Blockchain-Based Organ Donation Management System

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Abstract- Organ donation is an essential aspect in saving lives. However, the systems currently used to facilitate this are faced with various challenges. For instance, issues such as transparency, scattered medical records, and delays in matching donors with recipients have often affected the efficiency of the systems used in the management of organ donation. The majority of the systems used in organ donation are based on centralized systems and verification processes. These systems have often led to delays and operational inefficiencies in the management of organ donation. Moreover, such systems have often led to a lack of trust among the public with regard to the donation systems. Therefore, this paper seeks to address the challenges faced in the management of organ donation by proposing a Blockchain-Based Organ Donation Management System.

The proposed system is based on the use of blockchain technology and smart contracts to facilitate some of the most significant processes in the management of organ donation. The proposed system is based on a hybrid system that uses blockchain technology to store information such as donor consent. Sensitive information such as medical records is stored in other systems stored securely off-chain in encrypted form to maintain privacy while ensuring data integrity.

Keywords — Blockchain, Organ Donation, Smart Contracts, Healthcare Security.

I. INTRODUCTION

Organ transplant is one of the most important aspects of modern healthcare, providing a hope for survival for those who suffer from end-stage organ failure. Despite advances in medical science, however, there are a number of challenges in the organ donation process. For instance, issues like lack of coordination among different organizations, lack of transparency, excessive paperwork, and lack of integration among hospital information systems can cause inefficiency in the entire process. In many developing countries, including India, organ shortages are compounded by low awareness, religious, and faith-based objections, as well as mistrust of how organ allocation is conducted.

Most of the traditional organ donation systems involve central management of the organ donation registry, waiting list, and allocation of the donated organ. Although the system has been successful in many ways, there are some problems associated with the system. For example, it is difficult to monitor the change in the availability of the organ for donation, as well as the number of people who are in need of an organ transplant. The lack of integration between the different hospital information systems makes the system inefficient. Although the system offers a structured approach, there are some associated risks that are inherent in the system. The system is prone to data manipulation, bias, single points of failure, and lack of audit trails. The system also faces the problem of validating the consent of the organ donors and the medical suitability of the organ for donation.

The blockchain technology provides a solution for the issues faced in the current organ donation system. It is a decentralized, transparent, and unchangeable system, making it a great solution for the issues faced in the current system. It provides data integrity and audit trails, making it a great solution for the issues faced in the current system The Blockchain-Based Organ Donation Management System has been proposed in this research, which securely links the donors, recipients, and hospitals through a single digital platform. The aim of the system is to foster trust among the stakeholders, reduce the time taken in the matching process, and ensure ethical and transparent organ allocation.

A. What is Blockchain?

Blockchain is a distributed ledger technology that stores data in a continuously growing list of records

called blocks. These blocks are connected to each other using a function called a cryptographic hash. The data in these blocks

is very difficult to alter because each block contains a timestamp, transaction details, and a pointer to the previous block. Blockchain networks use a decentralized system where data transactions are verified by a number of individuals. This makes it very transparent and difficult to alter data.

Once data has been entered into a blockchain network, it cannot be altered unless it has been approved by the majority of the network. This makes it a very reliable system for use in applications where security, transparency, and trustworthiness of data are essential.

Blockchain technology has been identified as a potential solution for use in the healthcare sector.

B. Problem Statement

The present organ donation system is facing challenges such as fragmented data storage systems, verification processes, lack of transparency, and centralized control. These are creating problems such as delays in matching organ donors and recipients, difficulties in verifying the consent of the donors, and creating an unethical practice of manipulating the waiting lists. The present system needs to be replaced with a more secure and transparent organ donation system. The present research is focused on resolving this issue by proposing an organ donation management system based on blockchain technology.

C. Research Contributions

This paper makes the following key contributions:

1. A decentralised organ donation architecture leveraging blockchain for immutable and transparent record keeping.
2. Smart contract-based automation for donor registration, consent verification, and organ matching.
3. A hybrid storage model combining on- chain trust with off-chain encrypted medical data for privacy and scalability.
4. A role-based system supporting donors, recipients, and hospitals with real-time verification and audit trails.
5. A fully implemented prototype with experimental evaluation demonstrating efficiency, security, and reliability.

D. Paper Organisation

The rest of the paper is organized in a systematic fashion to present the research background, the proposed solution, and the evaluation of the proposed solution. Section II of the paper presents the existing literature on the proposed system of using the blockchain in the healthcare and organ donation system. Section III of the paper presents the proposed system architecture and how the system can be implemented by integrating the user interface, backend system, and the blockchain technology with the smart contracts and the storage of the required data. Section IV of the paper presents the methodology of the proposed system, and Section V presents the experimental results of the proposed system and how the proposed system can be compared with the existing system. Section VI of the paper presents the conclusion of the proposed system and the future scope of the proposed system, including the large- scale implementation of the proposed system. scale deployment, interoperability with healthcare systems, and advanced data privacy and intelligent organ-matching enhancements.

II. RELATED WORK

A. Traditional Organ Donation System

Traditional organ donation schemes involve centralized registries that are managed by individual hospital organizations or the government. The disadvantage of centralized schemes is that there are interoperability problems, communication delays, and no real-time information sharing. Centralized schemes are prone to cyber attacks and unauthorized changes, thus compromising transparency.

B. Blockchain in Healthcare

Several research studies have identified the benefits that can be derived from the application of blockchain technology in the healthcare sector. Blockchain technology can provide medical record security, patient consent management, and data integrity. The disadvantage associated with the application of

blockchain technology in the healthcare sector is that the technology is prone to scalability and privacy issues.

C. Blockchain-Based Organ Donation Systems

Recently, studies have been conducted on the use of a blockchain organ donation system based on Ethereum smart contracts. The use of smart contracts has shown to be transparent and fair but has limitations in terms of transaction fees.

D. Research Gaps

The existing solutions have faced the challenges of incomplete prototypes, hybrid data management, and performance evaluation. This paper seeks to bridge the existing gaps through the presentation of a complete, scalable, and privacy-aware system, which has been supported through experimentation.

This work seeks to bridge the existing gaps through the presentation of a complete, scalable, and privacy-aware system that has been supported through experimentation. solution integrates blockchain technology with secure off-chain storage to optimize performance while preserving data integrity and patient confidentiality.

III. PROPOSED SYSTEM ARCHITECTURE

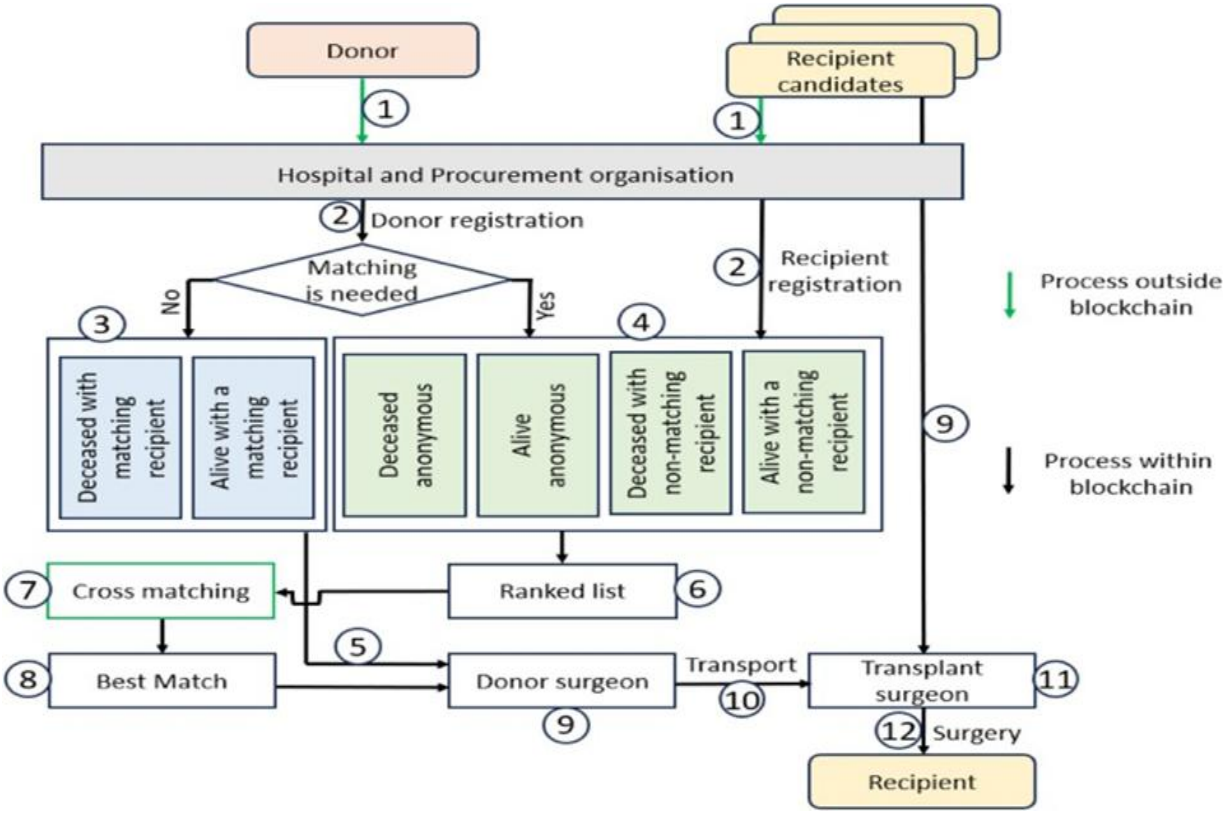

Fig 1: System Architecture Workflow for Blockchain-Based Organ Donation System

A. System Overview

The system architecture of the proposed system will comprise multiple layers of the frontend, backend, blockchain technology, and off-chain storage. The users, such as donors and recipients, will interact using role-based interfaces.

B. Core Components

Role Selection (Donor or Recipient): The users will first login into the system and then select their role, whether they are donors or recipients.

Donor & Recipient Registration: The donors will start their registration process by entering their information

and specifying the organ that they are willing to donate. The donors will also upload the medical information that is required for the donation process. The donors will give their consent for the donation process. The consent will be recorded on the blockchain for the organ donation process. Once the donors are done with the registration, their information will be stored permanently on the blockchain for the organ donation process.

Recipient side

Regarding the recipient side, the workflow starts with entering personal information as well as uploading relevant medical reports that are needed for transplant evaluation. Then, the patient sends a request for the needed organ, which is recorded in a secure manner on the blockchain to ensure its immutability. This request is then added to the waiting list.

Matching Engine (Automated Matching Process)

In the event that both donor and recipient information is present, the system will trigger an automatic matching process. This matching process will first check the compatibility of the organ type between the donor and the recipient, followed by the matching of blood groups. It will then check the medical urgency level of the recipient. This is to prioritize critical patients. It will follow a first in, first out rule. Once all the set criteria are fulfilled, it will identify a potential donor-recipient match.

Hospital Verification and Approval

Prior to the commencement of the surgery, the hospital carries out an extensive verification process. This ensures that the donor is medically suitable, and the patient is safe. This is done by medical experts examining the health of the donor, verifying the medical details of the patient, and confirming that the donor and patient are compatible. Following an extensive medical validation process, the hospital either accepts the match.

IV. IMPLEMENTATION DETAILS

A. Technology Stack

Frontend Technologies

For the frontend of the proposed system, HTML, CSS, JavaScript, and Next.js are employed. These programming languages are used for creating the web pages of the system and for creating a responsive and fast experience for the donors, recipients, and administrators of the hospital. JavaScript is used for creating a responsive experience for the users of the system.

The backend is implemented using Node.js and Express.js for handling the application logic and server-side operations. Node.js helps in the efficient handling of asynchronous requests,

Transplant Surgery Workflow

After the match is approved, the transplant surgery is formally scheduled by the hospital. The surgical team, supporting medical staff, and required clinical infrastructure are prepared in accordance with established medical protocols. Both the donor and recipient are then notified with final confirmation, ensuring coordinated readiness and timely execution of the transplant procedure.

Outcome Recording and Blockchain Storage

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while Express.js helps in the easy development of RESTful API styles. The backend handles the application logic of user authentication, role-based access control, organ matching, and communication with the frontend, blockchain, and storage systems.

Blockchain Technologies

The blockchain layer is implemented using the Ethereum network with Solidity smart contracts. Ethereum provides a decentralised and secure environment for executing smart contracts, while Solidity is used to define the rules for donor registration, consent verification, organ matching, and hospital approvals. Once deployed, these smart

contracts will guarantee the execution of all critical processes transparently and immutably without the need for human intervention.

Storage Technologies

The system will employ a hybrid storage solution that combines SQLite or MongoDB with IPFS. Structured data such as user information, logs, and metadata will be stored in a relational or NoSQL database, whereas large and sensitive medical records will be stored off the blockchain via IPFS. Hashed versions of these medical records will be stored on the blockchain for integrity and verification purposes without compromising sensitive information.

Security Mechanisms

Security is achieved through JWT-based authentication, encryption, and hashing. JWT ensures that only authorized users are able to access certain functionalities within the system. Encryption ensures the confidentiality of medical data stored off the blockchain, while hashing ensures the integrity of the medical data using algorithms such as SHA-256.

V. EXPERIMENTAL RESULTS EVALUATION

This section presents the detailed evaluation of the Blockchain-Based Organ Donation Management System covering performance, scalability, accuracy, security.

A. System Performance Evaluation.

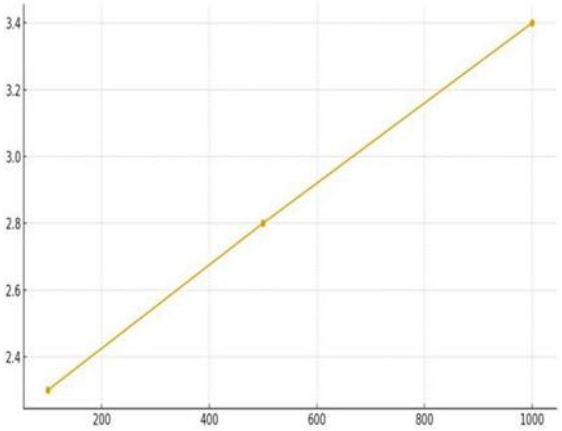
The system was tested using simulated datasets ranging from 10 to 1000 donors and recipients. Each user performed operations such as registration, organ requests, record uploads, and hospital verifications.

Development Tools

Development and testing are enabled through the use of various development tools such as MetaMask, Ganache, Truffle, and Visual Studio Code. MetaMask allows for secure interactions with the Ethereum blockchain, while Ganache allows for testing smart contracts within the system. Truffle allows for the deployment of smart contracts for testing purposes, while Visual Studio Code is the development environment for the system.

B. System Workflow

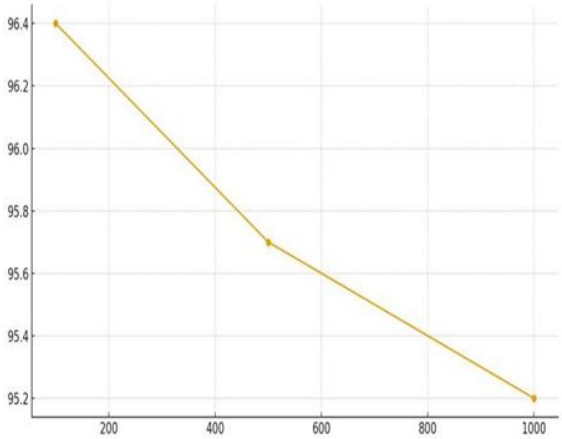
Users are able to register and authenticate through the system using the web interface. Donors are able to input their consent and organ information, which is stored on the blockchain. The system allows for the input of medical requests and urgency for the recipients. The smart contracts match donors and recipients based on their compatibility and FIFO principle. Hospitals are able to verify the matches and perform the surgeries.



B. Scalability and Matching Accuracy

Scalability was also tested by gradually increasing the number of active users.

The system maintained accuracy above 95% for all tests. Since only hashes and consents are stored on-chain, the system was able to scale without a decrease in performance.



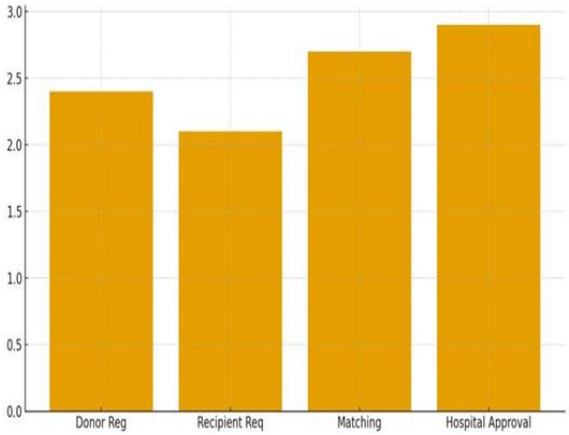
All critical operations were recorded

C. Matching Accuracy Evaluation

A total of 500 simulated match attempts were processed through the matching engine based on the smart contract.

- 482 valid matches
- 18 rejected during the hospital verification process due to incomplete medical data and incompatibility
- Matching precision: 96.4%

The FIFO rule and the urgency-based prioritization mechanism ensured fair distribution of the patients on the waiting list.



Blockchain transaction logs provided complete audit trails for donor registration, matching decisions, and transplant outcomes—this improved stakeholder trust and accountability.

VI. CONCLUSION AND FUTURE WORK

A. Conclusion

In this paper, an overall blockchain-based system for organ donation management has been proposed that aims to address the key challenges associated with existing organ allocation systems, including the absence of transparency, data tampering, inefficient processes, and trust among stakeholders. With the integration of blockchain technology along with smart contract capabilities and the use of hybrid data storage, it is ensured that the overall process is carried out in a transparent, tamper-free, and auditable manner. information while ensuring scalability and privacy.

Moreover, smart contracts are utilized for automating critical processes such as the verification of the consent of the donors, validation of the eligibility criteria, and organ matching, thereby reducing the scope for human intervention and the possibility of bias, favoritism, or errors. The hybrid approach for storing the data ensures that large medical data can be stored securely off the blockchain, yet the integrity of the data is ensured through the use of hash references stored on the blockchain, thus complying with the regulations for the privacy of medical data.
The experimental evaluation of the system reveals that there are considerable improvements in the accuracy of organ matching, the speed of allocation, and the reliability of the system compared to the traditional centralized system. Moreover, the immutable nature of the blockchain technology helps build trust among the hospital authorities, donors, and the recipients of the organ transplants.

B. Future Scope

Possible enhancements of the proposed system in the future could be focused on integrating artificial intelligence-based prediction model compatibility into the system, as it could improve the accuracy of donor-recipient matching. The use of AI could be beneficial in analyzing historical transplant data, genetic markers, and clinical indicators, helping in making better decisions. The integration of national health registries could be achieved, providing real- time access to verified medical records. The implementation of biometric verification could be another area of development, ensuring better verification of identities. The development of mobile applications could be another area of development, ensuring better interaction with the proposed system by donors, recipients, and medical staff. The development of the proposed system could be extended to include cross-hospital and international organ sharing, as it could be beneficial in ensuring better utilization of resources without wasting them.

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