



Blockchain Enabled Electronic Health Record Management System

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Abstract: Health care system is more affluent and more complex nowadays. One of the main resources in healthcare is health records of patients. Most of the hospital altered to Electronic Health Record (EHR) which enhanced the health care system. EHR consists of most subtle data and this has to be managed properly. There are a lot of issues faced in management of EHR like security, privacy, interoperability. The proposed system describes the solutions for the issues discussed here. This paper proposes a secure EHR system which will preserve the privacy and maintain interoperability using Blockchain. The Blockchain is a data structure that display the way the data are stored and sensibly joined together in a peer-to-peer network. Hyperledger Fabric is used to manage EHR. Sharing health records between the several hospitals is a vital and life-saving during emergency. This will significantly reduce the time needed for the physicians to prescribe and take precautionary actions required as swiftly as possible. This helps to attend the patient's on-time and save their lives during the emergency circumstances.

Keywords: - Blockchain, Hyperledger Fabric.

I. INTRODUCTION

Now a day's most of the records are warehoused in digital format. Health care records of the patient data is considered as one of the most important resources in healthcare system. So, health record has to be appropriately managed and correctly stored. Utmost of the hospitals changed to electronic health record system. The electronic health record system found to be more advantageous that provides improved health care services for patients and provides suitable security compared to the traditional paper-based health care system. Revolution to Electronic Health Record (EHR) system transformed the recent health care system.

The whole lot is digitized and it importantly helped the laboratory people to effortlessly uphold the patient's health records. But there are lot of issues and challenges faced in the existing EHR system. EHR consists of most sensitive and confidential information that no patient would like to disclose. Electronic Health Records comprises of patient's medical history along with patient's personal information and other significant information like payment specifics and the details of families. EHR should be properly managed by providing proper security, by maintaining the privacy of records when it is shared with different units. Sharing of health records between two health care providers helps in emergency situations and also beneficial for the patients. So, sharing of data between two or more entities should be secure because the number of data fissures is growing and the breaching in healthcare records data is swiftly increasing, because of no proper security and privacy. While sharing the information, providing both security and interoperability will make the system user-friendly. The scalability of data is also one of the important concerns. Blockchain can be used to achieve this by providing security, privacy, interoperability and scalability. Blockchain in, its simplest form, is a timestamped series of immutable record of data that is achieved by cluster of computers that are not maintained by any solitary entity. Each of these blocks of data are secured and bound to each other using cryptographic principles that is chain. A Blockchain has no central authority. There are mainly two types of Blockchain public and private or permissioned Blockchain. Hyperledger is a private or permissioned Blockchain.

II. LITERATURE SURVEY

R Cowie *et al.* [1] gives overview of Electronic Health Record (EHR) system and how this EHR is effectual to use. EHR help in improve patient care and to entrench performance measures in clinical practice, and to development the identification and recruitment of eligible patients and healthcare providers in clinical research. Applications of EHR system also discussed that will be accommodating for research.

Mathai *et al.* [2] proposed a survey on different types of issues in handling the electronic record. Issues linked to consumer where the consumers are anxious about the privacy and integrity of their data, privacy issue, data breaches where most of the data of people are breached over this electronic record only. Anticipation of different participants also discussed



in this paper that includes consumer expectation from electronic record to store data in the appropriate format that is safe and secure. Doctor's prospect is to access the patient medical history that will easy to treat the patients and to improve issues like low productivity, overwhelmed alert etc. Here different ethics and laws are discussed that is used to progress EHR like HITECH.

Harry Halpin *et al.* [3] proposed a study on issues of data management. In Blockchain the data won't be kept in centralized system all the data will be decentralized, so privacy and security will be provided. Here different cryptographic primitives and how Blockchain play its part is discussed. How Blockchain can safeguard security and privacy using consensus like proof work is also discussed here.

Anton Hasselgrena *et al.* [4] proposed a survey to categorize different issues in health care. Some of the issues are access control, interoperability, provenance and data integrity are all problems that are intended to be improved by Blockchain technology in this arena. In this study authors have discussed the benefits of two Blockchains. One of them is public Blockchain, the most used Blockchain is Ethereum. The other one is permission Blockchain the finest among them is Hyperledger which cracks all the issue addressed in this survey.

Dinh *Cetal.*[5] proposes an innovative EHR that mainly emphases in trustworthy access control mechanism that is permitted by mobile cloud storage and Blockchain. Patient data is collected using wearable sensor and the information of patients is alienated into two as personal and health care data.

Marek A Cyran *et al.* [6] proposed Blockchain based data-sharing solution which portrays two challenges linked with using Blockchain for health data sharing: protecting sensitive health information and fitting and installing Blockchain software across miscellaneous hospital environments. Inter Planetary File System (IPFS) decentralized file system is used in this system.

Ajaya Mandalet *et al.* [7] proposed a Blockchain based EHR system has been built for secure, efficient and interoperable access to medical records by both patients and doctors. So, in this system, it is demonstrated how features of delegation and Blockchain architectures could contribute to EHR system using IPFS and Ethereum smart contracts to orchestrate a suitable system.

K. C. Suhas Hollaet *et al.* [8] proposed a system provides security and permits patients act as an admin where they can own health records while still yielding other stakeholders like doctors to have an easy access to the records with right permissions. SHA3 encryption algorithm is used here.

Lanxiang Chen *et al.* [9] proposed a scheme; there are three main entities, namely data owner, user and Blockchain After this, the data performs encryption on EHRs using a symmetric encryption algorithm. After performing encryption EHR is stored to cloud server.

Shan Jiang *et al.* [10] proposed a Blockchain-based platform for healthcare information exchange. First step is to identify the different requirements for sharing healthcare data from dissimilar sources. In second step, off-chain storage and on-chain verification is combined together to satisfy the requirements of both privacy and authentic ability. In third step, two fairness-based packing algorithms are used to improve the system throughput and the courtesy among users jointly.

Qi Xia *et al.* [11] proposed a system that addresses the issue of medical data sharing among medical big data custodians in a trust-less environment. The system is built using Blockchain and provides features like data provenance, auditing, and control for shared medical data in cloud repositories among big data entities.

Jie Zhang *et al.* [12] proposed a secure system for PSN-based healthcare. Here two protocols are used to build the system. The first protocol used here is improved version of the IEEE 802.15.6 that display authenticated association.

Xia oguang Liu *et al.* [13] proposed a system that has many security properties such as decentralization, transparent, and tamper proof. The doctor can access and store the records. The consensus mechanism used here is DPOS. Furthermore, a symptoms-matching mechanism is also implemented between patients.

Jayneel Voraet *et al.* [14] The proposed system is a Blockchain-based framework for efficient storage and maintenance of EHRs. Unauthorized access by various actors is handled by and Ethereum and smart contracts. The privacy is maintained by using the encryption schemes on the patient private data stored on the Blockchain, this reduces the chances of unauthorized access to patient records.

Guang Yang *et al.* [15] proposed a Blockchain based architecture that implements Blockchain technology to the current EHR system. It is compatible with the existing systems and suitable for health providers. Smart contracts are utilized in



this design, and can be further developed with preferences, e.g., particular items in records can also be added to the Blockchain for tracking.

Hao Guo *et al.* [16] proposed Hybrid architecture using both Blockchain and edge nodes to impose attribute-based access control of EHR data. The architecture utilizes Blockchain, firstly it is used to execute smart contracts so as to impose ACL policy and secondly it is used to record legitimate access events into Blockchain.

Ruksudaporn Wutthikarnet *et al.* [17] presented a Blockchain based health care service application is built using Hyperledger fabric. Hyperledger composer is the open development tool set and it is a framework that gives a permission to develop a Blockchain application and integrate with the existing business system in an easier way.

Tomas Mikula *et al.* [18] proposed a system that demonstrates application of Blockchain in identity and access management using the Hyperledger Fabric framework. The system provides a proof of concept based on a use case concerning Electronic Health Records from the healthcare domain.

Aritra Mukherjiet *et al.* [19] proposed system that is about the necessity to transform the traditional EHR system and also throws light upon various opportunities as well as discussing about various challenges for using Blockchain Technology. The Hyperledger fabric is used which enables the participants to know each other and all the actions, like submitting application transactions, modifying the configuration of the network or deploying a smart contract on the Blockchain follows an endorsement policy that was established for the network. In this way, any kind of data tampering can be easily detected.

Sujit Biswas *et al.* [20] proposed a system that is built using Blockchain to provide a unified network of EHSs, where the complete system can share information and control access to it. It also addressed the management issue of combining the traditional and Blockchain networks, and more specifically, the data storage in relational databases and file-based database structures.

III.SYSTEM ARCHITECTURE

Figure 1 depicts the system architecture of a Blockchain based electronic health record system which involves entities or stakeholders like hospitals, doctors, patients, pharmacy, and laboratory. This system is implemented using Hyperledger Fabric. The proposed system provides security and preserves the privacy of the information stored on the Blockchain network. This proposed system not only provides security, it makes the system interoperable and user-friendly. To be part of this system, entities must get registered with the system. If the entities are registered with the system, then only they are considered as legitimate users. To validate this legitimacy, MSP will provide certification to each user once they are registered on the system. Once all the entities of the hospital, like pharmacy, doctors, and laboratory, are part of this network, patients can visit this hospital. Patients can book an appointment. The hospital is responsible for assigning the doctor and confirming the appointment. The next step is that the patient will consult the respective doctor, where the doctor can upload documents of the patient to the network. But other than patients, no one will have access to the patient data. In the same way, pharmacies and laboratories can upload respective documents. The hospital can generate a bill after the complete consultation. To view the documents, all the entities should request access. The decision is left to the patient. They can grant or revoke access. Once the request for Figure 1.2 Block Diagram of Transparent and Secure Drug Supply Chain using Blockchain access is granted, the entities will be able to view their respective documents. Here, security and privacy are maintained because each action taken here is considered as a transaction. Each action will invoke a chaincode and the endorser will validate the endorsement policy. Once the endorsement policy is validated successfully, the orderer will run consensus and the committer will commit the node to the ledger.

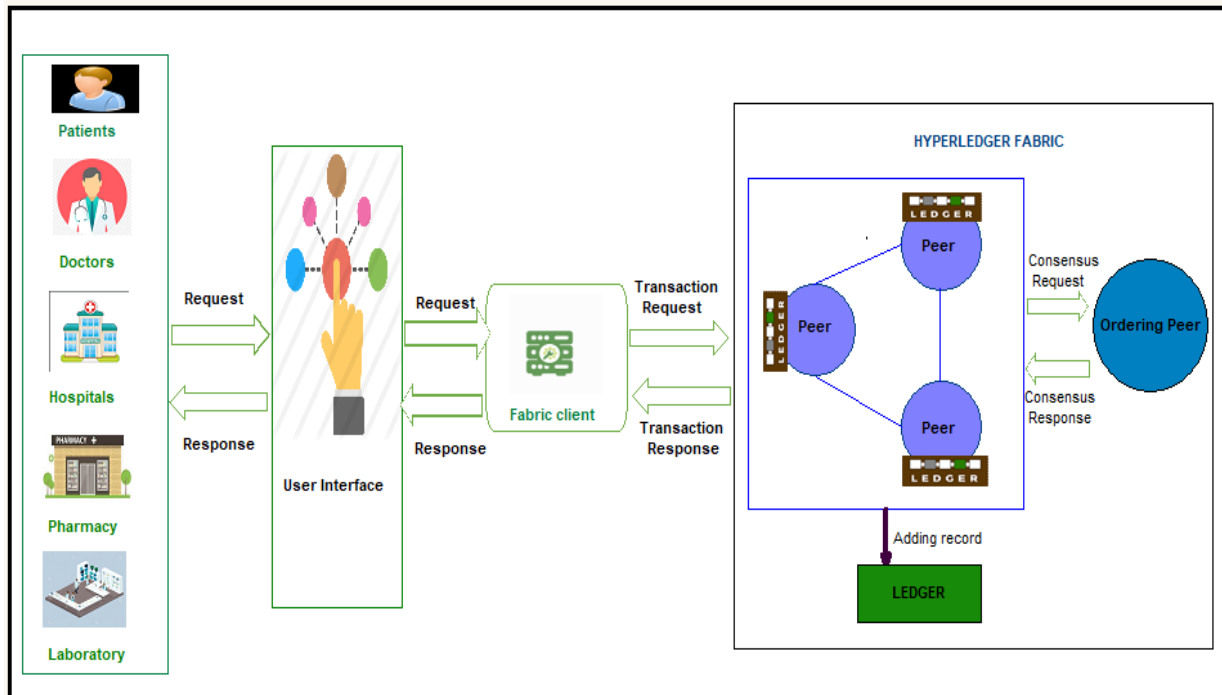


Figure. 1 System Architecture of Electronic Health Record Management System.

IV. METHODOLOGY & IMPLEMENTATION

Hyperledger Fabric:

Hyperledger Fabric is a blockchain platform for distributed ledger solutions underpinned by a modular architecture that delivers high degrees of confidentiality, resiliency, flexibility, and scalability. It is designed to sustainance of pluggable implementations of different components and put up the complication and details that exists across the economic ecosystem.

There are different Components of Hyperledger Fabric Network:

A **ledger** divided into two parts a “blockchain” and the “state database”, also known as “world state”. Unlike other ledgers blockchains are immutable that is, once a block has been added to the chain, it cannot be altered.

The **Membership Service Provider (MSP)** mentions to an abstract component of the system that delivers credentials to clients, and peers for them to partake in a Hyperledger Fabric network. The **smart contract** is code invoked by a client application exterior to the blockchain network that accomplishes access and alterations to a set of key-value pairs in the World State. The **peer** network object that maintains a ledger and runs chaincode containers in order to achieve read/write operations to the ledger. Peers are owned and preserved by members. **Ordering Service** described as a collective of nodes that orders transactions into a block. The ordering service exists independent of the peer processes and orders transactions on a first-come-first-serve basis for all channels on the network. A **channel** is a private blockchain overlap which allows for data isolation and confidentiality. A channel-specific ledger is shared crosswise the peers in the channel, and transacting parties must be appropriately authenticated to a channel in order to interact with it. Hyperledger Fabric CA is the default **Certificate Authority** component, this will issue PKI-based certificates to network member organizations and their users.

Organizations is also known as “members”, organizations are requested to join the blockchain network by a blockchain service provider. An organization is linked to a network by addition of its Membership Service Provider to the network. Figure. 2 describe the complete functioning of Hyperledger Fabric. Fabric client or SDK is application that will help the user to interact with blockchain network. The operating system used to implement the system is Ubuntu 16.04 LTE. Docker is used as containerization Engine. IDE used is vscode. Programming languages used is ReactJS for frontend and HTML, CSS, Javascript. CouchDB is the database used.

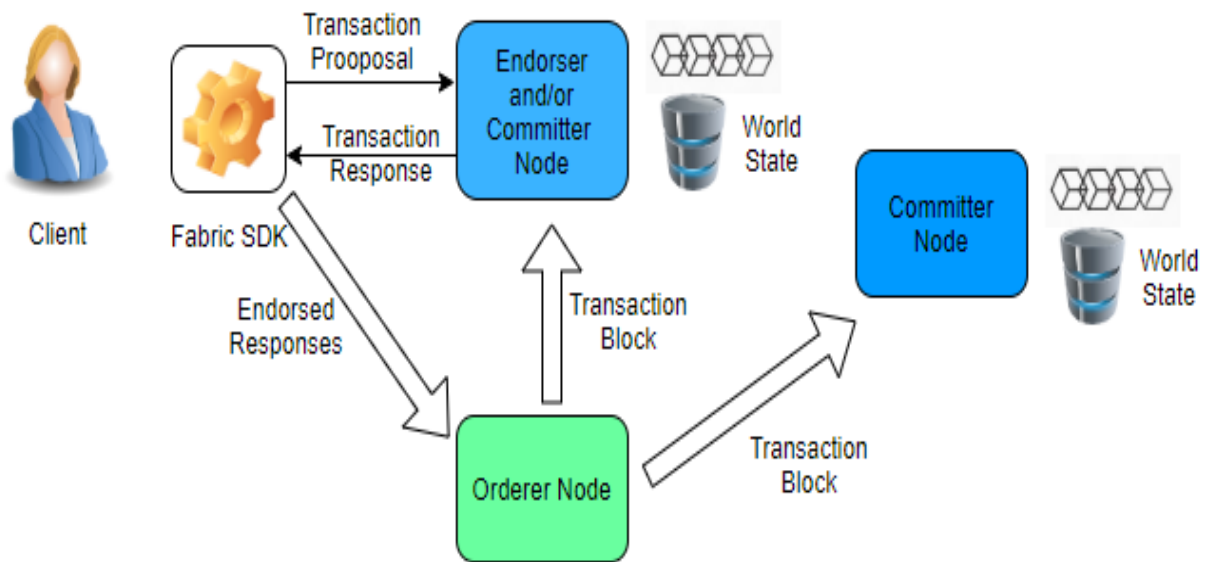


Figure. 2 Hyperledger Architecture

1. Blockchain Network setup Bringing up Hyperledger Fabric

The fabric version 2.2.1 is used to build the blockchain network.

2. Users involved and Registration of users to the network

This includes the user registration, user login and dashboard and functionalities for each user type. Here Algorithm is written how user can register to network and perform functionalities.

Algorithm:

Step 1: Launch the Electronic Health Record Management web application.

Step 2: Select the user role specified in the home page, the users involved in the system are Hospitals, Doctors, Pharmacies, Laboratories and Patients.

Step 3: The stakeholder is taken to the Signup Page to enter their details like Name, Registration ID (if applicable), Phone Number, Gender (if applicable), Age (if applicable), Blood group (if applicable), Address and also a unique Username and Password for the user to access the application, the user information is provided to the user role they select before sign up.

Step 4: If user is already registered, a pop up appears to the user and the user can navigate to the Sign In Page to login to the dashboard for that user.

Step 5: The username, password and registration id (if applicable) are entered in the login page and if the provided details are valid and is verified the user can have access to the respective dashboard.

3. Booking appointment

Algorithm:

Step 1: Patient will get registered to blockchain network when he tries to register through network.

Step 2: Chaincode will be invoked for registering to network and CA will provide certification

Step 3: Patient login using username and password

Step 4: Patient book appointment by inserting hospital ID, Patient ID, Description, Time

Step 5: Required fields will be verified according to endorsement policy

Step 6: This will invoke the transaction proposal through Fabric client.

Step 7: Validation of the request is done by running chaincode.

Step 8: If the session key is valid transaction will be successful

4. Pharma Product Lifecycle Validation

4. Assigning Doctor

*Algorithm:*

- Step 1: Hospital assign the doctor if patient requests through appointment
- Step 2: Hospital assign the respective doctor to the patient based on their request using appointment ID
- Step 3: Verify Patient has registered to network based on the session key
- Step 4: Chaincode will be invoked for verifying this
- Step 5: Check if the doctor is present in network
- Step 4: Required fields will be verified according to endorsement policy
- Step 6: If doctor is present then doctor will be assigned to the Patient

5. Request for Accessing Patient Record*Algorithm:*

- Step 1: All the hospital entities which includes hospital, doctors, pharmacy, laboratory can have access by sending a request for access to the patient.
- Step 2: They can request by entering specific patient ID
- Step 3: This will invoke the transaction proposal through Fabric client.
- Step 4: Validation of the request is done by running chaincode.
- Step 5: Patient receives access request if patient accepts doctor get access to the patient history if patient revoke access then cannot get access to patient records.

V. CONCLUSIONS & FUTURE ENHANCEMENT

Blockchain enabled digital health record for healthcare had been magnificently applied and tested with Hyperledger Fabric environment. The proposed machine turned into capable of offer safety to the facts and private statistics of the patients. The sharing of records among one-of-a-kind entities turned into secured and privateness of records is likewise maintained. This turned into viable due to the fact every transaction could be saved as a block and those blocks are neither editable nor may be deleted. Manipulation of blocks is not possible to perform. Here all entities had been capable of add facts however entities can view the files best in the event that they get right of entry to the record. They can view record best if affected person furnish get right of entry to. This procedure could be primarily based totally on permissioned Blockchain. Other than safety and maintain privateness, machine interoperability and user-friendliness.

The future enhancements to this project would be to include entity like insurance agents. Scalability also can be considered one of the future works that can be performed. Because, hospital records will increase day by day so this is one of the works that can implemented.

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