

Secure Digital Infrastructure for Organ Donation Life Cycle Management

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Abstract—Organ transplantation remains one of the most critical medical procedures for saving lives, yet but is hindered by challenges such as organ shortages, inefficient coordination, and insufficient transparency in allocation processes. This paper presents a novel framework based on distributed ledger technology to enhance the management of organ donation and transplantation. Using the decentralized, tamper resistant, and transparent nature of blockchain, the proposed system establishes a secure platform for all stakeholders involved, including donors, recipients, healthcare providers, and regulatory authorities. Smart contracts are used to automate key operations such as donor registration, consent management, organ matching, and allocation, ensuring accurate tracking and accountability throughout the process. The immutable ledger enables complete traceability of organ transactions, reducing the risk of manipulation, and improving trust in the system. Furthermore, the framework ensures that transplant activities are securely recorded and monitored within the blockchain network. Each stage of the transplantation process is documented in a safe way, creating a trustworthy and secure record that cannot be altered. This secure recording of transplant information enhances reliability, supports safe data management, and strengthens confidence among stakeholders involved in organ donation and transplantation.

Keywords—Distributed Ledger Technology, Blockchain, Organ Donation, Organ Allocation, Smart Contracts, Healthcare Systems, Transparency

I. INTRODUCTION

Organ transplantation is a big step forward for modern medicine because it can save the lives of people with end-stage organ failure. Even though medicine and technology are always getting better, the organ donation system still has big problems, such as not having enough organs, not having clear rules for how to give them out, and ethical issues. Organ trafficking is still a big problem that hurts the fairness and integrity of transplantation systems. Organ trafficking is the illegal trade of human organs that often takes advantage of weak groups and violates basic human rights [14]. This dishonest behavior not only makes it harder to fairly distribute organs, but it also makes people less likely to trust healthcare systems. Current centralized organ donation systems are constrained by risks including data tampering, insufficient traceability, and reliance on intermediaries, rendering them vulnerable to fraud and manipulation [13], [18]. Blockchain technology has come

up as a promising way to get around these problems. Blockchain is a safe way to store and manage data because it is decentralized, open, and unchangeable. It makes it possible to record transactions in a way that can't be changed, which makes sure that everyone is responsible and that the whole organ donation process can be traced, from registering the donor to the transplant [20]. Also, smart contracts automate important tasks like matching and allocating organs, which cuts down on delays and the need for people to be involved [8]. Recent progress has made this method even better by combining blockchain technology with Artificial Intelligence (AI). AI-based systems enhance donor-recipient matching by evaluating medical compatibility parameters, resulting in more precise and effective allocation decisions [2], [12].

Blockchain-based frameworks also make sure that all stakeholders, such as healthcare providers, donors, recipients, and regulatory authorities, can share data safely, keep their privacy, and work together [6]. The proposed system uses blockchain technology to create a safe and open framework for organ donation and transplantation. The system lowers the risks of fraud and organ trafficking by decentralizing control and keeping records that can't be changed. This also builds trust among all parties involved. It also makes sure that organs are fairly and efficiently given out based on how urgent and compatible they are with the person who needs them. This paper describes a complete blockchain-based framework that aims to make organ donation easier, more open, and free of unethical behavior. The goal of combining smart contracts with AI-driven matching systems is to create a strong, efficient, and reliable ecosystem for organ transplantation.

II. LITERATURE REVIEW

Existing research on organ donation systems can be broadly categorized into centralized approaches, blockchain-based frameworks, and hybrid models integrating advanced technologies. Even though many people use traditional centralized systems, they have problems like not being able to see what's going on, not being able to keep data safe, and not being able to work together well with other people [13]. These problems have pushed people to look for decentralized solutions. Blockchain-based approaches have gained significant attention for tackling these issues. Hawashin et al. [20] and

Rangarajan et al. [10] proposed decentralized frameworks that improve transparency, traceability, and trust by removing dependence on central authorities. Similarly, Rajesh et al. [6] and Sawant et al. [6] showed that blockchain boosts operational efficiency and ensures secure data sharing among healthcare entities. Ethereum-based implementations expand these capabilities. Sitharamulu et al. [8] used smart contracts to automate organ donation workflows. Shrihari et al. [7] focused on reducing fraud and improving system transparency. Recent advancements highlight the combination of Artificial Intelligence (AI) and blockchain. Nakashe et al. [2] and Igboanusi et al. [12] proposed AI-driven organ matching systems that improve donor-recipient compatibility and decision-making accuracy. These hybrid approaches greatly enhance allocation efficiency compared to traditional methods. Security and privacy are important concerns in healthcare systems. Studies by Deshmukh et al. [5], Prasantha [16], and Ghosh and Dutta [17] show that blockchain plays a key role in securely storing medical data, protecting privacy, and allowing for growth. Additionally, survey-based analyses [11], [13] point out major challenges like scalability, interoperability, and following regulations. The literature suggests that systems using blockchain and AI offer a hopeful path for improving transparency, security, and efficiency in organ donation and transplantation. However, issues with scalability, legal frameworks, and practical implementation still need to be resolved.

III. PROPOSED METHODOLOGY

The proposed system implements a blockchain based framework to ensure secure, transparent, and efficient management of the organ donation process. Initially, donors and recipients register through a user interface, where their details are securely recorded and stored on a decentralized blockchain ledger. An administrative module provides controlled access for verification and monitoring of all records, ensuring only authorized entities can manage sensitive data. Once a recipient raises an organ request, the system utilizes predefined criteria to identify suitable donors from the registered database. Smart contracts are employed to automate key processes such as validation, matching, and approval, thereby reducing manual intervention and delays. Each transaction, including registration, matching, and transplantation approval, is encrypted and stored as an immutable block, ensuring data integrity and traceability. The system also provides real-time status updates and maintains administrative records for auditing and transparency. Overall, the methodology enhances security, eliminates centralized vulnerabilities, and ensures a reliable and trustworthy digital infrastructure for managing the complete organ donation life cycle.

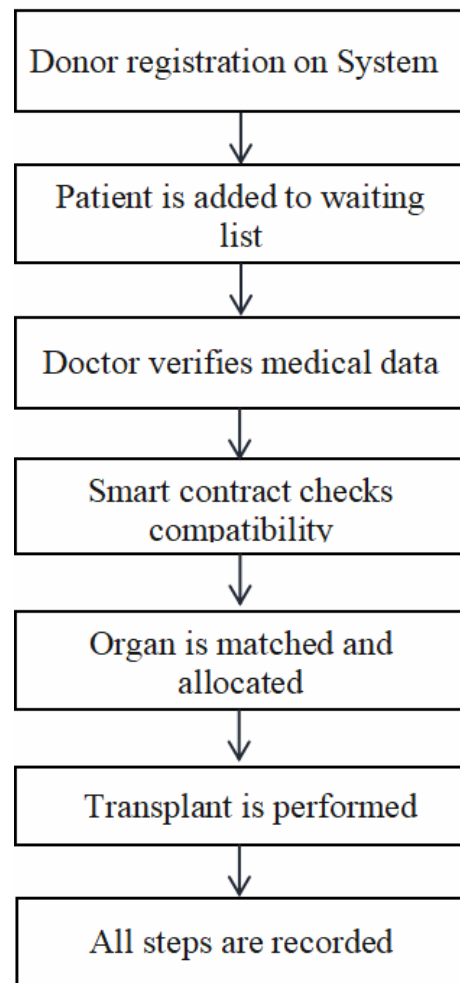


Fig. 1. Block Diagram of Proposed Secure Organ Donation Life cycle Management System

Fig.1 presents the proposed architecture for a secure digital infrastructure for organ donation life cycle management. The architecture integrates donor and recipient hospitals, organ procurement organizations, and advanced digital technologies into a unified and secure framework. The core component of the system is a blockchain network, which provides secure, transparent, and tamper-resistant storage of donor and recipient data through immutable records, smart contracts, and encryption mechanisms. Right after confirmation, a digital contract on the network evaluates compatibility between donor and recipient by checking blood type, medical condition, and urgency of need. Should alignment appear, the process advances toward organ allocation. Once permission is recorded, surgical teams at the hospital perform the transplant procedure. As verification is completed, steps proceed immediately.

At each stage i.e from donor registration to data verification, organ matching, and surgery execution gets stored securely on the blockchain. Since records are updated continuously, tracing events grows simpler, accuracy improves, every action stays visible, chances of fraud drop sharply, trust in the process naturally builds along the way.

consistency. Over time, trust takes root but no rush, just steady progress.

A. System Architecture

The framework consists of multiple stakeholders, including donors, recipients, hospitals, transplant coordinators, and regulatory authorities. Each participant interacts with the system through authenticated interfaces. All transactions are recorded on a distributed ledger, ensuring that no single entity has complete control over the data. This decentralized structure enhances reliability and prevents unauthorized manipulation.

B. Donor Registration and Consent Management

People who may give organs enter their name, health background, and choice about donation using a protected online form. After hospitals check what was submitted, the data becomes part of a permanent digital ledger. Whether someone gives while alive or after death, the record stays fixed once saved.

C. Recipient Enrollment and Waiting List Management

Enrolled through healthcare providers, patients needing organ transplants enter the process at various stages. Once listed, details like required organ, blood type, how urgent their case is, alongside matching factors get documented carefully. Prioritization happens under strict medical rules, shaping a ranked queue that reflects health needs alone. Fair access emerges not from preference but from structured clinical standards applied consistently across cases. Decisions rest on patient condition, keeping outside pressures separate from transplant eligibility.

D. Organ Matching and Allocation via Smart Contracts

A fresh organ triggers automatic assessment through digital agreements. Following availability, the system checks elements like blood classification alongside tissue alignment, patient age together with medical urgency. Selection of the best-matched individual occurs via preset criteria without human intervention. Fairness emerges naturally since decisions follow coded logic rather than personal judgment.

E. Transaction Recording and Traceability

Beginning at donor sign-up and moving through each phase toward transplant, every step gets recorded onto the blockchain. Stored data cannot be altered, carrying a precise timestamp that marks when actions occur. Because entries carry these fixed markers, tracking an organ's journey becomes fully transparent. Access is limited to approved parties who may review activity logs as needed. Oversight by permitted individuals helps maintain responsibility across roles. This level of visibility lowers chances for unlawful conduct, including unauthorized organ exchange.

F. Security and Privacy Mechanisms

Protected health records rely on encryption methods for security. Although access rules limit who sees what, certain individuals may still modify entries under defined

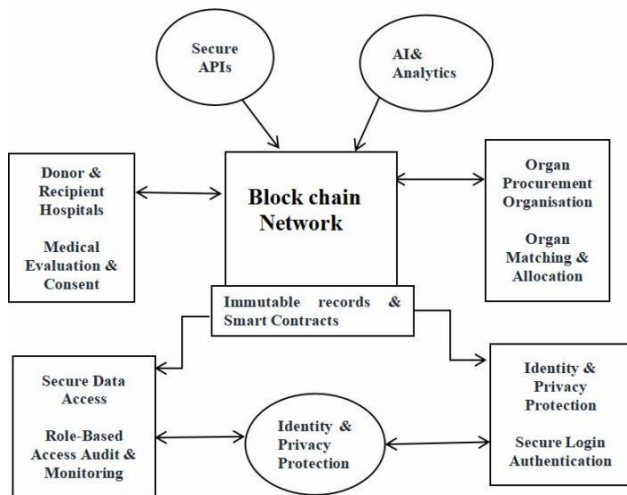


Fig. 2. Secure Organ Donation Management System Architecture

Checking health and verifying consent comes first when organs are donated. Matching donors to patients happens through careful review of details. Live updates on organ state move quickly using monitoring tools. Systems exchange messages instantly thanks to secure connections. When events move fast, smart software tracks each input carefully. As data pours in from many sides, choices form without waiting for everything to arrive. Flow depends on timing, speed matters most when delays cost too much. No step waits for manual approval once started properly. Parts work together but stay independent in design structure. Information flows where needed if rules allow passage. Every check happens before any transfer begins physically. Tracking continues even after initial handover occurs silently. Each time a state shifts, systems verify correctness immediately. Across linked platforms, changes appear without delay. Given fresh input, rules adjust subtly as needed. Depending on visible demand, operations modify their flow. Only after clearing all checkpoints does any activity proceed.

At all times, the system watches itself, spotting odd behavior fast. Each move someone makes leaves a mark, saved just in case. Oversight runs live, catching slipups before they spread. Only verified individuals may take part, confirmed using trustworthy techniques. Before access is granted, identity checks happen via fingerprint or face scanning. During analysis, personal information is removed from data collections. Shared results contain no identifying features, keeping privacy intact.

Fig.2 shows organ movements in real time, providing instant alerts whenever a shift occurs. Compliance happens quietly, built into each phase instead of forced. Transparency spreads through every part, piece by piece. Smooth operations emerge when structure supports flow. Because security keeps data contained, risks shrink without fanfare. Under heavy load, systems prove their worth quietly. Management online gains strength through

conditions. Even when activity logs stay visible for oversight checks, private facts about patients remain shielded by design.

G. Transparency and Audit Layer

Through a special audit portal, regulators observe every stage of organ transplants. Trust grows across parties involved when decisions are shown to follow laws and ethics clearly. Verification becomes possible, not just claimed.

IV. RESULTS AND DISCUSSION

The proposed Secure Digital Infrastructure for Organ Donation Life Cycle Management was implemented using blockchain technology to improve the security, transparency, and efficiency of the organ donation process. The results show that the system successfully records donor registration, recipient registration, organ matching, and transplantation approval as secure transactions in the blockchain ledger. Each transaction is protected using cryptographic hashing, which ensures data integrity and prevents unauthorized modifications. The use of smart contracts automates the verification and organ allocation process, reducing manual intervention and delays in transplantation procedures. Additionally, the decentralized nature of the blockchain provides better transparency and traceability, allowing authorized stakeholders such as hospitals and transplant authorities to verify records securely. Compared to traditional centralized systems, the proposed framework enhances data security, eliminates single points of failure, and ensures reliable management of the entire organ donation life cycle.

into the admin layer. Information from donors and recipients gets recorded safely on the blockchain, preserving accuracy and confidentiality. Through this setup, matching organs becomes smoother while oversight stays clear for approved staff. The platform enables efficient organ matching and transparent monitoring by authorized administrators, thereby supporting a secure and reliable organ donation life cycle management system.

TABLE I

Performance Comparison

| Metric | Existing | Proposed |
|----------------|----------|-----------|
| Transparency | Low | High |
| Security | Medium | High |
| Data Integrity | Editable | Immutable |
| Failure Risk | High | Low |
| Traceability | Limited | Full |
| Efficiency | Moderate | High |

Table I reveals differences between standard centralized organ donation systems and those using blockchain. Because control sits in one place, older models often struggle with openness, accurate record-keeping, and tracking overtime. When everything depends on a single hub, breakdowns can happen more easily - this weak spot risks disruption across the network. Matching organs usually needs human steps, slowing things down without guaranteeing better results. On the flip side, spreading information across many nodes makes tampering nearly impossible under the new method. Records stay fixed once logged, visible to authorized parties, reshaping how trust builds in medical coordination. A single point of breakdown becomes impossible under this distributed design, while every step-in organ donation stays fully trackable.

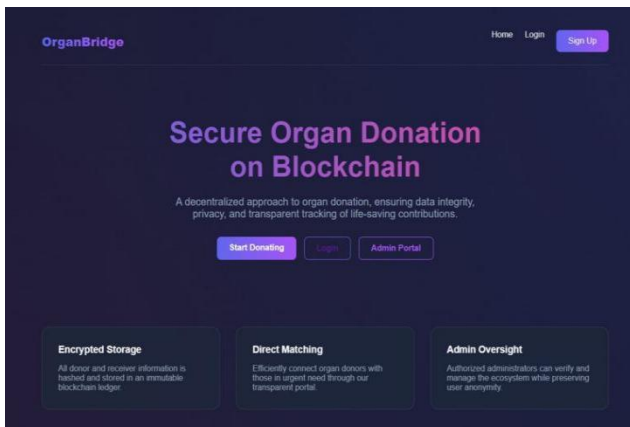


Fig. 3. User Interface of the Blockchain-Based Organ Donation System

These results demonstrate that the proposed system provides an effective and trustworthy digital platform for organ donation and transplantation management.

Figure 3 shows the primary screen of Organ Bridge, a blockchain-powered organ donation system. Built for safety and ease, the platform supports smooth handling of donations. Access begins with three entry points: Start Donating, Login, or Admin Portal. While encryption protects stored data, connections between donors and recipients happen directly. Oversight tools are also built

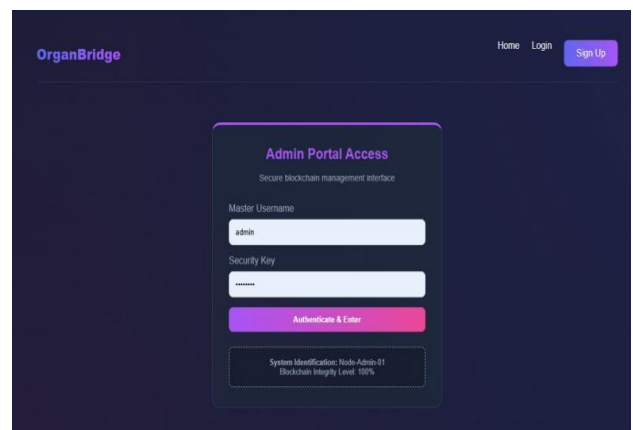


Fig. 4. Administrator Access Interface

Shown in Fig.4 is the login screen used by admins on Organ Bridge, a platform built using blockchain technology for organ donations. Accessible only to approved personnel, this entry point ensures protected interaction with critical system functions. To log in, an official inputs a primary user ID alongside a cryptographic key, both required for authentication into the network dashboard. Once verified, the admin can monitor donor and recipient records, verify organ

matching processes, and oversee system transaction. Verification of organ pairing steps occurs here, along with supervision of data exchanges across the chain. Security comes first when viewing who gets near critical data through controlled entry points across the network. Verified users appear clearly, their roles shaping what they see on screen at any moment. A live indicator shows whether the chain remains unbroken, its structure intact and functioning. Identity checks run silently in the background, aligning permissions with real-time actions taken.

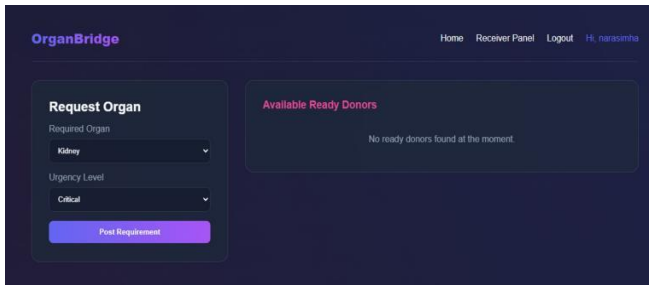


Fig 5. Organ Request and Donor Availability Interface

The above fig.5 shows the receiver panel of the proposed blockchain-based organ donation system. Within this layout, recipients initiate an organ request through choices like organ category along with how urgent it is. After submission, a search begins across donor records stored on the distributed ledger. Available matches appear directly within the view when present. Matching becomes faster while visibility into distribution grows clearer because of this function.

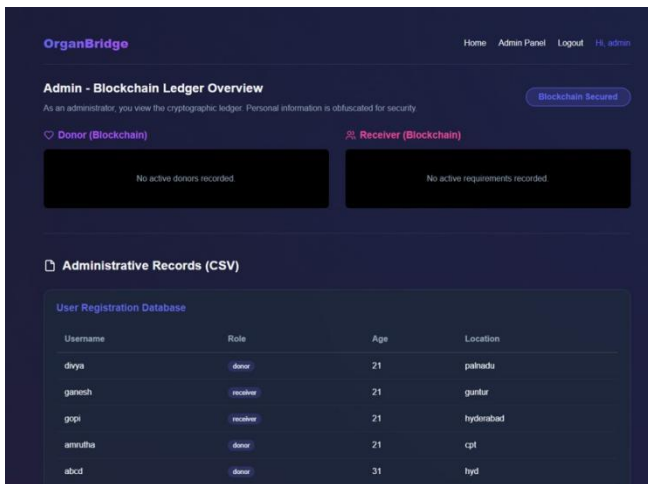


Fig. 6. Admin Panel Showing Blockchain Donor and Receiver Records

The above fig.6 illustrates the receiver panel of the proposed blockchain based organ donation system. In this interface, a recipient can submit an organ request by selecting the required organ type and specifying the urgency level. Upon submission, the system processes the request and searches for compatible donors registered within the blockchain network. The interface also displays the availability of ready donors, enabling real-time monitoring of matching results. This module enhances transparency and efficiency by streamlining the organ request and allocation process within a secure and decentralized environment.

The proposed system ensures efficient and secure management of all records associated with the organ donation process. It organizes information into distinct categories such as donor details, recipient requests, administrative data, and security controls to enable systematic handling and monitoring. By utilizing blockchain technology, the system maintains data integrity, transparency, and traceability while protecting sensitive information through encryption. Each component is designed to support accurate record maintenance and controlled access based on user roles, ensuring that only authorized participants can interact with critical data. This structured approach coordination among stakeholders and improves the overall reliability and effectiveness of the organ donation management system.

A. Donor Records

Inside the donor area, details appear for people signed up to give organs. Stored within a blockchain, every entry stays secure and unchanged over time. Encryption guards private facts, keeping them hidden yet verifiable. When zero entries exist, the interface reflects an empty status clearly.

B. Receiver Records

The receiver section shows patients who have requested organs. Unlike temporary records, patient entries live on a blockchain, keeping them protected and trackable over time. When the list stays empty, the platform simply reflects: nothing currently needed.

A. Administrative Records

The system also maintains a CSV-based database that stores user registration details such as username, role, age, and location. These records help the administrator manage users and verify their information.

B. Security and Access Control

The system uses blockchain technology to ensure data security, immutability, and transparency. It also implements role- based access control, where users are categorized as admin, donor, or receiver to restrict access to sensitive information.

V. CONCLUSION

A new approach to managing organ donations emerges through blockchain-based systems. Security strengthens when data lives across distributed nodes instead of centralized servers. Information about donors and recipients resists tampering once recorded on chain. Automation takes shape via smart contracts handling sign-ups, pairing organs, and validating procedures. Efficiency grows because fewer steps require human intervention. Trust builds as updates reflect instantly to authorized parties. Transparency becomes inherent since every change leaves a traceable mark. Reliability rises under conditions where records stay consistent over time. Despite differences in user roles, the system maintains consistent performance across hospitals, regulatory bodies, and management teams by securing data flow. Built on blockchain technology, it handles each phase of organ donation without relying on central oversight. From recording donor details to tracking transplants, operations run reliably while reducing errors.

Trust emerges naturally when all parties access the same unchangeable records. Transparency becomes routine rather than exceptional under this model. Fairness gains

structure through timed updates and auditable steps. Efficiency appears not from speed alone but from fewer repeated tasks. Security is built into every exchange, limiting unauthorized changes. Stakeholders interact with confidence because traces always remain visible. The full cycle from consent to delivery operates within one protected space.

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