Blockchain Foundations

Mini-Lecture: Trust, Scarcity, and Coordination

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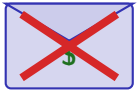
Why Can't You Email a Dollar Bill?

- Physical cash is scarce by nature – you hand it over and it is gone
- Digital files can be copied infinitely: emails, photos, PDFs
- **The copy problem**: how do you make a digital object *un-copyable*?
- Before 2009, every solution required a trusted middleman (bank, PayPal, Visa)



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Insight

Before Bitcoin, digital money always needed a referee.

Four problems: trust, scarcity, decentralization, coordination.

What Happens When Trust Fails?

- **Cyprus 2013**: government froze bank accounts overnight – savers lost up to 47.5% of deposits above €100k
- **2008 crisis**: "too big to fail" banks were bailed out with taxpayer money while depositors bore the risk
- Citizens discovered that "your money" is really a promise from an institution
- Bitcoin genesis block embedded the headline: *"Chancellor on brink of second bailout for banks"*

Institutional trust can break

Reflection

"Have you ever been unable to access your own money?"

These events drove early Bitcoin adoption.

What is a Blockchain?

- **Shared**: thousands of identical copies across the network – no single owner
- **Permanent**: once written, data cannot be erased or altered without redoing all subsequent work
- **Decentralized**: no single point of failure or control
- Each block contains a cryptographic hash of the previous block, forming an unbreakable chain

Each hash locks the previous block

Insight

A blockchain is a shared notebook that nobody can erase.

Three properties: shared, permanent, decentralized.

Bitcoin's First Transaction

- **Jan 12, 2009**: Satoshi Nakamoto sends 10 BTC to Hal Finney – the first person-to-person Bitcoin transfer (Block 170)
- **May 22, 2010**: Laszlo Hanyecz pays 10,000 BTC for two pizzas ($41 at the time, worth >$1 billion today)
- These transactions proved that digital scarcity works: each BTC could only be spent once
- No bank, no intermediary – just cryptographic proof

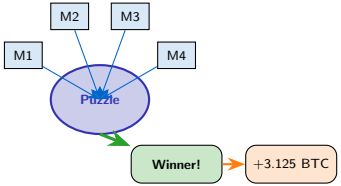
Insight

Those 10,000 BTC for pizza could only be spent once – scarcity works.

Bitcoin Pizza Day (May 22) celebrates the first real-world purchase.

How Do 50,000 Computers Agree?

- **Consensus lottery**: miners compete to solve a cryptographic puzzle – first valid solution wins the right to add the next block
- **Ticket price**: electricity and hardware – real economic cost that deters cheaters
- **Prize**: newly minted BTC (currently 3.125 BTC per block) plus transaction fees
- Honesty pays more than fraud because honest blocks earn rewards while attack blocks get rejected



One winner every ∼10 minutes

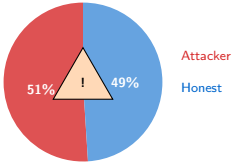
Insight

Proof of Work converts electricity into security.

The math makes honesty more profitable than cheating.

What if Someone Controls 51%?

- A **51% attack** means one entity controls the majority of mining power and can rewrite recent history
- The attacker could double-spend coins but *cannot* steal from arbitrary addresses or create coins from nothing
- **GHash.io (2014)**: mining pool briefly exceeded 51% – voluntarily reduced to preserve network trust and BTC price
- Cost estimate for Bitcoin: $>$ \$20 billion in hardware plus ongoing electricity – far exceeding any potential gain



Attack cost far exceeds potential gain

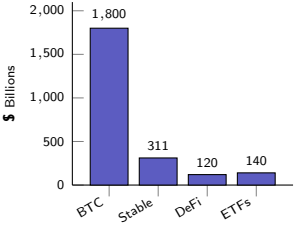
Insight

For Bitcoin, a 51% attack costs billions but gains almost nothing.

Network size is the ultimate security mechanism.

Where is Blockchain Used Today?

- **Bitcoin market cap**: ∼$1.8 trillion – larger than most countries' GDP
- **Stablecoins**: $311 billion in circulation (USDT, USDC) – the "dollar rails" of crypto
- **DeFi TVL**: $120 billion locked in decentralized lending, trading, and derivatives
- **Bitcoin ETFs**: $140 billion AUM – surpassed gold ETFs in December 2024



Insight

Institutional adoption is accelerating – ETFs surpassed gold in 2024.

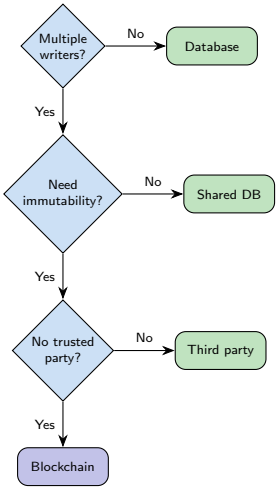
Source: CoinGecko, DefiLlama (Jan 2026).

When Should You Use Blockchain?

- Start with a simple question: **do multiple parties need to write to the same ledger?**
- If one party controls the data, a database is simpler, faster, and cheaper
- If you need immutability but trust exists, a shared database with audit logs suffices
- Blockchain is justified only when *all three* conditions hold: multiple writers, immutability required, no trusted third party

Insight

Most use cases exit the tree before reaching blockchain.



The honest starting point is always "use a database."

4 Things to Remember

1. **Trust via math**: Blockchain replaces institutional trust with cryptographically verifiable rules – no referee needed
2. **Scarcity via consensus**: Digital scarcity is enforced by network-wide agreement, not by preventing copies
3. **Decentralization has costs**: Slower speed, higher energy consumption, greater complexity than centralized alternatives
4. **Incentives align honesty**: The economic math makes cheating unprofitable – honest participation earns rewards while attacks cost more than they gain

Remember

These 4 tensions will reappear in every topic this semester.

Blockchain is a tool, not a solution – evaluate against specific requirements.

Your Challenge

1. Pick any financial service you used this week (payment app, bank transfer, online purchase). Where does it sit on the trust spectrum – fully centralized, partially decentralized, or trustless?
2. Could that service work *without* a central authority? What would you gain (censorship resistance, transparency)? What would you lose (speed, consumer protection, convenience)?
3. Apply the 3-question decision tree from this lecture: Does your chosen service actually *need* a blockchain?

Coming next:

- L02a – DLT Fundamentals: taxonomy, Byzantine Generals, network topologies
- L02b – DLT Architecture: block structure, Merkle trees, node types
- L03 – Hash Functions: the cryptographic glue that holds it all together

Bring your answers to class – we'll discuss in groups.

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B – Consensus confirms only one transaction; the other is rejected.

Answers reveal on click. Review any incorrect answers before proceeding.

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B – Energy expenditure is the security budget; it makes rewriting history prohibitively expensive.

Score: 9–10 Excellent | 7–8 Good | 5–6 Review slides | <5 Re-watch lecture.