Evaluating Solana for Enterprise Use: A Comprehensive Guide

What's this Article About?

Enterprises looking to integrate blockchain technology into their operations are considering Solana for its speed and cost-effectiveness. Solana is a strong contender for enterprise adoption, and has been growing in popularity recently.

In this article we'll examine the unique features and advantages that make Solana a viable option for enterprises. We'll also look at real-world case studies of companies that have successfully integrated with Solana, explore why existing blockchain projects are migrating to Solana, and how new Ethereum scaling solutions are finding value through the Solana Virtual Machine (SVM).

Why Should I Choose Solana?

Solana is designed for scalability as it offers high transaction speeds, low latency, and affordable fees. It also focuses on optimizing on-chain storage, maintaining a high level of decentralization, and minimizing its environmental impact.

In this section, we'll cover:

- Speed and Latency
- how Solana achieves high transaction throughput
- Transaction Fees
- the predictability and affordability of transaction fees
- State Compression
- optimizing on-chain storage
- Decentralization
- the network's level of decentralization
- Regarding Criticisms of Centralization
- addressing common concerns of centralization
- Energy Efficiency
- Solana's approach to sustainability

Speed and Latency

Speed is essential for enterprises. Slow transactions can hinder innovation and the practical use of blockchain technology. For instance, delays in transaction times can be problematic if wait times exceed the time users would expect to be waiting while using traditional systems.

Solana is designed for high transactions throughput. It averages 400 user-generated transactions per second (TPS) and can peak at over 2000 TPS. In terms of raw TPS (including vote transactions made by validators for consensus), Solana averages ~4000 TPS. Solana has a theoretical upper bound of 710 000 TPS on a standard gigabit network, and 28.4 million TPS on a 40 gigabit network. The network has the potential to reach these high speeds, thanks to innovations such as Firedancer, a new validator client created by Jump Crypto. For context, Ethereum's network, including all its sidechains, averaged ~42 TPS in the last month

While high Solana's TPS is impressive, it is not the sole metric that should be considered. For instance, a blockchain could process a block once an hour with a million transactions in the block and still get around ~275 TPS. This impressive statistically, however, it falls short for any consumer-grade experience.

What distinguishes Solana is its focus on low-latency transaction confirmation, measured by its slot times. A slot refers to the time it takes for each ledger to ingest transactions and produce a block. Solana aims for a target slot time of 400 milliseconds. In practice, it can vary between 500-600 milliseconds based on network demand, however this is still faster than other leading blockchains. For context, Bitcoin has a 10 minute block time and Ethereum averages a 12 second block time. The synergy of robust TPS and minimal slot times positions Solana as a highly responsive and cutting-edge piece of blockchain technology.

Unlike traditional blockchains that process transactions one at a time, Solana's runtime, Sealevel, is designed to process transactions in parallel. Sealevel achieves this by using as many cores as are available to the validator. Solana transactions specify all the states that they will interact with, allowing non-conflicting transactions to be processed simultaneously.

Proof of History (PoH) also helps to enhance Solana's speed. PoH is a cryptographic time-stamping function for transactions that allows nodes to agree on an order of events without talking to one another. This speeds up transaction confirmation times without compromising security or scalability.

Solana excels in transaction finality — the time it takes for a transaction to be confirmed on the network. For example, in a deep dive on Solana, Visa analyzed blockchain confirmation time in blocks and seconds/minutes using data provided by Circle. Visa noted that USDC on Solana took an average of ~0.4 seconds and 1 block to confirm. In comparison:

- USDC and EUROC on Avalanche took ~2 seconds and 1 block to confirm
- USDC on Stellar took ~5 seconds and 1 block to confirm
- USDC, EUROC, and ETH on Ethereum took ~3 minutes and 12 blocks to confirm
- Bridged USDC on Polygon took ~30 minutes and 372 blocks to confirm

Not only is Solana fast, but it outperforms every other blockchain in terms of transaction finality.

Transaction Fees

Solana's transaction fees are notably low, often falling below $0.001 USD, with the average non-voting fee floating around the 0.000005 to 0.00007 SOL range. At a SOL price of $23.75, this translates to approximately $0.000119 to $0.00168 USD.

What distinguishes Solana is the predictability of its fees. The network uses localized fee markets to manage demand, ensuring that only transactions trying to access a specific piece of high-demand state will see increased fees. This localization differs from gas-based networks, such as Ethereum, where users have paid upwards of $150 million USD collectively for failed transactions during periods of high demand in the past. Solana maintains low fees by isolating congestion and creating localized fee markets based on areas of state contention rather than using a global fee market.

Solana offers both low and predictable fees.

State Compression

Solana's ledger serves as a historical record of all transactions since the network's inception. State refers to a dynamic snapshot of this ledger, adjusting to real-time operations such as transfers and program execution. State compression is Solana's way of optimizing on-chain storage by using cheaper ledger storage space. Unlike traditional compression, Solana converts large sets of ledger data into a cryptographic hash. This hash is stored on-chain in state using a specialized data structure known as a Concurrent Merkle Tree. This data structure allows for quick updates and verification against a secure record of recent changes, known as a changelog.

This approach is cost-effective because it allows developers to use less expensive ledger storage instead of pricier account-based storage. State compression has led to innovative use cases such as enabling Dialect users to share NFT stickers on a mass scale, and DRiP's weekly airdrops of free collectibles to thousands of users. Messari notes that in Q3 2023 almost 45 million compressed NFTs were minted on Solana.

This unique approach to optimizing on-chain storage offers distinct advantages that are only possible on Solana.

Decentralization

Solana operates as one of the largest Proof of Stake (PoS) networks in the world by node count. It is considered one of the most distributed networks, with its level of decentralization quantified using the Nakamoto Coefficient, a metric that measures the minimum number of entities needed to compromise the network. As of September 6th, 2023, the Solana Foundation has Solana's Nakamoto Coefficient at 31.

The network is validated by nearly 2000 nodes located in over 40 different countries with different hosting arrangements at various locations. At the time of writing this article, there are currently 1965 validator nodes

securing the network

according to Solana Beach. Solana Beach has Solana's current Nakamoto Coefficient lower at 22, which is still one of the highest on the market.

Validator client diversity is another factor that enhances network resilience. Validator clients are applications that validators use to participate in consensus by proposing and attesting blocks. Validator client diversity leads to greater network resilience since a bug or vulnerability in one client will not cripple the entire network. Solana launched with one validator client developed by Solana Labs. Since then, there have been several independent efforts to create additional full or light

validator clients:

- Jito Labs - released a second validator client to mainnet in August 2022. It is a fork of the Solana Labs client that is maintained and deployed by Jito
- Firedancer - an independent validator client being developed in C++ by Jump Crypto. The client is capable of processing up to 1.2 million raw TPS and 600k after deduplication in testing
- Sig - an intelligently optimized Solana validator client written in Zig. The client is still a work in progress but its progress can be monitored here. Syndica's validator team introduced theirinitial implementation of their gossip protocol for Sig in September 2023
- TinyDancer - an open-source light client implementation for Solana. Their goal as a light client is not to produce blocks and participate in consensus. Instead, TinyDancer aims to make it easier for users to verify the state of a blockchain without having to run a full node themselves. TinyDancer is still in active development and champions itself as the first light client for Solana

Stake Distribution

It is crucial to not overlook the impact of external factors such as geopolitics, natural disasters, and corporate strategies. Operating a node involves more than just hardware and software - it also involves a significant human element.

Solana's high-performance requirements mean that many validator operators opt to lease server space from specialized data centers. This is a common practice across various blockchains, where the bulk of computational power is often outsourced to data centers. This is concerning as data center owners could potentially wield considerable influence over the blockchain's operations. It is advisable for stake distribution to be as decentralized as possible, particularly among companies that provide server leasing services. This approach helps to ensure a more resilient and democratic network as the network is less susceptible to single points of failure or control.

An Autonomous System (AS) consists of a server network identified by a unique routing number, known as an ASN. A single ASN can cover multiple physical locations, depending on the setup of internal networking and routers.

Solana's stake is relatively distributed among ASNs with no AS hosting close to 33.3% of active stake. Three data centers could, however, collude to amass more than 33.3% of stake and compromise the network.

A blockchain must be geographically diverse to maintain uninterrupted operation amid world events. For example, in January 2022, top Bitcoin mining pools lost an average of 10% of their hashrate in 24 hours on January 6th. This decline was attributed to political turmoil in Kazakhstan, who previously accounted for 18% of Bitcoin's global hashrate.

Solana boasts a diverse geographical distribution with no single country holding more than 33.3% of the active stake. The United States, however, has seen a substantial rise in active stake, and when combined with Canada, accounts for 34.3% of the active stake. To address this, the Solana Foundation is actively monitoring the situation and is implementing measures such as aiding stake pools in enhancing geographical decentralization through their scoring algorithms.

Regarding Criticisms of Centralization

Solana has faced criticisms regarding its level of decentralization, earning nicknames such as "SQLana." These criticisms often focus on Solana's architecture and governance, rather than the network's level of decentralization. For instance, Solana's initial close ties with FTX have been cited as a point of centralization. This, however, overlooks the fact that FTX has also invested heavily in other blockchain projects, suggesting a broader commitment to the blockchain ecosystem than what is being conveyed by these criticisms.

Solana has faced scrutiny for past network outages, raising questions about the network's resilience. In response, Solana has implemented a number of upgrades to strengthen its network. Since the adoption ofQUIC, for example, Solana has had no downtime related to spam or DDoS attacks, and has maintained 100% uptime for the past 8 months.

The network's high hardware requirements for validators has also been cited as a potential issue that could lead to it being centralized around a few well-funded entities. To address this, Solana's 1.16 update to the Solana Labs validator client has significantly reduced RAM requirements, making running a validator more accessible for a diverse range of participants. This is due to the fact that Solana relied on a validator's RAM for indexing accounts previously, but has now re-configured account indexing to a validator's disk by default. Yanshu from Luganodes has reported since the release of the 1.16 update their validator is running smoothly on just ~39 GB of RAM, compared to ~120 GB on previous versions:

By addressing these concerns, Solana continues work on enhancing its network's decentralization and resilience.

Energy Efficiency

A prevalent critique of blockchain technology centers on its high energy consumption. The competitive nature of Proof of Work (PoW) blockchains has given rise to massive Bitcoin mining farms that have had a detrimental impact to the environment. A single Bitcoin transaction, for instance, consumes an average of 5 billion Joules of energy. Projects such as

Ethereum have recognized these environmental concerns and have transitioned from a PoW system to Proof of Stake (PoS) through a process known as The Merge. This shift has resulted in a 99.84% reduction in the Ethereum network's energy consumption. Even after this transition, the average Ethereum transaction still consumes around 144 000 Joules.

In stark contrast, Solana is energy efficient. The average energy used per a transaction on Solana is only 658 Joules of electricity. The average energy used per non-voting Solana transaction (i.e., user-generated transactions) is only 7568 Joules. To put this in perspective, the energy used for a single Solana transaction is comparable to a few online searches. That's less energy-intensive than fully charging an iPhone or leaving an LED light bulb on for an hour.

The Solana Foundation is committed to neutralizing Solana's carbon impact. Solana is the first Layer 1 blockchain withreal-time energy emissions tracking. The emissions tracker software is embedded directly on Solana nodes offering dynamic and detailed metrics that are free to access. These metrics include RPC node emissions, emissions granularity, marginal (or consequential) emissions, embodied emissions, and Power Usage Effectiveness (PUE). The Solana Foundation encourages all projects and validators to examine their emissions data and adopt mitigation strategies. For instance, Orca has created the Orca Climate Fund (OCF), a community-driven initiative aimed at fostering a more sustainable climate.

The OCF is not an isolated effort; Solana boasts a growing climate-focused ecosystem. Some prominent climate-focused projects on Solana include:

- GainForest - a Swiss non-profit organization that leverages the transparent nature of Solana and artificial intelligence to help fight deforestation
- WaterDAO - a water credit verification body that works towards more decentralized and regenerative water infrastructure
- Sunrise Stake - a regenerative finance dApp aimed at strengthening the Solana blockchain while using staking rewards to offset carbon emissions

As stewards of both technological advancement and environmental sustainability, we have a responsibility to support and invest in solutions that align with these values. Solana's commitment to energy efficiency serves as a model worth considering - it offers a carbon-neutral blockchain solution with an annual carbon footprint of 9579 tons of CO_2 and a net carbon impact of zero. This commitment to energy efficiency is deeply embedded within the network's core architecture, making it a compelling choice for environmentally conscious enterprises.

Solana Permissioned Environments

For enterprises that need to abide by certain regulatory guidelines or compliance requirements, blockchains offer a flexible solution. Blockchains do not have to be a large, permissionless network. Instead, enterprise blockchains can opt for permissioned blockchains where a shared and immutable ledger is used and can be accessed by authorized members only. Network members can control what information is visible to each organization or member, and the actions that each can take. In this environment, business partners don't have to trust one another. Trust is built into the blockchain's design, providing greater transparency and verifiability.

While blockchains have the potential to be cost-effective by streamlining changes and automation, it's important to note that the actual cost savings can vary depending on the specific use cases, existing infrastructure, and a number of other factors relating to operational costs. Nevertheless, blockchains offer the advantage of reducing clerical errors, paperwork, and other administrative overheads.

Solana Permissioned Environments (SPEs) bring the power of Solana to enterprises with custom requirements. Here, enterprises can run their own instance of Solana in a dedicated environment that brings about all the benefits of Solana in a way that is tailored to their specific needs. SPEs offer high throughput, parallelization, affordable fees, fast settlement time, and a low environmental impact.

Solana comes with a suite of native innovations that eliminate the need for third-party tooling. This includes state compression, support for the Solidity programming language, programmatic ways of bridging across different blockchains, and built-in support for zero-knowledge proofs. Solana's new token standard, Token22, introduces a number of features such as confidential transfers and transfer hooks, further enhancing the capabilities of enterprises building in a SPE.

Solana Permissioned Environments are a new solution for businesses using Solana.Contact the Solana Foundation to learn more and see if an SPE is right for your business.

VISA: Why Companies Choose Solana

The growing interest from institutional and enterprise sectors in blockchain technology is evident, regarding payments and digital currencies. Visa, one of the first major payment networks to experiment with stablecoin settlements on Ethereum, has recently expanded its pilot program to include both issuer and acquirer partners as well as Solana. According to Visa's own analysis, Solana is "a blockchain whose innovative design enables it to process over 2k transactions per second."

In Visa's comprehensive review on Solana, they outline the network's potential for payments and success in Visa's

stablecoin settlement pilot. In the review they note “[Solana] holds promise for payments due to its speed, scalability, and low transaction costs, helping to make it a good candidate for efficient blockchain settlement rails using stablecoins like USDC.” The report also compares Solana’s capabilities to other leading blockchains and finds that Solana consistently scores the highest. While Solana’s current throughput doesn’t match Visa’s own capabilities of 65 000 TPS, it has the potential to scale beyond these current limitations. Nevertheless, Visa, a company responsible for moving $14.5 trillion total volume through 200 plus countries worldwide, believes Solana to be a “compelling value proposition for payments

.”

Visa’s interest in Solana is part of a broader trend of corporate adoption. Shopify, for example,has integrated with Solana Pay to open up millions of merchants to a more dynamic and efficient payment choice for their consumers.Discord has also added Solana integration for linked roles, a first for any blockchain. Google Cloud is also operating a block-producing validator on Solana.

As blockchain technology continues to develop and the ecosystem grows, Solana’s high throughput, low latency, low transaction fees, and parallel processing capabilities make it a candidate worth considering for enterprises to integrate into their operations.

Helium: Why Blockchain Projects Choose Solana

Existing blockchain projects are also choosing to migrate to Solana. This was the case withHelium, a decentralized LoRaWAN network that powers individual hotspots in more than 170 countries and 5G service to certain American cities. Helium aims to create decentralized wireless infrastructure to support Internet of Things (IoT) devices. To do this, they created a new protocol dubbed LongFi, which combined the long-range capabilities of LoRaWAN with Helium’s own blockchain. Users could buy and host their own hotspots and receive tokens in exchange for providing nodes for the network. These nodes were akin to miniature cell towers, creating a peer-to-peer wireless network of small, low-power devices connected over very long distances.

HIP 70 was proposed by the Helium core developer team to improve operational efficiency by moving Helium off of its own blockchain and onto Solana. The proposal noted that this migration would allow the Helium ecosystem to achieve higher uptimes

, greater composability

, and a faster user experience

all while maintaining a high degree of security

and low cost of use

. The Helium community voted overwhelmingly in favor of this proposal and Helium migrated to Solana in April 2023. During the migration process, Helium minted each hotspot as an NFT. This was only possible on Solana because of state compression; it was more economically viable to mint compressed NFTs than it was to mint NFTs on any other network by several orders of magnitude. Only on Solana could Helium migrate such a large chunk of state without any issues. Helium Foundation COO Scott Sigel described the migration as having “[n]o hiccups and nothing to report. It was boring! That’s exactly what we were hoping for.”

While the migration to Solana offers numerous advantages, it’s important for projects to consider the complexities and potential challenges involved in such a transition, including compatibility issues, community consensus, and the technical aspects of the migration process itself. This was a huge undertaking by Helium and required careful thought and a thorough migration process. Helium has outlined in their documentation the magnitude of this undertaking with their migration guides. Nevertheless, Helium’s migration was a huge success and greatly benefited the Helium community.

The migration of Helium to Solana is not an isolated event - yes, Helium’s migration was the first of its kind and was an amazing technological feat, however, blockchain projects are choosing Solana.

Maker, for example, is an Ethereum project through and through

. Maker is an Ethereum token that describes itself as “a utility token, governance token, and recapitalization resource of the Maker system.” Maker aims to unlock the potential of decentralized finance by building an inclusive platform, known as the Maker Platform, for economic empowerment and equal access to the global financial market. The Maker Platform consists of MakerDAO (for administering the Maker project) and Maker Protocol (for building and facilitating the use of DAI, “the world’s first unbiased currency and leading decentralized stablecoin”). The founder of Maker, Rune Christensen, caused quite a stir on Twitter in September as he proposed to begin the development of a Maker appchain using a fork of Solana’s codebase:

Given these developments, it’s clear that Solana is becoming an increasingly popular choice for well-established blockchain projects looking to improve operational efficiency, scalability, and user experience. These developments underscore Solana’s growing reputation as a blockchain that can meet the diverse needs of established projects.

Eclipse: Why New EVM Solutions Choose Solana

Despite its widespread adoption, Ethereum faces significant scalability issues that limit its transaction throughput and increases costs. New Ethereum Virtual Machines (EVM) solutions are increasingly turning towards Solana for its unparalleled scalability and efficiency in order to address these concerns.

Eclipse is a new Layer Two solution for Ethereum, powered by the SVM. A Layer Two (L2) is a collective term to describe a specific set of Ethereum scaling solutions. A L2 is a separate blockchain that extends Ethereum and inherits the security guarantees of Ethereum. The goal of L2s is to increase transaction throughput without sacrificing decentralization or security.

The Eclipse team highlights several key advantages of using the SVM over the EVM in theirMirror article:

- Parallel Processing -

the Sealevel runtime allows for parallel transaction processing, which enables the SVM to scale with hardware directly. This is beneficial as processors continue to add more cores at a lower cost and single-threaded runtimes, such as the EVM, fundamentally do not benefit from reducing the cost per core

- State Management
- unlike the EVM where state growth is a bottleneck, Solana's approach to state management is much more efficient. The entire state is merkelized (i.e., hashed into a Merkle tree) after every epoch (~2.5 days), which is cheaper than the real-time merkilization the EVM carries out.
- Dynamic Account Access
- in the SVM each transaction specifies all the state needed for execution, eliminating the impact of state size on performance. This allows for more predictable and efficient transaction processing
- EVM Compatability
- EVM compatibility via Neon EVM, the ability to compile Solidity smart contract code into SVM bytecode viaSolang, and the ability to onboard users using MetaMask Snaps are huge advantages in on-boarding EVM users onto a non-EVM environment
- Security
- Solana's runtime prevents reentrancy exploits, a common vulnerability that plagues the EVM and has lost projects and users millions of dollars in the past
- Efficient ZK Proofs
- the SVM's register-based architecture and smaller instruction set makes it easier to prove Zero-knowledge proofs compared to the EVM

Using the SVM as a scaling solution for EVM makes perfect sense

- it scales better, is more cost-efficient, is more performant, is easy to transition to due to the number of compatibility features, and is conducive to advanced cryptographic features in comparison to other current L2s.

Conclusion

Enterprises face a myriad of challenges and opportunities in today's rapidly evolving digital landscape. From scalability and efficiency to security and decentralization, the demands are ever-increasing. Solana emerges as the only blockchain built for scale, designed to meet and exceed these demands. Its high throughput, low latency, and affordable transaction fees make it a self-evident choice for any enterprise looking to integrate with blockchains. Combined with Solana's steadfast focus on environmentalism, robust security features, and the ability to create customized, permissioned environments makes it clear why Solana is becoming the go-to blockchain for enterprises.

Whether you're an existing blockchain project, such as Helium, or a traditional enterprise looking to explore the benefits of blockchains, like Visa, Solana is the perfect solution. The availability of innovations such as parallel processing and state compression in a single environment is unique to Solana.

As blockchain technology continues to disrupt multiple industries from supply chain management to electoral systems, the question is no longer "Why should I use a blockchain?" but rather "Why shouldn't I use Solana?"

At Helius, we are here to help explore what Solana can do for your enterprise today. Don't miss the opportunity to be at the forefront of this technological revolution. Join our Discord and contact us today to learn more about Solana's most loved RPC nodes, APIs, webhooks, and high-performance infrastructure.

Further Reading / Additional Resources

- Solana Website
- Solana Enterprise
- Solana Permissioned Environments
- Solana Beach - a dashboard for Solana related metrics
- Case Study on GainForest and Solana
- *A Deep Dive on Solana, a High Performance Blockchain Network* by Visa
- *Blockchains are entering their “broadband era”* by Cuy Sheffield, Head of Crypto, Visa
- Only Possible On Solana - Helius