# HemoChain: Blockchain Enabled Blood Donation

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***Abstract*—Donating blood is a voluntary medical procedure where the blood of a healthy individual is used by someone who needs blood. Blood is needed when a person gets extreme physical injuries, surgeries, diseases, or any medical conditions causing heavy blood loss. Blood donation is crucial at the time of such medical emergencies, and the unavailability of blood during this time can lead to the death of the patient. Thus, blood units must be timely accessible and its information should be transparent. This paper addresses the transparency challenges of hematological information and the timely delivery of blood by leveraging blockchain technology into the donation process. Tokenization of the blood units using the Decentralized Ledger Technology (DLT) like blockchain will make the system more transparent and efficient, enabling timely delivery of blood to the receiver (beneficiary). The current blockchain based blood donation solutions focus only upon information management of blood by making data transparent and secure. However, this paper proposes a system called HemoChain to simplify the blood supply chain and reduce blood supply time. This is achieved by eliminating the middlemen needed to find blood units and establishing direct communication channel between the donor, receiver and doctor.**

***Index Terms*—Blood donation, Tokenization, Decentralized ledger technology, Blockchain**

## I. Introduction

Blood donation is a medical procedure conducted by healthcare institutions such as blood banks, hospitals, non-profit organizations etc. Blood donation is done on a voluntary basis, where a healthy person donates their blood with the intention to help a needy patient. Blood is generally donated to those patients who recently suffered from sudden loss of blood caused due to reasons such as major surgeries, accidents or any other injurious emergency. Thus, blood donation holds a lot of importance because it helps to save lives. Timely delivery of blood units plays a crucial role when we look into its supply chain. A delay in accessing the blood units increases the patient's risk. Hence the blood donation supply chain must be simple, quick and efficient. A patient should easily be able to access the most compatible blood as fast as possible. They must also be able to obtain complete knowledge about the donor's haematological information. In summary, the blood donation system must be more transparent, inclusive and efficient. The system should be independent of middlemen and instead establish a direct communication pathway between the donor, receiver and the doctor. Decentralized ledger technology (DLT) specializes in achieving such goals. One of the DLT is called as blockchain. It uses a digital agreement called as smart contract which is written in a code having pre-defined conditions in it. It gets automatically executed whenever those conditions are met. Smart contracts are a great substitution for manual contracts as they are immutable, secure and do not need any intermediaries. They can be used for any activity that involves any kind of exchange between entities. Eg: Information exchange, trade and even establishing rules for a game. The contributions of this paper are as follows:

1) Decentralize the blood donation system and bring transparency to the information of blood inventory and donor data.
2) Eliminate the middleman needed to find compatible blood and establish a direct communication pathway between the receiver, doctor, and donor.
3) Leverage smart contracts to authenticate and automate the process of donor eligibility verification, donor registration, blood bag registration, blood consumption status monitoring, compatibility mapping, and certificate creation in the blood donation system.
4) Immediately notify the receiver and doctor when a compatible donor-receiver match is found.

The paper is further structured as follows: Section II explains some basic concepts of blockchain used in our proposed model called HemoChain. Section III gives the literature overview for the same subject matter. Section IV elaborates the problem at hand. Section V describes all the entities involved in HemoChain. Section VI and VII give a detailed explanation of HemoChain. Section VIII concludes the paper.

## II. Background and Terminology

### A. Blockchain

A distributed ledger technology that records any exchange of data, product or service etc. as transactions. These transactions are stored in the form of blocks in a network of computers called nodes. The blocks are connected together through cryptographic hash where the hash of the current block becomes the previous hash of the next block thus, forming a chain of blocks. Each block is divided into two parts namely block header and block body. The block header contains information of the block which includes nonce, hash, previous hash, timestamp, block height, etc. Whereas, the block body contains the set of transactions.

### B. Full Node

A computer on the blockchain network that hosts and manages a copy of the entire blockchain. This process involves checking the validity of transactions, ensuring they comply with the network's consensus rules, and verifying that the sender has the necessary funds to complete the transaction. Full Nodes ensure that the blockchain network continues to function even in the event of possible assaults or failures by adding to its decentralization, security, and resilience.

### C. Light Node

A Light Node only stores only its own data and does not retain the complete blockchain unlike full node. It depends on other full nodes to give the necessary data when needed. It is also referred to as a Lightweight Node or an SPV (Simplified Payment Verification) Node. This greatly lowers the node storage and processing needs. By requesting necessary information from full nodes, a Light Node can nevertheless verify transactions and blocks even when it does not store the complete blockchain.

## III. Literature Review

There is a need to automate the system for an efficient blood inventory management and simplify the operations within the supply chain of blood donation system. In [1], authors proposed a blood donation system hosted on a blockchain. It is named as BloodChain and it uses Hyperledger Fabric. This system maintains the hematological information of the donor and receiver to ensure the blood quality for receivers. However, scalability issues still remain. In [2], authors presented a blockchain-based blood donation management. It uses private ethereum blockchain network and Inter Planetary File System (IPFS) for decentralized storage of data. Authors focused on data security with the help of private blockchain. This paper's main focus is on data security. The drawback of this approach is that the system still remains centralized due to the usage of private blockchain. In [3], authors presented the blood bank management system by using Database Management System (MYSQL) and JDBC to manage the blood bag inventory. The objective is to get accurate and real-time information of blood inventory. In [4], the proposed framework is a Smart Platform for Data Blood Bank Management, which is about forecasting blood demand using the Autoregressive Moving Average (ARMA), AutoRegressive Integrated Moving Average (ARIMA), and AutoReg model. This would help in effective decision- making of blood supply management. In [5], authors have implemented a management platform for blood supply. The platform uses techniques like Long Short-Term Memory (LSTM) for demand forecasting, k-means clustering for campaign location suggestions, Geographic Information Systems (GIS) for visualization, and blockchain for securing the supply chain data. Results show improvement in supply-demand balance. In [6], authors are presenting a Blood Donation Security System using ethereum blockchain and IPFS. They ensure decentralization and secure data storage. The solution is generic and can be adapted for other industries with minimal changes. In [7], The authors propose a comprehensive system for managing blood resources using blockchain, smart contracts, and non-fungible tokens (NFTs). It includes features such as a supply chain oversight mechanism, digital certification for blood donors using NFTs, and execution via smart contracts. The proposed system is designed to be compatible with various blockchain platforms, offering a sustainable solution for blood donation ecosystems. In [8], the paper proposes a blockchain-based solution for blood donation and transfusion management, aiming to address issues like blood traceability and quality control. By using hyperledger fabric, the system ensures data accuracy and immutability, enhancing trust in the blood donation process, only legitimate blood data can be stored in the blockchain, minimizing the risk of transfusion-related diseases. The system's performance has been tested using real-time blood data from a blood bank, showcasing its potential for improving blood management systems. In [9], the authors suggest using blockchain technology to manage and distribute blood and blood components more effectively. The study emphasizes the value of blood in medical care as well as the difficulties in managing and distributing it, particularly in developing nations like Vietnam. The authors also describe implementing a proof-of-concept based on the hyperledger fabric platform. In [10], The authors are putting up a Blockchain-based Trust-based Blood Donation and Transfusion System (BDTMS). They draw attention to the present problems with blood management, such as the dangers associated with transfusion-related illnesses, the inability to track blood components, and a lack of quality control. By utilizing blockchain technology, especially hyperledger fabric, the suggested system seeks to address these issues by establishing a safe and transparent system for transfusion and blood donor management.

Overall, these research papers highlight the current challenges to manage data in the blood donation system and provide different kinds of solutions for the same.

The current state of the art solutions majorly focuses on information management challenges of the blood donation system. The solutions have improved the data transparency and security by storing it on blockchain, but the complexity of the blood donation supply chain still remains high. This paper introduces a novel approach called HemoChain to not only manage the data but also simplify the operations within the blood donation supply chain. HemoChain establishes a direct communication channel between the donor, receiver and doctor. It eliminates the intermediaries and makes the information more transparent. By establishing a decentralized database of blood inventory, HemoChain ensures transparency and prevents data manipulation. HemoChain also automates the process of assessing medical documents using smart contracts. This will assist the qualified doctors for mapping the medical data, thereby reducing the time taken to find the best donor-receiver pair.

## IV. PROBLEM STATEMENT

The current blood donation system has multiple supply chain challenges primarily due to the centralized nature of the system. These challenges are:

1) Lack of information transparency for the beneficiary.
2) Need of middlemen to search compatible blood units.

These issues increase the time gap between finding the most compatible blood and its actual transmission into the receiver's body.

Consider Fig: 1 a scenario of a centralized blood donation system. Alice (beneficiary) urgently needs blood. His family goes to the hospital's reception to know about the availability of compatible blood bags. Though the hospital has sufficient blood bags, the receptionist takes advantage of the urgency level and says that the inventory does not have the required blood. The receptionist advices that by paying extra money the blood bags can be arranged. The desperate and helpless family ends up paying extra money to save Alice. Such unethical ways of generating extra profits exist because of the centralized nature of the blood donation system and lack of information transparency.

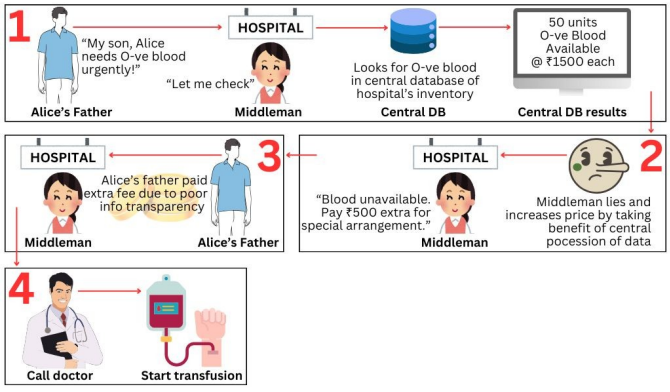


Fig. 1. Centralized Blood Donation System

## V. ENTITIES

This section explains the role of various entities involved in Hemo-Chain.

*1) Donor:* The donor voluntarily donates their blood in any near-by blood bank. The donor details are verified and medically approved by a qualified doctor before they donate blood.

*2) Receiver:* The receiver (beneficiary) gets the donated blood as per their need. The receiver's blood type should be compatible with the blood donated by the donor.

*3) Doctor:* The doctor medically examines the donor to determine the eligibility before donation. They guide and support the patients throughout the process, and ensure compatibility between donor and receiver before the blood transfusion.

*4) Blood Bank:* The blood bank/hospital will provide the necessary infrastructure, staff for the process of blood donation.

## VI. PROPOSED MODEL

A decentralized blood donation system will solve the information transparency issues that exist in the centralized system Fig: 2. If the information about blood availability is made public and the blood donation system becomes decentralized, the overall time taken from searching the blood till its transfusion gets reduced significantly. Thus, with the use of blockchain technology, the system brings transparency by eliminating middlemen and building a direct communication pathway between the donor and the receiver. Our proposed model is called as HemoChain Fig: 3 which is based on Ethereum blockchain network. It allows tokenization of blood units and development of smart contracts written in Solidity language. The donor and the receiver only need to store their own data, not the complete blockchain. Thus, they both are the light nodes. This increases storage efficiency. The blood bank and the doctor are the full nodes and have complete blockchain data. A Metamask wallet account is required by all the entities to perform transactions and store them on HemoChain.

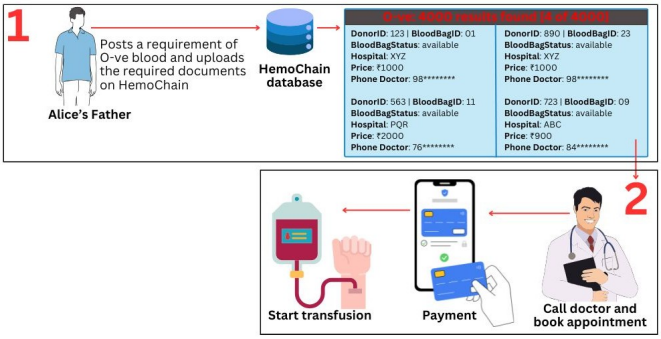


Fig. 2. Decentralized Blood Donation System

## VII. METHODOLOGY

This section explains the HemoChain framework as shown in Fig: 3 and functionality of each smart contract as shown in Table: I.

Scenario: To explain the working of the HemoChain framework, we considered one donor, one receiver, one doctor and one blood bank. Step 1: Anyone who wants to donate blood will register themselves on HemoChain. A new donor is defined as a potential donor. A donorID is created and stored on the HemoChain ledger using smart contract 1 (DonorRegistration). The potential donor gives their blood sample and an eligibility test using smart contract 2 (DonorEligibility). This helps to determine if they are eligible to donate blood or not as per the medical standards encoded in that contract. A qualified doctor's final approval is still mandatory even if the potential donor passes the test. The smart contract based test is intended to only assist the doctor and improve procedural efficiency by automation. However, the potential donor has to give a physical exam too after the smart contract based test. If any potential donor fails any test or does not get doctor's final approval, their donation process terminates

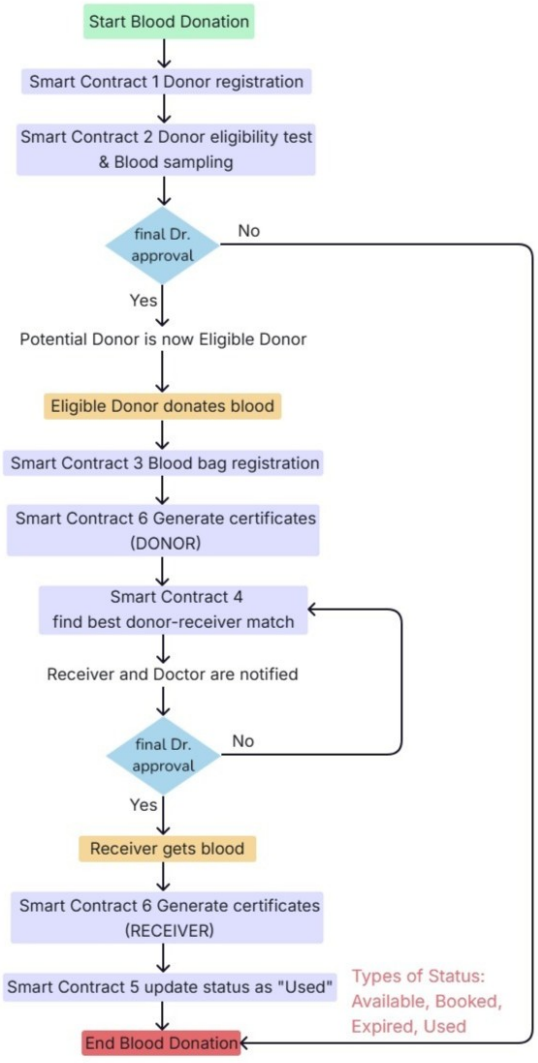


Fig. 3. HemoChain Methodology

immediately. However, if the potential donor passes all the test and gets final approval from the doctor, they become eligible to donate blood and are now referred to as an eligible donor. Step 2: Once the potential donor is eligible, the actual blood donation is conducted. Generally, it happens at a blood bank and takes 15-25 minutes. After successful donation, a new BloodBagID is generated and the donor receives a donation certificate using smart contract 6 (CertificateGeneration). Step 3: The generation of new BloodBagID and its mapping with the respective DonorID is done using smart contract 3 (BloodBagRegistration). Here the donation process for an eligible donor is completed.

Step 4: At this point, the ledger consists of the complete information of the blood bag and its donor. Now by using smart contract 4 (CompatibilityMatrix), the best donor-receiver match is searched from the ledger's database. The aim of this contract is to find compatible blood units for the receiver without the need of any intermediary. Smart contract 5 (BloodStatus) is used to look at the Consumption Status of each blood bag. Status gets allotted as "Available", "Booked", "Expired" or "Used". The default status is set as "Available". Step 5: Once the donor-receiver match is found, the receiver and the doctor are immediately informed. The doctor must approve that match before the transfusion takes place. If the doctor approves the match, the Consumption Status is updated to "booked". However, if doctor does not approve the match, a new compatible donor is searched until all the conditions meet. Step 6: Once the transfusion is done, the receiver gets their beneficiary certificate using smart contract 6 (CertificateGeneration). For the donor's certificate, the user-type is 0 and for the receiver's (beneficiary) certificate, the user-type is 1. Here the donation process for the receiver is completed.

A summary of all the smart contracts used in HemoChain is given in Table: I. Smart contract 1 is called as DonorRegistration. It registers all the new donors on the HemoChain ledger and creates a unique DonorID. Smart contract 2 is known as DonorEligibility. This contract assists the doctor to determine if the donor is fit to donate blood or not. It takes parameters like Gender, Age, Weight, Height etc. Smart contract 3 is called as BloodBagRegistration. It is used right after a qualified donor donates blood in a blood bank. Just like the registration of donor, the blood bag also gets registered on HemoChain's ledger. DonorID and BloodBagID are mapped to each other. Smart contract 4 is CompatibilityMatrix. It takes input of receiver's blood and donor's blood to find their medical compatibility. This contract is also used to assist the doctor in finding the best match. How Smart contract 5 is known as BloodStatus is used to track the consumption status of each blood bag. The status varies from 'Used', 'Expired', 'Available' or 'Booked'. This makes blood inventory data transparent and easy to comprehend. Smart contract 6 is named as CertificateGeneration. The donation certificate is generated once the blood is donated and a beneficiary certificate is generated once the blood is transfused into the receiver's body. the last smart contract used in the decentralized blood donation process of HemoChain. It is called as CertificateGeneration and as the name suggests, it automatically produces a donation certificate for the donor right after the blood is donated to the blood bank and a beneficiary certificate for the receiver when the blood is transfused in their body.

## VIII. Conclusion

In conclusion, our paper presents a blockchain-enabled blood donation system called HemoChain which allows tokenization of blood units. The system reduces time between finding the most compatible blood and its transfusion by establishing direct communication between donors and receivers. HemoChain automates many administrative and basic medical tasks with the use of smart contracts. These tasks include eligibility verification, blood bag registration, donor registration, blood status monitoring, medical report mapping,

TABLE I
SMART CONTRACTS AND THEIR FUNCTIONS

| S.No | Contract Name | Function Description |
|---|---|---|
| 1 | DonorRegistration | Creates and stores Donor ID. |
| 2 | DonorEligibility | Determines if a potential donor can donate or not. |
| 3 | BloodBagRegistration | Links Donor ID with BloodBag ID. |
| 4 | CompatibilityMatrix | Finds if recipient and donor's blood group match or not. |
| 5 | BloodStatus | Shows the consumption status of a blood bag. Status varies from 'Used', 'Expired', 'Available', and 'Booked'. |
| 6 | CertificateGeneration | Generates donation and beneficiary certificates. |

and certificate creation. Our approach contributes to the existing literature on blockchain-based blood donation systems by focusing on the direct mapping of donors and recipients within the donation and transfusion system. By increasing transparency and traceability, HemoChain intends to improvise overall patient care and their medical outcomes, ensuring a safe and sufficient blood supply. With these features, HemoChain demonstrates how blockchain technology has the ability to completely transform the blood donation process. The proposed method removes middlemen dependency and promotes inclusion of donors, receivers, doctors and blood banks. HemoChain demonstrates how blockchain technology may transform healthcare practices by setting a new standard for blood donation systems with its creative approach.

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