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DIGITAL HEALTHCARE RECORDS MAINTENANCE SYSTEM FOR HOSPITALS USING BLOCKCHAIN

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ABSTRACT:
The healthcare industry is undergoing a significant transformation with the increasing use of Digital health records (DHRs). However, the storage and sharing of these records pose challenges such as data privacy and security, data interoperability, and data ownership. Blockchain technology has become a viable means of addressing these issues by offering a decentralized and safe method of storing and exchanging data. We propose a healthcare records storage system using InterPlanetary File System (IPFS) and Ethereum blockchain to address the challenges of data privacy, security, and interoperability. The system provides a tamper-proof, decentralized, and standardized way to store and share healthcare records. Smart contracts manage the access and permission of healthcare records, ensuring data integrity and accountability. Our proposed system enhances data privacy and security, improves data interoperability, and reduces data ownership issues. Challenges related to scalability and governance need to be addressed for implementation. Our proposed system has the potential to revolutionize the healthcare industry by providing a secure, decentralized, and interoperable way to store and share healthcare records.
KEYWORDS: Healthcare records, InterPlanetary File System (IPFS), Ethereum blockchain, Decentralization, Data privacy, Data security, Data interoperability, Smart contracts, Data ownership, Tamper-proof, Standardized, Audit trail, Data integrity, Accountability, Scalability, Governance.

1. INTRODUCTION:

Electronic healthcare records (DHRs) have become an integral part of modern healthcare systems. Sensitive and private patient data, such as medical histories, diagnoses, prescriptions, and

treatments, are stored in DHRs. The storage and management of DHRs are critical to the quality of care provided to patients. However, traditional healthcare records storage systems have several limitations, such as lack of interoperability, security, privacy, and accessibility.

Blockchain technology provides a transparent, safe, and decentralized platform for DHR management and storage, which presents a viable answer to these problems. In this work, we present an Ethereum blockchain and InterPlanetary File System (IPFS) based healthcare records storage solution.

InterPlanetary File System (IPFS):

IPFS is a decentralized, peer-to-peer file storage system that allows users to store and share files in a secure and efficient manner. Unlike traditional file systems that rely on a centralized server to store and distribute files, A dispersed network of nodes is used by IPFS to store and retrieve files.

Files are divided into smaller pieces by IPFS, which is followed by their encryption, hashing, and network distribution. Each chunk is assigned a unique hash, which allows the network to identify and retrieve the file from multiple nodes simultaneously, improving speed and reliability.

Additionally, IPFS uses content-addressed storage, in which files are kept according to their content rather than where they are located. This allows users to access files from any node on the network, regardless of where they were originally stored.

Another key feature of IPFS is its version control system, which allows users to track and access different versions of a file over time. This makes IPFS ideal for applications that require data immutability, such as healthcare records, where it is critical to maintain a complete and accurate record of patient health data.

All things considered, IPFS has several benefits over conventional file storage systems, such as heightened security, resilience, and decentralization. By decentralizing file storage, IPFS increases data availability and accessibility while lowering the chance of data loss from server malfunctions, cyberattacks, or other security lapses.

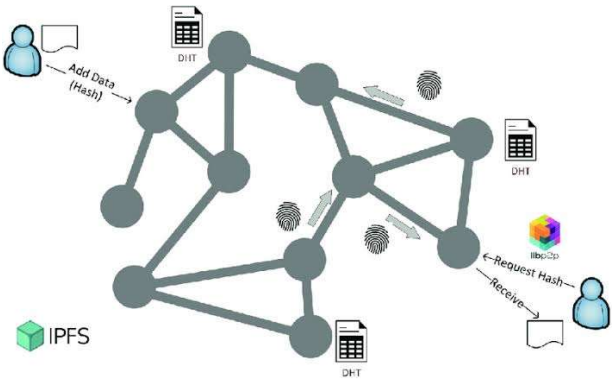

Fig.1: Interplanetary File Storage System (IPFS)

Ethereum Blockchain:

Ethereum is an open-source, decentralized blockchain platform that uses smart contracts to let programmers design and execute decentralized apps (Dapps). Smart contracts are self-executing programs that enforce terms of agreements on their own, enabling a transparent and trustless value exchange system.

The Ethereum blockchain is maintained by a network of nodes rather than a central authority, functioning as a distributed ledger. This feature makes sure that transactions are safe, transparent, and unaffected by censorship or manipulation.

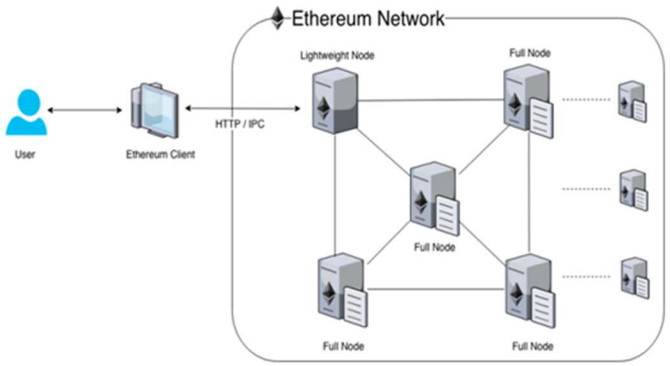

Fig. 2: Ethereum Architecture

A notable aspect of Ethereum is its implementation of a native cryptocurrency known as Ether (ETH), which serves as a means of payment for transactions and as an incentive for network participants. Furthermore, Ethereum enables developers to create custom tokens and launch Initial Coin Offerings (ICOs) on the platform.The smart contract functionality of Ethereum allows for the creation of diverse decentralized applications, encompassing domains such as finance, social networks, supply chain management systems, and more. These dapps are commonly developed using Solidity, Ethereum's native programming language, and are hosted on the Ethereum Virtual Machine (EVM).

Ethereum's reputation as a prominent blockchain platform is rooted in its adaptability and extensibility, making it an attractive choice for building decentralized applications and initiating blockchain-based projects. Its capability to accommodate a wide range of use cases, combined with its robust developer community and ecosystem, has established Ethereum as a leading player in the blockchain industry.

2. EXISTING SYSTEM:

Traditional healthcare records storage systems are paper-based and stored in physical filing cabinets or folders. However, with the advancements in technology, many healthcare organizations

have shifted to electronic health record (DHR) systems. These DHR systems use electronic storage and retrieval methods to store patient information and medical records.

There are several types of DHR systems available in the market, including on-premises, cloud-based, and hybrid systems. On-premises systems store data locally on the organization's servers, while cloud-based systems store data on remote servers that can be accessed from anywhere with an internet connection. Hybrid systems combine both on-premises and cloud-based storage methods.

Some of the commonly used DHR systems in the healthcare industry include:

1. Epic Systems Corporation: Epic is a cloud-based DHR system used by several large healthcare organizations. It provides a comprehensive set of tools for managing patient information, medical records, and clinical workflows.
2. Cerner Corporation: Cerner is an on-premises and cloud-based DHR system that offers a range of solutions for managing patient information and clinical workflows. It also provides advanced analytics and population health management tools.
3. Allscripts: Allscripts is a cloud-based DHR system that provides solutions for managing patient information, medical records, and clinical workflows. It also offers a range of tools for patient engagement and communication.

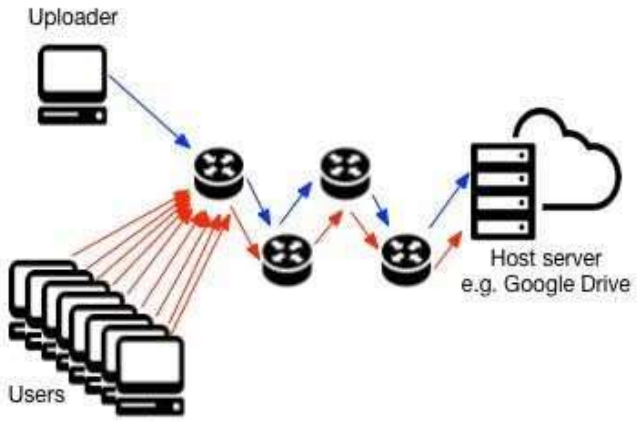

Fig.3: Existing System

While these DHR systems provide several benefits, they also have some limitations. One of the primary limitations is the lack of interoperability between different DHR systems. Different healthcare organizations use different DHR systems, making it difficult to share and exchange data between them. Additionally, data privacy and security are concerns with these systems, as they rely on centralized servers that can be vulnerable to cyber attacks.

3. PROPOSED SYSTEM:

Our proposed system is a healthcare records storage solution that utilizes the InterPlanetary File System (IPFS) and Ethereum blockchain technology to enhance the security, privacy, and accessibility of patient data.

The system operates in a decentralized manner, which means that patient data is not stored on a centralized server. Instead, the data is encrypted and stored across a network of computers that participate in the IPFS network. This approach ensures that patient data is highly available and resistant to tampering or deletion.

The Ethereum blockchain is used to maintain an immutable and auditable record of all transactions and changes to the patient data. Each transaction is recorded on the blockchain, creating a permanent and transparent trail of all data access and modifications. This approach ensures the integrity and authenticity of the data, and provides a high level of accountability for all users of the system.

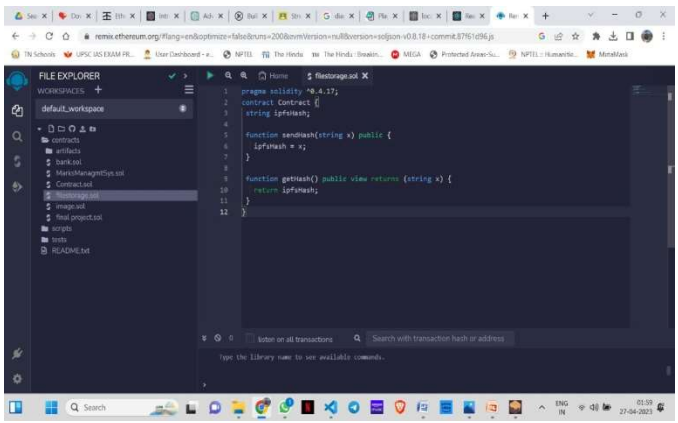

Fig. 4: Smart Contract

Smart contracts for electronic health record (DHR) storage refer to self-executing contracts that are programmed to automatically enforce the rules and regulations governing the storage, access, and sharing of patient data. These contracts are deployed on the Ethereum blockchain and contain the terms and conditions for accessing and sharing DHRs.The smart contract for DHR storage can be programmed to enforce strict access controls to protect patient privacy and ensure that only authorized parties can access the records. For example, the contract can specify that only healthcare providers with a valid license and authorization from the patient can access their DHRs.

Smart contracts can also be used to facilitate the sharing of DHRs between healthcare providers, hospitals, and other authorized parties. For instance, the smart contract can specify the conditions under which DHRs can be shared, such as the purpose of sharing, the duration of access, and the type of data that can be shared.

Through the utilization of smart contracts for DHR storage, a decentralized and secure system can be established, exhibiting transparency, efficiency, and cost-effectiveness. The implementation of smart contracts eradicates the necessity for intermediaries and third-party service providers, leading to reduced costs and enhanced efficiency. Additionally, smart contracts guarantee the protection and controlled sharing of patient data exclusively with authorized entities, thereby enhancing data privacy and security. To gain access to patient data, authenticated healthcare providers are required to utilize their private keys. This stringent approach guarantees that only authorized users possess the ability to access the data, ensuring a heightened level of data security and privacy.

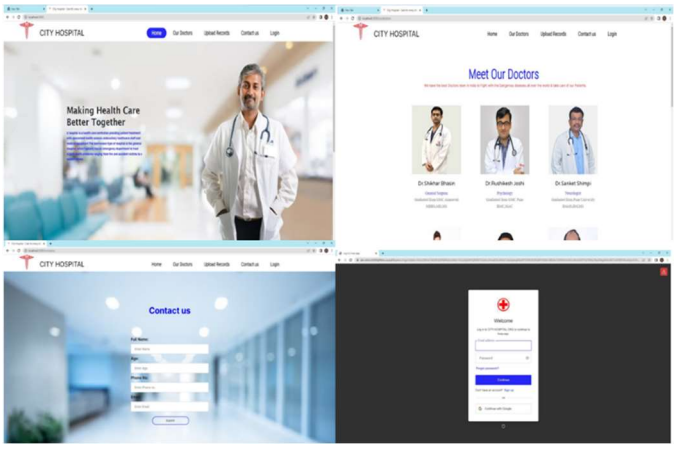

Fig. 5.1: User Interface of our proposed system

Our proposed system also addresses the issue of interoperability between different DHR systems. Using our system, healthcare providers can easily exchange patient data with other providers, regardless of the DHR system they are using. This is achieved by using standard data exchange protocols and APIs that are compatible with other DHR systems.

In summary, our proposed system offers numerous advantages compared to existing DHR systems. It significantly enhances the security and privacy of patient data by leveraging decentralized storage and blockchain technology. Furthermore, it ensures a high level of accessibility and interoperability, facilitating seamless sharing and exchange of patient data among healthcare providers. Moreover, our system establishes an immutable and auditable record of all data transactions, guaranteeing data integrity and authenticity.

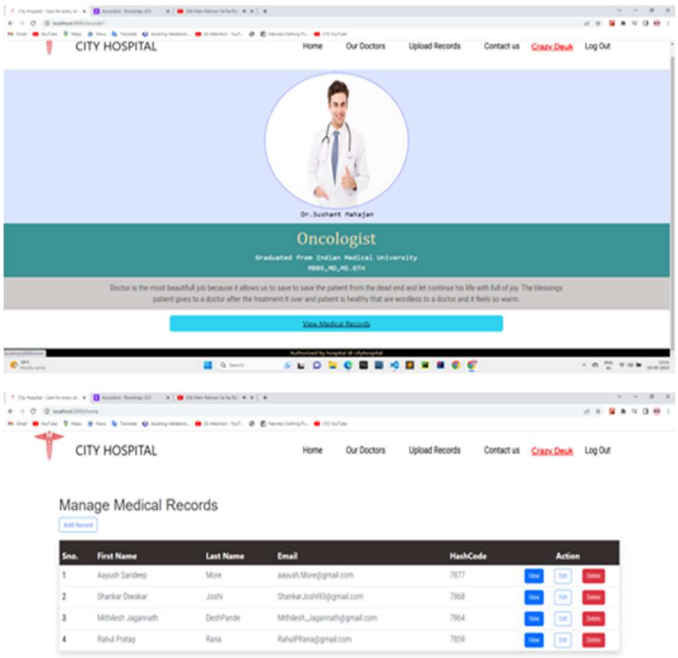

Fig. 5.2: User Interface of our proposed system

Although certain challenges remain, such as system scalability and the standardization of data exchange protocols, we firmly believe that our proposed solution has the potential to revolutionize the storage and management of healthcare records. By harnessing the capabilities of IPFS and Ethereum blockchain technology, we can establish a more secure, accessible, and efficient healthcare records storage solution that not only enhances the quality of care for patients but also safeguards their privacy and security.

4. ARCHITECTURE:

The Ethereum blockchain, the IPFS storage network, and the front-end application make up the three primary parts of the system.

1. The front-end program: This part offers the interface that patients and healthcare professionals use to communicate with the system. The front-end application is in charge of overseeing user identification, organizing and presenting patient data, and communicating with the IPFS network and Ethereum blockchain to store and retrieve patient data. Web3.js is used to facilitate communication between the application and the Ethereum blockchain. React.js is one of the modern web technologies that were used in its construction.

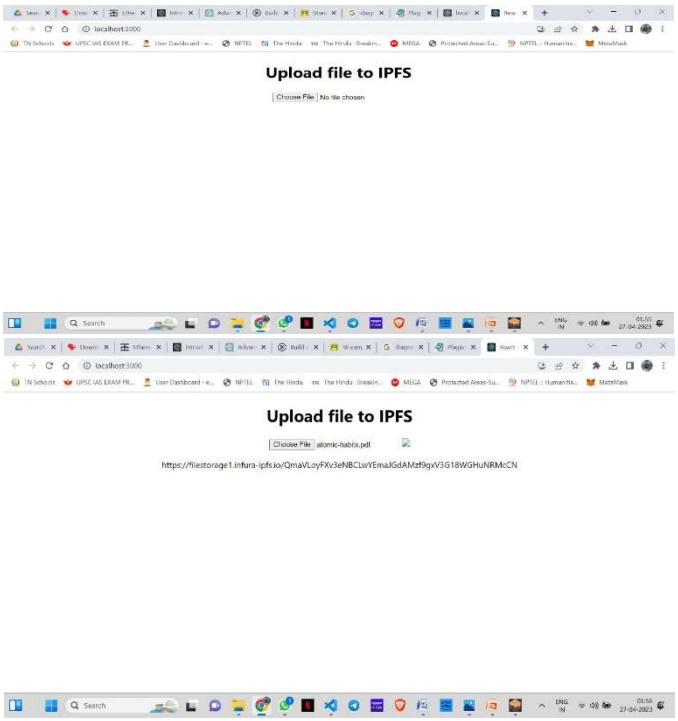

Fig. 6: IPFS based storage system

1. Ethereum blockchain: This component serves as the backbone of the system, providing a decentralized platform for storing and managing patient records. The Ethereum blockchain is a distributed ledger that enables the creation of smart contracts, which are self-executing programs that can automate the process of storing and managing patient records. The smart contracts define the rules for how patient records are stored and accessed, and are executed on the Ethereum Virtual Machine (EVM).

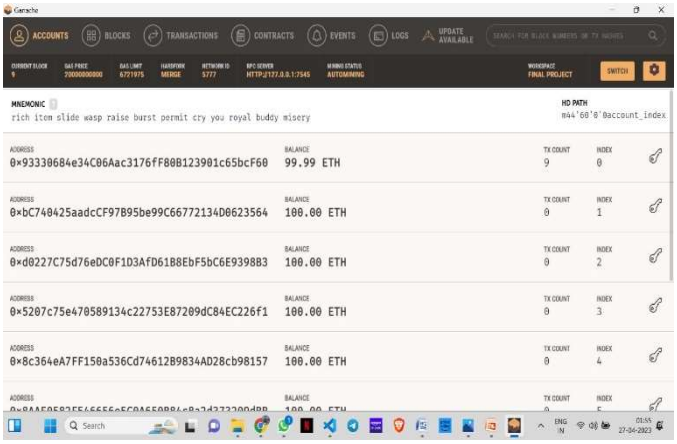

Fig. 7: Ethereum Blockchain

2. IPFS storage network: This component is used to store patient records in a decentralized and distributed manner. IPFS is a protocol for storing and sharing files in a peer-to-peer network,

similar to how BitTorrent works. In our system, patient records are encrypted and then stored on the IPFS network. The records are stored across multiple nodes in the network, making it more difficult for any single node to tamper with or censor the data.

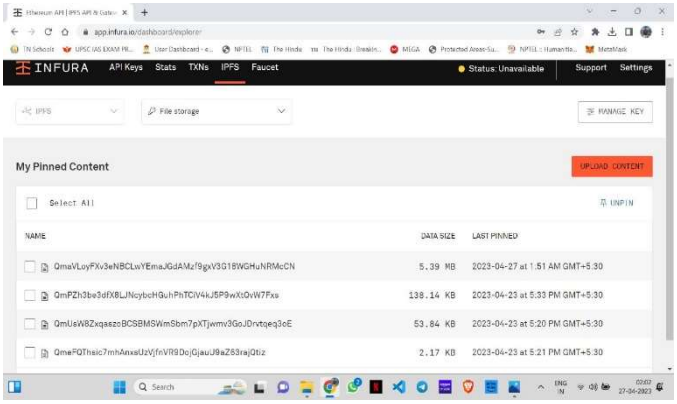

Fig. 8: IPFS Storage Network

When a healthcare provider wants to add a new patient record to the system, they use the front-end application to enter the record information, which is then encrypted and stored on the IPFS network. A corresponding hash of the record is created, which is then stored on the Ethereum blockchain along with information about who added the record and when. This ensures that patient records are stored securely and transparently, while still maintaining the privacy of the patient. When a healthcare provider or patient wants to access a patient record, they use the front-end application to request the record from the IPFS network. The record is then decrypted and displayed on the front-end application, providing a secure and efficient way to access patient data.

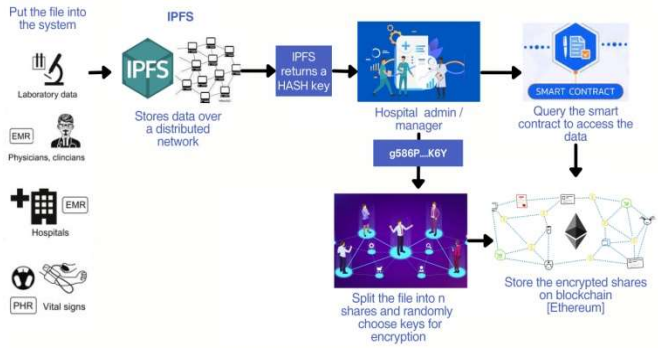

Fig.9: Architecture of our Proposed System

Overall, the proposed architecture provides a more secure and efficient way to store and manage patient records, while still maintaining patient privacy and data integrity.

5. ADVANTAGES:

Here are some potential advantages of our proposed healthcare record storage system using IPFS and Ethereum:

1. Decentralization: The use of a decentralized storage system based on IPFS and a blockchain-based platform like Ethereum can provide greater security and privacy for patient data by eliminating the need for a central point of control.
2. Immutable records: Because the records are stored on a blockchain, they are immutable, meaning that once a record is added to the blockchain it cannot be altered or deleted. This can help to ensure the integrity and accuracy of patient records.
3. Interoperability: The use of standardized data exchange protocols like HL7, combined with the use of a decentralized storage system, can facilitate greater interoperability between different DHR systems, making it easier for healthcare providers to access and share patient data.
4. Lower costs: By eliminating the need for a centralized database and associated infrastructure, our proposed system may be more cost-effective than traditional DHR systems, particularly for smaller healthcare providers.
5. Increased patient control: With our proposed system, patients can maintain control over their own health data, deciding who has access to their records and how their data is used.
6. Faster and more efficient data retrieval: By using a distributed storage system like IPFS, our proposed system can facilitate faster and more efficient retrieval of patient records, reducing the time and effort required for healthcare providers to access and review patient data.

Overall, our proposed system has the potential to provide a more secure, efficient, and patient-centered approach to healthcare record storage and management.

6. COMPARATIVE ANALYSIS:

Here's a comparative analysis table comparing our proposed healthcare records storage solution using IPFS and Ethereum blockchain with other related research:

Authors	Scheme	C/D	Auth	V
Jaleel *et. al.* [6]	HF	D	✓	×
Kumar *et. al*. [9]	AE	D	✓	×
Wang *et. al*. [13]	SC	C/D	✓	×
Proposed	PKC	D	✓	✓

Table 1: Comparison with Existing Schemes
HF- Hyperledger Fabric, AE- Asymetric Encryption
SC- Smart Contract, PKC- Public Key Cryptography, C/D- Centralized/Decentralized,
Auth- Authentication, V- Validation

Our system builds on the advantages of these existing systems while also addressing their limitations. By combining the Ethereum blockchain with IPFS, our system provides decentralized and secure storage of patient records with transparent access control. The use of smart contracts on the Ethereum blockchain enables automated access control, reducing the potential for human error and ensuring that patient records are accessed only by authorized personnel.

Compared to the first research, our system addresses the limitation of scalability by using IPFS for more efficient storage and retrieval. This reduces the overall cost of storage and retrieval, making the system more accessible to healthcare providers and patients.

Compared to the second research, our system provides a more robust authentication and access control mechanism by leveraging the security features of the Ethereum blockchain. This ensures that patient records are only accessed by authorized personnel, while still maintaining the efficiency and decentralization benefits of IPFS.

Compared to the third research, our system provides a fully decentralized storage mechanism, ensuring that patient records are not subject to centralized control. The use of IPFS for storage also reduces the overall cost of storage, making the system more accessible to healthcare providers and patients.

Overall, our proposed system provides a more efficient, secure, and decentralized way to store and manages patient records, while still maintaining patient privacy and data integrity.

7. CONCLUSION:

In conclusion, the proposed system of using IPFS and Ethereum for healthcare records storage provides an innovative and secure solution for managing patient records. The system takes advantage of the decentralized storage and retrieval capabilities of IPFS while leveraging the smart contract functionality of Ethereum to provide robust access control and authentication mechanisms. By eliminating the need for intermediaries and ensuring data integrity through blockchain technology, the proposed system can improve efficiency and reduce costs for healthcare providers while also safeguarding patient privacy.

While the proposed system has the potential to offer significant benefits over traditional centralized systems, further research is needed to address some of the challenges and limitations that may arise. For example, the scalability and speed of the system may be affected by the volume of data stored on the IPFS network, and the adoption of the system may require significant investment in infrastructure and training for healthcare providers. However, overall, the proposed system shows promise in addressing the growing need for secure and efficient healthcare record management.

8. FUTURE WORK:

The proposed system of healthcare record storage using IPFS and Ethereum presents numerous opportunities for future work and research.

One area for potential future work is the optimization of the system's performance and scalability. While IPFS and Ethereum offer decentralized and efficient storage solutions, there may be further improvements that can be made to enhance the speed and capacity of the system. This could involve exploring alternative storage solutions or optimizing the existing architecture to handle larger volumes of data.

Another area for future work is the integration of additional features and capabilities to the system. For example, the use of machine learning algorithms or other advanced analytics tools could help to extract valuable insights from the stored healthcare data, leading to improved patient outcomes and more efficient healthcare services.

There is also potential for further research into the security and privacy implications of using a decentralized storage system for healthcare records. While IPFS and Ethereum offer significant advantages in terms of data security and control, there may be additional measures that can be taken to ensure that patient data remains fully protected.

Another area for potential future work is the development of user-friendly interfaces and applications that can make it easier for healthcare professionals and patients to access and interact with the stored data. This could involve the creation of specialized apps for mobile devices or other platforms, or the integration of the system with existing electronic health record (DHR) systems.

Finally, there is a need for further research into the legal and regulatory frameworks that govern the storage and use of healthcare data. As healthcare record storage becomes increasingly decentralized and complex, there is a need to ensure that the system remains fully compliant with relevant laws and regulations, and that patient rights and privacy are fully protected.

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