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BLOCKCHAIN-BASED APPLICATION FOR ORGAN DONATION TRACKING

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ABSTRACT

Organ donation and transplantation systems encompass a complex array of challenges, spanning registration, donor-recipient matching, organ handling, delivery, and transplantation processes. These systems must navigate clinical, ethical, legal, and technical constraints while striving for fairness, efficiency, and patient trust. This article proposes a decentralized solution using a private Ethereum blockchain for managing organ donation and transplantation. The system aims to ensure security, auditability, privacy, and reliability throughout the process. Key components include the development of smart contracts and the validation of six algorithms. To assess its effectiveness, the proposed solution is compared against existing methods through evaluations of privacy, security, and confidentiality.

Index Terms: Organ donation, transplantation, blockchain, Ethereum, smart contracts, decentralized systems, privacy, security, auditability, healthcare technology.

I.INTRODUCTION

The damage or failure of an organ may be caused by disease or trauma. It diminishes the quality of life and, in extreme cases, may be lethal. Giving one's organs for transplantation is one of the most selfless acts a person can perform. The success of the transplant depends on three things: how well the organ fits the recipient, how well it functions, and whether or not it poses any threat to the donor's life. In 1954, a kidney transplant between two brothers was the first of its kind to be successful. Since then, the annual amount of transplants has been steadily increasing. Despite this, there is a chronic shortage of organs due to a lack of donors. Surprisingly, twenty people die per day while waiting for an organ transplant, and a new patient is added to the list every ten minutes. Getting on the organ donor waiting list is the most important step before organs may be distributed. Referrals for transplants may be affected by demographic and socioeconomic factors. Consequently, the waiting list allocation process should not discriminate against any patient category. Donating organs may be done in two ways: either while the donor is alive or after death. Figure 1 shows the conventional flow diagram for organ donation and transplantation. The hospital's transplant team will first check the donor's vitals; if they come back negative, they will do a brain death test. Meanwhile, doctors check the donor's health to see if they are a good candidate for live donation. An analysis of all medical data is then sent to the procurement organiser.
The procurement organizer's responsibilities include verifying the donor's accurate medical record and determining the donor's suitability based on his health assessment. If the donor is determined to be eligible for donation based on the evaluation, the

procurement organiser will provide all relevant information to the organ transplantation organiser. To ensure the recipient's anonymity, this step must be taken only after the donor gives their consent. Next, the organ transplant coordinator makes arrangements to match those on the transplant waiting list with donors who are willing to donate their organs.

Consequently, the transplant surgeons get a prioritised list as their output. The transplant surgeon then decides whether the organ is a good fit for the patient by looking at the donor's medical history and the current health status of the possible recipient, among other things. Once a transplant surgeon accepts a donated organ, they will call the donor's surgeon to arrange for its removal. Once the organ has been transported to the patient's hospital, it is finally received by the transplant surgeon. In contrast, imagine a situation when a live donor is required and a certain person is the designated receiver. If that's the case, the data will be sent directly to the transplant surgeon, who will then utilise it to initiate the procedure of removing and replacing the donor organ. When a patient died or was about to die, the hospital and organ procurement organisation used to work together to conduct an initial medical evaluation to see whether the patient would be a potential organ donor.

Although just 6% of these calls result in the discovery of possible organ donors, they take around fifteen minutes to finish. Over time, this phone call has been replaced by an instant message generated by central computer systems that store all the data needed for this procedure [8]. The key issue with this method is that the validity and security of such data is determined by the transplantation centres' abilities to maintain system security and recognise potential hazards to donors and recipients. The reliability of the wait-list information is greatly affected by the extent to which people trust these centres to keep their data safe from hackers and fraudsters. One further thing that makes the organ donation process less efficient is the lack of transparency. World Health Organisation (WHO) data suggests that as much as 10% of donated organs could have been obtained unethically via organ trafficking, while exact numbers are not available. There is a lack of transparency in the current system, which leads to medical professionals engaging in unethical practices and the illegal sale and purchase of organs. In addition, some facilities take advantage of the fact that people are in critical need of an organ by proposing to sell it to someone who would pay more, ignoring the patient who is currently at the top of the waiting list. Present transplant procedures are often slow, which is unacceptable in such a critical and perhaps lethal scenario. Very seldom do these systems provide even the most basic level of protection. Up until now, security breaches that jeopardise system integrity and user privacy have been on the rise. Modern systems often use standard databases for data handling, despite the fact that the majority of healthcare facilities, including hospitals and health ministries, lack a standardised data transmission method.

II.LITERATURE SURVEY

- Lama Abdulwahab Dajim and Sara Ahmed Al-Farras proposed a decentralized organ donation app using blockchain technology. It would be a web application for patients to register their information—most importantly, medical ID, blood type, organ type, and condition. The system would work on a

first-in, first-out basis unless a patient is in critical condition.

- Utsav Jain proposed that the organ donation system in the United States is centralized and difficult for the general public to audit. This centralized approach may lead to data integrity issues in the future. The Organ Procurement and Transplant Network (OPTN) was built and is maintained by a non-governmental organization called the United Network for Organ Sharing (UNOS) under its proprietary UNet(SM) platform. This platform is made up of proprietary closed-source software and does not provide the general public with easy access to organ transplant data for auditing. This study investigates the feasibility, challenges, and advantages of a blockchain-based OPTN.
- Mai He, Ann Corson, and Jessica D. Russo propose an approach to track unethically procured organs, particularly 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, we 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. A verified match between DNA profiles of transplanted organs and missing victims will establish proof of such a connection, thus providing evidence despite a lack of transparency.
- Pratyush Ranjan, Shubhanker Srivastava, and Vidit Gupta propose that in today's era of digitization, many technologies have evolved to the point where every manual task can be digitally automated. In the digital automation process, security and privacy are the most important and highly demanded aspects. Blockchain offers many features that can be used in almost every sphere of life. Features like decentralization, transparency, and privacy make it an extremely useful technology. Therefore, by utilizing all these features, several problems in the healthcare sector can be solved, such as removing the complex network of third parties and the lack of traceability of transactions. This paper presents a decentralized, secure, and transparent organ and tissue transplant web application (also called DApp), which not only nullifies the role of any third party involved in organ transplantation but also provides a cost-effective solution that saves patients from the high costs of transplantation. The details and Electronic Medical Records (EMR) are hashed using the IPFS (a distributed file server), which reduces the cost of upload to a great extent, as shown in the results section of this paper.
- Marko Hölbl, Marko Kompara, and Aida Kamišalić propose that blockchain technology enables a decentralized and distributed environment with no need for a central authority. Transactions are simultaneously secure and trustworthy

due to the use of cryptographic principles. In recent years, blockchain technology has become very trendy and has penetrated different domains, mostly due to the popularity of cryptocurrencies. One field where blockchain technology has tremendous potential is healthcare, due to the need for a more patient-centric approach to healthcare systems and to connect disparate systems and increase the accuracy of electronic healthcare records (EHRs). In this systematic review, an analysis of state-of-the-art blockchain research in the field of healthcare is conducted. The aim is to reveal the potential applications of the technology and to highlight the challenges and possible directions of blockchain research in healthcare. First, background information is discussed, followed by a description of the exact methodology used in this paper. Next, an analysis of the results is given, which includes a bibliometric overview, an analysis of gathered data and its properties, and the results of a literature quality assessment. Lastly, there is a discussion of the results from the analysis. The findings indicate that blockchain technology research in healthcare is increasing and is mostly used for data sharing, managing health records, and access control. Other scenarios are very rare. Most research is aimed at presenting novel structural designs in the form of frameworks, architectures, or models. Findings also show that technical details about the used blockchain elements are not given in most of the analyzed publications and that most research does not present any prototype implementation or implementation details. Often, even with a prototype implementation, no details about blockchain elements are given.

III.EXISTING SYSTEM

Managing organ donation and transplantation has become challenging due to the lack of data accountability, immutability, audit, transparency, traceability, and trust features in the existing systems.

The following are the paper's main contributions:

- We propose a privateEthereumblockchain-based solution that ensures organ donation and transplantationmanagement in a manner that is decentralized, secure, reliable, traceable, auditable, and trustworthy.
- We develop smart contracts that register actors and ensure data provenance through producing events for all the necessary actions that occur during the organ donation and transplantation stages. The smart contracts code is made publicly available on Github.
- We develop an auto-matching process between the donor and recipient through a smart contract based on certain criteria.
- We present six algorithms along with their full implementation, testing, and validation details.
- We conduct security analysis to determine that the proposed solution is secure against common security attacks and vulnerabilities. We compare our solution with the existing solutions to show its novelty. Our proposed solution is general and may be easily adjusted to meet the needs of a variety of related applications.

IV.PROPOSED SYSTEM

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The participants can access the functions and events of these smart contracts through a front-end decentralized application (DApp), which is connected by an application program interface (API). Every smart contract has unique functions that can be executed only by pre-authorized participants, who will have the ability to access data stored on the chain to review transactions, logs, and events.

The participants include doctors, hospital transplant team members, procurement organizers, organ matching organizers, a transporter and a transplant surgeon. The Organ Donation Smart Contract is responsible for creating a waiting list, accepting donors after medical test approval, and auto-matching between the donor and recipient. The Organ Transplantation Smart Contract is mostly in charge of the transplant process. It has three parts: removing an organ from a donor, getting the organ to the recipient, and putting the organ into the recipient. All the previous phases are logged and stored on the ledger for revision and verification purposes. Additionally, authorization, secrecy, and privacy are ensured by utilizing a private permissioned Ethereumblockchain.

V.SYSTEM ARCHITECTURE

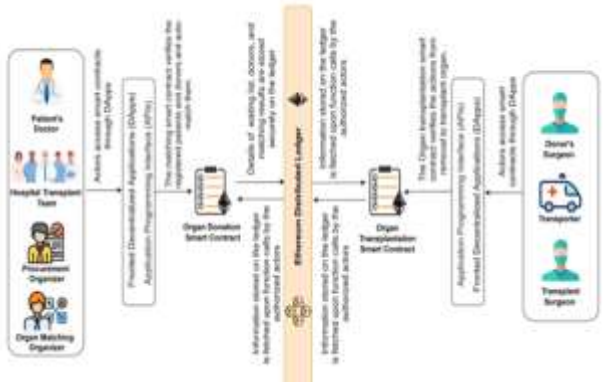

Figure 1. System Architecture

VI.MODULE

A. Non-Blockchain-Based Solutions For Organ Donation Management

Several methods and instruments are used in non-blockchain procedures to improve organ donation, transplant administration, and the matching procedure. To reflect the information pipeline model between recipient hospitals, regulators, and donor hospitals, the authors created a multi-agent software platform. By streamlining the pre-transplantation processes, this platform may increase process efficiency. Furthermore, it facilitates the storage of possible donor data and enhances direct contact amongst all parties involved in the organ transplant procedure. The built platform was used to mimic an information process, and it was calculated that three to five hours may be saved.

A.Blockchain-Based Solutions For Organ Donation Management

Kidner, a blockchain-based kidney donation system, has been put out. Rather of using the existing kidney waiting list, it provides a kidney-pair donation mechanism. For instance, the method connects a donor's kidney to another patient who also has an inconsistent donor's kidney when the donor wants to give to a family member but their kidney is incompatible with the recipient.

B. Private Permissioned Ethereum Network

Improved security and privacy are offered by private blockchains, in which only authorised organisations may see transactions and data. Businesses may create their own private-permissioned blockchain to enhance secrecy, security, and privacy by using the Ethereum blockchain. Details about the transplantation of donor organs are often kept completely private. These particulars include medical histories and familial information about the patients; thus,

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a private permissioned Ethereum blockchain is perfect for this kind of deployment.

C.Blockchain Integration

Our proposed solution is based on the blockchain network. It lays the groundwork for irretrievably storing transactions and events, which is necessary to ensure accountability and data provenance. Using smart contracts on the blockchain ensures that they will always be accessible. For testing purposes, however, it may not be a good idea to deploy them on the main network.

C. Participants Interactions

Interactions between different parties inside the matching smart contract consist of three stages. Phase 1 begins with a waiting list that is updated whenever a licenced physician adds a new patient. The doctor will make a note of the patient's age, blood type, identification, and body mass index. Donors who have consented to be transplanted finish the second step. An immediate event is sent after the test approval function is invoked by an approved member of the transplant team. After that, the procurement organiser may evaluate and sign up the donor. To let others know that a new donor has been registered, an event will be triggered. Thirdly, the coordinator of organ transplants oversees the process of auto-matching donors and recipients. The donor's age, blood type, and body mass index (BMI) range are used to carry out the auto-matching operation. Finally, the ranked list of patients who were a good fit is shown.

VII.RESULTS

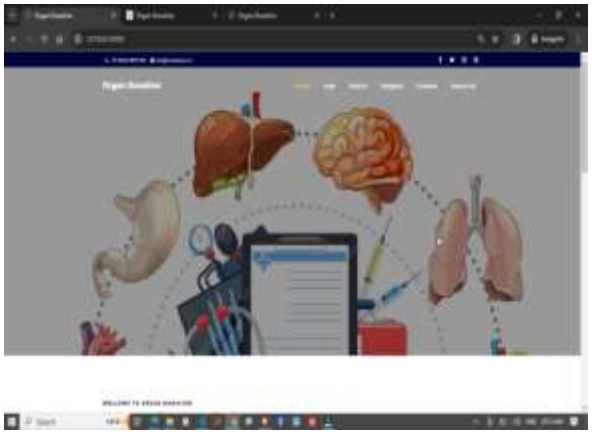

Figure.2 Home page

Figure .3 Login Page

Figure .4 User Registration page

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Figure .5 User Dashboard

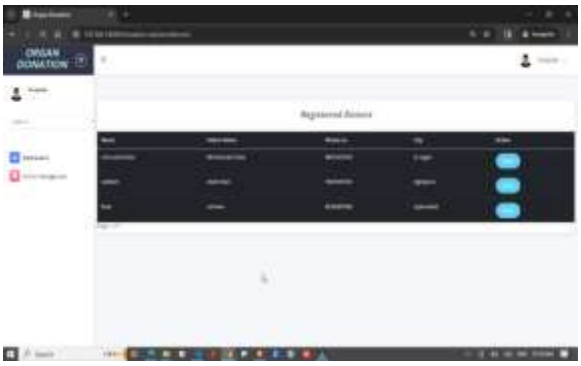

Figure.9 Hospital Donor Details

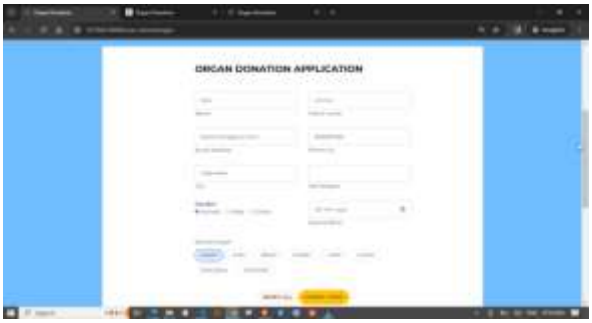

Figure .6 Donation Application Page

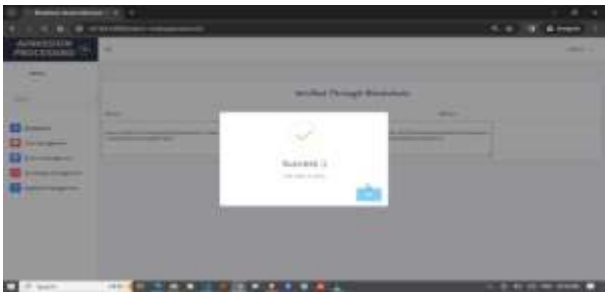

Figure .10 Validation

Figure .7 User-Profile

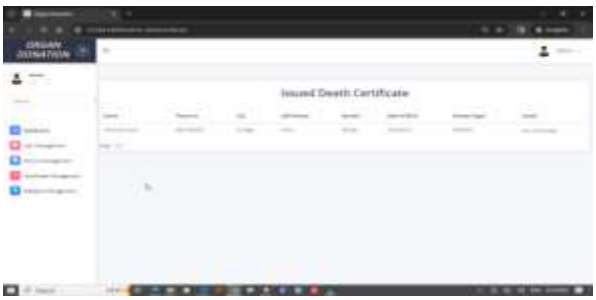

Figure.11 Certificate

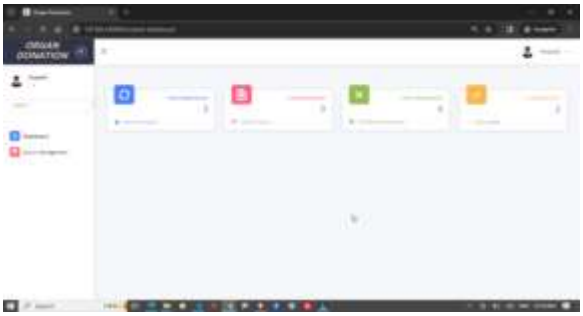

Figure .8 Hospital-Dasboard

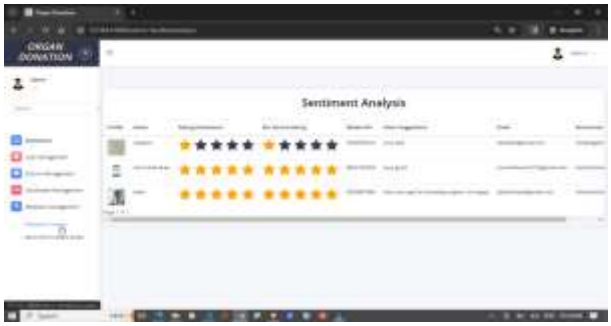

Figure .12 Analysis

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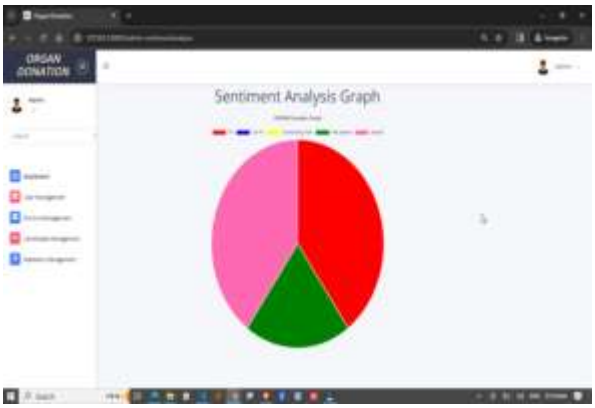

Fig-11 Sentiment Analysis Graph

VIII.CONCLUSION

In this paper, we have proposed a private Ethereumblockchain-based solution that manages organ donation and transplantation in a decentralized, accountable, auditable, traceable, secure, and trustworthy manner. We developed smart contracts that ensure the data provenance by recording events automatically. We present six algorithms with their implementation, testing, and validation details. We analyze the security of the proposed solution to guarantee that smart contracts are protected against common attacks and vulnerabilities. We compare our solution to other blockchain-based solutions that are currently available. We discuss how our solution can be customized with minimal effort to meet the needs of other systems experiencing similar problems.

IX.FUTURE ENHANCEMENT

In the future, our solution can be improved by developing an end-to end DApp. 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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