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Blockchain–based framework for Organ Donation System

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Abstract
Organ donation is a life-saving process that faces multiple challenges, including lack of transparency, inefficient donor-recipient matching, and security concerns. Traditional organ donation systems struggle with delays, fraud, and inadequate record-keeping. To address these issues, blockchain technology offers a decentralized, immutable, and secure framework form an aging organ donation. This survey paper explores existing organ donation systems, identifies their limitations, and presents a blockchain-based solution that integrates real- time smart contracts, secure transactions, and automated matching algorithms. A review of relevant literature highlights how blockchain improves security, trust, and efficiency in organ donation. Future research directions, such as AI- driven matching and multi-chain support, are also discussed.

Keywords: Blockchain, Organ Donation, Smart Contracts, Ethereum, Ganache, Transparency, Security, Donor Matching.

I. Introduction

Organ donation after cerebrum demise has gained momentum in India in the last not many years. Cerebrum demise as a type of death and made the offer of organs a culpable offense. With the acknowledgment of cerebrum demise it got conceivable to embrace kidney transplantations as well as start other strong organ transplants like liver, heart, lungs and pancreas. Donating an organ or organs is one of the most respectable demonstrations of mankind sparing the lives of the individuals who endure genuine diseases that require organ transplantation. At the point when the human body gets tainted with malady urgent organs in the body. For example, the kidney, lungs, heart, pancreas, liver or digestion tracts become non-functional, making life deplorable generally prompting passing. Anybody can get presented to an infection. Making an organ donation is a vital commitment to sparing lives. Organ transplantation tasks started during the 1950s and upset drug sparing incalculable lives and making life simpler for the individuals who endure long haul sicknesses. On account of givers, they might be alive, dead or in certain nations, cerebrum dead. Any live individual must be alive and well to give and gift is taken into account organs that won't influence their wellbeing. For example, a kidney, liver, lungs or bone marrow. There arena greatest or least age limits for organ donation however the organ must be in a decent condition and its misfortune won't present a risk to life. In many nations minors can possibly give organs in the event that one of their gate keepers gives assent. On account of perished organ donation, a giver probably gave their assent while they were as yet alive for the most part by marking their name in the donation framework.

Blockchain Framework

Blockchain is a secure distributed platform. It is a growing list of records called block and each maintain the cryptographic hash of its previous block.

System of Blockchain can be partitioned into three layers to be specific Network Layer, Data Layer and Application Layer. The Network Layer empowers the Blockchain to interface and cooperate with the environment and the clients. It likewise makes the whole framework decentralized using peer-to-peer system and IP protocols. One of the most significant tasks, accord is accomplished at this layer. Data Layer is the thing that makes the blocks in Blockchain. All the information and calculations and different mechanisms like digital signature, Merkle tree and hash pointers are characterized here. These calculations and information structures help in making the block chain transparent and decentralized

The Application layer speaks to various application that can utilize Blockchain and its highlights like shrewd agreements and digital currency for their motivation. The data is stored in a cluster chain. It is accordingly difficult to distort a block or include other no genuine data without the endorsement of all gatherings included.

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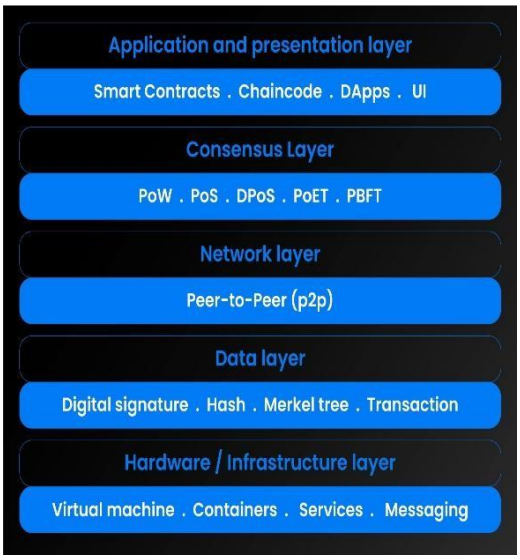

Figure: Blockchain Layers

Accomplishing information straightforwardness in any innovation is to have a trust-based connection between elements. The information or record in question ought to be made sure about and temper evidence. Any information being put away on the blockchain isn't gathered at one spot and isn't constrained by one hub however is rather conveyed over the system. The responsibility for is currently shared and this makes it to be straightforward and secure from any outsider mediation.

Security And Privacy

Blockchain innovation utilizes cryptographic capacities to give security to the hubs associated on this system. It utilizes SHA 256 cryptographic calculation on the hashes that are put away on the squares. SHA gives hashes and hashes give security to the blockchain as information uprightness is guaranteed by them. Cryptographic hashes are solid one way works that creates checksum for advanced information that can't be utilized for information extraction. This makes blockchain thusly a decentralized stage made secure by the cryptographic methodologies which makes it to be a decent assessment for security assurance of specific applications.

Benefits of Safeguarding Organ Donation System

1. Prevention of Illegal Activities

Safeguarding the organ donation system helps prevent illegal organ trade and unethical transactions. It ensures that every donation follows legal procedures, protecting both donors and recipients.

2. Fair and Transparent Allocation

A well-regulated system ensures that organs are allocated based on medical urgency and compatibility. This prevents favoritism or financial influence from affecting the distribution process.

3. Protection of Donor Rights

Proper safeguards ensure that donors, both living and deceased, are treated with dignity and respect. It also prevents coercion or exploitation, ensuring donations are made voluntarily.

4. Improved Public Trust and Participation

A transparent and ethical system encourages more people to register as organ donors. When people trust the system, they are more likely to support and participate in organ donation programs.

5. Ensuring Medical Safety and Standards

Strict medical protocols ensure that organs are thoroughly screened, reducing risks of infection and rejection. High medical standards guarantee safe transplantation procedures for recipients.

6. Increased Availability of Organs

By eliminating unethical practices and improving donor participation, more organs become available for transplantation. This helps save more lives by ensuring a steady and legal supply of organs.

7. Legal and Ethical Compliance

A safeguarded system ensures adherence to national and international laws governing organ donation. Ethical practices uphold the integrity of the healthcare system, ensuring fairness for all.

II. Literature Review

1. Title: Organ donation using Digital document

Author: Marco Baldi et al., 2020

This project leverages the RSA algorithm to ensure secure digital signatures and authentication in organ donation processes. It emphasizes enhancing security and integrity for digital documentation. However, the system faces challenges with slow data transfer rates. This issue arises primarily due to the involvement of a large number of participants.

2. Title: Organ donation transparency using blockchain

Author: Dsv Madala et al., 2020

The project utilizes Hyperledger Fabric to implement CTB smart contracts, enabling transparent organ donation transactions. It focuses on improving accountability and trust through blockchain technology. Despite its advantages, the system suffers from low scalability. Additionally, the number of transactions handled remains limited.

3. Title: Organ donation validation through public ledgers and blockchain

Author: Deepak Puthal, Nir Kshetri, Praveen P.

Ray, 2019
CRLs are distributed through a private blockchain shared among Certification Authorities (CA) for organ donation validation. The system simplifies reading and verifying organ donation data through public ledgers. However, the CA ecosystem is fragile and vulnerable to compromises. This affects its reliability and long-term sustainability.

4. Title: Blockchain Technology for healthcare
Author: Zewang Jingqiang Lin et al., 2018
This project explores the use of blockchain technology to develop web-based healthcare interfaces. The focus is on improving security and decentralization in healthcare data management. However, the system introduces a false sense of security. This is due to potential vulnerabilities in its implementation.

5. Title: A Systematic Literature Review and Research Agenda for Organ Donation Decision Communication
Author: Kathy Knox, Joy Parkinson, Bo Pang, Haruka Fujihira, 2017
The project follows PRISMA guidelines to document a systematic review and screening process for organ donation communication. It aims to enhance decision-making and streamline research methodologies. Unfortunately, the system remains prone to tampering.

6. Title: Organ donation validation through CRLs and Cas
Author: Boyina Saivamsi Rangarajan, 2017
This paper presents Certificate Revocation Lists (CRLs) are shared among Certificate Authorities (CAs) to ensure secure and decentralized management. This method voids organ donation fraud and improves transparency. However, it faces validation delays and may lead to a false sense of security.

7. Title: An Organ Donation Management System based on Blockchain Technology for Tracking and Security Purposes
Author: Che Akmal Che Yahaya, Ahmad Firdaus, Yong Yew Khen, 2016
This paper presents a blockchain-based Organ Donation Management System (ODMS) aimed at enhancing tracking and security in organ donation processes. The system leverages blockchain's immutable ledger to ensure transparent and secure management of donor and recipient information.

8. Title: Organ Harbour: A Blockchain Solution for Organ Donation and Transplantation
Authors: Nikita Bansal, Samyak Jain, Ribha Nishal, Kavita Pandey, 2016
This research introduces "Organ Harbour," an Ethereum blockchain - based decentralized application designed to automate and secure the organ donation and transplantation process. By integrating hospitals into the system, it ensures fair allocation of organs, transparency, privacy and trustworthiness.

Existing System

The current organ donation systems are characterized by several inefficiencies and limitations that hinder their effectiveness. These systems typically involve multiple stakeholders, including donors, recipients, hospitals and regulatory bodies all of whom must coordinate seamlessly to ensure successful organ transplants. However, the existing processes often fall short in several critical areas.

Drawbacks of Existing System

1. Lack of Real-Time Smart Contract Integration
Current systems do not utilize real-time smart contracts, leading to a lack of transparency and security in transactions. This absence increases the risk of fraud and mismanagement of sensitive data.

2. Inefficient Donor-Recipient Matching
The matching process between donors and recipients is often manual and time-consuming, resulting in delays that can be detrimental to patients in urgent need of organ transplants. The lack of a robust, automated matching algorithm further exacerbates this issue.

3. Fragmented Communication
Communication between donors, recipients, and medical professionals is often fragmented and inefficient. There is no streamlined platform that facilitates direct and seamless interaction among all parties involved in the organ donation process.

4. Limited Data Security and Privacy
Existing systems are prone to data breaches and do not provide adequate security measures to protect sensitive information. This vulnerability undermines trust among stakeholders and poses significant risks to patient confidentiality.

5. Administrative Overhead
The current system involves considerable admin overhead due to the need for processing and verification of data. This not only slows down the entire process but also increases the potential for

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human errors.

6. Transparency Issues
A significant lack of transparency in the current organ donation processes leads to mistrust among stakeholders. Donors and recipients are often not well-informed about the status and progress of the donation process.

7. Inadequate Donor Engagement and Retention
Existing platforms fail to engage donors effectively, leading to lower registration and retention rates. There is a need for a more user-friendly and engaging interface to encourage more individuals to participate in the organ donation process.

Proposed System

The proposed system leverages blockchain technology with Ganache to create a secure and transparent organ donation platform. It integrates real-time smart contracts and advanced matching algorithms to ensure data integrity and prevent fraud. Donors can register, pledge organs and access contract details while recipients request organs and receive updates. Hospitals manage donor data, conduct medical tests and facilitate communication, with admins overseeing hospital operations and transplant records. Enhanced security measures protect sensitive information, and a unified platform improves stakeholder coordination. By streamlining processes and ensuring compliance, the system enhances transparency and effectiveness, ultimately saving lives.

Advantages of Proposed System

1. Secure and Tamper-Proof Records
Blockchain ensures tamper-proof records, reducing fraud while smart contracts protect sensitive data and automate security**.**

2. Transparency and Trust
Decentralization boosts trust among stakeholders and access to smart contract details enhances the transparency.

3. Efficient Donor-Recipient Matching
Optimized matching algorithms reduce wait times, and automation streamlines pairing, minimizing errors.

4. Seamless Communication
A unified platform ensures seamless coordination, while real-time updates keep stakeholders informed.

5. User-Friendly Experience
An intuitive interface simplifies interactions, and engagement tools encourage participation.

6. Reduced Administrative Overhead
Automation reduces manual work and errors, improving the management of donor and hospital records.

7. Regulatory Compliance and Oversight
Compliance with regulations is ensured, with transparent audit trails enabling monitoring and accountability.

8. Scalability and Adaptability
A scalable system accommodates growing demand and adapts to evolving requirements.

Architecture

The diagram represents a system architecture for an organ donation and transplantation process, utilizing a blockchain-based database for secure and efficient data management. The process begins with two primary user categories: organ donors and patients (recipients). Both parties interact with the system through a website, where they can register or log in. Donors register their organs, while patients provide their details for matching and eligibility.

Once the data is collected, it is sent to blockchain server, which acts as a secure intermediary for the processing and storing information in the database then the system matches donor and recipient data. The system matches donor and recipient data by using blockchain server, ensuring compatibility and integrity of the information. Finally, the transplantation process is carried out based on the matched data, ensuring a seamless and transparent flow from registration to the medical procedure.

The blockchain server plays a pivotal role in ensuring the integrity and transparency of the data. By leveraging blockchain technology, the system guarantees that all transactions including registrations, matching and updates are secure and immutable. This ensures trust among stakeholders and prevents unauthorized tampering with sensitive information.

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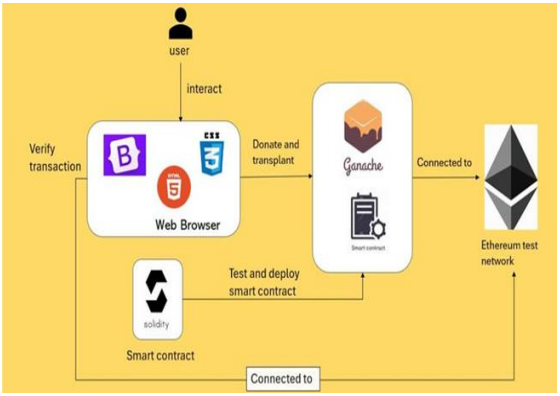


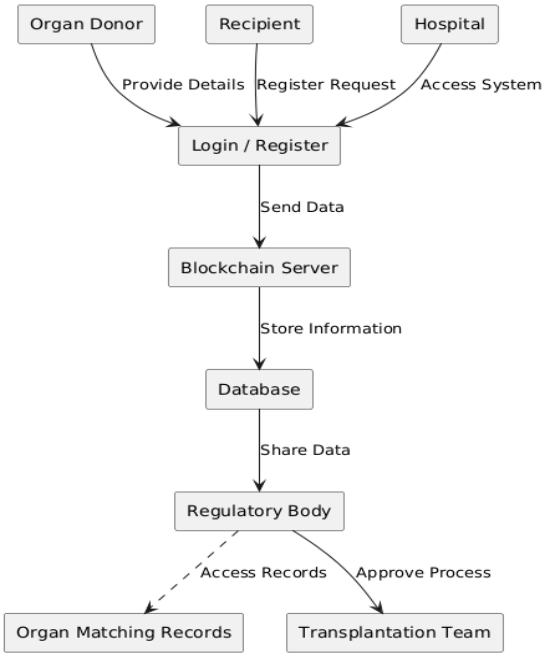
Figure: Architecture

Data Flow

The diagram illustrates a system for organ donation and transplantation, integrating blockchain technology to ensure secure and efficient management. The process starts with three primary stakeholders: organ donors, recipients, and hospitals. Donors provide their details, recipients register their requests, and hospitals access the system to facilitate these operations. Once the data is collected, it is processed through a login or registration system, which sends the information securely to a blockchain server. This server ensures the integrity and authenticity of the data while securely storing it in a database for further use.

The stored information is shared with a regulatory body, which plays a crucial role in monitoring and managing the organ donation process. This body accesses the records to oversee organ matching and grant approvals for transplantation. Using the database, the system identifies suitable matches for recipients, ensuring ethical and accurate pairing.

The transplantation team then takes over to perform the procedure, closing the loop on this highly secure and transparent system designed to streamline organ donation and transplantation effectively.



Data flow diagram

Algorithms

Hashing Algorithm

Hashing algorithm are crucial for maintaining the integrity and security of data within the blockchain. Ethereum uses Keccak-256 (a variant of SHA-3) for hashing, ensuring data immutability and resistance to manipulation.

Process

1. Padding the message to a length that is a multiple of the block size.

2. Initializing the state to zero is the second step of process.

3. Absorbing the message into the state block by block, with each block being mixed into the state using the Keccak-f permutation.

4. Squeezing the state to produce the final hash output is the final step of the process.

Input

Transaction data is input into the Keccak-256 (a variant of SHA-3) for hashing.

Output

The function outputs a fixed-size string of characters, which appears random. This is called the

hash value or digest.

Properties:

1. Deterministic: The same input always produces the same output.

2. Quick Computation: It is computationally efficient to generate the hash.

3. Pre-image Resistance: It is infeasible to generate the original input from the hash.

4. Collision Resistance: It is infeasible for two different inputs to produce the same hash.

5. Avalanche Effect: A small change in the input produces a significantly different hash.

6. Fixed-Length Output: Regardless of input size, the hash function generates a fixed-size hash value.

7. Uniqueness: A slight modification in the input changes the hash completely.

8. Security: Cryptographic hash functions, like Keccak-256, provide strong security against forgery and tampering.

9. Tamper-Proofing: Once hashed, data integrity is maintained, ensuring no unauthorized changes.

10. Lightweight Verification: Hashing allows quick validation of large amounts of data by comparing their hashes.

11. Efficiency in Blockchain: Hashing algorithms ensure efficient data indexing and retrieval of the data.

Smart Contracts

1.Smart contracts are programs that run on a blockchain, a network of computers that share a secure and transparent ledger of transactions.

2.Smart contracts are self-executing contracts with the terms of the agreement directly written into the code.

3.Smart contracts are tamper-proof, ensuring that once deployed, they cannot be altered without the consensus from the blockchain network.

4.They run on the blockchain networks and automatically enforce and execute the terms when predefined conditions are met.

5.Smart contracts eliminate the need for intermediaries, ensuring that transactions and agreements execute solely based on coded logic.

6.By automating processes and reducing administrative overhead, smart contracts lower transaction costs compared to traditional contract execution.

Properties

1. Autonomy: They self-execute according to the programmed rules.

2. Deterministic: Smart contracts produce the same output for a given input every time they are executed by ensuring consistent and predictable behavior.

3. Transparency: The code and transactions are visible on the blockchain.

4. Immutability: Once deployed on a blockchain, the smart contract code cannot be altered.

5.Security: Due to the blockchain's decentralized structure and cryptographic techniques ensure strong protection against tampering and fraud.

6. Interoperability: Smart contracts can interact with other contracts and the decentralized applications to facilitate the complex blockchain based ecosystems.

7. Fault Tolerance: Running on a decentralized network ensures that smart contracts remain operational even if some nodes fail, enhancing system resilience.

8. Programmability: Smart contracts can be customized with complex logic to support a wide range of applications, from financial transactions to supply chain management.

10. Global Accessibility: Being deployed on a blockchain, smart contracts can be accessed and executed from anywhere in the world, enabling borderless operations.

Requirements

1. Hardware Requirements

a. Server Specifications

- **Processor:** Intel i5
- **RAM:** 8 GB
- **Storage:** At least 256 GB SSD
- **Internet:** High-speed connection

b. Hardware Specifications

- Compatible with desktops, laptops, tablets and smartphones.
- Minimum screen resolution is 1024x768.

c. Software Requirements

- **Operating System:** Windows 7/8/10/11
- **Backend:** Python 3.12 with Django 3.2
- **Frontend:** HTML, CSS and JavaScript
- **Database:** MySQL for the secure and the structured data storage.

d. Development Tools

- **IDE:** Visual Studio Code (VS Code)
- **Version Control:** Git and GitHub for code management.

III. Conclusion

The blockchain-based organ donation system developed in this project successfully addresses the inefficiencies and limitations of existing systems by leveraging the security, transparency, and automation capabilities of blockchain technology. Through real-time smart contracts, an advanced donor-recipient matching algorithm, and streamlined communication channels, the platform enhances the overall efficiency and trustworthiness of the organ donation process. The user-friendly interface, robust security measures, and comprehensive management tools for donors, recipients, hospitals and administrators ensure a seamless and secure operation. The decentralized nature of blockchain eliminates the risk of data tampering, ensuring integrity and authenticity in all transactions. Automated workflows reduce manual intervention, minimizing errors and accelerating the overall process. Real-time status updates enable faster decision-making, improving transplant success rates and patient outcomes.

The system's compliance with healthcare regulations and data privacy standards enhances its reliability and scalability for future integrations. Additionally, integrating AI-driven analytics and machine learning can further optimize donor-recipient matching, enhancing efficiency and accuracy. By reducing bureaucratic complexities and ensuring transparency in organ allocation, this innovative solution not only improves coordination among stakeholders but also significantly reduces waiting times and increases the likelihood of successful transplants. Furthermore, the system fosters a more inclusive and accessible platform by supporting multi-platform accessibility and multilingual support making it easier for people from diverse backgrounds to participate. Future enhancements could include cross-border organ donation facilitation and enhanced biometric verification for added security. Ultimately, this blockchain-driven approach not only saves more lives but also fosters greater confidence in the organ donation system, paving the way for a more ethical and secure healthcare ecosystem.

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