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E-Healthcare Records Management Systems Using Decentralized Blockchain

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ABSTRACT: Blockchain technology is the most trusted all-in-one cryptosystem that provides a framework for securing transactions over networks due to its irreversibility and immutability characteristics. Blockchain network, as a decentralized infrastructure, has drawn the attention of various startups, administrators, and developers. This system preserves transactions from tampering and provides a tracking tool for tracing past network operations. A personal health record (PHR) system permits patients to control and share data concerning their health conditions by particular peoples. In the case of an emergency, the patient is unable to approve the emergency staff access to the PHR. Furthermore, a history record management system of the patient's PHR is required, which exhibits hugely private personal data (e.g., modification date, name of user, last health condition, etc.). In this paper, we suggest a healthcare management framework that employs blockchain technology to provide a tamper protection application by considering safe policies. These policies involve identifying extensible access control, auditing, and tamper resistance in an emergency scenario. Our experiments demonstrated that the proposed framework affords superior performance compared to the state-of-the-art healthcare systems concerning accessibility, privacy, emergency access control, and data auditing.

KEYWORDS: healthcare; blockchain; health record; patient monitoring; medical data security

I. INTRODUCTION

High maintenance and management costs are the dire problems that modern healthcare systems face [1]. The healthcare system is highly complex, containing several domains, each comprising physicians, researchers, practitioners, supportive staff, management employees, and patients [2]. As a result, categorization and management of patient data becomes a daunting challenge [3,4]. This challenge is further exacerbated by dissimilar data structures and disparate workflows in different healthcare domains. For these reasons, the lack of efficient interchange of healthcare-related information among various healthcare domains poses a great hindrance [5].

To tackle health information records and exchange, a system is required to be developed, managed, and maintained. A third party develops and maintains traditional personal health record and electronic health record systems, with trust, privacy, and data security remaining important challenges [6]. However, the third-party-based existing healthcare recording systems cannot satisfy stakeholders' privacy needs [7]. As a result, the traditional electronic healthcare model lacks transparency because of privacy and data security issues.

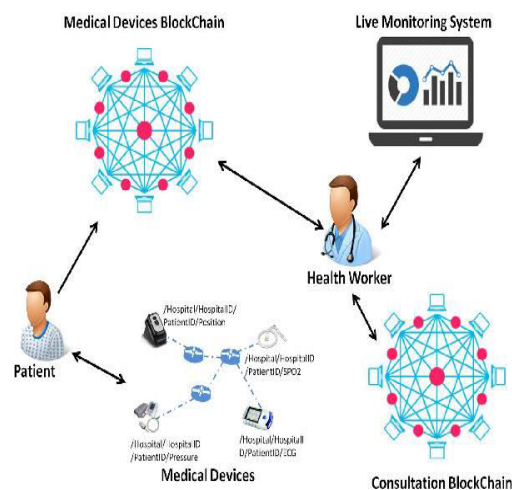


Fig 1: Overview of Health care Blockchain

In resolving the security-related concerns and the severe problem of enormous and highly diverse data in healthcare systems, blockchain technology offers significant prospects [8]. Blockchain is a decentralized, distributed database, peer-to-peer network, and digital ledger [9]. The blockchain could link many computers via nodes, and requires no transactions to build a new block that helps send safe information from one person to another. The client may access all the allowed and verifiable medical-related information using a blockchain secured by cryptography. Anyone may choose transactions and also add a new chain to the block. The master key of a blockchain is a hash, and by using this hash function, a blockchain can generate unique identifiers for cryptocurrency to add data.

Since traditional electronic health record and personal health record-based health information exchange systems have failed to cope with privacy and security-related issues, stakeholders are hesitant about collaborating and co-operating for the exchange of health information. As a result, the cost of healthcare has increased, which is a great burden on both patients and healthcare providers. To solve these trust-related problems, researchers and policymakers nowadays are turning towards blockchain technology. As per IBM, many leading healthcare organizations predict blockchain will bring a significant change to the healthcare system by upgrading healthcare management systems and by establishing a decentralized architecture for the interchange of electronic healthcare information [10]. By 2022, the blockchain technology market is anticipated to account for over USD 500 million [11]. Although several studies on blockchain in the healthcare industry have been conducted, the existing literature cannot provide a comprehensive picture of the application areas. Therefore, it becomes inevitable to conduct an extensive study to explore the applications of blockchain in the healthcare industry. Many servers are now being built to provide services to clients via mobile devices. In this current time of internet services, it is possible to create and transmit a huge amount of medical data every week or daily by using mobile devices and many applications. The current healthcare system has the potential to solve limitations in a variety of fields, such as cost limitation, tactical limitation, maintaining standardization, and individual behavioral constraint to services [12]. However, healthcare system providers do not always use the latest advantage of the technology in the supply chain. For example, they do not use the new accumulation and distribution of medical supplies in the proper way. In fact, a report on Healthcare Finance revealed that nearly USD 25.7 billion is required every year for unnecessary supply management and operations [13]. A massive amount of work needs to focus on a smart healthcare system to improve the limitations and satisfy rising expectations for better healthcare.

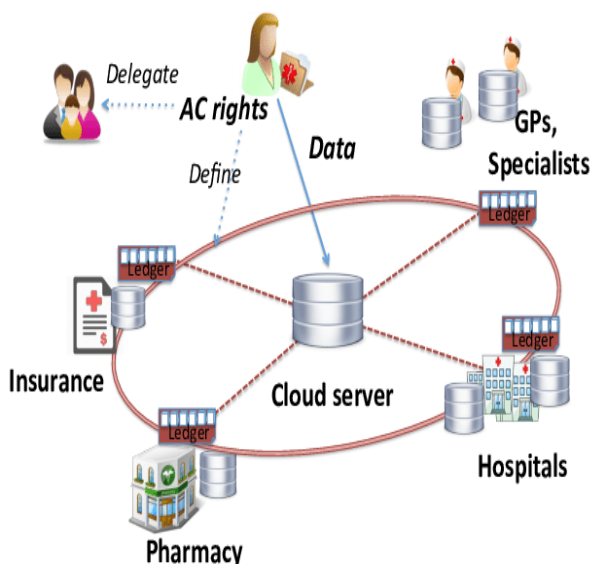


Fig 2: Different Delegate

It could work on design and development issues based on smart devices, tools, better facilities, and an updated healthcare organization. It could also develop smart healthcare on customer-connected apps, biosensors and the most updated emergency service systems [14]. Therefore, to build a better network, we need to identify consensus algorithms that are already being used in many blockchain networks and determine which ones are compatible with IoT-based infrastructure for the improvement of healthcare services [15]. There is another way to mitigate the large data storage problem of blockchain with the faster data sharing process called Distributed Data Storage System (DDSS) [16]. It uses data caching and file translation to keep track of multiple documents with the same name in the same place. However, sometimes when a massive file is uploaded to DDSS, it recesses the file into several smaller data objects, for example, 256 kb, and also connects all these objects to an empty object to retrieve the complete file using Distributed Hash Tables (DHT) [17]. Some sensors can collect data automatically from users and can transfer them to a certain storage or cloud for further processing by physicians, nurses, and medical staff [18]. Several pieces of rules and regulations have been proposed to save individual patients' privacy. These laws always require appropriate security management for controlling, sharing, and exchanging the health of patient data, and failure to follow them is strongly prosecuted, with severe penalties being imposed on electronic healthcare systems (EHRs) [19]. According to the report by IBM, almost 70% of healthcare leaders foretell the huge impact of blockchain on the areas of health domain improvement and the clinical trial system, regulatory compliance, and creating a decentralized structure for sharing electronic health records (EHR) [20].

Background Study of Blockchain

Blockchain is a decentralized, unchangeable database that simplifies the tracking of assets and recording of transactions in a corporate network. A blockchain is made up of an expanding collection of documents, known as blocks that are safely connected to one another using encryption. Each block includes transaction information, a timestamp, and a cryptographic hash of the preceding block. The timestamp shows that the transaction data was there at the moment the block was produced. The blocks effectively create a chain since each block holds information about the one before it, making them interconnected. Thus, once a transaction has been recorded, it cannot be undone without also undoing all following blocks, rendering blockchain transactions irreversible.

Decentralization is a key feature of blockchain technology. There is no central authority to control the content added to the blockchain, but rather the entry that enters the blockchain agrees to the peer-to-peer network and uses the various consensus minimization protocols here. This is further described in [Section 2.1.4](#). Security of data is the main key focus of blockchain transaction. As data are transferred through blockchain without the involvement of any third parties, there is practically no risk of data theft or alteration. Persistence is another key feature of the blockchain.

Entries can no longer be deleted once they have been recognized in the blockchain because of a shared ledger stored across many nodes [21]. In addition, an interesting feature of the pseudonymity blockchain is that it is used in many blockchains. [Figure 1](#) illustrates the main features of blockchain technology.

The key difference between blockchain in healthcare and general applications of blockchain is that in the healthcare sector, the key usage of blockchain is to create safe and secure systems for patient or, so to say, user data management. The healthcare sector also utilizes a secure monetary transaction service based on blockchain.

The use of blockchain has evolved rapidly in recent years. A system that was created for cryptocurrencies is now being used to cast votes due to its temper-proof characteristics. The use of smart contracts enforces accountability for all parties involved and ensures the contract's integrity. The data security issue of IoT systems has been solved through the utilization of blockchain-based data communication and storage systems. The limit to the applicability of blockchain is the imagination of the user. While in this study, our focus is to review the impact of blockchain in the healthcare sector, there is no difference between the application of blockchain in healthcare and the general sector as the healthcare sector uses all the services offered by blockchain, such as money transfer, personal data security, logistics, and overall data safety.

II. METHODS

Consortium Blockchain

Consortium blockchains are partially decentralized and made up of a combination of public and private blockchains. Data transactions can be performed in both private and public blockchains, and nodes can be pre-selected. A consortium blockchain is different from a private blockchain. Blockchain consortiums consist of extremely confident entity models in private blockchains and untrustworthy public blockchain entity models. Private blockchains are known as conventional centralized systems. Strong encryption methods are necessary for the verification and confirmation of transactions. The blockchain consortium still needs to be flawless for reliability, legitimacy, and precision

At an early stage of the review process, several research questions were formulated in relation to the objective of this study. The aim of this research work is to present a detailed review of the current research scenario of blockchain application in the healthcare industry and to identify the future prospective of this field. To that end, the research questions were used to select relevant research works from prestigious publications.

Search Strategy and Databases

To construct a meaningful and data-driven review paper, the right search strategy is needed, and the search keywords need to be defined to retrieve the correct information.

Before constructing search strings and paper selection criteria, extensive analysis of existing gaps in the healthcare system that could be solved with the help of blockchain is carried out. Multiple sectors were identified as potential fields where the application of blockchain would be most beneficial. The main focus of blockchain is secure data transfer and keeping records of all transactions, which could be most useful in the medical sector where patient information is required to be kept safe and proof of all monetary transactions is of utmost importance. Other than that, blockchain technology could help establish a safe remote patient monitoring system for telemedicine and offer faster data transfer. Blockchain secures the collection and storage of data from wearable devices. As blockchain allows real-time monitoring of data for multiple users simultaneously, it can offer better decision-making by allowing multiple doctors to access the same data at the same time. Decentralized nature of blockchain could prevent patient data tampering. These are just a few gaps that could be filled through the application of blockchain.

Result Analysis

Healthcare Record Sharing

One of the first blockchain-based healthcare systems involves the sharing of health information. This is difficult since it deals with the patient's personal information and is classified as sensitive data. Such a type of application of blockchain has been discussed

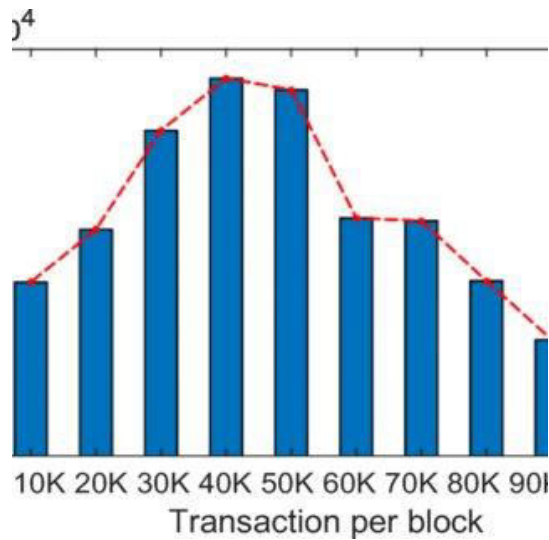


Fig 3: Health Care information

the topic of cloud computing is introduced, which could help create a new architectural design for sharing healthcare information via blockchain by providing a safer and more robust healthcare process used in medical practice. The author suggests a cloud-based architecture that embraces the blockchain data structure to connect node communications. Blockchain architecture utilizes intelligent contract concepts and transparent, unchangeable bookkeeping to supervise healthcare data sharing. In [96], the architecture of cloud junctions and blockchain concurrently is also pointed out to enhance management “access control” for the system. The author, for example, uses data collected from the Department of Radiation Oncology for testing. It specifies access control rules with two primary functions (patient and doctor). It also specifies transaction logic using intelligent contracts. These kinds of architectures have one objective for the future: to share radiology pictures and, if possible, test them on actual patients [96]. Recent papers linked to blockchain in healthcare discuss a network or system prototype. They also wish to develop a working system for testing with actual users.

Along with examining all of the components of the blockchain architecture for exchanging healthcare information with the use of cloud computing, it is also important to discuss other aspects such as data inspection. In [94], the authors discuss developing a solution based on blockchain for sharing records across health cloud service providers. The purpose of this solution is to ensure a better system for auditing and controlling record access, along with generating a query layer to establish a connection to the blockchain network while utilizing an activation set-off to execute the task through smart contracts.

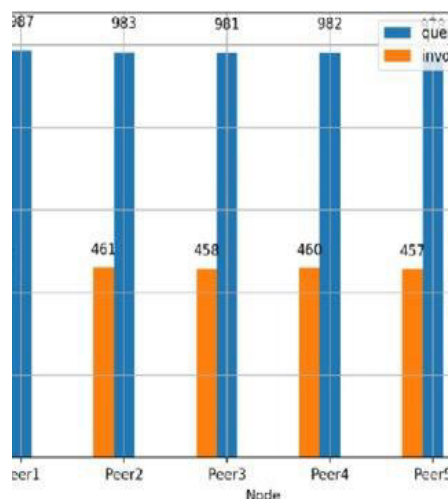


Fig 4: Medical Data

In the third stage, the drugs are stored in warehouses at the end of production. In the fourth step, the blockchain collects all the information used in transportation. In the fifth step, the medicines are sent from the warehouse to various healthcare centers or pharmacies. In the sixth step, all the information from the healthcare centers is stored through blockchain to prevent counterfeiting. In the seventh step, all the information about the retailer is saved. Finally, by collecting data from the blockchain supply chain, patients will be able to verify the veracity of the process.

III. CONCLUSIONS

This research aimed to conduct a thorough review, survey, and categorization of relevant research papers on blockchain and their integration into various healthcare applications where certain literary patterns may be detected. This paper presented the bibliometric and functional distribution of 144 research papers on blockchain in healthcare. We evaluated the distribution of blockchain platforms and the various kinds of blockchain techniques used or proposed in the examined papers. The blockchain platform allows the development of decentralized applications where the pattern of data transfers is uncontrollable by any third-party organization. The data transactions of the entities are kept in a decentralized database in a verifiable, secure, immutable, and transparent way, along with a timestamp and other pertinent information.

Additionally, blockchain technology has a variety of potential applications in healthcare, including data sharing, log management, medication, biomedical research and teaching, remote patient monitoring, and health data analytics. Even though blockchain adds many valuable features to healthcare applications, it has some drawbacks. We also analyzed the proposed solution in the reviewed papers for these drawbacks. Despite the considerable interest in blockchain technology, we discovered that its effect on healthcare applications is mostly in the documentation phase. There is yet to be a significant amount of study conducted in this area, as well as healthcare applications built on blockchain.

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