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A Private Permissioned Blockchain-Based Architecture for Secure Personal Healthcare Data Sharing in Telemedicine

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Abstract: *Blockchain technology has garnered significant attention for its potential to enhance the security, transparency, and trust of data-sharing frameworks. Its applicability spans diverse sectors, effectively addressing concerns such as data centralization, compliance, and traceability. In healthcare, managing Personal Health Records(PHR) poses challenges related to ownership, confidentiality, and accuracy. Integrating blockchain with telemedicine opens new avenues for secure remote healthcare services. This paper proposes a permission blockchain framework utilizing Hyperledger Fabric to safeguard PHR transactions among healthcare entities. The model adopts Byzantine Fault Tolerance (BFT) to maintain system integrity even under node failure or malicious activity. Off-chain data storage is handled using the Interplanetary File System (IPFS), ensuring decentralized and secure file management. Smart contracts offer fine-grained access control to empower patients with data autonomy. The framework's performance is evaluated using Hyperledger Caliper, focusing on latency, CPU usage, and memory efficiency during record access and update operations. Overall, the system enhances data security and efficiency in telemedicine, promoting patient empowerment and reliable health data sharing.*

Keywords: Hyperledger, Blockchain, IPFS, Telemedicine

I. INTRODUCTION

The primary objective of this paper is to develop a blockchain-based architecture that improves the storage, security, and accessibility of personal healthcare data within the telemedicine environment. By designing a decentralized infrastructure, the project aims to address the common issues associated with centralized healthcare data systems, such as security vulnerabilities and excessive reliance on third-party administrators. The implementation focuses on allowing patients to manage their comprehensive medical records, enabling seamless access across multiple healthcare facilities. This approach not only enhances the accuracy and continuity of patient care but also minimizes the redundancy of diagnostic procedures. Moreover, the proposed framework aims to uphold patient confidentiality and privacy, even when records are accessed for legitimate research or analysis. Through the integration of blockchain mechanisms, the project strives to create a reliable, secure, and patient-centric digital healthcare system.

II. LITERATURE SURVEY

V. D. S. Sri and S.Vemuru (2023): This research introduces a hybrid strategy that enhances the performance of cloud-based medical computing systems through effective data replication and partitioning mechanisms. In many traditional setups, replication is resource-intensive due to deployment across multiple virtual machines. The proposed method operates in two stages: first, decision patterns generated by machine learning algorithms are duplicated across various servers to enhance data recovery; second, partitioning is carried out to organize cloud-stored data more efficiently.This dual-phase system enables better handling of large-scale datasets in real-time environments. Experiments reveal that

this method surpasses existing techniques in computational speed and accuracy, achieving metrics like 98.23% accuracy, 94.53% sensitivity, and 92.29% recall, making it suitable for real-time health data applications.

C.Li et. al (2023):The authors propose an ovel framework to improve multi-view dataprocessing, which is essential for applications involving heterogeneous data sources. Traditional clustering methods fail to capture complex, nonlinear relationships due to their reliance on Euclidean distance and hard clustering models. To overcome these issues, this study introduces LRTGFL—a model that utilizes Jensen-Shannon divergence for better detection of nonlinear patterns, integrates fuzzy logic for soft clustering, and employs tensor decomposition to retain high-dimensional correlations.The training process is optimized using the ADMM algorithm. Tests on multiple real-world datasets show that the proposed model achieves more reliable and interpretable clustering results compared to state-of-the-art methods, thus benefiting applications like IoT-based data integration and cloud analytics.

Y.Cai et. al(2024): In complete multi-view datasets pose a significant challenge for clustering, particularly when data from various sources have inconsistent missing values. Most conventional models assume balanced missing data, which doesn't reflect real-world conditions. This study introduces a new model—PCL_UIMVC—that reconstructs missing features by leveraging existing data, uses a projection matrix to align feature dimensions across views, and includes a graph regularization term to maintain the structural integrity of data. An iterative solver is employed to train the model. The approach was tested across eight datasets, showing high accuracy and resilience against unbalanced data loss, which makes it highly applicable in medical and biometric datasets with irregular sampling.

III. METHODOLOGY

• User Interface Design

This module includes login and registration interfaces for all user roles. It manages authentication by verifying credentials before granting access. Users must register by providing details such as username, password, and email, which the server uses to maintain user accounts and data flow rates.

• Admin

Admin users can log in using their ID and password. They are responsible for adding new physicians to the system and can view all physician records for monitoring purposes.

• Physician

Once registered by the admin, physicians can log in and interact with patient data. They can view submitted symptoms, forward reports for scanning, review results, and issue electronic prescriptions, send to patient.

• HSP

The fourth module is a HSP. HSP will login and scan patient and send reports for physician based on HSP symptoms

• Patient

Patient is a fifth module. Patient have to register and login with a patient id and password. Patient has to enter symptoms and send to physician. After sending reports for patient physician will send reports for user and use prescription.

IV. ALGORITHMS USED

Blockchain

Blockchain is a decentralized ledger system that enables transparent, tamper-proof, and sequential recording of transactions across a distributed network. Every transaction is grouped into a block, cryptographically linked to the previous one, creating an immutable chain. Once data is added, it cannot be altered or deleted, making the system highly secure and trustworthy. Although blockchain is widely recognized for powering crypto currencies like Bitcoin, it has significant applications beyond finance, particularly in fields such as supply chain management, digital identity, and healthcare data security.

Hyperledger Fabric

Hyperledger Fabric is a permissioned blockchain framework developed under the Linux Foundation's Hyperledger project. Unlike public blockchain networks where anyone can participate, Fabric restricts access to known and verified

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participants, making it ideal for business and enterprise solutions that require data confidentiality and governance. It supports modular components, including consensus mechanisms, identity services, and smart contract logic—called "chaincode" in Fabric.

The framework allows organizations to define granular control over who can view, add, or modify data on the network. It also supports private channels for confidential transactions between specific participants, without revealing data to the entire network.

Blockchain framework using Hyperledger Fabric

Hyperledger Fabric serves as the backbone of the proposed permissioned blockchain system due to its modular and enterprise-friendly features. Unlike public blockchains, Fabric enables a controlled environment where only authorized users can participate in the network. Each participant is assigned a unique identity by a certificate authority (CA), which governs their access permissions within the blockchain. The system uses chaincode (smart contracts) to define the logic behind data sharing, access control, and transaction processing. It employs a pluggable consensus model such as Practical Byzantine Fault Tolerance(PBFT) to ensure fault tolerance and maintain network integrity even when some nodes act maliciously or fail. The ordering service component arranges transactions into a consistent sequence, ensuring accurate ledger updates. Furthermore, Fabric supports the use of private channels, allowing different healthcare entities—such as patients, physicians, and hospitals—to exchange sensitive data in isolation while preserving network-wide synchronization. These features make it a robust platform for handling confidential medical records in telemedicine.

System Architecture:

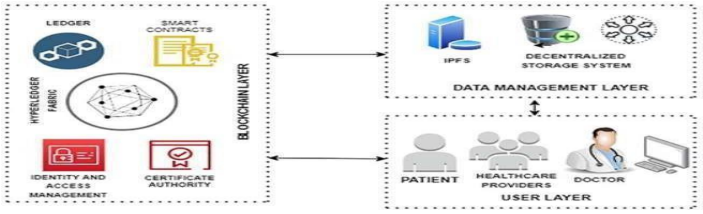

Fig 1: System Architecture

The proposed system architecture is structured as a layered model to ensure secure and efficient sharing of personal healthcare data in a telemedicine environment. It is composed of three main tiers: the user layer, the blockchain layer, and the data management layer. The user layer facilitates interaction between different stakeholders such as patients, physicians, and healthcare service providers through a web-based interface or decentralized applications. Each user is assigned a unique blockchain identity, which is used to authenticate their role and manage permissions within the system. The blockchain layer forms the core of the architecture and operates using Hyperledger Fabric, a permissioned blockchain framework. This layer ensures that only verified users can participate in transactions by issuing digital certificates through a Certificate Authority (CA). Every transaction request is evaluated against a set of smart contracts, which contain predefined rules for data access and operations.This not only enhances trust but also prevents unauthorized or fraudulent actions within the system. The data management layer handles the actual storage of medical records. To reduce the load on the blockchain and increase performance, large healthcare files are stored off-chain using the Inter Planetary File System(IPFS).This distributed storage system provides a secure and scalable method for managing sensitive data. Instead of saving files directly on the blockchain, only the IPFS-generated cryptographic hash of the data is stored on-chain. This hash acts as a verification key to ensure data integrity and allows seamless retrieval when required. Overall, this architecture strikes a balance between security, decentralization, and operational efficiency, making it highly suitable for healthcare environments where data privacy and integrity are paramount.

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V. EXPERIMENTAL RESULTS

Application Homepage–Solid State Interface

Fig 2: Application Homepage

This is the main homepage of the telemedicine application, which introduces a blockchain-based healthcare data sharing system aimed at enhancing data security and accessibility.

Main Menu Display–User Role Selection

Fig 3: Main Menu Display–User Role Selection

The menu displays the available user roles such as Admin, Physician, HSP(Healthcare Service Provider), Patient, along with a Sign-Up option for new users.

Patient Login Interface:

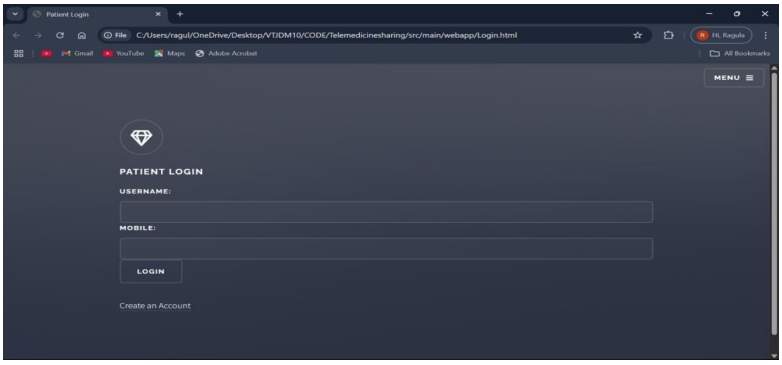

Fig 4: Patient Login Interface

The patient login interface provides a secure and user-friendly way for patients to access their personal dashboard.

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Patient Registration Interface – Extended View

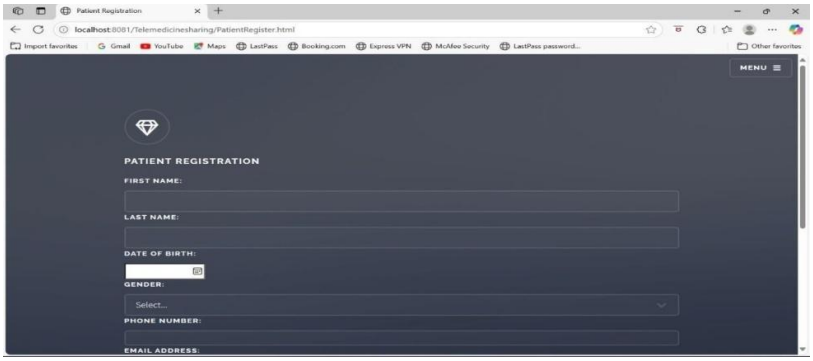

Fig 5: Patient Registration Interface–Extended View

This snapshot showcases an extended version of the patient registration screen, featuring additional fields to capture detailed personal and medical information.

VI. CONCLUSION

This paper presents a secure and efficient blockchain-based framework for managing personal healthcare records in a telemedicine environment. By implementing a permissioned blockchain using Hyperledger Fabric, the system ensures that only verified participant scan access and share sensitive medical data. This architecture addresses the key challenges faced by centralized systems, such as data breaches, unauthorized access, and lack of transparency. The inclusion of smart contracts enables fine-grained control over data access, empowering patients to decide who can view or modify their records. To reduce the load on the blockchain and improve scalability, large datasets are stored off-chain using the Interplanetary File System (IPFS), with cryptographic hashes ensuring data integrity.Performance metrics evaluated using Hyperledger Caliper confirm that the system maintains low latency and efficient resource usage during data access and updates. Overall, this approach strengthens data privacy, enhances interoperability, and paves the way for more patient-centric and reliable healthcare solutions through the integration of decentralized technologies.

VII. FUTURE ENHANCEMENT

Looking ahead, several enhancements can be introduced to further improve the capabilities of the system. Implementing backward security would prevent the exploitation of previously granted access once permissions are revoked, thereby increasing trust and data safety. The adoption of distributed query execution and parallel processing using multiple blockchain nodes could significantly reduce latency and enable real-time analysis of medical data. Adding a semantic interoperability layer would allow healthcare systems to interpret and integrate data from various formats more meaningfully, enhancing compatibility and system intelligence. Furthermore, the integration of Decentralized Identity (DID) frameworks can offer patients more control over authentication and authorization, reducing dependency on third-party verification services.

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