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Block Heal: A Patient-Governed Blockchain Framework for Secure Clinical Data Exchange

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***Abstract*— The ongoing digital evolution in the healthcare sector has increased the demand for reliable and secure systems to manage medical records. Conventional centralized storage methods are vulnerable to security threats such as data breaches, unauthorized usage, and potential data alteration, which can compromise patient confidentiality and data integrity. To overcome these challenges, this work presents a blockchain-enabled medical record management system designed to provide secure and tamper-resistant data storage. The proposed system is implemented as a decentralized web application, utilizing React.js for the user interface and Web3.js or Ethers.js to enable interaction with the blockchain network. Smart contracts written in Solidity are deployed on the Ethereum platform to handle record management and enforce strict access permissions. User authentication is facilitated through MetaMask, ensuring a secure and decentralized method of identity verification. Healthcare information, including patient records, diagnoses, prescriptions, and treatment details, is maintained on the blockchain to guarantee transparency and immutability. The system empowers patients by allowing them to control access to their data, including granting and revoking permissions for healthcare providers. Tools such as Truffle and Ganache are used during development for efficient testing and deployment. In summary, the proposed solution improves data security, privacy, and accessibility, offering a dependable and scalable approach for managing healthcare records in modern digital environments.**

***Index Terms*—Blockchain, Medical Record Management, Smart Contracts, Decentralized System, Healthcare Data Security, Data Integrity, Access Control, Web Application, Ethereum, Patient Data Privacy**

I. INTRODUCTION

With The rapid adoption of digital technologies in healthcare has significantly transformed how medical information is stored and managed. However, handling patient records remains a major concern due to the limitations of existing systems. Conventional approaches often depend on centralized databases or manual documentation, both of which are susceptible to data breaches, loss of information, and unauthorized access. These challenges not only impact the reliability of medical data but also hinder seamless data sharing among healthcare providers. Therefore, there is an increasing demand for a system that ensures security, transparency, and efficiency in managing healthcare records.

Blockchain technology has recently gained attention as a promising approach to overcome these issues. Its decentralized architecture distributes data across multiple nodes, removing reliance on a single controlling authority. Additionally, blockchain ensures that once data is recorded, it cannot be modified, thereby preserving its integrity. Transactions are protected using cryptographic techniques, which enhances trust and security. These characteristics make blockchain particularly suitable for healthcare applications, where safeguarding patient data and maintaining accuracy are of utmost importance.

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The proposed Blockchain-Based Medical Record Management System utilizes these advantages to create a secure platform for handling medical information. The system is implemented as a decentralized web application (dApp), with React.js used to build a responsive and user-friendly interface. Interaction between the user interface and the blockchain network is facilitated through Web3.js or Ethers.js, enabling smooth communication with smart contracts deployed on the Ethereum blockchain.

At the core of the system are smart contracts developed using Solidity. These contracts handle the storage and management of medical data while enforcing strict access control mechanisms. Only authorized users are permitted to perform specific actions such as uploading or viewing records. Once information is stored on the blockchain, it becomes permanent and tamper-resistant, ensuring that medical records remain accurate and trustworthy over time.

For user authentication and transaction management, the system integrates MetaMask, which provides a secure and decentralized method of accessing the application. Instead of relying on traditional login credentials, users authenticate through their blockchain wallets. The system supports role-based access, allowing patients, doctors, and other participants to interact according to their permissions. Patients retain full authority over their records and can grant or withdraw access to healthcare professionals as needed.

The development process incorporates tools such as Truffle for compiling and deploying smart contracts, along with Ganache for simulating a local blockchain environment during testing. This setup allows efficient development, testing, and debugging before deploying the system to a live network. Furthermore, the system is designed with scalability in mind, making it adaptable for future enhancements such as integration with hospital systems, improved security measures, and advanced data processing features.

In summary, this work aims to modernize healthcare record management by introducing a decentralized and secure framework. By combining blockchain technology with contemporary web development tools, the proposed system strengthens data protection, improves accessibility, and builds trust in the handling of medical information.

II. LITERATURE SURVEY

The expansion of digital healthcare infrastructures has driven significant research toward improving the security and efficiency of medical record management. Electronic Health Record (EHR) systems are commonly used for storing patient information, yet they present several limitations, including weak interoperability, potential security vulnerabilities, and minimal patient involvement in data control. Existing studies reveal that these systems often face difficulties in securely exchanging data among multiple healthcare entities, resulting in fragmented and sometimes inaccessible medical records.

To address these concerns, blockchain technology has been widely investigated as an alternative approach. Researchers have emphasized that blockchain offers a decentralized and tamper-resistant data structure, which strengthens security, transparency, and reliability in healthcare applications. By distributing data across a network, blockchain facilitates secure sharing of patient information among hospitals, laboratories, and medical professionals while preserving data consistency and integrity.

Various research efforts have introduced blockchain-based models for managing healthcare records. These approaches generally incorporate smart contracts, cryptographic techniques, and secure key management systems to maintain privacy and regulate access. Findings from these studies suggest that such decentralized frameworks provide better protection, improved traceability, and enhanced interoperability when compared to traditional centralized systems.

Comprehensive review studies further highlight the role of blockchain in promoting patient-centric healthcare systems. By allowing individuals to control access to their own medical data, these systems enhance privacy and foster trust between patients and healthcare providers. At the same time, researchers acknowledge that large-scale implementation remains limited due to factors such as scalability issues, infrastructure complexity, and regulatory constraints.

In addition, recent work has explored the integration of blockchain with complementary technologies like artificial intelligence and cloud computing. These combinations have the potential to enhance healthcare services through advanced data analysis, continuous monitoring, and intelligent decision support systems.

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Nevertheless, there remains a clear need for solutions that are practical, scalable, and easy to use in real-world healthcare settings.

Overall, the existing body of research demonstrates that blockchain has considerable potential to improve medical record management through secure, transparent, and decentralized mechanisms. However, challenges related to scalability, implementation, and usability continue to persist, providing motivation for the development of more effective systems such as the proposed Blockchain-Based Medical Record Management System.

III. PROPOSED METHOD

The proposed solution introduces a blockchain-driven framework for managing medical records in a secure and decentralized manner through a web-based application. Its main goal is to maintain data integrity, ensure privacy, and regulate access while offering a user-friendly interface for both patients and healthcare professionals. By combining modern web technologies with blockchain infrastructure, the system provides a dependable and tamper-resistant platform for handling medical information.

The workflow starts with user interaction through a web interface, where patients and healthcare providers can register, log in, and utilize system features. Authentication is performed using a blockchain wallet, eliminating the need for conventional username and password methods. This approach strengthens identity verification and reduces the risk of unauthorized access, thereby enhancing overall system security.

After successful authentication, authorized users can input medical information such as patient details, diagnostic reports, prescriptions, and treatment history. Before being stored, the data undergoes validation to ensure correctness and completeness. Once verified, the information is transmitted to the blockchain network, where smart contracts manage both storage and access permissions. Each entry is recorded as a blockchain transaction, ensuring that the data remains permanent and cannot be altered.

Access control within the system is governed by smart contracts. Patients are given complete ownership of their records and can decide who is allowed to view or update their data. They can grant or withdraw access rights to doctors or healthcare organizations as required. Any modification in access permissions is recorded on the blockchain, providing full transparency and a traceable history of all interactions.

When data needs to be accessed, authorized users submit a request through the application interface. The system checks the permissions via smart contracts and retrieves the necessary information from the blockchain. The data is then presented in an organized and readable format, allowing users to easily analyze and utilize the information for decision-making.

The architecture also incorporates a communication layer that links the frontend with the blockchain network using libraries such as Web3.js or Ethers.js. During development, a local blockchain setup can be used for testing and deployment purposes. The system is designed with scalability in mind, making it adaptable for future improvements such as enhanced security measures, integration with healthcare infrastructures, and advanced data analysis capabilities.

IV. ARCHITECTURE

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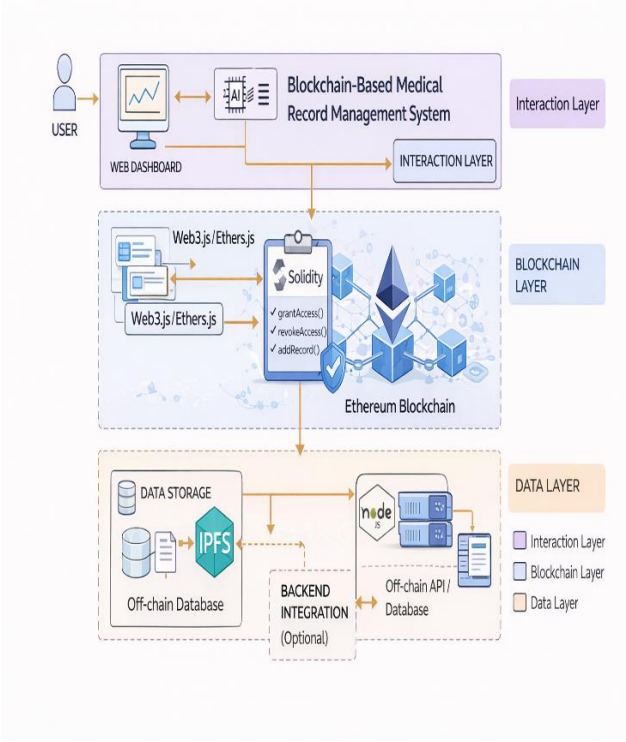

Figure 3.1: Architecture of the Proposed System

V. OUTPUT

Fig. 4.1 Login Page

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The project's Login page interface serves as the gateway for users, offering a seamless login experience. Users input their credentials in designated fields, ensuring secure access to the platform.

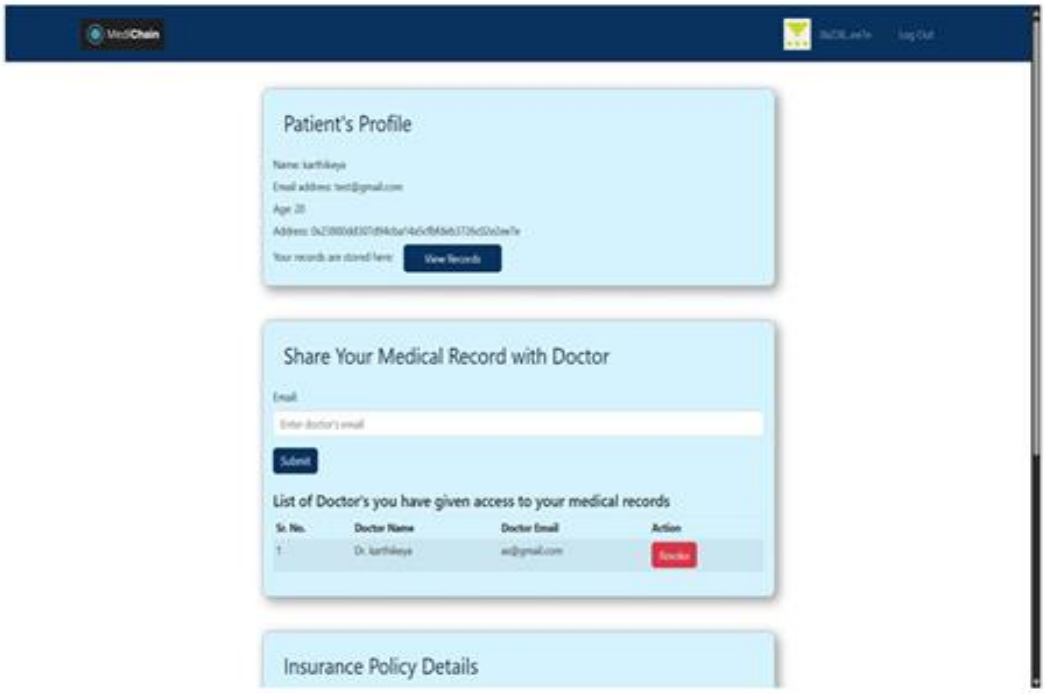

Fig.4.2 The Patients Dashboard Page

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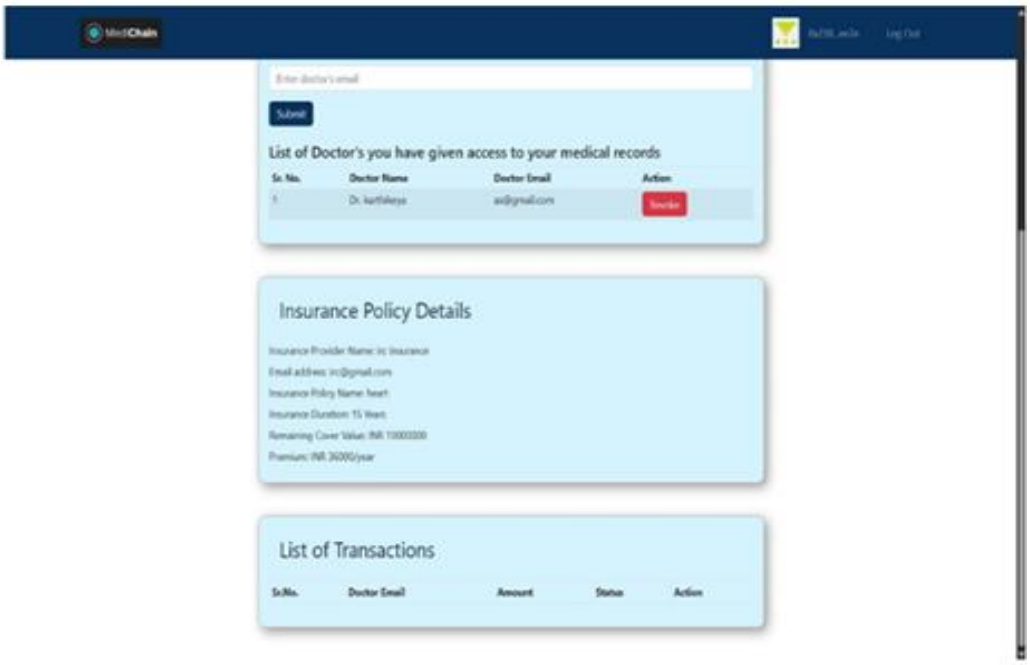

Fig. 4.3 Insurance Dashboard Page

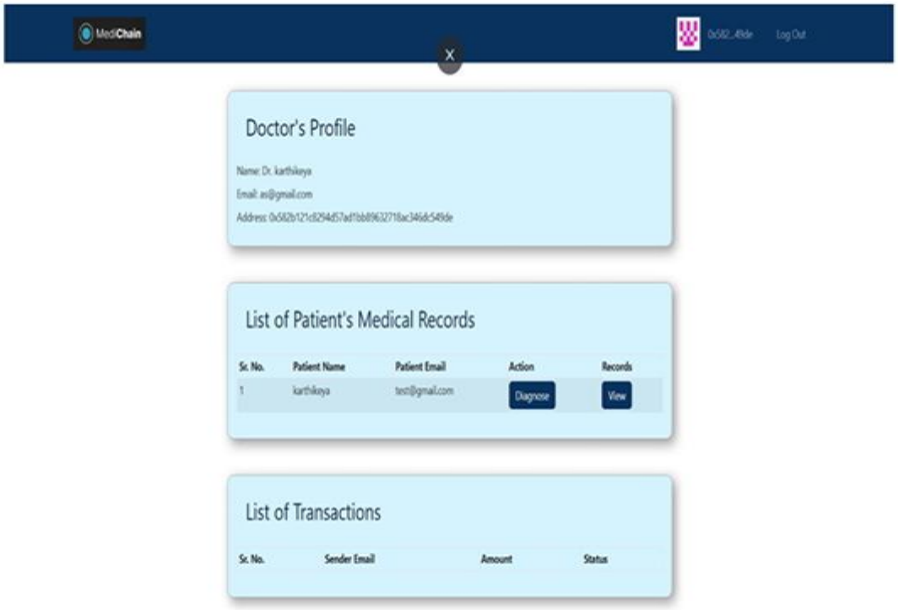

Fig. 4.4 Doctors dashboard page

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VI.CONCLUSION

The Blockchain-Based Medical Record Management System effectively demonstrates the application of modern technologies in addressing key challenges associated with healthcare data management. Conventional approaches that depend on centralized databases or manual documentation often encounter issues such as security vulnerabilities, lack of transparency, inefficient data exchange, and restricted patient involvement. The proposed system addresses these concerns by introducing a decentralized architecture that ensures secure, dependable, and tamper-resistant management of medical records.

Through the use of blockchain technology, the system guarantees that once medical information is recorded, it remains unchanged unless proper authorization is provided. This immutability strengthens trust among patients, healthcare professionals, and institutions. Additionally, the incorporation of smart contracts enhances system functionality by automating processes such as data storage, access regulation, and permission handling. These mechanisms ensure that only authorized individuals can view or modify records, thereby preserving confidentiality and data accuracy.

A key highlight of the system is its focus on patient empowerment. Unlike traditional models where healthcare providers primarily control medical data, this approach allows patients to manage their own records. They can selectively grant or withdraw access to doctors and other entities, ensuring privacy and complete ownership of their information. This approach not only improves trust but also aligns with current data protection and privacy standards.

The system also contributes to improved operational efficiency within healthcare environments. Since records are maintained on a decentralized network, authorized users can access up-to-date information instantly without delays caused by manual processes or organizational boundaries. This enables quicker diagnosis, more informed treatment decisions, and better coordination among healthcare providers. Furthermore, the intuitive and structured interface ensures that the system remains accessible even to users with minimal technical expertise.

From a technical standpoint, the integration of web technologies with blockchain platforms results in a scalable and adaptable architecture. The use of smart contracts, decentralized networks, and secure authentication methods ensures consistent performance while allowing room for future enhancements. Potential improvements include the incorporation of advanced encryption techniques, integration with hospital management systems, support for mobile platforms, and the use of data analytics for predictive healthcare insights.

Despite its benefits, the system may encounter challenges in large-scale implementation, such as blockchain performance constraints, infrastructure demands, and regulatory considerations. However, continuous advancements in blockchain technology and increasing emphasis on data security are expected to address these limitations over time.

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