OCTOBER 2024

Arweave Report

Valour Insights powered by
Reflexivity Research

valour | REFLEXIVITY RESEARCH

About the Authors

Valour

Valour Inc. and Valour Digital Securities Limited (together, "Valour") is a trusted leader in issuing exchange-traded products ("ETPs") that enable retail and institutional investors to access digital assets like Ethereum in a simple and secure way via their traditional bank account. Valour is part of the asset management business line of DeFi Technologies Inc. (CBOE CA: DEFI) (GR: R9B) (OTC: DEFTF). Backed by a globally esteemed team of experts with extensive experience in financial markets and digital assets, we are committed to revolutionising the way individuals and institutions interact with the evolving digital asset ecosystem.

Reflexivity Research

Reflexivity Research is one of the fastest growing research firms in the disruptive world of blockchain and cryptocurrencies. The company, founded by Will Clemente and Anthony Pompliano and acquired by DeFi Technologies Inc., aims to provide crypto-native research in easily digestible formats for traditional finance (TradFi) investors. Since launch, Reflexivity Research has partnered with some of the largest financial companies in the world and counts readers across major hedge funds, public company C-Suites and the most respected family offices. You can subscribe at www.reflexivityresearch.com

Table of Contents

Introduction

Arweave is a decentralized data storage network attempting to provide solutions to data impermanence on the internet. Arweave relies on its underlying technology, the Blockweave, which allows data to be stored across a distributed network. This ensures that the data is always available and secure. Unlike traditional blockchains, where each block only links to its predecessor, Arweave uses a unique design in which each block connects to the two previous blocks - one directly before it and one from the past, creating a web-like architecture.

The Arweave network is powered by its native AR token, which users utilize to pay for permanent data storage. AR is also a reward token given to miners who contribute their existing storage capacity on their local computers to the network. Other blockchain data solutions also use a similar model, but Arweave's is differentiated as users only need to pay a one-time fee to store data indefinitely, with the network covering storage costs for at least 200 years using a portion of the fees.

Overtop the Arweave network is the AO Computer (AO) - a decentralized, hyper-parallel computing system that introduces a modular, actor-oriented architecture to advance distributed computing capabilities. It enables parallel execution of processes, which allows it to scale indefinitely without bottlenecks. This is crucial for handling the growing demands of decentralized applications (dApps), particularly those involving complex computational workloads like AI models and smart contracts. AO was officially launched in February 2024 when the public testnet went live.

Why Decentralized Storage and Why Arweave?

Arweave is a decentralized data storage platform that leverages its underlying technology, called Blockweave, to offer permanent, immutable storage on the blockchain. Its primary utility is enabling long-term data preservation, removing the risk of data loss, censorship, or the need for recurring payments. This makes it especially suited for storing critical and large-scale data versus other existing solutions, both on-chain and off-chain.

Most data storage solutions, such as traditional cloud storage providers, are not necessarily set up for long-term storage as they rely on annual or month-to-month contracts, necessitating ongoing monitoring and maintenance. Arweave differentiates itself by focusing on providing true, long-term storage solutions that could be imperative for several entities, including AI companies, financial services, or government agencies. Arweave accomplishes this by incentivizing miners to store and replicate historical data across the network using a Proof of Access (PoA) mechanism. This system was upgraded to Succinct Proof of Random Access (SPoRA) in 2022, improving both security and data retrieval speed.

Key features of Arweave's data storage system include:

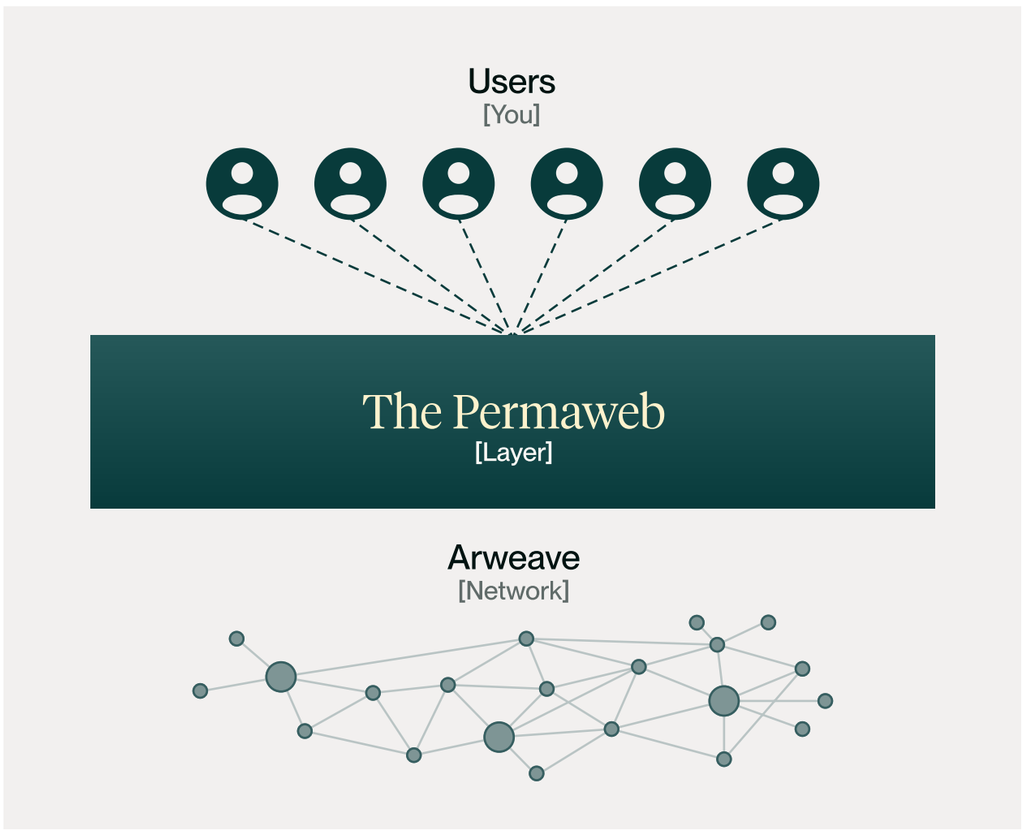
- **Permanent storage:** Users pay a one-time fee for indefinite data storage, which is supported by an endowment system that ensures miner incentives for the long term.
- **AR token:** The native currency that powers the network, used to pay for storage and reward miners for maintaining data integrity.

Decentralized infrastructure: Arweave removes the risk of centralized control over data by distributing storage responsibilities across a global network, ensuring data integrity, availability, and resilience against censorship

The Permaweb

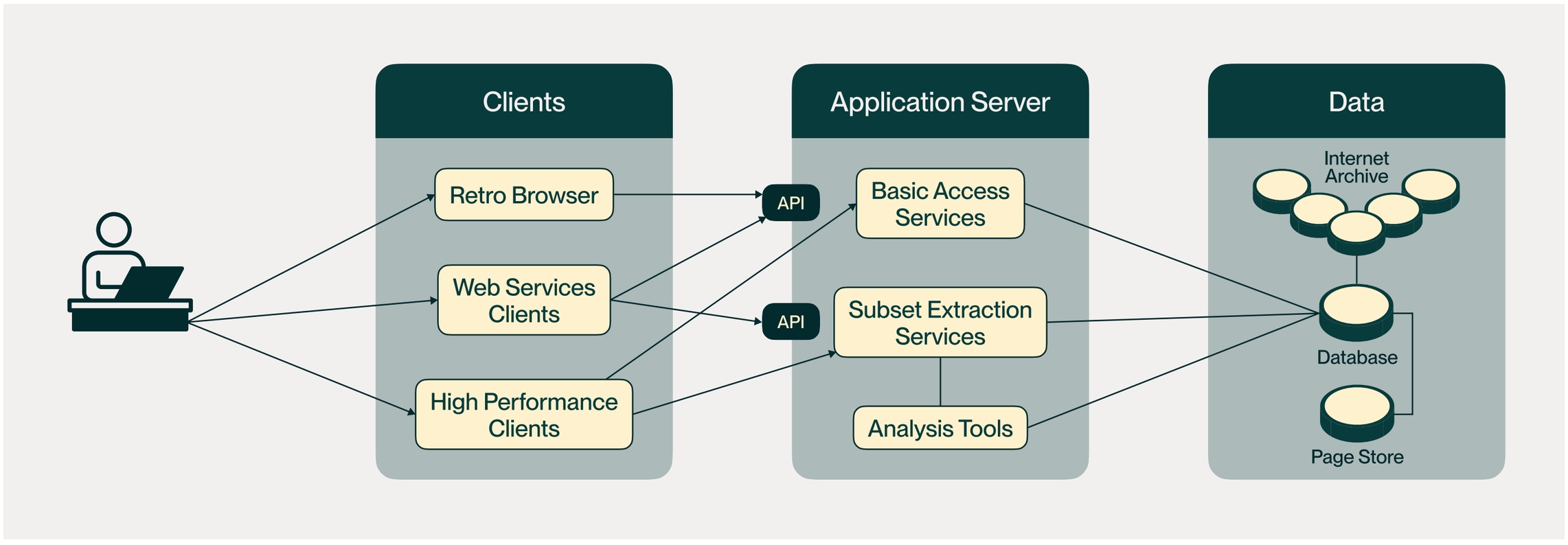
The Permaweb is Arweave's decentralized layer that allows developers to build dApps on top of the network, similar to how applications are built on the traditional web. This layer enables applications like permanent email, website hosting, and file storage. For example, Weavemail offers decentralized email, ArDrive provides file storage, and Spheron enables decentralized web hosting.

What distinguishes Permaweb from traditional cloud-based services is the immutability and resistance to censorship that Arweave's storage offers. This has drawn significant interest from developers seeking to store crucial NFT metadata and DeFi front ends permanently. For instance, the Solana-based Metaplex Candy Machine stores NFT metadata on Arweave, ensuring that digital collectibles retain their value without risk of data loss.



As of 2024, developers have built a wide range of dApps on the Permaweb, including email systems like Weavemail, file storage services like ArDrive, and hosting solutions like Spheron. These applications offer decentralized alternatives to centralized systems like Gmail, Dropbox, and GoDaddy, thereby enhancing the overall value proposition of the Arweave network.

To this end, the Permaweb has also become an essential tool for storing digital heritage and media archives, preserving important documents, research, and even digital cultural artifacts in an immutable, accessible format. This is somewhat similar to what the Internet Archive does for the broader internet, preserving legacy media, websites, files, and more.



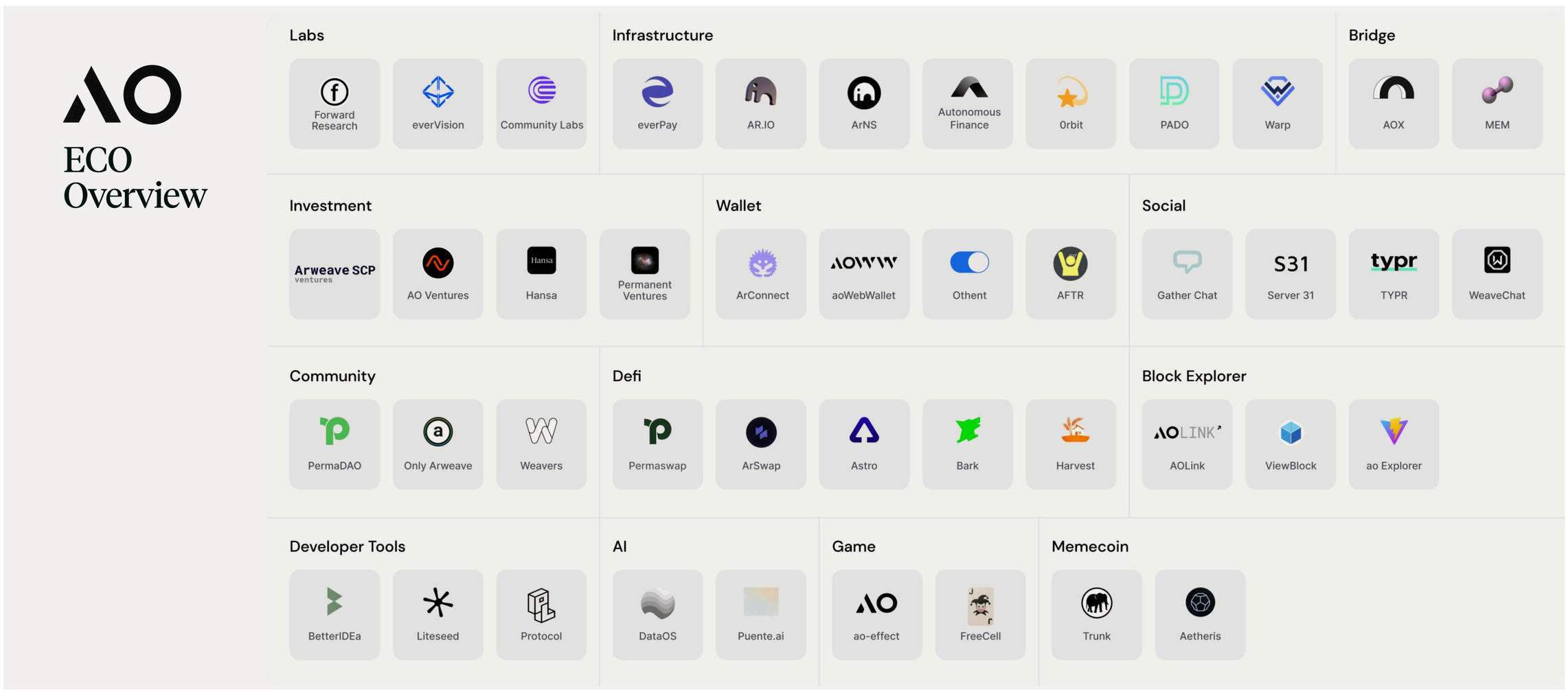
Use Cases Unlocked by AO

The introduction of the AO Computer in 2024 further expands Arweave's use cases by providing decentralized computing power alongside its storage capabilities. AO's hyper-parallel architecture is designed to handle complex workloads such as AI modeling, large-scale data processing, and decentralized applications that need robust computational power. This opens new possibilities for decentralized finance (DeFi), decentralized autonomous organizations (DAOs), and real-world assets (RWAs).

Some potential applications unlocked by AO include:

- **Autonomous agents:** Decentralized bots and AI programs that can operate autonomously on the blockchain, leveraging Arweave's verifiable on-chain compute.
- **Stablecoins and decentralized finance:** The Astro stablecoin uses Arweave's infrastructure to provide a decentralized, stable medium of exchange.
- **Decentralized data services:** Projects like DataOS offer blockchain data analytics through Arweave, unlocking better access to on-chain information

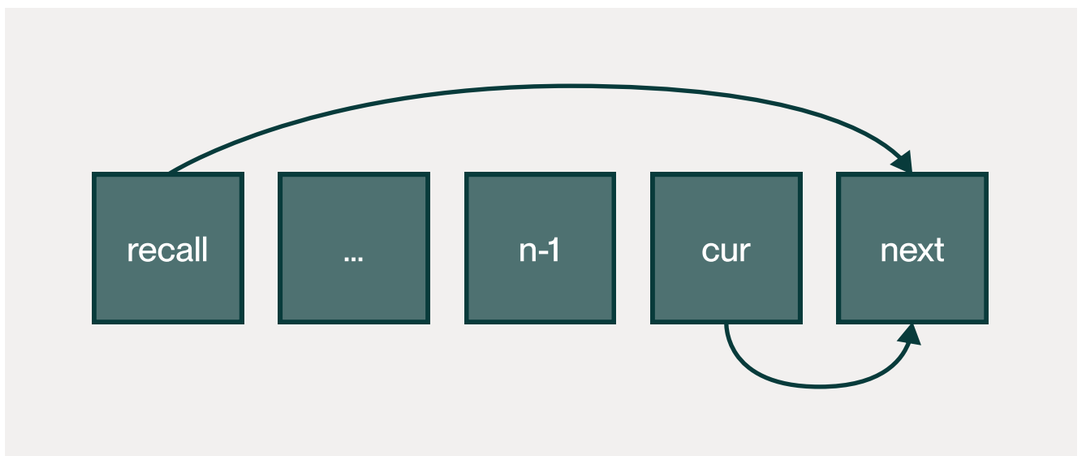
AO is particularly poised to make significant impacts on industries requiring scalable, decentralized computational resources, such as AI and financial technologies, giving Arweave a broader utility in the evolving Web3 ecosystem.



How Does Arweave Work?

Arweave's architecture is reliant on Blockweave. Blockweave enables permanent data storage by allowing users to interact with the network through gateways (i.e., arweave.net), which serve as entry points for uploading and retrieving data. Once data is uploaded, it becomes part of the Permaweb, allowing it to remain accessible and immutable. The unique combination of content-addressable storage and decentralized replication ensures that data is always available, resistant to censorship, and secure against alteration.

Blockweave itself is similar to a traditional blockchain but with key differences that make it optimized specifically for storage. Arweave's blockchain links each new block not only to the previous one but also to a randomly selected older block called a recall block. This dual linking structure ensures that older data is constantly validated, promoting redundancy and long-term preservation. This is integral in incentivizing miners to actually store and maintain access to historical data on the network. Essentially, Arweave's entire value proposition of long-term data accessibility and transparency relies on the recall block design.



Miners must prove they can access this recall block to mine a new one. This mechanism serves several important purposes:

- **Data Redundancy and Permanence:**
  The system encourages widespread replication of all data by requiring miners to access data from random points in the block weave's history.

- **Incentivizing Storage of Rare Blocks:**
  Miners are more likely to receive mining rewards if they store blocks that are not widely replicated (i.e., "rare" blocks). When a rare block is chosen as a recall block, fewer miners can compete for the reward, so those who have stored it have a better chance of winning.

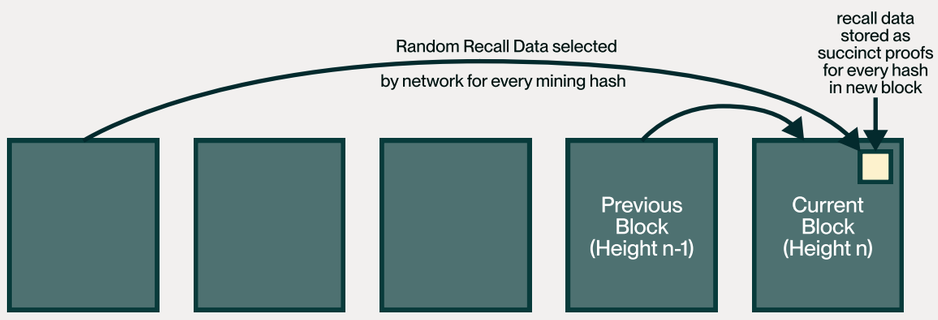
- **Security and Integrity:**
  The use of a recall block makes it difficult for any miner to tamper with or alter the data in the Blockweave. If a miner tried to change a block, it would break the link to the recall block, making it evident that tampering had occurred.

Consensus Mechanism (SPoRA)

Arweave's Proof of Access (PoA) is the consensus mechanism that ensures data integrity across the Blockweave. PoA requires miners to provide cryptographic proof that they have access to data from previous blocks in the Blockweave. Specifically, to mine a new block, miners must demonstrate access to a randomly selected recall block from the network's history, incentivizing them to store a broader range of older data.

In 2022, Arweave updated its PoA system with Succinct Proofs of Random Access (SPoRA). This upgrade addressed some of the challenges of PoA, such as slow data retrieval and centralization risks from miners using remote storage solutions. SPoRA improves the system by adding a performance dimension to the consensus mechanism: miners are rewarded based on both their access to data and the speed at which they can retrieve it.

SPoRA prevents centralization by discouraging the use of remote storage and ensures that miners who keep data "close" to their nodes have a better chance of earning rewards. The protocol aligns incentives with performance, ensuring that the network remains fast and decentralized while maintaining the permanence of stored data.



Succinct Proof of Random Access (SPoRA)

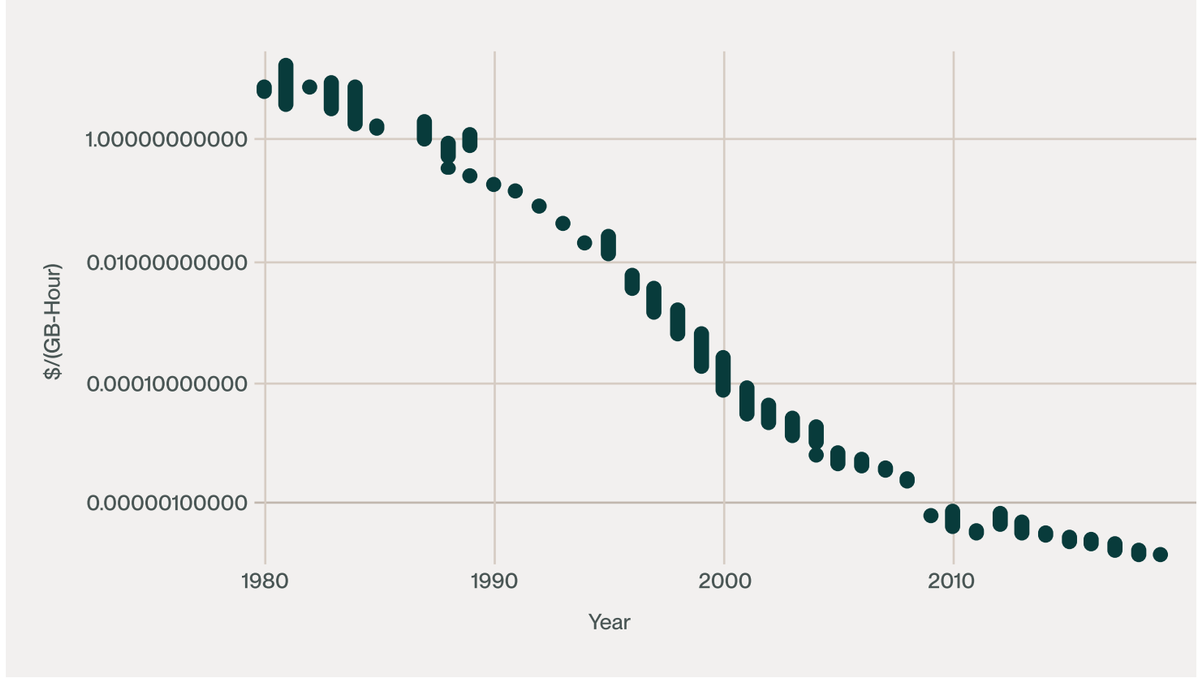
AR Tokenomics

Arweave's economic model is centered around the AR token, which is used to pay for storage. The AR token itself has a maximum supply of 66 million tokens, with nearly all (65.4 million) currently in circulation. When it launched, the AR token supply was set at 55 million tokens, but it has since inflated to its current supply.

Miners supporting Arweave are compensated through transaction fees, inflationary token emissions, and endowment payments. This is critically important, as miners should be expected to sell off their earnings to cover their operational expenses (such as electricity, hardware, and other overheads). This creates selling pressure on AR. However, because the endowment fund largely collects transaction fees as AR is used, it actually reduces the circulating supply on the market as tokens become locked up in the endowment. In short, while miner activity creates short-term selling pressure, the design of the endowment and the long-term deflationary assumption of storage costs provide a counterbalance.

Arweave has gone to great lengths to develop its tokenomics model carefully. First, users interested in utilizing the Arweave network must pay a one-time fee in AR, which grants them 200 years of storage. The proceeds are primarily allocated to a storage endowment. This endowment is used to cover the costs indefinitely as storage prices on the network decline (in theory). The assumption here is based on historical data, which shows that storage costs have dropped by just over 30% annually.

Storage costs, $/GB-Hour (log scale)
1980 - present



The idea is that, as technology advances, the cost to store data becomes progressively cheaper due to improvements in hardware efficiency, higher-density storage devices, and economies of scale. This deflationary trend in storage costs is fundamental to Arweave's model of paying for 200 years of data storage upfront in a single transaction. So, is this a solid assumption for Arweave to make?

For traditional data storage, data storage costs have been massively deflationary. Over the past several decades, storage technology (i.e., hard drives, flash memory) has followed a predictable trajectory of becoming cheaper and more efficient. Innovations in materials science, data compression, and manufacturing processes have driven this trend. Likewise, advances in storage density and cloud infrastructure have consistently driven down the cost per gigabyte of storage. Now, how does this relate to Arweave?

Remember that miners are the primary storage providers for the entirety of Arweave's distributed network, leveraging the storage capabilities of their individual devices for prospective on-chain customers. As the costs of data storage decline for traditional devices, this corresponds to cheaper storage costs for on-chain users. However, this also assumes that Arweave's own network capacity will continue to increase.

While the assumption of deflationary data costs has historically held up, there is no guarantee that this trend will continue indefinitely. If storage costs were to stagnate or even increase due to factors like supply chain constraints on the Arweave network, the Arweave economic model could face challenges. The endowment set aside to cover the long-term costs might not be sufficient. This could force miners to seek higher fees to maintain profitability, potentially increasing costs for users.

AO Computer

AO is an advanced initiative built overtop Arweave that enables parallel processing of dApps through a modular architecture that allows users to select their own virtual machines (VMs), sequencing models, and security protocols. This highly robust, customizable architecture is designed to scale massively while maintaining trustlessness and transparency, key qualities necessary for modern dApp design and functionality.

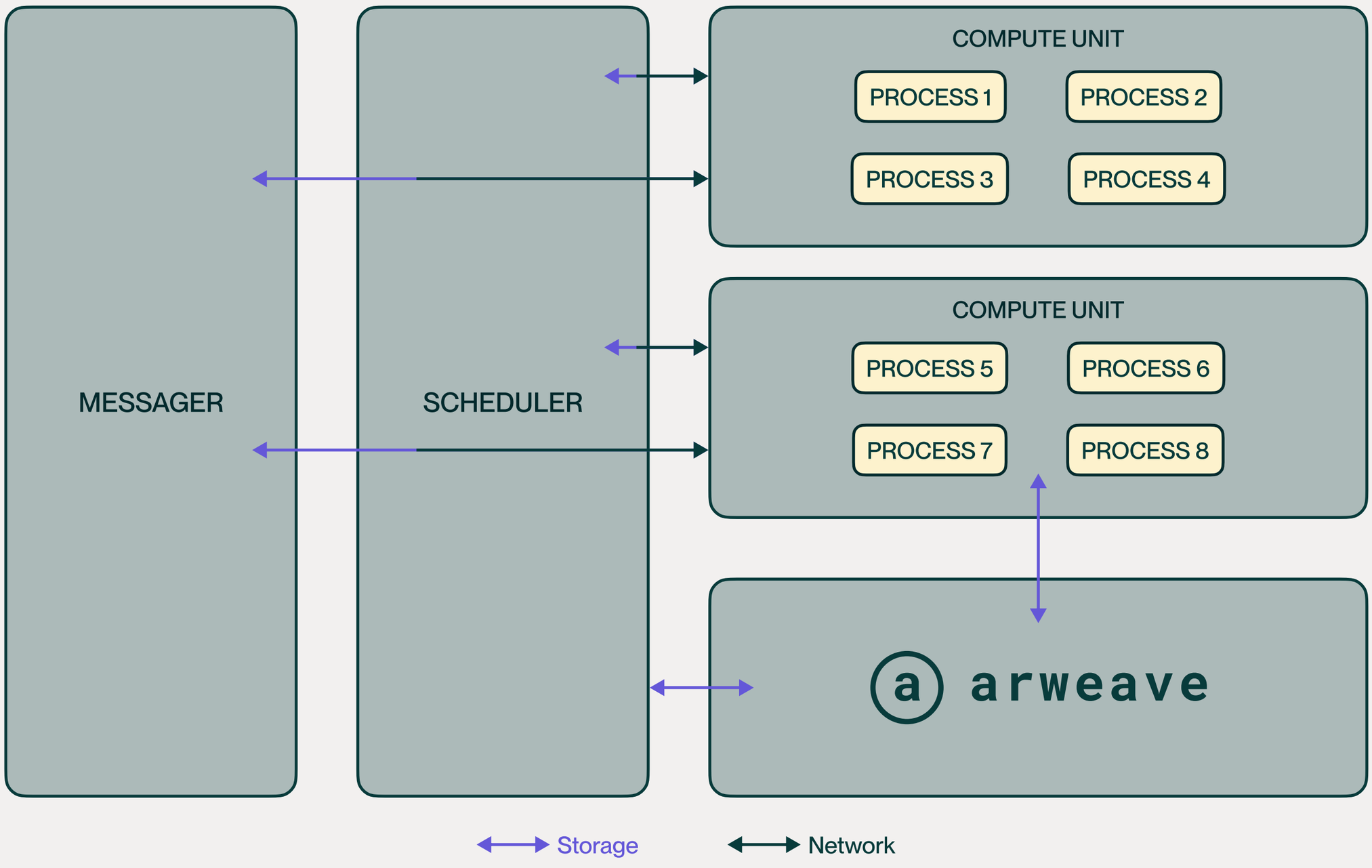
At its core, AO operates as a single, unified computing environment for developers, allowing for multiple independent processes to run simultaneously and communicate with one another. By localizing the state to each application, AO creates more efficient computation and the ability to run a higher number of parallel processes.

AO Architecture

AO's architectural design is purposely established to support actor-oriented processes, where each process operates independently but communicates with others through a message-passing system. This is relatively similar to the relationship between roll-ups and data availability (DA) layers, with AO enabling processes to interact without needing to access each other's state, creating highly scalable parallelization.

AO Architecture Diagram

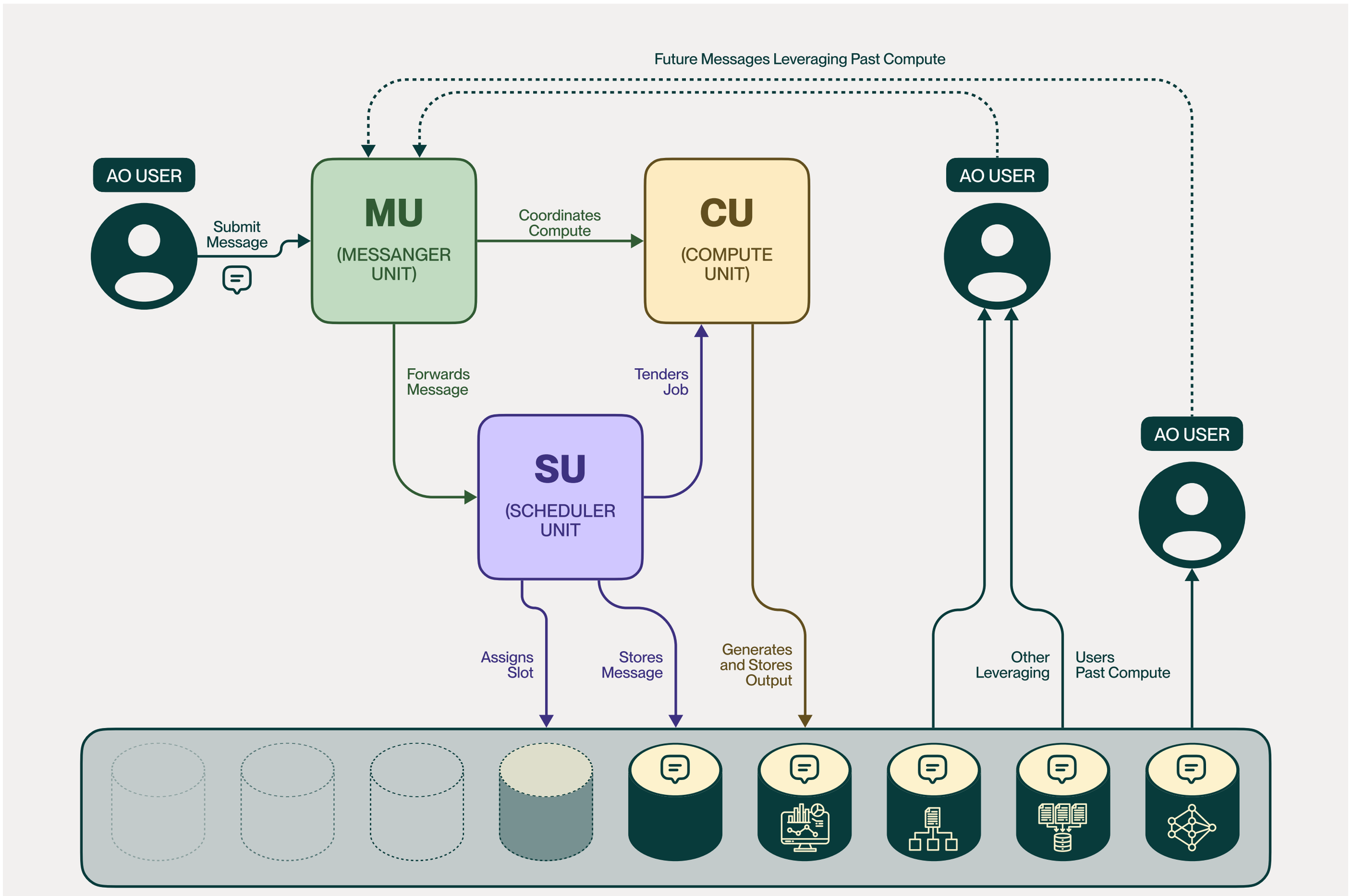
Source: coinlive.com



Several key components make message-passing possible:

1. **Message Creation and Dispatch:**
   When a process wants to interact with another process, it creates a message. This message contains relevant data such as the sender, target, and a unique identifier (message ID). It also includes a cryptographic signature to ensure authenticity.
2. **Messenger Units (MUs):**
   Once a message is created, it is sent to a Messenger Unit (MU), which is responsible for relaying it to the correct destination process. The MU ensures the message is signed properly and verifies its origin before passing it on.
3. **Scheduler Units (SUs):**
   The message is then forwarded to a Scheduler Unit (SU), which plays a role similar to a sequencer. It assigns a nonce (a unique sequence number) and epoch to the message, ensuring that all messages are ordered and timestamped correctly. The SU then stores the message on Arweave for permanence.
4. **Compute Units (CUs):**
   The message is processed by a Compute Unit (CU), which executes the required computation or action based on the message's content. CUs work in a competitive environment, where they can choose which processes to execute, adding flexibility to the system.

Result Retrieval: Once the computation is complete, the CU returns a signed attestation of the result back to the MU. This allows the originating process to retrieve the output of the computation from the Scheduler Unit using the message ID.



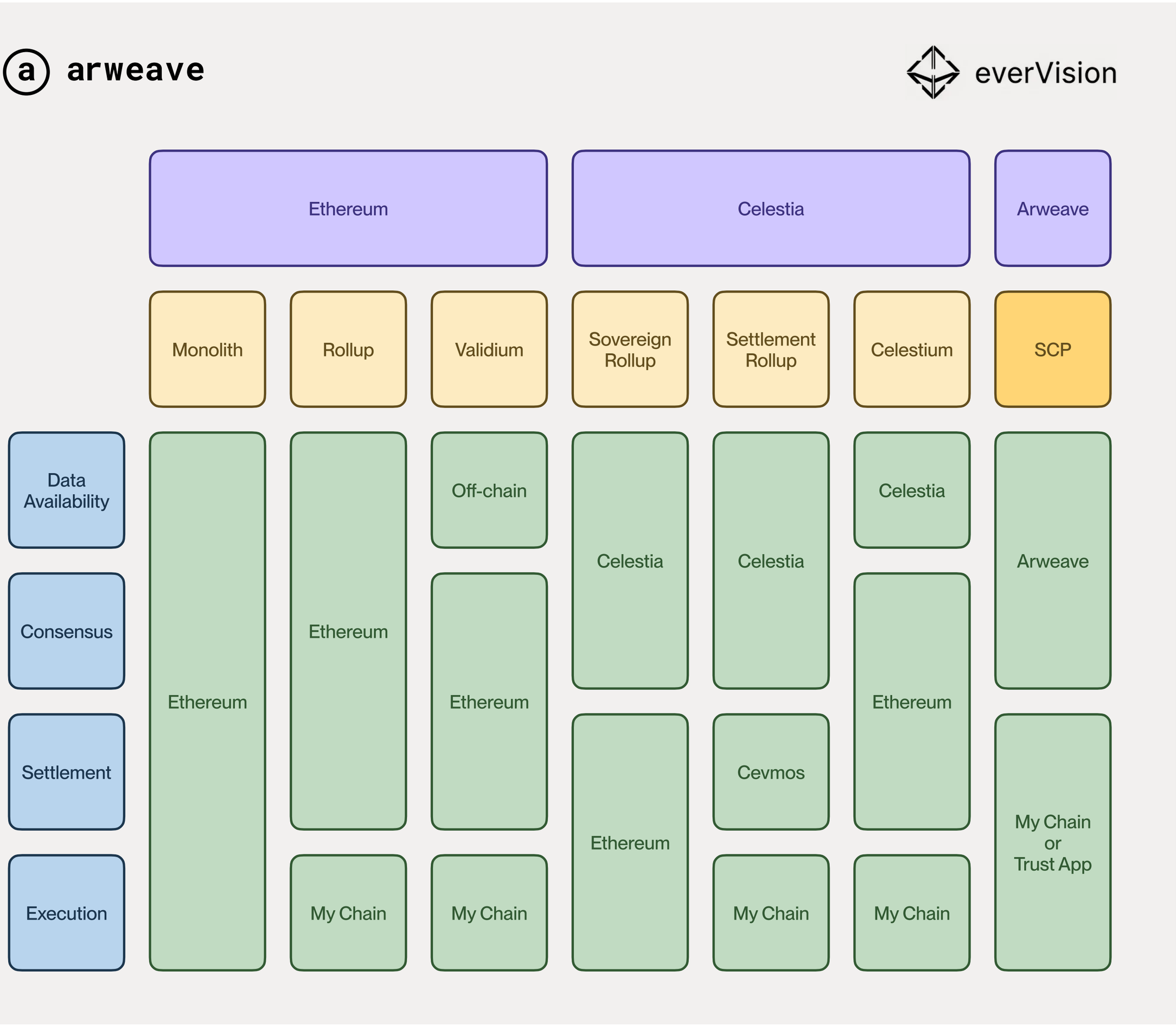
The entire system operates on ANS-104 protocol messages, ensuring that all interactions are verifiable, traceable, and permanently stored on Arweave. This design not only allows for scalability but also provides trust-minimized interoperability between processes.

What is Storage-based Consensus Paradigm (SCP)

The storage-based consensus paradigm (SCP) is a concept introduced by Arweave to separate computation from storage, enabling a more scalable, efficient, and secure system for dApps. SCP relies on off-chain computation using Arweave strictly for permanent data storage.

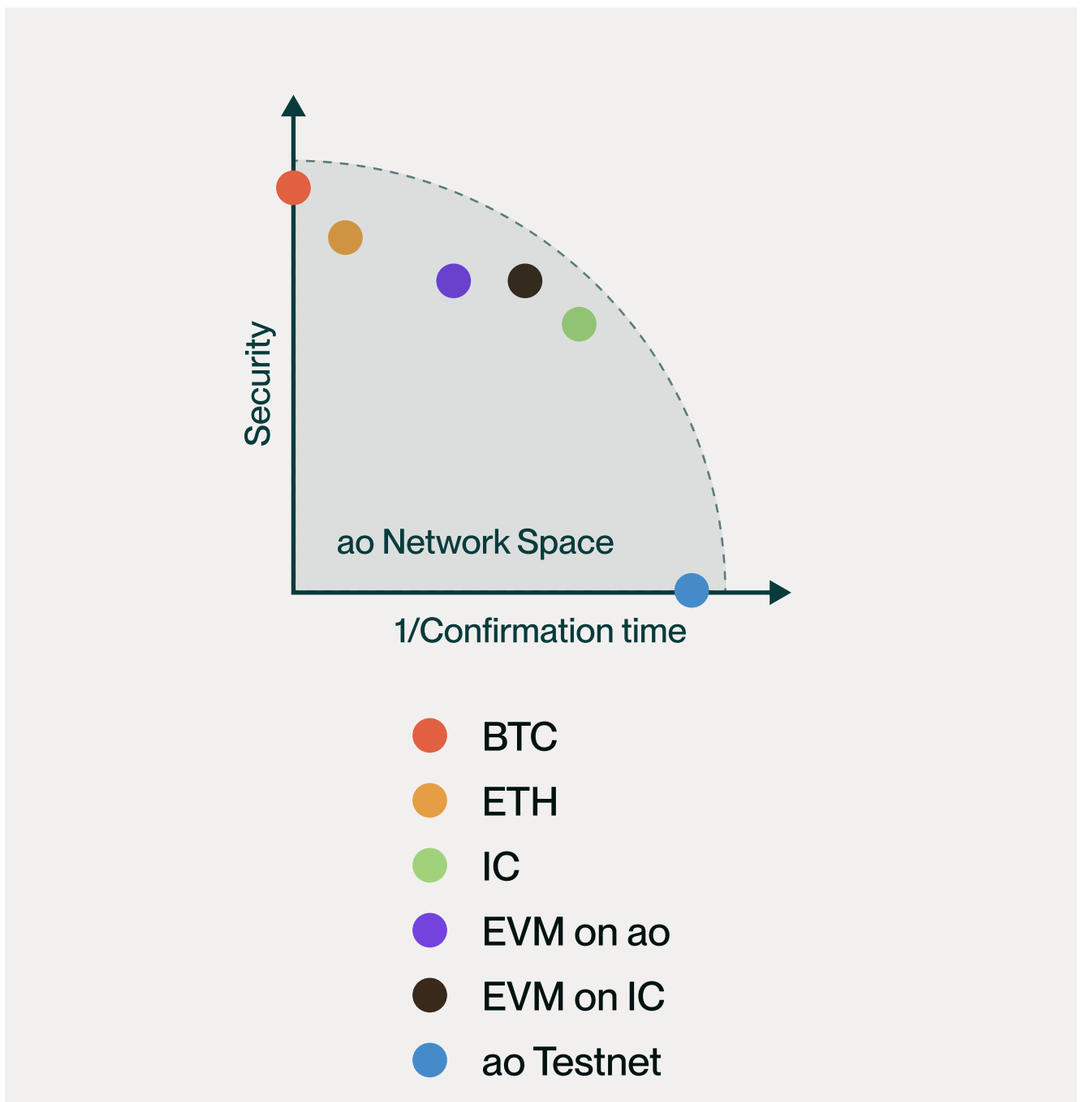
In SCP, Arweave more or less acts like a decentralized hard drive. Off-chain clients (i.e., nodes and servers) handle the computation, boosting scalability considerably as computation can occur on virtually any device without burdening the actual blockchain. By keeping just the data on-chain, SCP guarantees the immutability and verifiability of stored information. Additionally, SCP allows developers to use any programming language for off-chain computations, eliminating the need to rely on specialized languages like Solidity in Ethereum. This makes development easier, enabling the seamless transformation of traditional applications into decentralized ones.

Some of the early implementations of SCP are evident in projects like everPay, which leverages Arweave's storage to facilitate fast, gas-free payments. Other projects like KYVE also use SCP to manage data reliability for various blockchain ecosystems. SCP's ability to combine the transparency of blockchain with the efficiency of traditional computing makes it ideal for a wide range of applications, from financial services to decentralized storage.



What about Verifiability?

Verifiability in AO is achieved through a decentralized system that allows any process or user to verify computational outputs using the stored logs of interactions on Arweave. While computations are performed off-chain, the results are stored on-chain, ensuring that any participant can reprocess the inputs to confirm the accuracy of the outputs.
In scenarios where high trust is required, AO can implement optimistic verification with staking and slashing mechanisms. Compute Units (CUs) can be required to verify the outputs of other CUs, ensuring that malicious actors are penalized and accurate results are incentivized. This modular security model enables different processes to select from a range of verification methods, including Proof of Stake, Proof of Authority, or advanced mechanisms such as zk-SNARKs, tailored to the specific needs of the application.

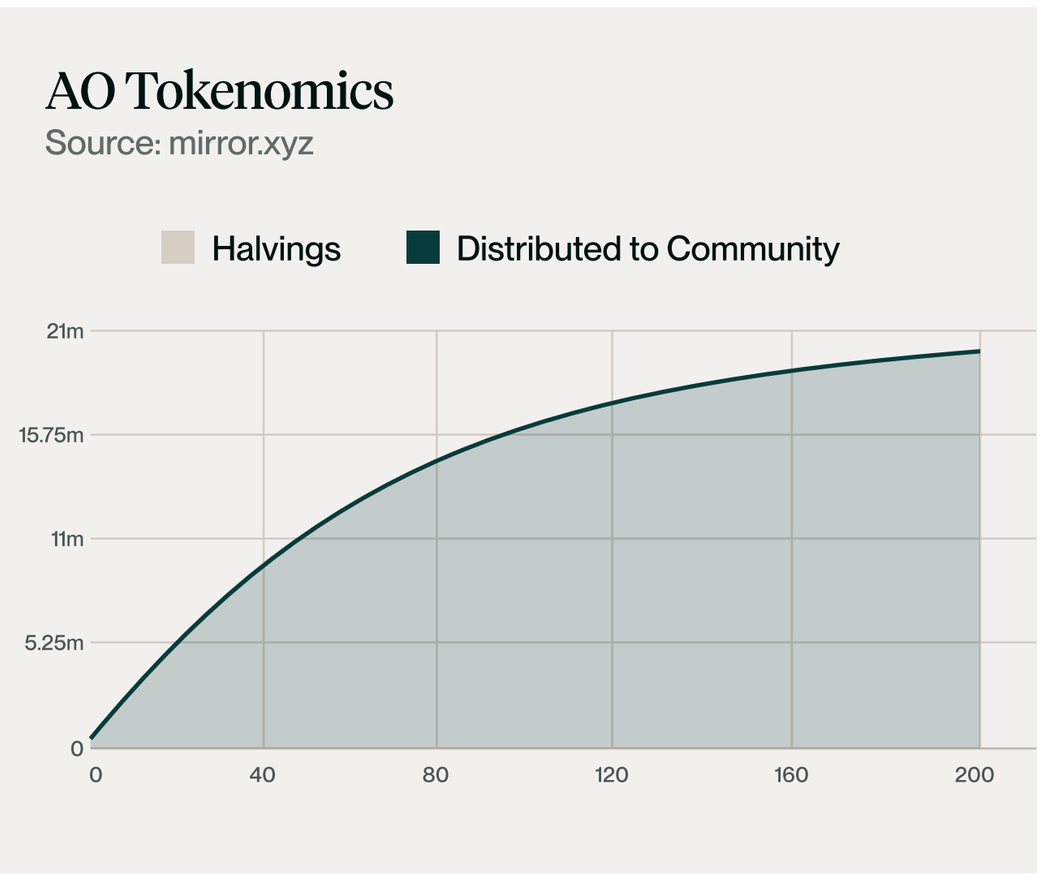


AO Economics

While connected to Arweave, AO offers its economic model and AO token. The AO token economics are structured similarly to Bitcoin's, with a total supply of 21 million tokens and a halving cycle every four years. However, unlike Bitcoin's sharp halving events, AO has a smooth emission curve where the number of new tokens minted decreases slightly every month. This creates a more gradual reduction in token issuance rather than sudden supply shocks.

AO Tokenomics

Source: mirror.xyz



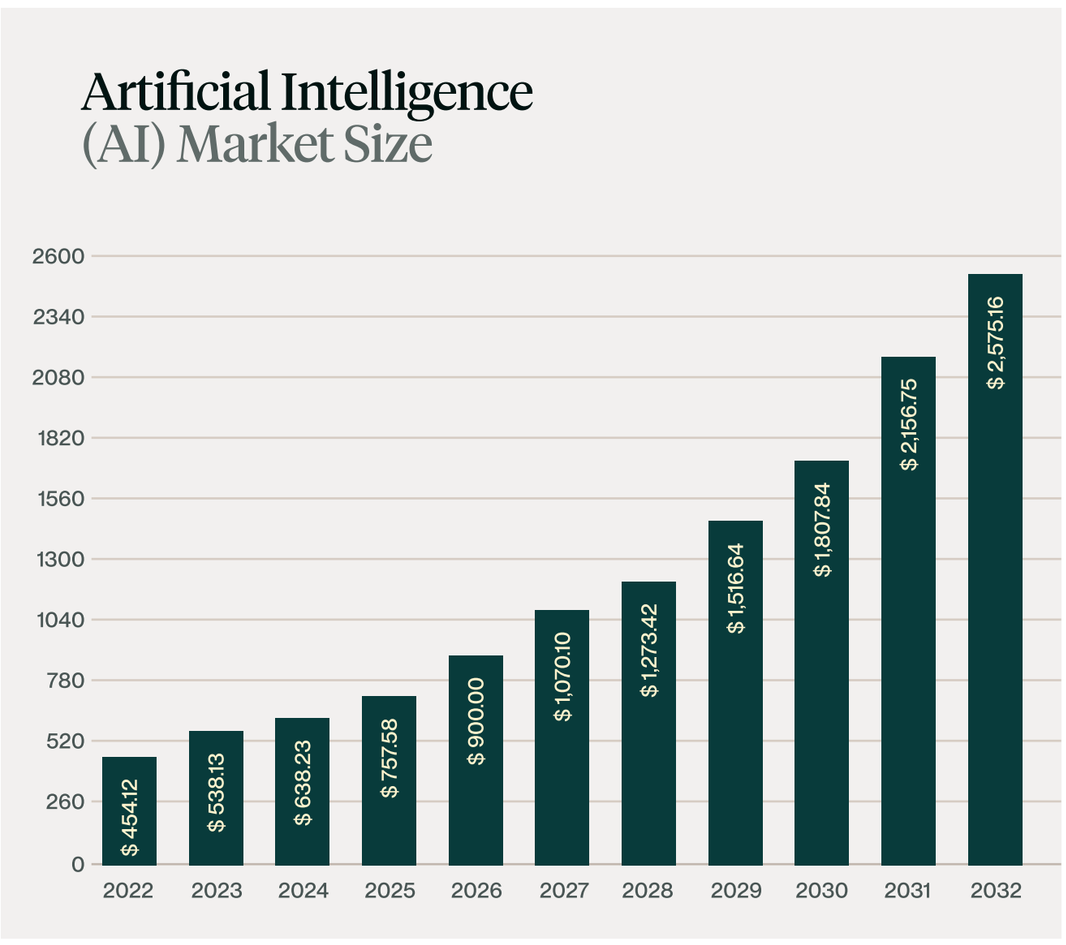
36% of the total AO supply is allocated to AR token holders, providing them with an additional incentive for holding AR tokens. This creates a direct link between the growth of the Arweave ecosystem and the value proposition of AR. The remaining 64% of AO tokens are distributed to users who bridge assets to the AO network. This is a significant component of AO's economic model, as it encourages external liquidity to flow into the network, fueling its growth and adoption. Overall, this model is designed to create a feedback loop or economic flywheel, where more asset bridging and network usage lead to an increasing supply of AO tokens entering circulation.

New AO tokens are minted every five minutes, and the monthly minting rate is approximately 1.425% of the remaining supply. Due to the halving mechanism, similar to Bitcoin, the supply will gradually decrease over time.

Total AO supply	21,000,000
AO supply in existence	1,038,700
Remaining AO supply	19,961,300
AO monthly mint rate	1.43%
AO monthly mint (tokens)	284,448
AR share of AO issuance (%)	36%
AR share of AO issuance (tokens)	102,401
AR share of AO issuance ($)	$5,679,659
AR market cap (SM)	$1,482.2
AR monthly yield from AO issuance (annualized)	4.60%

Arweave's Future

The thought process behind the development and launch of AO Computer is to better position the Arweave network as a strategic, highly competitive platform with which to host large datasets. The most obvious market penetration Arweave can accomplish via AO is artificial intelligence (AI). The global AI market is expected to appreciate into a multi-trillion dollar market over the next decade while simultaneously dragging all interrelated markets along with it - including data storage.



In short, there will be robust demand for storing massive quantities of data associated with the large language models (LLMs) behind the world's most adopted AI protocols. With AO, the thinking here is that the economic model and performance capabilities will be competitive and secure enough to disrupt traditional data hosting channels. Even a relatively small market share capture (1%) could lead to a substantial valuation for the Arweave ecosystem by 2030.

Valour AR ETP

Valour Arweave (AR) SEK is an exchange-traded product (ETP) tracking AR, the native token of the Arweave network. Arweave is a decentralized storage protocol designed for permanent data storage at a one-time cost, ensuring information remains accessible indefinitely. Built on its unique blockweave technology, Arweave enables fast, scalable, and low-cost data retrieval. The AR token is used to pay for data storage and incentivize miners who maintain the network. By offering a sustainable solution for preserving digital content, Arweave fosters a community-driven ecosystem that secures history, promotes transparency, and empowers decentralized applications with reliable, permanent storage.

Disclaimer

This research report is exactly that — a research report. It is not intended to serve as financial advice, nor should you blindly assume that any of the information is accurate without confirming through your own research. Bitcoin, cryptocurrencies, and other digital assets are incredibly risky and nothing in this report should be considered an endorsement to buy or sell any asset. Never invest more than you are willing to lose and understand the risk that you are taking. Do your own research. All information in this report is for educational purposes only and should not be the basis for any investment decisions that you make.