Use of blockchain for providing protection to sensitive health records

Keywords

Blockchain,

Distributed systems,

Electronic health records,

Medical Informatics

Security

Privacy

ABSTRACT

Blockchain Is an emerging technology being applied for creating innovative solutions in various sectors, including healthcare. A Blockchain network is used in the healthcare system to preserve and exchange patient data

through hospitals, diagnostic laboratories, pharmacy firms, and physicians. Blockchain applications can accurately identify severe mistakes and even dangerous ones in the medical field. Thus, it can improve the performance, security, and transparency of sharing medical data in the health care system. This technology is helpful to medical institutions to gain insight and enhance the analysis of medical records. In this paper, we studied Blockchain technology and its significant benefits in healthcare. Various Capabilities, Enablers, and Unified Work-Flow Process of Blockchain Technology to support healthcare globally are discussed diagrammatically. Finally, the paper identifies and debates fourteen significant applications of Blockchain for healthcare. Blockchain plays a decisive part in handling deception in clinical trials; here, the potential of this technology offer is to improve data efficiency for healthcare. It can help avoid the fear of data manipulation in healthcare and supports a unique data storage pattern at the highest level of security. It provides versatility, interconnection, accountability, and authentication for data access. For different purposes, health records must be kept safe and confidential. Blockchain helps for the decentralised protection of data in healthcare and avoids specific threats.

Introduction

Growing organizations aim to bring revolutionary changes to all aspects of their business as technology advances. When it comes to the healthcare industry, the speed of growth is increasing to higher levels and needs to be backed up with the latest technologies as the system is going towards a more patient-centric approach.

Many healthcare organizations still depend on outdated systems to maintain patient health records. Such outdated software keeps the patient medical data in local records that can make the diagnosis:

- time-consuming
- complicated for the doctor

From the patient's personal information to diagnostic reports and doctor's prescriptions, healthcare organizations currently use the centralized database for saving data.

As the data is stored at a single centralized location, it leads to problems like:

- Identity thefts
- spamming
- financial data crime

In recent times, there is an increasing trend in deploying blockchain in a broad range of applications, including healthcare (e.g. public healthcare management, counterfeit drug prevention, and clinical trial) (Esposito, Santis, Tortora, Chang, Choo, 2018, McGhin, Choo, Liu, He, 2019, Peterson, Deeduvanu, Kanjamala, Boles, 2016). This is not surprising, since blockchain is an immutable, transparent and decentralized distributed database (Ahram et al., 2017) that can be leveraged to provide a secure and trusty value chain.

An architecture of blockchain-based healthcare systems is shown in Fig. 1 . Blockchain is a distributed ledger database on a peer-to-peer (P2P) network that comprises a list of ordered blocks chronologically. In other words, this is a decentralized and trustworthy distributed system (without relying on any third party). Trust relation among distributed nodes is established by mathematical methods and cryptography technologies instead of semi-trusted central institutions. Blockchain-based systems can mitigate the limitation of the single point of failure. Besides, since data is recorded in the public ledger, and all of nodes in the blockchain network have ledger backups and can access these data anytime and anywhere, such a system ensures data transparency and helps to build trust among distributed nodes. It also facilitates data audit and accountability by having the capability to trace tamper-resistant historical record in the ledger.

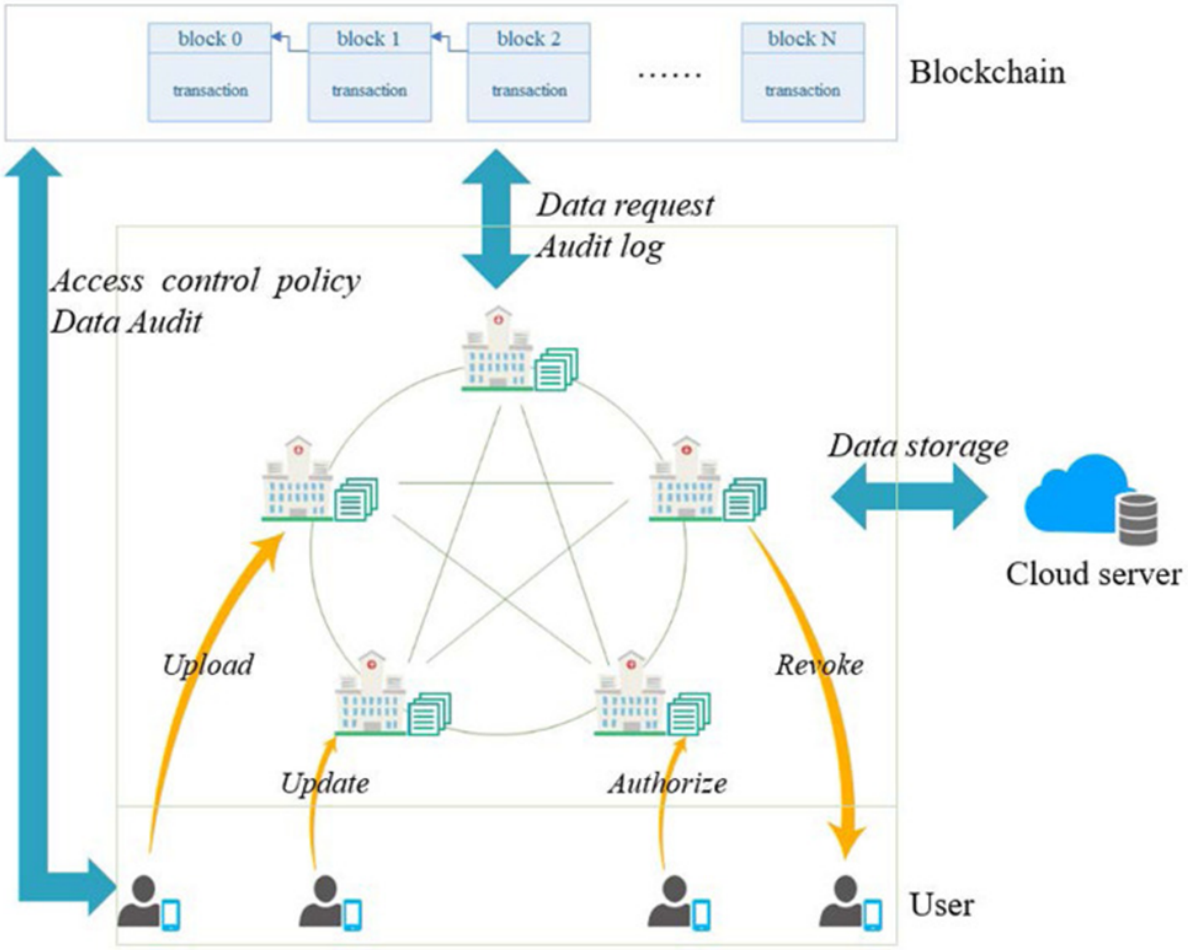

Fig. 1:

Need of blockchain in healthcare

As far as healthcare is concerned, the urgency of development increases to more incredible speeds. Today the need is for quality health facilities supported by advanced and newer technologies. Here, Blockchain would play a critical role in transforming the healthcare sector. In addition, the landscape of the health system is moving towards a patient-centred approach focusing on two main aspects: accessible services and appropriate healthcare resources at all times. The Blockchain enhances healthcare organisations to provide adequate patient care and high-quality health facilities. Health Information Exchange is another

time-consuming and repetitive process that leads to high health industry costs, quickly sorted out using this technology. Using Blockchain technology, citizens may take part in health study programs. In addition, better research and shared data on public wellbeing will enhance treatment for different communities. A centralised database is used to manage the entire healthcare system and organisations [1, 2, 3].
Until now, the most significant problems faced are data protection, sharing, and interoperability in population health management. This particular problem is reliable by using Blockchain. This technology enhances security, data exchange, interoperability, integrity, and real-time updating and access when correctly implemented. There are also significant concerns about data protection, especially in the fields of personalised medicine and wearables. Patients and medical personnel require safe and straightforward means of recording, sending, and consulting data over networks without safety concerns; thus, Blockchain technology is implemented to resolve these issues [4,5].

Blockchain will have a considerable impact on a patient's:

- record sharing
- billing
- medical research

Various Capabilities of Blockchain Technology to support the healthcare culture globally

In healthcare, Blockchain has a wide range of applications and functions. The ledger technology helps healthcare researchers uncover genetic code by facilitating the secure transfer of patient medical records, managing the drug supply chain, and facilitating the safe transfer of patient medical records. Fig. 2 reflects the variety of features and critical enablers of Blockchain philosophy in umpteen healthcare spheres and its allied domains. Protection of healthcare

data, various genomics management, electronic data management, medical records, interoperability, digitalised tracking and issues outbreak, etc., are some of the technically derived and impressive features employed to develop and practice Blockchain technology. The complete digitalised aspects of Blockchain technology and its use in healthcare-related applications are the significant reasons for its adoption [6,7].

EHR Systems

The electronic health record (EHR) is generally defined to be the collection of patients' electronic health information (e.g. in the form of electronic medical records – EMRs). EMRs can serve as a data source for EHR mainly from healthcare providers in the medical institutions. The personal health record (PHR) contains personal healthcare information, such as those obtained from wearable devices owned and controlled by patients. Information collected as part of PHRs can be available to healthcare providers, by users (patients).

In theory, EHR systems should ensure the confidentiality, integrity and availability of the stored data, and data can be shared securely among authorized users (e.g. medical practitioners with the right need to access particular patient's data to facilitate diagnosis). In addition, such a system if implemented well, can reduce data replication and the risk of lost record, and so on. However, the challenge of securing data in such systems, whether in-transit or at-rest, is compounded by the increasing connectivity to these systems (e.g. more potential attack vectors). For example, mobile devices that can sync with the EHR system is a potential attack vector that can be targeted (e.g. an attacker can seek to exploit a known vulnerability in the hospital-issued mobile devices and install malware to facilitate covert exfiltration of sensitive data (e.g. PHRs)).

One of the key benefits of EHR systems is the availability of large volumes of data, which can be used to facilitate data analysis and machine learning, for example to inform other medical research efforts such as disease forecasting (e.g. the 2019 Novel Coronavirus). Furthermore, wearable and other Internet of Things (IoT) devices can collect and upload relevant information, including those relating to PHRs, to the EHR systems, which can facilitate healthcare monitoring and personalized health services

Methods

This work is conducted using a systematic literature review methodology. A systematic literature review (often referred to as a systematic review) is a method for identifying,

evaluating, and interpreting all available research that is relevant to a research question, topic area, or phenomenon of interest.[8] Most research begins with a literature review.

However, unless a literature review is thorough and fair, it is of little scientific value. This is the main rationale for undertaking systematic reviews. A systematic review synthesizes existing work in a manner that is fair and is considered fair.

All reviewed articles in this systematic literature review were identified by searching reliable academic repositories such as PubMed, Google Scholar, ACM, ScienceDirect, and IEE in October 2018. These databases index research articles and abstracts from most major academic publishers and repositories worldwide, including both free and subscription sources.

Study design

This section focuses on describing the adopted research methodology, presenting procedures, and outlining the main subsequent decisions via a systematic literature review that is designed to provide an overview of EHRs in a Blockchain research area, to establish whether research evidence exists on a topic, and to provide quantitative evidence.

The systematic literature review approach was adopted because our objectives are to group and synthesize available academic content regarding EHRs and Blockchains and to identify promising directions, which do not require in-depth analysis or synthesis. Widely recognized empirical guidelines were followed in planning and running systematic mapping studies.

The presented systematic literature review method was carried out by defining and executing the following steps:[9]

1. *Research questions*. Introduce the research questions that are being investigated;

2. *Search strategy*. Outline the strategy and the libraries that are explored to collect data;

3. *Article selection*. Explain the criteria for selecting the studies;

4. *Distribution of studies*. Describe how the studies are distributed chronologically;

5. *Quality assessment*. Describe the quality assessment of the selected studies;

6. *Data extraction*. Compare the selected studies and research questions.

The following sections describe how this process of mapping the study was carried out.

Research questions

According to Kitchenham and Charters and Petticrew and Roberts, the definition of research questions is the most important part of any systematic review. Therefore, we seek to identify and classify the technology that is related to EHRs in a Blockchain. Specific and general research questions were formulated to address subjects that are related to the features, problems, challenges, and solutions that are currently being considered and the research opportunities that exist or are emerging.

General research questions have been refined into more specific questions (SQs) to facilitate classification and subject analysis and to pinpoint promising research directions for further investigation. Our research questions are classified into two categories, namely, general questions (GQs) and SQs, as follows:

- *GQ1*. What is the taxonomy for EHRs in a Blockchain?

- *GQ2*. What are the challenges and open questions that are related to EHRs in a Blockchain?

- *SQ1*. What are the important principles behind Blockchain when it is applied to healthcare?

- *SQ2*. What are the healthcare protocols and standards that should apply in a Blockchain network?

- *SQ3*. What are the types, models, and approaches of a Blockchain architecture?
- *SQ4*. How can Blockchain indefinitely store the “ever-growing” patient medical records?

Search strategy

For conducting a reproducible systematic literature review, a proper search strategy is defined, and it is necessary to define the search keywords and the scope, which are the key concepts of our research questions, for retrieving accurate results.

To build an optimal search string, authors Kitchenham and Charters suggest breaking down the research question into individual facets, namely, research units, where their synonyms, acronyms, abbreviations, and alternative spellings are all included and combined using Boolean operators.

The final search string is obtained via the following three steps:

1. Identification of synonyms, acronyms, and related words;
2. Identification of terms and related words in the abstracts of the articles that were identified in the first search;
3. Construction of the search string using Boolean characters such as OR and operators.

Finally, we obtain the following search string: (“Blockchain”) AND ((“healthcare”) OR (“health”)) OR ((“health record”) OR (“EHR”) OR (“PHR”) OR (“medical record”) OR (“EMR”)).

Conclusion and future work

In this study, a systematic literature review regarding EHRs within a Blockchain was conducted, with the objective of identifying and discussing the main issues, challenges,

and possible benefits from Blockchain adoption in the healthcare field. The application of Blockchain has exceeded the scope of the field of economics and we have highlighted Blockchain's potential for the healthcare area, while also revealing that it still highly depends on the acceptance of the new technology within the healthcare ecosystem.

Analyzing the results that were obtained from the literature review, we conclude that Blockchain technology might be a future suitable solution for common problems in the healthcare field, such as EHR interoperability, establishing sharing trust between healthcare providers, auditability, privacy, and granting of health data access control by patients, which would enable them to choose whom they want to trust and with whom to share their medical records. However, additional research, trials, and experiments must be carried out to ensure that a secure and established system is implemented prior to using Blockchain technology on a large scale in healthcare, since a patient's health data are personal, highly sensitive, and critical information.

This study may serve as a basis or inspiration for future works and studies. Our answered research questions and taxonomy may contribute to the proposition of an architecture or model that addresses the challenges that are discussed in this article. In addition, a possible direction for future work is to survey the combination of Blockchain and the Internet of the things (IoT) in healthcare, with the objective of realizing network scalability improvements by supporting low-end devices.

What are the Benefits of Blockchain In Healthcare?

There are multiple benefits of blockchain in healthcare, such as:

- **Simplified Approach to Data**

Unlike a traditional way of managing information, healthcare records can be shared across multiple nodes using the healthcare blockchain.

The need for storing data in various databases could be removed, hence, enabling the simplified approach to access the information.

- **System Interoperability**

The inability to exchange healthcare records could lead to delays in treatment. But blockchain could alleviate this problem by decentralizing the data. Everyone within the healthcare network could access a transparent yet immutable ledger while having data ownership.

- **Efficiency**

Blockchain in healthcare could turn the system highly efficient via real-time processing. It could remove the need for third-party companies, hence, eradicating the delays in accessing the data.

- **Control Over the Data**

Anyone willing to access the health records would require the patient's public key. Patients could seamlessly control who should access what data. Since the data is saved in an encrypted form, it remains unreadable to hackers.

Use Cases of Blockchain in Healthcare

Many healthcare organizations and blockchain companies are working on building blockchain-enabled systems to enhance healthcare services for both patients and healthcare professionals. Blockchain is all set to transform the healthcare sector by decentralizing patient medical history, improving payment methods and tracking pharmaceuticals.
Here are some of the use cases of blockchain in healthcare:

- **Patient Data Management**

Patient Data Management is one of the popular use cases of blockchain in healthcare. Health agencies tend to separate patients' medical records and make it possible to identify a patient's medical history without asking previous healthcare providers. It results in a significant amount of time and may lead to mistakes because of human error.But storing health records on the blockchain gives you a transparent and accessible view of medical history. By keeping the patient's information in one place, it becomes simpler for patients and doctors to view the data.

- **Overcoming counterfeit drugs**

It is predicted that tens of thousands of people die every year because of counterfeit drugs. Blockchain offers complete visibility into the medical supply

chain to track when a medicine has been altered or changed during transit. As a result, the recall of drugs becomes easy and counterfeiting is reduced.

- **Accessibility of EHRs**

It is difficult to manage EHRs. EHRs provided by one healthcare provider for a patient differ from the other provider for the same patient. Blockchain overcomes the issue of interoperability by allowing healthcare professionals to store the data in one place that can be distributed to all nodes of the network.

- **Medical Staff Credential Verification**

Similar to monitoring the provenance of medicines, blockchain can also help track the credentials and experience of medical professionals. A blockchain-based platform can be built where trusted healthcare organizations and medical institutes can log the credentials of the staff. It streamlines the hiring process for health organizations. Since the credentials would be stored on the blockchain, they will be more secure due to the immutability of blockchain and transparent to all members of the network.

The use cases of blockchain in healthcare are endless, and we may find new applications emerging in the market with each passing day. Let's look at some of the real-world examples of blockchain in healthcare.

What are some of the Real World Examples of Blockchain in Healthcare?

Here, we have listed four real-world examples of blockchain technology in healthcare:

TraceRX

Developed by LeewayHertz Technologies based in California, USA, TraceRx is blockchain based solution for pharmaceuticals' tracing and counterfeiting. TraceRX helps UNO to trace free drugs' distribution and identify any inefficiencies or losses.
TraceRX platform uses blockchain to deal with the problems of theft, recalling, and shipment of pharmaceuticals. It makes the process more secure, transparent, and safe.

BurstIQ

Located in Colorado, USA, BurstIQ uses blockchain to improve the way of sharing and using medical information. BurstIQ's platform allows healthcare organizations to manage a vast amount of patient data securely by ensuring strict HIPAA compliance while enabling:

-Safekeeping data

-Selling data

-Sharing data

-Licensing data

As the platform maintains complete and updated patient health information, it has facilitated prescription drugs and opioid abuse control.

Medical chain

Located in London, Medicalchain's blockchain based platform:

-Protects patient identities from outside sources

-Maintains records' integrity

-Maintains the records of origin

Medicalchain also announced its telemedicine platform in 2018, enabling patients to consult physicians and specialists via video calls and make payments in "MedTokens."

Patientory

Located in Atlanta, Georgia, Patientory's blockchain platform allows storing and transferring medical information securely.
It supports end-to-end encryption, which ensures the safe sharing of all patient data.
It also enables patients and providers to access, store, and transfer all critical information via blockchain.

Conclusion

We hope that you've got a better understanding of how blockchain technology combined with AI and IoT can be irresistible for the healthcare industry. AI-enabled automated health checks reducing cost

and time; patients' immutable health records stored securely on blockchain and millions of devices performing precise diagnoses and finding better – the future of healthcare can be witnessed soon.

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