

# Traversing Decentralized Storage

October 2023



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# Key Takeaways

- ❖ In recent years, decentralized storage has witnessed an increased adoption, with projects like Filecoin, Arweave, and Storj at the forefront. The recently launched BNB Greenfield is also a noteworthy entrant to the field. Yet, for the majority, centralized storage remains the go-to option, largely due to its intuitive user experience and mature product suite.
- ❖ Decentralized storage networks operate on a peer-to-peer model. They encrypt the data, and distribute the data shards among user-driven storage providers, who provide unused computer resources and earn remuneration in a project's native token.
- ❖ Currently, Filecoin stands out, both in market capitalization and in metrics like storage capacity and used storage. On the other hand, Storj's strategic focus on enterprise clients has contributed to its leading network utilization rate.
- ❖ BNB Greenfield's native integration with BNB Chain offers it a unique advantage: direct access to a robust DeFi ecosystem. This could potentially fuel a new data economy driven by financial activities, ushering in capital and a fresh user base to the sector.
- ❖ Looking ahead, the outlook for decentralized storage remains optimistic. The surge in global data generation, coupled with a rising interest in blockchain technology, are the key drivers propelling the sector's upward trajectory.

# Introduction

Over recent years, the adoption of decentralized storage (“dStorage”) has increased, with projects such as Filecoin, Arweave, and Storj leading the charge. The emergence of dStorage comes as a response to the challenges and risks associated with centralized storage. Centralized storage solutions, operated by a small number of entities, monopolize control over user data. By using these services, users inadvertently relinquish their data sovereignty, subjecting themselves to potential privacy breaches and the added risk of a single point of failure. Meanwhile, employing networks like Ethereum for extensive data storage isn’t currently viable due to the high costs associated with ensuring data redundancy. This has propelled the development of dedicated dStorage networks and protocols.

However, the dStorage sector still trails its centralized counterpart in several areas, including enterprise adoption, accessibility, user experience, and more. As a result, centralized storage remains the prevailing method for data storage. Evidenced by the disparity in adoption between centralized and decentralized exchanges and the rise of Telegram bots, it’s clear that, in the current digital asset landscape, users prioritize accessibility over decentralization. Nevertheless, as a foundational infrastructure of the evolving Web3 ecosystem, the subject of decentralized storage merits deeper understanding to increase public awareness.

This report starts off by introducing the basics of decentralized storage, comparing the pros and cons of centralized versus decentralized solutions. We then examine the present state of the market, emphasizing growth trends and future prospects, and analyze the business models of key ecosystem players. To conclude, we’ll share our thoughts on the sector’s impending challenges and its potential trajectory.

# Decentralized Storage 101

This section serves as an introduction to decentralized storage, reviewing the basic concepts, exploring the variants of its key components, and showcasing the pros and cons of centralized vs. decentralized storage.

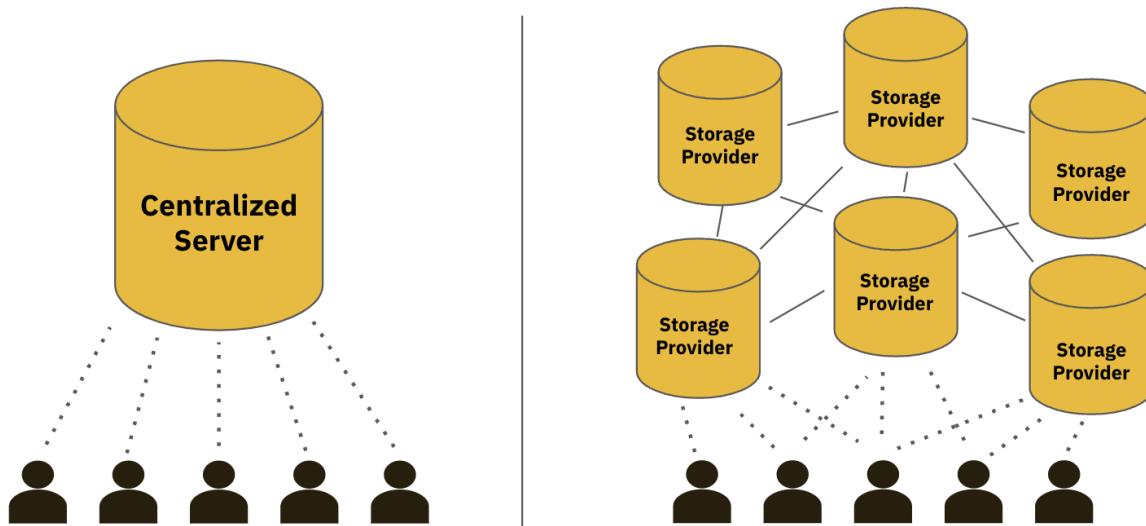
Note that this section aims to provide a structural understanding of decentralized storage for readers. For succinctness, not all projects and their relevant mechanisms may have been covered. As such, readers are encouraged to conduct further research on the topic.

3.1

## A Primer on dStorage

Decentralized storage systems operate on a peer-to-peer (“P2P”) network model, where user-driven storage providers (“SPs”) or miners allocate unused computer resources and earn remuneration in a project’s native token. Unlike centralized systems, where a single entity governs data, **dStorage encrypts and shards data, dispersing it across the network**. This process enhances accessibility and ensures data redundancy.

**Figure 1: Conceptual illustration of centralized and decentralized systems**



Source: Binance Research

There are four integral components that define a decentralized storage network:

1. **Data Storage Structure**
2. **Consensus & Challenge Algorithm**
3. **Data Persistence**
4. **Storage Incentive**

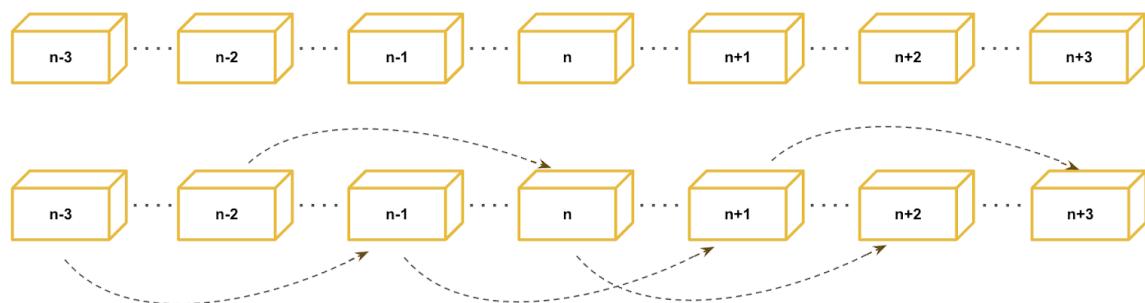
At their core, dStorage networks are rooted in blockchain frameworks, such as Arweave, or predominantly P2P models, like Filecoin. Within these networks, miners or SPs offer their computational storage capacities to consumers, obtaining fees for storage, retrieval, and other transactions in return. Each network employs a unique cryptography verification mechanism (“proof”) to maintain transparency and consistency across participants. This cryptographic foundation ensures that a consensus is achieved regarding the network’s state. To sustain resource contribution and align stakeholders’ interest, an incentive system is used, striking a balance by rewarding compliant behaviors and penalizing those that could harm the network. In the subsequent section, we’ll delve deeper into representative examples of these components.

## 1. Data Storage Structure

Data storage structure is the foundational design of how data is to be organized and managed within a dStorage network. Such structures can either be a blockchain-like architecture or a P2P structure. Two prime examples of these structures are Arweave’s **blockweave** and Protocol Labs’ **InterPlanetary File System (“IPFS”)**.

**Blockweave** is reminiscent of a blockchain but with a weave-like configuration. Instead of linear connections where each block is solely linked to its preceding block, the blockweave design ensures that every block is intertwined with both its immediate predecessor ( $n-1$ ) and a randomly selected older block, termed the “recall block.” The selection process is based on a hash and the preceding block’s height. A particular advantage of blockweave is its scalability: nodes aren’t required to retain the entire chain’s data, thereby optimizing storage efficiency.

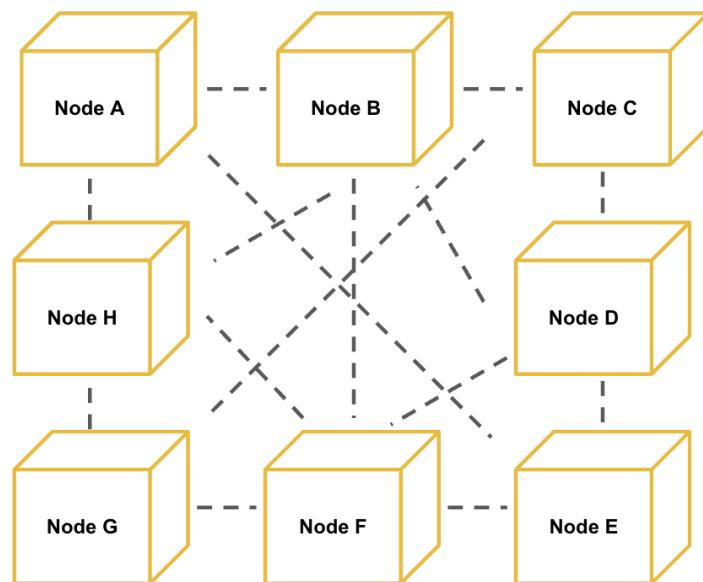
**Figure 2: Unlike blockchain, each block is connected to its precedent and a recall block in blockweave**



Source: Binance Research

**IPFS**, on the other hand, is composed of nodes (SPs) operated by users, ensuring a decentralized distribution of data copies. To efficiently pinpoint data and deter alterations, IPFS utilizes Content Identifiers (“CIDs”). Generated through cryptographic hashes, a CID offers a unique identifier for every data fragment. Due to the inherent nature of IPFS, where data preservation by nodes isn’t assured indefinitely, Filecoin was introduced as a complementary protocol to bolster the longevity and reliability of data storage atop IPFS.

**Figure 3: IPFS is based on a peer-to-peer network of storage nodes**



Source: Binance Research

## 2. Consensus & Challenge Algorithm

Consensus & challenge algorithm refers to implementations that institute trust in the system, allowing nodes to reach agreement on the state of the network without the need of a central authority. In dStorage networks, these mechanisms ensure the integrity and availability of stored data.

Different projects utilize varying consensus mechanisms:

- ❖ **Proof of Access (“PoA”): Arweave’s unique solution, Proof of Access, complements its blockweave structure.** To mine or validate a new block under PoA, miners have to prove their access to a specific recall block. It can be considered as a hybrid of Proof of Work (“PoW”); it mandates miners to solve the PoW computational challenge and also retain access to certain historical blocks. Consequently, to optimize profitability, miners aim to store an expansive array of blocks, especially those that are deemed to be rare in order to minimize competition. Through its design, the mechanism enhances data redundancy while also incentivizing the storage of under-replicated data.
- ❖ **Proof of Storage (“PoS”):** This consensus mechanism is **adopted by Filecoin**. On the platform, it bifurcates into two distinct proofs: Proof of Replication (“PoRep”) and Proof of Spacetime (“PoSt”). While PoRep demands that SPs demonstrate that they’ve effectively replicated the requested client data, PoSt mandates SPs to regularly prove that the specific data remains intact and accessible throughout the contract’s tenure. To ease the storage demands on nodes and to expedite the verification process, Filecoin employs zk-SNARKs to facilitate the compression of both PoRep and PoSt.
- ❖ **Proof of Stake (“PoS”):** Certain decentralized storage networks operate on their own native chain, like Arweave and Filecoin, whereas others reside on established chains like Ethereum. For instance, **Storj operates on Ethereum and benefits from its security, which is underpinned by the chain’s PoS mechanism**. Alongside this, Storj uses erasure coding and satellite audit to ensure data integrity.

In contrast, **BNB Greenfield runs on its native Greenfield chain, built on Cosmos SDK**. It employs the BFT Proof of Stake (“BPoS”) to bolster network security and incorporates a ‘Proof of Challenge’ module along with erasure coding to ensure data integrity. Proof of Challenge can be instigated either by users or stochastic events with the Greenfield chain. Challenges are executed via off-chain audit by challenge verifier, which requests specific data fragments from SPs. If the expected data isn’t retrieved, or there’s a discrepancy between the hash of the data that is challenged and recorded, the data is deemed unavailable, resulting in a challenge failure.

### 3. Data Persistence

Data persistence dictates the duration and manner in which data remains stored. This could be permanent, as seen on Arweave, or for a specified duration.

- ❖ **Permanent Storage:** Arweave, for example, offers permanent storage. A one-time payment ensures that the data remains accessible indefinitely. Arweave has formulated a pricing model for its perpetual storage based on the trend of decreasing data storage cost. This model aggregates the summation of continually reducing storage costs over time and charges it as a one-time payment.
- ❖ **Fixed-Term Storage:** In contrast, platforms like Filecoin utilize fixed-term storage. On Filecoin, the terms, including parameters like data size, price, and storage duration, are negotiated between clients and SPs. Once agreed, data storage adheres to the terms of the contract.

### 4. Storage Incentive

The incentive structures in decentralized storage networks are typically centered around a project's native token. These tokens are granted to miners, SPs, and retrieval providers as block rewards and service fees, incentivizing robust data storage and dependable services. Conversely, SPs frequently need to deposit collateral as a security measure. Failing to deliver reliable services, or engaging in malicious activities, can lead to penalties such as withheld rewards, slashed collateral, or even expulsion from the network. Through the carrot-and-stick approach for rewards and penalties based on performance, these measures maintain network alignment and integrity.

3.2

## Centralized V.S. Decentralized

The distinction between centralized and decentralized storage predominantly hinges on two facets: **security and cost**.

Centralized storage systems store data through a single authority that uses one or a handful of servers, presenting the risks of a single point failure. Such centralization can lead to issues such as data breaches and potential system paralysis, jeopardizing client data. Additionally, user privacy is at risk too - Once data is entrusted to centralized service providers, clients often lose control over its management, facing potential data leaks or unauthorized manipulations. The infamous "[Facebook–Cambridge Analytica data scandal](#)" stands as a stark reminder of these concerns. In contrast, decentralized storage systems encrypt data and distribute it among a network of nodes, mitigating security risks associated with centralization.

Cost emerges as another critical factor in the comparison. [An analysis](#) published in May, 2023 highlighted that decentralized storage, on average, is approximately **78% cheaper**

**than its centralized counterparts.** This price differential is even more pronounced in enterprise-grade data storage, where costs can be up to 121x higher. This disparity can be attributed to factors such as the significant capital investment required for centralized storage infrastructure and associated overhead expenses. Conversely, decentralized storage capitalizes on the availability of surplus computing resources worldwide. Moreover, while the centralized storage market is oligopolistic – with a few tech giants influencing pricing – the decentralized storage market is largely driven by open market forces.

In spite of its potential security loopholes and elevated costs, centralized storage still excels in certain areas, notably user experience and product maturity. These systems often offer interfaces that are more user-friendly for general users, complemented by a comprehensive product suite catering to various computing needs beyond mere storage. The amalgamation of user-friendly design and all-encompassing solutions has contributed to its continued dominance.

**Figure 4: Centralized vs. decentralized storage**

	<b>Security</b>	<b>Privacy</b>	<b>Cost</b>	<b>Ease of use</b>	<b>Maturity</b>
<b>Centralized</b>	Lower	Lower	Higher	Easy	Higher
<b>Decentralized</b>	Higher	Higher	Lower	Medium - High	Lower

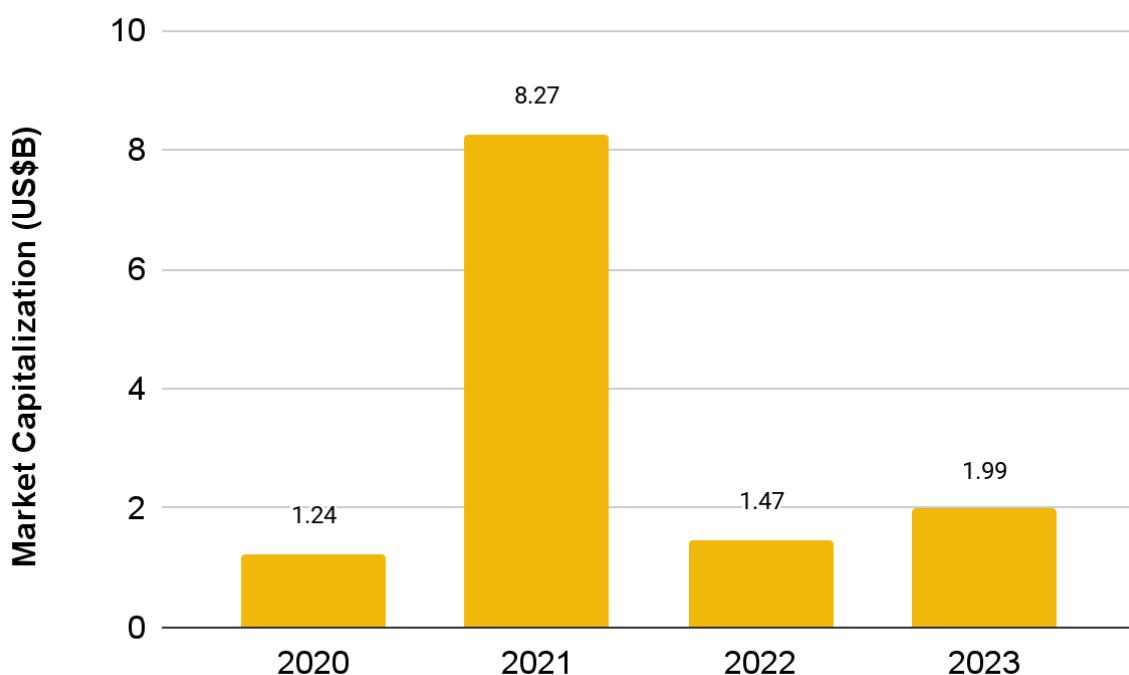
Source: Binance Research

# State of the Market

Kicking off this section, we first take a look at the market capitalization of notable projects in the decentralized storage sector.

The dStorage sector's market cap is predominantly captured by Filecoin, Arweave, Storj, and Sia Network. Other players in the landscape have a negligible market cap. Collectively, these four have spearheaded a remarkable ascent in the sector's market cap during 2021, peaking at US\$8.27B. The meteoric 560% rise can be attributed to the bullish market trend this year. However, the gains in 2021 were followed by a significant dip in 2022's bearish market phase, plummeting the market cap by roughly 83% to US\$1.47B. At the time of writing, the sector's total market cap hovers around US\$1.9B. Yet, considering the starting point in 2020, the sector still exhibits a modest growth of 60%<sup>(1)</sup> in its market cap to date.

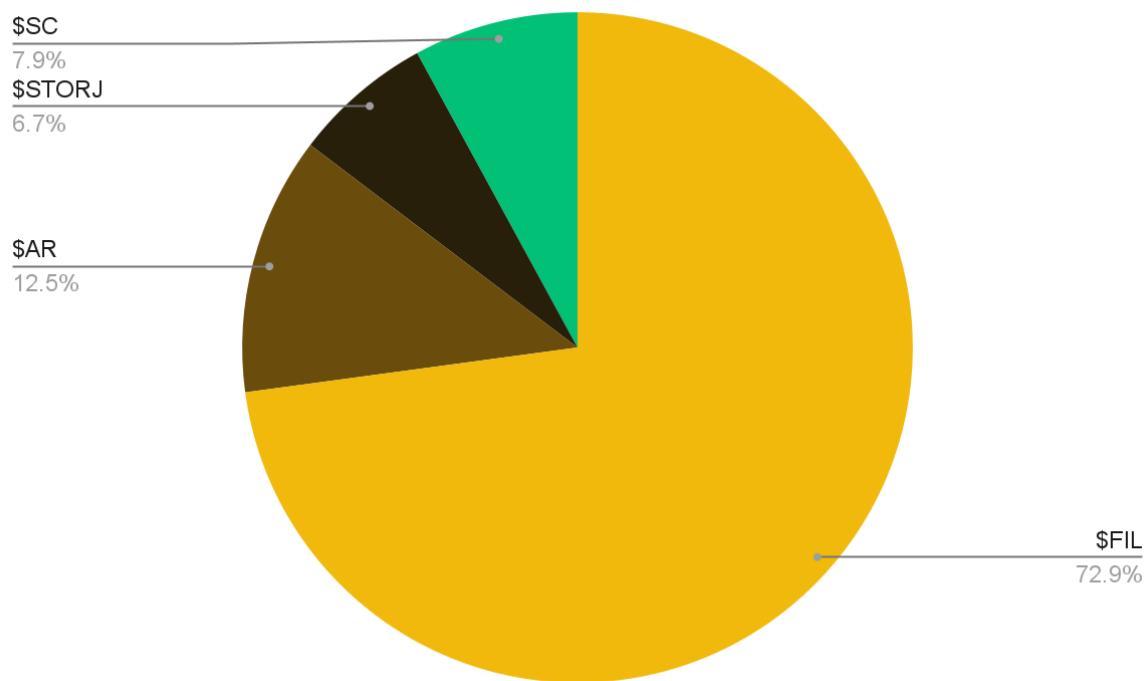
**Figure 5: The dStorage sector market cap has exhibited a growth of 60% since 2020**



Source: CoinMarketCap, Binance Research, as of October 19, 2023

Filecoin is the leading entity in the dStorage sector, capturing 73% of the sector's market cap. Despite an approximate 82% dip from its peak, Filecoin's valuation remains nearly 6x that of its nearest competitor, Arweave. Its substantial market cap hints at a strong valuation, liquidity and a vast user base.

**Figure 6: Filecoin captures 73% of the sector's market cap**



Source: CoinMarketCap, Binance Research, as of October 19, 2023

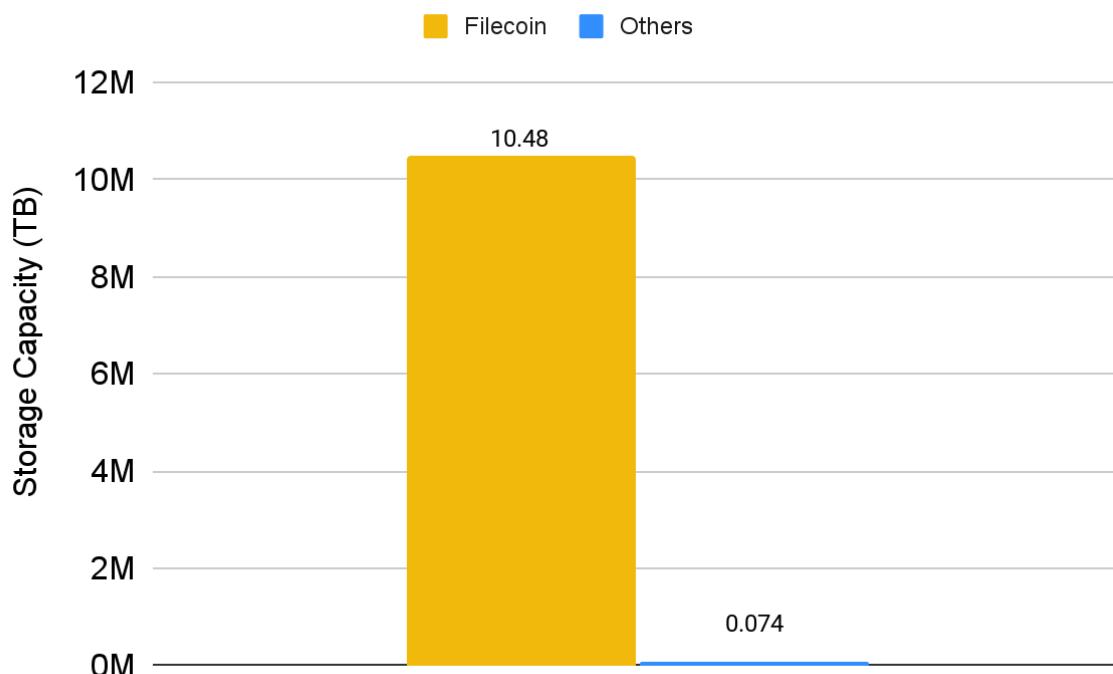
But when BNB is factored into the mix, the landscape shifts dramatically. BNB alone accounts for an immense 94% of the total market cap, overshadowing all, including the dominant Filecoin. However, this dominance doesn't directly translate into BNB's efficacy as a storage network. Its market cap is bolstered by its dual role as both the native token of BSC and Binance's platform token. As a recent entrant in the dStorage sector, it is too early to judge BNB's actual performance in this domain. Rather, we have brought up this point about BNB's market cap to provide an additional perspective for evaluation, rather than as a definitive assessment of capability.

4.1

## A Look at Storage Capacity

Storage capacity, which is indicative of the volume of data a network can store, is a crucial metric for decentralized storage networks. **Filecoin leads the race with a total storage capacity of 10.48M TB compared to the collective 0.074M TB of its peers, illustrating a striking 150-fold difference.** This vast difference mirrors the situation in market cap, where Filecoin emerges as the top-valued project.

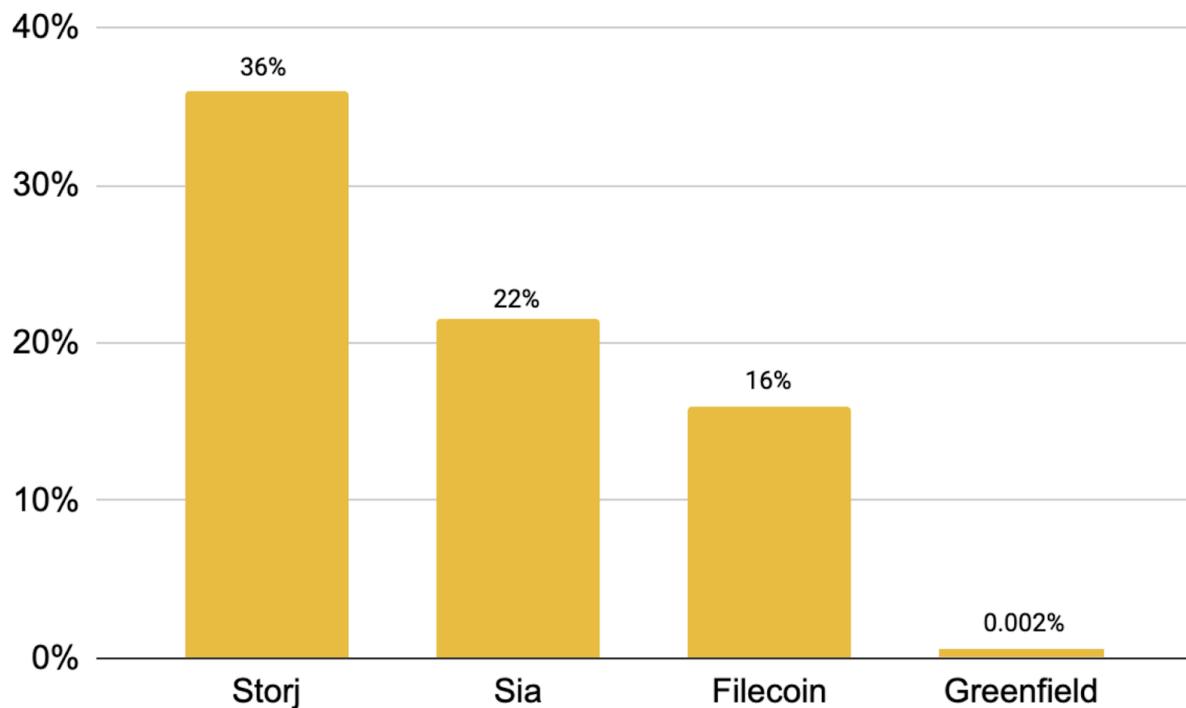
**Figure 8: Filecoin holds the most storage capacity among its peers**



Source: Starboard, ViewBlock, Storjstats, Siascan, Binance Research, as of October 19, 2023

Storj tops the list in terms of utilization with a 36% rate, likely due to its enterprise-centric strategy and its compatibility with Amazon S3. Meanwhile, Filecoin has experienced a tenfold yearly increase in utilization, moving from 1.56% last year to 16% today. For BNB Greenfield, it is not surprising that its utilization rate remains lower than others considering its recent launch at the time of writing, just a few days ago. Due to its unique design, Arweave's utilization rate is at a constant 100% and is not included in this comparison.

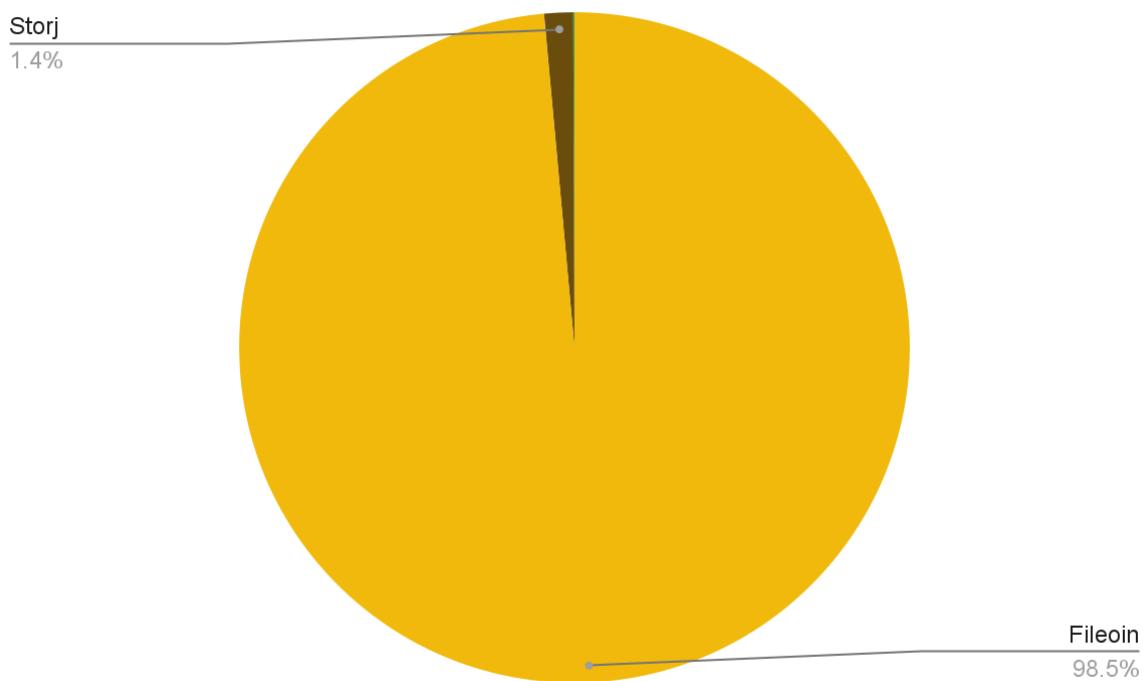
**Figure 9: Storj leads with a utilization rate of 36%**



Source: Starboard, Storjstats, Siascan, Binance Research, as of October 19, 2023

Regarding used storage market share, Filecoin's dominance persists, capturing 98.5% of the used storage market. Storj follows, storing about 1.4% while Arweave, Sia, and Greenfield combined account for 1,050 TB, equating to 0.1% of the market share.

**Figure 10: Filecoin accounts for 98.5% of used storage market share**



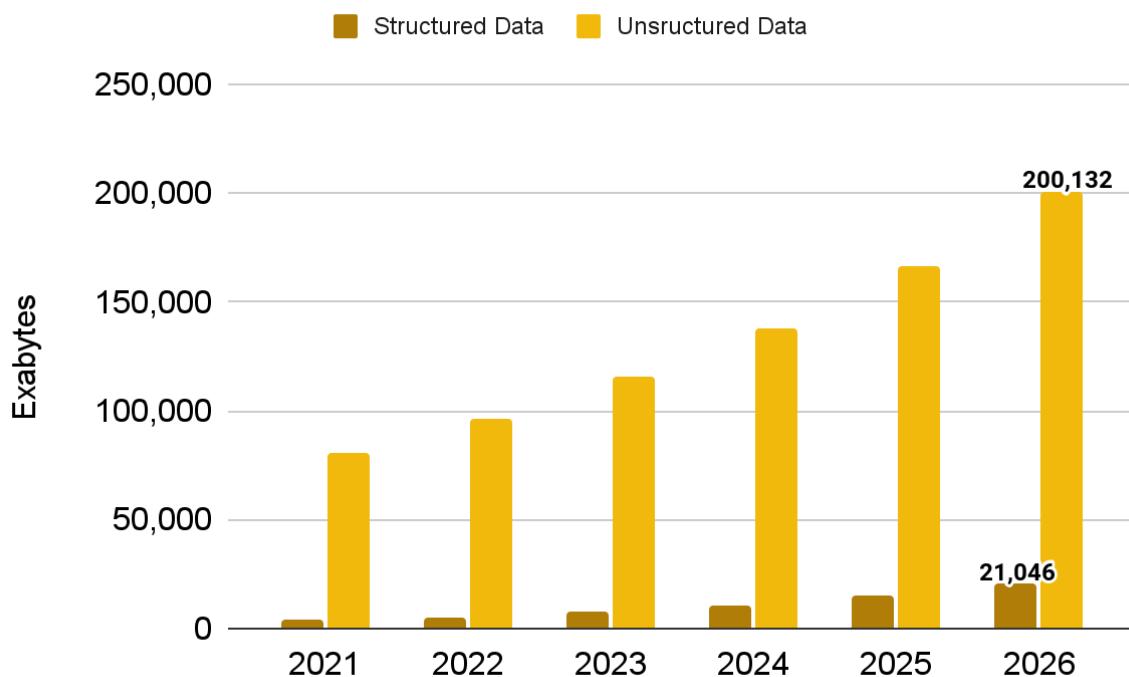
Source: Starboard, ViewBlock, Storjstats, Siascan, Binance Research, as of October 19, 2023

4.2

## Outlook of dStorage

In recent years, we've witnessed a seismic shift towards a digitally-centric world, with data creation rates skyrocketing. According to the International Data Corporation ("IDC") Global DataSphere Forecast<sup>(2)</sup>, it is estimated that the global data creation will touch approximately 221,000 exabyte (EB) by 2026. To break that down, 1 EB equals 1,048,576 TB. This means that by 2026, the global data volume will be an astounding 231.7B TB. This vast quantity underscores the enormous Total Addressable Market ("TAM") for dStorage protocols.

**Figure 11: The amount of data is expected to reach 221,000 EB by 2026**



Source: IDC, Binance Research

Presently, the total storage utilized by dStorage protocols stands at about 1.6 EB. In the conservative scenarios of dStorage protocols capturing just 0.25%, 0.5%, or 1% of the projected 221,000 EB in the coming years, they could potentially store 552.5, 1,105, or 2,210 EB of data. This suggests a remarkable growth of 345x, 690x, or 1360x from the current figures, emphasizing the significant potential of the sector.

Yet, this is a simplified way to gauge the potential growth of dStorage. Real-word adoption is influenced by a myriad of factors. Therefore, this analysis can be considered as a macro-level perspective rather than a definitive prediction.

# Major Ecosystem Players

To demonstrate how dStorage protocols operate, we highlight a few market participants and their respective unique features in this section.

Note that the mention of specific projects does not constitute an endorsement or recommendation by Binance. Instead, the projects cited are merely used for the purposes of illustrating the business models of dStorage protocols. Additional due diligence should be taken to better understand the projects and associated risks.

## Filecoin

Introduced by Protocol Labs, Filecoin is a dStorage network built atop its proprietary L1 blockchain. Functioning as an **incentivization layer of IPFS**, the protocol cultivates a decentralized marketplace for data storage and retrieval. It achieves this by incentivizing the contribution of unused computational resources through cryptoeconomics. A standout feature of Filecoin is the Filecoin Virtual Machine (“FVM”), which introduces programmability to the protocol, thereby expanding the chain’s ecosystem and fostering a more dynamic decentralized data economy.

### Business Model

To utilize Filecoin’s storage service, users first identify suitable SPs and then negotiate a deal, a service agreement stipulating terms such as data size, price, and storage duration. Once finalized, the deal is recorded on-chain, holding the SP publicly accountable for the deal.

To guarantee that the contract is honored, SPs must initially prove that they have accurately replicated the client’s data, which is verified using the PoRep. Subsequently, they must periodically confirm the continued accessibility of the client’s data through the PoSt. SPs are mandated to deposit collateral as a security measure against potential breaches of contract.

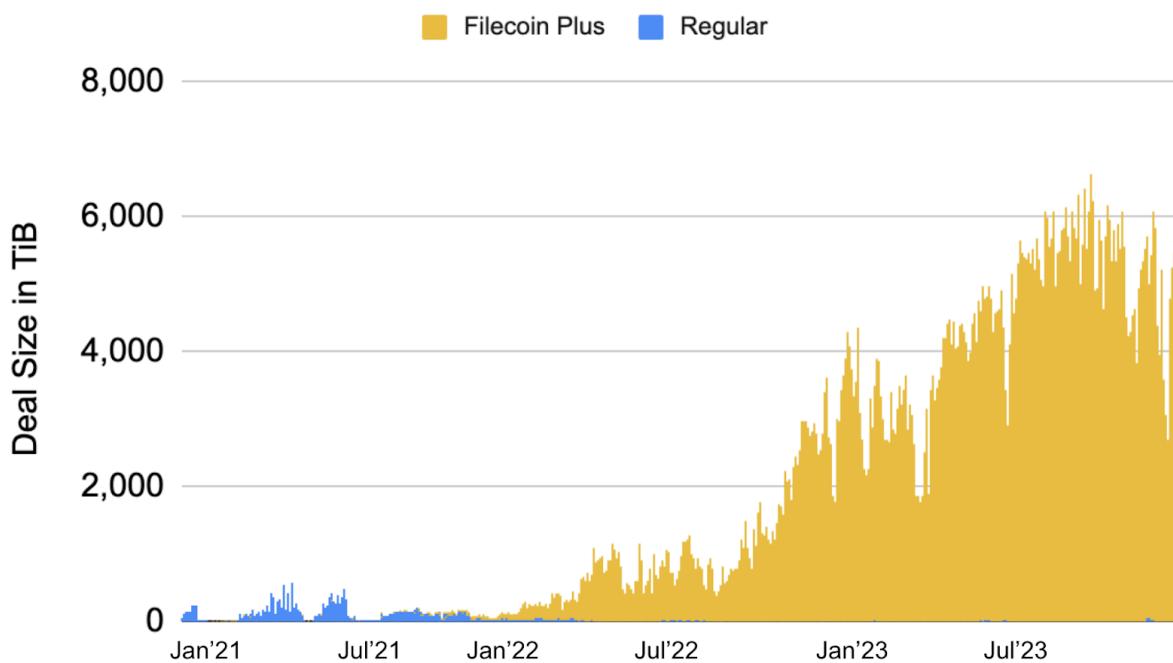
Additionally, SPs are also incentivized through block rewards. Their likelihood of being chosen by the network to mine new blocks is proportional to their storage power contribution; the higher their storage power, the greater their chances of being selected for block mining.

At the core of Filecoin’s economic structure is its native token, \$FIL. It facilitates all the platform’s transactions, with users paying storage and retrieval services using \$FIL, and storage providers receiving block rewards and depositing their collateral in the same token, powering the platform’s economics.

❖ **Filecoin Plus:**

- Filecoin Plus is an initiative designed to optimize the utility of storage on Filecoin, aligning with its vision of serving as a decentralized storage network for humanity's most valuable information.
- SPs are incentivized to store data from verified clients in return for boosted storage power, which in turn amplifies the block rewards they earn.
- Owing to the elevated rewards, Filecoin Plus deals have become the predominant choice for SPs. Since 2022, these deals have accounted for nearly 100% of all deals on Filecoin.

**Figure 12: Filecoin Plus deals have accounted for nearly 100% of the platform's deals**

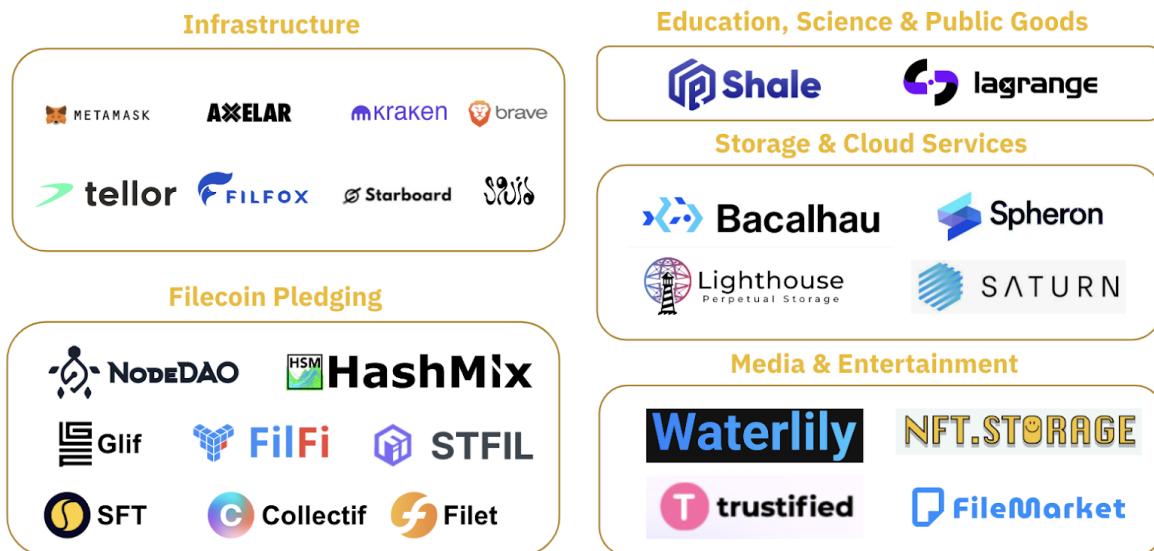


Source: Starboard, Binance Research, as of October 19, 2023

❖ **Filecoin Virtual Machine (FVM):**

- Launched in March 2023, the FVM serves as an execution environment tailored for smart contracts with the Filecoin network, paving the way for a more advanced data economy that capitalizes on Filecoin's foundational storage and retrieval market.
- The introduction of FVM aims to unlock a plethora of use cases. Some of these include native decentralized computation, Data DAOs, tokenized datasets, as well as a DeFi-driven data market.
- Since its inception, FVM has witnessed over 2,500 smart contracts being deployed, and the Filecoin blockchain has attracted over US\$80M in TVL (inclusive of liquid staking).

Figure 13: Decentralized applications built on top of Filecoin



Source: Filecoin, Binance Research

## Arweave

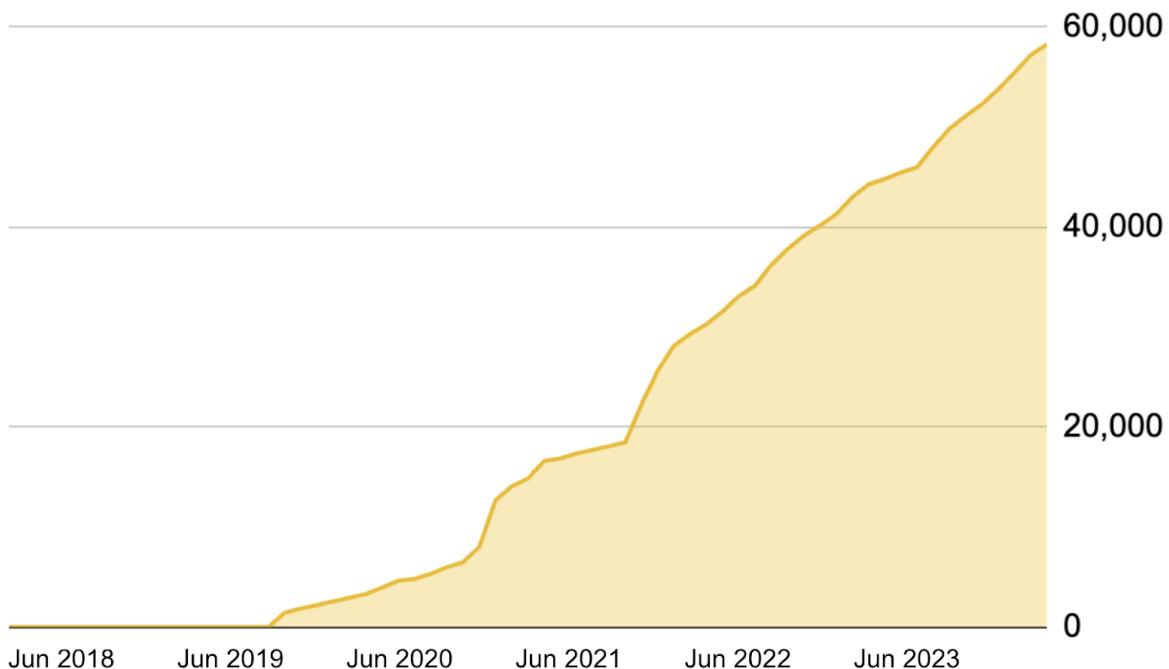
Arweave is a decentralized storage network tailored for permanent storage. The promised perpetuity is facilitated by Arweave's distinctive blockchain-like architecture known as the Blockweave, paired with its consensus mechanism, Succinct Proof of Random Access ("SPoRA"). The longevity of data storage is sustained by a Storage Endowment fund. Additionally, Arweave features Permaweb, a decentralized web application environment built on the Arweave network, cultivating an ecosystem that spans across multiple verticals.

### Business Model

Data storage on Arweave is secured by a network of miners within its blockweave structure. Miners' primary incentives are block rewards and transaction fees, propelled by Arweave's SPoRA. As miners are required to have access to specific recall blocks when mining new blocks, they are incentivized to store extensive data to optimize their profits. The current SPoRA is an evolution of the original Proof of Access. It is introduced to boost data retrieval speeds and curtail network energy consumption.

To achieve true perpetuity, Arweave established a Storage Endowment fund as a complementary financial incentive mechanism. When users upload data to Arweave, they pay a transaction fee, with 86% of this fee contributing to the endowment fund. The fund will compensate miners in situations such as block rewards are not enough to cover miners' costs, thus offering a sustainable incentive for long-term data storage.

**Figure 14: The Endowment fund has witnessed a growth of 140% over the past two years**



Source: ViewBlock.io, Binance Research, as of October 19, 2023

Transactions within the Arweave network uses \$AR, the platform's native token. To counterbalance the volatility of \$AR, a stability mechanism is employed. This mechanism, using network difficulty and inflation rewards as two core pricing components, adjusts the storage fee in response to \$AR value fluctuations, ensuring a stable storage price.

❖ **Arweave Bundle:**

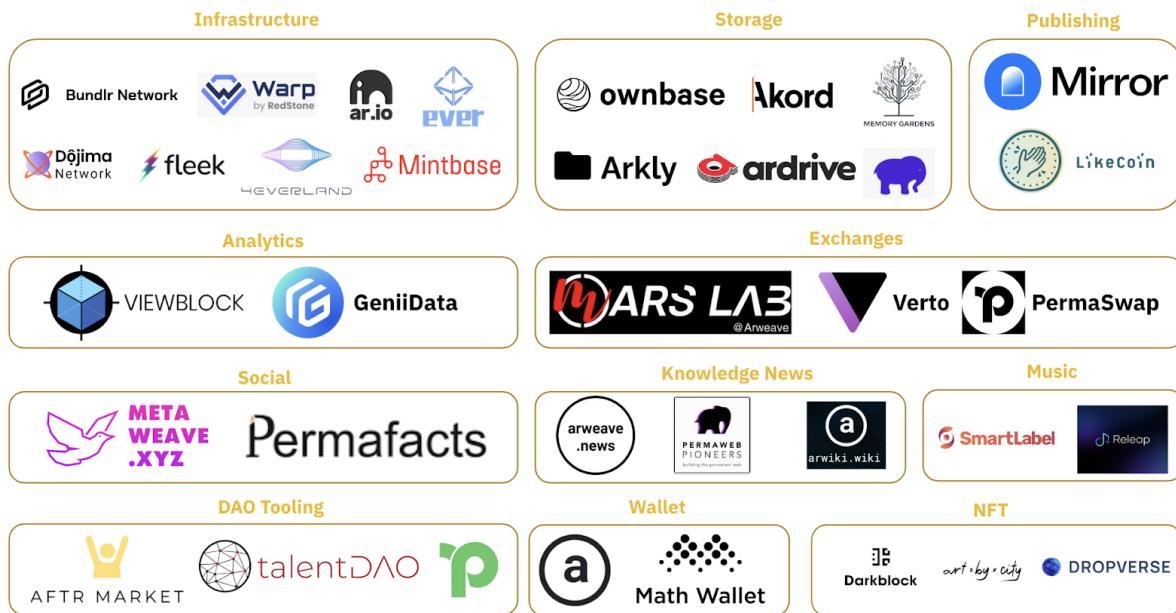
- Launched in September 2021, Arweave Bundle is a feature designed to boost the network's scalability.
- Much like Ethereum's rollup approach, Bundle consolidates multiple transactions into a single batch before submitting to Arweave chain, enhancing the overall capacity.
- This gives rise to 'Bundler' services, entities that group user transactions and submit them as a unified Arweave transaction. With bundlers accepting currencies beyond just \$AR, a broader user base can utilize Arweave for data storage.

❖ **Permaweb:**

- Permaweb is an ecosystem constructed atop Arweave Layer-1 ("L1") chain, enabling developers to create decentralized web applications that have immutable storage on Arweave's blockweave.

- Users make transactions in \$AR to engage with the PermaWeb applications. These applications encompass a wide range of sectors, from exchanges and social platforms, to NFTs, music, storage, and more.
- To stimulate ecosystem growth, Arweave introduced Profit Sharing Tokens (“PSTs”). Developers utilizing PSTs earn a tip every time a user processes a transaction through their web applications.

**Figure 15: A look at Arweave ecosystem**



Source: Warp Contracts, Binance Research

## Storj

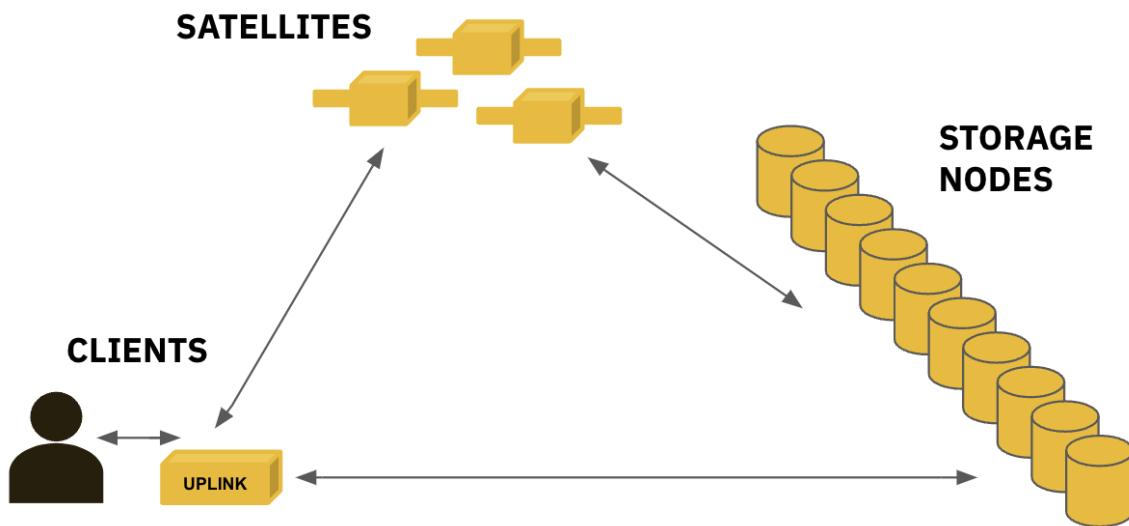
Storj operates as a decentralized cloud storage protocol on the Ethereum blockchain. It harnesses unused hard drive space and bandwidth from a global network of nodes to deliver its cloud storage service. Aiming to excel in the broader cloud storage market, Storj also provides enterprise-level services designed to surpass the performance of traditional Web2 alternatives and offers Amazon S3 compatibility to reduce transition costs for its users.

### Business Model

On Storj, storage nodes are rewarded in \$STORJ, the protocol’s native token, for offering their storage capacity and bandwidth. These nodes accrue fees in three distinct situations: hosting data for users, supplying egress bandwidth for user data downloads, and providing egress bandwidth for satellite file retrievals. When a file is uploaded to Storj, it undergoes encryption before being erasure-coded. This process divides the data into 80 shards, spreading them across a minimum of 80 nodes. To reconstruct the original file, only 29 of these shards are required.

Acting as intermediaries between storage nodes and users are entities known as satellites. These satellites play a crucial role in maintaining the network's efficiency, chiefly overseeing data audit and repair, and handling storage node payments. The audit procedure ensures node reliability by verifying the accurate return of requested data. Furthermore, a reputation is in place, where satellites can disqualify non-adhering nodes. Nodes have the liberty to dissociate from underperforming satellites.

**Figure 16: The three main peer classes in Storj**



Source: Storj, Binance Research

To address potential data accessibility issues arising from fluctuating node participation, Storj employs a phased payment model. Storage nodes are compensated incrementally: 25% for the initial three months of data storage, followed by another 25% for the subsequent three months<sup>(3)</sup>, and so on. This structure aims to encourage nodes committed to long-term participation and decrease the likelihood of data disruptions from nodes abruptly exiting the network.

## BNB Greenfield

BNB Greenfield, the third blockchain in the BNB Chain ecosystem, is a storage-centric blockchain supported by an array of SPs. Designed to serve as the foundational storage for both the BNB ecosystem and EVM-compatible addresses, Greenfield distinguishes itself through its **innate integration with the BNB Chain**. This unique linkage allows it to capitalize on BNB Chain's expansive DeFi ecosystem and its substantial developer community.

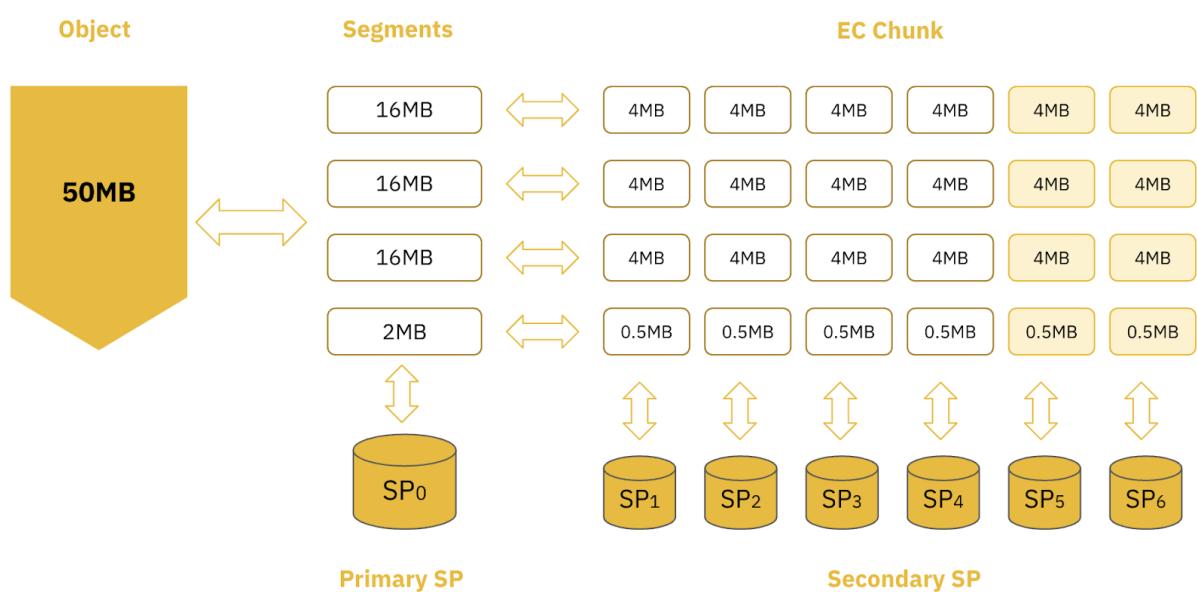
### Business Model

BNB Greenfield operates on a dual-layer architecture: a PoS-based blockchain safeguarded by \$BNB-staking validators and a storage network maintained by storage nodes. The role of the validators is to store meta-data on-chain, validate data availability, and secure the

Greenfield chain. In contrast, SPs handle the actual storage of data and offer various storage services.

These SPs are required to stake an amount of \$BNB that correlates to their storage volume, serving as a commitment mechanism to ensure reliable service. There are two kinds of SPs: primary and secondary. In Greenfield, users create a storage structure called bucket to store their uploaded objects. These objects are broken down into segments based on size. Every bucket is linked to one primary SP that is responsible for all segments within that bucket. Greenfield employs erasure coding for data redundancy. Therefore, each segment is split into four data chunks and two parity chunks, which are then stored by secondary SPs. For organization and clarity in responsibility, SPs are grouped virtually. Each group contains one primary and several secondary providers, and each object is tied to a particular group. To ensure data remains intact and accessible, the Proof of Challenge module is utilized. Events, either initiated by users or occurring randomly, prompt validators to confirm that specific data segments or pieces are effectively stored by the assigned SPs. SPs that can't meet the challenge are penalized.

**Figure 17: How a 50MB object is stored in BNB Greenfield**



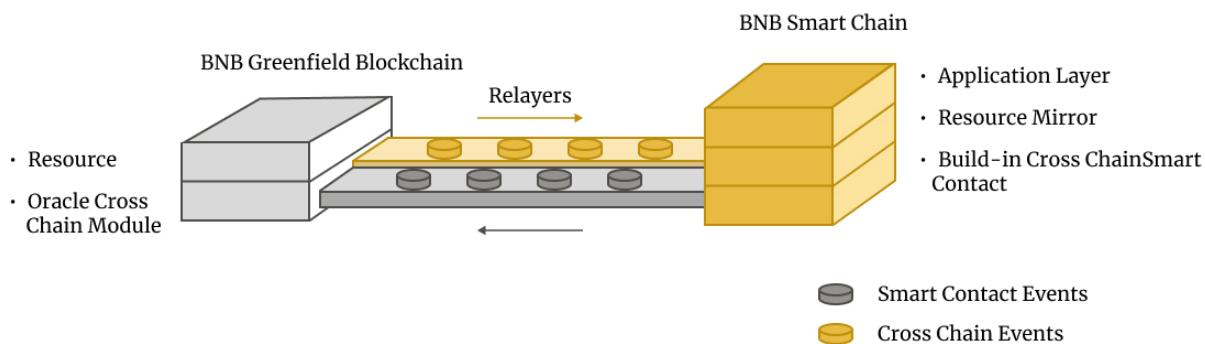
Source: BNB Greenfield, Binance Research

The network utilizes \$BNB for various purposes: staking, gas fees, and storage payments. Storage fees are applied in a continuous payment manner, influenced by parameters like size, replica count, base price ratio, and others. Users must ensure they have enough \$BNB in their payment accounts. Once funds are depleted, the service quality for the associated objects will be reduced. If the situation persists, the SP might permanently delete the stored data.

### ❖ **Cross-Chain Programmability:**

- BNB Greenfield boasts a unique cross-chain programmability, distinguishing it in the landscape. This capability allows users to integrate their data with financial applications in the BSC ecosystem.
- The bedrock of this cross-chain function is the native cross-chain bridge, coupled with a relayer system, bridging Greenfield and BNB Chain. These components collectively facilitate the interaction between the two ecosystems.

**Figure 18: BNB Greenfield's cross-chain architecture**



Source: BNB Greenfield

### ❖ **SocialFi Infrastructure:**

- Greenfield holds the capacity of serving as the foundational layer for SocialFi applications, amplifying the power of user-generated content.
- By harnessing Greenfield as a base layer, dApps can offer Key Opinion Leaders (“KOL”) an environment immune to censorship, enhancing the reach and impact of KOL-driven fandom and social networks. Crucially, this ensures all data remains under the exclusive control of its creators.

## Protocol Comparison

Overall, each protocol showcases unique attributes and designs. Acting as an incentive layer atop IPFS, Filecoin employs the system's decentralized model and CID feature to furnish quality storage services. Through the use of cryptoeconomics, the Filecoin team has established a data market catering to storage and retrieval demands. Two key strengths of the protocol are its competitive storage fee and expansive network scale.

Arweave, with its distinctive design, offers perpetual data storage, making it apt for saving valuable data like NFT metadata. This was highlighted last year when Meta chose Arweave to archive creators' digital collectibles<sup>(4)</sup>. However, protocols such as Filecoin and BNB Greenfield can offer similar perpetual storage capabilities via smart contract functionality. While these might not be as steadfast, given their reliance on incentives, they could appeal to some of the users due to varying factors, such as cost.

Storj's mission is clear: to surpass centralized storage services like AWS. Its strategy has been successful, reflected in its leading network utilization rate. However, it's worth noting that the protocol's operation relies heavily on satellites, intermediaries that coordinate SPs and end-users. This introduces centralization and risks the possibility of a single point of failure.

The introduction of BNB Greenfield has the potential to change the dStorage landscape with its unique cross-chain programmability. The native connection allows Greenfield to leverage BNB Chain's robust ecosystem, thereby fostering a new data economy driven by DeFi activities. Considering the market is often driven by speculative sentiment, this new type of data economy can elevate the dStorage sector, attracting both attention and liquidity.

Another dimension to ponder upon is token utility. While \$FIL, \$AR, and \$STORJ primarily serves as base currencies for their platforms, **\$BNB is utilized across the expansive DeFi landscape** and is also an exchange platform token, enjoying benefits like launchpad accessibility and yield. This might influence newcomers in deciding which network to join.

Regarding storage cost, it's important to highlight that the high cost of Greenfield is counterbalanced by its performance. **Users experience Web2-caliber speed and latency**, and they even have the capability to set up a website directly on the platform.

**Figure 17: Comparative table showcasing key features and metrics**

				
	Filecoin	Arweave	Storj	BNB Greenfield
<b>Key Features</b>				
Native Chain	Filecoin Chain	Blockweave	Ethereum	Greenfield Chain
Token	\$FIL	\$AR	\$STORJ	\$BNB
Consensus	Proof of Storage	SPoRA	Proof of Stake	Proof of Stake
Redundancy	Replication	Replication	Erasure Coding	Erasure Coding
Data Availability	PoSt	SPoRA	Satellite Audit	Proof of Challenge
Data Persistence	Fixed-Term	Permanent	Fixed-Term	Fixed-Term
Programmability	FVM	SmarWeave	No	EVM-Compatible
<b>Storage Metrics</b>				
Storage Usage	1.6 / 10 EB	138.4 / 138.4 TB	23.3 / 66.4 PB	127.3 GB / 7 PB
Cost (TB/Month)	\$0.19	\$3.6K (perpetual)	\$4.00	\$23.00

Source: Filecoin, Arweave, Storj, BNB Greenfield, Binance Research, as of October 19, 2023

# Challenges Ahead

Decentralized Storage, despite its promising value proposition and vast addressable market, isn't devoid of challenges that impact its wider adoption.

- ❖ **Volatile nature of digital assets:** The unpredictability associated with cryptocurrency poses a barrier to potential entrants. SPs and miners receive compensation in the protocol's native token that is subjected to frequent and significant price swings, introducing additional uncertainties. While hedging strategies may be applied, they necessitate a solid grasp of financial instruments, placing novice participants at a disadvantage.
- ❖ **User experience:** Centralized storage services like Google Drive and AWS offer an accessible & user-friendly experience. In contrast, dStorage platforms are often more complicated and require users to delve into their intricacies. The general user base may be disincentivized to explore and understand these nuances when more straightforward alternatives are readily available.
- ❖ **Product offering:** While centralized entities present comprehensive solutions that cater to a range of client demands, dStorage networks are often limited to basic storage, a shortcoming that decreases the appeal of dStorage.
- ❖ **Public perception:** Awareness plays a pivotal role in the adoption trajectory of dStorage. Even though dStorage offers tangible benefits over its centralized counterparts, it remains relatively obscure beyond the Web3 sphere. This limited visibility primarily stems from the broader public's unfamiliarity with blockchain technology, coupled with the intricate nature of digital assets. Consequently, only a small segment of the population currently appreciates the merits of decentralized storage.

Collectively, these barriers impede the mainstream adoption of dStorage networks. Overcoming them demands a prolonged, industry-wide initiative. The roadmap to success involves refining the UI/UX, enhancing functionality, and boosting public recognition of these platforms. Ultimately, **the broader public's priorities lean toward easy access and convenience** rather than the abstract notion of decentralization.

# Closing Thoughts

Utilizing a blend of peer-to-peer models, consensus algorithms, and incentivization, dStorage effectively counters many vulnerabilities found in centralized storage systems. However, the complexities of blockchain technology can often act as a barrier, disincentivizing potential users. Moreover, the mainstream populace largely leans toward easily accessible and user-friendly solutions, resulting in centralized systems continuing to dominate. Yet, the compelling advantages and a vast TAM of dStorage suggest a bright outlook for these decentralized protocols.

Surveying the present landscape, each protocol demonstrates unique attributes, catering to diverse user preferences. Filecoin has established itself as a dominant force with its network scale. Concurrently, both Arweave and Storj have carved out their own niches with sharp product positioning. The advent of BNB Greenfield could be a pivotal breakthrough for the sector. Existing users already recognize the benefits of dStorage, but enticing new users might necessitate additional incentives. **Yield and speculation opportunities could be potent catalysts.** Therefore, Greenfield's capacity to harmonize data with DeFi applications might well ignite renewed market enthusiasm, enticing fresh capital inflow and another wave of new users.

Given the inevitable growth of data in our digital-driven world, dStorage, as a bedrock of the burgeoning Web3 ecosystem, is brimming with potential. While it's premature to crown definitive market leaders, one thing is clear: **the accelerating growth of global data and rising interest in blockchain technology** offer a robust tailwind for the sustained expansion of the dStorage sector.

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