



## Using Hashing Algorithm for the Organ Procurement and Transplant Network

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### ABSTRACT

Today's organ donation and transplantation systems pose different requirements and challenges in terms of registration, donor-recipient matching, organ removal, organ delivery, and transplantation with legal, clinical, ethical, and technical constraints. Therefore, an end-to-end organ donation and transplantation system is required to guarantee a fair and efficient process to enhance patient experience and trust. Propose a private Ethereum blockchain-based solution to enable organ donation and transplantation management in a manner that is fully decentralized, secure, traceable, auditable, private, and trustworthy. Develop smart contracts and present six algorithms along with their implementation, testing, and validation details. Evaluate the performance of the proposed solution by performing privacy, security, and confidentiality analyses as well as comparing our solution with the existing solutions. As a result, a ranked list is generated as an output and provided to the transplantation surgeons. Next, the transplant surgeon decides whether the organ is appropriate for the patient based on various considerations, such as the donor's medical records and the current health of the prospective recipient. Later, when a transplant surgeon accepts the donated organ, the donor's surgeon is notified to remove the donated organ.

**Keywords:** Blockchain, Ethereum, Smart Contracts, Traceability, Security, Decentralized.

### 1 Introduction

Organ failure or damage occurs due to an injury or a disease. It affects the quality of life and, in some cases, leads to death. Donating an organ is one of humanity's most honorable actions to save the lives of patients through organ transplantation. For a successful transplant, the organ must be in acceptable working conditions with donor-recipient matching, and its removal should not pose a life-threatening risk to the donor. The first successful organ donation occurred with a kidney transplant between twin brothers in 1954. Since then, the annual number of transplants has steadily increased. However, the demand for organ donations still exceeds the number of donors. In fact, while waiting for an organ transplant, twenty people die every day. New patient is added to the waiting list in every ten minutes. More importantly, accessing the organ donation waiting list is a basic requirement for organ allocation. Referral for transplantation can be affected by both geographical and socioeconomic factors. Therefore, the allocation process on the waiting list should not



**Article Title: Using Hashing Algorithm For The Organ Procurement And Transplant Network**

discriminate against certain groups of patients Organ donation is conducted in two different ways, including deceased donation and living donation. Donating an organ and transplanting it to a patient. First, the donor is examined by the hospital transplant team, and if the donor is deceased, a brain death test is performed. Meanwhile, if the donor is still alive, doctors examine the donor and ensure that the donor is fit for live donation. Then, all medical records are reported to the procurement organizer. The procurement organizer is responsible for evaluating the donor's condition to decide if he is a fit donor and ensuring that the donor is properly registered in the medical system. Next, if the evaluation shows that the donor is eligible for donation, the procurement organizer.

## **2 Related Works**

### **2.1 A.Soni S. G. Kumar “Creating Organ Donation System with Blockchain Technology”, 2021**

Organ donation being the noblest deed requires revolutionization. One cannot imagine the urgency and desperation a person feels when his/her loved one is in need of such act and they could not locate an appropriate donor. On the other hand, people who wish to donate worries about the privacy, security and authenticity. The Proposed System is a web-based Application which uses FIFO approach to select an organ donor for each genuine patient requiring a transplant and if there is an emergency case then the priority is given to that patient. It provides an efficient platform for potential organ donors and those who need the organs to connect. It uses Blockchain as its underlying Technology.

### **2.2 U. Jain “Using blockchain technology for the organ procurement Transplant network”, 2020**

The organ donation system in the United States is centralized and difficult to audit by the general public. This centralized approach may lead to data integrity issues in the future. The Organ Procurement and Transplant Network (OPTN) was built and maintained by a non-governmental organization called the United Network for Organ Sharing (UNOS) under its proprietary UNetSM umbrella platform. This platform is made up of proprietary closed source software and does not provide the general public easy access to the organ transplant data for auditing. This study investigates the feasibility, challenges, and advantages of a blockchain-based OPTN. A prototype of a blockchain-based OPTN was created using the Hyperledger Fabric framework. The policies and guidelines issued by the United States Department of Health and Human Services for UNOS and the OPTN were used as the basis of this prototype. Four factors were identified to have a direct effect on the performance of this system, viz. max batch time out, max block size, endorsement policy, and transaction rate. Additionally, two variants of the blockchain chaincode were also developed.



**Article Title: Using Hashing Algorithm For The Organ Procurement And Transplant Network**

### **2.3 A. Corson J. Russo M. He “Use of forensic DNA testing to trace unethical organ procurement and organ trafficking practices in regions that block transparent access to their transplant data”, 2020**

This study proposes an approach to track unethically procured organs in particular in countries or regions where investigations cannot be performed by utilizing forensic DNA methodology. Using China as an example, previous research has concluded that organs in China are in part unethically and extra-legally procured (so called "forced organ harvesting") from living prisoners of conscience without consent. Using forensic DNA-analysis, propose building a DNA data bank from missing prisoners of conscience in China and comparing these results with DNA from donor organs in patients who received transplants in China. Biological materials collected in China will provide DNA directly or indirectly from potential victims of forced. Organ harvesting. Archival biopsies from transplant recipients' donor organs will provide DNA profiles of donors. Verified match between DNA profiles of transplanted organs and missing victims will establish proof of such connection, thus provides evidence despite a lack of transparency.

### **2.4 G. Alandjani “Blockchain based auditable medical transaction scheme for organ transplant services”2019**

Internet of Things have brought exciting changes in the social norms, work environments and the prospects for future generations. These devices (Things) have already changed the way our networks are used for communication. With the introduction of machine to machine communication (M2M), where devices communicate without human involvement to perform routine day to day tasks. These tasks on one hand, include services that provide convenience to the device owners such as setting off alarms, acting as personal assistant for reminders, keeping track of daily activities etc. On the other hand, there are certain tasks where these devices perform Transactions on behalf of the owners' i.e. financial transactions/ online ordering etc. These transactional tasks have significant legal implications if some problem / dispute arises due to such action performed by these devices on behalf of the owners. To ensure that these interactions take place under observation of the owners and to keep track of their occurrence, there is a need to keep record of all such communication. Propose use of Blockchain for tracking all these transactions without compromising secrecy of data by keeping its integrity intact for medico-legal requirements and prevent risk of Fraud.

### **2.5 S. Srivastava V. Gupta “Decentralised and distributed system for organ/tissue donation and transplantation”, 2019**

In today's era of digitisation, many technologies have evolved that every manual work can be digitally automatized. In the digital automatizing process, security and privacy are the most important and highly demanding aspects. Blockchain offers many features that can be used in almost every sphere of life. Features like decentralisation, transparency, privacy makes it



**Article Title: Using Hashing Algorithm For The Organ Procurement And Transplant Network**

an extremely useful technology. Therefore, by making use of all these features, several problems in healthcare sector can be solved like removing complex network of third parties and lack of traceability of transactions. This paper presents a decentralised, secure and transparent organ and tissue transplant web application (also called DApp), which not only nullifies the role of any third party involved in the organ transplantation, but also is a cost effective solution that saves the patient's from high cost of transplantation.

### 3 Proposed Work

In this project, proposed a private Ethereum blockchain-based solution that manages organ donation and transplantation in a decentralized, accountable, auditable, traceable, secure, and trustworthy manner. Developed a smart contracts system that ensure the data provenance by recording events automatically. Here present six algorithms with their implementation, testing, and validation details. Analyze the security of the proposed solution to guarantee that smart contracts are protected against common attacks and vulnerabilities. Hashing technique (SHA-256) is used for authorization, secrecy, and privacy.

#### 3.1 Supply Chain Management

Organ Transportation and Preservation: Transportation and preservation of organs require strict adherence to protocols and best practices to maintain organ viability and quality management in the organ donation and transplantation supply chain is crucial to ensure the safety and efficacy of the procedures and to maintain public trust in the system. Here are some key aspects of quality management in this context:



**Figure 1: Process of Organ Donation**

##### 3.1.1 Regulatory Compliance

The organ donation and transplantation supply chain must comply with applicable laws, regulations, and standards. Regulatory bodies, such as health ministries or transplant organizations, set guidelines to ensure the quality and safety of organs, tissues, and related processes. Compliance with these regulations is essential to maintain the integrity of the



**Article Title: Using Hashing Algorithm For The Organ Procurement And Transplant Network**

supply chain.

### 3.1.2 Donor screening and Evaluation

Rigorous screening and evaluation processes are critical to identify suitable donors and minimize the risk of transmitting infectious diseases or other adverse conditions to recipients. Quality management systems should define clear criteria and protocols for assessing potential donors, including medical history evaluation, laboratory testing, and imaging studies.

### 3.1.3 Organ Procurement Organizations (OPOs)

OPOs play a vital role in the organ donation process by identifying potential donors, evaluating them, and coordinating organ recovery. Quality management practices should be implemented by OPOs to ensure consistent and standardized procedures, accurate documentation, and adherence to established protocols. Quality management systems should cover transportation logistics, temperature control, packaging, and tracking mechanisms to minimize the risk of organ damage or loss during transit.

### 3.1.4 Tissue Typing and Matching

For successful transplantation, compatible matching between donors and recipients is essential. Quality management processes should be in place for accurate and timely tissue typing, cross-matching, and compatibility assessments to minimize the risk of graft rejection and improve transplant outcomes.

### 3.1.5 Transplant Surgery

Quality management in transplant surgery involves standardizing surgical procedures, maintaining sterile environments, and ensuring the competency and qualifications of the surgical team. Adherence to surgical checklists, infection control measures, and monitoring of outcomes are vital components of quality management in this phase.

### 3.1.6 Post-Transplant Care and Follow-up

Quality management extends to the post-transplant phase to monitor recipient outcomes, detect complications, and ensure appropriate follow-up care. Regular assessments, immunosuppressive medication management, and long-term monitoring are essential to improve patient outcomes and identify areas for quality improvement.

### 3.1.7 Continuous Quality Improvement

Regular audits, reviews, and performance evaluations are integral to continuous quality improvement in the organ donation and transplantation supply chain. Identifying areas of improvement, implementing corrective actions, and sharing best practices can enhance the overall quality and safety of the system.

## 3.2 Blockchain Technology

Blockchain is an overlay distributed ledger that packages important data into a chain structure using cryptography and consensus mechanisms. It is also decentralized, immutable, traceable, and maintained by numerous parties' distributed databases. The basic technology consists of encryption, hash algorithms, binomial structures, and a peer-to-peer network. Blockchain



**Article Title: Using Hashing Algorithm For The Organ Procurement And Transplant Network**

may be classified into three types based on the varying authority of nodes in the consensus mechanism: public chain, alliance chain, and private chain. And the difference between the three chain structures is the degree of de-naturalization.

| Platform name | Access type    | Consensus algorithm | Database            | Application Features                      |
|---------------|----------------|---------------------|---------------------|-------------------------------------------|
| Bitcoin       | public chain   | PoW                 | LevelDB             | Low access threshold and                  |
| Ethereum      | public chain   | PoW/PoS             | LevelDB             | anonymity                                 |
| Corda         | Alliance chain | Raft                | MySQL               | Low transaction speed, high               |
| TrustSQL      | Alliance chain | BFT-Raft PBFT       | MySQL               | reliability, and high security            |
| BigchainDB    | Alliance chain | Quorum Voting       | RethinkDB           |                                           |
| MultiChain    | private chain  | PoW                 | MultiChain<br>Feeds | Low cost, strong security,<br>and privacy |

**Figure 2.** Comparison of various blockchain platforms

V pointed out that the public chain is a permission less blockchain, which means that anyone can read and send transactions, participate in the consensus process, and maintain data on the chain [16]. The blockchain, in theory, has none at the core, and the degree of de-neutralization is the greatest. Bitcoin and Ethereum apps symbolize it. A consortium chain means that when a node participates in a pre-selected blockchain, it needs to be authorized to join. It is suitable for a certain type of user group or secret-related enterprises with specific purposes, represented by R3 Blockchain Alliance and BigchainDB applications. The private chain is a blockchain deployment paradigm with a single center, and all activities need to be approved by the center and subject to its limits and restrictions. Participating nodes on the chain have only limited rights. For example, node A can only access data, node B can only regulate data rights writing, and so on [20]. At present, blockchain platforms are commonly used in the market. This section summarizes the characteristics of the three types of blockchain and the corresponding applicable scenarios.

### 3.3 Advantages of Proposed Work

#### 3.3.1 Improved data security

Blockchain is known for its robust security features, which makes it ideal for storing sensitive data like aviation process quality data. A blockchain-based platform can prevent data tampering, hacking, and unauthorized access to data, thereby improving data security. The platform may use encryption and other security features to ensure that data shared by suppliers is safe and protected from unauthorized access. The platform can be designed to ensure privacy by giving suppliers control over who has access to their data. For example, suppliers can set permissions to limit access to only authorized parties and revoke access at any time.

#### 3.3.2 Enhanced transparency

A blockchain-based platform can offer increased transparency by providing real-time access to data across multiple stakeholders in the supply chain. This can lead to better coordination,

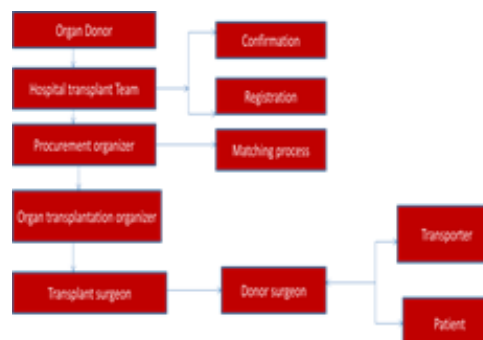


**Article Title: Using Hashing Algorithm For The Organ Procurement And Transplant Network**

collaboration, and faster decision-making. The platform's blockchain ledger provides transparency by allowing authorized parties to view and track the data shared by suppliers. This can help reduce disputes and ensure compliance with industry standards and regulations. Increased trust: A blockchain-based platform can help build trust among stakeholders by providing a decentralized and transparent system that ensures data integrity and eliminates the need for intermediaries. Increased trust is a key benefit of a blockchain-based platform for aviation suppliers. The platform can provide a secure and transparent platform for data exchange and increase trust between stakeholders in the aviation supply chain. By using an approved blockchain network, only authorized parties can participate in the network and view or modify data, ensuring data security and privacy. Smart contracts can automate processes like payment and quality assurance, reducing the need for manual intervention and streamlining the quality assurance process. The platform's blockchain ledger provides transparency by allowing authorized parties to view and track the data shared by suppliers, reducing the risk of disputes and breaches. By providing real-time access to data and transaction records, a blockchain-based platform can increase stakeholder trust and lead to more efficient and secure supply chain operations.

#### 4 Organ Donation Structural Design

Integration with Healthcare Systems: The ODTNS may need to integrate with electronic health record systems and other healthcare infrastructure to exchange relevant medical Organ Donation and Transplantation Network System (ODTNS) is a complex system that facilitates the process of organ donation and transplantation. While I don't have access to specific information about the architecture of a particular system, I can provide you with a general overview of the components and functionalities that such a system may include. Here are some notes on the potential architecture of an Organ Donation and Transplantation Network System



**Figure 3.** *Organ Donation Structural Design*

##### 4.1 Centralized Database

The ODTNS would have a centralized database that stores and manages information related



**Article Title: Using Hashing Algorithm For The Organ Procurement And Transplant Network**

to organ donors, potential recipients, transplant centers, and medical professionals involved in the process. This database would be responsible for storing and retrieving critical data in a secure and efficient manner.

#### **4.2 Donor Registration**

The system would provide a platform for individuals to register themselves as organ donors. This registration process may include gathering relevant medical information, consent forms, and preferences for organ donation.

#### **4.3 Organ Matching Algorithm**

An important component of the system would be an organ matching algorithm. This algorithm would evaluate compatibility between donors and potential recipients based on factors such as blood type, tissue compatibility, organ size, and urgency of the recipient's condition.

#### **4.4 Waiting List Management**

The system would maintain a waiting list of potential organ recipients, prioritizing them based on medical urgency and other factors defined by organ transplantation policies. The waiting list would be dynamically updated as new information becomes available. Organ Allocation: When an organ becomes available for transplantation, the system would initiate the organ allocation process. This involves identifying the best matching recipient(s) based on the organ matching algorithm and ensuring fairness and transparency in the allocation process.

#### **4.5 Communication and Notifications**

The system would facilitate communication between various stakeholders, including organ procurement organizations, transplant centers, medical professionals, and potential recipients. Notifications and alerts would be sent out to relevant parties when an organ becomes available or when there are updates in the status of a potential recipient.

#### **4.6 Tracking and Reporting**

The ODTNS would track and report various metrics and statistics related to organ donation and transplantation. This data could include the number of registered donors, successful transplants, waiting list dynamics, and overall system performance.

#### **4.7 Security and Privacy**

Given the sensitive nature of the data involved, the system would implement robust security measures to protect patient confidentiality and prevent unauthorized access. Compliance with relevant privacy regulations, such as HIPAA, would be a critical consideration information seamlessly. This integration would ensure that healthcare providers have access to up-to-date



**Article Title: Using Hashing Algorithm For The Organ Procurement And Transplant Network**

data on potential recipients and their medical conditions.

#### **4.8 Regulatory Compliance**

The system would adhere to regulatory requirements and standards related to organ donation and transplantation, ensuring compliance with laws and guidelines set by relevant governing bodies.

### **5 Modules**

#### **5.1 Smart Contract Module**

The organ transplantation smart contract is mostly in charge of the transplantation process. Removing an organ from a donor. Getting the organ from the recipient. Putting the organ from the recipient

#### **5.2 System Gateway Module**

The system and blockchain is linked with this layer. It is basically a gateway which equips various contracts and algorithms for the system. The registration and verification are gone through this layer. It takes care of authorization and tamper-proofing. And provides an uninterrupted connection between all the users in the system.

##### **5.2.1 Procurement Organizing Module**

All medical records are reported to the procurement organizer. The procurement organizer is responsible for evaluating the donor's condition. To decide if he is a fit donor and ensuring that the donor is properly registered in the medical system. To make the announcement that a new donor has been registered, an event will be triggered.

##### **5.2.2 Organ Matching Module**

The matching process between the available donors and patients on the waiting list is performed by the organ transplantation organizer. Organ matching organizer should add the following: Minimum age, maximum age, donor blood type, minimum BMI, maximum BMI, and donated organ type. Each patient must meet the defined conditions in the algorithms to decide if that patient is fit to receive a donated organ. Transplantation of organs Module: The organ transplantation smart contract: The Donor's Surgeon, Transporter, Transplant surgeon. The organ transplantation smart contract has a set of attributes used to describe the details of the transplantation process.

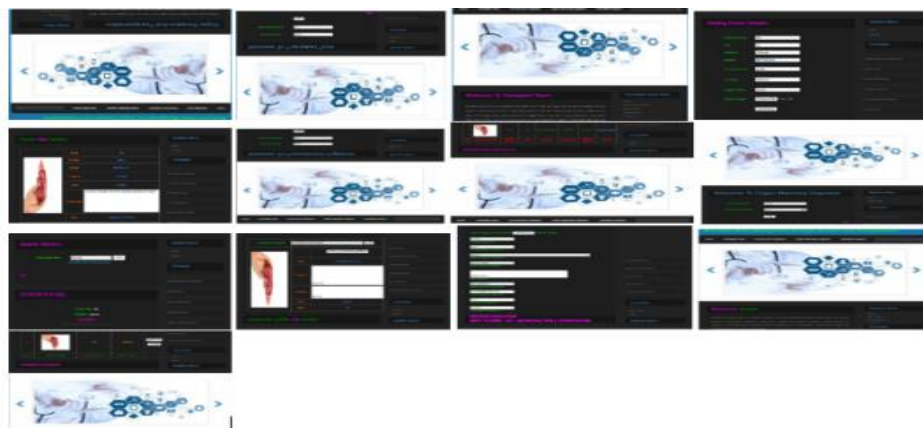
### **6 Result and Discussion**

The implementation of blockchain technology in the Organ Donation System enhances the privacy of contributors when contributing to the campaign. This is because the nature of blockchain transactions is transparent. The hospital can make a lock for a patient as soon, as they come across one who is most likely in critical condition and both the patient and their family are willing to give an organ. When a patient passes away, his or her organs become



**Article Title: Using Hashing Algorithm For The Organ Procurement And Transplant Network**

available for a limited period and must be transplanted at that time. The patient's name, the organ's description, the patient's blood group, and the organ's present state are among the entries that must be input and inserted into the chain. Once a record has been entered, it is crucial to monitor the organ and obtain its most recent changes. It must be transmitted within a specified time frame or it won't be viable, thus the process must be quick and secure. All of the migration files are located in the migration directory.



**Figure 4:** *result of application interface*

## 7 Conclusion

Thus designed a Private Ethereum blockchain-based solution to manage organ donation and transplantation in a decentralized, accountable, auditable, traceable, secure, and trustworthy manner. Developed a smart contracts system that ensure the data provenance by recording events automatically. Here present six algorithms with their implementation, testing, and validation details. Analyze the security of the proposed solution to guarantee that smart contracts are protected against common attacks and vulnerabilities.

## 8 Future Enhancement

Furthermore, the smart contracts can be deployed and tested on a real private Ethereum network. Finally, the Quorum platform can provide better confidentiality because transactions among entities can only be viewed by specific participants and nobody else, which is not the case in our solution, where transactions between two participants are viewed by other actors authorized in the private blockchain.

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**Article Title: Using Hashing Algorithm For The Organ Procurement And Transplant Network**

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