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IoT based Smart Blood Bank Management System

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***Abstract*—Shortage of blood is a major issue faced by blood banks and this is due to the lack of donors, this has led authorities to each out to the public via social media for patients who need blood transfusion urgently. A spike has been seen globally. In the efforts of utilising e-platforms to make the blood donation process more conveniently having a solid information system that allows donors and facilitating centres to communicate efficiently and coordinate with each other effortlessly. This study aims to incorporate blood bank data on its bloodstock and test results for both donors and medical facilitators; at the same time, allowing patients vital signs to be auto-updated to the application in order for medical practitioners to monitor remotely and provide the best care possible. In this project we have a bin which monitors the number of units available for each blood group and updates the dashboard in real time. Each blood pouch is associated with an RFID tag, which, when placed in the bin, monitors the quantity by RFID scanner. We also have a temperature sensor which monitors the temperature inside the bin. The data is shared to the cloud, and the data is monitored on the website made using Flask. A buzzer is triggered when the quantity is completed.**

***Index Terms*—Arduino mega, RFID em 18 scanner, RFID tags, DHT sensor, gsm module, LCD i2c adapter, power supply**

I. INTRODUCTION

Blood plays a vital role in saving lives, especially during surgeries, accidents, medical emergencies, and for patients suffering from chronic diseases like cancer or anaemia. Blood banks are the primary source of this life-saving resource, and they must ensure an uninterrupted supply of safe and compatible blood units. However, despite advances in medical science, many blood banks still face difficulties in managing blood inventory efficiently. Manual methods of tracking bloodstock and storage conditions often lead to human errors, delays in replenishment, and even spoilage of stored blood due to improper monitoring. As a result, there is an urgent need to enhance the reliability and accuracy of blood bank management through the use of technology. The traditional blood bank management systems are not equipped with real-time monitoring capabilities. This significant communication gap between hospitals, donors, and blood storage facilities. In many emergency cases, by the time the required blood group is arranged, critical time is lost, affecting the patient's chances of survival. Furthermore, lack of effective monitoring also leads to blood wastage due to expiry or temperature mishandling. This inefficiency not only affects patient care but also leads to financial losses and operational difficulties for healthcare providers. The evolution of the Internet of Things (IoT) provides a promising opportunity to overcome these challenges. IoT enables physical devices to collect and share data through the internet, allowing real-time monitoring, automation, and remote management. In the context of blood banks, IoT can be used to automate stock tracking, monitor environmental conditions, and send alerts to responsible authorities when action is required. Such a system not only increases efficiency but also ensures transparency and safety throughout the supply chain of blood management. In the proposed system, every blood pouch is embedded with an RFID tag, which uniquely identifies the blood group and unit. An RFID scanner placed inside the storage bin continuously reads the tags and updates the database accordingly. This helps in maintaining an accurate count of the available units of each blood group in real time. The data is then transmitted to a cloud server and displayed on a dashboard that can be accessed by hospital staff, blood bank officials, and authorities responsible for blood distribution and donations. Temperature plays a crucial role in the preservation of blood. If not maintained within the prescribed limits, blood can degrade and become unsafe for transfusion. To prevent such occurrences, a temperature sensor is installed within the storage bintomonitor the internal environment continuously. If the temperature crosses the permissible range, the system sends immediate alerts to the authorities and also triggers a buzzer alarm. This ensures that preventive measures can be taken before the blood gets spoilt, thereby enhancing patient safety. The integration of Flask-based web technology in this system adds an efficient interface for users to interact with the data. The Flask dashboard provides real-time statistics, graphical representations of stock levels, temperature logs, and notification alerts. Users can access this data through any internet-connected device, making remote monitoring feasible and efficient. This level of automation reduces dependency on manual labour, improves data accuracy, and speeds up decision-making processes, especially during emergencies. In conclusion, the IoT-based Smart Blood Bank Management System bridges the critical gaps in traditional blood bank operations. It creates a more efficient, transparent, and reliable platform for managing blood stock and storage conditions. With real-time tracking, remote access, and instant alerts, the system ensures better preparedness in medical emergencies, reduces wastage, and ultimately contributes to saving more lives. The integration of RFID, temperature monitoring, cloud computing, and a web dashboard makes this system a modern, scalable, and impactful solution for the healthcare sector. Related Works

Several research efforts have explored the application of IoT in healthcare systems, particularly focusing on efficient blood bank management. H. A. Attia, M. Takruri, and H. Y. Ali presented a system for electronic monitoring and protection to prevent drunk driving using local decision-making components, highlighting the importance of real-time response and system simplicity. While their work was centred around alcohol detection, it introduced the concept of locally processed sensor data, which can be analogously applied to IoT-based blood bank systems to ensure rapid alerts and efficient monitoring without depending solely on remote servers.K. Murata and colleagues proposed a noninvasive biological sensor system capable of detecting the effects of alcohol consumption by analysing physiological parameters like heart rate and pulse waves. Though their study focused on driver behaviour monitoring, it demonstrated how biological data can be monitored in real time using sensor networks and transmitted to a processing system for decision-making. This technique parallels the real-time tracking of blood unit availability and temperature monitoring in a smart blood bank system, thereby reinforcing the value of IoT-based sensor integration in healthcare.Further studies have delved into cloud-based healthcare monitoring systems. A study by N. Thomas and P. Leelavathy presented a smart health monitoring system using IoT for patient care, wherein sensors captured vital signs and transmitted them to the cloud for real-time updates. This model, similar to the architecture in the blood bank system, showcases how healthcare data can be efficiently managed through cloud integration, allowing medical professionals to respond quickly based on live data. Their research supports the concept of real-time inventory monitoring and centralised data availability in our project.In another relevant work, R. Sharma and M. Shrivastava developed a prototype for an IoT-based blood bank system that allowed blood donors and hospitals to communicate through a mobile app. Their focus was primarily on donor-hospital interaction and basic inventory control. While the concept was valuable, it lacked the integration of real-time physical monitoring through RFID and temperature sensors. Our proposed system builds upon this foundation by incorporating advanced sensing technologies and automated alerts to improve the overall management and reliability of blood storage.Additionally, various studies have emphasised the importance of maintaining proper environmental conditions for blood preservation. Research by S. Patel et al. addressed the risks associated with improper storage of medical resources and proposed temperature-based alerts in healthcare warehouses. Their findings highlight the necessity of real-time environmental monitoring, which aligns perfectly with our system’s inclusion of a temperature sensor inside the blood bin. Integrating such environmental safeguards ensures that blood units are not only tracked in quantity but also maintained under optimal storage conditions, making the system more comprehensive and dependable.

II. PROPOSED METHODS

The proposed system aims to revolutionise traditional blood bank management by incorporating the power of IoT and smart technologies to ensure real-time monitoring, transparency, and efficiency in handling blood units. At the core of the system lies an intelligent bin that is designed to monitor and manage the number of blood units available for. This bin is integrated with RFID technology, where each blood pouch is tagged with a unique RFID tag. As blood units are placed into or removed from the bin, an RFIDreader automatically detects the transaction and updates the inventory data in real time, eliminating the need for manual entry and reducing the chance of human error.One of the standout features of the proposed system is its integration with cloud computing. All data related to blood unit quantity, RFID identification, and storage conditions are instantly uploaded to a cloud-based database. This enables medical staff, administrators, and blood bank managers to access real-time information from any location through a dedicated web portal or dashboard. The dashboard, designed using Flask (a Python-based web development framework), displays the current stock of each blood group, historical data logs, and temperature.levels, offering a centralised and transparent view of the blood bank's operations.Temperature regulation is another critical factor addressed by this system. Blood products need to be stored under specific temperature conditions to preserve their viability. To ensure this, the proposed system incorporates a temperature sensor within the blood storage bin. This sensor constantly monitors the ambient temperature and transmits the data to the dashboard. In case of any abnormal rise or fall in temperature beyond the optimal range, the system immediately triggers an alert through a buzzer and a notification on the dashboard, allowing staff to take corrective actions swiftly.

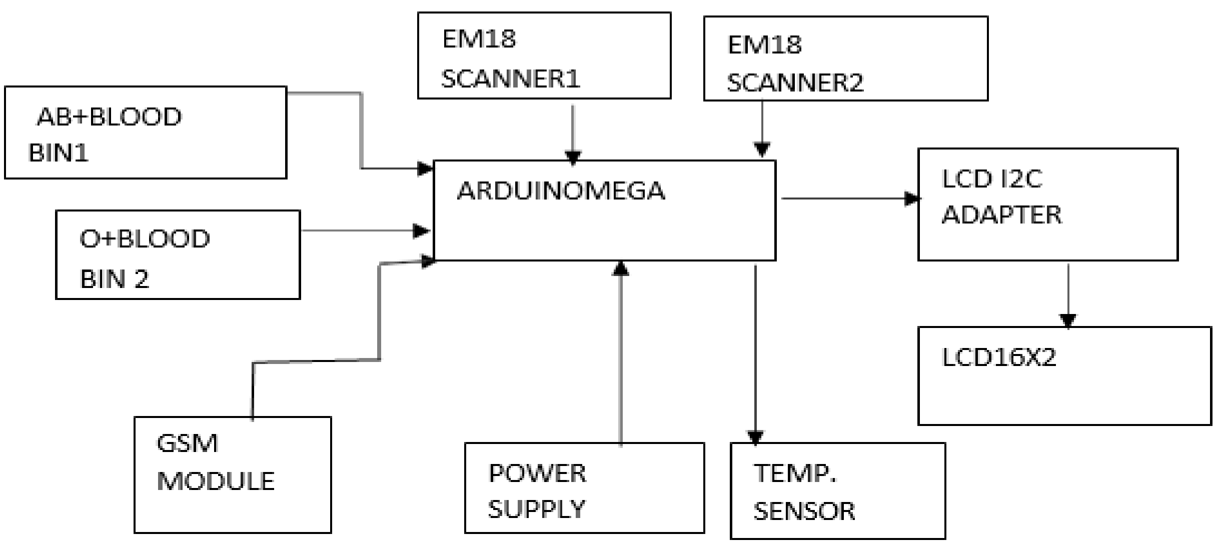

Fig.1: Proposed Methodology

II. HARDWARE REQUIREMENTS WE USE: ARDUINO MEGA

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It is designed for more complex projects requiring a higher number of input/output (I/O) pins, more memory, and enhanced processing power. It follows the same working principles as other Arduino boards but offers extended functionality. The board can be powered via a USB connection or an external power source (7-12V DC). When powered on, the microcontroller initialises andloads the bootloader, which allows the board to receive and execute code from the Arduino IDE. At the core of the Arduino Mega is the ATmega2560 microcontroller, which executes programmed instructions. It reads input signals from sensors, processes them using programmed logic, and produces output signals to control actuators, motors, LEDs, or displays. The board has 54 digital I/O pins (15 PWM-enabled) and 16 analogue input pins. These allow interaction with external devices such as switches, sensors, and displays. Inputs are read using functions like digitalRead() and analogRead(), while outputs are controlled using digitalWrite() and analogWrite(). The Arduino Mega supports multiple communicationprotocols, including UART (Serial), I2C, and SPI. These protocols enable the board to communicate with other microcontrollers, sensors, and external devices such as displays and motor drivers.Programs (sketches) are written in the Arduino IDE and uploaded via USB using a built-in ATmega16U2 chip, which acts as a USB-to-serial converter. The uploaded program is stored in flash memory and executed continuously in a loop (void loop ()). The Arduino Mega operates at a 16 MHz clock speed, ensuring smooth execution of tasks. Built-in timerscontrol PWM signals, delays, and interrupts, allowing precise timing operations for automation tasks. The board supports external shields and modules for additional functionality, such as Wi-Fi, Bluetooth, motor control, and LCD interfacing. This flexibility makes it suitable for advanced robotics, IoT, and automation projects. The Arduino Mega 2560 follows a simple yet powerful working principle—reading inputs, processing data, and generating outputs based on programmed logic. Its extensive I/O capabilities and communication interfaces make it ideal for complex electronic applications.

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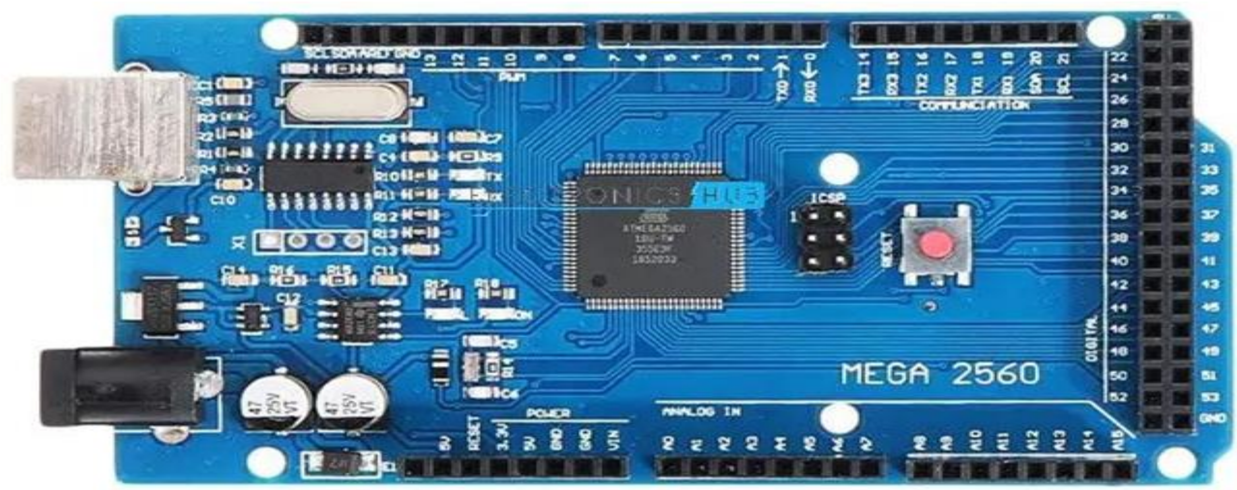


Fig.2: Arduino Mega

III. LCDI2CADAPTER

An I2C LCD adapter allows standard 16x2 or 20x4 character LCDs to communicate with microcontrollers like the Arduino Mega using the I2C protocol, significantly reducing the number of required connections. Instead of using 6-10 parallel pins, the adapter requires only two pins: SDA (Serial Data) and SCL (Serial Clock), making it ideal for projects with multiple peripherals. The adapter is based on the PCF8574 I/O expander chip, which converts I2C signals into parallel commands for the LCD. It also includes a contrast adjustment potentiometer and a software-controlled backlight toggle. The I2C address is usually 0x27 or 0x3F, but this may vary depending on the manufacturer. Since the Arduino Mega has multiple I2C ports, you must ensure you're using thecorrect ones: SDA is on pin 20, and SCL is on pin 21. Since the Arduino Mega supports multiple I2C devices on the same bus, the I2C LCD adapter is an ideal solution for projects that require additional sensors or peripherals while keeping wiring simple. Using I2C allows multiple modules (such as temperature sensors, EEPROMs, or real-time clocks) to communicate over the same two pins, making the Mega's extra GPIO pins available for other tasks. This modular approach not only reduces complexity but also enhances the scalability of projects. Whether you're working on a robotics project, a data-logging system, or an automation setup, the I2C LCD adapter provides an efficient and reliable way to display information with minimal display information wiring effort. To use an I2C LCD adapter with the Arduino Mega, connect VCC (5V), GND, SDA (pin 20), and SCL (pin 21). Then, install the LiquidCrystal_I2C library in theArduino IDE. In the code, initialise the display with LiquidCrystal_I2C lcd(0x27, 16, 2); call lcd.init(); to start it, and use lcd.print("Hello, Mega!"); to display text. If the LCD doesn't show anything, run an I2C scanner sketch to detect the correct address. Common troubleshooting steps include checking wiring,adjusting contrast, and ensuring the backlight is on. Since the Arduino Mega supports multiple I2C devices, this adapter is perfect for expanding projects that require additional sensors or modules while keeping wiring simple and efficient.

Fig.3:LCDI2C Adapter

IV. EM18SCANNER

The EM-18 RFID scanner is a popular 125 kHz RFID reader used for applications such as access control, attendance systems, and inventory management. It operates by emitting a low-frequency electromagnetic field, which activates nearby passive RFID tags, allowing the reader to capture and transmit their unique 12-character ID. The EM-18 module can communicate with microcontrollers like the Arduino Mega using either a UART (serial) or Wiegand interface. The UART mode is the most common and convenient for Arduino projects, as it sends RFID tag data in a simple serial format. Since the Arduino Mega has multiple hardware serial ports (Serial1, Serial2, Serial3) in addition to the default Serial0 (USB communication), it is well-suited for handling RFID data without interfering with other connected peripherals. To connect the EM-18 to an Arduino Mega, wire VCC (5V), GND, TX (from EM-18) to RX1 (pin 19 on the Mega), and optionally RX (from EM-18) to TX1 (pin 18) if bidirectional.Communication is needed. In the Arduino IDE, initialise the serial communication using Serial1. begin (9600); then read the tag data using Serial1.read(); When an RFID tag is scanned, the EM-18 sends a 12-character unique ID over the serial connection, which can be displayed on the Serial Monitor or processed further for authentication. If the Wiegand interface is used, additional libraries and wiring considerations are required. Ensuring the correct baud rate (9600 bps by default) and proper grounding helps prevent communication errors. With its ease of use and reliable performance, the EM-18 RFID scanner is a great addition to Arduino Mega projects that require RFID-based identification. Because the Mega has multiple serial ports, it can integrate the EM-18 alongside other communication modules like Wi-Fi, Bluetooth, or GSM. This makes it ideal for developing smart security systems, automated attendance tracking, or industrial inventory management solutions. The low cost, plug-and-play setup, and compatibility with existing Arduino libraries make the EM-18 an efficient and effective choice for RFID-based projects.

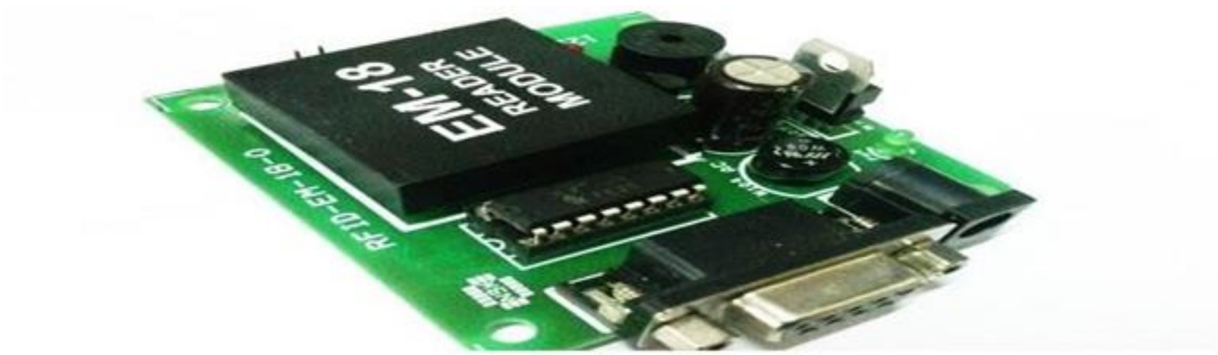


Fig.4:EM18Scanner

V. DHT SENSOR

A DHT sensor is a widely used temperature and humidity sensor that provides digital output, making it easy to interface with microcontrollers like the Arduino Mega. The most common models are the DHT11 and DHT22, both of which use a capacitive humidity sensor and a thermistor to measure environmental conditions. The DHT11 is more affordable but has lower accuracy and a limited temperature range (0°C to 50°C, ±2°C accuracy), while the DHT22 offers higher precision and a wider range (-40°C to 80°C, ±0.5°C accuracy). These sensors communicate using a single-wire digital protocol, which requires only one data point to transmit readings, making them efficient for weather monitoring, greenhouse automation, and smart homes.projects. They typically update their readings every 1-2 seconds, making them suitable for real-time environmental tracking. To connect a DHT sensor to an Arduino Mega, wire VCC to 5V, GND to GND, and the data pin to any digital I/O pin (e.g., pin 7), using a 10 kΩ pull-up resistor between VCC and the data pin for stable communication. In the Arduino IDE, the DHT library simplifies data retrieval with functions like dht.readTemperature(); and dht.readHumidity();. The Arduino Mega can process these readings and display them on LCDs, serial monitors, or IoT dashboards, enabling remote monitoring and automation. Since the DHT sensor is easy to use and power-efficient, it is ideal for projects like indoor climate monitoring, agricultural automation, and weather stations. However, its slow refresh rate and sensitivity to long wires require careful placement and shielding in complex applications.

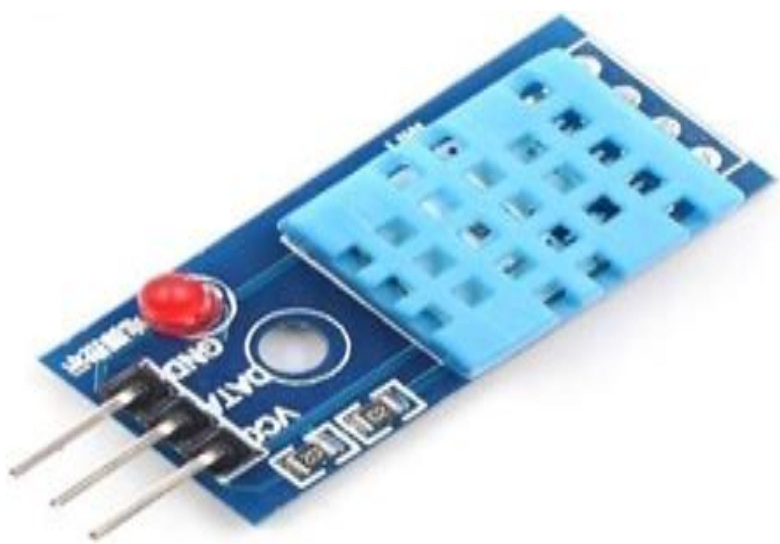


Fig.5.DHT Sensor

VI. GSM

The Global System for Mobile Communications (GSM) is a widely used standard for digital cellular communication, providing a reliable and efficient means of voice and data transmission. Developed to enable seamless communication across borders and different mobile networks, GSM has become the dominant technology for mobile communication globally. One of its key features is the use of SIM (Subscriber Identity Module) cards, allowing users to easily switch devices while retaining their identity and data. GSM technology facilitates voice calls, text messaging, and data transfer, making it a fundamental aspect of modern telecommunications. infrastructure. Beyond personal communication, GSM technology finds application in various sectors, particularly in machine-to-machine (M2M) communication and the Internet of Things (IoT). GSM modules, equipped with embedded SIM cards, enable devices to connect to cellular networks, facilitating remote monitoring and control. This capability is harnessed in applications like smart agriculture, where GSM-enabled sensors can transmit real-time data on environmental conditions, allowing farmers to make informed decisions. Additionally, GSM plays a critical role in security systems, asset tracking, and other M2M applications, demonstrating its versatility and reliability in enabling connectivity across a diverse range of devices and industries.

Fig.6: GSM

VII. POWER SUPPLY

A power supply board that converts alternating current (AC) to direct current (DC) is a fundamental component in numerous electronic devices and systems. This conversion is crucial because many electronic devices, such as computers, routers, and electronic gadgets, require stable and controlled DC voltage to function properly. The power supply board typically consists of a rectifier circuit, which converts AC to pulsating DC, followed by filtering components like capacitors to smooth out the pulsations. Additionally, voltage regulation components such as voltage regulators may be included to ensure a steady and reliable DC output. This board plays a pivotal role.in providing the necessary and regulated power for the optimal operation of electronic equipment. In various industries, from telecommunications to home appliances, power supply boards are tailored to meet specific voltage and current requirements. Switching power supply boards, known for their efficiency and compact design, have become prevalent due to their ability to convert AC to DC with minimal energy loss. The continuous evolution of power supply board technologies contributes to enhanced energy efficiency, smaller form factors, and improved overall performance in the diverse range of electronic devices we encounter in our daily lives.

Advantages and Applications

ADVANTAGES:

- Realtimemonitoring.
- Accuracy and reliability.
- Safety and quality control.
- Enhanced accessibility and remote monitoring.
- Alert and notification system.

APPLICATIONS

- The incorporation of AI-driven predictive analytics.
- Use of blockchain technology for secure and

transparent blood tracking.

- Expanding IoT integration for automated refrigeration control.
- Integrating GPS-based tracking for blood transportation.
- Implementing an automated donor notification system.
- Voice-command and chat bot integration.
- Global data-sharing networks.

VIII. KIT FINAL RESULTS:

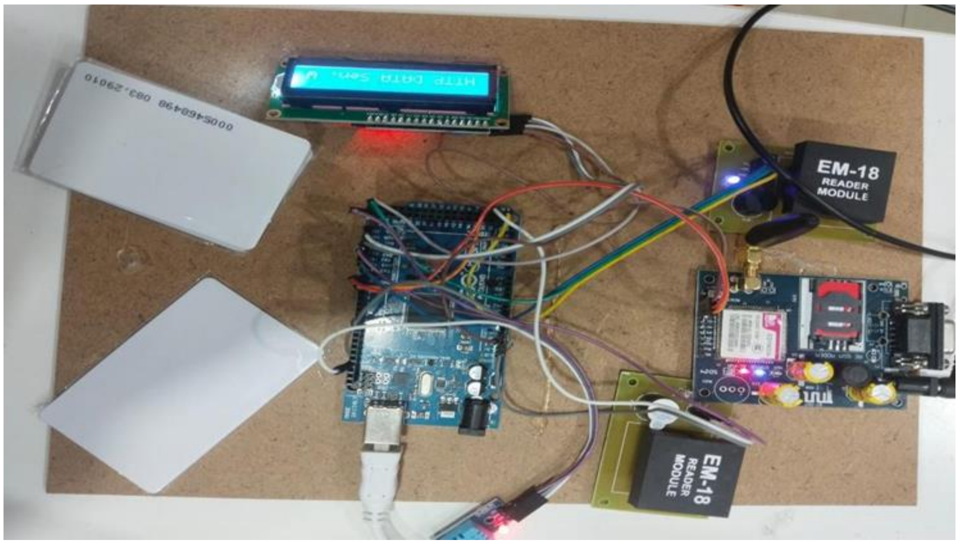


Fig.6: Totalkit

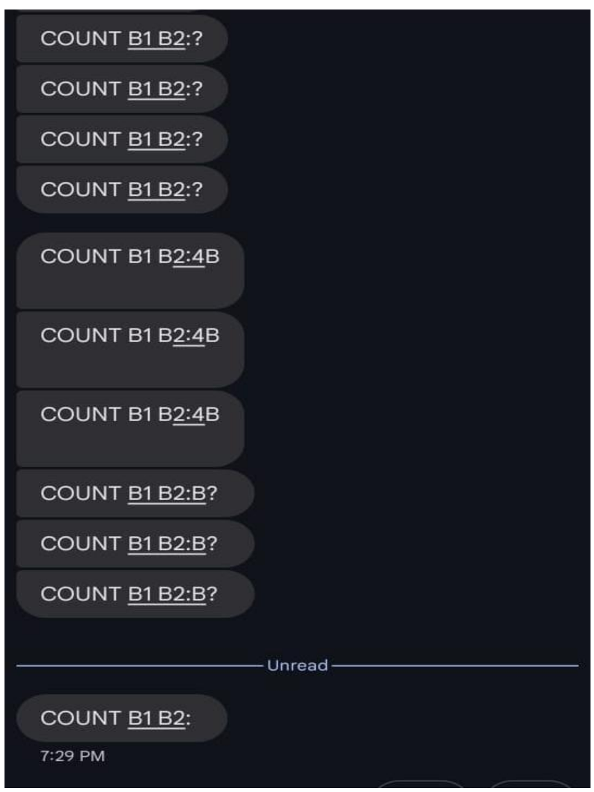
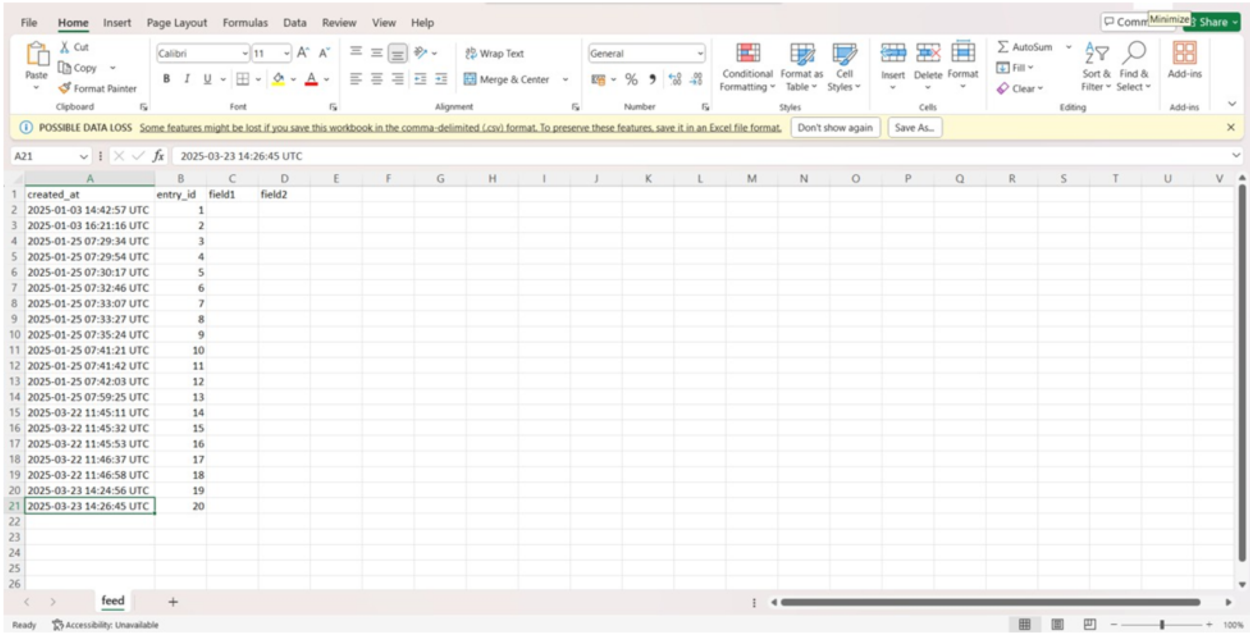


Fig6: Messageupdate



created_at	entry_id	field1	field2
2025-01-03 14:42:57 UTC	1		
2025-01-03 16:21:16 UTC	2		
2025-01-25 07:29:34 UTC	3		
2025-01-25 07:29:54 UTC	4		
2025-01-25 07:30:17 UTC	5		
2025-01-25 07:32:46 UTC	6		
2025-01-25 07:33:07 UTC	7		
2025-01-25 07:33:27 UTC	8		
2025-01-25 07:35:24 UTC	9		
2025-01-25 07:41:21 UTC	10		
2025-01-25 07:41:42 UTC	11		
2025-01-25 07:42:03 UTC	12		
2025-01-25 07:59:25 UTC	13		
2025-03-22 11:45:11 UTC	14		
2025-03-22 11:45:32 UTC	15		
2025-03-22 11:45:53 UTC	16		
2025-03-22 11:46:37 UTC	17		
2025-03-22 11:46:58 UTC	18		
2025-03-23 14:24:56 UTC	19		
2025-03-23 14:26:45 UTC	20		

Fig.7: Serverupdate

All hardware components (RFID scanners, LCD display, GSM module, etc.) are assembled and connected to get the required output on the LCD screen as shown in Fig. 5. RFID tags simulated new blood packet entries and removals, and the data is shown in Fig. 6. Real-time synchronisation is tested between hardware and cloud storage. When an RFID-tagged blood packet is scanned, Arduino identifies the blood type and sends this data to the cloud and the The update was shown in Fig. 7. Scan multiple RFID tags and verify the correct identification and tracking on the interface. Over-temperature alerts are tested to ensure SMS are triggered as designed. The temperature sensor (DHT) is connected to Arduino analogue/digital pins. The Arduino reads the temperature and sends the data via serial or GSM module. Arduino sends the data to a cloud platform like Thing Speak via the GSM module.

IX. CONCLUSION

The IoT-based Smart Blood Bank Management System has been designed and implemented to address the persistent challenges faced by traditional blood banks, such as manual record-keeping, delayed inventory updates, inefficient stock monitoring, and lack of real-time access to critical information. By integrating RFID technology, temperature sensors, and cloud-based dashboards, this system offers an intelligent, automated, and reliable solution for managing blood units efficiently and accurately. The proposed system ensures that the quantity of each blood group is monitored in real-time, which helps in avoiding stockouts or overstocking, ultimately leading to better inventory management. The use of RFID tags for every blood pouch provides traceability and accuracy, eliminating manual data entry errors. This enhances the overall operational workflow and allows blood bank personnel to focus more on service delivery rather than administrative tasks.One of the key highlights of this system is the incorporation of a temperature monitoring mechanism. Maintaining the ideal temperature for storing blood is crucial to ensure its quality and usability. The continuous monitoring and instant alert system helps staff to take immediate corrective actions in case of any temperature fluctuations, thereby preserving the integrity of the blood units and reducing wastage due to spoilage. The system's web-based dashboard, developed using Flask, plays a vital role in data visualisation and remote access. Stakeholders can view the live status of bloodstock and temperature conditions from anywhere, ensuring transparency and accountability. This also facilitates better decision-making and helps in planning for upcoming blood donation drives or procurement processes in advance. In addition, the alert system for low-stock levels ensures proactive replenishment of critical blood groups. The buzzer and digital alerts enhance the responsiveness of the system by notifying the concerned staff promptly, thereby reducing delays in blood availability, especially during emergencies or high-demand situations. This timely action mechanism significantly improves the quality of healthcare service delivery. From a broader perspective, the implementation of such a smart system supports the digital transformation of healthcare infrastructure. It not only ensures better management but also supports scalability for future enhancements like integration with donor databases, automated expiration alerts, and advanced analytics for predicting blood demand trends. In conclusion, the IoT-based Smart Blood Bank Management System offers a comprehensive, scalable, and future-ready approach to managing blood bank operations. It bridges the gap between technology and healthcare, ensuring that every drop of donated blood is stored, monitored, and utilised in the most efficient and responsible manner. The project showcases how smart technologies can significantly improve lives and strengthen the foundation of life-saving services.

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