

2023

# **BLOCKCHAIN & DAPP STORAGE**

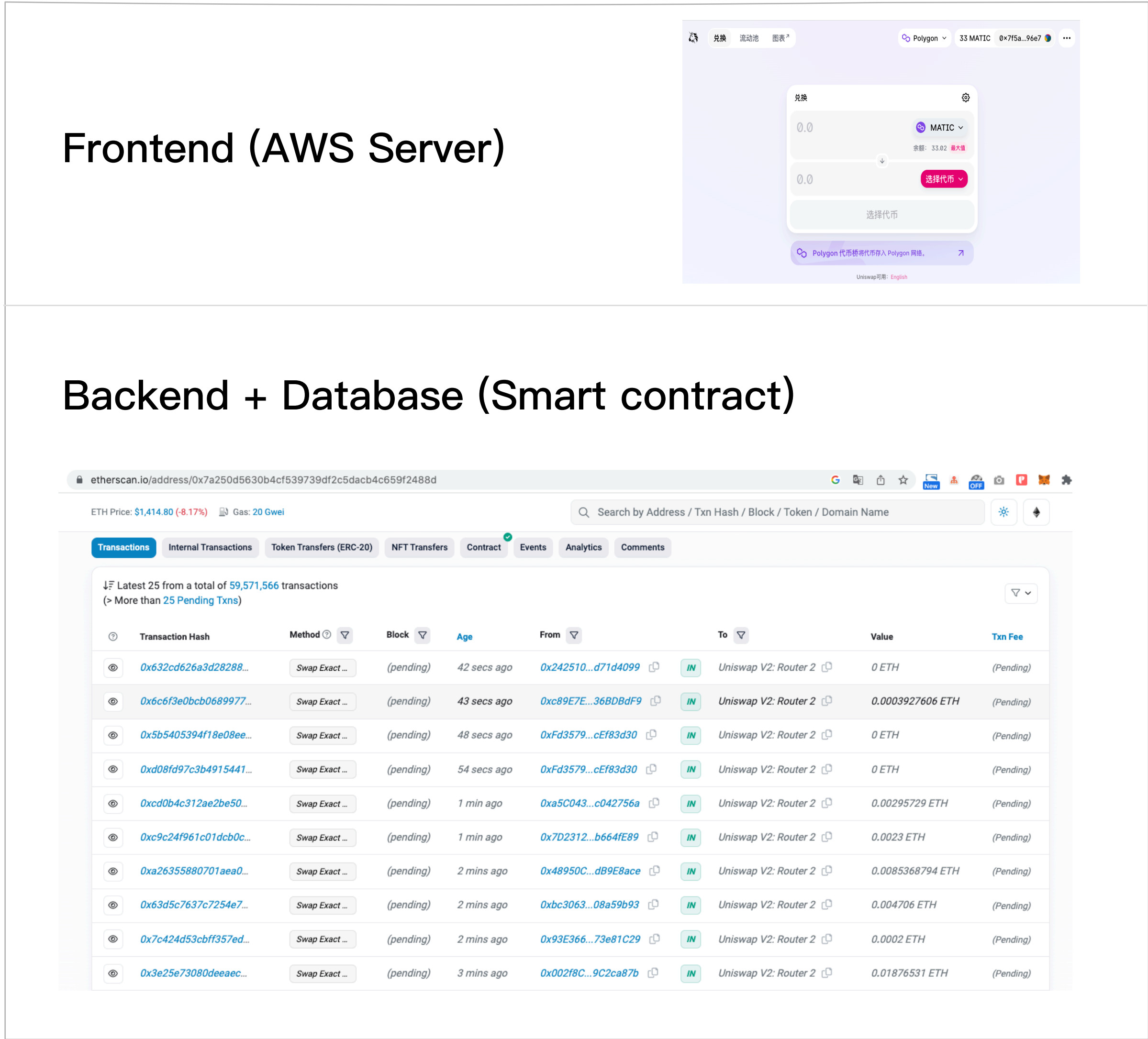
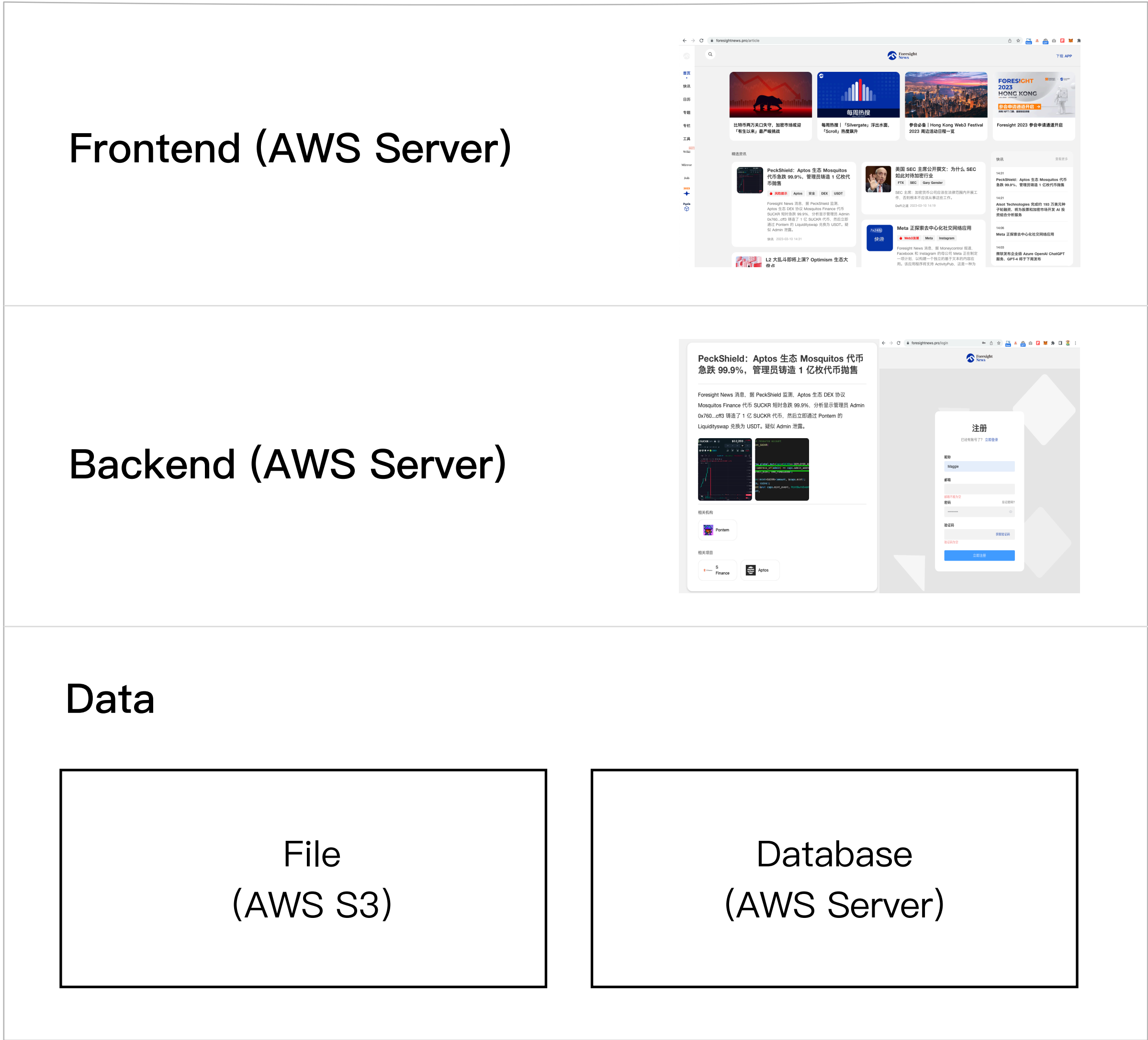


# App Architectures of Both Web2 and Web3 Applications



## Web2 App

## Web3 App





# Problem 1: Web3 DApps are Using Centralized Servers to Store Files



Need decentralized file systems to help DApps achieve full decentralization.

## File to store:

- DApp frontend pages.
- NFT metadata and pictures.
- Other DApp files like blogs.

## Solution:

- Decentralized file systems.

### Web2 App

#### Frontend (AWS Server)



#### Backend (AWS Server)



#### Data

File  
(AWS S3)

Database  
(AWS Server)

### Web3 App

#### Frontend (AWS Server)



#### Backend + Database (Smart contract)

Transaction Hash	Method	Block	Age	From	To	Value	Txn Fee
0x632cd626a3d28288...	Swap Exact ...	(pending)	42 secs ago	0x242510...d71d4099	Uniswap V2: Router 2	0 ETH	(Pending)
0x6c63e0bcb0689977...	Swap Exact ...	(pending)	43 secs ago	0xc89E7E...36BDBdF9	Uniswap V2: Router 2	0.0003927606 ETH	(Pending)
0x5b5405394f18e08ee...	Swap Exact ...	(pending)	48 secs ago	0xFd3579...cE83d30	Uniswap V2: Router 2	0 ETH	(Pending)
0xd08fd97c3b4915441...	Swap Exact ...	(pending)	54 secs ago	0xFd3579...cE83d30	Uniswap V2: Router 2	0 ETH	(Pending)
0xcd0b4c312ae2be50...	Swap Exact ...	(pending)	1 min ago	0xa5C043...c042756a	Uniswap V2: Router 2	0.00295729 ETH	(Pending)
0xc9c24f961c01dcb0c...	Swap Exact ...	(pending)	1 min ago	0x7D2312...b664fE89	Uniswap V2: Router 2	0.0023 ETH	(Pending)
0xa26355880701aea0...	Swap Exact ...	(pending)	2 mins ago	0x48950C...d99E8ace	Uniswap V2: Router 2	0.0085368794 ETH	(Pending)
0x63d5c7637c7254e7...	Swap Exact ...	(pending)	2 mins ago	0xbc3063...08a59b93	Uniswap V2: Router 2	0.004706 ETH	(Pending)
0x7c424d53cbf1357ed...	Swap Exact ...	(pending)	2 mins ago	0x93E366...73e81C29	Uniswap V2: Router 2	0.0002 ETH	(Pending)
0x3e25e73080deaeac...	Swap Exact ...	(pending)	3 mins ago	0x002f8C...9C2ca87b	Uniswap V2: Router 2	0.01876531 ETH	(Pending)





# Problem 2 : Smart Contracts are Not Enough for Backend and Database



## Need more decentralized databases and computation resources.

### Data to store in database:

- NFT metadata.
- DAO voting data.
- DEX order book.
- Decentralized social data, blog, email, etc.

### Backend requirement:

- Process requests and execute tasks.

### Solutions:

- Blockchain scaling / data availability.
- Decentralized database.
- Decentralized computation tools.

### Web2 App

#### Frontend (AWS Server)



#### Backend (AWS Server)



#### Data

File  
(AWS S3)

Database  
(AWS Server)

### Web3 App

#### Frontend (AWS Server)



#### Backend + Database (Smart contract)

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# Getting Web3 DApps Fully Decentralized Requires 4 Types of Products



## Decentralized File System

Store files (file data) for DApps:

- DApp front–end web pages.
- NFT metadata and pictures.
- Other DApp files like blog, pictures, videos.

## Decentralized Database

Store database (structured data) for DApps:

- NFT metadata.
- DAO votes.
- DEX order book.
- Other DApp structured data like social data, email, blog posts.

## Blockchain Scaling / Data Availability

Store financial and important data for DApps:

- ERC20/ERC721 smart contract.
- Coin / token transaction.
- Important smart contracts.

## Decentralized Computing Tools

Be the backend for DApps:

- Automating smart contracts by scheduling tasks for repeated execution.



# Topics

01

**Decentralized  
File System**

02

Decentralized  
Database

03

Blockchain  
Scaling / Data  
Availability

04

Decentralized  
Computation





# Decentralized File Storage Demands



## Demand

Demand is increasing, but not as urgent as blockchain scaling and decentralized database.

Decentralized file storage serves as a substitute for centralized storage, facilitating the realization of serverless DApps, and will be a vital component of the Web3 technology stack.

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## Data to store

Hot data (frequently accessed, needs faster retrieval times):

- DApp front-end web pages.
- NFT metadata and pictures.
- Other DApp files like blog, pictures, videos.

Cold data (not frequently accessed, long term store):

- Archived historical data and backups. (e.g. ETH block data on years ago)

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## Pros & Cons

Pros:

- Trusted third party is removed.
- Increased redundancy, **no single point of failure**.
- Cheaper.

Cons:


- Long retrieval time for data.
- Not suitable for files that need frequent updates.
- Some uncertainty regarding reliability.



# Decentralized File Storage Market Overview

## Overview of top 4 storage protocols.

- Market cap was nearly \$1.6 billion, down 83% from \$9.4 billion.
- Over 17 million terabytes (TB) of total storage capacity, up 2% YoY, and 532,500 TB of used storage, up 1280% YoY.
- Filecoin continued to hold the largest market share (67%),
- Arweave (19%)
- Sia (8%)
- Storj (6%)




Decentralized Storage Protocols Key Metrics Summary

		Filecoin	Arweave	Sia	Storj	Total
Market Cap (Billions)	2022	\$1.06	\$0.31	\$0.12	\$0.10	\$1.59
	2021	\$5.01	\$3.04	\$0.76	\$0.62	\$9.43
	% Change	-79%	-90%	-84%	-84%	-83%
Used Storage (TB)	2022	514,945	121	1,358	16,100	532,544
	2021	27,145	43	1,937	9,470	38,595
	% Change	1797%	183%	-30%	70%	1280%
Total Capacity (TB)	2022	17,109,355	-	5,492	42,300	17,157,146
	2021	16,740,420	-	6,598	15,340	16,762,358
	% Change	2%	-	-17%	176%	2%
Network Utilization	2022	3%	-	25%	38%	3.1%
	2021	0.2%	-	29%	62%	0.2%
	Change	2.8%	-	-4%	-24%	3%
Revenue (\$)	2022	\$13,166,134	\$688,605	\$162,000	\$501,912	\$14,518,651
	2021	\$595,533,914	\$837,363	\$217,000	\$567,283	\$597,155,560
	% Change	-98%	-18%	-25%	-12%	-98%

Source: Messari, Siastats, Storjstats, Viewblock, Starboard, Web3 Index

Note: Revenue is demand-side revenue. Sia's 2021 revenue is an estimate based off 2 quarters of data. Filecoin's revenue is an estimate.

 MESSARI

Data as of:  
Dec. 31, 2022



# Decentralized File Storage Products

	IPFS	Filecoin	Arweave	Swarm	StorJ	Sia
Node incentive	N	Y	Y	Y	Y	Y
Cost	Free	Store: 0.0002/TB/Month	Store: \$1–20/TB/M	NA	Store: \$4/TB/M Retrival: \$7/TB	Store: \$1.2/TB/M Upload:\$0.52/TB Retrival: \$2.2/TB
Hot/Cold data	Hot	Cold	Hot/Cold	Hot	Hot	Hot
Decentralization	Fully	Fully	Fully	Fully	Partially	Fully
Blockchain	NA	L1	L1	ETH	ETH	L1
Proofs	NA	Proof–of–Spacetime Proof–of–Replication	Proof–of–random–access	Merkle proof	Merkle proof	Merkle proof Proof of work
Comments	<ul style="list-style-type: none"><li>Widely used to store NFT metadata and images.</li><li><b>Lack of incentives. Service quality cannot be guaranteed. File loss.</b></li><li>To ensure reliability, it is often necessary for project owners to run their own IPFS nodes.</li></ul>	<ul style="list-style-type: none"><li><b>Difficult to retrieve data.</b> Cold data storage.</li><li>Some miners may accept low quality data to get rewards. The Filecoin community is actively addressing this issue and implementing measures to improve the overall quality of stored data.</li></ul>	<ul style="list-style-type: none"><li><b>Permanent storage</b> is popular for storing Web3 data.</li><li>Better ecosystem.</li><li><b>Price does not account for bandwidth.</b> Some nodes only provide storage services, not retrieval.</li></ul>	<ul style="list-style-type: none"><li>Highly decentralized. Complicate routing, <b>high bandwidth requirements</b>, and low profits for nodes.</li></ul>	<ul style="list-style-type: none"><li><b>Partially decentralized with good retrieval speed.</b> Has proven effective for large video file sharing.</li><li>Enterprise service–level protocol.</li></ul>	<ul style="list-style-type: none"><li>Skynet Labs closed due to a lack of new funding, which also led to a decline in Sia's usage.</li><li>PoW is too computationally intensive.</li></ul>

\* AWS about \$23/TB/Month



## 1. Data Retrieval Speed

Influencing factors:

- Bandwidth fee / data retrieval fee
- Partially or fully decentralized.
- Node quality.
- Data forwarding logic.
- CDN

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## 2. Incentive Model & Tokenomics

- Pricing model.
  - Main stream: storage fee + Bandwidth fee.
  - Free data retrieval leads to bad retrieval speed.
- Incentive model affects the participation willingness of miners.
- Tokenomics affect coin price and miner rewards.

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## 3. Data Available Guarantee Algorithm

- Main stream: proof of random access.
  - Also using erasure coding, merkle proof.
- Check frequency (e.g., once every 24 hours).
- Encrypt by default.
- Zero knowledge proof (ZKP) and encoding model.



# Decentralized File Storage Final Thoughts



The products and services that leverage decentralized storage protocols are still in their early stages.

- Important elements such as access layers, CDNs, and enterprise–scale storage providers are starting to appear in the market. These components will play a crucial role in furthering the development of the products and services layer, and thus, increase the adoption rate of decentralized storage networks.

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The main focus for improving storage protocols will be on reducing retrieval times.

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Data retrieval speed, incentive model & tokenomics, and the guarantee algorithm for data availability are key factors that determine whether a protocol will be widely used or not.

- StorJ is partially decentralized with good retrieval performance, providing enterprise–scale storage.
- Looking forward to storage protocols base on ETH L2.
- New protocols have better designs addressing the above three main issues.

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# Decentralized Database Demands

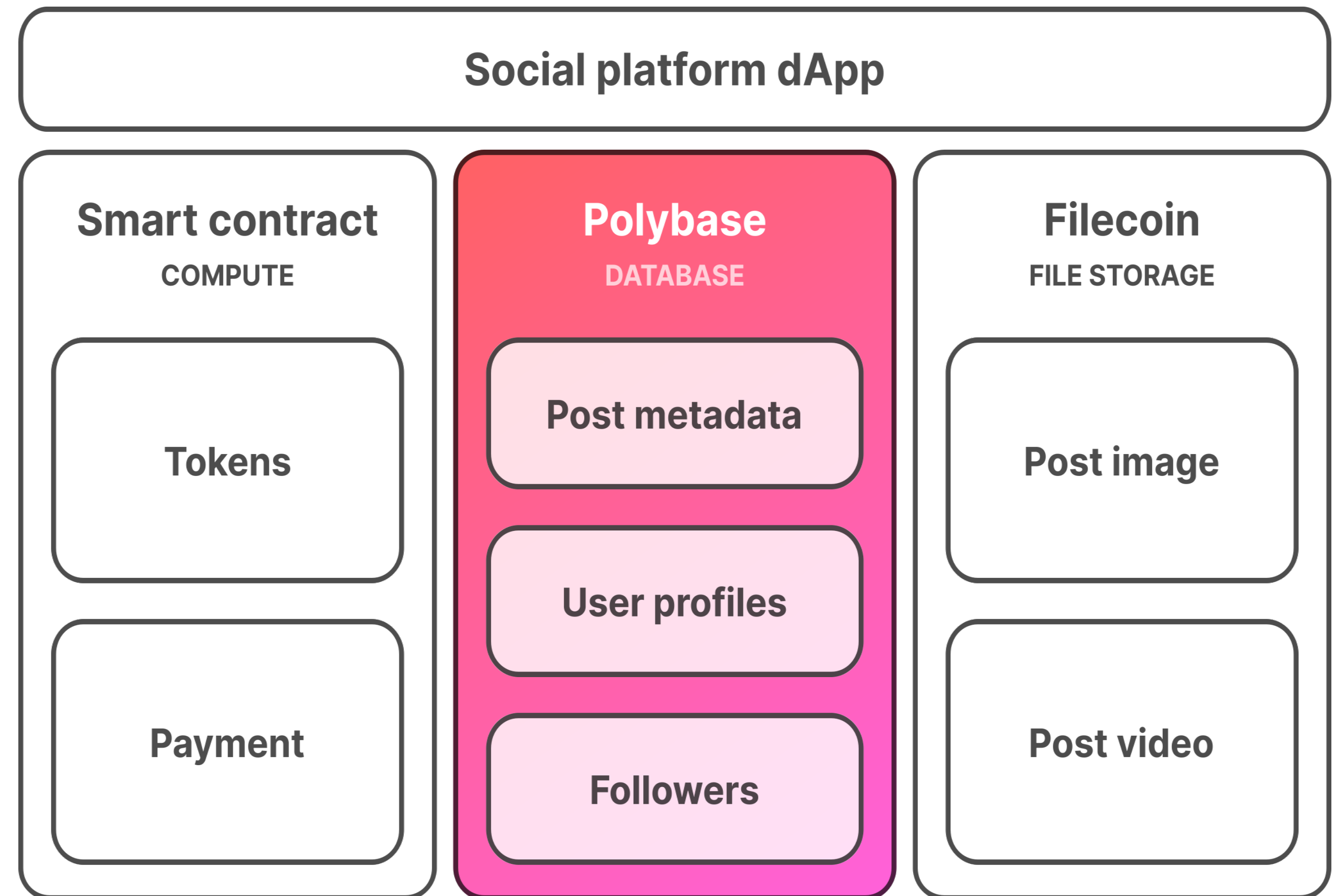
## Demand

Databases are widely used in applications, decentralized databases are a crucial technology for achieving full decentralization in DApps.

## Data to store

Hot data (frequently accessed, needs faster retrieval times):

- NFT metadata.
- DAO votes.
- DEX order book.
- Other DApp structured data like social data, email, blog.



Picture source: [https://polybase.xyz/?gclid=CjwKCAjw3POhBhBQEiwAqTCuBohZBI2EYzSgoEcfGH03\\_laiY89Z8XqGcPVU0v3n-4ATDY3N1IU-yxoCX5QQAvD\\_BwE](https://polybase.xyz/?gclid=CjwKCAjw3POhBhBQEiwAqTCuBohZBI2EYzSgoEcfGH03_laiY89Z8XqGcPVU0v3n-4ATDY3N1IU-yxoCX5QQAvD_BwE)

# Decentralized Database Products

	Ceramic	OrbitDB	Tableland	Polybase	Web3Q	Kwil	KYVE
Incentive	N	N	Y	Y	Y	Y	Y
Function	CRU	CR	CRUD	CRUD	CRUD	CRUD	CR
Charge	Free	Free	CUD	CRUD	CU charge D refund	CUD fee	C fee
DB type	–	NoSQL	SQL	NoSQL	NoSQL	SQL	–
Underlayer file system	IPFS	IPFS	Firebase, S3, IPFS, Sia, Storj	Local, IPFS, Filecoin, Polystore, S3	Local	Arweave	Arweave
Comments	<ul style="list-style-type: none"><li>• Project start from 2019.</li><li>• Data is stored and managed in units of streams, and formatted event logs are added to streams. The log will be made into a file and uploaded to IPFS.</li><li>• Provides GraphQL API queries.</li></ul>	<ul style="list-style-type: none"><li>• Project start from 2018.</li><li>• Support both database and file store.</li></ul>	<ul style="list-style-type: none"><li>• Project start from 2022. Testnet is alive.</li><li>• Mainnet will launch on 2023</li><li>• SQL defined in smart contract, have access control.</li><li>• Read data off-chain, free of charge.</li></ul>	<ul style="list-style-type: none"><li>• Project start from 2022. Testnet alive.</li><li>• Raised \$2M preseed 2023.3</li><li>• Use ZK proofs on-chain to verify off-chain activity.</li><li>• Charge for query with payment channel.</li></ul>	<ul style="list-style-type: none"><li>• Project start from 2022. Testnet is alive.</li><li>• Proposed a new URL patterns Web3: //access protocol for accessing data.</li></ul>	<ul style="list-style-type: none"><li>• Use smart contract for payment.</li></ul>	<ul style="list-style-type: none"><li>• Mainnet is alive.</li><li>• Switched from Plokdots substrate to Cosmos.</li></ul>



# Decentralized Database Final Thoughts

The field of decentralized databases is highly worth paying attention to, with an urgent demand, while a widely accepted and used product has not emerged yet.

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The maturity of decentralized databases is lower than that of decentralized file storage systems.

- Decentralized database tech is based on decentralized file system, more difficult.
  - Many projects are start from 2022.
- 

Data retrieval speed, incentive model & tokenomics, and the guarantee algorithm for data availability are key factors that determine whether a protocol will be widely used or not.

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# Data availability is different from decentralized file system and database.

Use Ethereum ▾Learn ▾Developers ▾Enterprise ▾Community ▾  
  
Home**Docs**TutorialsLearn by codingSet up local environment  
  
Overview  
Foundational topics ▾  
Intro to Ethereum  
Intro to Ether  
Intro to dapps  
Web2 vs Web3  
Accounts  
Transactions  
Blocks  
Ethereum virtual machine  
  

## WHAT IS DATA AVAILABILITY?

Data availability is the guarantee that the block proposer published all transaction data for a block and that the transaction data is available to other network participants. Ethereum transactions get processed in [blocks](#). These blocks are chained together to form the "blockchain".

Each block has two major parts:

- The **block header**: This contains general information (metadata) about the block, such as the timestamp, block hash, block number, etc.
- The **block body**: This contains the actual transactions processed as part of the block.

Can Celestia support both zk rollups and optimistic rollups?



Is Celestia only available for the Cosmos ecosystem?



**What is the difference between Celestia and data storage blockchains like Arweave and Filecoin?**



Celestia is a blockchain that focuses on data availability whereas blockchains like Filecoin and Arweave are focused on the separate problem of data storage.

Data availability is concerned with whether the data published in the latest block is available. This is distinctly different from data storage, which is concerned with storing data securely and providing guarantees that it can be accessed when needed.

These distinct focuses lead to differences between their target use-cases. Data storage blockchains are particularly focused on providing a decentralized way for data to be stored and accessed. Conversely, Celestia is designed to provide secure and scalable data availability for blockchains and specialized execution environments, like rollups.

For more information about data availability, [this post](#) by Celestia Labs co-founder Mustafa Al-Bassam is a good place to start.



# Data Availability VS Decentralized Storage

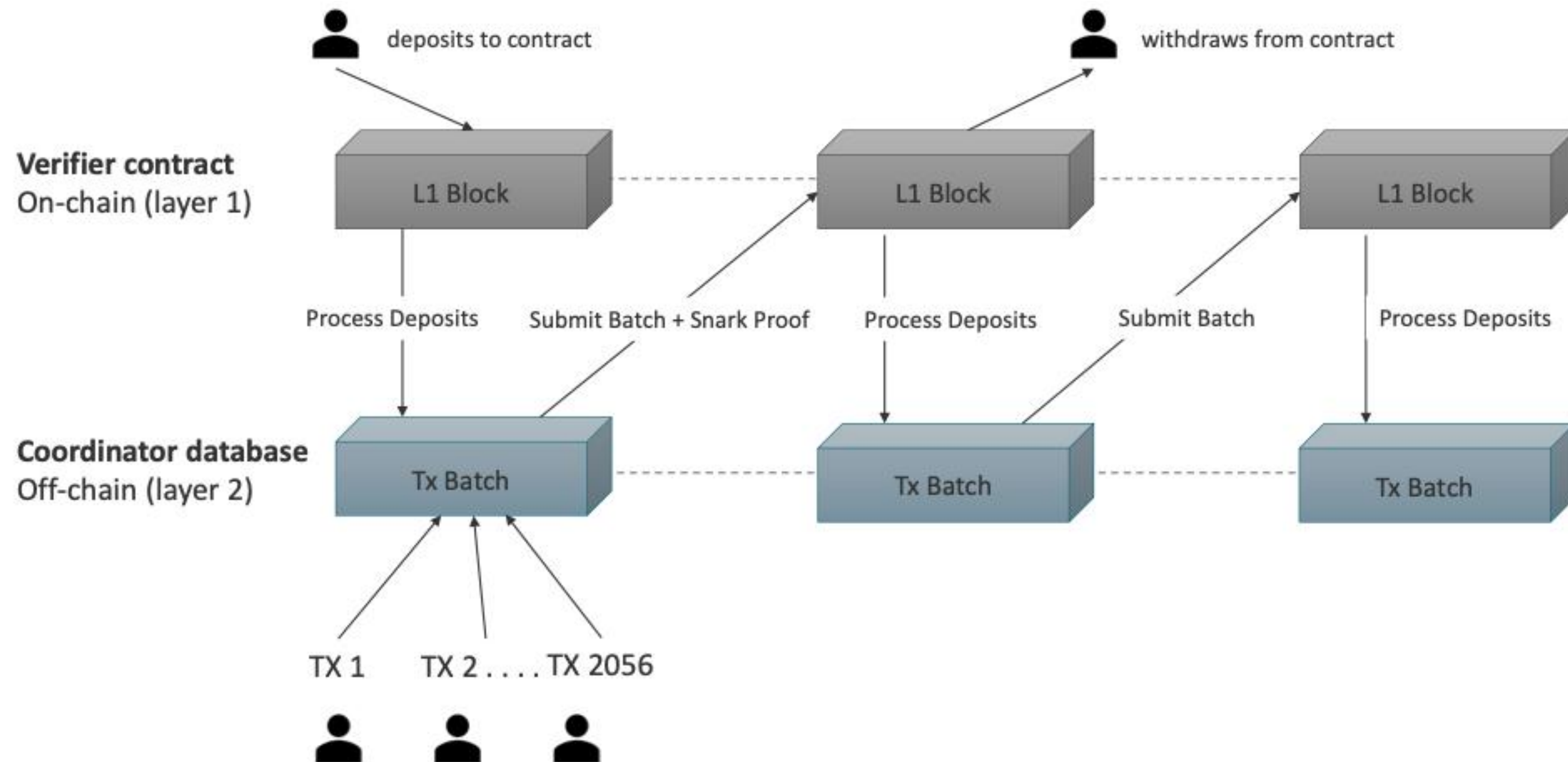
	Data Availability	Decentralized Storage
Target	Data availability is the guarantee that the block proposer published all transaction data for a block and that <b>the transaction data is available</b> to other network participants.  (Scaling blockchain).	<b>Store data securely and providing guarantees that it can be accessed when needed.</b>  (Not store data for blockchain, but for DApps or some person.)
Data	Transaction data, short-term storage.	Non-financial data, data requiring long-term storage
Method	1. Layer 2 rollup use ETH as DA layer. 2. Celestia as DA layer. 3. EigenDA and other products as DA layer.	1. Build a standalone L1 blockchain to store files and databases. 2. Connect to existing blockchains and use smart contracts on L1 or L2 blockchains for payment, reward and slash, storage verification, and access control of data.
Tech	1. Layering blockchain, modularize blockchain. 2. Use availability sampling and erasure coding to verify data availability. 3. Use commitment to prove availability. 4. Prove data availability through committees.	1. Use availability sampling and erasure coding to verify data availability. 2. Use commitment to prove availability.



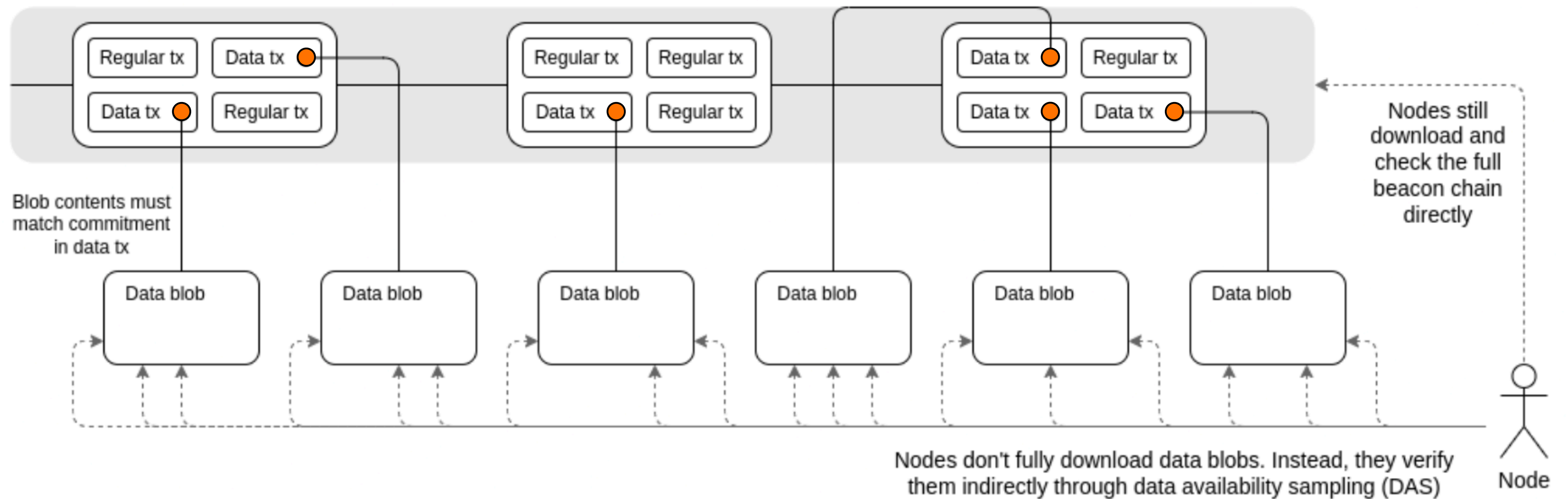
# Data Availability Products -- ETH

ETH is the DA layer of rollups.

Rollups use ETH to store transaction batches and proofs.



Danksharding expands the data storage space of ETH, make it a more powerful DA layer.

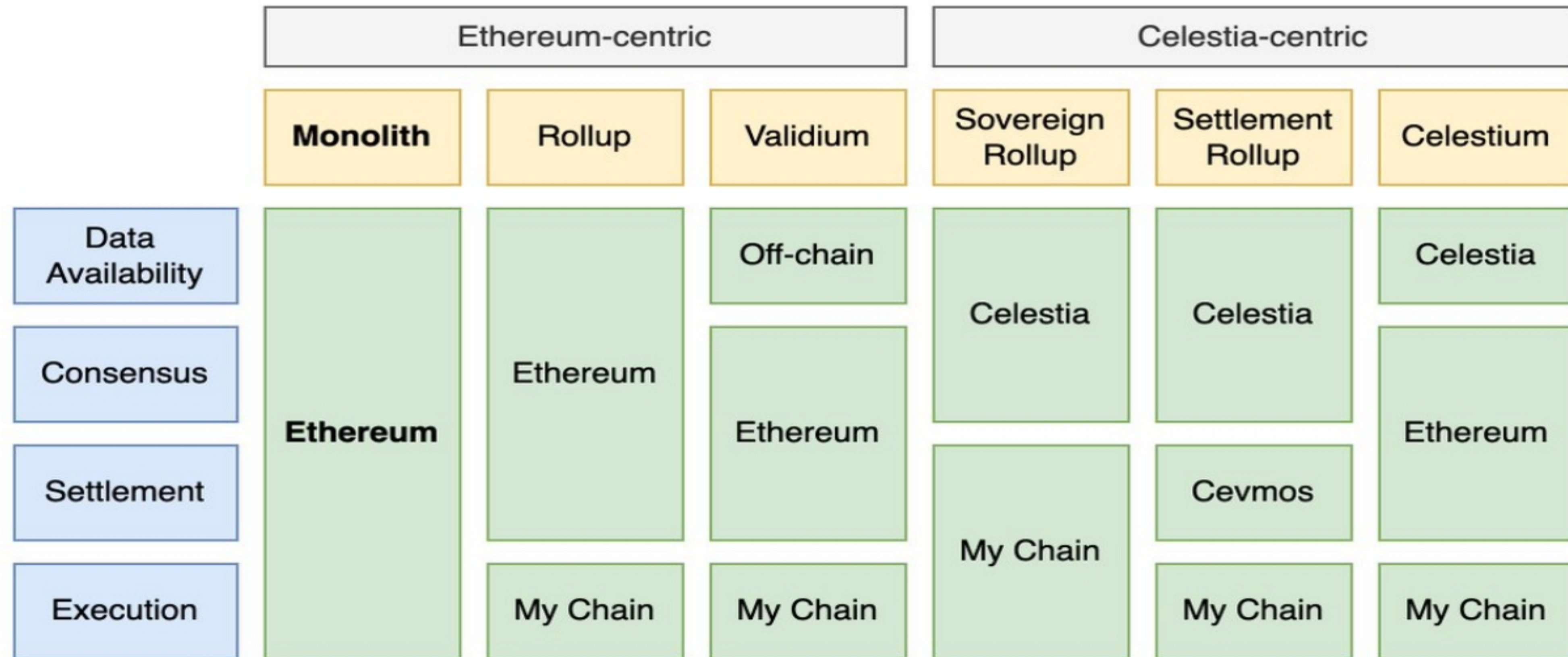




# Data Availability Products -- Celestia

Celestia only handles the DA and consensus layers to achieve high throughput.

Since Celestia does not validate and execute transactions, its throughput is not limited by transaction execution and state transition.

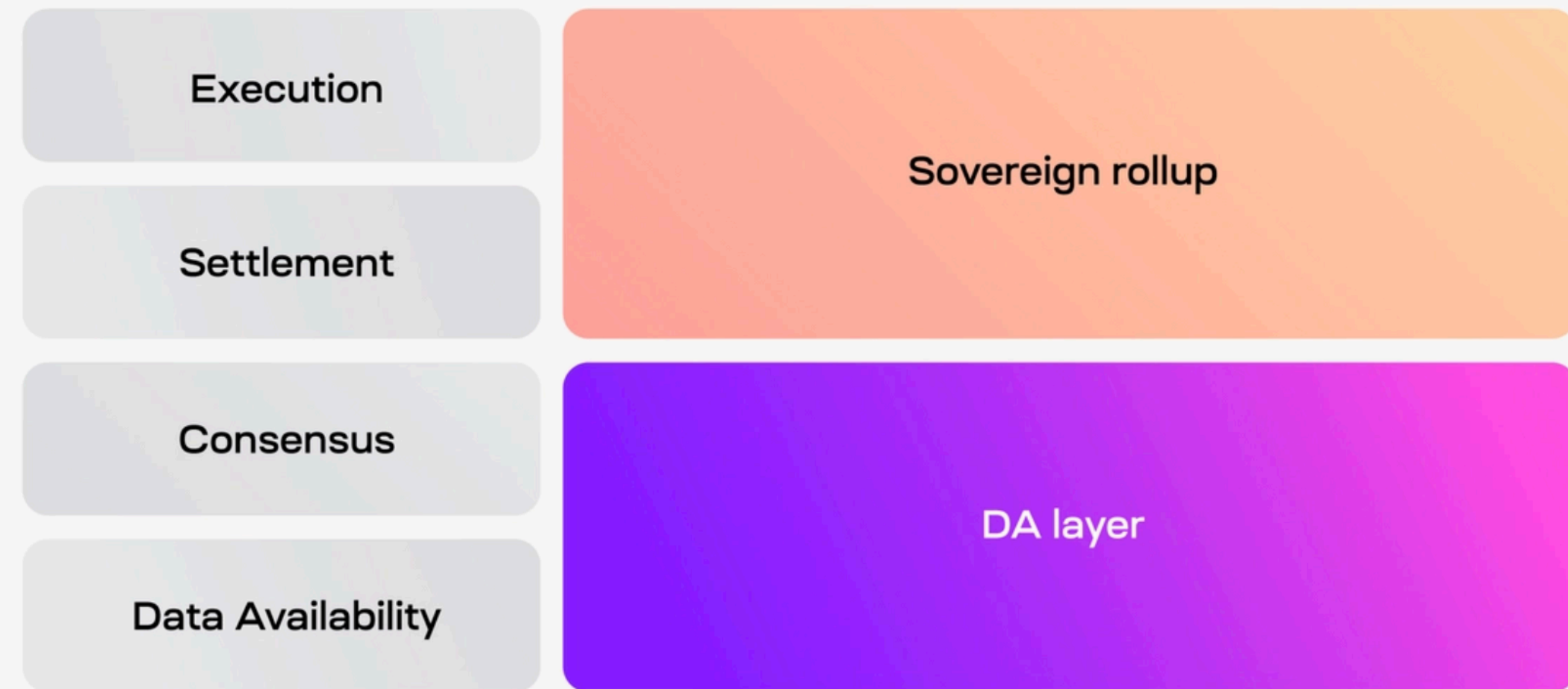




## Celestia is different from ETH

1. Celestia only does the DA and consensus layer, while ETH also does the settlement layer.
2. Celestia does not support Smart Contracts.
3. ETH rollup cannot fork, whereas Celestia sovereign rollup can.
4. Celestia don't have smart contracts, bridges with sovereign rollups would mainly facilitate the movement of the DA layer token.

### Celestia Rollup

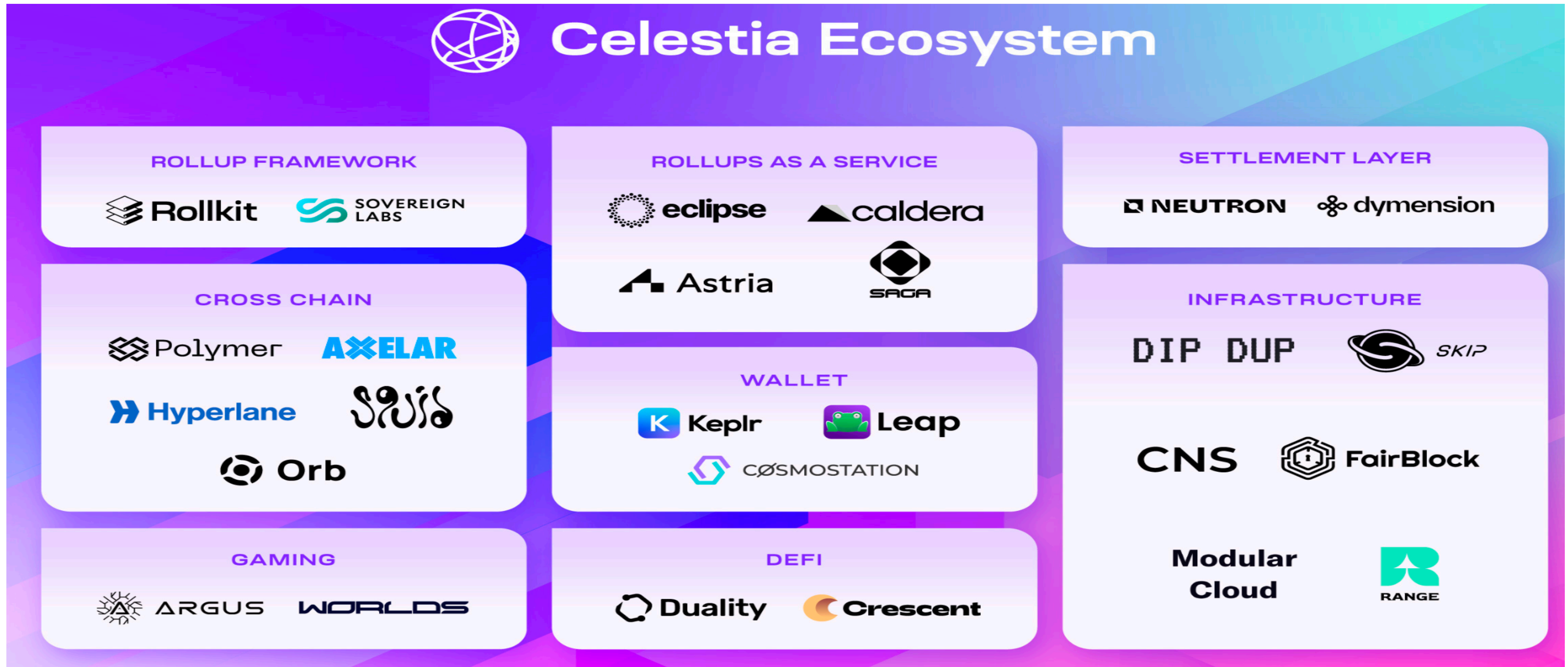


### ETH Rollup



# Data Availability Products -- Celestia

Celestia ecosystem is growing fast.





## Two types of off-chain DAs

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### 1. Data availability committees

- Store transaction data off-chain with a block producer, making them centralized to an extent. This reduces decentralization and security, since the block producer can publish invalid transactions and conceal the rollup's true state by hiding transaction data.
- E.g. Validiums and plasma

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### 2. Proof-of-stake data availability committees

- Proof-of-stake (PoS) validator system + DAC.
- E.g. EigenDA



# Data Availability Products Overview

	ETH	Celestia	Avail	EigenDA	Off-chain DA
Plan	Used as DA layer by ETH layer 2 rollups	Used by celestia sovereign rollups	Avail's rollup	–	Validium
Function	DA, Consensus, Settlement	DA, Consensus	DA, Consensus	DA ...	DA
Comments	<ul style="list-style-type: none"><li>• <b>ETH is already the DA layer of L2 optimistic and zk rollups.</b></li><li>• EIP-4844 (Proto-Danksharding) will also benefit L2.</li><li>• The storage space may not be larger than Celestia before fully implementing Danksharding.</li></ul>	<ul style="list-style-type: none"><li>• Testnet will be online in 2022.</li><li>• Its modular design is innovative.</li><li>• <b>Need to build a new validator set and new ecosystem.</b> Compete with ETH.</li><li>• Many ecosystem projects are starting to build on Celestia.</li></ul>	<ul style="list-style-type: none"><li>• The project was created by Polygon in June 2022.</li><li>• With the resignation of the founder, Avail is now an independent project.</li><li>• The Avail mainnet was planned to be bridged to Polygon and <b>use MATIC as the base currency.</b> Compared to Celestia tokens, MATIC is a more mature token.</li></ul>	<ul style="list-style-type: none"><li>• EigenDA is a data availability layer built on the Ethereum ecosystem. It <b>attracts ETH validators to maintain EigenDA through restaking.</b></li><li>• There is no startup burden.</li></ul>	<ul style="list-style-type: none"><li>• Validium uses off-chain storage for data availability, Ethereum for consensus and settlement, and Validium rollup for execution.</li><li>• <b>Validium may be phased out</b> as Celestia and Danksharding gain widespread adoption.</li></ul>



**A data availability layer is a promising and important approach to scaling blockchains.**

Ethereum serves as the data availability layer for Layer 2 Rollup. Celestia aims to create a data availability and consensus layer that is more pure. Additionally, there exist some off-chain solutions for data availability layers.

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**The current DA products have their own advantages, and they all deserve continuous attention.**

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**Celestia's technology still needs to be verified by the market, and ETH and Celestia may also converge technically in the future.**

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**Decentralized  
Computation**





# Decentralized Computing

Decentralized computing is still in its very early stages. The correctness of the computations is difficult to verify.



WEB3 30 NOMINEE

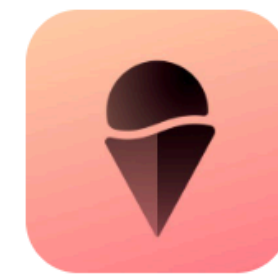
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Infrastructure Tools

An open source and decentralized peer-to-peer marketplace for cloud compute.

**CHAINS**  
Multichain

[Learn More →](#)



**Gelato**

DeFi Tools

Web3's decentralized backend - Build smart contracts that are automated, gasless & off-chain aware.

**CHAINS**  
Ethereum, Polygon, Arbitrum, Optimism, BNB Chain, Avalanche, Cronos

[Learn More →](#)



**Taubyte**

Infrastructure Tools

Taubyte is an easy to deploy decentralized web3 cloud computing platform.

**CHAINS**  
Ethereum, Polygon, Multichain

[Learn More →](#)



**Chainjet**

Infrastructure Tools

A decentralized platform for building on-chain or off-chain task automations.

**CHAINS**  
Ethereum, Polygon, Avalanche, Arbitrum, BNB Chain, Optimism

[Learn More →](#)

# Appendix Slides: Full Decentralization is Not a Must

## Three kinds of DApp architectures.

### (a) Direct (almost serverless):

- Exchanges, Finance, Gambling, Web3 game, Governance, Identity

### (b) Indirect (has backend):

- Governance(DAO), Health.

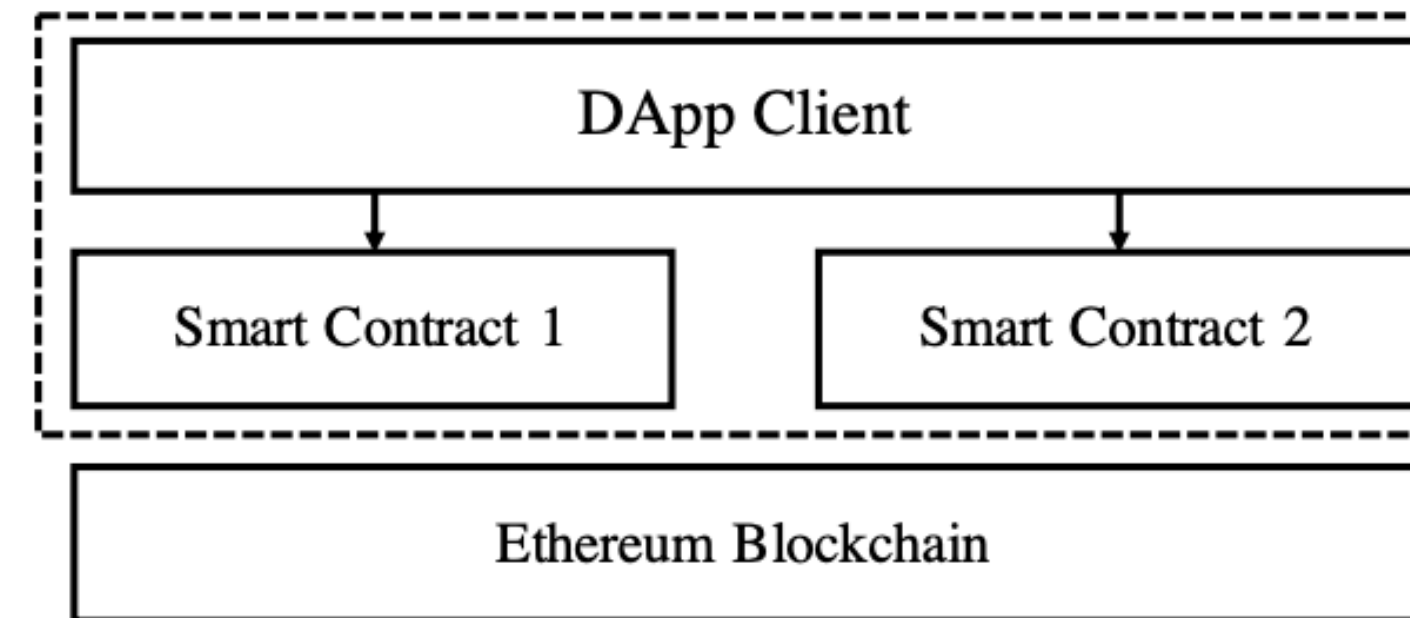
### (c) Mixed:

- Social, AAA Web3 Games, Media, Machine learning.

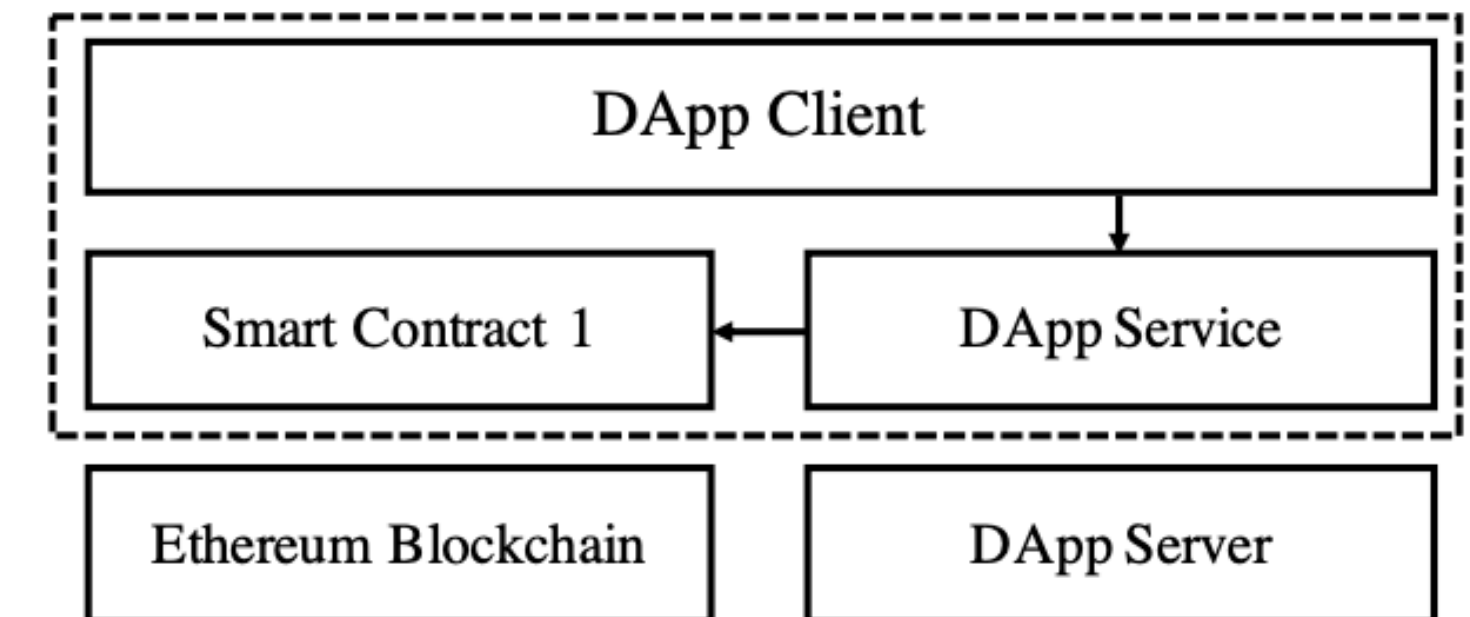
## Centralized services is good to use when:

- High performance is required.
- Complex or special computations are needed.
- Temporary and unimportant data or computations are needed.
- Black box data or operations are required.

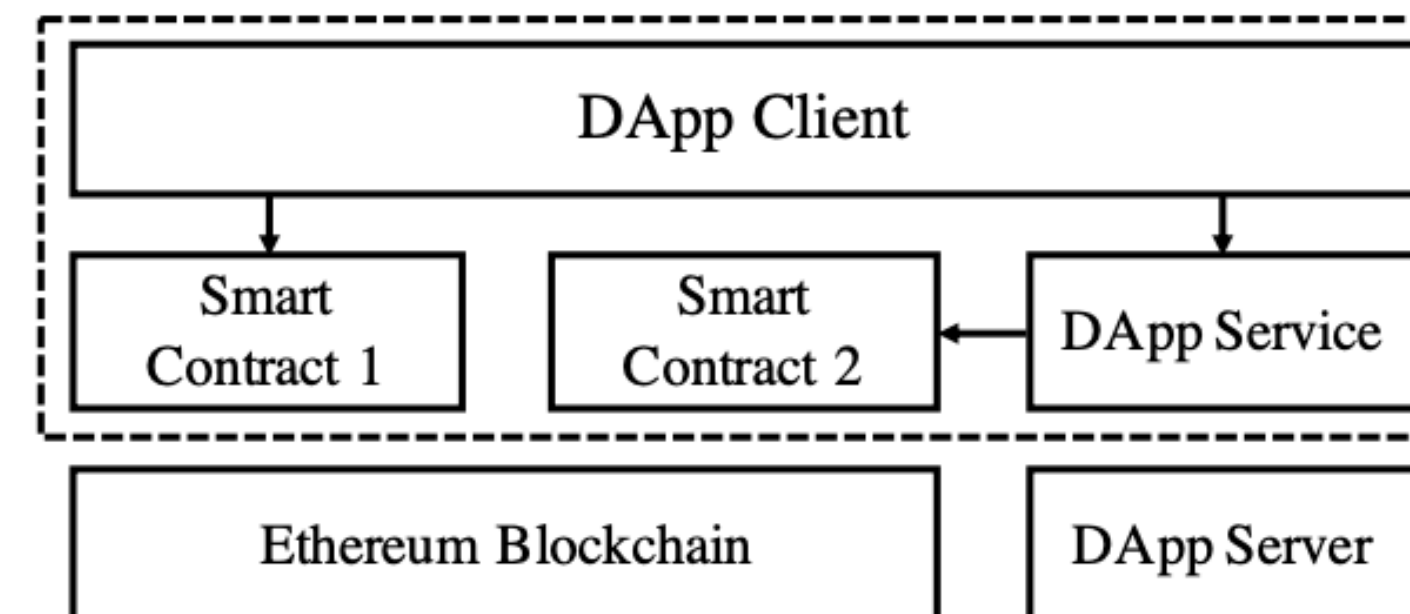
(a) Direct



(b) Indirect



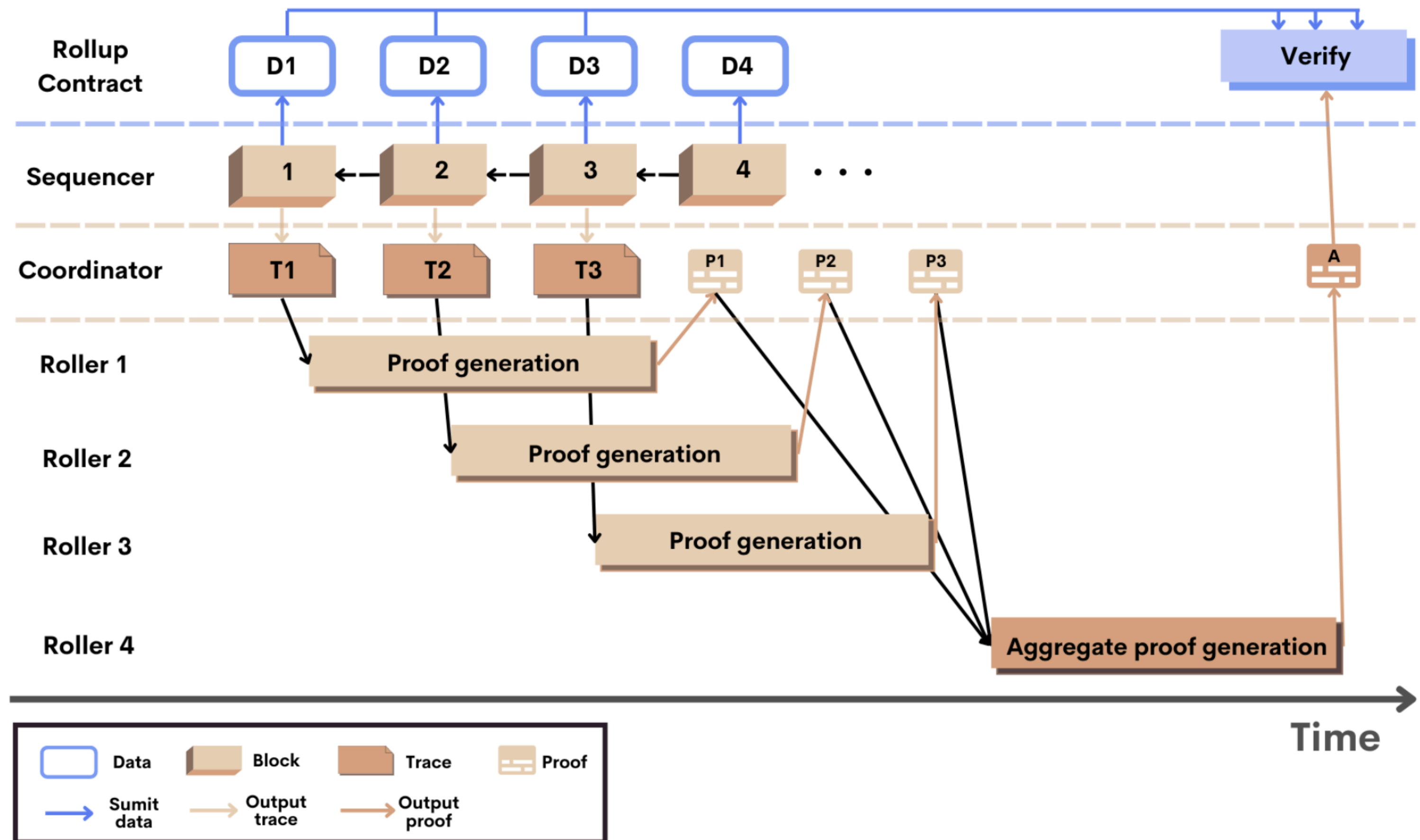
(c) Mixed:



# Appendix Slides: What is a Settlement Layer?

## Transaction process of ZK rollups

1. Sequencer submit transaction batches to L1.  
(L1 as **consensus**, data availability layer)
2. L2 nodes execute transactions and generate state change proof. (L2 as **execution** layer)
3. Submit proof to L1, transactions get settled.  
(L1 as **settlement** layer)





# Appendix Slides: Other Data Related Projects

	Opportunity Areas	Project Examples
Data Interoperability	Indexing On-chain Data	The Graph, Space and Time
	Linking CID on IPFS to physical location/IP where the file is stored.	Filecoin Indexer
CDN (Content Delivery Network)	Decentralized Streaming/ Bandwidth/CDN Market	LivePeer(vedio decode), Meson Network(bandwith trading, for IPFS, arweave), Media.network
Adoption Facilitator	Data storage provider reputation market	Filgram, Filrep,Cidgravity
	UI/UX	Web3.Storage, NFT.Storage



**THANKS**