THE BLOCK

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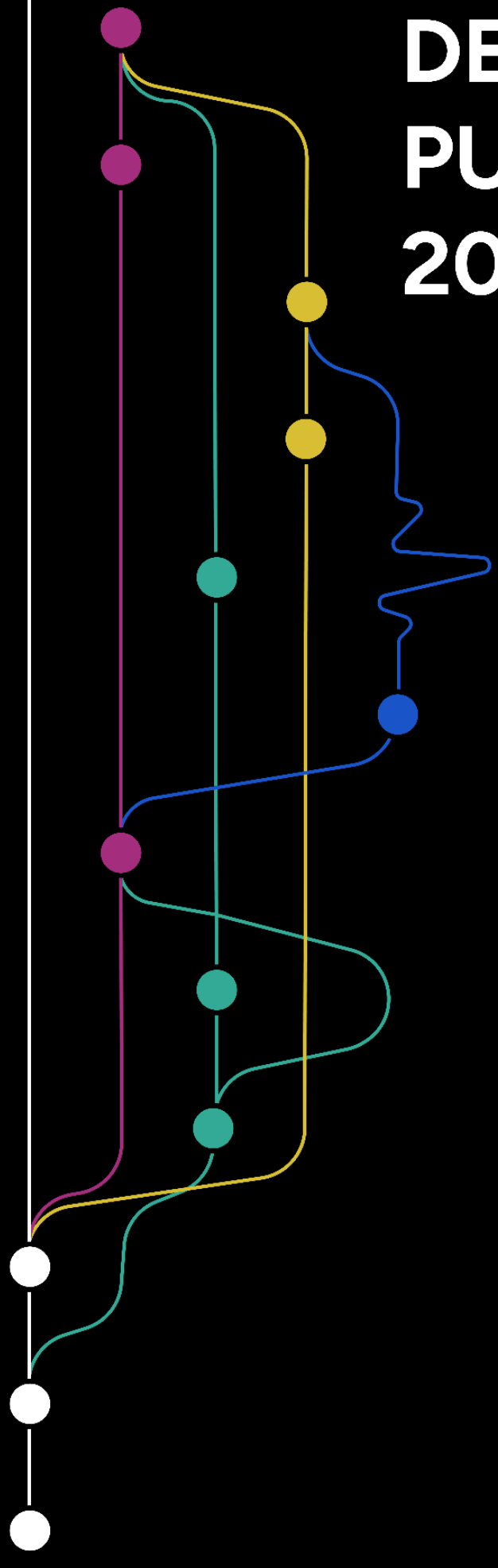

DEVELOPER PULSE-POINT 2024 REPORT

A Year In Review

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Executive Summary

In 2024, the crypto development landscape experienced significant growth and innovation, driven by robust GitHub activity and key technological advancements. Leading projects such as Shardeum, RSSNext, and Eliza garnered substantial attention, highlighting a strong emphasis on scalable architectures, AI integration, and enhanced user experiences. GitHub metrics showcased a vibrant developer community focused on modularity, interoperability, and developer-centric tools, with top repositories receiving thousands of stars and forks, reflecting widespread adoption and impact.

Major blockchain networks undertook critical upgrades to boost scalability and performance, including Ethereum's Dencun upgrade and Solana's Firedancer, which enhanced transaction throughput and network reliability. The convergence of artificial intelligence and blockchain emerged as a prominent trend, enabling the development of autonomous AI agents and intelligent decentralized applications. Developer tools like WebAssembly (WASM) and advancements in zero-knowledge proofs (zk-SNARKs) lowered entry barriers, fostering innovation and cross-chain compatibility.

Support from leading organizations and accelerators, including Paradigm and a16z Crypto, played a pivotal role in fueling development through funding and open-source contributions. Gitcoin Grants underscored community-driven projects focused on infrastructure, privacy, and developer tooling, demonstrating the collaborative spirit propelling the ecosystem forward.

Looking ahead to 2025, the foundations built in 2024 position the blockchain ecosystem for continued evolution. Anticipated advancements include deeper AI-blockchain integration, maturing and evolving zero-knowledge technologies, and standardized cross-chain interoperability. The sustained engagement of experienced developers and strategic investments ensure that the crypto industry remains poised for sustainable, impactful innovation, paving the way for a more interconnected and intelligent decentralized future.

Introduction

The year 2024 marked another pivotal year in the evolution and growth of Web3. Amid a landscape of rapid technological advancements and continually shifting market dynamics and events, Web3's community of developers, builders, and innovators have continually redefined what's possible in the world of decentralized computing. This report explores the trenches of infrastructure and application development focusing on what was built, how it was built, and the contributors and communities driving development in the space forward.

Through an analysis of GitHub activity, major chain upgrades, newly developed projects, research, and investment trends, this report aims to highlight the core achievements of the 2024 blockchain development space while recognizing directions and providing a forward looking perspective into where we are headed in 2025. Key themes include the rise of scalable solutions like zk-rollups, the integration and alignment of blockchain with artificial intelligence, advancements in user experience for Web3, and a push into decentralized physical infrastructure networks (DePIN).

This report captures the state of building and application development in 2024 from the GitHub trenches to the broader ecosystem development, uncovering trends that have begun to and will shape the future of blockchain innovation looking forward. To understand these developments and trends we begin at ground zero—the primary platform where development takes shape.

The GitHub Trenches: Examining Development Ground Zero

Github is the place where many projects begin, it is crypto's ground zero of development. GitHub activity in 2024 painted a vivid picture of the priorities, focuses, and innovations that are shaping the blockchain ecosystem. From artificial intelligence to scaling solutions, open-source repositories reflected the developer community's drive to innovate and solve existing challenges. Below is a detailed analysis of the most starred newly created projects in 2024 tied to blockchain and its associated tags on GitHub organized by stars to highlight the communities newest most followed and impactful projects and categorized thematically to provide a comprehensive overview.

High Impact Repositories Created 2024

The following repositories stood out in 2024 for their contributions to blockchain infrastructure and applications.

- **Shardeum (Stars 26,310)**

  Shardeum is an innovative and EVM-compliant blockchain platform that focuses on leveraging dynamic state sharding to achieve improved autoscaling without sacrificing decentralization or security. This allows the platform to achieve linear scalability, offering low fees and high throughput. The project relies heavily on Node.js and Rust, though the main repository is almost entirely written in TypeScript. It should be noted however that while Shardeum did not originate in 2024 as a

project the Shardeum repository was open sourced and started gathering traction in April of 2024 and grew nearly exponentially since. As the most starred blockchain project in 2024 Shardeum showed and continues to show significant growth and developer interest. The network has experienced an influx of development with over 78,057 validators, 37,170,042 transactions, and 728,603 wallets on their existing test-net with the Atomium Stage four test-net having launched mid December and continuing till mid January 2025 before main-net launch in 2025 Q1. By the end of 2024 Shardeum supported 155 dApp projects and counting ranging from high-performance DeFi platforms to decentralized marketplaces and file storage.

- **RSSNext (Stars 21,462)**

  RSSNext is a RSS feed follower and information aggregation platform streamlining user experience in content consumption. It is powered by RSS3, a decentralized network designed to index and structure open information, and WebIsOpen, a collective of blockchain associated and decentralized/distributed development advocates. RSSNext has its own token $POWER designed to be the first reward and incentive token of the open web allowing for users to support the creators of content they enjoy and consume regardless of whether said content is Web1, Web2, or Web3 based. The platform has fully Integrated monetization tools for creators, enabling direct financial support and engagement without intermediaries with user owned feeds and cross-platform capabilities enabling seamless data portability. RSSNext has been rapidly adopted within Web3 communities, among others and has grown exponentially since its launch with over 800 forks signifying significant developer attention.

- **Eliza (Stars 7,550)**

  Eliza is perhaps one of the most talked about projects to come out of the Web3 space within 2024. It is a simple, lightweight agentic artificial intelligence framework that allows autonomous AI agents to be built and deployed across a variety of social platforms with full text, voice, and media interaction capabilities. Eliza is written in full TypeScript and utilizes built in Retrieval-Augmented Generation (RAG) memory and supports multiple AI models all while designed to be completely modular and extensible. It is designed to create AI Assistants, Social Media Personas, Knowledge Workers, and Interactive characters. It is integrated seamlessly with blockchain technology and infrastructure, enabling on-chain applications to interact autonomously reading data, executing transactions and interacting with smart contracts. This was exemplified by the Eliza powered launch of ai16z, an investment DAO led by AI agents trained on VC data and continually trained on interaction data from the DAO and any chats the DAO AIs are involved in. There are currently over 2.3 thousand forks of the project and over 276 individual agents accounted for by the community stemming from the framework with more being created daily. Eliza is a significant contributor and a step towards autonomous systems operating within decentralized environments onchain.

- **Rig by 0xPlayground (Stars 1,950)**

  Rig is a rust library for building scalable, modular, and ergonomic LLM powered applications, providing a consistent and unified API for working with LLMs and embeddings regardless of provider, e.g. OpenAi, Claude, etc. It allows for extensible LLM abstractions and agentic interactions varying in complexity from basic LLM functionality to larger scale RAG systems with extensive and evolving knowledge bases. It allows for custom model implementation alongside those commonly used. The library also supports seamless integration with vector stores, which are essential for implementing efficient similarity search and retrieval functionalities in AI applications. By providing these capabilities, Rig empowers developers to create high-performance AI applications with complex workflows, all within the Rust ecosystem. It is closely associated with arc.fun, a group of developers associated with 0xPlayground building RIG and focusing on accelerating and integrating AI swarms into practical tools that understand context and meaning while exploring and encouraging exploration of how AI can make Web3 more intelligent and more human.

- **RAIR Protocol (Stars 1,290)**

  RAIR protocol is an open source deployment layer for Web3 dApps, enabling developers to create scalable decentralized applications with ease. It offers a comprehensive suite of tools for the deployment and development of full-stack dApps. The protocol architecture is modular in nature, composed of RAIR-Node, the core backend logic that offers users the ability to deploy their own backend and API endpoints to their own cloud architecture via RAIR-node. RAIR-Front, the default frontend application, RAIR-Sync, the core syncing that scrapes onchain data, RAIR-Stream, the core DRM engine for ownership identification using NFTs, and RAIR-Infra, the full cloud architecture code and infrastructure that powers the protocol. By fully open-sourcing everything RAIR is pushing an environment of full transparency and collaboration making it a valuable growing addition to the Web3 space.

Quick Metrics and Summary of Smaller Growing 2024 Repositories

The following table highlights additional repositories that, while smaller in size, demonstrate growing developer interest in 2024..

Repository Name	Stars	Forks	Description	Area of Impact
Equivariant Encryption for AI	825	136	Blockchain based end-to-end encryption for AI models	Privacy in decentralized AI
zkVerify	271	36	Zero-Knowlege proof verification protocol	Rollup scalability and privacy

Goat SDK	230	79	Open-Source Framework for onchain AI agent interaction	Developer tooling and AI
Hemera Indexer	177	45	Decentralized programmable indexing network	Developer tooling
Nomt by ThrumDev	169	13	Novel Merkle Trie implementation	Blockchain infrastructure
Op-Succinct by Succinct Labs	114	38	OP rollup to type-1 zkEVM rollup transformer	Zk-rollup and scalability

Thematic Trends in 2024 Development

Modularity and Scalable Architectures

Across the repositories, there is a clear emphasis on modularity and scalability. Projects like Shardeum and RAIR Protocol highlight a trend toward creating systems that can dynamically adapt to demand. Shardeum's dynamic state sharding ensures consistent network performance, while RAIR Protocol's modular deployment layers enable developers to create scalable dApps with flexible architectures. This modularity extends to projects like Rig, which simplifies integration with multiple LLM providers, and Eliza, which offers a plugin-based architecture for AI agent development. As development progresses in these sectors modularity and extensibility are a focus when looking to exist on the bleeding edge of technological development. This reflects the increasing complexity of blockchain systems, where adaptability and upgradability are essential for long-term viability. This trend aligns with the broader move toward composable and interoperable ecosystems, enabling rapid iteration and innovation and may prove valuable when looking forward to integrate and build primitives and frameworks as a research organization.

Interoperability Within Information and Ecosystems

Interoperability emerges as another critical trend. Repositories like Shardeum and Follow emphasize the need for seamless cross-platform functionality. Shardeum's EVM compatibility facilitates integration with Ethereum-based dApps, while Follow's multi web version infrastructure supports decentralized content aggregation across various blockchain and Web2 platforms. These projects demonstrate a shared goal of bridging ecosystem silos and enabling decentralized applications to interact with broader networks. This is especially important with data access as we enter the age of AI and RAG enabled systems.

Developer-Centric Focus

A strong focus on improving developer experience is evident in projects like Goat SDK, RAIR Protocol, Rig and Eliza. These repositories provide pre-built tools, APIs, and frameworks to streamline development workflows and lower barriers to entry for new builders. Goat SDK simplifies blockchain integration for dApp/smart contract and AI agent developers, RAIR Protocol offers an end-to-end deployment solution, and Rig and Eliza ensure flexibility when building LLM applications and agents that can interact with onchain data. This trend reflects the industry's commitment to expanding the developer base and fostering innovation through accessibility. As a research organization it would be beneficial for us to stay up to date on the newly launched developer tools and contribute to development of these tools when necessary allowing The Block to shape the development landscape.

The Alignment of AI and Blockchain

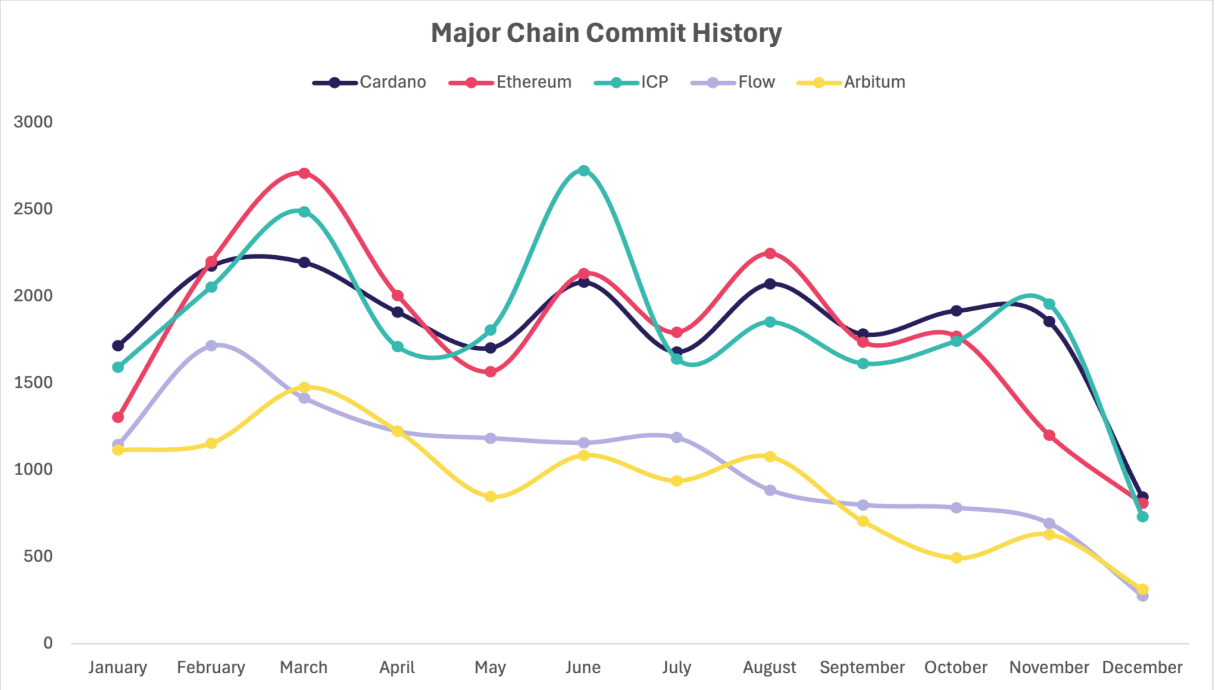
The integration of blockchain with artificial intelligence is becoming a defining feature of Web3 development in 2024. Repositories like ElizaOS and Rig showcase the potential for blockchain as a foundation for decentralized AI applications. ElizaOS provides tools for deploying autonomous agents with advanced functionalities, such as document analysis and memory retention, while Rig focuses on building efficient AI workflows using Rust. These projects underscore a broader trend of combining blockchain's transparency and security with AI's decision-making capabilities, paving the way for decentralized context-aware intelligence systems and applications capable of interacting with decentralized systems in real-time. This could transform areas like decentralized governance, predictive markets, and onchain interactions.

Infrastructure Development in 2024: An Analytical Overview

The year 2024 witnessed significant advancements in blockchain infrastructure with major protocol upgrades and significant commit activity among open-source projects. This section provides an in-depth analysis of these developments focusing on GitHub commit activity, monthly active developers, and major chain upgrades across several leading blockchain ecosystems.

GitHub Commit Analysis

Developer activity serves as a crucial pulse point for a blockchain platform's viability and innovation potential, with substantial numbers of commits indicating a dedicated core developer base for protocol infrastructure. While there has been a seven percent drop in total blockchain developers from last year, with shorter tenure developer involvement falling, established developers (those with over a consistent two year or more tenure in the space) reached a record high with a twenty-seven percent year-over-year increase in 2024 to 11,243 developers as of November 2024, according to Electric Capital. Several blockchain protocols demonstrated remarkable developer engagement as evidenced by the volume of GitHub commits across project repositories. According to data from Cryptomethius, the top five projects by commit count were:



- **Cardano (ADA)**

  Leading with a total of 22,263 commits across 550 core repositories, Cardano's developer community showcased a strong and consistent commitment to project development and enhancing the platform's capabilities and code bases. The top five individual repositories were cardano-ledger, Mithril, Hydra, cardano-wallet, and Plutus. There was significant project focus on enhancing security and scalability across top repositories with improvements in transaction handling, adjustments to use mismatch in predicate failures, 12,000 Hydra head deployments with each capable of processing up to 800 TPS, and improved smart contract efficiency and interoperability. The chain's continued commitment to academic rigor and research backed development was highlighted by the top languages used including Haskell, Nix and JavaScript.

- **Ethereum (ETH)**

  Barely trailing behind Cardano, Ethereum was a close second and maintained high levels of commit activity, with 21,762 commits across 278 repositories, as developers worked on key pivotal upgrades in the protocol and protocol tools. The major details of the developments in ETH will be covered later in the Major Chain Upgrades Section however, it should be noted that the top five repositories with most development was the ethereum-org-website, remix-project, consensus-specs, discv4-dns-lists (though it should be noted that this repository is an automated crawler so it automatically updates periodically but will still be mentioned), solidity, and go-ethereum. While within the Ethereum ecosystem as a whole the dominant languages are Solidity for smart contract development, C++ for development and expansion of Solidity, and Go for GETH development the most prevalent languages in the current 2024 commit cycle were Python, TypeScript, JavaScript and Go which corresponds to documentation pushes and updates to the ecosystem regarding the Dencun upgrade.

- **Internet Computer (ICP)**

  With its focus on decentralizing infrastructure and extending the public internet with native cloud computing functionality the Internet Computer Protocol saw significant developer activity with 21,580 commits in 80 repositories, most developments geared towards improving performance and reliability of the protocol as well as developer tooling upgrades. The ic, portal, oisy-wallet, nns-dapp, and examples repositories received the most activity with the main development languages being Rust, TypeScript and JavaScript. This corresponds with the core developments of their IC JavaScript Agent, a developer tool for interacting with canisters and managing calls, Pocket IC a testing environment with simulation and debugging capabilities, alongside several updates to their Network Nervous System and Service Nervous System improving governance.

- **Flow (FLOW)**

  Focusing on being a blockchain designed for scalable transactions, and digital assets Flow utilizes a unique multi-roll architecture allowing for multiple parallel chains resulting in significant scaling increases. With 12,659 commits across 75 repositories Flow, shows growth and decent developer activity given its size. Its flow-go, cadence, flow-cli, flow, and docs repositories received the most developer attention with Go and JavaScript being the two most used languages for protocol development. This correlates with the release of the Cadence 1.0 upgrade adding significant features and improvements to Flow's Go based Cadence smart contract language, improved command line tooling, and the Crescendo Upgrade released in September introducing full EVM equivalence, improved stability and backwards compatibility with Cadence and performance upgrades.

- **Arbitrum (ARB)**

  As a leading Layer 2 scaling solution for Ethereum, Arbitrum's commit history focused on scaling and efficiency with protocol upgrades being implemented in 11,228 commits over 47 repositories. The key repositories with developer activity were nitro, arbitrum-docs, stylus, go-ethereum, and arbitrum-token-bridge with the most used languages being TypeScript, JavaScript and Go. This activity corresponds with the documentation updates from key protocol changes including ArbOS 20 Atlas and ArbOS 31 and 32 Bianca, as well as Stylus integration. This integration grants a WASM compatible virtual machine that can run alongside the existing EVM. This WASM compatibility enables the development of smart contracts in WASM compilable languages like Go, Rust, C and C++ significantly expanding ease of access for developers who come from non-Web3 specific backgrounds.

Top Ecosystems by Monthly Active Developers

Beyond just GitHub commits, monthly active developers is a key metric for assessing not only ecosystem health, but where developers are active and moving into or out of, assessing the trends in developer attention.

Ethereum maintained its position as the leading ecosystem with 6,224 monthly active developers across all continents. Its robust community and widespread EVM compatibility continued to attract and retain developers as DeFi and NFTs expanded on the protocol, alongside significant protocol upgrades. The EVM remained the most active tech stack with 8,925 developers. Additionally, Ethereum's Layer-2 scaling solutions showed significant growth, with Arbitrum, Starknet, and Optimism each exceeding 2,000 active monthly developers. Base emerged as one of the fastest-growing Layer-2 networks, with 4,287 monthly active developers and contributing 42% of new code in the Ethereum ecosystem.

Solana emerged as the fastest-growing large blockchain network, with its Virtual Machine (SVM) stack supporting 2,499 developers. The ecosystem attracted 7,625 new developers in 2024, an impressive 83% year-over-year increase, surpassing Ethereum as the top ecosystem for new developers for the first time since 2016.

The Polkadot Network Stack maintained an active monthly developer base of about 1,301 developers, while Bitcoin continued to maintain a stable developer base with around 1,200 monthly developers active throughout 2024. Notably, 42% of Bitcoin developers focused on scaling solutions, indicating ongoing efforts to improve the network's capabilities.

The relation between the EVM, SVM, and PNS is rather drastic with the EVM being about 3.6 times the size of the SVM and around 6.9 times the size of the PNS.

The development landscape saw significant geographical shifts in 2024, with Asia emerging as the leading continent, accounting for one-third of all developers, while North America dropped from first to third place. India's significant influx of new developers in 2024 contributed substantially to this shift in the global distribution of blockchain developer talent.

Multi-chain development became increasingly prevalent, with one in three crypto developers working across multiple chains in 2024, a substantial increase from less than 10% in 2015.

Major Chain Upgrades in 2024

In 2024, the leading blockchain networks by TVL—Ethereum, Solana, TRON, and Bitcoin—underwent significant infrastructure upgrades aimed at enhancing scalability, security, and overall network performance. This section provides an analytical overview of these upgrades, reflecting their implications for application development and the broader crypto ecosystem.

Ethereum

Ethereum’s most significant upgrade in 2024 was the Dencun upgrade which combined the Cancun and Deneb upgrades for the execution and consensus layers respectively. The Dencun upgrade implemented nine EIPs with a focus on Proto-Danksharding (EIP-4844) which introduced blob-carrying transactions, significantly reducing costs for Layer 2 rollups

by allowing large data objects to be processed off-chain increasing the data throughput without burdening the main chain. It accomplishes this by attaching blobs to blocks but not storing them in the Ethereum state, rather keeping them in a temporary data structure called the blob pool. These blobs are committed to using KZG commitments, a cryptographic primitive that enables efficient verification of blob contents without full data download requirements. The protocol also offered new self-destruct limitations with EIP-6780 preventing unexpected state changes across transactions enhancing security and stability as well as new staking pool capabilities improving the decentralization and accessibility of staking with EIP-4788, among others. The Dencun upgrade launched on March 13, 2024, and marked a significant step towards Ethereum's stability goals, especially for Layer 2 solutions and corresponded with increased developer commit activity which spiked to 2,819 commits in February 2024 before the launch.

Solana

Solana's 2024 upgrades focused on network performance and reliability with key developments including the Firedancer Validator Client developed by Jump Crypto. This upgrade was a complete rewrite of the Solana validator software in C++ and introduced a modular architecture utilizing a novel messaging passing framework called "tiles" which operates at a speed faster than the Linux Kernel allows for. Firedancer addresses this issue by bypassing the kernel entirely reading directly from the network buffers. This tile system allows for high-performance computational concepts like NUMA awareness, cache locality optimization, lockless concurrency, and large page sizes. Firedancer supports zero-downtime upgrades by leveraging binary stability in the C runtime model enabling each tile to pick back up where it left off upon machine restart. This upgrade effectively doubled blockspace available for network utilization and introduced improved transaction landing pipelines which are crucial for managing high throughput demands on the network. Solana additionally introduced Token-22, a new token standard designed to build on top of the original token program allowing for token extensions on top of the core program with programmable transfer hooks, allowing for custom execution logic. Some examples of these extensions include transfer fees, closing mint, and interest-bearing tokens among others. These upgrades position Solana for continued developer attraction and bolster the protocol's position in a competitive market.

Tron

Tron's infrastructure upgrades in 2024 were centered around enhancing scalability and cross-chain capabilities. Building upon the Stake 2.0 foundation implemented in 2023, the protocol introduced advanced features that improved resource utilization within its Delegated Proof of Stake (DPoS) consensus mechanism. This included token-agnostic gas payments, enabling users to pay transaction fees with multiple tokens like USDT among others.

A critical component of TRON's strategy was the integration of BitTorrent Chain (BTTC), which enabled cross-chain asset transfers utilizing a multi-chain architecture. BTTC employs a unique bridging protocol that allows TRON-based assets to interact seamlessly with Ethereum and Binance Smart Chain (BSC), fostering liquidity across different ecosystems.

Additionally, TRON's development of a Bitcoin Layer 2 solution aimed to leverage Bitcoin’s liquidity while providing faster transaction capabilities through state channels. This initiative enhances TRON’s DeFi offerings by allowing users to utilize Bitcoin within its ecosystem without sacrificing speed or security, expanding the utility TRON possesses in DeFi applications.

Bitcoin

Bitcoin's infrastructure updates in 2024 were less pronounced compared to Ethereum or Solana but still noteworthy, characterized by incremental improvements rather than broad sweeping changes. The network continued its focus on improving transaction efficiency and enhancing the functionality of the Lightning Network, which facilitates off-chain transactions alleviating congestion on the main chain. The focus on the Lightning Network resulted in BOLT12, which improves invoicing structure and support for offline payments allowing the sending of low-cost Bitcoin anywhere at any point in time.

Developers on the network are looking forward to evaluating and possibly implementing the OP_CAP proposal a reactivation of a Satoshi-era opcode that could enable covenants, vaults, merkle trees, and drivechains among other uses.

The developments in blockchain infrastructure throughout 2024 reveal an ecosystem focused on scalability, developer accessibility, and cross-chain interoperability. High commit counts and active developer engagement underscore the vibrancy of leading ecosystems, while major upgrades position these chains to tackle the challenges of adoption and usability in 2025.

The substantial infrastructure developments and protocol upgrades of 2024 laid critical groundwork for innovation at the application layer. As networks enhanced their scalability, security, and interoperability through upgrades like Ethereum's Dencun and Solana's Firedancer, developers gained new capabilities to build more sophisticated and user-centric applications. This improved infrastructure, combined with the maturation of developer tooling and cross-chain capabilities, created fertile ground for application development that would shape user experiences and drive adoption. The following section examines how developers leveraged these foundational improvements to create innovative decentralized applications and push the boundaries of what's possible in the Web3 space.

Application Development in 2024: Building the Future of Decentralization

The landscape of decentralized applications in 2024 has been marked by significant growth and innovation. The industry witnessed an increase in active wallets hitting an impressive 10 million daily unique active wallets in Q2 alone. This surge in adoption reflects a broader shift from pure bleeding edge technological competition to application-driven strategies with developers focusing on identifying and building targeted solutions to user or market needs.

Emerging 2024 Trends Shaping the dApp Ecosystem

- **Multi-chain development:** Interoperability gained significant traction, with approximately 1 out of 3 of Web3 developers contributing to projects spanning multiple blockchain platforms. This shift away from platform silos reflects the growing importance of cross-chain compatibility and the need for seamless data transfer across different ecosystems as user adoption of blockchain technology grows.
- **AI integration:** The integration of artificial intelligence within blockchain applications emerged as a major force. AI-powered solutions began to enhance various aspects of dApps, including:
    - **Improved User Experiences:** AI-driven bots and agents were integrated into dApps and used data collection and machine learning to expand their knowledge bases making each interaction increasingly more personalized.
    - **Framework Development:** Several new AI frameworks were developed or announced to accelerate and assist developers in integrating AI.
    - **Decentralized AI Governance:** Machine learning algorithms were integrated into DAO governance mechanisms to utilize historical data and user interaction to automate decision making and improve efficiency.
- **Modularity and Composability:** Corresponding with the increase in multi-chain development the trend towards modular and composable architectures gained momentum. Developers increasingly focused on building dApps more modularly with associated primitives and interconnected components enabling greater flexibility, reusability and interoperability. This allowed developers to leverage existing primitives and seamlessly integrate with other protocols.

Developer Activity and Tooling

WebAssembly (WASM)

The adoption of WASM continued to gain momentum, significantly expanding the developer toolbox. Originally designed for allowing a wider variety of programming languages to be ran inside the browser besides JavaScript, WASM is a binary instruction format designed for efficient execution and portability across different platforms. It utilizes a compact binary format smaller than most native code formats allowing for accelerated transfer over networks and is completely operating system and language agnostic, allowing each WASM compiled binary to run on any platform and processor without alteration. WASM programs can also be split into smaller modules for independent transmission, caching or execution and these modules are interoperable with JavaScript allowing for seamless integration and call functions bilaterally.

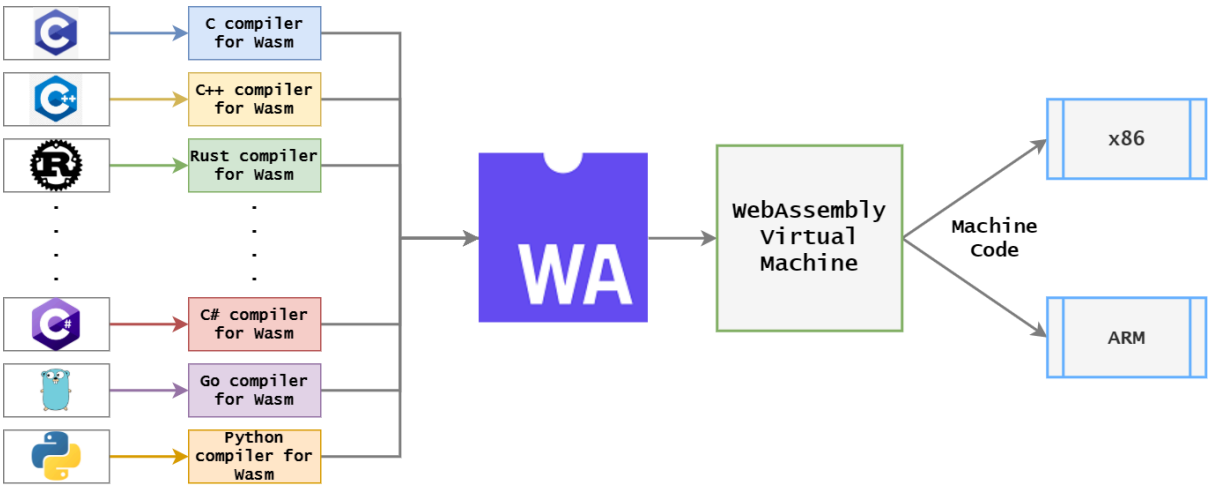


Image Credit: Medium

WASM has become increasingly important to developers in blockchain development due to its ability to significantly enhance performance.WASM's compatibility with multiple programming languages lowers and further democratizes the barrier to entry for dApp development as developers no longer need to learn Web3 niche languages like Solidity or Viper as languages like Go, Rust, C, and C++ can compile down to a WASM binary. This flexibility encourages broader participation in blockchain development and fosters increased innovation across sectors. WASM's portable format also plays a critical role in enhancing cross-chain interoperability. Platforms like Polkadot and NEAR have integrated WASM as part of their smart contract execution environments not only improving execution speed compared to traditional virtual machines but also allowing the facilitation of interaction between different blockchains. As a research organization it may be of benefit to investigate methods of creating primitives and frameworks for WASM standardization and development.

zk-SNARKSs

The usage of zk-SNARKs (Zero-Knowledge Succinct Non-Interactive Arguments of Knowledge) by blockchain developers also saw significant growth, driven by their applications to enhance privacy, scalability, and interoperability within decentralized applications. Within 2024 developers worked to advance both zk-SNARK technology and its integration into blockchain. A major breakthrough came with the introduction of dynamic zk-SNARKs from Weijie Wang et. all, allowing for efficient proof updates without full recomputation of the proof. Dynamic zk-SNARK's update algorithm allows a valid source statement-witness pair with a verifying proof and valid target statement-witness pair to output a new verifying prime proof in sublinear time. Within the same research the Dynaverse construction mechanism achieved $O(\sqrt{n} \log n)$ update time outperforming recursive-based approaches by at least an order of magnitude. SNARKtor by researchers at Telos and IOHK also introduced a protocol for recursive proof aggregation in a decentralized manner thereby reducing gas costs and improving verification speeds. These developments to zk-SNARKs indicate growing interest in their usability and implementations in distributed blockchain ecosystems. Developers can utilize zk-SNARKs through libraries like ZoKrates or Snarky which provide high-level specifications and frameworks for creating and integrating zero-knowledge proofs into your development workflow. Hardhat and Foundry are common

frameworks utilized by developers to facilitate the integration of these proofs into their smart contracts.

Cross-Chain SDKs

With the recurring growing emphasis on modularity and interoperability cross-chain SDKs are getting increasingly more developer attention as silos are brought down and developers integrate with each other more closely. Some standout cross chain SDKs include LI.FI a bridge aggregation protocol with DEX connectivity that enables cross-chain messaging capabilities across 32 chains with integrated bridge insurance and LI.Fuel, a mechanism that enables part of the bridged token to be converted into gas on the target chain. Rubic, a DEX and cross-chain aggregator enabling developers to aggregate over 90 blockchains and testnets. Rubic's development SDK allows for access to other aggregators further interconnecting chains by granting access to secondary aggregator assets. Squid is an SDK and Widget package that ensures secure interchain communication and token transfers independent of consensus and message details. DApps built with Squid are permissionless and immune to oracle censorship, validators or relayers. Squid enables developers to build cross-chain swaps, bridges and generic transactions. Cross-chain SDKs enable day one multichain launches reducing developer overhead and cross chain feature and compatibility rollout giving dApps instant access to increased liquidity pools and user bases. These SDKs serve as friction reduction points in the development pipeline increasing ease and accessibility of development. Utilizing cross-chain development methods like DAOhaus some DAOs began allowing governance votes to be cast from multiple chains, using cross-chain messaging to consolidate results on one main chain broadening their operational functionality and capabilities.

Notable pioneering dApps in 2024

Virtuals.io

Virtuals.io is a decentralized platform designed as a launchpad for co-ownership and management of AI agents across various applications focusing on gaming and entertainment, enabling real-time interactions with users. The platform has several key features including parallel hypersynchronicity, allowing the agents to function as superintelligent entities built upon a tech stack consisting of the parallel processor, a subsystem dedicated to the storage, retrieval, and management of persistent data structures enabling cross-session contextual awareness. The Stateful AI Runner, servers hosting the agents' personalities and the sequencer that processes model linking to achieve desired interaction outcome. The Coordinator synchronization daemon that monitors on and off chain state changes and updates the system. And the long term memory component among others. Virtuals possesses a modular consensus framework with contributions to the system stored as NFTs in the Immutable Contribution Vault. Virtuals.io tech stack, written in TypeScript, JavaScript, Python, and Solidity enables real time adaptation of their agents enhancing relevance, effectiveness, and awareness in various applications.

Pump.fun

Pump.fun is a decentralized platform built on the Solana blockchain that enables users to create and trade memecoins effortlessly. The core technology relies on a bonding curve model, where the initial supply of tokens is placed on a curve that dynamically adjusts prices based on demand; as more tokens are purchased, the price increases exponentially, rewarding early buyers. Once a token reaches a market cap of $69,000, liquidity is added to Raydium, a decentralized exchange on Solana, facilitating broader trading opportunities. Additionally, Pump.fun utilizes Solana's Sealevel architecture for parallel processing of smart contracts, ensuring efficient handling of multiple token creations and trades simultaneously while maintaining security through Solana's decentralized validation system. This combination of features creates a user-friendly environment for launching and trading memecoins with minimal technical barriers.

Gitcoin Grants

The Gitcoin Grants Round GG22 (Grants for Goods) provided valuable insights into developer and community support for various projects. By analyzing the funding distribution across different projects and domains the data can be used as a proxy pulse point of developer interest and focus. GG22 focused on four different categories: Dev Tooling and Libraries, Hackathon Alumni, Web3 Infrastructure, and dApps and apps. The top five of each category were:

Dev Tooling & Libraries	Core Project Theme	Hackathon Alumni	Core Project Theme	Web3 Infrastructure	Core Project Theme	dApps and Apps	Core Project Theme
DefiLlama	Data Access and Analytics	Geist dApp Kit	Reusable dApp component collection	L2BEAT	Ethereum Layer 2 analytics platform	Revoke.cash	Token approval management and wallet security
Passport XYZ	Proof of identity and Sybil Resistance	Warp Ads	Farcaster advertisement protocol	Eth.limo	Privacy focused ENS gateway	Superchain Eco dApps	Superchain native smart accounts
Blocksprout Open Source Block Explorer	Data Access and Analytics	UpStore	Multichain dApp store	Dappnode	Node hosting and management	Hey.xyz	Decentralized permissionless social platform
Ethers.js	Ethereum interface library	Realize It	Community organization and improvement	Ethereum Attestation Service (EAS)	Any subject attestation infrastructure	The Tor Project	Online privacy and anonymity nonprofit
Viem	Ethereum interface library	Postino	Identity verified secure document signing	EthStaker	Ethereum staking education resource	Giveth	Nonprofit crypto donation platform

From these top funded projects we can extrapolate that development trends reflected a strong focus on building scalable, secure infrastructure, alongside robust developer tools to streamline Web3 application creation from start to finish. There is a strong focus on the Ethereum ecosystem, which aligns with the continued stable developer presence on the platform and the continued increase in Layer 2 focus for scalability purposes, necessary for onboarding users to dApps and handling exponentially increasing transaction growth. Privacy and identity solutions gained prominence, with projects addressing identity verification, Sybil resistance, and secure communication. Community-driven initiatives flourished, emphasizing decentralized social platforms, governance tools, and collaboration frameworks. Security also remained a key priority, with advancements in wallet protection, token management, and smart accounts enhancing usability and safety. Additionally, there was a notable emphasis on leveraging blockchain for social impact, as seen in nonprofit-focused projects and crypto donation platforms. Education and knowledge sharing, especially around staking and ecosystem participation, highlighted the growing complexity of blockchain involvement and the community's dedication to clear and accessible learning and documentation.

The dApp development landscape in 2024 witnessed a significant shift towards user-centric solutions, interoperability, and the integration of emerging technologies like AI. Developers are increasingly leveraging modular architectures, cross-chain development tools, and advancements like WASM and zk-SNARKs to build scalable, secure, and feature-rich dApps. The Gitcoin Grants data highlights a strong focus on building robust developer tooling, infrastructure for Web3 applications, and privacy-preserving solutions. As the industry matures, we can expect continued innovation in these areas, along with a growing emphasis on user experience, cross-chain compatibility, and the exploration of novel targeted applications for blockchain technology which will set the stage for continued innovation for 2025.

While the previous sections have detailed the technical achievements and applications that emerged in 2024, these developments didn't occur in isolation. Behind many of these innovations stood organizations and investors who provided crucial resources, guidance, and support to the ecosystem. Understanding the role of these prolific builders and funders provides essential context for how innovation in the blockchain space is cultivated and sustained. By examining the focus areas of leading development organizations, venture capital investments, and accelerator programs, we can better understand the forces shaping blockchain development priorities and the strategic direction of the industry.

Prolific Builders and Funders: Accelerating Towards Tomorrow

In 2024 key organizations and contributors in the blockchain ecosystem helped to shape development trends. By examining prolific organizations, the direction of venture capitalist funding, and accelerator cohorts this section highlights the pulse of forces driving blockchain innovation and explores how their investments and initiatives are driving developer priorities.

Leading Development Organizations

Several organizations stood out for their continued contributions and commitment to blockchain ecosystems, emphasizing open-source community driven development, funding and technical innovation.

Paradigm

A major player in the crypto development ecosystem Paradigm, a research-driven investment firm, has continually invested money and developmental resources into the crypto space since 2018. Their focus on technical areas like mechanism design and security make them a valuable resource to the developer community, especially with their open-source contributions to the space. Paradigms continual support and promotion of valuable developer tools like Foundry, a rust based toolkit for Ethereum dApp development, RETH, an implementation of the Ethereum protocol in Rust, and WAGMI, a well fleshed out Web3 development library, among others signal help to push ecosystem development, giving developers valuable and continually supported tools to build with. With over 1,500 followers on github and over 12,000 stars across all associated repositories Paradigm's open-source contributions signal significant development and developer interest with the developer community, especially those that program in Rust, Solidity, Python, Go, and TypeScript.

A16z Crypto

Andresseen Horowitz's crypto division continues to drive innovation and contributions. Launching large-scale crypto focused funds with billions of dollars of capital as well as open-source contributions like Helios, a lightweight portable multichain Ethereum client, Halmos, a symbolic testing tool for EVM contracts, and zkdrops, zero-knowlege private airdrops for Ethereum a16z touches multiple lanes of blockchain development from privacy integrative solutions to full protocol support and RPC providers with over 1,300 GitHub followers and over 11,000 stars across all repositories. Their frameworks show significant developer interest and are especially beneficial for developers interested in Ethereum development across languages like Rust, Python, Solidity, JavaScript, and TypeScript.

Ithaca.xyz

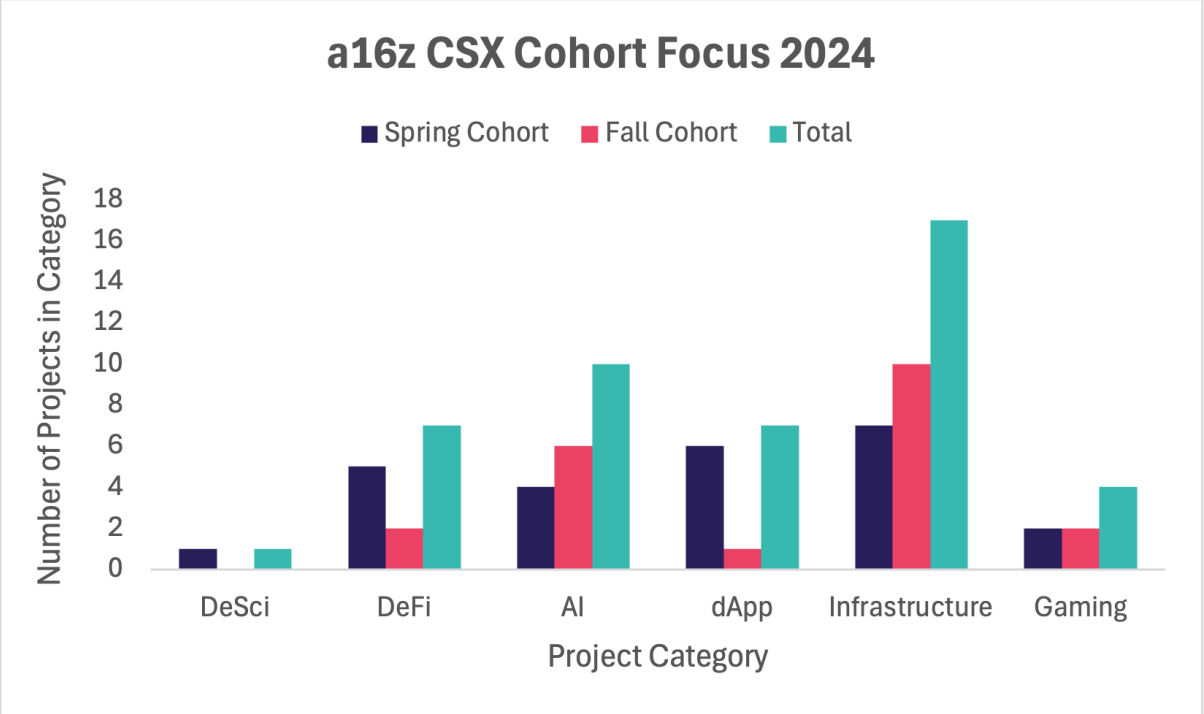
While Ithaca is a relative newcomer to the cryptocurrency space; they have quickly established themselves as a potentially significant contributor to the blockchain ecosystem. Sponsored by Paradigm with an $20 million investment, indicating Ithica's potential, Ithica focuses on accelerating crypto development believing in sustainable open-source development and incentive systems for commercial experiences. They do this by building, co-designing, and implementing open-source developer tool stacks. With 356 followers on GitHub and contributions like Odyssey, an open-source testnet OP stack Layer 2 enabling bleeding edge Ethereum EIP research without node forking, and Porto, a highly experimental "next-gen" account for Ethereum written in TypeScript that enables authentication, payments and, account recovery to be integrated into existing toolkits and workflows, Ithica positions themselves as a bleeding edge development team with a growing project base and increasing interaction in the blockchain ecosystem.

2024 Acceleration Cohorts

Accelerators and incubators play a pivotal role in shaping the trajectory of blockchain development. By funding and mentoring early-stage startups, they help identify emerging trends, support technical innovation, and provide resources to scale promising ideas. The 2024 accelerator cohorts across the space highlighted the growing emphasis on AI integration, decentralized governance, interoperability, and modular architectures.

A16z's CSX Accelerator (Spring and Fall 2024 Cohorts)

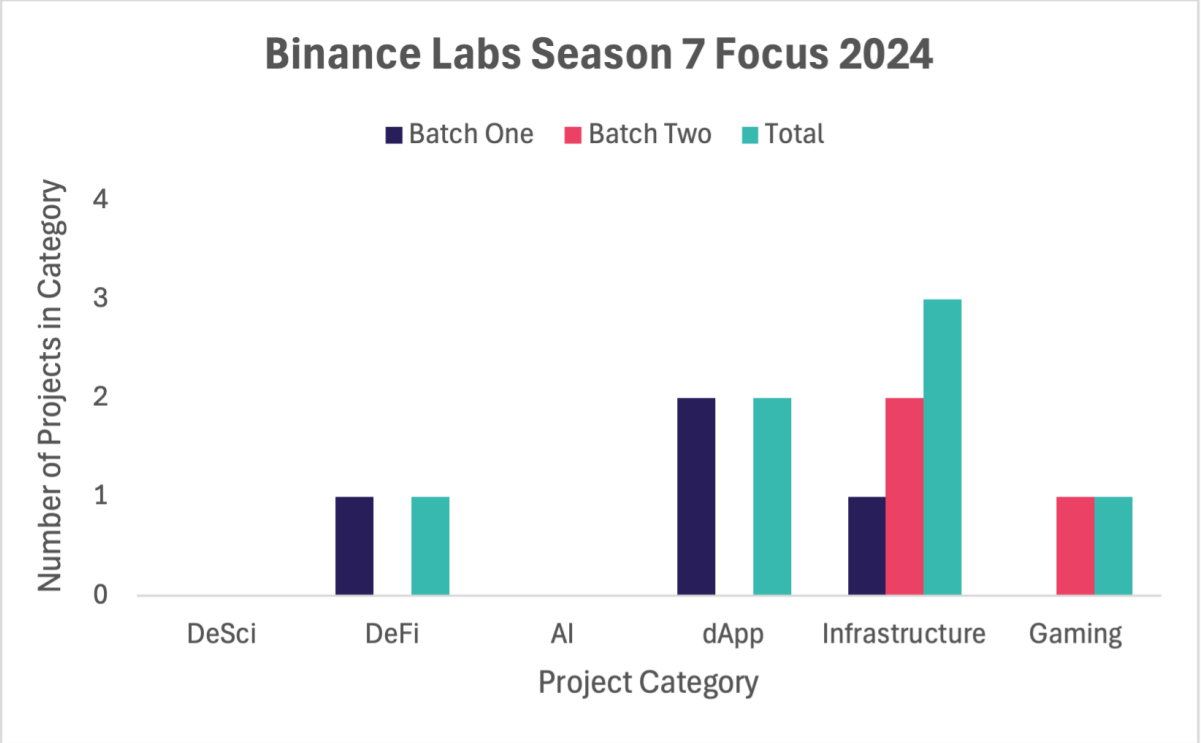
The a16z's two CSX accelerator cohorts this year included a wide variety of projects, totaling over 40 startups from over 11 countries worldwide. The resulting submissions for CSX created two cohort groups, Spring and Fall 2024, containing 25 and 21 startups respectively. The overall focus of the two cohorts varied slightly, though infrastructure was the leading overall category in both Spring and Fall with 7 and 10 infrastructure projects in each cohort. Behind infrastructure, Spring led with targeted dApp use cases, and DeFi projects. This varies from the Fall cohort, which while still leading with an increased number of infrastructure projects the secondary focus switched from dApps and DeFi to AI, mirroring the broader development and market shift to hype behind Artificial Intelligence and Agentic capabilities.



Binance Labs Season 7

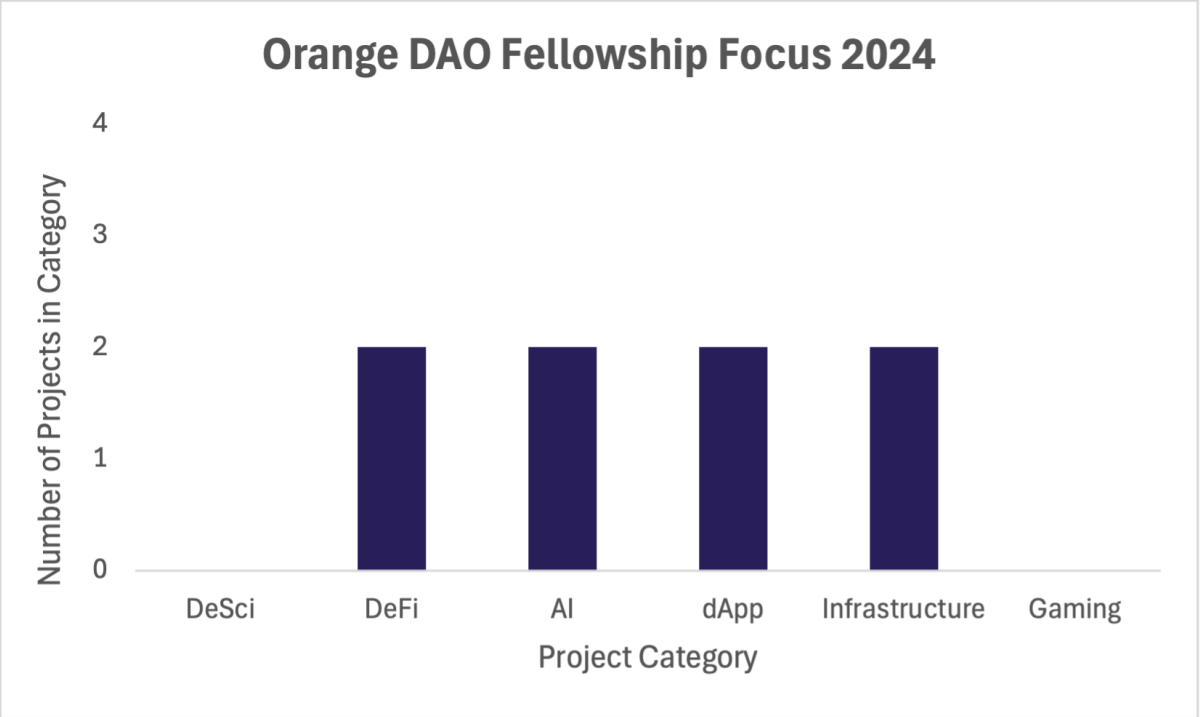
While a small cohort of projects was chosen in 2024 compared to other cohorts, Binance Labs focused on several small high quality projects choosing to incubate and accelerate only four projects in their season 7 batch one and three projects in their season 7 batch two. The projects chosen by Binance Labs in 2024 focused predominantly on dApps and infrastructure development with an equal split of two and two for both categories in both

batches with infrastructure taking a slight overall lead with three infrastructure focused development projects, DILL, Arc, and Flux Layer. The outliers out of the batches were Gaming and DeFi with one project under each category, those being Ton Ton Games and EigenExplore.



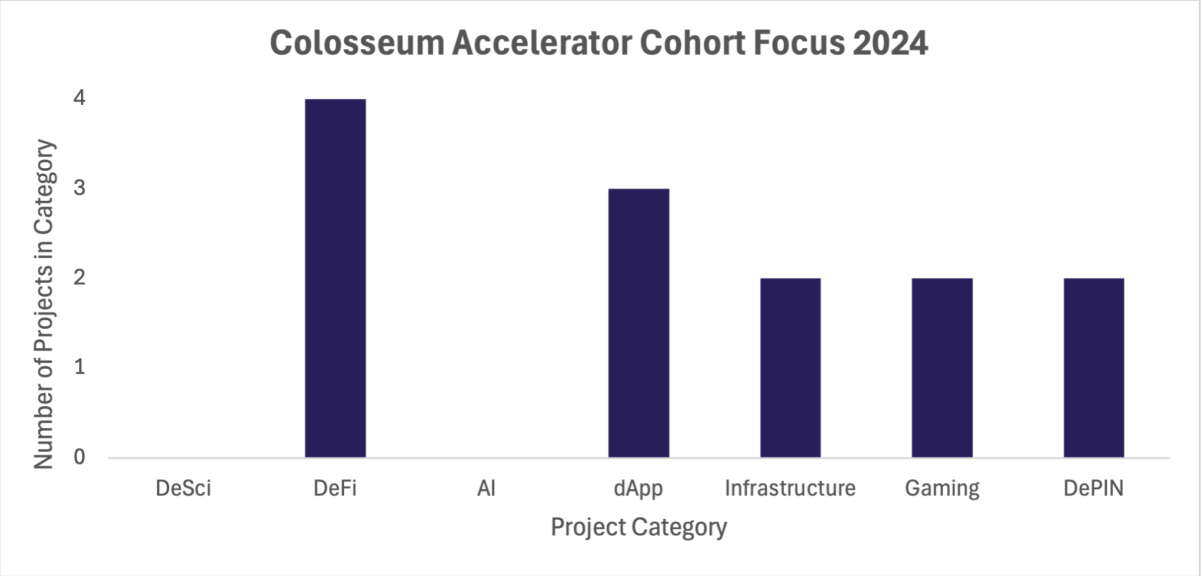
Orange DAO Fellows

In 2024 Orange DAO, a community driven venture capital platform aiming to democratize and revolutionize investments in the DeFi and Web3 space, hosted their third fellowship accelerator program resulting in a cohort of eight projects spread evenly across multiple sectors including DeFi, AI, dApps, and infrastructure. This even split demonstrates a well rounded cohort for the relatively new OrangeDAO, founded in 2022, which makes sense as they establish themselves as a DAO and project accelerator and look to focus on emerging technologies in blockchain poising themselves to support unique DeFi uses, the AI trend and focused dApp development among others.



Colosseum

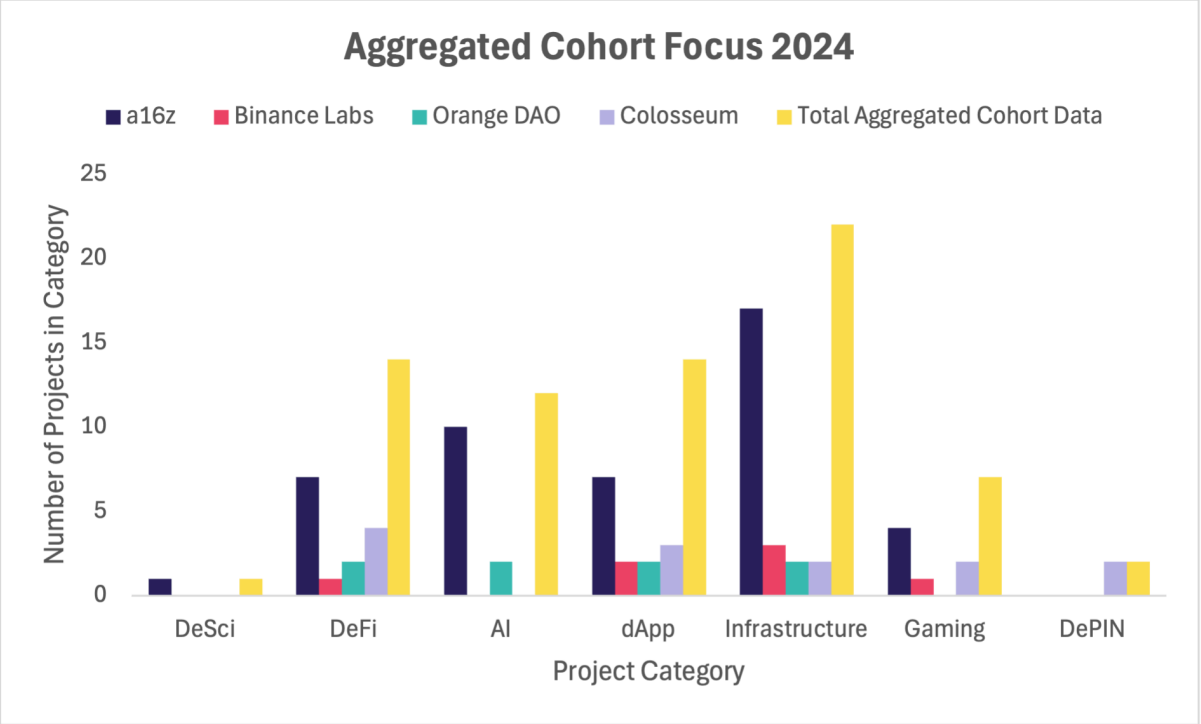
Considering that Solana attracted most new developers in 2024 it was no surprise that Colosseum, a Solana based acceleration platform announced their second accelerator cohort in 2024. In 2024 Colosseum took founders from the Solana Radar Hackathon where over 1,000 teams submitted projects with 39 awarded judge prizes. From that pool of winners Colosseum selected 13 startups to accept into the accelerator program that they believed could enrich the Solana ecosystem. Of those 13 projects, projects related to DeFi and dApps took the lead, a choice that made sense given the increased activity that the Solana ecosystem saw in 2024. Trailing behind those use cases Colosseum evenly accepted projects across the domains of infrastructure, gaming, and DePIN, highlighting an accelerator portfolio that pushes into time-sensitive market applicable domains while retaining emerging and essential projects.



Accelerator and Funding Trends from 2024

2024 saw a dynamic shift in crypto development, with AI emerging as a dominant force alongside the continued importance of infrastructure. Accelerators like a16z CSX reflected this trend, showcasing a growing interest in AI-powered applications within the crypto space. This suggests that developers are increasingly exploring the intersection of AI and blockchain, seeking to leverage AI's capabilities for tasks like decentralized AI governance, on-chain machine learning, and the development of more intelligent and user-friendly dApps. Simultaneously, the continued emphasis on infrastructure development highlights the ongoing need for robust and scalable solutions to support the growing demands of the crypto ecosystem. This presents exciting opportunities for developers specializing in areas like blockchain scalability, interoperability, and security, as these foundational technologies are crucial for the long-term growth and adoption of crypto.

The direction of VC funding closely mirrors the development trends observed in these accelerator cohorts. The significant investment in AI-focused projects, particularly within the a16z CSX program, indicates that VCs anticipate a surge in AI-powered crypto applications. This will likely drive further development in areas like decentralized AI, on-chain machine learning, and the creation of more sophisticated and user-friendly dApps. Moreover, continued investment in infrastructure projects suggests that VCs recognize the critical role of robust and scalable blockchain technologies in supporting the long-term growth of the crypto ecosystem. This will likely incentivize developers to focus on improving scalability solutions, enhancing interoperability between different blockchains, and strengthening the security of existing and emerging blockchain platforms. As VC funding continues to shape the crypto landscape, developers can expect to see increased demand for skills and an increase of development frameworks in these areas, along with a growing emphasis on building innovative solutions that leverage the power of AI and other cutting-edge technologies when interfacing onchain.



Looking Forward: The Evolution of Crypto Development in 2025

As we analyze the trajectory of blockchain development throughout 2024, several key trends emerge that will likely shape the ecosystem in 2025. The convergence of artificial intelligence with blockchain technology, the continued emphasis on scalability through zero-knowledge proofs, and the growing focus on cross-chain interoperability point toward a transformative year ahead for crypto development.

The AI-Blockchain Convergence Accelerates

The integration of artificial intelligence with blockchain technology, which gained significant momentum in 2024, is poised to deepen substantially in 2025. The success of projects like Eliza and the growing adoption of AI-powered dApps suggests that developers will increasingly focus on creating more sophisticated on-chain AI applications. We can expect to see:

The emergence of standardized frameworks for deploying and managing AI agents on-chain, building upon the foundational work done by projects like Eliza and Virtuals.io in 2024. These frameworks will likely emphasize modularity and cross-chain compatibility, allowing AI agents to operate seamlessly across different blockchain environments.

Advancements in decentralized machine learning infrastructure, enabling more complex AI models to be trained and deployed in a distributed manner. This will likely lead to new primitives for privacy-preserving AI computation and data sharing across blockchain networks.

Integration of large language models (LLMs) directly into smart contract development and testing processes, potentially revolutionizing how developers write and audit code. This could lead to more robust and secure smart contracts while reducing development time.

Zero-Knowledge Technology Matures

The significant developments in zk-SNARKs technology during 2024, particularly with dynamic zk-SNARKs and SNARKtor, signal a maturing zero-knowledge ecosystem. In 2025, we anticipate:

Widespread adoption of zero-knowledge proofs beyond privacy applications, with increased focus on scalability solutions and cross-chain communication. The success of protocols implementing these technologies suggests that zk-rollups will become increasingly prominent in the scalability landscape.

Simplification of developer tools for implementing zero-knowledge proofs, making the technology more accessible to mainstream developers. This will likely lead to an explosion of privacy-preserving applications across different sectors.

Integration of zero-knowledge proofs with AI systems, enabling privacy-preserving machine learning and creating new possibilities for confidential computing in decentralized environments.

Cross-Chain Development Becomes Standard

The trend toward multi-chain development, with one-third of developers working across multiple chains in 2024, indicates that cross-chain compatibility will become a standard requirement in 2025. We expect:

Further maturation of cross-chain development tools and frameworks, building upon the success of platforms like LI.FI and Squid. These tools will likely become more sophisticated, offering seamless integration across an even broader range of chains.

Emergence of new standards for cross-chain communication and asset transfer, potentially leading to more efficient and secure bridge protocols. This could help address the security concerns that have historically plagued cross-chain bridges.

Increased focus on cross-chain governance mechanisms, allowing DAOs and other decentralized organizations to operate more effectively across multiple blockchain networks.

Developer Tools and Infrastructure Evolution

Based on the strong focus on developer tooling seen in Gitcoin Grants and accelerator programs throughout 2024, we anticipate significant evolution in development infrastructure:

Greater adoption of WebAssembly (WASM) across blockchain platforms, continuing the trend observed in 2024. This will likely lead to more efficient smart contract execution and broader language support for blockchain development.

Advancement in debugging and testing tools, particularly for complex cross-chain applications and AI-integrated systems. These tools will become increasingly important as applications grow more sophisticated.

Emergence of new frameworks for managing decentralized physical infrastructure networks (DePIN), building upon the groundwork laid in 2024.

Market Dynamics and Developer Distribution

Several key trends in developer distribution and market dynamics are likely to continue shaping the ecosystem in 2025:

Asia's growing influence in blockchain development, particularly from India, is likely to continue expanding. This could lead to new innovation hubs and different approaches to blockchain application development.

The trend of experienced developers (those with more than two years in the space) becoming more prevalent suggests that 2025 will see more sophisticated and production-ready applications being built.

The success of Layer 2 solutions and the continued growth of networks like Solana indicates that competition for developer attention will intensify, potentially leading to more innovative developer incentive programs.

Challenges and Opportunities

As the ecosystem evolves, several challenges and opportunities will likely emerge in 2025:

The need for standardization across AI-blockchain interfaces will become more pressing as integration deepens. This presents an opportunity for early movers to establish industry standards.

Security considerations for cross-chain applications and AI-integrated systems will require new approaches to auditing and risk management.

The growing complexity of blockchain applications will demand more sophisticated development tools and educational resources, creating opportunities for tools and platform developers.

The convergence of these trends suggests that 2025 will be a pivotal year for blockchain development, characterized by deeper integration with AI, mature zero-knowledge implementations, and increasingly sophisticated cross-chain applications. Developers who position themselves at these intersections will likely find significant opportunities for innovation and growth in the evolving blockchain ecosystem.

Conclusion: The State of Crypto Development in 2024

The blockchain ecosystem in 2024 demonstrated remarkable acceleration and innovation, characterized by significant technical advancements and a maturing developer landscape. Despite experiencing a seven percent overall decrease in total blockchain developers, the industry saw a notable twenty-seven percent increase in experienced developers, signaling a consolidation of talent and expertise within the space while still remaining welcoming and open to newcomers.

The year was marked by several transformative developments that have set the stage for future growth. The successful implementation of major protocol upgrades, particularly Ethereum's Dencun upgrade and Solana's Firedancer, demonstrated the ecosystem's commitment to addressing scalability and performance challenges. The emergence of sophisticated developer tools and frameworks, especially in areas like WebAssembly and zero-knowledge proofs, has lowered barriers to entry while enabling more complex applications.

Perhaps most significantly, 2024 saw the beginning of a meaningful convergence between artificial intelligence and blockchain technology. Projects like Eliza and Virtuals.io among others, showcased the potential for intelligent, autonomous systems operating within decentralized environments, while accelerators and venture capital firms increasingly focused on supporting projects at this intersection.

The rise in cross-chain development activity, with one-third of developers now working across multiple chains, reflects a broader trend toward interoperability and composability. This shift away from chain-specific development suggests a future where blockchain applications seamlessly span multiple networks, unlocking new possibilities for innovation and user experience.

As we look toward 2025, the foundations laid in 2024 position the blockchain ecosystem for continued evolution. The combination of experienced developer growth, sophisticated technical infrastructure, and emerging technological convergences suggests the industry is entering a period of sustainable, focused development characterized by practical innovation and increased real-world utility while still always remaining on the bleeding-edge.

The state of crypto development in 2024 thus reflects an industry in transition – one that is increasingly focused on building robust, scalable solutions while embracing new technological paradigms. This maturation, coupled with ongoing innovation in areas like AI integration and cross-chain development, indicates an ecosystem poised for continued growth, evolution, and developer involvement in the years ahead.