RESEARCH ARTICLE OPEN ACCESS

Organ Donation And Tracking Of InformationManagement Based On Blockchain

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Abstract-Today's systems for organ donation and transplantation come with a variety of criteria and difficulties when it comes to registration, matching donors and recipients, removing organs for transplant, and doing so while adhering to medical, ethical, and technical standards.Therefore, a complete system for organ donation and transplantation is necessary to provide a just and effective procedure and to improve patient experience and trust. In this work, we present a fully decentralised, secure, trackable, auditable, private, and reliable private Ethereum blockchain-based solution for managing organ donation and transplantation. We create smart contracts and outline six algorithms with information on how they were implemented, tested, and validated. By conducting studies of privacy, security, and confidentiality as well as by contrasting our solution with the alternatives already available, we assess the performance of the suggested solution.

Keywords: Blockchain, ethereum, organ donation, organ transplantation, smart contracts, traceability.

I.Introduction

In this work, we present a fully decentralised, secure, trackable, auditable, private, and trustworthy private Ethereum blockchain-based system for managing organ donation and transplantation. Organ donation has transformed the medical field. Many people, whether they are alive or dead or even brain dead, are eager to donate their organs. The primary problem with organ donation is the delay in the supply of the organ due to a variety of causes; as a result, many individuals in need of an organ pass away. We want to use blockchain, a distributed database that can handle such datasets dynamically, to solve this problem. The participant receives a detailed rundown of the entire procedure.

The process will be made easier by the implementation of blocks that will store the entered data. Using blockchain, we will also ensure that no blocks can be altered or that no one can gain unauthorized access to the data, making all transactions incredibly safe. The transplant surgeon then determines if the organ is suitable for the patient based on several factors, including the medical history of the donor and the condition of the potential recipient.The transplant surgeon receives the donated organ at the hospital where the patient is being treated. But let's say that a live donor is involved and that it was decided to donate to a specific, named recipient.The information will then be sent immediately to the transplant surgeon, who will then begin the procedure to remove and transplant the donor organ. The existing system's participants lack transparency, which encourages the sale and procurement of illegally obtained organs as well as unethical behavior on the part of medical experts.Additionally, some medical facilities take advantage of individuals who require organ transplants by offering those who can afford to pay more the opportunity to receive the organ while ignoring the patient with the highest waiting list priority.Such systems hardly meet the bare minimum-security requirements. Up to now, there has been an increase in security lapses that jeopardize system integrity and user privacy.

II. Related Work

We discuss the existing blockchain and non-blockchain based solutions that have been proposed to address the issues in the organ donation system.

A. ON-BLOCKCHAIN-BASED SOLUTIONS FOR ORGAN DONATION MANAGEMENT

Reference(1) In non-blockchain-based processes, various approaches and tools are utilized to come up with solutions that enhance organ donation, transplantation management, and the matching process. The authors 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.

Reference(2): The TransNet 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.

Reference(3): The online matching of deceased organs to donors was presented as a manageable method, called MIN, to increase the effectiveness and fairness of patient selection in Australia's current system. The MIN process merely assigns an arriving organ to a patient, minimising |KDPI-EPTS|, tie-breaking by waiting list length, and then arbitrarily after that. The Kidney Donor Patient Index (KDPI) determines the organ's quality. The Expected Post-Transplant Survival Score (EPTS), on the other hand, gauges the recipient's quality of life after the transplant. Testing revealed that the MIN mechanism outperformed the one currently being considered by the Australian Organ and Tissue Authority..

B. BLOCKCHAIN-BASED SOLUTIONS FOR ORGAN DONATION MANAGEMENT

Reference(4): A blockchain-based kidney donation system named ''Kidner'' has been proposed. It offers a kidney-pair donation module instead of the traditional kidney waiting list, which is already in use. For example, when someone wishes to donate his/her kidney to a family member but their kidney is incompatible with the person they want to donate to, the system matches the donor's kidney to another patient who also has an inconsistent donor's kidney.

Reference(5): the suggested a decentralised blockchain-based app for organ donation. Patients register their information, such as their medical ID, organ type, blood type, and state, via an online application. Except when a patient is in a severe condition, the system would run on a first-in, first-out (FIFO) basis. It provided speedier service, more transparency, and improved security. However, it should be adjusted when used in other places in accordance with local laws and requirements.

Reference(6): The 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, where the registered hospital accepts the registered donors and registers the recipients to match them with a suitable donor based on the request.

Reference(7) : There has been development of a blockchain use case for organ donation. Simply put, the procedure starts when the patient submits a transplant request and the donor signs a smart contract for organ donation. A licenced physician or registered nurse verifies and hashes both documents, makes a confirmed mismatching pair, and broadcasts the result across the network. A doctor must approve the match before it can be sent via the network. In the event that a match is discovered, the doctor approves and generates a hash as the following step. The verified matched pair is added to the blockchain if the doctor creates a hash. Finally, all the information required for medical experts to get ready for the logistics of the procedure is sent to them.

III. PROPOSED METHODOLOGY

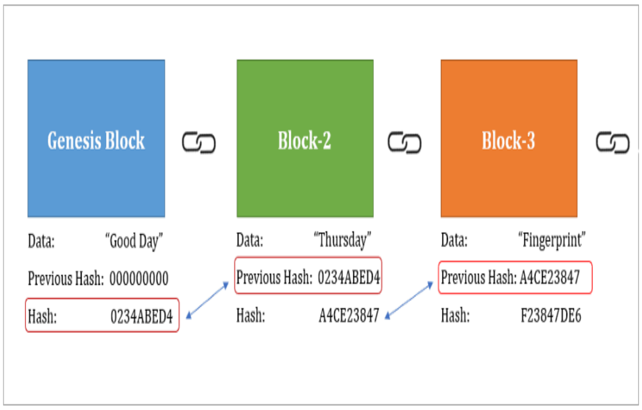
In this section, we present details of our blockchain-based organ donation and transplantation solution. Figure 2 presents an overview of the system architecture of our proposed solution. It shows that our solution uses two smart contracts (SCs); namely, organ donation and organ transplantation. The participants can access the functions and events of these smart contracts through a front-end decentralized application, which is connected by an application program interface . 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 Ethereum blockchain.

A.PRIVATE PERMISSIONED ETHEREUM NETWORK

Private blockchains provide enhanced security and privacy where the transactions and data are not accessible to the public and only viewed by authorized entities. Enterprises can use the Ethereum blockchain to develop their own private-permissioned blockchain to improve privacy, security, and confidentiality. In general, details of donated organ transplantation are strictly confidential. These details include the patients' health records and family histories;

therefore, a private permissioned Ethereurm blockchain is ideal for such an implementation.

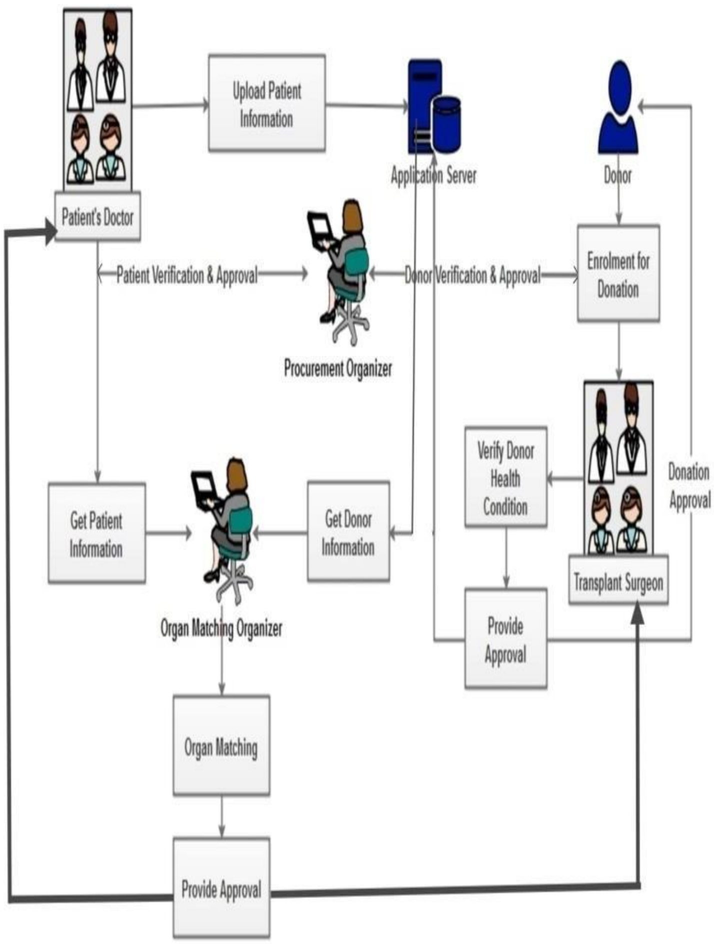
B. BLOCKCHAIN INTEGRATION



The blockchain network is the backbone of our proposed solution. It serves as the basis for recording transactions and events permanently to ensure accountability and data provenance. The developed smart contracts must be deployed on the blockchain to ensure they are accessible at all times. However, it would not be ideal to deploy them on the main network during the testing phase. Therefore, a local blockchain environment, a virtual machine such as the JavaScript-based Virtual Machine, or a test network should be used to test the Ethereum-based smart contracts. The smart contracts in our proposed solution are developed using the REMIX IDE, and they are deployed on the JavaScript-based Virtual Machine which runs an isolated Ethereum node in the browser itself, which is very useful for testing purposes. Once the developed smart contracts are tested and verified, they can be deployed on Ethereum's mainnet to test their performance in a real blockchain environment. However, the outcome of the functions of the smart contracts will always be the same because they are deterministic, which means that regardless of the node that is performing the operation, the outcome will always be the same.

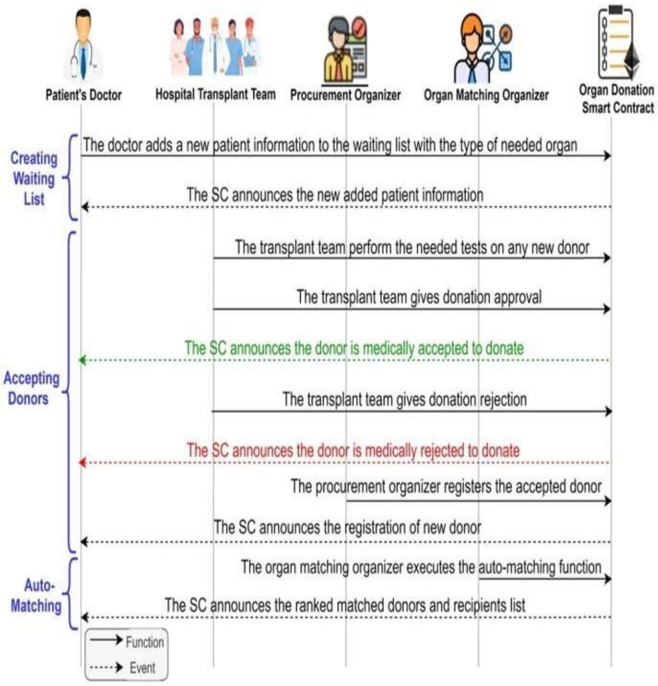
C.PARTICIPANTS INTERACTIONS

The interaction among different participants within the matching smart contract, which can be divided into three phases. Phase 1 begins with creating a waiting list, in which an authorized doctor will add a new patient to the waiting list. The doctor will record the patient's ID, age, BMI, and blood type. Phase 2 is fulfilled by receiving donors who have given their consent to donate their organs. Only an authorized transplant team member will run the test approval function, and an event will be sent immediately. After that, the procurement organizer is ready to evaluate and register the donor. To make the announcement that a new donor has been registered, an event will be triggered. In Phase 3, the auto-matching between the donor and recipient is handled by the organ transplantation organizer. The auto-matching process is done based on the age range, blood type, and BMI range obtained from the donor. Finally, a matched patient ranked list is announced. This smart contract includes removing the organ, the delivery process, and transplanting the organ. In Phase 1, the donated organ will be removed from the donor's body. Once the event is emitted for the donated organ's readiness for delivery, the transporter will execute the start delivery function. Starting and ending delivery functions in Phase 2 are called by an authorized transporter responsible for the transportation of the donated organ to the matched patient hospital and received by the transplant surgeon. In Phase 3, the donated organ is transplanted, and an event will be triggered to announce the end of the transplantation process.



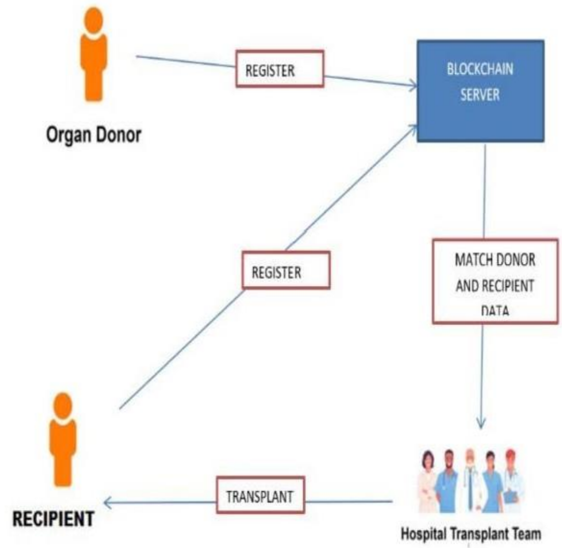
In this section, we present the implementation details of our proposed blockchain-based organ donation and transplantation solution along with the algorithms. The proposed system is built on a private Ethereum blockchain, to which validation nodes and only authorized participants are added.

The smart contracts are written in Solidity and tested with the Remix IDE, which is an open source web that enables developing and administering smart contracts. The implementation of our proposed solution is mainly two fold: organ donation and organ transplantation.



A. ORGAN DONATION

Four entities participate in the organ donation smart contract;namely, the patient's doctor, hospital transplant team member,procurement organizer, and matching organizer. Each entity has an Ethereum address and can participate by calling functions within the smart contract. This smart contract contains different types of variables. One of the variables is the Ethereum address, which is used to associate certain entities with a unique addre s, such as the procurement organizer and the matching organizer. The second type is mapping,which in our solution links the Ethereum address of an entity to a Boolean to reflect that the address needs certain conditions.For example, mapping is used for the authorized transplant surgeon and doctors. Moreover, mapping is used for patient validity to ensure that patient selection is not repeated. In addition, an enumerating variable called ''Bloodtype,''which contains the different types of blood, such as ''A,'' ''B,'' ''AB,'' and ''O''. This variable accepts uint8 input where ''0'', ''1'', ''2'', and ''3'' represent the blood types respectively. Additionally, the enumerated variable''OrganType'' accepts uint8 input where ''0'' represents''Heart,'' ''1'' represents ''Lung,'' ''2'' represents ''Liver'',and ''3'' represents ''Kidney''.The procurementorganizer will deploy the organ donation smart contract. The procurement organizer deploys the smartcontract and therefore becomes the owner, which permits this participant to assign the Ethereum address of the matching organizer. Then, the authorized doctor adds a new patient to the waiting list, which is then announced to all participants.Following this, the authorized medical team member performs the test and announces the test approval. Next, by the procurement organizer, the donor registration action is done and announced, including the type of donated organ. After that, the auto-matching process is conducted, and the information of matched patients with potential donors is stored.Fin this process depends on the main criteria such as age,blood type, BMI, and waiting time.



B. ORGAN TRANSPLANTATION

In the organ transplantation smart contract, the donor's surgeon, transporter, and transplant surgeon are the mainparticipants. Each participant can participate by calling functionswithin the smart contract. It includes various types of variables. For example, public Ethereum addresses hold the address of the donor and transplant surgeons. Moreover, it has a mapping for the authorized transporters, which is allowed to transport the removed donated organ from the donor hospital to the recipient hospital. Furthermore, the ''OrganStatus'' is an enumerated variable and contains all of the various states that the donated organ will go through.The Transplant surgeon will deploy the smart contract. You will define the initial condition of the removed organ and the donor's surgeon's Ethereum address.The transplantation tracing process occurs once the smart contract is deployed and the authorized transporters are assigned. First, the donated organ is removed by the surgeon and transported by the authorized transporter from where the location of the donor to the recipient hospital. Then, The start and end of the delivery procedure will be notified. After that, the transplant surgeon announces the reception of the donated organ and start transplanting it. Finally, the transplantation details will be announced, including the patient ID, time, and date of the process.

IV CONCLUSION

As stated in the study, this entire system demonstrates the significance of avoiding outside interference in a procedure that is so delicate and needs regular updating. Security and synchronization have been accomplished effectively thanks to the use of adecentralized platform, blockchain technology, and smart contracts. We contrast our approach with other already accessible blockchain-based alternatives. We go over how other systems dealing with similar issues may easily adapt our approach to fit their needs. By creating an end-to-end App, our solution may be enhanced in the future. Furthermore, a genuine private Ethereum network may be used to deploy and test smart contracts.

REFERENCES

[1] V. Ferraza, G. Oliveira, P. Viera-Marques, and R. Cruz-Correia, ''Organs transplantation—How to improve the process ?'' Eur. Fed. Med. Inform., Cardiff, U.K., Tech. Rep., 2011, doi: 10.3233/978-1-60750-806-9-300.
[2] Organ Procurement and Transplantation Network. Accessed: Nov. 27, 2021. [Online]. Available: https://optn.transplant.hrsa.gov/governance/ public-comment/standardize-organ-coding-and-tracking-system/
[3] A. Bougdira, A. Ahaitouf, and I. Akharraz, ''Conceptual framework for general traceability solution: Description and bases,'' J. Model. Manage., vol. 15, no. 2, pp. 509–530, Oct. 2019.
[4] N. Mattei, A. Saffidine, and T. Walsh, ''Mechanisms for online organ matching,'' in Proc. 26th Int. Joint Conf. Artif. Intell., Aug. 2017, pp. 345–351, doi: 10.24963/ijcai.2017/49
[5] S. Zouarhi, ''Kidner—A worldwide decentralised matching system for kidney transplants,'' J. Int. Soc. Telemed. E-Health, vol. 5, Apr. 2017, Art. no. e62. [Online]. Available: https://journals.ukzn.ac.za/ index.php/JISfTeH/article/view/287
[6] Kidner Project. Accessed: Dec. 28, 2021. [Online]. Available: https://www.kidner-project.com/
[7] L. A. Dajim, S. A. Al-Farras, B. S. Al-Shahrani, A. A. Al-Zuraib, and R. M. Mathew, ''Organ donation decentralized application using blockchain technology,'' in Proc. 2nd Int. Conf. Comput. Appl. Inf. Secur. (ICCAIS), May 2019, pp. 1–4, doi: 10.1109/cais.2019.8769459.
[8] A. Soni and S. G. Kumar, ''Creating organ donation system with blockchain technology,'' Eur. J. Mol. Clin. Med., vol. 8, no. 3, pp. 2387–2395, Apr. 2021.
[9] G. Alandjani, ''Blockchain based auditable medical transaction scheme for organ transplant services,'' Tech. Rep., 2019, doi: 10.17993/3ctecno.2019.specialissue3.