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Decentralized Blockchain Solutions for Enhanced Document Security in Healthcare

[1]Mandeep Singh, [2]Rajat Tyagi, [3]Shivam Rathore, [4]Pratyaksh Yadav, [5]Saksham Singh

[1,2,3,4,5] Computer Science & Engineering Department, Raj Kumar Goel Institute of Technology, Ghaziabad, UP, India
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ABSTRACT:

The management and security of the enormous volumes of sensitive patient data collected on a daily basis provide serious problems to the healthcare sector. It has been established that traditional centralized methods of managing healthcare data are susceptible to privacy violations, data breaches, and cyberattacks. Blockchain-based decentralized patient record management presents a viable answer to these problems. The potential of blockchain-based decentralized patient record management to improve the security, privacy, and interoperability of healthcare data is examined in this research study. An overview of the main components of decentralized patient record management, such as patient control, data distribution, and blockchain-based security, is given in this study. The study also looks at how decentralized patient record administration might increase data accessibility, cut down on redundancies, and improve data analytics. The research approach used in this investigation

1. Introduction

In today's ever-evolving healthcare landscape, the management and security of patient medical records are of paramount importance. Traditional centralized systems for patient record management have been the standard for many years, but they are increasingly facing significant challenges. These challenges include issues related to data security, accessibility, and patient empowerment [1]. As a response to these concerns, decentralized patient record manager applications have emerged as a transformative solution. In healthcare, patient records contain a wealth of critical information, ranging from medical history and diagnoses to treatment plans and laboratory results. The security and accessibility of this information are vital for both patients and healthcare providers. However, centralized systems have inherent limitations, such as vulnerability to data breaches, concerns about patient data privacy, and the difficulty patients face in accessing their own records promptly when needed [2].

Decentralized patient record manager applications represent a paradigm shift in the way patient records are managed and controlled. These applications leverage cutting-edge technologies, such as blockchain and distributed ledger systems, to offer a secure, accessible, and patient-centric platform for managing medical records. The driving force behind these applications is to empower patients by giving them more control over their health data while enhancing the efficiency and security of healthcare data management. In this comprehensive exploration of decentralized patient record management, we will delve into the intricacies and potential benefits of this innovative approach. This technology not only promises to resolve long-standing issues in the healthcare industry but also offers an opportunity to redefine the way patient records are handled and shared. This introduction sets the stage for a closer examination of the problem statement, objectives, scope, and existing software in the following sections, shedding light on the promising future of decentralized patient record management [3].

A centralized medical statistics managing system makes it grim to ensure the veracity of medical statistics. In such a system, medical statistics are often kept in a database of a health centre. An attacker can remove or alter the data after gaining the equivalent agreements of the database. What is more thoughtful is that in case of a health misconduct, the manager of the health centre may directly demand the administrator of the catalogue to remove or alter the information. The blockchain technology can unsurprisingly safeguard the integrity of health information. The medicinal information in a block chain is dispersed in storage device of different parties. It does not distress the data of other parties, if the data of a limited parties are changed or elected. Under a compromise mechanism, information in blockchain is still undamaged [4].

In traditional medical facts management systems, it is grim to maintain history of health conditions and diagnosis from the birth of the patient. This paper provides a solution to managing a chain of health and diagnosis records of patients from their birth which can be shared with different healthcare providers. The research studies have debated Blockchain based software throughout various industries and addressed several circumstances of use for this technology in a extensive manner. Lately 39 studies, presented summary of common channels and additional areas where block chain technology is employed for healthcare enrichment [5].

2. Literature Review

Romero et. al. [6], talks about the blockchain-based Healthy Block system, which is an architecture for electronic medical records (EMRs). The system offers a safe and reliable platform for integrating and accessing patient data, addressing the fragmentation of EMRs among healthcare facilities. Through the use of blockchain technology, patients actively manage their medical records within the system, and EMRs are more resilient to network issues. The article also provides information on the functionality and usability surveys that were done to assess the platform. Healthy Block's overall goal is to improve the accessibility, security and integration of electronic medical information in healthcare environments.

Shen et. al. [7], outline a verifiable private set intersection approach for the Internet of Medical Things (IoMT) that allows for fine-grained profile matching. The suggested plan uses re-encryption techniques and divides sensitive patient data into many tags to preserve patients' privacy during the profile-matching process. The Internet of Things (IoTs), 5G, and artificial intelligence (AI) technologies are some of the major technologies that are advancing IoMT that are highlighted in the document. The PDF file also offers a comparison of several PSI systems, their computation costs, and desired features, based on oblivious transfer and garbled circuit techniques.

Ruggeri et. al. [8], explain how federated hospitals are implementing a Blockchain based healthcare work flow for telemedical laboratory services. The suggested method delivers effective medical laboratory services by utilizing IoT and cloud computing technologies. The advantages of consuming blockchain technology in healthcare workflows including improved security, traceability, and transparency are highlighted in the essay. Additionally, the authors propose that IoT devices and cloud computing can enhance the effectiveness of clinical assessments conducted in hospitals. In general, the paper highlights the value of telehealth services, particularly in the event of a pandemic such as COVID-19.

Tian et. al. [9], explain the significance of safeguarding the confidentiality of medical data and suggest a blockchain-based shared key solution. The integrity, availability, and privacy of the system are characterized by the authors as its security features. They outline the system paradigm, in which several stakeholders including patients, relatives, physicians, nurses, pharmacists, insurers, attorneys, and medical specialists are involved. Each of these stakeholders has a fabric consumer that communicates with the fabric block chain. In addition, the writers analyse the system's security and performance. All things considered, the suggested approach that makes use of shared keys on a blockchain platform can enhance the security and usability of medical data as it is being diagnosed and treated.

Dwivedi et. al. [10], explains how IoT technology is being used in healthcare and why privacy and security issues must be taken seriously. It suggests a decentralized blockchain-based remedy to protect patient privacy in medical records. The advantages of wearable technology in healthcare as well as the difficulties in putting remote patient monitoring technology into practice are also highlighted in the article. The suggested method creates a patient centric access control for electronic health records by fusing the benefits of blockchain technology, public and private key cryptography, and lightweight encryption techniques. The paper ends by providing open-ended issues to lessen different types of threats and difficulties in putting such solutions into practice in IoT contexts with limited resources.

Bala et. al. [11], With an "iron triangle" to symbolize it, the review offers insights into the effects of cognitive computing in healthcare, including cost savings, tailored care, and speedy diagnosis or treatment.

Gabriel et. al. [12], explain a framework for decentralized predictive modelling in genomics and healthcare data that preserves privacy. Predictive correctness is to be maintained, risks associated with centralized architecture are to be reduced, and models are to be computed equitably. It makes use of blockchain technology so that different institutions can acquire generalizable models without exchanging patient information. The paper presents Glore Chain as an example, highlighting the elements of the consensus learning algorithm, group model learning, and blockchain network. Fair server rotation is ensured using the Proof of Equity consent algorithm. The framework prioritizes interoperability between sites and functions on the "semi trust" premise. For optimal system responsiveness and efficiency, hyperparameters such as polling time and waiting time can be changed. The paper demonstrates how decentralized methods can increase forecast accuracy while preserving model sharing fairness and privacy.

Gligoroski et. al. [13], possible uses of blockchain technology in the healthcare industry are thoroughly covered in the scoping review "Blockchain in health care and wellbeing sciences" by Anton Hasselgren and associates. The advantages of using blockchain in health sciences and health care, such as improved data security and integrity, are covered in the paper. It also looks at the different blockchain-related consensus procedures and smart contracts. The review identifies the primary contributions made by the listed publications and classifies them as either new algorithms/protocols or structural designs. It also describes the possible difficulties and restrictions associated with integrating blockchain technology into healthcare systems. All things considered; the assessment provides insightful information about how blockchain technology can revolutionize the healthcare industry.

Brindley et. al. [14], is a methodical analysis that investigates the different trade-offs associated with different blockchain architectures for electronic health record systems. The review talks about the study's shortcomings, such as the omission of research written in languages other than English and the absence of recognized MeSH words for "design" and "trade-off." The evaluation also emphasizes the need of using low-functionality language to prevent security breaches due to poor code, the significance of weighing present implementation against future proofing, and the requirement for a set of guidelines to direct enterprise design, planning, and implementation. this review offers enterprises wishing to create blockchain EMRs helpful design information.

In [15], the authors explain the problems with security and privacy in healthcare systems caused by administrators' concentrated control over medical records. It draws attention to the possible dangers of data loss, manipulation, and misuse in these kinds of systems. The article suggests using distributed and decentralized databases enabled by blockchain technology to address these problems. The solution seeks to reduce the danger of unwanted manipulation by facilitating safe and transparent access to medical records through the utilization of blockchain's public ledger and cryptography

characteristics. The interplanetary file system, smart contracts, node.js, and Docker engine are some of the technologies used in the implementation. The usefulness of the suggested method in maintaining the confidentiality and integrity of health information is demonstrated by the results of the experiments. In the future, the solution will be scaled up for more extensive testing and real-time resilience.

Harleen et. al. [16], explain the importance of using DNA cryptography and intelligent blockchain systems on cloud networks to manage and secure healthcare data. It draws attention to the difficulties in protecting private health information, the contribution of DNA cryptography to improving blockchain security, and the possible advantages of using intelligent blockchain systems for the administration of patient data. In the digital age, the paper highlights how crucial cutting-edge technology is to maintaining the privacy and accuracy of medical data.

Abid et. al. [17], The precision of diagnoses made by transfer learning algorithms and those made by clinical or health experts is compared in the study "A evaluation of Transfer Learning Performance VS Health Experts in sickness diagnosis from medical imaging" by Hassaan Malik et al. through a organized evaluation of the literature. The researchers looked through several databases for papers that were published between January 2014 and December 2019 and that supported the use of medical imaging to diagnose diseases using pre-trained algorithms. They purposefully set January 2014 as the deadline for taking into account the development of transfer learning strategies. Finding the most important and pertinent papers was a step in the research selection process, and the included articles' value was assessed by a quality assessment. The study's findings show that almost 81% of the chosen research studies received scores that were above average, and a thorough breakdown of how the included studies were distributed throughout various publication platforms is provided. To assess the accurateness of transfer learning algorithms against the diagnostic precision of medical specialists, the study also suggested a taxonomy of sickness diagnosis using medicinal imaging. To improve healthcare professionals' understanding of pretrained learning related health practices, this systematic review attempts to present a current overview of the range of pre-trained algorithms for illness diagnoses in comparison with human diagnosticians [18].

4. Technology Used

Ethereum: Ethereum is a decentralized, open-source block chain stage which allows the creation and execution of smart agreements and decentralized applications (DApps). Launched in 2015 by Vitalik Buterin and a team of developers, Ethereum was designed to expand on the capabilities of Bitcoin by providing a more flexible and programmable blockchain. Ethereum is used here for building and deploying smart contracts.

Web3.js: Web3.js is a JavaScript library which provides a set of utilities for interrelating with Ethereum based decentralized applications (DApps) and smart agreements. It is one of the most widely used libraries for building applications that connect to the Ethereum blockchain. Web3.js allows developers to make user interfaces, automate transactions, and relate with smart gets seamlessly. We used web3.js for interacting with our application’s front end and smart contracts.

Remix IDE: Remix IDE is an open-source web and desktop software designed to facilitate rapid bond advance on the Ethereum blockchain. It specifies a thorough amalgamated happening environment that lets developers to compose, deploy, plus interact with Ethereum smart contracts using various programming languages, primarily Solidity. Remix IDE is widely used aimed at its comprehensible interface and intense sort, put up it a standard pick for Ethereum developers. We used Remix for building smart contracts.

VS Code IDE: Visual Studio Code (VS Code) stands widely used; open-source code line editor developed by Microsoft. It must gain immense acceptance among developers due to its frothy nature, extensibility, plus rich set of features. While not specifically designed for blockchain development, VS Code has a vibrant ecosystem of extensions that make it a powerful choice for writing and managing smart contracts, especially on platforms like Ethereum. We used VS code for building the frontend application of our app.

MetaMask: MetaMask is an admired cryptocurrency holder and opportunity to decentralized web. It is a browser extension lead that lets users to administer their Ethereum-based assets relate with decentralized software plus securely store private keys. MetaMask simplifies the user experience of interacting with blockchain networks, making it more accessible for both developers and non-technical users. We used MetaMask for account-based authentication in our application [19].

QuickNode: QuickNode is a platform that offers blockchain infrastructure services, including Ethereum nodes and other blockchain-related solutions. QuickNode provides developers and projects with easy access to reliable and scalable blockchain nodes, allowing them to connect to various blockchain networks without the need to set up and maintain their nodes.

Solidity: Solidity is high-level programming language constructed for developing smart agreements that run on blockchain platforms. The situation is primarily associated with the Ethereum blockchain, where it serves as the language for writing and implementing smart contracts. Vigorous contracts are self-executing contracts with the terms directly carved into code, and they play a vital task in enabling decentralized applications (DApps) and various decentralized finance (DeFi) solutions. We used solidity for developing our smart contracts.

JavaScript: JavaScript is a widely used designing verbal known for its versatility likewise role as the primary scripting language for building dynamic web applications. It is a elevated, translated language that exists primarily associated with web growth, but it says extended its reach to extra domains, including server-side advance (Node.js), mobile app expansion, and even blockchain improvement. We used JavaScript to develop the front end of our application.

Express.js: Express.js, commonly known as Express, is a minimum and elastic web software framework for Node.js. It is concocted to make it easier to build web software and APIs by presenting a robust set of characteristics then a simple, unopinionated framework. Express.js is commonly benefited in the Node.js ecosystem plus exists considered one of the most popular frameworks for building server-side applications.

Node.js: Node.js is an open-source, cross-platform JavaScript runtime constructed on Hexavalent chromium V8 JavaScript engine. It grants developers to execute JavaScript computer code on the server side, permitting the expansion of climbable and high-presentation web software. Node.js is commonly used for building server-side applications, APIs, and real-time applications, and it has collected significant popularity in the web development cooperation.

React.js: React.js, commonly stated to as React, is an open-source JavaScript library exploited and upheld by Facebook. It is widely treated for fostering user lines, particularly intended for single-page concentrations anywhere dynamic with interactive content is a key requirement. React follows a component-based building, allowing developers near create reusable UI components that manage their state [20].

Sepolia Testnet: We used Sepolia Testnet of the Ethereum blockchain for testing our decentralized application.

5. Proposed Work

The goal of the proposed effort is to use blockchain technology and decentralization principles to create a reliable system for safely handling medical records. The security, privacy, and usability of traditional hospital document management techniques are frequently seriously compromised. Centralized systems run the danger of exposing private patient medical data due to their susceptibility to data breaches, unauthorized access, and lack of transparency. The suggested solution will use decentralization, which disperses data storage and control among a network of nodes as an alternative to depending on a single central authority, to overcome these difficulties. The foundational technology that will agreement the confidentiality, haven and integrity of medicinal data is blockchain technology.

To ensure that only authorized users with the right decryption keys can access medical records, the system will use encryption techniques to guarantee their confidentiality. Blockchain smart contracts will be used to construct access control methods, giving users fine-grained control over who can see, edit, or remove particular documents. By doing this, patients are guaranteed complete ownership and control over their medical records, and only appropriate parties or healthcare practitioners will be able to access them with their express consent.

Scalability and interoperability will also be prioritized in the system's design, enabling smooth connection with current healthcare systems and handling the expanding amount of healthcare data. To guarantee adherence to privacy and security rules, compliance with narrow criteria like HIPAA (Health Insurance Portability and Accountability Act) will also be a crucial factor to take into account during the development process.

Analysis of case studies and blockchain-based healthcare document management examples will be done in order to verify the system's viability and efficacy. Insights into best practices and potential hazards can be gained from real-world implementations and success stories. Prospects and consequences of blockchain technology for healthcare document management will also be investigated in this research. This covers prospective developments in legal frameworks, blockchain protocols, and interoperability standards that could affect the uptake and development of decentralized healthcare document management systems. In the long run, patients, healthcare providers, and other stakeholders in the healthcare ecosystem stand to gain from the proposed work's enhancement of safe and effective healthcare document management techniques.

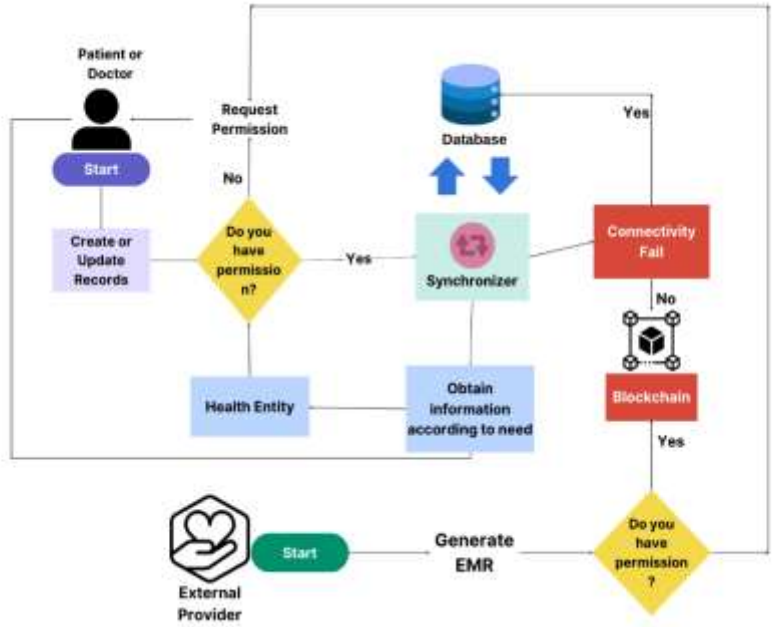

Fig. 1 Flow diagram of proposed work

A patient can provide access to his health records to different healthcare providers where doctors can create or update records which will be added to the diagnosis history of the patient.

```
function createRecord(string calldata _recordName, string calldata _date) public{
    records[recordId]=Record(recordId,_recordName,_date);
    recordId++;
}
```

Fig. 2 Pseudocode for creating a new record in smart contract

6. Conclusion

The paper is about the need for increased security and privacy in healthcare data management, highlighting the shortcomings of existing centralized systems. It proposes decentralizing patient records as a solution and advocates blockchain for its game-changing properties. By spreading medical information over various nodes, blockchain have ensured their tampering cannot happen without permission, therefore making medical information more secure. The paper describes the many-sided advantages of solutions based on blockchain technology that focus on better data protection, safety, and interconnectivity. Giving patients the authority to manage their health data helps to solve past issues regarding privacy and accessibility. A comprehensive review of literature shows that there are multiple uses of blockchain in healthcare ranging from electronic medical records (EMR) to privacy-preserving schemes and predictive modelling. In terms of scalability and effectiveness when used in healthcare settings, the technological architecture employed by utilizing the Ethereum blockchain, Web3.js, Remix IDE, and MetaMask is a good example. This emphasizes the importance of collaboration between healthcare experts and technologists to successfully innovate or integrate blockchain within healthcare systems. In summary, although blockchain comes with a promising new way of doing things; there is a need to deal with these problems for it to be successfully absorbed into the healthcare system and revolutionize data management.

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