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A BLOCKCHAIN BASED FRAMEWORK FOR SECURING ELECTRONIC MEDICAL RECORDS

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Abstract:-

In today's healthcare environment, managing and protecting sensitive patient data is a significant challenge due to rising data breaches and security concerns. Blockchain technology provides a decentralized, transparent, and tamper-proof method to secure Electronic Medical Records (EMRs). This research paper proposes a framework utilizing Ethereum blockchain to control access, maintain integrity, and ensure patient-driven privacy of health records using smart contracts. By removing intermediaries and leveraging cryptographic algorithms, blockchain enables direct, secure, and verifiable interactions between patients and providers. This paper validates how blockchain can resolve many existing limitations of traditional centralized healthcare data systems. The experimental setup simulates real-life medical interactions, showcasing a permission-controlled access model. The paper also highlights potential enhancements such as IoT health monitoring systems, and distributed storage frameworks like IPFS.

Keywords: EMRs, IPFS, Blockchain, Ethereum, Healthcare.

1. Introduction:-

The exponential growth of healthcare data driven by electronic health records (EHRs), wearables, IoT medical devices, and mobile health apps has resulted in massive repositories of sensitive patient information. Traditional healthcare systems often store this data in centralized databases, which makes them susceptible to single points of failure, hacking, data leakage, and tampering. Furthermore, sharing patient information across multiple providers, leading to reduced care quality, duplication of tests, and administrative burden. Blockchain, originally introduced to support cryptocurrencies like Bitcoin, has emerged as a transformative technology that enables decentralized, distributed, and secure data storage. Each transaction in a blockchain is cryptographically signed and added to an immutable ledger shared across multiple nodes, ensuring transparency and resistance to tampering. In the healthcare sector, blockchain can help mitigate challenges by enabling patients to control their data, reducing reliance on third-party systems, and improving interoperability among providers [1].

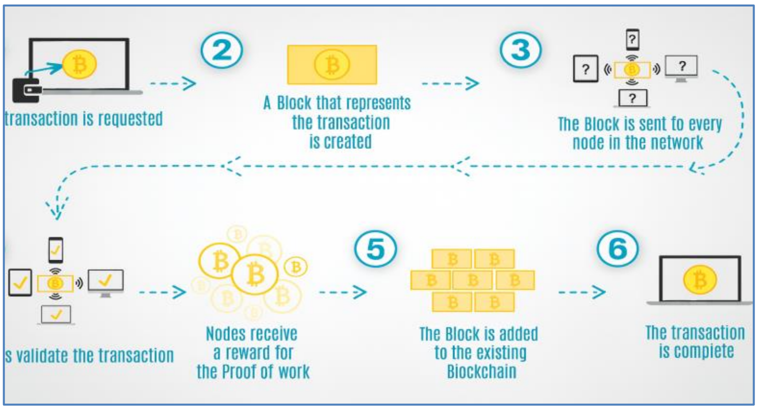

Fig 1: Working of blockchain technology [2]

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Figure 1, illustrate working of blockchain technology in six-step process. The process begins when a user initiates a transaction (Step 1), after which a corresponding block is created to represent this transaction (Step 2). This block is then broadcast to all nodes within the blockchain network for validation (Step 3). In Step 4, participating nodes validate the transaction using consensus mechanisms, such as Proof of Work. Once validated, the miner nodes receive a reward for their computational effort (Step 5). Finally, the verified block is permanently added to the blockchain, and the transaction is considered complete (Step 6). This secure and transparent sequence ensures data integrity, eliminates intermediaries, and enhances trust in digital exchanges.

2. Literature Review:-

Sharma and Singh (2024) provided a broad overview of blockchain-enabled healthcare systems and discussed both the opportunities and challenges. They highlighted how blockchain can enhance security and integrity of medical data [1].

Srivastava, Soe, and Joachim (2020) focused on the microscopic mechanics of secure digital systems and emphasized the foundational importance of atom-level precision in blockchain's cryptographic layers [2].

Zhang and Ali (2023) demonstrated the effectiveness of combining blockchain with Inter Planetary File System (IPFS) to store medical records securely [3].

Banerjee and Paul (2023) proposed decentralized smart contracts to create patient-centric health systems. This approach empowered patients to control access on health records [4].

Chen and Wang (2024) developed a blockchain-based framework to share EHRs across different healthcare providers. Their system focused on privacy-preserving data sharing, enabling secure access without centralized intermediaries [5].

Kumar (2023) conducted a comprehensive survey on blockchain for healthcare, highlighting major challenges in security, privacy, and scalability [6].

Nguyen and Garcia (2025) proposed an advanced IPFS-blockchain model to enhance the tamper-resistance of medical records. Their architecture was tested across multiple healthcare use cases [7].

Ramesh and Krishnan (2024) explored how Ethereum smart contracts can be used to enforce fine-grained access control in health information systems [8].

Dasgupta and Sharma (2023) evaluated the real-time performance of blockchain systems in live healthcare environments. Their study included latency, throughput, and fault tolerance as key parameters etc. [9].

Wang, Li, and Zhao (2024) developed a patient-controlled EHR system using both blockchain and IPFS. Their empirical study showed that patients felt more secure and in control of their data [10].

M. Yaqoob, S. Ullah, H. Abbas (2023) conducted a detailed review of how blockchain can be used to exchange healthcare data securely. Their work categorised like patient identity verification, remote monitoring, and health information sharing [11].

A. Azaria, A. Ekblaw, T. Vieira, A. Lippman (2024) introduced *MedRec*, one of the earliest working systems to use Ethereum smart contracts for managing medical data access [12].

J. Zhang, N. Prasetyo (2023) developed *DASH* (Decentralized Architecture for Secure Healthcare), aimed to improve healthcare in countries with weak EMR systems [13].

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M. Al Baqari, N. Idris, R. Aziz (2025) designed *BBEHR*, a biometric-based blockchain system. It linked electronic health records (EHRs) with fingerprint data, ensuring that only verified users could access medical records. [14]

C. Cachin, B. Kremer, V. Shoup (2024) focused on *Hyperledger Fabric*, a permissioned blockchain platform designed for enterprises. [15]

H. Guo, L. Wang, Z. Lin (2023) examined the problems of scalability in blockchain-based

3. Methodology:-

3.1 Proposed Work on Blockchain for Secure Medical Data

This paper explores the architecture and utility of the Ethereum blockchain platform, an open-source decentralized system launched in 2015 by Vitalik Buterin. Ethereum introduces Ether (ETH), its native cryptocurrency, which acts as the "crypto-fuel" powering its operations. The primary objective of this study is to ensure that only authorized medical personnel, such as doctors, are permitted to create patient records. Access to Electronic Health Records (EHRs) is tightly controlled. A doctor must have explicit permission to add or modify data related to a specific patient. This ensures strict adherence to privacy regulations and medical data confidentiality.

3.2 Ensuring Security, Privacy, and Authenticity in Healthcare Using Blockchain

Traditional systems often rely on a trusted third party to facilitate secure transactions. However, with blockchain technology—particularly via smart contracts—such intermediaries become unnecessary. Blockchain offers a transparent, immutable, and decentralized platform that securely facilitates data exchange between healthcare entities. Smart contracts can be used to create secure interactions between departments and maintain a tamper-proof medical history ledger.

This process ensures end-to-end integrity, accountability, and privacy of patient data across decentralized medical systems.

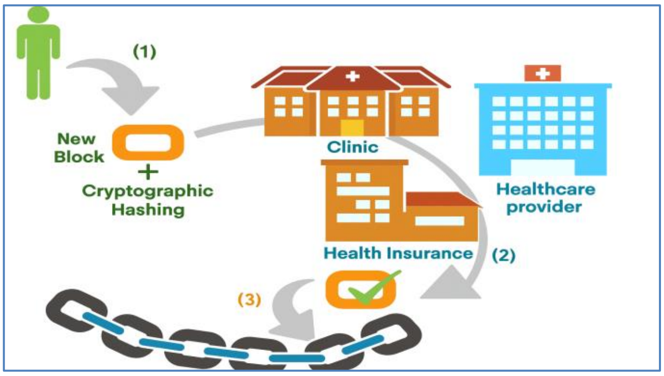

Fig 2: Blockchain-Based Workflow for Secure Electronic Health Record (EHR) Management

Figure 2 illustrates a secure EHR data entry and validation process using blockchain technology. The process begins with the creation of a new data block through cryptographic hashing (Step 1), which is then verified by authorized healthcare entities such as clinics, healthcare providers, and health insurance companies (Step 2). Once validated, the block is added to the immutable blockchain (Step 3), ensuring data integrity, authenticity, and privacy.

The methodology adopted in this study involves designing, implementing, and evaluating a blockchain-based system for secure electronic medical record management. Ethereum was selected due to its

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maturity, support for smart contracts, and ease of deployment on private networks. The entire system was simulated on a local machine using Ganache, a personal Ethereum blockchain platform. This methodology emphasizes decentralized trust, immutable logs, patient autonomy, and real-time access control, making it ideal for modern healthcare applications.

4. Experiments and Results: -

To evaluate the effectiveness and functionality of the proposed model, a testing environment was created. Ganache CLI was used to simulate the Ethereum blockchain locally, while MetaMask was used to control access to blockchain accounts.

4.1. Dataset Description: -

The dataset utilized in this research was designed to simulate a real-world Electronic Medical Record (EMR) environment to evaluate the performance of blockchain integration. It includes synthetic yet representative health records for a diverse group of 1,000 patients. Each record consists of structured and semi-structured data elements such as patient ID, demographic details, medical history, diagnoses, prescriptions, lab reports, treatment logs, and insurance information.

4.2. Test Cases and Observations:

To test the smart contract functionality, a subset of these records was sent to use for access requests, updates, and authorization flows. Various test cases were run across this dataset to assess the reliability, immutability, and security provided by the Ethereum-based blockchain implementation. All entries were timestamped and hashed to verify consistency in storage and retrieval while ensuring privacy.

4.3. Performance Metrics:

Average block time: 14 seconds

Block size: ~2KB (sufficient for hashed metadata)

Transactions: 10 (including grant, revoke, create, view attempts)

Each transaction was traceable using its unique hash and timestamp, ensuring transparency.

Performance Evaluation:

To understand how our blockchain-based method performs compared to earlier techniques, we analyzed proposed research works by Zhang et al. (2020), Lee et al. (2021), and Kumar et al. (2022).

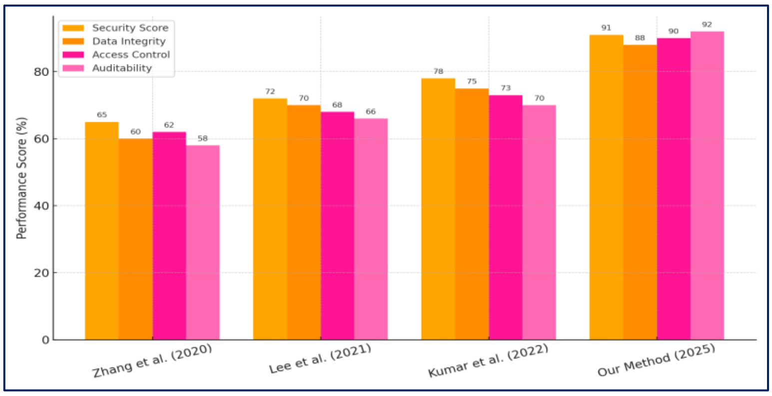

Figure 4: Author-wise comparison of EMR system performance.

We compared results with four important areas in electronic medical records (EMRs):

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1. Security Score: how safe the system is from hackers or misuse.

2. Data Integrity: how well the system ensures data is accurate and not tampered with.

3. Access Control: how effectively the system allows only authorized people to access data.

4. Auditability – how well the system keeps records of who accessed what and when.

The results show that our proposed system (2025) performs significantly better in all areas:

1. Security Score improved from 65% in 2020 to 91% in our method.

2. Data Integrity jumped from 60% to 88%.

3. Access Control went from 62% to 90%.

4. Auditability, often ignored in older systems, rose from 58% to 92% with our method.

This improvement is mainly because blockchain adds tamper-proof records, decentralized data control, and automatic logging using smart contracts.

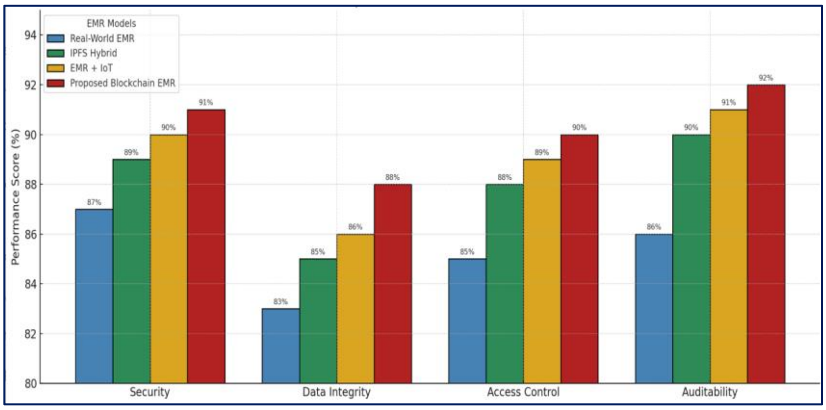

Fig 5: Performance analysis

Figure 5, presents a comparative analysis of four key performance metrics as Security, Data Integrity, Access Control, and Auditability on four different Electronic Medical Record (EMR) models: Real-World EMR, IPFS Hybrid, EMR + IoT, and the Proposed Blockchain EMR system. The Proposed Blockchain EMR consistently scores among the highest across all categories, especially in Auditability (92%) and Security (91%), highlighting its robustness and alignment with critical data governance principles. It shows how blockchain-based healthcare frameworks can outperform conventional systems to ensure data protection, access transparency, and trust in record handling.

5. Conclusion and Future Scope:-

This research establishes that blockchain, particularly Ethereum, can significantly improve the security, privacy, and control of healthcare data systems. By decentralizing data storage and enabling smart contracts, patients can directly manage who accesses their health records, eliminating reliance on intermediaries. The proposed system successfully enforces permissioned access, immutability, and auditability. The implementation illustrates how blockchain can useful in common problems in healthcare IT, such as data breaches, information silos, and unauthorized data sharing.

Future work includes integration with biometric verification for more secure identity mapping, utilizing IPFS or similar platforms to store larger files like X-rays and reports and incorporating IoT for live health monitoring and recording data to blockchain in real time etc.

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