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SMART BLOODBANK SYSTEM AND TEMPERATURE MANAGEMENT

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ABSTRACT

Ensuring the safe storage, accurate tracking, and timely availability of blood remains a major challenge in healthcare systems, particularly during medical emergencies where real-time information is critical. This research addresses the question of how Internet of Things (IoT) technologies can be effectively utilized to improve blood bank management by enabling continuous monitoring, automated identification, and efficient communication between blood banks and hospitals. Blood units must be stored within strict temperature limits to preserve their quality, and manual monitoring methods are often unreliable and prone to human error. Additionally, traditional inventory systems lack real-time visibility and accurate traceability of blood units. To overcome these challenges, this study proposes an IoT-based blood bank management system using an ESP32 microcontroller integrated with a temperature sensor and RFID technology. The system continuously monitors storage temperature, uniquely identifies blood bags using RFID tags, and transmits real-time data to a centralized web server via Wi-Fi. A web-based application displays sensor data, blood inventory status, and enables hospitals to place blood orders online.

KEYWORDS: Blood Bank Management System, ESP32 Microcontroller, Rfid Technology, ESP32 Microcontroller, Internet of Things (IoT).

INTRODUCTION

Blood banks are critical healthcare facilities responsible for storing, managing, and supplying blood for medical emergencies and routine treatments. However, conventional blood bank systems largely depend on manual monitoring and record-keeping, which often results in inadequate temperature control, inefficient inventory management, delayed emergency response, and increased blood wastage **[1]**. Blood must be stored within strict temperature limits to maintain its safety and effectiveness, yet continuous manual monitoring is impractical and unreliable **[2]**. Additionally, the absence of real-time inventory visibility and automated identification increases the risk of human error and mismatched blood transfusions **[3]**.The primary objective of this work is to design and implement an IoT-based blood bank management system that enables real-time temperature monitoring, automated blood bag identification, and centralized data visualization. The system aims to utilize an ESP32 microcontroller integrated with a temperature sensor and RFID technology to continuously monitor storage conditions and accurately track blood units **[4]**. A web-based platform is developed to display real-time sensor data, manage blood inventory, and allow hospitals to place blood orders efficiently.

The goal of the experimental work is to evaluate the system's ability to accurately sense temperature, reliably identify blood bags using RFID, transmit data wirelessly to a server, and present meaningful information through a web interface. System performance is assessed based on accuracy, reliability, response time, and usability under normal and abnormal storage conditions **[5]**.

Previous studies have explored IoT-based temperature monitoring, RFID-based inventory systems, and web-based blood ordering platforms independently **[6].**

MATERIALS AND METHODS

The temperature sensor is placed inside the blood storage unit to continuously monitor environmental conditions. The RFID reader scans RFID tags to uniquely identify blood bags and retrieve corresponding information from the database. The ESP32 collects sensor and RFID data, processes it locally, and transmits the information wirelessly to the web server using HTTP-based IoT communication techniques **[1].**

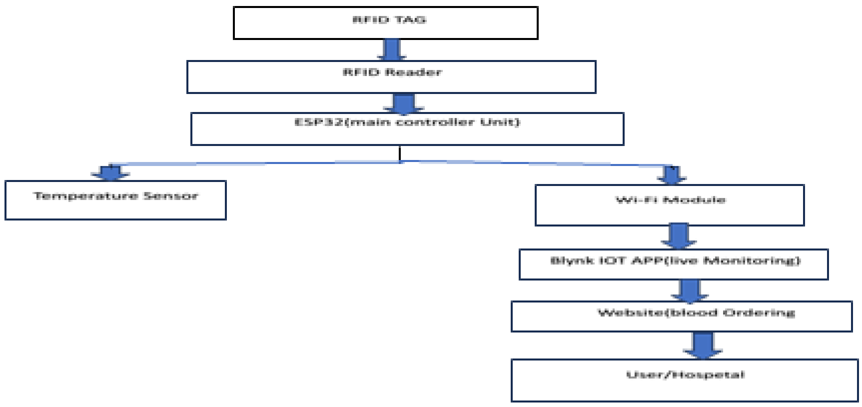
Material Used:

- Microcontroller: ESP32
- Temperature Sensor: DHT11
- RFID Sensor: MFRC522
- Website: myWebsite(own built)
- Database: Mysql
- Tools for execution: Arduino IDE, Tomcat Server

METHDOLOGY

The proposed IoT-based blood bank management system is developed using an integrated hardware– software approach to enable real-time monitoring, automated identification, and centralized data management. The methodology involves sensor data acquisition, wireless data transmission, server-side processing, and web-based visualization.

Initially, the DHT11 temperature sensor is installed inside the blood storage unit to continuously monitor the temperature conditions required for safe blood preservation. The sensor provides digital temperature readings at predefined intervals, which are captured by the ESP32 microcontroller. Simultaneously, the MFRC522 RFID reader scans passive RFID tags attached to individual blood bags to uniquely identify each unit and retrieve its corresponding details from the database.



The ESP32 processes the collected temperature and RFID data and transmits it wirelessly to a centralized server using Wi-Fi communication and HTTP protocols. This method enables real-time data transfer without the need for manual intervention. The received data is stored in a structured database and displayed through a web-based interface developed using standard web technologies. The website allows authorized users to monitor storage temperature, track blood inventory, receive alerts during abnormal conditions, and place blood orders efficiently.

Table1.Hardware Requirements.

Sr .N o.	Component	Specification
1.	Microcontroller	ESP32
2.	Temperature Sensor	DHT11
3.	RFID Sensor	MFRC522
4.	RFID Tag	MIFARE

RESULT AND DISCUSSION

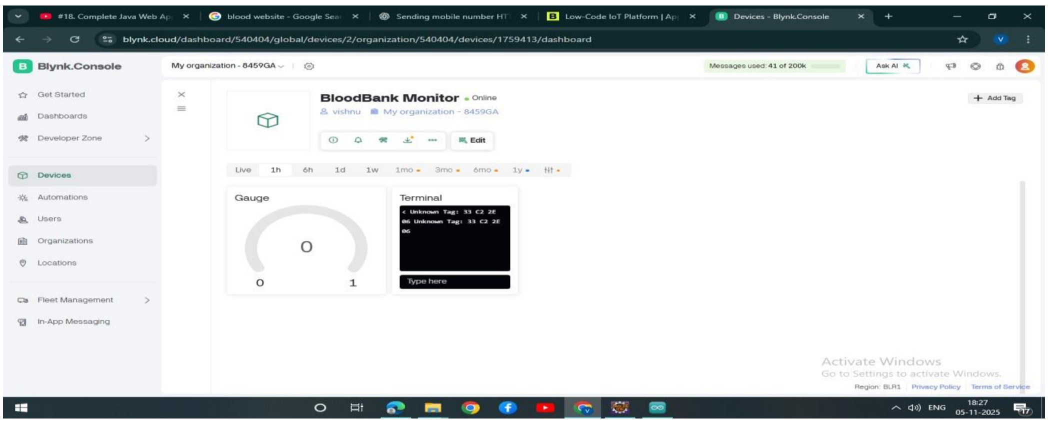
- Accurate temperature monitoring was achieved.

  The DS18B20 temperature sensor continuously monitored the blood storage temperature and provided real-time readings with minimal deviation from the reference thermometer. The average error observed was within acceptable medical storage limits, confirming the suitability of the sensor for blood preservation. A temperature vs. time graph can be used to clearly illustrate system stability under normal and abnormal conditions.
- Reliablen RFID-based blood bag identification was observed.

  The MFRC522 RFID reader successfully detected and identified RFID tags attached to blood bags without misreads. Each tag was uniquely recognized, reducing the chances of mismatched blood units. A table showing RFID tag ID, blood group, and availability status can be used to present inventory accuracy.
- Efficient wireless data transmission was achieved.

  The ESP32 microcontroller reliably transmitted temperature and RFID data to the web server using Wi- Fi. Data updates were reflected on the website with minimal delay, demonstrating low response time and reliable communication. A network latency comparison graph can support this result.
- Effective web-based visualization and blood ordering were implemented.

  The web application successfully displayed real-time temperature values, blood inventory details, and alert notifications during abnormal temperature conditions. Hospitals were able to place blood requests through the website, improving accessibility and response time. Screenshots of the dashboard and ordering page can be included for better clarity.



CONCLUSION

This work presented the design and implementation of an IoT-based blood bank management system that integrates real-time temperature monitoring, RFID-based blood bag identification, and web-based data visualization. The system effectively addresses key challenges in conventional blood bank operations, such as manual monitoring, inventory inaccuracies, and delayed response during emergencies. By utilizing an ESP32 microcontroller with temperature and RFID sensors, the proposed solution ensures continuous monitoring of blood storage conditions and accurate tracking of blood units.

The experimental results demonstrated reliable sensor performance, efficient wireless data transmission, and effective web-based monitoring and ordering capabilities. Automation of temperature control and blood identification significantly reduces human intervention, minimizes errors, and helps prevent blood wastage due to improper storage. The centralized web platform enhances accessibility, enabling healthcare facilities to make timely and informed decisions regarding blood availability.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

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