Electronic Healthcare Data Management using Hyperledger Fabric

Shreya Anand Gore | Snehal Chaudhari | Rahil Hastu

Group: Positive0

sgore12@asu.edu | sschaud5@asu.edu | rhastu@asu.edu

Computer Science and Engineering Department, Ira A. Fulton School of Engineering

Arizona State University

I. Introduction

People used to bring hard copies of their medical records to their doctor appointments because everything was recorded on paper in the past and there were no electronic storage options available. Patients would frequently forget important paperwork as a result of this practice, and keeping paper records presented additional difficulties. It was time-consuming to keep track of this manual documentation, and patients and physicians could run into problems if records were lost. As a result, electronic health records are becoming more and more popular worldwide (EMRs). The world is constantly working to improve the efficiency of the current system by storing the patient data electronically. EMRs have replaced paper-based records for many healthcare providers. EMRs make it possible for patient data to be digitally stored and made available to authorized healthcare providers.

After intensive research to gain deeper understanding of our domain from different papers and publication [1],[4],[6], we designed this project to be a best combination of most. Our project is a big step forward because it integrates the cutting-edge idea of blockchain into Electronic Health Records (EMRs). To improve patient data security and confidentiality, blockchain integration is the main goal. Blockchain uses a decentralized mechanism to store data, making it extremely safe and impenetrable. This method guarantees that patient data is secure and unaffected by unauthorized changes.

The EMR management system that we have implemented in this project is making use of a Hyperledger Fabric (v2.0) network to safely store patient medical records, with the patient at the centre of the system. This guarantees that any access to a patient's medical record necessitates express consent. By using this method, doctors can do all CRUD operations on their individual patient records, promoting effective and safe data management.

II. Application Design

The Electronic Medical Record (EMR) System we built is centered on three primary users: admin, patients, and doctors. Each user has unique use cases, and a user-friendly interface is in place to keep track of everyone's activity. The general topology of the system, as shown in Figure 1, highlights the detailed fabric network, which is color-coded for clarity.

One key design feature is the adaptability of every component, making the system highly customizable. This flexibility ensures that the system is not only functional but can also evolve with changing needs. The blockchain admin takes charge of setting up the network, providing essential access, and delivering credentials to users who manage the system.

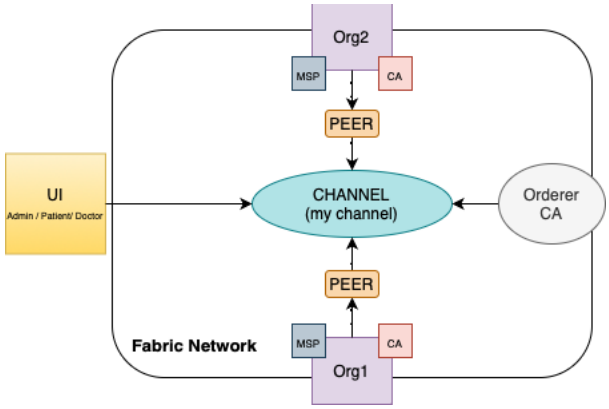

Figure 1. Architecture

In terms of technology, the backend code and smart contracts are written in JavaScript, and a strong REST API is built using the ExpressJS framework. The Vanilla JS framework is used to create the user interface, which emphasizes simplicity and responsiveness for an excellent user experience.

Aside from these aspects, the system introduces a significant shift in patient control.

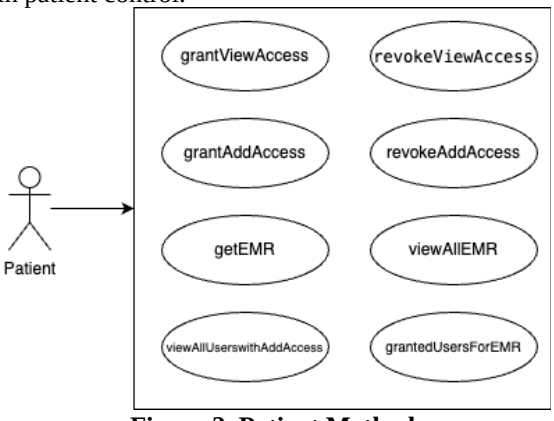

Figure 2. Patient Methods

Patients now play a vital role, with the ability to control how their records are accessed. They have the power to provide or revoke access to doctors. Patients can use this granular control

to decide whether a doctor can examine their EMR record or even add an Electronic Medical Record (EMR) item. This patient-centered approach improves privacy and empowers people to manage their own health data.

III. Individual Contributions

There are three main parts to the project. First is the User Interface, whose aim is to create an intuitive user interface that makes it easy for users to interact with the application. It acts as the front end, giving users an interactive, visual interface through which to enter data and receive information.

Second, a communication link between the system's backend and user interface is created by the server connections. This makes it easier for requests and data to move between the server's underlying processes and data and what users see and interact with on the front end.

Lastly, we make use of Chaincode for given features. The Hyperledger Fabric's functionalities are handled by this component. It includes the collection of guidelines and chaincode—that control how users interact with one another on the Hyperledger network. Within the Hyperledger Fabric framework, this system controls the logic and procedures for data storage, retrieval, and security. The task distribution is as follows:

Name	Contribution	Description
Shreya Gore	User Interface	Using HTML, CSS, Bootstrap
Rahil Hastu	Server Connection	Backend Integration using Node.js
Snehal Chaudhari	Chaincode Development	Using JavaScript

Table 1.0 Work Division

IV. Challenges faced

We gained more knowledge about the Hyperledger Fabric's chain code implementation during the course of this project. When we first set up the environment for the Hyperledger Fabric application, we encountered a few difficulties. To address these problems, we used more links from the course materials[7]. Once the networking setup problem was fixed, the next set of challenges was to comprehend the implementation of the chain code and create a workflow for it. Comprehending the syntax and development process for chain code in JavaScript, as well as the different functions of the 'fabric-contract-api' library—which aids in managing the ledger's state and triggering relevant events—were difficult assignments. We were able to overcome these obstacles with the aid of the course material, weekly posts from the discussion forum, and official documentation references[8].

Integrating the backend server with the chain code that was installed on the peers caused us with yet another significant challenge. We first had trouble connecting the packaged chain code to backend services that were exposed, but we were able to resolve this problem by using the examples found in the official documentation's 'fabric-samples/test/network' directory. Since generating valid root certificates was a significant problem for us, we chose to run the 'registerUser' and 'enrollAdmin' business logic prior to exposing the APIs to the specified endpoints. The lab 2 instructions were very useful in configuring the Hyperledger Fabric network. We used the same process, but we decided to use JavaScript instead of Golang since we were more familiar with it.

V. Solution Implementation

The proposed system uses Hyperledger Fabric to store and share medical records, and it is based on blockchain technology. The permissioned blockchain platform Hyperledger Fabric provides precise privacy and access control. Due to the grant and revoke access mechanisms, patients in this system have total control over the personal data that is shared with doctors. The admin, patient, and doctor user roles can interact in a transparent and secure manner thanks to the architecture. Each hospital has peers, orderers, and certificate authorities (CA) representing it in the fabric network of the high-level architecture. The steps for creating, editing, and accessing EMRs while preserving access control and privacy are described in the EMRContract smart contract. The deployed chaincode, named EMRContract, simplifies Electronic Medical Record (EMR) administration on a Hyperledger Fabric blockchain.

We decided to use CouchDB which is a more effective database option than LevelDB because of its flexibility and support for indexes. Individual transaction requests are spared from having to query the full transaction log because CouchDB acts as the ledger's world state. It is a good choice for patient data storage because it supports indexes and can handle images.
Healthcare providers, hospitals, and patients need to establish their credibility before being allowed to join the blockchain network. Hospital-specific certificate authorities bind the public keys of participants to certificates proving their identities and granting particular access. By verifying these identities, the Membership Service Provider makes sure every network user is participating consistently and securely.

The backend implementation makes use of Express since they provide a scalable and efficient server-side runtime. Express facilitates the creation of RESTful API endpoints and opens up a wider range of user interactions on the blockchain network. Changes made to the backend have given the user, patient, and doctor multiple options for completing the chaincode tasks. Physicians are able to import new EMRs and export old ones. These procedures will help you ensure that patient records are only accessible to and modified by licensed healthcare providers. Patients have access to add, remove, and retrieve information from any EMR by browsing a list of all owned

EMRs. Patients are able to control who has access to their medical records thanks to patient routes, which offer granular access control.

The query.js module allows the backend to interface with the Hyperledger Fabric blockchain network. This module makes it simple for the backend to carry out different tasks in response to user requests by abstracting the complexity of interacting with the blockchain.

VI. Result

We successfully implemented blockchain based healthcare records management system. We were able to improve the security, privacy, and accessibility of electronic medical records as a result of this project. The creation of electronic medical records and permission-based access control were two important features that were successfully implemented. Healthcare professionals can now safely exchange and access patient records in a decentralized, safe setting because of the system. Users of the application can now restrict access to patient records based on roles that have been predefined thanks to the implementation of a granular permission system.

Our system makes it easier to access records, guarantees the safe and open administration of electronic health records, and boosts overall healthcare data management effectiveness. We successfully streamlined the process of creating and managing electronic medical records using chain codes in permissioned network.

VII. Conclusion

Our project successfully helps keep in place all Electronic Medical Records (EMRs) for patients. Every patient can thus successfully access all of his/her records as well as grant or revoke doctor accesses on the same. Doctors can access and make changes to the EMRs and can all view all the patient EMRs collectively in one place. Entire system is completely decentralized and is not dependent on one central system. This project demonstrates the potential of blockchain technology to improve healthcare data management practices.

VIII. Supplemental instruction

The YouTube link for the presentation and demo are added in the here [10]. The github link for the code can be found here [11].

IX. References

[1] S. Aich et al., "Protecting Personal Healthcare Record Using Blockchain & Federated Learning Technologies," 2021 23rd International Conference on Advanced Communication Technology (ICACT), PyeongChang, Korea (South), 2021, pp. 109-112, doi: 10.23919/ICACT51234.2021.9370566.

[2] R. Saranya and A. Murugan, "A Hyperledger Fabric-based System Framework for Healthcare Data Management," 2023 7th International Conference on Computing Methodologies and Communication (ICCMC), Erode, India, 2023, pp. 552-556, doi: https://doi.org/10.1109/ICCMC56507.2023.10083620.

[3] Stamatellis C, Papadopoulos P, Pitropakis N, Katsikas S, Buchanan WJ. "A Privacy-Preserving Healthcare Framework Using Hyperledger Fabric". Sensors (Basel). 2020 Nov 18;20(22):6587. doi: https://doi.org/10.3390/s20226587. PMID: 33218022; PMCID: PMC7698751.

[4] Tian, H., He, J. & Ding, Y. "Medical Data Management on Blockchain with Privacy". J Med Syst 43, 26 (2019). https://doi.org/10.1007/s10916-018-1144-x

[5] S.B. Atreyapurapu, K. Amarendra and M. M. Alishah, "Hyperledger Fabric based Medical Record Security," 2022 4th International Conference on Smart Systems and Inventive Technology (ICSSIT), Tirunelveli, India, 2022, pp. 223-228, doi: 10.1109/ICSSIT53264.2022.9716403. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9716403

[6] I. G. A. K. Gemeliarana, D. Hanggoro, R. F. Sari and D. M. Romano, "Blockchain-Enabled Electronic Medical Record With Hyperledger Composer," 2021 8th NAFOSTED Conference on Information and Computer Science (NICS), Hanoi, Vietnam, 2021, pp. 71-76, doi: 10.1109/NICS54270.2021.9701546. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9701546

[7] https://hyperledger-fabric.readthedocs.io/en/latest/install.html

[8] https://hyperledger-fabric.readthedocs.io/en/latest/chaincode4ade.html

[9] https://github.com/hyperledger/fabric-samples

[10] https://youtu.be/yr27sgh6sK8

[11] https://github.com/rahilhastu/EMR-Management-System-using-Hyperledger-Fabric