AN APPLICATION FOR TRACKING ORGAN DONATION IN HOSPITALS USING BLOCKCHAIN

1G MANASA, 2B. SAI KRISHNA, 3K. VAISHNAVI, 4Y. ADI SEKHAR, 5S. PAVAN KUMAR

1Assistant Professor, Department of CSE, Sri Indu College of Engineering and Technology-Hyderabad

2345Under Graduate, Department of AI&DS, Sri Indu College of Engineering and Technology-Hyderabad

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.

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. The first successful organ donation occurred with a kidney transplant between twin brothers in 1954. Since then, the annual number of transplants has steadily increased. However, the demand for organ donations still exceeds the number of donors. 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. 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.

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. 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. 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.

The lack of transparency in the current system among participants leads to illegal organ trade and purchases and medical professionals engaging in unethical practices. 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. 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.

LITERATURE SURVEY

Title: "Organ donation decentralized application using blockchain technology,"

Abstract: The proposed system is an organ donation decentralized 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 state. The system would work on a first-in, first-out basis unless a patient is in critical condition.

Title: "Using blockchain technology for the organ procurement and transplant network," Abstract: The organ donation system in the United States is centralized and difficult to audit by the general public. This centralized approach may lead to data integrity issues in the future. The Organ Procurement and Transplant Network (OPTN) was built and maintained by a non-governmental organization called the United Network for Organ Sharing (UNOS) under its proprietary UNet(SM) umbrella platform. This platform is made up of proprietary closed source software and does not provide the general public easy access to the organ transplant data for auditing. This study investigates the feasibility, challenges, and advantages of a blockchain-based OPTN.

Title: "Use of forensic DNA testing to trace unethical organ procurement and organ trafficking practices in regions that block transparent access to their transplant data,"

Abstract: This study proposes an approach to track unethically procured organs in particular 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. Verified match between DNA profiles of transplanted organs and missing victims will establish proof of such connection, thus provides evidence despite a lack of transparency.

Title: "Decentralised and distributed system for organ/tissue donation and transplantation,'' Abstract: In today's era of digitisation, many technologies have evolved that every manual work can be digitally automatized. In the digital automatizing process, security and privacy are the most important and highly demanding aspects. Blockchain offers many features that can be used in almost every sphere of life. Features like decentralisation, transparency, privacy makes it an extremely useful technology. Therefore, by making use of all these features, several problems in healthcare sector can be solved like removing complex network of third parties and lack of traceability of transactions. This paper presents a decentralised, secure and transparent organ and tissue transplant web application (also called DApp), which not only nullifies the role of any third party involved in the organ transplantation, but also is a cost effective solution that saves the patient's from high cost of transplantation. The details and Electronic Medical Record(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.

Title: "A systematic review of the use of blockchain in healthcare,''

Abstract: 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 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 it 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.

SYSTEM ANALYSIS

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 private Ethereum blockchain-based solution that ensures organ donation and transplantation management 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.

Disadvantages of the EXISTING SYSTEM:

The primary drawback of the existing system is the lack of several crucial features that are essential for managing sensitive and critical processes like organ donation and transplantation. These deficiencies directly lead to challenges in efficiency, security, and trust:

- Lack of Data Accountability: The existing systems struggle to ensure who is responsible for data entries and modifications, potentially leading to errors or manipulation without consequence.
- Lack of Immutability: Data in the current systems might be susceptible to unauthorized alterations or deletions, compromising the integrity and reliability of the records.
- Lack of Audit: Tracking changes and accessing a comprehensive history of actions within the system is difficult or non-existent, hindering investigations and accountability.
- Lack of Transparency: The processes and data within the existing systems might not be easily accessible or understandable to all authorized stakeholders, potentially leading to mistrust and inefficiencies.
- Lack of Traceability: Following the journey of an organ donation and transplantation process, from donor registration to recipient transplant, is likely cumbersome and lacks a clear audit trail.
- Lack of Trust Features: Due to the aforementioned shortcomings, there's a lack of inherent trust in the data and processes managed by the existing systems. This can create friction and hinder collaboration among stakeholders.

The existing system suffers from a centralized and potentially opaque architecture that makes it difficult to guarantee the integrity, security, and trustworthiness of the organ donation and transplantation process.

PROPOSED SYSTEM

- The proposed blockchain-based solution for donated organ transplantation is explained in Section III. Then, it is followed by the implementation details of the proposed blockchain-based solution in Section IV and the details of testing and evaluation in Section V. The discussion and analysis of the proposed solution are given in Section VI. Finally, section VII concludes the paper by summarizing our contributions and outlining future research opportunities.
- 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 (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 Ethereum blockchain.

Advantages of the PROPOSED SYSTEM:

The proposed blockchain-based solution directly addresses the shortcomings of the existing system by leveraging the inherent properties of blockchain technology. Here are the key advantages:

- Decentralized: By utilizing a private Ethereum blockchain, the proposed system distributes data and control across multiple authorized participants, reducing reliance on a single point of failure and increasing resilience.

- Secure: Blockchain's cryptographic nature and distributed ledger make the data more resistant to tampering and unauthorized access, enhancing the overall security of the system.

- Reliable: The distributed and replicated nature of the blockchain ensures high availability and data durability, making the system more reliable than traditional centralized systems.

- Traceable: Every action and transaction on the blockchain is recorded with a timestamp and participant identity, providing a clear and immutable audit trail for the entire organ donation and transplantation process.

- Auditable: All transactions, logs, and events stored on the blockchain are accessible to authorized participants for review and verification, enhancing transparency and accountability.

- Trustworthy: The inherent properties of blockchain – immutability, transparency, and auditability – build trust among all stakeholders in the integrity and reliability of the data and processes.

- Data Provenance: The system ensures the history and ownership of data are clearly recorded through events generated by smart contracts, providing a verifiable lineage of information.

- Automated Matching: The implementation of a smart contract for auto-matching donors and recipients based on predefined criteria can streamline the process, potentially increasing efficiency and reducing human error.

- Clear Process Management: The separation of functionalities into two smart contracts (Organ Donation and Organ Transplantation) provides a structured and well-defined approach to managing the different stages of the process.

- Enhanced Authorization and Privacy: Utilizing a private permissioned Ethereum blockchain ensures that only authorized participants can access specific functions and data, addressing concerns about secrecy and privacy.

The proposed blockchain-based system offers a more secure, transparent, efficient, and trustworthy solution for managing organ donation and transplantation by leveraging the core benefits of distributed ledger technology and smart contracts.

IMPLEMENTATION AND RESULTS

MODULE DESCRIPTION

Admin: Admin can login in to the application, and can have a control over all the application operations

User: User can register into the application and then login into the application finally performs the operations like donate organ, check requests etc.

Hospital: In this module also hospital need to get registered into the application and perform their operations.

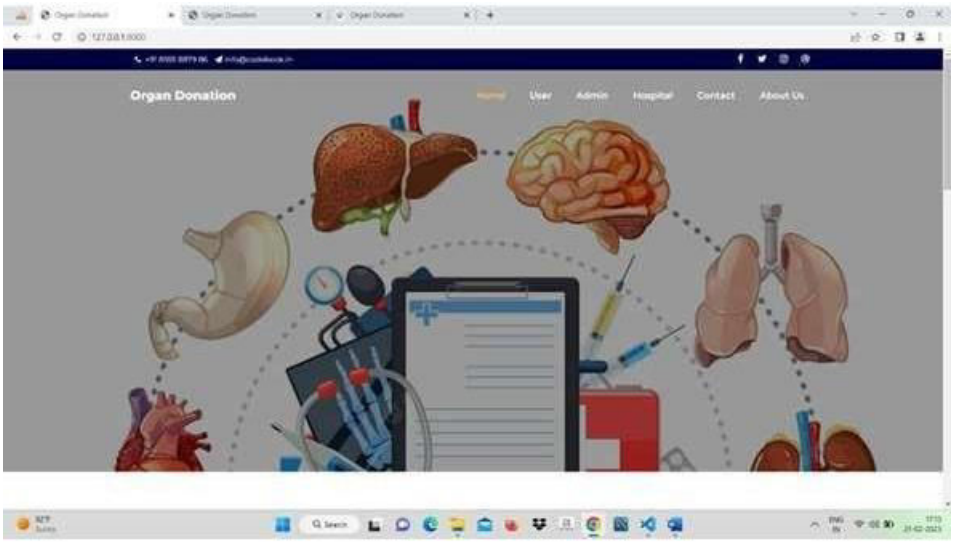
Pandas is an open-source Python Library providing high-performance data manipulation and analysis tool using its powerful data structures. Python was majorly used for data munging and preparation. It had very little contribution towards data analysis. Pandas solved this problem. Using Pandas, we can accomplish five typical steps in the processing and analysis of data, regardless of the origin of data load,

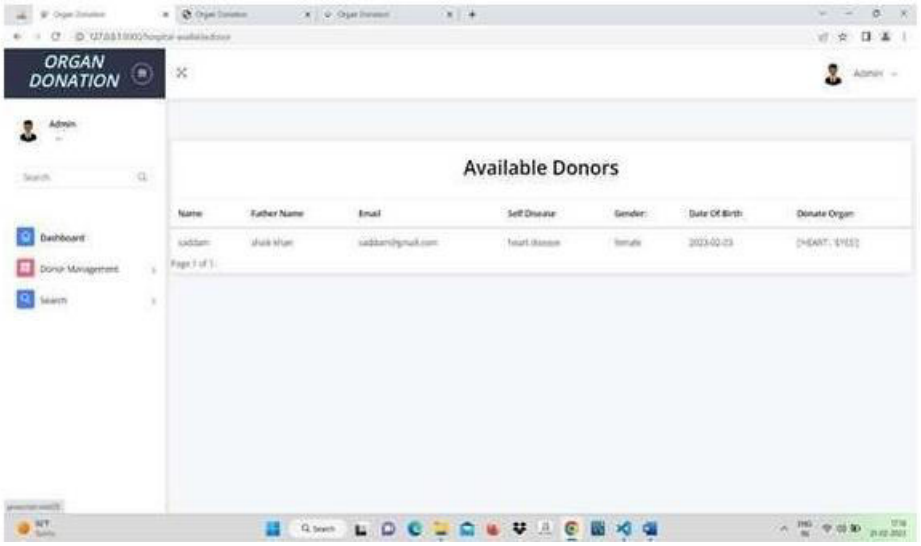
prepare, manipulate, model, and analyze. Python with Pandas is used in a wide range of fields including academic and commercial domains including finance, economics, Statistics, analytics, etc.

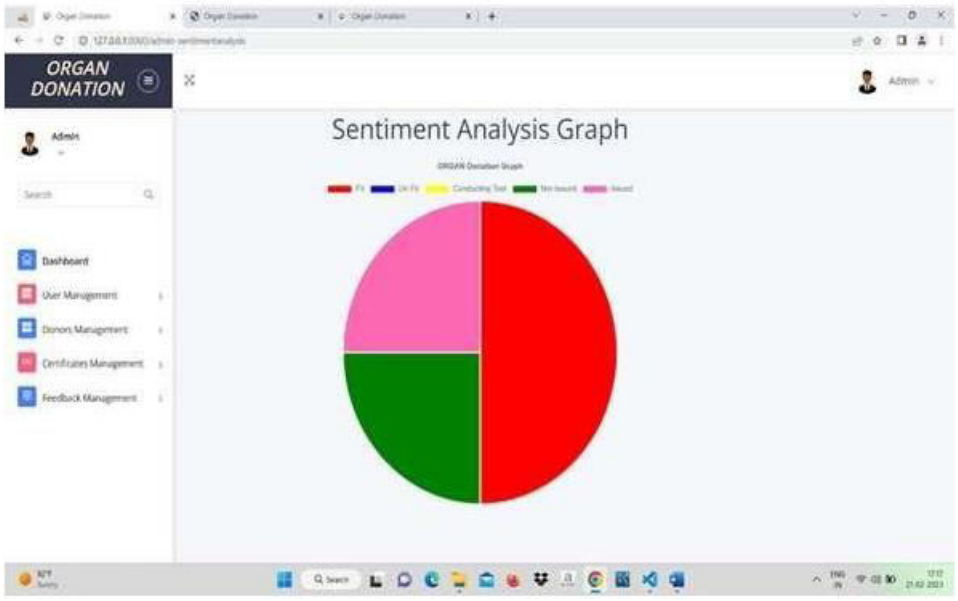
Matplotlib

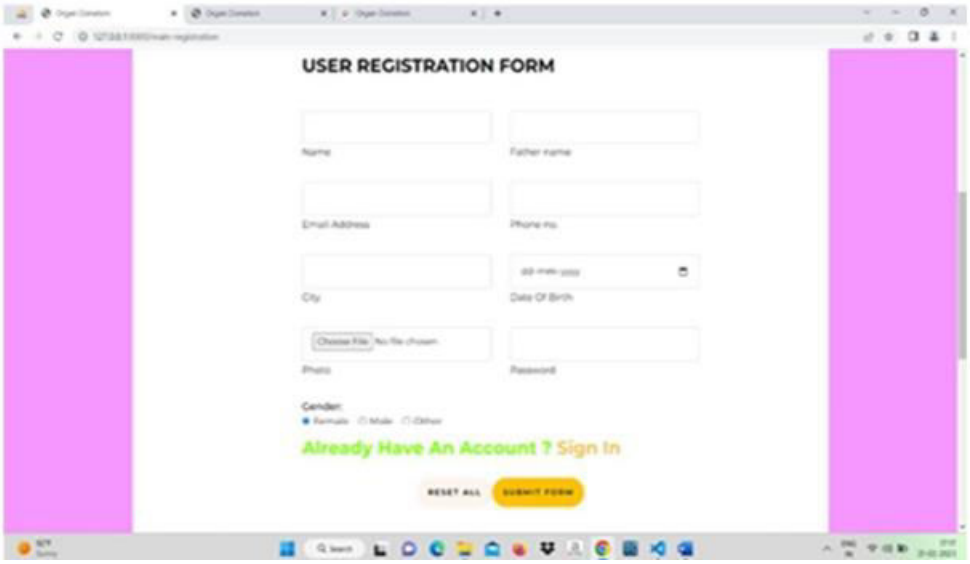
Matplotlib is a Python 2D plotting library which produces publication quality figures in a variety of hardcopy formats and interactive environments across platforms. Matplotlib can be used in Python scripts, the Python and IPython shells, the Jupyter Notebook, web application servers, and four graphical user interface toolkits. Matplotlib tries to make easy things easy and hard things possible. You can generate plots, histograms, power spectra, bar charts, error charts, scatter plots, etc., with just a few lines of code. For examples, see the sample plots and thumbnail gallery.

For simple plotting the pyplot module provides a MATLAB-like interface, particularly when combined with IPython. For the power user, you have full control of line styles, font properties, axes properties, etc, via an object oriented interface or via a set of functions familiar to MATLAB users.


Organ Donation
Home
User
Admin
Hospital
Contact
About Us


ORGAN DONATION
Admin
Dashboard
Donor Management
Search
Available Donors
Name
Father Name
Email
Self Disease
Gender
Date Of Birth
Donate Organ





CONCLUSION

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.

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] Powell. (Mar. 18, 2019). A Transplant Makes History. Harvard Gazette. [Online].

Available: https://news.harvard.edu/gazette/story/2011/09/atransplant-makes-history/

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

[4] (Mar. 21, 2019). Facts and Myths About Transplant. Accessed: Apr. 21, 2021. [Online].

Available: https://www.americantransplant foundation.org/about-transplant/facts-and-myths/

[5] 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/

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

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

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

[12] 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.

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

[14] History of Blockchain. Accessed: Apr.8, 2022. [Online]. Available: https://www.icaew.com/technical/technology/blockchain-andcryptoassets/blockchain- articles/what-is-blockchain/history

[15] 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.

[16] 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.

[17] 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/

[18] 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.

[19] 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