A Decentralized and Cooperative Methodology For Organ Donation Management Based on Ethereum Blockchain

P. Sheela Rani[1,*], Harini M.[1], Nandhitha N.[1], Teena A. Naahz G.[1]
[1]Department Information Technology, Panimalar Institute of Technology, India
Email: rpsheelaranipit@gmail.com; harinidharan874@gmail.com; nandhitha1910@gmail.com; teenaamish2001@gmail.com

Abstract

The digital world is a vast and ever- evolving ecosystem that encompasses a wide range oftechnologies, applications, and platforms. Blockchain has played a significant role in bringingthe healthcare business forward. Blockchain may significantly enhance the traceability, efficiency, andsafety of confidential data such as organ donation and transplantation, as well as the administration ofelectronic health data. This paper presents a secure and efficient web application for organ donation thatuses private Ethereum blockchain technology to create a proof of authority (PoA) model for thisconsortium and to automate a number of processes, including matching donors and recipients.The fairness of all the entities—patient, donor, hospital, or insurance company—involved in the system is guaranteed without the involvement of a third party. The security and privacy of the patient's details are protected. The logic of the application is implemented using smart contracts and deployed in Ganache. It depicts various interactions and transactions among the participants, thus helping toautomate these processes, promote transparency, improve efficiency, and minimize service time.

Keywords: Smart Contract; Decentralization;Ethereum Blockchain

1. Introduction

One individual can save several lives from serious disease by promising to donate their vital organs, suchas their lungs, kidney, heart, and tissues. Every year onAugust 13, World Organ Donation Day is observed to promote awareness of the importance of organ donation and to inspire individuals to do so. TheTransplantation of Human Organs and Tissues Act, 1994, regulates organ donation in India. It is feasible for both living and deceased donors to offer their organs. Teams of researchers, doctors, and altruistic patients pioneered the field of organ transplantation inthe 1950s by carrying out the first successful kidney transplant in a human because there were no other treatments available for conditions like nephritis at thetime [1].The first verifiably reported skin transplant happened in 1869. A newborn baby became the world's youngest organ donor in 2015 when he donated his kidneys to an adult struggling with renal failure. After birth, the boy lived for only 100 minutes.The oldest reported donor was a 107-year-old Scottishwoman who gave a cornea after passing away in 2016.A 95-year-old West Virginian man who donated his liver after death was the oldest known internal organ donor.

According to the World Health Organization (WHO),about 0.01 percent of Indians donate their body parts after passing away. Application that uses the FIFO approach to select an organ donor for each genuine patient requiring a transplant, and if there is an emergency case, then priority is given to that patient. [2] The organ donation process is a complex and highly regulated one involving multiple stakeholders,including donors, recipients, medical professionals,and regulatory bodies. Organ donation involvesseveral complex challenges and issues, including a shortage of organs, difficulties in donor registration, compatibility issues, medical ethics, transportation and logistics, and data management. Addressing these challenges requires a coordinated effort from various stakeholders, including healthcare providers, regulatory bodies, and the public.

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Education, technology, and ethical considerations canhelp ensure that the process is efficient, effective, andequitable for all involved. The use of a blockchain- based system can offer several advantages. Blockchain is a peer-to-peer network with a decentralized, indelible ledger. There is no central administration in place to validate transactions. A consensus algorithm is proposed to address this complexity, which is a toolthat uses blockchain nodes to achieve a single truth state in the absence of a centralized authority. The Proof of Authority (PoA) algorithm used in blockchaintechnology has various benefits, including faster transaction speeds, improved security, lower energy usage, and streamlined governance. Proof of Authorityis more eco - friendly and sustainable and its dependence on a trusted authority makes it safer against malicious attacks. Every participant canbenefit from transparency since blockchain technology can make the data accessible on every node. The privacy of nodes may be protected since blockchain can operate in an anonymous environment without requiring nodes to develop a sense of trust. It provides tamper-proof storage since the blocks are connected together with accurate hash values that would result in a violation if the block contents were modified. A secure task assignment scheme, which enables task content preservation and anonymous attribute requirement checking. Specifically, by adopting the cryptographic techniques, the proposed scheme enables task requester to safely place his task in a transparent blockchain [3]. Ethereum enables the generation of smart contracts, which are self-executingcontracts in which the conditions of the managing customer are directly written into lines of code. The smart contracts enable any application to perform the necessary business logic or operations while providingimmutability of generated data, transparency, and audibility of processes or transactions. On the Ethereum blockchain, transactions require the payment of gas charges, which are used to compensateminers for processing transactions and executing smart contracts.

2. Related Works

We discuss the proposed current blockchain-basedsolutions to fix the problems with the organ donation system. The authors in [1] discussed a blockchain- based organ donation and transplantation managementsystem using two smart contracts, one of which is connected to an API to access the features and events of smart contracts, automatically connecting the donorand receiver. All prior phases are recorded and kept onthe ledger. It seems that the smart contracts have not been deployed and tested on any private Ethereum blockchain, which is one of the major limitations. Thefirst-in, first-out (FIFO) approach is used in [2] to select an organ donor for each real patient in need of atransplant. This system is a web-based application. Insuch circumstances, the patient is given priority if there is an immediate need. It offers a productive forum for connecting potential organ donors and thosein need of organs. The Ethereum blockchain can be used to create a more effective system. This paper uses blockchain to secure a limited amount of data. Develop a platform for massive amounts of data.

The research paper [4] mentions that it offers a securemethod for organ donation on a decentralized network. This strategy will be implemented through a hospital-run website that connects organ donors and receivers.Kidner's goal in [5] is to increase the efficiency, security, and effectiveness of the current transplant system. As part of this endeavor, it deals with system governance and trust issues, as well as provides transparency for all system participants. The concept and execution of a diabetic blockchain network are thesubjects of this [10] proposed study. For this research,it is definitely recommended that transactions andblocks be combined on the blockchain, since this would increase transaction speed, lower transaction fees, and utilize less power in future blockchain architecture. This paper discusses the significance of EHR interoperability for seamless medical care interms of EHR ownership, EHR structure, and EHR exchange. This study [6] provides a thorough analysisof healthcare concepts for representing cutting-edge EHR knowledge, open standards for EHR interpreting, and huge data warehouses for EHR modelling. High communication and computing overheads, high complexity, insufficiency, and large payloads are justa few of the paper's limitations.

This paper [11] explores blockchain technology and the major contributions it has made to healthcare. Diagrams are used to discuss various blockchain technology features, enablers, and a single workflow procedure to assist healthcare globally. The study concludes by identifying and outlining fourteen important blockchain applications in healthcare. The lack of experience is the main issue with using this advanced technology in medical facilities. [13] The PRISMA framework was used in this study to systematically search for and assess the various models that were suggested, prototyped, and/or put into execution. All 143 papers from this study's bibliometric and practical distribution were shown. The 61 papers that covered prototypes, pilot projects, or implementations were analyzed for this study. These 61 articles underwent a thorough technical and architectural study for security, confidentiality, cost, and performance. This study's primary issue was its concentration on literary works, which may have unintentionally left out multiple continuing non- scholarly projects with still unpublished

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implementations. They have a significant architecture model, but some readers might require more specifics.The proposed study [14] evaluates the effectiveness ofblockchain technology concepts for protecting electronic medical records using an "integrated fuzzy-ANP-TOPSI" technique. A number of parameters are calculated and their respective weights are measured; other possibilities are ranked; and the total impact of blockchain models for protecting EHR (Electronic Health Record) is evaluated [15]. This work might be applicable to EHR; however, it still has certain drawbacks, such as time-consuming message update, considerable increases in capital and operating costs, and narrowly specialized knowledge.

3. Proposed System

The following section deals with the proposed model for a more secure and decentralized system that can offer greater security, accountability, andtransparency. Blockchain technology provides a more secure way of storing data and authenticating users. However, there are several issues to address, such as scalability, interoperability, privacy, and regulatoryconcerns. As a result, the problem statement for blockchain technology is to create a more scalable, interoperable, and privacy-preserving system capable of addressing the challenges while also ensuring greater security, transparency, and accountability.

The proposed system would address existing constraints and problems in the organ donation and transplantation process. Blockchain based web application is created which provides data privacy, security, authority, and performance without distribution channels. The proposed solution assures that no one gets access to a patient's data kept in a medical database unless the patient gives permission. Every single party in the proposed system has a uniqueID. Now of system registration, a smart contract produces these IDs. A single unique ID corresponds to a single key. There is no way to avoid the registration phase while receiving the benefits of the system. A smart contract generates these IDs at the time of registration in the system. Each data block canbe encrypted using hash value in Blockchain, which provides an open network that is available to all users.

Ganache is used to create a private EthereumBlockchain for testing Smart contracts. Ganache is highly customizable, enabling developers to change the number of accounts, the gas capacity, and the block time. Ganache is an open-source tool that is free to use, making it available to developers of all skill levels and budgets. Ganache provides various advantages over Remix, such as offline development, customization, user interface, quicker testing, and better debugging tools. SHA – 256 algorithm can be used to generate unique hash codes for each donor's medical record and organ donation information. These hash codes can then be stored on the blockchain along with other relevant information, such as the donor's personal information and the recipient's medical data.

To make sure that the nodes that validate and add newblocks to the blockchain are reputable authorities in the network, this project employs the Proof of Authority (PoA) consensus mechanism. PoA can be used to verify network nodes that take part in it. Onlyauthorised nodes, such as organ registries and hospitals, will be permitted to take part as validators. By doing so, it may be possible to stop nefarious individuals from entering the network and tampering with the data.The identity of organ donors and recipients can be confirmed utilizing PoA. You can rely on authorized healthcare providers to verify the donors and receivers identities and upload them to theblockchain. Data on organ donations that are stored onthe blockchain can benefit from PoA to help assure their security and integrity. One can rely on authorisednodes to verify the data accuracy and completeness and to stop any unauthorized additions, deletions, or alterations. Based on their medical histories, blood types, and other essential characteristics, PoA can also be used to match donors and recipients. We may rely on authorized healthcare providers to apply their skill and knowledge to find the best matches while preserving the anonymity and privacy of the donors and recipients.

Blockchain supports immutability, which implies thatdata that has been recorded cannot be changed or deleted. The blockchain forbids altering data within the network as a result. The use of SHA ensures that the information stored on the blockchain is secure andcannot be altered without detection. This is importantin an organ donation project because it ensures that thedata is accurate and up-to-date, which is essential for the success of the donation process. This proposed system uses EDDSA algorithm to validate theauthenticity and integrity of data stored on the blockchain. For example, if a person agrees to donatean organ, they may use their private key to sign a message, which can then be validated using their public key. Their signature is then added to the blockchain as confirmation of their permission to donate the organ. Moreover, EDDSA can be used to validate the data recorded on the blockchain. When a new transaction or data point is added to the blockchain, it may be signed with EDDSA to confirm

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that it was added by an authorized entity and that it hasnot been tampered with.

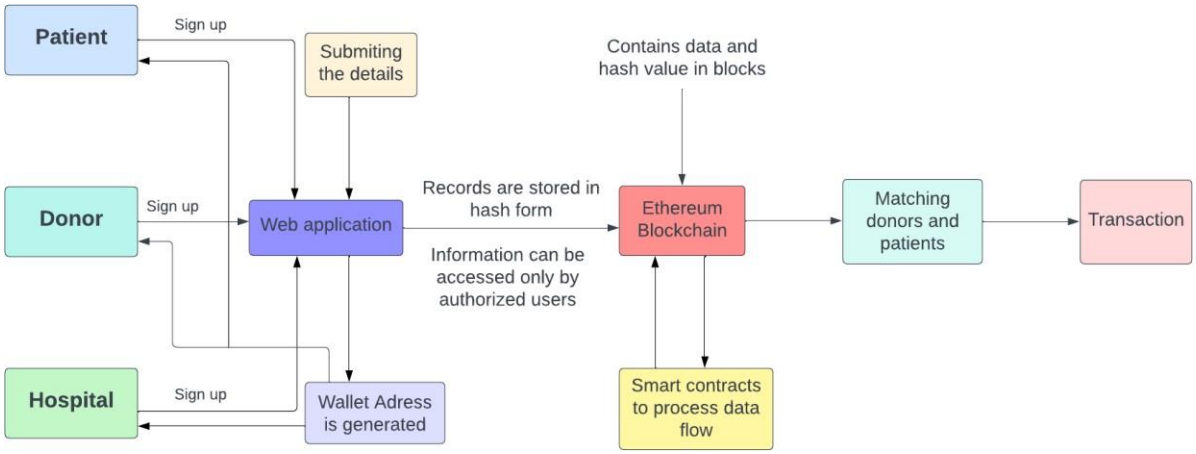

Figure 1: System Flow Diagram

Fig 1 depicts the overall workflow of the system, which denotes admins, or network-permitted nodes manage the registration process for differentstakeholders. According to government regulations, this necessitates the verification of people andinstitutions, necessitating a component for a government verification service. A matching wallet address is generated for each successful registration.

The following are major roles in the system:

Administrator: The healthcare network's administrator is in charge of running and maintaining it. Numerous reputable organizations and service points are numerous reputable organizations and service points that can be given this function. The administrator is incharge of adding new stakeholders to the network. They also have the authority to assign permissioned nodes and, under certain conditions, to remove a stakeholder from the network, upholding the established rules.

Patients: In a network, a patient is any user whoreceives healthcare and related services. In order to carry out a number of tasks, including accessing their medical information, obtaining prescriptions, filing insurance claims, and ordering the recommended treatments and medicines, patients can communicate with other stakeholders.

Donors: The group of network users who are able to donate their organs to patients are known as donors.

Doctor: A group of licensed medical professionals who work at a hospital and are able to review a patient's medical file, add a prescription to the patient'sfile, and review and confirm a patient's medical information for insurance companies.

Hospital: Institutions that offer people medical care and have the ability to schedule visits and upload medical information to patient records lists.

Insurance Company: Businesses that offer insurance- related services and are able to assess the registered patient's medical bills and expenses for their medical claim and distribute the cash.

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Table 1: Proof of Authority vs Proof of Work		
Metric	**Proof of Authority**	**Proof ofWork**
Energy consumption	Low	High
nsactiontime	Fast	Slow
Security	Less secure	More secure
Throughput	High	Low
Validators	Limited	Unlimited
Governance	Easier	Harder
Fork resistance	Low	High
Sybil resistance	Low	High

Table 1 shows the comparison between PoA and PoW consensus algorithms. PoA offers faster transaction times, higher throughput, and easier governance, but may have lower security.

4. Methodology

Our overall approach of this paper focuses on three algorithm.

1. Proof of Authority (POA)
2. EDDSA 3. SHA- 256

5. Proof of Authority (POA):

1. Select a group of validators: In PoA, a group of validators is selected by the network participants to validate transactions and create new blocks. These validators are usually pre-approved andtrusted members of the network.

2. Validators validate transactions: When a transaction is submitted to the network.

3. Validators create new blocks: Once a transaction is validated, the validators generate another new block containing the validated transaction.

4. Consensus on new blocks: The validators must reach consensus on the validity of each new block. Consensus is reached when a majority of thevalidators approves the block.

5. Add block to the blockchain: Once consensus is reached, the validated block is added to the blockchain, and the process repeats.

6. Rewards: Validators are incentivized to participate in the PoA consensus algorithm by earning rewards for validating transactions and creating new blocks.

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6. Pseudocode

```
import randomimport time
authorities = ["0x1234...", "0x5678...", "0x9abc..."]
current_block = { "transactions": [], "timestamp": time.time(),"previous_hash": ""}
previous_block = {}
def select_authority(authorities): return random.choice(authorities)
def calculate_block_time(current_block,previous_block):
return 10
def create_block(current_authority, current_block,block_time):
new_block = {
"transactions": current_block["transactions"],"timestamp": time.time(),
"previous_hash": previous_block["hash"],"authority": current_authority
}
return new_block
def add_block(new_block):
   Pass while True:
current_authority = select_authority(authorities)
   block_time = calculate_block_time(current_block,previous_block)
   new_block= create_block(current_authority,current_block, block_time)
add_block(new_block) previous_block = current_block current_block = new_block
time.sleep(block_time)
```

Edwards – Curve Digital SignatureAlgorithm (EdDSA)

There are several cryptographic signature schemes andamong them, one of the most important is EdDSA. EdDSA can be applied to ensure the integrity of digitaldocuments. When a digital document is generated andsigned, the digital signature leaves a unique footprint.Any alteration of it, no matter the outcome, is invalid.The document is therefore safeguarded against alteration and its validity is guaranteed in all circumstances. Among the many cryptographic signature systems, EdDSA is one of the mostsignificant.

The EdDSA technique is used to produce a digital signature on the blockchain and preserve the donor's information when their organs are donated fortransplantation. This signature can serve to guarantee the reliability and preciseness of the data and canhelp to stop offences or manipulation.

When the donor's organs are donated for transplantation, the details of the donor can be recorded on the blockchain using the EdDSA algorithm to create a digital signature. This signature can help to ensure the authenticity and integrity of thedata and can also help to prevent tampering or fraud.

When an organ transplant takes place, the EdDSA method can be used to create a digital signature on theblockchain to record the patient's particular. This can serve as a visible record of the process and make it easier to verify that the technique was applied correctly.

Secure Hash Algorithm (SHA)

The contents of blocks and transactions in a blockchain are hashed using SHA-256 as well. A blockchain's block headers are linked together in a tamper-evident manner because every block's header includes a hash value of the preceding block header. Moreover, the transactions in a block are hashed

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collectively to create a Merkle tree, allowing for quickconfirmation of a transaction's inclusion in a block.

In blockchain networks, SHA-256 is a crucial cryptographic building block that is utilized for a number of operations, including mining, hashing, creating digital signatures, and generating addresses. Because of its durability and security features, it is suitable for usage in blockchain applications.

SHA – 256 algorithm is used to generate unique hash codes for each donor's medical record and organ donation information. These hash codes can then be stored on the blockchain along with other relevant information, such as the donor's personal information and the recipient's medical data. Blockchain supports immutability, which implies that data that has been recorded cannot be changed or deleted. The blockchain forbids altering data within the network asa result. The use of SHA ensures that the information stored on the blockchain is secure and cannot be altered without detection.

7. Experimental Setup

To develop a web application, first we need to install PyCharm, which includes the Python IDE, Python 3.6.8, and Microsoft SQL Server Management Studio.PyCharm is a database that contains data on organ availability, recipients, donors, and other relevant information. This database may be created, modified, and managed using SSMS, ensuring that it is correctlyorganized and maintained. SSMS provides a user-friendly interface for querying the database, monitoring the database activity, managing the security, and analyzing the data. The SQL Serverinstaller for Express is a tool that simplifies the installation and configuration of SQL Server Express,making it easier to set up and manage a database for ablockchain-based organ donation project. Web3.py is an effective tool for creating programmers thatcommunicate with the Ethereum network. It is a popular option among developers who wish toconstruct decentralized applications and smart contracts due to its straightforward and intuitive interface and powerful capabilities. Smart contracts installed on a blockchain network may be interacted with using Web3.py. This involves transferring fundsto smart contracts, accessing their data, and receiving events they release. Developers may create and manage accounts on a blockchain network using Web3.py. This includes establishing new accounts, using account keys to sign transactions, and checkingaccount balances.

8. Result

The proposed system's outcomes are discussed in thispart once all the previous processes have been completed successfully. Using blockchain technology, the development of organ donation and management aims to give stakeholders a decentralized solution.Administrators or network-permitted nodes handle theregistration process for different stakeholders. This requires the verification of people and organizations in accordance with government regulations, necessitating a component for a government verification service. Each successful registration results in the generation of a corresponding wallet address. The idea might start by registering organdonors on the blockchain, together with their personaldetails and medical background. This might be accomplished using the secure web application.

A collection of data must be hashed from each block in the chain. This data might contain information suchas the sender and recipient addresses, and any further transaction details. The next step is to develop smart contracts on the Ethereum blockchain to match donorsand recipients according to factors such as blood type,tissue compatibility, and medical background. A smartcontract that automatically matches donors and recipients might do this. Once created, smart contractsmight be tested on the Ganache network to make sure they perform effectively and securely. The blockchain may contribute to streamlining the donation process and shortening patient wait times by automating many of the procedures associated with organ donation and maintenance. The SQL server might be used to gather information on organ management and donation, which could then be examined to interpret data and improve organ distribution.

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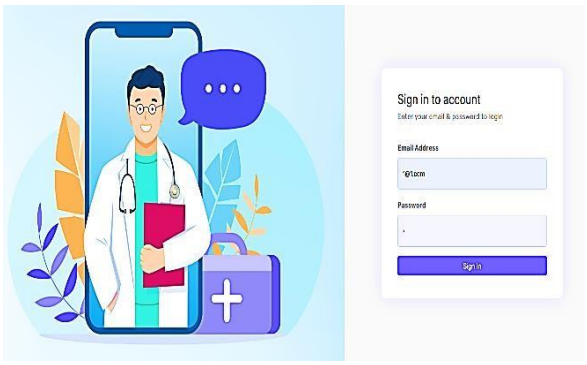

Figure 2: Login Page

Fig. 2 shows the phases of registration of variousstakeholders, which are conducted by administrators or permissioned nodes in the network. The system's administrator is in charge of regulating user access andpermissions.

Fig. 3 explains that when a registered donor donates organs, the donor's registered hospitalupdates its record of the donation, adding the asset Organ to the network. The relevant hospital may buildthe organ asset, update the organ information, and submit essential reports with the donor's consent. In a similar way, the hospitals of the recipient may uploadthe recipient's report into the network with the recipient's consent in order to broadcast the request forthe required organ with specific information.

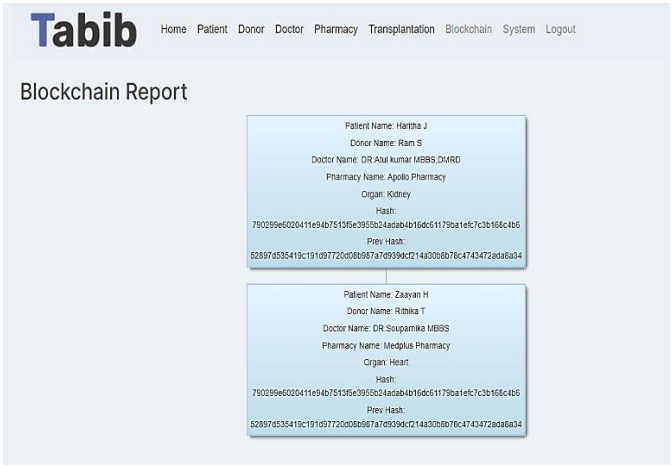

Figure 3: Blockchain Report

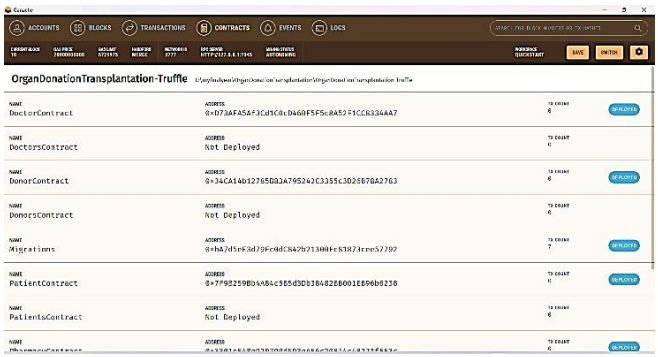

Figure 4: Ganache

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Fig. 4 shows the Ganache workspace with a description of the platform's capabilities, including the capacity to build a personal blockchain with configurable features, accessibility to transaction history and logs, and support for various accounts. Several accounts with various addresses, private keys,and balances may be managed.

Figure 5: Gas Limit vs Price

Fig. 5 The gas limit is the amount of work you predicta validator will complete on a given transaction. A larger gas limit generally indicates that the user anticipates the transaction to be more labor- intensive. The cost per completed unit of work isreferred to as the "gas price". A transaction cost is therefore equal to the gas limit times the gas price.

6. Conclusion

In this paper, we propose an Ethereum blockchain- based online application for managing organ donationthat has security, transparency, and scalability. The integrity and validity of the data being captured have been guaranteed by this system using cryptographic and consensus algorithms, which can also serve to increase stakeholder confidence in the system, including patients, healthcare practitioners, and governmental agencies. Administrators or permissioned nodes in the network conduct registration of various stakeholders. All the transactions among various stakeholders will be efficient, secure and transparent. The use of Ganache in this project can help in minimizing the possibility oferrors and bugs in smart contracts and in improving the development, testing, and debugging processes. Infurther study, standardization and stakeholder cooperation are required to fully realize blockchain technology's promise in organ donation and transplantation, as it is still in the early stages ofimplementation in the healthcare industry.

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