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A Secure Blockchain-Enabled Framework for Healthcare Record Management and Patient Data Protection

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Abstract

Blockchain (BC)-based technologies can help solve many problems in the healthcare (HC) industry, mainly when it comes to managing growing amounts of health information technology (HIT) data safely and efficiently. This article talks about a new BC-based way to improve many areas of healthcare administration. These include data accuracy, prescription drugs, pregnancy information, supply chain oversight, risk data administration, Electronic Health Record (EHR) administration, data on safe access, permanent record-keeping, and effective data sharing. The study offers a way to safely handle patient medical records in the cloud that uses blockchain-based technology and a Hyperledger system in Amazon Web Services (AWS). The established structure is in a Virtual Private Cloud (VPC) to ensure limited access and efficient resource use. It improves access, safety, accountability, and sharing, addressing significant problems in healthcare data management and providing a scalable, effective, and safe way for EHR management in modern healthcare settings.

Keywords – Blockchain, Healthcare, Security, Data Protection.

1 INTRODUCTION

It is essential to know how to use Health Information Technologies (HIT) networks in modern healthcare, especially when using basic tools like Electronic Health Records (HER) (Chong et al., 2022; Si et al., 2021). Existing HIT systems have a hard time dealing with the large amounts of private health data gathered and the need to share patient records between different medical facilities. So, it's hard to keep this info safe with traditional databases.

The current problems with privacy and access in HIT systems show that a new approach to managing healthcare data is needed (Pool et al., 2022). This emerging system must simultaneously achieve several goals, including (a) protecting HC information data from unauthorized access, (b) building trust between HC players through transparent, patient-focused data sharing, (c) providing a decentralized solution to overcome the constraints of centralized structures; and (d) establishing a mechanism that guarantees authenticity of data and honesty. This outlines the necessary solution or equipment specifications to address these issues.

Blockchain (BC) is becoming essential in transforming HIT systems as an innovative, decentralized, and immutable ledger technological advance (Dash et al., 2021). Although BC possesses the potential to enhance information safety, information decentralized management, retrieval, communication, and authenticity in HC, its early emergence was mainly focused on bitcoin transactions, without the foresight of its application in other areas such as HC (Andrew et al., 2023). Currently, efforts to leverage the various uses of BC computing in creating HC organizations are emerging. However, problems such as the absence of agreement on the most effective BC architecture for constructing medical devices remain.

2 SYSTEM STRUCTURE AND EXECUTION

The system is architected using Amazon Controlled BC, explicitly focusing on the Hyperledger Fabric platform (Guggenberger et al., 2022). This integration ensures a strong and secure repository for storing clients' HC information. Figure 1 presents the structural design of the proposed structure, depicting a schematic representation of the infrastructural configuration and data flow inside the structure. The research has implemented enhanced security mechanisms, ensuring network access is confined to the Virtual Private Clouds (VPC) to protect information and activities from illicit access and possible dangers (Rajasoundaran et al., 2021).

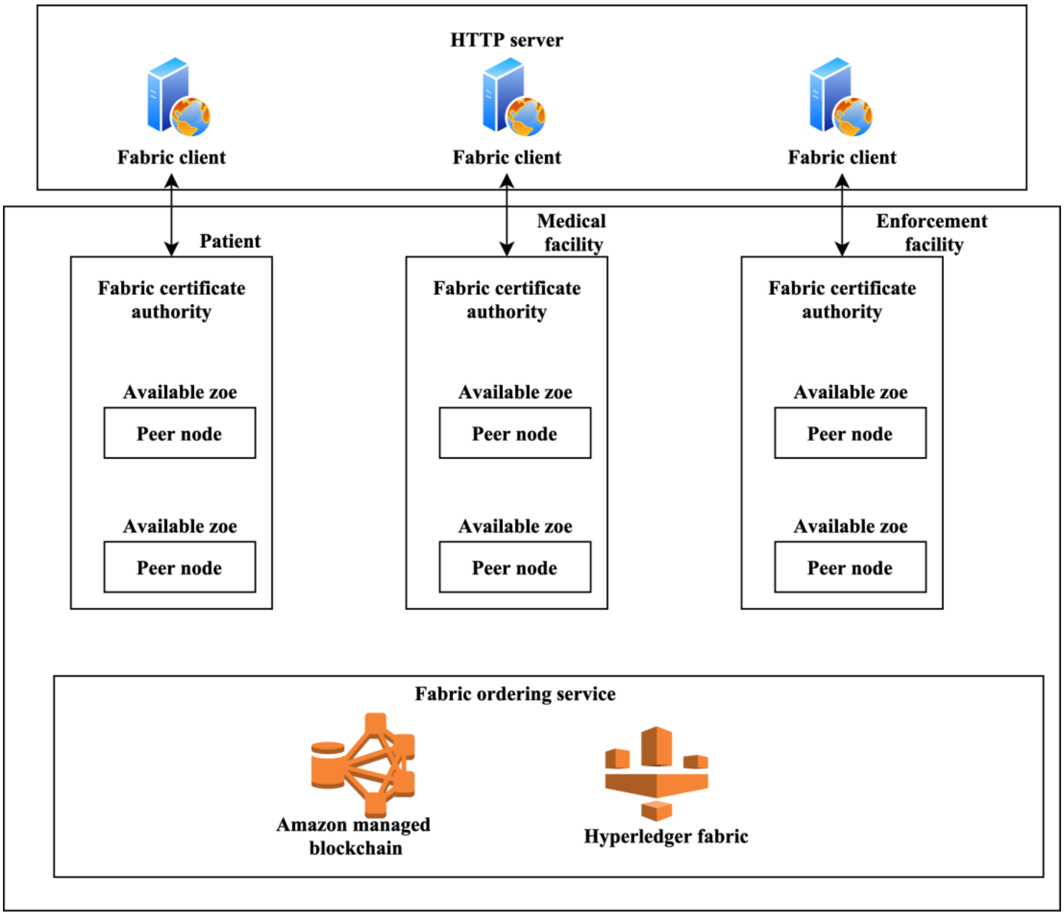

Figure 1: High-Level System Architecture

The solution emphasizes the inclusion of a suite of APIs designed for HC Managers, enabling them to safely produce, recover, revise, and remove patient records within the Hyperledger Fabric system. This guarantees secure data storage and promotes seamless communication with stored medical information, improving the speed and effectiveness of administrative duties within the medical field.

This undertaking signifies a crucial initial step in the exploratory endeavor to create a comprehensive system that integrates diverse user profiles inside a safe, transparent, readily available digital framework, including consumers, medical professionals, and hospitals. It facilitates the development of an integrated medical data management solution that allows many different groups to interact and access essential data effortlessly, guaranteeing every vital record is securely kept, accurately revised, and readily accessible, thereby enhancing the norms and effectiveness of medical care service delivery.

The AWS command-line interface offers a user-friendly and efficient platform for network building, allowing developers to progress through each stage of creation quickly (Maurya et al., 2021). This coordinated process systematically develops a resilient BC network that manages future data and transactional requirements. Figure 2 provides a visual guidance and structural plan, elucidating the process from inception to complete installation of networks in a straightforward, sequential manner.

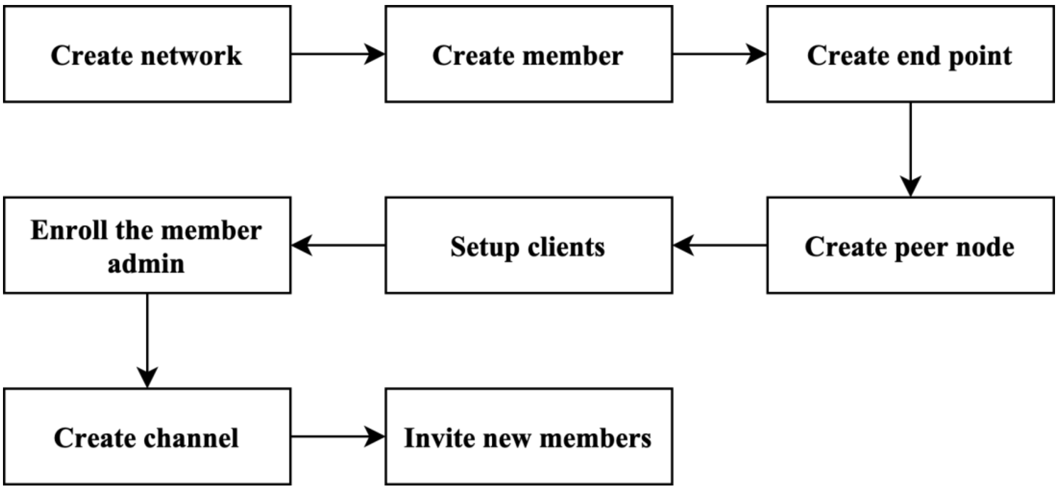

Figure 2: Creating BC Network

The initiation of BC network creation encompasses numerous essential elements, each aimed at guaranteeing optimal functioning and security. The following paragraphs clarify these steps:

1) The system's origin begins with its development, where the choice of foundation type is crucial. In this case, Hyperledger Fabric version 2.2 has been selected as the recommended framework.
2) Afterwards, a member is established with a small instance type, an approach designed to ensure cost efficiency during the initial setup stage.
3) A virtual private cloud gateway is established for the network to enhance security, ensuring exclusive access inside this VPC.
4) Proceed to establish a peer network. The nodes are vital for communication, enabling querying, modifying, and sustaining a regional version of the ledger through engagement with other members' peers within the distributed ledger.
5) Establishing a client is essential to optimize communication within the system and implement the chain code effectively.

6) The registration of administrative users within the established member's authentication authority occurs afterward. Securing the user's password is essential, a responsibility effectively managed by Amazon Secrets Management.
7) By employing an administrative client example, a channel is established, facilitating the dissemination of the ledger throughout the whole network, contingent upon the consensus of all participants on a common channel.
8) Future additions include inviting new users to associate with the social network. This enhancement promotes the involvement of diverse user groups, including managers and medical professionals, hence broadening user engagement.

Every step is crucial for guaranteeing efficient operation, dynamic functionality, and secure information storage inside the BC system. These methods should enhance the comprehensibility and accessibility of establishing a BC system on AWS.

3 IMPLEMENTATION OF THE SUGGESTED SYSTEM

The proposed architecture utilizes a BC with permissions to ensure that access is restricted to designated individuals, hence securing data access. The manager is registered by the Membership Service Provider (MSP), and his identification is integrated into the wallet. The identity comprises a public certification, a secret key, the certification type, and an identification version. The system administrator can then sign up and enroll fresh users. In addition to identity, a token is created for each registered user. A token is a key for encryption representing an asset belonging to a user. A fabric tokens administration system issues, transfers, and redeems tokens via Hyperledger Fabric. It is acknowledged that Tokens are retained in the channel ledgers and are possessed by every channel participant. The FabToken system utilizes Fabric's membership amenities to validate the token holders' identities and maintain their secret and public keys.

In the suggested system, those participating are limited to individuals, doctors, pharmacies, and laboratory workers. The research recommends utilizing two BC routes: a medical equipment BC route and a remote consulting BC route. Clinicians and patients use the BC route for devices to manage wearable HC equipment's facts, assignments, and statuses. This channel additionally preserves pertinent Internet of Things (IoT) gateway information. The discussion BC channel facilitates access to client medical records for patients, doctors, pharmacies, and laboratory workers, enabling the transmission of vital signs and the sharing of HC information with relevant parties.

4 RESULTS

This section conducts multiple experiments to assess the efficiency of the suggested medical system for transaction productivity, transaction delay, read productivity, block size, and read delay. The research utilized Hyperledger Caliper, an open-source measuring tool created by Linux, enabling users to assess the efficiency of BC applications. The study examines specific network metrics to analyze the experiment, including four peer nodes that reflect the subjects (peer cautious, peer physician, peer pharmacies, and peer lab worker) and a solitary orderer node.

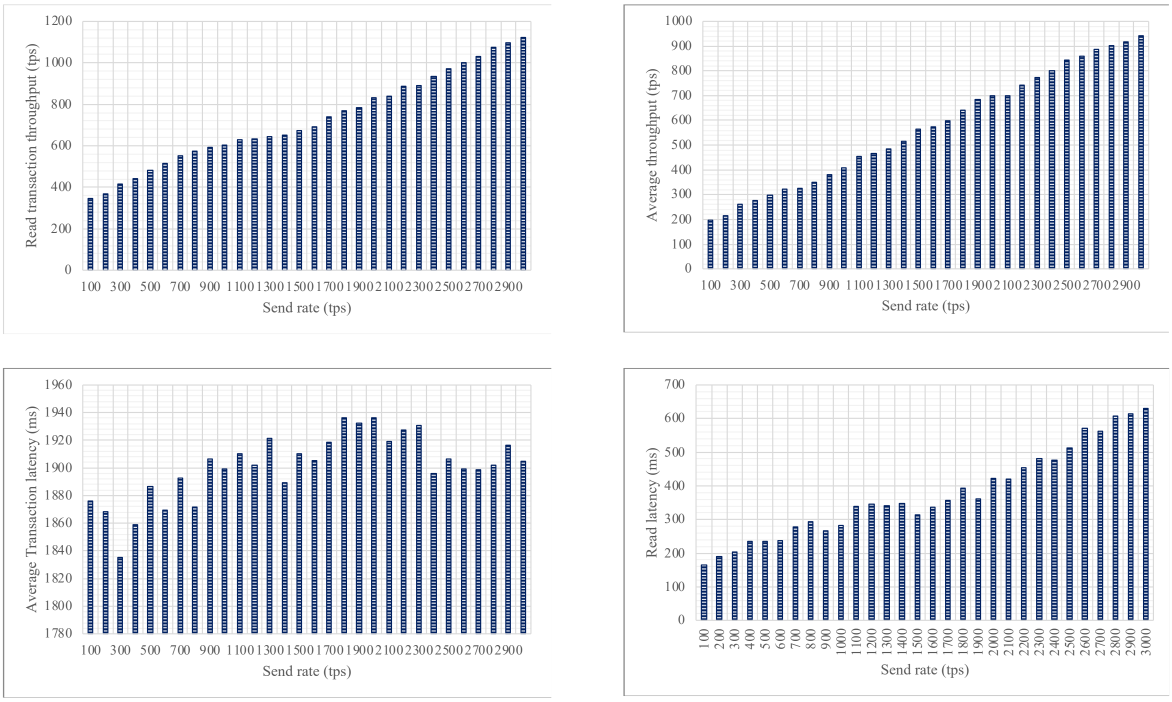

Figure 3: Throughput and Latency Analysis

The research subtracts the total number of mistakes from the overall transaction count to achieve successful deals. The read capacity of the developed system is evaluated by varying the send rate from 550 to 3500 events per second (eps), as illustrated in Figure 3, with a random arrangement of machine utilization. The chart indicates that read transaction speed markedly increases under the optimal case until it peaks, followed by a tiny decline after a send rate of 2650, deemed the optimal situation. The transaction flow is assessed by adjusting the send rate from 250 to 1450 eps. The average transaction speed rises with the send rate until it peaks at 1250 eps. The ideal situation for an average transaction rate is 1250 eps; thereafter, throughput declines as the final turn rate escalates.

The mean transaction delay is evaluated by adjusting the transmit rate from 250 to 1450. The research subtracts the total number of mistakes from the overall transaction count to achieve successful deals. The read capacity of the developed system is evaluated by varying the send rate from 550 to 3500 eps, with a random arrangement of machine utilization. The chart indicates that read transaction speed markedly increases under the optimal case until it peaks, followed by a tiny decline after a send rate of 2650, deemed the optimal situation. The transaction flow is assessed by adjusting the send rate from 250 to 1450 eps. The average transaction speed rises with the send rate until it peaks at 1250 eps. The ideal situation for an average transaction rate is 1250 eps; thereafter, throughput declines as the final turn rate escalates. The median transaction delay of the suggested medical BC network experiences a minor rise up to a transmit rate of 1150 eps. As the volume of requests escalates beyond

1150 eps, the delay of the BC platform rises linearly. The ideal transmission rate for transaction delay is projected to be 1150 eps.

The mean read transaction delay is assessed by altering the transmit rate from 550 to 3500 eps. The delay for reading transactions slowly grows until it reaches a send rate of 2550 eps, which is considered ideal. However, as the number of read requests increases, the read delay value goes up linearly beyond the perfect 2550 eps.

5 CONCLUSION

This study shows a new way to create a fast, cloud-based system for keeping HC data safe and returning it to a Hyperledger BC infrastructure. The system can quickly move five million historical papers around and handle daily data waves. The system's ability to handle multiple people simultaneously was tested with the basic version of Amazon Sponsored BC, which showed its strength and easy integration with AWS services.

The study stresses how important it is to use automatic testing and quality control to ensure that experimental results are correct, saving time and money and making things more accurate. The suggested system is mostly about storing and analyzing data, setting the stage for future improvements, and adding new features to make the system safer and easier to use. Speeding up testing processes could include combining them with the latest technologies like artificial intelligence and machine learning. Multiple-factor authentication to protect important and private data and the ability to expand to bigger machines for better efficiency are some improvements being considered. With these planned changes, it's clear that the system could keep improving to meet HC data governance's changing needs.

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