach adopted to design, develop and integrate the hardware, backend and frontend components of the system. The project follows a modular and iterative development process, ensuring each layer—hardware, backend and frontend—is independently functional yet seamlessly interconnected.

The hardware layer centers on an Arduino UNO interfaced with: a DHT11 temperature/humidity sensor (pin 4) for continuous blood storage monitoring; two HX711 load-cell amplifiers connected to 5 kg YZC-131 weight sensors (pins 8/9 and 10/11) tracking blood bag inventory; a 16×2 I^2C LCD display (SDA→A4, SCL→A5) for real-time local display; an ESP-01 Wi-Fi module (SoftwareSerial pins 6/7) for HTTPS data transmission to Firebase; and a SIM800A GSM module (SoftwareSerial pins 2/3) for SMS alerts.

The hardware development was performed using the Arduino IDE, where the Arduino UNO was programmed to interact with sensors and modules. An RGB sensor was employed for color detection and the collected data was processed by the microcontroller. The firmware was developed in C/C++ and uploaded via the Arduino IDE, enabling sensor readings, data transmission and actuator control. Libraries such as Wire.h, WiFi.h and other sensor-specific libraries were utilized to establish accurate and reliable communication. The circuit was initially simulated using Fritzing/Tinkercad before being implemented physically.

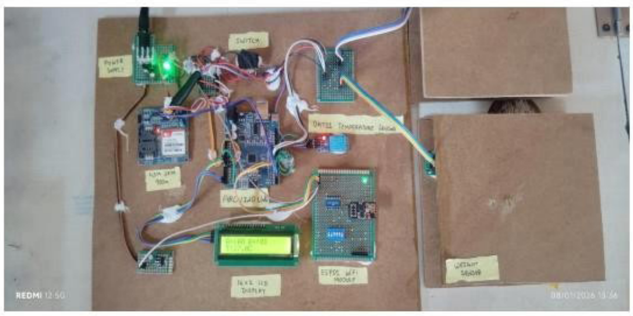
Fig. 1: Block diagram of the proposed system



HARDWARE REQUIREMENTS

Arduino UNO: The Arduino UNO is a popular open-source microcontroller board based on the ATmega328P processor. It features 14 digital input/output pins (6 of which support PWM), 6 analog input pins and a USB port for programming via the Arduino IDE. The board can be powered through USB or a DC barrel jack. Key features include: ATmega328P microcontroller; 14 digital I/O pins; 6 analog input pins; PWM on pins 3, 5, 6, 9, 10 and 11; USB programming port; 5V operating voltage (7–12V input); and a 16 MHz crystal oscillator.

Fig. 2: Arduino UNO



ESP-01 Wi-Fi Module: The ESP-01 is a small, low-cost Wi-Fi module built on the ESP8266EX microcontroller from Espressif Systems. It provides 802.11 b/g/n connectivity supporting Access Point (AP), Station (STA) and simultaneous modes. It includes a powerful 32-bit CPU, AT Command firmware for control via UART, 1 MB flash memory and operates at 3.0–3.6V (not 5V tolerant; requires logic-level conversion when interfacing with Arduino UNO). Standby power consumption is as low as 1.0mW, making it suitable for battery-powered IoT applications.

GSM Module (SIM800A): The SIM800A is a popular GSM/GPRS module supporting dual-band EGSM 900 MHz and DCS 1800 MHz (some versions quad-band). It supports voice calls, SMS messaging with DTMF support, and GPRS data transmission via TCP/IP. The module is controlled using standard AT commands over a serial interface and features Embedded AT capability for rapid development. It is used in the proposed system to send SMS alerts to staff when blood stock falls below critical levels or temperature exceeds safe thresholds.

DHT11 Temperature & Humidity Sensor: The DHT11 is a low-cost digital sensor that measures temperature (0°C to 50°C, ±2.0°C accuracy) and relative humidity (±5.0% RH). It uses a resistive humidity sensor and a thermistor, outputting a digital signal. Operating voltage is 3.3V to 5V with response time under 5 seconds. The sensor continuously monitors blood storage temperature against the safe range of 2°C–8°C, triggering alerts upon deviation.

16×2 LCD Display: A 16×2 LCD module displays 16 characters per line across two lines in a 5×8 pixel matrix. It is interfaced via an I^2C Serial Interface Adapter, reducing connections to four wires (VCC, GND, SDA→A4, SCL→A5). The display shows real-time blood bag counts for each blood type bay and current temperature readings.

Weighing Load Cell Sensor: The 5 kg YZC-131 aluminium alloy load cell (rated output 1.0 ±0.1 mV/V, input/output impedance 1000 ±10% Ω) converts weight into an electrical signal. Since Arduino cannot directly read the millivolt-level output, the HX711 24-bit ADC module is used for signal amplification and conversion. Wiring: Red (E+), Black (E−), Green (A+), White (A−). Two load cells independently track inventory levels for two blood type bays, with stock calculated as weight divided by BAG_WEIGHT (200 g per bag).

SOFTWARE REQUIREMENTS

Frontend Application: The frontend is built using React with Vite as the build tool and Tailwind CSS v3 for styling, providing a fast, modern and scalable development environment. ShadCN UI components (Button, Card, Input, Modal) ensure a consistent design system. Requirements: Node.js 18.x or higher; Vite 5.x; Tailwind CSS 3.x; npm ≥ 9.0.0; Visual Studio Code with Tailwind CSS IntelliSense. Environment variables are prefixed with VITE_ and accessed via import.meta.env. Setup: npm create vite@latest frontend → npm install → npxtailwindcssinit -p → npxshadcn@latestinit → npm run dev.

Backend Application (Firebase + Node.js): The backend uses Node.js 18.x with Firebase Cloud Functions and Express.js to expose RESTful APIs. Firebase Firestore handles real-time database operations and Firebase Authentication controls secure access. Key dependencies: firebase-admin, firebase-functions, express, cors, dotenv. Deployment: npm install firebase-tools -g → firebase init (select Functions, Firestore, Emulators) → firebase deploy --only functions. The deployed HTTPS function URL integrates with both the frontend dashboard and the Arduino ESP-01 data upload pipeline.

Hardware Development (Arduino IDE): Arduino IDE version 2.x is used for firmware development. Required libraries: Wire.h, LiquidCrystal_I2C, DHT.h, HX711, SoftwareSerial. The firmware implements: time-gated DHT11 reading (2 s interval); averaged HX711 weight readings (10 samples); a custom floatToChar() function for reliable float-to-string conversion in AT commands and JSON payloads; JSON payload transmission to ESP-01 at 9600 baud; and AT-command-based SMS dispatch via SIM800A.

RESULT PRESENTATION AND DISCUSSION

The proposed Smart Blood Bank Management System was implemented and tested using Arduino UNO with DHT11, weight sensors, GSM and Wi-Fi modules. Three key aspects were evaluated:

Real-Time Quality Monitoring (Temperature): The DHT11 sensor continuously recorded blood storage temperature displayed on the LCD. Deviations outside the safe range of 2°C–8°C were detected and GSM alerts triggered, preventing spoilage compared to manual monitoring.

Inventory and Stock Management: Weight sensors tracked the number of blood bags per bay. Alerts were generated when stock dropped to or below the critical threshold (2 bags). The custom floatToChar() function ensured accurate sensor data in Firebase payloads, eliminating NaN errors in API transmission.

Communication and Alert System: The SIM800A GSM module successfully sent SMS alerts to registered staff during low-stock and temperature-breach events. The ESP-01 module transmitted JSON data to Firebase Firestore in real time, updating the web dashboard. The system functioned reliably even without constant internet by falling back to SMS-only mode.

REFERENCES AND FOOTNOTES:

1. A. G. Mousa, "A Blood Bank Management System-Based Internet of Things and Machine Learning Technologies," 2020.
2. R. R. Mahalle and S. S. Thorat, "Smart Blood Bank Based On IoT: A Review," Int. Res. J. Eng. Technol., vol. 6, no. 1, pp. 1–3, Jan. 2018.
3. S. Pargaien, A. V. Pargaien, and B. Chilwal, "Urge To Implement IoT For Monitoring and Preventing Blood Bank System Crisis," in Proc. 1st Int. Conf. Adv. Comput. Future Commun. Technol. (ICACFCT), Dec. 2021.
4. M. Mandale et al., "Implementation of Blood Donation Application using Android Smartphone," Int. J. Adv. Res. Ideas Innov. Technol.
5. M. Kumaran et al., "Artificial Intelligence-Enabled IoT-Based Smart Blood Banking System," 2022.
6. A. P. Singh, "Blood Bank Management System," Int. J. Sci. Res.
7. S. Umchid and P. Samae, "Design and Development of a Temperature Controlled Blood Bank Transport Cooler," IEEE, 2019.
8. M. Babu and A. Khan, "Internet of Things (IoT)-Based Smart Blood Bank Services: A Review," 2020.
9. "Smart Blood Bank Management: Urge To Implement IoT For Monitoring and Preventing Blood Bank System Crisis," J. Emerg. Technol. Innov. Res., vol. 11, no. 4, Apr. 2024.
10. "Smart Monitoring, Management and Control of Blood Bank Management System using IoT," 2023.