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# A Comprehensive Review of Real-Time Blood Inventory Management Systems

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***Abstract - During medical emergencies, the prompt supply of blood can be the key to survival. Conventional blood banking systems usually suffer from issues like manual inventory management, ineffective donor recruitment, and lack of interoperability among hospitals and blood banks. This document presents DONARNET, an intelligent real-time blood stock management system that closes the gap among hospitals, blood banks, and volunteer donors. Principal innovations are geolocation - based donor filtering and notification, real-time inventory visibility, and a First-In-First-Out (FIFO) policy to reduce wastage of blood. The system also ensures scalability and improves responsiveness through mobile and web access, making it a comprehensive solution for modern healthcare infrastructure.***

***Keywords—Blood Bank Management, Real-Time Inventory, Donor Authentication, Blood Compatibility, Automated Notifications, FIFO Stock Management.***

## I. INTRODUCTION

Blood shortages continue to challenge global healthcare systems, especially during emergencies, natural disasters, and large-scale surgical operations. The unpredictability of blood demand, coupled with the limited shelf life of stored blood (typically 35–42 days), necessitates a system that can intelligently manage blood donations, storage, and distribution. Traditional blood bank systems often rely on manual record-keeping, fragmented communication channels, and static databases that fail to provide real-time insights into stock levels or donor availability. These shortcomings frequently result in delayed responses, inefficient inventory usage, and, in worst-case scenarios, preventable fatalities due to unavailability of compatible blood types.

To resolve these critical problems, we introduce DONARNET—a cloud-based, smart blood inventory management system that facilitates real-time communication and coordination among stakeholders. DONARNET features some sophisticated features such as geolocation-based identification of donors, blood compatibility checks, automated notification to donors, and a First-In-First-Out (FIFO) stock management policy to reduce wastage. A newly introduced chatbot assistant also improves user experience by providing real-time support and guidance to donors and hospitals.

The system is designed to scale and is web as well as Android accessible so that hospitals, donors, and inventory managers are able to engage with the system from any location and device. It seeks to transform the process of requesting, tracking, and delivering blood—changing reactive blood bank management to a proactive and predictive one.

By means of automation, centralization of data, and smart analytics, DONARNET not only provides timely access to blood but also enhanced donor participation, lesser administrative burden, and enhanced medical emergency preparedness. The proposed system is an important step towards creating a robust, efficient, and life-supporting healthcare framework. Through automation, data centralization, and intelligent analytics, DONARNET ensures not only timely availability of blood but also improved donor engagement, reduced administrative overhead, and better preparedness for medical emergencies. The proposed system represents a significant step toward building a resilient, efficient, and life-saving healthcare infrastructure.

## II. EASE OF USE

Most existing blood bank management systems face significant usability challenges due to their reliance on manual operations and outdated technologies. The absence of centralized, real-time inventory tracking limits visibility across facilities, often resulting in delays during emergencies and mismanagement of blood supplies. Without automated updates, hospitals and blood banks struggle to maintain accurate records, leading to either shortages or wastage of blood units.

Manual donor outreach is another major limitation. Traditional systems depend on phone calls or basic messaging, which delays donor mobilization during critical periods. DONARNET addresses this by introducing automated, location-based notifications to eligible donors using SMS, email, and mobile app alerts. This ensures faster response times and improved coordination during emergencies.

A key advancement in DONARNET is its real-time blood compatibility checker, which automatically validates blood types against request parameters. This eliminates the need for manual cross-checking, reduces the risk of transfusion errors, and speeds up the matching process.

Additionally, many legacy systems lack stock rotation policies, leading to the expiration of viable blood units. DONARNET implements a First-In-First-Out (FIFO) policy to ensure older units are used first, minimizing waste and optimizing resource utilization.

A significant enhancement in ease of use is the integration of a chatbot assistant. This AI-powered module guides users through common tasks, such as submitting requests, checking eligibility, or navigating the dashboard. It provides 24/7 support to donors

and hospital staff, reducing the need for technical training or human support.

The platform also enables automated escalation when blood is not available locally. It intelligently queries nearby inventories and notifies eligible donors in the vicinity, ensuring timely resolution of urgent requests. This eliminates delays caused by manual coordination between facilities.

Lastly, DONARNET ensures data security and usability through role-based access control and encrypted cloud storage. This protects sensitive donor and hospital data while enabling seamless access across devices via web and mobile platforms.

In essence, DONARNET enhances usability by streamlining operations, minimizing manual tasks, and providing intelligent tools for decision-making. Its automation, intuitive interface, and smart notification system make it a highly efficient solution for real-time blood inventory management.

## III. System Features

The DONARNET system proposed incorporates several intelligent aspects that automate, streamline, and secure blood bank processes. Every component addresses particular shortcomings in existing systems, seeking to enhance efficiency, responsiveness, and user satisfaction.

### 1. Donor Authentication

The system authenticates donor identities and health suitability prior to accepting blood donations. Donor profiles consist of certified medical history, blood group, previous donation date, and state of health. This ensures that only safe and qualified donors are involved, minimizing the chances of complications during transfusion.

### 2. Real-Time Inventory Management

DONARNET has a current inventory of blood stock at more than one site. Donation or request automatically refreshes the stock in real time. Blood banks and hospitals are able to see current availability by blood type, quantity, and date of expiration in an instant. This reduces lag time and avoids stock mismatches or overstocking.

### 3. Blood Compatibility Checker

The system performs automated donor and recipient blood type compatibility checks. The engine will instantly verify available blood units for compatibility when a request is submitted, eliminating manual cross-references and transfusion mistakes.

### 4. Automated Donor Notifications

DONARNET automatically alerts eligible donors by SMS, email, or app notification during shortages. The notifications are tailored according to blood group, previous donation date, and location. This helps to increase the response rate and encourage more donors, particularly in crisis situations.

### 5. Donor Filtering and Eligibility Checks

The system filters donors according to parameters like age, previous donation (at least two-month wait), and medical information. It only calls in eligible and accessible donors, supporting medical guidelines as well as optimizing donation success.

### 6. FIFO-Based Stock Management

To reduce blood wastage due to expiration, DONARNET follows a First-In-First-Out (FIFO) policy. It prioritizes older blood units for dispatch, ensuring that stored blood is used within its shelf life and enhancing overall resource efficiency.

### 7. Cross-Inventory Blood Request Routing

If the local inventory of a hospital does not have the requested blood type, the system automatically searches nearby inventories and propagates the request. This cross-inventory routing provides timely delivery and optimizes demand management across regions.

### 8. Registration Modules

There are separate registration modules for donors, hospitals, and blood bank personnel. Each user category is given personalized dashboards and permissions. The system accommodates role-based access control to provide secure and proper system usage.

### 9. Chatbot Assistant

There is an integrated AI chatbot in the web and mobile platforms. It provides 24/7 support for activities like verifying donor eligibility, system navigation, requesting, or viewing inventory status. The chatbot improves usability and minimizes reliance on training or human assistance.

### 11. Secured Handling of Data

DONARNET adopts stringent security measures such as end-to-end encryption, cloud storage, and role-based access control (RBAC). All sensitive information—donor information and medical history—is secured from unauthorized use and cyber attacks.

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## IV. COMPARATIVE STUDY

1. Analysis Models

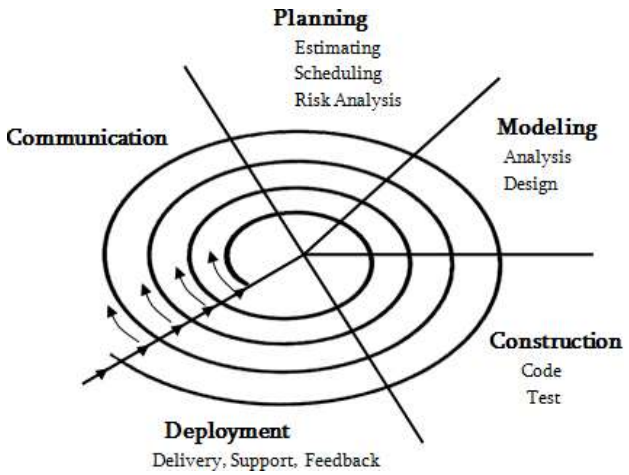


Fig 1.1 Spiral Model SDLC

We Use Spiral Model as the Software Development model focuses on the people doing the work how they work together and risk handling. We are using Spiral because it ensures changes can be made quicker and throughout the development process by having consistent evaluations to assess the product with the expected outcomes re- quested.

As we developed the application in the various modules, spiral model is best suited for this type of application. A Spiral approach provides a unique opportunity for clients to be involved throughout the project, from prioritizing features to iteration planning and review sessions to frequent algorithms containing new features, As our model consists of lot of risk and spiral model is capable of handling the risks that's the reason we are using spiral model for product development.

- Why We Use the Spiral Model ?

1. Risk Handling**:** One of the primary reasons for choosing the Spiral Model is its structured risk management process. Each phase of the spiral begins with identifying potential risks and implementing strategies to mitigate them. Given the critical nature of our system — dealing with life-saving blood availability and urgent hospital requests — risk handling is vital to ensure system reliability and accuracy.
2. Flexibility for Changes**:** The Spiral Model supports frequent evaluations and allows for incorporating changes at any stage of development. This flexibility ensures that evolving user requirements, stakeholder feedback, or unexpected technical challenges can be addressed promptly without derailing the overall progress.
3. Modular Development**:** Our application consists of several independent yet interlinked modules, such as the Donor Module, Hospital Interface, Notification System, and Blood Inventory Management. The Spiral Model allows us to develop and refine these modules in iterations, improving one segment at a time and integrating them progressively.
4. Client Involvement: The model provides a unique opportunity for stakeholders — such as healthcare professionals, donors, and system administrators — to be involved throughout the lifecycle. They can participate in planning, feature prioritization, algorithm testing, and review sessions to ensure the system meets real-world needs.

2. System Design

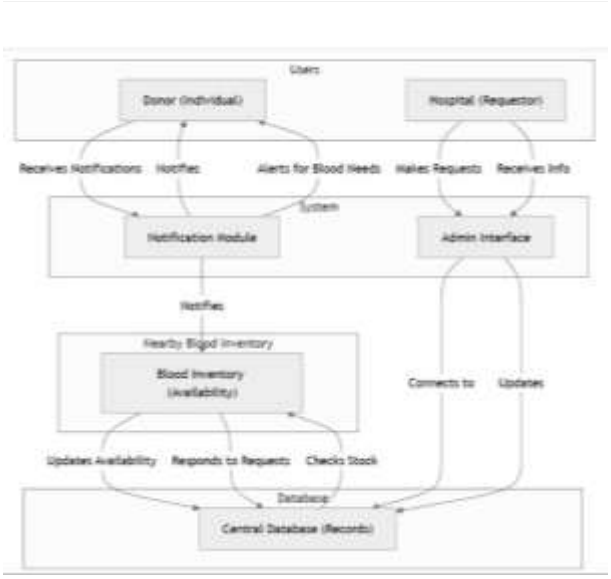


Fig.1.2 System Architecture

The proposed system architecture is designed to manage and streamline the process of blood donation, request, and inventory tracking in real-time. It involves key components including users (donors and hospitals), system modules (notification and admin interface), nearby blood inventories, and a central database.

.1. Users:

1.1 Donor (Individual):

- Represents individual blood donors.
- They are notified by the system when blood of their type is required.
- They receive notifications from the system's notification module about blood needs, and may respond by donating blood.

1.2 Hospital (Requestor):

- Represents healthcare institutions such as hospitals or clinics that require blood for medical needs.
- Hospitals make requests through the system for blood based on patient requirements.
- They also receive information from the system about the availability of blood in nearby inventories or through donors.

2. System

1.1 Notification Module:

A central system that handles communication between hospitals, blood donors, and nearby blood inventories.

This module alerts donors of specific blood needs when a request is made by a hospital.

It also notifies nearby blood inventories to check for the availability of blood, and informs the hospital about the status of blood stock.

1.2 Admin Interface

- The admin interface is used by hospitals to manage blood requests and to communicate with the central database and notification system.
- It allows hospitals to make blood requests, receive updates, and check the current availability of blood.
- The admin interface is also connected to the central database, updating the system on the hospital's requirements.

3. Nearby Blood Inventory

1.1 Blood Inventory (Availability):

- The nearby blood inventory represents external blood banks or regional blood storage centers that manage available blood stock.
- When the notification module sends a request, the blood inventory responds to requests from hospitals, either confirming available stock or notifying a shortage.
- Blood inventories also update availability in the central database, which is accessible to hospitals via the admin interface.
- The inventory checks stock internally and synchronizes with the central database, ensuring that the system has up-to-date information.

4. Database

1.1Central Database (Records):

- A centralized repository that stores data related to blood donors, blood requests, hospital needs, and blood inventory levels.
- The database is directly connected to both the admin interface (allowing hospitals to check and update information) and the nearby blood inventories (to check stock availability and update the system).
- It serves as the system's backbone, maintaining all critical records about the entire operation and supporting seamless communication across all modules.

## V. Future Enhancements

The proposed Real-Time Blood Inventory Management System can be further enhanced in several ways:

- Cloud-Based Integration: Future versions of the system can be implemented as cloud-based solutions to support broader access and scalability. This would allow seamless data sharing between different blood banks and healthcare providers.
- Android and Web Expansion: An Android-based mobile application alongside a web interface would enable donors, hospitals, and blood banks to interact with the system from any device, enhancing accessibility.
- Advanced Analytics: Integrating machine learning algorithms could improve forecasting of blood demand, leading to better stock management and resource allocation.
- Country-Specific Statistics: Including country specific statistics would allow the system to adjust based on local blood donation trends, needs, and regulations, improving its efficiency in various regions.
- AI-Powered Donor Matching & Eligibility Prediction: Incorporating Artificial Intelligence (AI) models can help predict donor eligibility based on historical health data, lifestyle patterns, and past donation history. This would reduce manual checks and help prioritize outreach to high-potential donors.
- IoT Integration for Smart Inventory Monitoring: Internet of Things (IoT) devices can be installed in storage units to automatically monitor blood temperature, expiry dates, and stock levels in real time, sending alerts to administrators for proactive action.
- Biometric Verification for Donor Identity Biometric systems like fingerprint or facial recognition can be used to verify donor identity securely and quickly during registration and donation, reducing fraud and duplication.

## VII. CONCLUSION

Finally, the Real-Time Blood Inventory Management System presents an improved alternative compared to current blood supply management options, solving significant issues confronting healthcare systems worldwide. With features such as real-time updating, computerized donor reminders, and FIFO inventory management, the system makes it possible for blood donations, requests, and stock to be processed more precisely and effectively. These developments minimize human error, maximize the use of inventory, and enhance the system's overall responsiveness, thus becoming an essential tool during emergency or peak-demand situations.

The automation and multiplatform capabilities of the system enable healthcare professionals to access and control inventory information effortlessly, improving decision-making and resource management. Real-time tracking of blood donations and requests for blood ensures that patient needs are addressed better and blood shortages or expirations minimized.

Looking ahead, the system's potential for future enhancements, including cloud integration, mobile access, and advanced analytics, holds the promise of further enhancing its capabilities. Cloud integration will enable greater scalability and storage, while mobile access will enable healthcare providers to have real-time data on the move. Advanced analytics may enable more precise demand forecasting, enhancing inventory management and ensuring optimal blood supply availability.

In total, this system provides a strong and scalable solution to real-time blood inventory management that is a more efficient and effective alternative to existing methods and advantageous to healthcare providers globally.

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