International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 05 | May - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

Secure Organ Donation Management: Leveraging Ethereum Based Blockchain Technology for Trust and Efficiency

N. Rakesh[1], B. Sai Kumar Reddy[2], K.Y. Saandeepa Gopal[3], N.Swapna[4]

[1]UG student, Dept. of Electronics and Computer Engineering, Sreenidhi Institute of Science and Technology, Telangana, India.

[2]UG student, Dept. of Electronics and Computer Engineering, Sreenidhi Institute of Science and Technology, Telangana, India.

[3]UG student, Dept. of Electronics and Computer Engineering, Sreenidhi Institute of Science and Technology, Telangana, India.

[4]Asst. Professor, Dept. of Electronics and Computer Engineering, Sreenidhi Institute of Science and Technology, Telangana, India

ABSTRACT:

The complexity of organ donation and transplantation in today's healthcare systems need specialized methods at several stages, including registration, donor-recipient matching, organ retrieval, delivery, and transplantation. In order to ensure justice, efficiency, patient happiness, and confidence, a comprehensive solution is required to address the legal, clinical, ethical, and technical difficulties. This paper proposes to use a private Ethereum blockchain to create a decentralized, secure, traceable, auditable, private, and trustworthy system. By creating smart contracts and putting six algorithms into practice, we offer comprehensive insights into validation and testing. We demonstrate the efficacy of our suggested approach using a comparative analysis with current solutions andprivacy, security, and confidentiality studies. Adopting a private Ethereum blockchain-based solution also has benefits over conventional centralized systems.

Decentralization lowers the possibility of bias or manipulation by ensuring that no one party controls the entire process. Furthermore, the immutability and transparency that come with blockchain technology improve confidence between all parties involved, including regulators, donors, beneficiaries, and medical experts.

KEYWORDS: Blockchain, Organ Donation, Organ Transplantation, Decentralization, Smart Contracts, Ethereum, Traceability, Data Privacy And Security.

1. INTRODUCTION:

Disease or trauma can cause organ damage or failure.

It lowers life quality and can even be fatal in certain situations. One of the most noble things that people can do to help save lives through organ transplantation is to donate an organ. The organ must match the donor and receiver in acceptable functional order for a transplant to be successful, and the donor should not be put in danger of death during the organ's removal [1]. In 1954, two brothers received a kidney transplant, which was the first successful organ donation [2]. The yearly total of

transplants has risen continuously since then. The number of organ donors is still

less than the demand for organs, albeit [3]. Twenty people actually pass away each day while waiting for an organ transplant, and a new patient is added to the waiting list every ten minutes [4]. More significantly, obtaining a spot on the organ donor waiting list is a prerequisite for organ distribution. Referrals for transplantation may be influenced by socioeconomic and regional considerations. As a result, particular patient categories shouldn't be treated differently throughout the waiting list allocation procedure [4].There are two methods for donating organs: living donation and donation from the dead.

The hospital transplant staff examines the donor first, and if the donor is dead, a brain death test is carried out. In the interim, medical professionals assess the donor, if they are still alive, to make sure they are suitable for live donation. The procurement organizer receives a report on all medical records after that. In addition to making sure the donor is correctly recorded in the medical system, the procurement organizer is in charge of assessing the donor's health to determine whether or not he is a suitable donor. The organ transplantation organizer receives all the information from the procurement organizer if the evaluation indicates that

the donor is qualified for donation. Only with the donor's permission may this step be carried out in order to gift to an

anonymous recipient. The organ transplant coordinator then arranges for the pairing of patients on the waiting list with donors who are available. The transplant surgeons receive an output in the form of a ranked list as a result. Next, based on a number of factors, including the prospective

recipient's present health and the donor's medical records, the transplant surgeon determines if the organ is suitable for the patient. The donor's surgeon is notified to remove the given organ when a transplant surgeon accepts it. Ultimately, the transplant recipient receives the donated organ when it has been delivered to the patient's hospital.

Let's say, however, that the circumstance calls for a live donor and that the intended recipient is a named individual.

If so, the transplant surgeon will receive the data directly and they will begin the process of extracting and transplanting the donated organ [6], [7].

In the past, the hospital and organ procurement organization collaborated to do an initial medical examination to determine whether a patient may be an organ donor when they passed away or were close to passing away. It takes about fifteen minutes to complete this call, and just six percent of them lead to the identification of potential organ donors. Because the current systems lack data accountability, immutability, audit, transparency, traceability, and trust aspects, managing organ donation and transplantation has become difficult. The primary contributions of the paper are as follows:

- We suggest a private Ethereum blockchain-based system that guarantees the decentralized, secure, dependable, traceable, auditable, and trustworthy administration of organ donation and transplantation.
- We create smart contracts that produce events for all the necessary actions that take place during the stages of organ donation and transplantation, registering actors and guaranteeing data provenance.

The code for the smart contracts is available to the public on Github.1.

- Using a smart contract, we create an automated matching system that matches donors and recipients based on predetermined parameters.

2. LITERATURE SURVEY

A blockchain-based kidney donation system called "Kidner" has been proposed in [21] and [22]. Rather than using the existing kidney waiting list, it offers a kidney-pair donation module. 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 donate to a family member but their kidney is incompatible with the recipient. The authors of [23] suggested a decentralized blockchain-based app for organ donation. Patients register their details, such as their medical ID, organ type, blood type, and state, via an online application. First-in, first-out (FIFO) would be the system's mode of operation, unless a patient was in a critical condition.

It provided a speedier system, increased openness, and improved security. When utilized in other regions, it should be adjusted to meet their specific needs and restrictions. Similar to this, the authors of [24] created a web-based application that uses FIFO to select an organ donor for each patient who is actually in need of a transplant; in the event of an emergency, the patient with the highest priority gets selected. Additionally, a blockchain-based organ donation and transplantation application has been presented in [12], wherein the registered hospital registers recipients and accepts registered donors, matching receivers with appropriate donors based on the request. Additionally, a blockchain use case for organ donation has been established [25].

To put it simply, the procedure starts when the patient files for a transplant and the donor signs a smart contract for organ donation. A registered physician or nurse verifies and hashes both documents, makes a confirmed mismatching pair, and broadcasts it over the network. When a match is found, the network notifies a physician for approval. In the event that a match is discovered, the physician certifies and proceeds to create a hash. In the event that the physician produces a hash, the confirmed matched pair is added to the blockchain.

3. METHODOLOGY

A) PROPOSED WORK

We describe our blockchain-based organ donation and transplantation solution in this section. An overview of our suggested solution's system architecture is shown in Figure 2. It demonstrates how two smart contracts (SCs)—organ donation and organ transplantation—are used in our approach. An application program interface (API) connects a front-end decentralized application (DApp) to the smart contracts, allowing participants to access its events and functions. Each smart contract has distinct features that can only be used by users who have been pre-authorized. These individuals will be able to access data kept on the chain and examine transactions, logs, and events.

Physicians, members of the hospital transplant team, procurement coordinators, organ match coordinators, a transporter, and a transplant surgeon are among the participants. The Organ Donation Smart Contract is in charge of setting up a waiting list, accepting donors following approval of a medical test, and automatically matching donors and recipients. The transplant procedure is mostly managed via the Organ Transplantation Smart Contract.

It is divided into three stages: harvesting an organ from a donor, transporting the organ to the recipient, and implanting the organ. For the purpose of review and verification, every prior step is recorded and kept on file in the ledger. Additionally, a private permissioned Ethereum blockchain is used to guarantee authorization, confidentiality, and privacy.

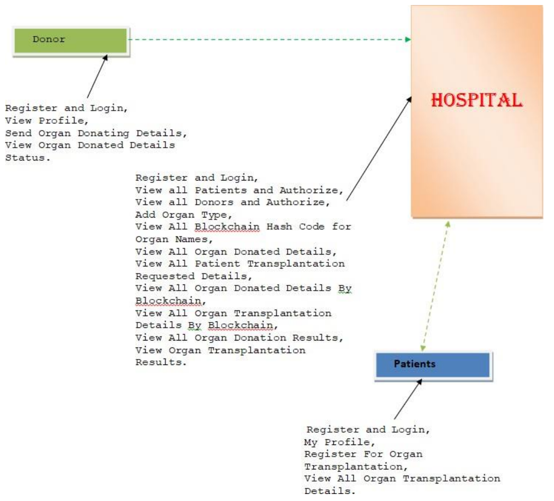

Figure 1. Project Architecture.

B) FLOW CHARTS:

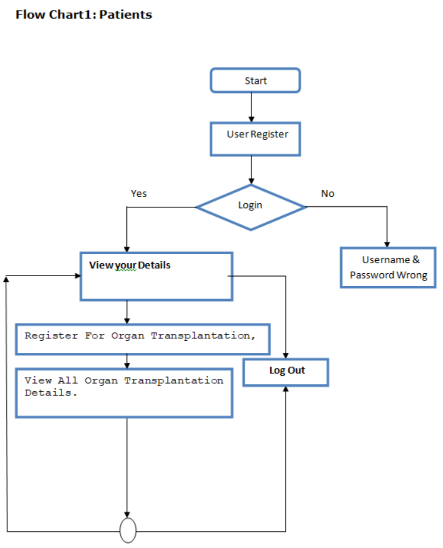

Figure 2. Flow Chart of Patients.

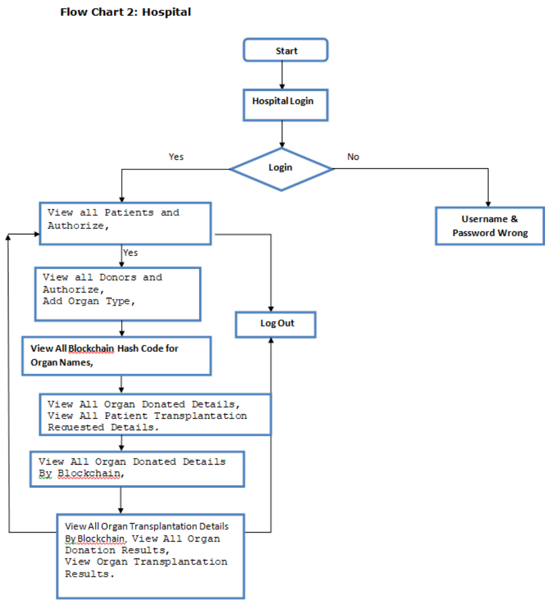

Figure 3. Flow chart of Hospital Transplant Team.

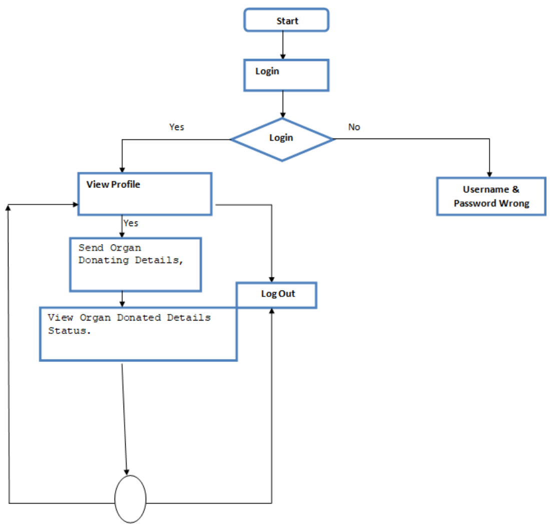

Figure 4. Flow chart of Recipient.

C) PRIVATE PERMISSIONED ETHEREUM NETWORK

In situations where transactions and data are only visible to authorized parties and are not accessible to the general public, private blockchains offer increased security and privacy. Businesses can create their own private-permissioned blockchain to increase secrecy, security, and privacy by utilizing the Ethereum network. Details regarding the transplantation of donor organs are typically kept completely private. These particulars include medical histories and family histories of the patients; hence, a private permissioned Ethereum blockchain is perfect for this kind of deployment.

D) BLOCKCHAIN INTEGRATION

The foundation of our suggested solution is the blockchain network. In order to guarantee accountability and data provenance, it forms the foundation for permanently preserving transactions and events. To guarantee that the created smart contracts are always accessible, they must be put into use on the blockchain. Deploying them on the primary network during the testing phase might not be ideal, though. Thus, the Ethereum-based smart contracts should be tested on a test network, a virtual computer like the JavaScript-based Virtual computer, or a local blockchain environment.

Our suggested solution's smart contracts are created with the REMIX IDE and implemented on a JavaScript virtual machine that simulates an isolated Ethereum node within the browser—a very helpful feature for testing. The created smart contracts can be put on Ethereum's mainnet to evaluate their functionality in an actual blockchain setting after they have been examined and validated. However, because the smart contracts' functions are deterministic—that is, independent of the node carrying out the operation, the result will always be the same—the outcome of their functions will never change.

E) PARTICIPANTS INTERACTIONS

The three stages of the interaction between various parties inside the matching smart contract. Phase 1 starts with the establishment of a waiting list, to which each new patient is added by a licensed physician. The patient's ID, age, blood type will be noted by the physician. Receiving donors who have granted permission to donate their organs completes phase two. The test approval feature can only be used by an authorized member of the transplant team, and once it is, an event is delivered right away. The procurement organizer is then prepared to assess and register the donor. An event will be set off in order to announce the registration of a new donor. Phase 2: The organ transplant coordinator manages the auto-matching between the donor and recipient. Based on the donor's age range, blood type, the auto-matching procedure is carried out. At last, a ranked list of matched patients is shown. This smart contract covers the organ's removal, transportation, and transplantation.

IMPLEMENTATION DETAILS:

This section contains the algorithms and implementation details for our suggested blockchain-based organ donation and transplantation solution. Validation nodes and only authorized users are added to a private Ethereum blockchain, which serves as the foundation for the suggested system.

The two main ways that our suggested solution will be implemented are through organ donation and organ transplantation. Below is a description of each one's specifics.

ORGAN DONATION:

The organ donation smart contract involves four parties: the patient's physician, a member of the hospital transplant team, the procurement organizer, and the matching organizer. Every entity has an Ethereum address and can invoke the smart contract's functions to take part.

There are several distinct kinds of variables in this smart contract. The Ethereum address is one of the variables; it is used to give specific organizations, like the procurement organizer and the matching organizer, a distinct address. The second kind is mapping; in our solution, this associates an entity's Ethereum address with a Boolean to indicate that the address is conditional. For instance, doctors and certified transplant surgeons employ mapping.

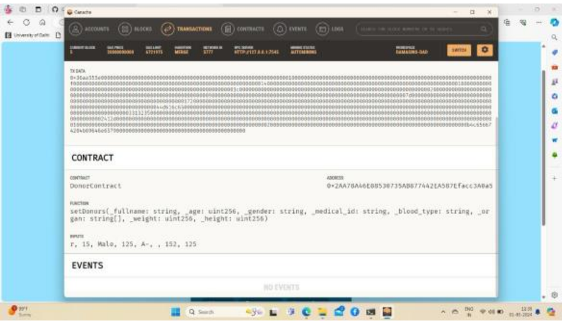

Figure 5. Organ Donation Smart Contract.

ORGAN TRANSPLANTATION:

The principal players in the organ transplantation smart contract are the transplant surgeon, the transporter, and the surgeon who performed the donation. By

using the smart contract's functions, each participant can take part. It contains a variety of variable kinds. For instance, the addresses of transplant doctors and donors are stored on public Ethereum addresses. Additionally, it has a mapping for authorized transporters, who are permitted to convey the donated organ from the hospital of donor to the hospital of recipient. Additionally, every condition that the given organ will experience is contained in the enumerated variable
"OrganStatus."

The smart contract will be activated by the transplant surgeon. The original condition of the removed organ and the donor surgeon's Ethereum address will be provided. After the smart contract is launched and the authorized transporters are designated, the transplantation tracing procedure starts. The given organ is first removed by the surgeon and then brought from the donor's location to the recipient hospital by a certified transporter. The beginning and finish of the delivery process will thereafter be announced. Subsequently, the transplant surgeon declares the received organ and proceeds with its transplantation. Lastly, information on the transplant will be made public, including the patient's ID, the procedure's time, and date.

Since there can only be one matching organizer and one procurement organizer in our solution, they are designated as Ethereum addresses. Since many of them exist in the system, the patient's physician, a member of the transplant team, and patient validity are declared as mappings in the interim. Finally, as there are various forms of each, blood type and organ type are stated to be enumerated.

The specifics of the transplantation procedure are described by a set of properties in the Organ Transplantation smart contract. They are identified as Ethereum addresses since there is only one surgeon who will handle donor-side responsibility and one surgeon who will do recipient-side transplantation. It is also declared as mapping since the system may contain several transporters.

Furthermore, there are five main operations of the smart contract: Organ_Transplantation, StartDelivery,EndDelivery, ReceiveDonatedOrgan,and RemoveDonatedOrgan.

Lastly, since only one organ donation smart contract may include all patients while multiple transplantation smart contracts can exist for the various conceivable donation processes, there will be a 1:n link between the organ donation smart contract and the transplantation smart contract.

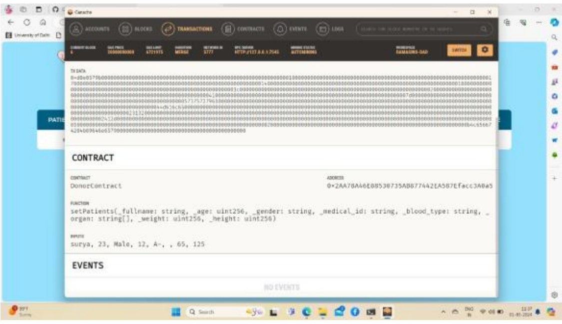

Figure 6. Organ Transplantation Smart Contract.

4. TESTING

The main features of the created organ donation and organ transplantation smart contracts are tested and validated in this part. Furthermore, the inputs utilized for

the functions are merely guesses meant to meet testing requirements; they do not represent actual data. The ensuing

subsections provide more details on the transactions and logs of the main smart contract features.

This is a detailed explanation of how the webpage functions:

A. Organ Donation Smart Contract: The AddingNewPatient function, which adds new patients to the waiting list, is shown in Figure 5 as having been successfully executed. The details of new patients can be stored on the Ethereum network by the approved doctors—the only players permitted to carry out this role. The data that is kept on the Ethereum network as an event is displayed in the "logs" column. The patient ID is "12345," the age is 24 years old, and the blood type is O. Furthermore, a successful call of the newly created patient ID, which is kept in the PatientID array, is displayed in Figure3 In a similar vein, further operations like TestApproval,RegisteringNewDon-or were carried out without any issues.

B. Organ Transplantation Smart Contract:

Figure 6 illustrates how the donor surgeon announced the removal of the donated organ, demonstrating a successful use of the RemovingDonatedOrgan function. In a similar vein, all tasks related to the delivery and transplantation phases were completed successfully.

5. DISCUSSION

We assess our solution's level of security, privacy, and confidentiality in this section. Smart contract implementation and execution expenses are typically presented by Ethereum-based solutions. Nevertheless, our approach uses the

private Ethereum blockchain to adjust the price of gas to zero. There are therefore no associated costs. Furthermore, a

comparative analysis is conducted between our proposed approach and the current ones. Lastly, we talk about the generalizability of our solution to different systems and applications.

A. Security Analysis

Integrity: The suggested method for managing organ donations is event-based and records every transaction on an unchangeable ledger, enabling users to follow the donation and transplantation procedures step-by-step. To ensure that the donor organ is provided to the recipient with the highest priority, any ranked list of recipients who have been matched with eligible donors, for instance, is documented as an event.

Authorization and Accountability: The suggested method, which makes advantage of the "Modifier" functionality, writes Ethereum smart contracts in Solidity. This feature enables specified users to carry out certain tasks.

As a result, everyone involved takes responsibility for their conduct, and any unlawful activity is recorded as an event in an unchangeable ledger. Consequently, errors and unlawful activity can be tracked down to determine their origins.

For example, the matching function, which stores the matched list for eventual retrieval by the DApp, can only be executed by the organ matching organizer. Furthermore, the organ transplantation process can only be managed by a transplant surgeon.As such, these individuals have responsibility for their conduct and will be held liable for any manipulation or errors made during these two stages.

Availability: Because the Ethereum blockchain is decentralized, a number of dispersed nodes are in charge of documenting and recording every transaction that takes place inside the network. This ensures that the network remains available and synchronized even in the event that a node fails.

B. Comparison with existing solutions

A comparison between our solution and the current blockchain-based solutions is shown in the table . A number of significant factors are compared, including the blockchain platform being utilized, the mode of operation, the creation of smart contracts, the capacity to trace transactions, real-time monitoring, deployment, and the creation of DApps.

The Ethereum network was utilized in a private mode of operation by our solution and [17]. Other solutions, on the other hand, made no mention of the kind of blockchain platform that was employed. Only our approach—and that of [21]—is based on smart contracts.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 05 | May - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

6. RESULTS

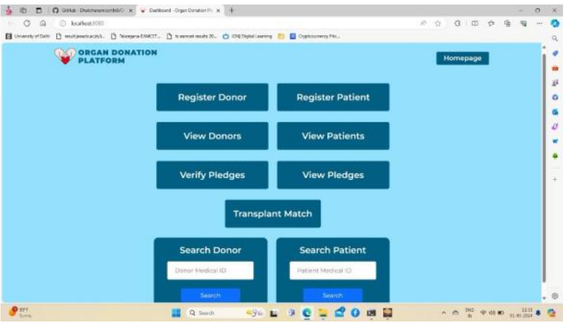

Fig 7. Website Homepage for Registering Donor and patient.

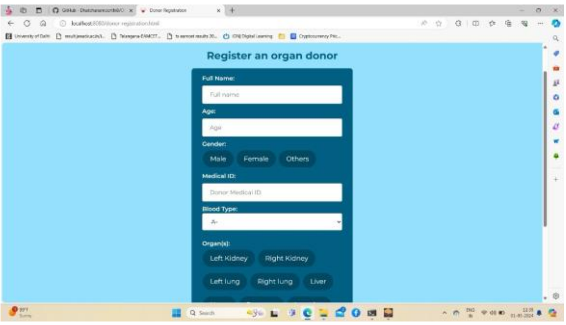

Fig 8. Organ Donor Registration

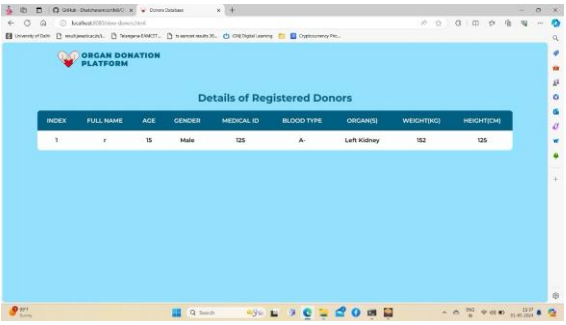

Fig 9. Details of Registered Donor

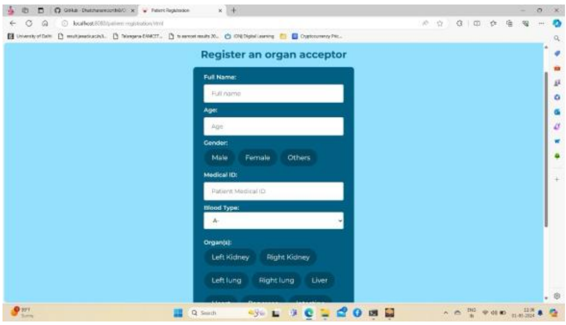

Fig 10. Organ Acceptor/ Patient Registration.

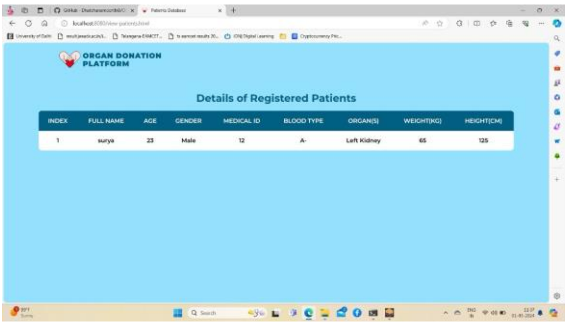

Fig 11. Details of Registered Patient.

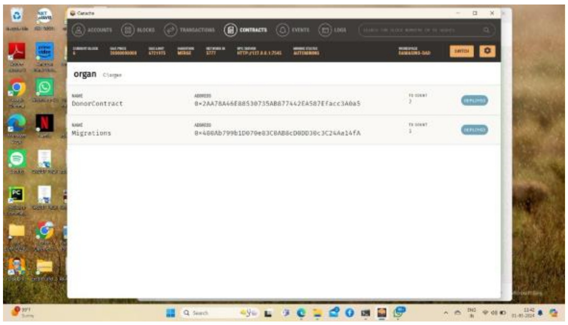

Fig 12. Blockchain Address of Smart Contract.

7. CONCLUSION

In this paper, we have presented a private Ethereum blockchain-based system that provides decentralized, transparent, auditable, traceable, safe, and reliable management of organ donation and transplantation. We created smart contracts that automatically record occurrences and guarantee the provenance of the data.We conduct a security analysis of the suggested method to ensure that smart contracts are shielded from frequent assaults and weaknesses. We evaluate our solution against other existing blockchain-based solutions. We go over how our solution may be easily modified to satisfy the requirements of other systems that are having comparable issues. By creating an end-to-end DApp, our solution can be enhanced in the future.

8. REFERENCES

[1] L. A. Dajim, S. A. Al-Farras, B. S. Al-Shahrani, A. A. Al-Zuraib, and R. Merlin 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.

[2] A. Powell. (Mar. 18, 2019). A Transplant Makes History. Harvard Gazette. [Online].Available: https://news.harvard.edu/gazette/story/2011/09/atransplant-makes-history/

[3] How Donation Works. Accessed: Jan. 7, 2022.[Online]. Available:https://www.organdonor.gov/le arn/process

[4] Organ Donation Facts and Info: Organ Transplants. Accessed: Apr. 18, 2021. [Online].Available: https://my.clevelandclinic.org/health/ articles/11750-organ-donation-and-transp lantation

[5] (Mar. 21, 2019). Facts and Myths About Transplant. Accessed: Apr. 21, 2021. [Online].Available: https://www.americantransplant foundation.org/about-transplant/facts-and -myths/

[6] Organ Procurement and Transplantation Network. Accessed: Apr. 18, 2021. [Online].Available: https://optn.transplant.hrsa.gov/ resources/ethics/ethical-principles-in-the-allocation-of-humanorgans/

[7] UFO Themes. (Aug. 1, 2017). Organ Donation and Transplantation in Germany. Plastic Surgery Key. [Online]. Available:https://plasticsurgerykey.com/o rgan-donation-and-transplantation-in-ger many/

[8] Harvard Business Review. (Dec. 13, 2021). Electronic Health Records Can Improve the Organ Donation Process. Accessed: Apr. 8, 2022. [Online].

Available: https://hbr.org/2021/12/electronic-health- records-can-improvethe-organ-donation-process

[9] U. Jain, ‘‘Using blockchain technology for the organ procurement and transplant network,’’ San Jose State Univ., San Jose, CA, USA, Tech. Rep., 2020, doi: 10.31979/etd.g45p-jtuy.

[10] M. He, A. Corson, J. Russo, and T. Trey, ‘‘Use of forensic DNA testing to trace unethical organ procurement and organ trafficking practices in regions that block transparent access to their transplant data,’’ SSRN Electron. J., 2020, doi: 10.2139/ ssrn.3659428.

[11] Livemint. The Illegal Organ Trade Thrives in India-and it isn't Likely to End Soon. Accessed: Dec. 21, 2021. [Online]. Available: https://www.livemint.com/Politics/pxj4YasmivrvAhanv6OOCJ/Whyorgan-traffick ing-thrives-in-India.html

[12] D. P. Nair. (2016). Organ is Free, Transplant Cost is Problem. [Online]. Available: https://timesofindia.indiatimes.com/life-s tyle/ healthfitness/health-news/Organ-is-free-t ransplant-cost-isproblem/ articleshow/54014378.cms

[13] P. Ranjan, S. Srivastava, V. Gupta, S. Tapaswi, and N. Kumar, ‘‘Decentralised and distributed system for organ/tissue donation and transplantation,’’ in Proc. IEEE Conf. Inf. Commun. Technol., Dec. 2019, pp. 1–6, doi: 10.1109/cict48419. 2019.9066225.

[14] V. Puggioni. (Feb. 26, 2022). An Overview of the Blockchain Development Lifecycle. Cointelegraph. Accessed: Apr. 8, 2022. [Online]. Available: https://cointelegraph.com/explained/an-o verview-of-the-blockchaindevelopment-l ifecycle

[15] History of Blockchain. Accessed: Apr. 8, 2022. [Online].Available: https://www.icaew.com/technical/technol ogy/blockchain-andcryptoassets/blockch ain-articles/what-is-blockchain/history

[16] M. Hölbl, M. Kompara, A. Kamišalić, and L. N. Zlatolas, ‘‘A systematic review of the use of blockchain in healthcare,’’ Symmetry, vol. 10, no. 10, p. 470, Oct. 2018, doi: 10.3390/sym10100470

[17] 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.

[18] Organ Procurement and Transplantation Network. Accessed: Nov. 27, 2021. [Online]. Available:

https://optn.transplant.hrsa.gov/governan ce/ public-comment/standardize-organ-codin g-and-tracking-system/

[19] 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.

[20] 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.

[21] 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

[22] Kidner Project. Accessed: Dec. 28, 2021.[Online].Available: https://www.kidner-project.com/

[23] 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.

[24] 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.

[25] G. Alandjani, ‘‘Blockchain based auditable medical transaction scheme for organ transplant services,’’ Tech. Rep., 2019,doi:10.17993/3ctecno.2019.