International Journal of Data Science and Artificial Intelligence (IJDSAI)
Volume 02, Issue 06, November – December (2024)

RESEARCH ARTICLE

DECENTRALIZED BLOCKCHAIN-BASED DISK RENTAL SYSTEM WITH ENHANCED SECURITY AND EFFICIENCY

Ashwini Kamble[1], Manoj Pise[1,*], Ajit Waman[1], Rameshwar Vishwakarma[1], Suraj Suryawanshi[1], Shankar Amalraj[2]

[1] Department of Computer Engineering, Savitribai Pune Phule University, Pune, India

[2] Associate Professor, Department of Electrical Computer Engineering, K J College of Engineering and Management Research, Pune, India

[*]*Corresponding e-mail: ashwinikamble.kjcoemr@kjei.edu.in*

Abstract – This paper presents a blockchain-based decentralized disk rental system designed to securely and efficiently utilize unused storage capacity. Unlike traditional cloud storage models reliant on centralized providers, this system integrates blockchain technology with the Inter Planetary File System (IPFS) to establish a decentralized, tamper-resistant storage solution. Smart contracts automate storage agreements, ensuring transparency and immutability, while advanced cryptographic techniques and proof mechanisms guarantee data integrity and confidentiality. Leveraging lightning network technology for fast, low-cost transactions, the system distributes data across a decentralized network of nodes, significantly enhancing data privacy, security, and availability. This architecture addresses key vulnerabilities of centralized storage models, such as single points of failure and data breaches, offering a robust, scalable alternative for distributed storage applications. The proposed solution provides a promising pathway for more secure and resilient storage infrastructure in decentralized environments.

Keywords *– Blockchain, Decentralized Storage, Data Integrity, Cryptography, Data Privacy.*

1. INTRODUCTION

In the digital era, the demand for large-scale data storage solutions has grown exponentially, driven by the surge in datadriven applications, in the field of media, scientific research documents, image applications, internet of things (IoT), artificial intelligence (AI), and other emerging technologies [1][2][3][4][5][6]. Traditional cloud storage systems, while offering scalable solutions, predominantly rely on centralized providers, creating significant security, privacy, and reliability risks [7][8][9]. These centralized systems are vulnerable to cyberattacks, data breaches, unauthorized access, and downtime due to single points of failure. Additionally, they require users to trust third-party service providers, which often leads to concerns about data control and privacy. As a result, there is a pressing need for more secure, transparent, and resilient data storage architectures that can address these limitations.

Blockchain (BC) has garnered considerable interest for its unalterable properties and the security and privacy advantages it offers [10]. Blockchain (BC) has the capability to address security and privacy issues across various software technologies. However, its high computational demands, limited scalability, and substantial bandwidth requirements, along with associated delays, can pose challenges in specific applications. The integration of blockchain technology is currently in its early stages, but it is poised to impact nearly every aspect of software systems we use. As these technologies become more embedded in our daily lives, the risk of exploitation increases. There is a pressing need to secure software applications from potential breaches.

The integration of blockchain technology with distributed storage networks, such as the Interplanetary File System (IPFS), provides an efficient, scalable, and secure alternative to traditional cloud storage [11]. IPFS, a peer-to-peer protocol designed to create a distributed file system, allows data to be stored across multiple nodes in a decentralized manner. Unlike centralized cloud storage systems, IPFS ensures that data is distributed and replicated across various nodes, reducing the risk of data loss, increasing data availability, and enhancing the overall performance of storage networks. By distributing data across multiple locations, IPFS also mitigates the risks of tampering and unauthorized access. While IPFS offers a decentralized storage framework, the security and integrity of data stored on such platforms require additional measures. Blockchain addresses these concerns by providing cryptographic mechanisms to ensure that the data stored on IPFS remains immutable and verifiable. Blockchain's consensus algorithms, smart contracts, and cryptographic proofs provide robust data validation without the need for trusted third parties. Cryptographic hashes in the blockchain enable the verification of file integrity, ensuring that the data has not been altered or tampered with[12]. Moreover, smart contracts can automate processes such as storage agreements,

payments, and access control, enhancing the transparency and efficiency of storage transactions.

One of the most innovative applications of blockchain technology in storage systems is the concept of a decentralized disk rental market [13][14]. By leveraging blockchain and IPFS, users can rent out their unused storage capacity to others in a secure, transparent, and automated manner. This decentralized storage rental model eliminates the need for centralized data centres and intermediaries, allowing individuals to monetize their idle storage resources while offering others a more affordable and flexible storage option. Blockchain's inherent security and immutability ensure that rental agreements are transparent and enforceable. Payments for storage services can be processed quickly and securely using the Lightning Network, a blockchain-based protocol that enables fast, low-cost transactions between users [15]. The combination of blockchain, IPFS, and the Lightning Network creates a

powerful and scalable framework for decentralized storage, addressing the limitations of traditional cloud storage systems. This paper explores the design, implementation, and potential benefits of a blockchain-based disk rental system. By offering a more secure, efficient, and cost-effective solution for data storage, the proposed system represents a significant advancement in the field of decentralized cloud storage. It not only ensures data integrity, privacy, and availability but also provides a new economic model for storage sharing and resource utilization [16][17].

2. PROBLEM STATEMENT

Traditional cloud storage solutions, reliant on centralized providers, are prone to security vulnerabilities, data breaches, and single points of failure. These systems also present challenges related to data privacy and user control, requiring trust in third-party entities. Consequently, there is an urgent need for a decentralized storage framework that guarantees improved security, data integrity, availability, and user sovereignty, while addressing these inherent risks.

3. OBJECTIVE

This research aims to design a blockchain-based disk rental system that:

- Design a decentralized disk rental system utilizing blockchain and InterPlanetary File System (IPFS) to provide secure and scalable storage solutions.
- Enhance data integrity and security through cryptographic proofs and smart contracts, ensuring immutable and verifiable storage transactions.
- Implement a decentralized storage market where users can rent out unused disk space securely, minimizing reliance on centralized storage providers.
- Facilitate fast and low-cost transactions for storage rentals using the Lightning Network, enhancing efficiency and reducing overhead costs.
- Ensure high data availability and fault tolerance by distributing data across multiple decentralized nodes, mitigating risks of data loss or tampering.
- Improve user control and privacy by eliminating third party intermediaries, giving users full autonomy over their data and storage agreements.

4. TECHNOLOGIES USED IN BLOCKCHAIN-BASED DISK RENTAL SYSTEM

3.1. Blockchain Technology

Provides a decentralized, immutable ledger for secure and transparent storage transactions.

3.2. Interplanetary File System (IPFS)

Enables decentralized file storage across multiple nodes, reducing dependency on centralized servers and enhancing data availability [11].

3.3. Smart Contracts

Automates storage agreements and transactions, removing intermediaries and increasing transparency [18].

3.4. Cryptographic Proofs

Ensures data integrity and security through encryption and hashing techniques, allowing verification without revealing the actual content.

These technologies collectively provide a scalable, secure, and transparent decentralized storage solution.

5. SYSTEM ARCHITECTURE AND WORKING

The proposed blockchain-based disk rental system utilizes IPFS for decentralized data storage, where files are fragmented and distributed across multiple nodes, with cryptographic hashes ensuring data integrity. Blockchain records file metadata, including the file hash and storage provider details, ensuring transparency and immutability [19]. Smart contracts automate storage rental agreements, specifying terms between users and storage providers. Once terms are established, these contracts facilitate secure access and payments, eliminating the need for intermediaries and enhancing operational security. Blockchain-based cryptographic proofs verify data integrity, allowing users to confirm that files remain unaltered. Any tampering with the data would be immediately detectable, safeguarding data reliability. Payments for storage rentals are processed via the Lightning Network, enabling fast, lowcost transactions between users and providers.

The system establishes a decentralized marketplace, enabling users to offer or rent unused storage space. Blockchain ensures secure, transparent transactions, while IPFS enhances data availability and fault tolerance through distributed storage across multiple nodes.

The proposed blockchain-based disk rental system utilizes a decentralized architecture by combining blockchain technology with the Interplanetary File System (IPFS) to create a secure and distributed storage network. This model addresses numerous challenges associated with traditional cloud storage, including centralized points of failure, dependency on third-party providers, and potential privacy risks. The IPFS system is integral to decentralized data storage, as it fragments files and distributes them across multiple nodes in a network. Each fragment is assigned a

cryptographic hash that ensures data integrity, making it more secure and reliable. This architecture provides redundancy, as data is stored across multiple nodes, reducing the risk of data loss and improving fault tolerance. Studies indicate that using IPFS within decentralized storage solutions can reduce data retrieval time and eliminate dependence on centralized servers, which are vulnerable to outages and cyberattacks [20][21].

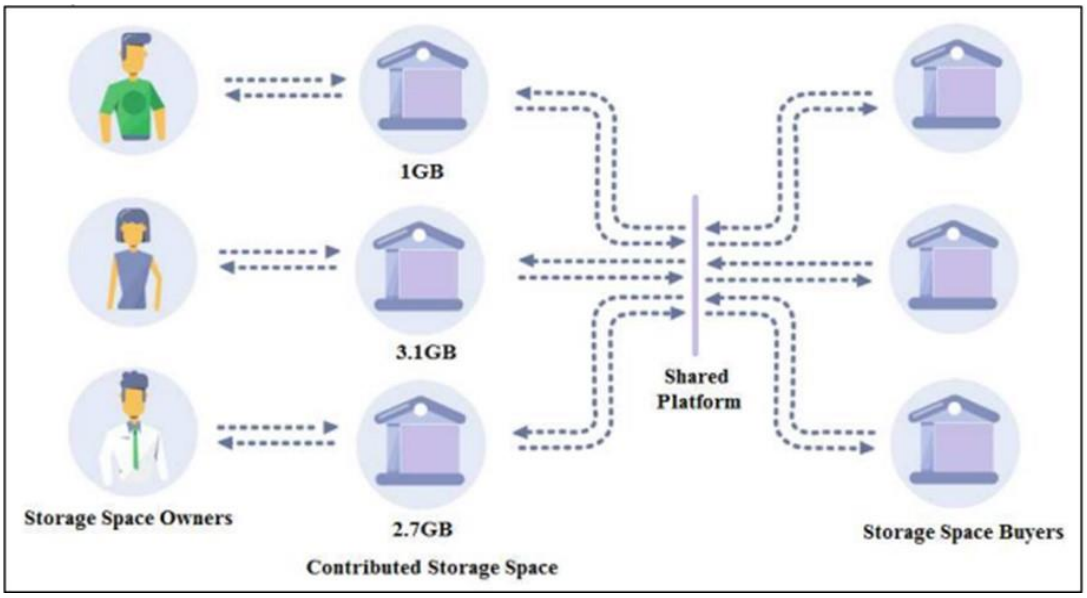

Figure 1. Blockchain-Powered Platform for Storage Buyers to Share Storage Space

Blockchain technology is used within the system to securely store metadata in an immutable, transparent format. For every stored file, the blockchain records critical metadata, including the cryptographic hash and storage provider details. This approach creates a tamper-resistant, transparent record of storage transactions, allowing users to verify the security and accuracy of their data's history[22]. This immutability has been shown to significantly enhance the security of metadata management in decentralized networks, as demonstrated in studies on blockchain applications for storage. By creating an unalterable ledger of data transactions, blockchain reduces the possibility of unauthorized modifications, fostering user trust and security[19].

The system further employs smart contracts to automate storage rental agreements between users and storage providers. These self-executing contracts define and enforce the terms of each agreement, including data access, storage duration, and payment. Once an agreement is established, smart contracts ensure secure access and automated payments, removing the need for intermediaries and increasing operational efficiency. Research on decentralized storage systems emphasizes that smart contracts provide significant advantages in terms of transparency, reducing the likelihood of fraud by ensuring that contract conditions are automatically fulfilled before transactions proceed. By eliminating the need for third-party oversight, smart contracts streamline operations and improve security within the system.

Data integrity in the proposed system is maintained through cryptographic proofs stored on the blockchain, allowing users to verify that their files remain unaltered over time. Each file's cryptographic hash, logged on the blockchain, serves as a mechanism for verifying data authenticity. If any tampering occurs, even a slight alteration in the data would change the hash, alerting users to potential breaches. Blockchain-based cryptographic proofs play a critical role in ensuring data reliability, especially in decentralized storage environments, where data might reside on several nodes across a network. These proofs provide verifiable assurances that data remains secure and unchanged, an essential feature for users concerned about data integrity and authenticity in storage applications.

Payments for storage rentals are facilitated through the Lightning Network, a protocol that supports rapid, low-cost transactions. This blockchain-based protocol allows payments to be conducted off-chain, reducing transaction costs and processing times, which are critical for services requiring frequent microtransactions, such as decentralized storage rentals. Recent research on blockchain finance systems shows that the Lightning Network's scalability makes it suitable for highvolume, low-cost transactions, particularly for applications like storage where cost efficiency is key. By integrating the Lightning Network, the system minimizes financial overhead and enhances user accessibility to decentralized storage services.

Overall, the architecture establishes a decentralized storage marketplace where users can offer or rent unused storage space. Blockchain technology guarantees secure, transparent transactions, while IPFS provides resilience and data redundancy by distributing data fragments across multiple nodes. This peer-to-peer marketplace introduces flexibility and cost efficiency not seen in traditional cloud storage models. Studies on decentralized storage highlight that such systems offer significant advantages in terms of cost savings, resilience, and security, particularly for small businesses and individual users who may lack trust in centralized providers. Furthermore, IPFS's distributed nature

mitigates risks of data unavailability during server failures, enhancing the reliability of stored data.

Finally, the system prioritizes user privacy and data control by enabling complete ownership of data without reliance on third-party providers. Blockchain's transparency provides an auditable, tamper-proof record of all storage transactions, allowing users to retain full autonomy over their stored data. Additionally, because data fragments are spread across various nodes, unauthorized access risks are minimized, supporting a more secure user experience. Research underscores the value of user sovereignty in decentralized storage, as it grants users greater control and privacy over their data compared to centralized cloud models.

In summary, this blockchain-based disk rental system offers a scalable, efficient, and resilient alternative to centralized cloud storage by integrating blockchain, IPFS, and the Lightning Network. It enhances data integrity, privacy, and user autonomy, while presenting a new economic model where users can monetize their unused storage resources. This system effectively addresses the limitations of traditional cloud storage and exemplifies the potential of decentralized technologies to transform data storage by providing a secure, user-controlled, and cost-effective solution.

6. UTILIZATION OF BLOCKCHAIN-BASED DISK RENTAL SYSTEM

The blockchain-based disk rental system offers a decentralized solution to optimize global disk space by enabling users to rent out unused storage. This system reduces reliance on centralized providers and addresses key challenges in traditional cloud storage.

Decentralized Storage Market: The system facilitates a peer-to-peer marketplace for renting excess storage capacity, offering a cost-efficient alternative to centralized services. The system enables a peer-to-peer marketplace where individuals and businesses can either rent out unused storage space or purchase storage capacity from others. This setup reduces reliance on traditional centralized providers, offering a more flexible and affordable alternative. By decentralizing the marketplace, it democratizes access to storage resources, which is particularly beneficial for small businesses and individual users who can gain access to secure, low-cost storage solutions without having to rely on major cloud service providers.

- **Decentralized Storage Market:** The system facilitates a peer-to-peer marketplace for renting excess storage capacity, offering a cost-efficient alternative to centralized services. The system enables a peer-to-peer marketplace where individuals and businesses can either rent out unused storage space or purchase storage capacity from others. This setup reduces reliance on traditional centralized providers, offering a more flexible and affordable alternative. By decentralizing the marketplace, it democratizes access to storage resources, which is particularly beneficial for small businesses and individual users who can gain access to secure, low-cost storage solutions without having to rely on major cloud service providers.
- **Privacy and Control:** Users retain full control over their data, with blockchain ensuring transparent, tamperproof transactions, The Privacy and Control feature of this blockchain-based disk rental system allows users to maintain full control over their data. Unlike traditional cloud storage models, where data is managed by third-party providers, this decentralized system gives users direct ownership and authority over their files. Blockchain's transparency and immutability ensure that all transactions related to data storage, access, and sharing are recorded in a tamper-proof ledger. This secure, transparent system enables users to verify that their data remains untouched and access records are fully auditable, offering greater confidence in data privacy. Additionally, this decentralized approach reduces the risks associated with unauthorized access or data manipulation, as blockchain and cryptographic proofs guarantee data integrity and user control.
- **Distributed Backup and Recovery:** By distributing data across multiple nodes, the system improves resilience, ensuring data recovery in case of failures The blockchain-based disk rental system offers a resilient solution for data backup and recovery. By distributing data across multiple nodes, it provides inherent redundancy and fault tolerance, ensuring data remains accessible even in the case of node failures. This feature is particularly valuable for organizations requiring reliable data backup solutions, as it ensures data recovery is possible without depending on a single storage provider. For sectors like media, where large files require frequent backups, this decentralized approach improves overall reliability and continuity.
- **Secure File Sharing:** Enterprises can securely share files with automated access control via smart contracts. Enterprises and individual users can securely share files with others through smart contracts. These contracts enable automated access control, granting permissions only to verified users and revoking them as required. This is ideal for collaborative environments and industries like legal services, where sensitive documents must be securely shared with authorized parties. Smart contracts ensure that file-sharing permissions are both transparent and automated, streamlining processes and reducing human error.
- **Cost Efficiency:** Using the Lightning Network for fast, low-cost transactions, the system offers affordable and efficient data storage. The use of the Lightning Network for transactions allows for fast, low-cost payments, which is essential in a marketplace where storage rentals may be relatively small in value but frequent in occurrence. By

avoiding high transaction fees, the system offers an affordable solution for users, making decentralized storage accessible to a broader range of users. This approach is also advantageous for long-term storage users, as the decentralized model reduces operational expenses associated with centralized data centres and expensive infrastructure.

- **Energy-Efficient Storage Solution:** Compared to large centralized data centres, this blockchain-based system utilizes a distributed network of smaller nodes, which collectively consume less energy. Many centralized storage solutions require significant energy resources for cooling and powering massive data facilities. In contrast, the decentralized approach spreads data storage demands across nodes that can operate with lower energy requirements, potentially making this a more sustainable and eco-friendly option for organizations seeking to reduce their carbon footprint.
- **Support for IoT and Edge Computing Applications:** The system's decentralized nature makes it well-suited for Internet of Things (IoT) applications, where data is generated and processed at the edge of the network rather than in centralized data centres. Edge devices can contribute their spare storage to the network, and blockchain's immutability and IPFS's distribution allow for secure data storage closer to where it is generated. This reduces latency and enables more responsive data access and analysis, which is critical for applications in smart cities, autonomous vehicles, and real-time monitoring systems.
- **Increased Security Against Cyberattacks:** Decentralized storage systems are inherently more resistant to cyberattacks, particularly distributed denial-of-service (DDoS) attacks, which often target single points of failure in centralized systems. By distributing data across a network of independent nodes, this system minimizes the risk of large-scale data breaches and offers enhanced security. Blockchain's cryptographic safeguards and IPFS's distributed architecture provide additional layers of protection against unauthorized access, making it a safer choice for sectors that handle sensitive data, such as finance, government, and defense.
- **Scalability and Flexibility:** The system's decentralized nature allows it to scale as new users join the network, providing a flexible storage solution that can adapt to growing data demands. Unlike traditional storage providers, which require substantial infrastructure investments to scale, this decentralized system can grow organically as more nodes contribute storage. This scalability is ideal for companies and industries with fluctuating storage needs, allowing them to avoid over-provisioning or under-utilizing resources.
- **New Economic Opportunities for Resource Monetiza- tion:** Users can monetize their unused storage space by participating in the decentralized marketplace, creating new revenue opportunities. This approach provides an economic incentive for individuals and businesses to share their spare storage, transforming otherwise idle resources into active, income-generating assets. This is especially beneficial in sectors like telecommunications, where companies with large storage capabilities can lease out space during low-demand periods, optimizing their resource utilization. summary, the blockchain based disk rental system provides a comprehensive decentralized storage solution, offering increased data privacy, enhanced fault tolerance, cost savings, energy efficiency, and scalability. Its innovative utilization of blockchain, IPFS, and smart contracts creates a robust, secure, and versatile alternative to centralized cloud storage, transforming the way individuals and enterprises manage, share, and monetize data in a secure, efficient, and sustainable manner.

7. ANALYSIS

The blockchain-based disk rental system presents significant improvements over traditional cloud storage solutions, particularly in terms of security, decentralization, and cost efficiency. However, several challenges must be addressed to ensure its successful adoption and scalability.

From a security and data integrity perspective, the system's decentralized architecture, combined with blockchain technology, offers robust protection. Blockchain's immutable ledger and cryptographic proofs ensure that data remains secure and verifiable, preventing unauthorized access or tampering. Smart contracts further automate transactions, providing transparency and minimizing the risk of fraud.

In terms of decentralization, the system leverages both blockchain and the Inter Planetary File System (IPFS) to distribute data across a network of nodes. This approach eliminates the dependency on centralized servers and mitigates the risk of single points of failure. The distributed nature of the system enhances data availability and resilience against failures or cyberattacks, making it more reliable than conventional cloud storage models.

Cost efficiency is another major advantage of the blockchain-based disk rental system. The use of the Lightning Network allows for fast and low-cost transactions, reducing overheads significantly. Unlike traditional cloud providers, which incur substantial infrastructure and maintenance costs, this decentralized model reduces operational expenses while offering a competitive storage service.

In terms of scalability, the system's peer-to-peer architecture allows for easy expansion as more nodes join the network. However, there are concerns related to data retrieval speed and network latency, especially in large-scale deployments. Optimizing these factors will be essential for ensuring the system performs well as it scales.

Despite its advantages, the system faces adoption challenges. Users need to trust decentralized networks and understand blockchain technology to fully embrace the system. Additionally, issues such as regulatory compliance, user experience, and interoperability with existing systems must be addressed to facilitate broader adoption.

The blockchain-based disk rental system offers considerable improvements over traditional cloud storage solutions by addressing core concerns related to security, decentralization, cost efficiency, and user control. Its decentralized architecture mitigates issues tied to single points of failure and the reliance on third-party providers, which are characteristic of conventional cloud storage models. However, for widespread adoption and scalability, several challenges remain, necessitating technical, regulatory, and user experience considerations.

From a security and data integrity perspective, the system's decentralized architecture, powered by blockchain, provides robust protections that are challenging to achieve with traditional centralized models. Blockchain's immutable ledger records all transactions, creating a verifiable and tamper-proof history of data interactions. Each piece of data is assigned a unique cryptographic hash that serves as a fingerprint, allowing users to verify data authenticity and integrity at any point. Any attempt to modify data would alter its hash, making unauthorized changes immediately detectable. This level of security is essential for industries handling sensitive information, such as finance, healthcare, and government services, where data protection and regulatory compliance are paramount. Furthermore, the system employs smart contracts, which automate storage agreements and other transactions without the need for intermediaries. These contracts ensure that conditions, such as storage duration, payment terms, and access control, are executed precisely as agreed upon, reducing risks of fraud and manual error, and ensuring consistency and transparency in storage agreements.

In terms of decentralization, the system integrates blockchain with the Inter Planetary File System (IPFS) to distribute data across a network of independent nodes. This model eliminates the dependency on centralized servers, which are vulnerable to outages, cyberattacks, and technical failures. By distributing data fragments across multiple nodes, the system ensures high data availability and resilience against failure. If any individual node becomes unavailable, data can still be retrieved from other nodes, significantly reducing downtime and providing a more reliable storage solution. Research on decentralized storage systems highlights that this approach mitigates the risk of data loss, particularly in largescale systems where single-point failures can disrupt service for entire networks. Furthermore, decentralized architecture offers an added layer of privacy, as no single entity holds the entire data set, thereby enhancing security in industries where data sovereignty is critical.

Cost efficiency is another fundamental advantage of the blockchain-based disk rental system. By utilizing the Lightning Network, the system processes fast, low-cost transactions, which is critical in a marketplace where frequent, small-value transactions are common. Unlike traditional cloud providers that require substantial investments in infrastructure, maintenance, and security, this decentralized model spreads operational costs across a network of nodes. Nodes are contributed by participants in the network who can monetize their unused storage resources, creating a decentralized marketplace that promotes resource sharing. This model reduces the need for centralized data centers, thereby lowering operational expenses and making storage services more affordable for users.

In terms of scalability, the peer-to-peer nature of the system enables it to expand seamlessly as new nodes join the network. This flexibility contrasts with traditional cloud storage providers, which must continually invest in scaling infrastructure as demand grows. The blockchain-based system allows for organic growth, as each new participant can contribute additional storage capacity, making the system adaptable to increases in demand. However, there are scalability challenges that need to be addressed. In particular, data retrieval speed and network latency may become issues in large-scale implementations. As data is distributed across multiple nodes, retrieving files from fragmented locations can slow access times, especially if nodes are located far apart geographically. To ensure optimal performance, the system would benefit from advancements in Distributed Hash Table (DHT) optimizations and more efficient consensus algorithms. By addressing these factors, the system can enhance data retrieval times and overall responsiveness, making it viable for larger and more demanding applications.

Despite its clear advantages, the system faces significant adoption challenges. One of the primary barriers to entry is user trust in decentralized networks. Many users are unfamiliar with blockchain technology and may be hesitant to store their data on a network that lacks a central governing entity. Education on the benefits of decentralized storage, including privacy and control advantages, will be necessary to build confidence among potential users. Additionally, the user experience must be simplified to facilitate broader adoption, especially for individuals who may not have technical expertise in blockchain or decentralized storage technologies. User-friendly interfaces and support resources could help bridge this gap and make the system accessible to a wider audience.

Regulatory and compliance issues represent another significant challenge. While decentralized storage models provide benefits such as privacy and data sovereignty, regulatory frameworks like the General Data Protection Regulation (GDPR) enforce stringent rules on data storage, access, and control. Compliance becomes challenging due to the decentralized structure, where data is distributed across numerous nodes that may reside in different legal jurisdictions. This raises questions about accountability and data protection, as there is no single entity responsible for compliance. Addressing these regulatory concerns will require collaboration with legal experts to develop compliance protocols that can align with existing data protection laws. Without solutions to these regulatory

challenges, adoption may be limited, particularly in regulated industries.

Interoperability with existing systems is also a factor that could impact the system's acceptance. Many organizations have established centralized storage systems, and transitioning to a decentralized model may not be feasible in the short term. For businesses that rely on legacy infrastructure, achieving interoperability between centralized and decentralized storage systems would be essential for hybrid deployments. Developing APIs and integration pathways could facilitate a smoother transition and encourage gradual adoption of decentralized storage solutions without disrupting existing operations. This interoperability would allow organizations to leverage both models as needed, providing flexibility while gradually transitioning to a more decentralized framework.

Finally, performance limitations within blockchain must be considered. While blockchain provides transparency and security, it can be constrained by transaction speeds and energy consumption, especially when using consensus mechanisms like Proof of Work (PoW). As the system scales, transaction congestion on the blockchain network may hinder performance, while the energy demands of certain consensus algorithms could raise sustainability concerns. Exploring more energy-efficient consensus models, such as Proof of Stake (PoS) or other off-chain solutions, may address these limitations and improve the scalability and environmental impact of the system. Reducing the energy footprint of the system is not only cost-effective but also aligns with sustainability goals, which are increasingly important to organizations and end users alike.

In conclusion, the blockchain-based disk rental system represents a transformative solution for data storage, combining enhanced data security, user privacy, and cost efficiency in a decentralized model. Its use of blockchain and IPFS creates a resilient and transparent framework that addresses many of the limitations of traditional cloud storage. However, for the system to achieve widespread adoption and success, challenges related to user trust, regulatory compliance, scalability, interoperability, and performance must be carefully managed. By addressing these issues, the blockchain-based disk rental system has the potential to reshape data storage, providing a secure, user-controlled, and cost-effective alternative that aligns with modern data privacy and economic needs.

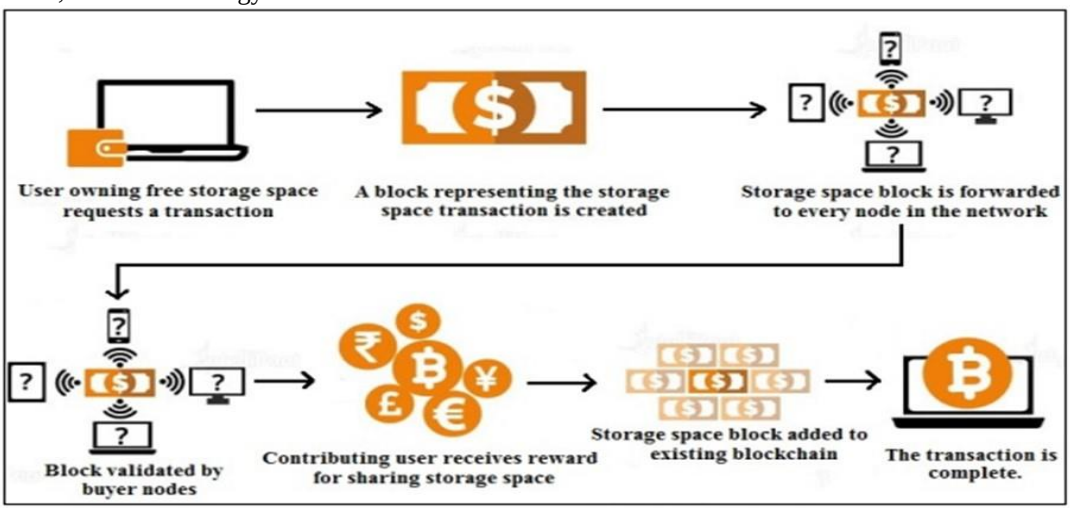

Figure 2. Architecture for Secure Decentralized Storage Network

8. BENEFITS OF BLOCKCHAIN-BASED DISK RENTAL SYSTEM

The blockchain-based disk rental system offers numerous benefits over traditional cloud storage models, particularly in the areas of security, cost efficiency, and user autonomy. These advantages are derived from the unique properties of blockchain and decentralized storage technologies, as outlined in the following:

1) **Enhanced Security and Data Integrity:** Blockchain technology ensures that data transactions are immutable and resistant to tampering. Its decentralized architecture, combined with cryptographic proofs, provides robust security and verifiability. By eliminating single points of failure, blockchain enhances data protection compared to traditional centralized systems, where breaches can expose sensitive information. In a blockchain network, data is distributed across multiple nodes, making it extremely challenging for attackers to alter or manipulate transaction records. Each transaction is cryptographically linked to the previous one, forming a secure and tamper-resistant chain. Additionally, block chain employs hashing algorithms to secure transactions, ensuring that once data is added, it becomes permanent and verifiable by all participants. This prevents unauthorized access and maintains data integrity, as any attempt to alter information would be immediately detected. Smart contracts further strengthen this system by automating and enforcing storage agreements. These self-executing contracts operate based on predefined conditions, reducing the risks of human error and fraud. They also enhance transparency, enabling all participants to verify agreements at any time, thereby creating a trustworthy and secure environment for data storage and rental operations.
2) **Decentralization and Elimination of Single Points of Failure:** By distributing data across a peer-to-peer

network using IPFS, the system eliminates reliance on centralized servers, thereby reducing the risks associated with single points of failure. This decentralized approach ensures that data is always available, even in the event of server failures or cyberattacks. However, despite these robust security features, certain challenges must be addressed to ensure the system's overall security posture. In traditional cloud storage systems, all data is typically stored in centralized servers or data centres, which presents a significant risk of data loss or downtime if the servers fail, are attacked, or experience other disruptions. However, a blockchain-based disk rental system eliminates these single points of failure by distributing data across a peer-to-peer (P2P) network, often using decentralized storage protocols such as the Inter Planetary File System (IPFS). This distribution ensures that data is stored redundantly across multiple locations, improving availability and reducing the risk of data loss. Even in the case of server outages or cyberattacks, the decentralized nature of the blockchain ensures that data remains accessible from alternative nodes in the network. This approach increases resilience against external threats and enhances data availability, providing a more reliable service compared to centralized cloud storage providers. Furthermore, decentralization reduces the reliance on a single authority, increasing trust in the system as a whole and promoting a more equitable distribution of storage resources.

3) **Cost Efficiency:** The blockchain-based disk rental system offers a cost-effective solution by utilizing the Lightning Network for low-cost, fast transactions. This reduces operational overheads compared to traditional cloud storage providers, which typically incur high infrastructure and maintenance costs. A blockchain-based disk rental system offers a more cost-efficient solution compared to traditional cloud storage models. Traditional cloud providers incur substantial infrastructure and maintenance costs, including the need for centralized data centres, personnel, and energy consumption. In contrast, blockchain-based systems operate on decentralized networks that require minimal centralized infrastructure, drastically lowering operational expenses. Blockchain networks also eliminate the need for intermediaries in transactions, such as third-party payment processors or storage managers, which typically charge high service fees. By utilizing technologies like the Lightning Network, which facilitates fast and low-cost transactions, blockchain can offer a more affordable solution for both data renters and providers. Additionally, smart contracts can automate various processes, reducing administrative costs and increasing operational efficiency. As a result, users benefit from lower transaction costs and more affordable data storage rates, while providers can reduce their overhead costs significantly, leading to a more sustainable and cost-effective storage ecosystem.
4) **Data Privacy and User Control:** Users retain complete control over their data, with no need to rely on third-party providers. The blockchain's transparency ensures that all data transactions are traceable and secure, giving users greater autonomy and privacy over their stored files. One of the most compelling advantages of blockchain-based disk rental systems is the enhanced control and privacy it offers to users. In traditional cloud storage models, users often need to trust a centralized provider with their sensitive data, potentially compromising their privacy. These centralized entities can access, control, and even sell user data without their consent. In a blockchain-based system, users retain complete control over their data. The decentralized nature of the system means that no single entity has full access to or control over the data, thus reducing the risk of unauthorized access. Blockchain also uses encryption to secure data, ensuring that only the rightful owner or authorized users can access it. Moreover, transparency in blockchain transactions enables users to track and verify any interactions with their data, including who accessed it and when. Smart contracts further enhance privacy by automating storage agreements, ensuring that users' preferences are respected without the need for third-party oversight. This increased level of control over one's data provides users with greater autonomy and privacy compared to traditional cloud storage solutions.
5) **Scalability and Flexibility:** The system's decentralized architecture allows it to scale easily by adding more nodes to the network. This flexibility makes the system adaptable to growing data storage needs without compromising performance. Blockchain-based disk rental systems are highly scalable due to their decentralized architecture. As demand for storage increases, new nodes can be added to the network, distributing the storage load and improving overall performance. This scalability allows the system to handle large volumes of data and growing storage needs without the bottlenecks associated with centralized infrastructure. Traditional cloud storage systems may require costly upgrades to their centralized data centers or rely on over-provisioning to meet increasing demand, which can lead to inefficiencies. In contrast, the blockchain-based system is designed to grow organically by adding more participants to the network, allowing for flexible, on-demand scaling. This flexibility ensures that the system can adapt to changing storage requirements, whether it's for small-scale personal storage or large enterprise-level needs. Additionally, blockchain can efficiently handle various storage types, including files, applications, and backups, making it adaptable to a wide range of use cases.
6) **Automated and Transparent Agreements:** Smart contracts ensure that all transactions and storage agreements are executed automatically and transparently. This removes the need for intermediaries, streamlining the process and reducing transaction costs. Blockchain's use of smart contracts enables automated and transparent agreements between data renters and providers. In the case of a disk rental system, this can include automatic payments, the allocation of storage space, and penalties for late returns or other breaches of contract. Because these contracts are executed on the blockchain, both parties can trust that the terms will be

executed exactly as agreed upon, without the need for intermediaries or manual intervention. Additionally, all transactions and agreements are recorded on the blockchain, providing a transparent, immutable record that can be audited by any party at any time. By eliminating intermediaries and automating the enforcement of agreements, blockchain reduces transaction costs and simplifies the rental process, creating a more efficient and transparent system for all participants.

9. CONCLUSION

The blockchain-based disk rental system presents a robust, decentralized alternative to conventional cloud storage models by combining blockchain technology with IPFS. This approach significantly enhances data integrity, security, and user privacy while eliminating the reliance on centralized providers and reducing the risks associated with single points of failure

Through the use of smart contracts and the Lightning Network, the system enables automated, transparent, and low-cost transactions, making it both efficient and economically viable. Users maintain full control over their data, ensuring a high level of privacy and autonomy.

However, the system faces challenges in terms of scalability and user adoption. Optimizing data retrieval speeds and network latency, alongside addressing user education and regulatory compliance, are key to ensuring broader acceptance and deployment.

The blockchain-based disk rental system represents a highly innovative and decentralized solution to the challenges of traditional cloud storage models. By leveraging the power of blockchain technology in conjunction with the Inter Planetary File System (IPFS), this system addresses several critical concerns faced by users and businesses in the realm of data storage, such as data integrity, security, privacy, and the risks associated with centralized storage providers. One of the core advantages of this approach is that it removes the reliance on central authorities, mitigating the risks associated with single points of failure and the vulnerability of data to hacks or breaches within traditional cloud storage models.

The integration of blockchain technology ensures that all data transactions are immutably recorded, promoting a high level of transparency and trust. Because the system is decentralized, consumers are still in charge of their own data, granting them significant autonomy and a heightened sense of privacy. In this model, data ownership is transparent and verifiable, allowing users to share, rent, or lease their storage space in a secure and decentralized manner without entrusting sensitive information to third-party cloud services. This level of control directly contrasts with traditional cloud storage systems, where users often have little visibility or control over how their data is stored or accessed by service providers.

The use of smart contracts further enhances the system's efficiency and transparency. These self-executing contracts enable the automation of agreements between users and providers, ensuring that storage rental agreements are executed without the need for intermediaries. This not only increases efficiency but also significantly reduces transaction costs, making the system both economical and accessible. Furthermore, the Lightning Network enables low-cost, instant transactions, enhancing the system's scalability and usability for a large number of users.

One of the primary concerns is scalability—the ability to handle a growing number of users and data transactions without sacrificing performance. As the number of participants in the network increases, it becomes crucial to optimize data retrieval speeds and minimize network latency, ensuring that the system remains fast and responsive even as the demand for storage grows. This challenge is compounded by the complexities of ensuring that data is consistently available and retrievable in a decentralized network, where data may be distributed across a wide range of nodes with varying levels of reliability.

Another hurdle lies in user adoption. For many users, especially those who are accustomed to traditional cloud services, the learning curve associated with blockchain-based systems can be a barrier. Education around blockchain, IPFS, and how decentralized storage works will be critical to overcoming this challenge. Furthermore, regulatory compliance remains an issue, particularly in regions with strict data protection laws. It is essential to ensure that the system aligns with local regulations regarding data privacy, user consent, and storage practices, which can vary significantly across jurisdictions.

The implementation of this system also faces the challenge of integrating blockchain with legacy systems. Addressing these challenges will require collaboration between blockchain developers, businesses, and regulators to create standards that ensure smooth transitions and compatibility with existing systems Nevertheless, the potential of the blockchain-based disk rental system to transform the landscape of data storage is undeniable. By blending the advantages of decentralization, security, and cost efficiency, this system provides a compelling alternative to traditional cloud storage models. It can significantly reduce reliance on large centralized providers, enhance data security through decentralized protocols, and offer users greater control and autonomy over their data.

In conclusion, while there are still obstacles to overcome, such as scalability, network performance, and user education, the blockchain-based disk rental system holds substantial promise for revolutionizing the way data is stored and managed. With continued advancements in blockchain technology, improvements in network protocols, and efforts to increase user adoption, this model has the potential to reshape the future of data storage, making it more secure, efficient, and accessible for individuals and organizations alike. If the technical and adoption challenges can be addressed, blockchain-based storage systems could ultimately replace or complement traditional cloud storage services, offering a more democratized and secure alternative in the future.

In conclusion, the blockchain-based disk rental system offers a transformative solution to data storage, blending decentralization, security, and cost efficiency. Its success

will depend on addressing the remaining technical and adoption challenges, but its potential to reshape the future of data storage is significant.

10. FUTURE WORK

Future development of the blockchain-based disk rental system should focus on addressing key challenges highlighted in the reviewed research papers. First, enhancing scalability by improving data retrieval speeds and reducing network latency is critical. Optimizing Distributed Hash Table (DHT) performance in IPFS and adopting more efficient consensus mechanisms could significantly improve system performance.

Scalability and Performance Optimization The scalability of the blockchain-based disk rental system is one of the most critical areas for improvement. Currently, the performance of decentralized networks like IPFS can suffer from slow data retrieval speeds and high latency, particularly when dealing with a large number of users or substantial data volumes. To address this, there is a need for optimizing the performance of the Distributed Hash Table (DHT) in IPFS. Enhanced DHT algorithms could make data lookups faster and more efficient, ensuring that large datasets can be retrieved with minimal delay. Additionally, exploring and adopting more efficient consensus mechanisms will be important for improving the throughput of transactions on the blockchain. Mechanisms such as Proof of Stake (PoS) or Delegated Proof of Stake (DPoS) can significantly improve transaction speed and scalability by reducing the energy and time-consuming nature of traditional Proof of Work (PoW) models.

Interoperability with Centralized Cloud Storage Systems Another important direction for future development is enhancing the system's interoperability with existing centralized cloud storage platforms. This would allow businesses to adopt a hybrid model, where they can benefit from the security and decentralization of blockchain technology while still leveraging the familiarity and convenience of traditional cloud services. Such integration would facilitate a seamless transition for enterprises looking to adopt decentralized storage solutions without entirely abandoning their current infrastructure. This hybrid model could help bridge the gap between the existing cloud paradigm and blockchain-based storage solutions, ensuring compatibility and offering businesses a smooth path towards decentralization.

Privacy and Confidentiality Enhancements As blockchain technology is inherently transparent, privacy remains a significant concern for users storing sensitive data. Future research should focus on integrating privacy-enhancing technologies (PETs) into the blockchain-based disk rental system to preserve data confidentiality while maintaining transparency. Homomorphic encryption allows data to be encrypted while still enabling computations on the encrypted data, making it a powerful tool for ensuring privacy without compromising functionality. Zero-knowledge proofs (ZKPs), which allow the verification of information without revealing the actual data, could also be integrated to enhance privacy further. Implementing these techniques could allow users to store private data securely on the blockchain without exposing sensitive information to other users within the network.

Energy Efficiency and Resource Optimization Blockchain technology, especially systems relying on Proof of Work (PoW), has faced criticism for its high energy consumption. As environmental concerns grow, it is crucial to explore energy efficient consensus mechanisms that can reduce the carbon footprint and resource consumption associated with blockchain networks. Proof of Stake (PoS) is one such mechanism that has been shown to be far more energy-efficient compared to PoW, as it does not require the extensive computational power for mining. Transitioning to PoS or similar alternatives could significantly reduce the energy costs of running a blockchain based disk rental system, making it more sustainable and suitable for wider adoption across industries.

Regulatory Compliance and Legal Considerations Lastly, one of the most important aspects of future work is ensuring that the blockchain-based disk rental system complies with existing regulatory frameworks, especially data protection laws such as the General Data Protection Regulation (GDPR) in Europe. Compliance with these laws is not only crucial for the legal operation of the system but also for gaining the trust of businesses and individuals who are concerned about the security and privacy of their data. Ensuring that the blockchain system is adaptable to different regions' legal requirements will be essential for broader adoption across industries. This will involve integrating features that allow users to have granular control over how their data is stored, accessed, and processed while complying with international data protection standards

Gathering feedback from relevant stakeholders, such as end-users, policymakers, or industry professionals, can guide the research toward practical and applicable outcomes, aligning with the recommendations made by Simon and Grant. Furthermore, involving the public and communities in the research process, as described in community-oriented work by Morgan and Patel.

In summary, the future development of the blockchain-based disk rental system should prioritize scalability, interoperability, privacy, energy efficiency, and regulatory compliance. By addressing these challenges, the system can become a more viable and practical solution for businesses and individuals looking to transition to decentralized storage models. Future research should focus on optimizing IPFS and blockchain protocols, integrating privacy-preserving technologies, and ensuring legal compliance to unlock the full potential of blockchain based storage solutions.

This holistic approach will ensure the widespread adoption of the blockchain-based disk rental system, making it a secure, efficient, and economically viable alternative to traditional cloud storage models. With ongoing innovation in blockchain technology and collaboration across industries, these solutions will be crucial in transforming the landscape of data storage in the coming years.

CONFLICTS OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

FUNDING STATEMENT

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors

ACKNOWLEDGEMENTS

The author would like to express his heartfelt gratitude to the supervisor for his guidance and unwavering support during this research for his guidance and support.

REFERENCES

[1] S. Amalraj, P.A. Michael, "Synthesis and characterization of Al2O3 and CuO nanoparticles into nanofluids for solar panel applications", *Results Phys*, vol. 15, pp. 102797, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[2] V.B. Korde, S. Khot, D.B. Kamble, S. Amalraj, "Review: Perovskite nanostructures materials versatile platform for advance biosensor applications", *Sensors and Actuators Reports*, vol. 7, pp. 100201, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[3] S.P. Deshmukh, D. Choudhari, S. Amalraj, P.N. Matte, "Hybrid Deep Learning Method for Detection of Liver Cancer", *Comput Assist Methods Eng Sci*, vol. 30, pp. 151–165, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[4] A. Fredderics, K. Vinoth Kumar, A. Shankar, "The FHA analysis of dual-bridge LLC type resonant converter", *Int J Power Electron Drive Syst*, vol. 4, pp. 538–546, 2014. [CrossRef] [Google Scholar] [Publisher Link]

[5] S. Goyal, A. Shankar, K.C. Das, "Manual and Adaptive tuned PID controllers for industrial application", *2024 4th Int Conf Adv Comput Innov Technol Eng ICACITE 2024*, pp. 1953–1958, 2024, [CrossRef] [Google Scholar] [Publisher Link]

[6] K.R. Kasture, W.V. Patil, A. Shankar, "Comparative Analysis of Deep Learning Models for Early Prediction and Subtype Classification of Ovarian Cancer: A Comprehensive Study", *Int J Intell Syst Appl Eng*, vol. 12, pp. 507–515, 2024[CrossRef] [Google Scholar] [Publisher Link]

[7] H. Hammouchi, O. Cherqi, G. Mezzour, "Digging deeper into data breaches: An exploratory data analysis of hacking breaches over time", *Procedia Comput Sci*, vol. 151, pp. 1004–1009, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[8] F. Cremer, B. Sheehan, M. Fortmann, "Cyber risk and cybersecurity: a systematic review of data availability", *Geneva Pap Risk Insur Issues Pract*, vol. 47, pp. 698–736, 2022, [CrossRef] [Google Scholar] [Publisher Link]

[9] L. Meng, B. Sun, "Research on Decentralized Storage Based on a Blockchain", *Sustain* vol. 14, 2022, [CrossRef] [Google Scholar] [Publisher Link]

[10] A.G. Gad, D.T. Mosa, L. Abualigah, A.A. Abohany, "Emerging Trends in Blockchain Technology and Applications: A Review and Outlook", *J King Saud Univ - Comput Inf Sci*, vol. 34, pp. 6719–6742, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[11] N. Sangeeta, S.Y. Nam, "Blockchain and Interplanetary File System (IPFS)-Based Data Storage System for Vehicular Networks with Keyword Search Capability", *Electron* vol. 12, 2023, [CrossRef] [Google Scholar] [Publisher Link]

[12] S. Sharma, "Defence Materials & Stores Research & Development Establishment (DRDO) A Comprehensive Study of Cryptographic Hash Functions", 2024[CrossRef] [Google Scholar] [Publisher Link]

[13] M.M. Merlec, "In HP Blockchain-Based Decentralized Storage Systems for Sustainable Data Self-Sovereignty: A Comparative Study", *Sustainability*, vol. 16, pp. 7671, 2024, [CrossRef] [Google Scholar] [Publisher Link]

[14] N. Vijaya, S.D.A. Sujitha, A. Shankar, "ZIF-67 derivatives of NiCo2S4 Decorated in Salen-Complex Amine Functionalization GO Layers for High-Performance Applications in Supercapacitor Devices", *Luminescence*, 2024, 39. [CrossRef] [Google Scholar] [Publisher Link]

[15] N. Zahed Benisi, M. Aminian, B. Javadi, "Blockchain-based decentralized storage networks: A survey", *J Netw Comput Appl*, vol. 162, pp. 102656, 2020, [CrossRef] [Google Scholar] [Publisher Link]

[16] S. Selvarajan, G. Srivastava, A.O. Khadidos, "An artificial intelligence lightweight blockchain security model for security and privacy in IIoT systems", *J Cloud Comput*, vol. 12, 2023, [CrossRef] [Google Scholar] [Publisher Link]

[17] X. Li, P. Jiang, T. Chen, "A survey on the security of blockchain systems", *Futur Gener Comput Syst*, vol. 107, pp. 841–853, 2020, [CrossRef] [Google Scholar] [Publisher Link]

[18] H. Taherdoost, "Smart Contracts in Blockchain Technology: A Critical Review", *Inf* vol. 14, 2023, [CrossRef] [Google Scholar] [Publisher Link]

[19] F. Hofmann, S. Wurster, E. Ron, M. Böhmecke-Schwafert, "The immutability concept of blockchains and benefits of early standardization", *Proc 2017 ITU Kaleidosc Acad Conf Challenges a Data-Driven Soc ITU K 2017 2018-Janua:1–8*, 2017, [CrossRef] [Google Scholar] [Publisher Link]

[20] U.M. Mulani, "Block chain based Secure Data Sharing in Cloud-Based IOT System", vol. 71, pp. 9834–9851, 2022[CrossRef] [Google Scholar] [Publisher Link]

[21] P. Ramesh, S. Amalraj, P. Arunachalam, "Covalent intercalation of hydrazine derived graphene oxide as an efficient 2D material for supercapacitor application", *Synth Met* vol. 272, pp. 116656, 2021, [CrossRef] [Google Scholar] [Publisher Link]

[22] T. Kolydas, "Timestamping Metadata Using Blockchain: A Practical Approach", *Commun Comput Inf Sci 1057 CCIS:451–458*, 2019, [CrossRef] [Google Scholar] [Publisher Link]

AUTHORS

Ashwini Kamble received B.E in computer Engineering from Shri Vithal Education & Research Institute, Solapur University and received M.E in computer Engineering from Bombay University. Currently she is working in KJ College of Engineering and Management Research, Pune. She is actively doing research in the field of Artificial Intelligence and Blockchain Technology.

Manoj Pise is currently doing B.E in Computer Engineering from KJ College of Engineering and Management Research, Pune. He is Actively doing research in the field of Artificial Intelligence and Blockchain Technology. His current Research area is disc Based rental system of Block chain technology.

Ajit Waman is currently doing B.E in Computer Engineering from KJ College of Engineering and Management Research, Pune. He is Actively doing research in the field of Artificial Intelligence and Blockchain Technology. His current Research area is disc Based rental system of Block chain technology.

Rameshwar Vishwakarma is currently doing B.E in Computer Engineering from KJ College of Engineering and Management Research, Pune. He is Actively doing research in the field of Artificial Intelligence and Blockchain Technology. His current Research area is disc Based rental system of Block chain technology

Suraj Suryawanshi is currently doing B.E in Computer Engineering from KJ College of Engineering and Management Research, Pune. He is Actively doing research in the field of Artificial Intelligence and Blockchain Technology. His current Research area is disc Based rental system of Block chain technology.

Shankar Amalraj received his B.E. degree in Electrical and Electronics Engineering from Anna University, Chennai, Tamil Nadu, India. He obtained his M.Tech degree in Power Systems from Kalasalingam University, Madurai,Tamilnadu. He earned his doctorate in Nanotechnology from the Karunya Institute of Technology and Sciences, Coimbatore. Currently, he is working as an Associate Professor at KJ College of Engineering and Management Research, Pune. He is actively engaged in the fields of Artificial Intelligence and Computational Sciences.

Arrived: 18.11.2024
Accepted: 23.12.2024