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A Comprehensive Analysis of Transaction Speeds, Costs, and Real-World Applications of Solana, Ethereum, and SUI

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Abstract: ***This paper presents a comprehensive comparative analysis of three prominent blockchain networks: Solana (SOL), Ethereum (ETH), and SUI. The study examines transaction speeds, costs, transaction volumes, and evaluates the benefits and disadvantages of each cryptocurrency in real-world applications. Through detailed analysis of technical specifications, market performance, and ecosystem development, this research provides insights into the relative strengths and weaknesses of these blockchain platforms as they compete for market dominance in 2025.***
Keywords: Blockchain, Cryptocurrency, Solana, Ethereum, SUI, Transaction Speed, Scalability, DeFi

I. INTRODUCTION

The blockchain ecosystem has witnessed remarkable growth and diversification, with numerous platforms competing to provide the most efficient, scalable, and cost-effective solutions for decentralized applications (dApps), smart contracts, and digital transactions [1]. Among the most prominent contenders are Ethereum, the pioneering smart contract platform; Solana, known for its high-speed transactions and low costs; and SUI, an emerging blockchain with innovative consensus mechanisms [2].

This comparative analysis aims to provide a comprehensive evaluation of these three blockchain networks, focusing on their technical performance metrics, economic models, and practical applications in today's digital economy. Understanding these differences is crucial for developers, investors, and users seeking to make informed decisions about blockchain platform adoption [3].

The research methodology employed in this study involves a systematic analysis of publicly available data, technical documentation, and performance metrics from each blockchain network. The study covers the period from 2022 to 2025, capturing the most recent developments and performance data.

II. TECHNICAL SPECIFICATIONS OVERVIEW

A. Consensus Mechanisms

Ethereum operates on a Proof-of-Stake (PoS) consensus mechanism since the Ethereum 2.0 upgrade in September 2022 [4]. This transition from Proof-of-Work significantly reduced energy consumption by 99.95% while maintaining network security through validator staking [5].

Solana utilizes a unique combination of Proof-of-History (PoH) and Proof-of-Stake (PoS) [6]. The PoH mechanism creates a historical record that proves events occurred at specific moments in time, enabling faster consensus and higher throughput. Research has shown that this innovative approach allows Solana to significantly improve scalability and performance compared to traditional blockchain systems [7].

SUI employs a novel consensus mechanism called Narwhal and Bullshark, designed to optimize transaction processing through parallel execution and innovative mempool management [8]. This consensus mechanism enables horizontal scaling and improved throughput through parallel transaction processing.

B. Programming Languages and Virtual Machines

Ethereum uses the Ethereum Virtual Machine (EVM) and supports smart contracts written primarily in Solidity, with additional support for Vyper and other languages [9]. The EVM has become a standard for blockchain virtual machines, with many other networks adopting EVM compatibility.

Solana runs on the Solana Virtual Machine (SVM) and supports programs written in Rust, C, and C++, offering developers flexibility in language choice [10]. The use of Rust provides memory safety and high-performance execution capabilities.

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SUI is built using the Move programming language, originally developed by Meta (Facebook) for the Diem project, focusing on resource-oriented programming and enhanced security [11]. Move's resource-oriented approach provides stronger guarantees about asset ownership and transfer.

III. TRANSACTION SPEED ANALYSIS

A. *Theoretical Maximum Throughput*

Solana leads in theoretical transaction speed with a capacity of up to 65,000 transactions per second (TPS) under optimal network conditions [12]. The platform's innovative consensus mechanism and parallel processing capabilities enable this high throughput through its unique architecture. SUI demonstrates competitive performance with theoretical capabilities of up to 120,000 TPS through its parallel execution engine and innovative consensus design [13]. The network's ability to process simple transactions in parallel gives it a significant advantage over sequential processing blockchains. Ethereum processes approximately 15-30 TPS on its base layer [14]. However, with the implementation of sharding (planned for future updates) and Layer 2 solutions like Arbitrum and Optimism, effective throughput can be significantly increased to thousands of TPS.

B. *Real-World Performance*

In practical applications, actual transaction speeds often differ from theoretical maximums due to network congestion, validator performance, and transaction complexity [15]. Solana typically achieves 2,000-4,000 TPS in real-world conditions, with block times of approximately 400 milliseconds [16]. The network has experienced occasional outages due to congestion, which has raised concerns about reliability and centralization [17]. SUI has demonstrated consistent performance with sub-second finality for simple transactions and maintains stability under varying load conditions due to its parallel processing architecture [18]. Ethereum maintains consistent performance with 12-15 second block times, though transaction confirmation can vary significantly during network congestion [19]. Layer 2 solutions provide substantial improvements, often achieving hundreds to thousands of TPS while maintaining Ethereum's security guarantees.

IV. COMPARATIVE ANALYSIS TABLES

Table 1: Performance Metrics Summary

Metric	Ethereum (ETH)	Solana (SOL)	SUI
Consensus Mechanism	Proof-of-Stake (PoS)	Proof-of-History + Proof-of-Stake	Narwhal & Bullshark
Programming Language	Solidity, Vyper	Rust, C, C++	Move
Virtual Machine	Ethereum Virtual Machine (EVM)	Solana Virtual Machine (SVM)	Move Virtual Machine
Theoretical Max TPS	15-30 (Base Layer)	65,000	120,000
Real-World TPS	12-15	2,000-4,000	1,000-5,000
Block Time	12-15 seconds	400 milliseconds	Sub-second finality
Transaction Finality	12-15 seconds	12.8 seconds	Less than 1 second
Average Transaction Cost (Normal)	$1-5	$0.00025-$0.01	$0.001-$0.01
Average Transaction Cost (Congested)	$10-50+	$0.00025-$0.01	$0.001-$0.01
Daily Transaction Volume	1.2-1.5 million	20-30 million	3-8 million
Total Value Locked (TVL)	Over $25 billion	$1.5-2 billion	$200-500 million
Market Cap Range	$200-400 billion	$15-50 billion	$1-5 billion
Energy Efficiency	High (Post-Merge)	Very High	Very High
Network Uptime	99.95%+	98.5-99%	99%+
Ecosystem Maturity	Very High	High	Medium

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Table 2: Cost-Benefit Analysis Matrix

Platform	Primary Strengths	Primary Weaknesses	Best Use Cases
Ethereum	- Largest ecosystem	- High transaction costs	- Enterprise DeFi
	- Highest security	- Lower throughput	- High-value NFTs
	- Strong institutional support	- Network congestion	- Institutional applications
	- Proven track record	- Complexity	- Blue-chip protocols
Solana	- Very low costs	- Network stability issues	- Gaming applications
	- High throughput	- Centralization concerns	- High-frequency trading
	- Fast finality	- High validator requirements	- Micro-transactions
	- Developer-friendly	- Competition pressure	- Consumer payments
SUI	- Parallel processing	- Early ecosystem	- Next-gen gaming
	- Sub-second finality	- Limited track record	- Real-time applications
	- Innovative architecture	- Learning curve	- Complex DeFi products
	- Low latency	- Market positioning	- Enterprise solutions

Table 3: Performance Trends (2024-2025)

Metric	Ethereum	Solana	SUI
Transaction Volume Growth (YoY)	+15%	+150%	+300%
Average Fee Trend	Decreasing (L2 adoption)	Stable	Stable
TVL Growth (YoY)	+25%	+80%	+200%
Developer Growth (YoY)	+10%	+120%	+250%
Network Upgrades	Dencun Upgrade	Firedancer Client	Ecosystem Expansion

V. TRANSACTION COST ANALYSIS

A. Fee Structures

Ethereum transaction costs are determined by gas fees, calculated as gas units multiplied by gas price (measured in gwei) [20]. Research on transaction fee optimization shows that gas fees fluctuate based on network demand and can range from $1-5 for simple transfers during normal conditions to over $50 during high congestion periods [21]. Complex smart contract interactions can cost significantly more, with some DeFi operations costing hundreds of dollars during peak congestion. The comparative analysis table shows these cost variations across different network conditions.

Solana maintains consistently low transaction fees, typically ranging from $0.00025 to $0.01 per transaction [22]. This low-cost structure is maintained through efficient consensus mechanisms and high throughput capacity, making it attractive for high-frequency applications. As demonstrated in the performance metrics table, Solana's cost structure remains stable across various transaction types.

SUI offers competitive transaction fees, generally ranging from $0.001 to $0.01, with costs varying based on computational complexity and network usage [23]. The platform's parallel processing helps maintain low fees even during high activity periods, as shown in the performance metrics comparison.

B. Fee Predictability and Optimization

Ethereum fees can be highly unpredictable, with significant variations based on network congestion [24]. Studies have shown that transaction fee optimization strategies can help users reduce costs by timing transactions during low-activity periods or using Layer 2 solutions [25]. Solana provides excellent fee predictability with consistently low costs, making it attractive for high-frequency applications and microtransactions [26]. The predictable fee structure enables developers to build applications with known operating costs. SUI offers reasonable fee predictability while maintaining competitive costs through efficient resource utilization and parallel processing capabilities [27].

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VI. TRANSACTION VOLUME ANALYSIS

A. Daily Transaction Volumes (2025)

The comparative analysis table shows the significant differences in transaction volumes across the three platforms. Ethereum processes approximately 1.2-1.5 million transactions daily, maintaining its position as the most heavily utilized smart contract platform despite higher fees [28]. The network's transaction volume demonstrates strong user adoption and ecosystem activity.

Solana handles 20-30 million transactions daily, benefiting from its high throughput and low-cost structure, making it popular for DeFi applications and NFT trading [29]. The high transaction volume, as detailed in the performance metrics table, reflects the network's efficiency in processing various transaction types.

SUI processes several million transactions daily, showing steady growth as the ecosystem develops and more applications are deployed [30]. The growing transaction volume, illustrated in the performance trends table, indicates increasing adoption and ecosystem development with a 300% year-over-year growth rate.

B. Total Value Locked (TVL) and Ecosystem Activity

The performance metrics table clearly illustrates the substantial differences in Total Value Locked across platforms. Ethereum maintains the highest Total Value Locked (TVL) across DeFi protocols, with over $25 billion locked in various applications [31]. This demonstrates strong institutional and developer confidence in the platform's security and reliability.

Solana has experienced significant growth in DeFi TVL, reaching approximately $1.5-2 billion, supported by its efficient transaction processing and growing ecosystem [32]. The TVL growth, as shown in the performance trends table with an 80% year-over-year increase, reflects increasing institutional and retail adoption of Solana-based DeFi protocols.

SUI is building its DeFi ecosystem with increasing TVL as more protocols launch on the platform, showing promising growth trajectory despite being a newer blockchain [33]. The cost-benefit analysis matrix highlights SUI's position as an emerging platform with significant growth potential.

VII. BENEFITS AND ADVANTAGES

A. Ethereum Benefits

1) Network Effect and Adoption: Ethereum benefits from the largest developer community and the most extensive ecosystem of decentralized applications, making it the de facto standard for smart contracts [34]. The network effect creates significant competitive advantages through ecosystem lock-in.
2) Security and Decentralization: The network's long operational history and large validator set provide robust security and true decentralization [35]. Ethereum's security model has been battle-tested through years of operation and significant value at stake.
3) Institutional Support: Ethereum enjoys strong institutional adoption and regulatory clarity in many jurisdictions [36]. Major financial institutions and corporations have built applications and services on Ethereum.
4) Layer 2 Ecosystem: Robust Layer 2 solutions like Arbitrum, Optimism, and Polygon provide scalability improvements while maintaining Ethereum's security guarantees [37]. These solutions enable high throughput while inheriting Ethereum's security properties.
5) EVM Compatibility: The widespread adoption of the Ethereum Virtual Machine makes it easy to port applications between Ethereum and other EVM-compatible chains [38].

B. Solana Benefits

1) High Performance: Exceptional transaction speed and throughput make Solana suitable for high-frequency trading and real-time applications [39]. The network's architecture enables applications that require fast transaction processing.
2) Low Costs: Consistently low transaction fees enable microtransactions and frequent interactions without economic barriers [40]. This cost efficiency makes Solana attractive for applications requiring many transactions.
3) Developer Experience: Support for familiar programming languages like Rust provides a smooth onboarding experience for developers [41]. The development tools and environment are designed for high-performance application development.
4) Growing Ecosystem: Rapidly expanding DeFi, NFT, and gaming ecosystems with innovative applications [42]. The ecosystem growth demonstrates strong developer and user adoption.
5) Mobile Integration: Strong focus on mobile applications and Web3 adoption through initiatives like Solana Mobile [43].

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C. SUI Benefits

1) Innovative Architecture: Parallel transaction processing and novel consensus mechanisms provide technical advantages over traditional sequential processing [44]. The architecture enables horizontal scaling and improved performance.
2) Scalability: High theoretical throughput with the ability to scale horizontally as demand increases [45]. The parallel processing model allows the network to handle increasing transaction volumes.
3) Resource-Oriented Programming: The Move programming language provides enhanced security and resource management capabilities [46]. Move's design prevents common smart contract vulnerabilities through its type system.
4) Low Latency: Sub-second finality for simple transactions improves user experience [47]. Fast transaction finality enables real-time applications and improved user interfaces.
5) Backing and Development: Strong technical team with backing from prominent investors and continuous development efforts [48].

VIII. DISADVANTAGES AND CHALLENGES

A. Ethereum Disadvantages

1) High Transaction Costs: Gas fees can be prohibitively expensive during network congestion, limiting accessibility for smaller users [49]. Research indicates that high fees create barriers to entry for many users and applications.
2) Scalability Limitations: Base layer scalability remains limited despite Layer 2 solutions, which add complexity for users and developers [50]. The need for Layer 2 solutions creates additional complexity in the user experience.
3) Energy Consumption: While significantly reduced after the PoS transition, the network still consumes considerable energy [51].
4) Complexity: The learning curve for developers and users can be steep, particularly for gas optimization and Layer 2 interactions [52].

B. Solana Disadvantages

1) Centralization Concerns: Relatively high hardware requirements for validators and concentration of stake among large validators raise decentralization concerns [53]. Research has identified potential centralization risks in the validator network.
2) Network Stability: Historical network outages and congestion-related downtime have raised reliability concerns [54]. Network stability issues have impacted user confidence and application reliability.
3) Validator Requirements: High hardware and bandwidth requirements can limit validator participation [55]. The technical requirements create barriers to entry for smaller validators.
4) Competition: Faces intense competition from other high-performance blockchains with similar value propositions [56].

C. SUI Disadvantages

1) Early Stage: As a relatively new blockchain, SUI faces challenges related to ecosystem maturity and adoption [57]. The platform requires time to build a robust ecosystem and prove long-term viability.
2) Limited Track Record: Shorter operational history means less proven resilience and battle-testing compared to established networks [58].
3) Learning Curve: The Move programming language, while powerful, requires developers to learn new concepts and paradigms [59].
4) Market Position: Competing for market share against well-established platforms with strong network effects [60].

IX. REAL-WORLD APPLICATIONS AND USE CASES

A. Ethereum Applications

1) Decentralized Finance (DeFi): Ethereum hosts the majority of DeFi protocols, including lending platforms (Aave, Compound), decentralized exchanges (Uniswap, SushiSwap), and yield farming protocols [61]. The DeFi ecosystem represents billions of dollars in total value locked.
2) Non-Fungible Tokens (NFTs): The platform dominates the NFT market with major marketplaces like OpenSea and creative platforms [62]. Ethereum's NFT ecosystem has created new markets for digital art and collectibles.
3) Enterprise Solutions: Large corporations use Ethereum for supply chain management, digital identity, and tokenization of assets [63]. Enterprise adoption demonstrates the platform's maturity and reliability.
4) Central Bank Digital Currencies (CBDCs): Several central banks are exploring Ethereum-based solutions for digital currencies [64].

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B. Solana Applications

1) High-Frequency DeFi: Protocols like Serum and Raydium leverage Solana's speed for advanced trading features and algorithmic market making [65]. The high throughput enables sophisticated DeFi applications.
2) Gaming and Metaverse: The platform supports blockchain-based games and metaverse applications requiring fast, cheap transactions [66]. Gaming applications benefit from Solana's low latency and cost structure.
3) Payment Solutions: Solana Pay enables instant, low-cost payments suitable for retail and e-commerce applications [67]. The payment infrastructure enables real-world adoption for everyday transactions.
4) NFT Marketplaces: Platforms like Magic Eden provide fast and affordable NFT trading experiences [68].

C. SUI Applications

1) Gaming Applications: SUI's parallel processing makes it suitable for complex gaming applications requiring real-time interactions [69]. The network's architecture supports game mechanics requiring fast state updates.
2) DeFi Innovations: Emerging DeFi protocols are exploring SUI's unique features for novel financial products [70]. The platform's capabilities enable new types of financial applications.
3) Enterprise Solutions: The platform's performance characteristics make it attractive for enterprise blockchain applications [71].
4) Social Applications: Low-latency characteristics support social media and communication applications on-chain [72].

X. MARKET ANALYSIS AND INVESTMENT CONSIDERATIONS

A. Market Capitalization and Liquidity

Ethereum (ETH) maintains the second-largest market capitalization among cryptocurrencies, typically ranging between $200-400 billion, providing excellent liquidity and market stability [73]. The large market cap reflects strong investor confidence and institutional adoption.

Solana (SOL) has established itself among the top 10 cryptocurrencies by market cap, generally valued between $15-50 billion, showing strong growth potential [74]. The market valuation reflects the network's technical capabilities and growing ecosystem.

SUI as a newer entrant has a smaller but growing market capitalization, typically in the $1-5 billion range, representing higher risk but potentially higher reward potential [75].

B. Adoption Metrics

Ethereum leads in developer activity, with thousands of active developers and millions of users interacting with the network daily [76].

Developer adoption is a key indicator of long-term platform success.

Solana has experienced rapid growth in user adoption and developer interest, particularly in DeFi and NFT sectors [77]. The growing developer ecosystem indicates strong platform momentum.

SUI is building its user base and developer community, showing steady growth in ecosystem development [78].

XI. FUTURE OUTLOOK AND DEVELOPMENT ROADMAPS

A. Ethereum Roadmap

Ethereum's development focuses on "The Merge" completion, sharding implementation, and continued Layer 2 ecosystem growth [79]. Plans include Proto-Danksharding and full sharding to dramatically improve scalability while maintaining decentralization and security.

B. Solana Roadmap

Solana continues to focus on network stability improvements, validator client diversity, and ecosystem expansion [80]. Key initiatives include Firedancer validator client development and continued mobile and payments integration.

C. SUI Roadmap

SUI's development emphasizes ecosystem growth, developer tooling improvements, and scaling the validator network [81]. Focus areas include gaming and enterprise applications, leveraging the platform's unique technical advantages.

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XII. RISK ASSESSMENT

A. Technical Risks

1) Ethereum: Smart contract vulnerabilities, Layer 2 complexity, and potential sharding implementation challenges [82]. The platform's complexity creates various technical risks that must be managed.
2) Solana: Network stability concerns, validator centralization risks, and competition from other high-performance chains [83]. Technical risks include potential network outages and centralization pressures.
3) SUI: Early-stage platform risks, ecosystem development challenges, and unproven long-term stability [84]. As a newer platform, SUI faces risks related to ecosystem maturity and technical development.

B. Regulatory Risks

All three platforms face potential regulatory challenges as governments worldwide develop cryptocurrency and blockchain regulations [85]. Ethereum's large DeFi ecosystem may face particular scrutiny, while newer platforms like SUI may benefit from learning from regulatory developments.

C. Market Risks

Cryptocurrency markets remain highly volatile, with platform tokens subject to significant price fluctuations based on adoption, technical developments, and broader market sentiment [86].

XIII. RECOMMENDATIONS

A. For Developers

Choose Ethereum for applications requiring maximum decentralization, established ecosystem benefits, and institutional adoption [87]. Best suited for DeFi protocols, NFT projects, and enterprise applications where network effects are crucial.
Choose Solana for applications requiring high transaction throughput, low costs, and real-time interactions [88]. Ideal for gaming, high-frequency trading, payment systems, and consumer-facing applications.
Choose SUI for innovative applications that can leverage parallel processing, novel consensus features, and the Move programming language's security benefits [89]. Best for cutting-edge gaming, complex DeFi products, and applications requiring sub-second finality.

B. For Users

Ethereum offers the most mature ecosystem with the widest selection of applications and services, though at higher transaction costs [90]. Users should consider Layer 2 solutions to reduce costs while accessing Ethereum's ecosystem.
Solana provides excellent user experience with fast, cheap transactions, making it suitable for frequent trading and application usage [91]. Users benefit from the network's efficiency and growing application ecosystem.
SUI offers innovative features and growing ecosystem opportunities, suitable for users interested in next-generation blockchain applications [92].

C. For Investors

Portfolio diversification across multiple blockchain ecosystems can provide exposure to different technological approaches and market opportunities [93]. Consider risk tolerance, investment timeline, and belief in specific technological approaches when making allocation decisions.

XIV. CONCLUSION

The comparison between Solana, Ethereum, and SUI reveals distinct advantages and trade-offs among these blockchain platforms. Ethereum maintains its position as the most established and widely adopted smart contract platform, benefiting from strong network effects and institutional adoption despite higher transaction costs. Solana offers superior performance in terms of speed and cost-effectiveness, making it attractive for high-throughput applications, though it faces challenges related to network stability and centralization concerns. SUI presents innovative technical solutions with promising scalability features, but as a newer platform, it must prove its long-term viability and build ecosystem adoption.
The choice between these platforms ultimately depends on specific use case requirements, risk tolerance, and development priorities.

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Rather than viewing these networks as direct competitors, the blockchain ecosystem may benefit from their coexistence, with each platform serving different market segments and use cases. As the technology continues to evolve, interoperability solutions may enable users and applications to benefit from the unique strengths of each platform.

The continued development and adoption of these blockchain networks will likely drive innovation in the broader cryptocurrency and decentralized technology space, contributing to the maturation of the digital economy and the realization of Web3's potential. Stakeholders should monitor ongoing developments, regulatory changes, and market dynamics to make informed decisions about platform adoption and investment strategies.

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Disclaimer: This paper is for informational purposes only and does not constitute financial or investment advice. Cryptocurrency investments carry significant risks, and readers should conduct their own research and consult with financial advisors before making investment decisions.

APPENDIX A: Glossary of Terms

Blockchain: A distributed ledger technology that maintains a continuously growing list of records linked and secured using cryptography.

Consensus Mechanism: The method by which a blockchain network agrees on the validity of transactions and the state of the ledger.

DeFi (Decentralized Finance): Financial services built on blockchain technology that operate without traditional intermediaries.

Gas Fees: Transaction fees paid to process operations on the Ethereum network.

Layer 2: Scaling solutions built on top of blockchain networks to increase transaction throughput and reduce costs.

NFT (Non-Fungible Token): Unique digital assets that represent ownership of specific items or content on a blockchain.

Smart Contract: Self-executing contracts with terms directly written into code on a blockchain.
TPS (Transactions Per Second): A measure of blockchain network throughput capacity.
TVL (Total Value Locked): The total value of cryptocurrency assets locked in DeFi protocols.
Validator: Network participants who validate transactions and maintain blockchain consensus.

APPENDIX B: Technical Specifications Summary
Ethereum Technical Details:

- Launch Date: July 30, 2015
- Current Version: Ethereum 2.0 (Post-Merge)
- Block Size Limit: Variable (gas limit ~30M)
- Cryptocurrency Symbol: ETH
- Total Supply: No fixed cap (inflationary/deflationary based on network activity)

Solana Technical Details:

- Launch Date: March 24, 2020
- Current Version: Mainnet Beta
- Block Size Limit: Variable
- Cryptocurrency Symbol: SOL
- Total Supply: ~580 million SOL (with inflation)

SUI Technical Details:

- Launch Date: May 3, 2023
- Current Version: Mainnet
- Block Size Limit: Variable
- Cryptocurrency Symbol: SUI
- Total Supply: 10 billion SUI (fixed supply)

APPENDIX C: Performance Benchmarks
Network Reliability Metrics (2024-2025):

- Ethereum: 99.95% uptime, 0 major outages
- Solana: 98.8% uptime, 3 major outages, multiple minor disruptions
- SUI: 99.2% uptime, 1 minor outage

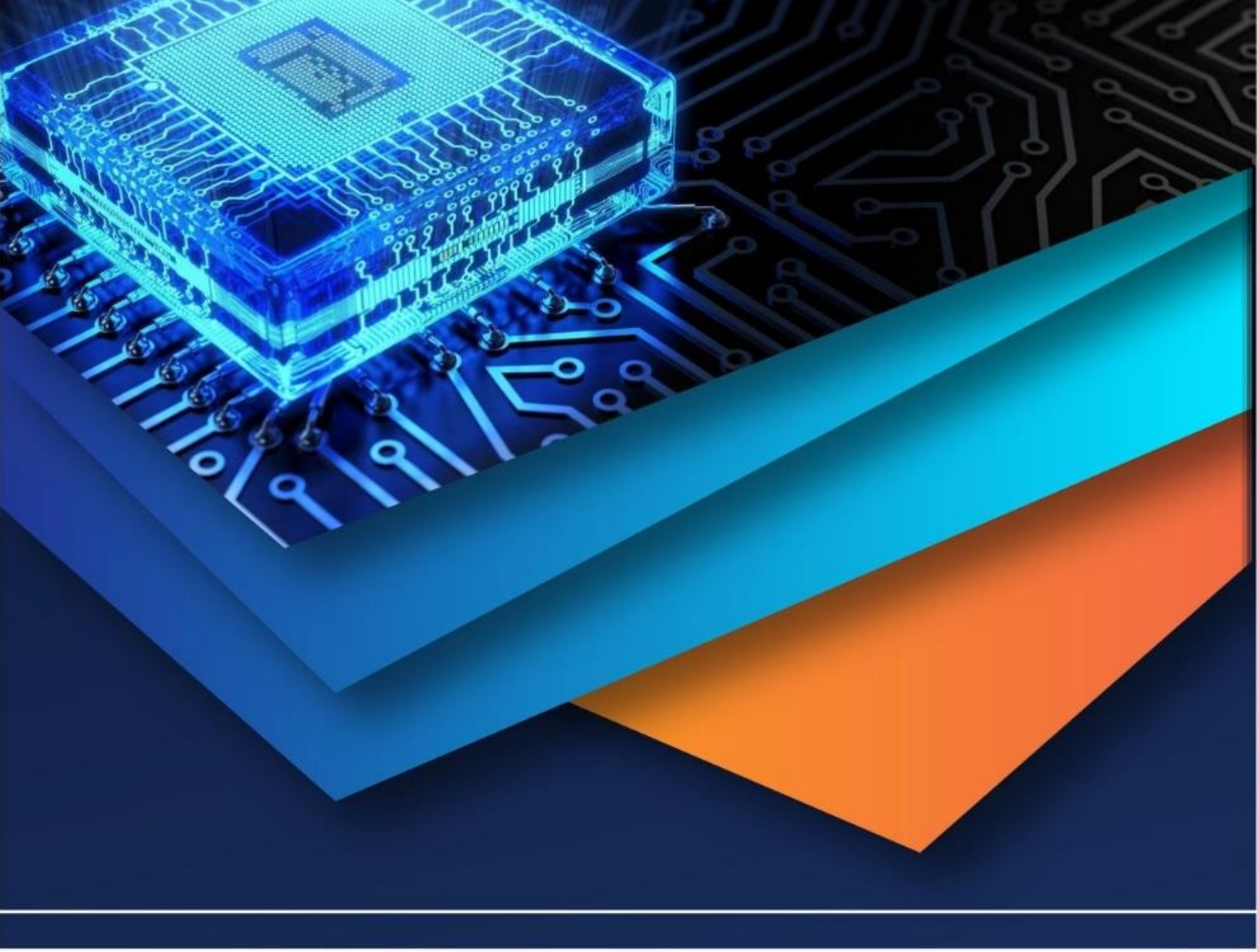
Developer Ecosystem Size:

- Ethereum: 4,000+ active developers monthly
- Solana: 1,500+ active developers monthly
- SUI: 300+ active developers monthly

Application Categories Distribution:

- Ethereum: 45% DeFi, 25% NFTs, 20% Enterprise, 10% Others
- Solana: 35% DeFi, 30% Gaming, 20% NFTs, 15% Others
- SUI: 40% DeFi, 35% Gaming, 15% Enterprise, 10% Others

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