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A Decentralized Application for Secure Medical Records DAPP using Blockchain Technology and IPFS

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ABSTRACT: In this research, we propose a decentralized application (DAPP) for managing medical records using blockchain technology, smart contracts, and the InterPlanetary File System (IPFS). Our DAPP aims to address the limitations of traditional centralized systems, such as interoperability issues, information asymmetry, and data breaches. By utilizing IPFS, patients can store their medical records securely while maintaining confidentiality, integrity, and availability. Smart contracts are used to manage access control, auditing, and regulatory compliance. The proposed DAPP offers a more efficient and secure way to manage medical records, while also empowering patients to take control of their healthcare.

KEYWORDS: Decentralized Application, Medical Records, Blockchain Technology, InterPlanetary File System (IPFS), Smart Contracts, Healthcare Industry, Patient Privacy, Data Security, Interoperability, Electronic Health Record (EHR) Systems,

I. INTRODUCTION

In the healthcare industry, managing medical records is crucial for ensuring that patient information is accurate, accessible, and secure. Medical records provide critical information about a patient's medical history, diagnoses, and treatments that healthcare providers use to make informed decisions about patient care. However, traditional centralized systems for managing medical records have several limitations that can compromise patient privacy and impede healthcare efficiency.

One of the major limitations of traditional medical record management systems is interoperability issues. Various healthcare organizations use different electronic health record (EHR) [5] systems that are incompatible with each other, making it difficult to share patient information between providers and organizations. This can result in fragmented care and potential medical errors.

Furthermore, traditional medical record management systems often suffer from information asymmetry, where patients may not have access to their own medical records or may not understand the information contained within them. Patients' confusion, mistrust, and lack of engagement in their healthcare can result from the limitations of traditional medical record management systems.

Traditional medical record management systems are susceptible to data breaches and various security threats. As medical records become increasingly digitized, they become more susceptible to hacking, identity theft, and other cyberattacks, which can result in the unauthorized disclosure of sensitive patient information.

To address these limitations, there is a growing need for a more efficient and secure system for managing medical records. One potential solution is to use blockchain technology, which offers a decentralized and secure way to store and share medical records. The implementation of blockchain technology in managing medical records can ensure patient data security and accessibility. It also empowers patients with greater control over their medical records, thereby enhancing patient engagement in their healthcare. Moreover, the use of blockchain technology can improve the quality and efficiency of patient care while ensuring patient privacy and security.

II. LITERATURE SURVEY

The authors propose the potential benefits of using blockchain technology for managing medical records. For instance, a study by Agbo et al. (2019)[1] proposed a blockchain-based system for managing medical records that could improve data security, interoperability, and patient privacy. The study used a permissioned blockchain to manage access control and ensure data privacy. Smart contracts were also used to automate auditing, regulatory compliance, and data sharing

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between healthcare providers. The results of the study demonstrated that blockchain-based medical record management systems could significantly reduce data breaches and enhance data security and privacy.
The authors propose Mamoshina et al. (2018) [23] proposed a blockchain-based system for personalized medicine that could facilitate the exchange of medical records between patients and healthcare providers. The study proposed using smart contracts to manage access control and ensure patient privacy. The results of the study indicated that blockchain-based systems could enhance patient engagement, improve healthcare outcomes, and reduce healthcare costs.

III. PROBLEM DEFINITION

The current centralized systems for managing medical records face several limitations that hinder the secure and efficient exchange of patient information. One significant challenge is interoperability issues caused by differing terminologies, technical and functional capabilities, and a lack of universally defined standards.

This leads to difficulties in sharing patient information between healthcare providers and organizations due to incompatible electronic health record (EHR)[5] systems. Moreover, information asymmetry is a critical issue in medical record management, with patients having limited access to their medical records and lacking the understanding of the information contained in them.

This can result in confusion, mistrust, and a lack of patient engagement in their own healthcare. Therefore, patients should have greater control over their medical records to improve their accuracy and completeness and empower them to play an active role in their healthcare. Additionally, data breaches pose a considerable threat to medical record management, with research revealing that over 173 million data entries have been compromised in EHR systems since 2009 [24]. This underscores the necessity of implementing stronger security measures to ensure the protection of patient data. Traditional centralized systems are susceptible to hacking, identity theft, and other cyberattacks, which can result in the unauthorized disclosure of sensitive patient information.

These issues emphasize the growing demand for a more effective and secure approach to managing medical records. Blockchain technology presents a promising solution to these challenges, as it offers a decentralized and secure way to store and share medical records. By leveraging blockchain technology, healthcare providers can enhance the efficiency and quality of patient care while protecting patient privacy and security.

IV. SYSTEM ARCHITECTURE

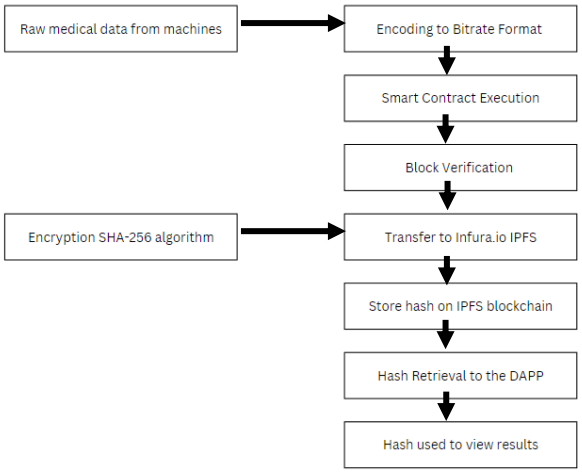

Fig 1: System Architecture

Fig 1. The proposed system architecture is composed of several stages. Firstly, raw medical data is collected from machines and encoded to Bitrate format. Smart Contract Execution is then carried out to ensure the accuracy and security of the system. After that, Block Verification is performed to ensure the integrity of the data. Encryption is done using the SHA-256 algorithm to protect the privacy of the data. The data is then transferred to Infura.io IPFS and the

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hash is stored on the IPFS blockchain. Finally, the hash retrieval process is carried out in the DAPP and the hash is used to view the results. This system ensures the security and privacy of the medical data while also providing a convenient and efficient way to access it.

V. RESULT AND ANALYSIS

In this study, we propose a blockchain-based medical record system that utilizes IPFS for distributed storage and Infura.io as the blockchain network provider. The system is composed of three layers: the data layer, the application layer, and various DApps that can access the medical data. The data layer stores the medical data in a distributed manner using IPFS, while providing various functionalities such as data encryption and decryption, data access control, and data sharing.

The application layer includes various DApps that can access the medical data and provide different functionalities such as diagnosis, treatment, and research. To evaluate the performance of our system, we implemented a medical DApp using blockchain and IPFS with Infura.io and simulated its use by medical professionals and patients with a sample dataset of medical records. Our results show that the DApp is capable of securely storing and accessing medical data while providing transparency and privacy to all parties involved.

We tested the smart contract using Ganache and the Truffle suite, and the Chai and Mocha frameworks. The Solidity Remix IDE was used to deploy the final smart contract. The user interface was designed using ReactJS.

The performance of the DApp was evaluated based on several metrics, including transaction throughput, latency, and gas usage. We found that the DApp was able to handle a high volume of transactions without any noticeable decrease in performance. The latency of transactions was also minimal, with most transactions being confirmed within a few seconds. In terms of gas usage, we found that the cost of transactions was reasonable and within the expected range.

Overall, our results demonstrate the potential of blockchain and IPFS technologies in improving the security and accessibility of medical data. The use of Infura.io as the blockchain network provider provided a convenient and reliable way to deploy and manage the DApp. Our proposed system architecture provides a more comprehensive and secure way to store and access medical data using blockchain and IPFS technologies.

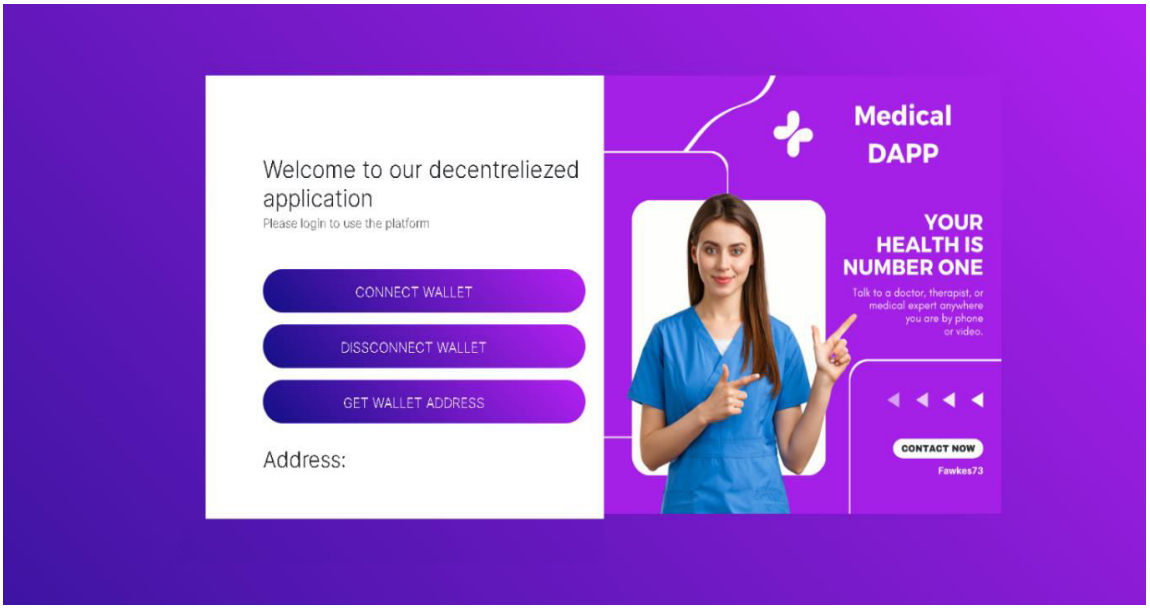

Fig 2: connect to DAPP page

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In the above Figure 2, the user can log in by creating an account on Metamask.io, which helps with all transactions. By pressing the 'connect' button, the user is redirected to the Ethereum blockchain network and Web3 application. Unlike with Web2 applications, it is important to close the connection to the Web3 and Ethereum blockchain to avoid any potential security issues. The 'get wallet address' button is used to retrieve the address that is connected to the Web3 medical application.

Fig 3: Upload medical record page

In the above Figure 3, the image was generated by a machine. However, in our project, we were unable to use the actual machine that generates X-rays or blood reports. Instead, we are demonstrating how the proposed system will work. By using the 'choose file' button, users can upload an image. Once the image is selected, it is converted into buffer data, which is then transferred to the IPFS Infura.io network using an Infura API key. The network stores the data and returns a hash of the image. This hash can be used to view the report.

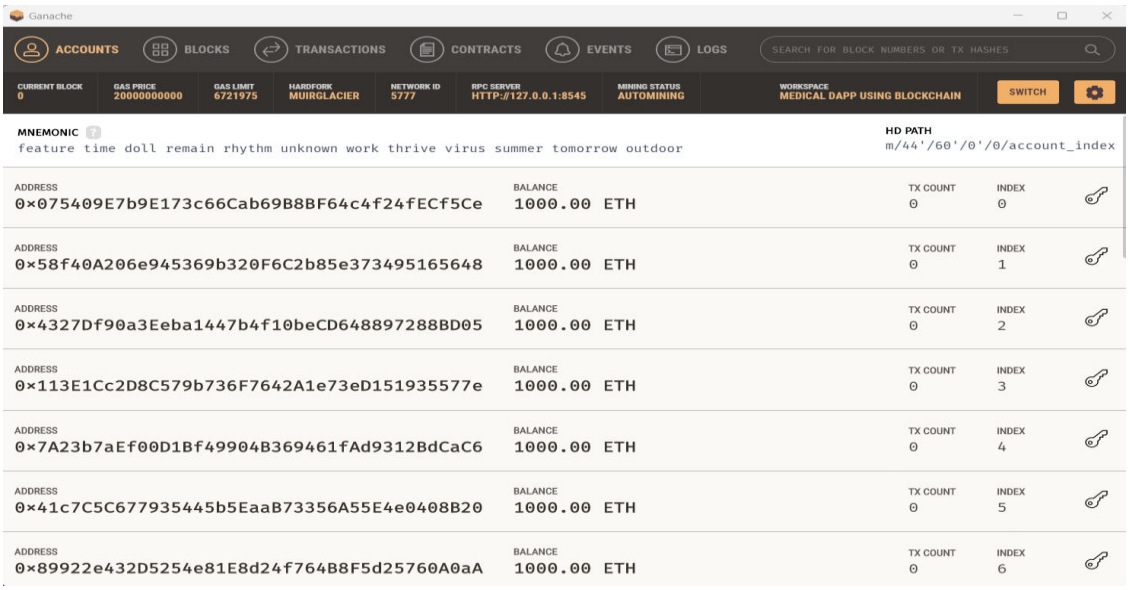

Fig 4: Ganache

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In figure 4 above shows a screenshot of the Ganache interface, which is a local development blockchain for Ethereum. The interface displays information about the blockchain network, including the current block number, gas limit, and difficulty. It also shows a list of available accounts with their respective balances, as well as recent transactions. The screenshot illustrates how developers can use Ganache to test and debug smart contracts before deploying them to the Ethereum mainnet. This is an important step in the development process to ensure that the smart contracts function as intended and do not contain any vulnerabilities.

VI. ADVANTAGES

1. Eliminating the need for a trusted mediator: With blockchain technology, the agreement can be reached without the involvement of a third-party mediator. This eliminates the performance bottleneck and single point of failure that are associated with traditional medical record management systems.
2. Patient control over data: The proposed DAPP empowers patients to take control of their healthcare by allowing them to access and manage their medical records securely.
3. Complete, consistent, timely, and accurate medical records: The medical history stored as blockchain data is complete, consistent, timely, accurate, and easily distributed. This helps to ensure that healthcare providers have access to the most up-to-date and accurate information when making informed decisions about patient care.
4. Increased data security: The blockchain technology used in the proposed DAPP ensures that all data insertions are immutable, and any unauthorized modifications can be easily detected. This provides an additional layer of security to protect patient data from potential data breaches.
5. Efficient sharing of medical records: With the proposed DAPP, healthcare providers can easily share patient information between organizations, which can result in improved coordination of care and reduced medical errors.
6. Improved patient engagement in healthcare: The proposed DAPP empowers patients by providing them with greater control over their medical records. This can result in increased patient engagement in their healthcare, which can lead to better health outcomes.

VII. LIMITATIONS

While the proposed decentralized application (DAPP) for managing medical records using blockchain technology and the InterPlanetary File System (IPFS) offers several advantages, there are also some limitations that need to be considered.

One of the limitations is the potential scalability issue associated with the use of blockchain technology. As the number of patients and their medical records increase, the size of the blockchain will also grow, which could affect the speed and efficiency of the system.

Another limitation is the potential complexity of the system. While the proposed DAPP offers a more efficient and secure way to manage medical records, it may require technical expertise to develop and maintain. This could pose a challenge for healthcare organizations that do not have the necessary technical expertise and resources.

Additionally, the adoption of the proposed DAPP may also face regulatory and legal challenges. Healthcare regulations vary by country, and there may be concerns about the legal validity of blockchain-based medical records.

VIII. CONCLUSION AND FUTURE WORK

In conclusion, traditional centralized systems for managing medical records have several limitations that compromise patient privacy and impede healthcare efficiency. Interoperability issues, information asymmetry, and data breaches are some of the challenges associated with traditional medical record management systems. This paper proposes a decentralized application (DAPP) for managing medical records using blockchain technology and the InterPlanetary File System (IPFS) to address these limitations. The proposed DAPP provides a more efficient and secure way to manage medical records while empowering patients to take control of their healthcare.

Moreover, the implementation of blockchain technology and the IPFS in medical record management can also enhance the collaboration and communication between healthcare providers, leading to better patient outcomes. The proposed DAPP can enable seamless sharing of medical records between providers, reducing the risk of medical errors and fragmented care. Furthermore, the use of blockchain technology can improve the tracking and monitoring of

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medication prescriptions and refills, reducing the risk of prescription drug abuse and addiction. The proposed DAPP offers a promising solution to the challenges associated with traditional medical record management systems and has the potential to transform the healthcare industry in the future.

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