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Blockchain-Powered Healthcare Record Management System

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Abstract: ***The rapid growth of digital healthcare systems has improved the accessibility and storage of medical records but has also raised significant concerns regarding security, privacy, transparency, unauthorized access, and data manipulation due to reliance on centralized databases vulnerable to cyberattacks and single-point failures. To address these challenges, this paper proposes a blockchain-based healthcare record management system designed to provide secure, decentralized, and patient-centric management of medical data using blockchain technology and smart contracts. The proposed system enables tamper-resistant storage, transparent auditing, and controlled access, allowing patients to maintain ownership of their medical records while granting or revoking permissions to healthcare providers through smart-contract-based authorization. Authorized doctors can securely access and update patient information, with every transaction permanently recorded on the blockchain to ensure integrity and traceability. By integrating a web-based interface, backend services, decentralized storage, encryption mechanisms, and blockchain infrastructure, the system enhances reliability, accountability, privacy, and trust in healthcare data management while preventing unauthorized modifications and ensuring usability for both patients and healthcare professionals.***
Keywords: Blockchain, Healthcare Record Management, Smart Contracts, Decentralized Storage, Data Security, Patient Privacy, Medical Data Management, Access Control.

I. INTRODUCTION

The healthcare industry is rapidly transitioning from paper-based records to digital healthcare systems to improve accessibility, efficiency, and continuity of patient care. Although digitalization has simplified the storage and exchange of medical information, it has also introduced major challenges related to data security, privacy, integrity, and unauthorized access. Healthcare records contain highly sensitive information such as diagnoses, prescriptions, laboratory reports, and treatment histories, making them common targets for cyberattacks and data breaches. Traditional healthcare systems primarily rely on centralized databases managed by hospitals or third-party organizations, which create issues such as single points of failure, unauthorized record modification, insider threats, and limited transparency in healthcare data access.

Blockchain technology offers a reliable solution to these limitations by introducing decentralization, immutability, transparency, and cryptographic security into healthcare data management. Blockchain enables medical records to be maintained in a distributed and tamper-resistant environment where every transaction is permanently verified and recorded, significantly reducing the risk of unauthorized modifications. In addition, smart contracts improve system efficiency by automating access control and authorization mechanisms without relying on intermediaries, thereby enabling secure and transparent data-sharing processes between patients and healthcare providers. This paper presents a blockchain-powered healthcare record management system designed to provide secure, decentralized, and patient-centric healthcare data management. The proposed system enables patients to maintain ownership of their medical records and manage access permissions, while authorized doctors can securely access and update patient information. By integrating blockchain infrastructure, smart contracts, backend services, decentralized storage, encryption mechanisms, and a user-friendly web interface, the system enhances healthcare data protection, ensures transparency and traceability, prevents unauthorized modifications, and strengthens trust in digital healthcare management systems.

II. LITERATURE SURVEY

Several studies have explored the use of blockchain technology in healthcare to improve security, transparency, and privacy in medical record management. Recent research highlights how decentralized blockchain architectures, smart contracts, and cryptographic mechanisms can reduce unauthorized access and ensure tamper-resistant storage of electronic health records (EHRs). Studies by researchers such as Horst Treiblmaier and Vijaykumar Bidve emphasize patient-controlled access, immutable transaction history, and secure data sharing using blockchain-based systems.

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Existing research also discusses challenges such as scalability, interoperability, and integration with existing healthcare infrastructure. While many proposed systems improve healthcare data security and transparency, most are limited to small-scale implementations or theoretical models. These limitations highlight the need for a secure, scalable, and patient-centric healthcare record management system that combines blockchain technology, smart contracts, and decentralized storage for efficient and transparent medical data management.

III. PROBLEM STATEMENT

Traditional healthcare systems store sensitive medical data in centralized databases, making them vulnerable to cyberattacks, unauthorized access, data breaches, and system failures. These systems often lack transparency, secure access control, and data integrity, increasing the risk of record manipulation or loss. Therefore, there is a need for a secure and tamper-resistant healthcare record management system. The proposed blockchain-based solution ensures secure, decentralized, and patient-centric management of medical records with improved transparency, privacy, and trust.

IV. OBJECTIVES

The objectives of this project are:

1) To develop a secure and tamper-proof healthcare record management system using blockchain technology.
2) To ensure data integrity by preventing unauthorized modification or deletion of medical records.
3) To provide decentralized and secure storage for healthcare data.
4) To enable transparent and patient-centric access control using smart contracts.
5) To reduce risks such as data breaches, unauthorized access, and single-point failures.

V. PROPOSED SYSTEM

The proposed system is a blockchain-enabled healthcare record management system designed to provide secure, decentralized, transparent, and patient-centric handling of medical records. It addresses the limitations of traditional healthcare systems by integrating blockchain technology, smart contracts, cryptographic security, and decentralized storage to improve data protection, transparency, and reliability.

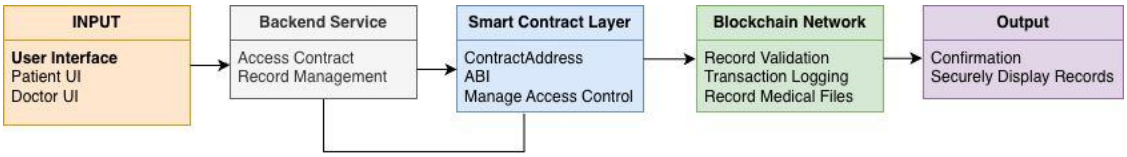


Fig. 1 Block Diagram of the Proposed System

In the proposed architecture, patients are treated as the owners of their medical records and are given complete control over access permissions. Patients can grant or revoke authorization to healthcare providers using smart-contract-based access control mechanisms, ensuring that only authorized doctors can securely access or update patient records. To improve scalability and privacy, encrypted healthcare files are stored in decentralized storage, while metadata, timestamps, transaction logs, and cryptographic hashes are maintained on the blockchain to ensure immutability, accountability, and traceability.

Smart contracts automate authentication, permission validation, and secure transaction execution without requiring intermediaries. The system provides several advantages, including decentralized and tamper-resistant record management, patient-controlled permissions, immutable audit trails, secure healthcare data sharing, and protection against unauthorized access or malicious modifications. Furthermore, the modular architecture supports future enhancements such as multi-hospital integration, AI-driven healthcare analytics, IoT-based patient monitoring, and improved interoperability between healthcare institutions.

VI. SYSTEM ARCHITECTURE

The proposed blockchain-powered healthcare record management system follows a modular and layered architecture to ensure security, scalability, transparency, and efficient communication between healthcare participants. The system consists of five major layers: *User Interface Layer, Backend Layer, Smart Contract Layer, Blockchain Network, and Decentralized Storage Layer*.

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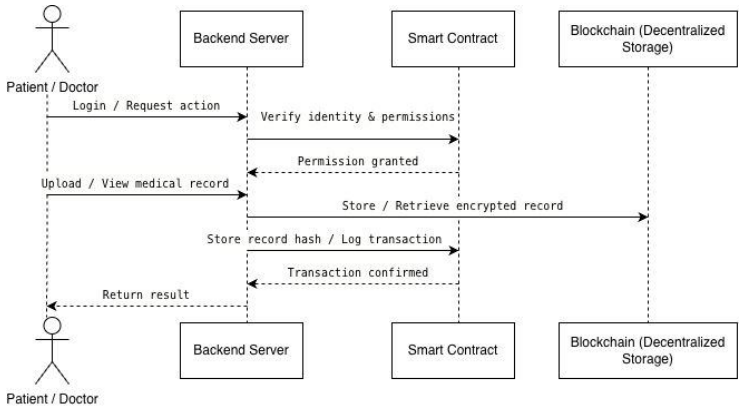


Fig. 2 Sequence Diagram of Record Access and Validation

A. User Interface Layer

The User Interface Layer enables interaction between patients, doctors, and the healthcare platform through a web-based application developed using React.js. It allows users to securely log in, manage permissions, upload medical records, and access authorized healthcare information.

B. Backend Layer

The Backend Layer acts as an intermediary between the frontend and blockchain infrastructure. Developed using Node.js and Express.js, it manages authentication, request processing, encryption, decentralized storage communication, and blockchain transaction handling.

C. Smart Contract Layer

The Smart Contract Layer enforces access control and system security using Solidity-based smart contracts deployed on the blockchain. It manages permission verification, authorization and revocation, healthcare record metadata storage, immutable transaction logging, and prevention of unauthorized access.

D. Blockchain Network

The Blockchain Network functions as a decentralized ledger that securely stores transaction logs, timestamps, record metadata, and permission updates. Its decentralized nature ensures transparency, immutability, integrity, and protection against single-point failures.

E. Decentralized Storage Layer

The Decentralized Storage Layer stores large healthcare files such as prescriptions, reports, and diagnostic documents using platforms like IPFS. Only encrypted hashes and metadata are stored on the blockchain, improving scalability while maintaining data security and integrity.

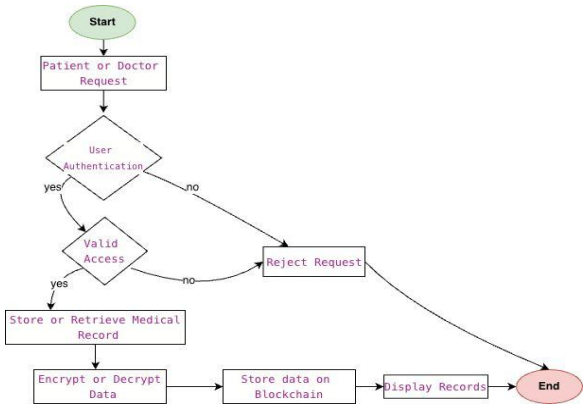


Fig. 3 Data Flow of the MedBlock System

VII. IMPLEMENTATION

A. Overview

The implementation phase focuses on transforming the proposed blockchain-based healthcare record management system into a secure and functional platform. The system integrates smart contracts, backend services, decentralized storage, and a web-based interface to ensure secure, decentralized, and patient-centric healthcare data management. A modular approach was followed to independently implement and test core functionalities such as authentication, medical record storage, access control, blockchain interaction, and audit logging.

B. Software Implementation

The proposed system was implemented using React.js, Node.js, Express.js, Solidity, IPFS, and Blockchain technologies, where each component plays a specific role in ensuring security, scalability, and transparency.

1) *Frontend Implementation*: The frontend was developed using React.js to provide an interactive and user-friendly interface for patients and doctors. Patients can securely upload medical records, manage permissions, and access healthcare information, while doctors can view authorized records. The frontend communicates with backend APIs for authentication and healthcare data management.
2) *Backend Implementation*: The backend was developed using Node.js and Express.js to handle authentication, API requests, encryption, blockchain communication, and secure file management. RESTful APIs were created for user registration, login, medical record upload, access control, and audit log generation. The backend also validates user permissions before processing requests.
3) *Smart Contract Implementation*: Smart contracts were developed using Solidity to automate access control and transaction validation. These contracts verify doctor authorization, manage permission granting and revocation, store encrypted record hashes, and maintain immutable logs of healthcare transactions to ensure transparency and integrity.
4) *Decentralized Storage*: Large healthcare files such as prescriptions and reports are securely stored using IPFS (InterPlanetary File System). Instead of storing files directly on the blockchain, only encrypted hashes and metadata are recorded on-chain, improving scalability and reducing storage overhead while maintaining security.
5) *Blockchain Network*: The blockchain network acts as a decentralized ledger for storing transaction logs, timestamps, permission updates, and record metadata. Its immutable nature prevents unauthorized modifications and ensures transparency, traceability, and protection against single-point failures.

C. Functional Workflow

The workflow begins with secure user authentication, where patients and doctors register and log in through role-based access control. Patients can upload encrypted medical records, which are stored in IPFS, while corresponding hashes and metadata are recorded on the blockchain through smart contracts.

Patients maintain complete control over their medical records by granting or revoking access permissions for doctors. Whenever a doctor requests access, the smart contract validates authorization before allowing record retrieval. All activities, including uploads, access requests, and modifications, are permanently logged on the blockchain to ensure accountability, transparency, and secure healthcare record management.

VIII. RESULTS

The proposed blockchain-based healthcare record management system was successfully implemented and tested to evaluate its functionality, security, and performance.

The system effectively supported major operations such as secure user authentication, medical record upload, patient-controlled access management, authorized doctor access, and immutable audit logging. Smart contracts successfully validated permissions, ensuring that only authorized healthcare providers could access patient records, while blockchain-based transaction logging-maintained transparency and traceability of all activities.

The integration of backend services, blockchain, and decentralized storage provided secure, reliable, and tamper-resistant healthcare data management.

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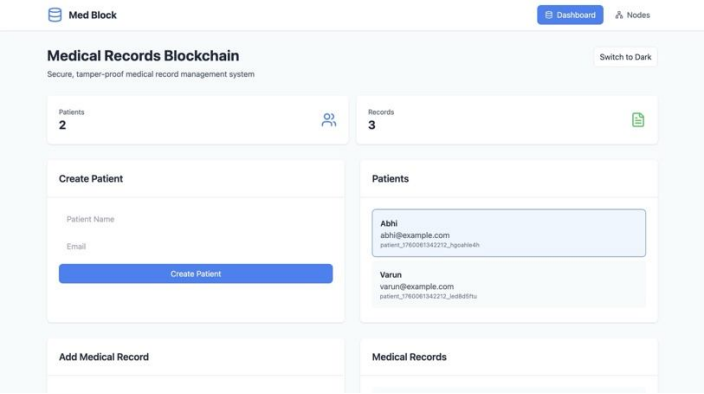


Fig. 4 Dashboard Interface of the Healthcare Management System

The results demonstrate that the system provides secure and patient-centric healthcare record management while maintaining transparency, privacy, and data integrity. The use of IPFS improved scalability by securely storing healthcare files off-chain, while blockchain maintained immutable transaction records. Although minor delays were observed during blockchain transaction confirmation, the system consistently delivered stable performance and reliable access control. The modular architecture further supports future enhancements such as multi-hospital integration, interoperability, and advanced healthcare analytics.

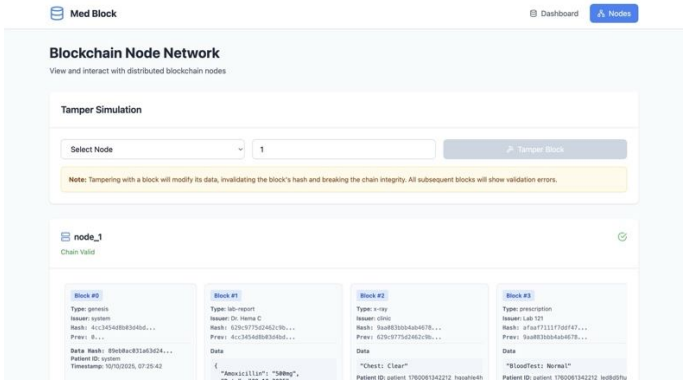


Fig. 5 Blockchain Node Validation and Tamper Detection Mechanism

IX. CONCLUSIONS

The proposed blockchain-based healthcare record management system successfully demonstrates the effectiveness of blockchain technology in providing a secure, transparent, and patient-centric solution for managing medical records. By integrating blockchain, smart contracts, decentralized storage, and a user-friendly interface, the system addresses major challenges such as unauthorized access, data tampering, lack of transparency, and centralized system failures. The implementation ensures secure medical record storage, patient-controlled access permissions, immutable audit logs, and reliable healthcare data management.

Overall, the system improves security, privacy, integrity, and trust in healthcare data management while providing a scalable foundation for future real-world deployment. The results confirm that blockchain technology can significantly enhance transparency and accountability in digital healthcare systems.

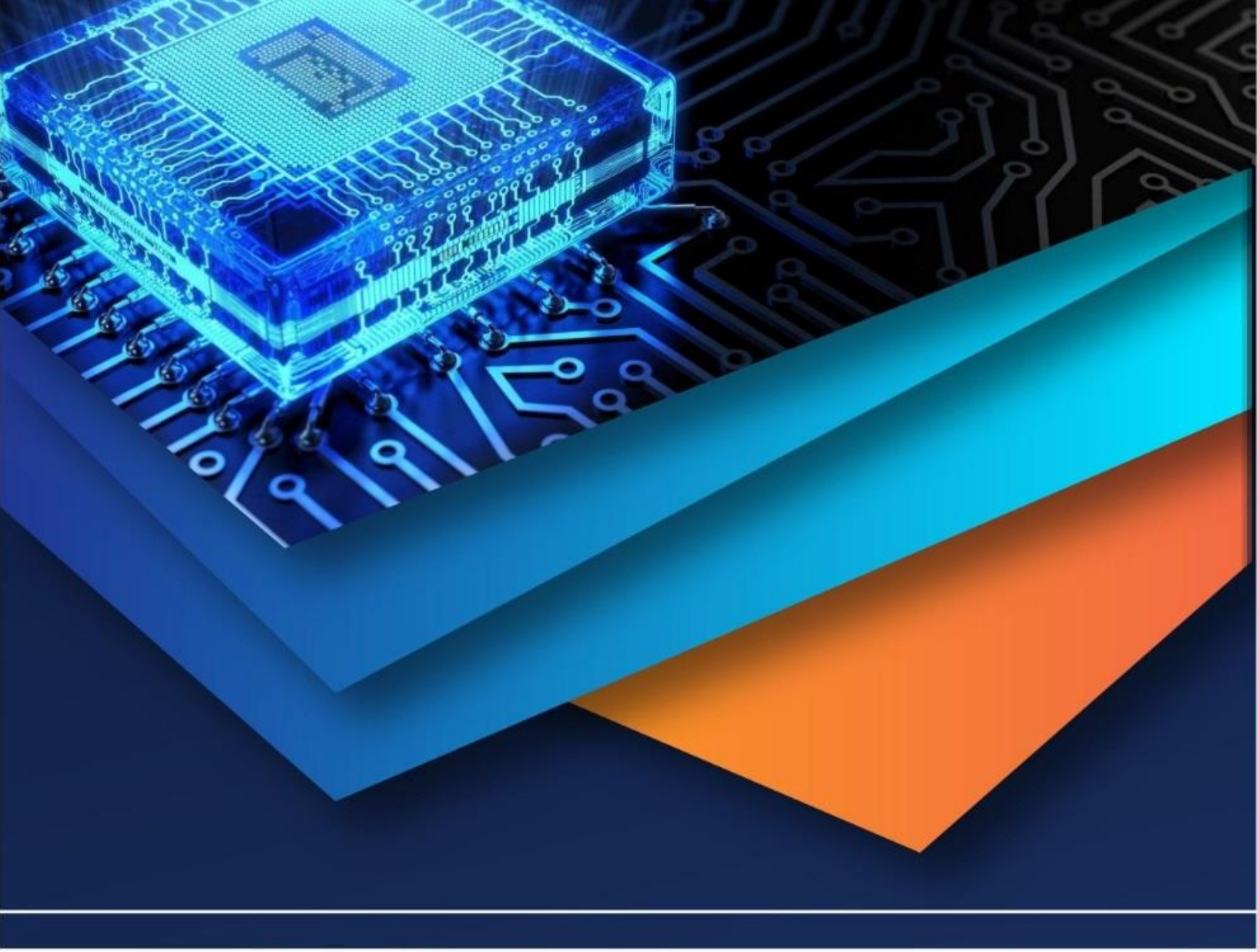
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