Organ Ledger: Decentralized Network of Organ Donation Using Block Chain

[1]Assistant Prof. K. Rajeshwar Rao, [2]P. Akshitha, [3]K. Akshith, [4]Ch. Akshitha, [5]G. Akshith, [6]M. Akshitha

Artificial Intelligence & Machine Learning, Department of Computer Science and Engineering
Malla Reddy University, Hyderabad, Telangana, India

Abstract: ***This research paper explores the implementation of blockchain technology in organ donation and transplantation processes. The current organ donation infrastructure faces challenges related to transparency, security, and efficient matching of donors with recipients. We propose a decentralized blockchain framework that addresses these challenges while ensuring data privacy and system integrity. Our solution leverages smart contracts to automate donor-recipient matching based on medical criteria and urgency levels. The implementation demonstrates significant improvements in matching accuracy, security, and overall process efficiency compared to traditional centralized systems. This paper details the architecture, implementation methodology, and evaluation results of our proposed system.***

1.INTRODUCTION

Organ transplantation is a life-saving medical procedure for patients with end-stage organ failure. However, the current organ donation and allocation systems face numerous challenges, including lack of transparency, potential security breaches, inefficient matching processes, and fragmented record-keeping. These issues contribute to longer waiting times for recipients and potential organ wastage.

Blockchain technology offers promising solutions to these challenges through its inherent properties of immutability, transparency, and decentralization. By implementing a blockchain-based system for organ donation management, we can create a secure, transparent, and efficient framework that enhances trust among stakeholders while protecting sensitive medical data.

This paper presents a comprehensive blockchain solution for organ donation management, focusing on the technical implementation, security features, and performance evaluation. We analyze how blockchain can transform the organ donation ecosystem by addressing current limitations and introducing innovative approaches to donor-recipient matching and transplantation coordination.

2.LITERATURE REVIEW

Recent research has shown growing interest in applying blockchain technology to healthcare and specifically to organ donation management. Bansal et al. (2024) implemented a Hyperledger Fabric-based solution called "Organ Harbour" that demonstrated successful organ donation matching through smart contracts. Their system employed AES encryption and zero-knowledge proofs to ensure data security and privacy while achieving 100% accuracy in donor-recipient matching with zero security breaches.

Bawa et al. (2024) conducted a comprehensive review comparing blockchain technology with traditional centralized approaches in organ donation management. Their findings highlighted blockchain's superior transparency and trust-building capabilities. They also emphasized the potential of integrating artificial intelligence (AI) and Internet of Things (IoT) technologies with diverse blockchain platforms to enhance system efficiency and security. Other studies have explored various aspects of blockchain implementation in healthcare, including patient record management, medical supply chain tracking, and clinical trial management. These applications share common benefits with organ donation management systems, such as improved data integrity, enhanced privacy, and streamlined processes.

3.METHODOLOGY

3.1 SYSTEM ARCHITECTURE

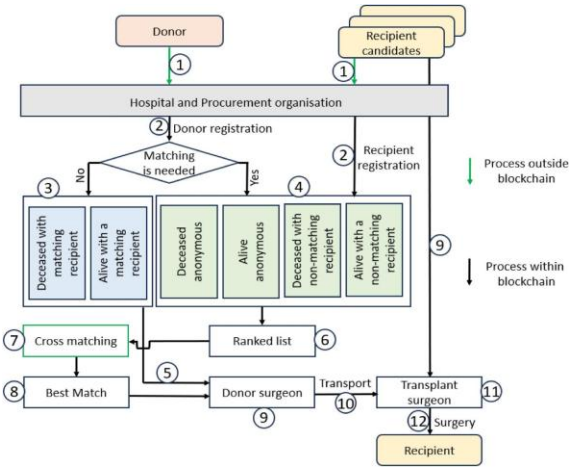

FIG 3.1 SYSTEM ARCHITECTURE

Our proposed blockchain-based organ donation management system utilizes a permissioned blockchain network to ensure data privacy while maintaining transparency among authorized participants. The system architecture consists of the following components:

1. Blockchain Network: A Hyperledger Fabric network with multiple channels to separate different types of transactions and data.
2. Smart Contracts: Chain code implementations that automate donor-recipient matching, organ allocation, and transplantation tracking.
3. Off-chain Storage: For storing sensitive medical data with encrypted references on the blockchain.
4. User Interfaces: Web and mobile applications for different stakeholders (donors, recipients, hospitals, transplant coordinators).
5. Integration Layer: APIs and middleware for connecting with existing hospital information systems.

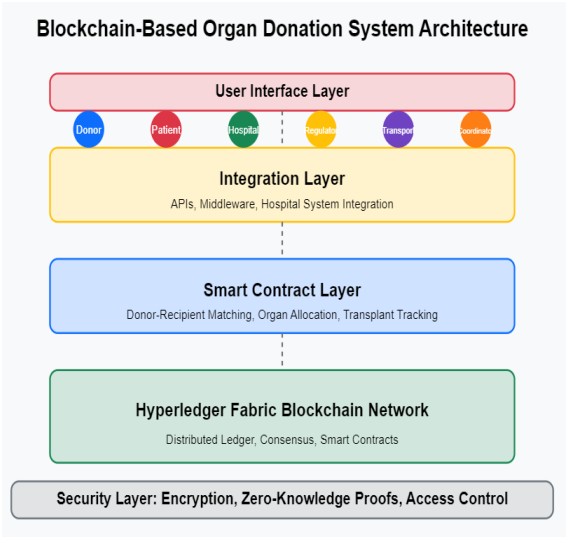

FIG 3.1.1 SYSTEM FLOW DIAGRAM

3.2 PROCESS FLOW

The organ donation and transplantation process in our system follows these steps:

1. Registration: Donors register their willingness to donate organs through a secure interface, providing necessary medical information.
2. Validation: Medical professionals validate donor eligibility based on health criteria.
3. Recipient Registration: Patients in need of organ transplants register in the system with detailed medical profiles.
4. Matching Algorithm: Smart contracts automatically match donors with recipients based on medical compatibility, urgency level, waiting time, and geographical proximity.
5. Allocation and Notification: When a match is found, the system notifies relevant stakeholders and initiates the allocation process.
6. Transplantation Coordination: The system tracks the organ from procurement to transplantation, ensuring proper handling and timely delivery.
7. Post-transplant Monitoring: The system maintains records of post-transplant outcomes for future analysis and improvement.

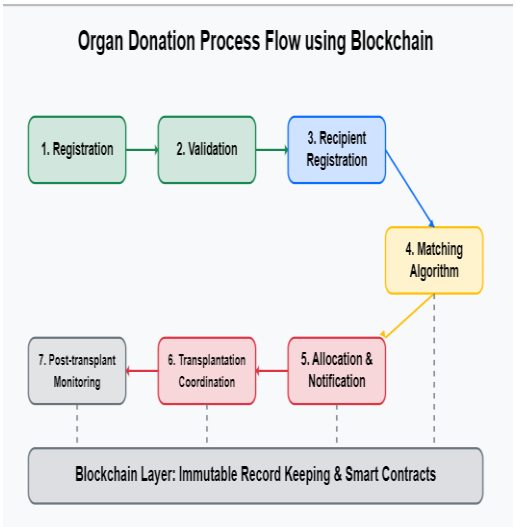

FIG 3.2 PROCESS FLOW DIAGRAM

3.3 Security and Privacy Measures

1. Encryption: All sensitive medical data is encrypted using AES encryption.
2. Zero-knowledge Proofs: Used to verify information without revealing sensitive details.
3. Access Control: Role-based access control ensures that participants can only access information relevant to their roles.
4. Audit Trail: All transactions are recorded on the blockchain, creating an immutable audit trail.

5. Data Partitioning: Different channels in the Hyperledger Fabric network separate various types of data based on sensitivity and access requirements.

4. IMPLEMENTATION

4.1 SMART CONTRACT IMPLEMENTATION

Donor Management Contract: Handles donor registration, validation, and status updates.
Recipient Management Contract: Manages recipient registration, medical profile updates, and waiting list status.
Matching Contract: Implements the matching algorithm based on medical compatibility criteria.
Organ Tracking Contract: Tracks the organ from procurement to transplantation.

4.2 RESULTS AND INTERFACE:

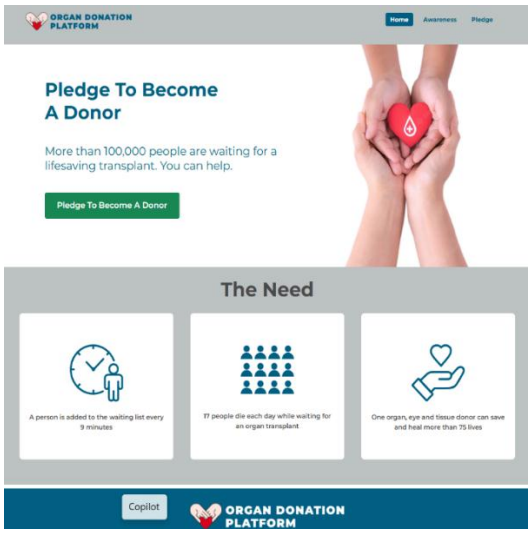

FIG 4.2.1 DASHBOARD

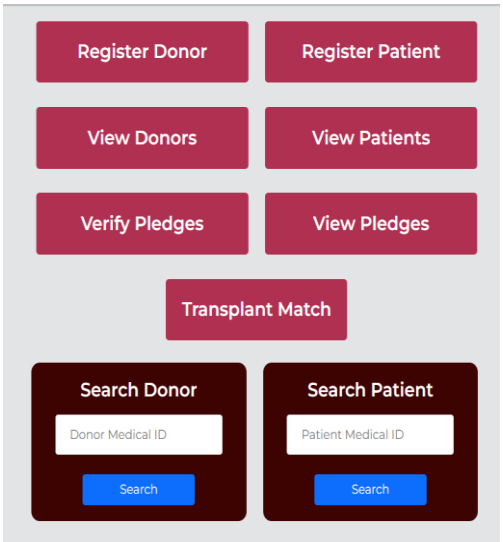

FIG 4.2.2 USER INTERFACE

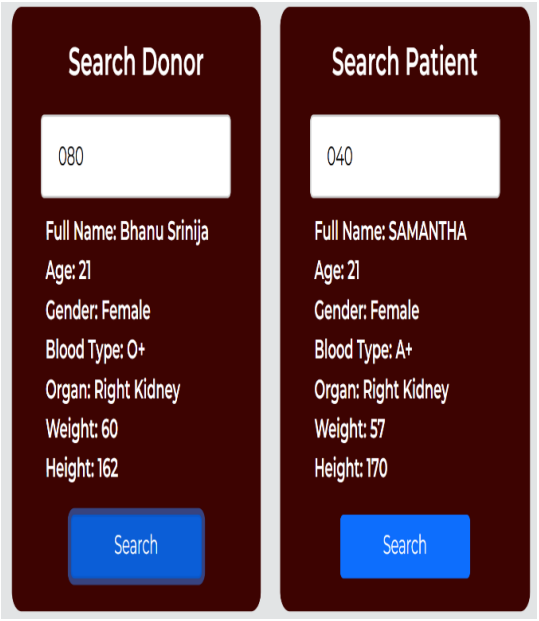

FIG 4.2.3 DONOR-PATIENT ID CHECKING

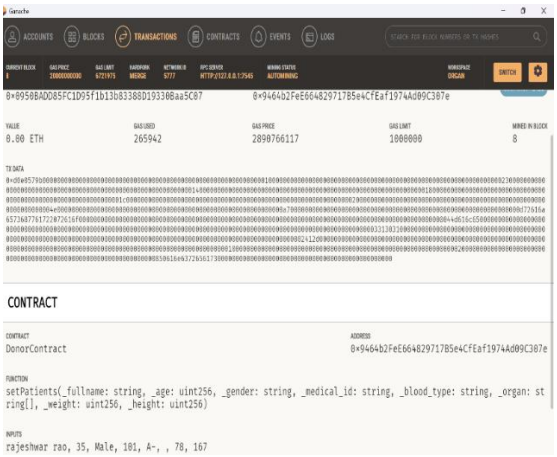

FIG 4.2.4 SMART CONTRACTS IN GANACHE

5.CONCLUSION

Our system demonstrates several key advantages over traditional centralized approaches:

1. Enhanced Trust and Transparency: The immutable nature of blockchain creates a transparent and auditable record of all transactions in the organ donation process, from donor registration to post-transplant monitoring. This transparency builds trust among all stakeholders.
2. Improved Security: Through AES encryption, zero-knowledge proofs, and role-based access control, our system ensures that sensitive medical data remains private while allowing necessary information sharing between authorized participants.

3. Efficient Matching: Smart contracts automate the donor-recipient matching process based on medical compatibility, urgency, and other factors, reducing manual intervention and potential human bias. This leads to faster organ allocation and potentially improved transplantation outcomes.
4. Reduced Administrative Overhead: Automation of various processes reduces paperwork and administrative tasks, allowing medical professionals to focus more on patient care.
5. Comprehensive Audit Trail: All actions within the system are recorded on the blockchain, creating an immutable audit trail that can be used for regulatory compliance, dispute resolution, and process improvement.

6.FUTURE SCOPE

1. Integration with AI and Machine Learning: Future implementations could incorporate AI algorithms to improve matching accuracy by considering additional factors and predicting outcomes. Machine learning models could analyse historical transplantation data to identify patterns and optimize matching criteria.
2. IoT Integration: Internet of Things (IoT) devices could be integrated for real-time organ monitoring during transportation, ensuring optimal preservation conditions and providing location tracking. These devices could automatically update the blockchain with environmental data and organ status.
3. Cross-border Organ Sharing: Expanding the system to facilitate international organ sharing would require addressing regulatory differences, transportation logistics, and interoperability between different healthcare systems. A blockchain network spanning multiple countries could significantly increase the pool of available organs.
4. Diverse Blockchain Platforms: Exploring alternative blockchain platforms like Ethereum, Corda, or newer platforms with faster transaction processing capabilities could enhance system performance and scalability.
5. Mobile-based Donor Registration: Developing user-friendly mobile applications with biometric authentication could simplify the donor registration process and potentially increase donor registration rates.
6. Integration with Existing Health Information Systems: Developing robust APIs and middleware solutions for seamless integration with legacy hospital information systems would facilitate wider adoption.

7.REFERENCES

[1] Cite this article : Igboanusi, I.S., Nnadiekwe, C.A., Ogbede, J.U. *et al.* BOMS: blockchain-enabled organ matching system. *Sci Rep* 14, 16069 (2024).
[2] L. A. Dajim, S. A. Al-Farras, B. S. Al-Shahrani, A. A. Al-Zuraib and R. Merlin Mathew, "Organ Donation Decentralized Application Using Blockchain Technology," 2019
[3] DOI: https://doi.org/10.1145/3675888.3676050
[4] Transpl Int. 2023 Feb 8;36:10800. doi: 10.3389/ti.2023.10800 PMCID: PMC9945518 PMID: 36846602
[5] Sajwan, A., Das, S., Phamila, A.V., Kathirvelu, K. (2024). Blockchain-Based Organ Donation and Transplant Matching System. In: Goundar, S., Anandan, R. (eds) Integrating Blockchain and Artificial Intelligence for Industry 4.0 Innovations. https://doi.org/10.1007/978-3-031-35751- 0_11