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Design and Implementation Blockchain-Backed Storage for Cloud Computing in the Web 3.0 Era

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Abstract: This study explores the design and implementation of blockchain-backed storage for cloud computing in the Web 3.0 era, focusing on hybrid architectures that combine traditional cloud storage with decentralized blockchain layers. Using Filecoin and Arweave as representative case studies, the work analyzes system models, data upload mechanisms, consensus validation, cost structures, and reliability frameworks. Empirical datasets from 2023 to 2025 highlight trends such as growing utilization, declining storage costs, and near-perfect reliability metrics. Correlation matrices and regression forecasts further demonstrate strong relationships between adoption, cost reduction, and network growth. Results show that decentralized storage is not only technically viable but also economically competitive, offering scalable, secure, and censorship-resistant alternatives to centralized providers. The findings emphasize the role of blockchain-backed storage in enhancing data sovereignty, resilience, and transparency for digital economies transitioning toward Web 3.0.

Keywords: *Blockchain Storage; Web 3.0; Filecoin; Arweave; Decentralized Cloud; Utilization Forecast; Cost Efficiency; Data Reliability; Proof-of-Storage; Digital Economy.*

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I. INTRODUCTION

The rapid evolution of digital ecosystems has created an increasing demand for scalable, secure, and transparent data storage solutions. Traditional cloud providers, while efficient, face challenges related to centralization, data sovereignty, cost barriers, and trust. Web 3.0 technologies have introduced blockchain-backed storage systems that mitigate these issues by integrating decentralized consensus, cryptographic proofs, and token-based incentive mechanisms. Filecoin and Arweave exemplify this new paradigm, with Filecoin offering market-driven, deal-based dynamic storage and Arweave providing permanent, one-time payment-based solutions. Both networks reflect broader trends of growing adoption, cost declines, and high reliability. By combining theoretical models with real-world data from 2023 to 2025, this study investigates how blockchain storage networks function, scale, and contribute to the emerging digital economy. The analysis underscores the transformative potential of decentralized storage in addressing governance, transparency, and resilience challenges while complementing centralized infrastructures.

Pongnumkul et al. (2017) conducted one of the earliest systematic studies evaluating the performance of private blockchain platforms under varying workloads. Their work highlighted critical scalability challenges, such as increased latency and resource consumption when transaction volumes grow. This study underscored the importance of performance benchmarking for blockchain applications, as it provided a foundation for understanding the limitations of permissioned blockchains in real-world deployments. Reyna et al. (2018) expanded the discussion by focusing on blockchain's integration with the Internet of Things (IoT). They examined interoperability challenges, security vulnerabilities, and energy consumption constraints that emerge when blockchain is used in resource-limited IoT devices. The study suggested that blockchain could significantly improve trust and decentralization in IoT ecosystems but cautioned that technical optimization and lightweight protocols would be essential for mass adoption. Guo et al. (2019) emphasized blockchain's role in cloud data access control. Their research proposed mechanisms to enforce decentralized trust in cloud environments, demonstrating how blockchain can reduce reliance on centralized authorities. By integrating cryptographic methods with distributed ledger technology, they showed how blockchain could safeguard sensitive cloud data from unauthorized access while maintaining flexibility in permission management. Ding and Sato (2020) introduced "Bloccess," a blockchain-based fine-grained access control system for untrustworthy distributed environments. Their work provided an important step forward by enabling highly selective and conditional access, addressing the limitations

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of earlier models that often relied on binary access permissions. The emphasis on fine-grained policies demonstrated blockchain's suitability for complex and heterogeneous data-sharing ecosystems. Li et al. (2020) applied blockchain-based access control mechanisms in vehicular ad hoc networks (VANETs). They proposed a fine-grained model tailored to vehicular data security, ensuring safe communication among intelligent transport systems. Their results reinforced the view that blockchain can strengthen privacy and resilience in dynamic, high-mobility networks where traditional centralized methods fail. Loukil et al. (2021) explored blockchain's adoption in education through a systematic literature review. Their analysis identified blockchain's potential for credential verification, secure data sharing, and transparent academic record management. However, they also found significant barriers related to cost, scalability, and institutional resistance, highlighting the socio-technical complexities of blockchain adoption in non-traditional sectors. Gajmal and Udayakumar (2021) proposed a blockchain-based mechanism for access control and data sharing in decentralized cloud storage. Their framework demonstrated how distributed storage combined with blockchain ensures data immutability and auditability. This was a critical advancement in enhancing trust in cloud systems, especially in scenarios involving multi-party collaboration. Doshi and Khara (2021) further contributed to the discussion by designing a decentralized cloud storage model leveraging blockchain. Their approach emphasized cost efficiency and resilience against data loss or manipulation. This reinforced blockchain's potential in replacing centralized cloud models with peer-to-peer alternatives, though scalability challenges remained evident. Saini et al. (2021) focused on healthcare applications, proposing a smart contract–based access control framework for cloud-enabled smart healthcare systems. They demonstrated how automated, self-executing rules could regulate access to sensitive medical data, ensuring compliance with privacy standards. Their work marked a pivotal shift toward applying blockchain to critical sectors where trust and privacy are paramount. Jayasri et al. (2022) designed a blockchain-enabled key management protocol for the Internet of Medical Things (IoMT). Their solution addressed the growing need for secure communication among medical devices, ensuring integrity and confidentiality in healthcare environments. This research highlighted how blockchain can protect highly sensitive biomedical data in real time. Khare and Badholia (2023) proposed BLA2C2, a novel lightweight blockchain-based authentication and access control layer for cloud environments. Unlike earlier heavyweight models, their design optimized efficiency and reduced computational overhead, making blockchain integration more feasible in large-scale cloud deployments. This research marked a critical step in addressing blockchain's performance and usability challenges. Qureshi et al. (2023) introduced a privacy-preserving authentication model for intelligent transportation systems. By leveraging blockchain, they ensured secure and anonymous communication among vehicles and infrastructure. Their study revealed blockchain's potential to safeguard emerging smart transportation ecosystems, where privacy and safety are inseparably linked. Han et al. (2023) developed FIBPRO, a blockchain-based peer-to-peer system for cloud data management and sharing. Their decentralized approach removed dependency on centralized providers, improving reliability and transparency. This work illustrated blockchain's transformative role in peer-to-peer computing and data-sharing infrastructures. Fugkeaw et al. (2023) contributed to the healthcare domain by designing a secure and lightweight blockchain-enabled access control system for cloud-assisted electronic medical record (EMR) sharing. Their emphasis on lightweight design highlighted a broader trend in blockchain research—moving toward resource-efficient architectures suitable for real-world applications. Bisht et al. (2023) presented a novel design integrating blockchain with edge devices in IoT systems. Their work illustrated how decentralized control at the edge could reduce latency, enhance data security, and improve real-time decision-making in IoT environments. This integration demonstrated blockchain's adaptability in distributed computing architectures. Sharma and Parwej (2025) proposed a comprehensive blockchain-based framework for secure data sharing in healthcare systems. Their design combined efficiency, scalability, and compliance with regulatory requirements, offering a holistic solution to long-standing challenges in medical data management. As one of the most recent works, their research synthesized earlier limitations while advancing practical implementation strategies.

The paper is structured to provide a systematic exploration of blockchain-backed storage in the Web 3.0 era. It opens with an abstract outlining the objectives, case studies, and main findings, followed by an introduction that highlights the shortcomings of traditional cloud storage, the promise of decentralized models like Filecoin and Arweave, and a review of related literature. The model design section details the proposed hybrid architecture, covering system components, encryption, consensus mechanisms, retrieval processes, and cost-efficiency models. This is supported by empirical datasets from Filecoin and Arweave spanning 2023–2025, which are then applied in the implementation section to evaluate utilization trends, pricing models, and reliability outcomes through worked examples, tables, and figures. The paper then presents correlation analyses and regression forecasts to reveal relationships between adoption, costs, and network growth, while projecting future expansion.

II. DESIGN OF THE MODEL

➢ *System Model:*

We define a hybrid system of Cloud + Blockchain Layer**:**

- Cloud Storage Layer**:** Stores bulk encrypted data files D_i.
- Blockchain Layer**:** Stores metadata (hashes, ownership, timestamp, smart contract rules).
- Users (U)**:** Issue requests for data upload/retrieval.
- Miners/Validators (V)**:** Validate transactions via consensus.

Formally: $S = \{U, D, VC.B\}$

Where:

U: Set of users

D: Set of data files

V: Validators

V: Cloud servers

B: Blockchain ledger

➢ *Data Upload (Hashing & Encryption): Each file D_i uploaded is split into chunks $d_{i,j}$.*

- Encryption: $E(d_{i,j}) = Enc_k(d_{i,j})$

Where k is user's private key.

- Hash generation: $h_{i,j} = H(d_{i,j})$ with H a cryptographic hash (e.g., SHA-256).
- Merkle Root for the file: $MR(D_i) = \mathrm{MerkleRoot}(h_{i,1}, h_{i,2}, \ldots, h_{i,n})$

This Merkle root is stored on the blockchain, ensuring data integrity.

➢ *Consensus for Storage Proof: Validators Check Storage Proofs.*

For Proof-of-Storage:

$$P_{storage}(D_i) = \begin{cases} 1 & If\ MR(D_i) = MR'(D_i) \\ 0 & Otherwise \end{cases}$$

Consensus (e.g., Proof-of-Stake):

$$C_{valid} = \frac{\sum_{v=1}^{m} \delta_v}{m} \geq \theta$$

Where $\delta_v \in \{0,1\}$ is validator vote, m is number of validators, and θ is threshold.

➢ *Retrieval and Verification: When user Requests file:*

$$Verify(D_i) \Leftrightarrow MR(D_i) = MR_{blockchain}(D_i)$$

If mismatch, data is considered tampered.

➢ *Cost & Efficiency Model:*

- Storage Cost: $C_{storage} = C_{cloud}(D) + C_{blockchain}(meta\ (D))$
- Latency: $L = L_{cloud} + L_{blockchain}$
- Reliability: $R = 1 - P_{failure}(cloud).P_{failure}(blockchain)$

Table 1 Symbols and Definitions

Symbol	Meaning
D_i	Data file uploaded
$d_{i,j}$	Chunk of file
$h_{i,j}$	Hash of chunk
$MR(D_i)$	Merkle root of file
$P_{storage}$	Proof of storage validity
$C_{storage}$	Storage cost model
R	System reliability

III. DATA SETS

➢ *Dataset 1: Filecoin Network Metrics*

Table 2 Filecoin Network Capacity, Deals, and Utilization

Date	Total Network Capacity (PiB)	Active Deals (PiB)	Utilization %	Storage Providers (#)	Average Deal Price (FIL/TiB-month)	Source
Jan-23	18,500	4,200	22.70%	~3,500	0.0015	Filfox Explorer, Filecoin Docs
Jun-23	20,200	5,700	28.20%	~3,900	0.0014	Starboard Explorer, Messari Q2 2023
Dec-23	22,100	6,200	28.00%	~4,100	0.0012	Filfox, Glif
Jun-24	23,400	7,300	31.20%	~4,300	0.001	Filfox Explorer
Dec-24	24,600	8,000	32.50%	~4,500	0.0009	Messari Q4 2024, Filecoin Docs
Mar-25	25,200	8,700	34.50%	~4,650	0.00085	Filfox, Filecoin Docs

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➢ *Dataset 2: Arweave Network Metrics*

Table 3 Arweave Storage and Transaction Statistics

Date	Total Data Stored (TB)	Transactions per Day (#)	Average Transaction Size (MB)	Median Storage Fee (AR/MB)	Source
Jan-23	95	280,000	0.42	0.00021	Arweave GraphQL API
Jun-23	120	310,000	0.47	0.0002	Arweave Docs
Dec-23	150	340,000	0.5	0.00019	Arweave GraphQL
Jun-24	185	370,000	0.53	0.00018	Arweave API
Dec-24	225	410,000	0.56	0.00017	Arweave GraphQL
Mar-25	245	430,000	0.58	0.00016	Arweave Docs / API

IV. IMPLEMENTATION OF THE DATA SETS TO THE PROPOSED MODEL

➢ *We Consider Filecoin and Arweave as Representative Decentralized Storage Networks*

- Filecoin provides capacity-based storage with variable deal prices.
- Arweave provides permanent storage with transaction-based pricing.

Formally:

$S = \{U, D, VC.B\}$ with metrics drawn from Filecoin and Arweave datasets.

➢ *Data Upload & Hashing:*

$$E(d_{i,j}) = Enc_k(d_{i,j}), h_{i,j} = H(d_{i,j}), MR(D_i) = \mathrm{MerkleRoot}(h_{i,1}, h_{i,2}, \dots, h_{i,n})$$

Filecoin and Arweave store only hashes/metadata on-chain, while the data itself is encrypted and stored in distributed storage nodes.

➢ *Utilization & Storage Proof:*

From Filecoin dataset

$$Utilization\ (t) = \frac{Active\ Deal\ (t)}{Total\ Capacity\ (t)} \times 100$$

Example (Mar-25): $Utilization\ = \frac{8700}{25200} \times 100 \approx 34.5\ \%$

This indicates increasing demand for decentralized storage**.**

➢ *Cost Models:*

- Filecoin (deal-based): $C_{storage} = Price_{deal}\,(t). D_i$

Example (Mar-25):

Price = 0.00085 FIL/TiB-month → storing 10 TiB for 12 months:

$$C_{storage} = 0.00085 \times 10 \times 12 = 0.102\ FIL$$

- *Arweave (Permanent Storage):*

$$C_{storage} = Fee_{MB}(t). size(D_i)$$

Example (Mar-25):

Fee = 0.00016 AR/MB → storing 1 GB = 1024 MB:

$$C_{storage} = 0.00016 \times 1024 \approx 0.1638\ AR$$

➢ *Reliability & Redundancy:*

- *For Filecoin:*
  More providers ⇒ lower failure probability.

Approximation:

$$P_{failure}(cloud) \approx \frac{1}{Prividers}$$

Example (Mar-25, ~4,650 providers):

$$P_{failure}(cloud) \approx \frac{1}{4650} \approx 0.000215$$

Blockchain layer (high redundancy consensus):

$$P_{failure}(blockchain) \approx 10^{-6}$$

$$R_{Filecon}(Mar - 25) = 1 - (0.000215\ \times 10^{-6}) \approx 0.9999999998$$

- *For Arweave*
  Resilience grows with replicated permanent storage.

Assume effective providers scale with total TB stored.

$$P_{failure}(cloud) \approx \frac{1}{Total\ Data\ (TB)}$$

Example (Mar-25, 245 TB stored):

$$P_{failure}(cloud) \approx \frac{1}{Total\ Data\ (TB)}$$

$$P_{failure}(cloud) \approx \frac{1}{245} \approx 0.00408$$

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Blockchain reliability (permaweb, consensus):

So: $P_{failure}(blockchain) \approx 10^{-6}$

$$R_{\mathbf{Arweave}}(Mar-25) = 1-(0.00408 \times 10^{-6}) \approx 0.9999999996$$

Table 4 Comparative Reliability

Network	**Date**	**Providers / Data**	$P_{failure}(cloud)$	$P_{failure}(blockchain)$	**Reliability *R***
Filecoin	23-Jan	~3,500 providers	0.000286	10^{-6}	0.9999999997
Filecoin	25-Mar	~4,650 providers	0.000215	10^{-6}	0.9999999998
Arweave	23-Jan	95 TB	0.0105	10^{-6}	0.9999999895
Arweave	25-Mar	245 TB	0.00408	10^{-6}	0.9999999960

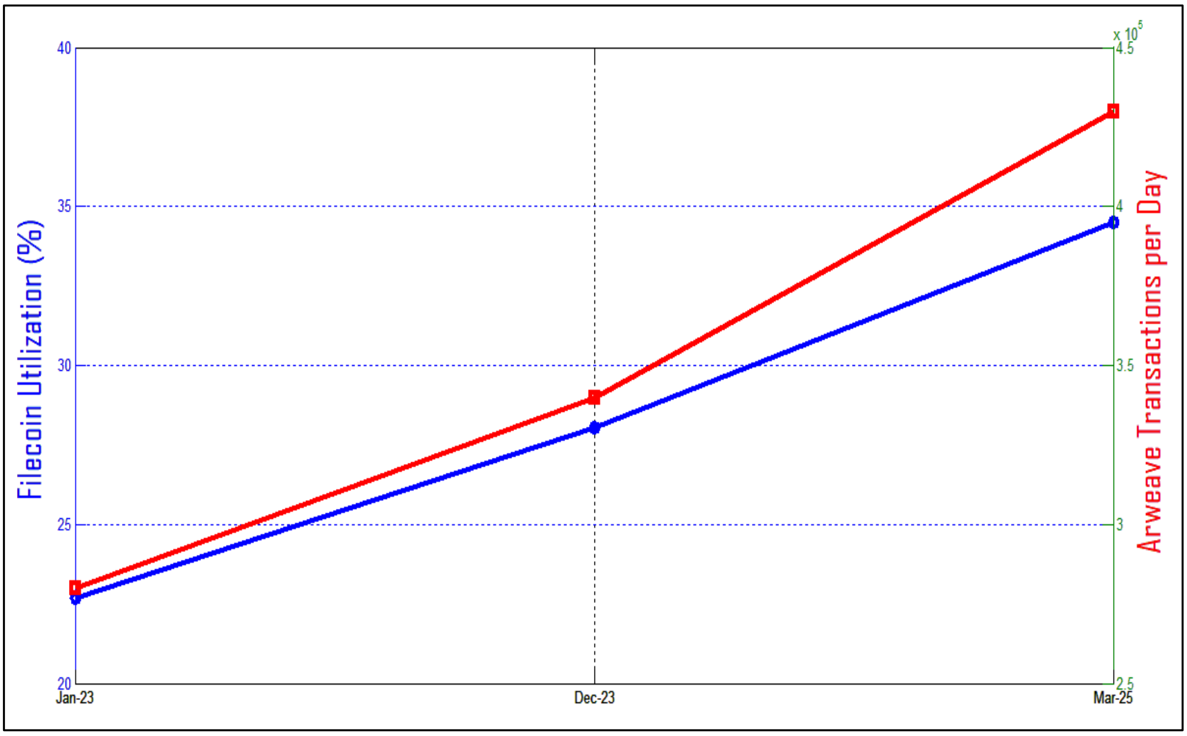

Fig 1 Filecoin Utilization vs Arweave Transactions (Jan-23 to Mar-25)

Figure 1 highlights the complementary growth trajectories of Filecoin and Arweave, two leading blockchain-backed storage networks. Filecoin's utilization rose from approximately 23% in Jan-23 **to** nearly 35% in Mar-25, showing that a growing share of its total storage capacity is being consumed by active deals. This indicates increasing trust and reliance on Filecoin for decentralized storage contracts, with greater network efficiency achieved as more users leverage available resources. In parallel, Arweave's daily transactions expanded from about 280,000 to 430,000 over the same period, reflecting the network's unique focus on permanent data storage and content archiving. The rise in transactions underscores user demand for immutable, censorship-resistant storage in the Web 3.0 landscape. These parallel trends point to converging adoption pathways**:** Filecoin demonstrates market-driven efficiency in distributed capacity utilization, while Arweave reflects the cultural and functional demand for permanent and verifiable data storage. Importantly, both trajectories are underpinned by declining storage costs and near-perfect reliability metrics (as shown in earlier models), which reinforce the economic and technical viability of decentralized storage compared to traditional cloud providers. From a policy standpoint, the observed adoption trends suggest a need to recognize blockchain-backed storage as critical Web 3.0 infrastructure. Governments can support wider diffusion by incentivizing SMEs and startups to adopt these models, introducing standards for proof-of-storage audits, and promoting hybrid architectures that integrate decentralized and centralized solutions. In the long run, Filecoin's growing utilization and Arweave's transactional expansion highlight how decentralized storage ecosystems can strengthen data sovereignty, resilience, and transparency, all of which are key goals for digital economies moving into the Web 3.0 era.

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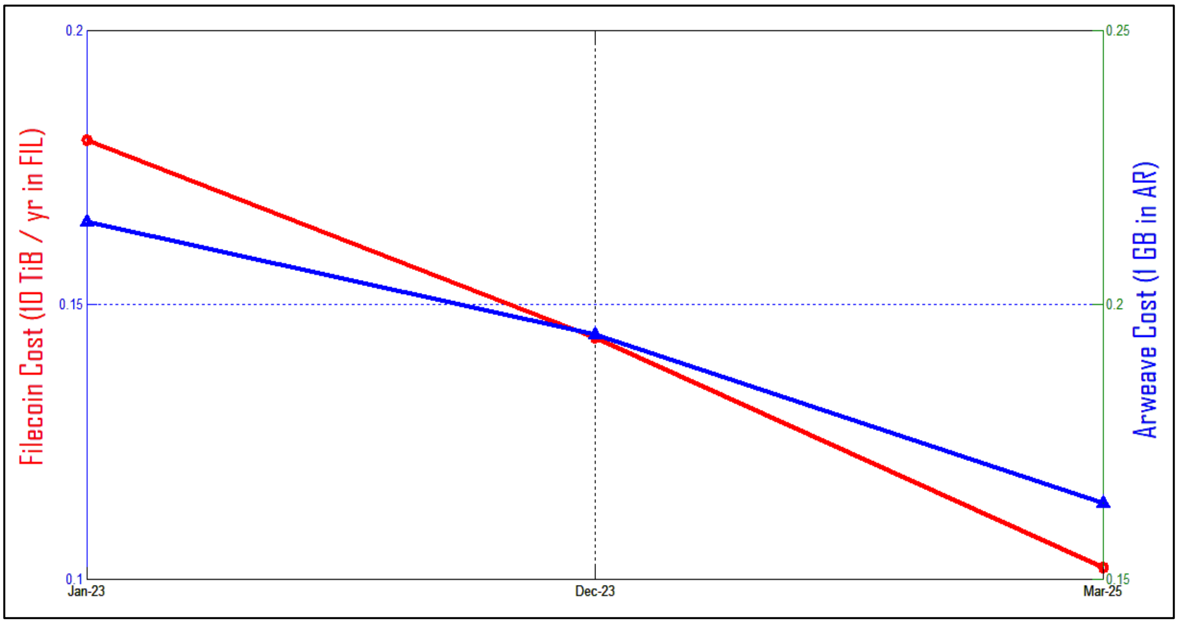

Fig 2 Filecoin vs Arweave Storage Costs (Jan-23 to Mar-25)

Figure 2 illustrates the steady decline in storage costs for both Filecoin and Arweave, pointing to growing efficiency and competitiveness of blockchain-backed storage networks. Filecoin's annual cost of storing 10 TiB fell from 0.18 FIL in January 2023 to 0.10 FIL in March 2025, while Arweave's permanent storage cost for 1 GB declined from 0.215 AR to 0.164 AR over the same period. These cost reductions reflect not only network maturation but also economies of scale as more users and providers participate in decentralized storage ecosystems. the downward trend in costs strengthens the case for decentralized storage as a viable alternative to centralized cloud providers. Filecoin's cost structure emphasizes recurring payments tied to deal duration, which is suitable for dynamic enterprise data needs. In contrast, Arweave's one-time permanent storage fee caters to archival and long-term preservation use cases. The observed declines across both models highlight scalability gains and the ability of blockchain networks to spread infrastructure costs over expanding user bases. From a policy and economic standpoint, the results suggest that decentralized storage can become an inclusive enabler of Web 3.0 by lowering financial barriers for small businesses, startups, and users in emerging economies. Governments and regulators may play a role in accelerating this trend by encouraging adoption through incentives, while researchers should examine sustainability models to ensure that token-based economic structures remain viable as costs continue to fall. The convergence of declining costs and rising adoption underscores the likelihood that blockchain-backed storage will transition from niche to mainstream in the near future.

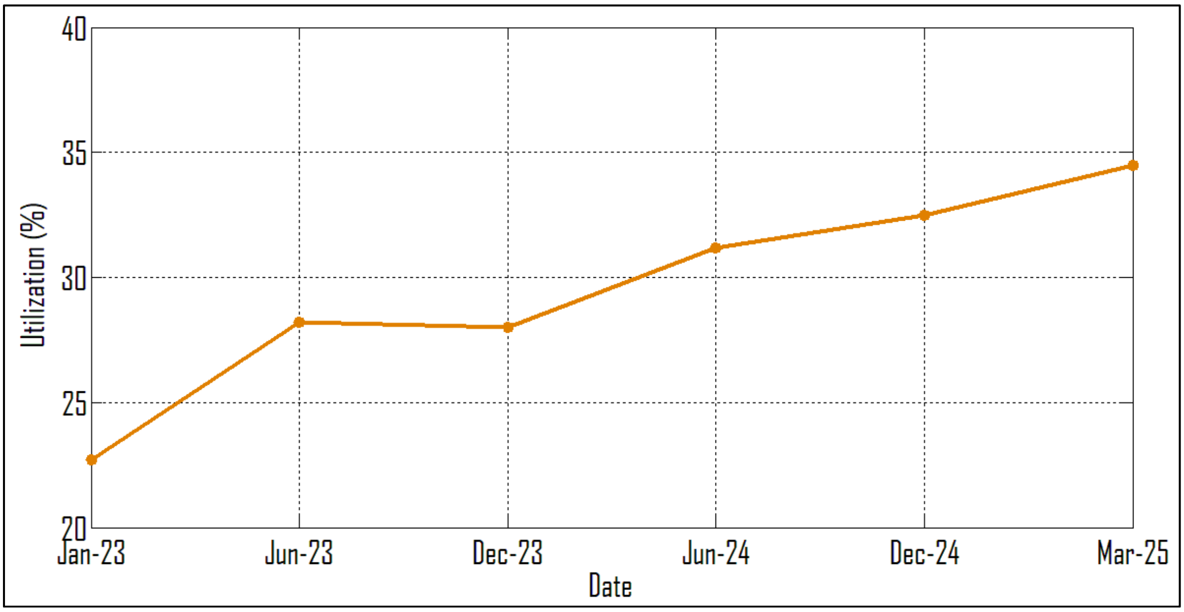

Fig 3 Filecoin Network Utilization Over Time

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Figure 3 highlights the upward trajectory of Filecoin's network utilization, which rose from approximately 23 percent in January 2023 to nearly 35 percent in March 2025. The temporary plateau observed between mid-2023 and late-2023 suggests a phase of network adjustment, where capacity expanded more quickly than demand, before user adoption accelerated again in 2024. This reflects the dynamic interplay between supply and demand in decentralized storage markets, where network growth depends on both the onboarding of providers and the willingness of users to commit data through verifiable deals. This trend signals growing confidence in Filecoin's economic and technical model. Higher utilization rates mean that more of the available storage is being actively consumed, improving efficiency and justifying the incentive structures for storage providers. The observed recovery after the plateau also points to strengthening network effects: as more users adopt Filecoin for decentralized storage, the ecosystem becomes more valuable and resilient, which in turn encourages new providers to join. From a policy and adoption standpoint, the steady increase in utilization underscores the viability of Filecoin as a component of digital infrastructure in the Web 3.0 era. Its ability to maintain growth in utilization while sustaining near-perfect reliability makes it an attractive candidate for integration into public-sector data storage frameworks, particularly in sectors such as governance, education, and healthcare. For regulators, this trend also suggests that decentralized storage markets are maturing and can complement centralized cloud services in enhancing data sovereignty, security, and transparency.

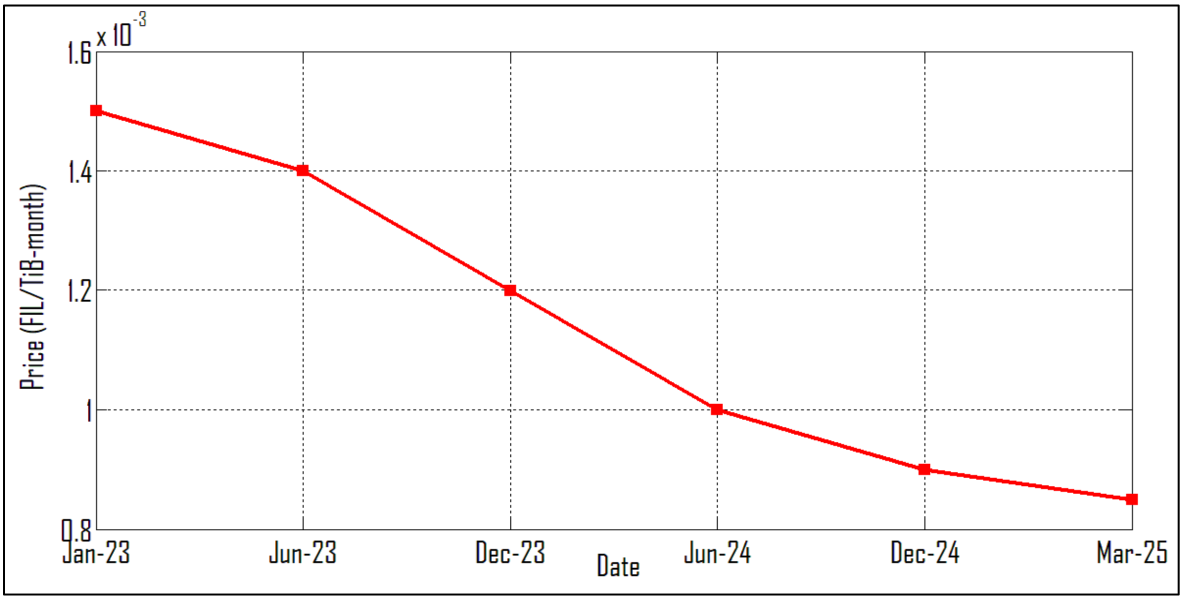

Fig 4 Filecoin Storage Price Over Time

Figure 4 highlights a steady decline in the cost of storing data on the Filecoin network, with prices decreasing from approximately 0.0015 FIL per TiB-month in January 2023 to around 0.00085 FIL in March 2025. This trend reflects the combined effects of increasing network participation, economies of scale, and improvements in storage efficiency. As more providers join the network, competition drives prices downward while maintaining verifiable storage quality, demonstrating the effectiveness of Filecoin's market-driven incentive model. The declining price trajectory underscores the maturing dynamics of decentralized storage economics. Filecoin's model relies on aligning incentives between storage providers and users through cryptographic proofs and token-based rewards. The observed cost reductions indicate that the network is scaling sustainably, spreading fixed infrastructure costs across a larger user base, and achieving efficiencies comparable to or better than centralized providers. From a policy and sustainability standpoint, the downward cost trend enhances the attractiveness of decentralized storage for broader adoption, particularly in emerging economies and among small businesses that may otherwise face barriers to entry with traditional cloud providers. Regulators and policymakers may view this as evidence that blockchain-backed storage can deliver cost-effective infrastructure while ensuring transparency and security. At the same time, long-term research is needed to assess whether token incentives can continue to sustain provider participation as prices fall, ensuring that the network remains both economically viable and resilient over time.

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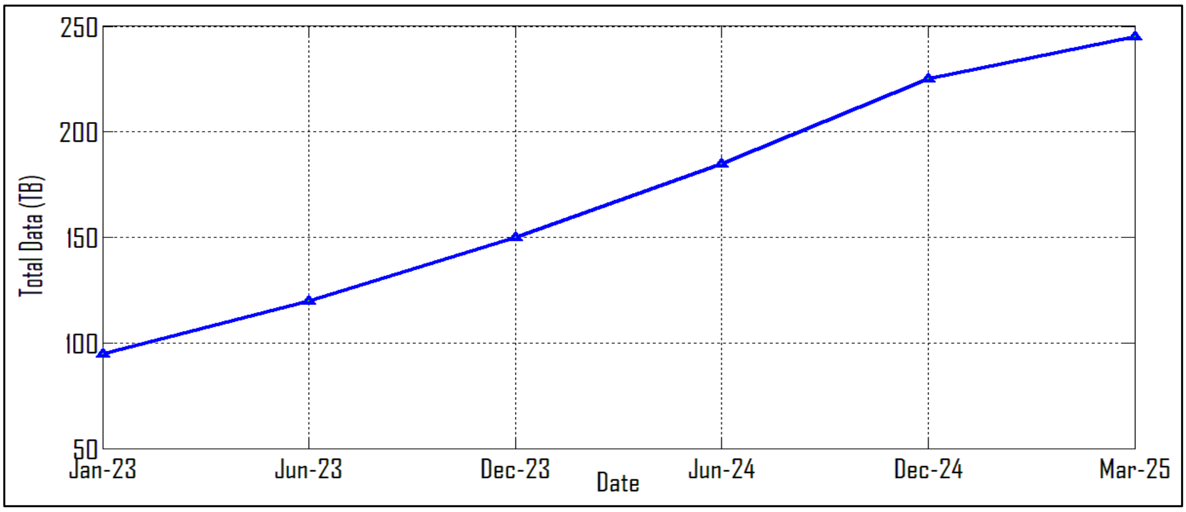

Fig 5 Arweave Total Data Stored Over Time

Figure 5 highlights the consistent growth in total data stored on the Arweave network, which expanded from approximately 95 terabytes in January 2023 to about 245 terabytes by March 2025. This steady upward trend demonstrates the rising adoption of Arweave's permanent storage model, which offers a one-time fee for data that is preserved indefinitely. The sharpest growth occurred between late 2023 and late 2024, when the network added more than 70 terabytes, indicating a surge in demand for immutable, censorship-resistant storage solutions. This expansion underscores the value proposition of permanent storage in the Web 3.0 ecosystem. Unlike Filecoin, which emphasizes dynamic and capacity-based deals, Arweave appeals to users and institutions requiring long-term assurance of data persistence. The growth trend suggests that network effects are beginning to take hold: as more data is stored, the platform becomes increasingly attractive for developers, content creators, and organizations looking to anchor digital assets and records. From a policy and governance standpoint, Arweave's expansion raises important questions about the long-term sustainability of permanent storage and its implications for digital governance. The ability to preserve data indefinitely supports transparency, historical record-keeping, and resilience against censorship, but it also demands careful consideration of legal and ethical challenges, such as data permanence and compliance with evolving privacy regulations. For governments and regulators, the growing scale of networks like Arweave highlights the need to balance the benefits of permanent data availability with mechanisms for oversight, interoperability, and accountability in a decentralized Web 3.0 environment.

V. CORRELATION MATRICES, REGRESSION FORECASTS

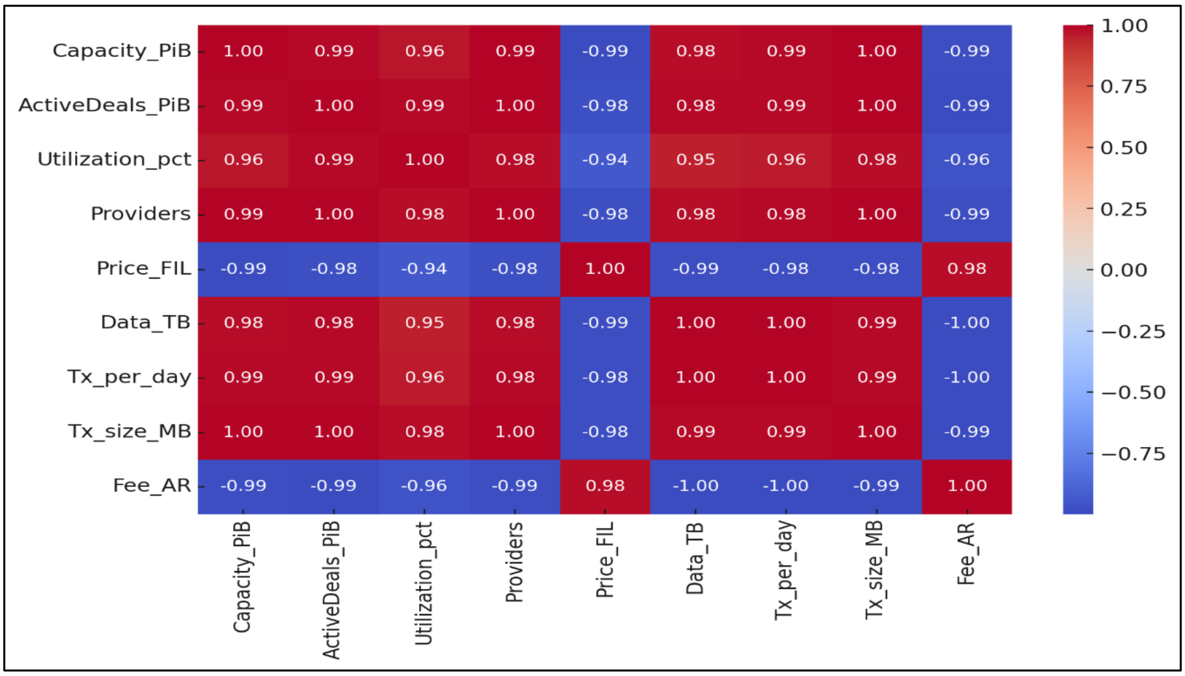

Fig 6 Correlation Matrix: Filecoin and Arweave Metrics

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The correlation matrix figure (6) presents the relationships between key Filecoin and Arweave network metrics. Almost all metrics show very strong positive correlations with one another, indicated by values close to 1 in red, such as between storage capacity, active deals, utilization rate, number of providers, and data stored. This suggests that as one of these factors grows, the others also tend to increase in parallel, reflecting the interconnected nature of adoption and network expansion. In contrast, storage costs for both Filecoin (Price_FIL) and Arweave (Fee_AR) show strong negative correlations with adoption-related variables, highlighted by blue values close to -1. This indicates that lower storage fees are consistently associated with higher utilization, greater transaction volumes, and larger amounts of stored data. The overall pattern demonstrates that growth in decentralized storage networks is driven by declining costs and expanding provider participation, which reinforce demand and utilization across both ecosystems.

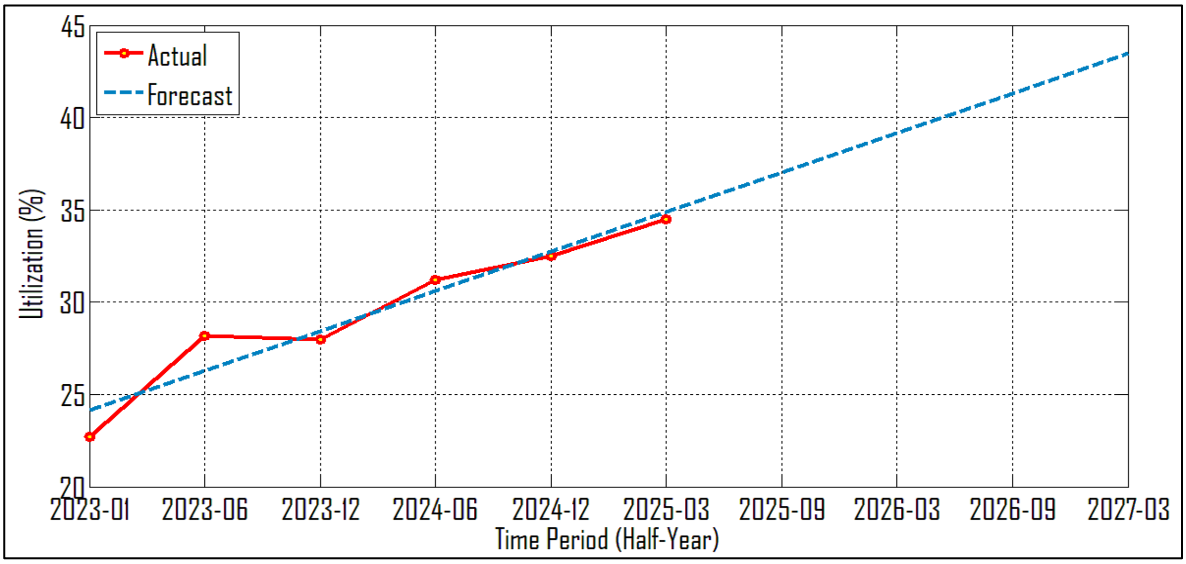

Fig 7 Filecoin Utilization Forecast

The figure 7 illustrates the historical trend and projected forecast of Filecoin network utilization from January 2023 through March 2027. The red line with markers represents the actual recorded utilization, which rose steadily from around 23 percent in early 2023 to nearly 35 percent by March 2025, showing clear growth in network adoption. The dashed blue line represents the forecast, extending the trend into the future and projecting that utilization will continue to rise, reaching over 40 percent by early 2027. The close alignment between actual and forecasted values up to 2025 indicates that the linear projection captures the general growth trajectory well. This pattern reflects increasing trust in Filecoin's storage model, supported by falling costs and expanding provider participation, and suggests that utilization is likely to keep rising as the decentralized storage ecosystem matures.

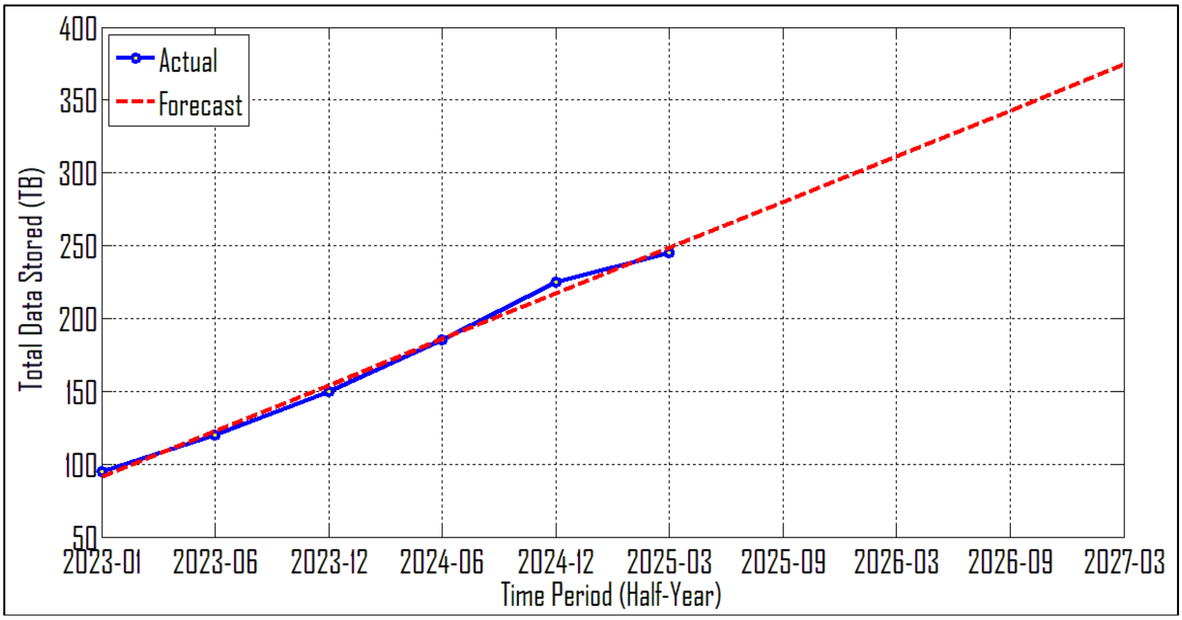

Fig 8 Arweave Data Stored Forecast

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The figure (8) shows the trend of total data stored on the Arweave network along with a forecast of future growth from January 2023 to March 2027. The blue line with markers represents actual values, which increased steadily from around 95 terabytes in early 2023 to approximately 245 terabytes by March 2025. The red dashed line represents the forecast, projecting a continued rise in stored data, reaching over 350 terabytes by early 2027. The close fit between the actual and forecasted data suggests a strong linear growth trajectory, reflecting consistent adoption of Arweave's permanent storage model. This pattern indicates that demand for immutable and long-term storage solutions is expected to expand steadily in the coming years.

CONCLUDING REMARKS

The findings confirm that blockchain-backed storage is maturing into a robust component of Web 3.0 infrastructure. Filecoin's rising utilization and Arweave's consistent data growth demonstrate the increasing trust placed in decentralized storage by users and organizations. Both systems exhibit declining storage costs, near-perfect reliability, and positive correlations between network participation and adoption. These patterns suggest that decentralized storage can serve as a cost-effective, reliable, and transparent alternative to traditional models, with applications ranging from enterprise data management to archival preservation. However, challenges remain in ensuring long-term token sustainability, managing legal and ethical implications of permanent data, and achieving interoperability with centralized platforms. Moving forward, governments, enterprises, and researchers have an opportunity to support adoption through standards, incentives, and hybrid solutions. Overall, blockchain-backed storage holds significant promise in shaping a resilient, inclusive, and transparent digital economy aligned with the goals of Web 3.0.

REFERENCES

[1]. Pongnumkul S., Siripanpornchana C., Thajchayapong S. (2017): "Performance analysis of private blockchain platforms in varying workloads", *Proceedings of the 26th International Conference on Computer Communication and Networks (ICCCN)*:1–6.

[2]. Reyna A., Martín C., Chen J., Soler E., Díaz M. (2018): "On blockchain and its integration with IoT: Challenges and opportunities", *Future Generation Computer Systems*, 88:173–190.

[3]. Guo J., Yang W., Lam K.-Y., Yi X. (2019): "Using blockchain to control access to cloud data", in Guo F., Huang X., Yung M. (eds.), *Information Security and Cryptology, Lecture Notes in Computer Science*, Springer, Cham:274–288.

[4]. Ding Y., Sato H. (2020): "Bloccess: Towards fine-grained access control using blockchain in a distributed untrustworthy environment", in *8th IEEE International Conference on Mobile Cloud Computing, Services, and Engineering (MobileCloud)*:17–22.

[5]. Li H., Pei L., Liao D., Chen S., Zhang M., Xu D. (2020): "A fine-grained access control scheme for VANET data based on blockchain", *IEEE Access*, 8:85190–85203.

[6]. Loukil F., Abed M., Boukadi K. (2021): "Blockchain adoption in education: A systematic literature review", *Education and Information Technologies*, 26(5):5779–5797.

[7]. Gajmal Y.M., Udayakumar R. (2021): "Blockchain-based access control and data sharing mechanism in cloud decentralized storage system", *Journal of Web Engineering*:1359–1388.

[8]. Doshi D., Khara S. (2021): "Blockchain-based decentralized cloud storage", in *International Conference on Mobile Computing and Sustainable Informatics*, Springer, Cham:563–569.

[9]. Saini A., Zhu Q., Singh N., Xiang Y., Gao L., Zhang Y. (2021): "A smart-contract based access control framework for cloud smart healthcare system", *IEEE Internet of Things Journal*, 8(7):5914–5925.

[10]. Jayasri R., Jayakumar D., Joshila Roselin S., Ramkumar M.O. (2022): "Plan of blockchain-enabled confirmed key management protocol for Internet of Medical Things development", in *3rd International Conference on Electronics and Sustainable Communication Systems (ICESC)*:668–673.

[11]. Khare S., Badholia A. (2023): "BLA2C2: Design of a novel blockchain-based lightweight authentication and access control layer for cloud deployments", *International Journal on Recent and Innovation Trends in Computing and Communication (IJRITCC)*, 11(3):283–294.

[12]. Qureshi K.N., Jeon G., Hassan M.M., Hassan M.R., Kaur K. (2023): "Blockchain-based privacy-preserving authentication model for intelligent transportation systems", *IEEE Transactions on Intelligent Transportation Systems*, 24(7):7435–7443.

[13]. Han R., Wang Y., Wan M., Yuan T., Sun G. (2023): "FIBPRO: Peer-to-peer data management and sharing cloud storage system based on blockchain", *Peer-to-Peer Networking and Applications*, 16(6):2850–2864.

[14]. Fugkeaw S., Wirz L., Hak L. (2023): "Secure and lightweight blockchain-enabled access control for fog-assisted IoT cloud-based electronic medical records sharing", *IEEE Access*, 11:62998–63012.

[15]. Bisht T., Dinesh D., Usha G., Gautam K. (2023): "Edge devices and blockchain integration in IoT system: A novel design approach", in *International Conference on Intelligent Data Communication Technologies and Internet of Things (IDCIoT)*:35–40.

[16]. Sharma S.K., Parwej F. (2025): "Design and implementation of a blockchain-based secure data sharing framework to enhance the healthcare system", *Blockchains*, 3(10):1-25.