

Blockchain for Secure Donor Matching Systems

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ABSTRACT

Protecting the integrity and security of the donor's data has become very challenging due to the rise of digital technology. The present study has explored implementing blockchain for decentralized, tamper-proof donor matching systems that guarantee data authenticity. By considering the distributed ledger of blockchain technology, the authenticity of the data can be ensured.

This approach can also help mitigate the issue of fraud and data manipulation. In the present study, multiple challenges are associated with the security of the donor's data, and it has also demonstrated how blockchain could be utilized to mitigate the challenges. It has also been illustrated that the technology could be used to promote transparency, immutability and data control mechanisms could be enhanced. The solution emphasized in the present study focuses on the security of data, privacy as well as operational efficacy in the overall process of donor matching.

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Introduction

The donor matching system is a very important aspect in the healthcare and nonprofit sectors because it connects donors with recipients in need, the system is responsible for organ transplants or blood donations. Security challenges are one of the most important concerns in the traditional system, and the issue of data breaches, tempering, and unauthorized access to data can profoundly jeopardize the integrity of the security of sensitive information on the donor. However, the need for a secure and reliable system for matching is increasing day by day, and blockchain technology is one of the promising technologies to mitigate the issue.

The United Arab Emirates has considered a blockchain-based organ donation system in the year 2022. It could help to enhance the overall process by improving transparency, traceability, and security. Estonian e-health system has considered a technology that includes blockchain to secure the data of the patients, and it also helps to protect the integrity of the records. The adoption of the technology in the healthcare sector demonstrates the feasibility of the approach and the level of administration burden that the approach could reduce. The BOMS (Blockchain-Enabled Organ Matching System) could also be a promising outcome.

Decentralized and immutable characteristics of the blockchain technology could allow it to maintain the security, transparency and traceability of the donor data. The paper aims to explore the advantages of blockchain technology in developing a secure matching system for donors, which could address all of the contemporary prevalent problems with the existing systems, providing a framework to enhance the security and integrity of data.

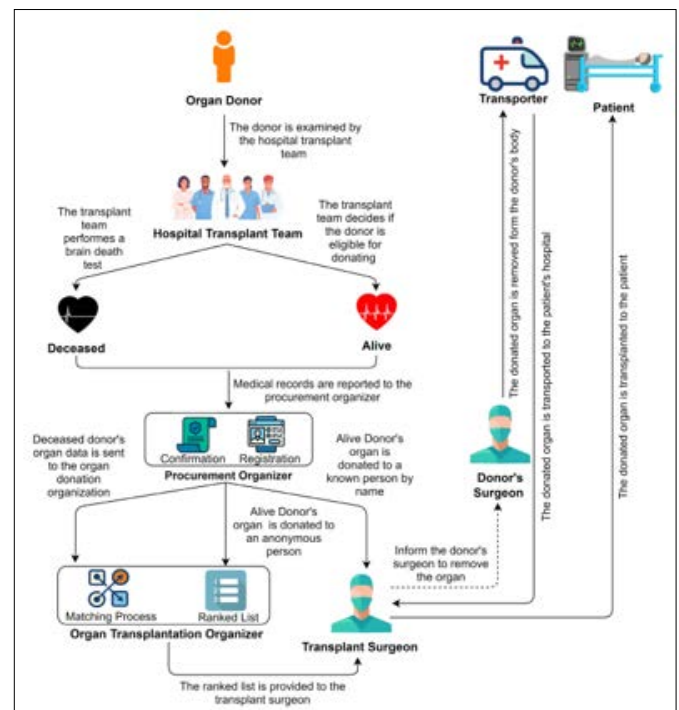


Figure 1: Flow Chart of Organ Donation

Background

The present system of donor matching is centralized, which means all of the data or information is stored as well as managed by a single authority. In the centralized process, the process of data management becomes simple; however, it increases the vulnerability of the data to cyberattacks or data breaches due to a single-point failure. Despite that, in a centralized system, the transparency could be inadequate, which could make it significantly difficult to track unauthorized modifications.

Moreover, the information of the donors in the centralized system could be compromised, and it may cause ethical concerns, or lead to mistrust among recipients and donors. One of the most prominent emerging technologies, Blockchain, a distributed ledger technology, has the potential to resolve the challenges.

The need for a single authority gets eliminated due to the decentralized nature of the blockchain technology, it also spreads the control to different nodes, which makes it nearly impossible to corrupt them without obtaining proper consensus from the network [1,2].

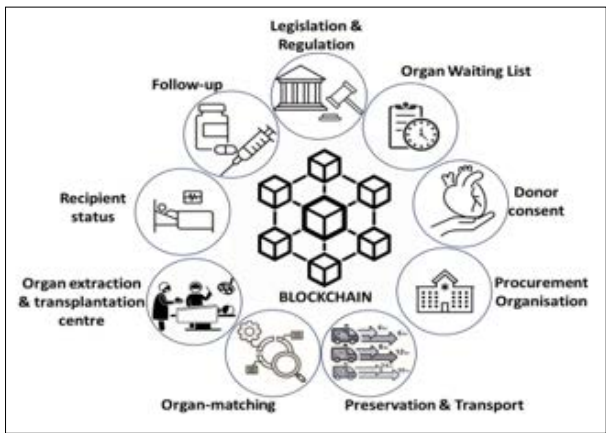


Figure 2: Blockchain-Based Organ Transplantation Process

Problem Statement

The most critical challenge in the donor matching system lies in ensuring in protection them in terms of their integrity and securing it due to the sensitivity of the donor data. The current system used is vulnerable to data breaches, unauthorized access and tempering, which puts the privacy of the donors at risk, and also negatively affects the accuracy of the matching process. Despite that, transparency and traceability of the data flow can also be affected in the centralized database system.

Moreover, centralized systems in contemporary times have become inefficient, and the need for a more efficient system is increasing. To be precise, the accuracy and security of the data is one of the vital aspects of donor matching; therefore, a robust and efficient system is needed that can guarantee the authenticity and integrity of the data, as well as it also can maintain data privacy [3,4].

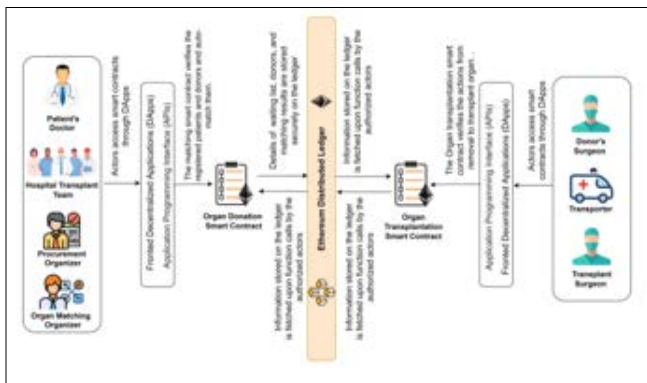


Figure 3: Architecture for Blockchain-Based Solution

Proposed Solution: Blockchain Implementation

Blockchain technology considers a decentralized approach for the donor matching system, which can also ensure the integrity as well as security of the data. In the implementation of blockchain, the data of the donor could be stored in different nodes of a distributed

network, which could make it extremely difficult for unauthorized individuals to tamper with any information.

Key Features of Blockchain in Donor Matching Systems

- **Decentralization:** The reliance on a central authority gets eliminated by considering blockchain technology because it distributes control over multiple nodes [3]. Every update or transaction to the data of the donor is verified by the entire network, which could ensure the accuracy and consistency of the data.
- **Immutability:** After recording the data of the donors on the blockchain, it cannot be altered without the consensus of the network. It could help to ensure that the tempering of the data is near to impossible. Hence, it provides a tamper-proof system that protects the information of the donor.
- **Transparency and Traceability:** Every transaction on the blockchain is time-stamped and traceable, which provides a very transparent audit trail. Such a level of transparency can help to ensure that the data of the donor can be verified at any time, ultimately leading toward enhanced trust in the overall system.
- **Enhanced Security:** The cryptographic method of blockchain technology ensures that the information of the donors is encrypted securely, which provides an exceptional level of protection from unauthorized access.
- **Smart Contracts:** To automate the matching process, smart contracts could be considered, which can ensure that certain conditions such as blood type, and organ compatibility are met before confirming the match. It can add an extra security layer to the system and also enhances the efficiency.

Implementation Considerations

Data Privacy and Regulations

Blockchain can ensure the privacy of the data; however, the concerns associated with the privacy of the donors are also required to be addressed. Therefore, solutions such as zero-knowledge proofs could be integrated with the blockchain, which could ensure that only authorized persons could access the sensitive information of the donors.

The regulatory and ethical aspects also need to be considered, and the blockchain systems are required to adequately comply with the robust regulations including the Health Insurance Portability and Accountability Act (HIPAA) for businesses operating in the U.S. On the other hand, the requirements of the General Data Protection Regulation (GDPR) are required to be considered for the European organizations.

To be precise, the blockchain needs to encrypt the accumulated data of the patients for sharing to comply with HIPAA regulations. Data consent mechanisms and the right to be forgotten are some of the concepts that could be considered to address the ethical concerns, because it will allow the users to control their data, and it could also help to prevent unauthorized access of sensitive data in the blockchain system.

Interoperability

To ensure seamless operations across platforms, the blockchain-based donor matching system is required to be able to integrate with the existing system of donor management and healthcare. The challenge of adopting a blockchain-based donor matching system is interoperability with the existing healthcare system associated with the existing system of donor matching. The approach of middleware solutions can help to connect the traditional database with the blockchain networks.

It is a middleware solution, and it can adequately help to ensure that the data is getting synchronization real-time in between the two systems. For example, to facilitate secure the exchange of data among between blockchain-based donor-matching platforms and existing health information systems (HIS) or electronic health record (EHR) systems APIs need to be developed.

Technical Implementation

Cryptographic methods could be considered one of the vital aspects of a blockchain-based donor-matching system. The data of the donors are encrypted in each of the transactions, for which an advanced cryptographic algorithm can be employed, and it will ensure that only authorized individuals can access the sensitive data. For instance, zero-knowledge proofs can be considered to verify the data, which requires data verification and leads to the security of data.

Despite that, in regards to the automated scripts, smart contracts could be adopted, which can trigger a specific action in the blockchain, such as by considering pre-defined criteria (compatibility of organ or blood type to confirm the match between the recipient and donor).

Regulatory and Ethical Concerns

Methodology

A systematic approach for the implementation of blockchain-based donor matching systems is as follows

System Design: The blockchain-based donor matching system is considered a distributed ledger for the date of the donor, for automating the machining process smart contracts are considered, and a cryptographic algorithm is incorporated to secure the sensitive information [5,6].

Node Setup: A permissioned blockchain network is created, with multiple nodes such as healthcare institutions, and donor registries, along with transplant centers, to participate in the verification or validation of data.

Data Entry and Encryption: Using cryptographic techniques, the data of the donors is encrypted while the data is entered into the system using a secure interface. It can help to ensure that all of the information is accessed by authorized individuals, and they are the only ones who can update any information.

Transaction Validation: Every transaction such as adding or updating donor data is required to be validated by the network because it is considered a consensus mechanism. Only after verification, the transition of data could be added to the blockchain, which could help to ensure the integrity of the data.

Smart Contract Execution: For matching donors with recipients' smart contracts could be considered which considered predefined criteria such as organ compatibility.

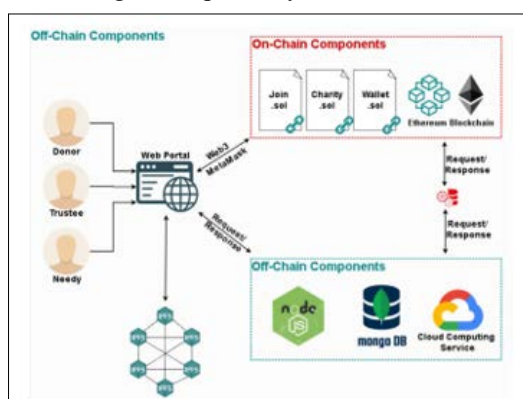


Figure 4: System Architecture

Results and Discussion

The utilization of blockchain in donor-matching systems can profoundly improve the efficacy of healthcare because it can help to enhance operational efficiency. It can also positively influence the trust of the patients, and ensure global scalability. Due to the automotive approach in the matching process utilizing unique approaches like smart contracts can significantly reduce the total needed time to find a suitable match. Despite that, the immutable approach can also help to increase the level of trust among the patient.

The approach of using blockchain in the donor matching system can also influence the global healthcare and interoperability. To be precise in the discussion context, on a global level, blockchain can help create an articulated interconnected healthcare ecosystem, where the privacy of the parties is protected. It could eventually lead to the development of international donor registries, which could profoundly improve access and save the lives of patients around the world.

- **Data and Metrics:** A significant improvement could be attained by implementing a blockchain-based donor-matching system, and it could also help the security efficacy. As shown by Hawashin et al. (2022), the prevalence of data breaches could be reduced by more than 50% by implementing blockchain in comparison to traditional centralized databases. Despite that, blockchain-based smart contracts can also help to reduce the required time by around 30% due to their reduced manual verification needs. Further, the cost of administration and operation can also be reduced by 20-25% due to its automated approach.
- **Data Privacy:** The most important aspect of donor matching systems is the privacy of data because some sensitive information is there. Blockchain offers solutions through advanced cryptographic techniques, and it is also considered an effective approach to zero-knowledge proofs (ZKPs), this approach can help to ensure that the verification of donor and recipient data, and the process do not reveal any actual personal information. To be precise, ZKPs can verify the type of blood of the donor and match it with the requirements of the recipient without exposing the medical records of either party.
- **Increased Data Integrity:** By securing the data of the donor and ensuring that it is immutable, the emerging technology blockchain can provide a framework that is reliable for the matching of donors. It also eliminates the number of errors as well as ensures fraudulent activities.
- **Enhanced Security:** Due to the decentralized nature of blockchain, which is mixed with leading technology such as encryption, can help to ensure the data of the donor is highly protected against cyberattacks, and it's also immune to unauthorized access.
- **Improved Efficiency:** The matching process is due to the consideration of smart contracts, which also significantly reduces the required time and effort. It may lead to faster and more accurate results for donor matching.
- **Trust and Transparency:** A transparent audit trail of blockchain could ensure trust between the donors and recipients due to the integrity of the system, which may also lead to more confidence in the process of donor matching [5,7].

Conclusion

In regards to the contemporary challenges of ensuring integrity and securing data of donors in the present donor matching systems, blockchain presents a revolutionary solution. Due to

its decentralizing control system, enhancing transparency and ensuring immutability, blockchain provides a system that cannot be tempered and protects sensitive information of the donors. Further, it also enhances the overall process, reducing errors that develop confidence among the donors and recipients. With this advancement in the new donor matching system using blockchain, it could become a standard system that provides security, trust and overall efficiency in the operation in the healthcare sectors.

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