X1 Blockchain

Whitepaper

v1.0 | January 2025

X1 Labs

x1.xyz

X1 Labs

X1 Blockchain: Architecting Economic Efficiency in Layer-1 Protocol Design

Jack Levin and Axel Eckerbom

Abstract

X1 Blockchain is a low-cost, high-speed, high-performance, high-throughput, censorship-resistant and monolithic Layer-1 blockchain designed to enable freedom to transact with minimal technical and economic limitations. As a fork of the Solana open-source project, X1 Blockchain introduces notable enhancements to its economic model and performance architecture, providing an optimized environment for scalability and efficiency. X1 Blockchain is Solana Virtual Machine (SVM) compatible, ensuring that applications built for Solana can seamlessly deploy on X1 Blockchain without modification, leveraging the same execution environment and developer tooling while benefiting from X1 Blockchain's improved design.

Traditional Proof-of-Stake (PoS) networks often face centralization risks due to high validator costs and stake-weighted leader selection, which concentrate power among a small number of participants. X1 Blockchain overcomes these challenges with an optimized validator model that significantly reduces operational costs, ensuring a high Nakamoto Coefficient and strong resistance to censorship. Additionally, X1 Blockchain's low barrier to entry for validators promotes further decentralization by increasing validator participation and enabling fairer access to block rewards.

By maintaining atomic composability and high-speed transaction finality at the base layer, X1 Blockchain eliminates the need for Layer-2 scaling solutions, preserving execution efficiency and interoperability across decentralized applications (dApps).

X1 Blockchain also integrates a dynamic base fee mechanism that efficiently prices block space, reducing spam and mitigating toxic MEV, ensuring sustainable network usage and economic stability. Furthermore, X1 Blockchain addresses MEV centralization by integrating MEV capture and redistribution directly into its native validator offering, reducing proliferation of third-party MEV block-builders and searchers. This ensures fair and decentralized MEV extraction, preventing monopolization by external actors while aligning incentives with network participants.

With its focus on validator accessibility, fair block production, demand-based fee structuring, SVM compatibility, and decentralized MEV design, X1 Blockchain provides a robust and scalable foundation for decentralized applications and next-generation blockchain infrastructure.

1. Introduction

Decentralization and high performance are critical elements in the evolution of blockchain technology. Achieving both simultaneously is a challenge that many existing Layer-1 solutions fail to overcome.

Decentralization ensures a trustless, censorship-resistant ecosystem, while high performance enables real-world scalability and user adoption. A blockchain that lacks decentralization risks becoming another centralized financial system, while one that lacks performance struggles with congestion, high fees, and usability. X1 Blockchain bridges this gap by implementing an architecture that prioritizes both, ensuring an optimized balance between efficiency and decentralized governance.

The blockchain landscape has evolved rapidly, yet existing Layer-1 solutions still struggle to achieve an optimal balance between decentralization, performance, and economic sustainability. Many blockchains either compromise decentralization for scalability, leading to validator centralization, or impose high costs that restrict network participation. Poor protocol decisions in some blockchains have led to fragmented scaling solutions like Layer-2 networks, which are inherently centralized and introduce additional complexity and latency. For example, Ethereum's reliance on a single-threaded execution model requires a significant overhaul to handle high demand, driving the need for Layer-2 solutions that compromise decentralization.

X1 Blockchain is designed to resolve these issues by creating a monolithic, high-throughput blockchain that maintains strong decentralization, lowers operational costs for validators, strives to achieve lower transaction fees, and integrates MEV decentralization protocols as core feature. With its SVM compatibility, X1 Blockchain also ensures a seamless transition for existing Solana-based applications, fostering innovation without the need for significant redevelopment.

2. Optimized Validator Economics

By minimizing hardware and staking requirements as well as operational validator costs, X1 Blockchain reduces barriers to entry for validators, fostering broader participation and a more decentralized distribution of network control. On X1 Blockchain, validators only need to cover server costs, not network participation fees, meaning they can retain more of their rewards relative to the effort applied.

Unlike Ethereum, where staking requires a minimum of 32 ETH and often involves long-duration locking mechanisms, X1 Blockchain has no minimum self-staking requirement and offers flexible staking without lock-ins. This allows a higher percentage of liquid assets to be actively staked, increasing overall network security and validator engagement. This streamlined cost model, combined with flexible and accessible staking policies, not only enhances validator profitability but also reduces financial barriers that typically hinder broader participation. This inclusive approach enables a greater number of participants to join the network without requiring significant capital investments, fostering a more robust and decentralized validator ecosystem.

Additionally, X1 Blockchain enhances accessibility and participation in the blockchain's consensus by providing opportunities for smaller and mid-sized validators to meaningfully contribute to network security and decision-making. By minimizing validator costs and

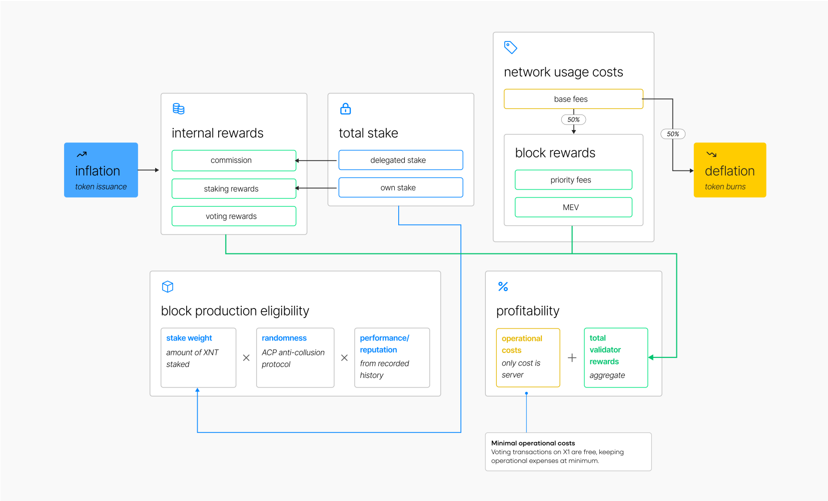

Figure 1: The validator financial model on X1 Blockchain, illustrating how validators earn revenue and profit from network participation.

maximizing financial incentives, X1 Blockchain fosters an inclusive environment that attracts a diverse range of participants to its validator set. This democratization of access directly combats validator centralization, improving the overall resilience and security of the network. Validators need to be profitable in order to sustain operations. If they are not, they are forced to delegate, which creates a centralizing force, leading to a limited number of validators. This results in a validator set that becomes increasingly difficult to scale over time, as only a small number of participants can afford to be part of it.

A key outcome of this design is X1 Blockchain's significantly higher Nakamoto coefficient—a measure of decentralization—when compared to other blockchains [1] that often suffer from lower coefficients due to high financial barriers, such as stake concentration and high validator operation costs. With a larger number of active validators distributed across a diverse network, X1 Blockchain is better equipped to resist censorship, attacks, and validator collusion, offering enhanced security and reliability.

Lower entry barriers also ensure that the network remains adaptable and continuously scalable, as new participants can onboard without being hindered by prohibitive hardware or financial constraints. As a result, X1 Blockchain creates a dynamic ecosystem where validator participation remains balanced, supporting sustainable long-term growth and innovation.

This approach ensures:

- Lower operational costs for validators, improving profitability.
- A diverse validator set that resists censorship and collusion.
- A high Nakamoto Coefficient, reflecting better decentralization than many existing Layer-1 networks.

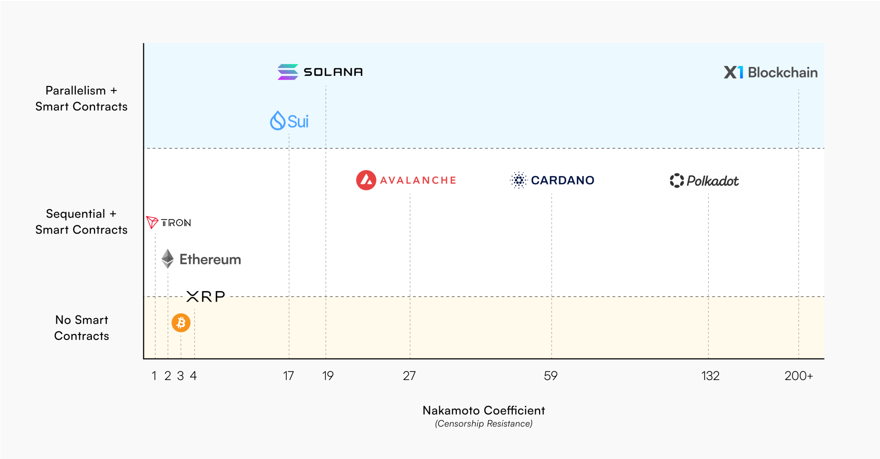

Figure 2: Comparison of the decentralization and censorship resistance of blockchains, as measured by the Nakamoto Coefficient, alongside their parallel processing and smart contract capabilities.

3. Leader Selection Mechanism

X1 Blockchain leverages a monolithic architecture to maximize transaction throughput while maintaining decentralization. Unlike modular blockchains that separate execution, consensus, and data availability layers, X1 Blockchain retains all these functions within a single network, ensuring atomic composability and reducing complexity.

3.1 VRF-Based Leader Selection, Anti-Collusion Measures, and Leader Schedule Optimization

X1 Blockchain employs a Proof-of-Stake (PoS) leader selection mechanism that leverages Verifiable Random Functions (VRFs)—inspired by Cardano's Ouroboros protocol [2]—to ensure fairness, unpredictability, and decentralization in the block production process while maintaining efficiency and security. By integrating the Anti-Collusion Protocol (ACP) into the leader selection mechanism, X1 prevents validators from forming hidden alliances or manipulating stake distributions, reducing centralization risks and promoting a more equitable block production process.

3.2 Key Features

- Enhanced Randomness and Verifiability: X1 Blockchain's VRF-based leader selection enhances randomness and verifiability, ensuring that validators are selected pseudo-randomly based on their stake and performance. Each validator privately generates a random value that determines their eligibility for block production during a given epoch, reducing the risk of centralization and ensuring an unbiased leader selection process.

- Anti-Collusion Protection: The inclusion of the ACP mitigates scenarios where larger stakeholders would otherwise monopolize block production by disproportionately influencing consensus outcomes. Validators are continually monitored, and any signs of collusion or unfair influence trigger mechanisms to rebalance participation, ensuring no entity gains excessive control over the leader schedule.

- Balanced Stake Influence and Randomness: Validators with more stake have a higher probability of selection, but the pseudo-random nature of the VRF, combined with ACP protections, prevents any single validator or group from consistently dominating the network. The inclusion of the VRF proof in the block allows for public verification, ensuring that block producers are selected according to the protocol's rules.

3.3 Performance-Based Leader Scheduling

Building upon this foundation, X1 Blockchain optimizes leader scheduling by dynamically preselecting leaders, ensuring efficient block propagation and minimizing latency. The selection process incorporates performance-based metrics, evaluating validators not only by stake but also by reliability and past contributions. High-performing validators maintain consistent participation, while underperforming nodes are deprioritized without exclusion, preserving network efficiency and resilience.

This dynamic scheduling mechanism adapts to network fluctuations, fostering a robust, decentralized system where fairness and efficiency drive block production.

3.4 Minimizing Centralization Risks

Optimized performance-based leader selection and the fair distribution of block rewards through the Anti-Collusion Protocol (ACP) and Verifiable Random Function (VRF) ensure that validators receive their fair share of rewards while maintaining a decentralized block production process—minimizing the risk of Proof-of-Stake (PoS) centralization over time.

Figure 3: Factors determining block production eligibility on X1 Blockchain. These include stake weight, randomness (via VRF), and performance/reputation from recorded history.

4. Scalable Consensus Mechanism

4.1 Geographic Optimization and VRF-Based Consensus Participation

X1 Blockchain enhances consensus efficiency by implementing a subcommittee-based voting model within its consensus protocol, together with a Verifiable Random Function (VRF)-based validator selection process that considers validator geography.

While validator votes do not directly influence transaction execution—since they operate on separate threads from the four threads dedicated to transactions—a tenfold increase in the validator set would significantly increase the leader's workload, introducing inefficiencies and degrading system performance.

To mitigate this, X1 Blockchain leverages Solana's Proof of History (PoH) [3] as a cryptographic clock to structure voting more efficiently. PoH provides a linear, verifiable sequence of events, allowing validators to incorporate a specific target PoH hash in their block votes. This target hash is pseudo-random, universally fair, and resistant to manipulation, ensuring vote integrity. As a result, the leader processes only a subset of votes based on the designated target hash, significantly reducing computational overhead while preserving validator participation. Importantly, all validators still receive rewards for their votes, maintaining incentives and ensuring equitable participation without unnecessary resource strain.

4.2 Addressing Consensus Complexity

Beyond immediate optimizations, this methodology addresses the inherent quadratic complexity of traditional consensus models, where consensus complexity scales as $O(n^2)$ due to the need for all validators to communicate across the network. Without intervention, as the validator set expands, the sheer volume of communication required would exponentially increase, even if transaction throughput remains constant.

A widely adopted solution—seen in protocols such as HotStuff2 [4], Avalanche's "neighborhoods"[5], and Ethereum's attestation committees—is to introduce subcommittees. This refinement reduces consensus complexity from $O(n^2)$ to $O(k^2)$, where k represents the subcommittee size.

4.3 Optimizing Consensus for Scalability

By structuring consensus around dynamically formed, efficient voting groups, X1 Blockchain optimizes scalability, minimizes latency, and significantly reduces the computational load on block leaders. This subcommittee-based structure ensures that consensus remains both performant and decentralized, even as network participation scales over time.

5. Dynamic Base Fee Mechanism

X1 Blockchain employs a dynamic base fee mechanism inspired by Ethereum's EIP-1559 to optimize transaction pricing and ensure network sustainability. Unlike other blockchains where base fees are set too low, leading to unchecked spam transactions, X1 Blockchain enforces a base fee that dynamically adjusts based on compute units (CU) and overall

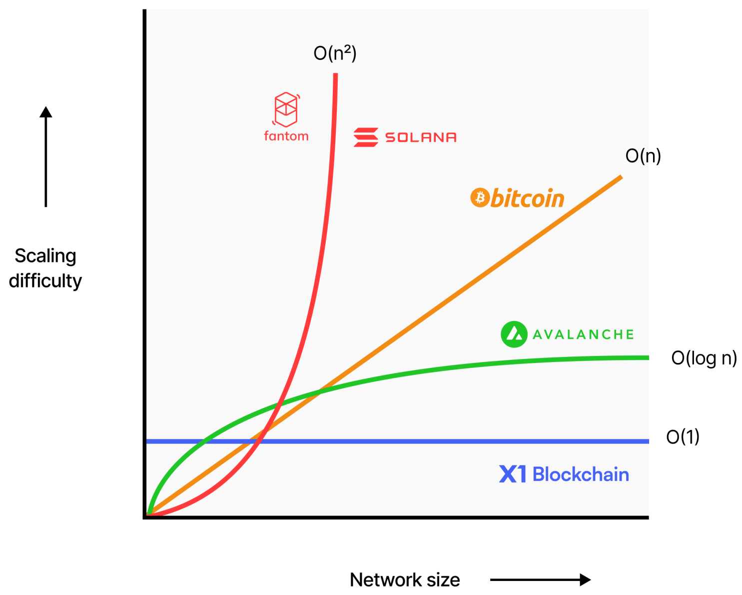

Figure 4: Comparison of how different blockchains scale based on Big O Notation. X1 Blockchain achieves O(1) complexity, indicating minimal scaling difficulty with increasing network size, while other chains such as Solana and Fantom face O(n^2) complexity.

blockchain load. This ensures that transaction fees accurately reflect network resource consumption, preventing congestion and enhancing economic efficiency.

By implementing an adaptive auction system, X1 Blockchain dynamically prices block space, leveraging statistical analysis of compute units (CU) and real-time network activity. This dual-factor pricing model ensures that fees are allocated efficiently and fairly, preventing manipulation and enabling sustainable network usage. Additionally, a portion of the transaction fees is burned, reducing native token net-inflation and promoting long-term economic stability.

5.1 Key Benefits of this Approach

- Efficient Block Space Pricing: Implements a dual-factor pricing system that considers both computational demand and overall network load, preventing unnecessary congestion while maintaining fair fee dynamics.
- Spam Reduction: Enforces a dynamic base fee that discourages excessive low-value bids, preventing network spam while keeping transaction costs predictable and sustainable.

- MEV Mitigation: Introduces statistical fee adjustments that prevent artificial congestion and manipulative bidding, ensuring fairer transaction execution and reducing toxic MEV extraction.

By integrating these mechanisms, X1 Blockchain optimizes economic sustainability, enhances network security, and ensures that transaction pricing remains both efficient and equitable across all network participants.

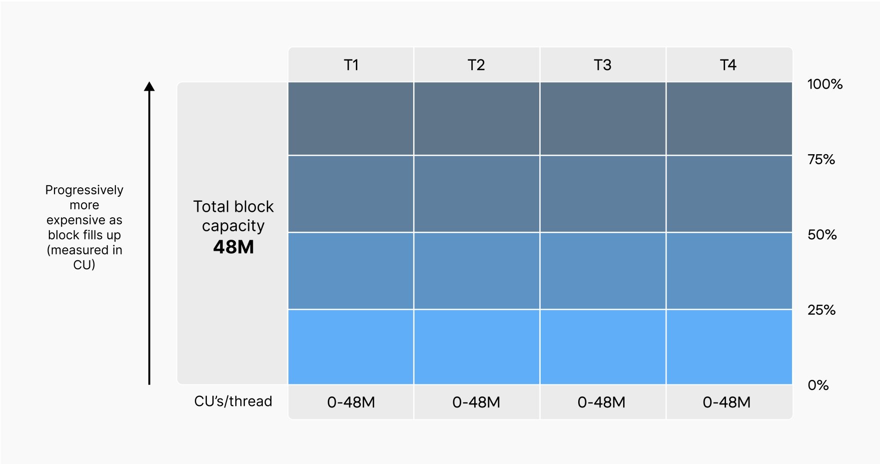

Figure 5: Visualization of X1 Blockchain's dynamic base fee mechanism. The fee increases progressively as the block fills up, with block capacity measured in Compute Units (CU) across threads.

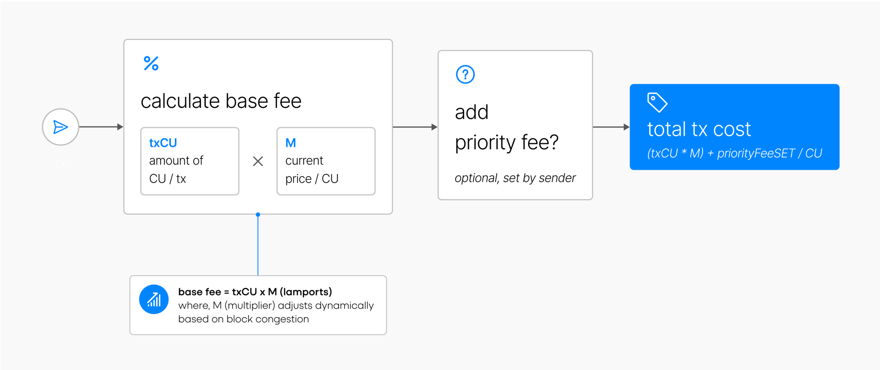

Figure 6: Diagram illustrating how transaction fees are calculated on X1 Blockchain. The total transaction cost is determined by the base fee (txCU × M) and an optional priority fee set by the sender.

5.2 Staking Incentives and Fee Adjustments

X1 Blockchain introduces a strategic enhancement to its dynamic base fee mechanism by incorporating fee adjustments that are influenced by participant staking. This innovative feature decreases base fees in proportion to the amount of tokens staked and the duration for which they are locked. The primary goal of this approach is to incentivize network participation through staking, thereby aligning participant activities with the broader objectives of network health and security.

The integration of staking incentives into the fee structure not only encourages participants to stake their tokens but also rewards them with reduced transaction costs. This reduction is scaled by both the volume of tokens staked and the length of time they are committed to the network, promoting long-term participation and investment in the stability of the blockchain. As participants are motivated to lock in their tokens for extended periods, the network benefits from enhanced security and a more robust consensus mechanism.

Moreover, this fee adjustment mechanism serves to mitigate potential economic barriers for active participants by lowering the cost of transactions for those who contribute significantly to the network's capital. This fosters a more inclusive economic environment and ensures that the blockchain remains accessible and sustainable.

By dynamically adjusting transaction fees based on staking parameters, X1 Blockchain not only enhances its economic model but also fortifies network security and encourages a deeper commitment from its participants, ensuring long-term growth and stability.

6. Decentralized MEV Handling and Fair Extraction

X1 blockchain integrates native MEV block engine within framework, reducing the proliferation of third-party MEV block builders and ensuring a more decentralized and transparent approach to MEV extraction.

6.1 Native MEV Block Engine and Validator Integration

Unlike traditional blockchains where MEV opportunities are dominated by private searchers and external builders, X1 Blockchain fights MEV centralization by incorporating an MEV block engine directly into its validator infrastructure. This integration enables validators to participate in MEV extraction autonomously, eliminating dependence on third-party intermediaries and promoting a fairer, more decentralized ecosystem.

6.2 Reducing MEV Centralization Through Fair Rewards Distribution

X1 Blockchain ensures that MEV rewards are distributed more equitably, reducing the ability of dominant MEV extractors to accumulate disproportionate power and further exploit extraction opportunities [6]. By aligning incentives more fairly among validators, X1 Blockchain prevents excessive MEV concentration and enhances overall network security.

6.3 Key MEV Safeguards

- Front-running Mitigation: Reduces the effectiveness of bots attempting to manipulate transaction order for profit, ensuring a fairer transaction execution process.
- Fair Sequencing Mechanisms: Guarantees that transactions are processed equitably, preventing the prioritization of specific actors over others.
- Validator-Driven MEV Capture: Enables validators to directly capture and redistribute MEV rewards in a decentralized manner, eliminating reliance on privileged external searchers.

By embedding these mechanisms, X1 Blockchain enhances decentralization, improves validator incentives, and establishes a more balanced MEV extraction framework that benefits the entire network.

7. Technology and Performance Enhancements

7.1 Dynamic Transaction Scheduling and Thread Optimization

X1 Blockchain improves transaction scheduling by dynamically managing execution threads based on network load and computational demand. Unlike static thread allocation, which can lead to inefficiencies during periods of fluctuating activity, X1 Blockchain employs an adaptive thread scheduler that optimally distributes transaction processing across available computational resources. This approach ensures that validators can efficiently scale their workload, minimizing bottlenecks while maximizing throughput.

	SOLANA	X1
Thread pool capacity	4 threads	16-32 threads 4-8X more

Figure 7: Comparison of thread pool capacity between Solana and X1 Blockchain. X1 supports 16-32 threads, providing 4 to 8 times more capacity than Solana's 4-thread pool.

7.2 Key Benefits of Dynamic Thread Scheduling in X1 Blockchain

- Adaptive Resource Allocation: Threads are dynamically assigned based on real-time transaction load, preventing network congestion and ensuring smooth execution even during peak demand.
- Parallel Execution Optimization: By leveraging multi-threaded processing, X1 Blockchain maximizes CPU utilization across validator nodes, significantly enhancing transaction finality speeds.

- Load Balancing Across Validators: Dynamic scheduling prevents overloading any single validator by intelligently distributing transactions across the network based on available capacity.

This optimized scheduling mechanism ensures that X1 Blockchain maintains high performance without compromising decentralization. By dynamically allocating computational resources and optimizing thread execution, validators can efficiently manage network demands while ensuring low-latency finality of transactions.

8. Conclusion

X1 Blockchain represents a next-generation Layer-1 blockchain that achieves a crucial balance between decentralization, high performance, and economic sustainability. By addressing key limitations in existing blockchain architectures, X1 Blockchain introduces enhanced validator economics, optimized consensus mechanisms, dynamic fee structures, and decentralized MEV handling—all designed to support long-term scalability and widespread adoption.

Unlike networks that rely on centralized Layer-2 scaling solutions or inefficient economic models, X1 Blockchain's monolithic architecture ensures atomic composability, high-speed transaction finality, and cost-efficient block production without sacrificing decentralization. The VRF-based leader selection and subcommittee-driven consensus model further enhance security and resilience while preventing validator centralization.

By integrating adaptive fee mechanisms inspired by EIP-1559, X1 Blockchain maintains a fair and efficient transaction pricing model that mitigates spam, optimizes block space usage, and minimizes toxic MEV extraction. Meanwhile, its native MEV engine ensures that block rewards are distributed fairly, eliminating reliance on third-party MEV builders and preserving decentralization at the protocol level.

In addition, technical optimizations such as dynamic transaction scheduling and multi-threaded execution guarantee that X1 Blockchain remains highly performant, even under high network demand. Its SVM compatibility further strengthens its ecosystem by seamlessly supporting Solana-based applications, reducing migration friction for developers and fostering broader adoption.

With its focus on decentralization, fairness, and efficiency, X1 Blockchain establishes a new standard for Layer-1 blockchain design, ensuring that developers, users, and validators alike benefit from a censorship-resistant, scalable, and economically sustainable network. By democratizing access to blockchain infrastructure and maintaining an inclusive validator set, X1 Blockchain paves the way for mass adoption and the next era of decentralized applications.

References

[1] B. S. Srinivasan and L. Lee. Quantifying decentralization. news.earn.com, 2017.

[2] B. David, P. Gaži, A. Kiayias, and A. Russell. Ouroboros praos: An adaptively-secure, semi-synchronous proof-of-stake blockchain protocol. Cryptology ePrint Archive, Report 2017/573, 2017.

[3] J. Yakovenko, E. Goldschmidt, and G. Fitzgerald. Solana: A new architecture for a high performance blockchain. Solana Whitepaper, 2017.

[4] D. Malkhi and K. Nayak. Hotstuff-2: Optimal two-phase responsive bft. Cryptology ePrint Archive, Report 2023/397, 2023.

[5] I. Amores-Sesar, C. Cachin, and P. Schneider. An analysis of avalanche consensus. arXiv preprint arXiv:2401.02811, 2024.

[6] C.-C. Chen and W. Golab. A game theoretic analysis of validator strategies in ethereum 2.0. arXiv preprint arXiv:2405.03357, 2024.