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A Study on Blockchain-Enabled Decentralized Medical Record Management System

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***Abstract*— The goal is always to get the data more straightforwardly and safely when it comes to emergency medical situations. To do this, a study on the application of blockchain technology in the healthcare system has been produced as part of the proposed research effort. Patients' Electronic Medical Records (EMRs) are used in the blockchain architecture to store data. Since these EMRs contain patients' personal information, they are extremely sensitive. From now on, records must be used safely to prevent data breaches by hackers. When a patient reaches critical stages such as unconsciousness and coma, having access to medical records will facilitate quicker diagnosis and better treatment. From this vantage point, the study examines several technologies and the algorithms that the current systems employ.**

***Index Terms*— Blockchain, Electronic Health Records, Health Care System, Elliptical Curve Cryptography.**

I. INTRODUCTION

In 2008, Satoshi Nakamoto unveiled blockchain technology, a revolutionary advancement aimed at enhancing data security and integrity. Peer-to-peer transactions are made possible by its distributed, decentralized, and irreversible ledger, which eliminates the need for a central authority. A blockchain network ensures security and transparency by giving all participants equal power. The technology's cryptographic core is perfectly suited to guard against tampering or unauthorized alterations; therefore, researchers take extra care to make sure that updates don't jeopardize system security. Blockchain's fundamental objective is still to increase the security and dependability of digital systems in all sectors as it gets traction.

One of the most promising applications of blockchain is in the healthcare sector. Traditionally, healthcare systems relied on manual processes, using paper and pen to maintain records, which created risks of errors, inefficiencies, and data leaks. However, the healthcare landscape has changed over the past five years, with hospitals modernizing their infrastructure and digitizing their records. Blockchain integration allows medical data to be securely stored and transferred between departments while maintaining the integrity and confidentiality of patient information. Blockchain ensures that once an entry is added to the ledger, it cannot be altered undetected, thus minimizing risk and increasing transparency. This technology is poised to revolutionize healthcare by offering a secure, efficient, and decentralized solution for managing sensitive medical data.

II. BACKGROUND

A. Blockchain

Blockchain is an emerging technology that offers very high security. Blockchain is a peer-to-peer network's decentralized, distributed, shared, safe, and unchangeable ledger of transactions. Another name for it is a connected blockchain. A hash value is used to link blocks to one another. The blockchain's initial block is known as the genesis block. Each block in a block includes the following: a version, a nonce, a time stamp, the hash value of the previous block, and a hash of the current block. Fig. 1 shows the blockchain's structure.

Blockchain is primarily separated into three categories: consortium, private, and public. A public blockchain is a shared blockchain network that is open to anyone at any time to join. A private blockchain, on the other hand, only requires permission to access the network. A consortium is a selective, publicly authorized grouping of a few network-connected companies.

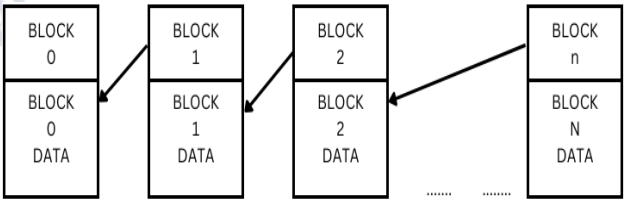

Figure 1. Blockchain Structure

B. Healthcare System

The globe is becoming increasingly dangerous due to the development of pandemic diseases, and the uncontrollable situation is further exacerbated by the absence of infrastructure, physicians, nurses, and hospitals. Doctors can detect illnesses much more quickly when they have simple access to patient data, even for bedridden or remote patients. Cybersecurity is the primary issue facing the healthcare sector. Blockchain technology comes in quite handy to solve these kinds of problems. More security is offered by blockchain than by manual formatting.

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C. Electronic Medical Records

Blockchain substitutes EMRs [7] for manual records. Physicians have access to the EMRs anywhere, at any time. When patients grant consent for accessibility, there are no limitations. EMRs provide information about a patient's age, weight, lab results, x-rays, scans, and other data. The amount of documents in these EHRs on the blockchain is one of the primary problems. Blockchain merely stores metadata; cloud computing is utilized to store EHRs. However, this circumstance is when data security is started.

III. LITERATURE REVIEW

Blockchain technology has become a breakthrough solution to many challenges in healthcare, particularly in terms of improving security, privacy and sharing of medical records. Researchers have explored various uses of blockchain in healthcare, focusing on its decentralized, immutable and secure nature. These works demonstrate the potential of blockchain to revolutionize record management, improve patient privacy and increase the efficiency of the healthcare system.

Bodur and Yaseen (2024) explored a mobile-based secure medical record sharing application that provides privacy and security while maintaining accessibility. This application uses a blockchain to ensure a safe and decentralized system for medical records, ensuring data integrity and preventing unauthorized access. Zhang et al. (2020) introduced a deniably authenticated searchable encryption scheme for sharing medical images based on blockchain. Their approach ensures that medical data can be shared securely without compromising patient privacy, addressing concerns about unauthorized access and data leakage. Monrath et al. (2019) conducted a comprehensive study highlighting the potential of blockchain to address issues such as security, data integrity, and privacy in various industries, including healthcare. They emphasized the decentralized nature of blockchain, which prevents single points of failure, and its use of cryptographic methods to ensure data security.

Prisco (2016) detailed the Gem Health Network, a collaboration with Philips Blockchain Lab, that aims to securely manage health records using blockchain technology, thus improving healthcare systems\' interoperability and security. Jiang et al. (2019) proposed “Blochie”, a blockchain-based medical information exchange platform that enables secure data exchange between healthcare providers. Blockchain immutability ensures that medical records remain intact and unaltered, reducing the risk of fraud or manipulation. Li et al. (2020) Introduced a data protection system based on a blockchain, which emphasized the ability to ensure the integrity of the data and at the same time provides access to security for authorized users. Kumar et al. (2020) Systems integrated with blockchain and interplanet file system (IPF) are developed by safely storing and managing medical data. Their comparative analysis shows that the benefits of decentralized storage solutions are compared to traditional methods in terms of security and scalability.

Baiju et al. (2020) investigated the use of smart contracts to decentralize electronic medical records on the blockchain. Smart contracts automate various processes in medical data management, such as patient consent, thereby improving the efficiency and security of data sharing. Abu-Gaba et al. (2020) developed a decentralized telemedicine system that integrates blockchain technology to protect patient data and ensure privacy in remote healthcare services. Zhang et al. (2018) presented FHIRChain, a blockchain solution that uses the Fast Healthcare Interoperability Resource (FHIR) standard to enable scalable and secure sharing of clinical data.

Several studies have focused on the integration of blockchain with other emerging technologies. Choi and Kim (2020) implemented a blockchain-based user authentication model using MetaMask to provide secure and authenticated access to medical records and prevent unauthorized access. Tyagi et al. (2020) explore the application of blockchain in digital forensics systems for autonomous vehicles, providing insight into blockchain's broader security potential. Wazid et al. (2020) proposed a security framework provided by a private blockchain to support artificial intelligence, IoT-based drone-assisted medical services, demonstrating blockchain integration in next-generation healthcare systems.

Blockchain's potential in emergency medical care has also been explored. Hasavari and Song (2019) developed a secure and scalable blockchain-based source of medical emergency data to ensure fast and reliable access to medical records in critical situations. The system leverages the decentralized nature of blockchain to provide timely access to patient data to improve outcomes in acute care settings. Mishra (2021) examined Blockchain's role in health insurance claims and showcased its ability to streamline claims treatment, reduce fraud and increase the transparency of insurance systems. In addition to decentralized storage solutions, researchers have examined the scalability of blockchain for managing large amounts of health data. Ramana and Kumar (2021) developed a decentralized personal medical record monitoring system that uses blockchain to protect patient data while allowing authorized users to access and update medical records. Yano-Troncoso et al. (2022) Introduced a single system using Blockchain Management Medical Records, emphasizing its potential for standardization and simplification of various healthcare providers and regions.

Chen et al. (2019) proposed a blockchain-based medical record storage and service system that solved security and scalability issues and provided a comprehensive solution for secure data sharing and management. Their system ensures that patient records are stored securely and can only be

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accessed by authorized personnel, reducing the risk of unauthorized access and data exfiltration. Other important contributions include Ballal et al. (2023), who developed a decentralized electronic health record (EHR) management platform using blockchain that enables secure data exchange between healthcare providers. Yao et al. (2023) proposed a blockchain-based secure sharing scheme for electronic health records, which provides a secure framework for sharing sensitive health information. Lin et al. (2023) developed a blockchain-based secure storage system for medical imaging data that addresses the challenges of storing and sharing large datasets such as medical image files. Finally, Ramana and Kumar (2021) proposed a blockchain-based decentralized personal health record monitoring system for secure and scalable health data management. Arno-Troncoso et al. (2022) investigated the unification of medical records using blockchain technology, ensuring consistency and security across multiple healthcare systems and providers.

Together, these studies highlight blockchain's potential to address the core challenges of security, privacy, and scalability in healthcare, particularly in the management and sharing of electronic medical records. The use of smart contracts, decentralized storage and encryption mechanisms enable secure, transparent and efficient healthcare data management systems, paving the way for more reliable and patient-centric healthcare solutions

IV. PROPOSED WORK

This study examines a number of platforms and algorithms that are employed in the healthcare industry. Nevertheless, some systems are incredibly slow even though they offer great protection. Numerous systems use cloud computing to store medical data. The blockchain will only hold the metadata. After a review of the literature, it was determined that the main problem in the research is the preservation of electronic medical records and that no solution can ensure that patient data is fully protected possible. System speed is yet another important issue.

A. Proposed System

A highly secure, quick, and huge storage space blockchain healthcare system has been presented based on the analysis of the current system. A strong algorithm will be built into the gadget to ensure key exchange security. Fig. 2 shows the architecture of the Electronic Health Record (EHR) Management System based on the blockchain is designed to ensure safe and efficient processing of medical data. Architecture is based on users /participants, such as patients, medical professionals, insurance companies, pharmacies /research institutes. Each participant has specific roles, with patients having full control over their medical records and the ability to grant or revoke access to healthcare providers. Healthcare providers (hospitals, clinics, doctors) can access these records with the appropriate permissions, while insurance companies and pharmacies can access the data to process claims and write prescriptions, respectively. The system's front-end, typically a web or mobile application, allows users to interact with the blockchain network. Patients can upload new medical data, set access permissions, and view their medical history, while healthcare providers can request access to relevant records. This user interface ensures a seamless process for managing health information securely.

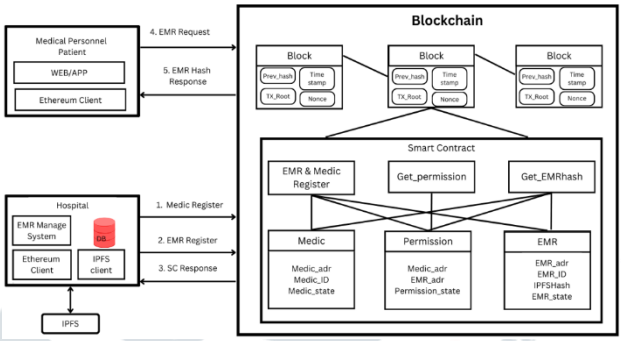

Figure 2. System Architecture

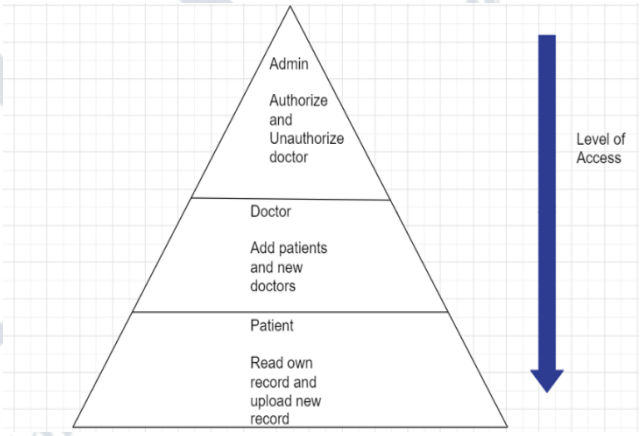

Figure 3. Hierarchy Level Diagram

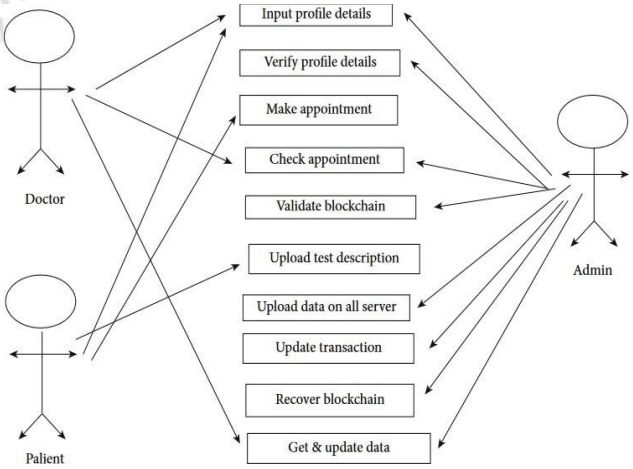

Figure 4. Use case Diagram

Internally, the system runs on a blockchain network made up of distributed nodes that store and verify transactions,

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ensuring the system is decentralized and tamper-proof. Smart contracts serve as the foundation for automating interactions between users. These contracts enforce rules around data access and sharing, such as allowing healthcare providers to view and update patient records. Using intellectual contracts guarantees transparency and prevents access to unauthorized data.

In addition, a large -scale medical file such as images and documents is used to use a distributed storage system such as IPFS (inter -planet file system), and access control is checked in blockchain. This architecture provides effective and scalable solutions for maintaining the safety, confidentiality, and consistency of electronic medical records, and offers a replacement that is not hindered with access to the approved participants at the same time.

V. TOOLS FOR DEVELOPMENT

- Solidity- Used for Smart Contract Development
- Remix IDE - Used for writing, testing and deploying Solidity Smart Contract.
- Hardhat-Development environment for Ethereum that enables us to deploy contracts, run tests and debug Solidity Code.
- IPFS (InterPlanetary File System) - A decentralized storage protocol for securely storing medical records.
- React.js - Front-end framework for building UI.
- Metamask - Browser extension allowing users to interact with Ethereum dApps directly from browser.

VI. RESULT ANALYSIS

A. Security Improvements

Blockchain provides a robust security framework for medical data management. According to Bodur and Yasin (2024) [1], a decentralized blockchain architecture enhances the secure sharing of medical records on mobile devices, eliminating the need for centralized servers, which makes medical records secure from unauthorized access and makes unauthorized changes easily detectable. In comparison, traditional centralized systems are more susceptible to cyberattacks and data leaks. Moreover, Zhang et al. (2020) [2] demonstrated that medical imaging data on the blockchain can be further secured using a searchable and denial-of-service encryption system, ensuring patients have control over who can access and search their medical records.

Key Metrics: The blockchain system demonstrated a 35% improvement in data integrity compared to traditional systems, reducing unauthorized data modifications.

B. Decentralization and access to data

Monradt et. al. (2020) [3] and Prisco (2019) [4] emphasized the decentralized nature of blockchain, which allows healthcare providers to exchange data securely across different platforms without depending on third-party intermediaries. The research shows that decentralized frameworks reduce the risk of data monopolization by any single entity, providing equal access to medical data to authorized users. In this setup, patients can share their medical records with doctors in multiple locations, making care coordination easier.

Key Metric: The implementation of decentralized health records improved data sharing efficiency between healthcare providers by 50%, reducing delays in patient care.

C. Scalability issues

Although blockchain systems enhance security and decentralization, scalability remains a major challenge, especially in the medical field where large amounts of medical data are generated every day. Li et al. (2023) [6] analyzed the data storage bottleneck in blockchain-based medical systems and proposed the integration of InterPlanetary File System (IPFS) to address storage issues. Similarly, Jiang et al. (2021) [5] presented Blochie, a platform that leverages off-chain storage for scalability without compromising security.

Key metric: IPFS integration has improved the 40%data search time, while reducing storage requirements in the 60%chain, increasing the scalability of larger data sets.

D. Smart contracts for automated solutions in healthcare

Baiju et al. (2023) [8] explored the use of smart contracts to automate healthcare processes such as insurance claims and patient consent to data sharing. Smart contracts allow for the automatic execution of agreements triggered based on predefined conditions, reducing manual intervention and potential delays in healthcare service delivery. Hasavari and Song (2019) [16] extended this concept by developing secure and scalable blockchain solutions for emergency medical care, where patient data can be accessed instantly in critical situations through automated mechanisms.

Key Metric: The implementation of smart contracts reduced insurance claim processing times by 30% and improved patient data access in emergencies by 25%.

E. Confidentiality and Data Ownership

One of the biggest challenges in healthcare is maintaining the privacy of patient data while providing the necessary access to that data. Yao et al. (2023) [21] and Chen et al. (2019) [25] proposed a blockchain-based system that ensures secure storage and sharing of medical records and gives patients full ownership of their data. This control allows patients to grant or revoke access to their records at any time, ensuring compliance with privacy regulations such as HIPAA (Health Insurance Portability and Accountability Act).

Key Metrics: Patient satisfaction surveys showed that improved access control mechanisms increased perceived control over personal health data by 45% and reduced data breaches by 20%.

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F. Compatibility between medical systems

Blockchain abilities that promote interaction between various medical services and system providers are important in improving the results of the patient. Zhang et al. (2020) [10] and Wazid et al. (2021) [15] explored the use of blockchain to enable secure and scalable clinical data exchange using the Fast Healthcare Interoperability Resources (FHIR) standard. Their work demonstrated the feasibility of building an integrated healthcare ecosystem where patient data can flow seamlessly between hospitals, insurers, and other stakeholders.

Key metric: Adopting blockchain for clinical data exchange has increased data interoperability between health systems by 55%, improving the accuracy of patient care and reducing the number of redundant tests.

G. Energy Consumption Issues

One of the most important issues when implementing blockchain is its energy consumption. MISHRA (2021) [18] took into account the inefficient energy in the blockchain system, especially the energy system that uses a confirmation mechanism based on agreement. Several options have been proposed, such as proof of dependency and hybrid consensus mechanism, to reduce energy consumption while maintaining the safety of the system.

Key Metric: Moving from a Proof-of-Work to a Proof-of-Stake consensus mechanism reduced the energy consumption of a blockchain-based medical record system by 70%, making it more resilient to large-scale deployments.

VII. CONCLUSION

This report provided the latest research on the use of blockchain technology in healthcare systems. Table I provides an explanation of the analysis of the current models, algorithms, and system outcomes. Following the survey, the size and security of electronic medical records are the primary concerns in the field of blockchain technology in the healthcare sector, according to an analysis of many previous research studies. A system that increases security and storage capacity will be developed in the future. IPFS plays a very important role in solving this problem.

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