Organ Chain

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Abstract—**We aim to increase government transparency and create a more cost-effective and secure way to store national transplant waiting list and organ sharing transactions by putting the organ sharing transactions onto private permissioned blockchain and making the transaction data public while hiding the patient's personal information. This project aims to create a web application-Organ Chain to track organ donation with blockchain technology. To achieve this we are using Hyperledger Fabric v1.0 which is a blockchain framework with private and permissioned property. Participants in the system include organ donor, hospital, recipient, and UNOS. A donated organ is our asset and Organ Chain stores its movement around the system on our blockchain running on a blockchain network simulated by Hyperledger composer.**

I. INTRODUCTION

A. How Organ Sharing Works

United Network for Organ Sharing(UNOS) is a private non-governmental organization(NGO), which was awarded the sole contract for maintaining an Organ Procurement and Transplantation Network(OPTN). The responsibilities of UNOS includes managing the national transplant waiting list, matching donors to recipients based on a numeric score, and maintaining the database that contains information about all organ transplants performed in the United States. The numeric score is based on the data collected and stored by the hospital. In order to keep the data under intense security, UNOS has an in-house IT security team. The order of organ recipient waiting list is very important since it has to be fair. Power and influence should not be a factor for moving people up and down in the list.

B. Problem

Even though the system is designed to be impenetrable to tampering, the system is opaque. If UNOS assigns an organ to someone, we just need to trust UNOS that it assigned the organ to the person at the top of the list. This calls for an increase in transparency.

C. Proposed Solution

The blockchain technology is a perfect solution to solve this problem because it can maintain an immutable ledger. In a Blockchained data storage multiple peers in the network have their own replicated copy of the ledger. In addition to ledger information being distributed, the processes which update the ledger require a quorum. Moreover, in a permissioned and private blockchain, very specific data and operation access control can be specified. This project, Organ Chain, is a prototype of a web-based application that tracks an organ from its donation to transplant with blockchain technology.

D. Hill Statement

"As a member of the general public, I can view all the transactions performed on the patient waitlist, without being privy to the personal identities of the patients."

II. WHAT IS BLOCKCHAIN

Blockchain is also called systems of proof, and it is basically a distributed ledger which records all the transactions that take place of the network. Blockchain has the characteristic of decentralized, collaborative and immutable. The followings are the core ideas of blockchain.

- Smart contracts: computer programs that execute predefined actions when certain conditions within the system are met and they provide controlled access to the ledger.
- Consensus: the process of keeping the ledger transactions synchronized across the network, and ensuring that parties agree to a certain state of the system as the true state.
- Timestamping: each block is timestamped, with each new block referring to the previous block. Combined with cryptographic hashes, this timestamped chain of blocks provides an immutable record of all transactions in the network, from the very first block.
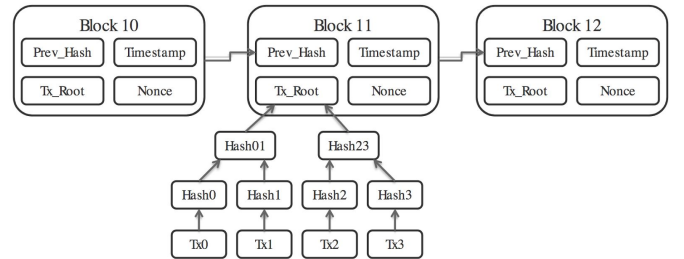

Fig. 1. Blockchain Structure

III. WHAT IS HYPERLEDGER FABRIC

Hyperledger Fabric is one of the blockchain projects within Hyperledger, which has a ledger, uses smart contracts, and is a system by which participants manage their transactions. Hyperledger Fabric is private and permissioned, rather than an open permissionless system that allows unknown identities to participate in the network. The members of a Hyperledger Fabric network enroll through a Membership Service Provider (MSP). In addition, Hyperledger Fabric offers several pluggable options: Ledger data can be stored in multiple formats, consensus mechanisms can be switched in and out, and different MSPs are supported.

TABLE I. ABOUT HYPERLEDGER FABRIC

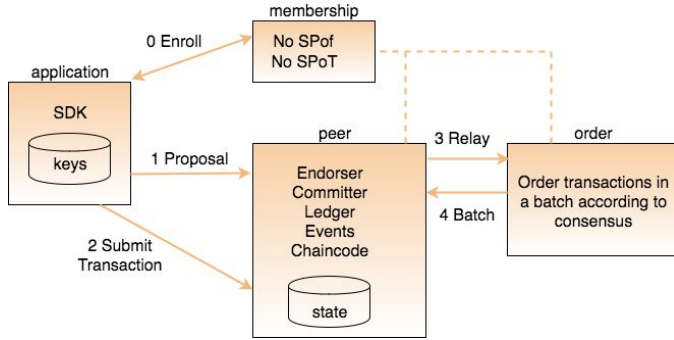|	
Cryptocurrency required	none
Network	permissioned
Transactions	Public or confidential
Consensus	PBFT
Smart contracts	Yes (chaincode)
Language	Golang, Java

Fig. 2.   Hyperledger Fabric v1.0 Architecture

IV. WHY HYPERLEDGER FABRIC

For organ donation, the recipient waiting list is not just a list but actually a pool of candidate who is waiting for the transplant. Hyperledger Fabric makes it is a dynamically generated list, from which the donor organ is allocated. Since Hyperledger Fabric is permissioned and private blockchain, it meets the needs of Organ Chain. In a permissioned network, which provides collectively defined membership and access rights, only selected participants can be added to the Organ Chain. On the other hand, due to the private property, Hyperledger Fabric gives the flexibility and security to make transactions visible to selected parties with the correct encryption keys. That is, only selected data can be accessible to the public via Organ Chain.

V. ORGAN CHAIN

In this project, we use a 3-tier architecture. The Organ Chain web application front-end is created in HTML, CSS, JavaScript with React library. The back-end is implemented in JavaScript and Node.js, and the server is built using express modules. MongoDB is used as the database and it only stores useful the information. Blockchain transactions are stored by Hyperledger. For blockchain, Hyperledger Composer REST server communicates with Hyperledger Fabric Network using web socket. In Hyperledger Fabric network, a peer is the network entity that maintains a ledger and runs chaincode containers and it is connected to certifying authority. Ordering service is a defined collective of nodes that orders transactions into a block. It is a common binding for the overall network, which contains the cryptographic identity material tied to each member. Peer and ordering service communicate via gRPC Apache CouchDB is open source database software that focuses on ease of use and having a scalable architecture. Hyperledger Fabric uses CouchDB to improve performance.
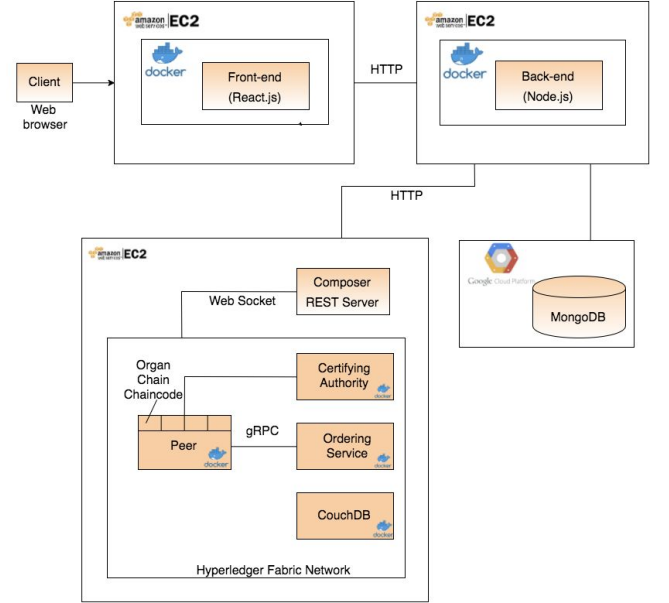

Fig. 3.   Organ Chain Architecture Overview

A. Application Scenarios of Organ Chain

Steps:
- ❏ A donor creates a donor account and logs in.
- ❏ The donor picks a hospital to make an appointment for medical testing.
- ❏ The hospital conducts tests, gathers data and shares with UNOS.
- ❏ Other hospitals add recipients and share with UNOS.
- ❏ UNOS matches suitable donor-recipient organ pairs and generates appointment for transplant.
- ❏ The recipient hospital performs the transplant.
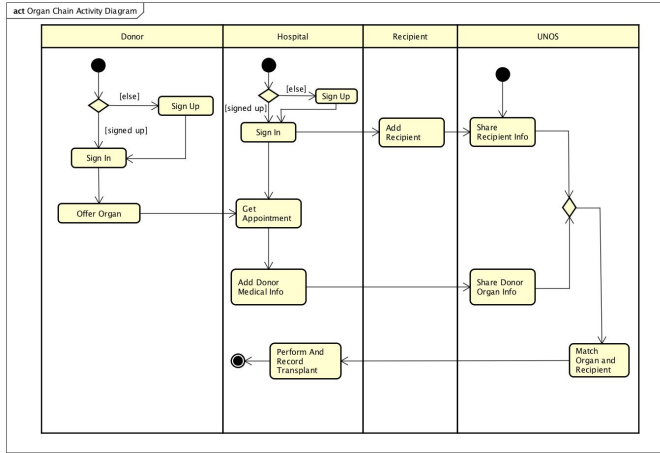
B. Organ Chain Activity Diagram

Fig. 4.   Organ Chain Activity Diagram

C. Life Cycle of Organ

Each organ in blockchain has these four stages:

- Offered: This refers to the stage that recipient has signed up, logged in and his/her organ information has been recorded into blockchain.
- Tested: This means that the hospital has finished testing the donor's health condition and the organ has been approved to donate. The information has been shared with UNOS from the hospital.
- Matched: At this stage, the UNOS has successfully matched the donor's and with the recipient's organ based on the hospital's information.
- Transplanted: At this final stage, Hospital has successfully finished organ transplant between the donor and recipient.

Fig. 5.   Life Cycle of Organ

VI. Technology Stack

At the front-end, React library from JavaScript provides the use of reusable, composable, and stateful components, which is running in a docker container. It also provides the nature of reactive updates and the virtual representation of views in memory. At the back-end, Node.js is used to create a web server connecting the front end with the blockchain server is created using Composer REST Server. The back-end server is also dockerized. For login and session data storage, we use MongoDB, since it makes possible to build applications faster, handle highly diverse data types since we need to store organ's lab data whose schema will differ from organ to organ. In addition, MongoDB manages applications more efficiently at scale, which meets our needs in terms of our data storage. Hyperledger Fabric is used for blockchain data storage. AWS Elastic Compute Service (EC2) is IaaS, which is responsible for networking, storage, server, and virtualization. For our project, the front-end, back-end, and blockchain are all hosted on AWS EC2. And Google App Engine is used for MongoDB deployment. Since we are looking for a setup which is easy to scale and migrate, not complex to configure, in order to provide a stack to run an application on, we need something else than the traditional server. By comparing the container setup with its predecessors such as virtual machine, we can conclude that containerization is the fastest, most resource efficient, and most secure setup we know to date. Containers are isolated instances that run our application. In Docker, containers share the kernel with the host; hence it is lightweight and can start and stop quickly.

Fig. 6.   Organ Chain Technology Stack

VII. Future Enhancements

- Organ-Specific Smart contracts
- Provide APIs to public to make their own visualization tools
- Improve security by using TLS and HTTPS
- Providing Hospitals ability to update the status of the patient.
- Approach more Sponsor User
- Follow up with HyperLedger Community

VIII. Summary

Using a Hyperledger Fabric blockchain to store the patient waiting list has these major advantages: viz. improved security, increase the operational transparency by displaying out transaction data to the public and at the same time has the potential to reduce the operational cost of UNOS' IT infrastructure by making it distributed across the transplant centers (hospitals).

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