

CSC 116: Blockchain Overview / Proof of Work

2008

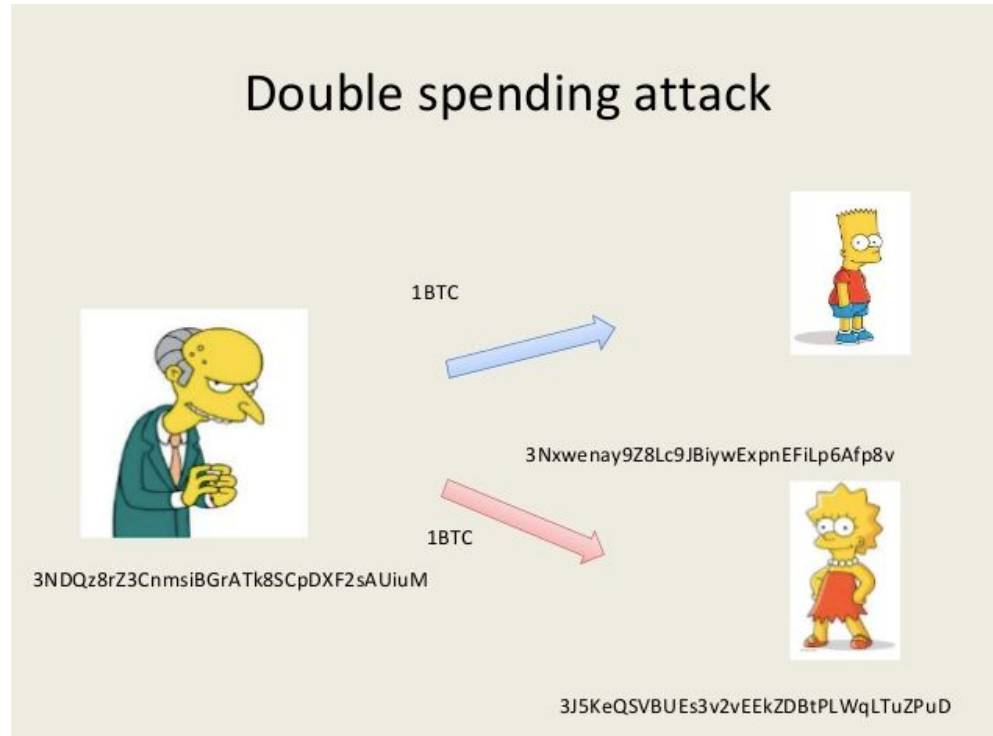
Bitcoin: A Peer-to-Peer Electronic Cash System

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Abstract. A purely peer-to-peer version of electronic cash would allow online payments to be sent directly from one party to another without going through a financial institution. Digital signatures provide part of the solution, but the main benefits are lost if a trusted third party is still required to prevent double-spending. We propose a solution to the double-spending problem using a peer-to-peer network. The network timestamps transactions by hashing them into an ongoing chain of hash-based proof-of-work, forming a record that cannot be changed without redoing the proof-of-work. The longest chain not only serves as proof of the sequence of events witnessed, but proof that it came from the largest pool of CPU power. As long as a majority of CPU power is controlled by nodes that are not cooperating to attack the network, they'll generate the longest chain and outpace attackers. The network itself requires minimal structure. Messages are broadcast on a best effort basis, and nodes can leave and rejoin the network at will, accepting the longest proof-of-work chain as proof of what happened while they were gone.

Double Spending

Imagine you have a \$10 bill, and you give it to a friend to buy coffee. Once you give away the bill, you no longer have it—you can't use it again.



Now, think about digital money, like Bitcoin. Since it's just data, you could try to send the same Bitcoin to two different people at the same time. This is called **double spending**—it's like copying your digital money and using it twice, which is a problem because it would make the money worthless.

Block 51

Proof of work:
0000009857vvv

Previous block:
000000432qrza1

Transaction
lk54lfvx

Transaction
09345w1d

Transaction
vc4232v32

Block 52

Proof of work:
000000zzxvzx5

Previous block:
0000009857vvv

Transaction
dd5g31bm

Transaction
22qsx987

Transaction
001hk009

Block 53

Proof of work:
00000090b41bx

Previous block:
000000zzxvzx5

Transaction
94lxcv14

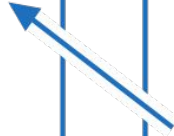
Transaction
abb7bxxq

Transaction
34oiu98a

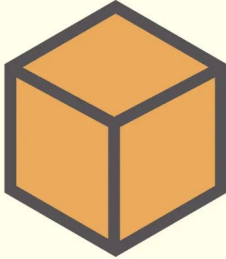
receipt

receipt

receipt



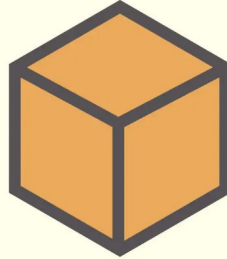
Block 1



Hash: 6U9P2
Previous Hash: 0000



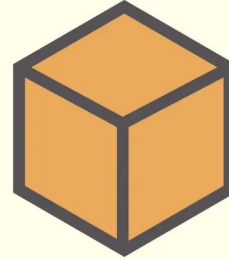
Block 2



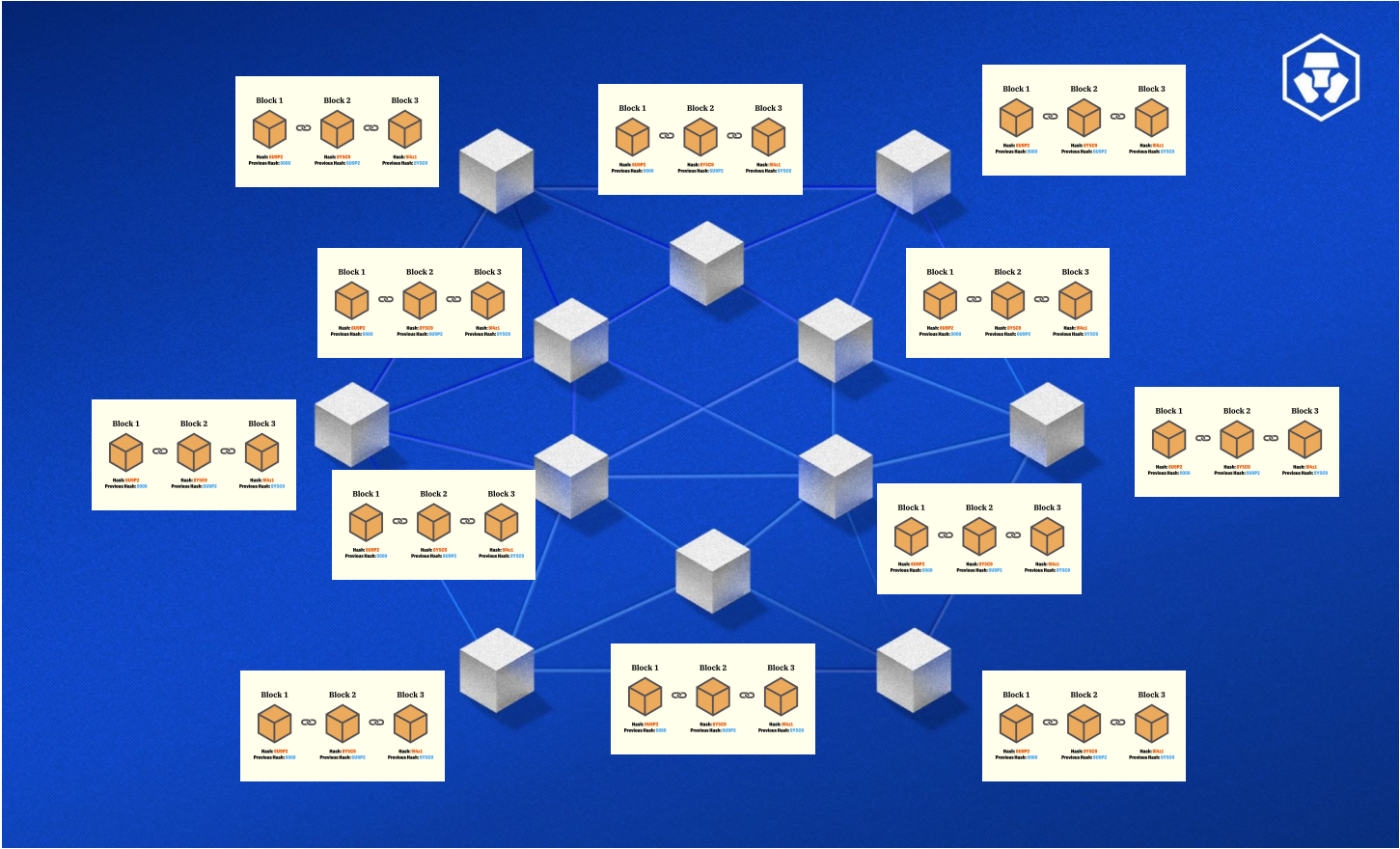
Hash: 8Y5C9
Previous Hash: 6U9P2



Block 3



Hash: 9l4z1
Previous Hash: 8Y5C9



<https://mempool.space/graphs/lightning/nodes-map>

Everyone in Bitcoin has a copy
of the blockchain



10 years ago,
it is easy to
win bitcoins



Now! You
need to buy
whole
building of
GPUs to win

Why these crazy people (Miners) buy so many GPUs?

They want to make money!!!

They want to win bitcoin

- 1 A Miner first creates a block!
- 2 Collecting all the transactions from different users.
3. This miner needs to prove its ability to store the datasets.
4. All the miners start their hard working on calculating puzzles.

What is the puzzle?

Hash function SHA-256

000000000000000000000000000000008af93b8a4c68e58a2
e4a234b2bd2d09c2f0bbff7f2f01

5, Broadcast this block to every nodes, and attached to the last position of the blockchain.

6, These nodes verify the block:

Is the Proof of Work valid?

Are the transactions valid? (**No double spending**, correct signatures, etc.)

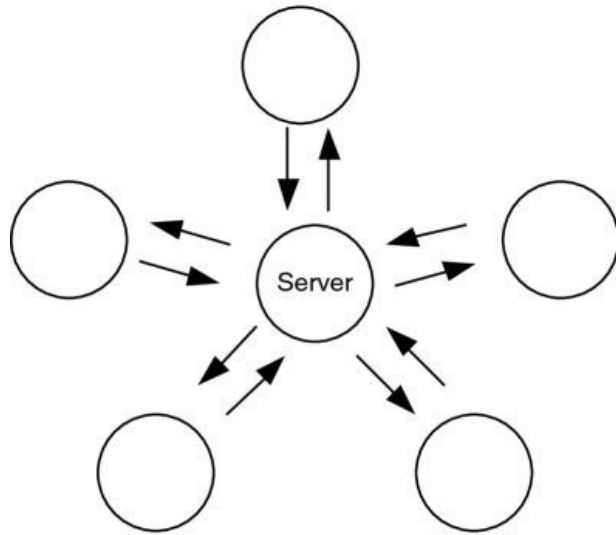
Is the block properly linked to the previous block? If valid, the node **forwards the block to other nodes By Gossip protocol**.

7, This miner will get **3.125** Bitcoin reward.

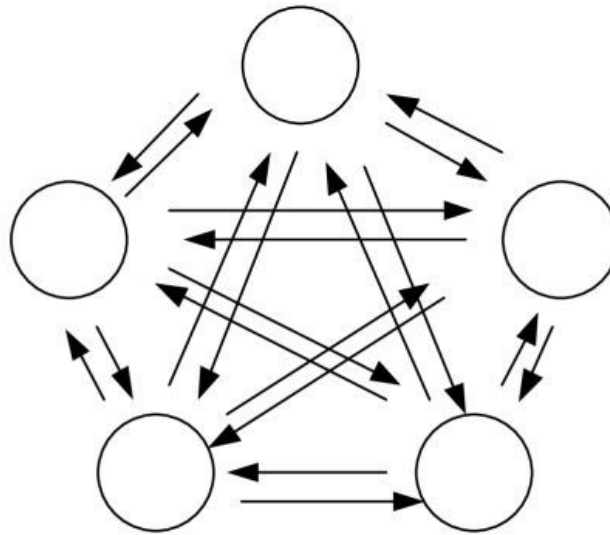
Gossip protocol

Why not BFT?

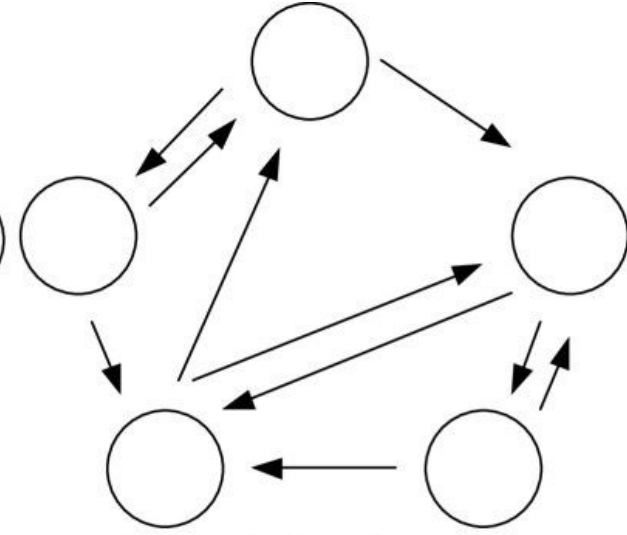
1. +10000 nodes
2. Latency



(a) Centralized approach, which uses a centralized server for forwarding and mixing of multimedia streams



(b) Fully connected overlay approach, where all peers are in direct contact with one another



(c) Gossip-based approach, where peers operate in parallel, and each peer communicates with one or more randomly selected partner

Gossip protocol vs Broadcast

Feature	Gossip Protocol 🗣️	Broadcast 📢
How It Spreads	Nodes forward messages to a few peers, which continue spreading.	A node directly sends to all other nodes.
Scalability	✅ Highly scalable (works in large networks).	❌ Not scalable (network congestion in large systems).
Efficiency	✅ Less network traffic per node.	❌ High bandwidth usage (each node must handle all messages).
Speed	❌ Slower (takes multiple hops to spread).	✅ Faster (all nodes receive the message at once).
Fault Tolerance	✅ Works even if some nodes fail.	❌ If sender fails, message may not reach all nodes.
Redundancy	❌ Some nodes receive duplicate messages.	✅ No duplicates (one-time send to all).

Every 4 years, Miners will lose half reward.

1st	2012	50 → 25
2nd	2016	25 → 12.5
3rd	2020	12.5 → 6.25
4th	2024	6.25 → 3.125
5th (Next)	2028	3.125 → 1.5625
6th	2032	1.5625 → 0.78125
...
~33rd (Final Halving)	~2140	0 BTC

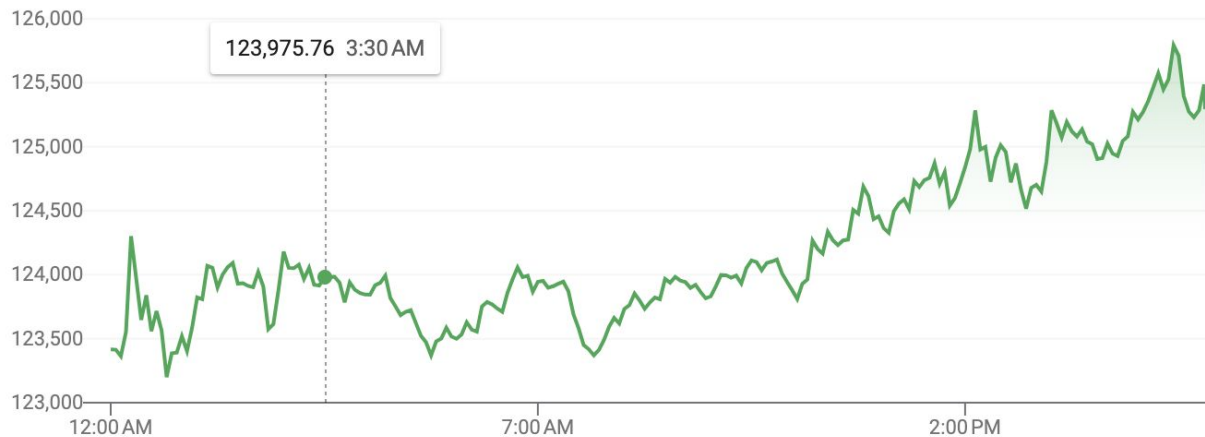
Market Summary > Bitcoin

125,307.90 USD

+1,892.10 (1.53%) ↑ today

Oct 6, 5:56 PM UTC · [Disclaimer](#)

1D | 5D | 1M | 6M | YTD | 1Y | 5Y | Max



1 | BTC ▼ | 125307.90 | USD ▼

More about Bitcoin →

Feedback

Important Roles:

Wallets: Everyone registered has a global wallet

Miners: Want to make money

Regular Users: Buy products off-networks and pay the bitcoin on-line.

<https://www.blockchain.com/explore/r/addresses/btc/1XPTgDRhN8RFnzniWCddobD9iKZatrVH4>

The main feature of Blockchain is transparency and immutability.

No any privacy!!!

Bitcoin like a virus spreading your data to every corners on the earth.

It is secure because everyone have your datasets

Drawbacks of Bitcoin:

Harm to the environment !

Wasting electricity!

10 mins generating a block,
there are 10,000 nodes, more than
1,000,000 miners all over the world, only
1 miner wins at 10 mins.

Harm to the environment



Some countries banned Cryptocurrency:

They afraid of money laundering.

Government can not control your money.

[https://mempool.space/graphs/lightning/
nodes-map](https://mempool.space/graphs/lightning/nodes-map)

Difference of Bitcoin and Blockchain

- 1, Bitcoin is an application.
- 2, Blockchain is an algorithm.

Difficently to attack blockchain



You need to **control** 51% precentage of nodes. Randonly attack is not meaningful.

Miners will try hard to protect the data because they want to make money.

Conclusion for PoW

Proof of Work (PoW) is a **consensus mechanism** used in Bitcoin and many other blockchains to ensure that all transactions are valid and that new blocks are added securely.

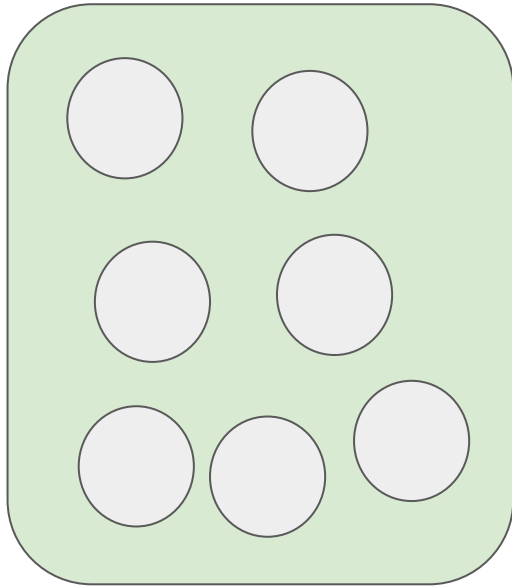
In simple terms, **miners must solve a difficult mathematical puzzle to add a new block to the blockchain**. This process requires **computational power**, which prevents spam, fraud, and malicious attacks.

Feature	Proof of Work (PoW) 	Byzantine Fault Tolerance (BFT) 
Security	✓ Very high (51% attack is costly)	✓ Secure but only tolerates up to 33% bad nodes
Energy Usage	✗ Very high	✓ Low (energy-efficient)
Decentralization	✓ Highly decentralized	✗ Less decentralized (limited validators)
Transaction Speed	✗ Slow (minutes per block)	✓ Fast (seconds)
Scalability	✗ Low (~7-30 TPS)	✓ High (~1000+ TPS)
Finality	✗ Probabilistic (longest chain wins)	✓ Instant finality
Resistance to Sybil Attacks	✓ Strong	✓ Strong (validators are known)
Best For	Public blockchains (Bitcoin, Ethereum)	Private blockchains (Hyperledger, Cosmos)

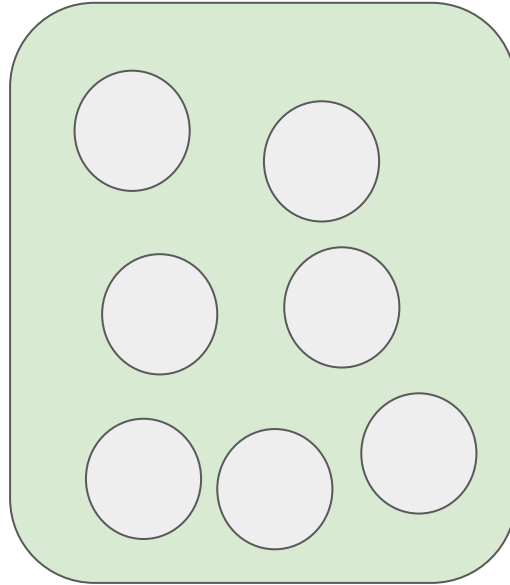
Which one is more secure between Permissioned Blockchain and Public Blockchain?

Aspect	Permissioned Blockchain	Public Blockchain
Participation	Restricted to authorized nodes	Open to anyone
Consensus Mechanism	Efficient (e.g., BFT, PBFT)	Resource-intensive (e.g., PoW, PoS)
Decentralization	Limited (fewer nodes, controlled environment)	High (thousands of nodes, fully decentralized)
Transparency	Limited (only authorized participants can view data)	Fully transparent (all transactions public)
Immutability	High (but depends on participants' honesty)	Extremely high (cryptographically secured)
Attack Resistance	Vulnerable to insider attacks	Resistant to censorship and external attacks

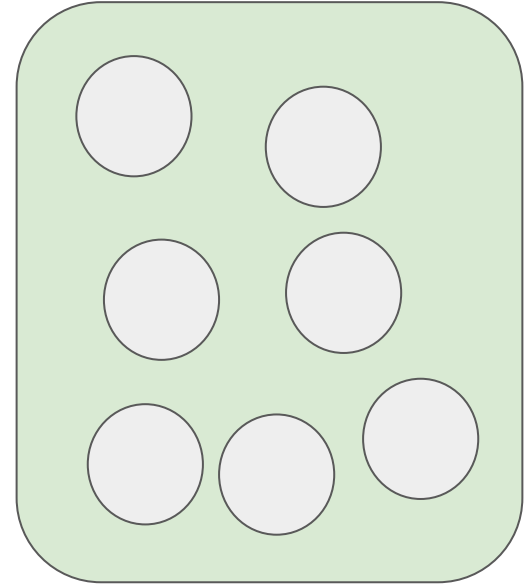
Permissioned Blockchain: Why it named Permissioned?



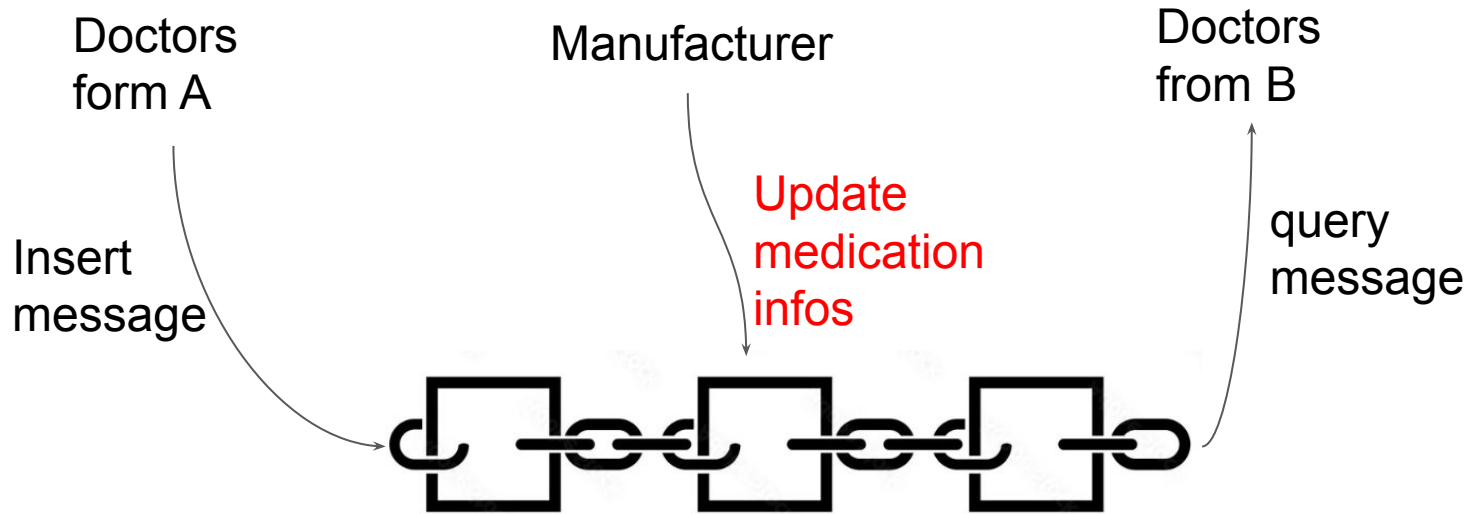
Hospital A



Hospital B



Hospital C



Permissioned Blockchain share information with everyone.

Every authorized users with proper access control can update, insert, and search?