

Decentralized Document Management System (DDMS)

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***Abstract—*In this study, we conduct a comprehensive analysis of a decentralized document management system utilizing Ethereum, IPFS, and blockchain technology. The project involves several key steps, including the deployment of smart contracts on the Ethereum blockchain to manage document access and permissions, the use of the InterPlanetary File System (IPFS) for distributed and immutable document storage, and the implementation of secure document retrieval protocols. We evaluate the system's performance using metrics such as storage efficiency, retrieval time, data integrity, and system scalability. Furthermore, the study explores the security and privacy aspects of decentralized document management, including resistance to data tampering, unauthorized access, and ensuring document authenticity. The results of our study provide insights into the effectiveness of blockchain and decentralized storage technologies for document management, offering valuable guidance for practitioners and researchers in developing secure, efficient, and scalable document management solutions.**

1. Introduction

Traditional document management systems have long relied on centralized servers, a model that poses inherent vulnerabilities such as susceptibility to data breaches, unauthorized access, and system failures. Furthermore, users often find themselves with limited control over their own documents once uploaded to these centralized platforms. In response to these challenges, Decentralized Document Management Systems (DDMS) represent a paradigm shift. By

distributing document storage across a network of nodes, DDMS significantly enhance security, transparency, and user control.

Our DDMS leverages the groundbreaking capabilities of blockchain technology to address these shortcomings. By utilizing blockchain for storing document metadata and ensuring data integrity, we establish a robust foundation for document management. Each document within our system is intricately linked to a unique Ethereum hash stored on the blockchain. This hash serves as a cryptographic fingerprint, facilitating tamper- proof verification of document authenticity and ownership. Furthermore, this Ethereum hash is associated with its corresponding IPFS hash, which directs to the actual document stored on the (IPFS) network.

This hybrid approach seamlessly integrates the immutability and transparency of blockchain with the decentralized file storage capabilities of IPFS. The blockchain ensures that document metadata remains secure and unaltered, while IPFS provides a distributed and resilient storage solution for the actual document contents. The synergy between these technologies results in a DDMS that offers unparalleled levels of security, transparency, and user control.

In this paper, we embark on a detailed exploration of the architecture and deployment of our innovative Document-

Driven Management System (DDMS). With a particular emphasis on the upload and retrieval processes, we delve into the intricacies of our system's operation. Through the presentation of a functional prototype, we aim to not only showcase the feasibility of our approach but also underscore its numerous advantages over traditional document management systems.

Our overarching goal is to provide a comprehensive overview of DDMS and its transformative potential within the realm of document management. By highlighting real-world applications and leveraging insights gained from our prototype, we seek to inspire continued research and development in this exciting and promising domain.

1. Related Work

This section reviews key research and technologies that informed the development of our decentralized document management system. The focus is on how existing solutions and advancements have been adapted and integrated in our experimental and educational project.

1. *Foundational Technologies*
2. *Benet (2014) aimed to develop a distributed file system to connect all computing devices using the same system of files. This was achieved by employing a peer-to-peer (P2P) hypermedia protocol for content addressing and versioning. The findings indicated that IPFS is highly effective for decentralized file storage and sharing. In our project, we utilized IPFS for decentralized storage of documents, leveraging its content addressing to ensure data integrity and efficient retrieval.*
3. *Zyskind et al. (2015) focused on using blockchain for secure and decentralized data management. By ensuring data integrity and security in a trustless environment, the feasibility of blockchain for secure data management was demonstrated. We integrated blockchain to manage document metadata and access controls in our project, ensuring secure and transparent permissions management.Integration of Smart Contracts*
4. *Integration of Smart Contracts*

Huang et al. (2018) developed a secure and efficient data sharing system using blockchain and decentralized storage. By combining blockchain for data transactions with IPFS for storage, they improved security and efficiency in data sharing. This inspired our use of blockchain for transaction logging and IPFS for storage, ensuring secure document sharing and storage.

Zhang et al. (2020) implemented access control in document management using Ethereum smart contracts. This approach enhanced access control security and

flexibility. We adopted Ethereum smart contracts to manage and enforce access control policies, providing secure and automated access management.

Comprehensive Systems

Li et al. (2021) created a decentralized document management system using IPFS for storage and blockchain for metadata. This integration proved effective for decentralized document management. Our project was directly influenced by this work, as we adopted a similar approach to integrate IPFS for storage and blockchain for metadata and access control.

1. *Educational and Experimental Projects*

Various academic projects and experiments have explored the integration of decentralized technologies for learning purposes, providing a practical understanding of blockchain, smart contracts, and decentralized storage. Our

project follows this educational approach, aiming to understand and demonstrate the integration of decentralized technologies.

# Summary

The reviewed works provide the technological foundation and inspiration for our project. By integrating IPFS for storage, blockchain for metadata management, and smart contracts for access control, our project serves as an educational and experimental platform. It showcases the practical implementation of these technologies, emphasizing learning and experimentation.

1. Methodology

Our methodology integrates IPFS for decentralized storage and blockchain for access control and encryption. This project employs advanced encryption techniques to enhance document privacy and validates scalability and superiority over centralized solutions through extensive testing. The approach provides a comprehensive analysis and implementation of a decentralized document management system leveraging modern technologies to address the limitations of traditional centralized systems.

This project developed a sophisticated web application utilizing a robust combination of technologies. ASP.NET MVC 5 was chosen for building the application due to its powerful capabilities in creating dynamic, data-driven web applications.

The InterPlanetary File System (IPFS) was employed for decentralized storage, providing a distributed and immutable storage solution for documents. Additionally, the Ethereum blockchain was utilized to manage document metadata and store IPFS hashes, facilitating secure and verifiable data access.

Visual Studio served as the primary development environment, supporting the integration of various technologies and libraries necessary for the project. Among these, the http.ipfs library was crucial for facilitating communication with the local IPFS node, which was established for development purposes. This setup enabled efficient document upload and retrieval, with documents uploaded to IPFS generating unique hashes. These hashes were subsequently linked with document metadata managed by smart contracts deployed on the Ethereum network, ensuring a secure and tamper-proof storage solution.

The application architecture was meticulously designed to ensure seamless interaction between the Ethereum blockchain and IPFS. Custom smart contracts were developed and deployed on the Ethereum blockchain to manage document metadata, including document names, versions, and IPFS hashes. This ensured secure and transparent document management, with all metadata changes being recorded immutably on the blockchain. Documents uploaded to IPFS were stored in a decentralized manner, with their unique IPFS hashes stored on the blockchain, providing a robust, distributed storage solution resistant to tampering and unauthorized access.

Several key components formed the core of the application. The DocumentViewModel class was created to encapsulate document information for display in the user interface. This class included fields such as document ID, name, version, and Base64-encoded PDF data, ensuring that all relevant document details were available for user interaction. The DocumentsController was responsible for handling user

requests related to documents. This included retrieving document lists, fetching details for specific documents, and retrieving the actual document data (PDF) from IPFS using the IPFS hash obtained from the blockchain. The Razor views were employed to display document lists and individual document details. The user interface presented document information such as ID, name, and version, allowing users to interact with different document versions. The document details view displayed retrieved document information and the PDF content, if successfully retrieved from IPFS, using appropriate UI elements to ensure a seamless user experience.

To ensure the integrity and confidentiality of the documents, several security and privacy measures were implemented. Advanced encryption techniques were used to encrypt documents before uploading them to IPFS, enhancing privacy and security. The Ethereum smart contracts ensured that only authorized users could access and manage documents, leveraging the inherent security features of blockchain technology. The blockchain recorded all transactions

immutably, ensuring data integrity and providing a transparent record of all document-related operations.

The system’s performance was evaluated using several key metrics. Storage efficiency was measured by assessing the space utilized on IPFS and comparing it with traditional centralized storage solutions. Retrieval time was evaluated by measuring the time taken to retrieve documents from IPFS. Data integrity was verified by ensuring the consistency of document hashes stored on the blockchain with the actual documents retrieved from IPFS. System scalability was tested by simulating multiple simultaneous document uploads and retrievals to evaluate the system’s performance under load. These tests validated the system’s ability to handle large volumes of data and numerous concurrent users without compromising performance or security.

# A.

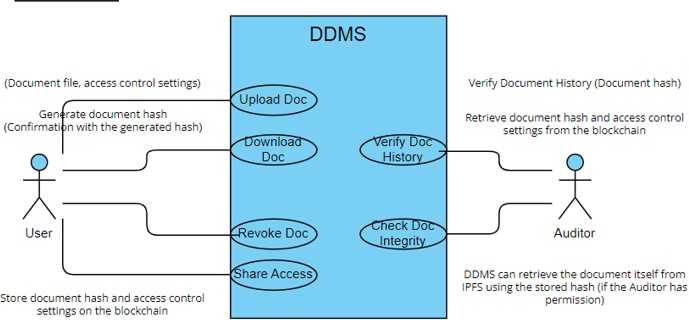
**Figure 1:** Sequence Diagram for Decentralized Document System Interaction

This sequence diagram demonstrates the interaction between the user, frontend, system, IPFS, and blockchain in a decentralized storage environment. The user initiates actions

via the frontend interface, which communicates with the system to execute operations. Data is stored and retrieved through the InterPlanetary File System (IPFS), ensuring efficient and distributed file storage. The blockchain component is utilized for recording transactions, verifying data integrity, and managing metadata. The sequence of interactions ensures

secure, immutable, and decentralized management of user data, with each component playing a crucial role in maintaining the system’s integrity and functionality.

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**Figure 2:** Decentralized Storage Use Case Diagram This diagram illustrates the use cases for a decentralized

storage system. The primary actors include users, who interact with the system to store, retrieve, and manage data, and nodes, which participate in the network to provide storage and maintain data integrity. Key use cases include data uploading, data retrieval, data replication, and data verification. The system ensures data security, privacy, and redundancy through distributed ledger technology and cryptographic techniques.

This decentralized approach mitigates the risks associated with single points of failure and enhances data availability and resilience. Each use case is designed to provide a robust and user-friendly experience, ensuring that all interactions are secure, efficient, and reliable.

By integrating these components and following this methodology, we demonstrated the feasibility and advantages of a decentralized document management system using Ethereum, IPFS, and blockchain technology. This approach offers a secure, efficient, and scalable solution for document storage and management, addressing the limitations of traditional centralized systems. The comprehensive analysis and implementation of this system provide valuable insights for practitioners and researchers looking to develop similar decentralized applications, showcasing the potential of combining blockchain technology with decentralized storage solutions to create innovative and reliable document management systems.

1. CONCLUSIONS

Our project represents a significant advancement in the field of document management, leveraging decentralized

technologies such as blockchain and IPFS to create a secure, transparent, and efficient system. By addressing the limitations of traditional centralized systems, our Decentralized Document Management System (DDMS) provides enhanced security, user control, and auditability.

Key accomplishments of our project include:

Enhanced Security: Through the use of blockchain technology, we ensure document integrity, authenticity, and confidentiality. Each document is cryptographically linked to its unique Ethereum hash, providing tamper- proof verification.

Decentralized Storage: Leveraging IPFS for decentralized file storage, we eliminate single points of failure and create a resilient storage solution that enhances data availability and reliability.

Access Control: Smart contracts on the Ethereum blockchain enforce access control policies, allowing for secure and automated management of document permissions.

Version Control: Our system includes robust version tracking capabilities, enabling users to roll back to previous document versions if needed, ensuring data consistency and reliability.

Furthermore, our project contributes to the educational and experimental exploration of decentralized technologies. By integrating insights from related research and educational projects, we have created a platform that not only demonstrates the feasibility of decentralized document management but also encourages further research and development in this domain.

In summary, our Decentralized Document Management System offers a scalable, secure, and user-centric approach to document management, with potential applications across various industries where data integrity and security are paramount.

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