L41: Layer 2 Scaling Solutions

Module F: Advanced Topics

Blockchain & Cryptocurrency Course

December 2025

Why Should We Care About Layer 2 Scaling?

- Gas fees during NFT mints can exceed $200—users rage-quit to centralized exchanges
- The scalability trilemma forces impossible choices: speed, security, or decentralization—pick two

[COMIC: Frustrated user watching gas fees spike during mainnet congestion. Speech bubble: "$150 to send $20?!" Background shows Ethereum network traffic jam with transactions queued up]

[PLACEHOLDER] — When Ethereum gets congested, everyone pays the price—literally

Learning Objectives

- Describe the blockchain scalability trilemma
- Compare Layer 2 design patterns (channels, rollups, sidechains)
- Analyze Optimistic vs ZK-Rollups tradeoffs
- Evaluate the impact of Dencun upgrade (EIP-4844)
- Explain Account Abstraction (ERC-4337) and its UX improvements

Building on L40: Lab: Testnet Lending

The Problem: How do we scale without sacrificing security?

The Challenge

Ethereum can only process 15 transactions per second, while Visa handles 65,000 TPS (transactions per second). Traditional scaling approaches (increasing block size, reducing block time) sacrifice decentralization or security.

Why It Matters

- High gas fees (~$50-200 during peak) exclude everyday users
- Bitcoin Lightning Network launched in 2018, but adoption remains low
- Ethereum's Dencun upgrade (March 2024) reduced L2 fees by 90% via EIP-4844

What We Need

- Understanding design constraints
- Mechanisms that inherit L1 security while increasing throughput 10-1000x
- Solutions that don't require users to trust new validator sets

The Cryptoeconomics Question

How do we optimize for scalability without breaking decentralization or security?

Today's lesson: How Layer 2 Scaling addresses this challenge

Continued

Why Can't Blockchains Have It All?

The Trilemma:
Can only optimize 2 of 3 properties:

- **Decentralization**: Independent validators
- **Security**: Cost to attack network
- **Scalability**: TPS throughput

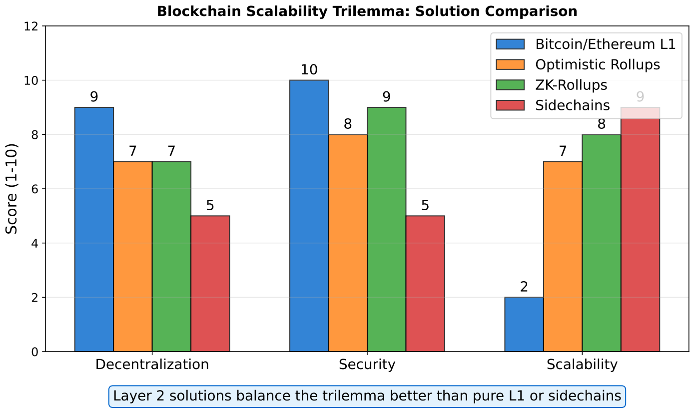
Current TPS:

- Bitcoin: ~7 TPS
- Ethereum: ~15 TPS
- Visa: ~65,000 TPS

Solution: Layer 2 moves transactions off-chain while inheriting L1 security

→ *Problem: How do we scale without sacrificing... — The Blockchain Scalability Trilemma shows we cannot have decentralization, security, AND scalability simultaneously—L2 solutions choose which to optimize*

How Do Different Solutions Navigate the Trilemma?



Rollups achieve better balance than L1 alone or sidechains

How Does Layer 2 Make Ethereum Faster?

Layer 1 (L1)

- Base blockchain protocol
- Full consensus for every transaction
- High security, low throughput
- Examples: Bitcoin, Ethereum

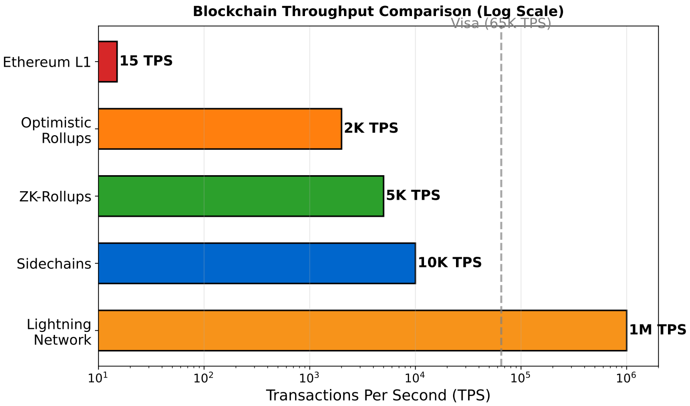
Layer 2 (L2)

- Built on top of L1
- Process transactions off-chain
- Settle final state on L1
- Inherit L1 security guarantees

Key Insight: Trade immediate finality for higher throughput

Compare the approaches shown above

How Much Faster Are Layer 2 Solutions?



L2s can match or exceed traditional payment networks like Visa

What Are the Different Layer 2 Approaches?

State Channels:

- P2P direct channels
- Ex: Lightning Network

Sidechains:

- Independent chain
- Two-way peg to L1

Rollups:

(batch transactions off-chain, post summaries to L1)

- Batch off-chain
- Post data on-chain

Optimistic: Fraud proofs
ZK: Validity proofs

Plasma:

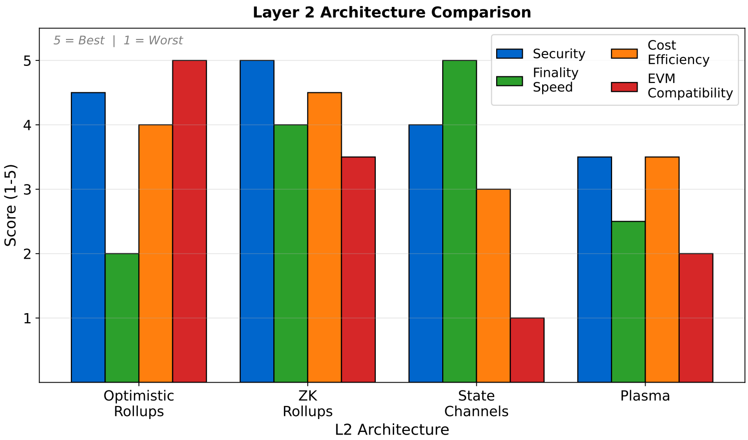
- Child chains
- Merkle commits

Validium:

- Off-chain DA
- Validity proofs

Compare the approaches shown above

How Do Layer 2 Architectures Compare?



ZK-Rollups excel in security; State Channels offer instant finality; Optimistic Rollups lead in EVM compatibility

How Does Lightning Network Scale Bitcoin?

Problem: Bitcoin's 7 TPS cannot support global payments
Solution: Bidirectional payment channels
Mechanism:

1. Open channel (on-chain funding)
2. Transact off-chain (update state)
3. Close channel (broadcast to L1)

Network Topology:
Channels form payment routing graph

Capacity:

- Millions of TPS possible
- Sub-second finality
- Minimal on-chain footprint

$\rightarrow$ *Problem: How do we scale without sacrificing... — Lightning Network: Bitcoin's Layer 2 demonstrates moving transactions off-chain solves throughput but requires trust in channel counterparties staying online*

Why Are Rollups Ethereum's Best Bet?

Core Idea:
Execute off-chain, post compressed data on-chain

Architecture:

- **Data Availability (DA)**: TX data on L1 (ensuring data is accessible for verification)
- **Computation**: Off-chain sequencer (operator that orders transactions for a rollup)
- **State Roots**: Merkle root to L1

Benefits:

- 100-1000x throughput gain
- Inherit L1 security
- Lower transaction costs

Two Variants:
Optimistic vs ZK (differ in validity proof)

Compare the approaches shown above

How Do Optimistic Rollups Work?

Mechanism

- Assume transactions valid by default
- Anyone can submit fraud proof (evidence proving a transaction was invalid)
- Challenge period: 7 days
- If no challenge, state finalized

Advantages

- EVM compatibility (easy migration)
- Lower gas costs than L1

Fraud Proof System

- Verifier claims state is invalid
- Interactive bisection game on L1
- Dishonest party loses stake

Disadvantages

- Long withdrawal delay (7 days)
- Honest verifier assumption

Compare the approaches shown above

What Makes ZK-Rollups More Secure?

Mechanism:

- Cryptographic validity proofs per batch
- SNARK/STARK: Prove without revealing
- L1 verifies proof (constant cost)
- Finality: $\sim$10-30 min after proof

Advantages:

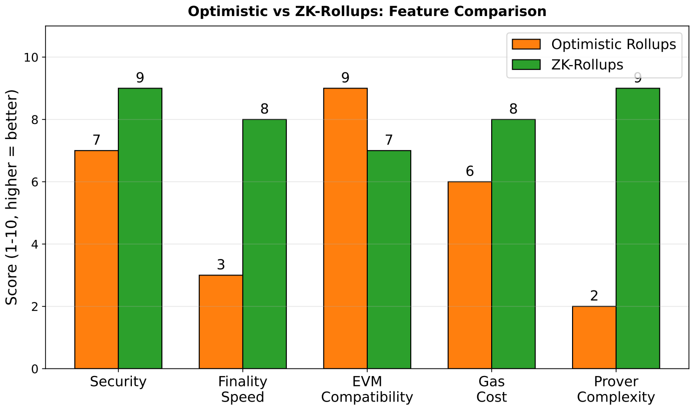
- Fast withdrawals (no challenge)
- Stronger security guarantees

Disadvantages:

- Complex crypto, higher prover costs
- EVM compatibility (improving)

Compare the approaches shown above

What's the Difference Between Optimistic and ZK-Rollups?



ZK-Rollups excel in security and finality; Optimistic wins on EVM compatibility

Problem Check-In: Layer 2 Scaling

Recall Our Problem

How do we scale without sacrificing security?

What We've Learned So Far

- The scalability trilemma forces trade-offs: you cannot maximize decentralization, security, AND throughput
- L2 solutions (rollups, channels, sidechains) move computation off-chain while settling on L1
- These patterns let us scale 100-1000x while choosing which security properties to preserve

Still to Address

- How specific rollup types (Optimistic vs ZK) differ in their security/speed trade-offs
- Do rollups truly inherit L1 security, or do sequencer centralization and bridge risks undermine this?

Think About

- Based on what you've seen, how would *you* solve this problem?
- What trade-offs do you expect?

Pause and reflect: How does what we've learned so far address "How do we scale without sacrificing..."?

Why Don't Sidechains Inherit L1 Security?

Definition

- Independent blockchain with own consensus
- Two-way peg to main chain
- Assets locked on L1, minted on sidechain

Examples

- Polygon PoS (Ethereum)
- Liquid Network (Bitcoin)

Advantages

- Custom consensus rules
- High throughput, low fees

Disadvantages

- **Weaker security**: Does NOT inherit L1 security
- Trust in sidechain validators
- Bridge attack surface

→ *Problem: How do we scale without sacrificing... — Sidechains reveals sidechains sacrifice L1 security inheritance—faster but riskier than rollups*

How Do Bridges Connect Different Chains?

Purpose: Transfer assets between L1/L2 or across chains

Lock-and-Mint Pattern:

1. Lock assets on source chain
2. Mint wrapped tokens on dest
3. Burn to unlock original

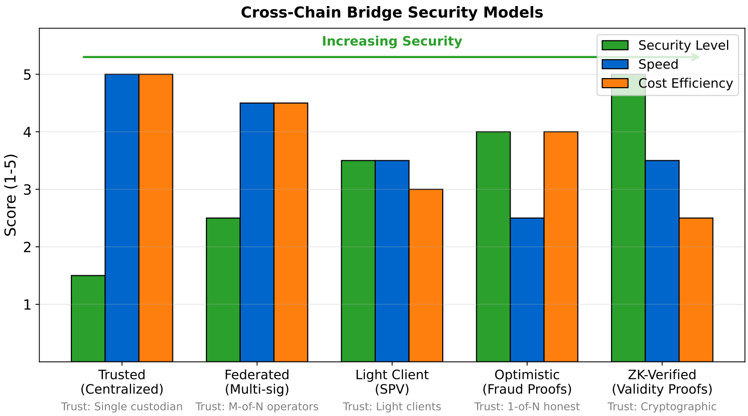
Bridge Types:

- **Trusted**: Centralized (fast)
- **Federated**: Multi-sig ops
- **ZK-Verified**: Highest security

Risk: Major attack targets ($2B+ stolen 2022-2023)

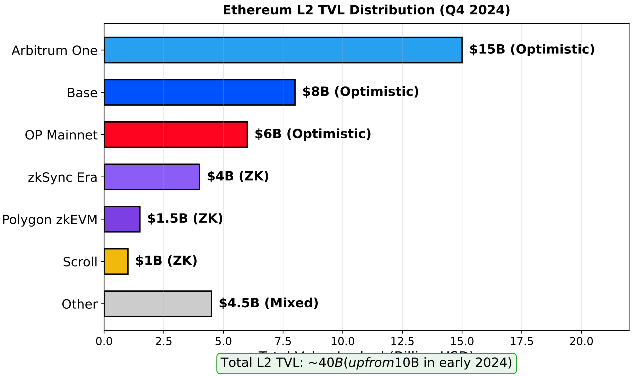
Compare the approaches shown above

How Do Bridge Security Models Compare?



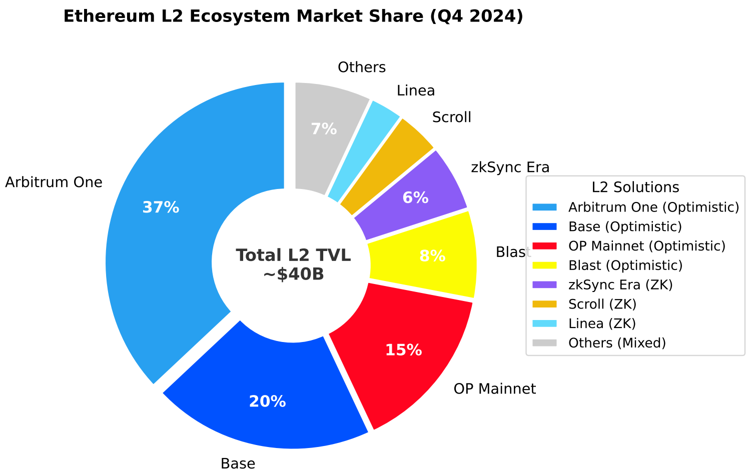
ZK-verified bridges offer the highest security; trusted bridges are fastest but riskiest

Where Is Layer 2 Value Locked?



Arbitrum leads by TVL; optimistic rollups currently dominate

Who Leads the Layer 2 Ecosystem?



Optimistic rollups (Arbitrum, Base, OP) hold 72% market share; ZK rollups growing rapidly

What Is the AI + Blockchain Convergence Frontier?

Beyond rollups: a parallel scaling frontier emerged in 2024-2025.

- **AI agents on-chain**: autonomous trading bots, MEV agents, copy-trading agents that act through smart-contract wallets
- **Decentralized AI compute**: token-incentivised GPU networks (Bittensor TAO, Render RNDR, Akash AKT, Fetch.ai FET) compete with AWS/Google for inference workloads
- **AI-powered security**: ML-augmented audit tools (Slither + AI, Forta AI threat detection) automate exploit discovery
- **Risk surface**: deepfake-driven scams, automated exploit discovery against deployed contracts, market manipulation at scale

Sources: Bittensor whitepaper (bittensor.com), Forta Network docs (forta.org). AI+Blockchain TVL/market-cap surged in 2024 alongside L2 expansion

Decentralized AI Compute Networks

Network	Mkt cap	Workers	Throughput
Bittensor (TAO)	\$3.2B	4,500	70/100
Render (RNDR)	\$2.1B	12,000	85/100
Akash (AKT)	\$0.6B	400	50/100
Fetch.ai (FET)	\$1.4B	8,000	60/100

Bittensor (decentralised ML), Render (GPU rendering), Akash (cloud compute), Fetch.ai (autonomous agents). Each pays validators in native tokens for verifiable compute work. Figures are mid-2025 illustrative magnitudes

How Do AI Agents Operate On-Chain?

Agent capabilities (2024-2025):

- Autonomous portfolio rebalancing
- MEV extraction (priority fee bidding)
- Social copy-trading bots
- Agent-to-agent settlement

Security stack:

- Forta AI: real-time threat detection
- Slither + AI: contract audit augmentation
- OpenZeppelin Defender automations

AI agents typically deploy via ERC-4337 account abstraction so a smart-contract wallet, not an EOA, signs transactions on the agent's behalf

What Risks Does AI + Blockchain Introduce?

Risk	Attack cost	Impact
Deepfake-driven phishing scams	low	high
Automated exploit discovery	medium	catastrophic
AI-driven market manipulation	high	high
Oracle manipulation via ML	high	high
Agent-to-agent collusion	medium	medium
MEV super-bots	low	medium
Inference-cost griefing	low	low

Highest-urgency: low-cost / high-impact (top-left quadrant) such as deepfake phishing and MEV super-bots. Regulatory frameworks lag the technology

Why Did Layer 2 Explode in 2024?

Dencun Upgrade (March 2024):

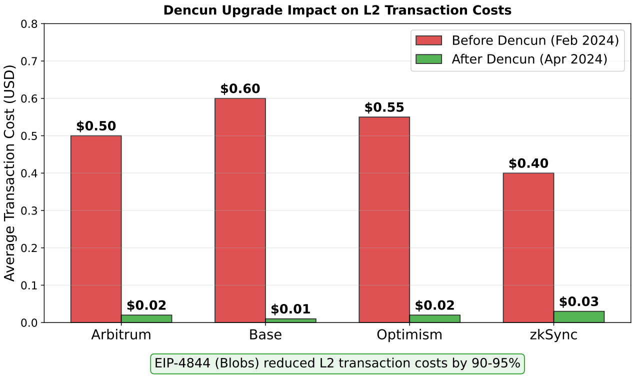
- EIP-4844 blob transactions
- L2 fees reduced by 90%+
- $0.50-2.00 → $0.01-0.05
- User migration accelerated

Key Trends:

- TVL: $54B (205% YoY)
- L2 TX ¿ L1 daily volume
- App chains for specific use
- ZK maturity (zkSync, Scroll)

Compare the approaches shown above

How Much Did Dencun Reduce Layer 2 Fees?



EIP-4844 blob transactions were the most significant scaling upgrade since the Merge

How Do Security Models Compare?

Solution	Inherits L1 Security	Trust Model	Finality
Optimistic Rollup	Yes	1-of-N honest	7 days
ZK-Rollup	Yes	Cryptographic	10-30 min
State Channel	Yes	Counterparty online	Instant
Sidechain	No	Validator set	Chain-dependent

Key Takeaway: Rollups inherit L1 security; sidechains do not

→ *Problem: How do we scale without sacrificing... — Security Comparison confirms rollups inherit L1 security while sidechains require trusting a new validator set—the core scaling trade-off*

What's Next for Layer 2 Scaling?

Scaling:

- **Full Danksharding**: 100K+ TPS
- **zkEVM**: Full EVM equivalence
- **Layer 3**: App-specific rollups

Infrastructure:

- **Interoperability**: Cross-rollup comms
- **Sequencer Decentralization**: Remove SPOF
- **Shared Sequencing**: Multi-rollup infra

Compare the approaches shown above

How Does Account Abstraction Fix Wallet UX?

EOA Problems:

- Must hold ETH for gas
- Single key = single point of failure
- No batching (2 TX for approve+swap)
- Lost key = lost funds forever

ERC-4337 Solution:

- Programmable smart wallets
- Custom validation (multi-sig, recovery)
- Sponsored transactions
- Bundled ops (1 click)

No protocol changes required – works on existing Ethereum

How Does ERC-4337 Work?

Key Components

- **UserOperation**: Pseudo-transaction struct
- **Bundler**: Collects and submits UserOps
- **EntryPoint**: On-chain singleton contract
- **Smart Account**: User's wallet contract
- **Paymaster**: Pays gas on user's behalf

Transaction Flow

1. User signs UserOperation
2. Bundler collects UserOps
3. Bundler submits batch to EntryPoint
4. EntryPoint validates and executes
5. Paymaster (optional) covers gas

ERC-4337 achieves account abstraction without modifying Ethereum protocol

Continued

What Can You Do with Smart Wallets?

1. **Gasless Transactions:**
   - DApp sponsors gas for users
   - Pay gas in USDC/DAI
2. **Social Recovery:**
   - Guardians can recover wallet
   - No seed phrase SPOF
3. **Session Keys:**
   - Limited time permissions
   - Gaming: no constant signing
4. **Batch Transactions:**
   - Approve+swap+stake in 1 click
   - Better UX, lower gas

Compare the approaches shown above

How Widely Adopted Is Account Abstraction?

Milestones:

- Mar 2023: ERC-4337 mainnet
- 2024: Major wallet integration
- Late 2024: 10M+ smart accounts
- 2025: Default on L2s

Leading Implementations:

- **Safe**: Multi-sig + modular
- **Coinbase**: Passkey-based
- **ZeroDev**: Developer SDK
- **Alchemy**: Bundler infra

Account abstraction is key to achieving Web2-like UX in crypto

Problem Solved? Layer 2 Scaling

The Original Problem

How do we scale without sacrificing security?

How Layer 2 Scaling Solves It

- Assume validity by default, use fraud proofs for disputes (7-day challenge period)
- Prove correct execution cryptographically via SNARKs/STARKs (10-30 min finality)
- Move repeated interactions off-chain, settle final state on L1 (Lightning Network)

Remaining Limitations

- $2B+ stolen from cross-chain bridges (2022-2023)
- Most rollups use single sequencer (SPOF)
- Optimistic rollups require 7-day wait for L1 finality

Open Questions

- Will rollups become the dominant scaling paradigm, or will app-specific chains (L3s) fragment liquidity?
- Risk: Over-optimization for TPS at the expense of decentralization (sequencer monopolies)

Layer 2 Scaling solves throughput bottleneck but introduces new trust assumptions and operational complexity

The Economics of Layer 2 Scaling

Incentive Structure

- Optimizing multiple competing goals
- Choose based on use case requirements
- Gain in one dimension, sacrifice in another

Economic Security

- Attack cost must exceed potential gain
- Honest behavior = Nash equilibrium

Key Economic Question

Who Pays, Who Earns?

Gain in one dimension, sacrifice in another

Design Principle

$$\text{Attack Cost} > \text{Potential Gain}$$

Cryptoeconomic security: Honest behavior must be the Nash equilibrium

Design Space

Design Space: Layer 2 Scaling

Alternatives Considered

1. Different points on trade-off frontier
2. Layer 2 solutions, hybrid approaches

Trade-offs Made

- Every design optimizes some properties
- ... at the expense of others

Design Questions

- What would YOU change?
- What's optimized? What's sacrificed?
- Are there other approaches?

Key Insight

No Perfect Solution

All blockchain designs involve trade-offs between decentralization, security, and scalability.

Every design is a trade-off. Understanding alternatives reveals the "why" behind choices.

Failure Modes: Layer 2 Scaling

Critical Failure Mode

- **What breaks:** Over-optimization for single metric
- **Why it happens:** Economic incentives misaligned

Root Cause

- Assumption violated
- Incentive structure broken
- External shock

Historical Context

- Multiple real-world failures documented
- Patterns repeating across protocols

Early Warning Signs

! Unusual economic behavior
! Incentive misalignment
! Centralization drift

Prediction: What could cause this to fail? How would you detect it early?

What Are the Real Risks of Layer 2?

- Bridges are the weakest link: $2B+ stolen from cross-chain exploits (2022-2023)
- Moving assets between L1 and L2 requires trust in bridge security—a new attack surface

[COMIC: User nervously crossing a rickety bridge labeled "L1 to L2" while hackers saw at the ropes below. Warning sign reads: "Bridge Exploits Ahead!" User's assets shown as bags of money on the swaying bridge]

[PLACEHOLDER] — Layer 2 solves scalability but bridges introduce new risks—always verify bridge security models

Summary

L2 Solutions:

- **State Channels**: P2P, instant (Lightning)
- **Optimistic**: Fraud proofs, 7-day wait
- **ZK-Rollups**: Validity proofs, fast

Next Lesson: L42 – Flash Loans

Key Developments:

- **EIP-4844**: L2 fees $\downarrow$90%
- **ERC-4337**: Smart wallets UX
- **Future**: L3s, danksharding

L2 solutions scale blockchains while preserving decentralization and security

Reflection

Questions for Reflection

1. Why do optimistic rollups have a 7-day withdrawal delay?
2. What makes ZK-rollups more secure than optimistic rollups?
3. Why don't sidechains inherit Layer 1 security?
4. How did EIP-4844 reduce L2 transaction costs so dramatically?
5. How does ERC-4337 solve the onboarding problem for new crypto users?

Key point: Questions for Reflection

Quiz Questions (1–5)

Q1. What is the blockchain scalability trilemma?
A) Trade-off between speed, cost, and privacy
B) Trade-off between decentralization, security, and scalability
C) Trade-off between throughput, latency, and data availability
D) Trade-off between validators, miners, and users
Answer: B – The trilemma states you can only optimize 2 of 3 properties: decentralization, security, and scalability.

Q2. What is the approximate transaction throughput of Ethereum Layer 1?
A) 7 TPS B) 15 TPS C) 65 TPS D) 1000 TPS
Answer: B – Ethereum L1 processes around 15 transactions per second, while Bitcoin does 7 TPS.

Q3. What is the primary purpose of Layer 2 solutions?
A) Replace Layer 1 blockchains entirely
B) Process transactions off-chain while inheriting L1 security
C) Create new cryptocurrencies
D) Increase the block size of Layer 1
Answer: B – L2s move computation off-chain but settle final state on L1, inheriting its security.

Q4. Which Layer 2 pattern is used by Bitcoin's Lightning Network?
A) Rollups B) Sidechains C) State Channels D) Plasma
Answer: C – Lightning uses bidirectional payment channels for peer-to-peer transactions.

Q5. What is the key difference between Layer 2 rollups and sidechains?
A) Rollups are faster than sidechains
B) Sidechains are cheaper than rollups
C) Rollups inherit L1 security; sidechains do not
D) Sidechains use proof-of-stake; rollups use proof-of-work
Answer: C – Rollups post data to L1 and inherit its security, while sidechains have independent consensus.

Quiz Questions (6–10)

Q6. How do optimistic rollups verify transaction validity?
A) Every transaction is verified immediately on L1
B) Transactions are assumed valid unless challenged with a fraud proof
C) Cryptographic proofs are generated for every batch
D) A trusted third party validates all transactions
Answer: B – Optimistic rollups assume validity by default and allow anyone to submit fraud proofs during a challenge period.

Q7. What is the typical withdrawal delay for optimistic rollups?
A) Instant B) 10-30 minutes C) 7 days D) 30 days
Answer: C – The 7-day challenge period allows time for fraud proofs before finalizing state.

Q8. What type of cryptographic proofs do ZK-Rollups use?
A) Proof-of-Work B) Fraud proofs C) SNARK/STARK proofs D) Merkle proofs
Answer: C – ZK-Rollups use SNARK or STARK zero-knowledge proofs to verify correct execution.

Q9. What is the main advantage of ZK-Rollups over optimistic rollups?
A) Lower transaction costs
B) Better EVM compatibility
C) Fast finality without challenge period (10-30 min)
D) Simpler technology
Answer: C – ZK-Rollups achieve finality after proof verification (10-30 min), avoiding the 7-day wait.

Q10. Which Ethereum upgrade significantly reduced L2 transaction fees in March 2024?
A) The Merge B) Shanghai upgrade C) Dencun upgrade (EIP-4844) D) Shapella
Answer: C – Dencun introduced blob transactions (EIP-4844), reducing L2 fees by 90%+.

Quiz Questions (11–15)

Q11. What was the approximate fee reduction after EIP-4844 implementation?
A) 10-20% reduction B) 50% reduction C) 90%+ reduction D) No change
Answer: C – L2 fees dropped from $0.50-2.00 to $0.01-0.05, a 90%+ reduction.

Q12. Which L2 solution currently leads by Total Value Locked (TVL)?
A) Optimism B) Arbitrum C) zkSync D) Polygon zkEVM
Answer: B – Arbitrum has the highest TVL among Ethereum Layer 2 solutions.

Q13. What is the primary security risk associated with cross-chain bridges?
A) High gas fees
B) Slow transaction speed
C) Major attack target ($2B+ stolen in 2022-2023)
D) Incompatibility with smart contracts
Answer: C – Bridges are vulnerable to attacks, with over $2B stolen in recent years.

Q14. What is the "lock-and-mint" pattern used for?
A) Creating new cryptocurrencies
B) Transferring assets between chains via bridges
C) Mining new blocks
D) Validating transactions
Answer: B – Assets are locked on source chain, wrapped tokens minted on destination, then burned to unlock.

Q15. Which trust model provides the highest security for bridges?
A) Trusted (centralized custodian)
B) Federated (multi-sig operators)
C) ZK-Verified (cryptographic proofs)
D) All are equally secure
Answer: C – ZK-verified bridges use cryptographic proofs for the highest security level.

Quiz

Quiz Questions (16–20)

Q16. What is the combined Layer 2 TVL as of late 2024?
A) \$15B B) \$30B C) \$54B D) \$100B
Answer: C – Combined L2 TVL reached \$54B by Dec 2024 (205% YoY growth).

Q17. What is a Layer 3 (L3) solution?
A) A faster version of Layer 1
B) Application-specific rollups built on top of Layer 2
C) A replacement for Layer 2
D) A sidechain for Layer 1
Answer: B – L3s are specialized rollups built on L2s for specific applications.

Q18. What does "sequencer decentralization" aim to address?
A) High transaction fees
B) Slow transaction speed
C) Single point of failure in L2 architecture
D) EVM compatibility issues
Answer: C – Decentralizing sequencers removes the centralized bottleneck in current L2 designs.

Q19. What is the primary advantage of state channels like Lightning Network?
A) Highest security
B) Instant finality with millions of TPS
C) Best for smart contracts
D) Lowest setup cost
Answer: B – State channels enable instant finality and can handle millions of TPS for payments.

Q20. What future upgrade promises 100,000+ TPS through massive data availability?
A) EIP-4844 B) Full Danksharding C) The Merge D) zkEVM
Answer: B – Full Danksharding will dramatically increase data availability, enabling 100,000+ TPS.

Quiz Questions (21–24) – Account Abstraction

Q21. What standard defines Account Abstraction on Ethereum?
A) ERC-20 B) ERC-721 C) ERC-4337 D) EIP-1559
Answer: C – ERC-4337 enables smart contract wallets without protocol changes.

Q22. What component in ERC-4337 allows third parties to pay gas for users?
A) Bundler B) EntryPoint C) Paymaster D) UserOperation
Answer: C – Paymasters sponsor gas fees, enabling gasless transactions for users.

Q23. Which is NOT a benefit of Account Abstraction?
A) Social recovery of wallets
B) Gasless transactions
C) Faster block times on L1
D) Batch transactions in single click
Answer: C – Account abstraction improves wallet UX, not L1 block production speed.

Q24. What role does the Bundler play in ERC-4337?
A) Validates smart contracts
B) Collects UserOperations and submits them to EntryPoint
C) Stores user private keys
D) Processes fraud proofs
Answer: B – Bundlers aggregate UserOps and submit batches to the EntryPoint contract.

Quiz Questions (25–27) – AI + Blockchain

Q25. Which decentralised compute network rewards validators with the TAO token for verifiable ML inference?
A) Render B) Akash C) Bittensor D) Fetch.ai
Answer: C – Bittensor's subnet validators are compensated in TAO for honest ML scoring.

Q26. Why do on-chain AI agents typically deploy via ERC-4337 smart-contract wallets rather than EOAs?
A) Lower gas fees on L1
B) Programmable signing logic, social recovery, and gas abstraction (paymaster)
C) Required by MiCA regulation
D) Mandated by the EVM
Answer: B – ERC-4337 lets agents define custom signing rules and use Paymasters; EOAs cannot.

Q27. Which AI-powered security tool monitors deployed contracts for real-time anomalies?
A) Slither (static-only) B) Forta C) MythX D) Echidna
Answer: B – Forta runs detection bots that scan transactions live; Slither and Echidna are pre-deployment static/fuzz tools.