Systematic Review of Decentralized Web Hosting: Integrating IPFS and Hyperledger Fabric

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**ABSTRACT** The purpose of this comprehensive analysis is to gain a deeper understanding of the potential integration of the InterPlanetary File System (IPFS) and Hyperledger Fabric for decentralized web hosting. Conventional web hosting faces limitations related to scalability, security, and data integrity, whereas decentralized approaches hold promise for resolving these issues by distributing computational resources and storage. IPFS, an open-source blockchain platform, and Hyperledger Fabric, a peer-to-peer hypermedia protocol, provide a strong foundation for distributed storage. Additionally, Hyperledger Fabric, an open-source blockchain platform, ensures secure and verifiable transactions. This review provides an overview of current research and explores how these two technologies can collaborate to establish a decentralized web hosting infrastructure that is resilient, efficient, and safeguarded. The benefits of increased data accessibility are emphasized in the main conclusions. Furthermore, the research identifies deficiencies in existing literature and provides suggestions for future investigations aimed at addressing these issues and enhancing the integration of IPFS and Hyperledger Fabric for decentralized web hosting.

**INDEX TERMS** decentralized web hosting, interplanetary file system, Hyperledger fabric, peer to peer network, smart contracts, blockchain

**I. INTRODUCTION**

**A. BACKGROUND**

Distributed technology [1,2] enhances security [3], scalability [4] [17], and data integrity [18], representing a significant shift from traditional centralized hosting setups. The InterPlanetary File System (IPFS) [19-23] and Hyperledger Fabric [24-30] technologies have gained popularity due to the increasing demand for reliable web hosting solutions [31]. IPFS enables distributed storage through a peer-to-peer hypermedia system [32] that utilizes cryptographic hashes [33- 36] instead of centralized URLs to address content. This approach ensures data redundancy and efficient content retrieval across a global network of nodes. Hyperledger Fabric, an enterprise-grade permissioned blockchain technology [37-39], offers a transparent and secure framework for managing decentralized applications (dApps) [40-45]. Its modular architecture supports smart contracts [46-51]and adaptable consensus mechanisms [52-56], both vital for ensuring the accuracy and dependability of transactional data.

**B. SIGNIFICANCE OF DECENTRALIZED WEB HOSTING [9]**

Decentralized web hosting [57-60] replaces the traditional client-server architecture [61-63] with a distributed network of nodes that store and access data on a peer-to-peer basis. This strategy not only reduces the risks associated with centralized points of failure, but it also promotes data integrity [64], allows for speedier content delivery, and supports a more inclusive and robust internet infrastructure. Compared to conventional centralized solutions, decentralized web hosting provides revolutionary advantages by tackling important problems with efficiency, security, and durability. By dispersing data throughout a network of nodes, it reduces the impact of single points of failure and increases availability and dependability. Cryptographic techniques [65] provide increased security by safeguarding data integrity and thwarting illegal access. One major benefit is that material is not dependent on centralized servers, which makes it more difficult to censor or manage. By allowing the network to expand naturally as new nodes join, scalability is greatly enhanced and bottlenecks related to centralized infrastructures are removed. Additionally, decentralized hosting improves speed by using peer-to-peer data retrieval and local caching to cut down on latency. It also gives people more ownership and control over their data, promoting privacy and lessening reliance on centralized organizations. In general, decentralized web hosting creates a foundation for an internet that is stronger, more inclusive, and more effective.

**C. INTEGRATION OF IPFS AND HYPERLEDGER FABRIC**

At the forefront of decentralized web hosting technologies are InterPlanetary File System (IPFS) and Hyperledger Fabric, both adding distinct capabilities to the ecosystem:

1. **INTERPLANETARY FILE SYSTEM (IPFS) [19]**

It revolutionizes content addressing and distribution by identifying and retrieving material across a decentralized network of nodes via cryptographic hashes (CIDs) [74] [75]. The peer-to-peer architecture [76] improves data availability and resilience, making it perfect for scalable and censorship-resistant web hosting solutions [77]. The InterPlanetary File System (IPFS) transforms content addressing and distribution with its revolutionary design and features. IPFS uses cryptographic hashes (CIDs) to protect content integrity and simplify data retrieval by enabling access to material based on its unique hash rather than its location. IPFS, organized as a Merkle Directed Acyclic Graph (DAG) [78], improves data management through efficient versioning, deduplication, and linking. Peer-to-peer networking using the libp2p protocol enables safe communication and data exchange across nodes, improving decentralized access and cooperation. IPFS' usage of a Distributed Hash Table (DHT) [79] allows for decentralized content routing and discovery, which improves scalability and censorship resistance [80][81]. By storing data locally and allowing offline access, IPFS improves content delivery efficiency and resilience, providing the groundwork for decentralized web hosting infrastructure and building a more resilient and decentralized internet.

1. **HYPERLEDGER FABRIC [24]**

Hyperledger Fabric, part of the Linux Foundation's [82] Hyperledger project, is a permissioned blockchain platform intended for decentralized applications (dApps). Hyperledger Fabric is a permissioned blockchain [83] architecture that enhances IPFS by providing a secure and transparent platform for managing decentralized applications (dApps). Its modular design and smart contract capabilities ensure data integrity, transactional transparency, and flexible governance frameworks, making it ideal for decentralized hosting environments. Fabric operates as a permissioned network, allowing only authorized users to join, improving security and privacy. Its modular design allows for customization of identity management, ledger storage, and consensus methods, enabling bespoke solutions for specific business requirements. Smart contracts, implemented using chaincode languages like Go [84] and JavaScript [85-87], execute complex business logic on the blockchain. Private channels limit sensitive data visibility to authorized parties, while its pluggable consensus algorithms and high throughput capabilities enable scalable and efficient transaction processing.

One of the best blockchain frameworks for corporate applications is Hyperledger Fabric, which provides flexibility, scalability, and security. The platform's permissioned architecture, modular design, and ability to accommodate intricate business logic make it perfect for creating scalable and secure decentralized applications in a variety of sectors. Hyperledger Fabric allows for a wider adoption of blockchain technology in corporate environments by overcoming major issues with conventional blockchain systems.

The combination of IPFS with Hyperledger Fabric provides a robust solution for decentralized web hosting that addresses scalability, security, data integrity, and censorship resistance. IPFS uses cryptographic hashes and a peer-to-peer network for decentralized storage, assuring data retrieval and integrity. Hyperledger Fabric, on the other hand, offers secure transaction records via its permissioned blockchain, which is supported by a modular design for improved efficiency and security. Together, these technologies provide for safe content delivery, data integrity and auditability, scalable web hosting options, and increased privacy and censorship resistance. This comprehensive method lays a solid basis for next-generation decentralized applications, providing secure, scalable, and robust web hosting infrastructures.

**D. RESERCH QUESTIONS**

The following question summarizes the primary aspects we need to explore in our review:

**RQ1:** Based on currently available research, how feasible is decentralized web hosting using IPFS and Hyperledger Fabric?
**RQ2:** What use cases and potential applications does this technology have?
**RQ3:** Based on the research, what are the technical, economic, and social challenges?

**E. PRIOR REVIEWS**

Huynh et al. [9] offer a decentralized network prototype based on the Interplanetary file system and the Ethereum blockchain. The concept supports data transport and access across nodes, with changeable connections having specific rights. The Ethereum blockchain facilitates smart contracts, which manage these nodes. The article explains the process of creating a functional model and hosting online applications, emphasizing the decentralized web's improved anonymity, integrity, and availability. J. Benet et al. [10] introduce the Interplanetary File System (IPFS), comparing it to the existing web and examining topics such as Distributed Hash Tables, Block Exchange, Version Control Systems, and Self-certified File Systems. It also compares BitTorrent, Git, and IPFS. The author talks about node IDs, routing systems, block exchange, Object Merkle DAG, file system, IPNS naming, and changeable state. The draft also makes use of IPFS in several ways. R. Kumar, R. Tripathi, et al. [10] propose the Interplanetary File System (IPFS), comparing it to the existing web and covering topics such as Distributed Hash Tables, Block Exchange, Version Control Systems, and Self-certified File Systems. It compares BitTorrent and Git to IPFS and covers node identities, routing systems, block exchange, Object Merkle DAG, file system, IPNS naming, and changeable state. Huynh et al. [8] describe how to improve peer-to-peer file-sharing systems by adding a Content Service provider, solving high bandwidth difficulties, and refining the IPFS block storage architecture. They employ a zigzag-based storage model to improve BitSwap protocol performance and provide tailored optimization for content service providers. The proposed architecture incorporates three distinct systems.

Thegroundbreaking work by Benet [7] presents IPFS, describing its design and how it may completely change how data is distributed and stored. The advantages of decentralized storage, effective data retrieval, and content addressing are emphasized throughout the study. A Survey of Decentralized File Systems[6] examines different decentralized file systems, including IPFS, highlighting their design principles, benefits, and limitations when compared to typical centralized systems. An article [8] delves into Hyperledger Fabric's architecture, concentrating on its modular design, security features, and scalability. It emphasizes the system's applicability for corporate applications that require strong permissioning and privacy.

Thebook [5] examines the architecture and use cases of several blockchain systems, such as Hyperledger Fabric, and shows how they may be combined with other technologies to improve functionality and security. Alessi et al. [11] examine data privacy and protection, emphasizing user knowledge and permission. It examines how to improve privacy networks by leveraging the Interplanetary File System and Ethereum to reduce privacy abuse. The author divides validation into three phases: explicit personal data insertion, personal data sharing, and intrinsic personal data extraction. They also talk about a mobile prototype that uses an IPFS daemon for IPFS and device sharing situations, as well as an algorithm prototype for personal data storage or vault on Windows and Android. Q. Zheng et al. [12] explore the rise and popularity of blockchain, finding that in 2018, Bitcoin's entire ledger size topped 200 GB. The author offers an IPFS-based storage strategy for transaction ledgers that increases storage capacity and speeds up the synchronization of additional nodes. The paper also explores the advantages of interplanetary file system storage, including theoretical considerations and metadata for generalization and solution.

Q. Xu et al. [13] describe the creation of a social networking system employing an Ethereum virtual computer to perform smart contracts. These decentralized apps (DApps) require an ecosystem to function. The author stores and transfers data via the IPFS protocol, which is currently only supported by the browser. They develop an app that, like Twitter, operates on a decentralized basis and includes account management and smart contracts. The author writes the prototype smart contract for the Ethereum virtual machine using the Solidity programming language. The software is built and shown until it reaches the proof-of-concept level.

The empirical research [14-16] mentioned assesses the performance, security, and practical uses of decentralized web hosting with IPFS and Hyperledger Fabric. Studies on decentralized Content Delivery Networks (CDNs) that use these technologies regularly outperform standard CDNs in terms of latency, throughput, and fault tolerance. Blockchain-based supply chain management systems that use IPFS for document storage and Hyperledger Fabric for transaction management exhibit increased transparency and efficiency. Security investigations validate the reliability of IPFS's content addressing via cryptographic hashing, which ensures data integrity and authenticity. Identity management and privacy capabilities included into Hyperledger Fabric, such as Membership Service Providers and private channels, efficiently protect access control and data confidentiality in complicated networks. The technologies' potential to improve censorship resistance, user privacy, and data availability is further highlighted via case studies on decentralized social media and healthcare data management systems. Even with these developments, problems with interoperability and optimization still exist, requiring more study to fully realize the transformational potential of the integrated approach in decentralized web hosting and data management.

**F. PAPER ORGANIZATION**

The remaining sections of this paper are organised such that the research approach gives a detailed methodology for our systematic review. The Preferred Reporting Items for Systematic and Meta-Analysis (PRISMA) chart of the methodology is shown in Figure 1. We used the discussions section to expand on and provide detailed analysis of the findings by each research question. Identified limitations to this study were outlined in the discussion section. The conclusion section was used to summarise the study while laying the foundation for future work.

**II. RESEARCH APPROACH**

1. **SYSTEMATIC DATABASE SEARCH**

We reviewed scholarly materials in order to gain an understanding of the notion of decentralized web hosting. The databases searched for the study include academic databases like ScienceDirect and additional resources such as Google Scholar for a broader search, and Semantic Scholar. The core keywords and search terms used are "Decentralized web hosting" OR "distributed web hosting," "IPFS" (InterPlanetary File System), and "Hyperledger Fabric." Optional additional terms include "Blockchain" (to capture broader context), "Peer-to-peer" (P2P), "Distributed storage," "Censorship resistance," and "Smart contracts." These keywords and terms are combined using Boolean operators (AND, OR, NOT) to create precise search strings. An example search string is: ("decentralized web hosting" OR "distributed web hosting") AND (IPFS OR "Hyperledger Fabric").

1. **INCLUSION CRITERIA**

The inclusion criteria for selecting articles include a timeline from 2018 to 2024, peer-reviewed research articles focusing on scholarly publications for reliable and validated research, primarily English language articles, and a focus on studies specifically exploring decentralized web hosting using IPFS and Hyperledger Fabric.

1. **EXCLUSION CRITERIA**

The exclusion criteria rule out articles beyond the specified year range, articles in the pre-publication stage, studies published in non-academic sources (e.g., blogs, news articles), studies not directly related to decentralized web hosting, IPFS, or Hyperledger Fabric (e.g., studies focusing on other blockchain applications), and articles where the abstracts did not focus on the subject.

**PRISMA CHART for: A Systematic Review on Decentralized Web Hosting using IPFS and Hyperledger Fabric**

Studies included in review

(n = 64 )

**Screening**

Records screened

(n = 9011 )

**Records excluded (n=2379)**

* (Articles beyond the specified time line)

Reports sought for retrieval

(n = 6632)

**Reports not retrieved** (n =4957 )

* [context(unrelated, awareness)]

Reports assessed for eligibility

(n =1685 )

**Reports exclude:**

* Pre- publishing stage articles excluded (n=456)
* Exclusion based on the title of the article (n =674)
* exclusion based on abstract of the article (n =491)

**Included**

**Identification**

Records identified from\*:

ScienceDirect (n = 8216)

Semantic Scholar (n =4526)

Google Scholar (n= 4010)

**Records removed *before screening*:**

* Duplicate records removed (n = 3065 )
* Period covered by search (2018-2024) (n=2034)
* articles published in non-academic sources (n =2642)

FIGURE 1. **PRISMA CHART for the review process**

**III DISCUSSION AND LIMITATION**

The implications of systematic review on decentralized web hosting using ipfs and hyperledger fabric are covered here. The discussions were intended to cover further the subject of study on the state of the art at present and new and developing trends. This section also discusses the study's prominent limitations.

1. **DISCUSSION**

The discussion grouped by the research questions interprets the findings from reviewed articles in the context of each research question.

RQ1: *Based on currently available research, how feasible is decentralized web hosting using IPFS and Hyperledger Fabric?*

Research on decentralized web hosting with IPFS and Hyperledger Fabric so far indicates that it has a lot of potential but also has some substantial obstacles. By utilizing a peer-to-peer network and content-addressable storage, IPFS provides a novel method of data distribution and storage that improves data availability and integrity (Benet, 2014). In contrast, Hyperledger Fabric offers a strong architecture for building permissioned blockchains, which is crucial for maintaining security and confidence in business settings (Androulaki et al., 2018). Scalability, network performance, and the difficulty of administering decentralized apps are among the problems that must be resolved for these technologies to be integrated (Jogalekar & Woodside, 2000; Xu et al., 2019). Moreover, even while IPFS improves access speeds and data redundancy, maintaining stable performance over a worldwide decentralized network is still difficult (Huynh et al., 2019). Therefore, in order to handle the underlying complexity, even while it is doable, its implementation requires more breakthroughs in consensus processes, network protocols, and user-friendly interfaces.

RQ2: *What use cases and potential applications does this technology have?*

Blockchain technology and distributed ledger technology (DLT) have many potential applications and use cases in various sectors. DLT improves trust in financial exchanges by facilitating safe and transparent transactions, which lowers fraud (Sunyaev & Sunyaev, 2020). Increased traceability and transparency in supply chain management improve efficiency and accountability (El Ioini & Pahl, 2018). DLT improves patient privacy, data security, and medical record integrity in the healthcare industry (Ogiela & Majcher, 2018). Furthermore, DLT facilitates the creation of smart contracts and decentralized applications (DApps), which automate procedures and lessen the need for middlemen (Xu, Weber, & Staples, 2019). Peer-to-peer data sharing and data integrity preservation are made possible by this technology, which is also essential to secure decentralized storage systems like IPFS (Benet, 2014; Huynh, Nguyen, & Tan, 2019).

RQ3: *Based on the research, what are the technical, economic, and social challenges?*

There are a number of technological, financial, and social difficulties in implementing decentralized web hosting with IPFS and Hyperledger Fabric. From a technical standpoint, scalability and performance are guaranteed by both IPFS and Hyperledger Fabric, and merging these technologies can be challenging because of their disparate consensus procedures and topologies. Decentralized hosting can be economically costly to establish up and maintain, which may discourage smaller businesses from using it. The general public's acceptance and confidence in decentralized web hosting are still developing on a social level, with worries about security, privacy, and the law playing major roles. The advantages of improved security, resilience, and data ownership continue to spur interest and advancement in this field despite these obstacles.

1. **LIMITATION**

Systematic reviews on implementing decentralized web hosting using IPFS and Hyperledger Fabric have several limitations. First, the review's applicability is limited by the speed at which decentralized technologies are evolving and the potential for study findings to go out of date. Second, there may be gaps in understanding because systematic reviews mostly rely on the literature that is currently available, which may not fully address all advances or practical implementation issues. Third, the selection of studies may be biased since studies with stronger or more notable outcomes are frequently published and featured in reviews, leaving out weaker or undecided studies. Furthermore, it may be difficult to combine findings coherently due to the interdisciplinary nature of decentralized web hosting, which incorporates elements of economics, social sciences, and computer science. Finally, differences in the context of implementation across various studies can make it difficult to generalize conclusions, as results may vary significantly depending on specific use cases, environments, and stakeholder requirements

**IV. IMPLICATION AND FUTURE SCOPE**

* 1. **IMPLICATIONS**

The study of decentralized web hosting using IPFS and Hyperledger Fabric has important implications for the future of internet architecture, data management, and application development. Using IPFS's decentralized storage and content addressing capabilities in conjunction with Hyperledger Fabric's safe and scalable transaction management, various constraints inherent in traditional centralized web hosting approaches may be overcome. This connection improves data quality, privacy, and resilience, providing a solid platform for future web application development. The combined capabilities of these technologies promote a more open and censorship-resistant internet, giving consumers more control over their data and less reliance on centralized authority.

* 1. **FUTURE SCOPE**

The review's findings suggest various avenues for further research and advancement. One area with a lot of promise is improving the interoperability between IPFS and Hyperledger Fabric to allow easy data exchange and management throughout the whole system. Furthermore, investigating the performance tradeoffs and overheads generated by this collaboration may result in more effective implementations. Furthermore, there is potential for developing particular applications, such as decentralized social media platforms, supply chain management systems [66-68], and healthcare data solutions [69-72], to demonstrate the practical benefits of this collaborative approach. Furthermore, as technology advances, it will be critical to resolve legal and regulatory issues in order to allow widespread use. Overall, this systematic review [73] not only demonstrates the revolutionary power of combining IPFS with Hyperledger Fabric, but it also lays the groundwork for future innovation and development in decentralized web hosting solutions.

**V. CONCLUSION**

The combination of IPFS with Hyperledger Fabric for decentralized web hosting has the potential to revolutionize several fields, as evidenced by this systematic review. IPFS's decentralized storage and content addressing, along with Hyperledger Fabric's secure, permissioned blockchain, offer a strong alternative to traditional web hosting. This connection improves data quality, security, scalability, and resilience, hence enabling next-generation online applications. IPFS focuses on data availability, efficiency, and censorship resistance, whereas Hyperledger Fabric prioritizes safe transaction management, identity verification, and privacy. The combination of these technologies fosters a more open and tamper-resistant internet. The assessment emphasizes the practical advantages to areas such as supply chain management, healthcare, and content delivery networks. However, effective integration necessitates addressing interoperability, performance, and regulatory issues. Overall, the combination of IPFS with Hyperledger Fabric has the potential to transform web hosting and data management, spurring creativity and hastening the adoption of decentralized technologies.

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