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Blood and Organ Donation using Blockchain Technology

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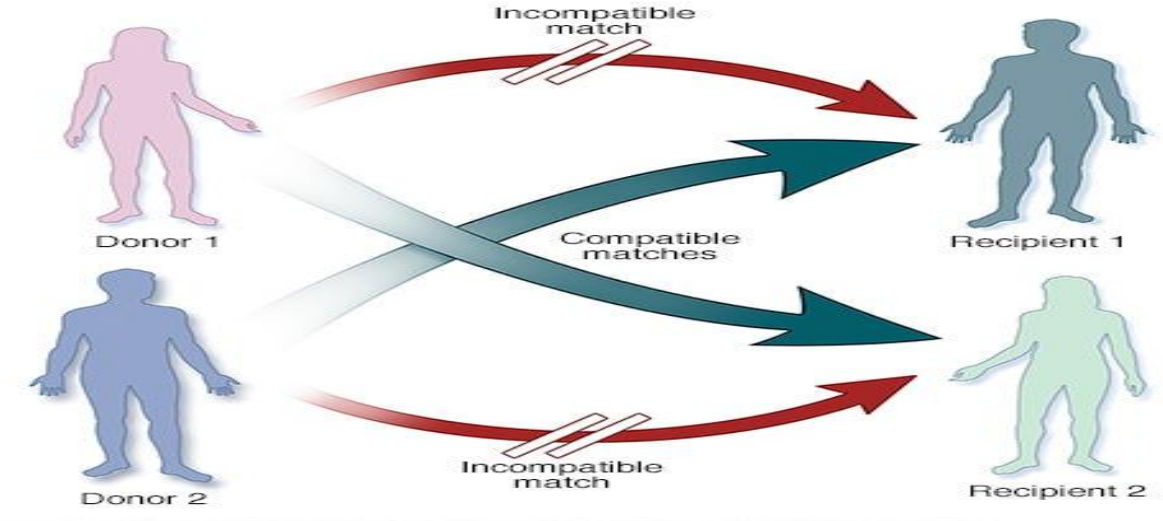
Abstract: *In order to ensure a fair and efficient process for organ donation, an end-to-end system is necessary to address the various challenges and requirements related to registration, donor-recipient matching, legal, clinical, ethical, and technical considerations. To achieve this, we propose a solution based on the public Ethereum blockchain, which is fully decentralized, secure, traceable, auditable, private, and trustworthy. Our approach involves the development of smart contracts and the implementation of six algorithms, which we thoroughly test and validate. Through privacy, security, and confidentiality analyses, we evaluate the effectiveness of our proposed solution and compare it to existing solutions.*

Keywords: Blockchain, Ethereum, organ donation, smart contracts

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.. 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.

1.1 Organ Donation Matching



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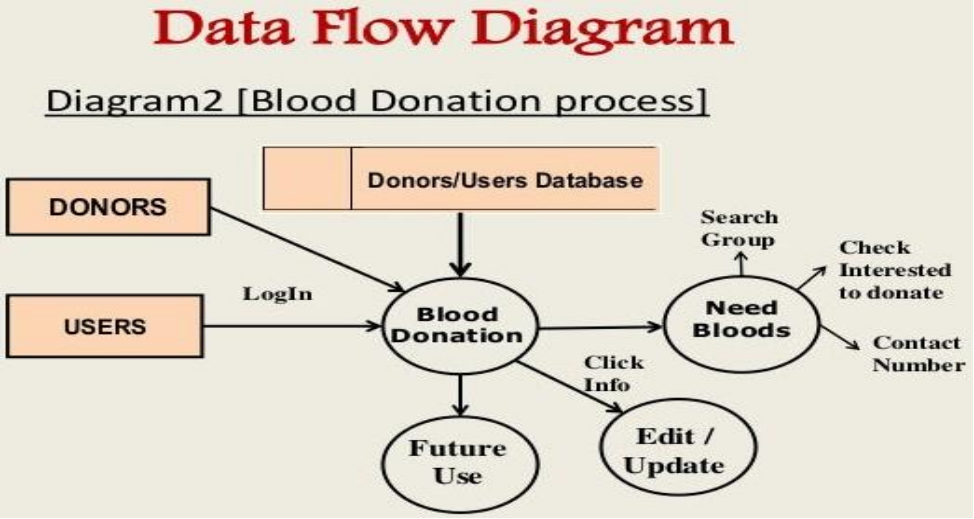
1.2 Data Flow Diagram of Blood System



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. 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. 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 .

In recent years, blockchain technology has attracted much attention in different sectors because it offers a distributed and secure database without the need for a third party or a central authority Later, the Ethereum blockchain architecture inserts computer programs into blocks to represent financial instruments, which are known today as smart contracts.. By using blockchain, medical information may be stored securely, and patient data could be updated in real-time and across various entities.

- 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. Our proposed solution is general and may be easily adjusted to meet the needs of a variety of related applications.

II. LITERATURE SURVEY

TABLE I

Title Name	Year	Publisher	Description
Blockchain Based management for organ donation and transplantation.	2022	IEEE	We can perform registration, donor-recipient matching, delivery and transplantation on We can perform registration, donor-recipient matching, delivery and transplantation
Organ donation decentralized application using Blockchain technology	2019	IEEE	We perform patient registration ID, blood type, organ type and state. perform patient registration ID, blood type, organ type and state.

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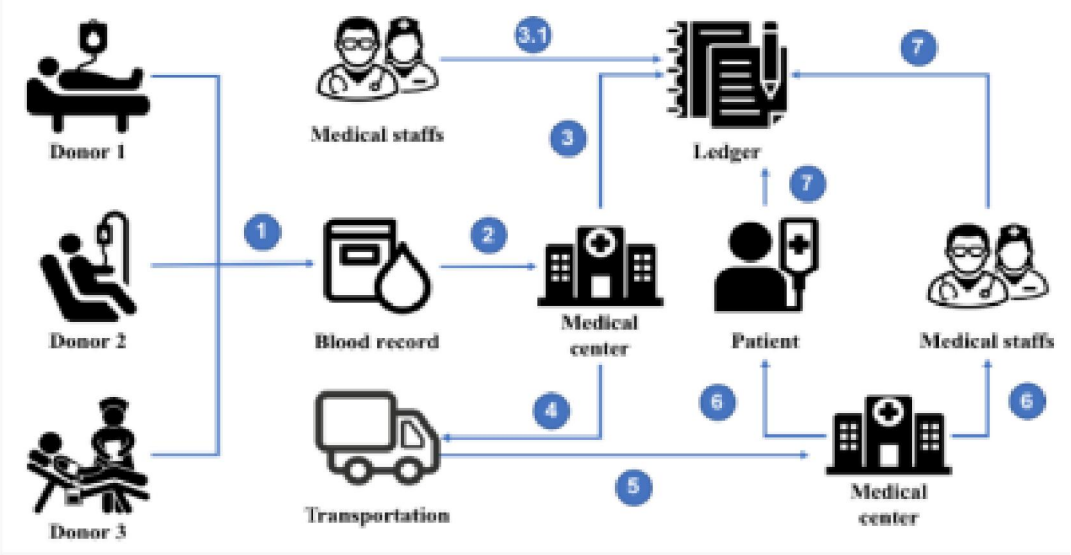
III. SYSTEM ARCHITECTURE

The aim of this system is to detect and address supply chain issues related to blood donation, including problems with blood origin and quality, especially in emergency situations. The primary focus of the system is on ensuring high-quality blood, and it achieves this by utilizing blockchain technology to manage the supply and demand of blood through recorded transactions.



The system is composed of five primary components: patient donors, medical staff, transportation, and ledger components, which are defined by Hyperledger Fabric. These components work together to send and receive data, with the ledger component serving as the central hub for all information

Based on their role in the system, stakeholders such as donors can access their own information from the ledger, which may be hidden from other parties. This allows for increased transparency and accountability in the blood donation process, ultimately leading to better outcomes for both donors and recipients.

IV. PROPOSED BLOCKCHAIN-BASED SOLUTION FOR ORGAN DONATION

In this section, we present details of our blockchain-based organ donation and transplantation solution. 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 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.

4.1 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.

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4.2 Blockchain Integration

The blockchain network is the backbone of our proposed solution. 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 main net 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.

V. IMPLEMENTATION DETAILS

This section provides a detailed description of our proposed blockchain-based solution for organ donation and transplantation. Our system is built on a private Ethereum blockchain and only authorized participants and validation nodes are added to it. The smart contracts are written in Solidity and tested with the Remix IDE, which is an open source web tool for developing and administering smart contracts. Our solution has two main components: organ donation and organ transplantation. The implementation details of each component are discussed below.

5.1 Organ Donation

The organ donation smart contract involves four entities: 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. The smart contract contains different types of variables such as the Ethereum address, mapping, Bloodtype, and OrganType. The procurement organizer deploys the smart contract and assigns the Ethereum address of the matching organizer. The authorized doctor adds a new patient to the waiting list and announces it to all participants. The authorized medical team member performs the test and announces the test approval. The procurement organizer registers the donor and announces the type of donated organ. The auto-matching process is conducted based on the main criteria such as age, blood type, BMI, and waiting time.

5.1 Blood System

The blood system will be added in the future scope to enhance the organ donation architecture.

The smart contract contains various types of variables such as public Ethereum addresses and mapping. The Transplant surgeon deploys the smart contract and defines the Ethereum address of the donor's surgeon and the initial state of the removed organ. The transplantation tracing process begins once the authorized transporters are assigned. Finally, the transplantation details are announced, including the patient ID, time, and date of the process.

The organ donation smart contract has four main functions: AddingNewPatient, TestApproval, RegisteringNewDonor, and MatchingProcess. Six algorithms are presented to explain the details of the various functions involved in our smart contracts.

Algorithm 1, 2, and 3 represent the phases of the organ donation smart contract, while the rest of the algorithms illustrate the organ transplantation smart contract. Our solution aims to streamline the organ donation and transplantation process using blockchain technology, which ensures transparency, security, and efficiency.

VI. ALGORITHMS

Algorithm 1: Patient Registration
Algorithm 2: Donor Registration and Medical Examination
Algorithm 3:Describes the Matching Process of the organ donation smart contract.
Algorithm 4:Outlines the steps to remove a donated organ from a donor..
Algorithm 5:Organ Delievery.
Algorithm 6: Receiving and Transplanting Donated Organ.

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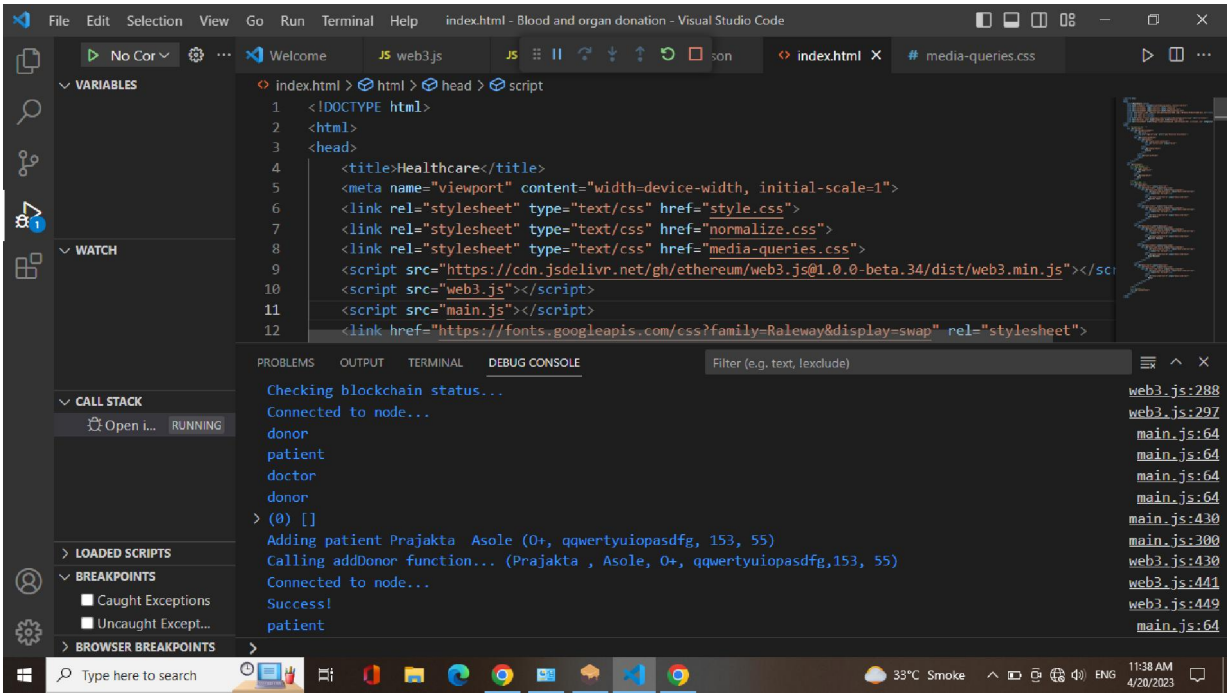
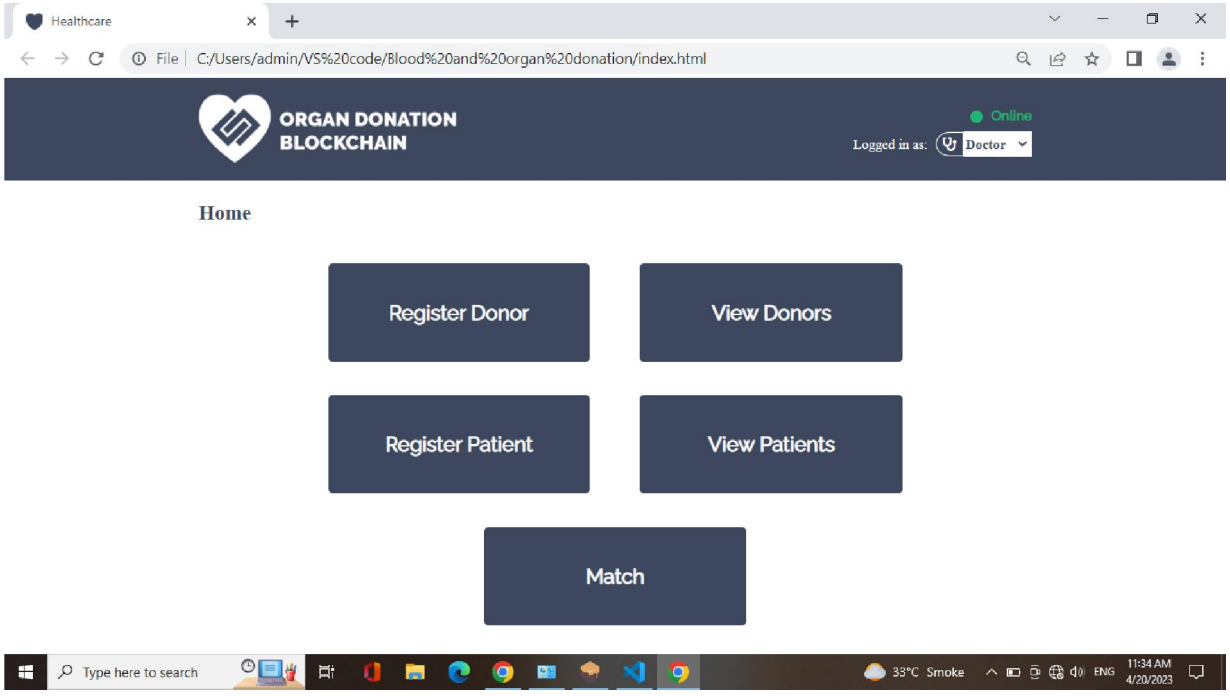
VII. OUTPUT

Remix IDE Code:



Home Page:



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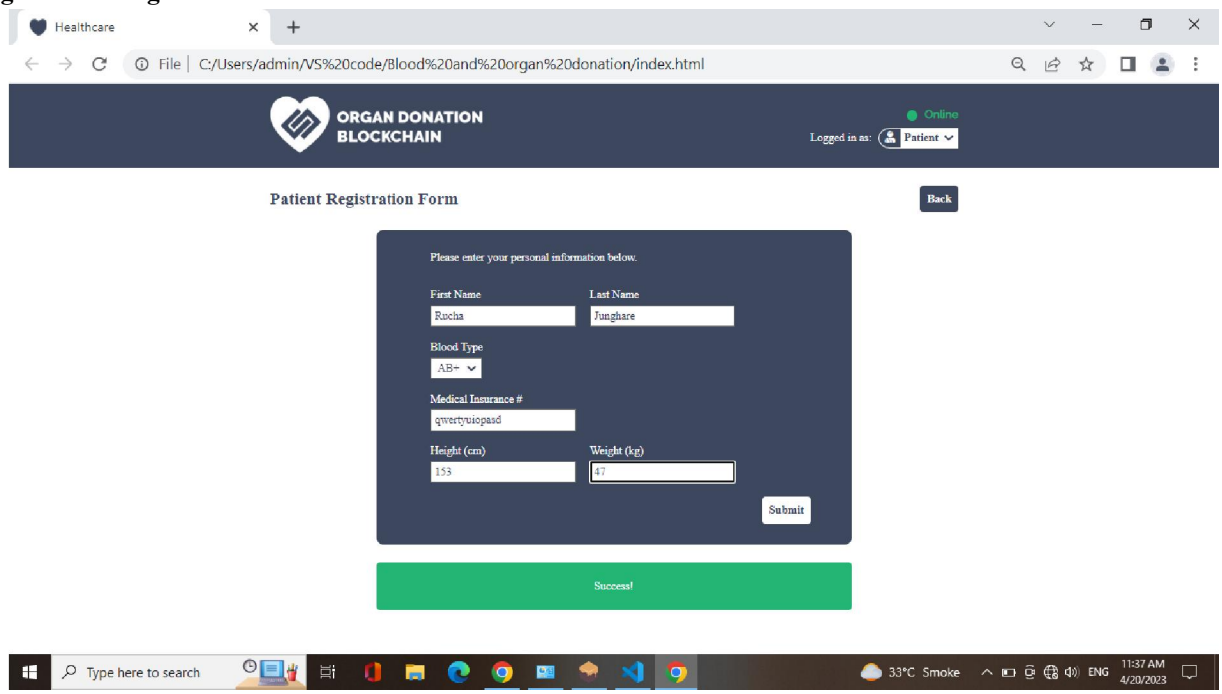
Registration Page:



VIII. DISCUSSION

This section discusses the evaluation of the privacy, confidentiality, and security of the proposed solution, which utilizes a private Ethereum blockchain with zero gas price. A comparison with existing solutions is also conducted, and the potential generalization of the solution to other applications is explored.

In terms of security analysis, the proposed solution employs an event-based strategy to ensure transaction integrity, where all transactions are recorded and stored on an immutable ledger. The Ethereum smart contracts written in Solidity language utilize the 'Modifier' feature to permit specific participants to run certain functions, ensuring accountability and traceability of actions taken. Furthermore, the decentralized nature of the Ethereum blockchain guarantees availability and synchronization even if a node fails.

A comparison is made between the proposed solution and existing blockchain-based solutions based on several parameters such as blockchain platform, smart contract development, and real-time monitoring. The proposed solution utilizes the Ethereum network in a public mode of operation and adds a blood system in the future scope.

Finally, the potential generalization of the proposed solution to other highly sensitive systems is discussed, such as blood donation operations, medical device donation, and industry products. The designed smart contracts representing different phases of the organ transplantation management system can be customized to fit the requirements of other applications that require tracking, tracing, and accountability

IX. CONCLUSION

In this paper, we have introduced a solution for organ donation and transplantation management that utilizes a private Ethereum blockchain for decentralized, secure, and accountable management. Our approach includes the development of smart contracts that record events automatically to ensure data provenance. We have presented six algorithms and provided details on their implementation, testing, and validation. Additionally, we have conducted a thorough security analysis to ensure that our solution is protected against common attacks and vulnerabilities.

To validate our approach, we have compared our solution to other existing blockchain-based solutions. Furthermore, we have discussed how our solution can be customized and applied to other systems facing similar challenges with minimal effort. In the future, we plan to develop an end-to-end DApp to improve our solution further. We also aim to deploy and test our smart contracts on a real private Ethereum network.

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Overall, our proposed solution provides a trustworthy and auditable solution for organ donation and transplantation management using blockchain technology.

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