Collaboration of Blockchain and Machine Learning in Healthcare Industry

B L V V Kumar, K Raja Kumar

Abstract: ***The purpose of this paper is to explore the applications of blockchain in the healthcare industry. Healthcare sector can become an application domain of blockchain as it can be used to securely store health records and maintain an immutable version of truth. Blockchain technology is originally built on Hyperledger, which is a decentralized platform to enable secure, unambiguous and swift transactions and usage of medical records for various purposes. The paper proposes to use blockchain technology to provide a common and secured platform through which medical data can be accessed by doctors, medical practitioners, pharma and insurance companies. In order to provide secured access to such sensitive data, blockchain ensures that any organization or person can only access data with consent of the patient. The Hyperledger Fabric architecture guarantees that the data is safe and private by permitting the patients to grant multi-level access to their data. Apart from blockchain technology, machine learning can be used in the healthcare sector to understand and analyze patterns and gain insights from data. As blockchain can be used to provide secured and authenticated data, machine learning can be used to analyze the provided data and establish new boundaries by applying various machine learning techniques on such real-time medical data.***

Keyword: ***healthcare industry, Hyperledger, decentralized platform, doctors, medical practitioners, pharma and insurance companies.***

I. INTRODUCTION.

The main reason blockchain technology is preferred in order to achieve quality data maintenance is due to its distributed public ledgers which secure encrypted immutable data.This technology of distributed ledgers is preferred for broad variety of use cases ranging from data storage, financial transactions to real estate and asset management. . Though blockchain technology has been under research from many years, it has become an interest to huge number of people after its applications of cryptocurrencies such as Bitcoin. Many market players have presented various applications of blockchain to the industry. One such application of blockchain is Electronic Health Records (EHR), which is explored through this paper.

Patients visit many healthcare organizations depending on their circumstances in life, thus leaving traces and bits of their medical data scattered among various organizations. In such a scenario, it is difficult if not impossible for the patient to retrieve their past medical history. The patient's medical data is scattered among various hospitals and medical organizations making it difficult for the organizations to maintain proper updated information and leaving the patient in an ambiguous state. This lack of coordinated data management leaves the data shattered. To overcome these barriers, a digital platform like EHR where the patients and medicine practitioners can access the data efficiently.

The Electronic Health Records System is a digital platform of a patient's medical history. It is maintained by the healthcare providers. These records include information on diagnosis, medical history, lab tests and other medical data. Major uses of enforcing the usage of EHR is maintenance of updates medical information, reduced errors, quick access to patients records and increased involvement of patients in their healthcare.

II. BLOCKCHAIN IN HEALTHCARE

Although EHR has many benefits, it stores data from various workflows, hence the security of data is not guaranteed. This hinders the trust environment in medical fraternity. The nature of sensitivity associated with the data along with the challenged of interoperability and health information exchanged has built opportunities for advancement of blockchain in this domain of industry. The successful deployment of the application of blockchain in healthcare allows secured transition of data in an efficient and coherent manner. The advantage of using blockchain technology is that every organization does not require to maintain a distinct database to store the records of their patients. The decentralized behavior of blockchain allows any authenticated participant to access the data. Blockchain's architecture provides patients with complete control over the access and data exchange in EHR.

III. MACHINE LEARNING IN HEALTHCARE

Machine Learning can be used to provide the doctors with insights on the secured and quality data provided using blockchain technology. With increasing number of applications of machine learning in various domains, healthcare allows is to glimpse at the future where data analytics and innovation together help people in large numbers by making smart decisions and analysis. The main application of machine learning is identification and providing treatment to a disease. Many algorithms and techniques in ML are implemented to analyze the symptoms, test results and condition of the patient to identify the disease.

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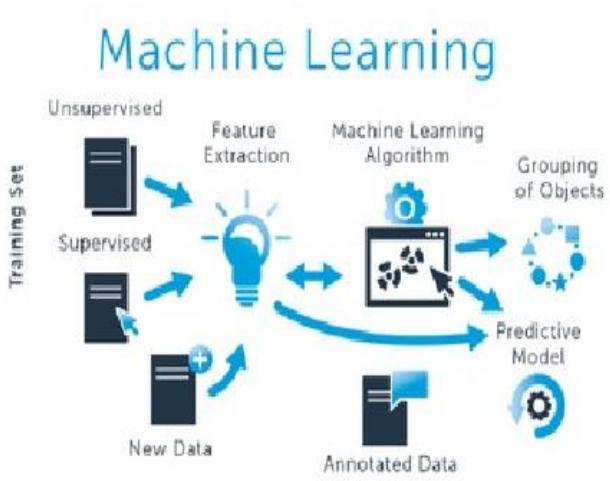
It can also be used to suggest relevant diagnosis based on the previous similar cases, symptomatic history and available genetic history. As part of the diagnosis for a disease, machine learning techniques can be used to provide lifestyle suggestions to patients on the basis of their current medical records and medical history.

Apart from medical records analysis, machine learning models can be trained for monitoring and predicting future outbreaks of epidemics. Since many third-word countries encounter major epidemics due to lack of crucial medical infrastructure and education system, predicting outbreaks is very helpful.

Applications of machine learning on healthcare data is not limited to text records but can also be applied on images. Various machine learning and deep learning techniques are responsible for the breakthrough technology of Computer Vision. Computer Vision can be used in medical image detection which includes tumor detections, tracking tumor development, blood flow qualification and visualization, and diabetic retinopathy etc.

Machine Learning plays a vital role in the domain of healthcare by providing efficient methods to save time, effort and money. Computer vision systems such as Google Cloud Vision API and MATLAB's machine learning based handwriting recognition technology are few of the machine learning models for document classification using vector machines and ML-based optical character recognition.



IV. Blockchain Background

Blockchain ensures secured storage of data through public key cryptography. Through public key cryptography, every participating node in the blockchain network has access to the blockchain. The chain of contents in blockchain are immutable and time-stamped. The proof-of-work algorithms ensure security of the contents present in the nodes.

The model of Electronic Health Records enables different healthcare provides and agents like doctors, hospitals, laboratories, pharmacists and researchers to request permission to access medical records. Each medical transaction is a blockchain transaction on the distributed ledger. All transactions are transparent and secure. The EHR model is built of the permission-based Hyperledger architecture which contains various access levels.

Patients can solely control the permissions of who can view their records and contents. Providers can add new medical records associated with the corresponding patient and patients can also grant authorization for sharing records between providers.

The model maintains a blockchain contract which holds references to all the relationships between patient and provider which in turn provides a single reference to check updates in the corresponding medical history.

V. System Implementation

A. *Smart Contract Structure:*

1. Registrar Contract:

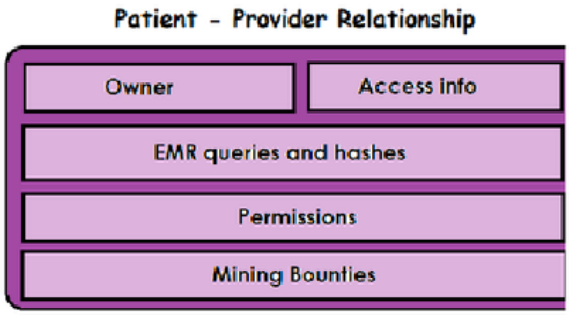
This contract is a global contract which is used to map the user or participant's identification information to their respective Ethereum address. It can register new participants or modify the mapping of existing participants. This contract also maps to address of a special contract called summary contract.

2. Patient-Provider Relationship (PPR):

This contract plays a vital role in maintaining the relationship between patient and provider node. Each node stores and maintains the medical records of the other node.

It consists of various data pointers and permissions associated with various providers. The data pointer consists of a query which when executed return only part of the record data that the provider is permitted to view. In order to ensure efficient security of data, the query string is attached with hash of the data. The data queries can be created and modified by the provider.

A dictionary implementation that maps the addresses of the viewers to their query strings in maintained in order to provide patients the ability of sharing data with others.

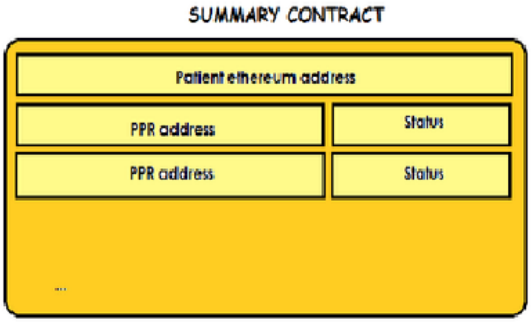


3. Summary Contract (SC):

The summary contract helps the participants to check the transactions made on their medical records. All the relationships between patient and provider are referenced in this contract. This patient-provider relationship represents the participant's previous and current participation in a transaction. Patient's SC will contain references to all the providers who are involved in the transaction. Similarly, providers' SC will contain references to all the patients and third parties they have been involved with.

This contract plays a very important role in restore and backup. Thus, blockchain log is maintained. This permits patients to exit and re-enter the network multiple times without worrying about the loss of their previous data.

It has a status variable which specifies whether it is a new relationship or has to be updated or is yet to be approved by the patient. This enables the functionality of user notification. Only providers can update status variable for security reasons. The patient can accept or reject a request.



VI. System Description

The blockchain smart contracts define the behavior of patients and providers in the EHR system. Though patient nodes contain same components as the provider node, provider nodes manage databases with patient data. These databases are considered as a backup of the patient medical records. So, any missing data can be securely retrieved using the summary contract.

The design model consists of four software components:

1. Back-end Library:

The back-end library acts as an interface of the Ethereum client to perform low-level formatting. It deals with uncertainties and ambiguities that occur during a transaction. It facilitates system operations, communications with blockchain and avoids hurdles of directly working with blockchain through its user interface.

2. Ethereum Client:

Ethereum client is the main components which enables users to participate in the Ethereum blockchain network. It connects users to the peer-to-peer network and sends encoded transactions. The clients are made aware of their identity and address. The SC is located and this service is run continuously to monitor the changed or updates performed. It signals to sync the local database in an event of update requirement.

3. Database gatekeeper:

Clients request through a query string which is cryptographically signed by the issuer. This request also contains a reference to PPR that permits it. The gatekeeper listens to the request, verifies the address of the client and returns the result of the requested query if the address of the client is valid.

4. EHR Manager:

EHR Manager is the backbone of the model which connects all the other components, back-end library, Ethereum client and database gatekeeper with the user interface.

VII. IMPLEMENTATION

The implementation of the EHR model can be illustrated as the following sequence of points:

1 Provider adds a new patient record.
2 The corresponding patient identity is retrieved by matching the Ethereum address and the respective summary contract is located using the registrar contract.
3 Provider create a new PPR and a query to reference the medical data after which the PPR is updated.
4 The updated PPR is linked to the patient's SC so that the transaction can be located for later use.
5 The Ethereum client of the patient continuously checks for any updates in respective summary contracts.
6 If a new PPR is linked, then the user receives a notification. The user can accept or reject the request and the SC will be updated accordingly.
7 Once the communication is accepted, the provider can issue a query request to access the medical records. The provider is located through new PPR and is connected to the database gatekeeper server.
8 The patients choose the data that is to be shared with the third-party organizations and creates a PPR with a query string and the respective third-party address. All such requests can be accessed when the database gatekeeper grants access.

VIII. PROTOTYPE EVALUATION

In the model proposed in this paper, patients are completely provided with their medical history. The data is stored in separate provider database, with patient and also in the blockchain network. Because of the decentralized architecture, using blockchain in the age of cyberattacks and data leaks becomes a great advantage.

Due to the links between providers and organizations, better access to data can lead to wide range of trend discovery. Patients can choose to allow permissions to third parties for research purposes.

Patients can communicate with providers in a secure manner. It provides enhanced privacy and access control where users can setup permissions and give certain providers permission to write data to their blockchain.

IX. CONCLUSION

Machine learning can be used in gathering and analyzing the data. The ML algorithm models help in diagnosing diseases and in research and development thus adding a tangible value to healthcare.

In order to achieve maximum results from machine learning, the models should be provided with quality and authenticated data. Blockchain can be used to store, share and protect sensitive data thus improving quality of data among various groups. In this view, patients are the authority of their medical data by monitoring the access permissions of payors and providers as required in the blockchain network. Blockchain in Healthcare Global is a trade organization whose aim is to use blockchain innovatively and extensively by reducing the deeply entrenched governance and regulatory barriers. Even though various technologies were used to aiming to provide efficient security, there were aa lot of privacy problems encountered. Blockchain technology ensures that patients can lead a healthy life by connecting their electronic medical data across various healthcare providers with the consent of the patients.

APPENDIX

It is optional. Appendixes, if needed, appear before the acknowledgment.

ACKNOWLEDGMENT

It is optional. The preferred spelling of the word “acknowledgment” in American English is without an “e” after the “g.” Use the singular heading even if you have many acknowledgments. Avoid expressions such as “One of us (S.B.A.) would like to thank ... .” Instead, write “F. A. Author thanks ” *Sponsor and financial support acknowledgments are placed in the unnumbered footnote on the first page*.

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