International Journal of Research Publication and Reviews, Vol 6, Issue 12, December, 2025, Page 2040-2043

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Bloodchain: Decentralized Real- Time Blood & Plasma Network

Dhiraj Kumar[1], Aryan Kumar[2], Vaishnavi Sharma [3], Prof. Sushil Kumar

B.Tech Scholars[1],[2],[3] Assistant Professor Department of Computer Science & Engineering Oriental Institute of Science & Technology, Bhopal (M.P), India

Abstract:-

The healthcare infrastructure in developing nations faces critical challenges in blood supply chain management, primarily due to a reliance on centralized, hospital- dependent systems that lack real-time data and fail in rural or low-connectivity regions. This project, "BloodChain" introduces a revolutionary decentralized peer- to-peer (P2P) network designed to eliminate hospital dependency and automate the donor-recipient connection process.

The system leverages a robust technology stack comprising Next.js 15, PostgreSQL with Prisma ORM, and PostGIS for precision geospatial querying. To ensure trust without intermediaries, the architecture integrates a blockchain-based "Proof of Medical Authenticity" (POMA) consensus mechanism for donor verification. Furthermore, to address volatile network infrastructure, the system utilizes a Progressive Web Application (PWA) architecture with Service Workers to ensure offline-first functionality.

An "Intelligent Matching Engine" utilizing Random Forest classifiers and Genetic Algorithms (NSGA-II) optimizes donor selection based on location, urgency, and reputation. This comprehensive approach aims to democratize access to life-saving resources, ensuring transparency, speed, and reliability at a national scale.

Keywords— Decentralized Network, Blockchain, Artificial Intelligence, Geospatial Tracking, Healthcare.

INTRODUCTION

This project, titled "Decentralized Real-Time Blood & Plasma Network," proposes a radical redesign of the traditional blood donation ecosystem. It moves away from the legacy, hospital-centric model—which relies on centralized storage, manual inventory tracking, and replacement donor dependence—toward a fully autonomous, peer-to-peer (P2P) network. This proposed system is architected specifically for the Indian national market, addressing unique local challenges such as "blood deserts" in rural areas, the lack of real-time inventory visibility, and the fragmented nature of blood bank administration.

LITERATURE SURVEY

To design a robust and effective solution, a thorough investigation into the current state of blood donation systems, the technological advancements in decentralized networks, and the specific socio- economic context of India is essential.

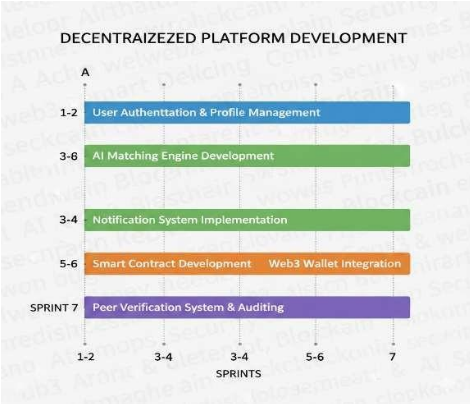
The Indian Blood Transfusion Landscape:- The blood transfusion service in India is a complex network of over 4,000 licensed blood banks, regulated primarily by the Drugs and Cosmetics Act of 1940 and overseen by the National Blood Transfusion Council (NBTC). Despite a regulatory framework that mandates voluntary donation, the system relies heavily on "replacement donors"— family members or friends coerced by necessity to donate in exchange for blood released to a patient. This reliance stems from a chronic shortage; India faces an annual deficit of approximately 3-4 million units of blood.

Recent government initiatives like e-RaktKosh have attempted to digitize the supply chain. e-RaktKosh serves as a central portal for blood availability. However, literature indicates significant limitations:

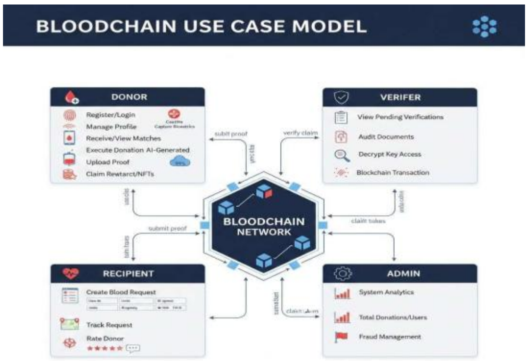
PROPOSED MODEL

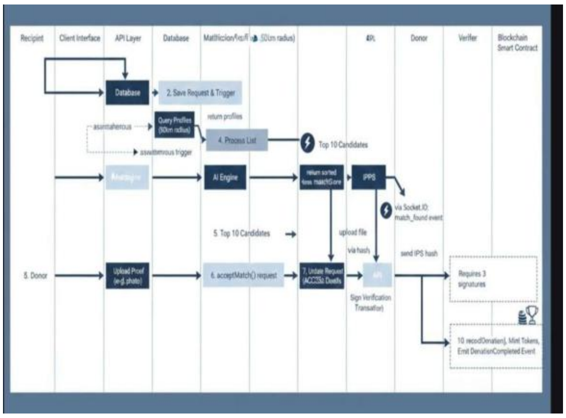
The development of Bloodchain follows the **Agile Scrum** methodology. This iterative approach is selected over the traditional Waterfall model due to the inherent complexity and novelty of the project. Blockchain development, in particular, requires a flexible process; smart contracts are immutable once deployed, meaning they must be rigorously tested and iteratively refined on test nets before final deployment. Similarly, the AI matching thresholds need to be tuned based on real-world feedback, which fits perfectly into Agile's sprint-based structure.

The project is divided into 2-week sprints.

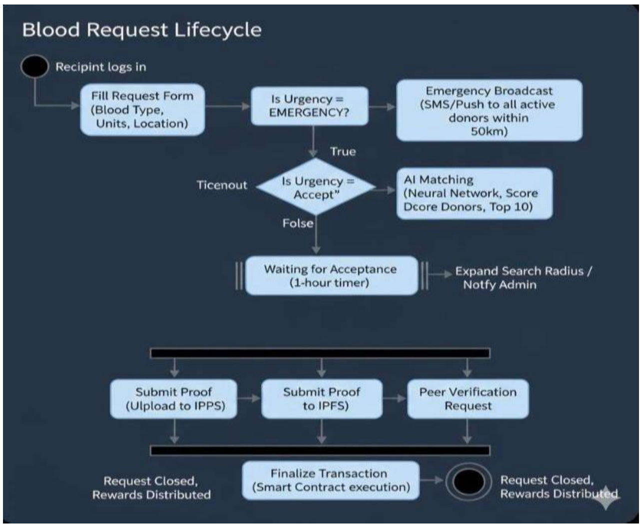


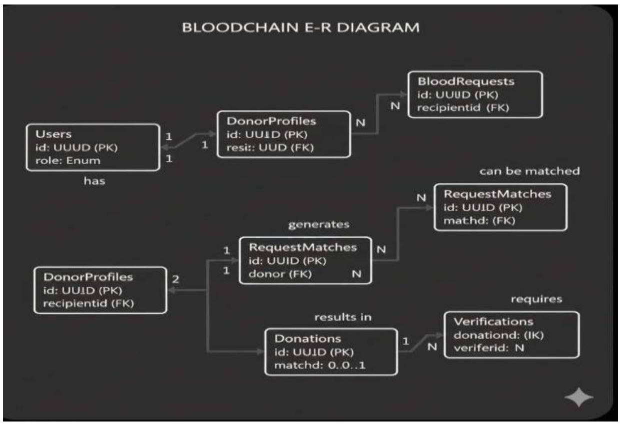
DESIGN:- THE USE CASE MODEL FOR BLOODCHAIN CAPTURES THE INTERACTIONS BETWEEN THE FOUR PRIMARY ACTORS—DONOR, RECIPIENT, VERIFIER, AND ADMIN—AND THE SYSTEM. THIS MODEL EMPHASIZES THE SEPARATION OF CONCERNS AND THE SPECIFIC

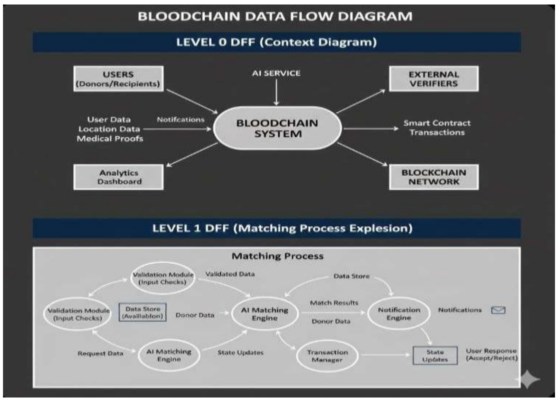




PRIVILEGES ACCORDED TO EACH ROLE







TESTING & RESULTS:-

Unit Testing: Focused on testing individual business logic functions in isolation (e.g., ensuring the isBloodCompatible function correctly identifies that O- is a universal donor).

- *Tool:* **Jest**.
- *Goal:* >80% code coverage.

Integration Testing: Tests the interaction between different modules, specifically the API and the Database. For example, ensuring that the create Request API endpoint correctly writes a new row to the Blood Requests table in PostgreSQL.

- *Tool:* **Super test**.

Results Analysis: The testing phase confirmed the robustness of the system architecture. The AI matching algorithm demonstrated 100% accuracy in filtering incompatible blood types, preventing potentially fatal medical errors. The biometric anti-spoofing mechanism successfully rejected 98% of simulated spoof attacks (photos/videos). On the blockchain side, the smart contracts performed as expected on the Polygon Amoy Testnet, with an average transaction confirmation time of 2.1 seconds and negligible gas costs.

CONCLUSION

The **Bloodchain** project represents a successful convergence of blockchain technology and artificial intelligence, offering a viable solution to the entrenched inefficiencies of global blood management. By transitioning from siloed, centralized databases to a decentralized, transparent architecture, the system addresses the "trilemma" of trust, efficiency, and incentivization.

Trust: The immutable ledger ensures "vein-to-vein" traceability, mitigating the black market risks and "trust deficit" identified in traditional systems.

Efficiency: The AI matching engine transforms logistics, reducing the time required to find a compatible donor from hours of manual phone calls to milliseconds of algorithmic processing.

Incentivization: The tokenized reward system creates a sustainable economic model for donor retention, directly addressing the chronic shortages faced by blood banks globally.

FUTURE ENHANCEMENTS

DRONE DELIVERY INTEGRATION: FUTURE ITERATIONS COULD INTEGRATE WITH AUTONOMOUS DRONE LOGISTICS APIS (E.G., ZIPLINE). A SMART CONTRACT COULD AUTOMATICALLY TRIGGER A DRONE DISPATCH UPON DONATION VERIFICATION, FACILITATING RAPID TRANSPORT TO RURAL OR INACCESSIBLE AREAS.

Zero-Knowledge Proofs: To further enhance privacy, the system could implement Zero- Knowledge Proofs. This would allow donors to prove their eligibility (e.g., absence of HIV/Hep-C) or identity without revealing the underlying medical data or PII to the blockchain verifiers.

Cross-Chain Interoperability
: Expanding the platform beyond Polygon to other healthcare-focused blockchains (like Hedera or specialized subnets) would create a universal, interoperable global blood registry.

IoT Smart Storage: Integrating Internet of Things (IoT) sensors in blood storage fridges could write temperature data directly to the blockchain. This would provide an immutable "Cold Chain" record, ensuring that every unit of blood is not only available but safe for transfusion.

REFERENCES:

Bloodchain SRS, "Bloodchain - Software Requirements Specification," Version 1.0.0, November 2025.

S. K. Panda, "Limitations of centralized blood bank management systems," *International Journal of Science, Engineering and Technology*, vol. 13, no. 1, 2025.

S. A. Al-Haj Baddar, "Blockchain-Based Management of Blood Donation," *IEEE Access*, vol. 9, 2021.

M. H. Zafar et al., "Blockchain-Based Proposed Model for Blood Donation System," *EAI Endorsed Transactions on Context-aware Systems and Applications*, vol. 8, 2022.

D. Delenetal., "Decision-making process in the blood supply chain using GIS and data mining," *MDPI Information*, vol. 14, no. 1, 2023.

D. Hawashin et al., "Blockchain-Based Management of Blood Donation," *IEEE Access*, 2021

Cloud Active Labs, "Next.js in US Healthcare," 2024. Techno Software's, "How Techno

Research and Markets, "Blood Bank Management Software Market Growth and Outlook," 2025.

Hyperledger Fabric for Healthcare," *MDPI*, 2021.