A Resolution to Facilitate Healthcare Systems Using Blockchain Technology

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Abstract

One of the most recent technologies is blockchain. It is used in many industries, including healthcare, finance, supply chain management, etc. A distributed technology called blockchain makes data or information available to all network nodes. It serves as an electronic database and stores information in digital form. Blockchain is widely famously employed in cryptocurrency systems to create a secure and decentralized transaction. However, a blockchain may be used to store any data. Not only is the data related to cryptocurrency but it is also used in healthcare systems. We can use blockchain to record and store patient data due to its distributed nature. But on the dot, this has become a problem as the data of the particular patient will be all over the network which increases the risk and complexity to handle the data. So, we are going to look for a solution and utilize it. Hence, the data will be authorized, authenticated, transparent as well and highly secured. The patient controls access to the data by using the consortium type of the blockchain. The patient decides who can use and access their data and this can be the most beneficial aspects of using blockchain in healthcare.

Keywords: Medical record, Smart Contract, MetaMask, Decentralized system, Authentication

1. Introduction

The increased fragmentation of medical data causes problems for several practitioners, researchers, and patients. Disparate data formats and work processes make this situation difficult [1]. Health Care Information Exchange (HIE) has been proved to be privileged in recent years [2]. HIE is particularly useful for a patient's diagnosis, treatment, or checkup. Because the patient does not have to repeat the checkup when he or she visits another doctor. Doctors may readily access patients' previous data and records and treat them accordingly. Cloud computing was an early area of HIE success [3]. In contrast to storing data on a computer or a server at work, cloud computing stores data online. Anyone with the necessary credentials may instantly access the information from any location with an internet connection. On the other hand, it was challenging for CSP (Cloud Service Provider) to manage and retain the data on the cloud [4]. Because if we utilize cloud computing, there is a potential that the data may be changed or tampered with. In such cases, Blockchain technology, which came forth in 2008 [5] and sparkles in 2014 [6]. The authors created a blockchain which is a decentralized, distributed, and

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frequently public digital ledger made up of records called blocks, which are used to register transactions across several computers [7]. We are developing a smart contract that automates transaction procedures, ensuring data is immutable and non-repudiable, ensuring successful completion [8]. Blockchain securely stores patient data on multiple computers, improving member health management, sharing data across health systems to lower transaction costs and risks.

2. Literature Review

A healthcare platform using blockchain secures patient data by using smart contracts, enhancing privacy by replacing patient identifiers with pseudonyms and implementing fine-grained access control. Efficient protocols and data sharding improve scalability, but concerns about centralization arise compared to public blockchains. The platform stands out for its privacy focus [9].

Liu et al. proposed a blockchain-based system for managing multimedia data, enhancing security, transparency, and user control. Despite challenges like performance, technical complexity, and legal considerations, the potential is vast, paving the way for secure applications like music streaming and healthcare data sharing [10].

Chendeb, et al. have created a blockchain-IoT system that integrates multiple layers of technology, ensuring transparency in data sharing, ensuring health data safety, and allowing authorized parties to access and share it securely [11].

Emeka Chuwu and Lalit Garg have explained, blockchain technology uses a tamper-proof ledger to store and share patient information, enhancing security and transparency. It improves care coordination and efficiency by enabling seamless data exchange. Despite challenges like scalability and clear guidelines, blockchain's potential to revolutionize healthcare is undeniable [12].

Faheem et al. proposed [13] a novel blockchain-based interoperable framework (BCIF-EHR) that combines the strengths of HL7 and HIPAA, to address the challenges of electronic health record (EHR) systems. The framework aims to improve interoperability between different healthcare entities while protecting patient data privacy and security. It leverages the flexibility and communication efficiency of HL7 for data sharing and the robust privacy and security features of HIPAA.

Vishal Patel proposed [14] a decentralized blockchain system, where data is distributed across multiple nodes. Each node holds a complete copy of the data, creating a "digital ledger" tamper-proof and transparent. In this system, data remains encrypted, and the key is under your control. Every change to the data needs verification from the network, making it virtually impossible to tamper with. It's a transformative step towards a healthcare system that is secure, efficient, and, most importantly, patient-centric.

2.1 Blockchain implementation in health care systems

Privacy, integrity, sharing records, enrolment of patients' data and other difficulties may come up in medical studies [15]. Healthcare researchers are using blockchain technologies to address issues in the rapidly growing healthcare sector. They are combining permissioned cryptocurrency with a hospital-based database management system. Ethereum network agreements are found to improve database reliability in clinical trials [16].

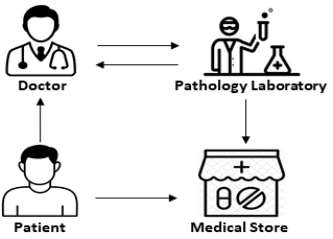

Fig 1: Medical Record Management

Even while all departmental activities, including physician diagnoses or prescriptions, laboratory tests, and doctor-recommended medications are recorded or remotely handled, monitoring each patient's data activity is essential. Thus, one of the current uses of blockchain technology breakthroughs in medical research is patient participation. In different research, a mechanism was put in place to get patients' express consent for keeping track of and storing it in a reliable, safe, and unverifiable manner.

2.2 Blockchain-based healthcare system framework

In Fig. 2, the suggested healthcare platform's design is depicted. It consists of a web-based application with two sides: a front end that connects patients and a back end that facilitates communication through blockchain [17]. The recommended healthcare system is straightforward to comprehend and features web-based interactions between patients and doctors, by running a back end that functions as a network of networks and is related to the blockchain communications process.

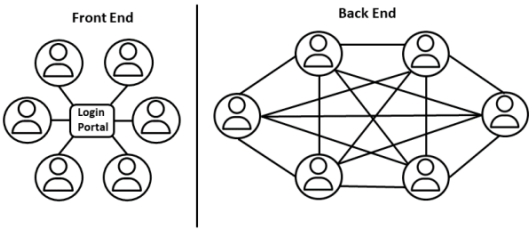

Fig 2: Framework Architecture

The healthcare blockchain process was examined using 2 distinct types of networks: authentication nodes or miners, with the remaining nodes serving as execution nodes [18].

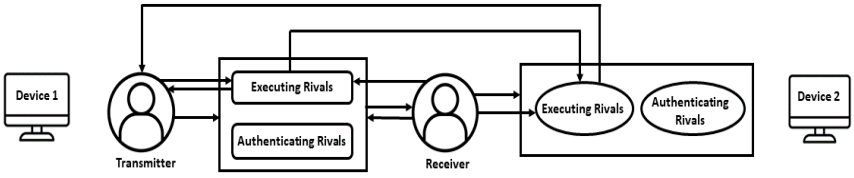

Fig 3: Components of Virtual Machine System

The miner and execution nodes verify the validity of transactions after accepting or rejecting them, ensuring correctness in database data replication. Two virtual machines

(VM) mimic real blockchain operations, with Device 1 hosting the executing network and Device 2 running the miner and execution nodes.

2.3 Functional requirements for blockchain in healthcare

Blockchain technologies are popular for their potential in various industries, tax collection, and unification, particularly in the medical field for accurate disease cost estimation and report tracking. Patients may be pressured into unnecessary tests or change their primary care physician, leading to data, test results, prescriptions, and billing being stored on the blockchain. The blockchain system ensures transparency and accountability in medical treatment by preventing suppliers from changing prescription drugs or expense reports without patient consent and storing invoices for multiple tests or drugs.

3. Methodology:

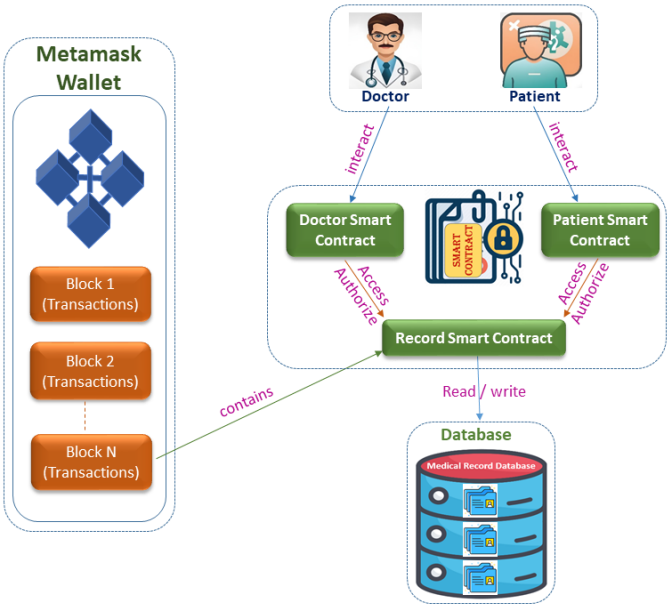

Fig 4: System Architecture

The block diagram illustrates a blockchain-based system for securely managing medical records, granting patient data authority and allowing medical professionals to access it safely.

3.1 MetaMask Registration

MetaMask, a browser plugin, simplifies wallet management and blockchain connectivity. It allows users to generate new Ethereum wallets or link existing ones to the platform. The plugin and strong authentication ensure secure transactions. Users can link their online applications to their wallets, promoting an efficient and user-friendly experience. This enhances the platform's security and user-friendliness.

3.2 Authentication

Authentication is the process by which the patient verifies their identity to gain access to the blockchain-based medical record system. This typically involves providing credentials such as a username and password, which are securely stored and authenticated against the system's database. Authentication ensures that only authorized individuals can access the patient's medical records, protecting sensitive health information from unauthorized access.

3.3 Smart Contract Execution

Smart contracts on blockchain validate patient access to medical records, ensuring authorized individuals only. They use decentralized consensus to verify identities and provide a secure, transparent method of managing access without intermediaries.

```
contract MedicalRecord{
    uint public recordId;
    mapping(uint=>Record) records;
    mapping(uint=>bool)public isDeleted;
    struct Record{
        uint recordId;
        uint timestamp;
        string name;
        uint age;
        string gender;
        string bloodGroup;
        string allergies;
        string diagnosis;
        string treatment;
    }
```

Fig 5: Declaring state variables and defining the structure of a medical record

In Struct Record (fig 5), attributes required for storing a patient's medical record are declared. In Solidity, mapping creates a relationship between keys and values, allowing convenient access to the data stored within the previously defined struct. When marked as 'public,' these values become accessible. This system encompasses patient data, medical backgrounds, and treatment specifics.

```
function addRecord(
    string memory _name,
    uint _age,
    string memory _gender,
    string memory _bloodGroup,
    string memory _allergies,
    string memory _diagnosis,
    string memory _treatment
) public {
    recordId++;
    records[recordId]=Record(
        recordId,
        block.timestamp,
        _name,
        _age,
        _gender,
        _bloodGroup,
        _allergies,
        _diagnosis,
        _treatment
    );
```

Fig 6: Function to add the medical record

Upon invoking addRecord (fig 6) with the necessary inputs, it raises the recordId, generates a fresh Record structure containing the given specifics, and deposits it into the records mapping, utilizing the increased recordId as the reference point. This process seamlessly introduces a distinct medical record into the system, complete with individual identification and pertinent.

3.4 Granting Access to Doctors

Patients have the ability to retrieve their medical records via a blockchain-based system, setting permissions and initiating access requests. Smart contracts enforce access control rules, ensuring only authorized parties can view the information.

3.5 Accessing Medical Records

Blockchain allows patients to securely access their medical records, ensuring privacy and continuity of care. The user-friendly interface allows easy navigation through diagnoses, treatments, medications, and lab results.

4. Implementation

Fig 5 shows a potential workflow for a blockchain-based medical record system that emphasizes data validation and storage.

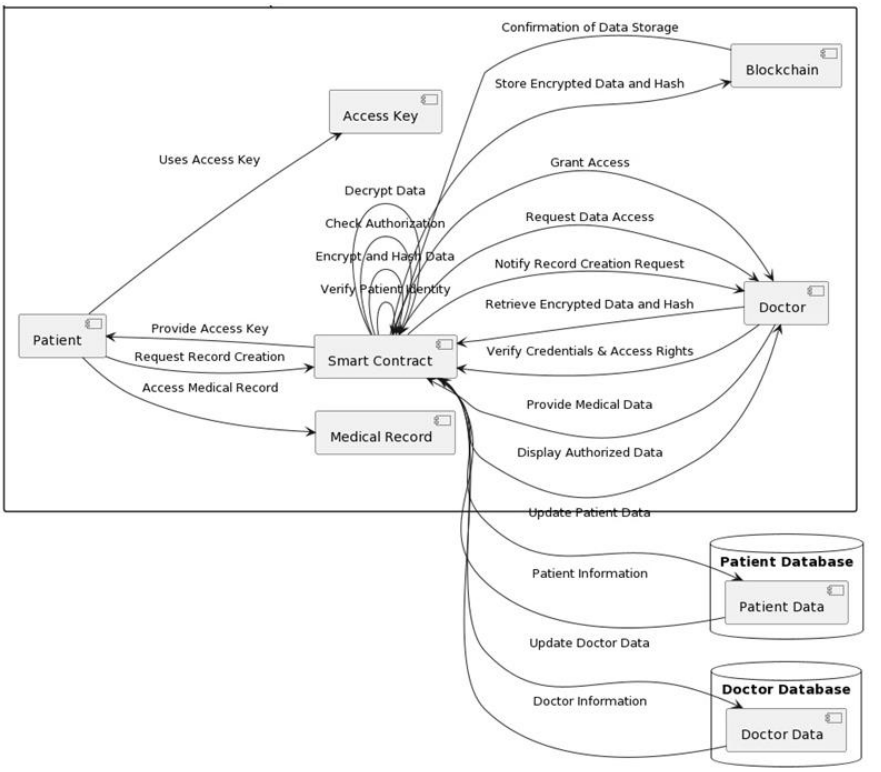

Fig 7: Dataflow diagram

A. Data Storage Encrypted:

- The word "Store Encrypted Data and Hash" is highlighted in the top centre box, highlighting the fact that medical records are encrypted and kept on the blockchain.
- Sensitive patient data is protected and confidentiality is guaranteed.
- Every record also generates a hash, which functions as a distinct fingerprint to confirm data integrity without disclosing the actual content.

B. Blockchain Technology:

- The main concept—that medical records are kept on a distributed ledger—is furthered by the noticeable blockchain symbol that appears beneath the encryption box.
- Since all authorised participants would be able to see any changes, this decentralised approach makes data transparent and impervious to tampering.

C. Access Controlled by the Patient:

- The "Provide Access Key" and "Verify Patient Identity" actions are located in the "Patient" block on the left.
- This shows that individuals actively control who has access to their medical records. They go through an identity verification process and give authorized individuals a unique access key.

D. Requests for Doctor Access:

- Actions like "Request Data Access" and "Verify Credentials & Access Rights" are displayed in the "Doctor" block on the right.
- Physicians request access by submitting their credentials for validation and making data requests.
- They might also have to supply pertinent medical information to create records.

E. Smart Contracts as Gatekeeper:

- The "Smart Contract" block in the middle is essential to access control.
- It serves as a gatekeeper, receiving requests from physicians and patients.
- Based on pre-established guidelines and patient consent, the smart contract authenticates identities and access rights.
- If everything is in order, access is either granted or denied.

F. Data Updates and Flow:

- Record Creation: A patient must authenticate their identity and a doctor must submit medical information to create a new record. Next, the hash and encrypted data are recorded on the blockchain.
- Data Access: Using the patient's key and their login credentials, doctors can request access. If approved, the smart contract verifies both and provides access to pertinent encrypted data.
- Updates to Data: Physicians can add new information to a record after gaining access to it. An unchangeable audit trail is produced by hashing, encrypting, and storing this updated data on the blockchain.

G. Verification and Extra Information:

- The blockchain symbol with a green checkmark next to it indicates that encrypted data storage was successful.
- Under the labels "Patient" and "Doctor," separate sections are provided, suggesting that supplementary information might be stored in distinct databases to enhance accessibility.

5. Results and Discussion

We have created a blockchain network that can be used to store patient medical data, and patients have full control over granting or denying access to the doctor they choose. We used a solidity-written smart contract to accomplish this task. After the smart contract has been successfully executed, the process begins with the creation of the contract address and block, shown in figure 8.

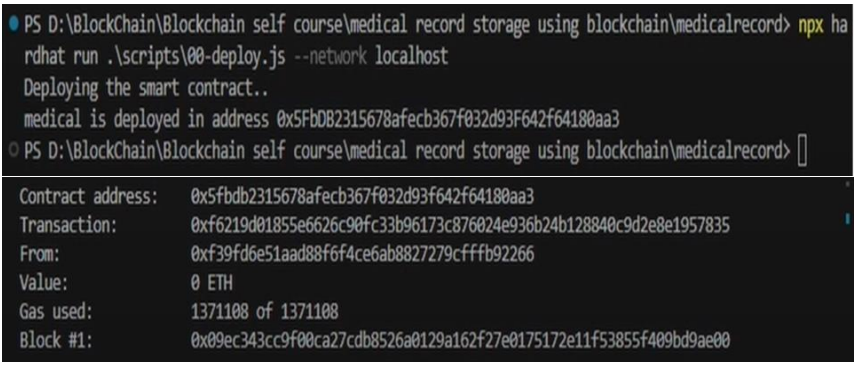

Fig 8: Creation of contract address and block

After the creation of contract address and block, Hashcode and a private key will be generated. These can be used to authenticate the user while accessing the data. Resulting to achieve data privacy and security from data breachers and prevents data tampering.

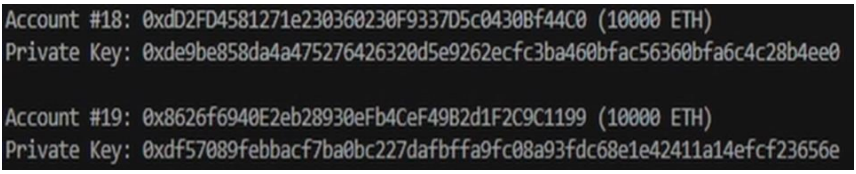

Fig 9: Hashcode and private key

Hardhat can deploy a smart contract for secure patient data storage, addressing data privacy concerns. Blockchain technology's transparent feature ensures data access for specific purposes, enhancing transparency and safety in healthcare. Implementing blockchain in healthcare can provide interoperable medical record management for patients and doctors.

6. Conclusion

Blockchain-based medical record systems are poised to revolutionize healthcare, but challenges like legal frameworks, technical integrations, and public trust need to be addressed. Despite these challenges, the promise of secure, transparent, and patient-centric data management remains exciting. By combining various data sources, blockchain technology has the potential to completely transform the healthcare industry and guarantee accuracy and attentive treatment of each patient's unique needs. This technology not only bridges the gap between different data sources but also acts as a unified presence in a decentralized world, paving the way for personalized health experiences. Its ability to meet each patient's needs with precision and care is a testament to its potential in a secure future for healthcare.

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