SOON:
Bring Solana Everywhere

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Abstract

The scalability and performance limitations of current blockchain virtual machines, such as the Ethereum Virtual Machine (EVM), pose significant challenges to mass adoption. This whitepaper introduces SOON's Super Adoption Stack (SAS), a comprehensive solution that leverages the Solana Virtual Machine (SVM) to address these challenges.

By decoupling the SVM's execution environment from Solana's consensus layer, we enhance performance, scalability, and flexibility. The decoupled architecture enables efficient state verification using tailored Merkle Patricia Tries and robust security through fault-proof mechanisms.

SAS comprises three core components: the SOON Mainnet, a general-purpose Layer 2 that settles on Ethereum; the SOON Stack, a modular SVM rollup stack allowing deployment of SVM-based Layer 2 chains on any Layer 1; and InterSOON, a cross-chain messaging protocol ensuring seamless interoperability between networks.

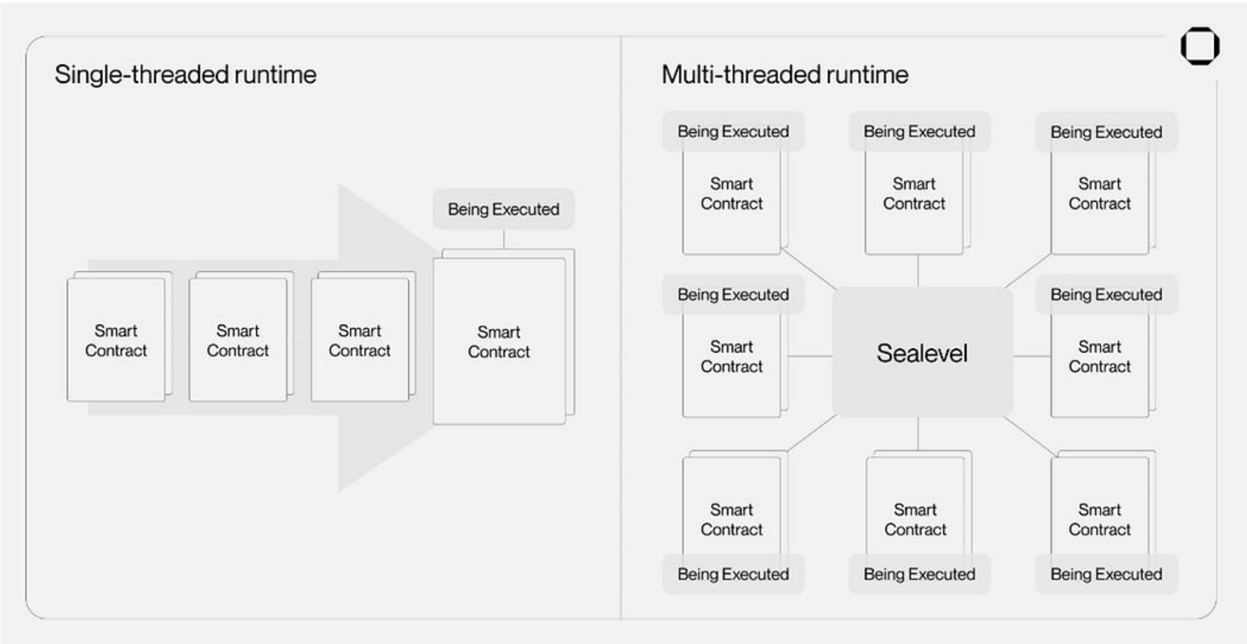
The integration of Sealevel's parallel processing in SVM provides unprecedented transaction throughput, overcoming the sequential execution constraints of traditional VMs. By standardizing SVM across major ecosystems and enabling interoperability, SOON lays the groundwork for a fully interconnected blockchain infrastructure, advancing toward mass adoption and unlocking the full potential of decentralized technologies.

Introduction

What is SVM?

The Solana Virtual Machine(SVM) stands at the heart of the Solana blockchain's operations, playing a crucial role in handling transactions and the execution of smart contracts, also known as programs. Distinguished from the traditional Ethereum Virtual Machine (EVM) used by blockchains such as Ethereum, the SVM propels Solana ahead in performance metrics.
At the heart of the Solana Virtual Machine's revolutionary performance lies Sealevel, a cutting-edge parallelization mechanism designed to leverage horizontal scaling capabilities within Solana's execution environment. This forward-thinking technology facilitates the simultaneous execution of numerous smart contracts, ensuring they operate independently without impeding each other's efficiency through parallel processing techniques.

The genius of Sealevel arises from its sophisticated approach to managing transactions and smart contracts by predefining the data interactions — both reads and writes — before execution. This foresight allows Sealevel to identify and segregate non-overlapping transactions, enabling them to be processed in parallel, even if they access the same data for reading purposes. Consequently, this innovation markedly amplifies SVM's capacity to process a vast quantity of transactions concurrently, reaching into the tens of thousands, and setting a stark divergence from the sequential execution model employed by EVM.



Source: Squads

Solana Virtual Machine brings an innovative approach to handling transaction fees, courtesy of its unique architectural design. This innovation has given rise to localized fee markets within the Solana ecosystem, allowing transaction fees to be determined on a per-smart-contract basis. By implementing a localized fee market, the Solana Virtual Machine essentially transforms block space into a non-homogeneous resource, a benefit that is clear and significant.

Other Blockchain Virtual Machines

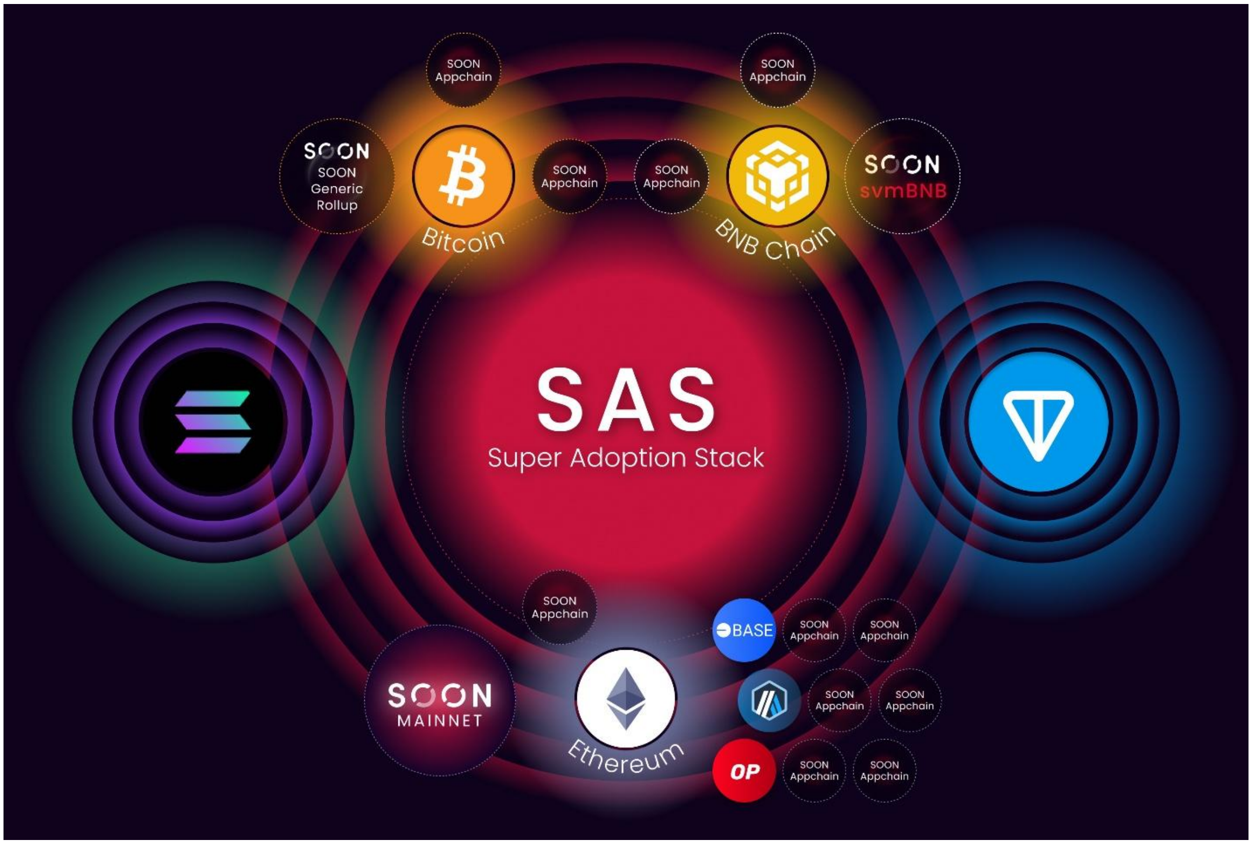
There are many types of virtual machines (VMs) in the current blockchain ecosystem. Among the most widely adopted are the Ethereum Virtual Machine (EVM), Solidity-based zk-VMs, newer zk-VM variants, and the MoveVM, among others.

The Ethereum Virtual Machine (EVM) is widely regarded as a cornerstone of the blockchain ecosystem due to its large and active developer community, extensive suite of decentralized applications (dApps), and well-established tooling. These elements provide newcomers and projects with a robust network of support and resources. However, the EVM faces notable performance bottlenecks, particularly in the areas of transaction throughput and execution efficiency. Its single-threaded execution model can lead to network congestion and higher fees when demand spikes, making it challenging to handle high transaction volumes. Although Layer 2 solutions, sharding, and other scaling approaches can help alleviate these issues, ensuring the right balance between decentralization, security, and enhanced scalability remains an ongoing challenge for the EVM ecosystem.

While zk VMs and other virtual machine technologies have gained attention for their potential to enhance privacy and scalability, they face several limitations that may hinder their development and widespread adoption. zk VMs, or zero-knowledge virtual machines, employ sophisticated cryptographic techniques to ensure privacy and scalability. However, the complexity of these techniques makes the development and maintenance of zk VMs significantly more challenging. Developers need specialized knowledge in cryptography and zero-knowledge proofs, which are not as widely understood or accessible as the skills required for developing on more established platforms like the EVM or SVM. This steep learning curve can slow down innovation and the rollout of zk VM-based applications.

The biggest problem with zk VMs today is their economic impracticality. The cost of operating zero-knowledge proofs is prohibitively high, making it difficult to achieve large-scale applications that could drive down these costs through economies of scale. Without widespread adoption and significant usage, the expenses associated with zk VMs remain elevated, hindering their ability to reduce proof costs and making them less viable for broader implementation.

SOON Vision — Super Adoption Stack



Our longstanding goal has been to drive the mass adoption of crypto and blockchain. We believe that achieving this requires two essential components.

- First, introduce high-performance execution environments — specifically, the Solana Virtual Machine (SVM) — to all major L1 ecosystems. This serves as the foundational performance layer for achieving mass adoption. To achieve this goal, we have chosen to promote the standardization of SVM.
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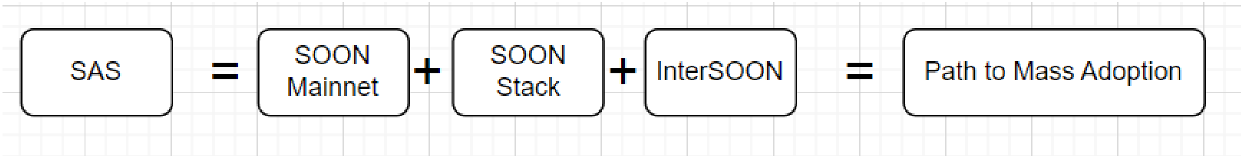
- Second, establish interoperability between these SVM chains and all major L1s to enable seamless interaction. This forms the foundational communication layer for achieving mass adoption.

Introducing SVM-based L2 solutions into ecosystems like Bitcoin, Ethereum, and TON is crucial, as we believe SVM represents the ultimate evolution for all virtual machines. SVM's performance advantages significantly reduce interaction costs, addressing the long-standing performance bottlenecks in blockchain. With leading L1 ecosystems already achieving a high degree of decentralization and sufficient security guarantees, the integration of SVM creates a solid foundation for achieving mass adoption. SOON Mainnet and the SOON Stack are critical to solving this challenge, enabling developers to deploy SVM across any L1s.

The second condition involves the introduction of a cross-chain communication protocol, ensuring that developers can interact seamlessly across different stacks without being confined to isolated ecosystems. This goal is realized through our product, InterSOON.
SAS is designed as a comprehensive suite of interoperable tools to create a fully interoperable blockchain ecosystem. It combines three core components:

- **SOON Mainnet** — SOON Mainnet is a general-purpose Layer 2 that settles on Ethereum.
- **SOON Stack** — SOON Stack is a modular SVM rollup stack allowing for an SVM Layer 2 to be deployed on any Layer 1.
- **InterSOON** — A cross-chain messaging protocol that ensures smooth interaction between networks. It enables interoperability between SOON Mainnet, the SOON Stack, and other L1s, connecting them all in one seamless interface.



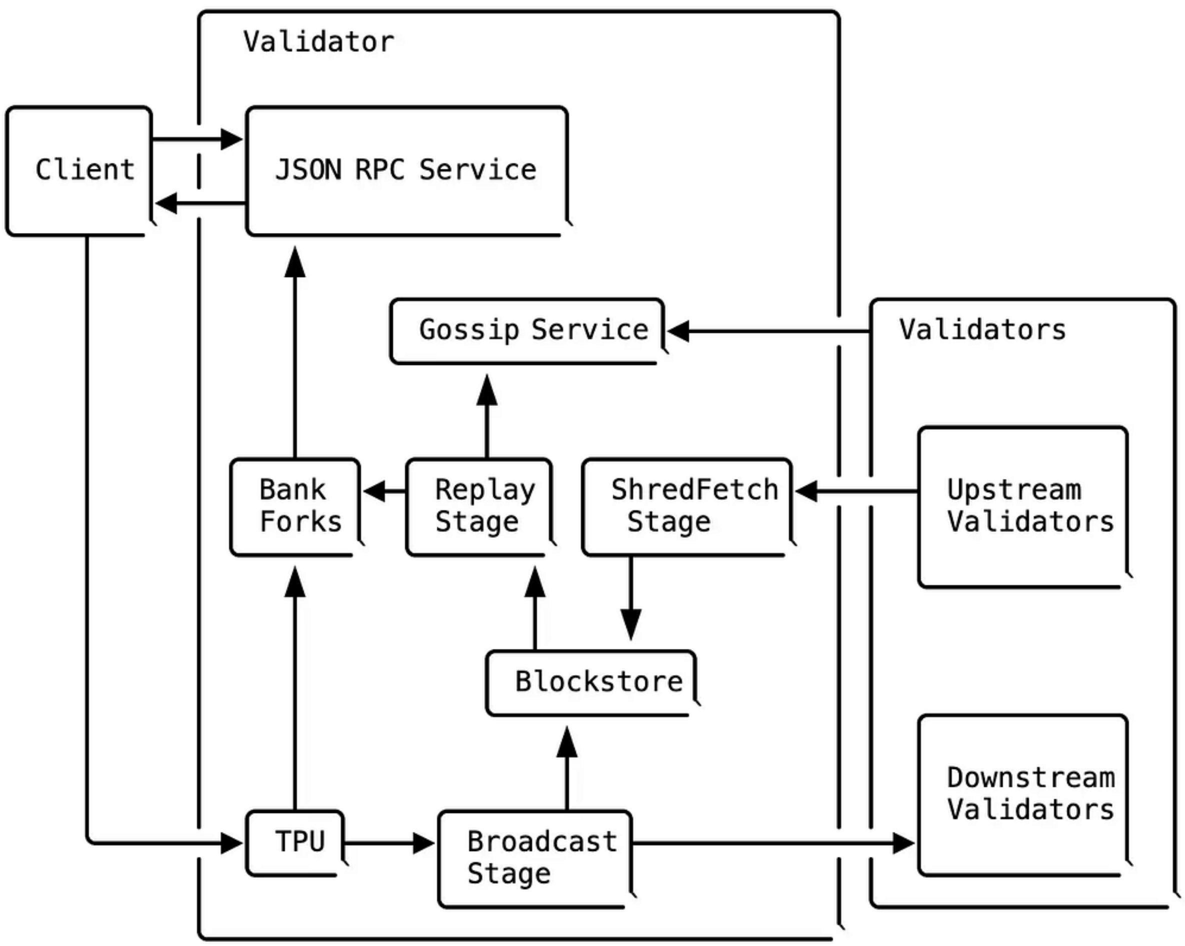
Standardization of SVM: SOON Way

SOON promotes SVM standardization by decoupling the SVM's core execution environment from Solana's consensus layer, constructing a derivation pipeline, and ensuring security through the implementation of a fault-proof system. Inspired by the OP Stack architecture, SOON's main innovation lies in building the first SVM rollup stack by separating the SVM core execution environment from Solana. SOON also addresses Solana's merklization challenges and creates the conditions necessary for horizontal scaling.

Technical Architecture

Structure of Solana Validator

Validators play a crucial role in Solana's architecture, serving as the core components for achieving consensus, verifying transactions, and maintaining the network state. Validators ensure transaction validity and consensus by running multiple modules. Solana's validator structure is relatively complex, integrating the execution environment (SVM) and consensus mechanisms (Tower BFT and PoH).



Source: Solana Docs[1]

- **Json RPC Service**: The client (such as a wallet or dApp) sends requests to the Solana validator through this service. This service serves as the external interface for the Solana system, handling requests like submitting transactions, querying account statuses, and retrieving block information.
- **TPU (Transaction Processing Unit)**: This is the core module responsible for receiving and executing transactions. It integrates the SVM, sorts transactions, and processes their

execution logic. In the TPU, transactions are first sorted and packaged, then executed in the SVM environment. The transaction results generate state changes, which are submitted to the consensus module in the form of state roots, ultimately reflecting in the entire network's state.

- **Bank Forks**: This module handles chain state forks when the network experiences state divergences (e.g., when multiple validators produce blocks simultaneously).
- **Gossip Service**: This protocol manages communication between nodes in the Solana network, propagating the latest state, transactions, and block information across the validator network. Validator nodes receive blocks and transactions from other nodes through this service, ensuring the network's state consistency.
- **Other Consensus-related Processes or Modules**: The Replay Stage re-verifies transactions packaged in blocks, ensuring data consistency by replaying transactions.Validator continuously obtains transaction information, executes, verifies, and accepts information from other nodes, and finally reaches a consensus under the Tower BFT and PoH consensus to produce blocks.

In Solana's architecture, the execution layer (SVM) is tightly coupled with the consensus layer. However, for Optimistic Rollups, many of these modules are unnecessary. In an Optimistic Rollup, after receiving a transaction, a Rollup node can immediately execute, package, and produce a block without the need for consensus. The only requirement is to periodically submit verifiable transaction batch data and state root information to the DA layer or L1 while ensuring access to deposit and withdrawal transactions, transaction batch data, and state root information from L1 or the DA layer. Combined with the fault proof mechanism, this is enough to ensure security.

Decoupled SVM Architecture

How to decouple SVM?

To decouple Solana's core execution environment (SVM) from Solana, the first step is to remove the consensus-related modules from the Solana validator and reassemble the rest. The next step is to build the mechanism for L2 to derive information from L1, which is the derivation proces. Lastly, the fault proof mechanism needs to be constructed. With these elements in place, SOON can achieve an extremely flexible and secure Optimistic Rollup. This is the work that SOON has undertaken.

Decoupled SVM architecture separates the SVM as core execution layer from the underlying consensus layer. This separation allows the execution layer to operate independently, enabling enhanced performance, scalability, and efficiency.

Key Benefits of Decoupled SVM

- **Enhanced Performance and Scalability:** By decoupling, the SVM can process transactions more efficiently and scale independently of the consensus layer or settlement layer, supporting higher throughput and accommodating growing application demands.
- **Improved Security:** Decoupled SVM supports fault proof mechanisms, enabling validators to verify transaction integrity independently. This ensures the reliability and consistency of the blockchain, mitigating risks associated with tightly coupled architectures.
- **Greater Flexibility:** Developers can optimize and customize the execution environment, facilitating innovation and supporting a diverse range of decentralized applications. The architecture allows integration with various Layer 1 networks and data availability layers.
- **Efficient Resource Utilization:** Removing consensus-related components from the execution layer frees computational resources, resulting in a more responsive and robust system.

Derivation Pipeline

Although in the process of decoupling the execution and consensus layers, L2 can independently produce blocks, the security of the system still relies on the derivation pipeline of L1.

The derivation pipeline resolves the potential security and consistency issues that may arise during L2's independent block production. Specifically, the derivation pipeline provides a trusted foundation for L2's block generation. Even if L2 does not wait for L1's real-time confirmation, it can still ensure the legality and security of transactions through derived data. When independent verifiers replay transactions and discover discrepancies between L2's data and what was submitted to L1, the derivation pipeline provides sufficient data support, allowing fault proofs to be raised and triggering a rollback mechanism. Without this derivation process, L2 cannot guarantee the verifiability of its data, and fault proofs would become meaningless.

SOON has restructured the block derivation layer in engineering and designed a complete interface system to support key processes such as derivation, packaging, and fault proofs. This section will explain in detail how SOON's derivation layer obtains and processes data from Layer 1 (L1) and integrates it into Layer 2 (L2) block production processes, ensuring system consistency and security.

During the block derivation process in SOON, L2 block production relies on key information derived from L1. This information includes L1 block headers, deposit transactions, data availability batch information, and more. These data are parsed and packaged into L2 blocks to complete final block production. The specific process is as follows:

Derivation

The first step in derivation is to obtain the latest block header from L1 and extract the key information needed for derivation. This information includes:

- **Block header**: Metadata of the block, used to confirm the block's timestamp and basic information.
- **Deposit transactions**: Cross-chain deposit transactions that occur on L1 need to be reflected in the accounts on L2.
- **Data availability batch information**: Critical information about data availability to ensure that data on L2 can be correctly accessed and verified by validators.

Packing
After parsing and obtaining the derived information from L1, L2 needs to package this information with regular transactions submitted by L2 clients (i.e., transactions initiated by users on L2). During the packaging process, the system processes transactions from multiple sources, including:

- **L1-derived data**: Such as block headers, deposit transactions, etc.
- **L2 local transactions**: Regular transactions submitted by users on L2, which enter the packaging process through L2's TransactionStream.

Finally, these transactions are combined into a standardized block payload, which is ready for execution and processing.

Transport and Production
The packaged BlockPayload is sent to SOON's core module—Engine—which is a kernel module implementing the EngineAPI interface. The Engine module is responsible for executing the packaged transactions on the SVM and generating the final block. During this process, the system handles transaction execution, reorganization (Reorg), and final block confirmation.

Transaction Execution
Through the new_block function in the EngineAPI interface, the system can generate a new block based on the received BlockPayload and add it to the L2 blockchain. During this process, SVM ensures the correctness of transaction execution and verifies state updates.
In certain cases, the system may need to reorganize the L2 blockchain, which usually occurs when L1 experiences a reorg, requiring L2 to synchronize with L1's state. The final step in block production is block confirmation and finalization.

SOON's derivation layer not only supports block production and reorganization but also ensures system security through a fault-proof mechanism. Independent validators can replay L2's transactions based on the state root and transaction batches submitted through the derivation layer to verify the correctness of the data. If discrepancies are found between L2's submitted data and the actual execution results, validators can initiate a challenge by submitting a fault proof.
Fault Proof Process:

1. **Validators replay transactions**: Using transaction data derived from DA Layer, validators can replay L2 transactions, compute the state root, and compare it with the submitted results.
2. **Submit fault proof**: If a discrepancy is found, validators can submit a fault proof through L1, requesting a system rollback.
3. **Block rollback and reorganization**: Once the fault proof is verified, the system will trigger a block rollback mechanism, cancel the erroneous block, and use the derivation mechanism to ensure data consistency.

Merklization

Merklization organizes blockchain data into Merkle trees, enabling efficient and secure verification of transactions and states through succinct proofs.

Solana's Merklization poses several challenges. Firstly, it merklizes transactions into multiple roots per block, complicating the creation of global state proofs. Additionally, state roots are calculated only once per epoch (approximately 2.5 days) and are not included in block headers. This absence of state roots in block headers makes verifying state and inclusion proofs difficult

SOON's Merklization Solution

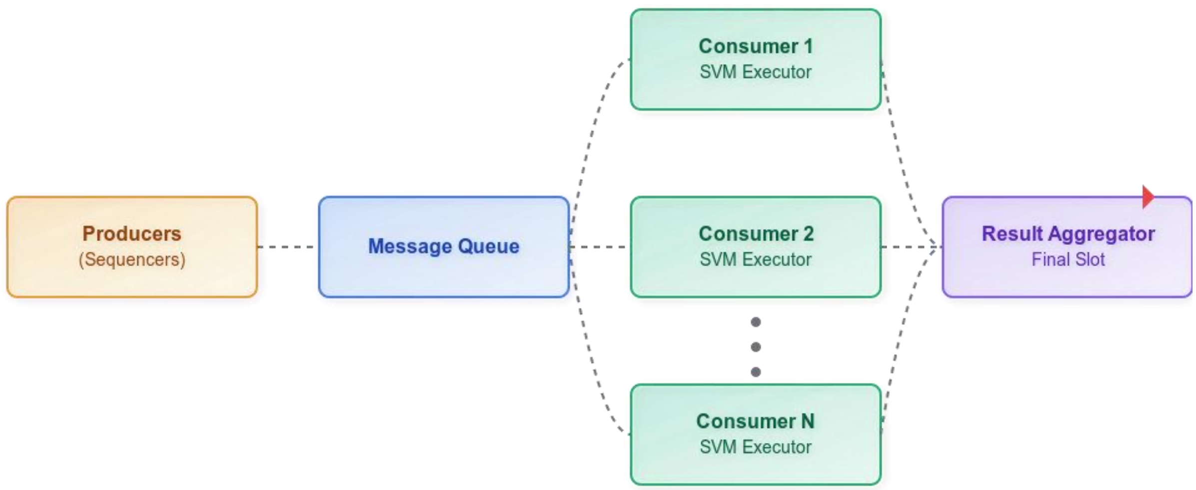
SOON integrates Merkle Patricia Tries (MPT) tailored for Solana's account structure to efficiently manage and verify state. It introduces UniqueEntry traits to embed state roots directly into SVM-based blockchains, enabling seamless state tracking. Every 450 slots, SOON computes and submits state roots and withdrawal roots to Layer 1, ensuring consistent and verifiable state updates.

Benefits of Merklization in SOON:

- **Enhanced Security:** Enables robust inclusion and fraud proofs, ensuring transaction and state integrity.
- **Improved Scalability:** Efficient state management supports high transaction throughput and seamless Layer 1 integration.
- **Interoperability:** Aligns with Ethereum's MPT model, facilitating cross-chain operations and compatibility with existing blockchain infrastructures.
- **Support for Light Clients:** Consistent state roots enable the development of light clients, enhancing accessibility and security.
- **Trustless Interactions:** Ensures secure bridging between Layer 2 and Layer 1 through Merkle trees, enabling trustless verification of withdrawal transactions.

Horizontal Scaling

Horizontal scaling involves expanding a system's capacity by adding more machines or nodes to the network, rather than enhancing the power of individual machines. This approach distributes the workload across multiple nodes, allowing the system to handle increased demand efficiently. Unlike vertical scaling, which is limited by the physical and economic constraints of single machines, horizontal scaling offers virtually unlimited growth potential by leveraging the collective resources of the network.

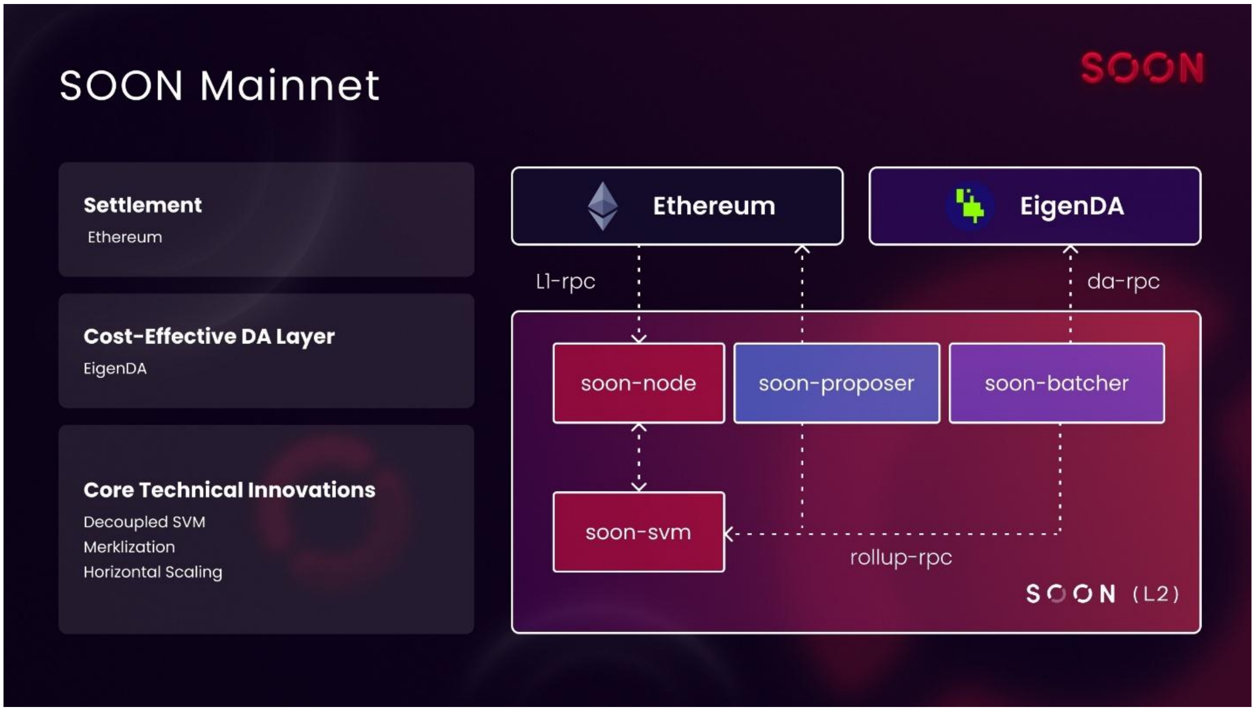


Benefits of Horizontal Scaling:

- **Unlimited Growth Potential:** By adding more nodes, the system can scale indefinitely, accommodating growing user bases and transaction volumes without being restricted by the limitations of individual machines.
- **Improved Reliability and Redundancy:** Distributing the workload across multiple nodes reduces the risk of single points of failure, enhancing the overall resilience and uptime of the network.
- **Enhanced Performance:** Load distribution ensures that no single node becomes a bottleneck, maintaining consistent transaction processing speeds even as the network expands.
- **Cost-Effective Expansion:** Utilizing standard, commodity hardware allows for scalable growth without the need for costly upgrades to existing infrastructure.
- **Flexibility and Adaptability:** Horizontal scaling supports dynamic adjustments to the network, enabling seamless integration of new nodes and resources as demand fluctuates.

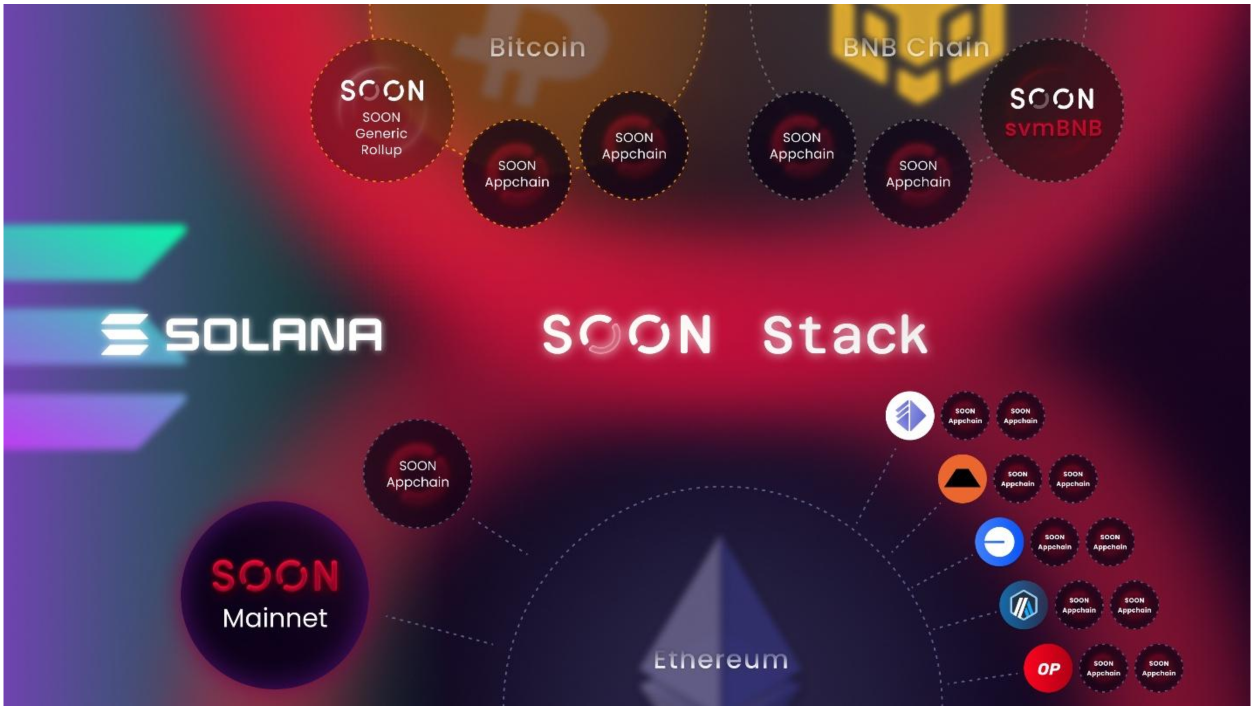
SOON Mainnet

SOON Mainnet is a general-purpose Layer 2 that settles on Ethereum, with its core execution layer powered by Decoupled SVM.



We believe that the SVM offers the most effective path toward widespread blockchain adoption, based on its active user base, ecosystem quality, and significant transaction throughput. Achieving true adoption requires more than just Solana-based builders — it requires participation from Ethereum (EVM) developers and builders across other major ecosystems. This is precisely where the SOON Mainnet come into play: enabling developers to leverage the benefits of SVM.

SOON Stack



SOON Stack is the collection of infrastructure that allows for the deployment and running of an SVM Layer 2 on top of any base Layer 1. Chains deployed using the SOON Stack are referred to as SOON Chains. SOON Stack now supports Ethereum as the settlement layer, AltDA solutions like EigenDA, supported by Caldera and Altlayer. In the future, we will expand to more L1 and DA. We will also continue to include more excellent RAAS providers. By SOON Stack, projects can launch SVM-based Chains with unprecedented simplicity. SVM's high performance and flexibility make it an ideal execution layer for a wide range of use cases:

- **Customizable Consumer Applications:** Applications that require fine-tuned control over transaction costs, such as custom gas fee structures tailored to user needs, can leverage SVM to achieve a seamless user experience.
- **High-Performance Applications:** Use cases such as gaming, where real-time responsiveness and scalability are critical, can benefit greatly from SVM's parallel processing capabilities.
- **Financial and Trading Platforms:** Transaction-heavy applications like DeFi protocols and trading systems can utilize SVM's efficiency to handle high throughput and low latency operations, ensuring optimal performance under heavy loads. As the first truly functional SVM Rollup Stack, the potential use cases extend far beyond those listed above. We look forward to seeing more builders explore the vast possibilities of SVM, and we are committed to providing strong support for these innovations.

Available RAAS supporting SOON Stack

Caldera

Caldera's RAAS services now support the SVM via integration with SOON Stack.It's Caldera's first integration with an AltVM ecosystem beyond EVM. Caldera is the fastest-growing rollup ecosystem on Ethereum, empowering web3 teams to launch high-performance, customizable, application-specific rollups with its 1-click rollup deployment platform. With over 75 modular rollups in its network, Caldera powers an ecosystem of unified rollups that share collective network effects and enjoy greater efficiency, scalability, and security.

Altlayer

Altlayer supports SVM via integration with SOON Stack. AltLayer is backed by leading investors including Polychain Capital, and Hack VC. With AltLayer, projects can deploy their SVM-based rollup chains with ease. In addition, through AltLayer's AVS services, these Rollup Chains can benefit from a decentralized and highly secure sequencer infrastructure.

InterSOON

InterSOON is a cross-chain messaging protocol that ensures smooth interaction between networks. It enables interoperability between SOON Mainnet, the SOON Stack(SOON Chains), and other L1s, connecting them all in one seamless interface. InterSOON's underlying cross-chain messaging is supported by Hyperlane.

Current interoperability solutions such as interoperability systems, token bridges, and wrapped assets have significant limitations that hinder the realization of seamless asset sharing across blockchains.

To overcome these challenges and build a truly interoperable blockchain ecosystem, we choose to make InterSOON a cross-chain messaging protocol. This approach eliminates the need for duplicated assets or centralized custodians, enabling native, standardized interaction between blockchains. By allowing smart contracts and assets to interact seamlessly across networks, message-level communication ensures smooth and transparent transactions, unlocking the potential for more complex cross-chain interactions beyond simple token transfers.

Key Features

- **Unified Communication Standard:** InterSOON enables different blockchains to communicate using a standardized messaging layer, eliminating the need for developers to build custom bridges or wrapping mechanisms for each new chain.
- **Preserved Liquidity:** By keeping assets in their native form across chains, InterSOON avoids the liquidity fragmentation caused by traditional token bridges. Assets can move freely between chains while maintaining their original liquidity, providing a more efficient and transparent cross-chain experience.
- **Enhanced Performance:** The Decoupled SVM brings unprecedented performance improvements to cross-chain interactions by enabling chains to communicate without the technical overhead of bridges or token wrapping. This reduces transaction fees and increases the scalability of cross-chain DeFi applications.

Conclusion

The blockchain landscape is at a pivotal moment, seeking solutions that enable mass adoption while overcoming inherent scalability and performance challenges. Traditional virtual machines like the EVM have established a foundation but face limitations in throughput and efficiency. Emerging technologies such as zk VMs offer potential improvements but are hindered by economic and developmental barriers that impede widespread adoption.

SOON presents a transformative approach with its Super Adoption Stack (SAS), aiming to standardize the Solana Virtual Machine (SVM) and introduce it across major Layer 1 ecosystems. By decoupling the SVM's core execution environment from Solana's consensus layer, SOON enhances performance, scalability, and flexibility. This decoupling allows for efficient state verification using tailored Merkle Patricia Tries (MPT) and ensures robust security through fault-proof mechanisms.

The SOON Mainnet, a general-purpose Layer 2 settling on Ethereum, leverages the high throughput and efficiency of the SVM to significantly reduce interaction costs and alleviate performance bottlenecks. Complementing this, the SOON Stack provides a modular rollup stack that enables the deployment of SVM-based Layer 2 chains on any Layer 1 blockchain, empowering developers across various ecosystems to harness the power of SVM and fostering innovation in high-performance applications.

Recognizing the importance of seamless interoperability, InterSOON introduces a cross-chain messaging protocol that ensures smooth interaction between the SOON ecosystem and other Layer 1 networks. By facilitating standardized, message-level communication, InterSOON overcomes the limitations of traditional interoperability solutions, preserving liquidity and enhancing the performance of cross-chain interactions without the need for duplicated assets or centralized custodians.

By addressing the fundamental challenges of performance, scalability, and interoperability, SOON lays the groundwork for a fully interconnected and efficient blockchain infrastructure. Its innovative approach not only enhances the capabilities of the blockchain ecosystem but also brings us closer to achieving mass adoption, realizing the full potential of decentralized technologies. SOON envisions a future where the SVM becomes the standardized execution environment across major blockchain ecosystems, unlocking unprecedented performance and scalability while fostering a new era of blockchain innovation and collaboration.

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