BLOCKCHAIN BASED MANAGEMENT FOR ORGAN DONATION AND TRANSPLANTATION

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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. In this

paper, we 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. We develop smart contracts and present six algorithms along with their implementation, testing, and validation details. We evaluate the performance of the proposed solution by performing privacy, security, and confidentiality analyses as well as comparing our solution with the existing solutions. We make the smart contract code publicly available on Github.

I.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 [1]. The first successful organ donation occurred with a kidney transplant between twin brothers in 1954 [2]. Since then, the annual number of transplants has steadily increased. However, the demand for organ donations still exceeds the number of donors [3]. In fact, while waiting for an organ transplant, twenty people die every day, and a new patient is added to the waiting list in every ten minutes [4]. 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 discriminate against certain groups of patients [4].

Organ donation is conducted in two different ways, including deceased donation and living donation. Figure 1 illustrates the typical flow chart for 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 sends all the data to the organ transplantation organizer. This step can be performed only if the donor gives consent to donate to an anonymous person. After that, the matching process between the available donors and patients on the waiting list is performed by the organ transplantation organizer. 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. Finally, the donated organ is transported to the patient's hospital and received by the transplant surgeon. However, suppose the situation is for a live donor and it has been planned to donate to a known person by name. In that case, the data will go directly to the transplant surgeon to start the surgery of removing and transplanting the donated organ [6], [7].

In the past, when a patient died or was near death, the organ procurement organization and hospital worked together to do an initial medical test to decide if the patient could be an organ donor. This call takes around 15 minutes, and only 6% of these calls result in possible organ donors' being identified. Over the years, this phone call has been replaced by an instant message generated by central computer systems that store all the data required for this process [8]. However, the core issue with this strategy is that the security and validity of such data are entirely dependent on the transplantation centers' ability to keep their systems secure

and identify potential harm to donors and recipients. The accuracy of the wait-list data is largely dependent on people's faith and trust in these centers' ability to keep it secure from hackers and fraudulent employees [9]. Moreover, transparency is another challenge affecting the success of the organ donation process. According to World Health Organization (WHO) reports, up to 10% of transplanted organs may have been obtained unethically via organ trafficking, but the exact numbers are unknown [10]. The lack of transparency in the current system among participants leads to illegal organ trade and purchases and medical professionals engaging in unethical practices [11]. Moreover, there are hospitals that take advantage of the patient's need for the organ and offer the opportunity to transfer the organ to those who pay a higher amount to the hospital while ignoring the patient with the highest priority on the waiting list [12], [13]. In addition, current transplant systems are also frequently slow, which is unacceptable in such a critical and life-threatening scenario. Such systems are hardly up to date with the minimum security standards. So far, there has recently been a surge in security breaches affecting user privacy and system integrity. In general, modern systems manage data through the use of standard databases; however, most hospitals, health ministries, and other medical facilities lack a standardized data communication
system [1].

II. EXISTING SYSTEM

The authors in [17] developed a multi-agent software platform to represent the information workflow model among donor hospitals, regulators, and recipient hospitals. This platform optimizes the pre-transplantation tasks, which can improve the

process efficiency. In addition, it allows storing potential donor information and improves direct communication among all participants in the organ transplantation process. An information workflow was simulated using the developed platform, and it was estimated that the saved time might be between three to five hours.

The TransNet in [18] is a system using scanning technology for barcodes at the point of organ recovery to assist in labeling, packaging, and tracking organs and other biological materials for transplantation. It involves supplementing the labeling system with an application developed and a portable barcode printer corresponding with DonorNet. During organ recovery, procurement coordinators will use the operating room's system to print labels and scan all organs to be transported. Similarly, many supply chain management solutions have relied on barcodes, RFID tags, and Electronic Product Codes (EPC) for identifying and sharing product information to facilitate the tracking of items through various phases [19].

Finally, the authors in [20] proposed a manageable mechanism, MIN, for the online matching of deceased organs to donors to improve efficiency and fairness in selecting patients within the current system in Australia. The MIN mechanism simply designates an arriving organ to a patient that minimizes |KDPI-EPTS|, tie-breaking by time on the waiting list and later randomly. The Kidney Donor Patient Inde (KDPI) estimates the quality of the organ. On the other hand, the Expected Post-Transplant Survival Score (EPTS) measures the life quality of the recipient after the transplant. After testing, the results showed that the MIN mechanism outperforms the current

mechanism under consideration by the Organ and Tissue Authority in Australia.

The authors in [23] proposed an organ donation decentralized app using blockchain technology. Patients use a web application to register their information, including their medical ID, organ type, blood type, and state. The system would operate on a first-in, first-out (FIFO) approach, with the exception of a patient being in a critical state. It offered better security, added transparency, and a much faster system. However, it should be modified when used in different regions according to their regulations and needs. Similarly, the authors in [24], developed a web-based application using FIFO to choose an organ donor for each actual patient seeking a transplant, and in the case of an emergency, that patient is given priority. Furthermore, an organ donation and transplantation application utilizing blockchain has been proposed in [12], where the registered hospital accepts the registered donors and registers the recipients to match them with a suitable donor based on the request.

Moreover, in [25], a use case for blockchain in organ donation has been developed. Simply, the process begins with the donor signing a smart contract for organ donation and the patient ling a transplant request. Both papers are verified and hashed by a registered doctor or nurse, who then creates a verified mismatching pair and announces it over the network. The network finds a match and sends it to a doctor for approval. If a match is found, the doctor approves, and the next step is for the doctor to generate a hash. If the doctor generates a hash, the verified matched pair becomes part of the

blockchain. Finally, doctors and healthcare professionals
are given all the information they need to prepare for the logistics of the surgery.

Disadvantages

❖ The system is not implemented blockchain based organ donation which leads less security and less communication between hospitals and donors..

❖ The system is not implemented an auto-matching process between the donor and recipient through a smart contract based on certain criteria.

III.PROPOSED SYSTEM

❖ The system proposes a private Ethereum blockchain-based solution that ensures organ donation and transplantation management in a manner that is decentralized, secure, reliable, traceable, auditable, and trustworthy.

❖ The system develops 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.1

❖ The system develops an auto-matching process between the donor and recipient through a smart contract based on certain criteria.

❖ The system presents six algorithms along with their full implementation, testing, and validation details.

❖ The system conducts 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.

Advantages

➢ The system is implemented an organ donation based on blockchain techniques which is more fast and secure.

➢ In the proposed system, the system is implemented an automatic process of human organ donation.
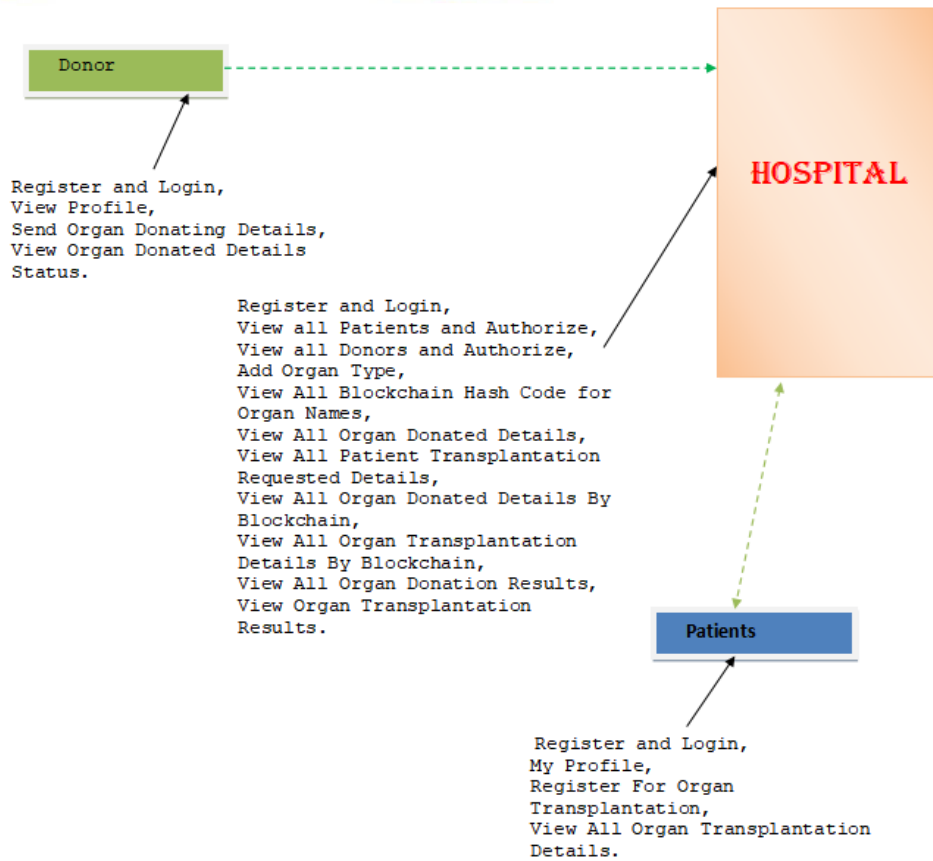
Donor

Register and Login,
View Profile,
Send Organ Donating Details,
View Organ Donated Details
Status.

HOSPITAL

Register and Login,
View all Patients and Authorize,
View all Donors and Authorize,
Add Organ Type,
View All Blockchain Hash Code for
Organ Names,
View All Organ Donated Details,
View All Patient Transplantation
Requested Details,
View All Organ Donated Details By
Blockchain,
View All Organ Transplantation
Details By Blockchain,
View All Organ Donation Results,
View Organ Transplantation
Results.

Patients

Register and Login,
My Profile,
Register For Organ
Transplantation,
View All Organ Transplantation
Details.

Fig1: System Architecture

IV.IMPLEMENTATION

- **Donors**

    In this module, the Donor will register and login then uploads their organ donor data to the Hospital and will do the following operations such as View Profile, Send Organ Donating Details, View Organ Donated Details Status.

- **Patients**

    In this module, patients logs in by using his/her user name and password. After Login User will do some operations such as My Profile, Register For Organ

    Transplantation, View All Organ Transplantation Details.

- **Hospital**

    The Hospital manages Hospital records to provide organ storage service for donation and transplantation and also performs the following operations such as View all Patients and Authorize, View all Donors and Authorize,Add Organ Type, View All Blockchain Hash Code for Organ Names,View All Organ Donated Details,View All Patient Transplantation Requested Details,View All Organ Donated Details By Blockchain,View All Organ Transplantation Details By Blockchain, View All Organ Donation Results,View Organ Transplantation Results.

V.CONCLUSIONS

In this paper, we have proposed a private Ethereum blockchain-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. 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.

VI. REFERENCES

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