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Smart Blockchain-Based Organ Donation System for Secure Donor-Recipient Matching

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ABSTRACT

Although organ donation is a life-saving medical practice that has helped countless individuals, it continues to face major challenges that hinder its effectiveness and fairness. Issues such as lack of transparency, the rise of illegal organ trafficking, and ineffective donor-recipient matching often plague traditional systems. These problems not only lead to unnecessary delays in life- critical situations but also increase the chances of fraudulent practices and significantly reduce public confidence in the donation process. Many potential donors and recipients are left uncertain or excluded due to the inefficiencies and lack of trust in existing systems. To address these pressing concerns, we propose a Blockchain-Based Organ Donation System that leverages the decentralized, transparent, and immutable nature of blockchain technology. This system ensures that all data and transactions are securely recorded and cannot be altered, which enhances accountability and traceability. By integrating smart contracts, the platform can automatically execute and manage donor-recipient matching based on real-time medical data, compatibility, and urgency, ensuring that the allocation process is both fair and tamper-proof. This automation not only eliminates the need for third-party intermediaries but also minimizes the risk of human error and corruption. Additionally, every step in the process—from donor registration and organ availability updates to hospital coordination and recipient assignment—is permanently logged on the blockchain, creating a complete and auditable history. As a result, our approach reduces delays, curbs illegal activities, and fosters a reliable, efficient, and trustworthy ecosystem where patients, families, and healthcare providers can participate with greater confidence and transparency.

INTRODUCTION

Organ donation is a life-saving medical procedure that offers a second chance at life to individuals suffering from end-stage organ failure, including heart, liver, kidney, and lung diseases. Each year, thousands of lives are lost due to the unavailability of suitable organs, highlighting the urgent need for a more efficient and reliable donation system. Despite the noble intent and life-saving potential of organ transplantation, the global system remains deeply flawed and inefficient. Patients often face extensive waiting periods, sometimes stretching over months or even years, due to the limited availability of matching organs and delays in coordination among hospitals, registries, and transplant centers. Additionally, the lack of transparency in donor-recipient matching and allocation processes creates opportunities for unfair practices and misuse of authority. In many regions, centralized databases are prone to manipulation, data breaches, and administrative bottlenecks, further compounding the problem. This not only causes unnecessary delays and missed opportunities for saving lives but also erodes public confidence in the integrity and fairness of the organ donation system. As a result, many potential donors remain hesitant to register, and recipients lose hope in a system that should be built on trust, urgency, and ethical practices.

Introduction about the project

In response to these pressing challenges, blockchain technology emerges as a transformative solution capable of revolutionizing the organ donation and transplantation ecosystem. Blockchain is a decentralized, immutable, and transparent digital ledger that securely records transactions across a distributed network of computers. These core features make it ideally suited for handling sensitive and mission-critical medical data. By implementing a blockchain-based organ donation system, we can eliminate many of the inefficiencies and

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vulnerabilities that plague traditional systems. Donor and recipient information, medical reports, availability status, and transplant history can be securely stored on a blockchain, ensuring that all data is accurate, consistent, and protected from unauthorized access or alteration. The use of smart contracts—self-executing programs that run on the blockchain—can automate donor-recipient matching based on predefined medical criteria such as blood type, tissue compatibility, and urgency level. This removes the need for human intervention, reduces the risk of bias or manipulation, and ensures that organs are allocated fairly and efficiently. Furthermore, all actions and decisions recorded on the blockchain are fully traceable and auditable, which significantly increases transparency and accountability. Hospitals, regulatory authorities, and stakeholders can access real-time updates and verifiable records, creating a secure and trustworthy environment for all participants. In essence, blockchain can transform the organ donation process into a faster, more secure, and more ethical system—one that truly serves the best interests of both donors and recipients.

Existing System and its limitations

• Centralized Database Management: Organ donation systems currently operate through centralized databases that are typically maintained by government bodies, health ministries, or authorized transplant organizations. While these databases help in tracking donor and recipient information, they are often prone to inefficiencies. Centralized systems create a single point of failure, making them vulnerable to data breaches, server downtimes, and hacking attempts. Any compromise in the central system could result in loss of critical medical data or delay in decision-making during emergencies.

• Manual Donor and Recipient Registration: The registration process for donors and recipients is largely manual or semi-digital. Individuals must visit hospitals, health camps, or official portals to submit forms and medical records, which are later verified by staff. This manual process introduces delays, data entry errors, and limits accessibility, especially for people in rural or remote areas. Additionally, paper-based documentation increases the risk of data loss or duplication.

• Organ Matching via Hospital Networks: Donor-recipient matching is typically performed within individual hospitals or regional transplant registries based on predefined medical criteria like blood type, age, organ size, and urgency. However, these isolated systems may not communicate efficiently with national or international databases, resulting in sub-optimal matches. This often leads to situations where an organ that could have saved a life elsewhere remains unused or is allocated inefficiently.

• Approval and Allocation through Authorities: Once a potential match is found, the case must go through a centralized approval process conducted by regulatory authorities. This involves multiple steps, including verification of documentation, medical evaluations, and logistical planning. These bureaucratic layers can cause significant delays, which is critical when dealing with organs that have a very limited survival time outside the body.

• Limited Data Sharing Between Institutions: Hospitals and transplant centers do not always have seamless data integration or sharing mechanisms. In many cases, institutions work in silos, and the lack of real-time data exchange hinders fast and informed decisions. This fragmentation also prevents a unified view of nationwide organ availability, resulting in reduced efficiency and missed opportunities for life-saving matches.

• Paper-Based or Semi-Digital Record Keeping: Despite advancements in digital health tech- nologies, many hospitals still rely on paper-based systems or standalone software applications that are not integrated with central registries. This lack of synchronization means that important updates are delayed or missed entirely. It also increases the risk of forgery, tampering, or unauthorized alterations to records, especially in regions where regulatory enforcement is weak.

• Reliance on Human Intervention: From data entry and verification to approval and allocation, almost every stage of the current system depends heavily on human involvement. While human oversight is necessary, excessive manual processing leads to errors, inconsistencies, and potential manipulation. In critical cases, human error or corruption can result in misallocation of organs or bypassing of eligibility criteria.

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LITERATURE SURVEY

The integration of blockchain technology into organ donation systems is gaining significant attention due to its ability to improve transparency, security, and automation. Traditional organ donation methods suffer from issues such as fraud, lack of real-time data sharing, and manual intervention. To overcome these challenges, recent studies have proposed decentralized blockchain- based systems for organ donor-recipient management.

1. Blockchain-Based Organ Donation System (2024) – Nagendra Reddy et al. This paper presents a decentralized organ donation system developed using the Ethereum blockchain. It automates various stages such as donor and patient registration, transplant matching, and pledge verification through smart contracts. The system ensures tamper-proof data, reduces fraud, and improves real- time updates. However, it faces challenges like high computational costs and difficulty in integrating with legacy healthcare systems.

2. Secure Organ Chain (2024) – S. Shanmugam et al. This system integrates Ethereum Virtual Machine (EVM) smart contracts with Electronic Health Records (EHR) using Ganache for development. It focuses on improving transparency and secure record handling. The paper addresses donor-recipient coordination and aims to use machine learning in future implementations. Scalability and adoption by hospitals remain key barriers.

3. A Study of Private Donation System Based on Blockchain (2024) – Junho Jeong et al. This study proposes a private organ donation system using the Hyperledger Fabric framework, emphasizing privacy and accountability. It follows a three-step process: user registration, recipient verification, and matching. The framework ensures secure data encryption and traceability. However, it demands high technical expertise for deployment and faces limited adoption by non-profit organizations.

4. Blockchain-Based Management for Organ Donation and Transplantation (2022) – Diana Hawashin et al. This paper introduces a private Ethereum-based solution that implements six specific algorithms for donor management and transplantation. It highlights fair organ matching, security, and traceability. Despite its strengths, the paper notes latency and transaction cost issues, along with the technical burden for hospital integration.

Relevant recent paper's summary

Transparency and Security as Common Goals: All four papers highlight the importance of blockchain's immutable nature for secure and transparent data handling in the organ donation process.

Smart Contracts for Automation: Each paper utilizes smart contracts to automate donor-recipient matching and verification, reducing human intervention and potential bias.

Privacy Considerations: Especially in the third paper, privacy of donors and recipients is ensured using encrypted, permissioned blockchain frameworks like Hyperledger Fabric.

Challenges Identified: Across the board, challenges such as scalability, computational costs, and adoption hurdles (especially in developing regions) are consistently mentioned.

Conclusion about literature survey

The surveyed literature emphasizes the potential of blockchain to transform the organ donation landscape by addressing critical issues of transparency, trust, and efficiency. By utilizing smart contracts and decentralized ledgers, the proposed systems aim to automate and secure organ allocation processes, ultimately saving more lives. However, despite the promising results, real-world adoption is limited due to factors such as high implementation costs, technical complexity, and resistance from traditional medical institutions. Future research should focus on making these systems more scalable, user-friendly, and integrable with existing health infrastructures to bridge the gap between research and practical deployment.

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Problem Statement

Organ donation and transplantation rely heavily on manual processes and centralized databases, which are prone to cyber threats, unauthorized access, and data manipulation, increasing the risk of illegal activities and other big challenge in organ donation is the inefficiency in finding the right match between donors and recipients.

Objectives

1. Design a Blockchain-Based System:

Architecture: Define a permissioned blockchain network (e.g., Hyperledger Fabric or a private Ethereum consortium) linking transplant centers, hospitals, registries, and oversight bodies.

Data Model: Specify on-chain record structures for donor profiles, recipient profiles, organ availability logs, and audit trails.

Governance: Establish roles, endorsements, and consensus policies to ensure only authorized nodes validate transactions.

2. Streamline Donor–Recipient Matching:

Smart Contracts for Matching: Encode eligibility rules (blood type, tissue match score, urgency score, geographic constraints) into self-executing contracts that automatically rank and propose candidate recipients the moment an organ becomes available.

Real-Time Notifications: Integrate off-chain oracles and event listeners to push instant alerts to transplant teams and patients via secure channels (SMS/email apps) when a match is confirmed.

Inter-Registry Interoperability: Build APIs that let regional and national registries query the shared ledger, ensuring no viable match is overlooked due to geographic siloing.

3. Enhance Data Security:

Immutable Audit Trail: Every creation, update, or match-approval transaction is cryptographically hashed and time-stamped, preventing retrospective tampering.

Encryption and Access Controls: Store personally identifiable health information off-chain in encrypted databases, with only safe metadata (hash pointers, consent flags) on-chain. Implement attribute-based access control (ABAC) so that each stakeholder sees exactly what they're permitted to.

Resilience and Redundancy: Distribute ledger copies across multiple health institutions to eliminate single points of failure and ensure continuity even if one node is down or compromised.

4. Promote Trust and Transparency:

Patient and Public Portal: Expose a read-only dashboard (with de-identified, aggregated stats) showing waitlist lengths, average match times, and transplant outcomes, so donors and families can see impact metrics and system health.

Regulatory Oversight Module: Grant health authorities a privileged "view" channel to audit all transactions in real time, simplifying compliance checks and fraud detection.

Consent Management: Allow donors to set and update consent preferences (e.g., which organs, which recipient categories) via signed transactions, guaranteeing that no organ is used outside their wishes.

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System Architecture/Block Diagram

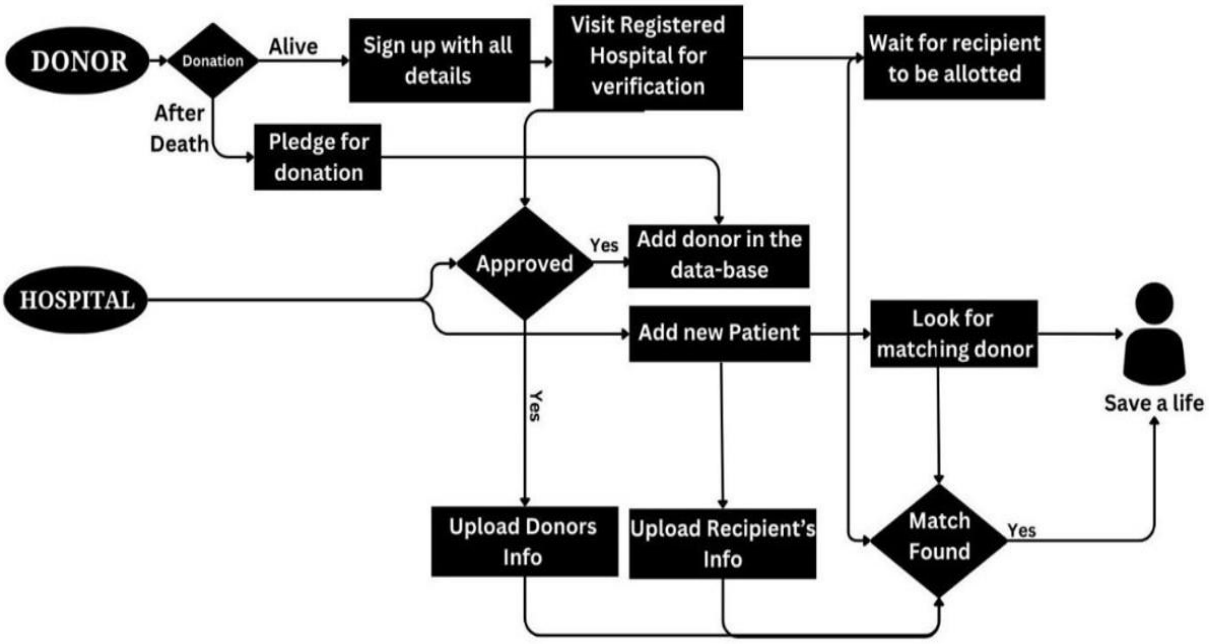

Figure 4.1: Block Diagram

Functional Requirements

1. User Registration and Authentication-Secure login for donors, recipients, and hospitals.

2. Donor-Recipient Matching-Smart contract-based matching of donors and recipients.

3. Blockchain Data Storage-Secure and tamper-proof storage of donor and recipient details.

4. Access Control and Permissions-Only authorized entities (hospitals, authorities) can access sensi- tive data.

Non-Functional Requirements

1. Security-Cryptographic techniques to prevent data breaches.

2. Scalability-System should handle increasing user registrations and transactions.

3. Reliability-Ensures 24/7 availability without data loss.

4. Performance- Fast blockchain transactions with minimal delay.

User Requirements

1. Donor Requirements Donors can register and provide organ donation details. They can update or withdraw consent anytime. Personal and medical data is secure and private. Donors get notified when matched.

2. Recipient Requirements Recipients can register with medical details. They can track their match status. Receive alerts when a match is found. Their data is kept confidential.

3. Hospital/Doctor Requirements Can verify donors and recipients. Can upload reports and approve matches. Must log transplant details on the blockchain.

4. Admin Requirements Can add hospitals to the network. Can manage rules for matching. Can monitor all transactions for security.

5. Public Viewer Requirements Can view general statistics and success stories. Cannot access any personal information.

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IMPLEMENTATION

Flowchart:

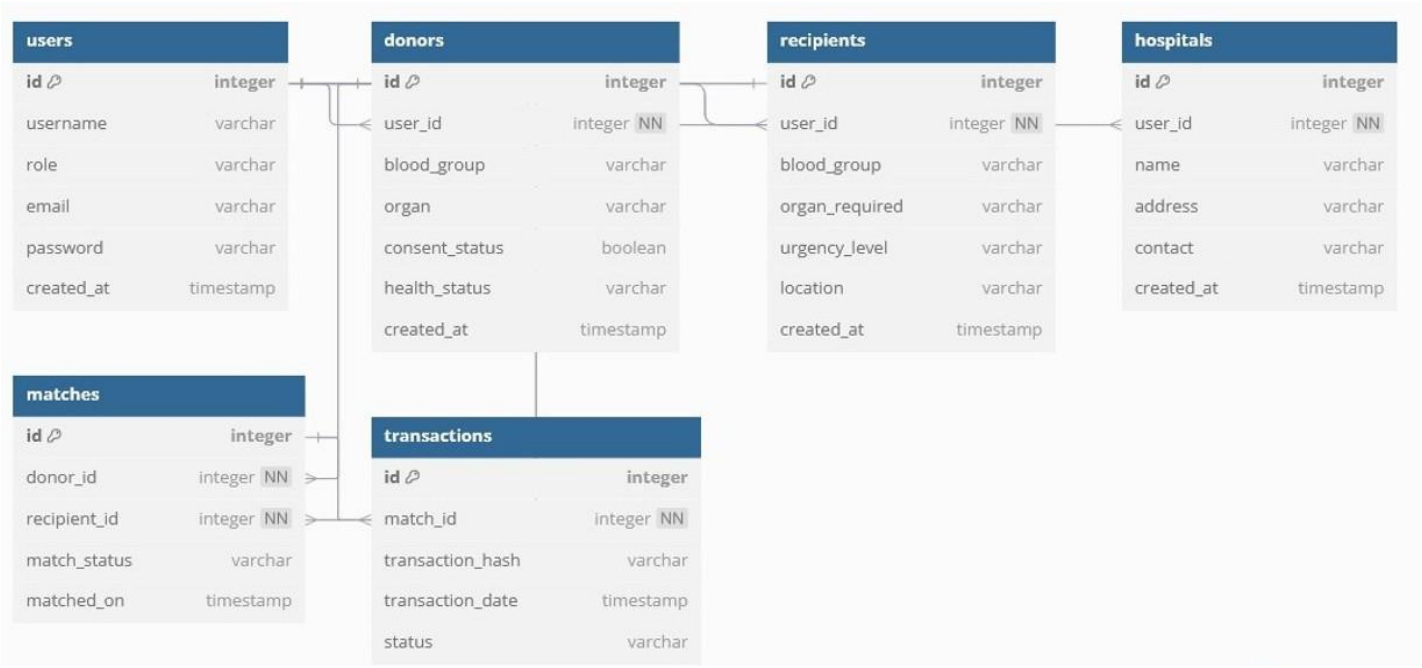

Figure 5.1: Schema Diagram

Packages used:

1. keccak256():

Used in: Step 4 – String Comparison

Purpose: Securely compares two strings (e.g., blood type, tissue type).

Details: Converts strings to hashed values before comparison.

2. abi.encodePacked() Used with: keccak256()

Purpose: Encodes multiple data types into a single bytes array before hashing.

Algorithms/Methods/Pseudocode

Algorithm 1

Organ Matching Algorithm (Pseudocode Style)

1. Donor Registration

Input: Blood Type, Tissue Type

Step 1: Collect input from the donor.

Step 2: Store the donor's data in the blockchain with status isAvailable =

2. Recipient Registration

Input: Blood Type, Tissue Type, Urgency Level Step 1: Collect input from the recipient.

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Step 2: Store the recipient's data in the blockchain.

3. Organ Matching Logic Input: recipientAddress

Step 1: Initialize matchedDonor as null and highestUrgency = 0. Step 2: For each donor in the system:

a. Check if:

Donor is isAvailable = true

Donor's blood type matches recipient's blood type Donor's tissue type matches recipient's tissue type

b. If yes:

Compare recipient's urgency level with highestUrgency

If higher, update:

highestUrgency = recipient's urgency level matchedDonor = current donor

Step 3: Return matchedDonor address

4. String Comparison Function

Use hash comparison (keccak256) to compare two strings securely.

RESULT AND SNAPSHOTS

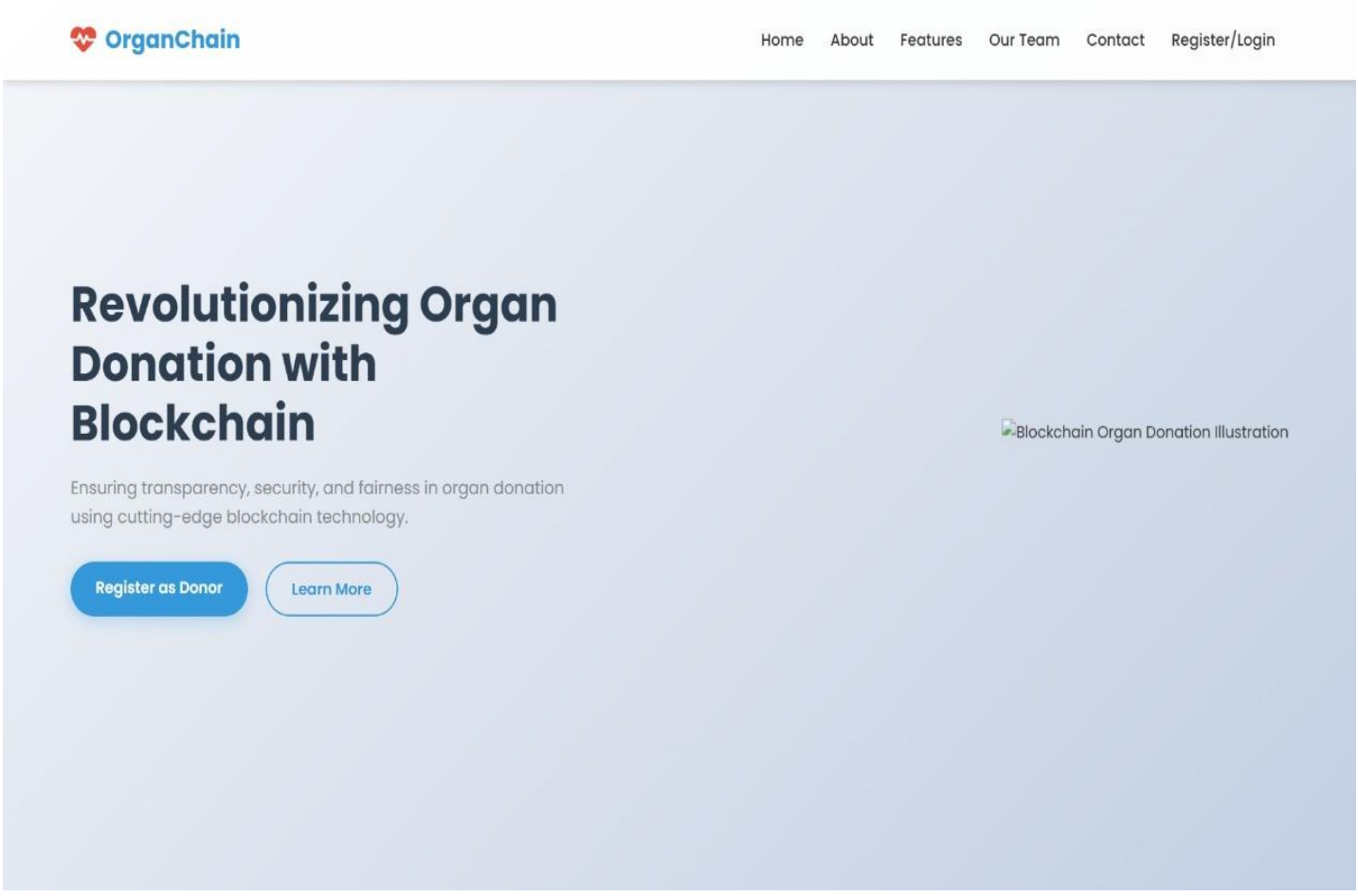

Figure 6.1: Homepage – Revolutionizing Organ Donation

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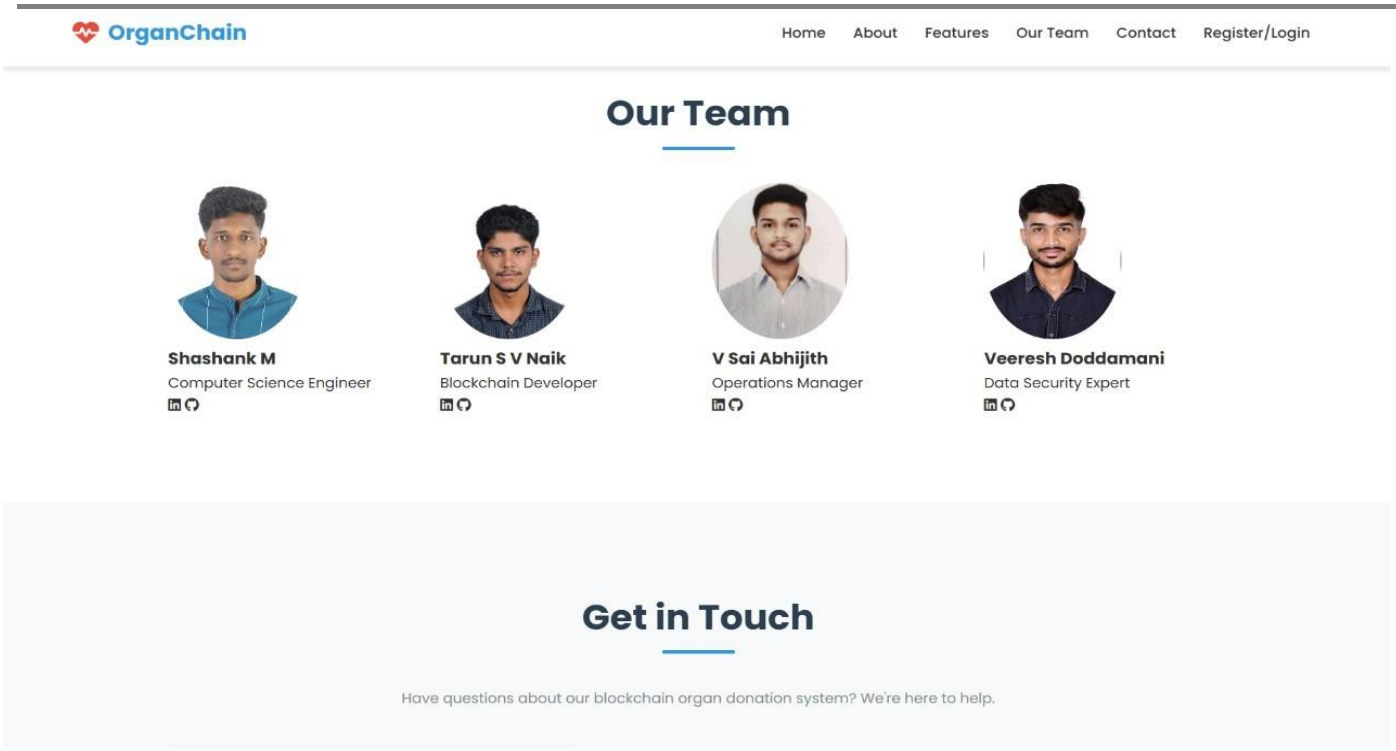

Figure 6.2: Team Page – Meet the Minds Behind OrganChain

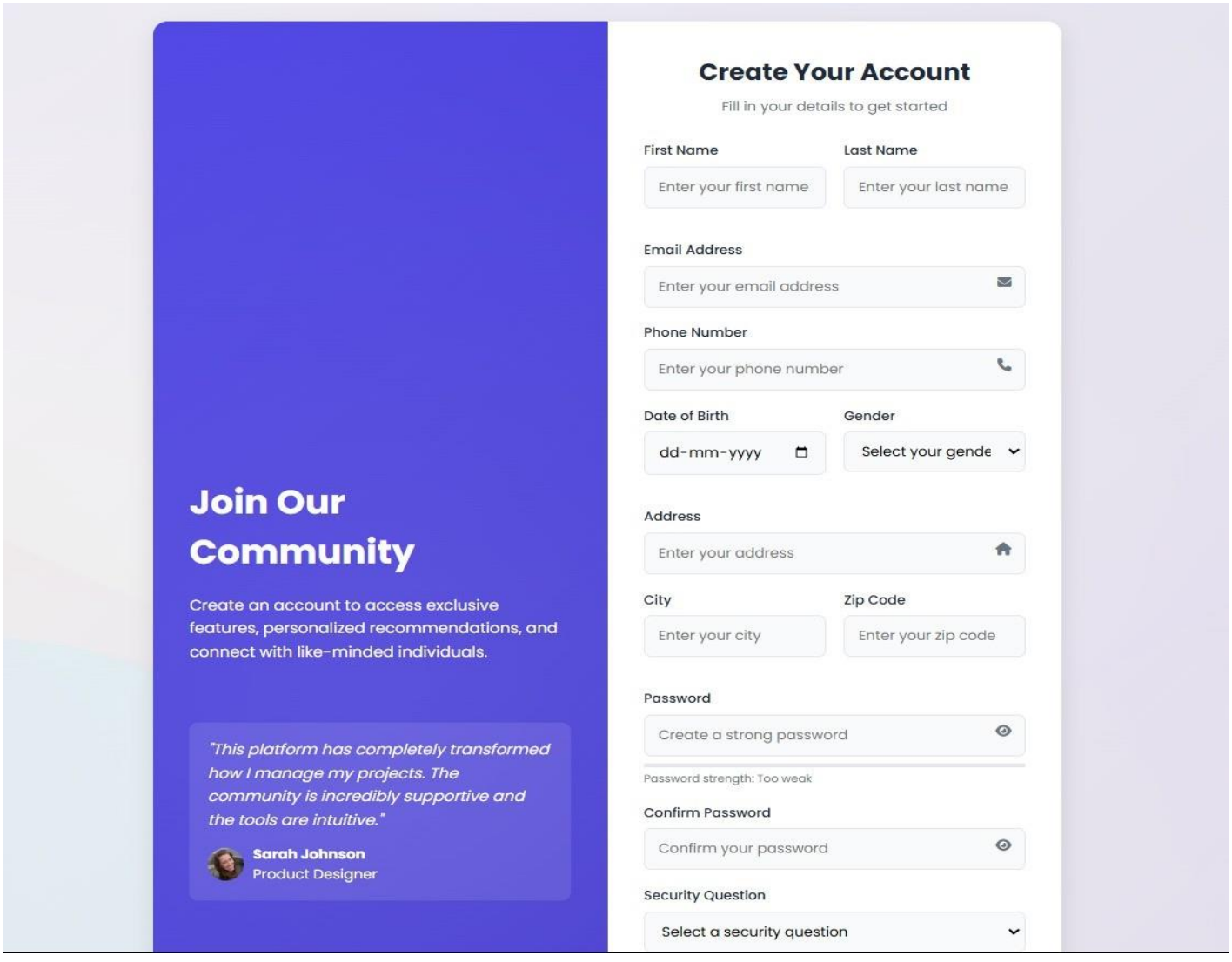

Figure 6.3: Registration Page – Join Our Community

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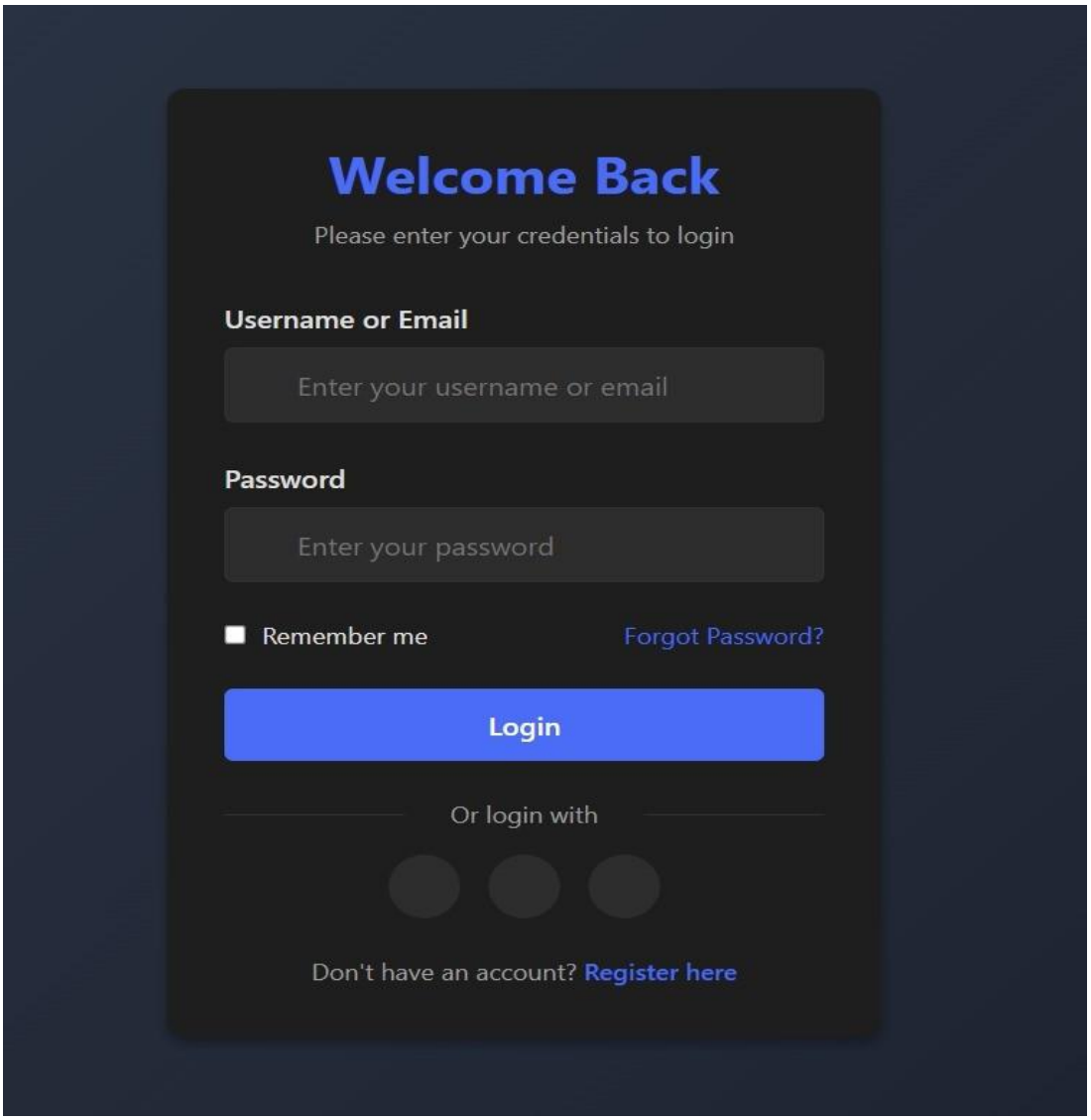

Figure 6.4: Login Page – Secure Access to Your Account

CONCLUSION

Conclusion

The Smart Blockchain-Based Organ Donation System offers a transformative solution to the long- standing challenges in organ donation and transplantation. Traditional systems often suffer from a lack of transparency, manual inefficiencies, data manipulation, and limited accessibility, all of which compromise the fairness and trust in the organ allocation process. By integrating blockchain technology, this project introduces a decentralized and tamper-proof framework that ensures the integrity of donor and recipient data, enhances transparency, and eliminates the risk of fraud or unauthorized access.

Through the use of smart contracts, the system automates the donor-recipient matching process based on medical compatibility and urgency, thereby reducing waiting times and improving the overall efficiency of organ distribution. The immutable nature of blockchain records increases accountability and trust among medical institutions, patients, and authorities. Moreover, real-time data tracking and secure sharing of information among verified stakeholders further strengthen the reliability of the system.

While the current implementation addresses core issues like data security, trust, and automation, it also sets a strong foundation for future integration with advanced technologies such as artificial intelligence and Internet of Things (IoT). Overall, this system paves the way for a transparent, secure, and ethically sound organ donation process that can significantly improve healthcare outcomes, restore public confidence, and ultimately

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save more lives. With continued research and cross-sector collaboration, this blockchain-based framework has the potential to become a global standard in organ transplantation systems.

Future Enhancements

• Hybrid Blockchain Models:Combining permissioned and public blockchains can provide an optimal balance between security, cost, and data accessibility. Research should focus on creating interoperability frameworks that connect different blockchain networks and healthcare databases.

• AI-Driven Blockchain Solutions: AI-enhanced blockchain platforms can improve predictive analytics, optimize donor-recipient matching, and ensure ethical allocation. Further exploration of federated learning models in AI-driven matching algorithms can enhance privacy and data security.

• Regulatory and Policy Development: Governments must collaborate with healthcare and technology experts to draft policies for blockchain-based organ donation sys tems, ensuring legal compliance and ethical use. Future studies should assess the impact of different legal frame works and recommend international regulatory guide lines.

Certificate

Certified that the Project work entitled Smart Blockchain-Based Organ Donation System for Secure Donor-Recipient Matching has been successfully carried out at RNSIT by Shashank.M bearing 1RN22CS149, Tarun S V Naik bearing 1RN22CS168, V.Sai Abhijith bearing 1RN22CS173, and Veeresh C Doddamani bearing 1RN22CS179 bonafide students of RNS Institute of Technology in partial fulfillment of the requirements of final year degree in Bachelor of Engineering in Computer Science and Engineering of Visvesvaraya Technological University, Belagavi during academic year 2024-2025. The Project report has been approved as it satisfies the academic requirements in respect of project work for the said degree.

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