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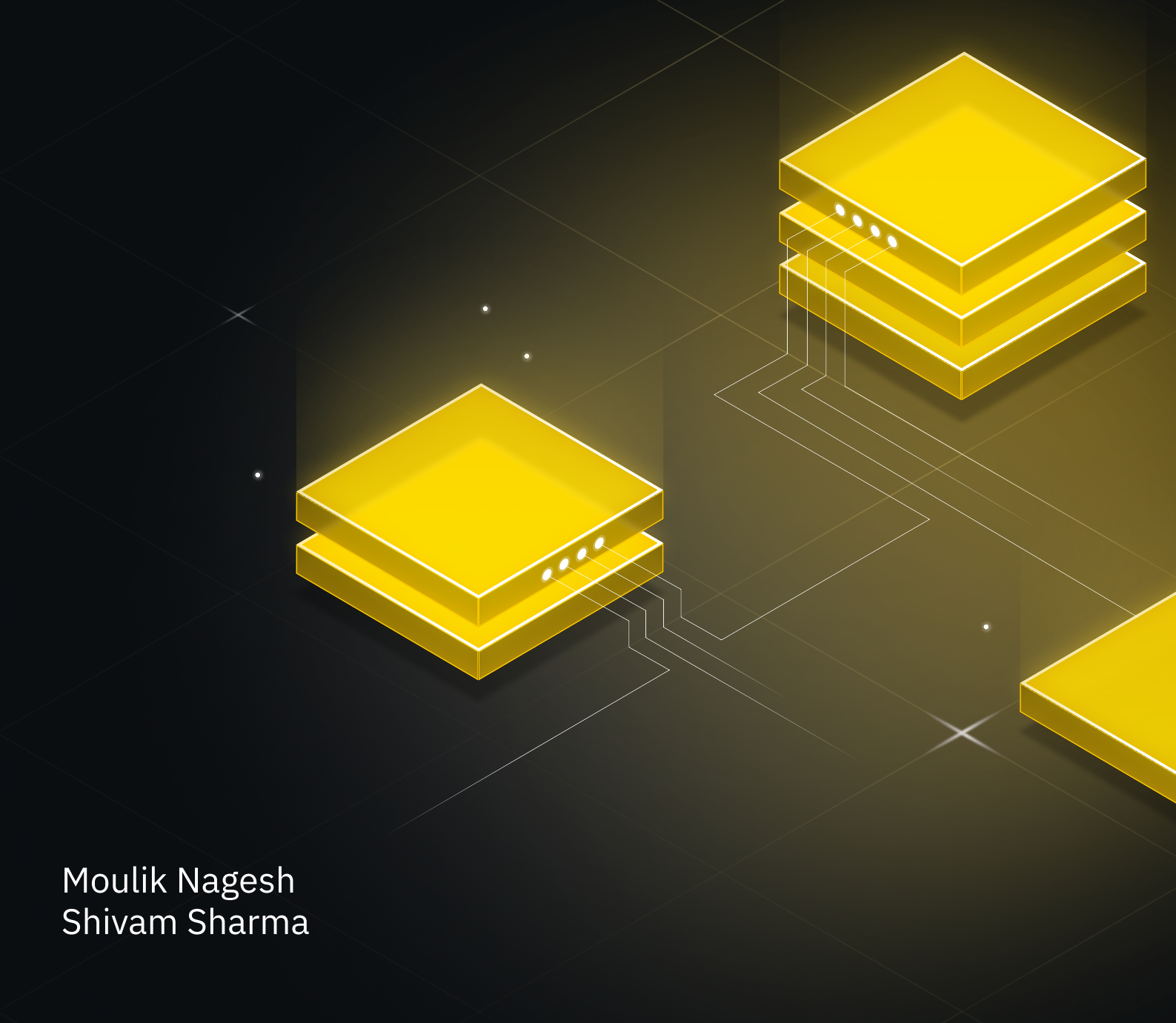
# The Layer-2 Evolution:

## Superchains, L3s, and More



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# 1 Key Takeaways

- An emerging trend in blockchain scalability is the evolution of Layer-3 networks, Superchains, and hyperchains. These advancements are being adopted by several Layer-2s and are poised to underpin the next generation of Ethereum scaling, streamlining the development process, bolstering security, and fostering greater interoperability across the ecosystem.
- Optimism's OP Stack is pioneering the path towards a highly interoperable network of blockchains known as the Superchain, and the recent Bedrock upgrade represents one of the initial steps towards realizing their vision.
- Arbitrum is also at the forefront of Ethereum scaling with its development of Layer-3 networks through Arbitrum Orbit, offering a permissionless framework for deploying customized chains on top of Arbitrum L2.
- zkSync has introduced the concept of hyperchains, a network of customizable and trustless linked blockchains, enabling hyperscalability, improved composability, and enhanced security.
- StarkWare, the innovative minds behind fractal scaling, is developing a multi-layered solution, exploring L3s for customized scaling and utilizing L2s for general-purpose scaling.
- Polygon 2.0 aims to create the "Value Layer of the Internet" by unifying its suite of L2 solutions, including Polygon PoS, Supernets, and zkEVM, through a cross-chain coordination protocol.

# 2 Introduction

For much of the last few years, we have seen Ethereum co-founder Vitalik Buterin's vision of a rollup-centric future materialize. Indeed, Layer-2 ("L2") rollup technologies have set the stage to solve the Layer-1 ("L1") scalability problem. Successful projects like Optimism and Arbitrum have effectively harnessed optimistic rollup technology, demonstrating reliable service to users for nearly two years. At the same time, zero-knowledge ("zk") rollups, represented by Starknet, zkSync Era, and Polygon zkEVM, have started to gain traction after successfully launching their mainnets in recent months. **After attaining a fair amount of market validation, the L2 focus is now shifting towards a new thesis in blockchain scalability, catering for the next hundreds, thousands, and maybe even millions of rollups**. With this shift, we may finally achieve **blockchain scalability** and attract hordes of developers who can summon their collective energies to onboard the next million (and even billion) users to crypto.

As the L2 market progresses toward its next phase, rollups are beginning to define their visions to prevail in the rollup-dominated future. In this report, we explore the rapidly evolving area of blockchain scalability. Our focus is to dissect the intricacies of different L2 approaches, assess their current position within the marketplace, and dive deeper into the new thesis that is defining the landscape of this sector.

# 3 Background

## Challenges with the current scalability paradigm

Ethereum, as an L1 network, must be capable of functioning on the same scale as the Internet, yet this is a feat that no single L2 chain is currently capable of achieving. The fact of the matter is, **as expanding applications and ecosystems search for a blockchain to deploy on, their options are limited and far from ideal**. They may opt for deploying on Ethereum at the expense of scalability, settle for an L2 solution and risk dependency on that ecosystem, or decide to deploy and maintain their own chain, consequently fragmenting liquidity and forgoing the potential of harnessing network effects. Moreover, **interoperability has been a key challenge, and our solutions to this challenge, namely, cross-chain bridges, have been fragile** and a consistent target for malicious actors.

## What is the new thesis?

The idea behind the next stage of L2 evolution is to **simplify the process for developers to deploy rollups of all types and manners**, whether they be application-specific or general purpose. The current leaders within the L2 space seek to reach this new stage through **reducing technical complexities, increasing resource availability, and providing a platform for developers to share existing overhead**.

In our current system, each rollup has its own infrastructure overhead (bridges, sequencers, node providers), common standards, and design structures. This is unsustainable and leads to continued fragmentation and wasted resources. Many teams do not want to think about running infrastructure and simply want to focus on building applications. The ultimate idea is that **deploying a new rollup chain should be more or less analogous to creating a new webpage**; as close to "one-click deployment" as possible is the desired outcome.

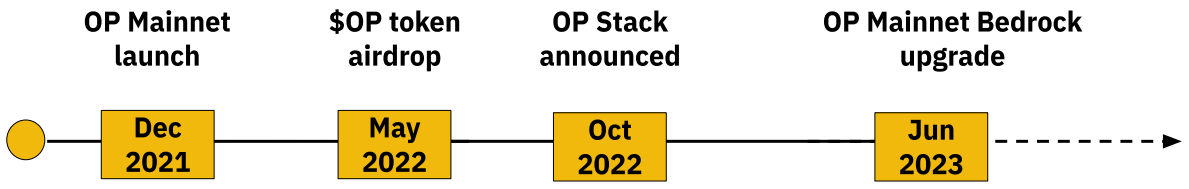
This **second generation of rollups, whether they are OP Chains on Optimism, L3s on Arbitrum Orbit, or hyperchains on zkSync, will allow different entities with different intentions to build their own custom environments while reusing existing and battle-tested infrastructure from the parent L2**. With this, they will hope to create a seamless, secure, and highly interoperable environment which can truly deliver the next level of scalability.

# 4 Key Players

## Optimism and the OP Stack

Optimism is the collective behind OP Mainnet, an **Ethereum Virtual Machine ("EVM")-equivalent optimistic rollup** that has been live since December 2021 and is one of the leading Ethereum L2 solutions. As of the time of writing this report, **OP Mainnet has over US$2.2B in total value locked ("TVL")** and commands the second largest market cap among all Ethereum L2 solutions with over 23% in total market share[1]. In October 2022, Optimism introduced the **OP Stack**, which they described as a "**modular, open-source blueprint for highly scalable, highly interoperable blockchains of all kinds**"[2]. This marked an evolution in their design and vision for the world of Ethereum scalability beyond just running their optimistic rollup solution. It also introduced us to the idea of the so-called **Superchain**, which refers to a group of highly integrated and unified L2 blockchains built on the OP Stack. The most recent development in this next stage for **Optimism has been the migration of their flagship L2 rollup to Bedrock**, which is the first official release of the OP Stack and brings numerous operational and user improvements to their product.

**Figure 1: An abbreviated timeline of Optimism's journey thus far.**

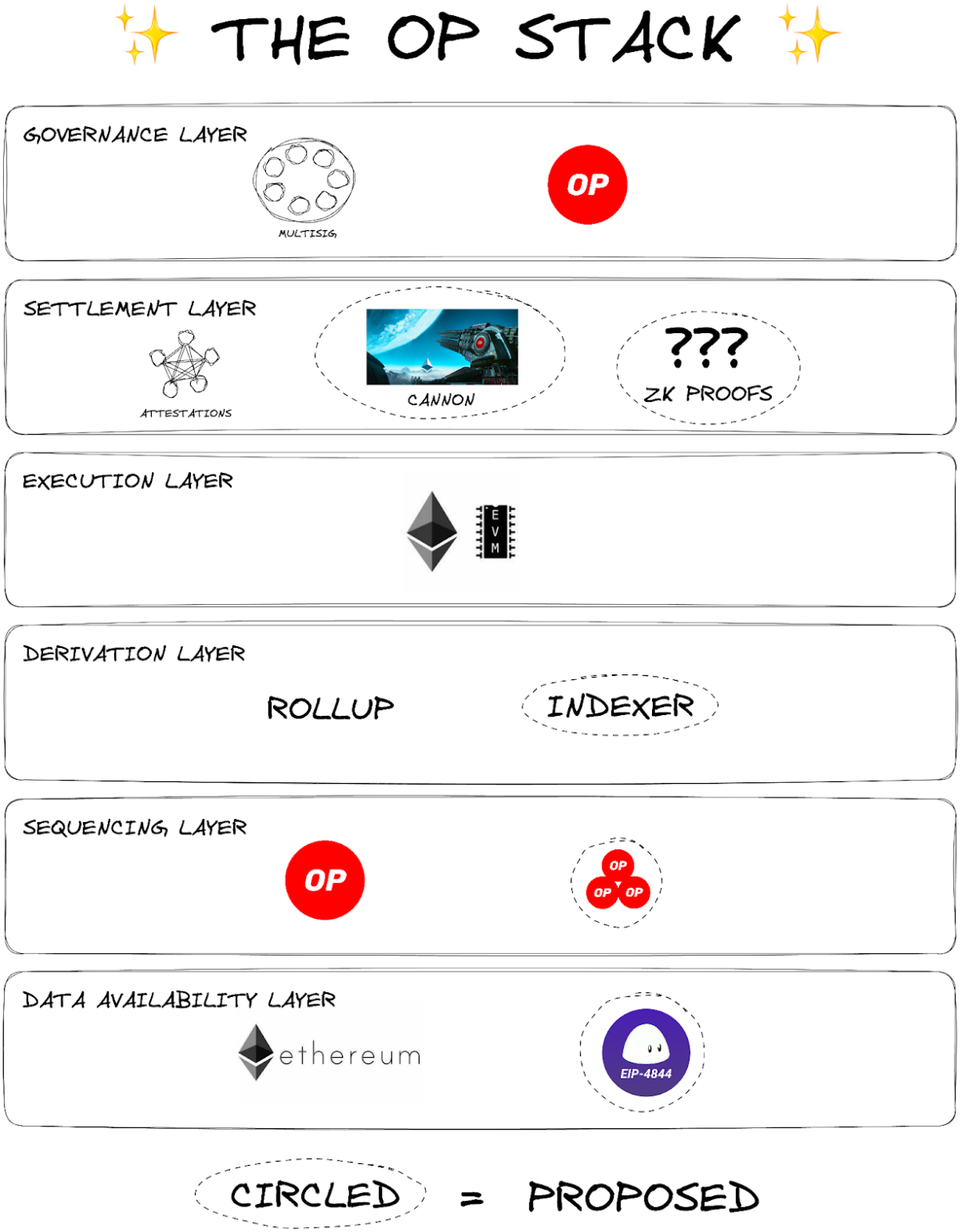



Source: Optimism website, Binance Research

### What exactly is the OP Stack?

The **OP Stack is a standardized, shared, and open-source development stack** (i.e., set of software) that powers OP Mainnet. It consists of **various software components** (i.e., modules or libraries of code) that together form Optimism's L2 rollup and can be used to create a network of shared, interoperable, and coordinated set of L2 blockchains. It is important to note that the **OP Stack is an evolving concept** that will grow as Optimism itself grows. Essentially, the OP Stack aims to simplify the creation of L2 blockchains and can be considered a **"build-an-L2" supermarket**.

**Figure 2: The different conceptual layers of the OP Stack.**




Source: Optimism website, Binance Research

- **Data Availability ("DA") Layer:** This layer defines **where the raw inputs to an OP Stack-based chain are published**. The most widely used DA module for the OP Stack is the Ethereum DA Layer, which the OP Mainnet rollup uses. Notably, we recently saw the testnet launch of Taro[3], the first OP Stack rollup chain that utilizes Celestia as a DA Layer instead of Ethereum.

- **Sequencing Layer:** This layer determines **how transactions on an OP Stack chain are collected and published to the DA Layer.** In its current state, the sequencer module for the OP Stack is a single sequencer setup. Future proposed modifications will include Multiple sequencers to enhance the decentralization of the platform. Economically, the **sequencer generates protocol revenue from transaction fees paid by OP Mainnet users**, which primarily goes toward retroactive public goods funding. In the future, when the sequencer is decentralized, there are also plans to distribute some of this revenue to $OP stakers.

- **Derivation Layer:** This defines how **raw data from the DA Layer is processed to form the inputs that are sent to the Execution Layer**. It is very closely linked to the DA Layer as it must understand how to parse the raw data from there.

- **Execution Layer:** This layer **defines the state within an OP Stack chain and how it changes after receiving inputs from the Derivation Layer**. A slightly modified version of the EVM is the current Execution Layer module that features in the OP Stack, although this can be modified to include the Move Virtual Machine, for example.

- **Settlement Layer:** This layer traditionally **handles the withdrawals of assets from a blockchain by first proving the state of the target blockchain and then processing a withdrawal based on that state**. More broadly, for the OP Stack, the Settlement Layer allows a third-party blockchain to become aware and establish a view of the state of an OP Stack chain. The OP Stack currently includes a module built around attestation-based fault proofs to establish this view. However, Optimism is also working on their trust-minimized Cannon proof system and has added functionality for ZK validity proofs in their recent Bedrock upgrade.

- **Governance Layer:** This refers to the **general set of tools and processes used to manage upgrades, design decisions, and system configuration**. This is a more abstract layer relative to the others and can contain a variety of mechanisms. Two of the modules featured in the OP Stack are MultiSig Contracts and Governance Tokens. MultiSig Contracts are smart contracts that carry out a given action after reaching a predefined threshold of signatures from a participant set. This is the current mechanism used to manage upgrades of bridge contracts on OP Mainnet.

Governance Tokens, on the other hand, are generally used to decentralize decision-making, with exact functionality varying on a case-by-case basis.

The important thing to remember is that **builders can easily modify existing modules or create new ones to tailor to the needs of whatever application they are focused on**. For example, as mentioned in the DA Layer section, Taro is a rollup that utilizes Celestia for DA rather than Ethereum. The **OP Stack essentially deconstructs all of the different components that go into building an L2 and packages them as separate modules**. Builders can then combine the most suitable modules to create their own L2. Eventually, Optimism foresees an incoming explosion of highly compatible L2s and L3s, which they refer to as **OP Chains**. They believe these chains will eventually bring forth the Superchain. The first step in realizing this future was their recent Bedrock upgrade.

## Benefits of the OP Stack

Optimism has always had a strong focus on alignment with Ethereum, and the OP Stack is therefore an EVM-equivalent rollup development kit. This comes with a number of key benefits that will be crucial in helping them realize a potential Superchain future.

- **Extensibility:** OP Stack code is designed with the view that other builders will want to use and build on top it. As such, their **code is open-source and generally modular so that other developers can easily build on it**. This means that Ethereum Improvement Proposals ("EIPs") and future upgrades should be simple to implement.
- **Simplicity:** Optimism builds with the philosophy that complex code does not scale. They strive to **make their code as simple as possible and prefer to re-use existing code that has been battle-tested**. This vision is why they chose to use a Geth fork as OP Stacks' default execution engine[4] (which has been tested on Ethereum for years). Generally, the simpler the code, the less vulnerable it is to potential bugs and attacks.
- **Familiarity:** Existing Ethereum developers should find it relatively easy to build on the OP Stack given their alignment with Ethereum and its code.
- **Client Diversity:** Multiple client implementations are possible across the OP Stack. This diversity brings liveness and safety benefits. We have already seen the **mainnet launch of OP-Erigon**, an alternative execution client for the OP Stack, and the **announcement of Magi**, an alternative OP Stack rollup client.

## The Bedrock upgrade

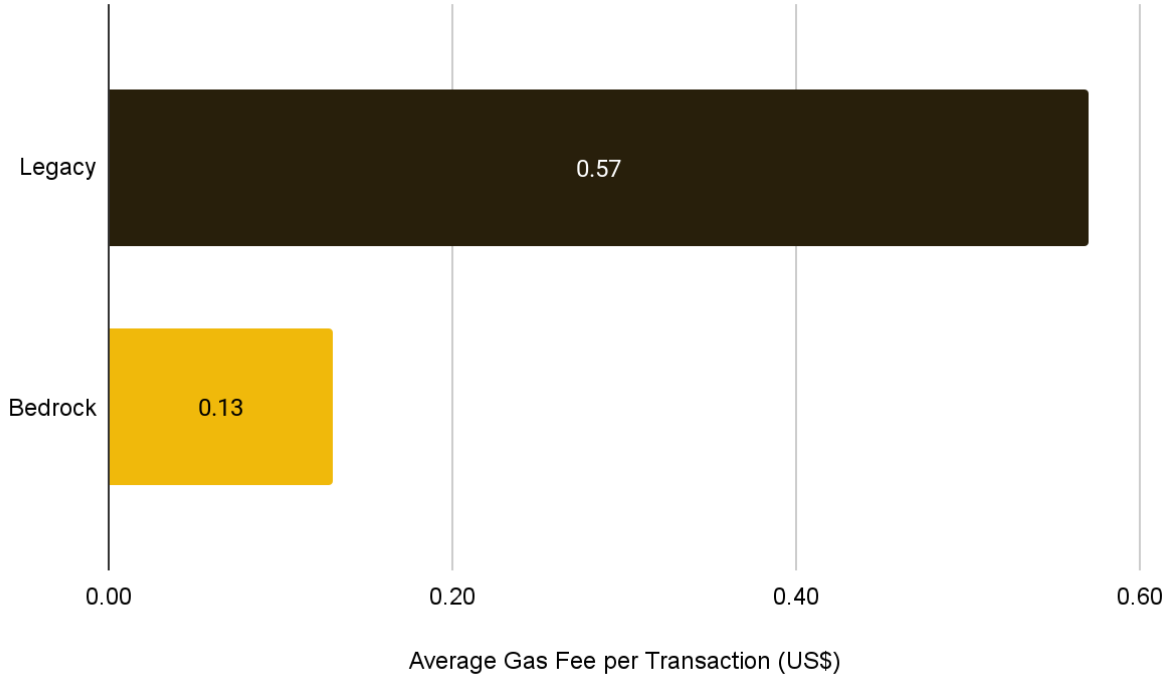
The Bedrock upgrade, released June 6, 2023, was the **first official release of the OP Stack and represented a complete, modular rewrite[5] of the core components of OP**

**Mainnet's rollup architecture**. Optimism's flagship rollup is now built with the modular OP Stack. Not only does Bedrock represent the upgrade to the OP Mainnet rollup, but it also provides the tools for launching a production-quality optimistic L2 rollup blockchain.

**Key improvements**

- **Lower fees:** Bedrock implemented an optimized data compression strategy to minimize data costs. This has caused a significant reduction in **transaction fees, which are now over 77% cheaper per transaction on average**[6]. This has also resulted in **Optimism's L2 rollup now being the cheapest Etheruem L2 to swap tokens** on.

**Figure 3: Average OP Mainnet gas fees are roughly 77% lower after the Bedrock upgrade.**




Source: Dune Analytics (@oplabspbc), Binance Research, as of June 26, 2023

**Figure 4: OP Mainnet is now the cheapest Ethereum L2 rollup to swap tokens on.**

| Logo | Name | Rollup type | Cost to swap tokens (US$) |
|---|---|---|---|
| | OP Mainnet | Optimistic | 0.06 |
| | zkSync Lite | Zero Knowledge | 0.08 |
| | Arbitrum One | Optimistic | 0.14 |
| | Boba Network | Optimistic | 0.16 |
| | zkSync Era | Zero Knowledge | 0.24 |
| | Ethereum | Base Layer | 3.95 |

Source: l2fees.info, Binance Research, as of June 26, 2023

- **Shorter deposit times:** Bedrock introduced support for L1 re-orgs in the node software, leading to a shorter waiting time for deposits. **Deposit times are down around 70% from around 10 minutes to roughly 3 minutes**. This is an important addition to the user experience, especially for those who are newer or less experienced with L2 rollups.
- **Improved proof modularity:** Bedrock abstracted the proof system from the OP Stack (targeting the Settlement Layer from Figure 2) so that an **OP Stack chain may use either a fault proof or validity proof** (i.e., a ZK-proof) for transaction verification. Notably, there is already an RFP in place to build a ZK validity prover for the OP Stack[7].
- **Improved node performance:** Bedrock enabled the **execution of several transactions in a single rollup "block" instead of the prior "one transaction per block" model**. At current transaction volumes, this will reduce state growth by around 15GB/year.

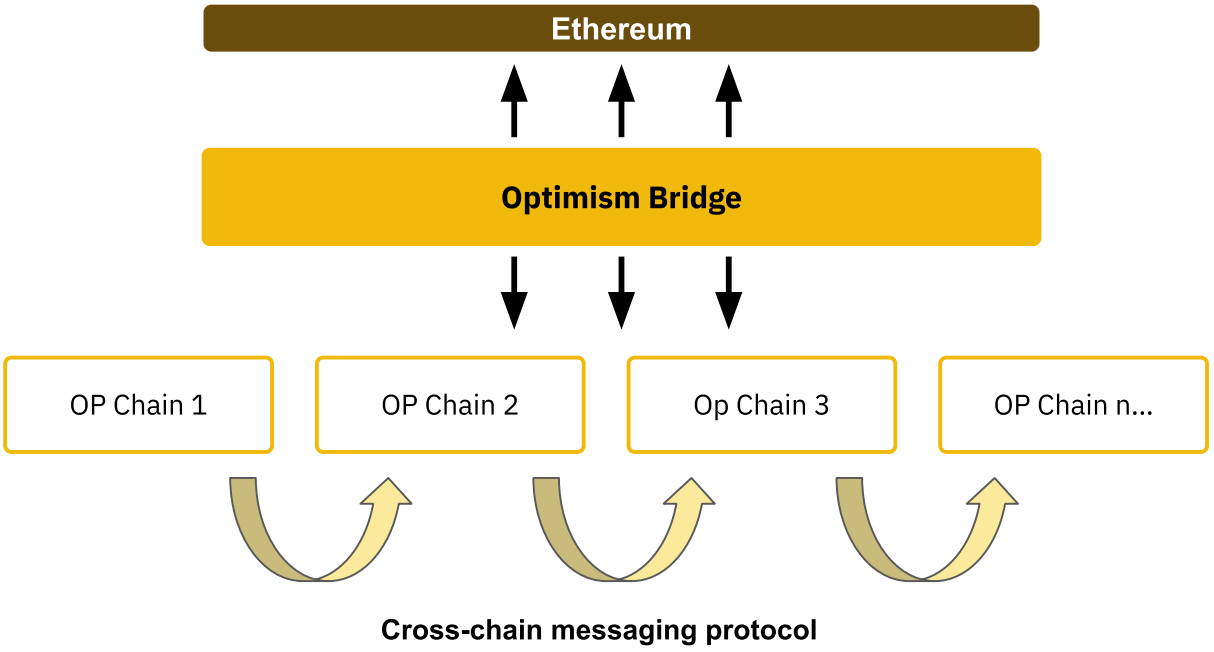
As we previously discussed, the OP Stack has helped to deconstruct the various components that go into building an L2 chain, and Bedrock is the first such implementation of this software. **The key unlock here is modularity**. Builders can now build their own L2s utilizing the same standardized modules as Bedrock, or alternatively, swap various components around to create customized L2s. Overall, the Bedrock upgrade has not only

endowed Optimism's L2 rollup with a number of significant improvements, it has also brought Optimism one step closer to their Superchain vision.

## The Superchain thesis

The next step after the Bedrock upgrade is for Optimism to begin the process of upgrading itself to the Superchain. **The Superchain is envisioned as a decentralized network of L2 chains (called OP Chains) that share security, a communication layer, and an open-source technology stack (the OP Stack)**. These chains will be standardized and intended to be used as interchangeable resources. This standardization will enable builders to create applications which target the Superchain as a whole, rather than just the underlying chain the app runs on. It is important to note that the Superchain is currently just a concept and very much a work in progress. In fact, the Optimism team believes it to be a "multi-year (if not decade) journey"[8].

**Figure 5: Visual representation of the Superchain.**




Source: Optimism website, Binance Research

**What will the Superchain unlock?**

- **Hardened and secure code base:** As the number of chains grows, each sharing and contributing to the modular and standardized codebase underpinning them, it hardens the system. More iterations and development on the same standardized code will help simplify it, making it more resistant to attacks and bugs. Given the prevalence of hacks and security breaches in the system, this will be a key benefit of a structure like the Superchain.

- **Atomic cross-chain composability**[9]**:** This refers to seamless transactions between different OP chains simultaneously without any need for bridging or intermediaries. Despite the Superchain being made up of multiple chains, the end user gets the experience of using a single, unified chain. In practice, this can lead to improvements such as universal block explorers (as opposed to different explorers for each chain like we currently have) and the removal of network switching when using apps (e.g., no dropdown menu inside MetaMask).
- **Common Ethereum infrastructure:** This makes the job of developers significantly easier and allows existing Ethereum developers to seamlessly switch over to building OP Chains.

**Hacks**

Chains that swap out standardized modules with experimental alternatives are considered "Hacks" in the OP world. These hacks create chains that aren't exactly OP Stack, possibly leading to security vulnerabilities and ineligibility to join the Superchain. However, they provide a useful avenue for developers to experiment with and create novel apps. OPCraft[10] is one such experiment that runs a modified EVM at the execution layer to create a fully on-chain crafting-based 3D voxel game. The Optimistic Game Boy[11] was another example where developers swapped out the execution engine for a Game Boy emulator.

**What is next?**

Optimism's L2 rollup chain, following the Bedrock upgrade, is the first member of the Superchain. Coinbase's upcoming **Base L2**[12] will be the second member, with a mainnet announcement expected this year. **Worldcoin** has also committed to building on the OP Stack[13]. **Conduit** is another interesting project[14] aimed at making it easier for developers to launch their own OP Stack rollups to eventually become part of the Superchain. **Aevo**, a decentralized options exchange, recently launched its rollup based on the OP Stack in collaboration with Conduit, which operates the Aevo rollup sequencer[15]. Interestingly, **BNB Chain also announced the testnet for opBNB**, which is their EVM-compatible L2 chain based on the OP Stack. In the NFT world, decentralized NFT marketplace **Zora recently launched the Zora Network. The Zora Network is an L2 built on the OP Stack** that aims to make NFTs cheaper and more accessible. Their documentation states that minting on Zora can cost less than US$0.50, with transactions confirmed in seconds[16].

As we can see, developments around the OP Stack are ongoing and widespread across the crypto ecosystem. It will be interesting to see how their solution fares against competitors like Arbitrum, zkSYnc, and Polygon and how things progress over the next few months.

# Arbitrum Orbit

Developed by Offchain Labs, Arbitrum is another popular EVM-equivalent optimistic rollup in the L2 space that has been live since August 2021. **In fact, Arbitrum is currently the largest and most dominant L2 network in terms of TVL, having amassed over US$5.9B. To put this in perspective, that is a total market share of over 60%**[17]. With such impressive traction, the Arbitrum ecosystem comprises several products, including Arbitrum One, Arbitrum Nova, Arbitrum Nitro, and, moving forward, Arbitrum Orbit.

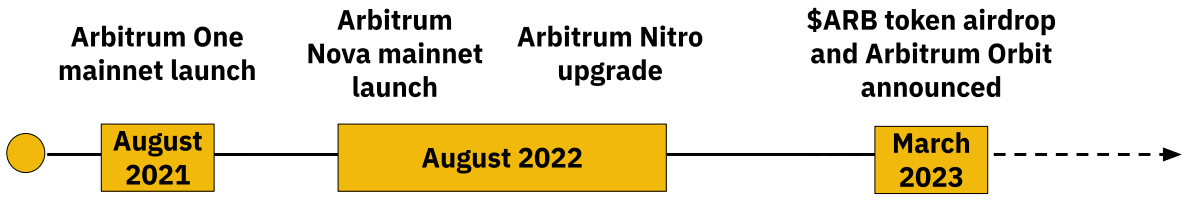
- **Arbitrum One**: The first and core mainnet rollup of the Arbitrum ecosystem. One is fully trustless and inherits Ethereum L1's security guarantees without the introduction of additional trust assumptions.

- **Arbitrum Nova**: An AnyTrust solution that is Arbitrum's second mainnet rollup for projects with cost-sensitive, high transaction volume expectations.

- **Arbitrum Nitro**: The technical software stack that powers the Arbitrum L2, enabling the rollup to be faster, cheaper, and more EVM-compatible. Nitro introduces interactive proofs that run over the WebAssembly ("WASM") code used by Arbitrum.

- **Arbitrum Orbit**: The development framework for creating and deploying L3s on top of the Arbitrum mainnet.

**Figure 6: An abbreviated timeline of Arbitrum's journey thus far.**




Source: Arbitrum website, Binance Research

**What is the Arbitrum vision?**

Similar to Optimism, **Arbitrum has charted a development path that started from a relatively monolithic approach to a more modular and component-based framework.** The Arbitrum thesis is based on a core strategy that is focused on drawing a diverse set of applications to its general-purpose chains in Arbitrum One and Arbitrum Nova. An important building block of Arbitrum's strategic vision is to do with L3 rollups that settle transactions to Arbitrum's chains. **L3s are fundamental to the next phase of Arbitrum's scaling journey and the solution to realizing their vision. Arbitrum is calling this Arbitrum Orbit.**

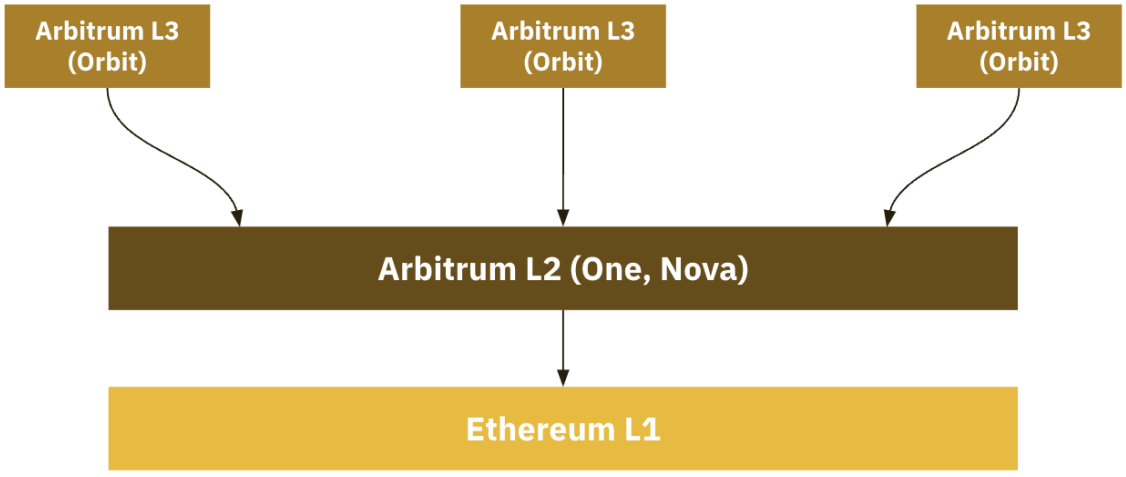
## What is a Layer-3?

**L3 networks, sometimes labeled as app-chains though their scope extends beyond this term, are dedicated networks built on top of an L2, each hosting smart contracts that support specific decentralized applications**. They leverage the security from L2 networks, which in turn borrow their security assurances of a foundational L1 network such as Ethereum. Ultimately, L2s are utilized for general-purpose scaling, whereas L3s are envisioned to accommodate specific-purpose applications.

The easiest way to understand L3s is to think of them as the rollup for an L2. Instead of settling on an L1, L3s settle on an L2. What's more, they offer vastly increased scalability, rendering them an ideal solution for high-throughput applications, as seen in particular use cases within DeFi or crypto gaming - one notable example is dYdX, which was among the first dApps in the DeFi space to migrate from an L1 to its very own app-chain in order to better scale its product[18].

To illustrate, if an L3 boosts throughput 10 times compared to an L2, and an L2 enhances throughput 10 times relative to L1, then the L3 offers a throughput that is 100 times greater than L1. More importantly, L3 networks serve to improve interoperability and communication among protocols by interlinking different aspects of the blockchain and Web3 ecosystems.

**Figure 7: Arbitrum Orbit is one such example of an L3 solution.**




Source: Arbitrum website, Binance Research

## Where does Arbitrum Orbit fit in?

**Introduced in March 2023, Arbitrum Orbit offers a new permissionless frontier for developers to build chains on top of Arbitrum One or Arbitrum Nova, referred to as L3 chains.** Simply put, Orbit is a permissionless development framework that provides the

ability for anyone to deploy L3 chains on top of Arbitrum L2 chains. Permissionless is a key characteristic here, as it enables developers to create new L3s on top of Arbitrum L2s without requiring permission or formal approvals.

Arbitrum envisions Orbit as a highly accessible product and an integral part of the Arbitrum public infrastructure. Steven Goldfeder, CEO of Offchain Labs, shared the team's commitment to further developing and tooling the solution, with the aim of positioning Orbit as the easiest and most convenient platform for dApps to introduce an L3. This is certainly advantageous for application teams, allowing them an opportunity to test the waters and gain firsthand experience with L3s before committing to their own deployments.

Through Orbit, Arbitrum intends to support the following use cases for protocols looking to launch their own L3 chains:

- **Layer-3 rollups**: Launching L3 rollup chains, similar to Arbitrum One.
- **Layer-3 AnyTrust:** Launching L3 AnyTrust chains, similar to Arbitrum Nova.
- **Customizable Layer-3**: Deploying a customized L3 chain, built on Arbitrum Nitro, for application-specific needs. This includes components such as privacy, permissions, fee tokens, governance, and more.

With this solution, Arbitrum aims to attract developers that want more control and are seeking customizability, allowing them to fork and freely tweak Arbitrum source code as per their specific requirements. **Arbitrum places a significant emphasis on customizability, even going as far as branding their solution as "tailored chains".** Orbit is set to be compatible with the forthcoming Arbitrum Stylus upgrade, opening up possibilities for developers to build decentralized applications using standard programming languages like C, C++, and Rust, thereby expanding the versatility and reach of Arbitrum. Additionally, transaction fees on these L3 rollups will be paid in $ETH to the Arbitrum sequencers.

**Orbit is set to transform Arbitrum into a settlement layer akin to Ethereum, adding more value to its core chain and bolstering the long-term scalability of the wider Arbitrum ecosystem.** While the Arbitrum team acknowledges that the optimal L3 structure is yet to be found, this upgrade will enable dApps to reap benefits from the increased throughput and secure bridging offered by L3s in addition to the network effects already present within the Arbitrum ecosystem. Projects have already begun to express interest in this development, with Xai, a decentralized gaming network, set to make its mark as the inaugural L3 on the Arbitrum platform.

# zkSync and Hyperscaling

zkSync, founded by Matter Labs, is an L2 scaling solution for Ethereum that utilizes zk-rollup technology. The second iteration of zkSync was launched earlier this year and is known as zkSync Era, which is Matter Labs' version of a zkEVM rollup. Since deploying on its mainnet, zkSync Era has become one of the most widely utilized L2 and zkEVM solutions, reaching a TVL of over US$625M[19].

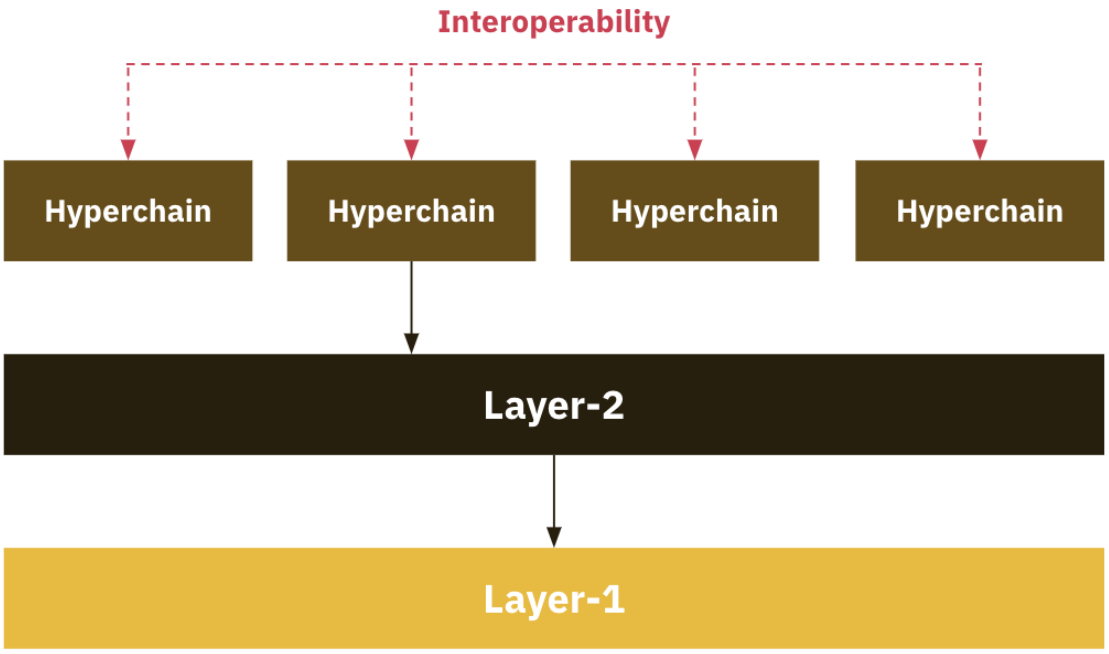
For more information on zkSync Era, please make sure to check out our report, The zkEVM World: An Overview of zkSync.

As zkSync Era signifies the second iteration of the zkSync product suite, hyperscalability epitomizes its ultimate ambition: managing an infinite number of transactions without compromising on either security or decentralization. In order to accommodate the burgeoning demand of Web3, zkSync has designed its end-game solution around the concept of hyperchains. The zkSync architecture aims to incorporate a network of hyperchains, all anchored to a central basechain.

## What is a hyperchain?

**Hyperchains are zkSync's vision of an L3, conceived as an extensive ecosystem of trustless and customizable linked blockchains**. They are parallel-operating, fractal-like instances of zkEVM and can be created or deployed by any entity in a permissionless way. The implementation of zkSync hyperchains utilizes a modular approach, with a hyperchain software development kit ("SDK") framework available for developers to leverage, allowing them to either select various components for their blockchains or to develop their own.

**Figure 8: Hyperchains are sovereign ZK-chains on Ethereum, connected with a network of customizable and fully trustless hyper-bridges.**




Source: Project teams, Binance Research

The zkEVM engine plays an important role in maintaining uniformity across the network. To maintain trust and interoperability within this ecosystem, each hyperchain must be fueled by the zkEVM engine, identical to the one powering the main zkSync L2 platform. This enables hyperchains to inherit their security directly from the L1, regardless of who deploys them.

**What is a Basechain?**

The Basechain is analogous to zkSync Era. It can be thought of as the main hyperchain instance of zkSync Era, with the added feature of settling its blocks directly on Ethereum's L1. Not only does it serve as the primary computational layer for general-purpose smart contracts, but it also acts as a settlement layer for all other hyperchains, including those of L3 and beyond.

**zkSync hyperchains aim to offer infinite scalability, covering the following areas:**

- **Security**: Hyperchains would overcome the typical vulnerabilities associated with non-native bridges, which often lead to hacks. Interaction between the fractal hyperchains in zkSync's L3 will be through native bridges, further enhancing security.

- **Performance:** By virtue of implementing hyperchain architecture and achieving hyperscalability, L3 performance is improved.

- **Cost**: Data fees are significantly reduced as a result of data availability solutions.

- **Ease of use**: zkSync foresees substantial enhancements to SDKs, including the introduction of low-code and no-code solutions, making application development significantly easier.

- **Composability**: The LLVM compiler of the system supports Solidity and any other modern programming language, increasing accessibility for developers specialized in languages like Rust, C++, and Swift.

Additionally, features such as on-chain privacy, tokenomics, and data availability with the hyperchain itself can be tailored to meet specific needs. zkSync's permissionless solution offers developers three distinct data availability options. This allows developers to directly choose their tradeoff between price, performance, and security.

- **ZK rollups**: Ideal for those requiring the full security features of Ethereum, primarily suited for DeFi applications.

- **zkPorter**: This option is for those who prefer a balance of on-chain and off-chain data, aiming for affordability, speed, and security, all of which are excellent choices for game developers.

- **Validium**: For those seeking optimal performance levels with a slight compromise on security compared to Ethereum.

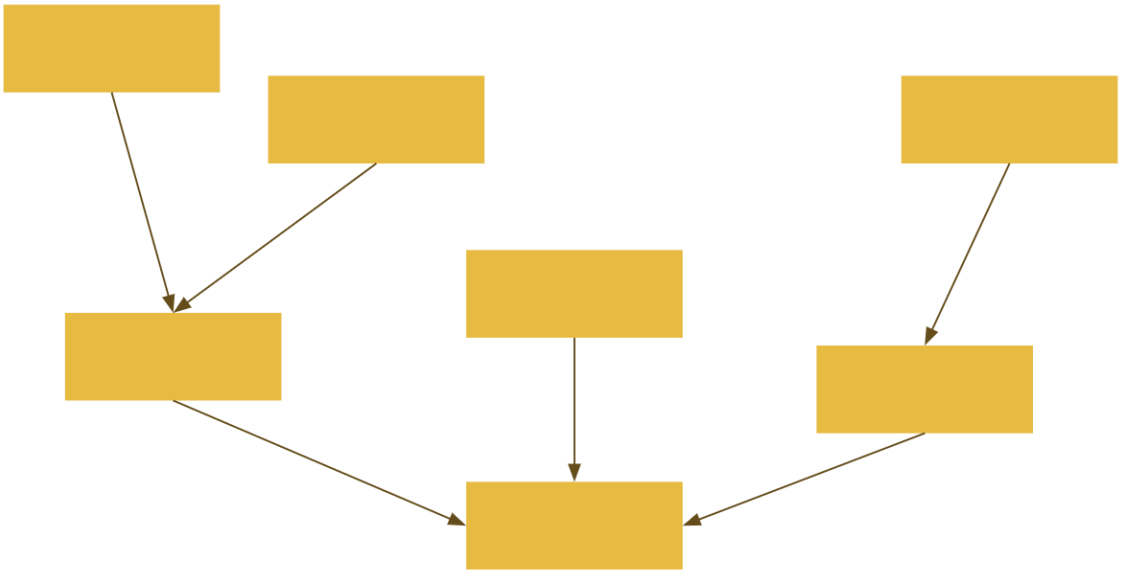
## The hyperscaling thesis

We are all aware of the term scaling, which means being able to process many transactions without compromising security or decentralization. While today's framework behind scaling is relatively sufficient, it does not account for the ever-growing demand in Web3 and ultimately infinite demand for that matter. This is where the concept of hyperscaling fits in. **Hyperscaling refers to the ability of processing infinitely many transactions without compromising security or decentralization**[20]. Remember the blockchain trilemma, where a network is able to only choose two from scalability, security, and decentralization? Hyperscalability aims to make this redundant as it breaks out of this well-known tradeoff.

**A hyper-scalable blockchain system involves multiple different ZK chains (or hyperchains) running in parallel, with block proofs being aggregated and settled on the L1**. In theory, this could even be an infinite number of hyperchains, which are representative of the entire system. This entire process is related to an idea known as fractal scaling, which was first introduced by StarkWare. Fractal scaling is based on a multi-layer network concept where application-specific L3s are built recursively over an L2.

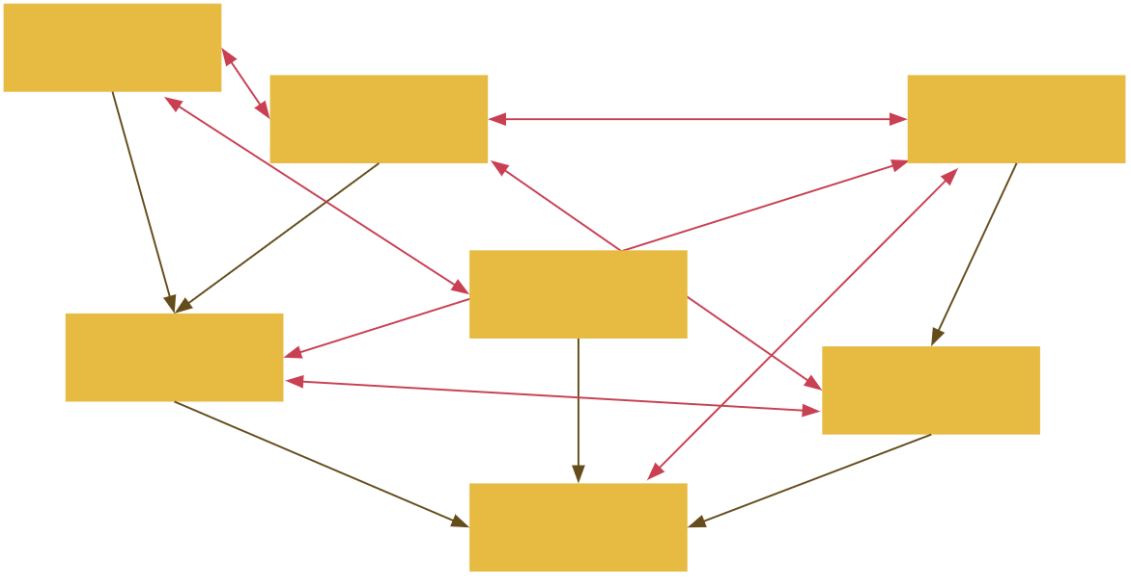
**However, hyperscaling takes this a step further by introducing hyper-bridges, which are native bridges that link each of the L3 appchains to one another**. This enables transfers between hyperchains without the consumption of resources on a third chain and further ensures that the basechain doesn't become a central scalability bottleneck, thereby maintaining the principle of parallel hyperscalability. The contrast between fractal scaling and zkSync's hyperscaling vision is depicted by Figures 9 and 10 below.

**Figure 9: Without hyper-bridges, fractal scaling may position the basechain to become the main intersection for most transfers over time, potentially causing an obstacle to scalability.**



Source: zkSync website, Binance Research

**Figure 10: With hyper-bridges, transfers from one hyperchain to another become as simple and cost-efficient as any regular transfer, mirroring how hyperlinks allow seamless navigation from one webpage to another with just one click, eliminating the need for additional navigation through each layer.**



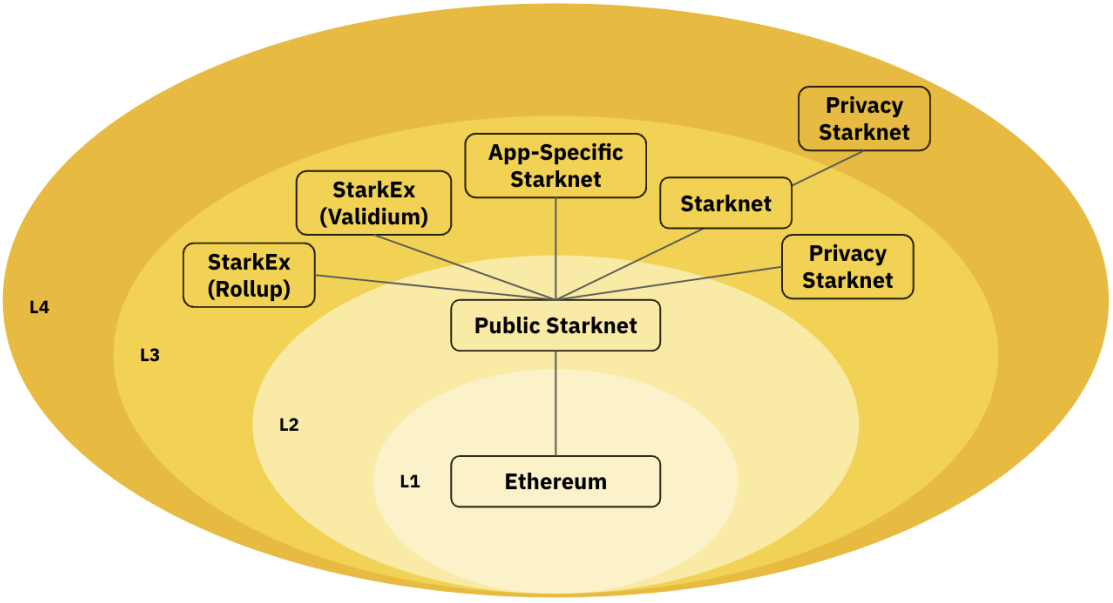
Source: zkSync website, Binance Research

# StarkWare and Fractal Scaling

StarkWare, the company behind the general-purpose Ethereum L2 ZK rollup, Starknet, can be considered the first major organization to start the discussion around fractal scaling and multi-layer architectures. In their December 2021 blog post, Fractal Scaling: From L2 to L3, StarkWare published their view on L3s, including their functional use cases and the benefits that they may provide.

**In a nutshell, StarkWare's multi-layer network thesis suggests that while L2s' function is for general-purpose scaling, L3 should be leveraged for customized scaling.** This narrative is certainly not dissimilar to what we have previously explored in some of the L2s. Indeed, it's quite plausible that StarkWare's initial concept inspired other L2 projects to embark on their own explorations into the next phase of Ethereum's scaling evolution.

**Figure 11: Visual representation of StarkWare's initially proposed multi-layer architecture framework.**




Source: StarkWare Blog, Binance Research

While StarkWare hasn't made further announcements beyond the initial publication of the above thesis, we continue to see several developments take place in their ecosystem. Slush has taken the fractal scaling idea further and has been working on an SDK for building zkVM L3s on top of Starknet. While the exact details of the project are extremely technical and fall beyond the scope of this report, it is worth keeping a close eye on how Slush progresses with their roadmap[21] and what sort of players they can attract to their zkVM L3 universe.

Additionally, in August last year, StarkWare announced Recursive STARKs, an innovative solution that offers a new magnitude of scalability for blockchain systems. These STARKs enable the bundling of multiple transaction proofs into a single proof, enhancing the capacity of L2 scaling. The technology relies on Cairo, a programming language supporting proof generation for complex computational tasks, and SHARP, which enables transaction aggregation from multiple apps into a single STARK proof. **This development not only dramatically increases the number of transactions that can be written to Ethereum via a single proof, but it also opens new horizons for hyperscaling and advanced applications.**

The implementation of Recursive STARKs aims to optimize cost, latency, and computational resources, thereby facilitating the development of L3 solutions on top of the public Starknet network. As StarkWare continues to refine the Recursive Verifier, we can anticipate further improvements in performance and cost-effectiveness. Undoubtedly, Recursive STARKs sets the stage for Starknet's move towards the domain of L3 networks.

Building upon these noteworthy advancements, it will certainly be interesting to observe Starknet's continued progression and their regular updates detailing their strategic approach to Ethereum scaling.

# Polygon 2.0

Polygon's latest announcement concerning the next phase of their L2 journey was released during the early part of June. **Polygon 2.0 was announced with the vision of creating the "Value Layer of the Internet"**[22].

Before diving deeper, let's cover some background on Polygon. Polygon is a platform dedicated to enhancing Ethereum's scalability, a goal they accomplish by utilizing a diverse range of solutions. Their flagship product is the **EVM-compatible Polygon PoS sidechain**. Polygon's L2 solution handles approximately 2-3M transactions daily from 300-400K consistently active addresses[23]. **Polygon has also ventured into the app-chain thesis, releasing their very own solution known as Supernets**, which empowers developers to establish customizable app-chains. Several companies have announced Supernets, including gaming giant Nexon for their new game set in the MapleStory Universe. What's more, **Polygon zkEVM, their EVM-equivalent ZK-rollup** solution, had its mainnet debut in late March and has since garnered over 177K unique addresses and 20-50K transactions daily[24].

Polygon 2.0 is the latest addition to their suite of L2 products and seeks to unify these platforms to create a seamless interface for users. Conceptualized as a **conglomerate of L2 chains powered by ZK technology, Polygon 2.0 utilizes a unique cross-chain coordination protocol**. This solution is set to incorporate a series of upgrades for seamless interoperability among Polygon zkEVM, PoS, and Supernets. The network boasts the ability to accommodate an essentially unlimited number of chains with the assurance of safe and immediate cross-chain interactions, devoid of extra security or trust requirements. The Polygon team aspires for this solution to offer infinite scalability and a unified pool of liquidity, mirroring the vast expanse and accessibility of our internet.

**Key points**

- **Interoperability:** Utilizing a groundbreaking cross-chain coordination protocol (the specifics of which are yet to be disclosed), Polygon 2.0 is designed to facilitate fluid movement and interaction across multiple blockchains. Through the employment of cost-effective and swift ZK proofs, these interactions should feel like interacting with one unified large chain. This could, in theory, unlock unprecedented levels of synergy and collaboration across different Polygon chains.

- **Security:** By employing zero-knowledge technology, alongside their existing PoS mechanism, Polygon aims to bolster both security and privacy. They aspire to merge the strengths of both technologies in their forthcoming Polygon 2.0. Their recent announcement to transition Polygon PoS to a zkEVM validium is a testament to this.

- **Scalability:** The team at Polygon is architecting Polygon 2.0 to support a "practically unlimited number of chains"[25], aiming to reach unprecedented levels of capacity and scalability through this approach. Co-founder, Sandeep Nailwal, has even articulated the aspiration of an "unlimited and ever increasing blockspace"[26]. The incorporation of zero-knowledge technology will be crucial in realizing this vision, as ZK has the potential to significantly amplify scalability.

## Latest updates and timeline

Governance will be an integral part of the Polygon 2.0 transition. Polygon Labs President Ryan Wyatt has emphasized the objective of instituting sustainable decentralized governance as a cornerstone of the Polygon 2.0 strategy. To this point, the latest update in the Polygon 2.0 plan came via a preliminary governance proposal to **upgrade Polygon PoS to a zkEVM validium, described as a "first-of-its-kind decentralized L2 secured by ZK proofs"**[27].

The Polygon PoS sidechain is currently secured by its own validator set rather than by ZK proofs, but the Polygon 2.0 vision is that each Polygon chain should be a ZK L2. The solution the Polygon team has put forward is to upgrade the PoS sidechain to a zkEVM validium. **Validiums** are scaling solutions[28] that **leverage ZK proofs** to guarantee transaction validity **but store transaction data off-chain**. This is in contrast to rollups like Polygon zkEVM, which store the data on-chain. The publication of transaction data is expensive and can limit throughput. In this way, **validiums can be seen as a lower-cost, higher-throughput cousin of rollups**. The major tradeoff is that validiums must ensure transaction data availability outside of Ethereum, which Polygon PoS can support through their 100+ validator set, which can serve as a guarantee for data availability.

The **user and developer experience will not change as a result of this transition,** and Polygon PoS will continue to function in the same way as always, just with a higher degree of security due to the addition of ZK proofs. **Both Polygon PoS and Polygon zkEVM will remain as the two public networks of the Polygon ecosystem after this upgrade**. Additionally, both networks will then be using zkEVM technology, one as a rollup and the other as a validium.

The Polygon team believes the **two networks will complement each other**. More specifically:

- **Polygon zkEVM:** The highest level of security, with a tradeoff of slightly elevated fees and limited throughput. Best used for high-value applications where security is of the highest priority, i.e., DeFi.

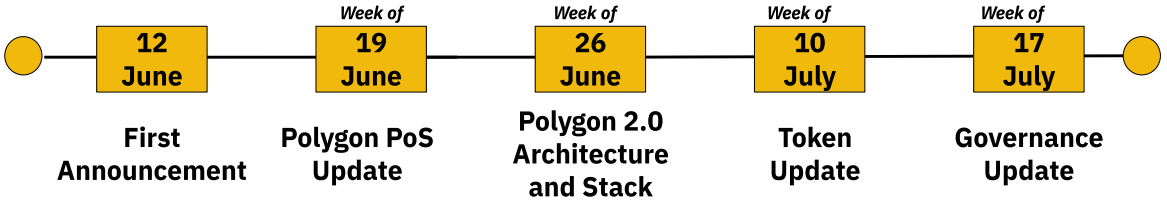
- **Upgraded Polygon PoS (zkEVM validium):** Very high scalability and low fees, with a tradeoff of slightly more limited security compared to Polygon zkEVM. Best used for

applications requiring high transaction volume and very low transaction fees, i.e., gaming and social applications.

Assuming the preliminary proposal gathers support, it will go to a formal governance proposal and then be discussed on governance calls and other forums. If consensus is reached, the **Polygon team envisions a zkEVM validium mainnet launch by the end of Q1 2024.**

The Polygon team has also released details about the announcement schedule for further details on Polygon 2.0. A summer of announcements is coming.

**Figure 12: Polygon 2.0 announcement schedule.**




Source: Polygon website, Binance Research

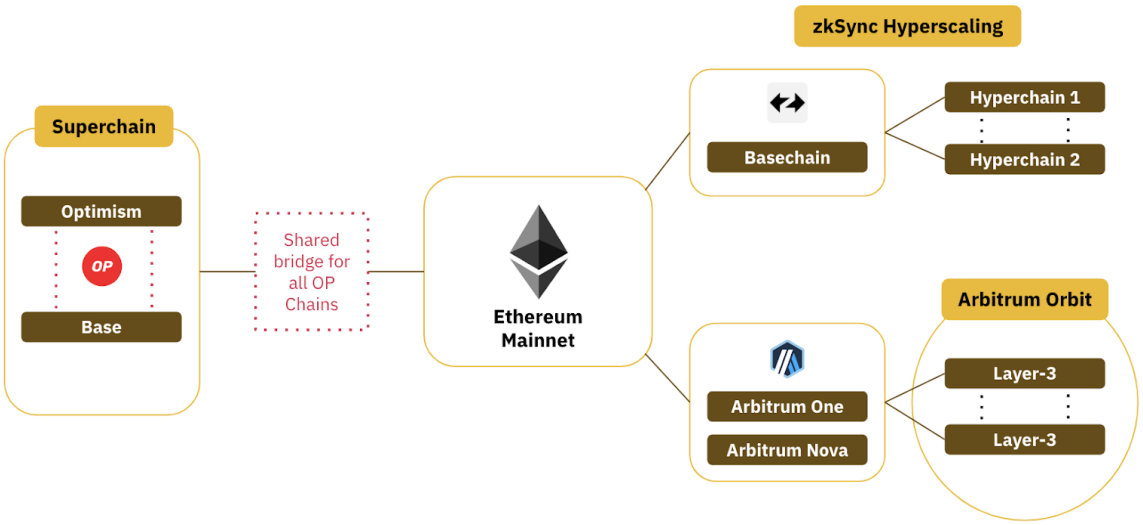
Considering Polygon's performance with their PoS sidechain and the successful deployment of their zkEVM solution, this new vision holds considerable promise and could present an intriguing enhancement to the broader L2 ecosystem. We look forward to monitoring developments as more details about Polygon 2.0 are released.

# 5 Market Comparison

The L2 space is characterized by its dynamic and competitive nature, presenting us with a captivating landscape to analyze. Each network brings its own unique perspective to the table, and while there are commonalities, notable differences do exist. Building on our previous discussions on L2s and their evolving visions, Figure 13 provides a preliminary glimpse into this emerging market.

While all protocols share a broad objective that mirrors the Ethereum Co-founder's endgame narrative to some extent, Optimism, in particular, distinguishes itself through its Superchain thesis. zkSync shows some degree of overlap with Optimism, considering its proposed open-source zkEVM rollup SDK, which offers developers the flexibility to interchange modules similar to OP Stack Hacks. Yet **Optimism largely stands in contrast to zkSync and Arbitrum, both of which present somewhat aligned visions of L3**, albeit with variations in their execution strategies.

**Figure 13: Visual representation of the interplays between the next generation of Layer-2 rollups and the Ethereum Mainnet. Please note that the graphic does not include Polygon and Starknet, as we await further developments from these projects.**




Source: Project teams, Binance Research

Both Starknet and Polygon have so far conveyed distinct strategies in molding their own approaches to the scaling thesis. **Starknet, in some ways echoing the approaches of zkSync and Arbitrum, is placing its bet on a multi-layered structure that employs fractal scaling L3s**. On the other hand, **Polygon is opting for a more integrated model that brings together its suite of L2 products**, including the capacity for dApps to establish their own chains within the realm of supernets.

These L2 visions, diverse as they are, hold customization and app-specific chains at their core. Details, however, continue to evolve – particularly for Polygon, as we eagerly await more revelations on their concept of Polygon 2.0 in the upcoming days and weeks. To help conceptualize these points of comparison further, Figure 14 below captures some of the nuances between the networks.

**Figure 14: Comparative snapshot of Layer-2s and their next phase for Ethereum scaling.**

| | Optimism | Arbitrum | zkSync | Starknet | Polygon |
|---|---|---|---|---|---|
| **Product** | Bedrock, OP Stack | Arbitrum Orbit | Hyperscaling | Layer-3 | Polygon 2.0 |
| **Thesis** | **Horizontally scalable network of chains, forming a Superchain** | **Development framework for creating L3s** | **ZK rollup as a fractal hyperchain in L3** | **Fractal scaling L3s** | **Conglomerate of ZK-powered L2 chains, including supernets** |
| **Software Stack** | OP Stack | Arbitrum Nitro | Hyperchain SDK | Starknet Stack | Polygon zkEVM |
| **Layer-2** | Permissionless | Permissioned | Permissionless | Permissionless | Permissionless |
| **Layer-3** | No | Permissionless | Permissionless | TBC* | No |
| **Value Capture Method** | Sequencer Fees, Sequencer Network, MEV | Sequencer Fees, Sequencer Network, MEV | , Sequencer Fees, Sequencer Network, MEV | Sequencer Fees, MEV, Gas Fees | Sequencer Fees, MEV |
| **Timeline** | October 2022 (OP Stack introduced), June 2023 (Bedrock upgrade - first release of the OP Stack codebase) | March 2023 | TBC* | TBC* | April 2022 (Supernets introduced), July 2023 (Polygon 2.0) |

**TBC stands for "to be confirmed"*

Source: Project teams, Binance Research, as of June 20, 2023

From the above table, Arbitrum's separation of its licensing between permissioned L2 developments and permissionless L3 developments is certainly an interesting distinction. Arbitrum Orbit provides a permissionless platform for creating L3 chains but still demands DAO approval for utilizing Arbitrum's IP to develop L2s. This semi-closed structure, while potentially limiting interoperability between Arbitrum Orbit chains and other L2 chains on Ethereum, effectively mitigates the risk of competing chains diluting user activity from the Arbitrum L2. This is markedly different from some of the other L2 designs. For instance, Optimism and their OP Stack, which employs a complete open-source framework in

Optimism's code, enable developers to freely deploy L2s with shared sequencer sets. While Optimism's model does instill greater flexibility, it could unintentionally pave the way for general-purpose rollups, developed using the OP stack, to cannibalize Optimism's liquidity and users.

Yet, the reality is that the growing network of chains on the Superchain directly corresponds with the increase in Optimism's revenue, a substantial portion of which is anticipated to be channeled back into the broader Optimism ecosystem. This increase in revenue can be largely attributed to Optimism's role as a sequencer and the accruement of fees derived from other OP Chains (even though fee-sharing is not strictly required). In comparison, Arbitrum Orbit displays a rather unique approach to value accrual, mandating L3s built on Arbitrum to pay fees to its sequencers.

**Regardless of the underlying technology, the cornerstone for L2s aiming to scale and unlock network effects is to ensure the creation of an inherently sustainable system**. Amid the intricacies of open-source or closed-source licensing and permissioned or permissionless L2s and L3s, the following areas should also be considered in determining how projects are accruing value in their respective ecosystems.

- **Software customizability**: The ease of replicating code and building on an L2 will be a key differentiating factor. It is likely that projects building on L2s will seek particular modifications and may invest resources to fund such customizations. The best L2 software stacks to accommodate these instances will undoubtedly have a competitive edge.

- **Transaction fees and sequencers**: Sequencers, who shoulder significant responsibilities and operational expenses in maintenance and cloud service charges, should be compensated fairly by the transaction fees levied on users.

- **The role of governance tokens**: As the trend veers towards decentralization, the function of an L2's governance token becomes even more important. It's probable that most rollups will necessitate token staking for inclusion in the shared sequencer network.

# 6 Closing Thoughts

The L2 ecosystem has certainly come a long way in terms of establishing itself as a critical component for enhancing scalability, efficiency, and usability in the industry. Discussions are now unfolding about the 'next phase' of L2 evolution, which has led to the emergence of diverse schools of thought, each with its own vision for the path forward. Vitalik Buterin himself has weighed in on the conversation, pondering potential routes but equally suggesting that there are numerous possibilities moving forward.

The value of L3s, Superchains, and hyperscalability is apparent, but as we stand on the cusp of these advancements, it's clear that there isn't a single, definitive vision or answer. Despite differing viewpoints, they do somewhat converge on a shared underlying objective: infinite scalability. The ultimate goal is to create a Web3 world that scales in the same seamless manner as its Web2 counterpart and provides the best possible playground for builders and users alike.

Indeed, it is still very early days for this subject, with projects yet to strictly formalize and execute their approaches. As such, the views and definitions presented today are snapshots of a dynamically evolving space. We look forward to witnessing how the next phase of Ethereum scaling unfolds and its impact on L2s and the wider blockchain ecosystem.

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