Integration of Blockchain and IoT for securing and exchanging health records

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Abstract

In recent years, the healthcare industry has been on the forefront of adopting cutting-edge technologies in order to deal with data integrity, security of the information, interoperability and information sharing between patients and healthcare providers. This paper proposes a model to improve the Radiology Information System (RIS) by integrating blockchain technology and the Internet of Things (IoT). The integration of these technologies has the potential to improve patient care by ensuring real-time monitoring of patients, a secure and tamper-proof system, as well as secure management and exchange of patient data. In addition, this paper discusses the advantages of using blockchain technology and IoT in healthcare, as well as the ways in which these technologies can address the challenges that currently exist within healthcare systems.

Keywords

Blockchain, IoT, Smart Contracts, Healthcare.

1. Introduction

Health technologies have the potential to enhance access to healthcare, address health disparities and contribute to the overall health of the population [1] by ensuring that individuals receive timely and appropriate medical care.

According to the World Health Organization (WHO), the majority of digital technology's potential uses for improving the health of populations have not yet been explored and there is a huge amount of potential for the implementation of digital health solutions, despite the widespread use of digital technologies and the fact that digital technology is the field where innovation is most evident.

Meanwhile, blockchain technology has huge potential in the healthcare industry, especially in health information exchange (HIE). According to many studies, blockchain-powered platforms can take the place of current HIE mechanisms because of their cost-effective, efficient, and secure environment. However, despite these proposals, few blockchain-based projects have been implemented in the healthcare sector to date. [2]

One of the most fundamental challenges that a modern healthcare management system must overcome is the process of storing and transmitting data. In addition, several problems exist with centralized EHR systems, such as healthcare data breaching issues, a single point of failure, personal and sensitive personal information privacy concerns, and interoperability issues with multiple systems and data sources [3]. In addition, there are several other challenges associated with healthcare records, including access control, user trust, and authentication.[4] [5]

The adoption of digital health technologies has the potential to transform healthcare by enabling remote patient monitoring, improving patient outcomes, reducing healthcare costs, and securely exchanging and storing health information. Meanwhile, IoT devices, including sensors and

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wearables, have the potential to collect and transmit real-time patient data, enabling healthcare providers to provide care that is both more individualized and more preventative with more information regarding the patient's current state of health. However, implementing a client-server architecture result in increased security risks, which can be mitigated by taking advantage of blockchain technology, which implements a distributed architecture. [6]

The use of blockchain technology has the potential to enhance the interoperability and security of healthcare data. Blockchain, which uses a decentralized and secure ledger system, can help ensure the privacy of patient data as well as the data's integrity, while also enabling the secure sharing of information. The findings indicate that blockchain technology has a wide variety of potential applications and uses within the healthcare industry.[7]

The remainder of this study is organized as follows: In section 2, the principles of blockchain and IoT are discussed, as well as the significance of integrating IoT and Blockchain into healthcare. Section 3 discusses the work related to the existing approaches for integration of Blockchain and IoT into healthcare. The proposed model based on the integration of blockchain, and IoT into the Radiological Information System is proposed in Section 4. In addition, the conclusions as well as future work are presented in Section 5.

2. Background

A blockchain is a digital ledger that serves as a public, decentralized, and distributed database that is managed by multiple participants across multiple nodes, where each node communicates and shares information through a peer-to-peer (P2P) network.[8] The development of blockchain technology as described in [9] describes the development of blockchain technology, which includes the following stages: The first stage is Blockchain 1.0-Bitcoin, which introduced the decentralization of virtual currency. The second stage is Blockchain 2.0—Ethereum, which introduced smart contract authentication. The third stage is Blockchain 3.0—IOTA, where IoT connectivity was established.

In a private blockchain system, smart contracts are compiled using the Solidity programming language, and each node represents a unique private blockchain account. The smart contract is a type of computer protocol that is executable via the account. The deployment of smart contracts is illustrated in Figure 1. [10]

The policies and restrictions that are associated with privileges and services are outlined in the smart contract. Access control policies are turned into smart contracts, and then the smart contracts are deployed on blockchain platforms, which offer a decentralized and tamper-proof network that ensures the contract is executed in accordance with its rules. [11]

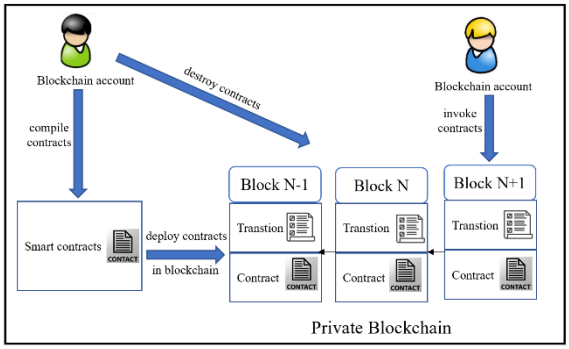

Figure 1: Smart contracts deploy and invoke process in Private Blockchain [10]

A blockchain network employs a consensus algorithm to establish its level of trust and ensure that transactions are recorded properly on blocks. In blockchain networks, some of the consensus algorithms that are used most frequently include Proof of Work (PoW), Proof of Stake (PoS), Delegated Proof of Stake (DPoS), and Practical Byzantine Fault Tolerance (PBFT). [12]

Decentralization, which represents the openness of blockchain technology as well as the difficulty of avoiding being manipulated by people, is an essential indicator of blockchain technology. The Proof-of-Stake (PoS), Distributed Proof-of-Stake (DPoS), and Casper consensus algorithms are fully decentralized, whereas the Proof-of-Equity (PoET), and Raft consensus algorithms are semi-decentralized. [13]

The Internet of Things (IoT) refers to a collection of equipment, people, objects, and everything else that has the capacity to communicate and transfer data over a network without the intervention of any external agents. In the meantime, IoT presents users with a wide variety of risks that endanger their privacy and security. Internet of Things vulnerabilities can lead to attacks on the integrity of data and equipment, as well as on users' privacy, network access, and service provisioning.[14]

2.1 Importance of IoT and Blockchain healthcare

The integration of blockchain with IoT applications in healthcare can help address some of the key challenges related to trust, confidentiality, integrity, and privacy of data.[15]

Their integration has the potential to bring significant changes to healthcare, such as better outcomes for patients, lower costs, more efficiency, better security, interoperability, and better coordination of care. IoT devices can be used to monitor patients in real time, and blockchain can ensure the integrity and privacy of patient data. This can help reduce the risk of data breaches and protect sensitive patient information. The decentralized architecture of blockchain and a secure ledger system can help ensure the integrity and privacy of patient data.

Blockchain technology has the potential to address some of the challenges facing the healthcare sector, as it can provide a secure and tamper-proof environment [16] for storing and sharing sensitive healthcare data and ensure that patient health records are protected against unauthorized access and tampering through the use of smart contracts. The use of smart contracts reduces the risk of tampering since their execution is not dependent on any third party, nor can any entity modify the rules defined in them.[17]

Additionally, blockchain technology can facilitate interoperability among healthcare systems while offering patient-centered access and allowing the users to exchange and share health information in a standardized and secure manner, as the users can communicate with the blockchain only by using recognized interoperability standards such as FHIR, [18] as FHIR also improves the exchange of health care data as presented in our previous work in [19].

Blockchain offers numerous opportunities for usage in the healthcare sector, e.g., in public health management, user-oriented medical research based on personal patient data as well as drug counterfeiting [20]. Meanwhile, the advantages of using blockchain technology in healthcare are summarized in the following table [21]:

Table 1
Blockchain Advantages in Healthcare [21]

Blockchain Feature	Advantage in Healthcare
Peer-to-peer network	Network infrastructure security
Smart Contracts	Permissioned access to patient data
Permissioned closed network	Data integrity
Shared real-time updates to all members	Collaboration
Distributed, secure access	Patient health record
Cryptography	Protecting patient identity
Disintermediation of trust	Secure health data
Distributed framework	Health information exchange
Disintermediation of transactions	Reduced transaction costs

In addition, blockchain is used in integrating distributed health records in a unified, safe, and interoperable manner for use by health providers and patients, sharing of PHRs among health care providers, with the possibility of knowledge and consent of the patient [22].

In the current era of digital technologies, IoT has become an increasingly important component of smart healthcare, especially in light of the COVID-19 pandemic. Patients can benefit from the exceptional care made possible by the IoT, which enables them to receive more targeted treatment [23].

Figure 1 provides an overview of the general architecture of EHR systems that are based on Blockchain technology and IoT [24].

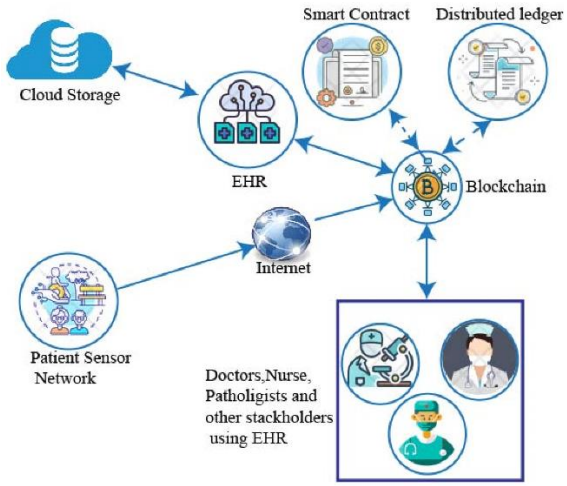

Figure 2: General EHR system architecture based on blockchain and IoT.[24]

3. Related works

Gohar et.al proposed a Patient-Centric Healthcare Framework (PCH) using blockchain technology to protect health data sources, specifically by implementing a smart contract design on top of the Hyperledger blockchain platform on Amazon cloud to exploit smart contracts and blockchain access control capabilities for managing healthcare business and system integrity. Their study details the architectural design and implementation of data sharing design using Blockchain, Cloud, and IoT in healthcare systems [3].

Alam et.al proposed Blockchain based EHR framework that allows IoT device integration an can be upgraded to integrate with other healthcare facilities that need patient monitoring and personal health record integration. It consists of four layers as below [24] and presented in Figure 3:

- EHR layer: Healthcare provider layer, healthcare providers share their records regardless of EHR storage type),
- Blockchain layer: An interface that translates records into a unified format and uses IPFS storage to support interoperability. Smart contract, storage policy, EHR manager, consensus mechanism, and IPFS storage comprise the BC layer.
- IoT-based patient monitoring layer: The patient sensor layer to measures patient inputs
- User Layer: Users interact with the system. They can enter or view health information in a standard template regardless of storage format.

Meanwhile in [25] is presented and the architecture of Blockchain-Assisted Cybersecurity for the IoMT, which can overcome cybersecurity and privacy problems and comprises of the following stages:

- Healthcare instrument state which is equipped with numerous IoMT healthcare instruments;
- Blockchain state;
- Edge network state;
- Data synthesis state.

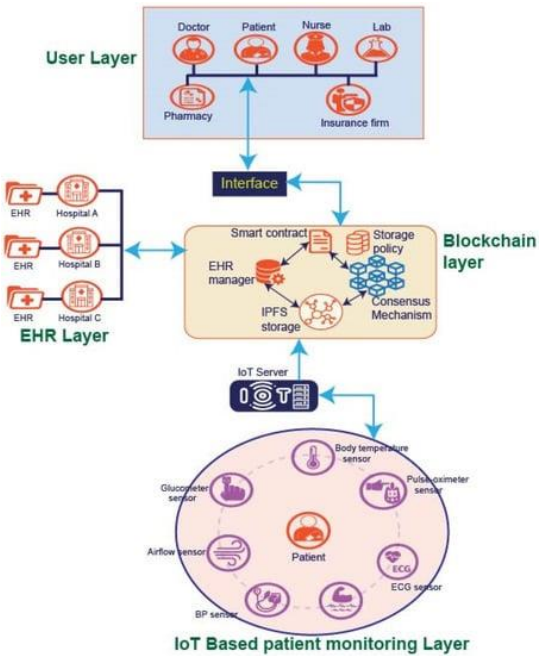

Figure 3: General EHR system architecture based on blockchain and IoT [24].

4. Proposed Model

In [26] we proposed a Radiology Information System designed to assist physicians in managing patient information. The system provides a user-friendly interface for storing and retrieving relevant patient data, including techniques and results. In addition, the system is capable of displaying DICOM scan images of the patient, allowing for a comprehensive view of the patient's medical history.

In this paper, we propose to enhance the system by incorporating blockchain technology and IoT.

Blockchain technology can improve the security of the system by providing a decentralized and tamper-proof record of all transactions and data exchanges. To ensure the confidentiality of the information participants share with one another, it is essential that they authenticate one another using blockchain technology. Implementation of blockchain technology can significantly enhance the level of trust and security associated with the exchange of information between parties. This step is essential for ensuring the integrity and confidentiality of the shared information. The use of smart contracts can guarantee that all participants with access to patient data are authenticated and authorized and granted access to the appropriate data and records.

In addition, by integrating IoT devices, the patients can be monitored in real-time. This data can be transmitted in a secure manner to the RIS using blockchain technology.

5. Conclusion and Future work

This article presents a model that we proposed with the intention of improving the Radiology Information System (RIS) by incorporating blockchain technology and the Internet of Things (IoT). By integrating these technologies into the system, we can guarantee real-time monitoring of patients, a secure and tamper-proof system, as well as the secure management and exchange of patient data.

In our future work we will provide security analysis of the proposed model. In addition, the integration of Blockchain and IoT will require further investigation in GDPR compliance, resources constraints, bandwidth constraint, connectivity constraint and memory constraint [24].

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