

# L04: Consensus Mechanisms

BSc Blockchain Course

Digital Finance

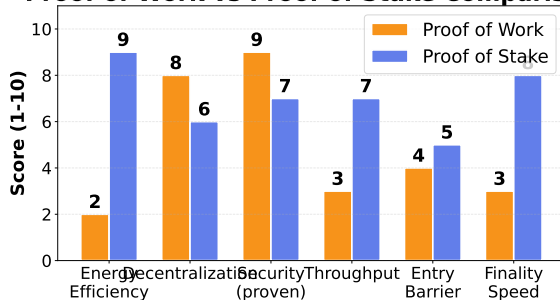
2026

## By the end of this lesson, you will be able to:

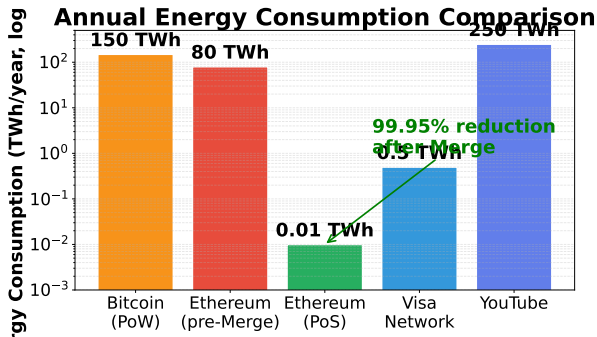
- 1 Compare Proof of Work and Proof of Stake mechanisms
- 2 Explain Byzantine Fault Tolerance and its requirements
- 3 Analyze trade-offs between finality, security, and efficiency
- 4 Understand slashing conditions and validator economics
- 5 Evaluate different consensus mechanisms for various use cases

*Consensus is the heart of blockchain – how distributed nodes agree.*

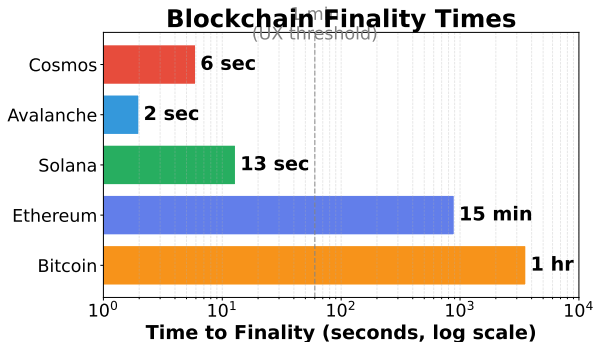
## Proof of Work vs Proof of Stake Comparison



*Neither is objectively better – different trade-offs for different goals.*

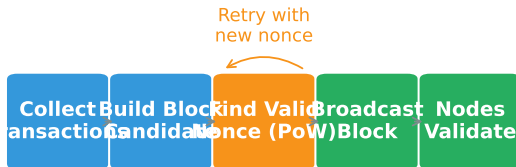


*Ethereum's Merge reduced energy by 99.95%. Bitcoin remains PoW by design.*



*Finality = when transaction cannot be reversed. Critical for user experience.*

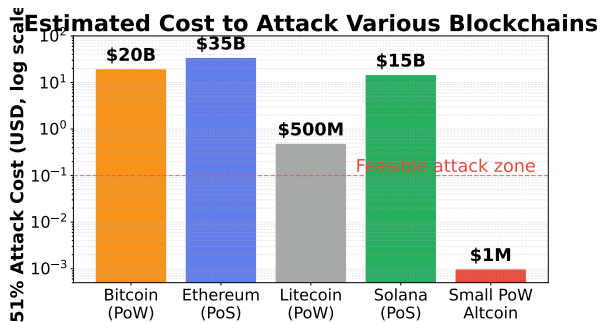
## Nakamoto Consensus (Proof of Work)



### Key Properties:

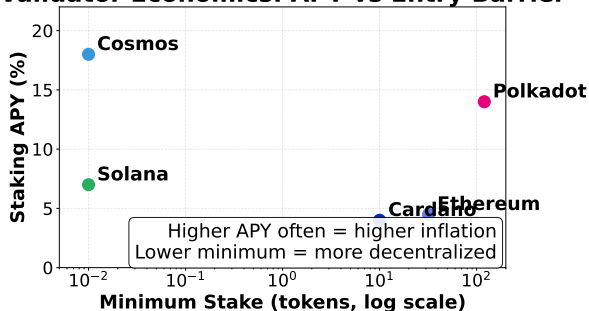
- Probabilistic finality
- Energy-backed security
- Longest chain wins
- Permissionless

*Bitcoin's innovation: probabilistic consensus without known participants.*



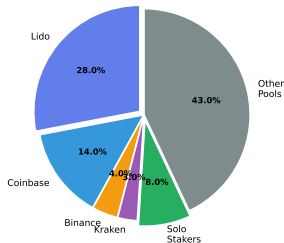
*Security measured by cost to attack, not theoretical guarantees.*

## Validator Economics: APY vs Entry Barrier



*Higher APY often means higher inflation – real yield matters.*

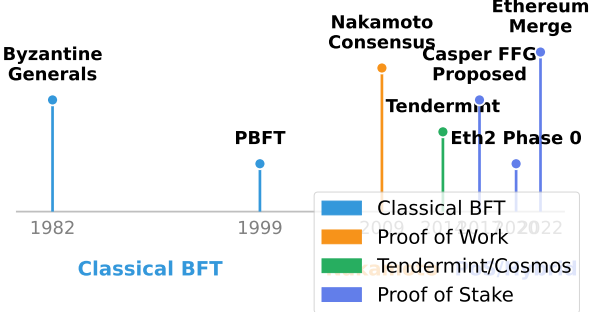
## Ethereum Staking Distribution (2024)



*Note: Top 3 entities control 46% of stake*

*Centralization risk: top entities control significant stake.*

## Evolution of Consensus Mechanisms



From academic theory (1982) to trillion-dollar networks (2022).

## Remember These Points

- 1 PoW: energy-intensive but proven secure, permissionless
- 2 PoS: energy-efficient, faster finality, requires stake
- 3 BFT tolerates up to 33% Byzantine (malicious) nodes
- 4 Slashing penalizes misbehavior in PoS systems
- 5 No consensus mechanism is perfect – all have trade-offs

**Next Lesson:** Ethereum and Smart Contracts – EVM, gas, and state.