A Synopsis on

A Compehensive Blockchain Based Web Framework for Blood Banks

Submitted in partial fulfillment of the requirements
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in

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by

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CERTIFICATE

This is to certify that the project Synopsis entitled ***"A Compehensive Blockchain Based Web Framework for Blood Banks"*** Submitted by ***"Chinmay Dharap (18104062), Prajwal Sonar (18104019), Tejas Jadhav (18104030)"*** for the partial fulfillment of the requirement for award of a degree ***Bachelor of Engineering*** in ***Information Technology*** to the University of Mumbai,is a bonafide work carried out during academic year 2019-2020

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Abstract

Our project intends at enhancing the current Blood supply chain management system. We urge an innovative blood collection chain system based on blockchain technology using a distributed ledger structure and transaction execution process of the situation where the collected blood arrives at the final stage - hospitals. Existing centralized blood management systems have various disadvantages including lack of data on blood bags, incapacity to reflect real-time updates in details, and the trust factor. In this regard, blockchain offers the opportunity to maintain a transparent blood bank management system, particularly since data cannot be falsified and tampered with. In addition, the system stores blood contracts within hospitals in the event of emergencies through the transaction and consensus flows. This proposal is to allow hospitals that are far from the blood banks to accrue blood supply in emergencies. Since blood has a certain storage period, it is expected that it will be possible to fulfill the demand for blood bags by supplying and using the bags that are nearing their expiration. Not only does it solve the prime purpose that is it helps to save lives, but it will also act as a waste management strategy for Blood by using near expiration bags first.

Introduction

As a daily consumer ourselves, many a time we find ourselves in the wonderment, trying to figure out the entire lifecycle of a product when we purchase it. Right from its creation (manufacturing) process, until it is in our shopping cart. Every product that we purchase, is in turn connected to a chain of other products that are used as a basic set of ingredients in order to build the product we just purchased. Thus, emphasizing the fact that this intricate network of chain hierarchy is the basic building block for a product to be built and this is what we call Supply Chain. In order to ensure that the quality of the end product is up to the required mark, it depends on every single entity in the entire supply chain to be in place, in a timely manner whilst possessing good quality. It thus goes on to depict that proper management is required to handle the entire process, which is termed as Supply Chain Management (SCM). In our project, using the Blockchain (BC) implementation, we aim at providing rather simplified yet quality-assured support for maintaining and monitoring the data from the collection of the blood from various different sources and tracking the physical conditions of those blood bags as well.

Objectives

Blockchain is a distributed and replicated data structure that is shared among the members of a network. Multiple nodes connect to a blockchain and make up the network. So all the data which we are going to store on the blockchain will be distributed among all the nodes in the network So the data becomes completely tamper-proof. Each member has a copy of the same blockchain, providing traceability that is transparent and trusted.

Using blokchain we will be able to achieve the following objectives:

- **To ascertain the quality of blood & details including expiry of blood from any node of the chain.**

    1. Tracing of the entire life cycle of blood donations, every unit of blood, is possible using Blockchain.
    2. The lifecycle of a blood bag is prepared by deriving physical and digital data from the life cycle of a patient's data collection, blood analysis, and collection reports, etc. The bag can be given a unique QR code for identification. Once the data are validated by Smart Contracts, they are entered into Blockchain.
    3. Thereafter, the system becomes full-proof. This way, data integrity, and data immutability are highly ensured across the blood value chain.

- **To verify the donor history from each node in the blockchain.**

    1. In India, 90% of blood donations are carried out in camps set up by various organizations. While all the donated blood goes through the testing phase and safe blood is separated, sometimes unsafe blood can also penetrate this test and reach the patients infecting them. Though this problem may go unnoticed the consequences are fatal.
    2. The biggest challenges are setting up a blood repository is donor authentication, identification, and more importantly, donor filtration based on past eligibility records. This makes it important to have a centralized platform for blood donors.
    3. So anyone can verify the donor by checking the donor's medical history. The donor details could also be verified by the collection centers to ensure unsafe donors are excluded. The blood bank or the organizer can see the medical history as well as the donation history of a particular donor. That's possible because of the Blockchain's unique identity given to that donor that is a hundred-percent tamper-proof.

- **To check the Availability of blood concerning blood banks.**

    1. Another challenge in blood cycle management is the gap in demand and supply. On the one hand, 30% of the patients don't get the components that they need, and on the other hand, 10-12% of the components get wasted due to expiry.
    2. Most blood donation drives are occasion-driven or time-driven with less co-relation with the actual demand at that time. The need is to get all the stakeholders of the blood ecosystem on a single platform and align the drives with the actual regional requirements.
    3. Because of the one platform, we can bring all the entities together in the blood ecosystem so that the availability of blood will be known to each entity particularly to the hospitals. So according to the availability blood donation drives can be organized.

Literature Review

Blood bank systems should be reliable and trustable and that is where blockchain plays a huge role[1]. As blockchain can provide the ability to remain unchanged to transactions, it helps in maintaining transparency and keeping these transactions decentralized. This serves to be of great importance as far as blood bank systems are concerned since tampering with these transactions is not possible.[1] Blood bank systems currently face a major issue handling the data related to blood bags, donors, receivers, etc which can be solved using blockchain as it provides a list of blocks on which this data can be stored and fetched easily. [1] Blockchain offers important traits like decentralization, persistency, anonymity, and audibility that lowers the cost and boost the efficiency of the system.[1]

Many other blockchain-based supply chain management papers include the one proposed by Patrick Sylim et al. [2]. This paper focuses on solving one of the major problems faced by the existing supply chain management in the medical field i.e. drug counterfeiting, using Blockchain to track the supply chain of medicines using Ethereum and proof-of-stake algorithm for consensus. In the field of medicine, blockchain contributes to increased safety and reduced costs which is ensured by identifying changes in ownership of drugs between different participants of the chain such as manufacturers, distributors, packers, and end-users.

In another paper, Feng Tian proposed the use of RFID which allows the users to scan the product and validate its supply chain history, along with BlockChain to track the agri-food Supply Chain [3]. Tian supported the idea that a decentralized approach for tracking products could solve the issues in a centralized approach, such as trust, tampering, etc.

Research on the blood cold chain system has been conducted by several approaches. Davis et al. proposed an RFID-based system that dynamically manages the information related to blood [4]. Quite a few problems faced by the currently existing system for blood information management were pointed out in [4]. For example, the amount of information that can be contained in the bar code is limited, and the information is not reflected in the blood source in real-time, trusting the particular actors on updating legit information on the system, etc. Jabbarzadeh et al. proposed a robust network design model for the blood supply chain in the event of a disaster [5]. They took into consideration a set of decision parameters such as the number of blood centers nearby etc to manage blood allocation, blood collection, and other such critical decisions during a disaster.

In today's era of a globalized supply chain of goods and services, the supply chain has now involved various actors and entities from different parts of the globe who have never seen each other and may not trust the genuineness of either one or multiple parties/actors. With such complex issues in hand, the main concerns are the lack of transparency and traceability[7]. The lack of traceability and transparency leads to Incidents where parties are affected and consumption of particular goods or services is reduced. This motivates us for developing transparent and traceable supply chains[7].

This is where Blockchain technologies can help us create more efficient and effective supply chains with the above concerns minimized or even completely diminished in some cases. Blockchain Technology has been accepted and adopted in past years throughout the technological globe. A blockchain is a form of database storage that is non-centralized, reliable, and difficult to use for fraudulent purposes[8]. It stores the data across the network which makes

the occurrence of malpractices difficult.

A review [6] identified the use of Blockchain technologies in sectors other than cryptocurrency. These areas include data storage management, identity management, rating systems, data, and goods trading, along with a few cases of IoT Devices. Implementations of blockchain-based traceability solutions have been done in sectors such as cobalt mining to produce lithium-ion batteries, where suppliers are required to abide by legal and responsible sourcing practices [7]. The food sector discusses Tuna fish traceability to ensure authorized fishing compliance and proper cold chain management. [7]

According to [8] the Blockchain has 4 elements that are replicated that is the ledger, cryptography, consensus, and business logic. There are various Blockchain applications like Bitcoin, Ripple, etc being financial applications and Ethereum, Hyperledger, etc being non-financial applications. In our Blockchain-based blood supply chain management system, we have used Ethereum. Ethereum is explained as [8] a Next-Generation Smart Contract and Decentralized Application Platform that was created by a cryptocurrency researcher and programmer named Vitalik Buterin. It uses a Blockchain-based distributed computing platform with a Turing complete scripting language that enables the processing of smart contracts on Blockchain. The use of a Private Ethereum network can also be done for efficiently integrating Blockchain technologies with other technologies like IoT Devices, for achieving various functionalities and applications[6].

Blockchain is now used in the healthcare industry[8] to protect patient privacy, procure untampered history, and complete transactions using cryptocurrency. Using this technology, patient health records can not be lost or tampered with. It cannot be used for malpractices and record thefts. The same concept can be applied and visualized in a Blockchain-based blood supply chain management system. Payments can be done using a virtual wallet based on Ethereum cryptocurrency.

An Effective Supply chain[7] requires multiple verified documents from all the parties and actors involved. This genuine verification and storage can be achieved with Blockchain technologies. In the case of the Blood Bank Supply chain, verified donor history and its documents are crucial for building a trustable and genuine platform for all users seeking to procure, donate or manage blood independently or from blood banks.

Problem Definition

In India, 90the donated blood goes through the testing phase and safe blood is separated, sometimes unsafe blood can also penetrate this test and reach the patients infecting them. Though this problem may go unnoticed but the consequences are fatal. The biggest challenges are setting up a blood repository is donor authentication, identification, and more importantly, donor filtration based on past eligibility records. This makes it important to have a centralized platform for blood donors. National AIDS Control Organization (NACO) recently reported that 2,234 patients got infected with HIV cause of bad blood transfusion in the last 16 months. The figure stands at more than 14000 infections in the last 7 years. In spite of the latest testing methodologies leading to lesser window period of these fatal diseases, the problems are still increasing. One of the key reasons has been the absence of centralized blood donor registry and unique donor identification program. With no centralized blood donor registry in place,

blood donors found reactive during their previous donation at a particular blood bank again end up donating at multiple blood donation camps. Also a lot of under quarantine donors end up donating again Another challenge in blood cycle management is the gap in demand and supply. On the one hand 30% of the patients don't get the components which they are in need of, and on the other hand 10-12% of the components get wasted due to expiry. Existing blood management systems in India function as Information Management systems that lack dynamic updates of blood usage and detailed blood trail information, starting from donation to consumption.

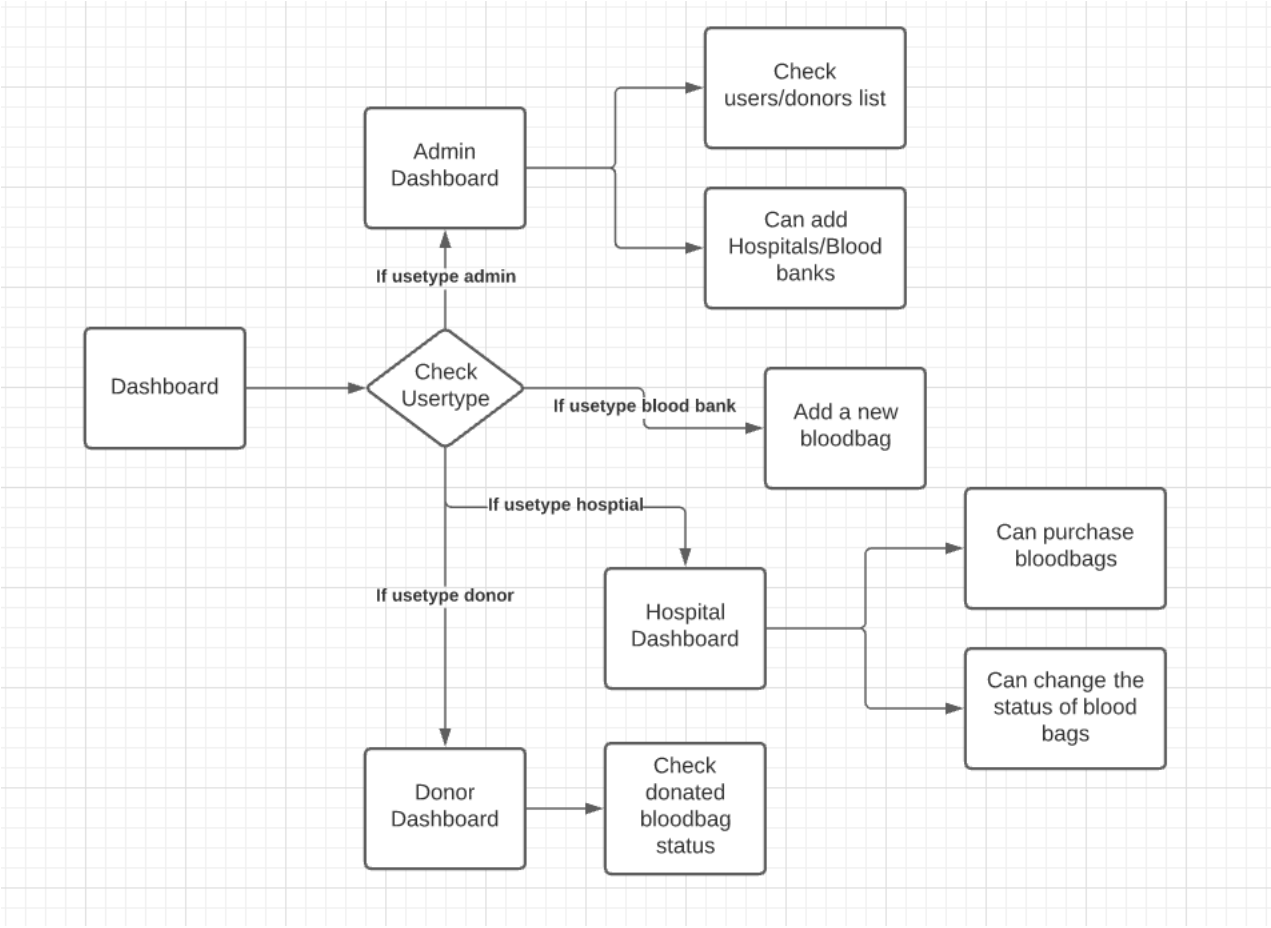
Proposed System Architecture/Working

In order to maintain transparency in the entire system/network, our solution proposes the use of Blockchain. That is, integrating BC in the SCM network where each and every entity can be tracked as per their movement.

- The inclusion of Blockchain solves the disadvantage of 'distrust'. By providing total transparency to its users, the entities involved in the network that are not be acquainted with one another and may become a potential cause for dissension during the phase of payment transactions. Our system resolves this problem, with the help of Smart Contracts, a feature of BC, that helps take control of the security aspect of these transactions. Only when a certain criterion is satisfied, the Smart Contract is fired, releasing the due payment.

- Secondly, all the data on a blockchain is stored securely through cryptographic hash function and the ledger is owned by each node in the network. This makes it very difficult for any intruder to manipulate the ledger data, ensuring protection against any possible mutations or fraudulent manipulation of the data stored insofar, thus establishing a common base of trust and immutability Also by exposing the supply chain ledger publicly, it helps gain the trust of blood donors.

- Our solution also provides a remedial strategy for improper waste management, which is one of the factors that deter donors away from this system. Using the data uploaded on the BC network, the internal entities can have access to the transparent data and consequently prioritize the process of dispatching the blood bags that are nearing its expiry. The bags which are nearing their expiry are flagged and are placed as ready to be dispatched in a case when an urgent call from a hospital is received.



Block Diagram

Design and Implementation

Our system, heavily relies on the 'Smart Contracts' written in programming solidity. Shown below are the snippets of our main contract – 'Blood.sol'.

- **Mappings**: Mappings can be seen as hash tables which are virtually initialized such that every possible key exists and is mapped to a value. Here we have 6 main mappings:

```
mapping(uint => Bloodbag) public bloodbags;
mapping(address => uint[]) public donors;
mapping(address => uint[]) public hospitals;
mapping(address => User) public usertype;
mapping(address => uint[]) public notification;
mapping(uint => User) public users;
```

Mappings

1. **Bloodbags** – This is a very general list of bloodbags. It stores and returns the entire structure(object) of a Bloodbag, whose 'id' will be equal to the uint (integer) provided to the mapping.

2. **Donors** – The Donors mapping will store and return an array, consisting of the bloodbag id(s) corresponding to each and every donor for a particular Blood Collection Center. Based on the address of the Bank provided, the list of donors for that center will be retrieved.

3. **Hospitals** – This mapping stores and returns an array, consisting of the bloodbag id(s) that are currently in possession and owned by the given address's hospital.

4. **Usertype** – This is the type of mapping used for administrative purposes. It is used specifically to provide the client's information, such as the type of user. For example-

   - 1 id for Donor
   - 2 is for Blood bank
   - 3 is for Hospital

   This 'usertype' mapping helps the system to dynamically recognize the type of client, who is visiting the webpage. Based on the usertype and the address of the client, we can provide a fluent access to the data belonging to the user/client.

5. **Notification** – This mapping stores and returns an array, consisting of the bloodbag id(s) that have been used by the hospital(s). It is then used to notify respective donors about their donated blood. It is initially set to false by Blood Bank admin and updated to true by Hospital Admin.

6. **Users** – Lastly, the 'users' mapping is used to contain the list of entire user network, including the donors, hospitals, and the banks. It helps to keep the access of id of every user in a simplistic yet efficient manner.

- **Structs**: Every system has to use a type of data structure that is efficient enough to handle the application of the system and suffice with its use-case. Our system comprises of two different 'structs'.

```
struct User {
    uint id;
    uint user_type;
    string user;
    address payable user_address;
    string name;
    string number;
    string blood_group;
    string city;
}

struct Bloodbag {
    uint id;
    bool used;
    bool expired;
    uint donation_date;
    address payable donor;
    address payable bank;
    string blood_group;
    uint expiry;
    string owner_name;
    address payable owner;
    string city;
}
```

Structs

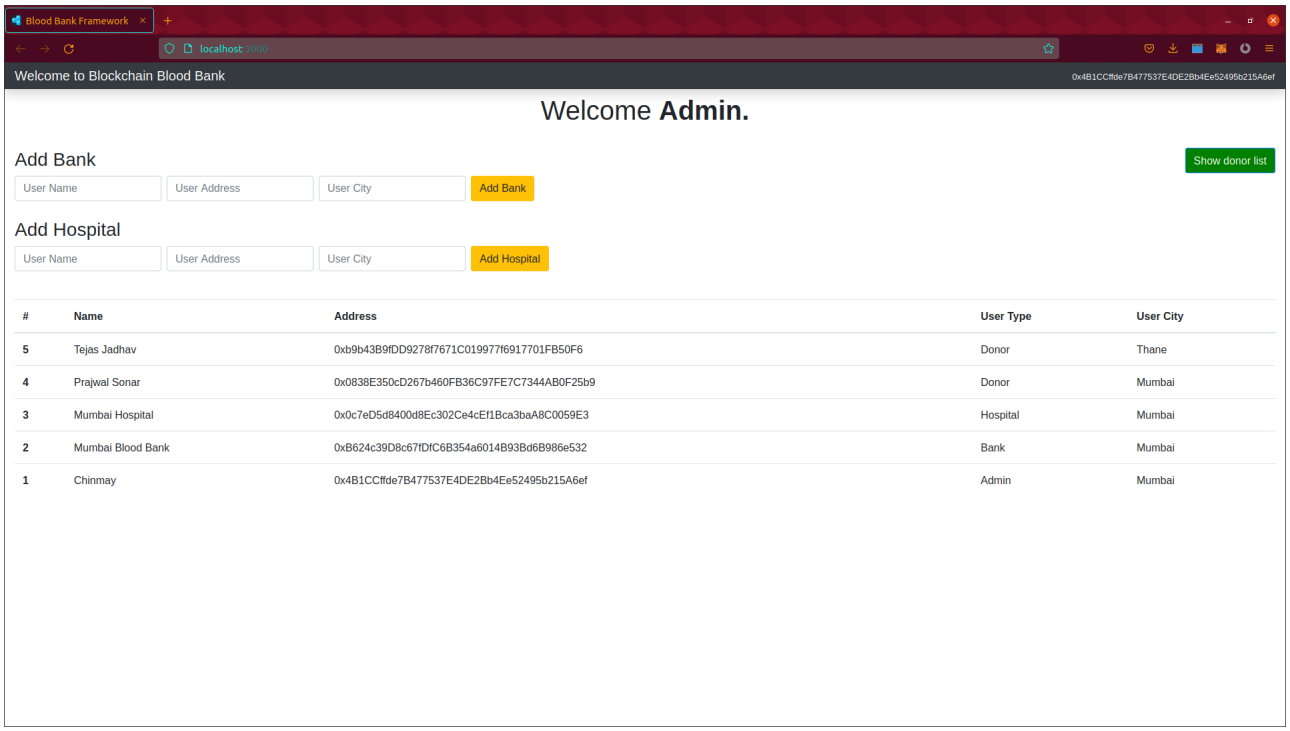
1. **User** – The user struct is a skeleton holding certain parameters for each and every user that is registered on our network. These value are –
    - **Id** - Used for listing and identification purposes.
    - **user_type** – It helps denote the category of the user (Bank/Hospital/Donor).
    - **user** – Contains the description of the given user.
    - **user's network address** – The blockchain network enabled address of the user.
    - **unique name** – For listing and Identification Purposes.
2. **Bloodbag** – The bloodbag struct holds the information unique to each and every bag created/donoted to the blood bank, that enters into our network.

- Id - Used for listing and identification purposes
- Donation date – It is factored in for the authenticity of the bloodbag created. It helps in calculating the expiry date of the blood bag.
- Used – A boolean field to check if bag is used or not.
- Address (Donor) – Used to maintain the link to donor, inorder for the donor certificate's tracking.
- Address(bank) – Used for maintaining the relation to the bank that has generated the bag.
- Blood Group – Used for Medical purposes.
- Expiry – Used for secure medical Purposes.
- Owner name – Used to track the current dynamic ownership/holder of the bag in the system.
- Address Owner – Used to track the purchase details for the owner where the payment is transacted.

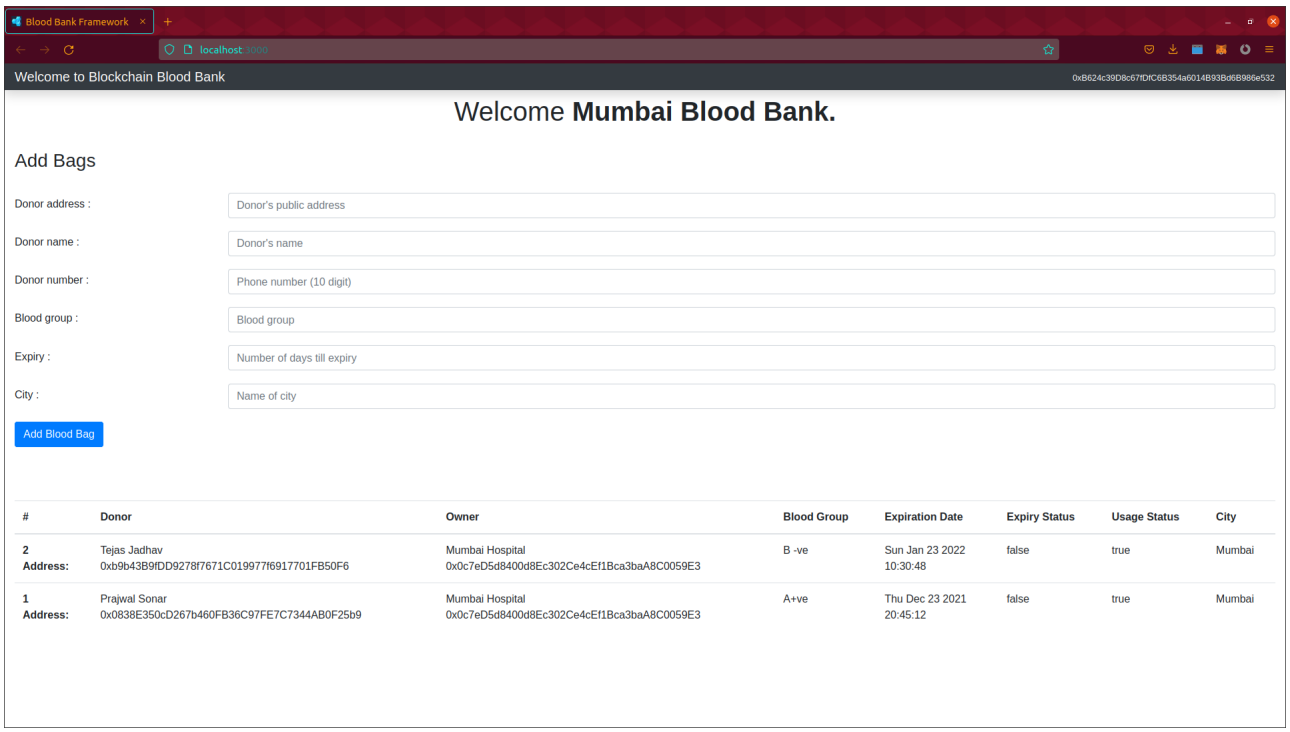
- **Funtions:**
  - **Admin Functions**: These are the functions designed for the admin panel to carry out the backend tasks namely:
    1. **createBank** – The admin will assign the registration 'creation' of every blood bank.
    2. **createHosp** – The admin will handle the registrations for every hospital that get affiliated with our network.
  - **System Functions**:
    1. **createBloodbag** – The banks on receiving the donations made by the donor, will log in to their systems and register the details on the blood bag.
    2. **h_placeOrder** – The hospitals, when in need of new blood bags, will order for the purchase of bloodbags from the nearby Banks and other Hospitals. This transaction will be validated and performed securely through this function.
    3. **useBag** – Whenever the hospital uses a blood bag from its inventory, the donor of that blood bag will be notified. The bag ID will be pushed at the back of the notification array corresponding to the donor ID of same bag.

- **Working**:
  - The framework uses the Metamask wallet to handle the crypto currency. In order to make any transaction with the web application all the entites will need an account on metamask. If an entity does not have an account and tries to interact with web application then it will not allow that entity to use the application as the metamask account is a mandatory requirement.

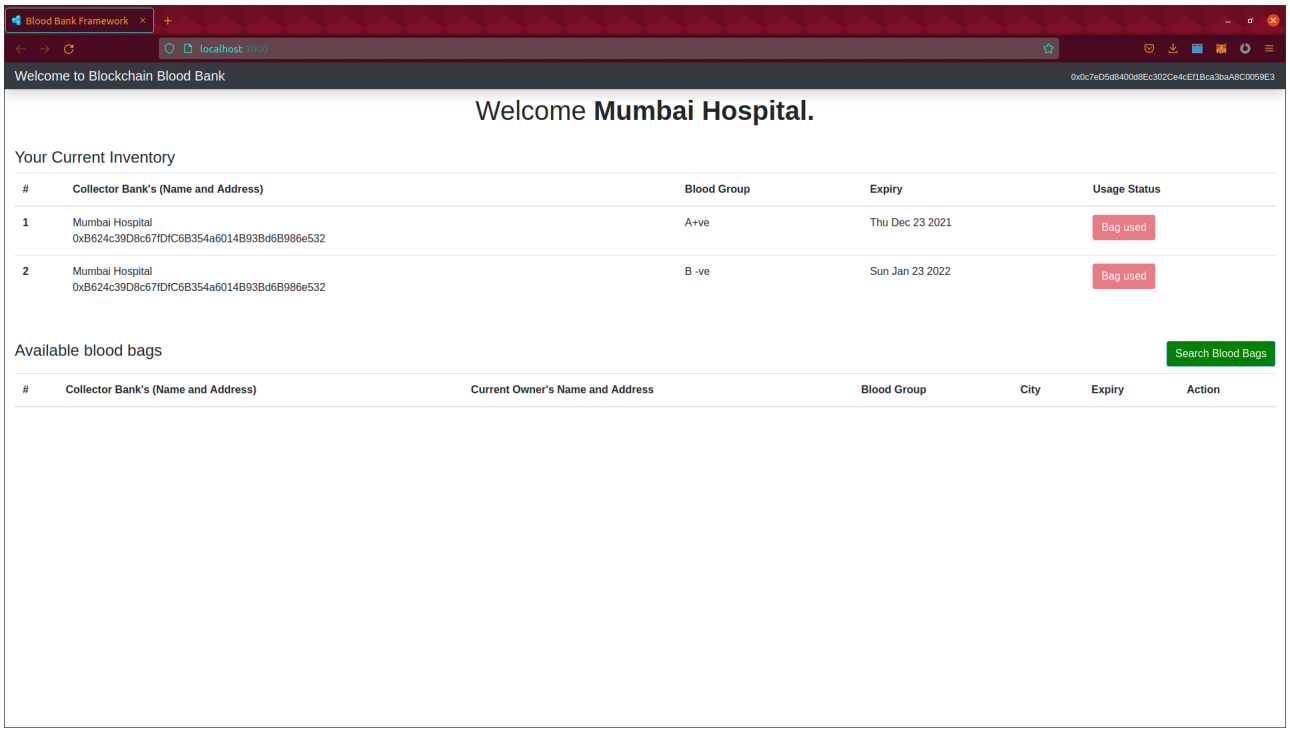
- By using Metamask we can skip the traditional login/register part in this system as metamask handles all the accounts by default. Therefore, overall system becomes simple, fast but secure too, as users just have to log into there wallet account to proceed.
- The framework will automatically detect the usertype and according to that it will redirect to the desired page. For example - if a blood bank accesses the application, it will redirected to the bank's page where it allows them to add new bloodbags.
- Admin can only add new blood banks and hospitals manually. Admin can also check donor's list by blood group. Bloodbank can add new blood bags if available. After adding new blood bags it will be shown in hospital's available blood bag's list from where any hospital can purchase the blood bags.
- Once hospital buys the bag it will be shown in the hospital's inventory as available for use. If a bag gets used for a patient then hospital will change the bag's usage status as used in the web application.
- Donor can also check the status of his blood by accessing the application. Donor can find out the blood bag's expiry date and usage status. Below there are some snippets of web application.



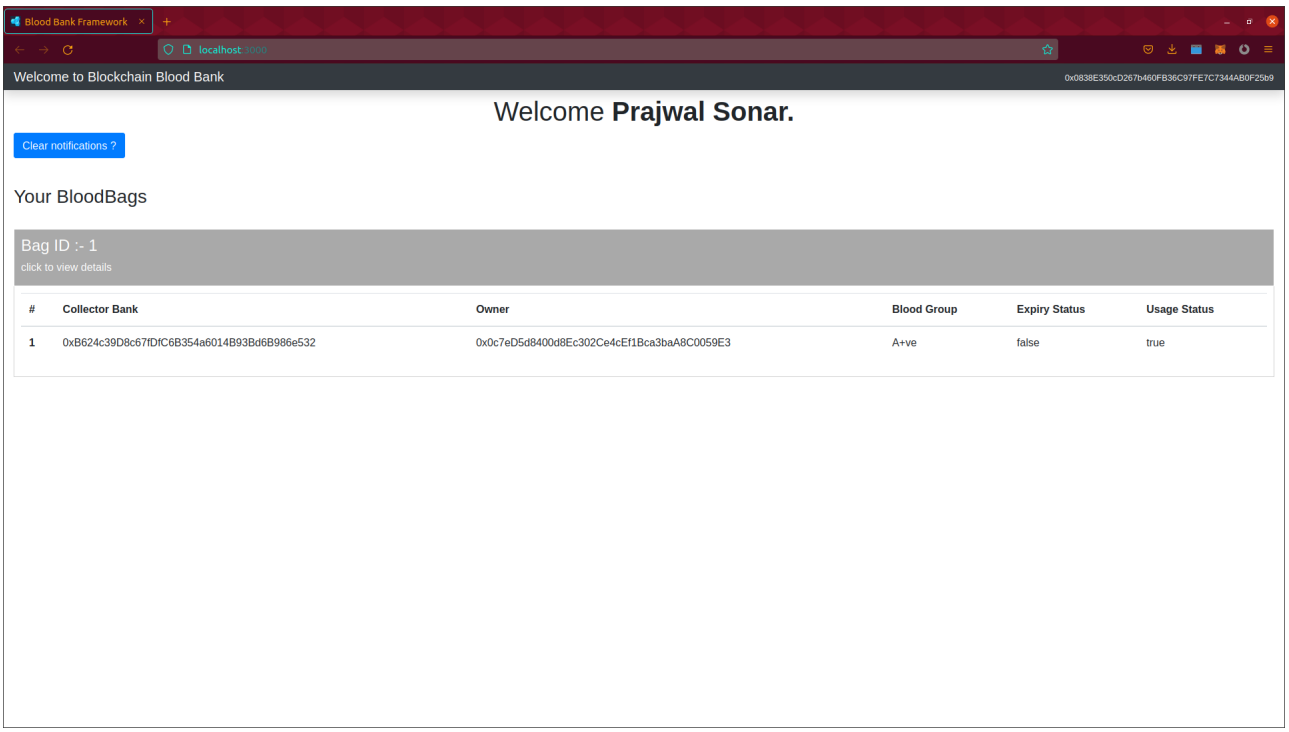
Admin Page



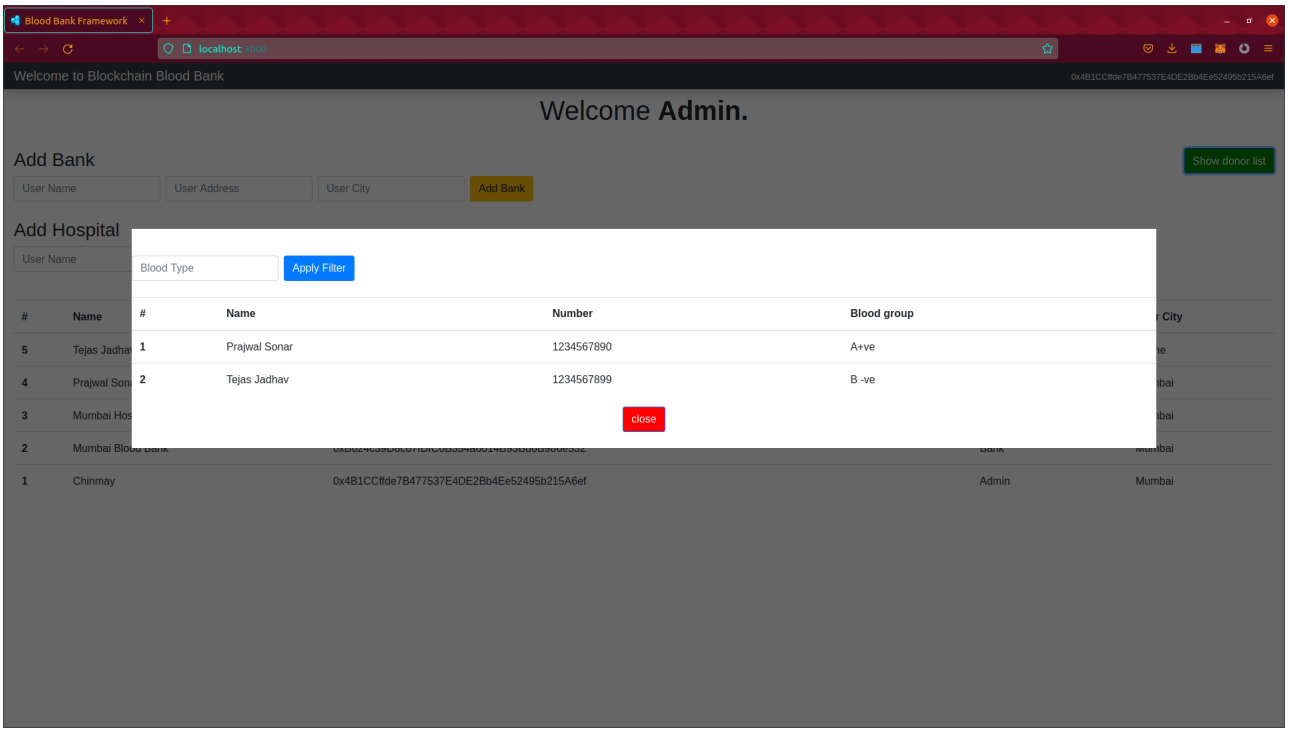
Blood Bank Page



Hospital Page



Donor Page



Blood Bag Status

Summary

The work presented in this report is related to a new technology called blockchain which can be used in solving a crucial issue about blood management in blood banks. By using blockchain we can achieve three main objectives - Security, Transparency, Availability. Because of its distributed ledger architecture it is completely tamper-proof. So we have made a web based framework for blood banks which uses blockchain in backend to store the data of blood donations. This is a centralized platform for the blood ecosystem so that it can solve the issue of improper co-ordination in demand and supply and create no misunderstandings between blood banks and hospitals. It also helps donors to check the blood bag's usage and expiry status.

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1 Publication

Paper entitled **"Paper Title"** is presented at **"International Conference/Journal Name"** by **"Author Name".**