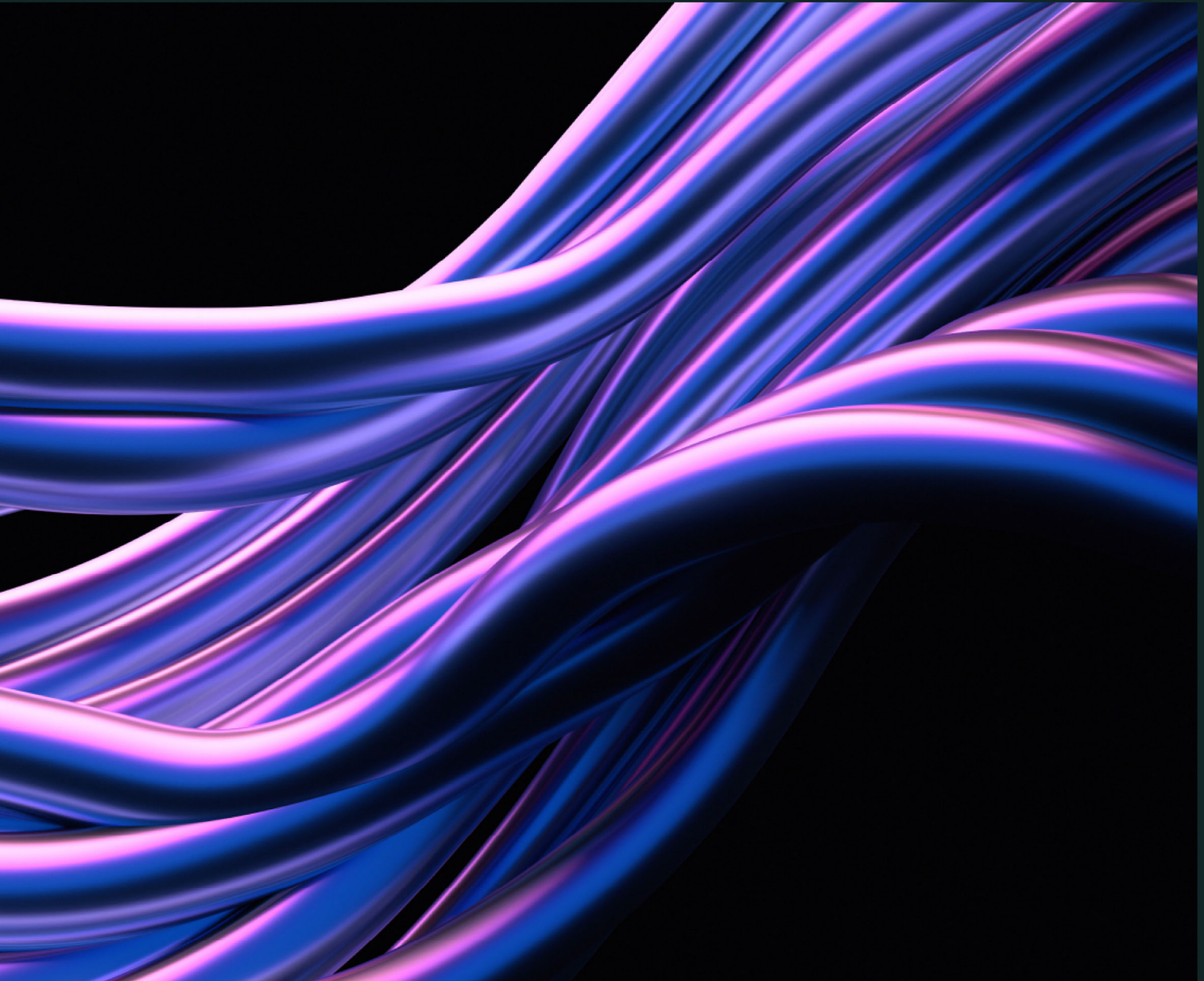


Accessing Web3: Developments and Opportunities



Commissioned by **W3BCLOUD™**



[W3BCLOUD™](#) (pronounced Web3Cloud) is a leading infrastructure provider powering Web3. We believe everything that should be decentralized will be decentralized, and we provide robust infrastructure required to scale these decentralized protocols and their applications. In short, we are the AWS of Web3, providing enterprise grade infrastructure that is optimized for the next generation of the Internet.

Researched by **The Block Research**



[The Block](#) is an information services company founded in 2018. Its research arm, [The Block Research](#), analyzes an array of industries including digital assets, fintech, and financial services.

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Section I: Introduction

As decentralized applications (dapps) continue to evolve, the tools needed by developers and users to make effective use of them have become more sophisticated. Trends such as decentralized finance (DeFi), non-fungible tokens (NFTs), decentralized autonomous organizations (DAOs), play-and-earn (P&E) gaming, and the metaverse are bringing new infrastructure requirements to the dapp development space. There is a new awareness and demand to access, operate, and store both on-chain and off-chain data in a decentralized and trustless way.

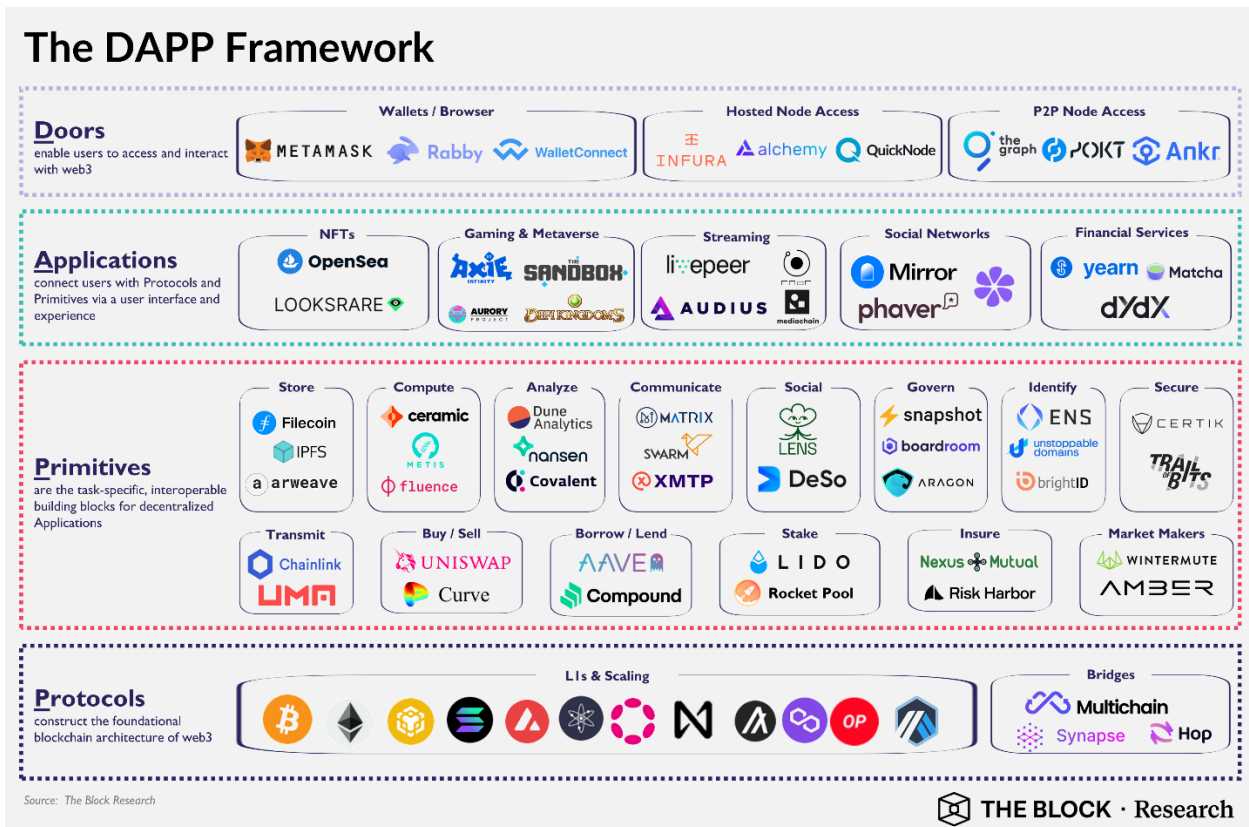
These dapp trends collectively define what “web3” is today. Web3 is an idea born out of the dapps it is composed of. What makes dapps special is their use of blockchains, which allows anyone to participate without monetizing their data. Moreover, blockchains allow something that web2 lost as it became dominated by companies providing services in exchange for your personal data: *decentralization*.

However, while decentralization infrastructure to support next-generation dapps is developing at a rapid clip, there is still an overreliance on centralized infrastructure. At one level or another of the web3 stack, this presents centralization concerns that proponents of web3 eschew in favor of decentralized and permissionless systems born from peer-to-peer (p2p) and cryptographic technologies. It is only through these later technologies that [web3](#) can be built, operated, and owned by its users – the hallmark of decentralization.

Web3 faces a pressing need to implement more decentralized infrastructure to access blockchains and other distributed systems involved in storage, security, and execution. However, developers generally see few advantages and experience many disadvantages in hosting and operating their own node hardware. They would – and probably should – rather focus on building and shipping their product than allocate attentional and financial resources to backend blockchain integration and basic functionality. As such, opportunities for infrastructure providers abound.

Here, we present the doors-applications-primitives-protocols (DAPP) framework of the web3 stack to illustrate where and how dapps can decentralize their infrastructure, and the various opportunities for web3 infrastructure providers to provide access to distributed node networks at each level of the stack. The DAPP framework is broken down into four major layers – starting from top to bottom:

1. **Doors** – Comprises various entry points to web3 activity and their means of access
2. **Applications** – Comprises user-facing interfaces supported by specific combinations of primitives and protocols to build user-facing applications
3. **Primitives** – Comprises task-specific infrastructure that act as building blocks for web3 applications
4. **Protocols** – Comprises the Layer-I (LI) blockchains, scaling solutions, and bridges that set the foundation for all of what we call “web3”



When developing a web3 application, developers face tradeoffs at each level depending on how much decentralization they want to introduce. Options at each level keep as new protocols and companies enter the scene, and the technologies keep improving as they build upon each other. With these developments, so do the infrastructure requirements for an app to be “adequately” decentralized. To keep resources focused on the product, teams may look to the rapidly growing ecosystem of infrastructure providers in the business of “decentralization as a service (DaaS).”

Next, we dive into each layer in detail and focus on prominent projects building at each layer to highlight how web3 operates today, where the limitations and opportunities are, and what the web3 of tomorrow may look like.

Section 2: The Web3 Stack (DAPP)

Protocols



Starting at the bottom, the protocol layer comprises the blockchain architecture on which all web3 applications are built. It includes L1s like [Bitcoin](#), [Ethereum](#), [Solana](#), [Avalanche](#), and [BNB Chain](#); scaling solutions like [Optimism](#), [Arbitrum](#), and [Polygon](#); and cross-chain bridge protocols such as [Synapse](#) and [Multichain](#).

Base layer L1s may have additional protocols built on top of them that expand their capabilities. For example, Bitcoin's [Lightning Network](#) is a Layer-2 (L2) [payment channel network](#) that enables faster and cheaper Bitcoin transactions. Ethereum scaling solutions like [Polygon](#) offload execution from the base Ethereum network to a faster and lower-cost environment, reducing congestion on the main chain. Polygon's general-purpose sidechain has become industry-leading, with [over \\$2B](#) in value deployed over [250+](#) apps in DeFi, gaming, and more.

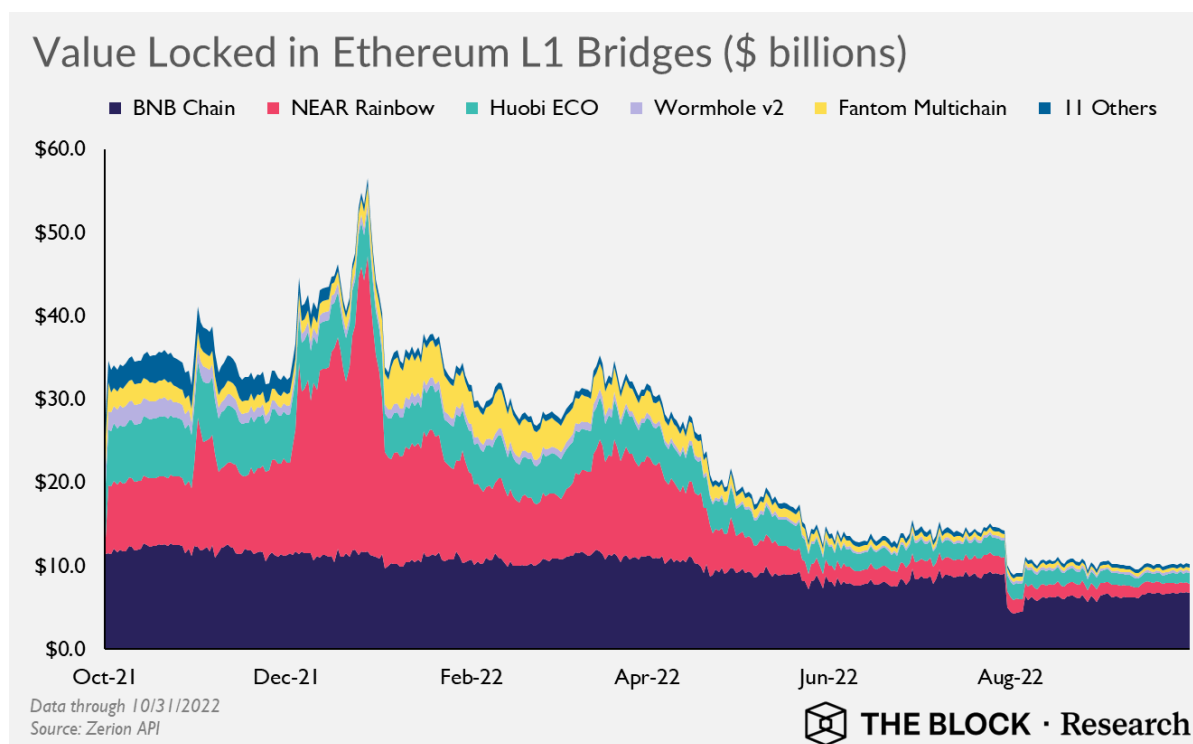
Ethereum also has multiple L2 scaling protocols that utilize [rollups](#) to increase throughput. The general idea behind rollups is processing transactions off chain and then batching, compressing, and delivering the transaction data or some reference to it to the main Ethereum chain – thus, lessening the execution load on the Ethereum network. This technology has seen significant adoption and [development](#) over the past year.

Rollups come in two different flavors – [optimistic rollups](#) and [zero-knowledge \(ZK\) rollups](#). Optimistic rollup protocols like [Optimism](#) and [Arbitrum](#) assume that transaction data sent to the Ethereum network is valid, as the name implies. They depend on a dispute resolution mechanism to validate fraud proofs, detect fraudulent transactions, and dissuade malicious behavior. In contrast, ZK rollups such as [Aztec](#), [StarkNet](#), and [zkSync](#) use validity proofs which necessitate that state changes included in the proof are valid. Instead of relying on game theory to secure the blockchain state, they rely on mathematics and cryptography.

With the rise of many L1, L2, and sidechain networks, there is a growing need for cross-chain communication and interoperability to [bridge value](#) across the composite network space. [Cross-chain bridges](#) aim to serve this purpose by enabling users to move value from one chain to another.

The most popular bridge implementation is the [lock-and-mint design](#). In this design, the original assets are locked in a smart contract on the sending side (e.g., Ethereum), while the receiving network (e.g., Solana) mints a replica of the original token on the other side. Note that this means that Ether bridged to Solana via a lock-and-mint bridge is only a “wrapped” representation of Ether, not Ether itself.

Total value locked (TVL; the dollar value of cross-chain assets stored in bridge smart contracts at a given time) in Ethereum L1 bridges bootstrapping liquidity on Ethereum alone reached over \$55B early this year. Though, that value has since declined along with the value of assets held.



For a detailed overview of the emerging cross-chain interoperability market, see [The Block’s recent interoperability report](#).

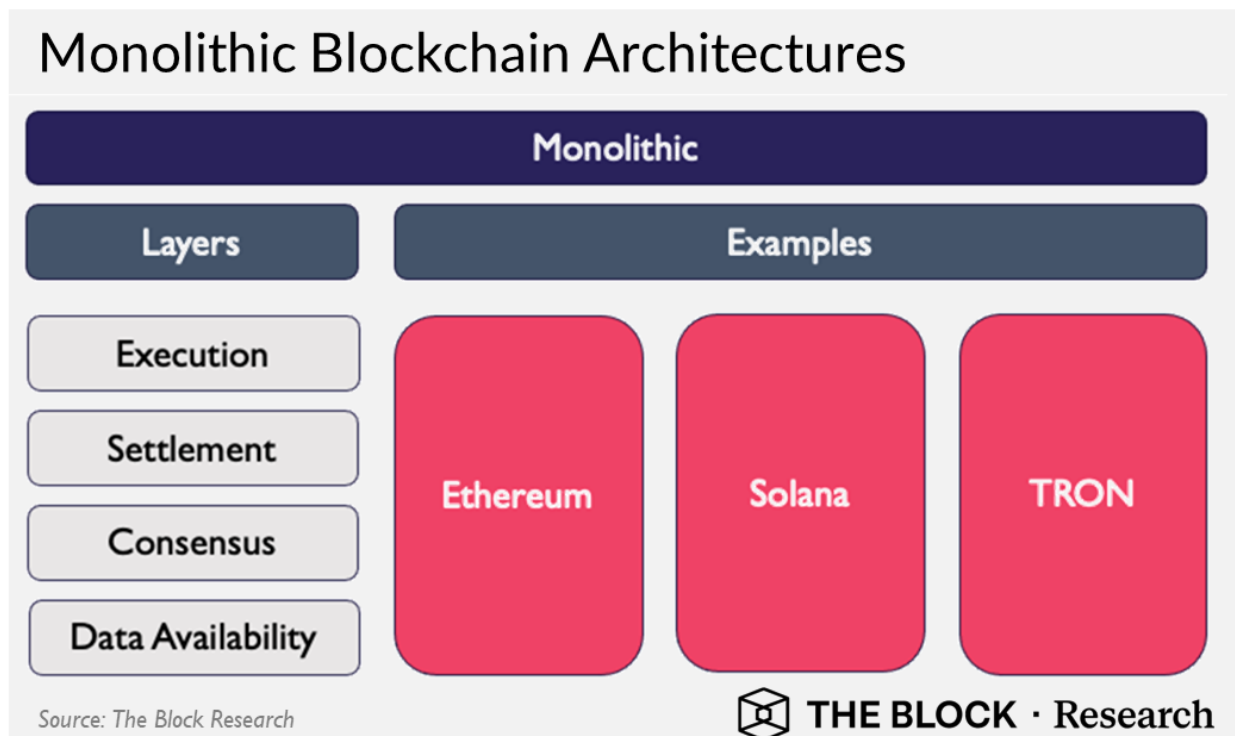
Furthermore, while the interoperability market has shown promise, it’s not without its growing pains. Bridges introduce another layer of [systemic complexity](#) to blockchain architecture and introduce points of centralization where assets are bridged from one chain to another. Both technical vulnerabilities and centralized control over bridged funds have led to several high-profile bridge exploits totaling over [\\$1B cumulatively](#) in the last year alone. Bridges are thus a major area of weakness for blockchain networks that require more reinforcement.

Protocol Layer Interoperability Vs. Modularity

As the protocol layer ecosystem develops, there has been a shift toward interoperability between chains as well as [modularity](#), with different chains delegated different tasks. One of the big remaining questions about the future of web3 is whether the protocol layer will be more about monolithic-and-interoperable blockchains vs. modular-and-stacked blockchains.

Below, we present an example of a monolithic-and-interoperable web3 where monolithic chains like Ethereum, Solana, or TRON handle the four major blockchain operations – execution, settlement, consensus, and data availability:

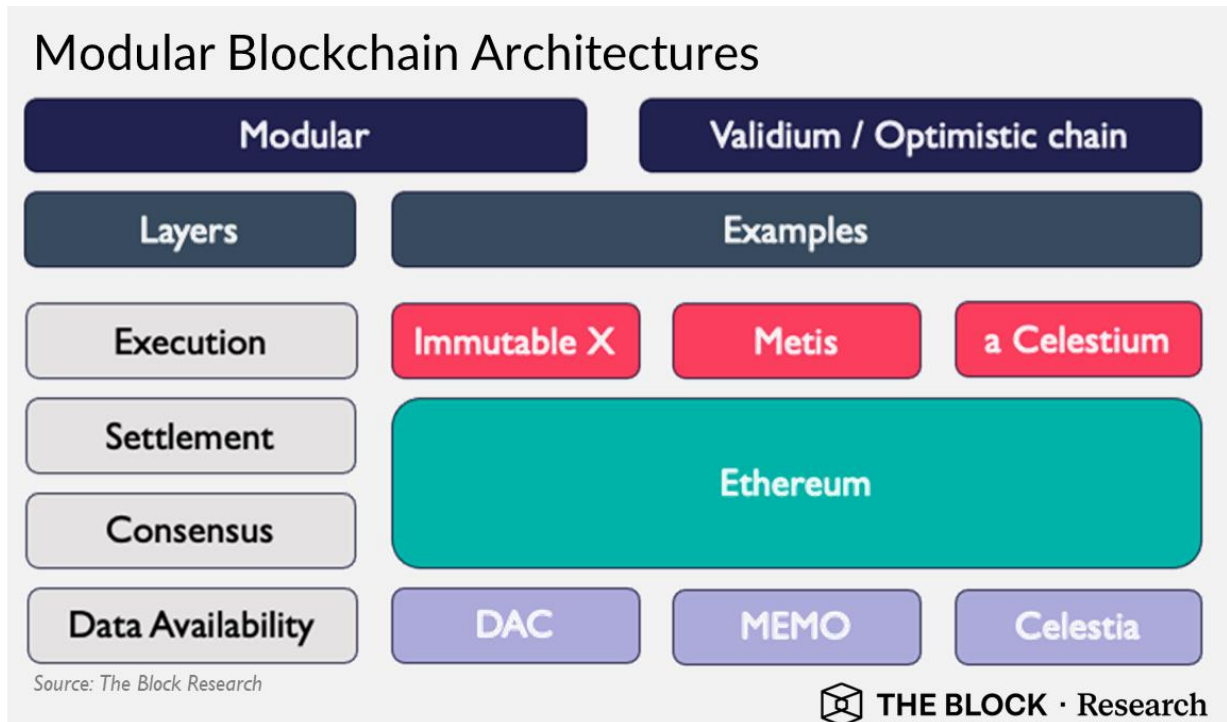
- **Execution** – Execute transactions and produce new state commitments
- **Settlement** – Establish transaction correctness and finality; facilitate cross-execution layer communication
- **Consensus** – Reach agreement on transaction ordering
- **Data Availability** – Attest to availability of transaction data and provide transaction data on demand



Source: [The Block Research](#)

In the monolithic model, chains talk to each other through communication hubs, but a single blockchain protocol handles the four core blockchain functions. Scalability may be achieved via advanced communications protocols (at “[Layer-0](#),” L0) or [sharding](#) (at L1).

Next, we present an example of a modular-and-stacked blockchain system where different protocols handle different components and blockchain operations.



Source: [The Block Research](#)

In the modular model, different chains are responsible for different blockchain functions. For example, Ethereum may be responsible for settlement and consensus while “outsourcing” data availability to chains like [Celestia](#) and execution to chains like [Metis](#).

For infrastructure providers, the monolithic-versus-modular debate is central to predictions about which blockchains will have the most demand in terms of access and usage. For example, in a modular future where the primary data network and execution environment is Celestia and a Celestium, respectively, instead of Ethereum, there would be a greater demand to access Celestia’s blockchain.

Primitives



On top of the protocol layer is the primitives layer, comprising interoperable tools and building blocks that are designed for accomplishing specific tasks. Primitives carry out diverse tasks including transaction, security, storage, computation, analysis, communication, social functions, governance, and identification.

These apps have limited use on their own, but when combined, they act like LEGO blocks that a developer can use to build all sorts of potentially novel and useful user-facing web3 applications. For example, the creation of Chainlink oracles brought about the possibility of lending and borrowing platforms like AAVE and Compound that depend on high-quality, real-world data about asset prices. All three of these protocols are built on audited Ethereum smart contracts. These DeFi platforms allowed crypto investors to leverage their holdings for the first time to generate interest via lending, as well as to borrow collateralized stablecoins instead of selling their holdings and incurring a taxable event.

Next, we describe a market-leading exemplars from each category.

Transactions. These tools are the financial primitives enabling various DeFi functions, including buying/selling, borrowing/lending, staking, insurance, and more. So far, in terms of the [value held in smart contracts](#), the leading financial primitives in the web3 application space center around the first three categories listed here.

- **Buy / Sell.** [Uniswap](#) is a decentralized exchange built on Ethereum that utilizes automated market maker (AMM) technology instead of a traditional order book where individual buy and sell orders are matched. Instead, users pool together two assets and trade them against the pool, with the price determined by the constant product market maker model, $X * Y = K$, where X and Y are the reserve quantities of two tokens and K is the constant product that must be maintained. So, in order to withdraw some amount of Token X, one must deposit a proportional amount of Token Y, to maintain the constant K before fees. From the constant product formula, it follows that the price of X = X / Y . While Uniswap does have a frontend enabling direct user interaction like a standalone app, at its core is simply a series of smart contracts enabling AMM-based digital asset exchange.
- **Borrow / Lend.** [Aave](#) is an open-source and non-custodial platform for users to earn interest on deposits and borrow assets with variable or fixed interest rates. Unlike its main competitor [Compound](#), Aave also supports [flash loans](#) which enable smart contracts of external apps to borrow assets without collateral as long as the liquidity is returned to the protocol within one block transaction.
- **Stake.** [Lido](#) is a liquid staking solution for Ethereum that allows users to stake their tokens without having to lock assets or maintain staking infrastructure. It does this by exchanging staking derivative tokens representing the staked token at a 1:1 ratio while also providing daily rewards in those derivative tokens.
- **Insure.** [Nexus Mutual](#) is an Ethereum-based decentralized insurance protocol that provides various products to protect users from smart contract failures. It aims to be a decentralized alternative to traditional centralized insurance companies.

Security. Crypto and [exploits](#) have gone hand in hand since crypto's inception with no sign of slowing. As such, the web3 stack needs to include a robust security infrastructure. While [Certik](#) is the largest smart contract auditing company in the world – self-reporting audits of over 3,000 projects with market caps totalling [\\$364B](#) – it has lost popularity with its clients overrepresented in the [REKT](#) leaderboard. [Trail of Bits](#), on the other hand, has a leading reputation and doesn't currently appear on the REKT list. These blockchain security firms provide a wide variety of services, including smart contract audits, on-chain monitoring, identity verification, attack simulations, wallet tracing, and more.

Storage. The metadata and hypermedia associated with NFTs (e.g., JPEGs, GIFs) have set a new precedent for [storage requirements](#) that typical blockchains are not built for. Consequently, a new generation of [cooperative storage clouds](#) has emerged to meet the storage requirements of new web3 applications.

[Filecoin](#) and its complementary protocol [IPFS](#) lead this space and utilize *contract-based* storage where buyers and sellers negotiate temporary storage deals in open markets. These protocols power [NFT.Storage](#) and [Web3.Storage](#), popular options for storing the NFT metadata/hypermedia and web3 files, respectively. [Arweave](#), on the other hand, is currently leading the way in decentralized *incentive-based* storage where clients pay a single upfront fee for long-term “permanent” storage.

Compute. [Ceramic Network](#) builds on IPFS and other open storage standards to create a general-purpose protocol for computing and processing data. While persistence networks like Filecoin ensure data availability at addressing layers like IPFS, they lack advanced database-like features such as mutability, version control, access control, and programmable logic that enable the computation and state management capacities. Ceramic aims to provide developers with such advanced database-like functionality to complement their existing blockchain infrastructure and raw data storage solutions.

Analysis. As dapps evolve, it’s important to keep track of data-driven insights and current market trends. With [Dune Analytics](#), anyone can create SQL queries on blockchain data and visualize the results in charts. Charts are assembled into dashboards that provide an overview of a project’s key metrics. Dune users can then explore and share others’ queries and dashboards, creating networked crypto analytics by and for the community.

Communication. [Matrix](#) is an open standard for interoperable, decentralized, real-time-time communication. It supports chat, VOIP, IoT, VR/AR, social, and more applications. Matrix is evolving to support more p2p functionalities, empowering users to have more autonomy and privacy over their data. For example, users can store their data in IPFS by embedding their own servers into their Matrix client. Matrix powers [Element](#), a Matrix-based messaging app.

Social Networking. [Lens Protocol](#) is a composable and decentralized social graph, designed for “plugging in” social networking functions into web3 applications. It defines core aspects of social networking platforms like users, followers, posts, comments, likes, and so forth for social media apps the next layer up to build on top of. The result is an open social graph on top of which various user interfaces and algorithms can be built. The vertices in this graph are users who mint a Lens profile as an interoperable NFT, while the edges are the social primitive functions. Lens is built on Polygon and was spun out of [Aave](#) development.

Governance. [Voting](#) is one of the core functions of organizations and governance in web3. And [Snapshot](#) is the go-to voting tool for web3 apps. Most web3 apps still use a form of coin voting governance – despite its [limitations](#) – for “vote signaling,” the process of querying what a DAO’s community thinks about a given proposal. However, signaling preference using tokens on chain can incur prohibitive gas fees. Snapshot solves this by utilizing IPFS for off-chain, token-based vote signaling. By recording user votes on IPFS, vote data is stored and shared in a decentralized p2p network while avoiding the gas costs associated with on-chain voting.

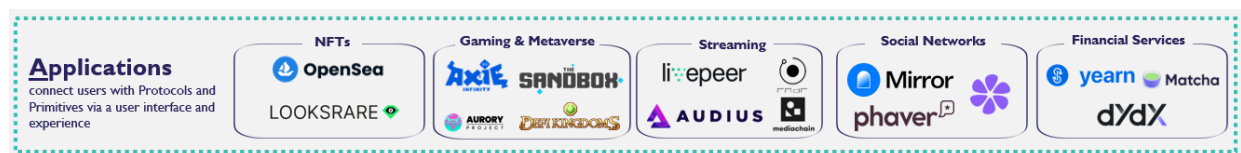
Identification. Identification is a nascent part of web3 with significant potential to fundamentally change how we interact with the web and with each other. Currently, however,

most of what we call “web3” centers around expressing transferable, financialized assets – there is little adoption around identity systems, and the ones in place are limited by transferability. If one’s identity information can be sold and transferred, then it’s hard to weave social relationships of trust.

Despite this limitation, there are promising beginnings of identity systems in web3, such as the [Ethereum Name Service](#) (ENS) – a distributed, open, and extensible naming system based on the Ethereum blockchain. ENS maps human-readable names like ‘johndoe.eth’ to machine-readable identifiers like cryptocurrency addresses, content hashes, and metadata. As all ENS names are ERC721-compliant NFTs, they are non-fungible but still transferable, limiting their use for trusted identification. To build networks of trust, researchers, including Ethereum co-founder Vitalik Buterin have proposed [soulbound tokens](#) (SBTs) – non-transferrable attestations of identity information.

The kinds of apps that gain the most traction in web3 will determine which primitives get the most usage. For example, if NFTs are linked to larger and larger hypermedia, there will likely be increased demand to access and use the major decentralized storage networks like Filecoin and IPFS. If web3 social networking apps are adopted by billions of users like current web2 social networking apps, infrastructure providers will need to meet a massive demand to access the blockchain protocol powering the social primitive tools – for example, the Polygon network in the case of Lens Protocol.

Applications



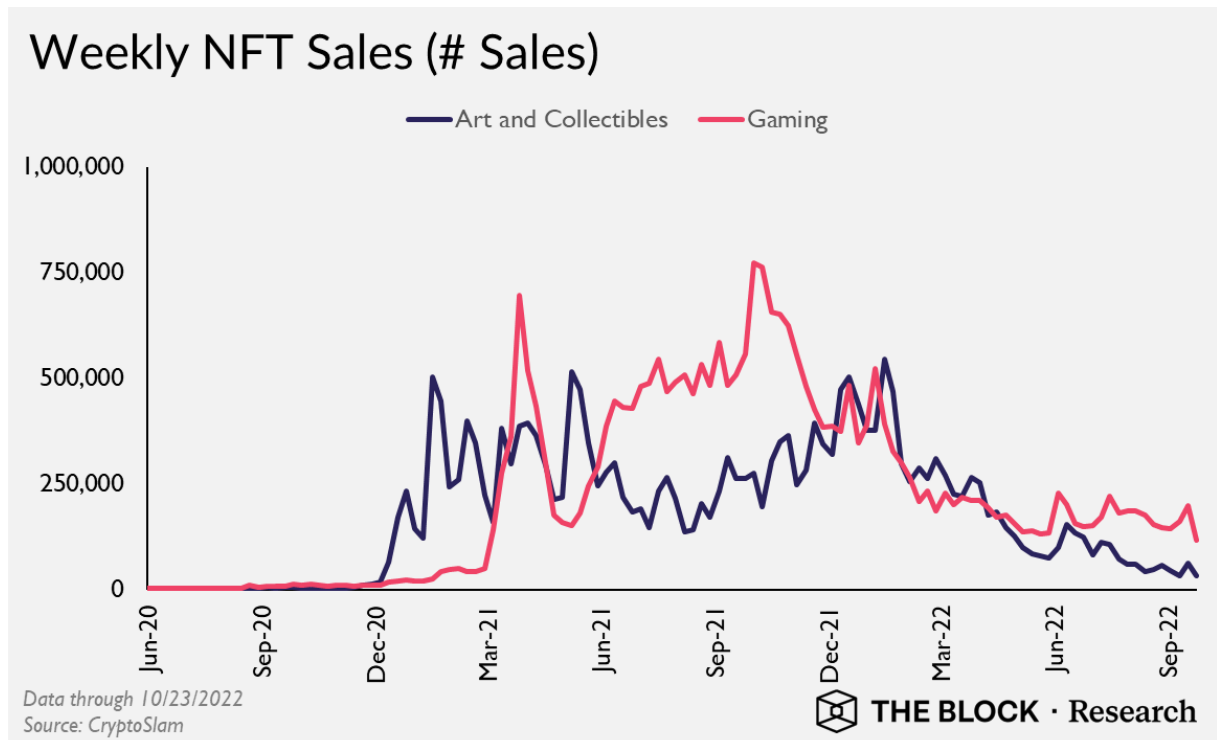
At the next level up is the applications layer. Here, protocol and infrastructure layers combine into user-facing applications that prioritize user experience. The web3 application space is already diverse and expanding, including applications specific to NFTs, gaming, the metaverse, streaming, content, social media, financial services, and more. Next, we will focus on exemplars from each of these categories and how these use cases point to opportunities for infrastructure providers.

Gaming & GameFi

GameFi is a portmanteau of gaming and finance that has rapidly become one of the most talked about application sectors of web3. While the mechanics and economics of individual GameFi games vary, they do share some common features including (a) the use of a blockchain, (b) a play-to-earn (P2E) or P&E business model; (b) asset ownership; and (d) DeFi elements such as yield farming, liquidity mining, and staking.

GameFi made headlines in 2021 as the adoption of blockchain into gaming progressed rapidly, primarily through the introduction of in-game assets like NFTs and game tokens. These in-game rewards exhibit real utility for gamers and can be traded in free and open marketplaces, which has led weekly NFT sales to flip from being dominated by arts and collectibles to gaming. As such, infrastructure providers should keep apprised of which games are gaining traction, what

chains the games need to access and use, and the NFT marketplaces where the in-game assets are being transacted.



[Axie Infinity](#), a turn-based strategy game, was one of the early pioneers of GameFi along with the play-to-earn (P2E) gaming model. P2E is in many ways the opposite of traditional pay-to-play gaming models, where gamers pay before playing, receive no financial returns, and their in-game assets are controlled and held by the gaming company. In contrast, in the P2E model, gamers can play without incurring upfront costs (e.g., [Axie Infinity Origin](#)) and have ownership and control over their in-game assets, which they can choose to monetize both inside and outside of the game.

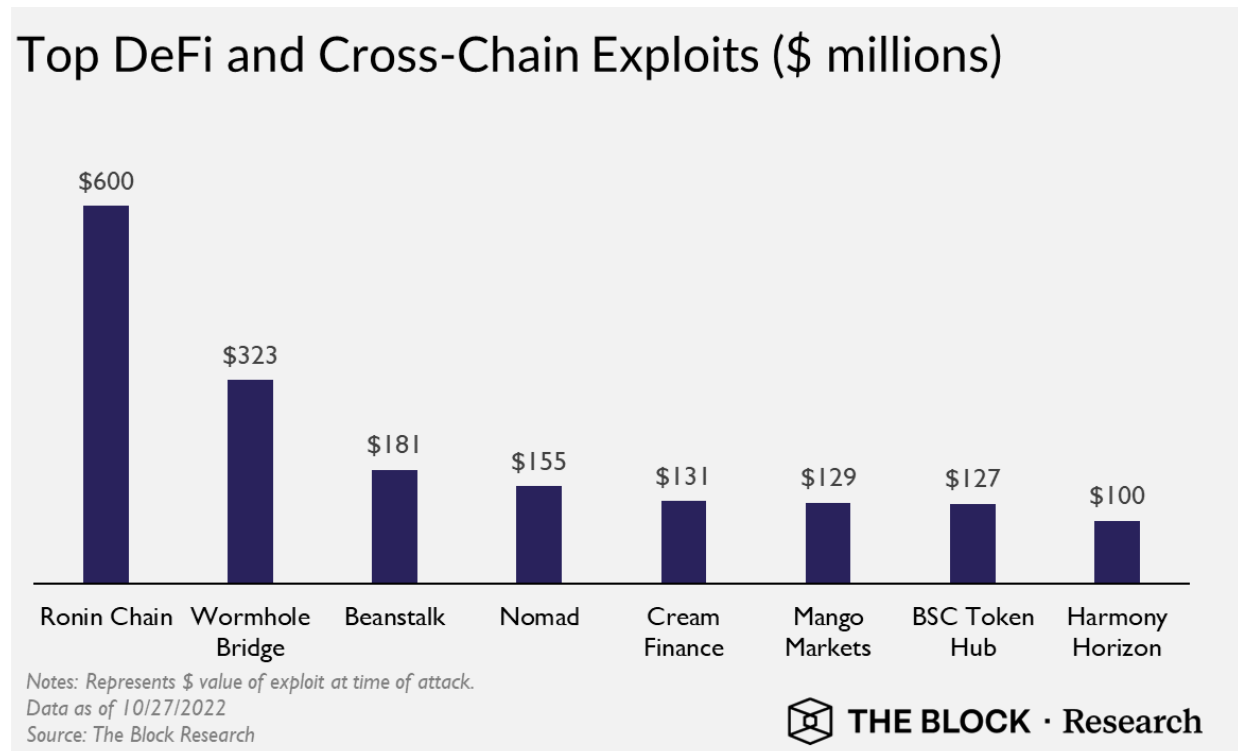
However, the P2E gaming model is not without its critics. Many criticize these games as unsustainable [Ponzi](#) schemes, where the profitability of the game centers around new players joining and earlier players cashing out at the expense of those new players. To make such games sustainable (as well as ethical), gamers and developers are [advocating](#) a move toward “play-and-earn” or P&E gaming, where the reward of playing is not only profit but entertainment too. Providing real value to users beyond the hope of profit is one step toward solving the problem of retaining players.

While Axie Infinity saw wild success in 2021 – with its native utility token AXS nearly reaching a [\\$10B](#) market cap (MC) – 2022 has been a year full of setbacks for the GameFi giant. Daily active users (in-game battlers) [dropped](#) by over 90% from an all-time high of over 2.7M. Beyond questionable tokenomics and the question of whether the game is fun, Axie Infinity was at the center of the [Ronin bridge exploit](#) in March 2022 – arguably the worst exploit in DeFi history, purportedly orchestrated by North Korean [Lazarus](#) hackers.

The Ronin bridge is used to bridge Ethereum-based tokens and NFTs used in Axie Infinity to the Ronin Chain, an Ethereum sidechain built by [Sky Mavis](#) specifically to make it faster and

cheaper to play Axie Infinity. The Ronin Chain can be used to breed, collect, and trade in-game and one-of-a-kind creatures known as Axies, each represented by its own NFT, as well as transact any NFTs of other games on the same chain.

But as aforementioned, bridges are currently one of the main weaknesses in blockchain networks. There have been several high-profile bridge attacks in 2022 alone. In the case of Ronin, even if the bridge smart contract code itself was secure, it faced several [issues](#) ranging from a lack of decentralization to excessive permissions to a lack of monitoring. In effect, hundreds of millions of dollars were being handled by a few controlling entities, and human error and heedless decision making led to the historic exploit.



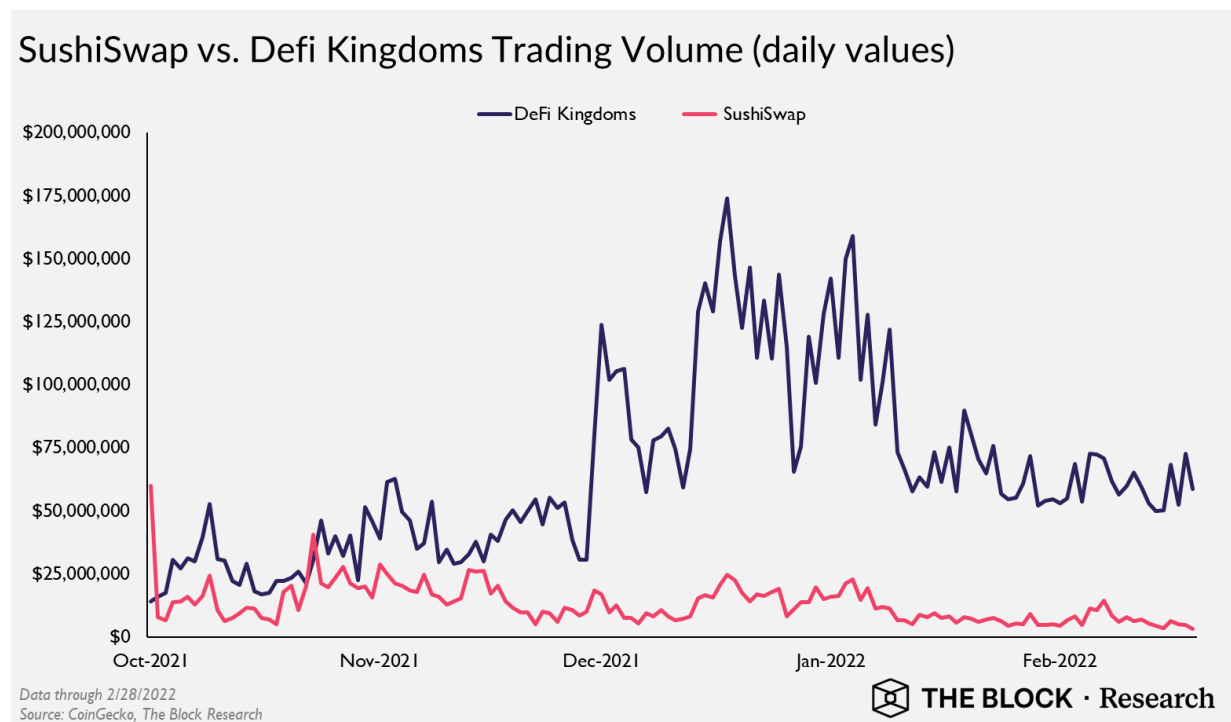
In brief, hackers stole ~\$600 million from the bridge contract by taking control of 5 of 9 validator keys needed to control it. In reality, they only needed to get control of 2 validating entities (4 Sky Mavis validator keys + 1 Axie DAO validator key). To make matters worse, these validating entities were not actually independent, as Axie DAO had allowed Sky Mavis to sign transactions on their behalf several months earlier.

This case highlights the need for developers to be particularly careful when deciding whether to use a bridge and how to implement that bridge. Security should never be undervalued, and the appropriate primitives should be utilized for securing user and investor funds. For example, games like Axie Infinity could employ a [Gnosis Safe](#) – a multisig account security primitive – requiring large-N independent validation to control any bridge funds to prevent (yet another) devastating bridge hack. The number of Safes created shows a steady [uptrend](#), with implementations on Gnosis Chain and other popular blockchains, including Ethereum, Polygon, BNB Smart Chain, Arbitrum, and Optimism.

[DeFi Kingdoms](#) is a browser-based game that gamifies DeFi activities like providing liquidity, yield farming, and protocol staking in 2D pixel imagery. It is built on both [Harmony](#) and its own

DFK chain (an Avalanche [subnet](#)). The expansion of the game to the Avalanche subnet allows DeFi Kingdoms to open their virtual kingdoms to third-party protocols that can set up their business within the DeFi Kingdoms ecosystem. Such blockchain-based interoperability and composability bring the potential to make content richer, user experience better, and appeal broader for DeFi Kingdoms and other blockchain-based games. It also sets a new precedent for the games-as-a-service (GaaS) model in that DeFi Kingdoms not only can sell subscriptions and in-game items, but also profit from business partnerships.

Beyond the computational demands of gaming, trading volumes in games like DeFi kingdoms suggest that the infrastructure requirements of GameFi may soon surpass that of DeFi. Below, we can see that DeFi kingdoms saw 19x the trading volume of “bluechip” DeFi protocol Sushiswap earlier this year.



Source: [The Block Research](#), CoinGecko

[Aurory](#). Aurory is Solana’s first role-playing game (RPG) backed by Alameda Research, CMS Holdings, Animoca Brands, Jump Capital, Serum, and the Solana Foundation. Like Axie Infinity, it is a P2E game where players breed pets called ‘Nefties’ that can be sold or transferred as NFTs. Unlike Axie Infinity, it is built on the Solana blockchain instead of its own chain.

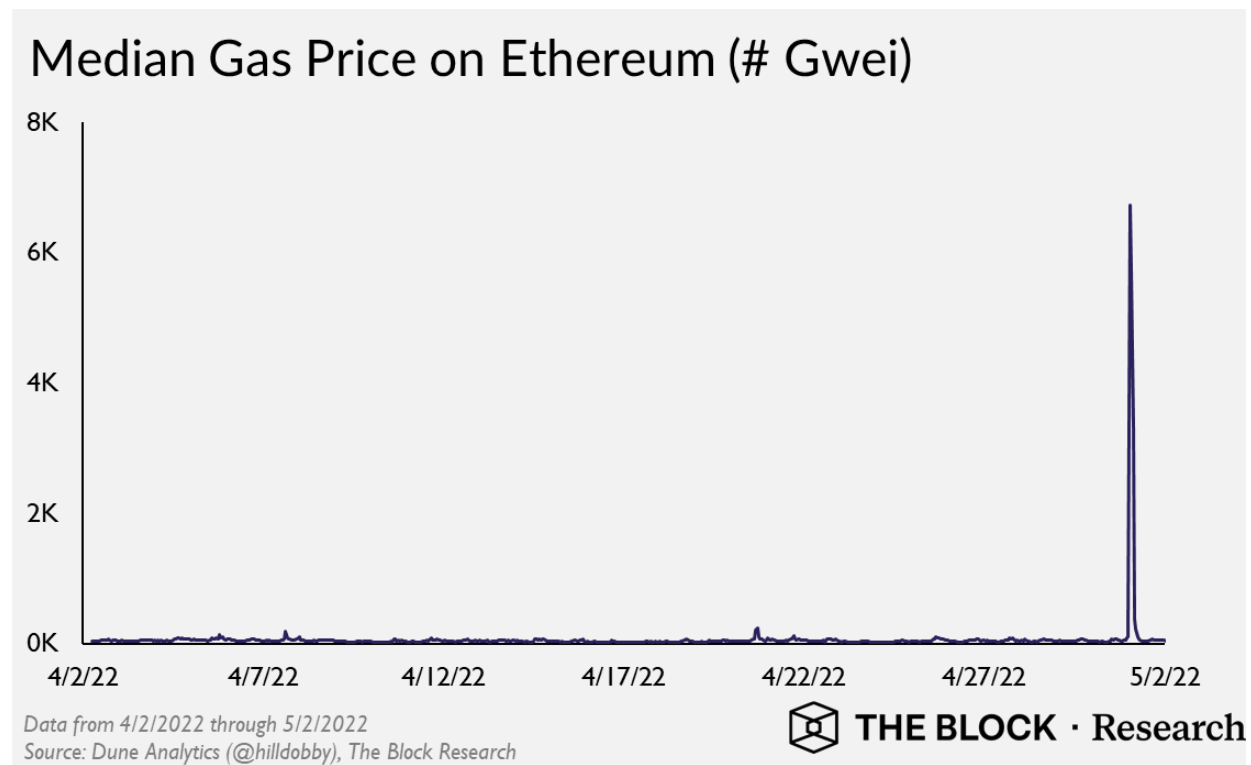
Although this makes the game Solana-centric, the benefit to this strategy is that Aurory developers can focus on building the game instead of spending resources developing the underlying blockchain infrastructure while benefiting from Solana’s low transaction costs, near-instant transaction speeds, and greater decentralization relative to Ronin. For low-friction access to the Solana network, they can forgo setting up their own Solana node and instead connect via Solana nodes hosted by Alchemy, Quicknode, Chainstack, or many other infrastructure providers.

Aurory’s use of the Solana chain is an example of how future web3 developers face critical choices when combining protocols and primitives in their designs, as each choice at each level of the web3 stack presents unique ramifications, such as on bandwidth allocated to the project and options regarding infrastructure providers.

Metaverse. First mentioned in the novel [Snow Crash](#), the metaverse transcends beyond digital asset ownership, P&E, and GameFi. The ‘metaverse’ is a developing concept about an online 3D universe comprising various interconnected virtual spaces. Much like in our physical world, people can meet, socialize, work, and game together in the persistent virtual worlds of the metaverse.

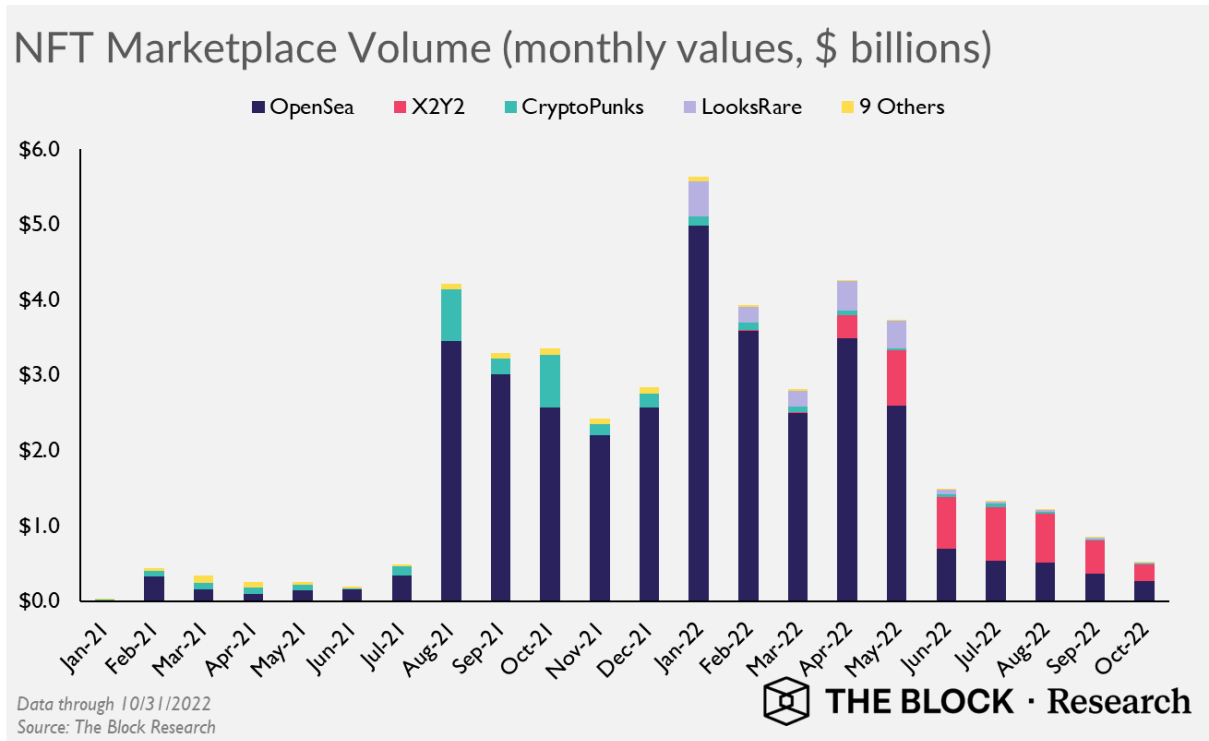
Cryptocurrencies and other digital assets lend themselves to opening new capacities in the metaverse, such as digital economies and access control. Utility tokens like [SAND](#) in [The Sandbox](#) drive/underpin its metaverse economy and can be earned through gameplay and spent to play the game, customize avatars, buy land, trade assets, and vote in governance. NFTs like the [Otherside](#) NFTs providing claims to land (“Otherdeeds”) in the Otherside metaverse have raised over [\\$300M](#) for the game’s development while providing owners with the right to sell and rent their digital land.

The Ethereum-based Otherdeed mint kickstarted a gas war among Ethereum users trying to outbid each other, driving gas prices to 8,000 GWEI. Aggregate transaction fees associated with the sale soared to ~\$172M, with individual buyers paying between \$4-10K to mint an Otherdeed. This case highlights the need for alternative minting methods, [bot-eliminating selection criteria](#), and Ethereum scaling infrastructure for any high-demand NFT sale in the future. With NFTs still in an early stage of adoption, future NFT projects may seek out scaling infrastructure solutions with increasing frequency.



Source: [The Block Research](#); Dune Analytics (@hilldobby)

NFTs. Buying and selling NFTs typically takes place on platforms like [OpenSea](#) and [LooksRare](#). While OpenSea remains the market leader, a new cohort of more decentralized NFT marketplaces like LooksRare has emerged to capitalize on growing discontent with [centralization concerns](#) over OpenSea.



For instance, OpenSea has been criticized for frequent server downtimes, a major [data breach](#), excessive centralization in handling supposedly fraudulent transactions, arbitrarily blocking accounts, [front running their own users](#), and pocketing all generated trading fees. LooksRare, in contrast, prioritizes community-centricity and hands back all of its trading fees to its community of [LOOKS](#) token holders. In addition, LOOKS is a governance token, enabling its platform to be overseen by a DAO while OpenSea is governed by a centralized company.

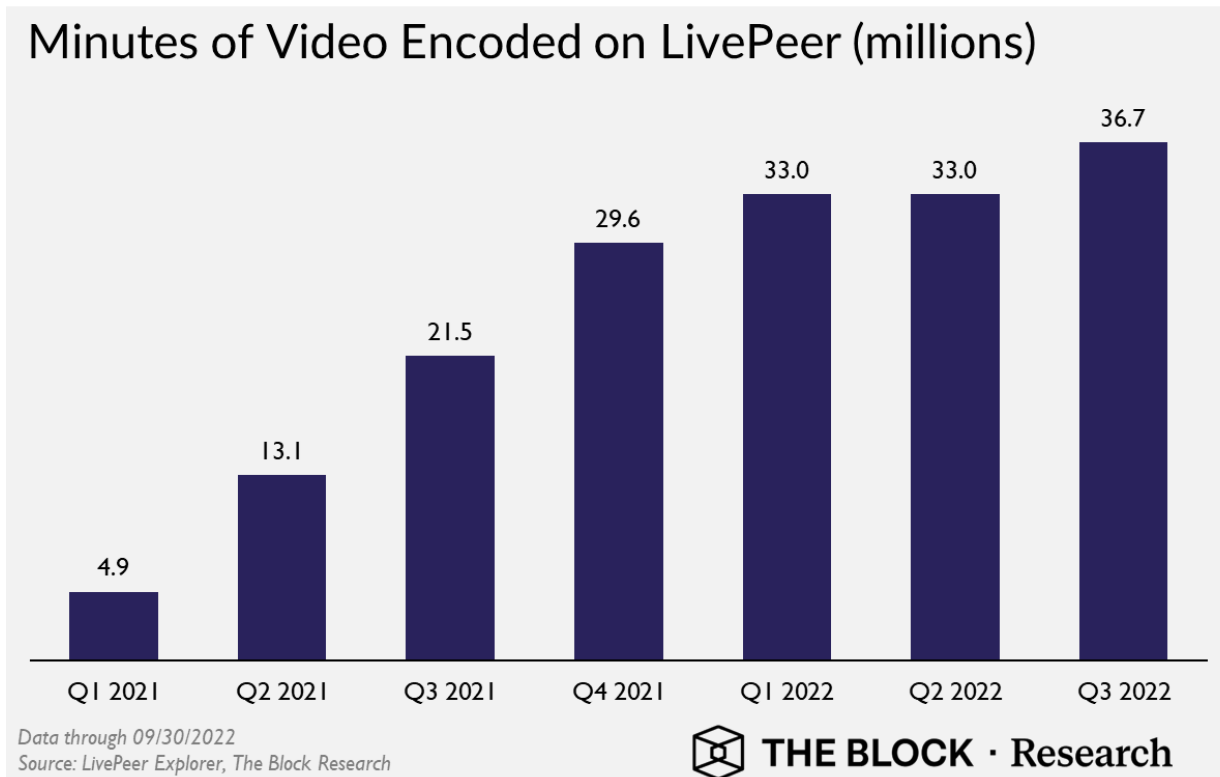
Looking ahead, these trends highlight the need for improvements in site uptimes, security, and censorship resistance. Decentralized storage protocols like Filecoin boast virtually [100% uptimes](#) (so far) while offering the security of decentralization. Utilizing governance tokens can give users a vested interest in NFT marketplaces and put the future of the product in the hands of the community, supporting web3 ideals including censorship resistance and permissionless access.

Decentralized Streaming / Compute. Beyond finance, many expect the next major category for crypto applications to be in decentralizing the compute stack. There are reasons to believe that decentralized compute could see explosive growth in the coming years, as we saw in DeFi in the previous years. For reference, DeFi grew from less than \$1B to over \$250B in value locked in less than two years (May 2020 – Dec 2021).

Furthermore, while some are saying the GPU supply shortage [is over](#), demand is still up since pre-COVID times, and there is a rising demand for GPU-intensive consumer applications like video streaming, and AR/VR, setting the stage for decentralized compute businesses to fill a

potentially lucrative demand gap. Even if GPUs are not useful anymore on the Ethereum network following [The Merge](#) – which transitioned Ethereum away from GPU mining – they might be profitably repurposed in a new wave of decentralized compute networks.

Projects like LivePeer (decentralized video streaming), Audius (decentralized music streaming), RNDR (decentralized GPU rendering), and Mediachain (decentralized data co-op) are leading the development of this emerging sphere of web3. For example, LivePeer has seen relatively [steady growth](#) in the usage of its video transcoding service – even in the bear market of 2022, LivePeer network usage increased by 12% from Q2 to Q3 2022. Comparing Q1 2021 to Q1 2022, YOY network growth reached nearly 600%.



There are at least three major arguments for decentralized compute:

- 1. Censorship Resistance** – A fully decentralized compute stack, including both file storage and GPU image rendering, does not have single points of control, such as centralized hosting providers that can arbitrarily shut down Internet services.
- 2. Economic Opportunity** – Crypto networks can bring more resources (e.g., storage, GPUs) online by tapping into latent supply through p2p economic models like AirBNB or Uber.
- 3. Open Composability** – The idea of reusable applications and a single or few global APIs enables mashups and interoperability that web2 has eschewed. But, open-source code and sharing code freely and publicly has proven effective in making software development [faster and cheaper](#). Rapid innovation is supported by the capacity for anyone able to build applications on top of decentralized compute protocols and improve the core infrastructure.

That said, there is a question about costs, as trust-minimization in decentralization incurs additional overhead costs. For example, reliable storage requires paying for multiple backups, service providers have to post collateral to discourage bad behavior, and scaling transaction throughput while maintaining security and decentralization is [difficult](#). The use of open markets of service providers and network effects (e.g., aggregating latent GPU capacity) can help drive overhead costs down.

[LivePeer](#) has been able to maintain attractive economics while being trust-minimized by focusing on transcoding live and on-demand video. Transcoding – the process of taking a raw video file and reformatting it for different viewing formats and [bitrates](#) – uses a [different and mostly idle part of GPUs](#). And currently, there are millions of GPUs already mining that could earn extra revenue from transcoding for LivePeer as well. Open market dynamics help drive LivePeer transcoding fees down to as low as a [sixth of the cost](#) of AWS transcoder prices.

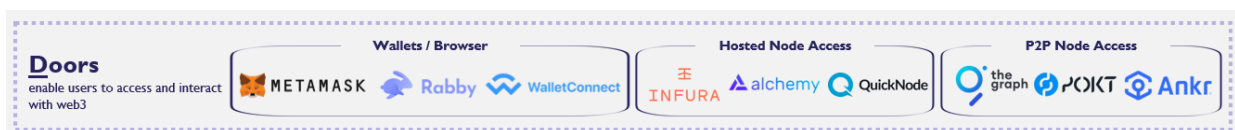
As LivePeer and other protocols employ latent GPUs scale, it'll be important to track responsiveness and reliability. While LivePeer has seen [steady growth](#), the hours transcoded on its network (roughly ~2M annually based on Q1 2022 estimates) is still a tiny fraction of the [500+ billion hours](#) of video being transcoded and streamed annually around the world. To increase throughput, LivePeer is working on a [fast verification procedure](#) to increase the efficiency of transcoding verification and dispute resolution over faulty transcoding. Such protocol upgrades and new infrastructure are needed to support a worldwide scale, where apps using LivePeer on the backend comprise potentially billions of users.

Social. This emerging area includes [Mirror](#), a decentralized blogging platform that utilizes Arweave infrastructure to store data. All blog posts are available to access permanently on Arweave and are fully controlled by the author. Their site, [Mirror.xyz](#), is one way to view this data in an organized way. So, if [Mirror.xyz](#) censors content or inserts paywalls, pop-ups, and so forth, users can simply switch to another client for viewing Mirror posts. Mirror also utilizes Ethereum infrastructure, allowing authors to get paid in crypto, often to their ENS domain.

[Lenster](#) is a fully open-source social media app built with the Lens Protocol social primitives. Users who have minted a Lens profile NFT can comment, like, share (“mirror”), and curate (“collect”) each other’s posts on the Polygon chain that Lens Protocol is built on.

Financial Services. [Yearn](#) offers a yield aggregator that channels users’ funds across DeFi protocols, including Compound, Aave, and Curve, to optimize returns. For trading, [Matcha](#) utilizes financial primitives, including Uniswap as well as many other decentralized exchanges across chains like BNB chain, Avalanche, Celo, Fantom, and more. With smart order routing powered by [Ox](#), Matcha finds the best prices across exchanges and merges them into one trade, helping users save time and reduce slippage costs.

Doors



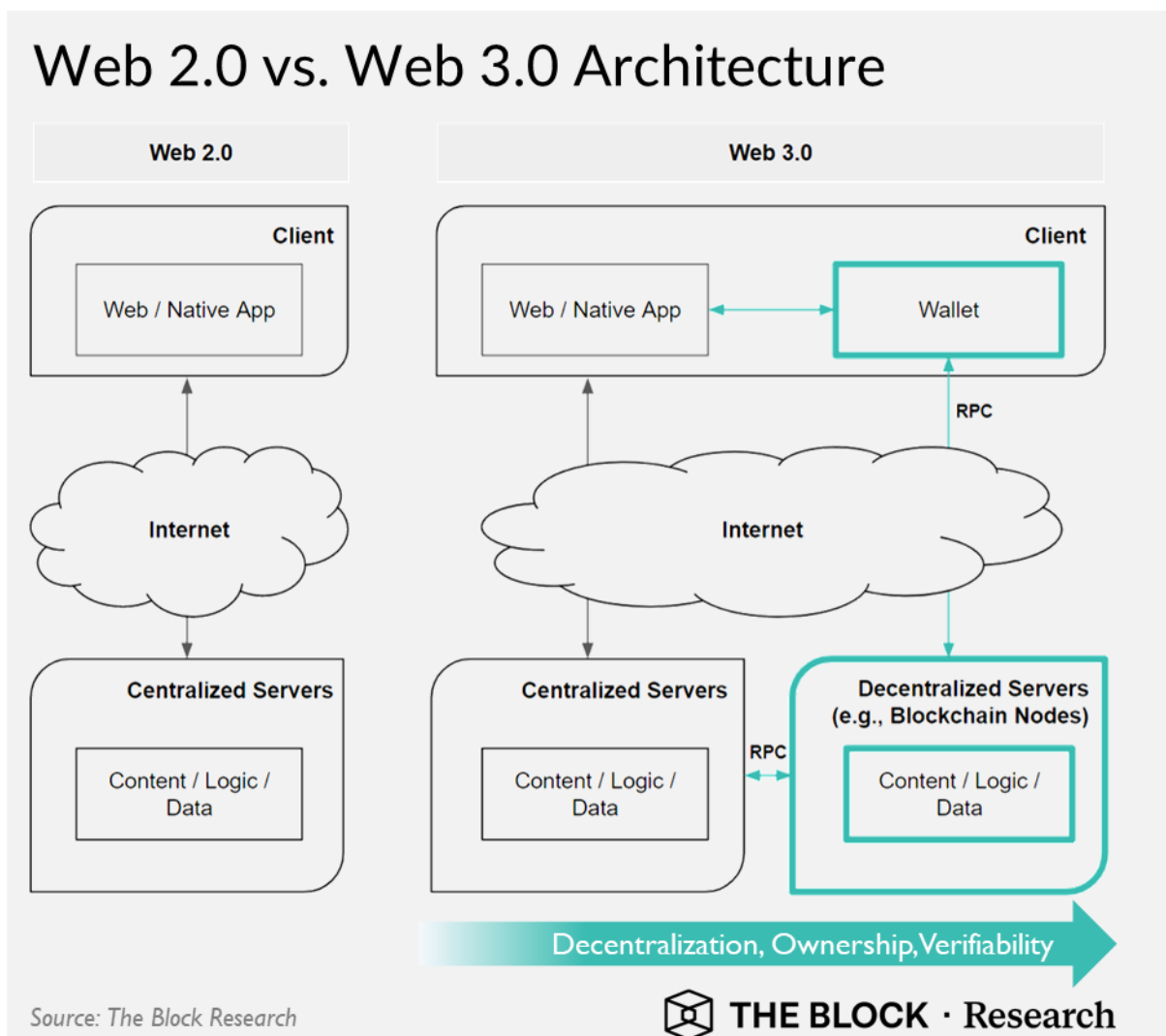
At the top of the web3 stack is the doors layer – comprising the “connect and ingest” component of the web3 stack. These are the applications, services, and infrastructure that

enable access to web3 activities. Without this layer of the web3 stack, there would be no way to engage with any of the aforementioned applications nor the primitives and protocols that they are built from.

Whether it's a popular protocol like Bitcoin or Ethereum, or a highly scalable blockchain like Solana, a dapp must first connect to the respective network to access and use data from that blockchain. There are three ways to [connect](#) to any blockchain network:

- **Via a self-hosted node** – The user or dapp connects to the blockchain network through its own full node. This option requires understanding client software, client settings, and hardware environments (e.g., local or cloud). It also puts maintenance demands in the hands of the user or dapp. Although initial hardware costs for a self-hosted proof-of-stake (PoS) node (e.g., consumer laptop) may be significantly lower than for a proof-of-work (PoW) node (e.g., ASIC miner), there are few benefits and many disadvantages for a developer to go this route. The [long-term costs](#) of operating and managing the node may be significant, and then there is the potential for lost revenue (and social capital) in the event of any downtime.
- **Via a hosted node network** – A third party provides blockchain infrastructure and the know-how regarding access optimizations and security. This option offloads blockchain maintenance to the third party and can benefit from better responsiveness and reliability, but still runs the risk of service failures by that third party (see section “Degree of Decentralization & Keeping Doors Open” below). One of the major advantages here is that centralized decision making by the hosting company can bring about faster shipping of advanced prototyping and development tools.
- **Via a p2p node network** – The newest of the three options, there are now decentralized blockchain infrastructure providers like [Pocket Network](#) and [Ankr](#) that incentivize individuals to run full nodes for multiple blockchains. In this way, they can grow large p2p node infrastructure that benefits from increased decentralization and potentially higher reliability with lower costs, while also offering the convenience and simplicity of hosted node networks.

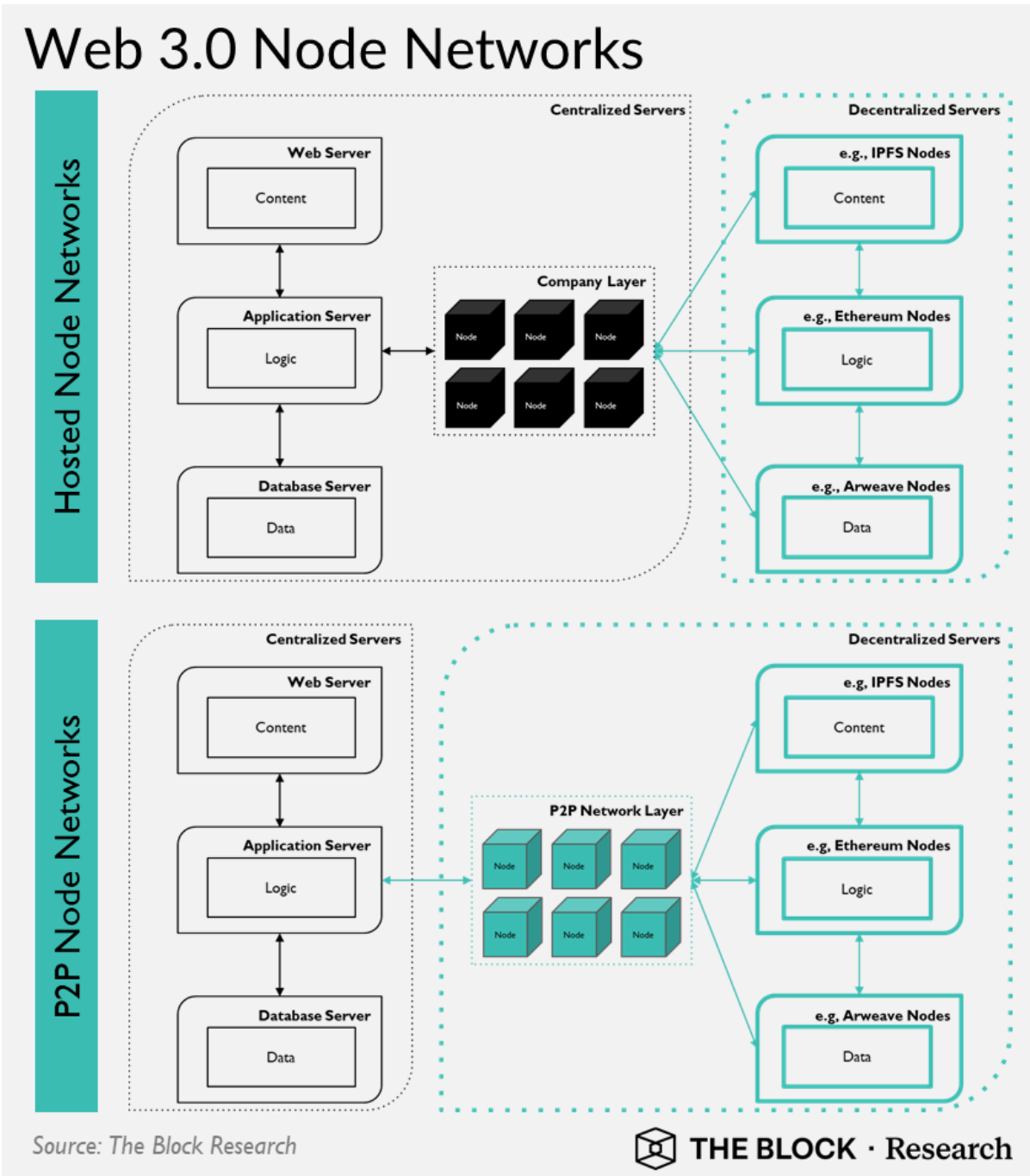
To access hosted and p2p node networks, one must use remote procedure calls (RPCs) – a communications protocol in distributed computing that enables a procedure call in one place to run in a different place as if it were a local procedure call. RPCs are crucial for web3 activity as they enable wallets and applications to talk with blockchains, [bridging](#) web3 architecture with web2 architecture.



For example, the popular wallet [MetaMask](#) acts as a doorway to web3 by providing a simple way to access the Ethereum network. It does this via RPC calls to an [Infura](#)-hosted node by default. Because [ConsenSys](#) is the third-party company that owns and operates all Infura nodes, the company could choose to censor this access route to web3.

However, MetaMask can be set up with a custom EVM-compatible network RPC, so if ConsenSys were to force access permissions, for example, the user could choose a relatively decentralized and permissionless network RPC like Pocket Network or Ankr. It simply involves changing the network RPC URL to target the new address space. (However, [note](#) that both Pocket Network's and Ankr's off-chain distributor mechanisms are currently centrally operated.)

To see a comparison between hosted networks and p2p node networks, see the figure below. It illustrates how the main difference between these two access configurations is about who owns and operates the blockchain nodes. That is, for hosted node networks, a single company typically controls these nodes, whereas in a p2p node network, the nodes are controlled by a distributed p2p network of smaller servers.



After establishing a connection, one can start engaging with all sorts of web3 applications, including DeFi, NFTs, web3 games, and more. If those applications require high bandwidth and frequent interactions with the underlying blockchain (e.g., a high-activity liquid DEX like dYdX or high-volume trading in a game like Axie Infinity), it's important that the infrastructure connecting wallets and application servers to blockchains is fast and reliable.

For example, in GameFi, there are both fully on-chain games like Dark Forest (all app logic kept on chain), where every action triggers a blockchain transaction and off-chain games with native exchanges for trading in-game assets like Axie Infinity and Aurory. The on-chain throughput requirements in these web-scale apps can be extremely large, so it is necessary for the access infrastructure handling the API request and responses to be scalable, responsive, and secure.

Furthermore, as games like Axie Infinity or DeFi Kingdoms require the player to first connect to a compatible wallet like MetaMask, we can expect that as the GameFi trend picks up speed, so will the adoption of these wallets and the usage of the access infrastructure they are connected to. It is no wonder, then, that the ecosystem of infrastructure providers has been proliferating to capitalize on this new web3 trend and the opportunities it brings (see “Section 3: Access by the Numbers” for more info).

Degrees of Decentralization & Keeping Doors Open

The trustless, censorship-resistant, and permissionless nature of the most popular blockchains (e.g., Bitcoin and Ethereum) arises from their *degree of decentralization*. Decentralization is a spectrum that involves many tradeoffs because blockchain engineering limitations result in the “[blockchain trilemma](#)” – a term coined by Ethereum co-founder, Vitalik Buterin. The blockchain trilemma describes a simple relationship between three desired properties of a blockchain system – decentralization, scalability, and security – wherein a typical blockchain must choose two at the expense of the third. So, for example, high-throughput blockchains that rely on delegated PoS for consensus verification may be scalable and secure, but at the expense of decentralization as the delegated nodes are few (often 10-100), with users needing to trust the majority of these nodes

Decentralization is difficult, and the most “web3” of blockchain ideals as scalability and security are ideals of web2 apps as well. Developers still focus on these latter two properties – perhaps due to a status quo bias – and the resulting track record for new blockchains reaching “adequate” decentralization is quite poor. While some new entrants in the market propose to innovate their way out of this trilemma, many others still simply test the limits of what minimal level of decentralization the market will accept while focusing on achieving scalability and minimizing transaction costs.

On the DeFi side, the controversial concept of [centralized-DeFi](#) (CeDeFi) has gained popularity. And, there is also the issue of popular staking providers like Lido acquiring a concerning amount of power in its [dominance](#) of the ETH2 staking pool. Critics, including Ethereum Foundation researcher Danny Ryan, have argued that Lido’s staking dominance poses a security risk to Ethereum in its transition from PoW to PoS. For example, as of writing, [~28%](#) of the total ETH staked in Ethereum’s PoS consensus is staked through one protocol: Lido. Accordingly, one could argue that Lido poses a centralization risk as collusion within the Lido DAO could result in one entity being mission-critical to the entire Ethereum network. It would only take one staking pool in addition to the Lido staking pool to gain control over [33%](#) of the total staked ETH – enough to halt the network.

Beyond the potential for such centralization at the protocol level, there may be issues related to the centralization of the hardware underpinning blockchain systems. Single entities that dominate the critical infrastructure of an ecosystem of dapps also represent centralization chokepoints and single points of failure. With nearly [~\\$70 billion](#) locked in DeFi across the most dominant chains as of writing, hardware centralization should be as important a consideration as protocol centralization.

We have only seen glimpses of the potentially disastrous effects of hardware infrastructure centralization, where major dapps have gone offline due to outages from cloud service providers. For example, the decentralized exchange dYdX [stopped working](#) when some parts of its exchange infrastructure went down due to an AWS outage, preventing them from

canceling potentially erroneous transactions. Similarly, Infura faced a [major outage](#) that caused delays in price feeds in late 2020, leading Binance and other exchanges to temporarily halt ETH withdrawals.

Nodes hosted by blockchain tooling services are thought to make up an appreciable percentage of all nodes in some networks. For example, a recent [study](#) concluded that three cloud providers (AWS, Hetzner, and OVH) represent nearly two-thirds of hosted nodes for Ethereum and Solana. Also, according to 2018 [estimates](#), Infura operated 5-10% of all Ethereum full nodes, servicing some 13 billion queries per day and supporting ~70% of the top Ethereum dapps.

This demonstrates the need for many more infrastructure providers in the web3 space to reach sufficient decentralization, including both hosted and p2p node networks, as well as distributed computing across them. In the ideal case, all vital functions of a dapp would be supported by distributed infrastructure that is unlikely to stop working all at once for any reason, be it technical failure, censorship, or service closure. In the event of an attack or technical breakdown, dapps would have emergency backup preparations in place to immediately remedy any loss of vital functions.

With regards to censorship resistance, it is also ideal for node infrastructure to be sufficiently decentralized to maintain a permissionless web3 ecosystem. The RPC layer is particularly at risk of censorship, and therefore, dapps should be built out in a way that protects the RPC layer from any single entity controlling it.

Section 3: Access by the Numbers

The most popular option so far for interfacing with blockchains is via hosted node networks. There is now a thriving ecosystem of such infrastructure providers that target blockchain-related businesses to help build out their blockchain-enabled products/services. These companies operate managed platforms letting customers easily interface with blockchain network(s). The primary value proposition for the customer is that they can focus on building and shipping their product, rather than allocating resources to backend blockchain integration and basic functionality.

A number of these web3 infrastructure providers have raised significant capital in recent years:

Firm / Protocol	Network Type	Founded	HQ	Total Funding (millions)	Last Funding Type	# of Investors	Employee Count	Website Visits (Monthly)
Alchemy	Hosted	2017	USA	\$563.9	Series C	52	251-500	456,100
Blockdaemon	Hosted	2017	USA	\$431.3	Series C	45	101-250	76,425
Lukka	Hosted	2014	USA	\$201.3	Series E	17	101-250	9,361
InfStones	Hosted	2018	USA	\$110.2	Series C	13	11-50	2,225
Tenderly	Hosted	2018	Serbia	\$58.6	Series B	10	11-50	459,990
Moralis	Hosted	2021	Sweden	\$53.4	Series A	4	51-100	831,313
BlockApps	Hosted	2015	USA	\$44.1	Series B	18	101-250	3,776
QuickNode	Hosted	2017	USA	\$41.9	Series A	12	51-100	297,045
Aligned	Hosted	2021	USA	\$34.0	Seed	9	1-10	985
Ankr	P2P	2017	USA	\$27.3	Venture	13	11-50	253,798
Bloq	Hosted	2015	USA	\$21.0	Venture	6	11-50	4,577
Pocket Network	P2P	2017	USA	\$20.3	Venture	16	11-50	63,044
Infura	Hosted	2016	USA	Acquired (ConsensSys)	-	-	11-50	474,465

Note: Companies sorted in descending order based on cumulative funding. Data as of November 2022. Sources: Crunchbase, Pitchbook, company websites, press releases. Data as of 10/31/2022.

Common services offered are designed to cater to both developers and enterprise customers. Offerings include API support for analytical queries (e.g. filtering, sorting, and aggregating blockchain data) as well a streamlined workflow and RPC functionality. Some also provide professional consultancy services along with monitoring and development for dapp building, including dashboards to view and analyze blockchain events.

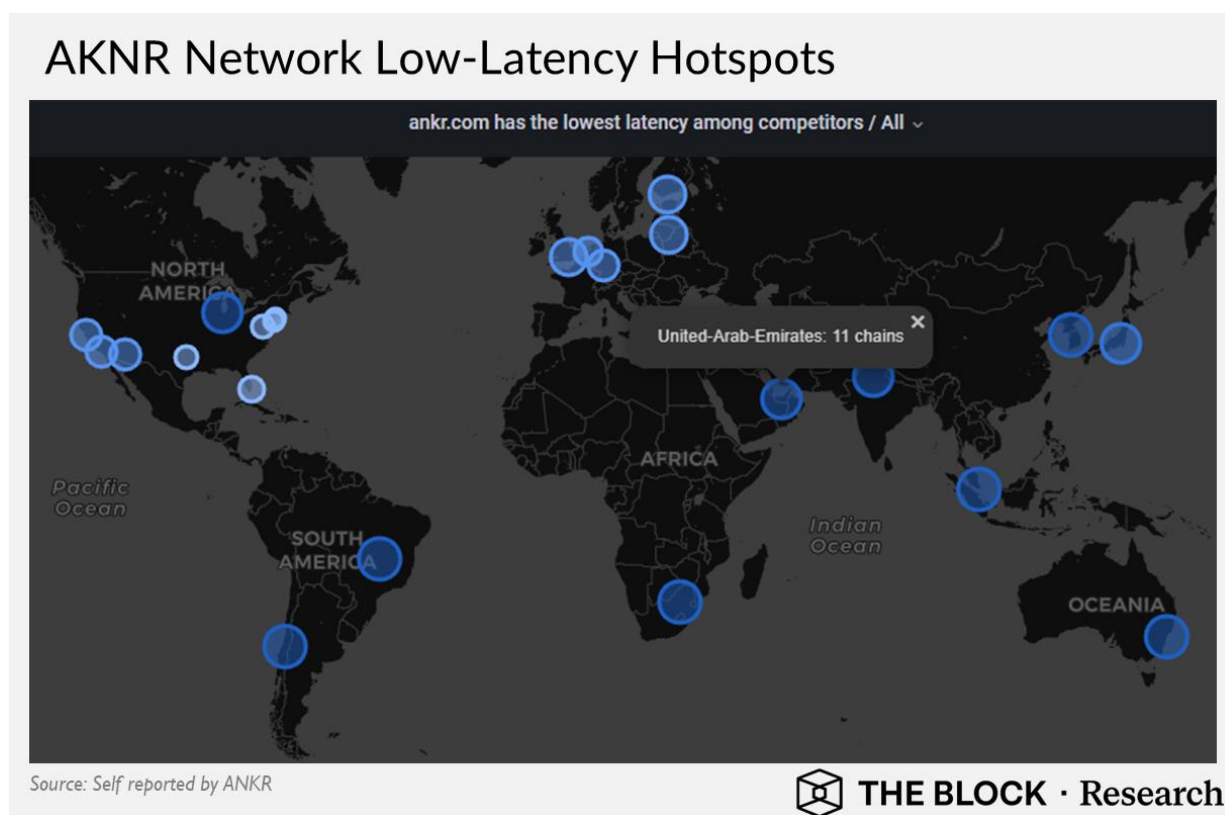
Firm / Protocol	Nodes				Client Tools				
	Shared	Dedicated	Blockchain Agnostic	Supported Networks	REST API	SDK	WebSocket	JSON-RPC	Dashboard
Alchemy	✓	✓	✓	6	✓	✓	✓	✓	✓
BlockChair	✓	✓	✓	19	✓	✗	✗	✓	✓
BlockCypher	✓	✗	✓	6	✓	✓	✓	✓	✓
Blockdaemon	✓	✓	✓	60	✓	✓	✓	✓	✓
Bloq	✓	✓	✓	6	✓	✓	✓	✓	✗
Infura	✓	✗	✓	11	✓	✓	✓	✓	✓
Moralis	✓	✗	✓	10	✓	✓	✓	✓	✓
QuickNode	✓	✓	✓	15	✓	✓	✓	✓	✓
Tenderly	✓	✗	✓	14	✓	✗	✓	✓	✓

Data for "Supported Networks" as of November 2022; all other data as of July 2022. Sources: Company websites, The Block Research

Detailed information about the companies listed in the table above can be found in a separate [report](#) by The Block.

Decentralized P2P node networks have also seen rapid adoption over the last year. Notably, Ankr now serves 7+ billion RPC requests per day over 27 supported node networks distributed over 30+ global regions.

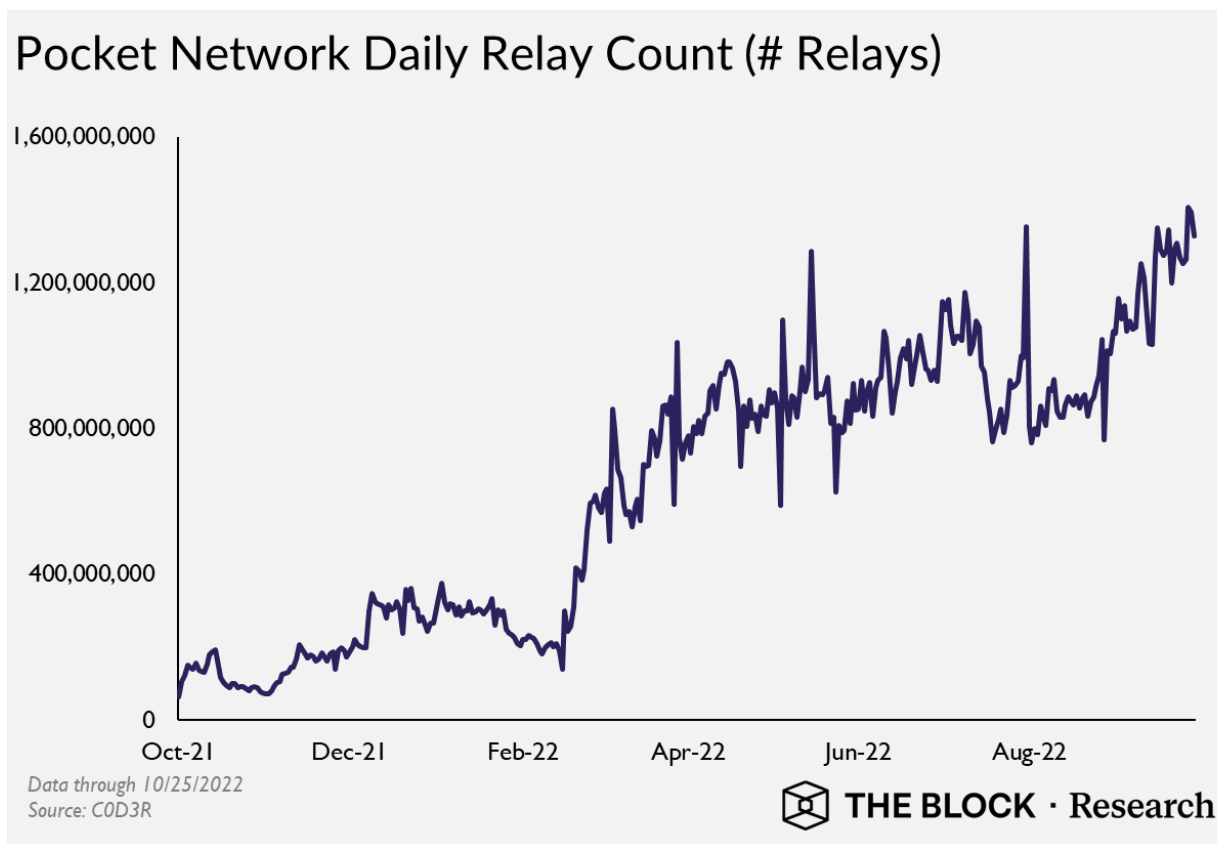
In terms of speed, Ankr recently [self-reported](#) internal tests demonstrating that their node network outperforms their main competitors (Infura, Alchemy, Chainstack, and Quicknode) across the globe. The blue circles below show where Ankr performs faster in terms of latency in milliseconds and the number of chains they are providing lower latency for. Note that the radius of the circles is determined by where the nodes are located, not coverage area.



In terms of reliability, uptime during the testing period (July 31 to August 6) was excellent across the board, with Ankr performing slightly better (>99.99%) than its major competitors (99.97- 99.99%).

Decentralized node networks can also have a cost advantage as prices are set by competitive open market dynamics rather than corporate pricing departments. Ankr, for instance, estimated that the monthly cost for SpiritSwap’s 8.59B monthly RPC requests on the Ankr network totals ~\$86K compared with \$268K on Alchemy and \$1.688M on Infura.

Pocket Network, which also supplies nodes to the Ankr network, has also seen significant growth in the past year – with daily relays over 40 supported chains reaching ~1B in mid-2022 at the time of writing.



Source: [COD3R](#)

While such p2p node networks have seen significant traction over the last year, they are still relatively new and there are [questions](#) as to whether devops can keep pace with that of their relatively centralized competitors.

We may see a future where relatively centralized and decentralized infrastructure solutions have different roles in web3 depending on the tradeoffs for each use case. For example, if advanced prototyping and development tools are sought after, then a hosted node provider with robust tooling like Alchemy may be more desirable despite the added expense. If permissionless and trustless access or cost of simple cold storage are priorities, then one of the [decentralized p2p node networks](#) may be more desirable. In the ideal case, there will be minimal vendor or network lock-in, so vital app functions experience minimal downtime.

See the first report in this three-part series, [Decentralized Storage: A Primer](#), for a comprehensive look at decentralized storage.

Section 4: Outlook & Conclusion

The DAPP framework enables one to holistically assess how access to web3 is instantiated and the variety of factors that impact relative levels of decentralization.

On the one hand, the newest trends in web3 like gaming, streaming, and social media point to a future where decentralized data access, operation, and storage are more complicated than ever. Decentralized infrastructure requirements for maintaining responsiveness and reliability for such web-scale dapps are a pressing challenge. And for developers, the cons of self-hosting their own infrastructure generally outweigh the pros.

On the other hand, there is a rich and expanding ecosystem of hosted infrastructure providers and p2p infrastructure networks developing to meet the market demand. No solution is perfect, with hosted infrastructure providers potentially creating single points of failure and other centralization concerns and p2p infrastructure networks lacking in terms of devops and tooling. However, both solutions have so far demonstrated excellent reliability under normal conditions.

With [massive value](#) stored and transacted in web3, it is of utmost importance to find ways to ensure security while also maintaining decentralization and scalability – in other words, solving the blockchain trilemma. In the ideal case, the web3 stack will be supported at all levels by an *infrastructure cooperative*, where hosted and p2p nodes support each other in blockchain access and operations.

Where infrastructure is most needed will depend entirely on which web3 applications gain the most traction. For example, if popular web3 apps demand data availability and integrity of NFT metadata and hypermedia, there may be a significant increase in demand to access and use Filecoin/IPFS infrastructure and other decentralized storage solutions. If computation-intensive application spaces like GameFi and streaming keep gaining traction, we can expect demand for infrastructure that can handle greater loads responsively and reliably – for example, L2 networks like StarkNet (ZK rollup) and sidechains like Polygon that are built for general-purpose scaling. The value or potential value to secure is also a major factor. For example, frequent low-value transactions of in-game items may prioritize infrastructure providing throughput over security whereas high-value lending and borrowing transactions may prioritize security over throughput.

Storage and computation requirements will likely keep increasing globally. Current trends indicate accelerating digitalization on the horizon, as well as increased demands for 5G mobile communication, Internet of Things (IoT) devices and infrastructure, and metaverse and GameFi products. All of this points to a deluge of data with no end in sight that will demand not only more storage but also more and more sophisticated storage infrastructure.

For web3 to flourish, the importance of meeting infrastructure needs cannot be overstated. While web3's core activity happens at the level of basic protocols like Ethereum, these protocols need more than developers and crypto enthusiasts to thrive. They also need infrastructure providers to make it easier and more economical for both general consumers and enterprise users to ensure reliable and secure access to dapps.

Beyond providing technological support for foundational protocols – the very “soil” on which these protocols can mature into advanced forms – infrastructure providers also support a better user experience. User experience is often seen as the final step for unlocking mass adoption of web3. Mass adoption would benefit consumers and producers alike via increased revenue, liquidity, and networking effects. Infrastructure providers can also help simplify decentralization with DaaS to the extent that they participate in a global infrastructure cooperative for web3.

Finally, we should also keep monitoring broader trends in the web3 space concerning modular versus monolithic chains and generalized versus application-specific chains to see which blockchains and other distributed systems involved in storage, security, and execution will need the most infrastructure provision.

Section 5: Disclosures

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