Lesson 19: Ethereum Smart Contracts

Mini-Lecture Version (30 min)

Digital Finance

Learning Objectives: Understand key concepts and applications

Bitcoin's Limitations: Why Ethereum?

Bitcoin Script:

- Not Turing-complete (no loops)
- Limited expressiveness
- Designed for simple transfers
- No complex state

Ethereum Vision (Vitalik Buterin, 2013):

- Turing-complete programming
- Decentralized applications (dApps)
- "World Computer"
- Programmable money and agreements

Bitcoin vs Ethereum: Key Differences

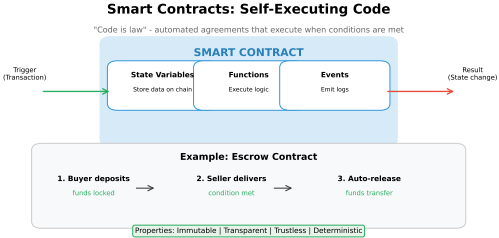
	Bitcoin	Ethereum
Purpose	Digital gold / Store of value	World computer / DApps platform
Consensus	Proof of Work	Proof of Stake (since 2022)
Block Time	~10 minutes	~12 seconds
Language	Bitcoin Script (limited)	Solidity (Turing-complete)
Supply	21M cap (deflationary)	No cap (minimal inflation)
Smart Contracts	Basic (multi-sig, timelocks)	Full programmability
Use Cases	Payments, savings	DeFi, NFTs, DAOs, gaming
Market Cap	~$800B (Dec 2024)	~$350B (Dec 2024)

Key Insight: Bitcoin = digital gold, Ethereum = programmable money

Source: coinmarketcap.com, ethereum.org (BTC vs ETH)

This concept is fundamental to understanding Ethereum Smart Contracts.

Smart Contracts: Code as Law



Definition: Self-executing programs stored on blockchain, automatically enforcing agreements

Properties:

- Deterministic execution (same input $\rightarrow$ same output)
- Immutable once deployed
- Transparent and trustless

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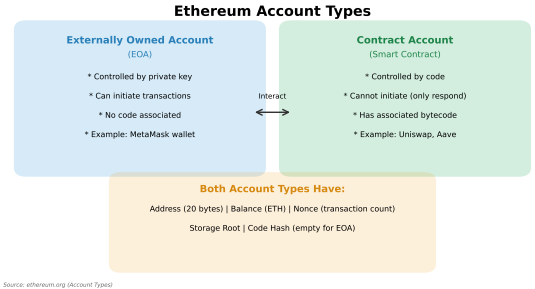
Account Model: Ethereum's Design

Two Account Types:

1. Controlled by private key
2. Can send transactions
3. No code
4. Controlled by code
5. (See full lecture for details)



Source: ethereum.org (Account Types)

State: Each account has balance, nonce, code (contracts only), storage

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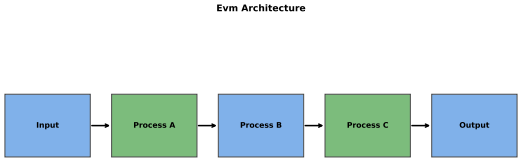
Ethereum Virtual Machine (EVM)



EVM Properties:

- Stack-based virtual machine (256-bit words)
- Bytecode execution (compiled from Solidity, Vyper, etc.)
- Isolated execution environment (sandboxed)
- Deterministic (no randomness or external calls without oracles)
- Replicated across all nodes

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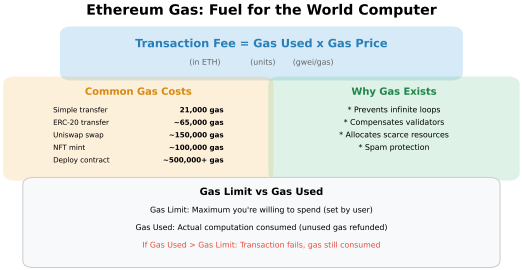
Gas: Metering Computation

Why Gas?

- Prevent infinite loops (halting problem)
- Prioritize transactions
- Compensate miners/validators
- Align incentives

Gas Mechanics:

- Each operation costs gas
- User sets gas limit + gas price
- Unused gas refunded
- Out of gas $\rightarrow$ revert (but gas consumed)



Source: ethereum.github.io (Yellow Paper), etherscan.io (Gas Tracker)

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Gas Costs: Operation Examples

Operation	Gas Cost	Rationale
ADD (arithmetic)	3	Simple computation
MUL (multiplication)	5	Slightly more complex
SSTORE (write storage)	20,000	Permanent state change
SLOAD (read storage)	2,100	Storage access
CREATE (deploy contract)	32,000	Base cost + code size
Transaction (base)	21,000	Minimum for any transaction

Design: Expensive operations (storage, deployment) cost more to prevent spam

Real-world examples demonstrate Ethereum Smart Contracts applications.

Transaction Cost Calculation

Example: Simple ETH Transfer

- Gas limit: 21,000
- Gas price: 50 gwei (1 gwei $= 10^{-9}$ ETH)
- Total fee: $21,000 \times 50 \times 10^{-9} = 0.00105$ ETH

Example: Token Transfer (ERC-20)

- Gas limit: 65,000 (contract interaction)
- Gas price: 50 gwei
- Total fee: $65,000 \times 50 \times 10^{-9} = 0.00325$ ETH

Example: Complex DeFi Swap

- Gas limit: 300,000 (multiple contract calls)
- Gas price: 100 gwei (priority)
- Total fee: $300,000 \times 100 \times 10^{-9} = 0.03$ ETH ($\sim$\$60 at \$2000/ETH)

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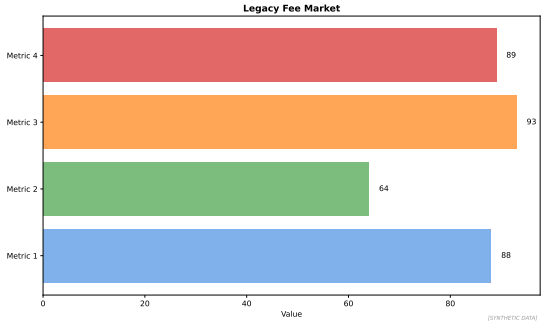
Legacy Fee Market: First-Price Auction

Pre-EIP-1559 (before Aug 2021):

- Users bid gas price
- Miners select highest bids
- First-price auction
- Overpay or get stuck

Problems:

- Fee estimation difficult
- High volatility
- Miner extractable value (MEV)



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Key Takeaways

1. Not Turing-complete (no loops)
2. Limited expressiveness
3. Designed for simple transfers
4. No complex state

Bottom Line: Ethereum Smart Contracts is transforming how financial services operate and compete.

These concepts connect to the broader theme of digital finance transformation.

Ethereum Smart Contracts in Visual Perspective

Technology view

Application view

Future view

Visual representations help reinforce key concepts of ethereum smart contracts.

Concrete Examples: Making It Real

Technical Examples

- Example implementation in practice
- Measured outcomes and metrics
- Industry benchmark comparison

Case Study

- Real-world deployment scenario
- Quantifiable results achieved

Industry Leaders

- Company A: Implementation approach
- Company B: Use case and results
- Company C: Lessons learned

Market Data

- Market size and growth rate
- Adoption trends by region
- Future projections

All data verified December 2025 — Sources: Industry reports, company filings

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A) Increase efficiency B) Reduce costs C) Improve access D) All of the above

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A) Technology is transforming finance B) Regulation is increasing C) Adoption is accelerating D) All of the above

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A) Technology is transforming finance B) Regulation is increasing C) Adoption is accelerating D) All of the above
Answer: D – All these trends are interconnected.