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Data Management in Healthcare using Blockchain

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ABSTRACT: Blockchain is a data-management system that has the potential to improve transparency and accountability. It is commonly considered as a potentially disruptive technology. Moreover, the healthcare industry has experienced rapid growth in the adoption of health information technology, such as electronic health records and electronic medical records. Furthermore, blockchain is transforming traditional healthcare methods into more dependable ways of effective management and therapy through safe and secure data sharing. Blockchain offers the opportunity to enable access to longitudinal, complete, and tamperaware medical records that are stored in fragmented systems in a secure and pseudo-anonymous fashion.

KEYWORDS: Cognitive Radio, Spectrum Sensing, Efficient Communication, System Security.

I. INTRODUCTION

This Satoshi Nakamoto originally unveiled blockchain technology in 2008 with his Bitcoin cryptocurrency concept. Blockchain technology has since been employed in a variety of fields, including business, banking, and healthcare. There are three sorts of blockchain technology designs: public (permissionless), private (permissioned), and hybrid [3]. Public blockchains are open source and designed to allow everyone to engage in the blockchain. The most well-known method for public blockchains is Proof of Work (PoW) [1]. Furthermore, all transactions completed in a public blockchain are totally accessible to all persons participating, implying that no one user or entity has control [3]. In contrast, private blockchains require members to obtain permission to enter the networks, and all transactions are visible only to authorised participants, whereas hybrid blockchains are flexible, allowing users to select whether specific data should be made public or kept private [3]. Because healthcare services are life-critical, any errors may have irreversible implications.

The interaction between the patient and the technology must be secure. Several nations [2,3] experienced significant data loss as a result of recent assaults on healthcare systems. Because the confidential personal health data was retained on the server without encryption, these assaults were effective. Cyber-attackers occasionally infiltrate the data storage system, rendering personal private data unsafe. 'Ransomware' Hospitals in England are being crippled as a result of a cyberattack. EHR systems enable patients to exchange personal information with doctors or healthcare groups. Personal data must be supplied with the system before it can be saved on the Blockchain. Data accountability is centred on the system in this case. The systems will also continue data sharing with doctors or healthcare organisations, and as a consequence, the system will be accountable for patients' personal data loss. In our approach, we overcome the aforementioned issues by keeping encrypted data in the system. If the system loses control of the Blockchain, the data will be protected since the patient is responsible for it. The patient is also in charge of data sharing. Our approach overcomes data protecting issues by combining cryptographic functions with Blockchain technology.

1. Applications of Block chain in healthcare

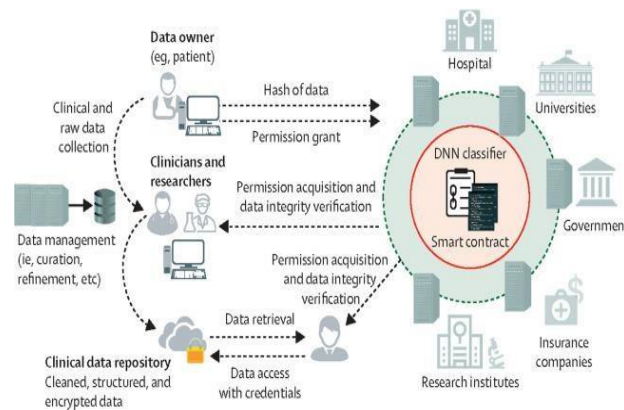
Swan defined blockchain as a decentralized transparent ledger with transaction records. Protecting patients' data is the most well-known block chain healthcare application. Security is also a major issue in the healthcare industry. Between 2009 and 2017, more than 176 million patient records were revealed in data breaches. (Sam Daley,20221). Block chain can keep a log that is reliable, accessible, and clear data of the patients makes it easy for security applications of

technology. The decentralized nature of this block chain allows patients, doctors and healthcare providers to share and access data quick and safe. Block chain technology is used store digital health records securely.

Below are the examples of the companies which uses block chain to secure the healthcare data.

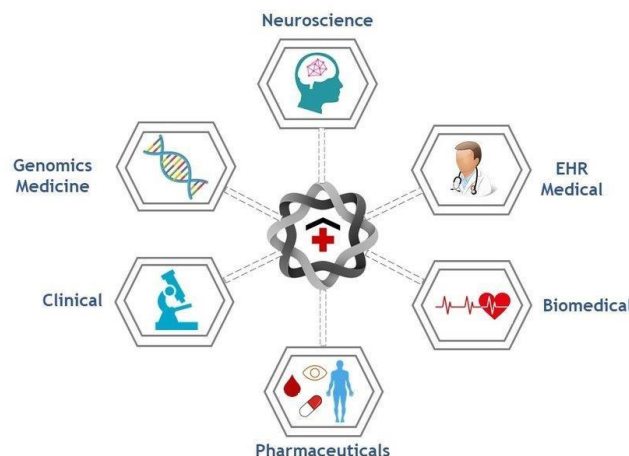
- Akiri
- BurstIQ
- Factom
- MedicalChain
- ProCredEx

Each company uses block chain in different ways to protect the data.



With the growing interest in blockchain and its acceptance in various organizations and industries, healthcare has emerged as a prominent area where a lot of use cases for blockchain have been discovered. Even though blockchain is a relatively new technology, there is a lot of inaccurate information, speculations, and uncertainties about its potential utility in the healthcare industry in the press as well as in grey publications in the form of opinion pieces, commentaries, blog posts, interviews, and so on. Members of the research community and practitioners in the healthcare industry would like to study more about the specific areas of application or use cases for blockchain. (Cornlius)

In olden days block chain was only designed for implementation in the area of economies and cryptocurrencies, but now it has been expanded it various fields including health and biomedical field such as health insurance, Pharmacy and medical treatment.



1.1 Blockchains in Electronic Health Records (EHR)

Medical practitioners, hospitals, and healthcare equipment have all driven an increase in the digitization of medical health records over the last decade, as digitization of this data allows for simple access and sharing, as well as a foundation for better and faster decision making. EHRs often include extremely sensitive and vital patient information that is routinely exchanged among doctors, radiologists, healthcare providers, pharmacists, and researchers for accurate diagnosis and treatment.

The patient's treatment may be jeopardized throughout the storage, transfer, and distribution of this highly sensitive patient information around numerous organizations, posing serious risks to the patient's health and the up-to-date medical history. Because of a long history of pre-and posttreatment, follow-ups, and rehabilitation procedures, the incidence of such hazards might grow larger in patients fighting chronic illnesses (e.g., cancer and HIV). As a result, keeping track of a patient's medical history has become critical to ensuring appropriate therapy, to overcome these challenges Dubovitskaya et al proposed a blockchain-based platform for organizing, preserving, and exchanging cancer patients' electronic medical records to access, manage, and store encrypted patient data, they used permissioned blockchain technology. These suggested frameworks can be utilized to incorporate blockchain technology in clinical practices for accessing and controlling the privacy and security of patient data and history.

1.2 Blockchains in Clinical Research

A variety of problems including data privacy, data integrity, data sharing, record keeping, patient enrolling [Gunjan Bhardwaj, How Blockchain Will Revolutionize Clinical Trials, June 2018]etc. may emerge in clinical trials. Blockchain, being the next phase of internet [Moe Alsumidaie, Blockchain Concepts Emerge in Clinical Trials, Applied Clinical Trials, May 2018], can offer workable solutions to these issues. With the use of blockchain, healthcare experts are attempting to resolve these difficulties. Blockchain applications, blended with artificial intelligence (AI) and machine learning, will surely take the medical industry.

1.3 Blockchains in Medical Fraud Detection

Application of block chain includes supply chain management, also supply chain is a critical problem but it is an increased significance, as a result of its growing complexity. This is due to any fault in supply chain management of healthcare products effects the lives of people or community directly. Block chain helps in avoiding fraud occurrence as well since a record in the block chain cannot be edited it can only be updated and validated with every user's consent. (. Mauri, R. Blockchain for Fraud Prevention: Industry Use Cases. July 2017)

1.4 Blockchains in Neuroscience

Modern neural technologies aim to create a new paradigm in which one may manage equipment and data via mental instructions rather than mechanical engagement with the surrounding infrastructure. Such neural devices are capable of interpreting brain activity patterns and translating them into commands for operating external equipment, as well as recognizing a person's present mental state based on data from their brain activity. Neural interface devices comprising multiple sensitive sensors, computation processors, and wireless connection tackle the unique issue of reading and interpreting brain impulses. When two or more individuals experience the same time from subjective views, we might reassemble their experiences to be more objective about the events of that instant using an augmented version of this technology. Using these techniques block chains can be applied in neuroscience.

1.5 Blockchains in Pharmaceutical Industry and Research

The pharmaceutical business is one of the fastest growing in the world, and it is a key player in healthcare delivery. The pharmaceutical industry not only assists in the introduction of new and potentially beneficial pharmaceuticals MPUE: In this attack, the objective is to obstruct the DSA process of SUs- i.e., prevent SUs from detecting and using vacant licensed spectrum bands, causing denial of service.

Using the Trust-Worthy algorithm it defines a threshold value to the SUs to overcome the PUE attacks. It enables CR-Networks nodes to efficiently utilize the available spectrum channels. Nodes, which can easily find various licensed channel opportunities without interfering the primary system increases. This reveals that it has a potential to be able to convert the various network conditions into a performance improvement.

1. Privacy protection and interactiveness of Data The introduction of Health Data Bank is to the secure the data, but its openness makes data sharing at risk. Many health data scams were reported while they were using traditional pattern of data storage. Data scam or forge can create panic and trust issues in individual. Powerful data encryption is very much essential without restricting the data exchange those who are in need. Thus, only authorized people can decode the data, in which the level are set differently for different users.

2. Rights

Personal health data and medical knowledge data are easily duplicated throughout the sharing and circulation process. The long-term operation of HDB will be hampered if the individual property rights of the data provider, user, manager, and beneficiary cannot be identified. If the datasharing system is built by different parties, another difficulty arises in the operating structure. Any party in this arrangement would want to be in charge of the operation, which would eventually lead to rivalry for rights.

3.Data Supervision

To gain users' confidence, transactions involving personal health data and medical knowledge data inside the HDB should be overseen by functional departments or non-profit organizations. Increasing the openness of health data and transactions while maintaining data privacy are significant concerns.

II. WILLINGNESS TO SHARE DATA

HDB services are supplied to consumers based on massive volumes of health data contributed by people and medical organizations. It is critical to have an incentive scheme in place to encourage people to contribute health data. Users will be unsatisfied with HDB in the long term if they receive the same revenue or return regardless of the quantity and quality of the supplied health data.

The implementation of blockchain brings vast development to solve issues faced by health data bank.

In the review conducted by Angraal et al. [Angraal, S.; Krumholz, H.M.; Schulz, W.L. Blockchain Technology Applications in Health Care. *Circ. Cardiovasc. Qual. Outcomes* 2017], they came out with some examples of the application of blockchain technology in healthcare. These include the Guardtime, a firm which operates a blockchainbased healthcare platform to check the patient's identities and the MedRec, which was built to control the management of permissions, legitimatization and data exchange between healthcare system. Likewise, Engelhardt [Engelhardt, M.A. Hitching Healthcare to the Chain: An Introduction to Blockchain Technology in the Healthcare Sector. *Technol. Innov. Manag. Rev.* 2017] sketches a group of examples of blockchain technology firms in the healthcare sector. These firms are categorized under different healthcare use cases, namely prescription drug fraud detection, patient-centered medical records and the dental industry. This review is uniform to the one done by Mettler [Mettler, M. Blockchain

Technology in Healthcare the Revolution Starts Here. In Proceedings of the 2016 IEEE 18th International Conference on E-Health Networking, Applications and Services (Healthcom), Munich, Germany, 14–17 September 2016] where he reports examples of blockchain applications domain of public health management, medical research and drug forging in the pharmaceutical industry. On the other part, Ku et al. [Kuo, T.T.; Kim, H.E.; Ohno-Machado, L. Blockchain Distributed Ledger Technologies for Biomedical and Health Care Applications. *J. Am. Med. Inform. Assoc.* 2017] bring out the best of blockchain when compared to traditional databases for healthcare applications. He additionally describes how these bests can be utilized to improve medical record management, boost insurance claim processes, upgrade clinical research and advance healthcare record book. Finally, Roman-Belmonte et al. [RomanBelmonte, J.M.; De la Corte-Rodriguez, H.; RodriguezMerchan, E.C.C.; la Corte-Rodriguez, H.; Carlos RodriguezMerchan, E. How Blockchain Technology Can Change

Medicine. *Postgrad. Med.* 2018] in their review, explains the existing and possible applications of blockchain in areas of medicine, health data analytics, biomedical research, electronic medical records medical payment services etc.

A. Storage Challenge

Blockchain was designed to record and process transaction data with a limited scope, so it does not require large amounts of storage. Healthcare apps usually service thousands or millions of users, including clinicians, patients, billing agents, and other stakeholders. When vast volumes of data are stored on a Blockchain, it may incur enormous cost, especially if data normalisation and denormalization techniques are not carefully examined.

For instance, the Ethereum public Blockchain defines a “gas limit” that limits the capacity of data operations to prevent attacks manifest through infinite looping. Blockchain applications are transaction based so that the databased used will grow at a rapid rate. Hence the speed of data searching and accessing tends to be low which is not suitable for the transaction-based technology. That is the reason why the block chain solution needs to be scalable and resilient.

B. Privacy Challenge

Although keeping patient health data on the Blockchain has the potential to deliver enormous benefits in terms of interoperability and quick availability, there are also significant risks associated with the data's transparency. Each Blockchain manager/miner keeps a complete copy of Blockchain on their computer. data. Even when encryption is used, it is possible that information could be intercepted. It's possible that present encryption systems will be broken in the future, or that vulnerabilities will be discovered. It's possible that flaws in the encryption techniques utilized will result in personal information being leaked. In the future, information could be decrypted and compromised.

As the blockchain technology removes the single trusted third party, the data becomes vulnerable to potential privacy and security risks. Because all nodes can access the data transmitted by a single node, data privacy is compromised. In the absence of a third party for authorization, the patient must designate one or more representatives who can access his information and/or medical history on his behalf in the event of an emergency

C. Scalability Challenge

Communication gaps and information sharing issues are major impediments to healthcare innovation and patient care quality. Providers, hospitals, insurance companies, and even departments within the same health organization are disconnected as a result of delays or a lack of information flow. Patients are frequently cared for in a variety of settings, including private clinics, regional urgent care centers, enterprise hospitals, and telemedicine practices. A provider may serve hundreds or thousands of patients, all of whose health-related activities must be tracked. Without any activity monitoring or filtering mechanism in place, a provider would have to expend enormous computational effort to review a patient's health transactions on-demand.

III. ADVANTAGE

The medical business can benefit greatly from blockchain technology. Similarly to how the internet revolutionized healthcare and introduced telemedicine, blockchain technology is likely to take medical science to the next level in the future by lowering the costs of monitoring, configuration, and having a central server for data, as well as for the administration managing the medical data. Using blockchains in healthcare settings would substantially cut processing time since, as soon as a patient enrolls in a study, the whole collection of data will be available at once owing to the distributed ledger's availability.

A. Data Privacy and Protection

The access to a patient's healthcare data is limited to individuals and/or entities authorized by the patients. Which includes specific information such as diagnoses, prescriptions, examination and test results or all the health data. Patient data can be protected by encrypting it with a key known only to the patient, and subsequent access to the data should be restricted to parties who have the patient's private key. Besides other type of protective data, the health records need to be kept and access-protected for a long time. Blockchain technology is highly resistant to attacks and failures, and it offers a variety of access control methods. As a result, blockchain provides an excellent framework for healthcare data.

Although the autonomous and transparent structure of blockchains will surely prevent data from being manipulated or stolen, many of the usual worries about large-scale data collecting remain. That sensitive data may be sold to third parties for dubious marketing objectives, and individuals may still be indirectly recognisable (as with bitcoin) via

pseudonymous identities or data patterns. As a result, this blockchain-based healthcare model will engage people more in their healthcare, eventually improving their quality of life in a more appropriate way.

IV. PERFORMANCE

In this part, we analyze the suggested framework's performance. We can limit the dangers connected with this innovative technology that only a few people understand by analyzing its performance.

A. EXPERIMENTAL CONFIGURATION

We conducted tests using the following settings to assess the performance of the proposed framework: • Intel Core i76498DU CPU @ 2.50GHz 2.60GHz processor • 8.00 GB RAM with Windows 64-bit operating system (version 10) We created our proposed framework with Solidity, Ethereum's programming language. JavaScript and Python are encased in the Solidity language, which Ethereum provides for writing code in smart contracts.

B. COLLECTION OF DATA FOR PERFORMANCE EVALUATION

This section describes the types of data utilized to assess the performance of the proposed framework. This part also goes through the measures that will be used to describe the outcomes of the performance review.

1) TRANSACTION INFORMATION

Following transaction records with its details are utilized to evaluate the performance of the proposed framework. • Time Required for Transaction Deployment (tx1) It is defined as the moment at which the transaction is deployed. A smart contract in Ethereum is deployed using the transaction, hence this deployment time corresponds to that moment.

• Transaction Closing Time (tx2) It is defined as the point at which the transaction occurs and confirmed by the blockchain, in this instance Ethereum.

2) METRICS OF EVALUATION

The suggested framework's execution time, latency, and throughput are among the metrics considered for assessment. These are briefly discussed below: • Execution Time is defined as the time elapsed (in seconds) between the confirmation of a transaction and its implementation in the blockchain network. It is calculated as (max (tx2) - min (tx1)).

- Throughput is the quantity of data that can be transported from one point to another in a unit of time.
- Latency is defined as the delay that happens while one system component waits for another system component to respond to an action. In terms of time, it might be defined as the period between transaction deployment and completion.

V. RESULTS

1) PERFORMANCE EVALUATION

To understand how our proposed framework will perform in a real-world situation with several users executing different activities on the framework, we performed a performance evaluation using Apache JMeter version 5.1.1 and Apache Version 2.00. Apache JMeter is a desktop performance testing tool used for application analysis and testing [34].

a: EXECUTION TIME ON AVERAGE

The execution time grows in proportion to the number of transactions. These transactions are carried out for the different functions included in the smart contract, the algorithm of which is outlined in Section V. When just one user is logged in to the system, the functions Assign Roles, Add Patient Record, and Delete Patient Record are disabled. View Patient Records would take 18.29 seconds, 1 minute 48 seconds, and 50 seconds to complete, respectively. This time would grow if 100 people used the system at the same time.

b: THROUGHPUT

Algorithm 1 describes the many functionalities contained in the proposed framework's smart contract. We used JMeter to simulate a range of 100 to 500 users (with periods ranging from 10 to 35) utilizing the system and completing its different operations. In JMeter, throughput is measured in data/time units, i.e., KB/sec. During the studies, we simulated the number of users stated above and evaluated the system's performance. These simulations are conducted on the suggested framework, and the throughput is analyzed at the conclusion. During this experiment, it was discovered that as the number of users and requests rose, the system's throughput increased significantly in a linear fashion. The suggested framework's efficiency is demonstrated by the linear rise in throughput.

c: AVERAGE LATITUDE

Latency, as previously stated, is the time difference between when one system component submits a request and when another system component generates a response. The time elapsed between these two acts is referred to as latency. Using JMeter, we determined the average latency of the proposed framework. JMeter was used to simulate the number of users while analyzing the latency of the proposed framework. Latency is measured in milliseconds in JMeter. In this experiment, the longest measured delay is 14ms. We also assessed the proposed framework's performance by calculating the size and cost of the transaction. We examine the transaction payload before determining the transaction size. This evaluation is explained in full in the section that follows.

VI. CONCLUSION

Blockchain technology has evolved from the time it was introduced to the world through Bitcoin into a generalpurpose technology with use cases in many industries including healthcare. To understand the state-of-the-art of the application of blockchain technology in healthcare, we conducted a systematic review in which we created the map of all relevant research using the systematic mapping study process [12].

Our study shows that blockchain has many healthcare use cases including the management of electronic medical records, drugs and pharmaceutical supply chain management, biomedical research and education, remote patient monitoring, health data analytics, among others. A number of blockchain-based healthcare applications have been developed as prototypes based on emerging blockchain paradigms, such as smart contracts, permissioned blockchain, off-chain storage, etc. However, more research still needs to be conducted to better understand, characterize and evaluate the utility of blockchain technology in healthcare. The practical utilization of blockchain technology in the healthcare domain will benefit a large number of individuals, medical practitioners, healthcare providers, R&D specialists, healthcare entities, and biomedical researchers to effectively disseminate the vast amount of data, share clinical knowledge, and communicate recommendations with greater security and guaranteed privacy protection. The successful implementation of blockchain technology in healthcare clinical settings would surely open new research avenues for the advancement of biomedical research. While, on the other hand, in precision medicine applications, the safe, secure, and scalable acquisition, storage, and sharing of this clinical data would assist in developing potential strategies for the diagnosis and treatment of diseases.

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