How to Build Whatever

with Celestia underneath ✨

Josh Stein | Austin, TX | 30 May 2024

CELESTIA

About me

gm

- Solutions Engineer at Celestia Labs
- Previously at Ankr & buildspace
- Web3-pilled by Developer DAO and buildspace in 2021
- BSc Business, Supply Chain Management at VCU

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Overview

How to Build Whatever

What is Celestia?

- Modular blockchains
- Data availability & DAS

How can I build whatever?

- Run a light node
- Run a sovereign rollup with Rollkit
- Monitor the namespace

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What is Celestia?

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Celestia is a modular data availability network that makes it easy for anyone to securely launch their own blockchain.

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Celestia allows anyone to make their own modular blockchain.

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What is a modular blockchain?

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A modular blockchain is one that decouples the core functions of a blockchain — execution, settlement, consensus, and data availability.

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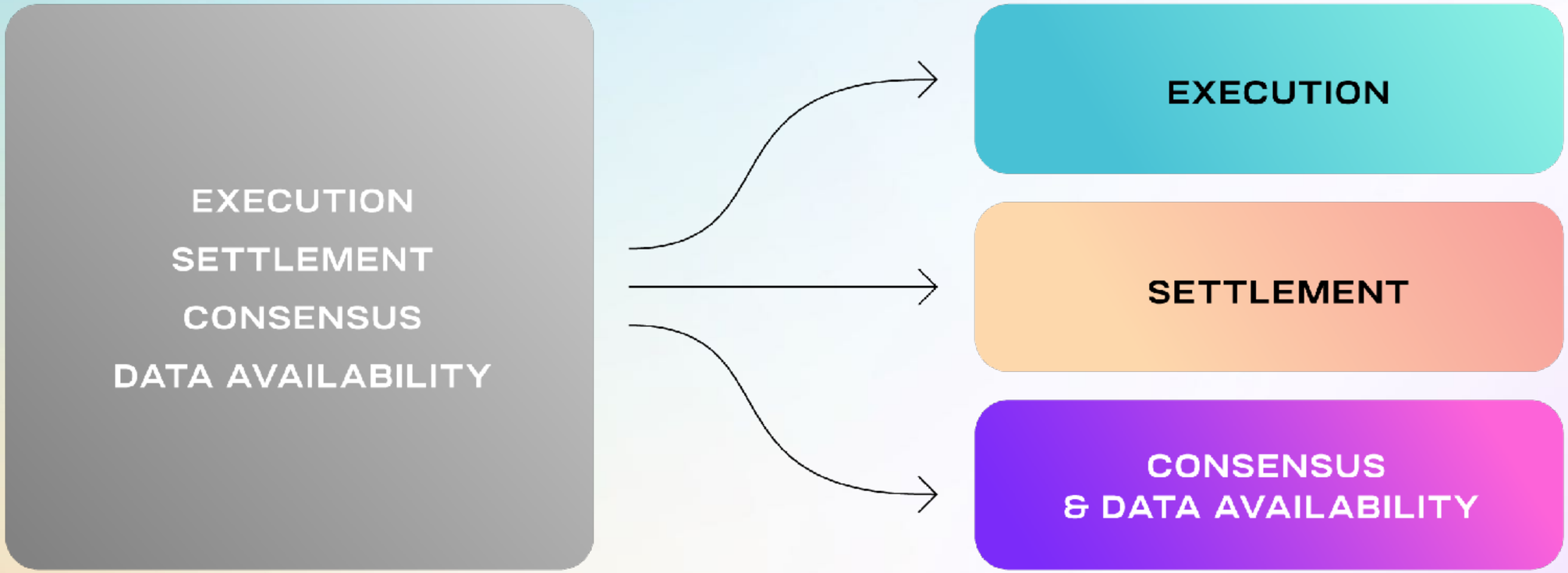
Modular blockchain design



A modular blockchain is just a blockchain.

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What’s this look like in practice?

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Execution

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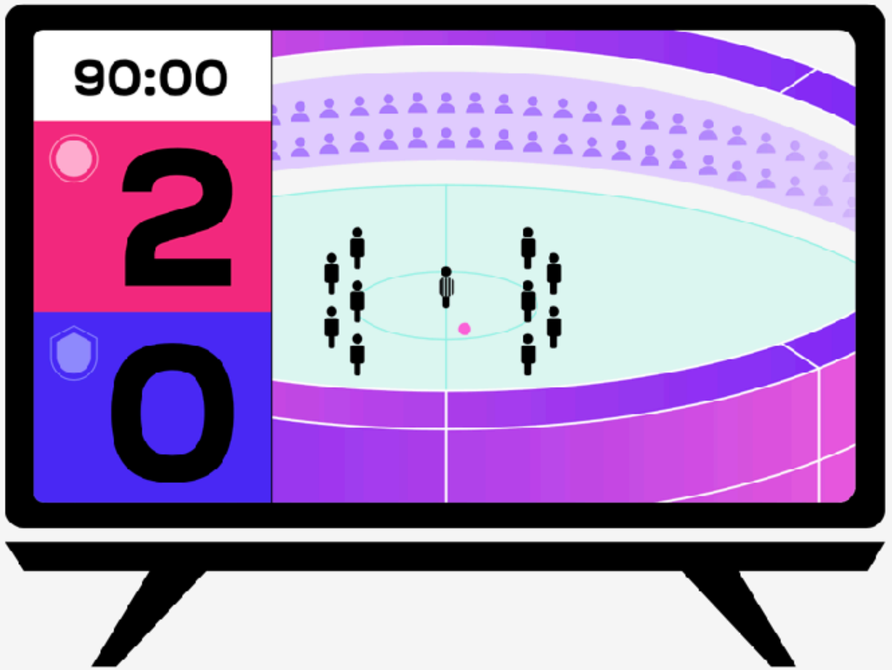
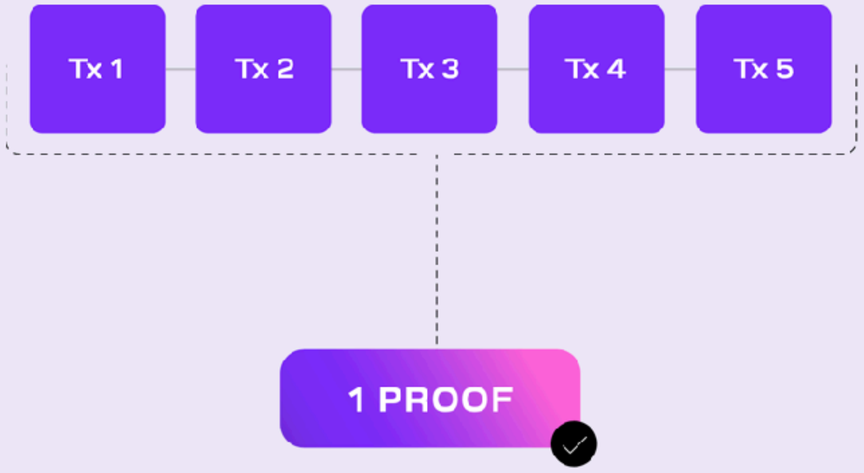
Football game

Can see who won without watching the whole game



Execution

Can see the outcome of transactions without looking through all of them



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Settlement

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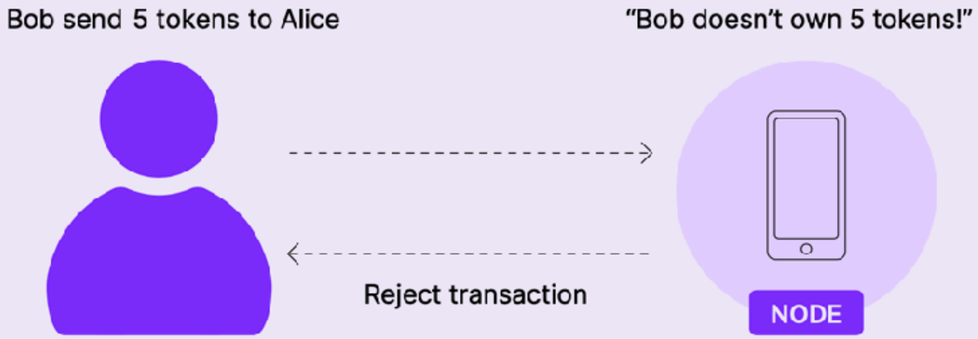
Football game

Umpires solve disagreements during the game

Settlement

The process of solving disagreements about transactions



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Consensus

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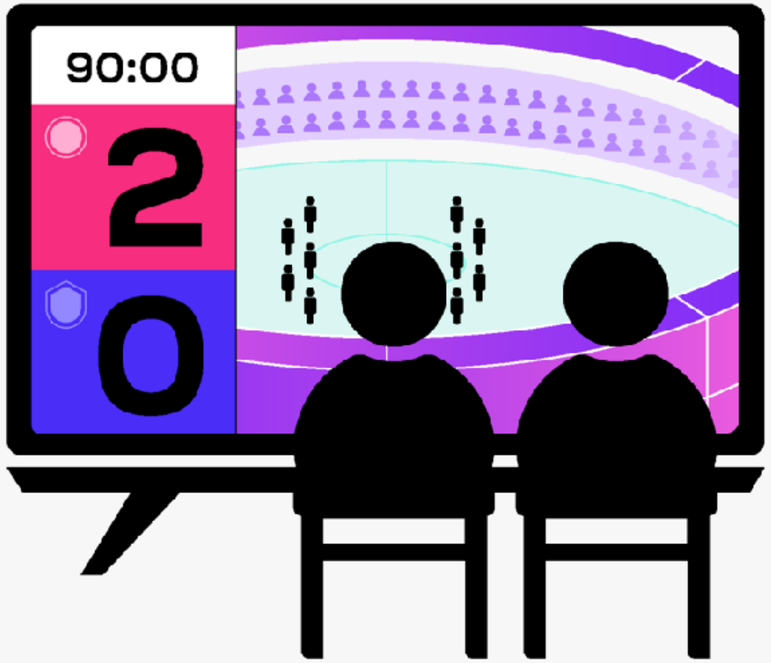
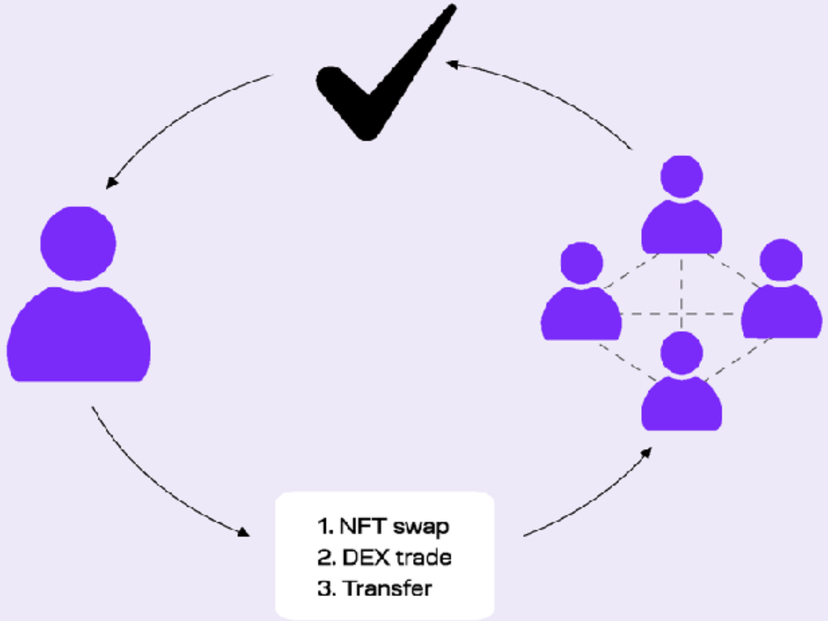
Football game

Agreeing to watch the same football game as your friend.



Consensus

Agreeing on the order of transactions.



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Data availability

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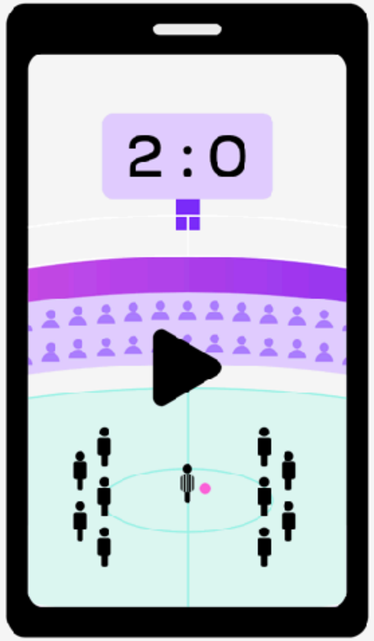
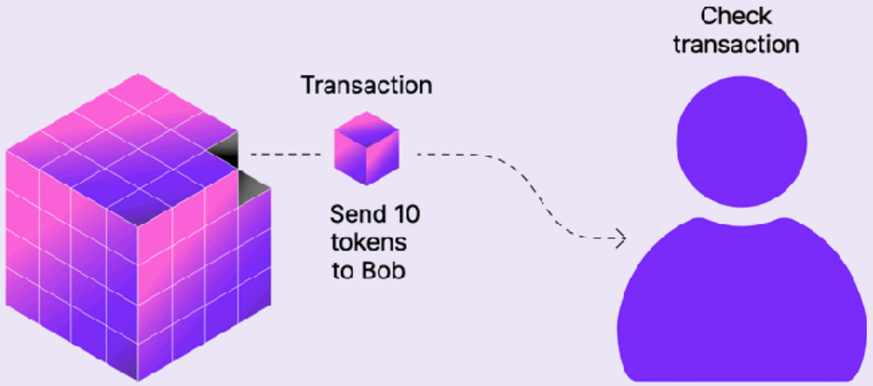
Football game

Recording so anyone can
watch the game if they want



Data availability

Lets anyone check the contents of
a transaction to see what happened



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What is data availability?

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Data availability in a blockchain ensures that transaction data included in each block produced is accessible to every node in the network, allowing everyone to independently verify the validity of transactions.

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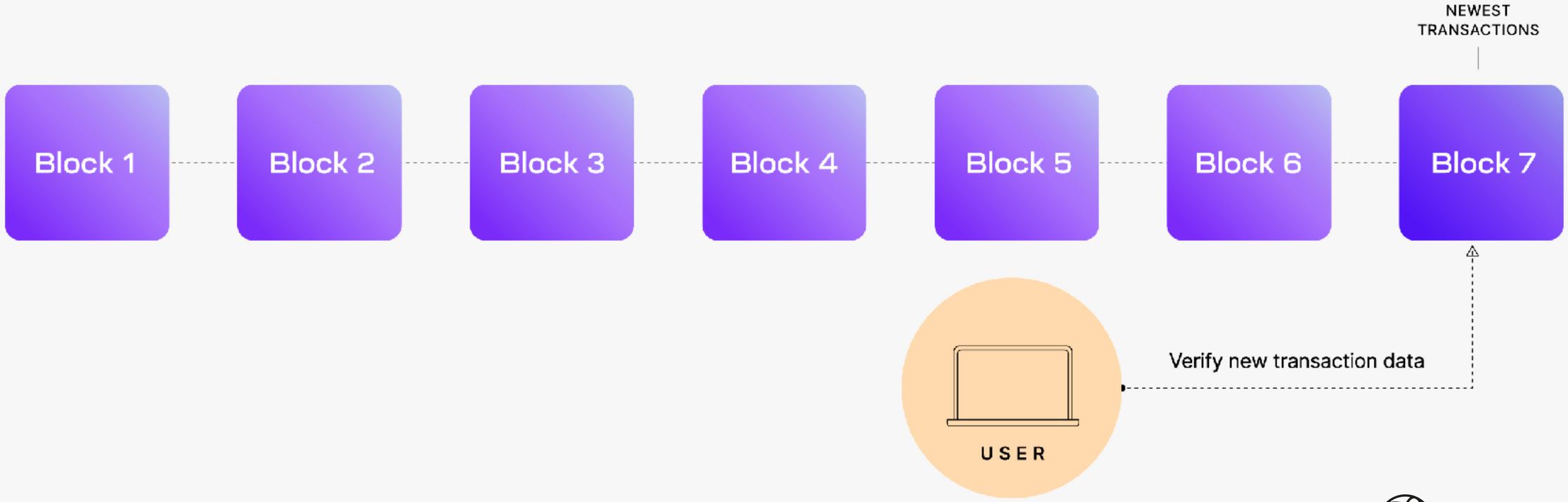
Data availability

Verify data has been published



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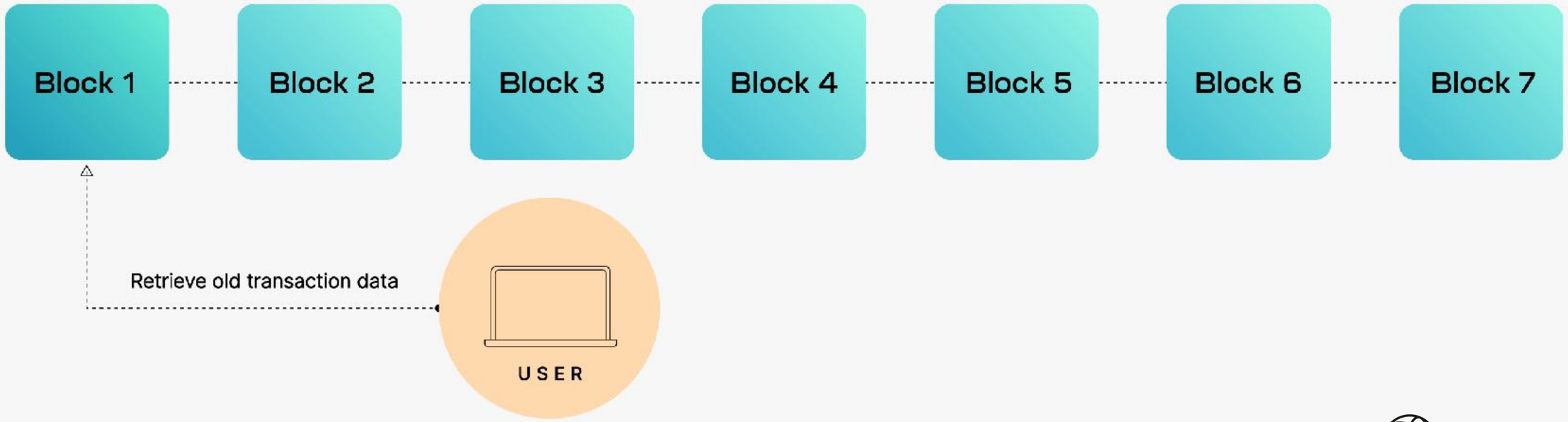
Data storage

Transaction data that
has already been verified



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What is data availability sampling (DAS)?

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Data availability sampling (DAS)

The magic of Celestia

- Data availability sampling allows light clients to have a very high probability guarantee that the entire block is valid by only downloading less than 1% of the block
- Increases scalability by reducing the cost for users to operate nodes and verify the network
- The more nodes there are on the network, the more capacity the network has

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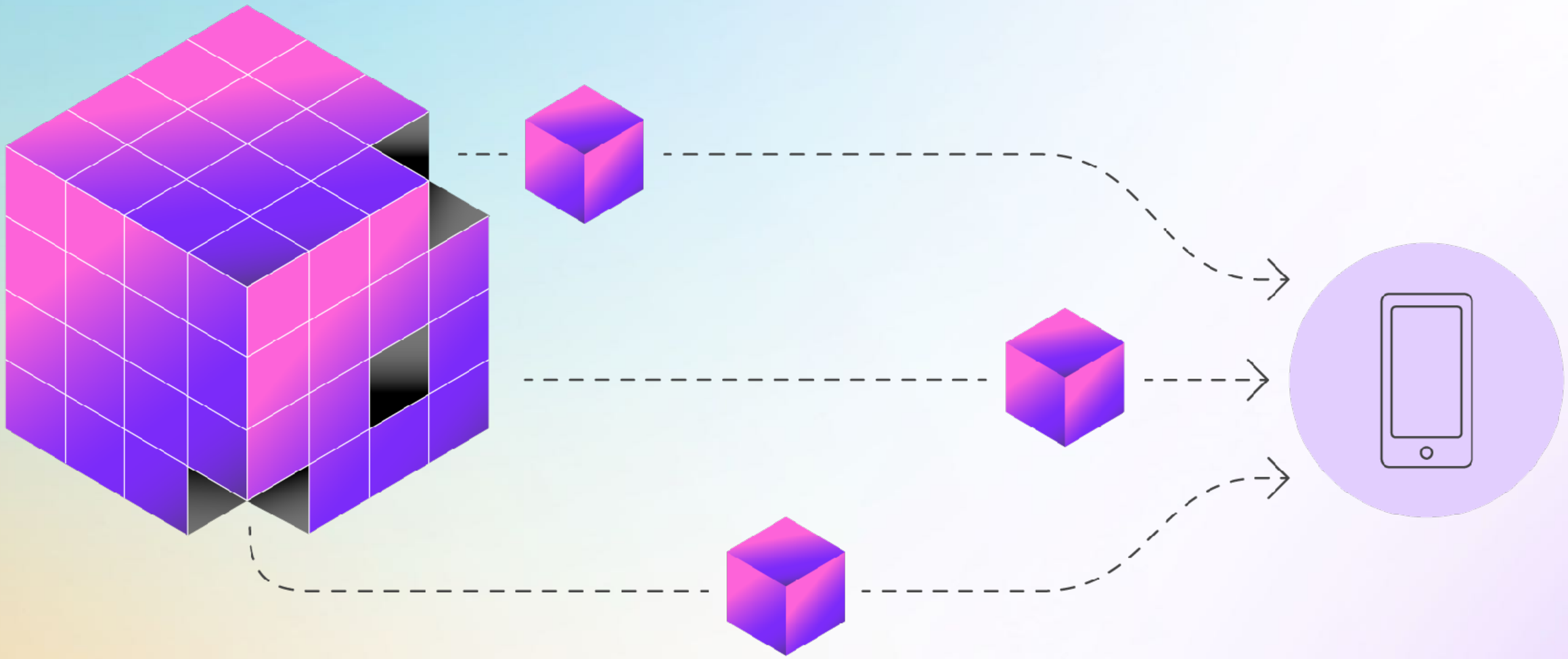

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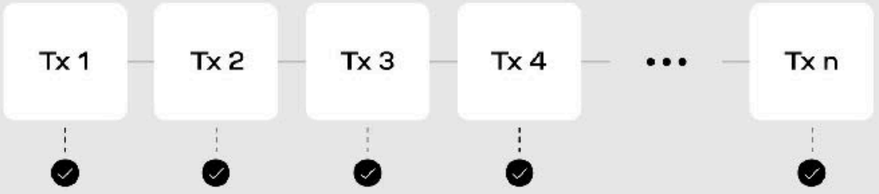
Monolithic

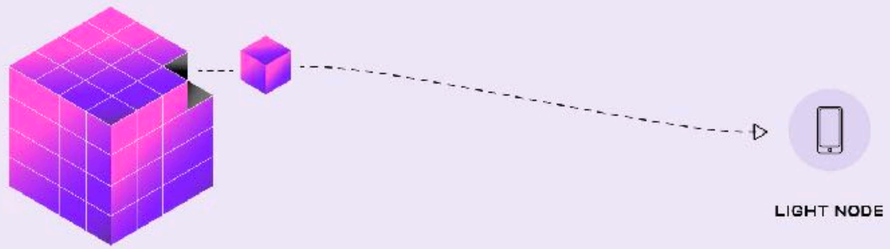
DOWNLOAD **ALL** THE DATA

VERIFY **EVERY** TRANSACTION

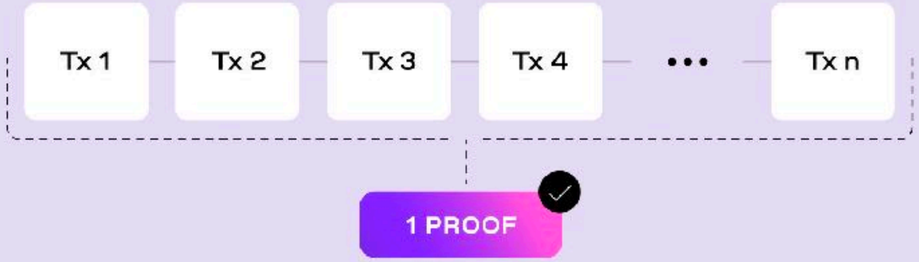


Modular

DOWNLOAD **A TINY SAMPLE** OF THE DATA



VERIFY **A SINGLE** PROOF



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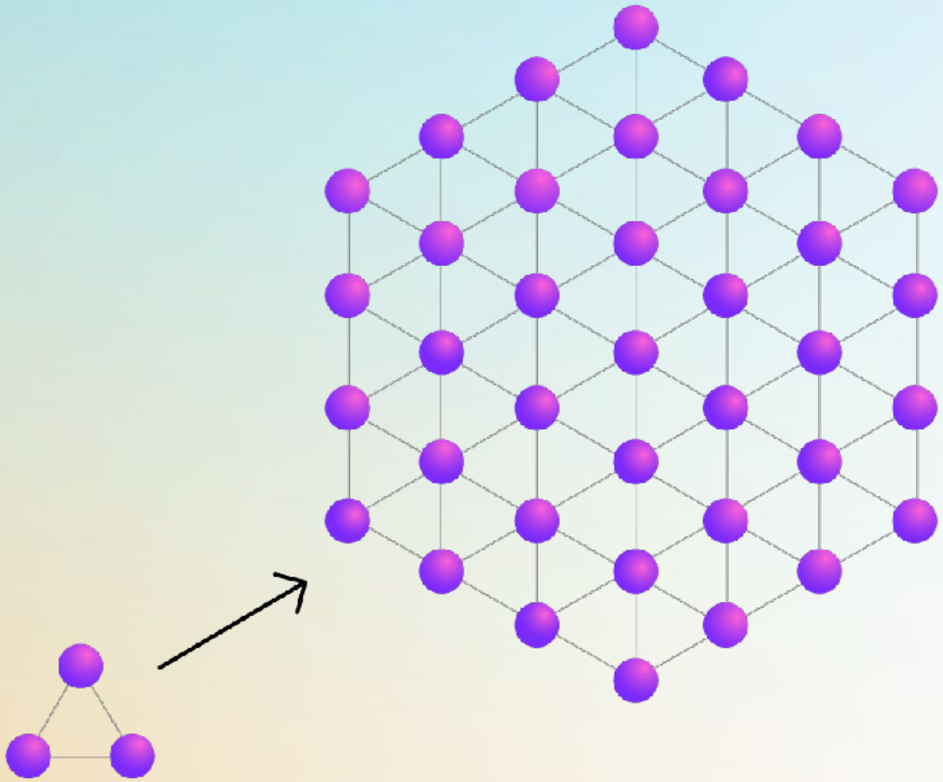
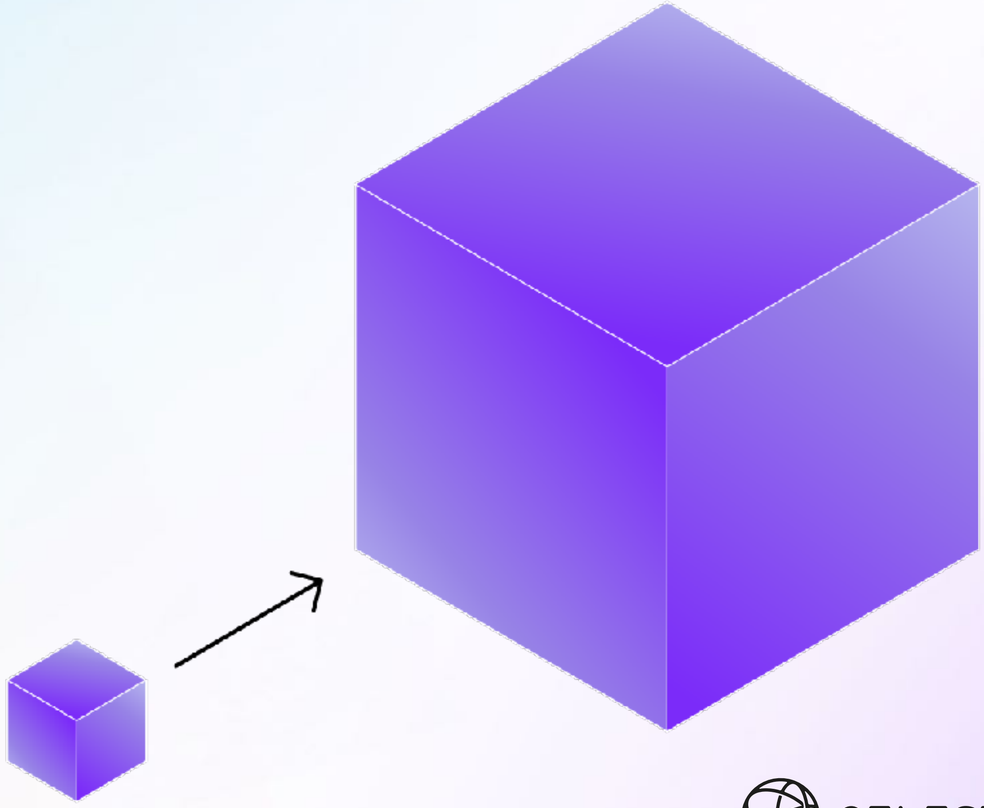
More nodes = Larger blocks





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Monolithic

FULL NODE

DOWNLOAD FULL BLOCK

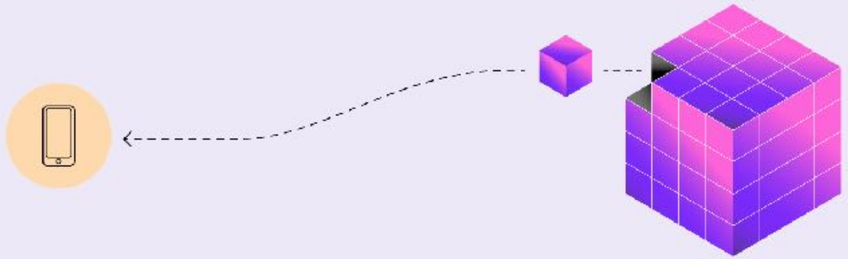
BIGGER BLOCKS

LARGE COST INCREASE

Modular

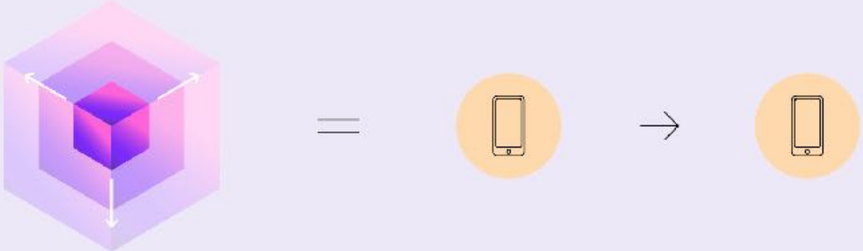
LIGHT NODE

DOWNLOAD A PORTION OF THE BLOCK



BIGGER BLOCKS

MINIMAL COST INCREASE



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And most importantly

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Verifiable by all

Run nodes on IoT

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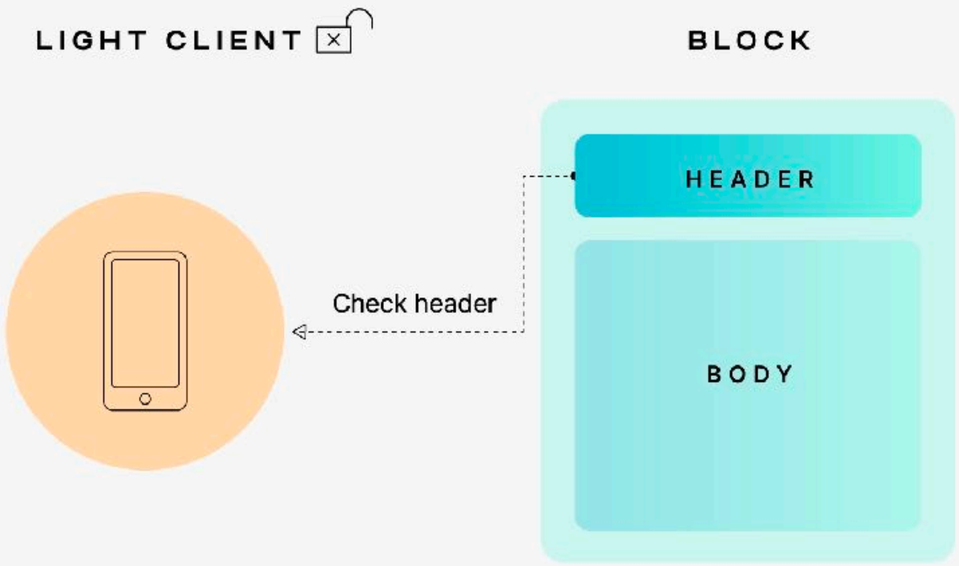
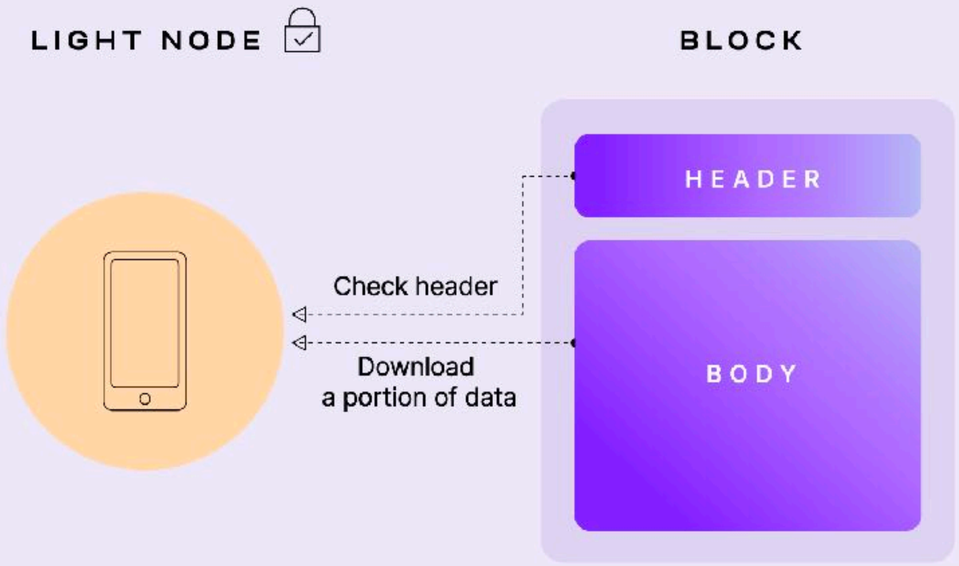
Basic light client

Trust majority of validators



Celestia light node

Verify block with high security



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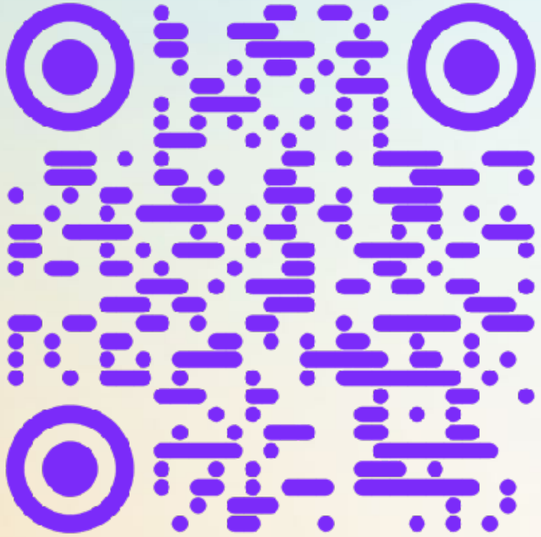
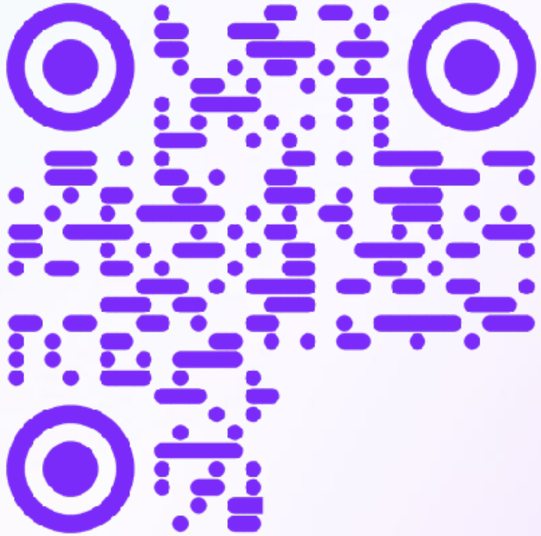
DAS and erasure coding

- QR codes and CDs use erasure coding
- Both QR codes work by replicating data





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Data availability sampling (DAS)

More resources

- Read more in:
  - LazyLedger: A Distributed Data Availability Ledger With Client-Side Smart Contracts - Mustafa Al-Bassam, 2019
  - Fraud and Data Availability Proofs: Detecting Invalid Blocks in Light Clients - Mustafa Al-Bassam, Alberto Sonnino, Vitalik Buterin, and Ismail Khoffi, Financial Cryptography and Data Security (FC), 2021

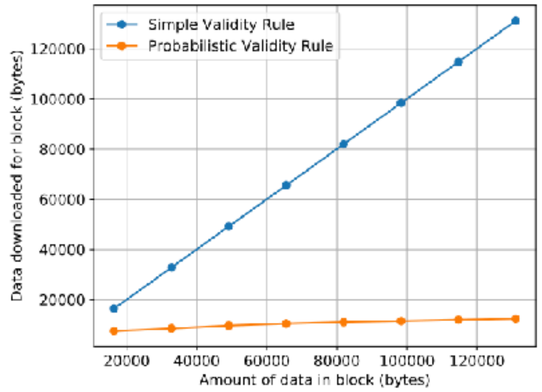

Figure 3: A graph showing how much data needs to be downloaded to execute the block validity rule to validate data availability versus the size of the block. For the Probabilistic Validity Rule, 15 samples are used.

14 Mustafa Al-Bassam, Alberto Sonnino, Vitalik Buterin, and Ismail Khoffi

$p_e(Z \geq \gamma)$	$s = 2$	$s = 5$	$s = 10$	$s = 20$	$s = 50$
$k = 16$	692	277	138	69	28
$k = 32$	2805	1,122	561	280	112
$k = 64$	11,289	4,516	2,258	1,129	451
$k = 128$	>40,000	~18,000	~9,000	~4,500	1,811

Table 1: Minimum number of light clients (c) required to achieve $p_e(Z \geq \gamma) > 0.99$ for various values of k and s. The approximate values have been approached numerically as evaluating Theorem 4 can be extremely resource-intensive for large values of k.

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Anyone can run a light node.

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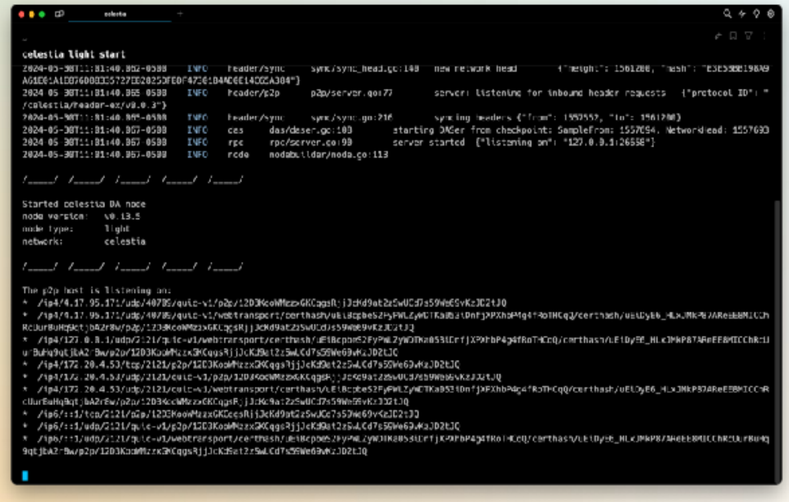
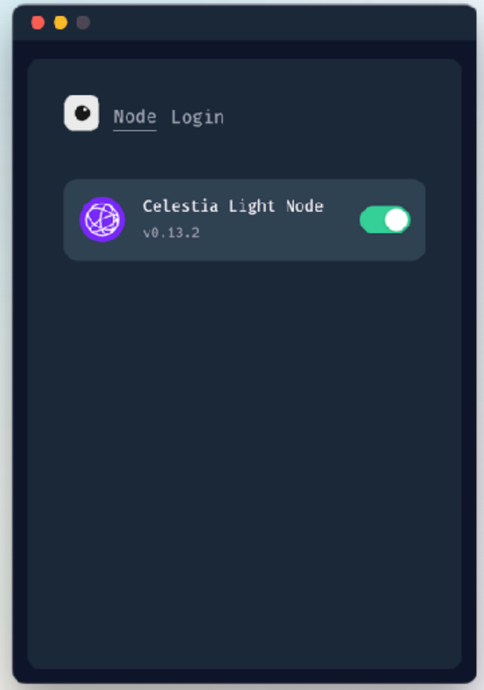
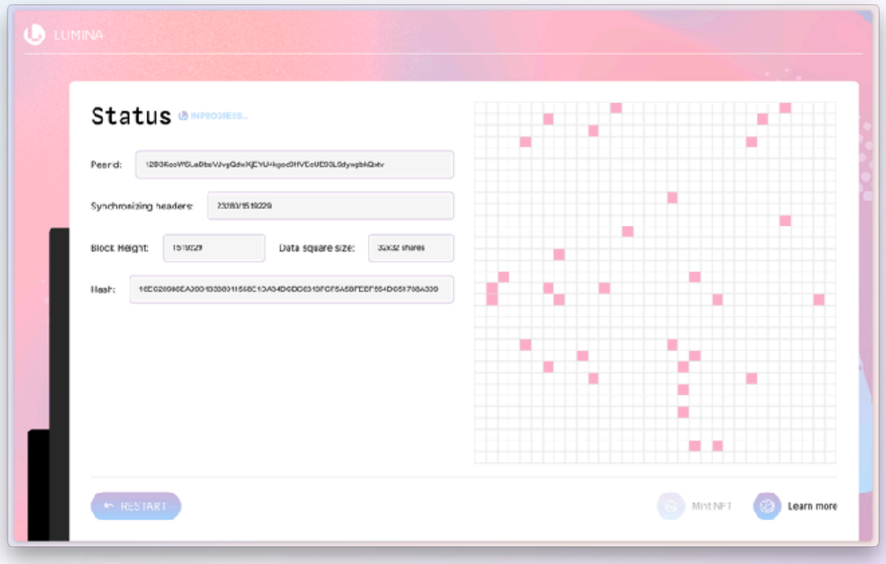
How to run a light node

- In your web browser
- On your phone
- On your computer







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```
> celestia light start
```

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What is a rollup?

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A rollup is blockchain that outsources one of its components to another blockchain.

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A rollup is a blockchain.

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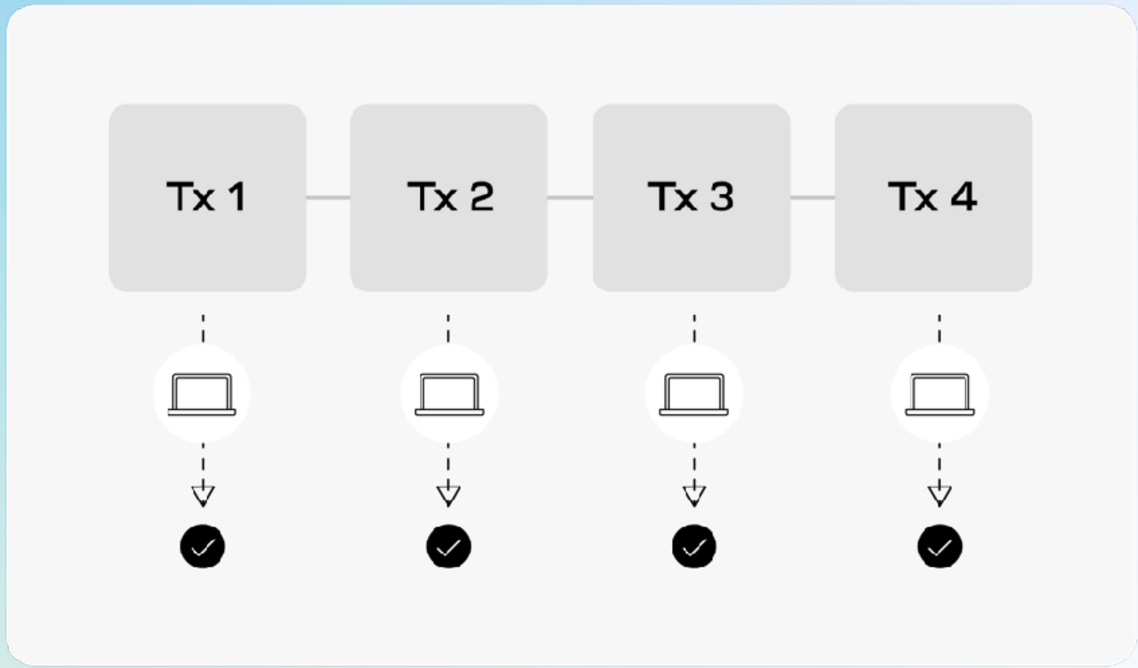

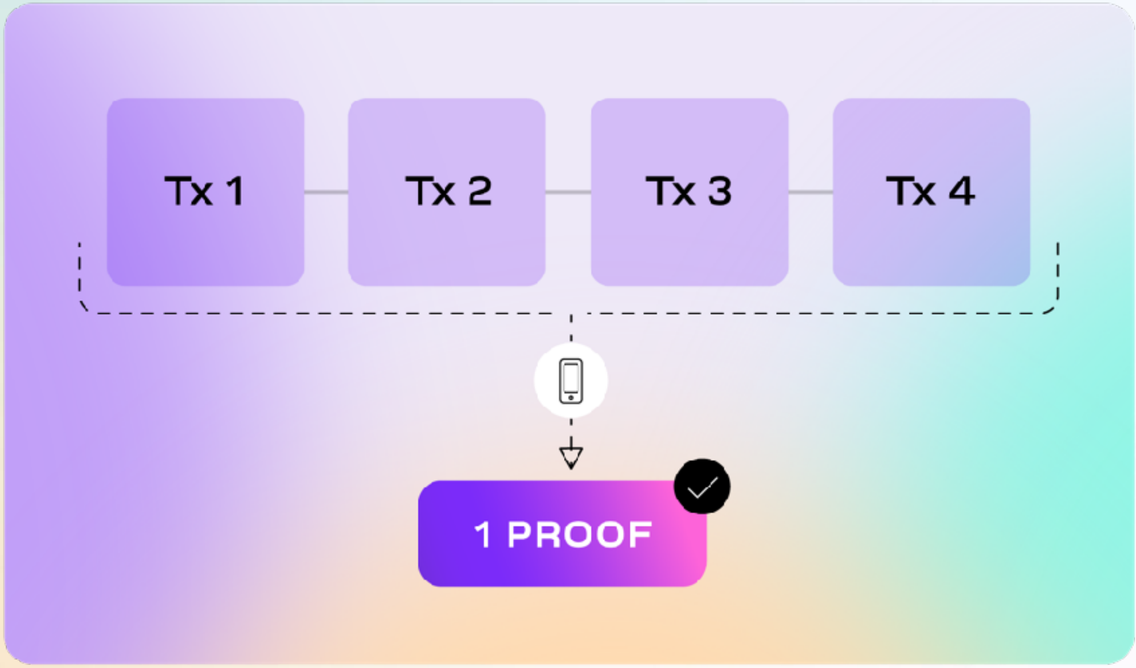

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What is a sovereign rollup?

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A sovereign rollup is a rollup that doesn’t use a settlement layer.

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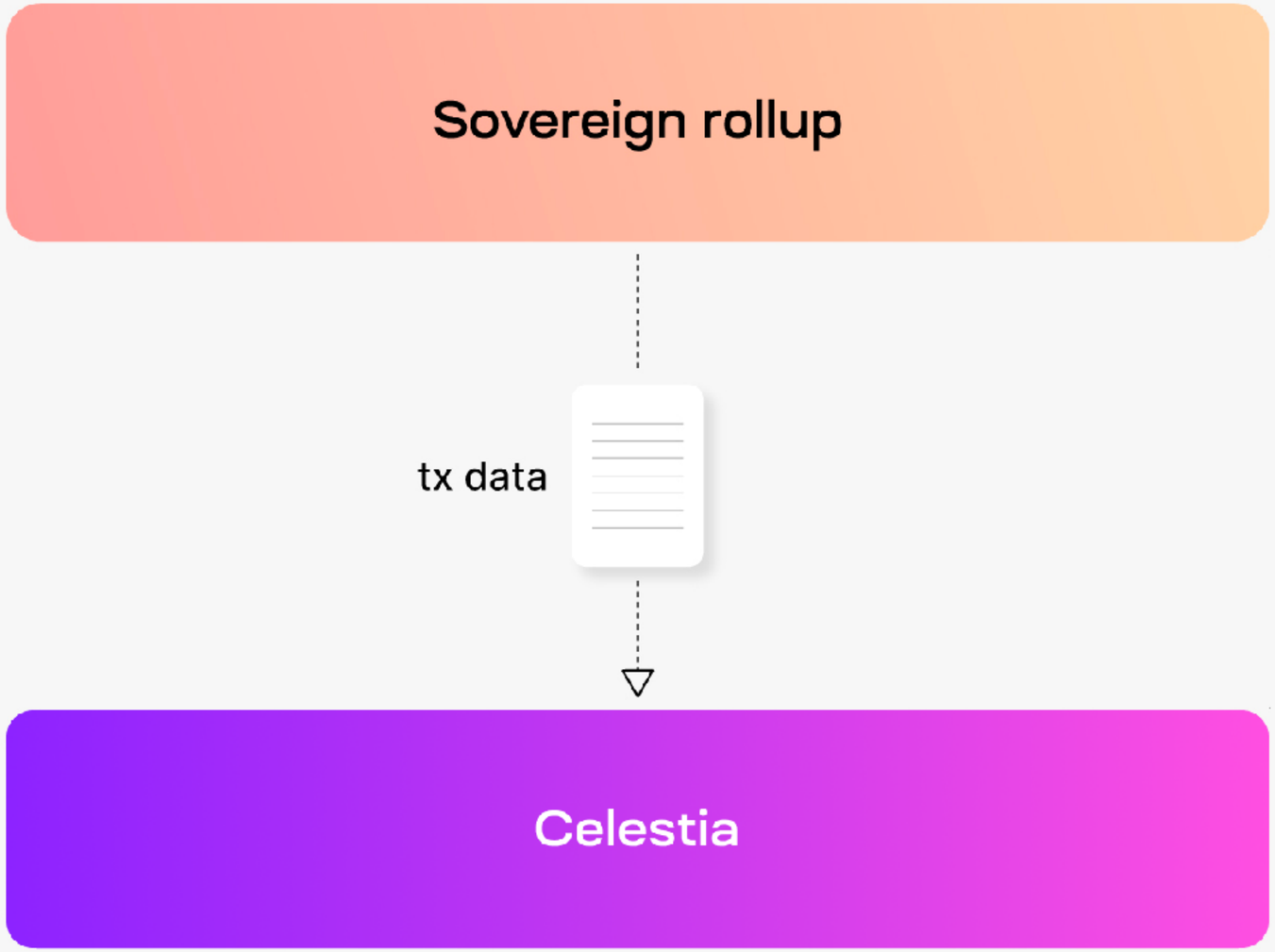

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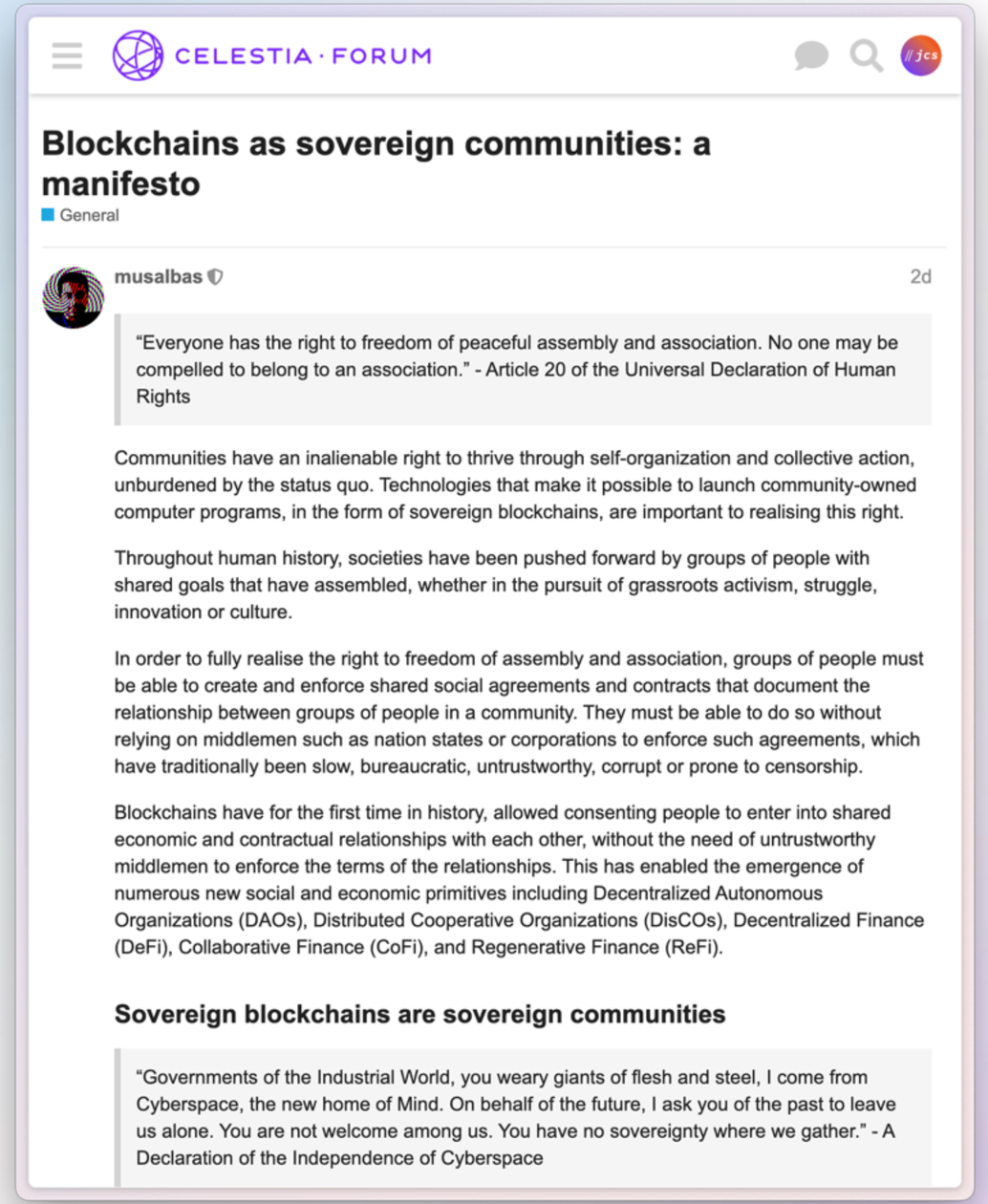
Read more

On forum.celestia.org



CELESTIA · FORUM

Blockchains as sovereign communities: a manifesto

General

musalbas 2d

> "Everyone has the right to freedom of peaceful assembly and association. No one may be compelled to belong to an association." - Article 20 of the Universal Declaration of Human Rights

Communities have an inalienable right to thrive through self-organization and collective action, unburdened by the status quo. Technologies that make it possible to launch community-owned computer programs, in the form of sovereign blockchains, are important to realising this right.

Throughout human history, societies have been pushed forward by groups of people with shared goals that have assembled, whether in the pursuit of grassroots activism, struggle, innovation or culture.

In order to fully realise the right to freedom of assembly and association, groups of people must be able to create and enforce shared social agreements and contracts that document the relationship between groups of people in a community. They must be able to do so without relying on middlemen such as nation states or corporations to enforce such agreements, which have traditionally been slow, bureaucratic, untrustworthy, corrupt or prone to censorship.

Blockchains have for the first time in history, allowed consenting people to enter into shared economic and contractual relationships with each other, without the need of untrustworthy middlemen to enforce the terms of the relationships. This has enabled the emergence of numerous new social and economic primitives including Decentralized Autonomous Organizations (DAOs), Distributed Cooperative Organizations (DisCOs), Decentralized Finance (DeFi), Collaborative Finance (CoFi), and Regenerative Finance (ReFi).

Sovereign blockchains are sovereign communities

> "Governments of the Industrial World, you weary giants of flesh and steel, I come from Cyberspace, the new home of Mind. On behalf of the future, I ask you of the past to leave us alone. You are not welcome among us. You have no sovereignty where we gather." - A Declaration of the Independence of Cyberspace

“Communities have an inalienable right to thrive through self-organization and collective action, unburdened by the status quo. Technologies that make it possible to launch community-owned computer programs, in the form of sovereign blockchains, are important to realising this right.”

Dr. Mustafa Al-Bassam, Blockchains as sovereign communities: a manifesto, 2024

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“All rules and laws which govern contractual relationships ultimately derive their authority from social contracts.”

Dr. Mustafa Al-Bassam, Blockchains as sovereign communities: a manifesto, 2024

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Top-level social contracts

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What are the benefits of building modular?

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Specialize

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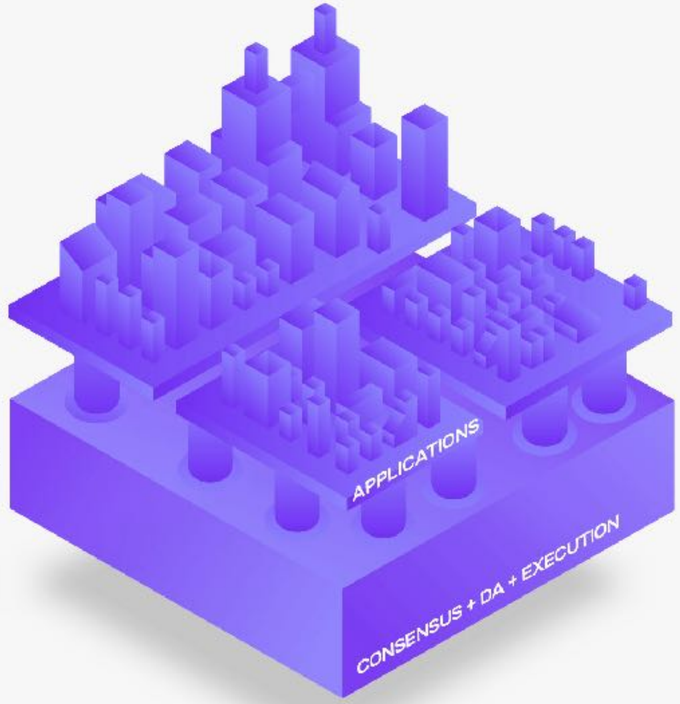
Monolithic

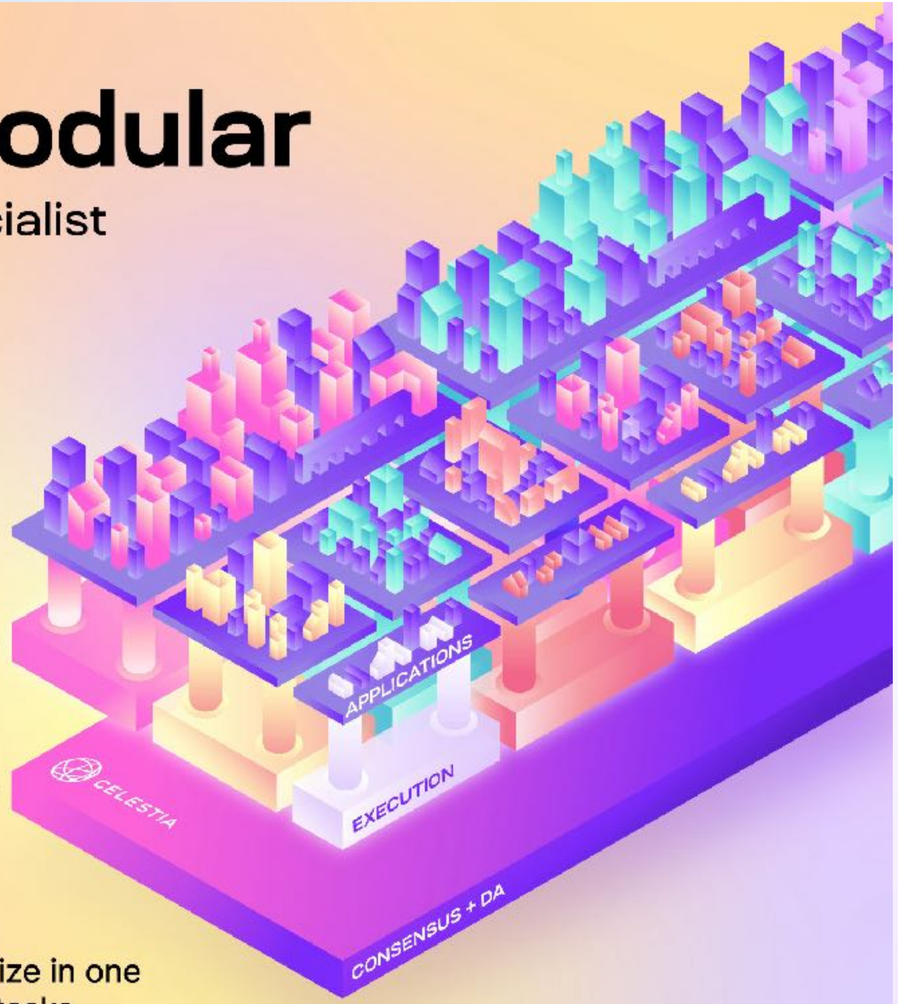
Generalist



Perform
all tasks

Modular

Specialist



Specialize in one
or two tasks

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Iterate quickly

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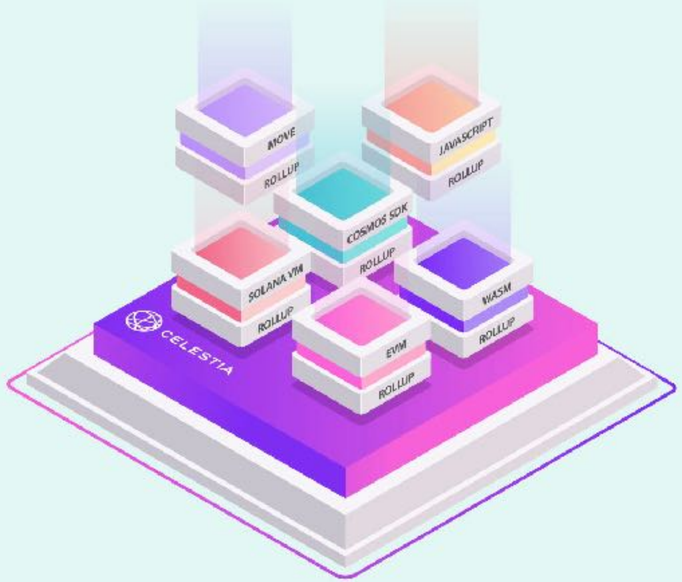
Start fast

Deploy your own blockchain in minutes, as easily as a smart contract

Use any VM

Unlock unique application features and use cases



Access scale

Support more users as your application grows

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Scale

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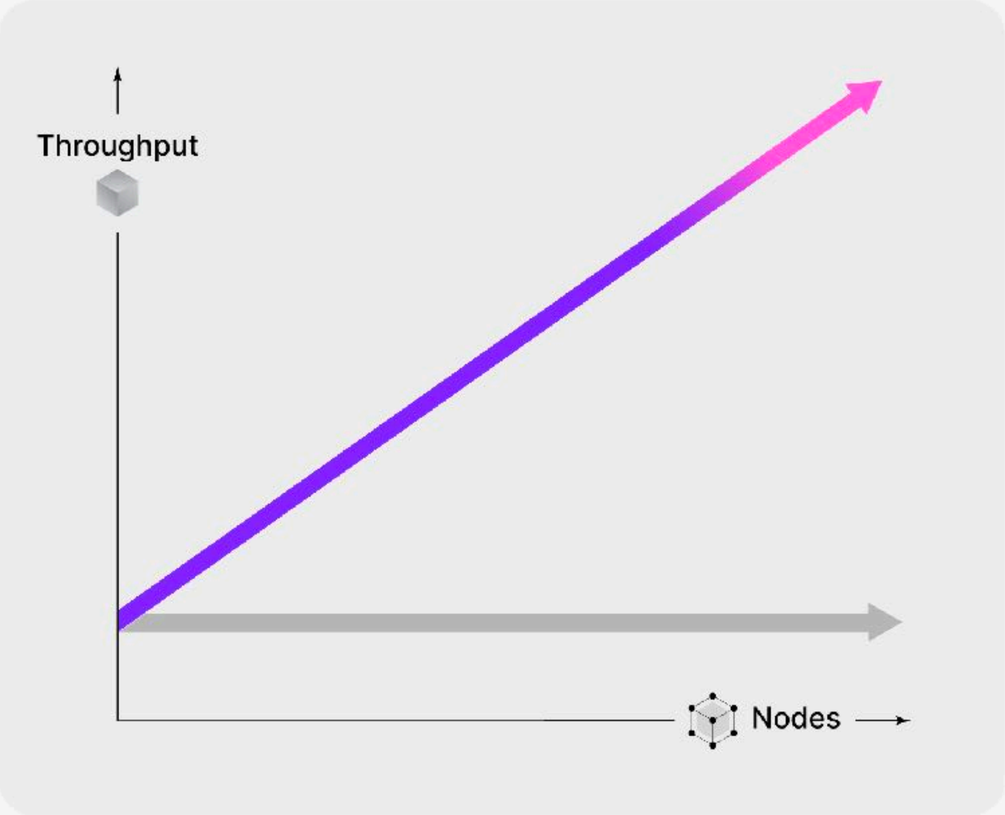
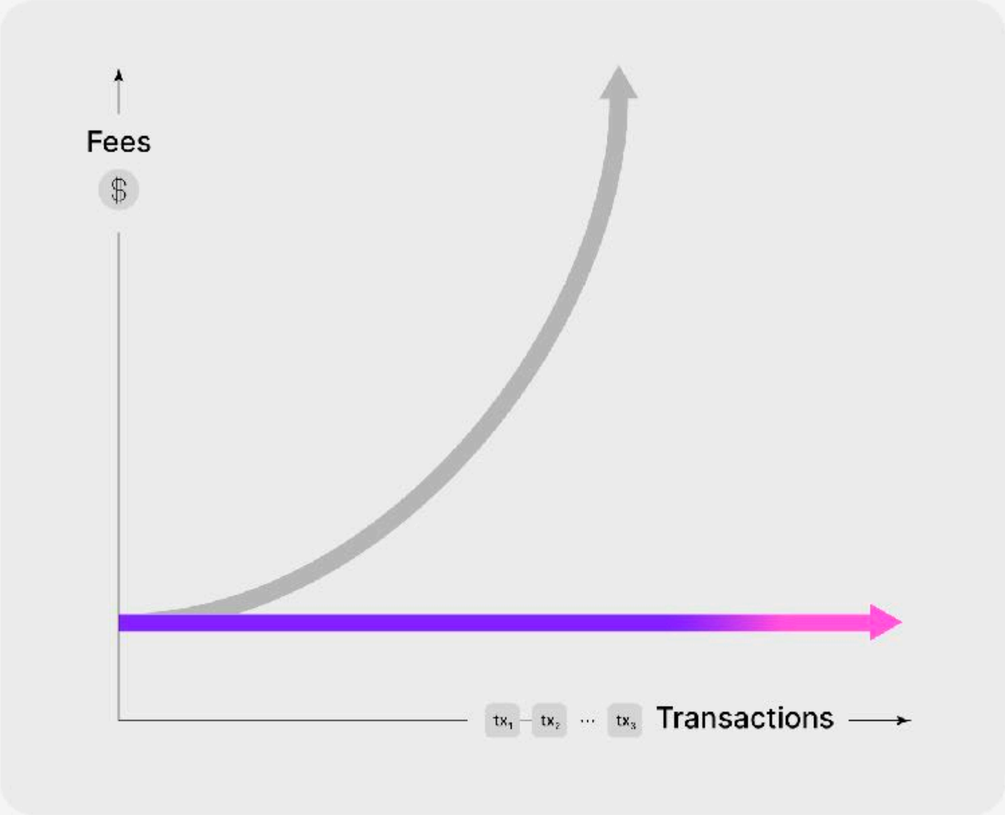
Monolithic — Modular —





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Unlock sovereignty

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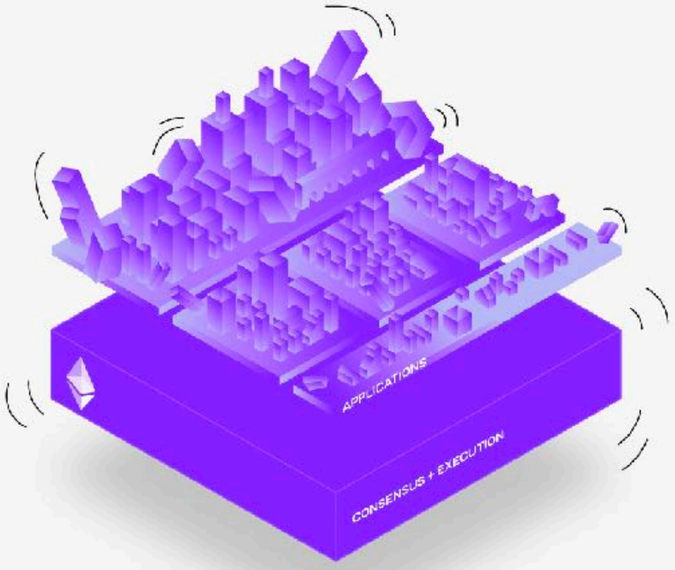
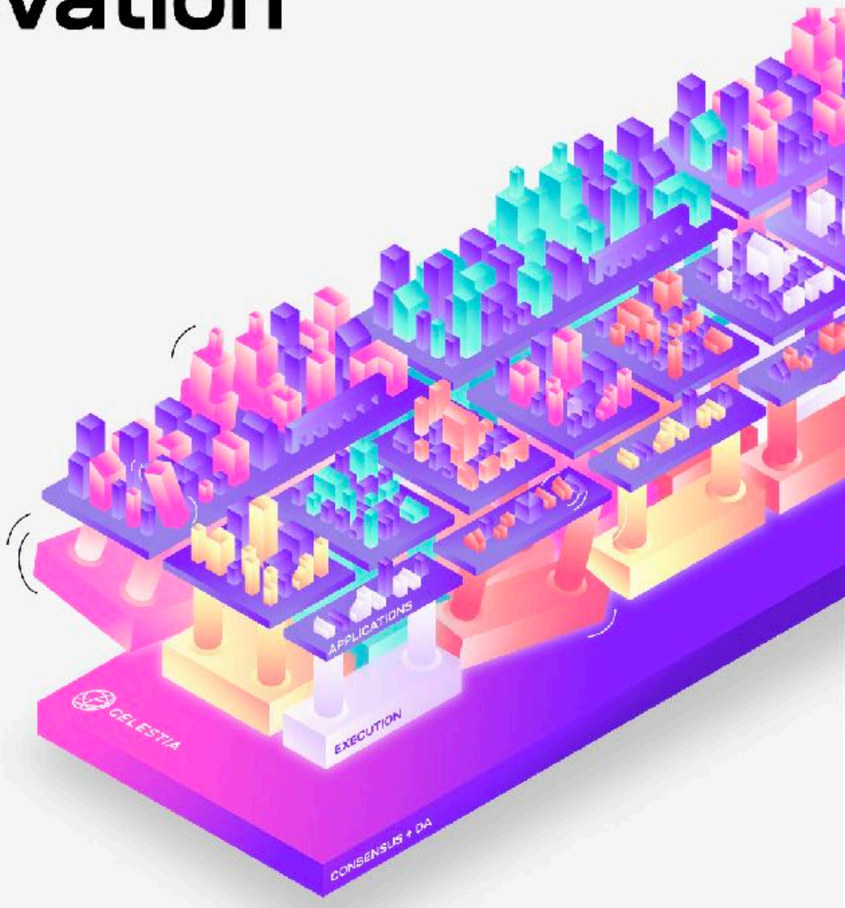
Balancing stability & innovation

STABLE BUT STAGNANT



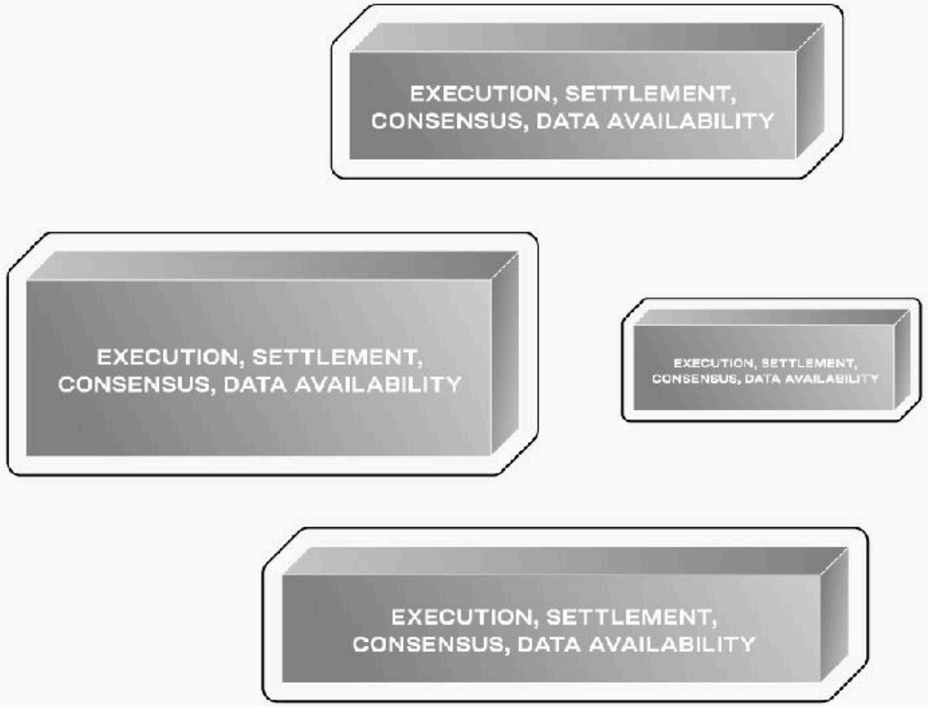
INNOVATIVE BUT UNSTABLE



STABLE AND INNOVATIVE

Monolithic Approach

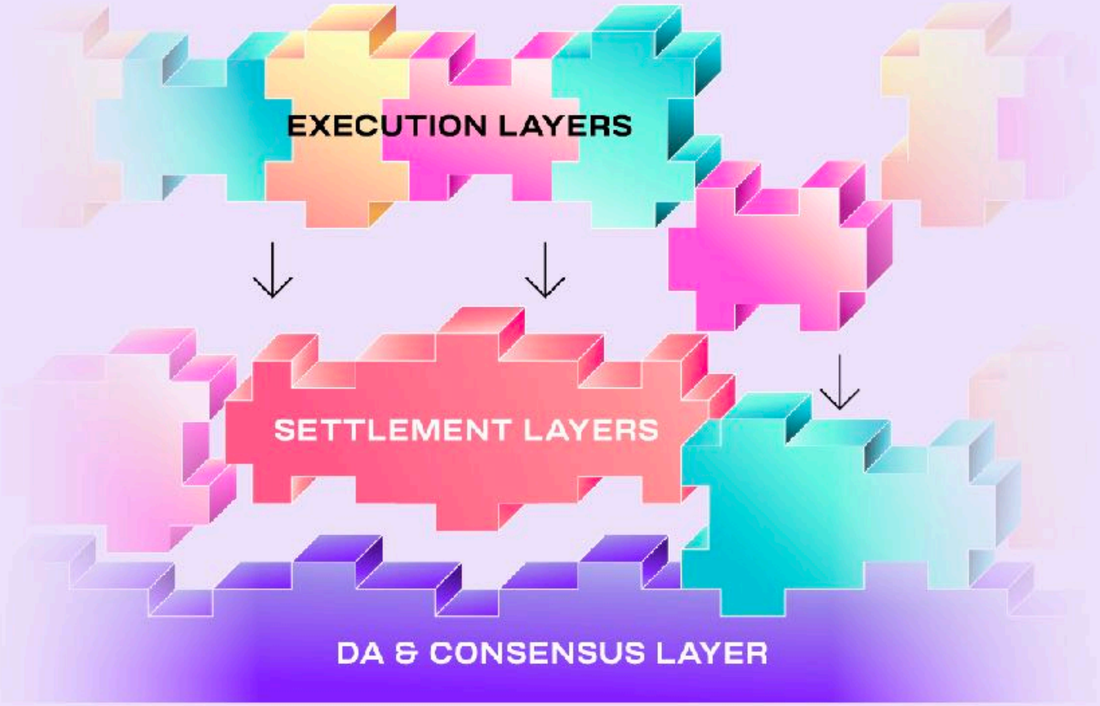
Build another siloed ecosystem that FOSTERS MAXIMALISM by competing with everyone else



VS

Modular Approach

COLLABORATE and tap into existing modular blockchains



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Wait, how is this different from Cosmos or Ethereum?

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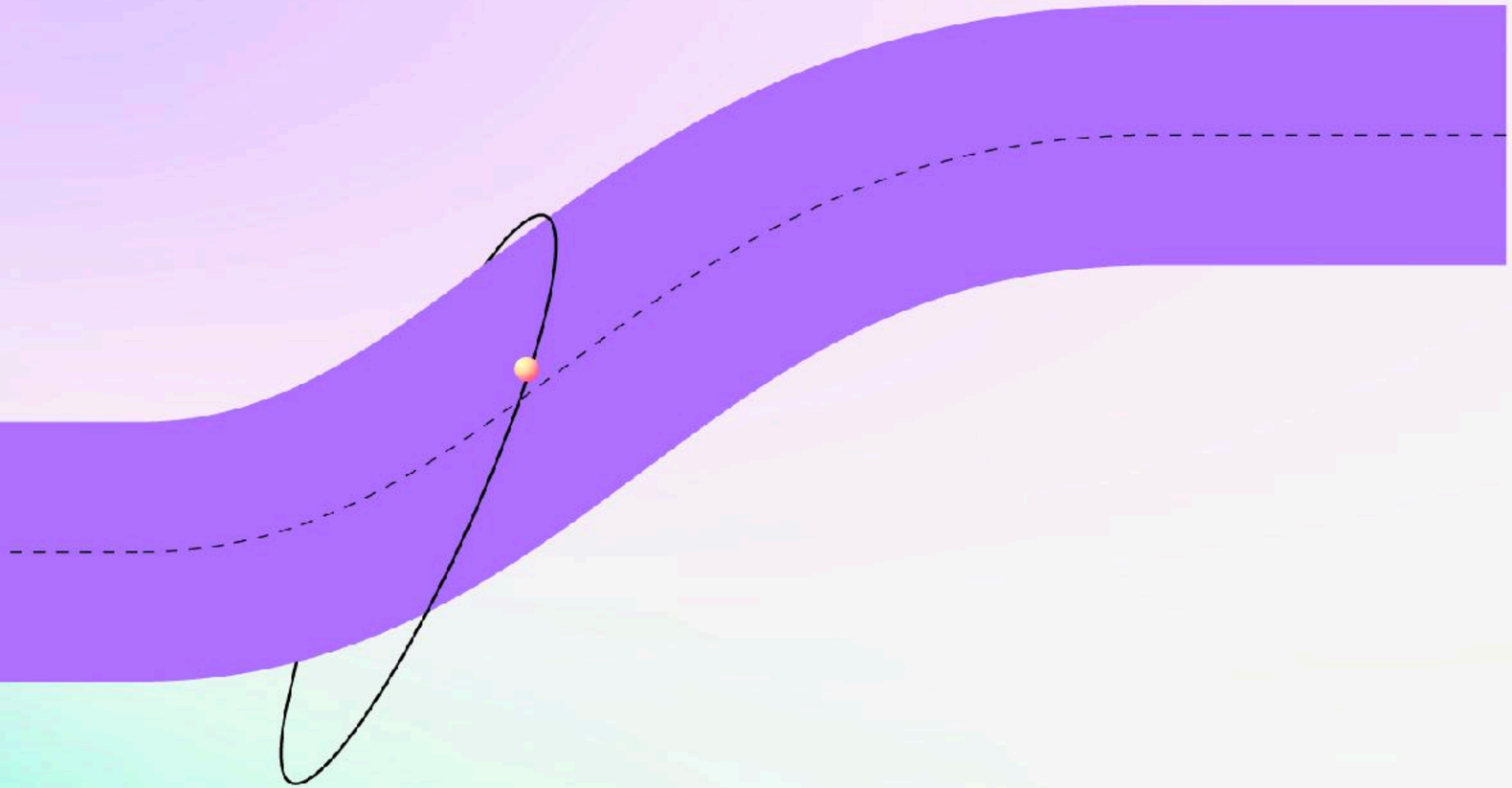
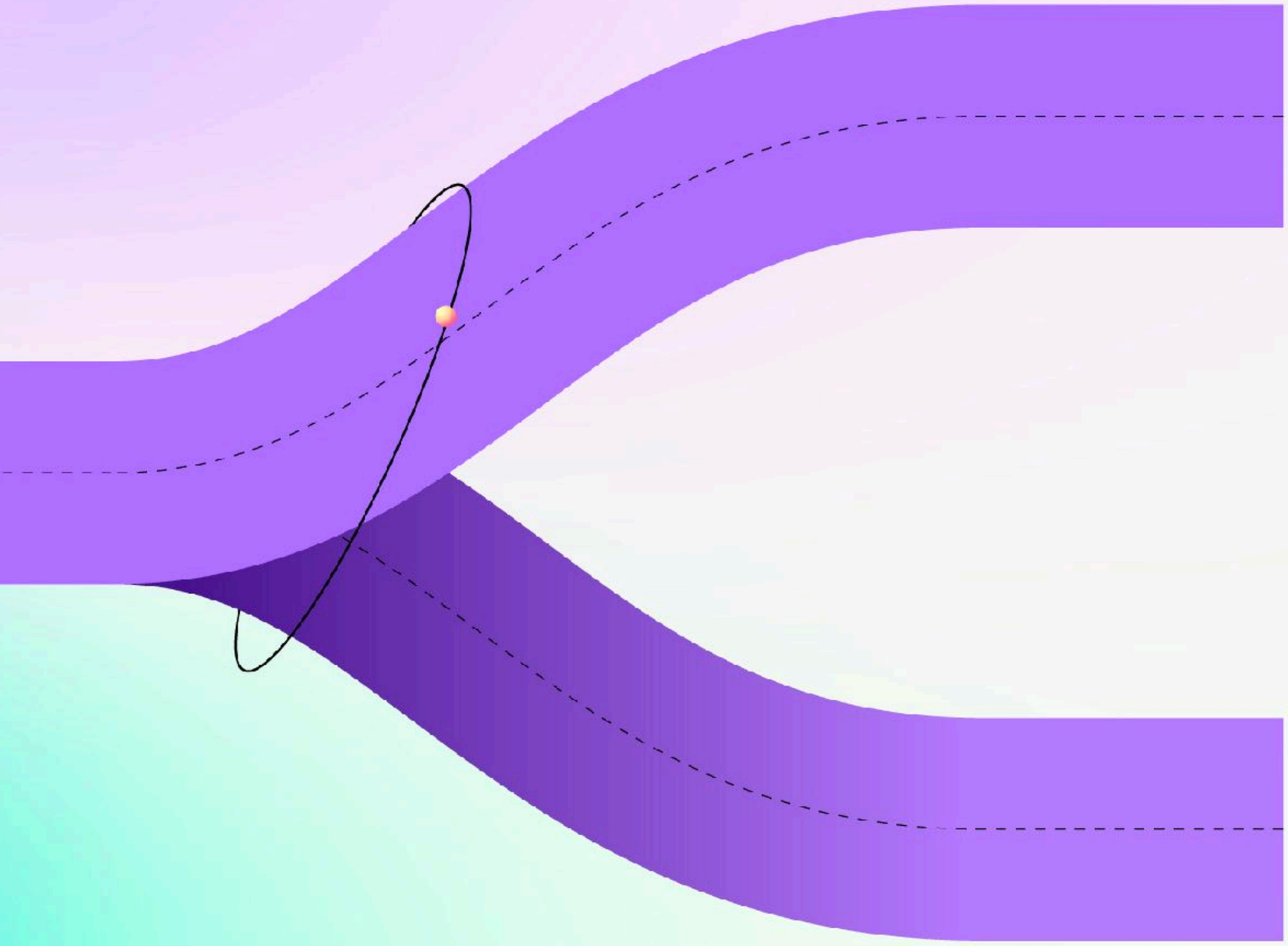


Ethereum

Shared security	✓
Easy to deploy	✓
Sovereignty	✗
Scalability	✗

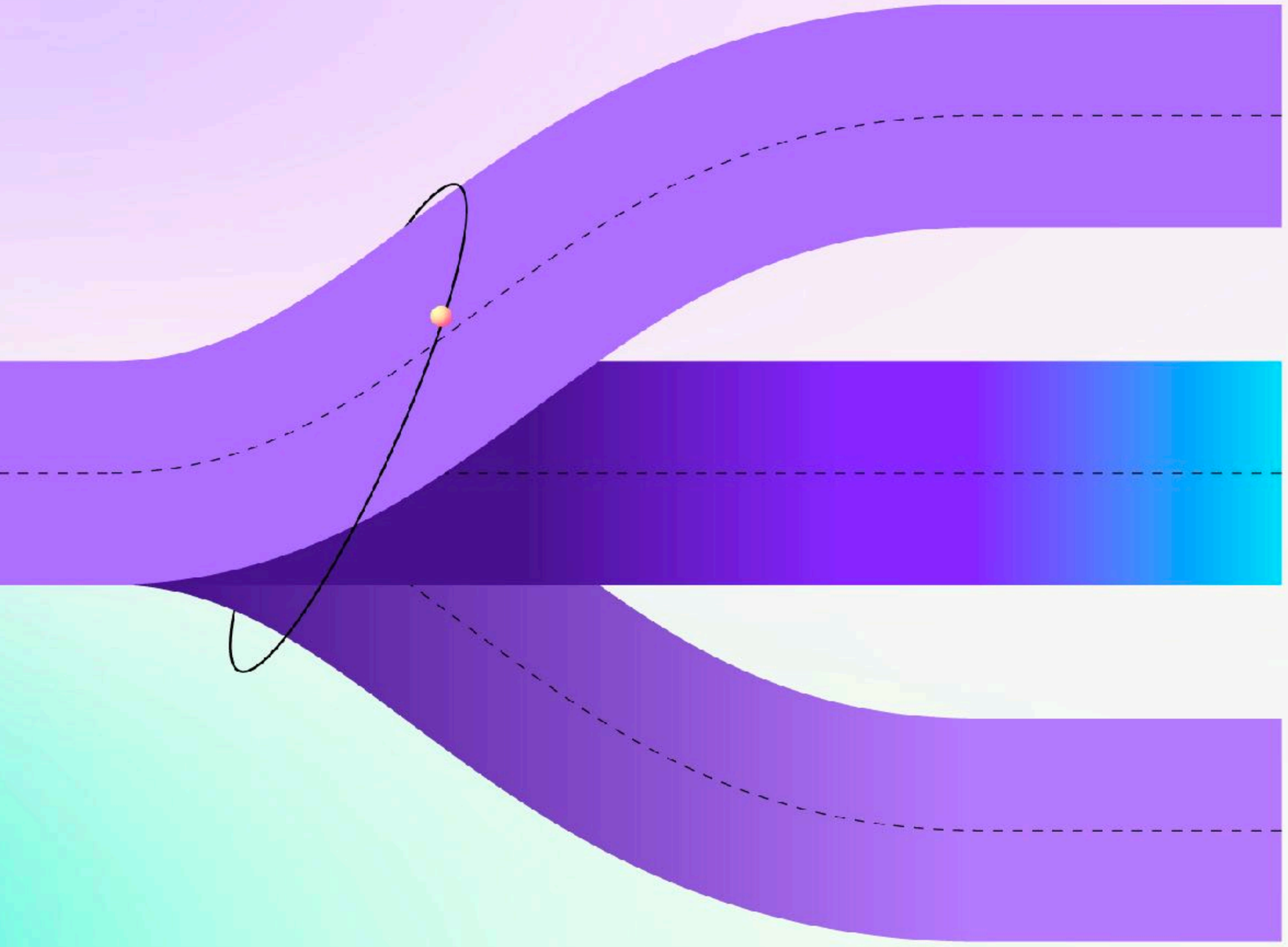


Ethereum

Shared security	✓
Easy to deploy	✓
Sovereignty	✗
Scalability	✗

Cosmos

Shared security	✗
Easy to deploy	✗
Sovereignty	✓
Scalability	✓



Ethereum

Shared security	✓
Easy to deploy	✓
Sovereignty	✗
Scalability	✗

Celestia

Shared security	✓
Easy to deploy	✓
Sovereignty	✓
Scalability	✓

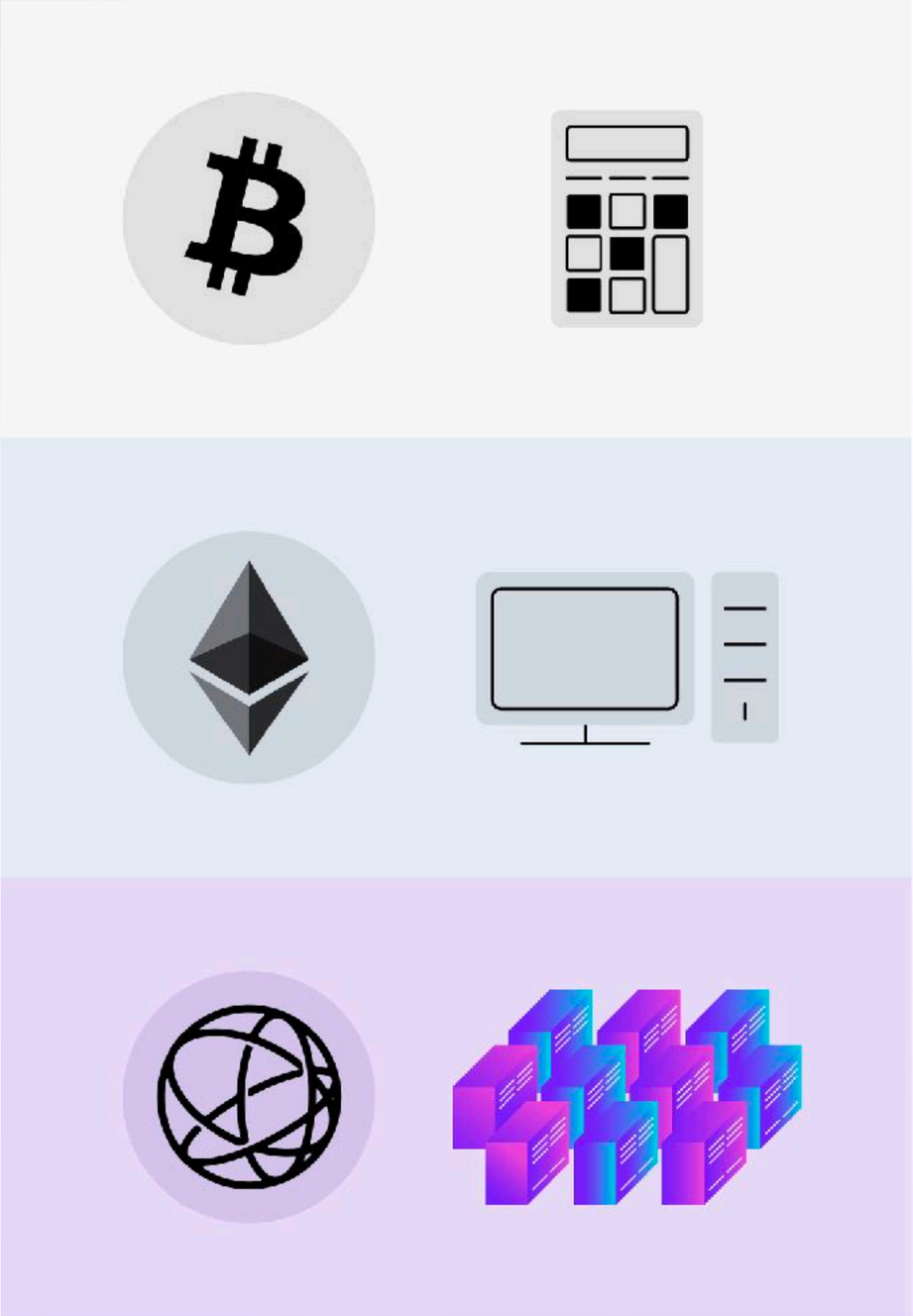
Cosmos

Shared security	✗
Easy to deploy	✗
Sovereignty	✓
Scalability	✓

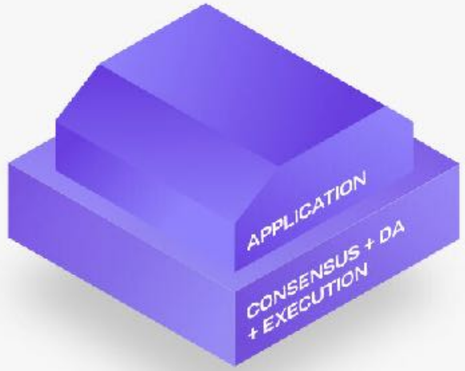
CELESTIA

Evolution of blockchains

From calculator to cloud computer

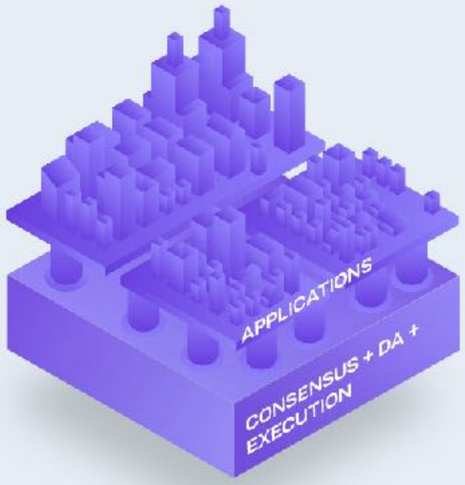


bitcoin



calculator

ethereum



computer

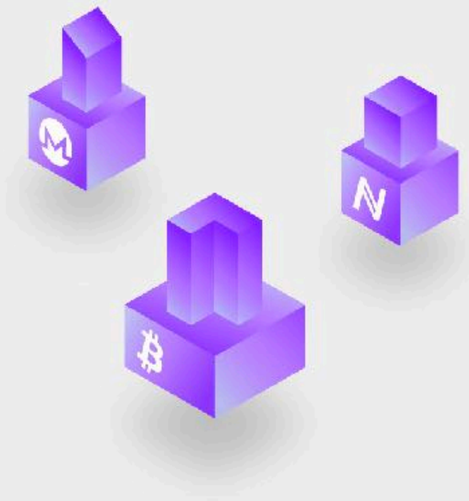
CELESTIA

cloud computer

The Evolution of Shared Security

Bitcoin

Appchain Era

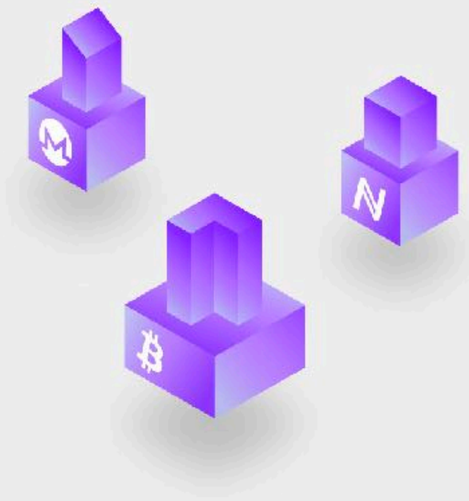


Satoshi Nakamoto
publishes Bitcoin whitepaper

2008

The Evolution of Shared Security

Bitcoin
Appchain Era



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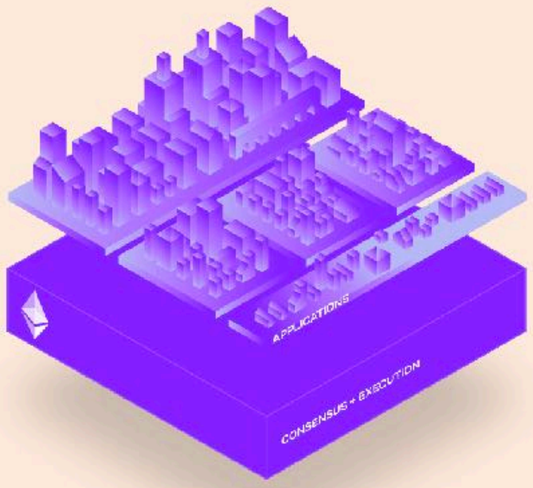
2008

Ethereum
Monolithic Era

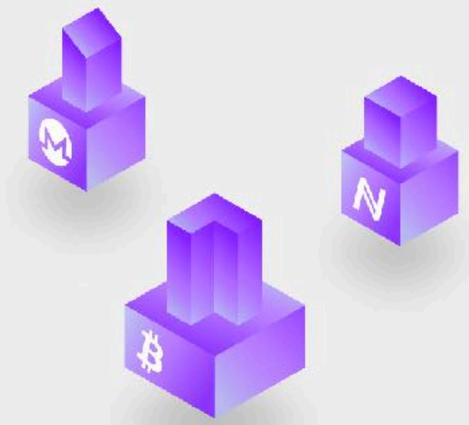


Vitalik Buterin publishes
Ethereum whitepaper

2013

The Evolution of Shared Security

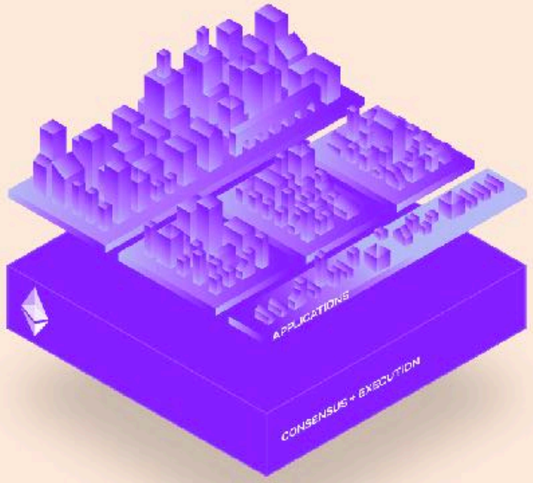
Bitcoin
Appchain Era



Satoshi Nakamoto publishes Bitcoin whitepaper

2008

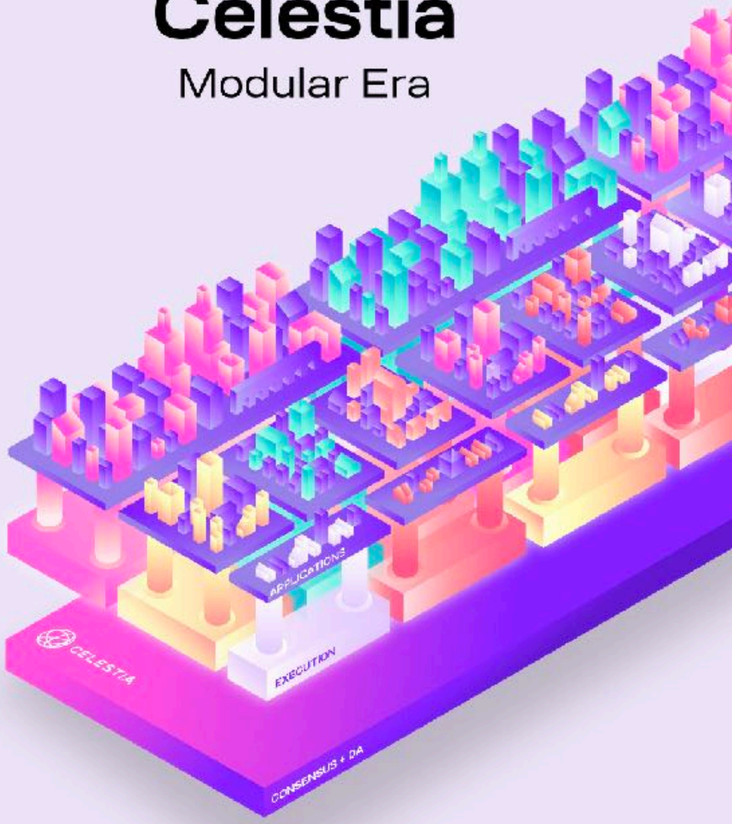
Ethereum
Monolithic Era



Vitalik Buterin publishes Ethereum whitepaper

2013

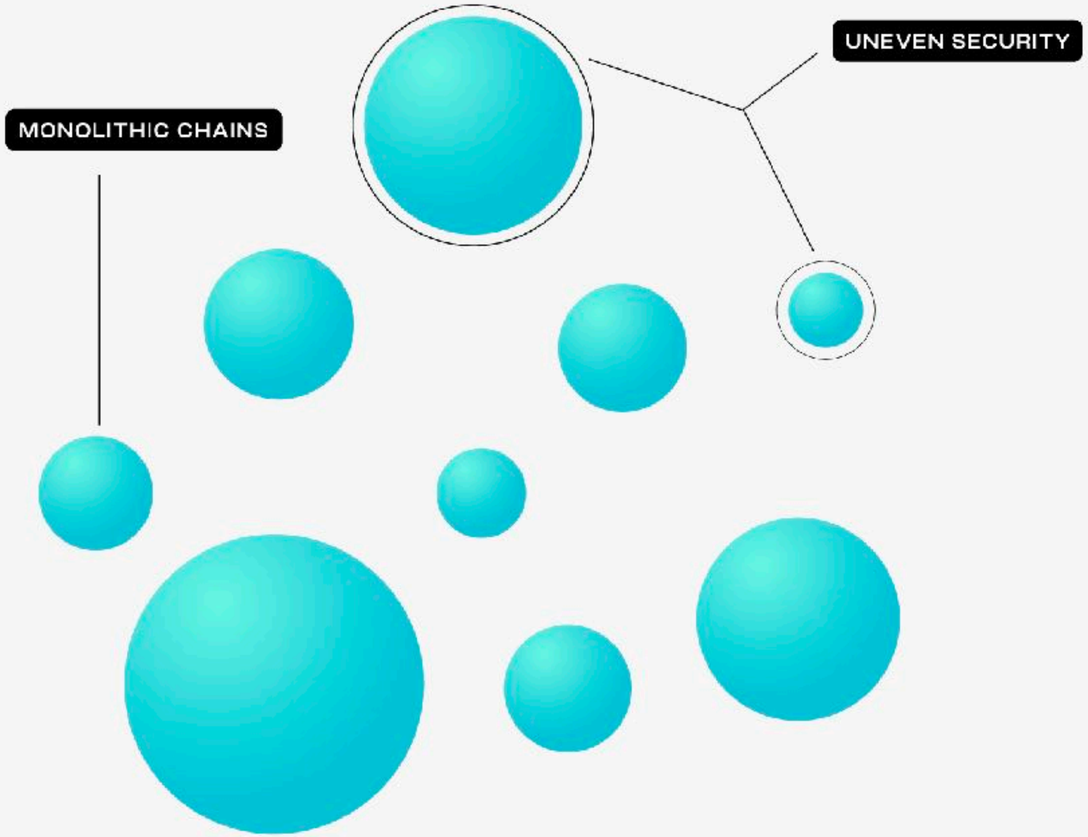
Celestia
Modular Era



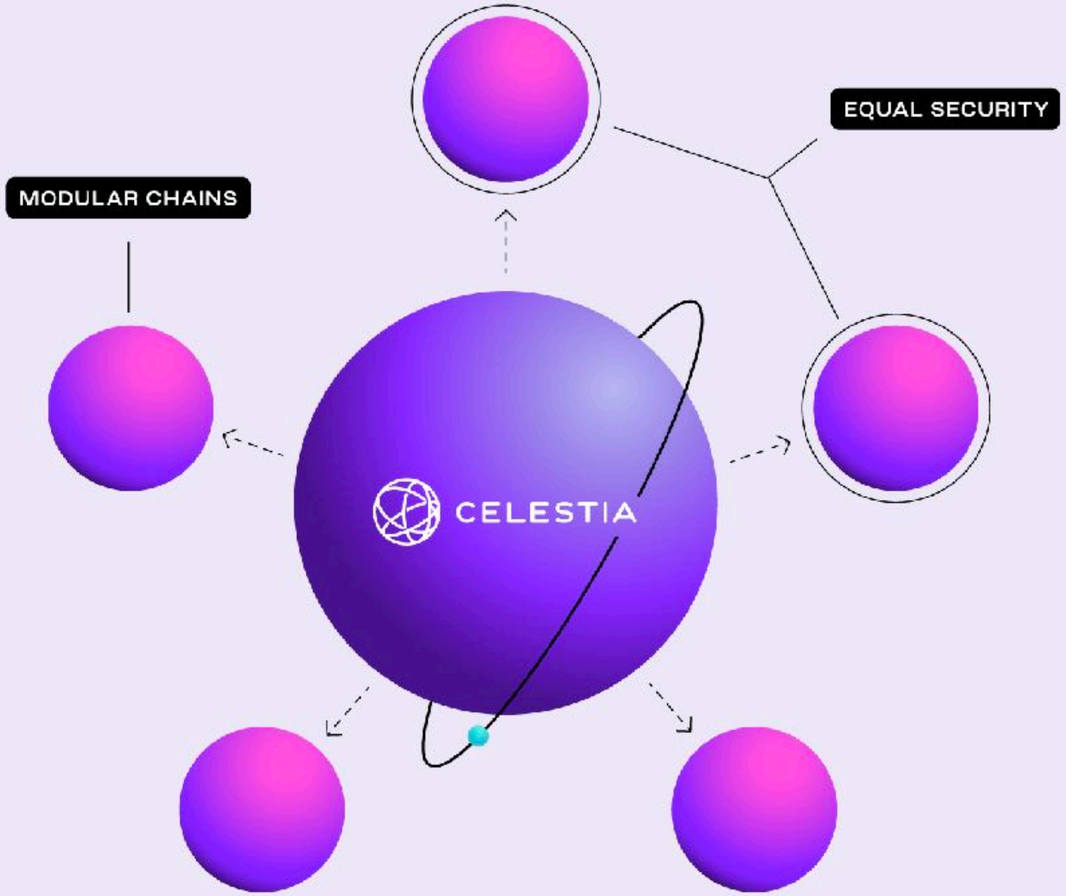
Mustafa Al-Bassam publishes LazyLedger whitepaper

2019

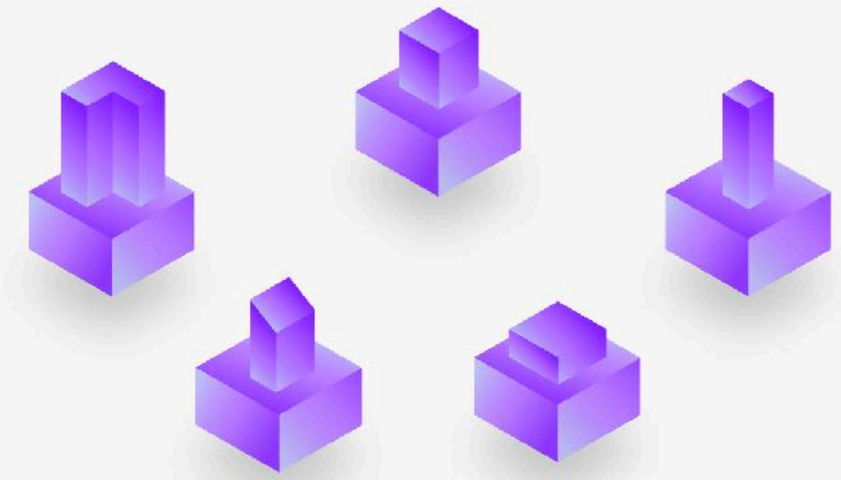
Monolithic



Modular

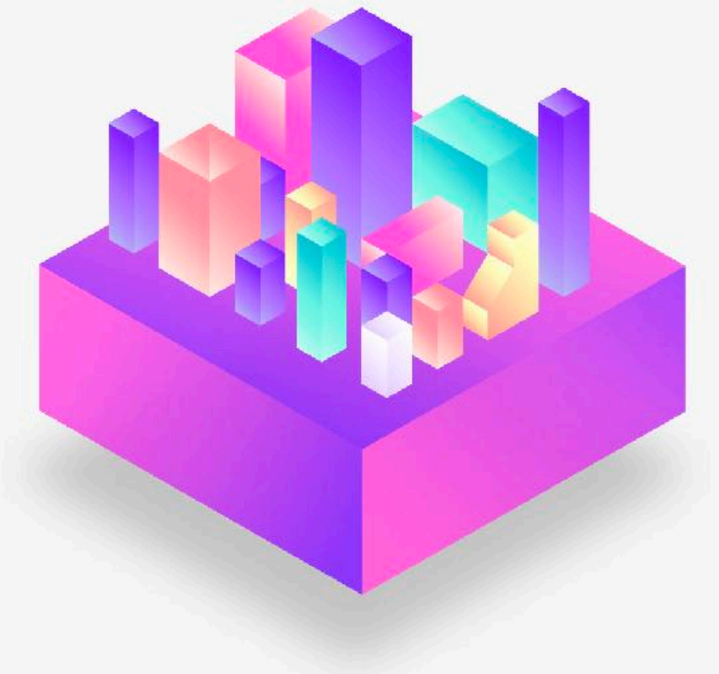


Without shared security



Isolated functionality

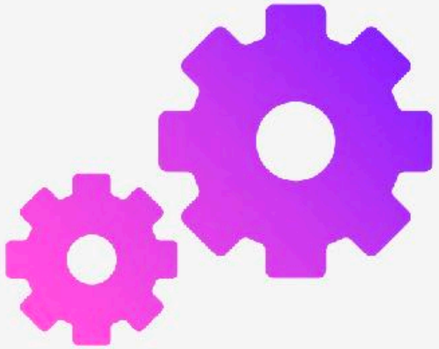
With shared security



Rich emergent functionality

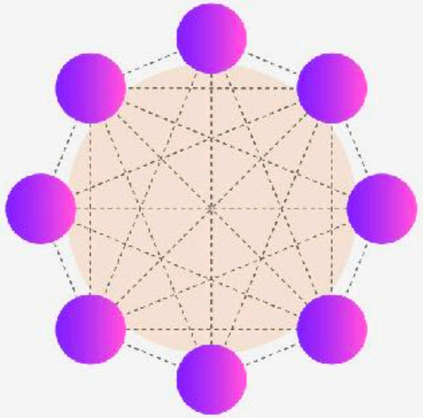
Bootstrapping Security

Technical



Requires protocol engineering expertise

Social



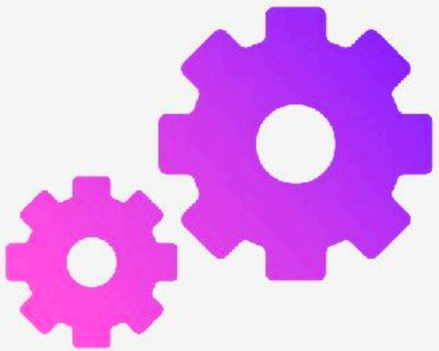
Must gather a set of validators

Economic

Must issue token, high operating cost

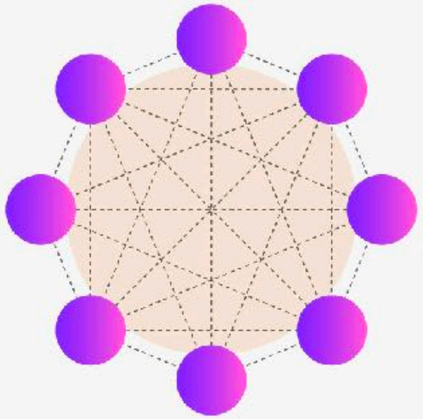
Inheriting Security

Technical



Just write
business logic

Social



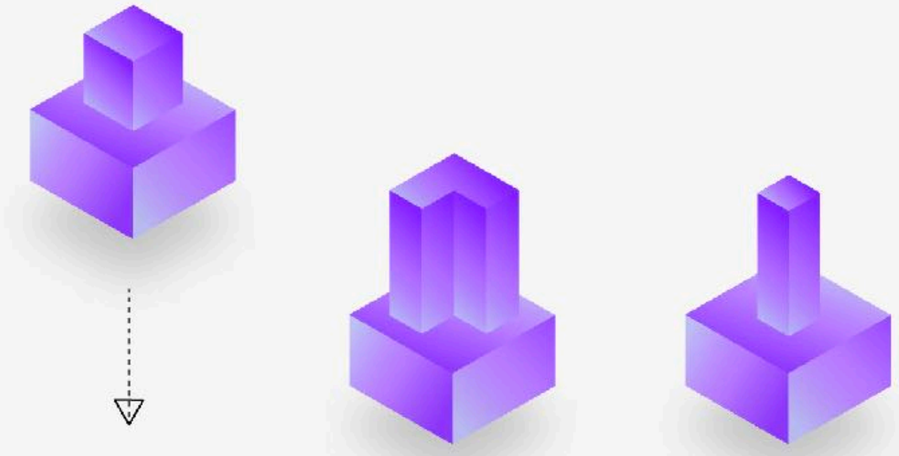
Permissionless
to deploy

Economic

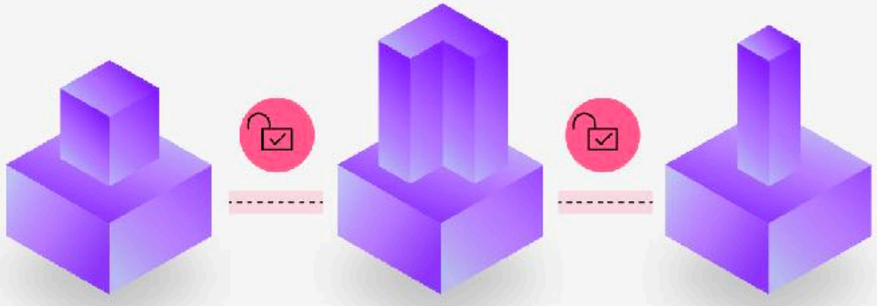
No token required,
minimal operating cost

Without shared security

Applications must bootstrap own security

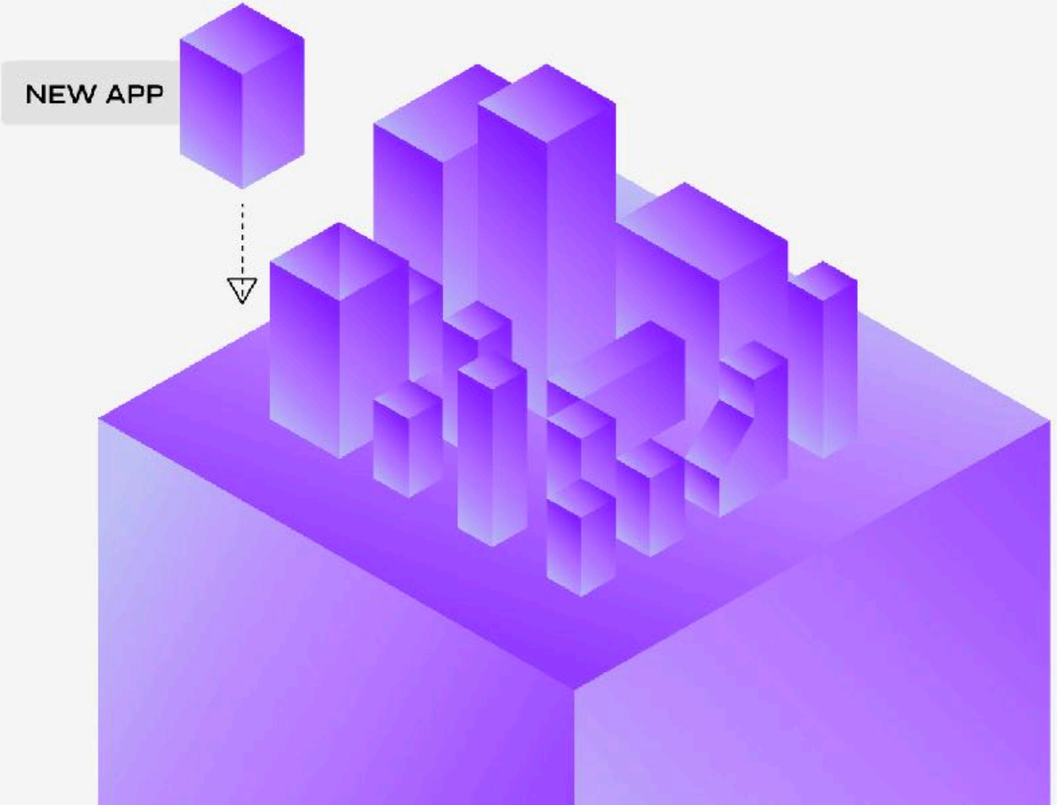


Insecure interoperability



With shared security

Applications inherit security from existing source



Secure interoperability

Without shared security

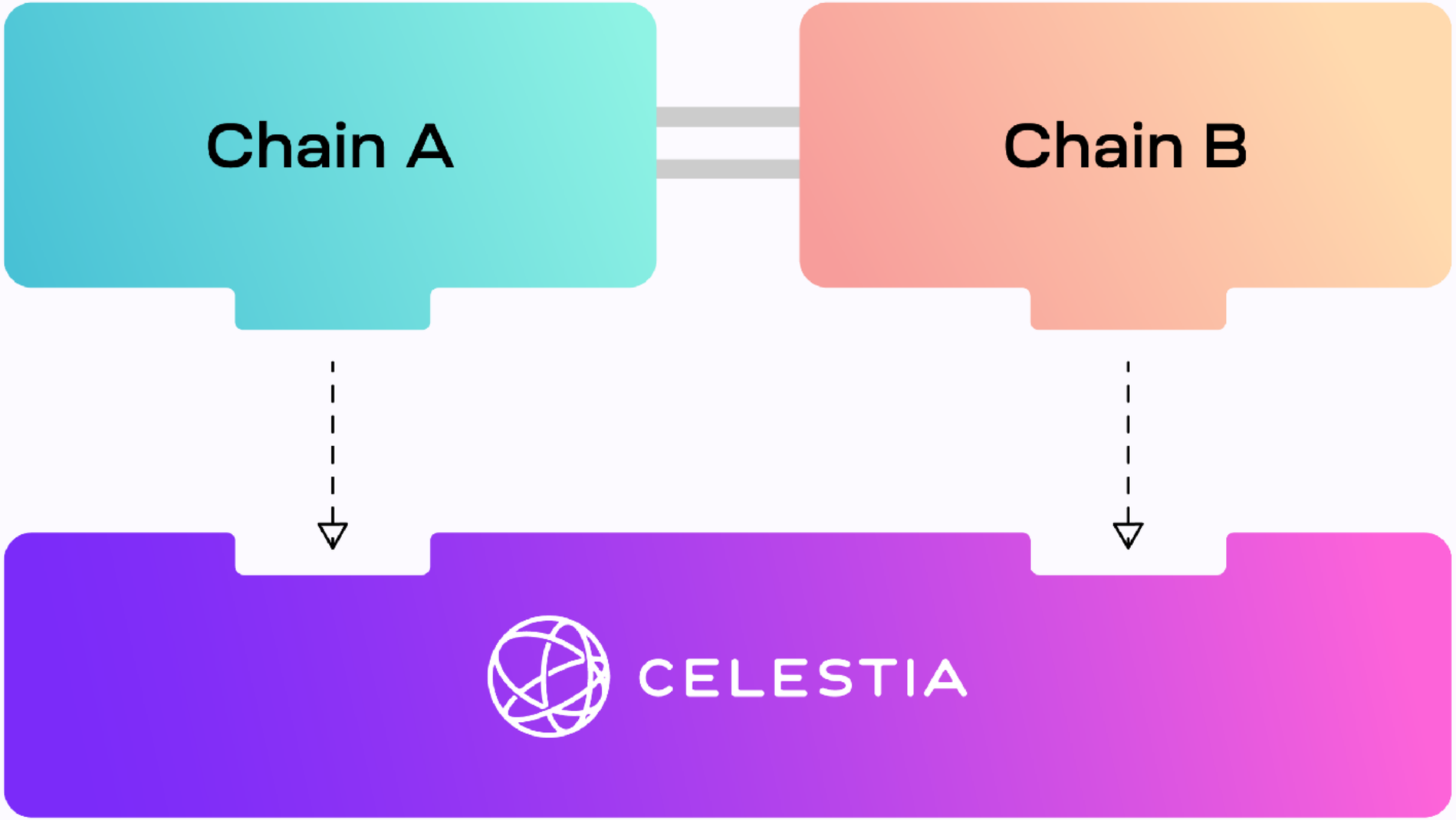
With shared security

Overhead cost

Speed of innovation

What’s this look like in practice?

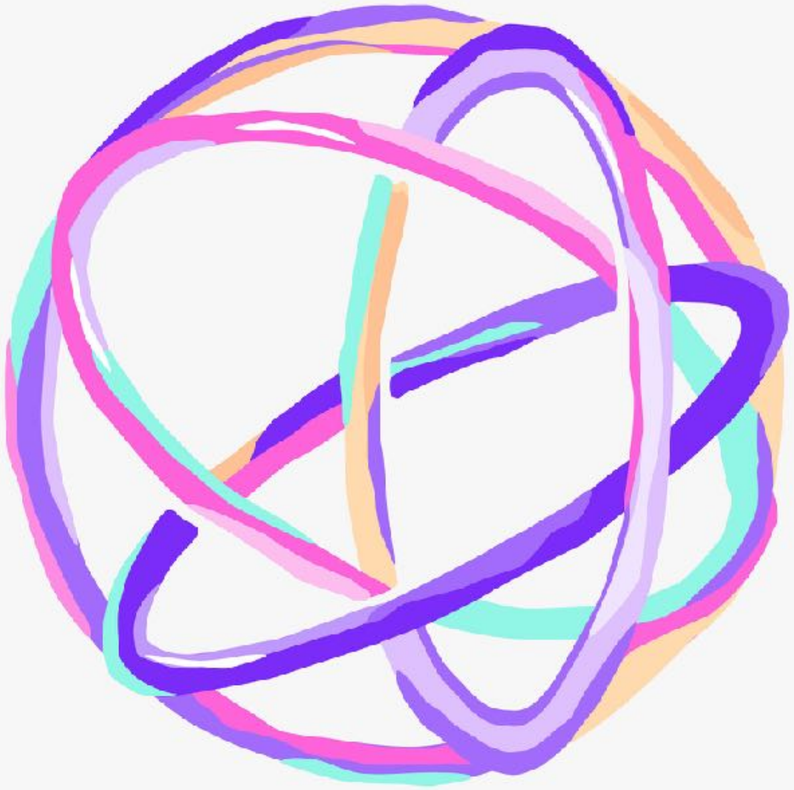
CELESTIA


Chain A
Chain B
CELESTIA

CELESTIA

Wdym build whatever?

Whatever?



Build Whatever

CELESTIA

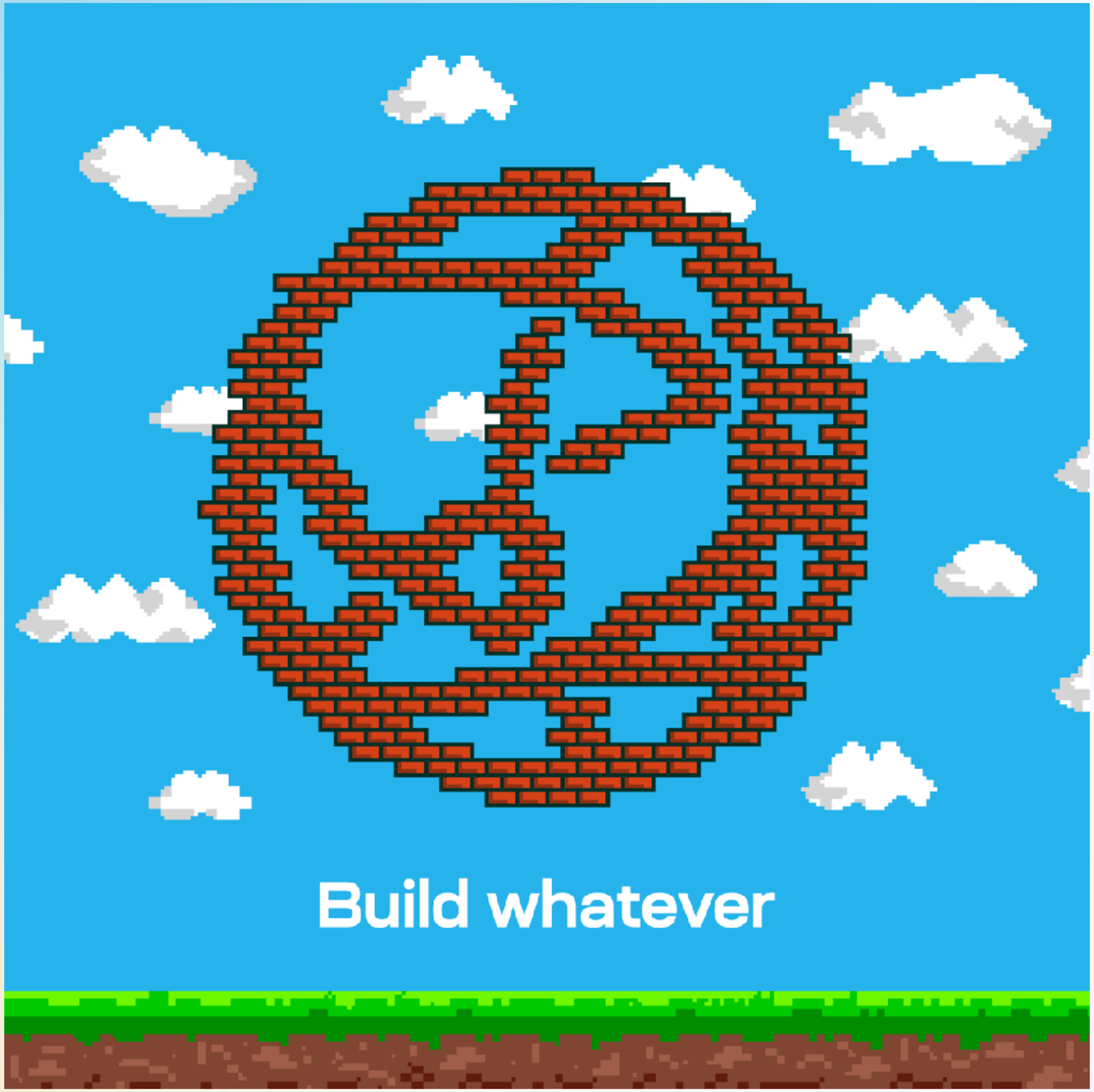
mix

CELESTIA

CELESTIA

and

CELESTIA



CELESTIA

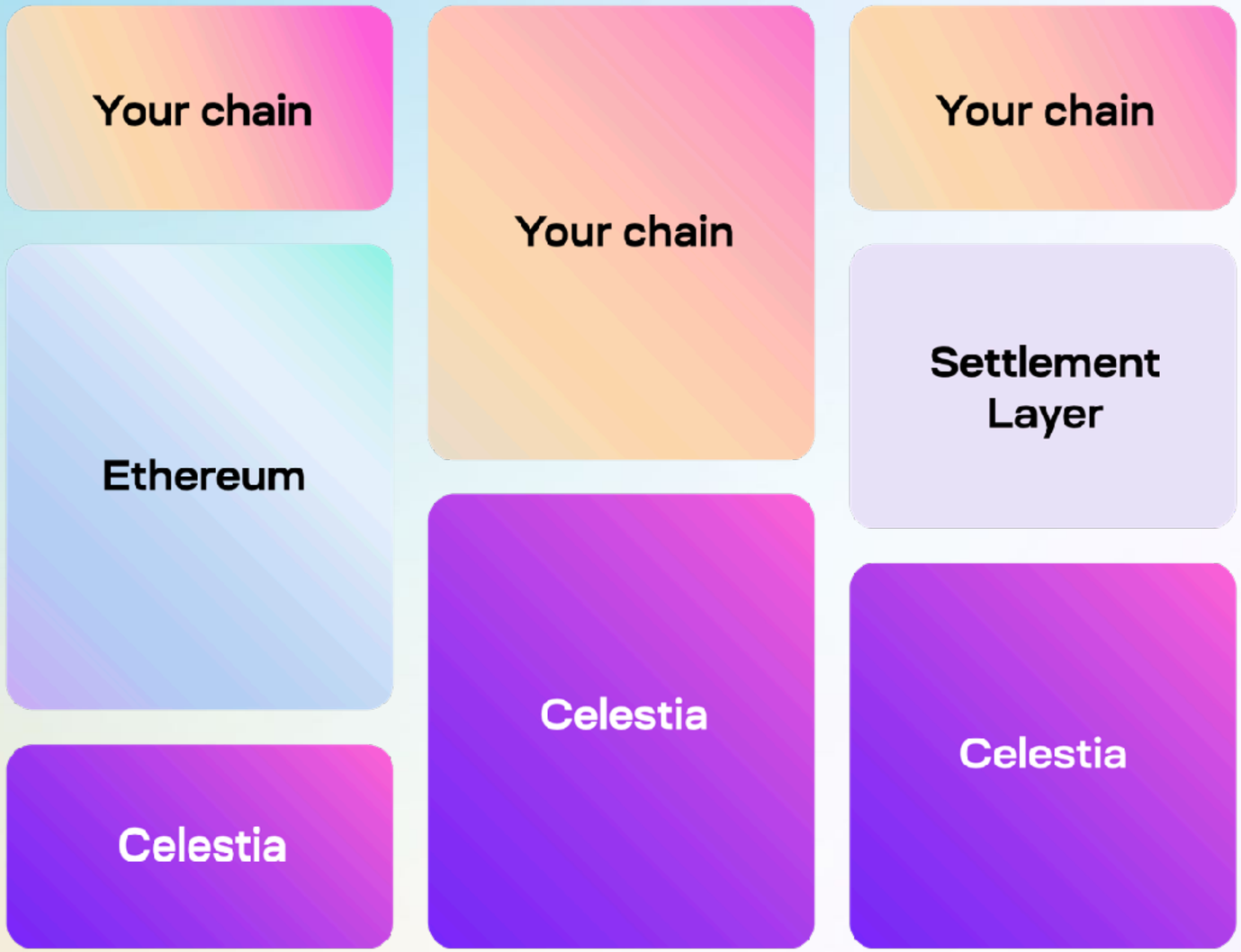
match

CELESTIA

CELESTIA

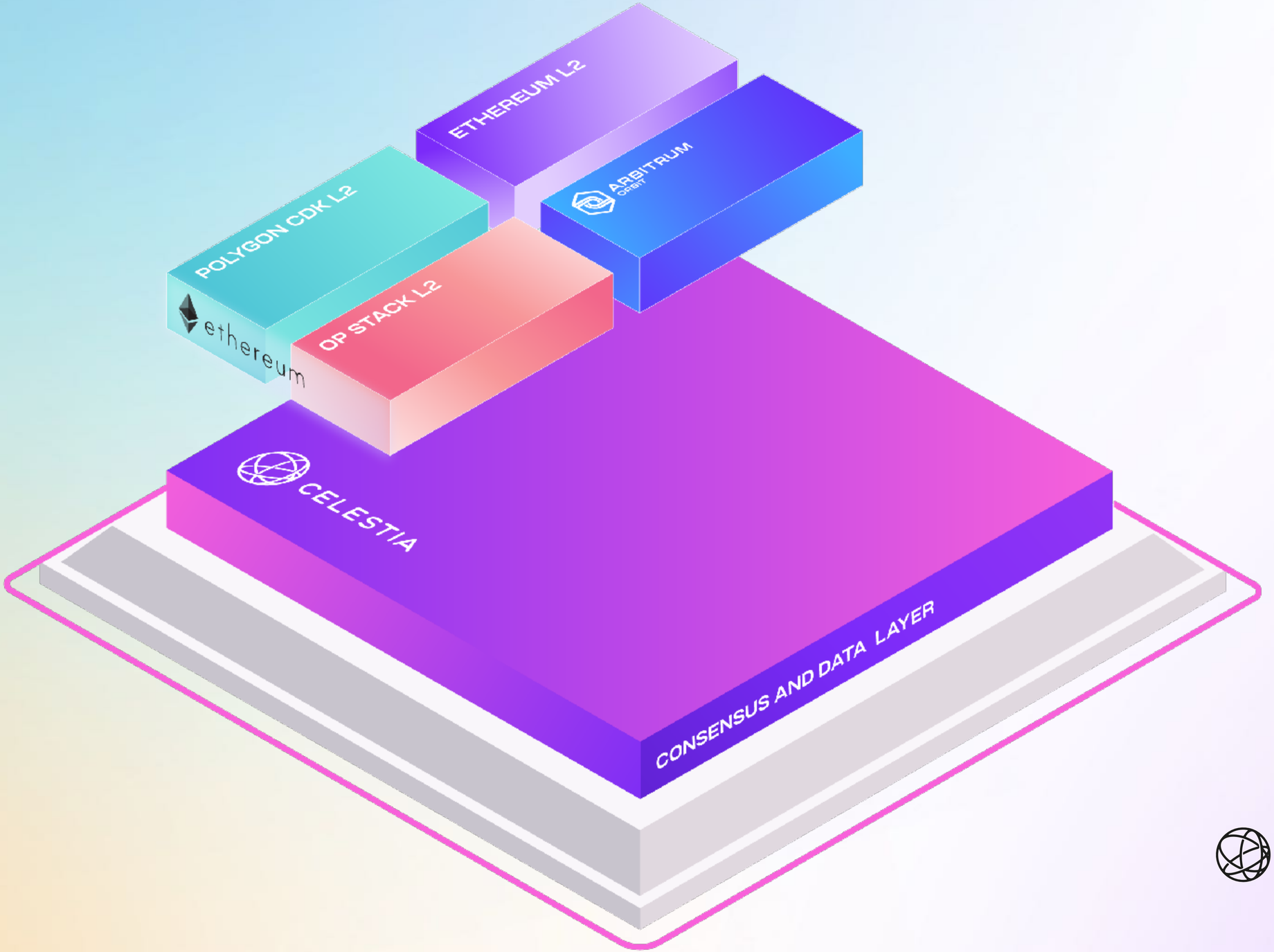
the modular stack

CELESTIA

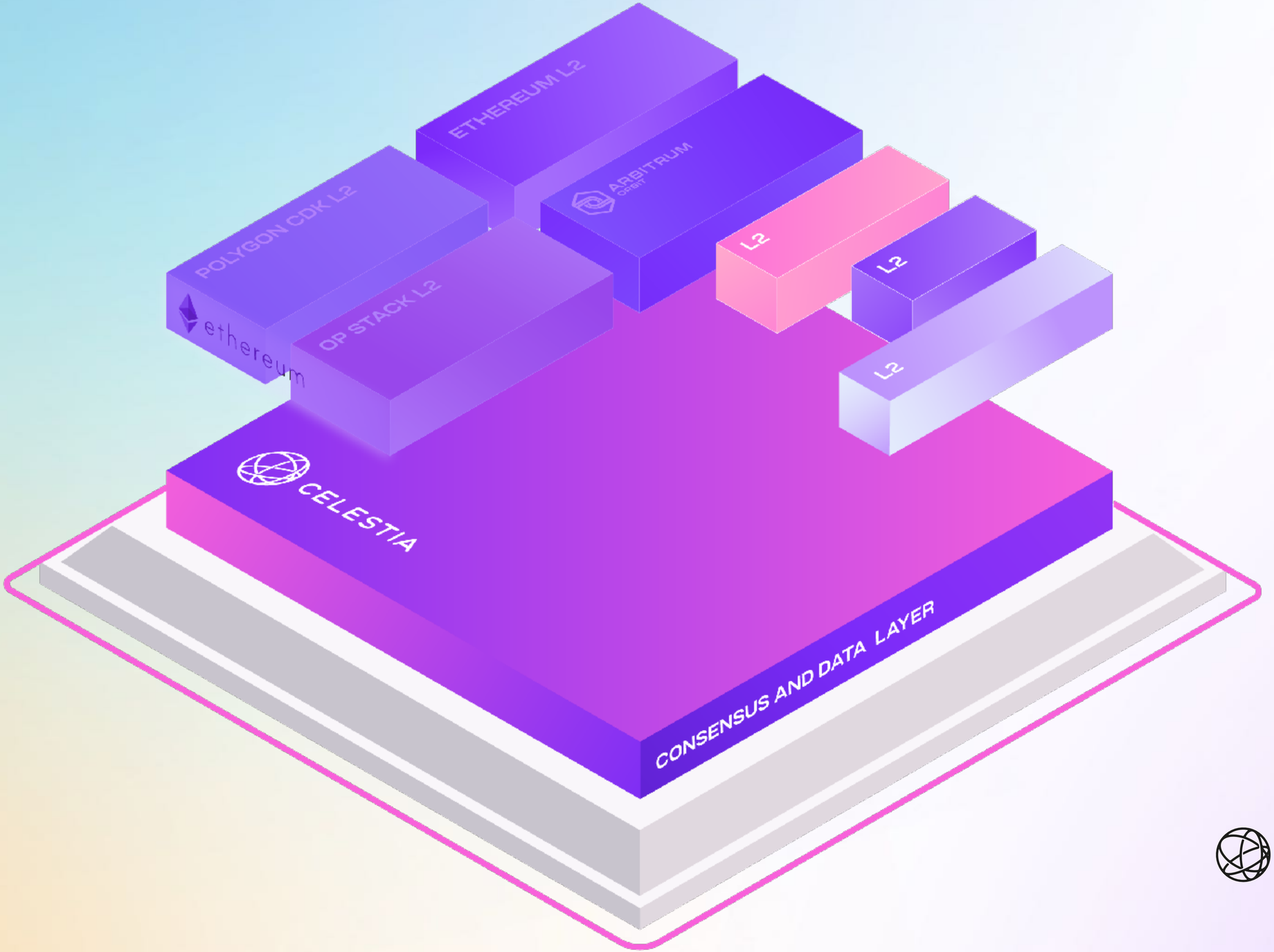

Your chain
Ethereum
Celestia
Your chain
Celestia
Your chain
Settlement Layer
Celestia

CELESTIA

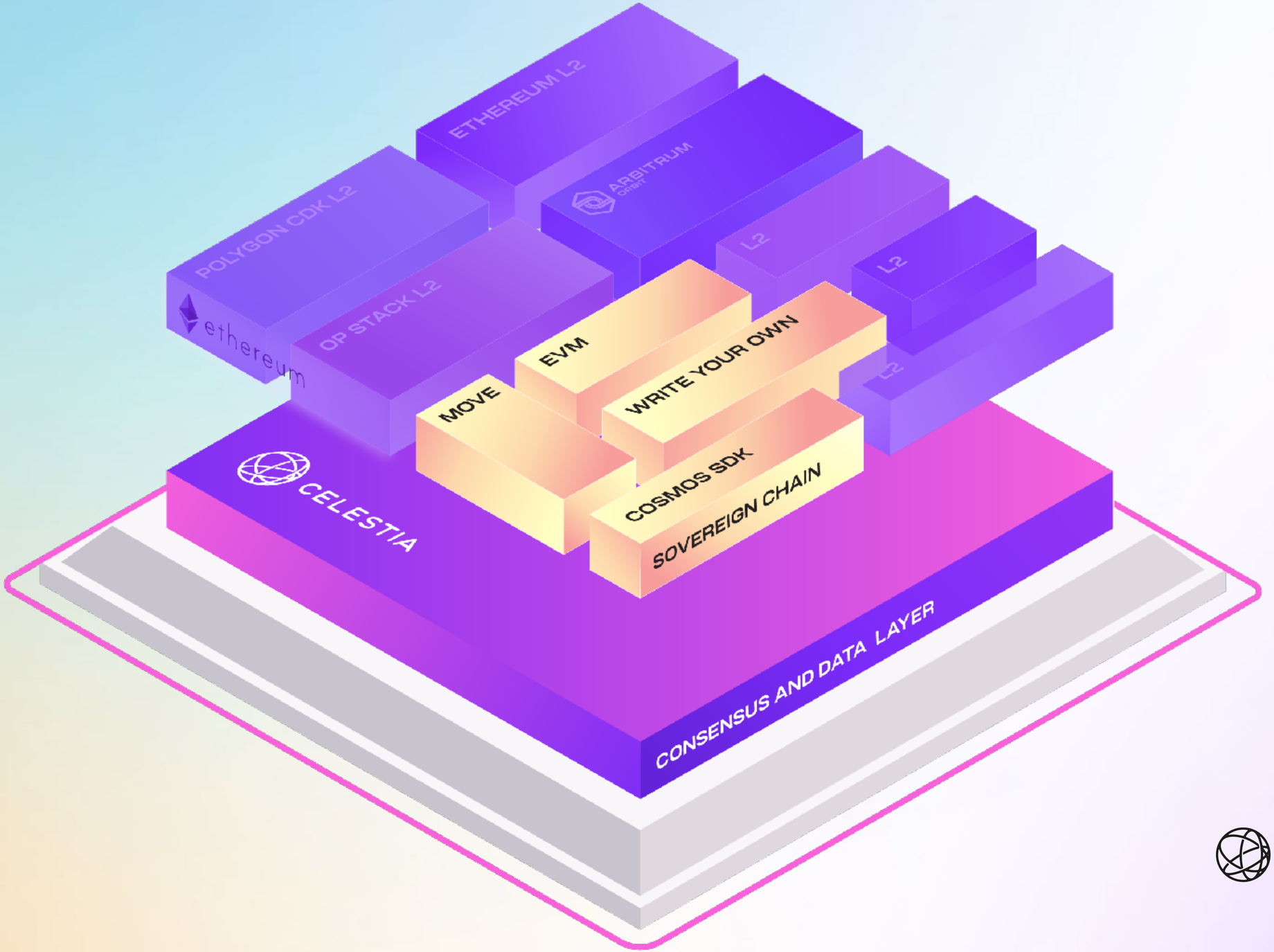
CELESTIA


ETHEREUM L2
ARBITRUM
ORBIT
POLYGON CDK L2
ethereum
OP STACK L2
CELESTIA
CONSENSUS AND DATA LAYER

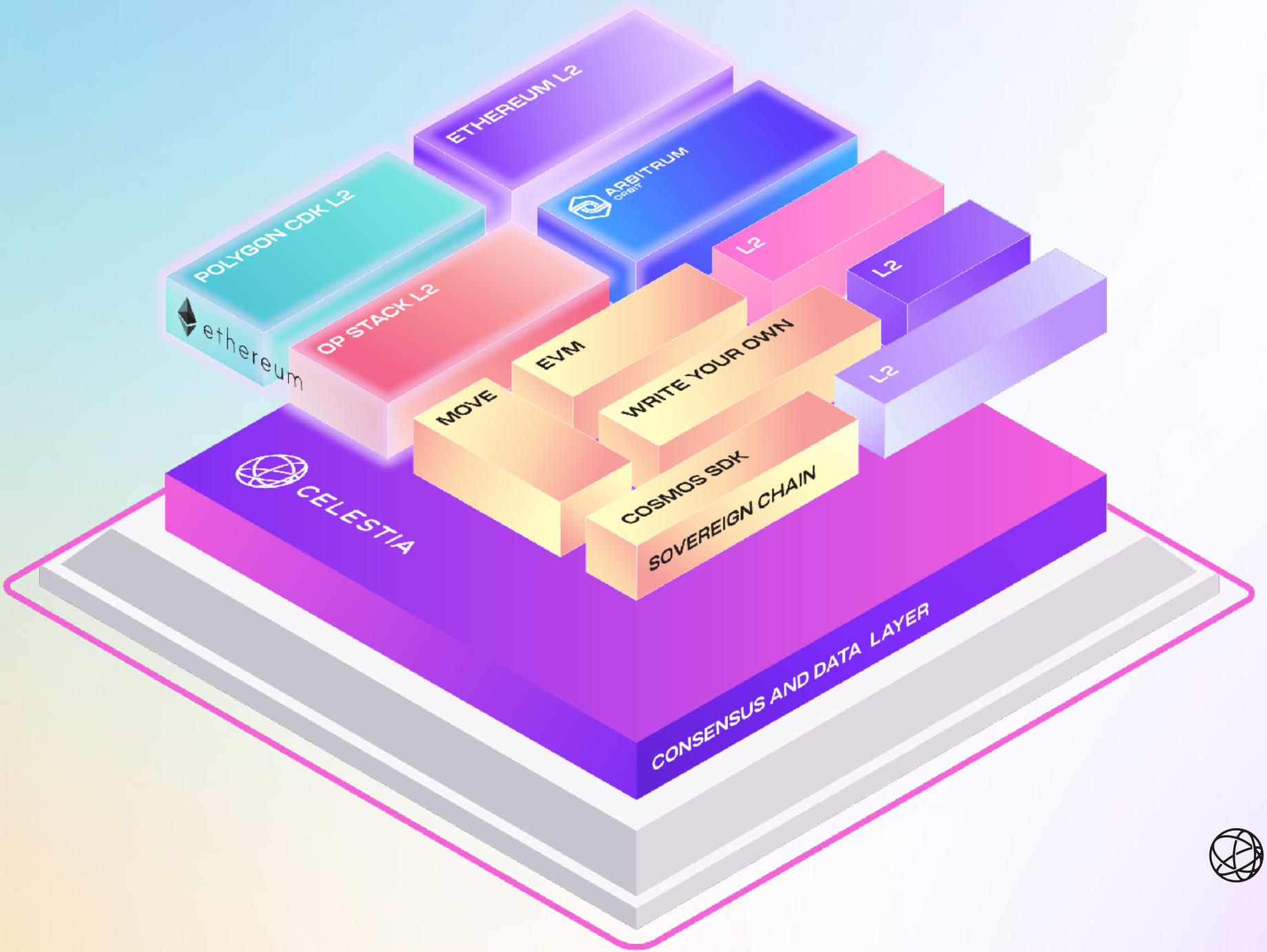
CELESTIA


ETHEREUM L2
POLYGON CDK L2
ARBITRUM
ethereum
OP STACK L2
L2
L2
L2
CELESTIA
CONSENSUS AND DATA LAYER

CELESTIA


ETHEREUM L2
ARBITRUM
POLYGON CDK L2
ethereum
OP STACK L2
L2
L2
L2
EVM
WRITE YOUR OWN
MOVE
COSMOS SDK
SOVEREIGN CHAIN
CELESTIA
CONSENSUS AND DATA LAYER

CELESTIA

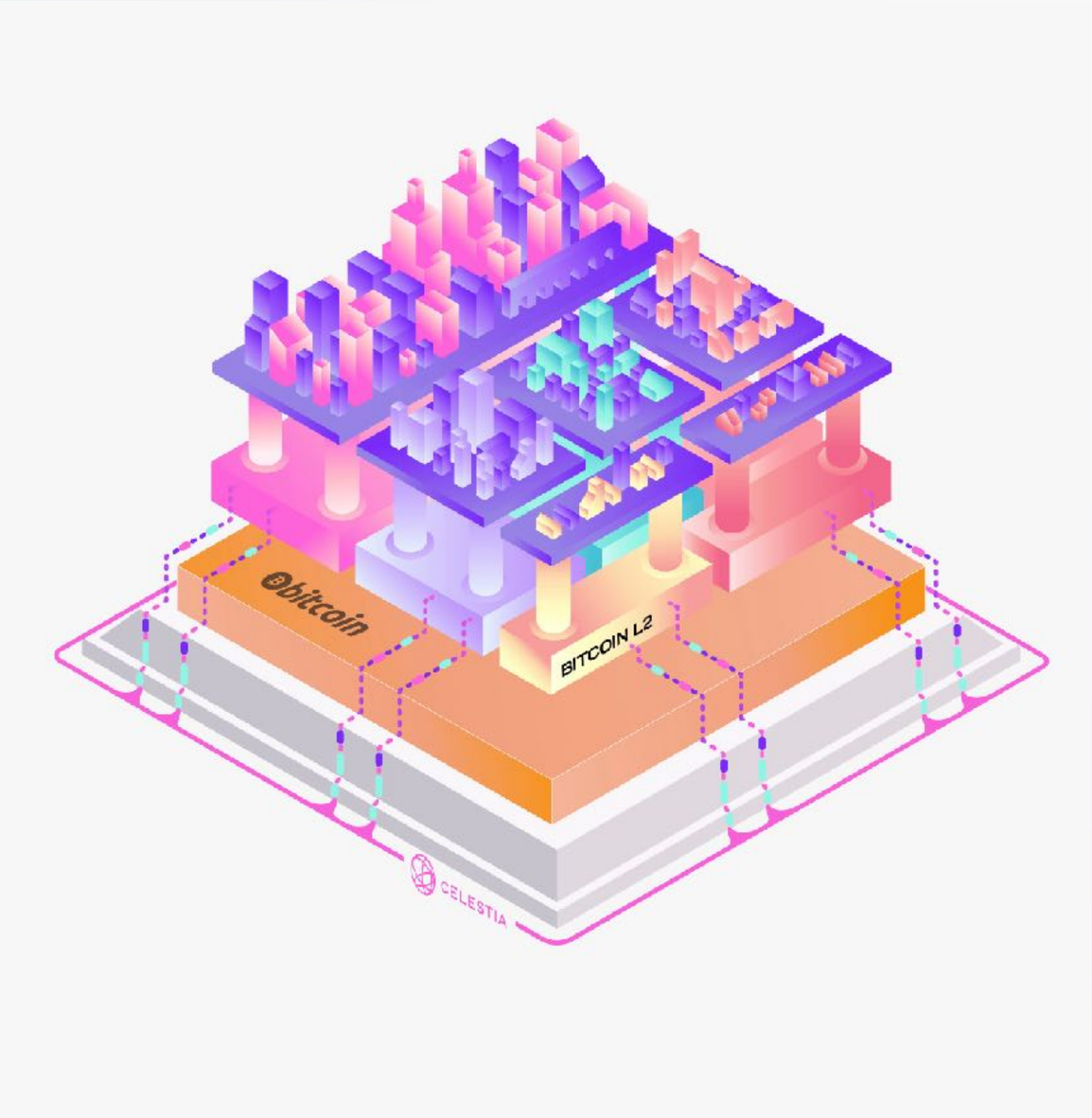

ETHEREUM L2
ARBITRUM
ORBIT
POLYGON CDK L2
ethereum
OP STACK L2
L2
L2
L2
EVM
WRITE YOUR OWN
MOVE
COSMOS SDK
SOVEREIGN CHAIN
CELESTIA
CONSENSUS AND DATA LAYER

CELESTIA

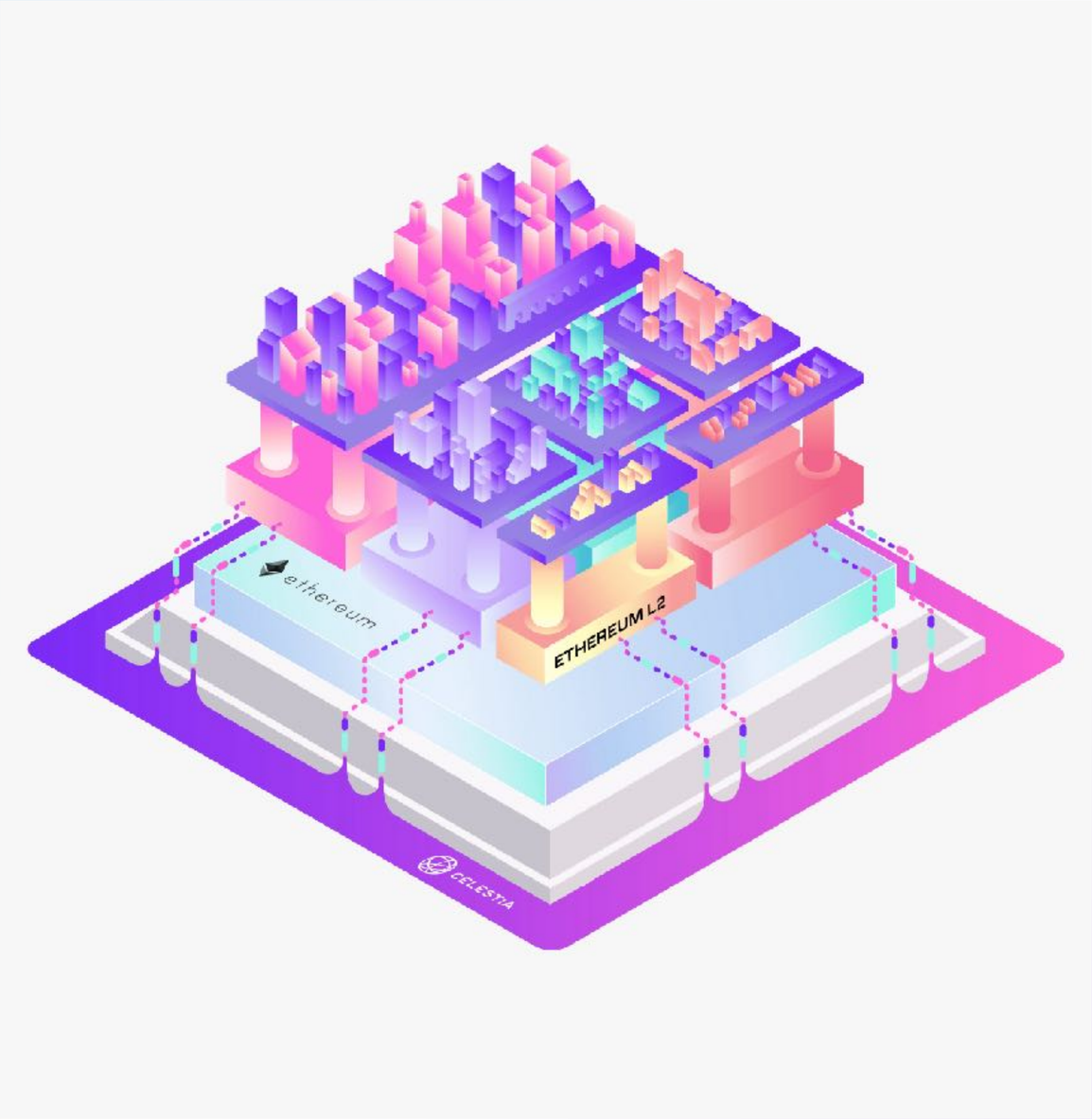
What can we build?

CELESTIA

Bitcoin L2s



Ethereum L2s



Sovereign rollups

Whatever

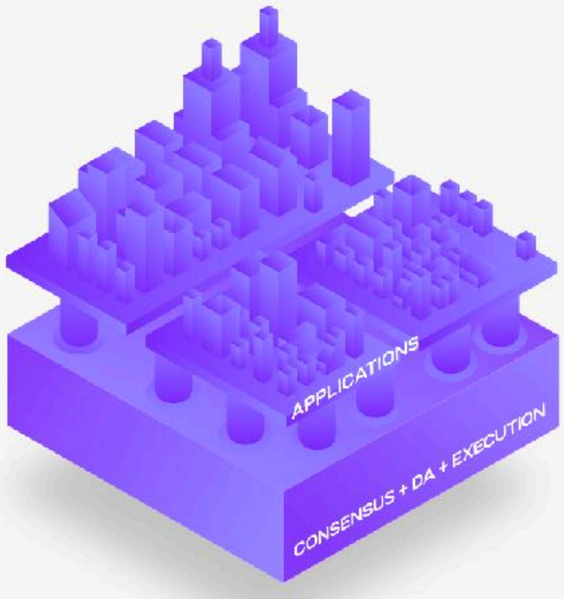
Let’s enter the modular era

CELESTIA

Monolithic

Generalist

Perform
all tasks



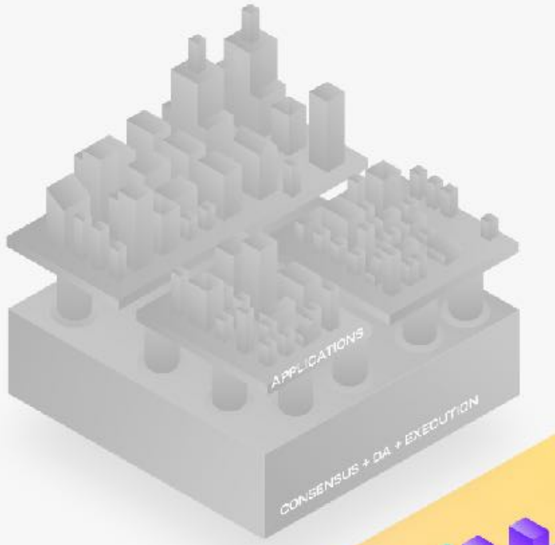
Modular

Specialist

Specialize
in one or
two tasks

CELESTIA

The monolithic era Generalist



The modular era Specialist

CELESTIA

Why should I deploy a rollup?

CELESTIA

Rollups on Celestia Mainnet Beta

Celenium | Explore | Rollups | Transactions | Blocks | Validators | Namespaces | Mainnet | Connect

Total Txs: 17.1M • Total Supply: 1.05B TIA • Total Blobs Size: 13.73 GB • Total Fees: 238.2K TIA • TIA: $11.04 5.55%

Explore → Rollups Leaderboard

Rollup Registration

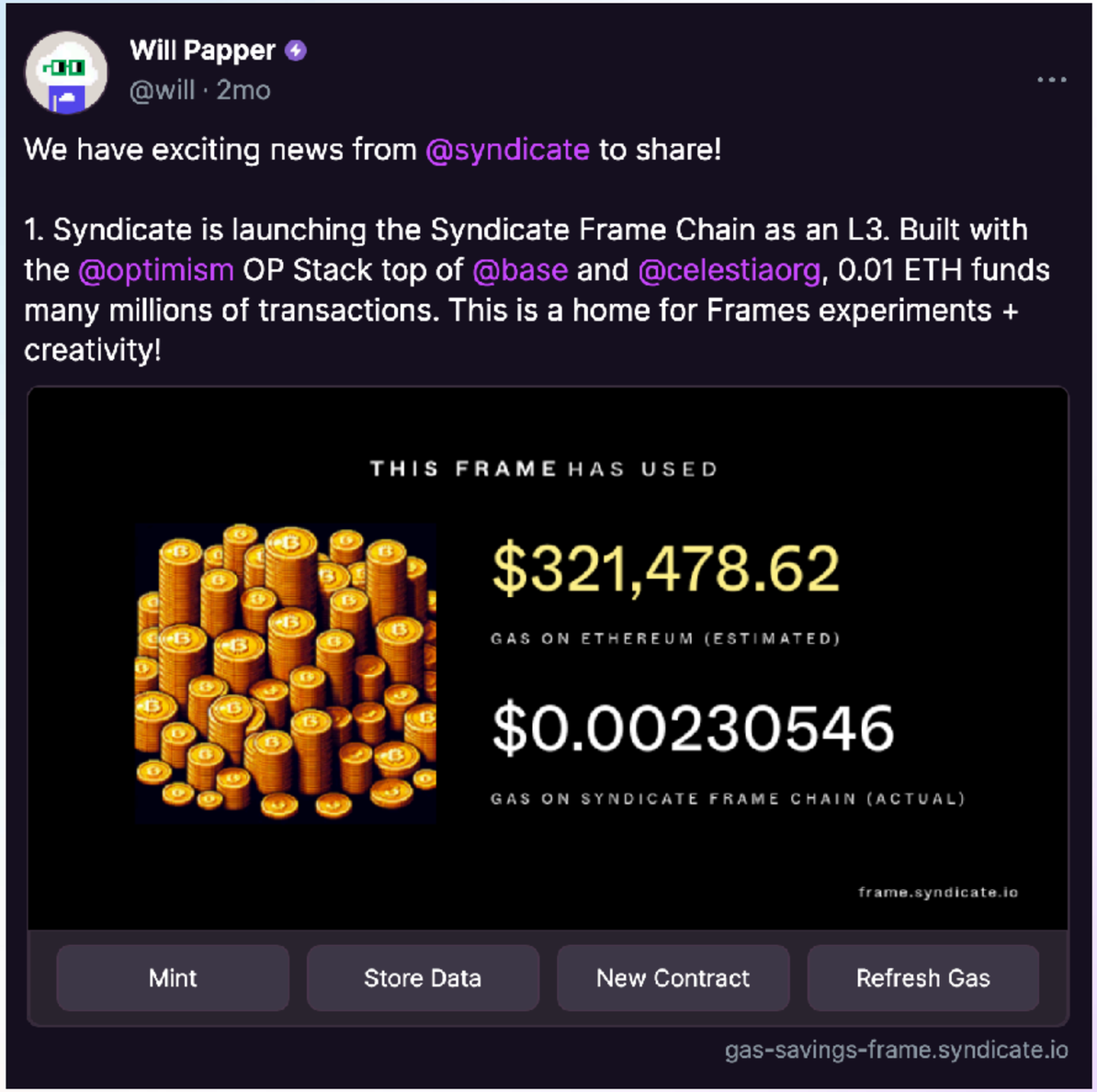
Rollups Leaderboard

1 of 1

#	Rollup	Last Active	Size	Blobs	Blob Fees Paid	Paid per MB
1	Orderly	14 min. ago May 29, 10:43 AM	3.56 GB 33.8%	33,074	70.02 TIA 7.77%	0.02 TIA
2	Manta Network	6 min. ago May 29, 10:51 AM	2.05 GB 19.52%	27,428	517.95 TIA 57.5%	0.25 TIA
3	Hokum	4 min. ago May 29, 10:53 AM	1.62 GB 15.38%	37,248	75.79 TIA 8.41%	0.05 TIA
4	Lyra	2 hr. ago May 29, 8:56 AM	1.16 GB 11.04%	11,448	22.97 TIA 2.55%	0.02 TIA
5	Aevo	49 min. ago May 29, 10:08 AM	549.26 MB 5.1%	6,350	10.77 TIA 1.2%	0.02 TIA
6	Ancient8	1 hr. ago May 29, 9:17 AM	453.4 MB 4.21%	8,457	9.39 TIA 1.04%	0.02 TIA
7	Karak	15 min. ago May 29, 10:42 AM	423.72 MB 3.93%	15,202	176.58 TIA 19.6%	0.42 TIA
8	Public Good Networks	24 min. ago May 29, 10:33 AM	268.64 MB 2.49%	3,423	5.32 TIA 0.59%	0.02 TIA
9	Hypr	5 days ago May 23, 2:54 PM	237.16 MB 2.2%	3,049	4.7 TIA 0.52%	0.02 TIA
10	Stack	26 min. ago May 29, 10:31 AM	153.5 MB 1.42%	4,799	3.48 TIA 0.39%	0.02 TIA
11	Eternal AI	53 min. ago May 29, 10:03 AM	58.59 MB 0.54%	628	1.14 TIA 0.13%	0.02 TIA
12	Bittendo	1 hr. ago May 29, 9:40 AM	33.03 MB 0.31%	1,912	0.89 TIA 0.1%	0.03 TIA
13	Forma	2 min. ago May 29, 10:55 AM	2.91 MB 0.03%	3,630	0.34 TIA 0.04%	0.12 TIA
14	Gold	29 min. ago May 29, 10:28 AM	1.93 MB 0.02%	5,094	0.83 TIA 0.09%	0.43 TIA

Benefits of rollups

- Cheaper for users
- Verifiable by all
- Scalable
- Customizable
- Secured by the base layer



And now it’s as easy to deploy a rollup as it is a smart contract.

CELESTIA

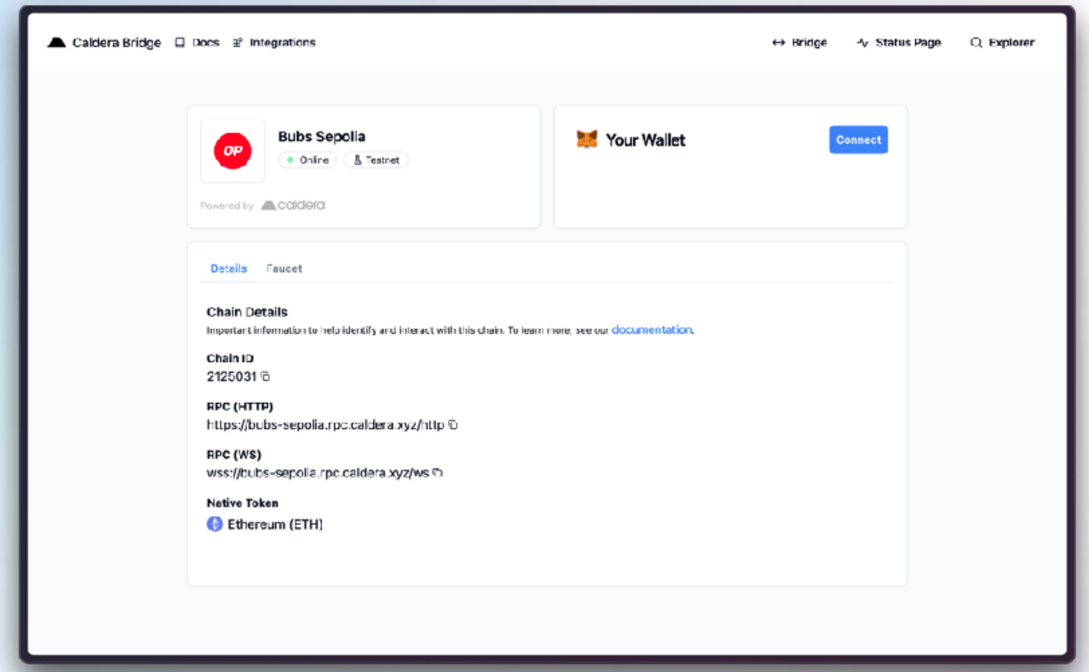
Use existing EVM rollup testnets

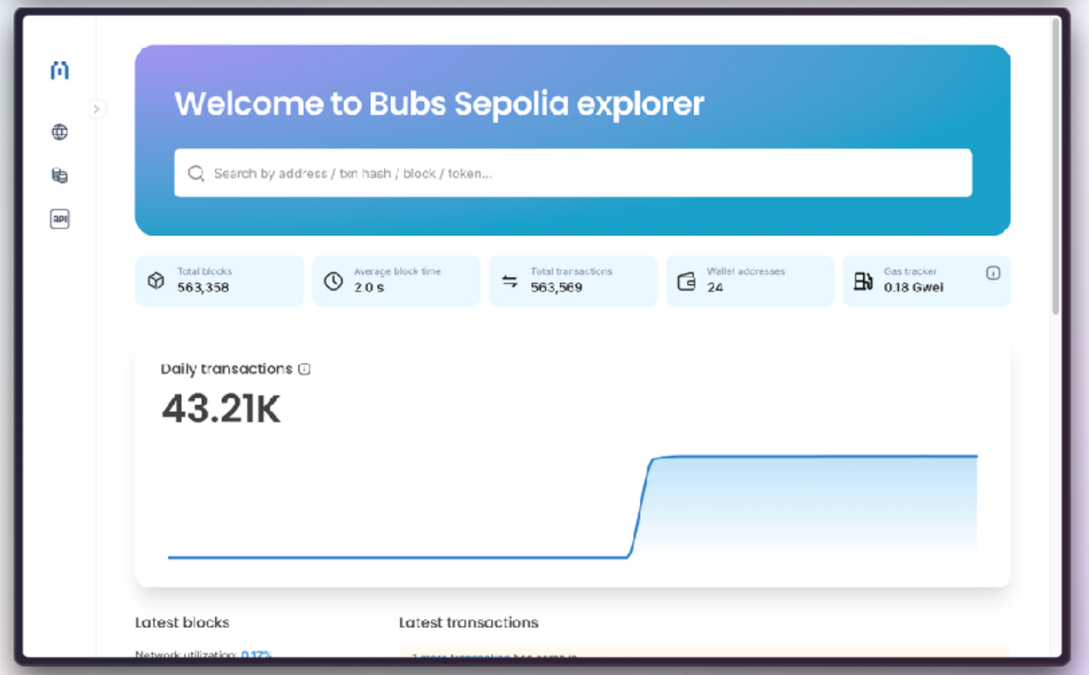
CELESTIA

Bubs testnet 🧋

Hosted by Caldera

- https://bubs-sepolia.hub.caldera.xyz
- OP Stack testnet with Celestia underneath

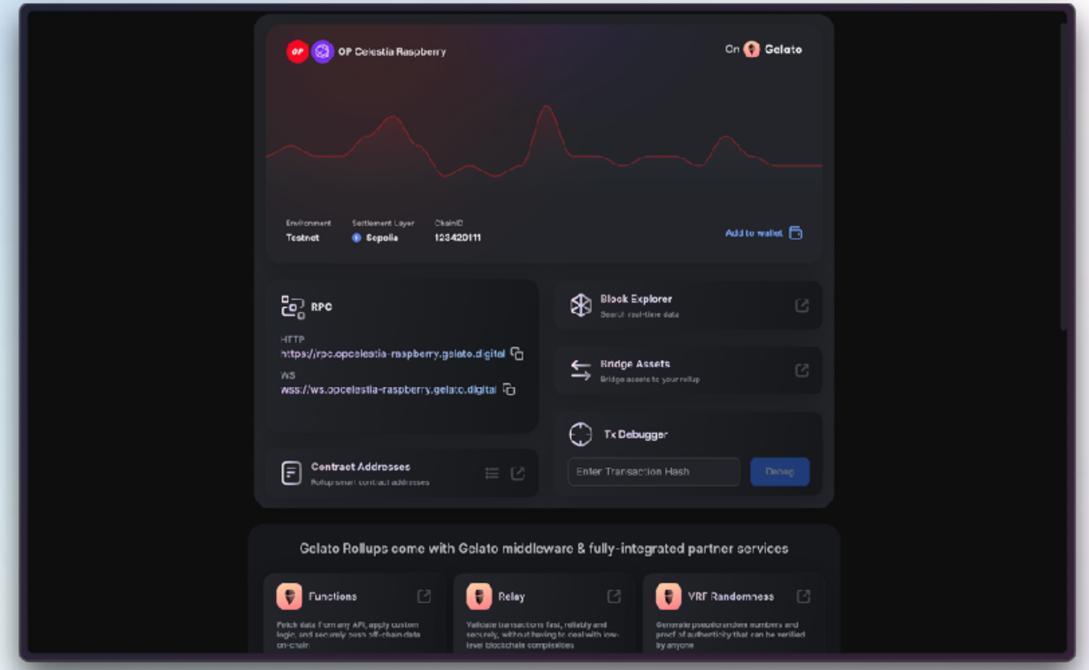


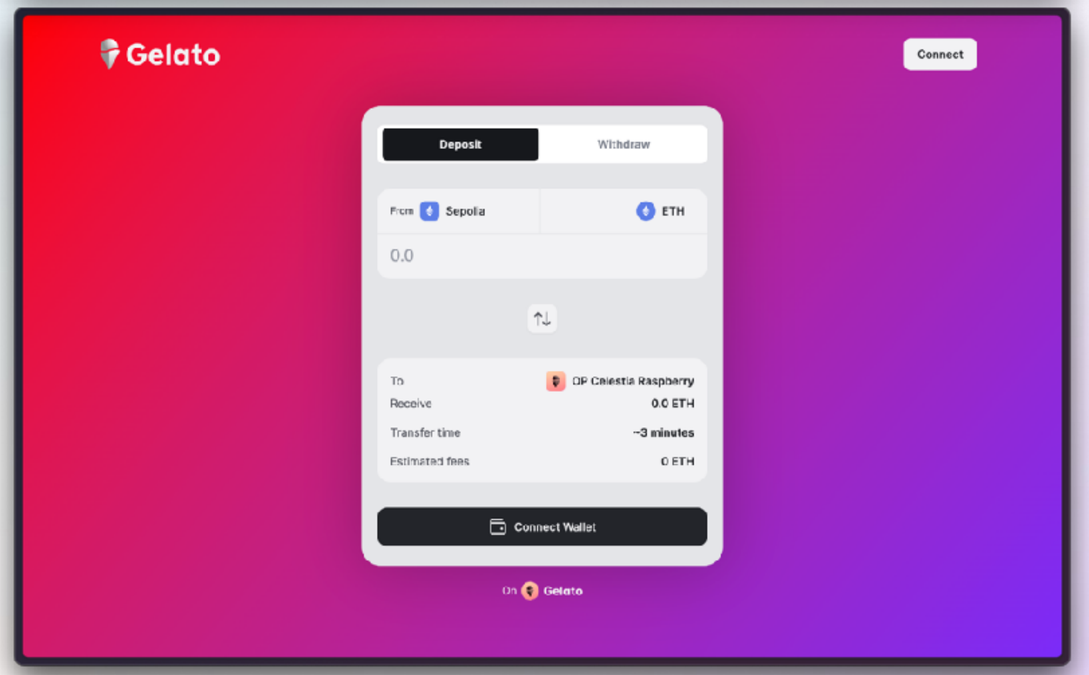


Raspberry testnet

Hosted by Gelato

- https://raas.gelato.network/rollups/details/public/opcelestia-raspberry
- OP Stack testnet with Celestia underneath





How to deploy an EVM rollup

A familiar yet enhanced development experience for EVM developers

- An EVM rollup that settles to Ethereum is a blockchain that is posting data to Celestia instead of as calldata on Ethereum allows for faster and cheaper transactions without sacrificing security.
- Deploy Nitro or OP Stack from source on your own (devops experience required)
- Deploy using a Rollup-as-a-Service provider (Caldera, Conduit, Gelato)
- Use an existing OP Stack testnet

CELESTIA

How to deploy a sovereign rollup

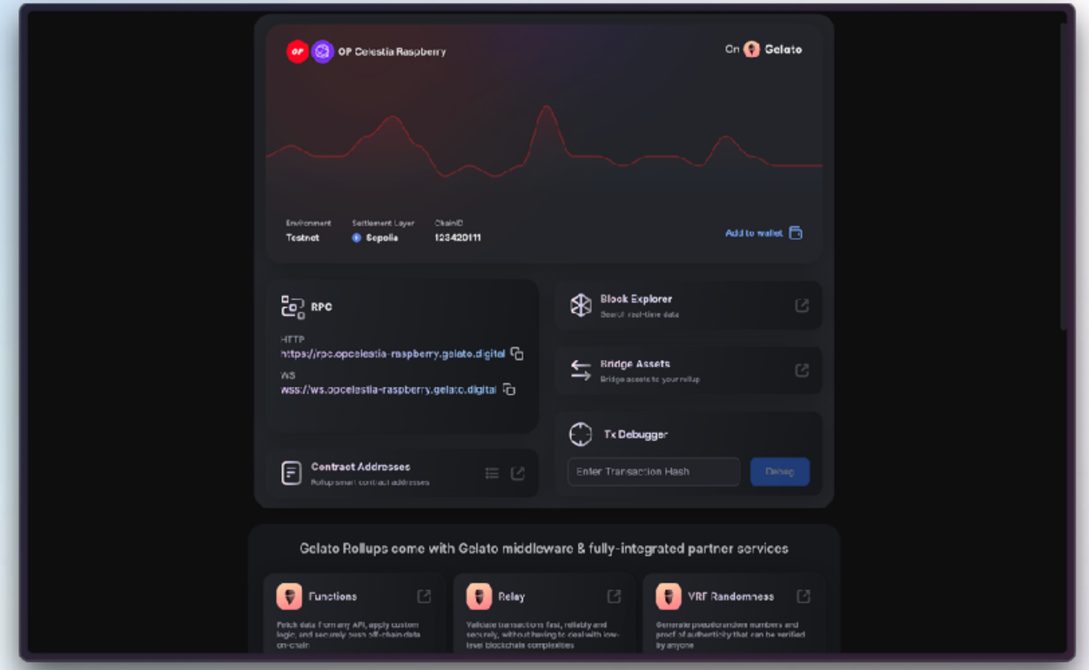
- Astria - astria.org
- Rollkit - rollkit.dev
- Sovereign SDK - sovereign.xyz
- Make your own

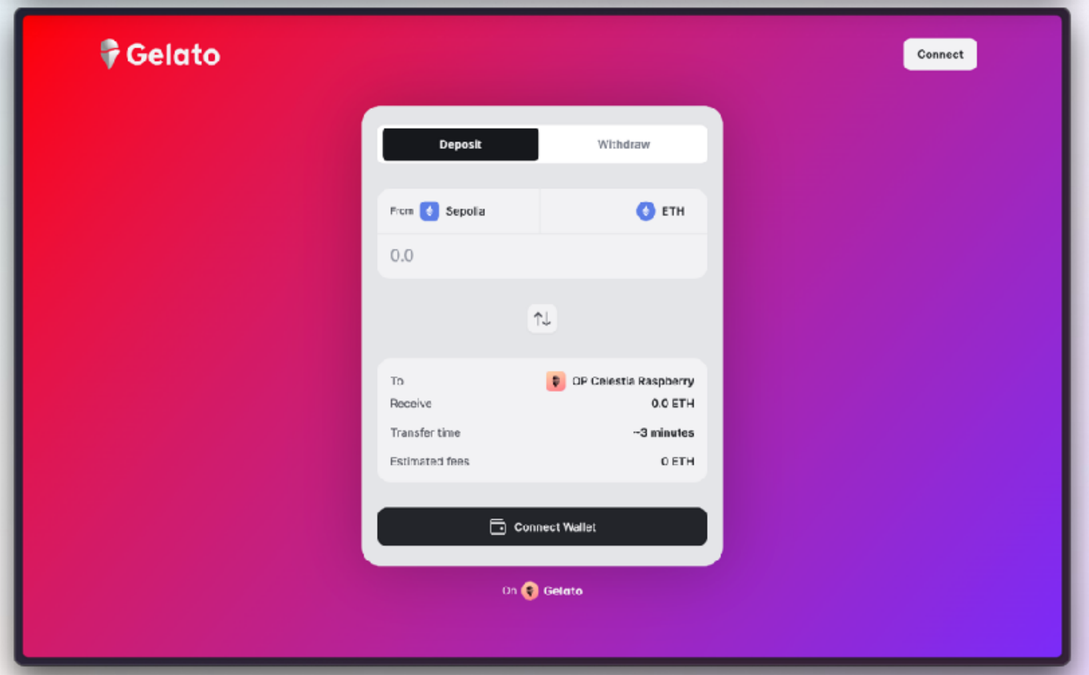
CELESTIA

CosmWasm testnet

CosmWasm testnet hosted by Rollkit

- https://rollkit.dev/testnets/cosmwasm-testnet
- CosmWasm sovereign rollup with Celestia underneath

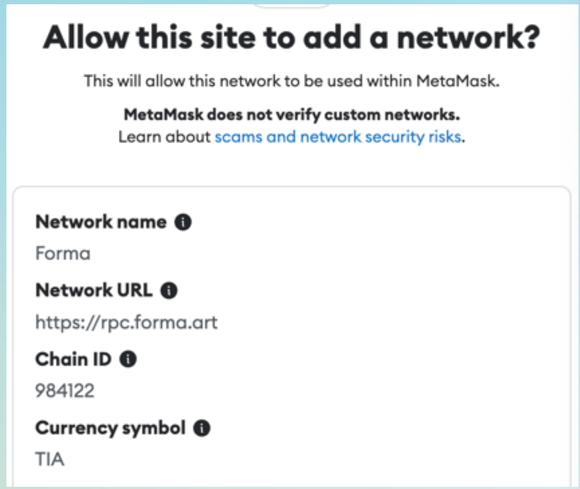


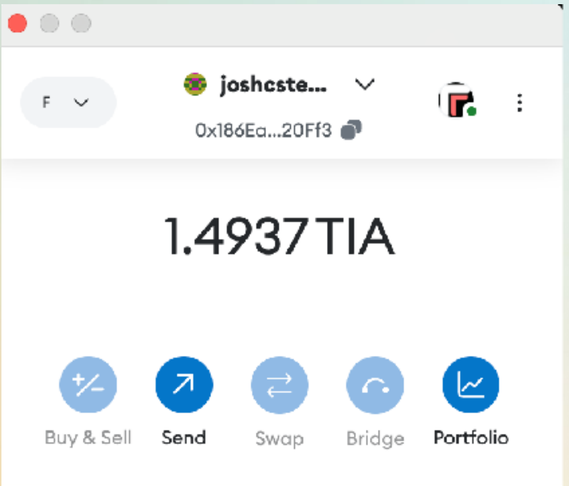


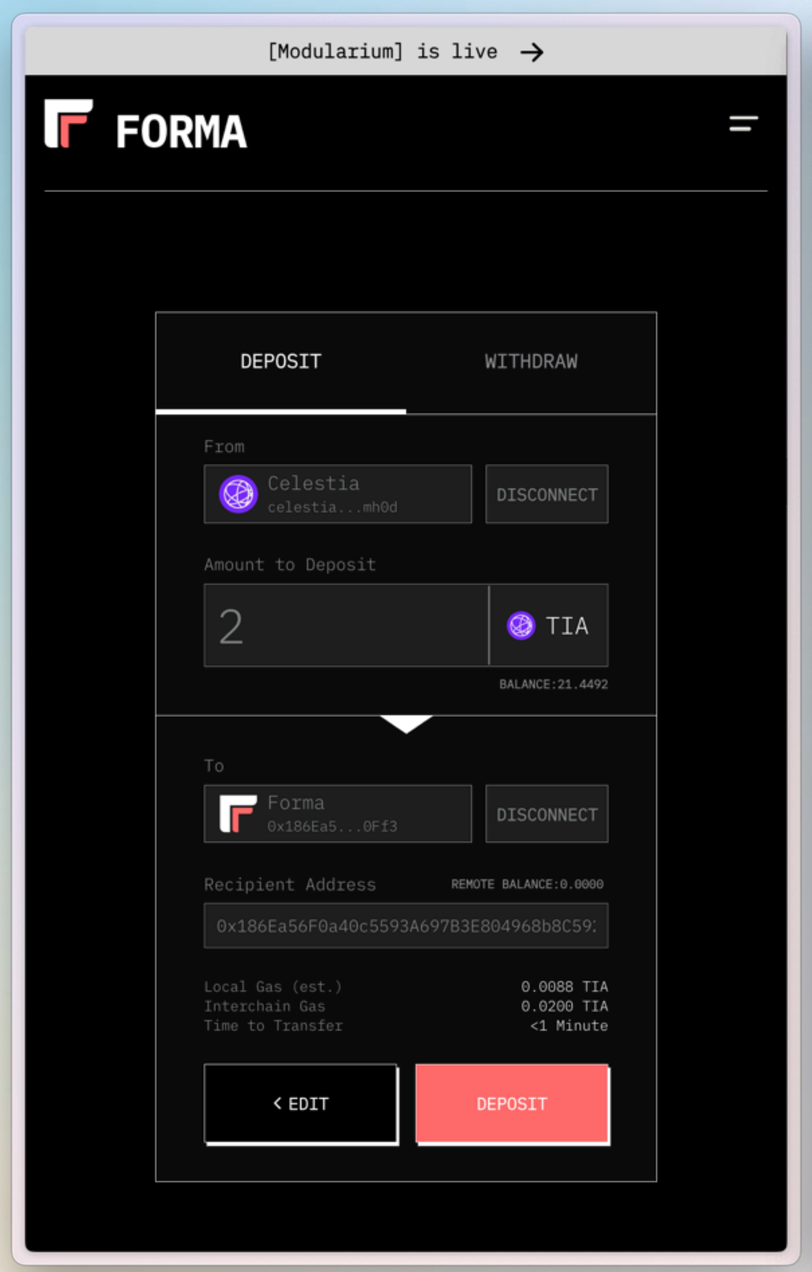
Forma

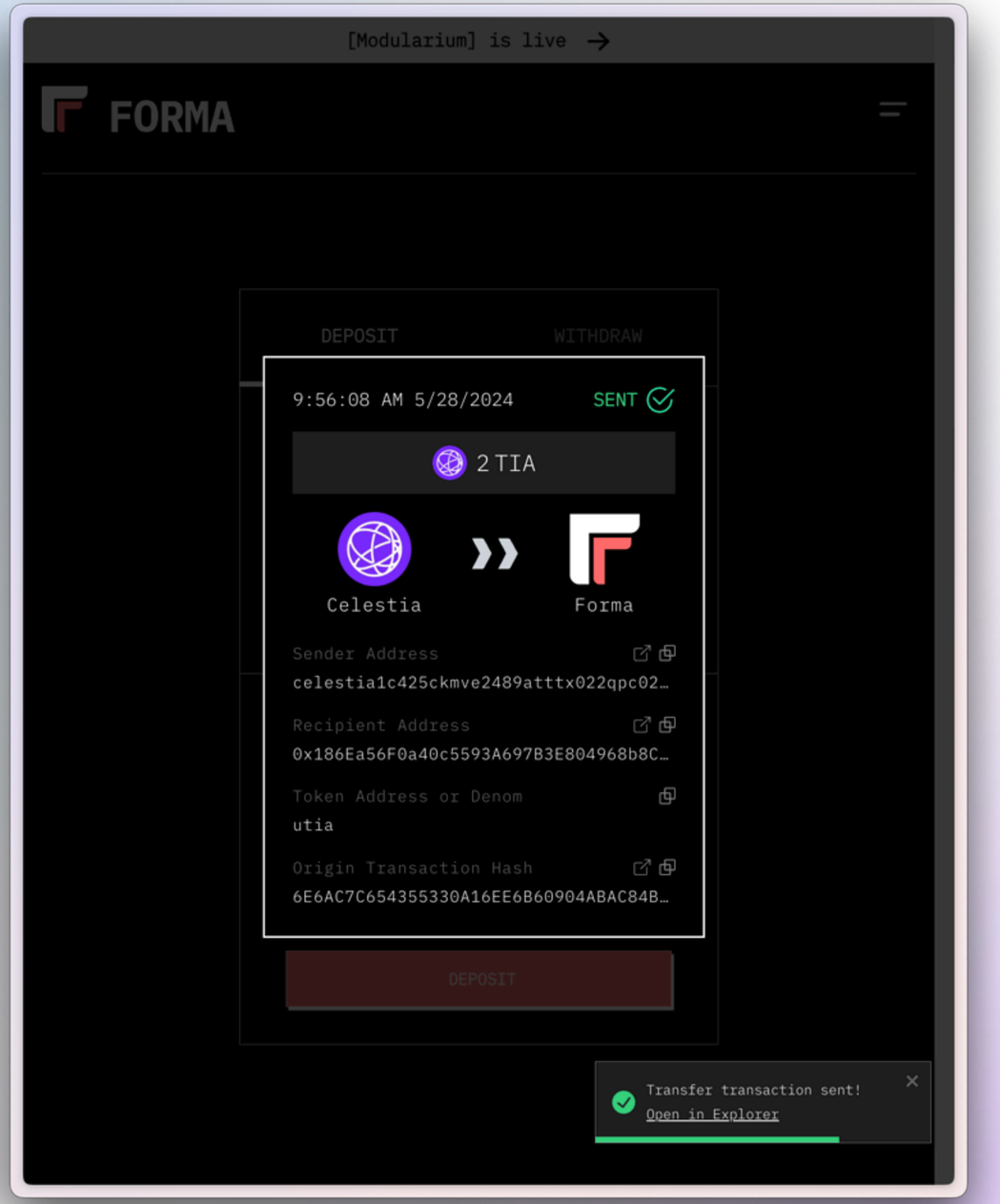
The first sovereign rollup

- Forma is a sovereign EVM rollup that is deployed on Astria's shared sequencing layer
- It uses TIA as the native token
  - Bridged with Hyperlane and Stride
- With Celestia underneath for DA


Allow this site to add a network?
This will allow this network to be used within MetaMask.
MetaMask does not verify custom networks.
Learn about scams and network security risks.
Network name
Forma
Network URL
https://rpc.forma.art
Chain ID
984122
Currency symbol
TIA


joshcste...
0x186Ea...20Ff3
1.4937 TIA
Buy & Sell
Send
Swap
Bridge
Portfolio


[Modularium] is live →
FORMA
DEPOSIT
WITHDRAW
From
Celestia
celestia...mh0d
DISCONNECT
Amount to Deposit
2
TIA
BALANCE:21.4492
To
Forma
0x186Ea5...0Ff3
DISCONNECT
Recipient Address
REMOTE BALANCE:0.0000
0x186Ea56F0a40c5593A697B3E804968b8C59
Local Gas (est.) 0.0088 TIA
Interchain Gas 0.0200 TIA
Time to Transfer <1 Minute
< EDIT
DEPOSIT


[Modularium] is live →
FORMA
DEPOSIT
WITHDRAW
9:56:08 AM 5/28/2024
SENT
2 TIA
Celestia
Forma
Sender Address
celestia1c425ckmve2489atttx022qpc02…
Recipient Address
0x186Ea56F0a40c5593A697B3E804968b8C…
Token Address or Denom
utia
Origin Transaction Hash
6E6AC7C654355330A16EE6B60904ABAC84B…
DEPOSIT
Transfer transaction sent!
Open in Explorer

[Modularium]

[HOME] [DEPOSIT TIA] CONNECT WALLET

Glover Interface

By Nic Hamilton

MINT LISTINGS OWNED

Price
0.5 TIA

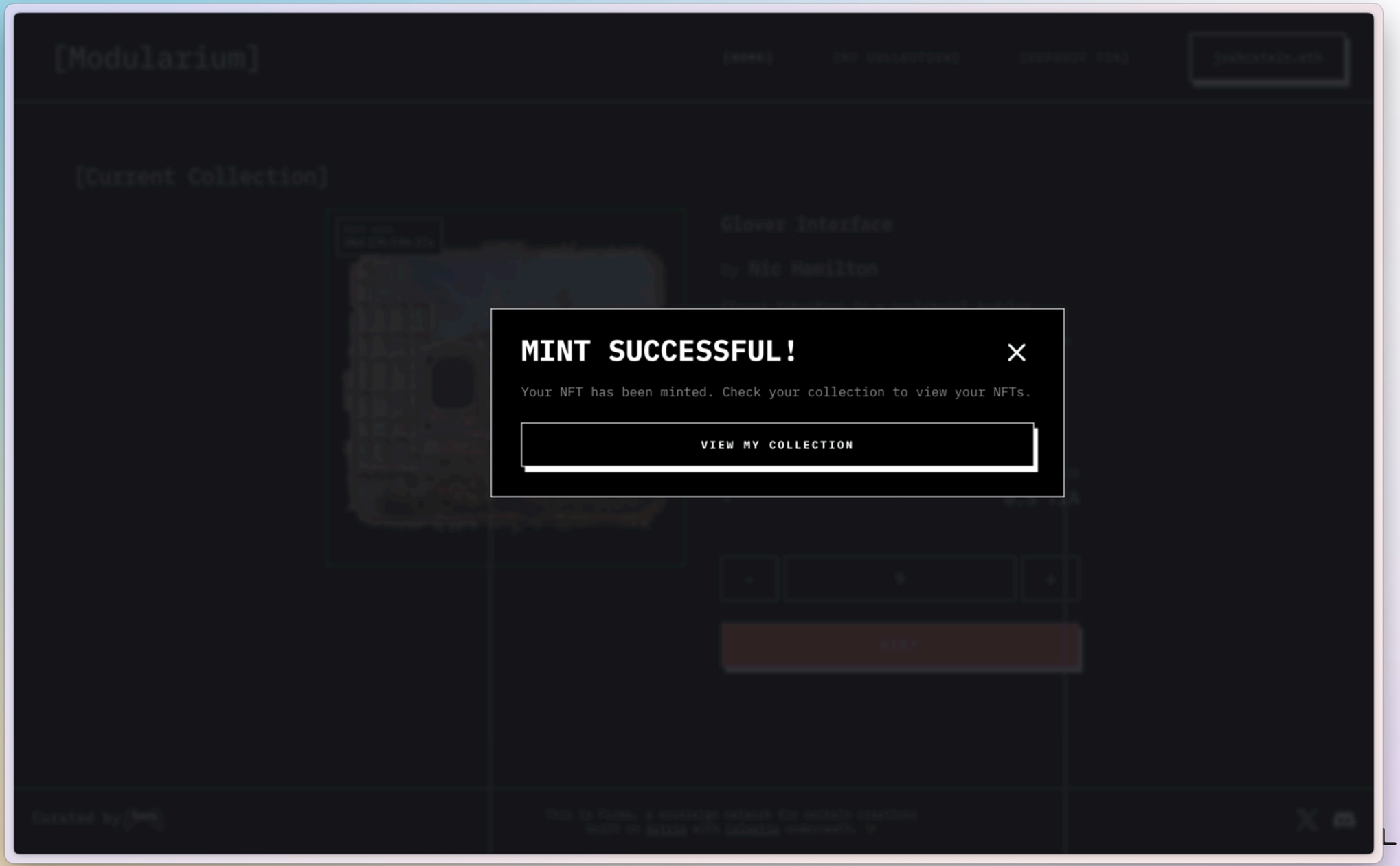
Minted
5469

Minting Ends
05d 11h 45m 15s

Owned
0

CONNECT WALLET

CELESTIA


MINT SUCCESSFUL!
Your NFT has been minted. Check your collection to view your NFTs.
VIEW MY COLLECTION

LESTIA

Let’s build

Run a light node, a rollup, and monitor your namespace

CELESTIA

Demos

Run a light node

- Run a sovereign rollup
- Monitor your namespace

Mint an NFT on Forma

CELESTIA

Follow along

Clone the repo

How to get involved

- Forum discussions
- Celestia Improvement Proposals (CIPs)
- Infinite Space Bazaar Hackathon
- GitHub issues

CELESTIA

Questions?

CELESTIA

Thank you!

CELESTIA

@jcstein on GitHub
@jcs on Farcaster
@JoshCStein on X

// jcs

CELESTIA