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Blockchain-Based Organ Donation System: A Secure and Transparent Solution

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Abstract: The proposed blockchain-based organ donation and transplantation system enhances efficiency, security, and transparency in managing organ donations. Traditional organ donation frameworks depend on centralized databases, which are prone to unauthorized access, data breaches, and inefficiencies in organ allocation. To overcome these challenges, this system leverages a private Ethereum blockchain, ensuring secure, immutable, and decentralized management of donor and recipient records. Smart contracts, developed using Solidity, automate key processes such as donor registration, recipient matching, and organ allocation. By eliminating manual intervention, the system ensures fairness and accuracy. Medical institutions can securely register donors and recipients, with every transaction permanently recorded on a tamper-proof ledger, promoting transparency. Once a suitable match is identified, real-time notifications alert all relevant stakeholders, enabling recipients to track their organ request status through a hospital-issued unique identification number. The platform employs advanced cryptographic methods and role-based access controls to safeguard sensitive medical data, restricting access to authorized personnel only. Additionally, integrated data visualization tools offer insights into organ donation patterns, aiding policymakers in making informed decisions.By incorporating blockchain technology and smart contracts, this system introduces a decentralized, trust-driven approach to organ donation, ensuring data integrity, optimizing efficiency, and reinforcing security. It represents a transformative advancement in medical technology, setting a new benchmark for ethical and transparent organ transplantation processes.

Keywords: Organ Allocation Integrity, Blockchain based system, Smart Contracts, Data Security, Decentralized System, Ethereum blockchain

I. INTRODUCTION

Organ donation and transplantation are essential medical procedures that save lives, yet traditional management systems often face challenges related to inefficiencies, security vulnerabilities, and transparency issues. Many existing frameworks rely on centralized databases, which are susceptible to data breaches, unauthorized modifications, and limited accessibility, making it difficult to ensure fairness in organ allocation while maintaining confidentiality and preventing fraudulent activities.To overcome these limitations, this project introduces a decentralized organ donation and transplantation system powered by blockchain technology. By utilizing blockchain's secure and transparent infrastructure, the system eliminates the risks associated with centralization, ensuring that donor and recipient records remain immutable and protected. Hospitals and medical institutions can securely register participants, store records, and utilize smart contracts to automate the organ matching process, enhancing efficiency and reliability.This blockchain-driven approach strengthens security through advanced cryptographic methods, ensuring data integrity and controlled access. By reducing manual intervention and establishing a trust-based framework, the system creates a more efficient, transparent, and secure method for organ donation and transplantation, ultimately improving healthcare outcomes.

The main objectives of this project are:

1. Develop a secure and decentralized platform for organ donation and transplantation management.
2. Automate donor registration, recipient matching, and organ allocation using blockchain-powered smart contracts.
3. Enhance data security and privacy through cryptographic techniques and access control mechanisms.
4. Ensure transparency and traceability by recording all transactions on an immutable blockchain ledger.
5. Provide real-time notifications and tracking features to keep stakeholders informed throughout the process.

II. LITERATURE SURVEY

A literature survey examines existing research relevant to our project, providing an overview of blockchain-based organ donation systems. It explores methodologies, technologies, and their impact on organ transplantation.

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Modern applications integrate blockchain for security, transparency, donor-recipient matching, immutable records, and decentralized management. Research highlights advancements in data privacy, smart contracts, and secure authentication in organ donation. The following research papers were reviewed in this study:

1. Title: Creating Organ Donation System with Blockchain Technology [1] Authors: Soni, A., and S. G. Kumar Year: 2021 Publisher: European Journal of Molecular & Clinical Medicine Description: This paper presents a blockchain-based organ donation system that ensures transparency and security in organ transplantation. The study highlights issues in traditional organ donation systems, including data manipulation and donor privacy concerns. It proposes a decentralized platform using smart contracts to automate the organ matching process and securely store donor-recipient information. However, challenges such as system scalability, network latency, and regulatory compliance remain. Our project improves upon these limitations by implementing an optimized blockchain architecture with AI-driven donor-recipient matching, real-time tracking, and enhanced scalability through hybrid storage mechanisms.

2. Title: Blockchain-Based Management for Organ Donation and Transplantation [2] Authors: D. Hawashin, R. Jayaraman, K. Salah, I. Yaqoob, M. C. E. Simsekler, and S. Ellahham Year: 2022 Publisher: IEEE Access Description: This research focuses on blockchain integration in organ donation systems to improve data security, integrity, and trust among stakeholders. It presents a decentralized ledger for organ donor registration and real-time updates of organ availability. While the paper highlights the strengths of blockchain in eliminating fraud and ensuring traceability, it lacks an efficient AI-powered matching mechanism. In contrast, our project enhances the organ allocation process by integrating machine learning algorithms for optimal donor-recipient matching, reducing waiting time and increasing transplant success rates.

3. Title: Organ Bank Based on Blockchain [3] Authors: N. Chaudhary, S. S. Manvi, and N. Koul Year: 2022 Publisher: IEEE International Conference on Electronics Computing and Communication Technologies (CONECCT) Description: This study discusses a blockchain-based organ bank that securely manages donor records and organ availability. The system employs cryptographic hashing for data protection and smart contracts for automating organ allocation. However, limitations include dependency on a single blockchain framework and challenges in real-time organ tracking. Our project overcomes these limitations by integrating multi-chain interoperability and IoT-based organ tracking systems, ensuring seamless data synchronization and real-time monitoring of organ transportation.

4. Title: A Framework of Blockchain Technology Adoption: An Investigation of Challenges and Expected Value Authors: Toufaily, E., Zalan, T., & Dhaou, S. B. Year: 2021 Publisher: Information Management Description: This paper examines the adoption challenges of blockchain in various industries, including healthcare. It identifies barriers such as regulatory issues, scalability, and lack of awareness. The study proposes a framework for successful blockchain adoption by addressing security, reliability, and governance aspects. Our project aligns with these findings by incorporating regulatory compliance measures, scalable blockchain solutions, and user-friendly interfaces to enhance system adoption and usability in organ transplantation.

These studies provide valuable insights into blockchain-based organ donation applications, emphasizing security, transparency, and efficiency. Our project builds upon these findings by integrating AI-powered organ matching, IoT-enabled real-time tracking, and a hybrid blockchain architecture to enhance data integrity, reduce organ wastage, and ensure ethical organ allocation.

III. PROPOSED METHODOLOGY

1. System Architecture:

The Organ Donor and Matching System is designed as a secure and decentralized web application to streamline the organ donation and transplantation process. It consists of two main components: the Hospital Application, which allows healthcare institutions to register, manage donor and recipient data, and track organ availability, and the User Application, which enables individuals to register as donors or recipients and monitor their organ matching status. The system leverages blockchain technology to enhance security, transparency, and data integrity by storing all records on an immutable ledger. A smart contract-based authentication mechanism ensures that only verified hospitals and registered users can access and modify relevant data. By eliminating unauthorized alterations and central points of failure, the system fosters trust among stakeholders while enabling real-time tracking and seamless coordination between hospitals and patients, making the organ donation process more efficient and reliable.

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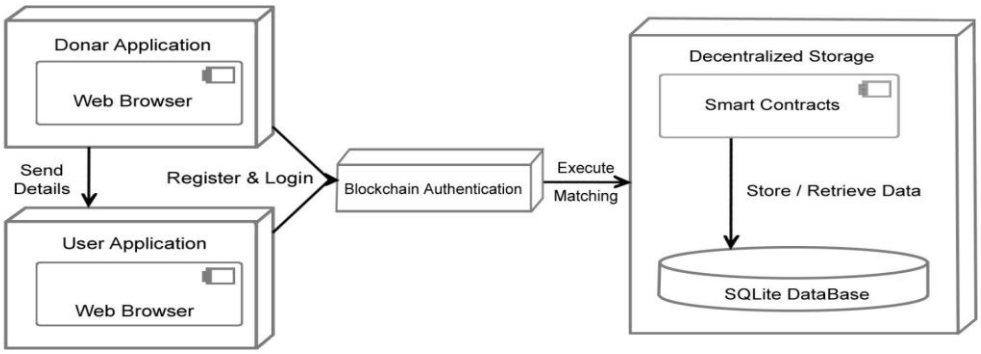

Fig. 1. System Architecture

2. Technology Stack:

The Organ Matching & Transplantation System is built using a secure and decentralized technology stack, leveraging Blockchain and Web Technologies to ensure transparency, security, and efficiency. The frontend is developed using HTML, CSS, and JavaScript, providing a simple yet effective user interface. The backend is powered by Python with Flask/Django, authentication, and Blockchain interactions. Solidity is used for writing smart contracts, which securely store and manage hospital, donor, and patient data on the Ethereum Blockchain. The system is tested and deployed using Truffle, ensuring a reliable smart contract execution environment. Web3.js facilitates communication between the frontend and the blockchain, enabling seamless interactions. The SQLite database is used for storing non-sensitive metadata and improving performance. To run the application, a local Python server is utilized, managing the backend operations efficiently. This technology stack ensures secure, immutable, and decentralized storage of organ donation and matching records, preventing unauthorized access or tampering, while maintaining system reliability and accessibility for hospitals, donors, and recipients.

3. Key Technological Components:

The Organ Matching & Transplantation System is built on a robust and secure technology stack designed to ensure transparency, efficiency, and data integrity. The frontend is developed using HTML, CSS, and JavaScript, providing a responsive and user-friendly interface. The backend is powered by Python (Flask/Django) to manage authentication, business logic, and Blockchain interactions. Solidity is used for writing smart contracts, which securely handle hospital, donor, and patient data, stored immutably on the Ethereum Blockchain. Web3.js enables seamless communication between the frontend and Blockchain, while Truffle facilitates smart contract deployment and testing. SQLite is integrated for storing non-sensitive metadata, enhancing overall system performance. Leveraging Blockchain's decentralized architecture, the system ensures tamper-proof record-keeping, preventing unauthorized modifications while maintaining high availability and security.

4. System Workflow:

The Organ Matching & Transplantation System is a secure, Blockchain-based platform designed to manage hospital, donor, and patient records transparently. Hospitals can register, log in, and oversee donor and patient data, ensuring efficient organ matching. Each donor and patient is assigned a unique ID to track their status. When an organ is required, the system searches for a compatible donor, notifies both parties, and enables hospitals to coordinate the transplantation process.The backend, built with Python (Flask/Django), manages authentication and system logic, while Solidity smart contracts securely handle data storage on the Ethereum Blockchain to prevent unauthorized modifications. Web3.js facilitates seamless interaction between the frontend and Blockchain, and SQLite stores non-sensitive metadata to enhance system efficiency. This decentralized approach ensures data integrity, security, and system availability, eliminating risks associated with traditional centralized databases.

IV. SECURITY IMPLEMENTATION

1. Authentication Mechanisms: Blockchain-Based Identity Verification:

The system ensures secure access by implementing Blockchain-based authentication, where hospitals must register and login to manage donor and patient records. Instead of relying on a traditional centralized authentication system, each hospital is assigned a unique cryptographic key that grants them permission to add, update, and retrieve data. This approach prevents unauthorized access and ensures that only verified medical institutions can modify records.

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2. Data Integrity & Tamper Protection: Smart Contracts & Hashing:

Every transaction in the system—such as donor registration, organ matching, and status updates—is securely stored using smart contracts on the Ethereum Blockchain. Each block of data is linked to the previous one using cryptographic hashing, making it impossible to alter past records without breaking the entire chain. This guarantees that donor and patient details remain immutable and tamper-proof, ensuring trust and transparency in organ transplantation processes.

3. Secure Data Storage & Retrieval: SQLite Database Integration:

In our Organ Matching & Transplantation system, critical donor and patient records are stored securely on the Ethereum Blockchain, while non-sensitive hospital data and associated metadata are maintained in an SQLite database. This dual-storage approach optimizes system performance and efficiency by segregating sensitive and ancillary data. The SQLite integration is designed to process only validated and sanitized data, ensuring that all information is securely managed and that the risk of unauthorized access is minimized.

V. EXPERIMENTAL RESULTS AND ANALYSIS

1. Screenshots of the Application:

Fig.1: Home Page

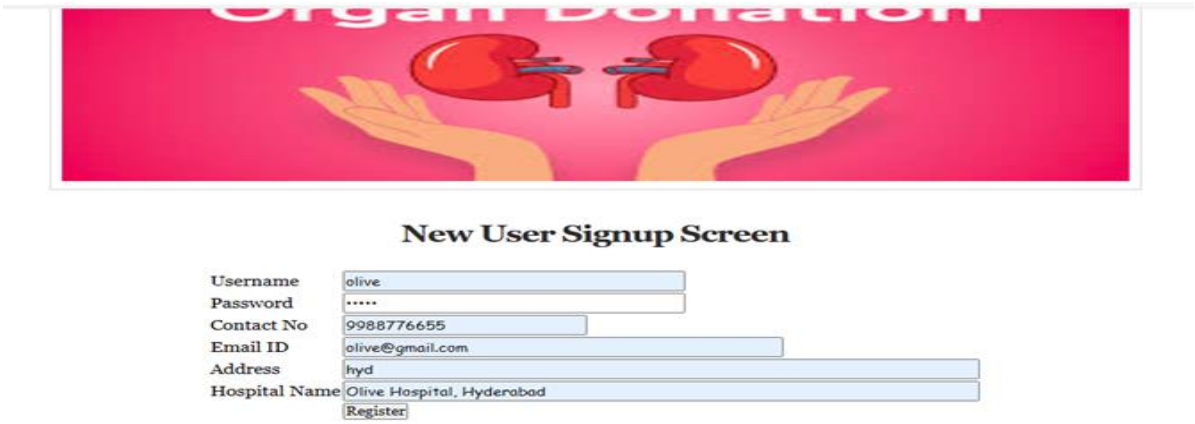

Fig. 2. Hospital Sign Up Page

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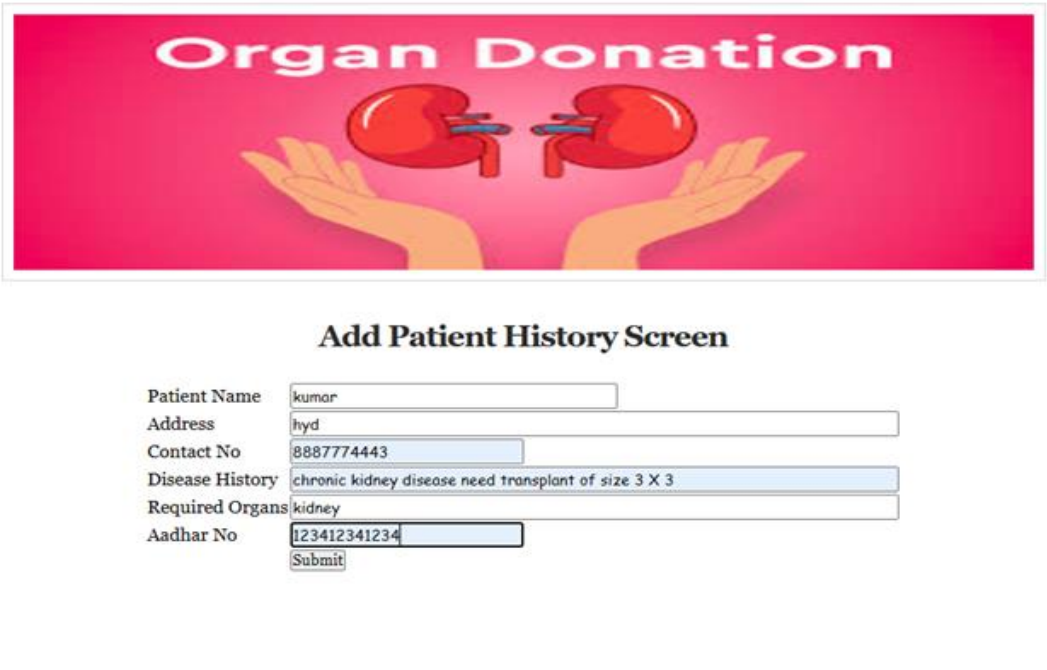

Fig. 3. Add Patient Account Details

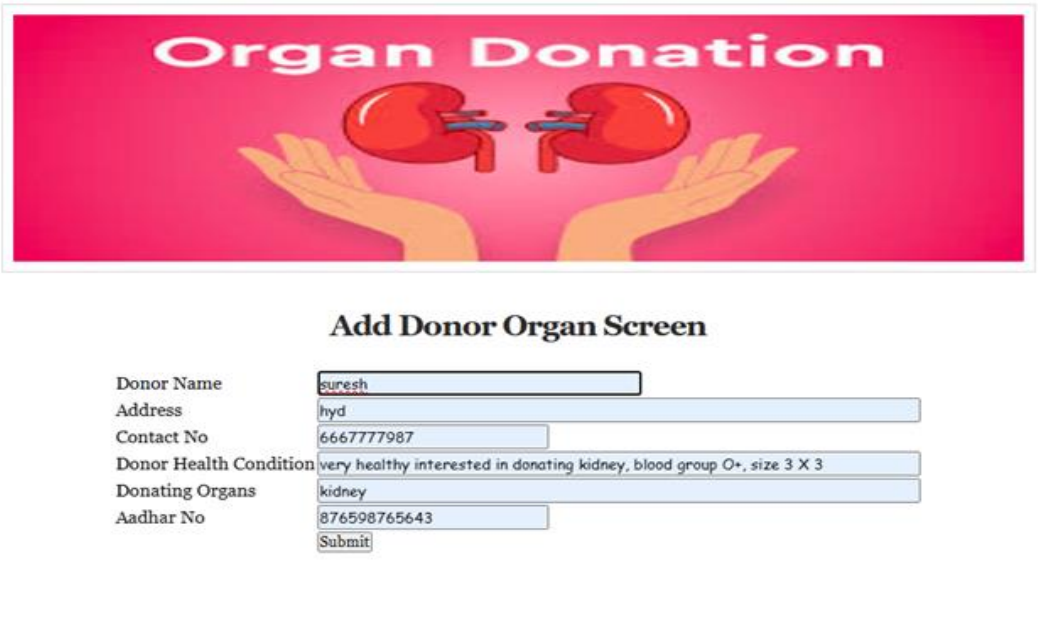

Fig. 4. Add Donor Account Details

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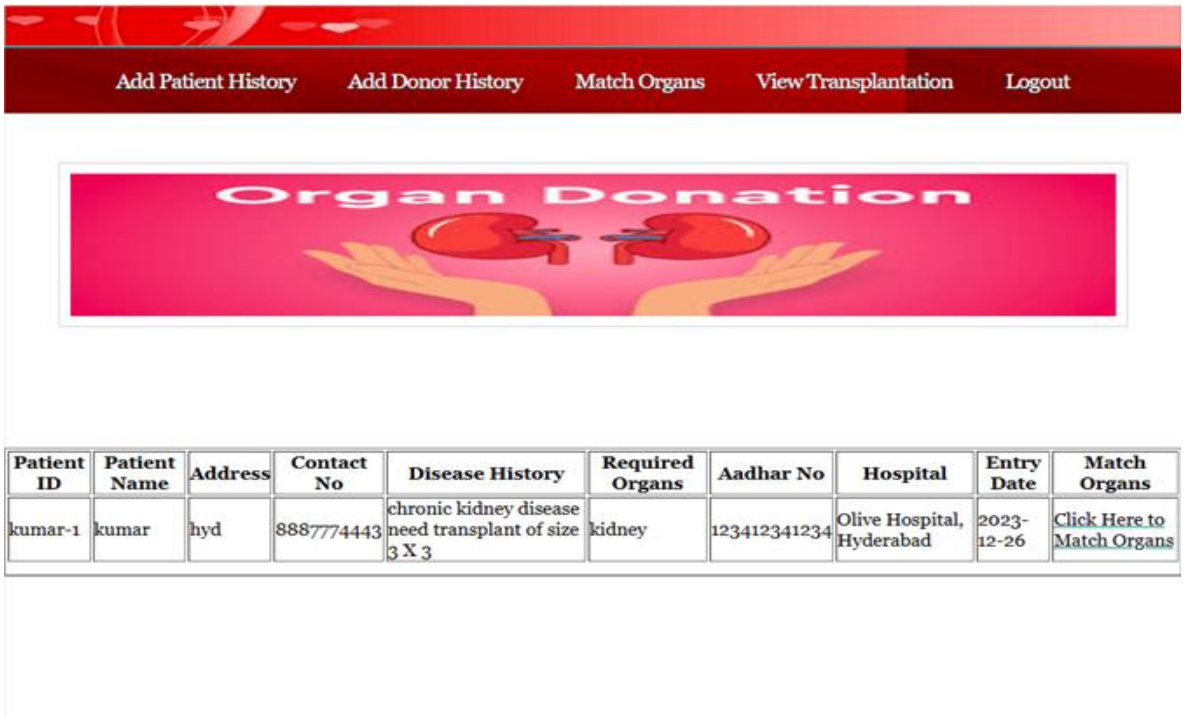

Patient ID	Patient Name	Address	Contact No	Disease History	Required Organs	Aadhar No	Hospital	Entry Date	Match Organs
kumar-1	kumar	hyd	8887774443	chronic kidney disease need transplant of size 3 X 3	kidney	123412341234	Olive Hospital, Hyderabad	2023-12-26	Click Here to Match Organs

Fig. 5. Patient Match Organs Records

Donor ID	Donor Name	Address	Contact No	Health Condition	Donating Organs	Aadhar No	Hospital	Entry Date	Alert User & Donor About Matching
suresh-1	suresh	hyd	6667777987	very healthy interested in donating kidney, blood group O+, size 3 X 3	kidney	876598765643	Olive Hospital, Hyderabad	2023-12-26	Send Alert

Fig. 6. Donor Match Organs Records

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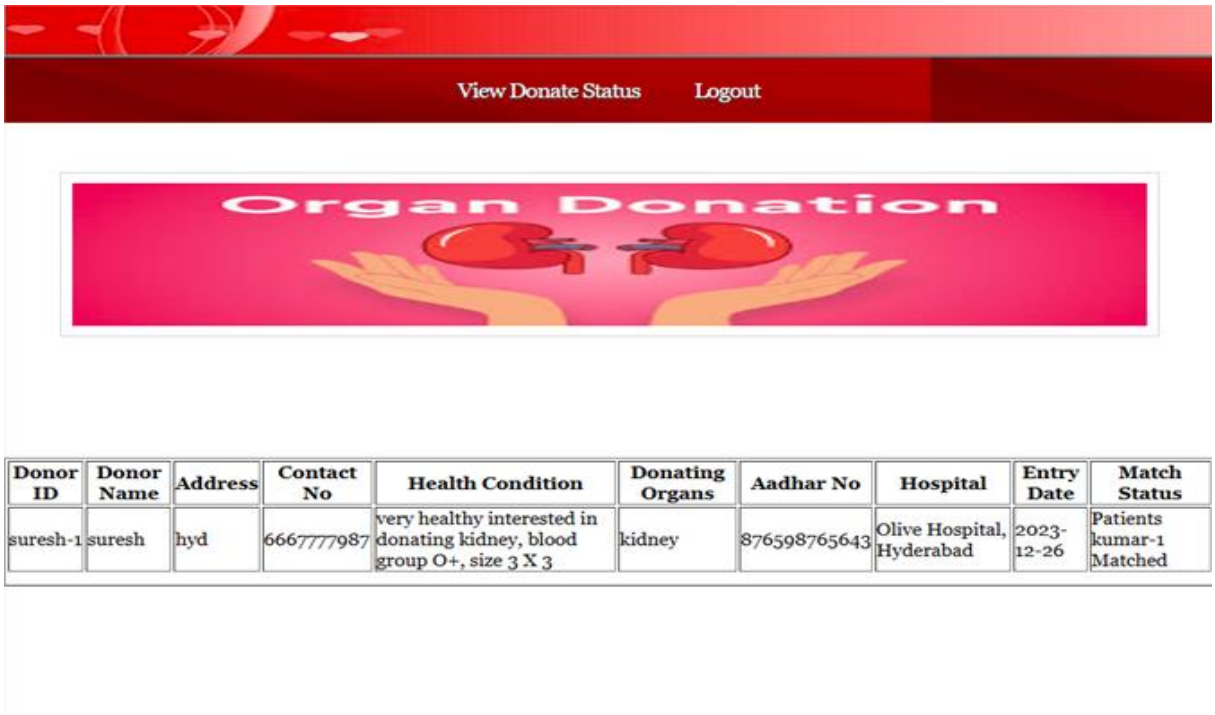
Fig. 7. Organ Match Alert Notification



Donor ID	Donor Name	Address	Contact No	Health Condition	Donating Organs	Aadhar No	Hospital	Entry Date	Match Status
suresh-1	suresh	hyd	6667777987	very healthy interested in donating kidney, blood group O+, size 3 X 3	kidney	876598765643	Olive Hospital, Hyderabad	2023-12-26	Patients kumar-1 Matched

Fig. 8. Patient Confirmed Match

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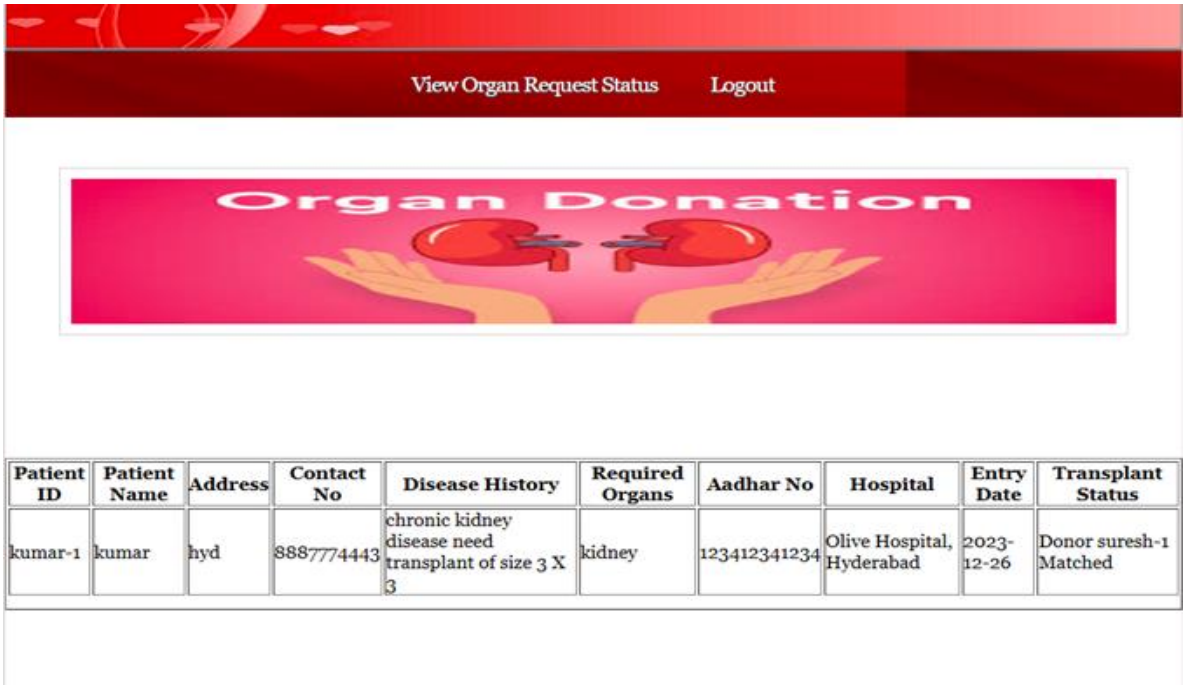

Patient ID	Patient Name	Address	Contact No	Disease History	Required Organs	Aadhar No	Hospital	Entry Date	Transplant Status
kumar-1	kumar	hyd	8887774443	chronic kidney disease need transplant of size 3 X 3	kidney	123412341234	Olive Hospital, Hyderabad	2023-12-26	Donor suresh-1 Matched

Fig. 9. Donor Confirmed Match

2. Comparative Analysis:

Feature	Existing System [1]	Existing System [2]	Existing System [3]	Organ Matching and Transplantation
Organ Matching Method	No	Yes (Basic Match)	No	Yes (Advanced Matching Process)
Real-Time Donor Patient Alerts	No	No	Limited Notifications	Yes (Email / SMS notifications)
Secure Authentication	No	Yes	No	Yes (Multi - layer Verification)
Hospital Integration	No	Limited	No	Yes (Connected with Hospital Database)
Cross Platform Support	Web based	Not Specified	Android Only	Yes (Web - application)
User Friendly Interface	Basic UI	Limited	Outdated UI	Yes (Modern and Responsive UI)

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Table 1. Comparison with Existing Systems

Feature	Existing System 1	Existing System 2	Existing System 3	Organ Matching & Transplantation
Organ Matching Method	No	Yes (Basic Match)	No	Yes (Advanced Matching Process)
Real-Time Donor-Patient Alerts	No	No	Limited Notifications	Yes (Email/SMS Notifications)
Secure Authentication	No	Yes	No	Yes (Multi-Layer Verification)
Hospital Integration	No	Limited	No	Yes (Connected with Hospital Database)
Cross-Platform Support	Web-based	Not Specified	Android Only	Yes (Web Application)
User-Friendly Interface	Basic UI	Limited	Outdated UI	Yes (Modern & Responsive UI)

The Organ Matching & Transplantation System improves upon existing solutions by offering an advanced matching process for organ allocation, real-time donor-patient alerts, multi-layer authentication, and seamless hospital database integration. Unlike traditional systems that lack user-friendly interfaces and real-time communication, this system ensures efficient tracking, secure access, and a smooth user experience.

VI. CONCLUSION

Organ Matching & Transplantation System is a robust and secure solution designed to transform the management of organ donation. By leveraging Blockchain technology, the system ensures tamper-proof data storage and transparent record-keeping, enabling hospitals to reliably register, match, and track donor and patient details. Utilizing Ethereum smart contracts, the platform automates critical processes—from donor registration and patient matching to alert notifications—eliminating vulnerabilities associated with centralized databases. Rigorous testing has confirmed the system's stability and security, with all components performing reliably under various conditions.

Compared to traditional organ donation management systems, our solution offers enhanced data integrity, real-time transparency, and improved operational efficiency. Unique ID-based tracking, immutable record-keeping, and decentralized storage foster trust among hospitals, donors, and patients. With its scalable and adaptable design, the Organ Matching & Transplantation System is well-positioned for future enhancements, such as integrating advanced analytics and AI-driven matching algorithms, making it a pioneering tool in the field of organ transplantation management.

VII. FUTURE SCOPE

Future developments for the Organ Matching & Transplantation System include integrating advanced AI algorithms to further enhance donor-recipient matching precision and predict transplantation outcomes more effectively. The incorporation of electronic health record (EHR) integration is planned to enable seamless data exchange between hospitals, thereby accelerating real-time decision-making in organ allocation. Additionally, security enhancements such as multi-factor authentication, biometric verification, and advanced cryptographic methods like zero-knowledge proofs will be considered to further protect sensitive medical data on the Blockchain.

Looking ahead, the system could expand its reach by interoperating with global healthcare networks, enabling a unified, worldwide organ allocation platform that reduces wait times and improves patient outcomes. Future iterations may also incorporate IoT-enabled monitoring devices to track organ condition during transit, ensuring optimal preservation, along with AI-powered decision support and advanced visualization tools for clinicians. With continuous improvements in Blockchain, AI, and healthcare connectivity, the Organ Matching & Transplantation System is poised to evolve into a comprehensive, intelligent platform that transforms the landscape of organ donation and transplantation management.

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