

Storage of Electronic Health Records Securely using Blockchain Technology

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Abstract:

Blockchain is a secure and decentralised technology to store any kind of information which is gaining immense popularity in various sectors. As these sectors stand to benefit from this concept, it encourages them to employ it within their organisations. This paper essentially describes the use of this exceptional technology in maintaining health records digitally, avoiding the need of any physical documentation prone to loss and error and analyses it for its effectiveness in the field

Keywords — Blockchain, nodes, peer-to-peer, hash, decentralised network, EHR, Ethereum, Smart Contracts.

I. INTRODUCTION

Blockchain as a technique was introduced in the year 1991 explained as a chain of blocks containing information intended to timestamp the digital documents so that there is no backdating or tampering of any kind. The concept was unused until 2009, when Satoshi Nakamoto, the founder of Bitcoin employed this in creating a digital cryptocurrency.

Blockchain is a kind of distributed ledger, completely open for anyone to access and once any data is entered into it, it is close to impossible to make any changes to the data. Hence, providing a secure way to save data digitally. In a more technical way, blockchain can be described as a shared immutable record of transactions each consisting of a block held together by cryptographic keys stored in a shared ledger called hashes. Another added advantage to the blockchain technology is that the need of having a central server is avoided here, the system is a distributed one. It works on a peer-to-peer network.

The ledger is maintained in all the nodes present in the network. It will be discussed how tampering is tracked and avoided in the network in the following sections of the paper. Its tamper-resistant and decentralized nature makes it a remarkable way to store any kind of personal or business related information.

II. LITERATURE REVIEW

This paper puts light on blockchain being used to share and store Electronic Health Records over a decentralised peer-to-peer network. It reviews the present literature and focuses on details like the data types to be used, the standards to follow and about the architecture of the system. [1] This paper analyses the benefits of blockchain technology on open science. It reviews literature and also projects to describe the current situation. It also points out the challenges and states the research potential. [2]

Blockchain in the healthcare sector is a boon. This paper talks about using blockchain in healthcare to provide security, privacy, confidentiality using decentralization. It highlights the issues faced such

as data security, integrity and management. It provides a framework to implement blockchain technology for EHR and to provide secure storage of electronic records by defining granular access rules for the users of the proposed framework. It further discusses the scalability of blockchain technology. [3]

A comprehensive classification of blockchain applications across various sectors such as healthcare, IoT, business etc is explained in the paper. It also gives the limitations of blockchain technology across public, private and federated sectors. [4]

This paper puts forth an overview of the blockchain technology's power to solve problems in various businesses. The immutability, decentralisation and the overall speed of the transaction has been able to empower these businesses greatly. However, it also puts light on the security issues the system faces. [5]

This paper essentially focuses on the patient's perspective when contacted by a possessor of his Electronic Health Records (EHR). Ethical concerns arise when properties like EHR are used by researchers. However, any discrepancies that might have happened can be put forth. Thus, improving and holding a lot of potential in diagnosing and treating diseases. [6]

III. ASSOCIATED CONCEPTS

A. Blockchain

A blockchain is essentially a digital ledger of transactions that is duplicated and distributed across the entire network of computer systems on the blockchain. Each block in the chain contains a number of transactions, and every time a new transaction occurs on the blockchain, a record of that transaction is added to every participant's ledger. The decentralised database managed by

multiple participants is known as Distributed Ledger Technology (DLT).

B. Decentralized Consensus

This is a decentralized peer-to-peer system which does not have a central administrator to control the flow of information. In usual cases, a central authority makes decisions but in the case of

blockchain it has no leader. The peers or members in the network come to a consensus via "consensus algorithm" or voting. **Proof Of Work** is one of the earliest and most popular consensus algorithms used by various blockchain technologies to validate a transaction and add relevant blocks to the blockchain.

C. Smart Contracts

Smart contracts are the basic building block of any blockchain application. It automatically controls the transfer of digital assets between two parties under certain contracts. The contract is embedded in the blockchain making it transparent, decentralized and

D. Blockchain Node

A single blockchain node consists of its hash value, the data or payload and the hash value of the previous block. The hash values depend on the data in the node. This ensures that in order to change the data of the current node by some intruder or hacker they have to change the data of the previous node too, which in turn has to modify its previous node data. So basically if you need to modify one node you have to modify the whole blockchain. This makes the data practically immutable.

E. Ethereum

Ethereum is an open source blockchain based distributed computing platform. Ethereum is a public blockchain ledger that means anyone who has a system and internet can login to the peer-to-

peer network and view the transactions and ledger data.

F. Hyperledger Fabric

This is also a blockchain based computing platform but this one is more useful. It creates a private peer-to-peer blockchain which is essentially industry useful as only authorized peers can join the peer-to-peer network which helps to keep the data confidential and not to expose it to the outside world.

IV. ISSUES WITH BLOCKCHAIN

Blockchain might also have possible issues to deal with-

- **Power consumption-** All the nodes have to be connected to the network at all times. This demands an immense amount of power. And with the existing conflicts around global power consumption, blockchain comes with a major disadvantage.
- **Complexity-** due to the existing centralised networks in many organisations, switching to a completely new technology or adjusting to it breeds complexity.

V. ADVANTAGES OF THE BLOCKCHAIN TECHNOLOGY

The previous section presents the downside of employing blockchain technology, however the advantages of using the blockchain technology are immense.

- **Enhanced security-** Since the network is distributed, i.e. the information is saved in multiple systems known as nodes, it is difficult for the hackers to access data. In addition to that, the records created are end to end encrypted, which ensures security by preventing any possible unauthorized activity.

- **Transparency-** The ledgers are maintained identically at multiple locations and only permissioned access is granted to these records for any kind of edits to be made. This change is visible at all locations at the same time. The time and date stamp is recorded. This eliminates any kind of fraudulent activities that can take place and enables viewing the entire history of the record.

- **Efficiency and speed-** Unlike physical paperwork, the blockchain technology eliminates the need for constant efforts to maintain all the updation done to the records, any alteration done is reflected at all nodes and human errors are totally avoided. This allows us to store and transfer the documentation details forward efficiently and quickly without any need of a third party mediation.

- **Reduced costs-** Maintaining documentation and involving third parties to do that for the organisations is a continuous expense. With blockchain, no third party is required and hence this additional cost to the company is reduced. The only one time cost would be to build its own system.

VI. ARCHITECTURE AND WORKING OF BLOCKCHAIN

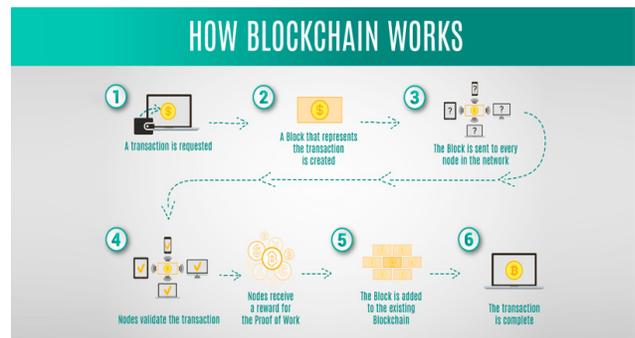


Figure 1: Architecture of Blockchain [7]

The request for a new transaction implies the creation of a new block to be added in the network which contains the transaction. This block is distributed to all the nodes in the network. The

nodes, each having a copy of the whole blockchain, verify this incoming block for any kind of

tampering and if successfully verified, this block is added to the respective copies contained by the node and thus the whole network gets updated.

The process of verification includes all nodes reaching upon an agreement whether or not a block is to be added to the blockchain. This is validated using the existing consensus algorithms by the nodes to verify that the sender is an authenticated part of the network.

The process is considered to be completed once this validation is done and the block is added. That is how a blockchain network works.

Apart from the general working, there are a few important terms that appear-

- Hash value- any arbitrary length input is converted into a fixed length numerical value called the hash value using an algorithm called the hash function. It is primarily used for the identification of the block. Hash function can be any algorithm such as the message digest or SHA. This conversion is done for security purposes to store the data in the block.

- Block- A blockchain is formed by a number of blocks in the network. Each block contains the hash value of the previous block, the data and the hash value of the next block. These blocks are connected in a peer-to-peer network.

VII. ELECTRONIC HEALTH RECORDS

It is a systematic way of storing any medical records in the digital format. And for storing these records the blockchain technology can be employed. To support the idea of EHR, we can first

look at the problems with the traditional paper based records. These records might be handwritten and not legible. Pen paper based documentation is prone to errors. Storing and maintaining these documents is a tedious job. Papers can be misplaced or damaged due to any kind of accident or a disaster. Considering the downside of the traditional method, switching to a digital method to save records appears to be serviceable. However, adopting a completely new method becomes difficult as the physical system is still so prevalent. And the users still find it less laborious. Apart from that, there are a few major concerns related to EHR that need to be addressed.

Firstly, the possible technology failure. The record system needs a machine (computer system) to be saved at. These computers that store all the data are no longer useful if due to any fault they crash. A foolproof system is required to be maintained at all times.

Secondly, the human threats. These data can be tampered by a hacker or any person with malicious intentions. The data security would be at risk. Thus, ensuring the security and privacy of the records constantly is vital.

A. Blockchain in EHR

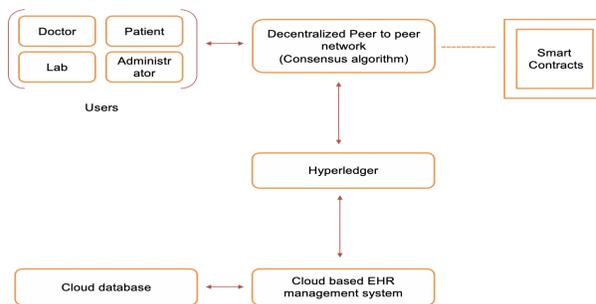


Figure 2: Architecture of an EHR System.

The idea of Electronic Health Records can be further strengthened by incorporating blockchain technology. The core of the blockchain technology, the decentralisation of the whole network, makes it

attractive to incorporate it within the healthcare sector. This allows for the implementation of a distributed healthcare application that does not rely on a centralised authority. In addition to that, the blockchain replicates any changes done to a block to all the blocks in the network. This ensures that the ledger is updated and gives a sense of clarity to the user of this record (hospitals or any kind of healthcare facility) and the patient, as to how, where and who updated the record.

Advantages of using blockchain in EHR-

- Efficient exchange of health records- blockchain facilitates interoperability and hence the movement and distribution of this crucial data is securely done.
- Data security and privacy- data integrity and authenticity of the user is always a major concern when it comes to EHR. It hinders the healthcare operation. Blockchain enables to overcome that hindrance by ensuring that only authorized users get to access the network.
- Effective management of the bills- any data entered into any block in a blockchain has to be validated by all the blocks. Once this confirmation is received by all the blocks, the data gets permanently added in the database. This helps reduce any kind of fraudulent entries and shifting of data illegally.
- Medical supply chain empowerment- blockchain helps to check each level of the drug supply chain. The functionalities that the blockchain provides such as the private key, which allows authorized pharmacists to be its part and thus maintains credibility.
- Enhanced trust in medical research- blockchain adds data which is timestamped, thus any lab or clinical trials that must have taken place is recorded and the timestamp feature of the blockchain reduces the possibility of scam greatly.

VIII. CONCLUSIONS

The blockchain technology is surely transforming the way organisations work and store their records. It has provided them with an alternative to the traditional way of storing and accessing information which might be less secure. This paper has put forth the idea of employing this remarkable technology into the healthcare sector to maintain user records. There certainly are a few issues to look at. However, the advantages of switching to the digital method of storing such crucial data undoubtedly outweighs the traditional physical records. This paper has further discussed the application of blockchain in the EHR system and the way it serves as a foolproof technology in the medical sector.

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