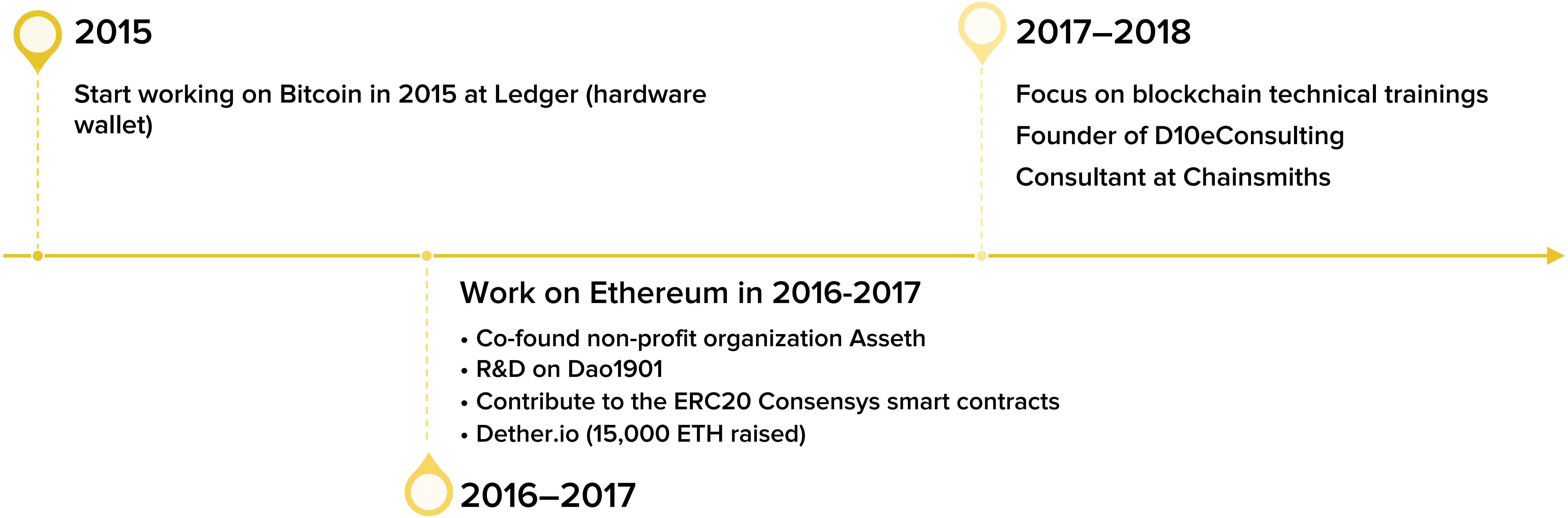
Mining, Consensus & forks

ENFORCING RULES WITHOUT A CENTRAL AUTHORITY

Stéphane Roche

ABOUT STEPHANE



2015

Start working on Bitcoin in 2015 at Ledger (hardware wallet)

2016–2017

Work on Ethereum in 2016-2017

- Co-found non-profit organization Asseth
- R&D on Dao1901
- Contribute to the ERC20 Consensys smart contracts
- Dether.io (15,000 ETH raised)

2017–2018

Focus on blockchain technical trainings

Founder of D10eConsulting

Consultant at Chainsmiths

@janakaSteph on Twitter
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OUTLINE

1. The Bitcoin network
2. Mining and Consensus
3. Natural Fork
4. Hard Fork
5. Soft Fork

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THE BITCOIN NETWORK

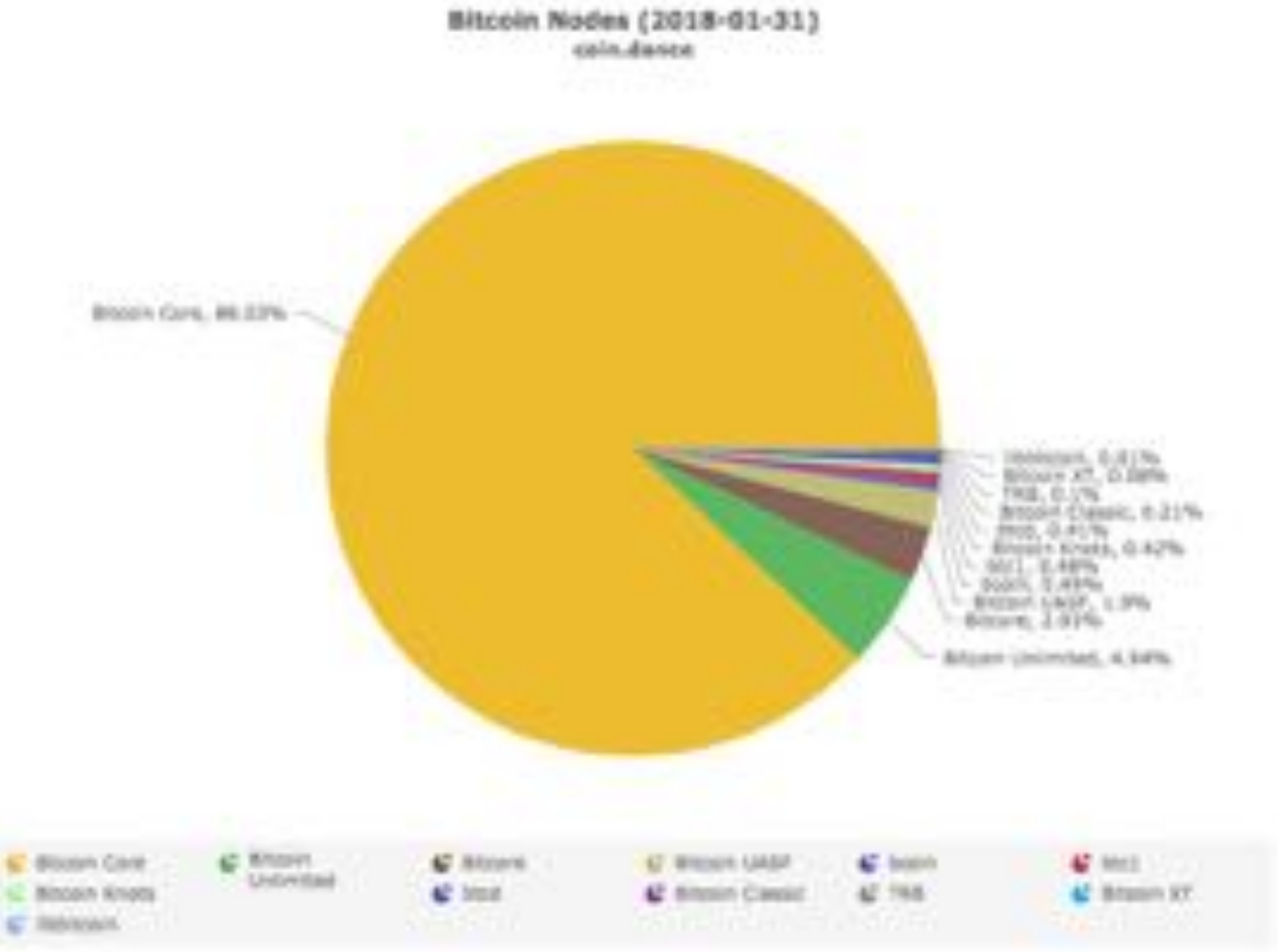
SEVERAL IMPLEMENTATIONS

- Bitcoin Core defines the Bitcoin protocol => reference implementation

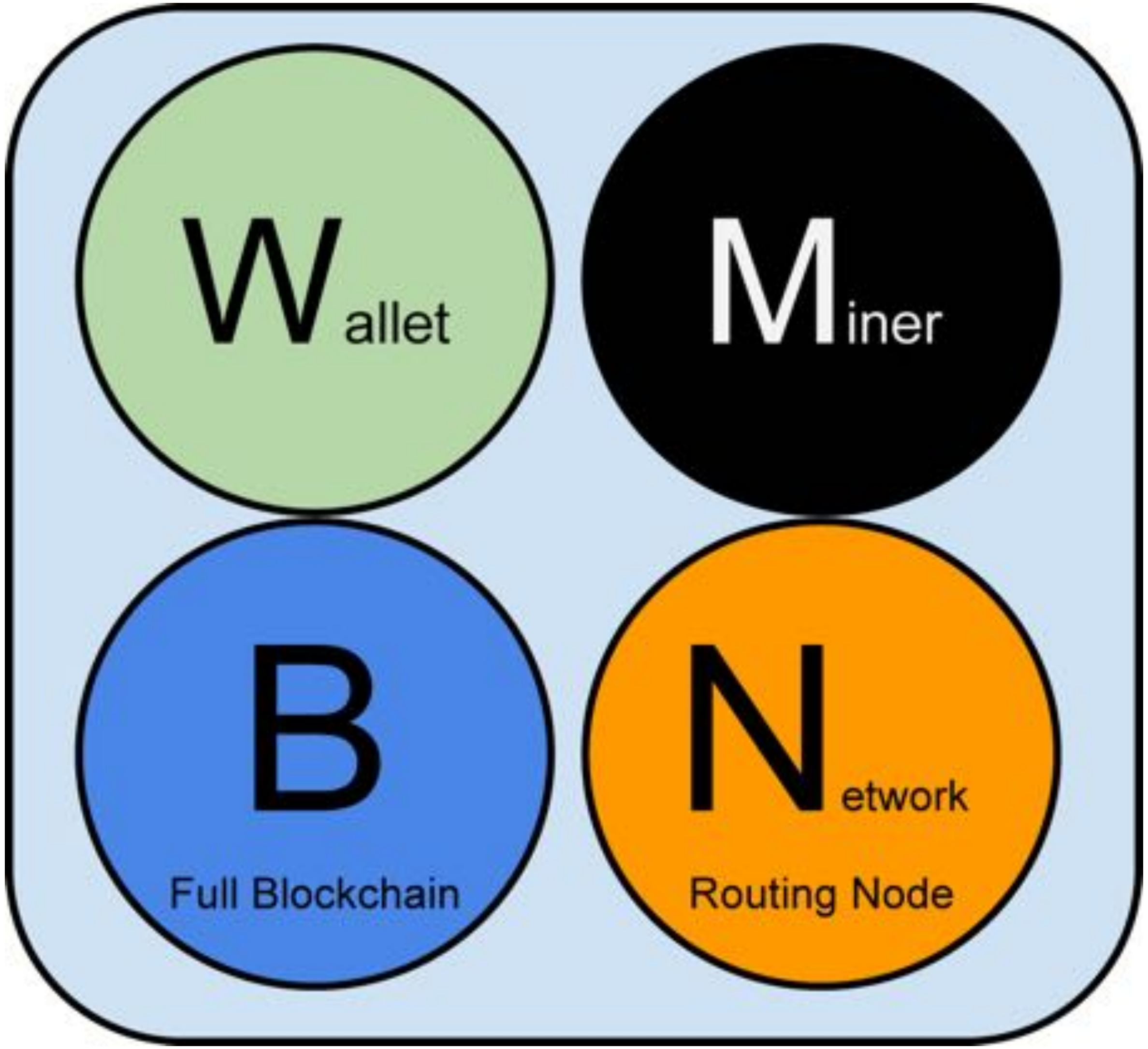
- “The implementation is the specification” (?)

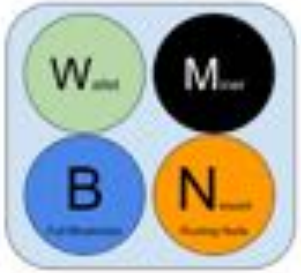
- Around 10 other alternative implementations

- Multiple implementations
  - Pro: help the network being more resilient
  - Con: higher risk of unintentional fork


Bitcoin Nodes (2018-01-31)
coin.dance
Bitcoin Core, 88.03%
Unknown, 0.01%
Bitcoin XT, 0.08%
TRB, 0.1%
Bitcoin Classic, 0.21%
btcd, 0.41%
Bitcoin Knots, 0.42%
btc1, 0.48%
bcoin, 1.49%
Bitcoin UASF, 1.9%
Bitcore, 2.01%
Bitcoin Unlimited, 4.94%
Bitcoin Core
Bitcoin Unlimited
Bitcore
Bitcoin UASF
bcoin
btc1
Bitcoin Knots
btcd
Bitcoin Classic
TRB
Bitcoin XT
Unknown

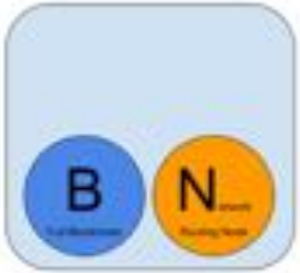
The four functions of a node





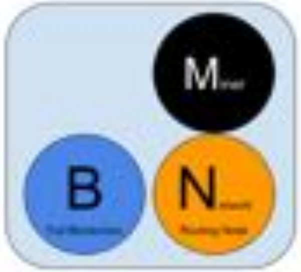
Reference Client (Bitcoin Core)

Contains a Wallet, Miner, full Blockchain database, and Network routing node on the bitcoin P2P network.



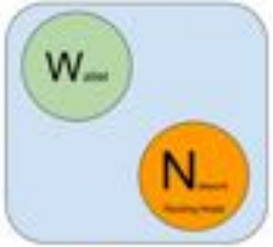
Full Block Chain Node

Contains a full Blockchain database, and Network routing node on the bitcoin P2P network.



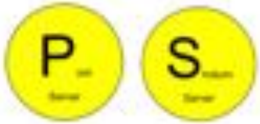
Solo Miner

Contains a mining function with a full copy of the blockchain and a bitcoin P2P network routing node.



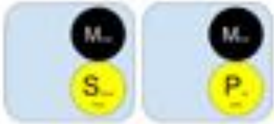
Lightweight (SPV) wallet

Contains a Wallet and a Network node on the bitcoin P2P protocol, without a blockchain.



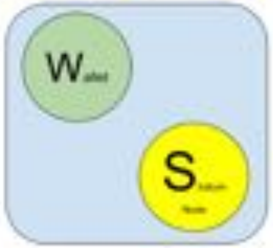
Pool Protocol Servers

Gateway routers connecting the bitcoin P2P network to nodes running other protocols such as pool mining nodes or Stratum nodes.



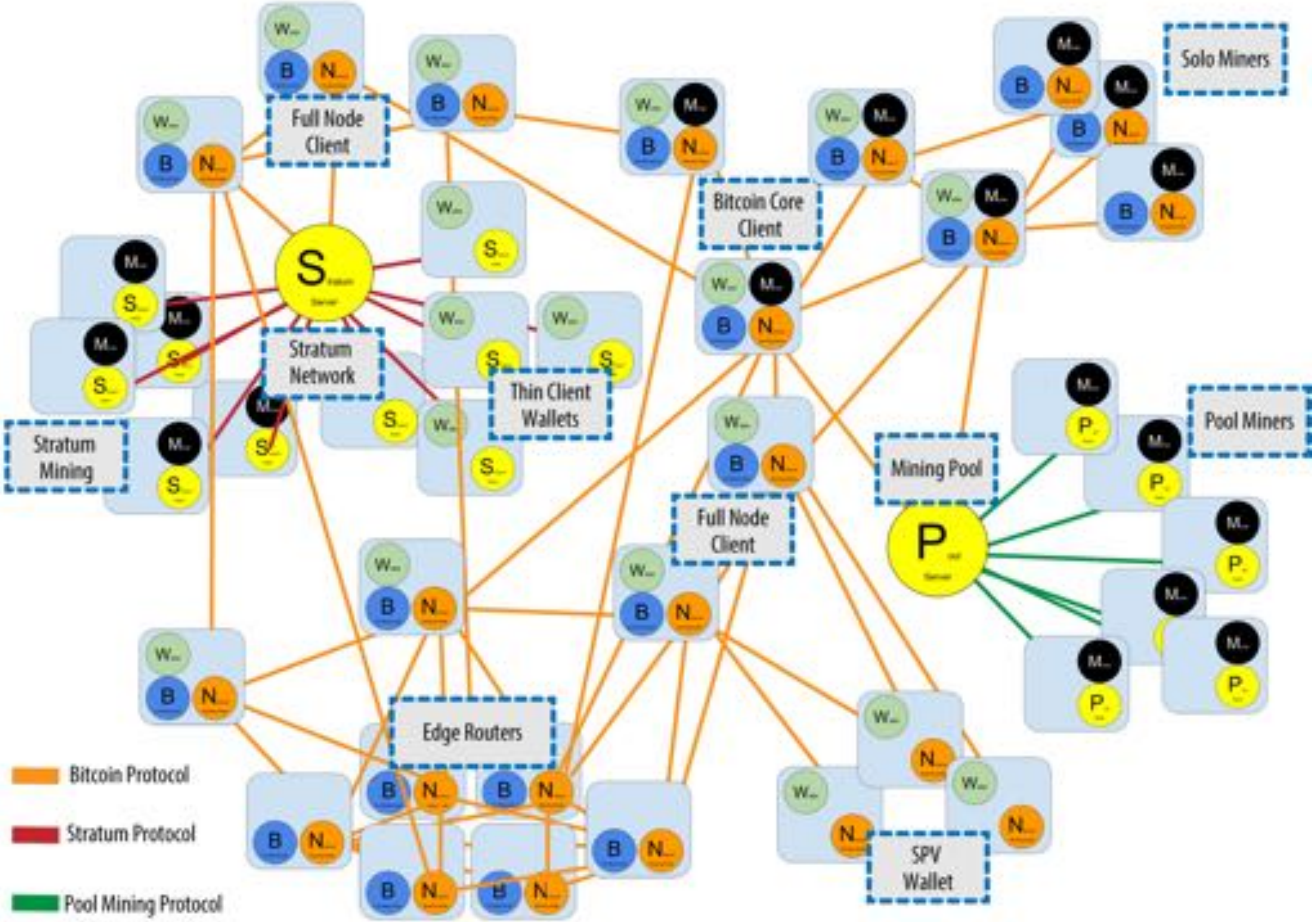
Mining Nodes

Contain a mining function, without a blockchain, with the Stratum protocol node (S) or other pool (P) mining protocol node.



Lightweight (SPV) Stratum wallet

Contains a Wallet and a Network node on the Stratum protocol, without a blockchain.


Full Node Client
Solo Miners
Bitcoin Core Client
Stratum Network
Thin Client Wallets
Stratum Mining
Pool Miners
Mining Pool
Full Node Client
Edge Routers
SPV Wallet
W
B
N
M
S
P
Bitcoin Protocol
Stratum Protocol
Pool Mining Protocol

RECAP

- Multiple software implementations

- Multiple node functionalities / roles

- Each node has its own view of the blockchain and the network

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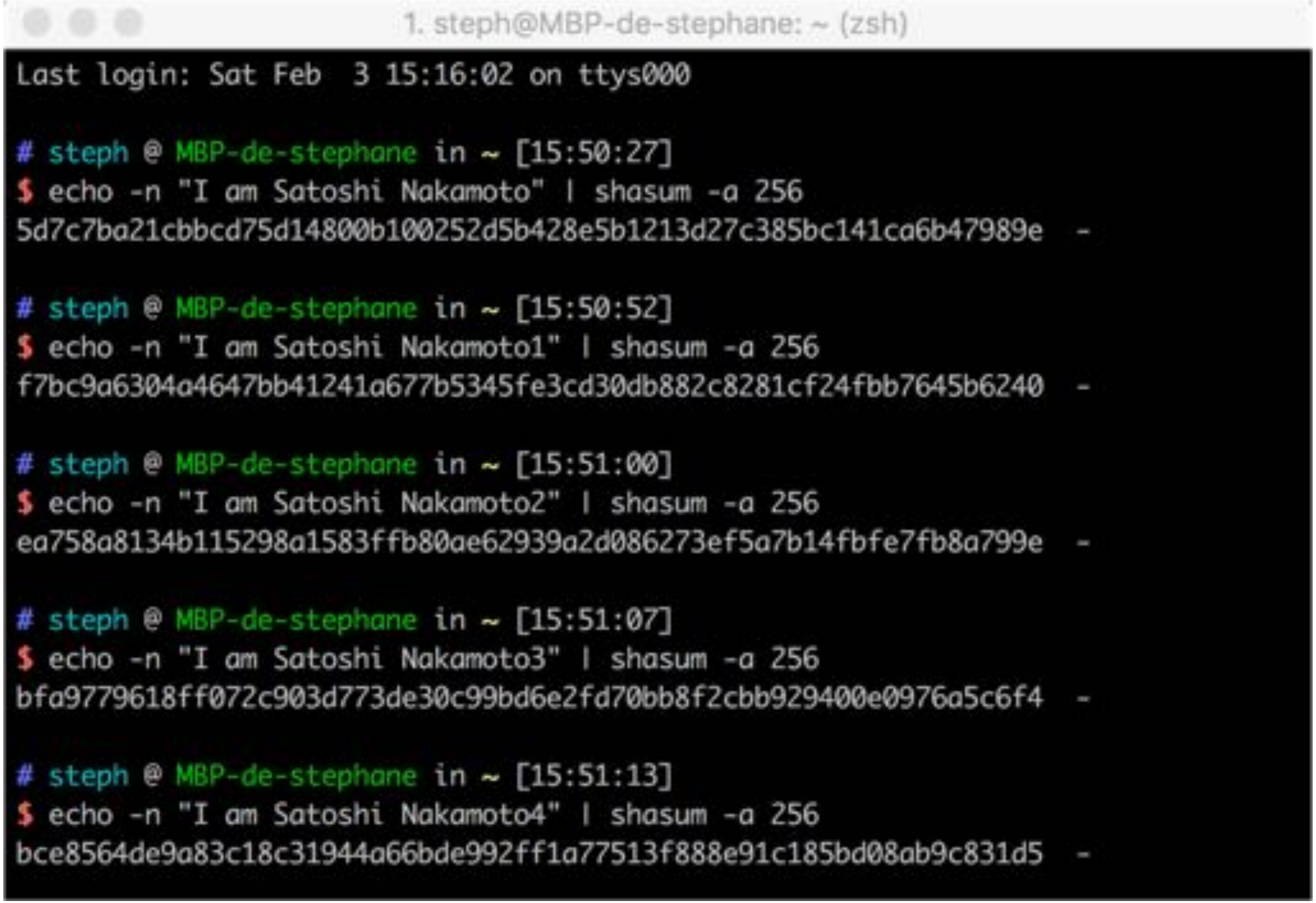
MINING AND CONSENSUS

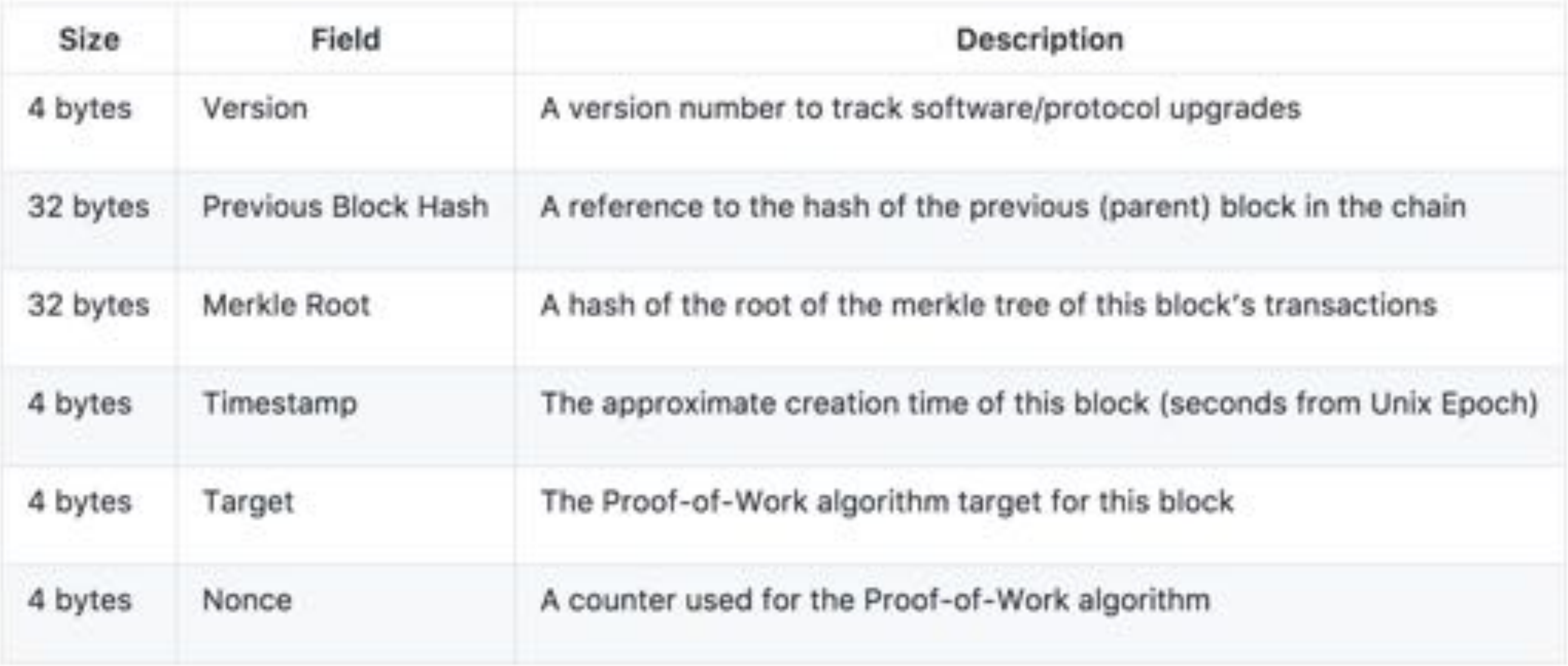
MINING

- Proof-of-Work consensus algorithm
- Secures the Bitcoin system
  - Bitcoin hash rate currently around 20 exahash/s
- Currency creation
- Enables the emergence of network-wide *consensus without a central authority*



```
Last login: Sat Feb  3 15:16:02 on ttys000

# steph @ MBP-de-stephane in ~ [15:50:27]
$ echo -n "I am Satoshi Nakamoto" | shasum -a 256
5d7c7ba21cbbcd75d14800b100252d5b428e5b1213d27c385bc141ca6b47989e  -

# steph @ MBP-de-stephane in ~ [15:50:52]
$ echo -n "I am Satoshi Nakamoto1" | shasum -a 256
f7bc9a6304a4647bb41241a677b5345fe3cd30db882c8281cf24fbb7645b6240  -

# steph @ MBP-de-stephane in ~ [15:51:00]
$ echo -n "I am Satoshi Nakamoto2" | shasum -a 256
ea758a8134b115298a1583ffb80ae62939a2d086273ef5a7b14fbfe7fb8a799e  -

# steph @ MBP-de-stephane in ~ [15:51:07]
$ echo -n "I am Satoshi Nakamoto3" | shasum -a 256
bfa9779618ff072c903d773de30c99bd6e2fd70bb8f2cbb929400e0976a5c6f4  -

# steph @ MBP-de-stephane in ~ [15:51:13]
$ echo -n "I am Satoshi Nakamoto4" | shasum -a 256
bce8564de9a83c18c31944a66bde992ff1a77513f888e91c185bd08ab9c831d5  -
```

BLOCK HEADER STRUCTURE



Size	Field	Description
4 bytes	Version	A version number to track software/protocol upgrades
32 bytes	Previous Block Hash	A reference to the hash of the previous (parent) block in the chain
32 bytes	Merkle Root	A hash of the root of the merkle tree of this block's transactions
4 bytes	Timestamp	The approximate creation time of this block (seconds from Unix Epoch)
4 bytes	Target	The Proof-of-Work algorithm target for this block
4 bytes	Nonce	A counter used for the Proof-of-Work algorithm

DECENTRALIZED CONSENSUS

- Trust model: centralized vs decentralized

- Emergent consensus (arising casually or unexpectedly)

- Independent nodes following the same set of rules

- Independent nodes assembling their own copy of the authoritative, trusted, public, global ledger

INTERPLAY OF FOUR PROCESSES

- Independent transaction verification
- Independent transaction aggregation into *candidate blocks* + PoW
- Independent block verification and assembly into the chain
- Independent selection of the greatest-cumulative-work valid chain

RECAP

- PoW mining, independent validation and selection of the longest chain work together to produce *decentralized consensus*

- The consensus mechanism depends on having a majority of the miners acting honestly out of self-interest

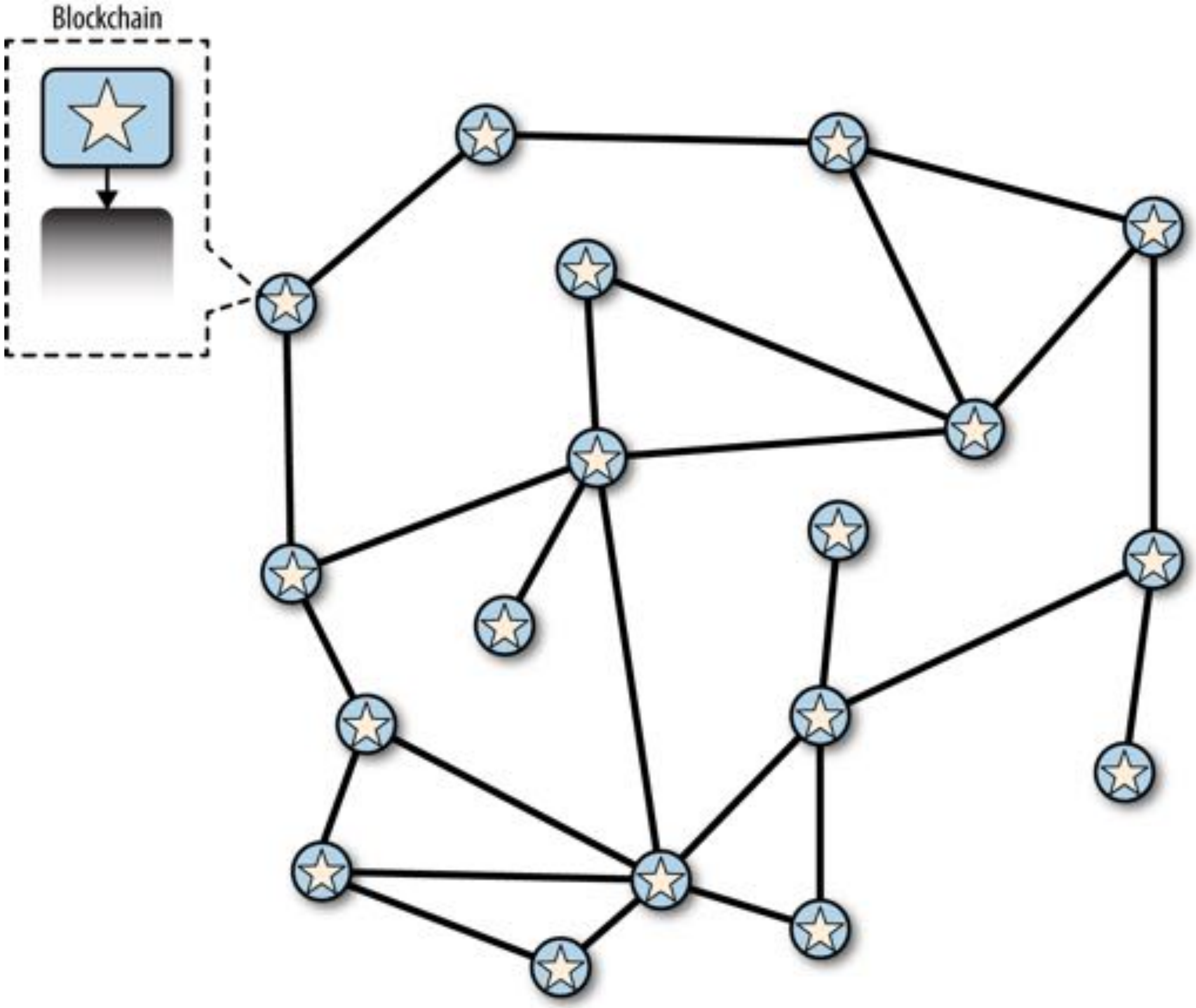
3 NATURAL FORKS

- Two *candidate blocks* extends the same *parent*, competing to form the longest blockchain

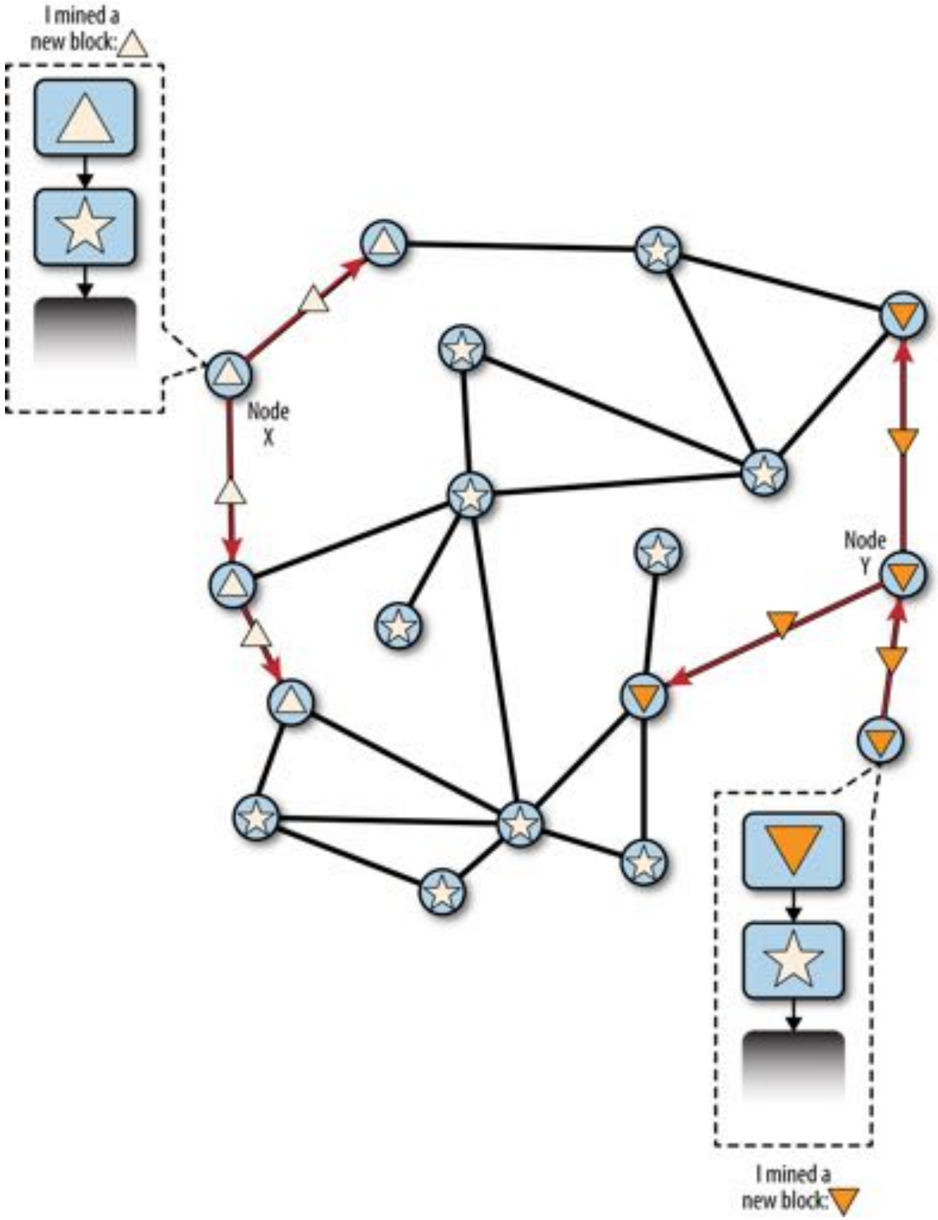
- Occurs naturally as a result of transmission delays

- Resolved by the independent selection of the *greatest-cumulative-work* chain

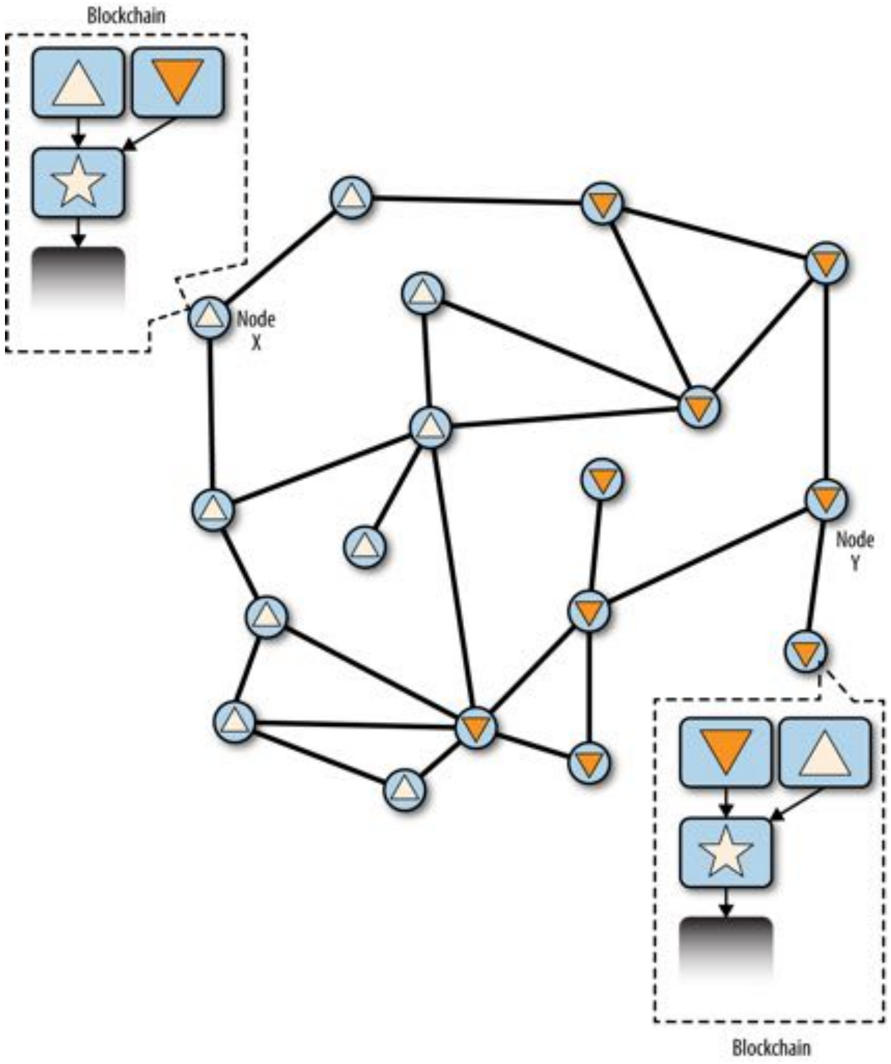
Before the fork—all nodes have the same perspective



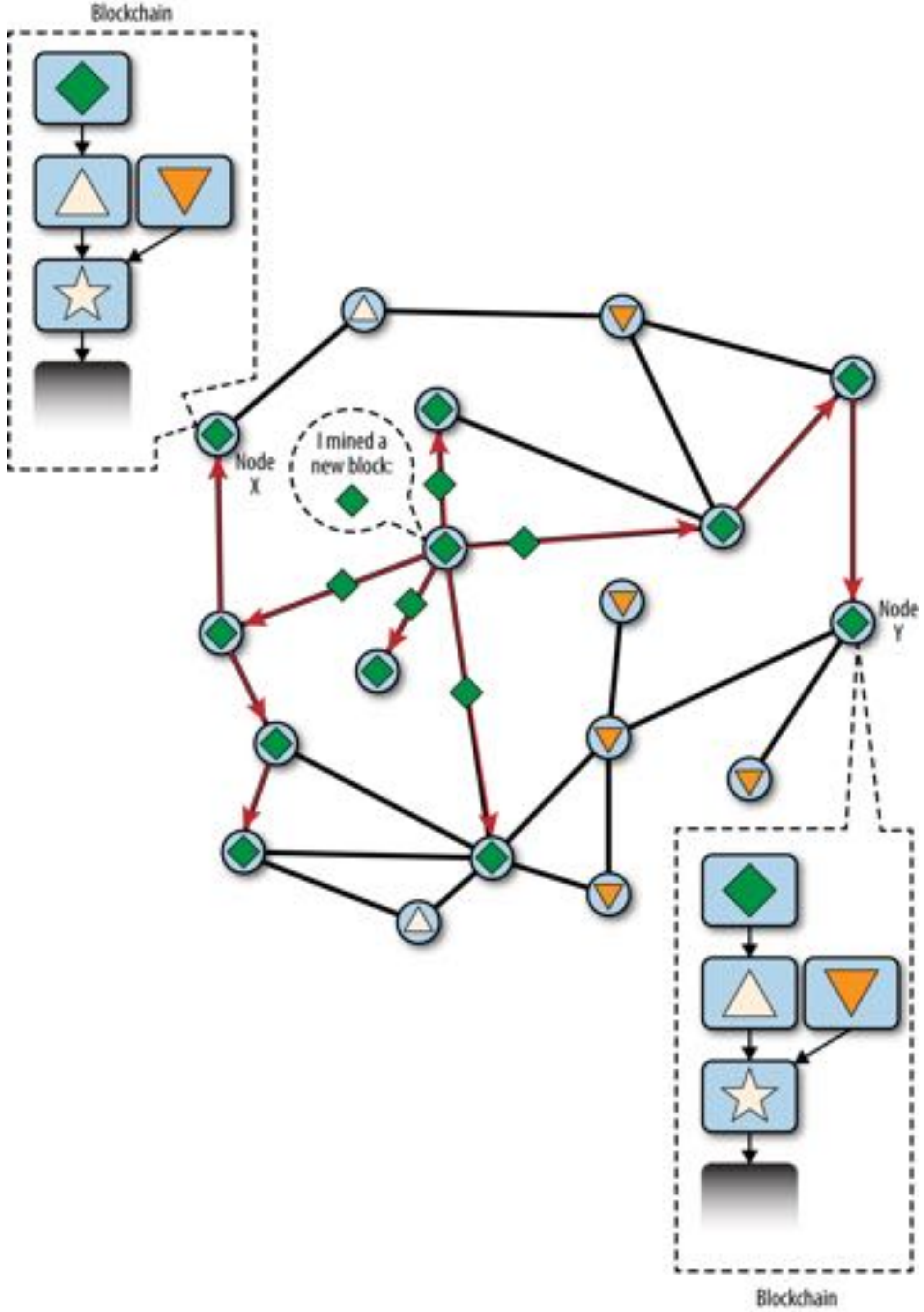
Blockchain fork event: two blocks found simultaneously



Blockchain fork event: two blocks propagate, splitting the network

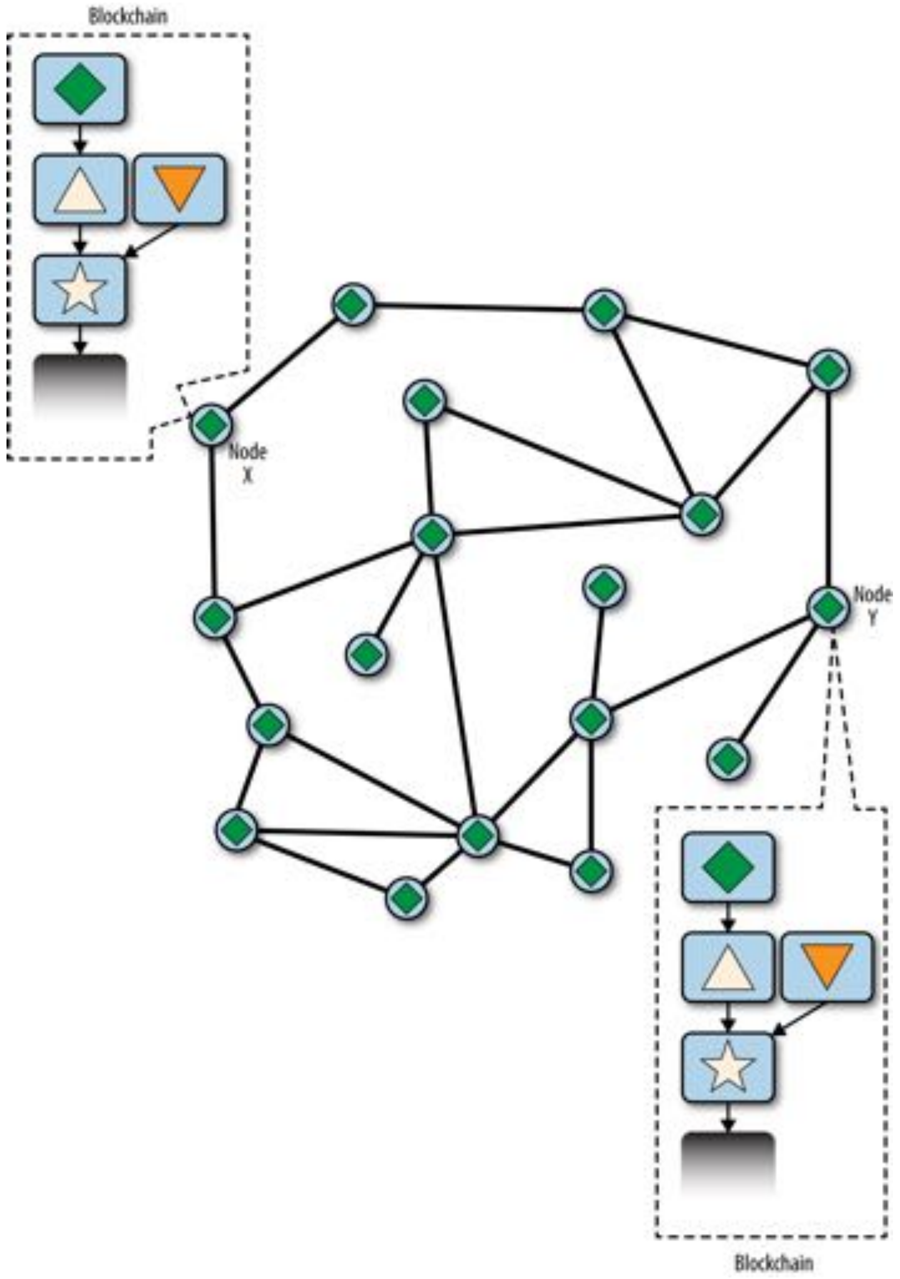


A new block extends one fork, reconverging the network



- Some nodes are forced to revise their view of the blockchain (chain reconvergence/reorganization)

The network reconverges on a new longest chain



RECAP

- Forks happens regularly and naturally

- Usually resolved after 1 block

- Bitcoin’s block interval of 10 minutes is a design compromise between fast confirmation times (settlement of transactions) and the probability of a fork

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Hard Fork

REASONS CONSENSUS RULES MAY DIFFER

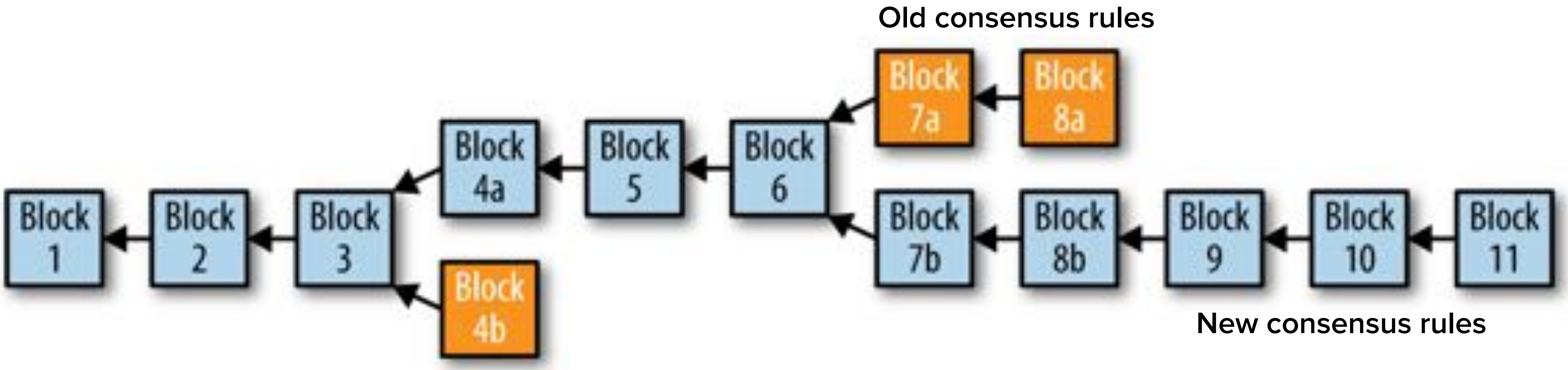
- Validation of transactions or blocks

- Implementation of Bitcoin scripts or cryptographic primitives (ECDSA, …)

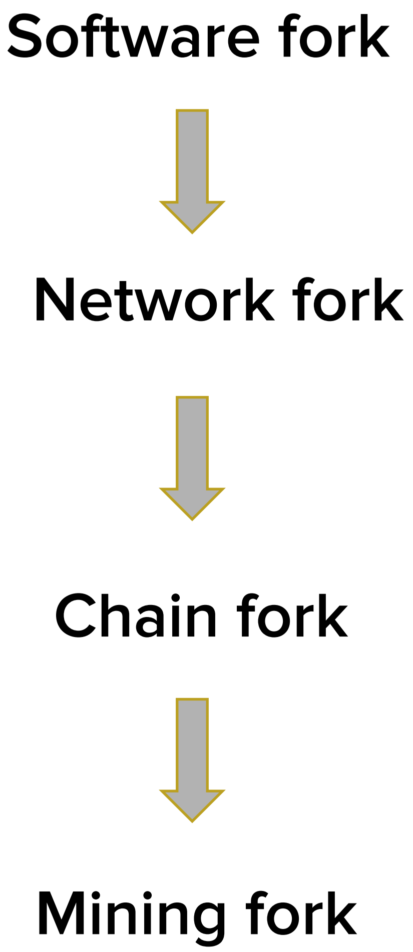
- *Implicit consensus constraints* imposed by system limitations or implementation details (database, …)

- Forward-incompatible: non-upgraded nodes will find themselves in a partitioned network
- Seen as risky because they force a minority to either upgrade or remain on a minority chain
- Highly controversial in the Bitcoin development community

HARD FORK


Old consensus rules
Block 7a
Block 8a
Block 4a
Block 5
Block 6
Block 1
Block 2
Block 3
Block 7b
Block 8b
Block 9
Block 10
Block 11
Block 4b
New consensus rules

FOUR STAGES



Software fork

Network fork

Chain fork

Mining fork

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Soft Fork

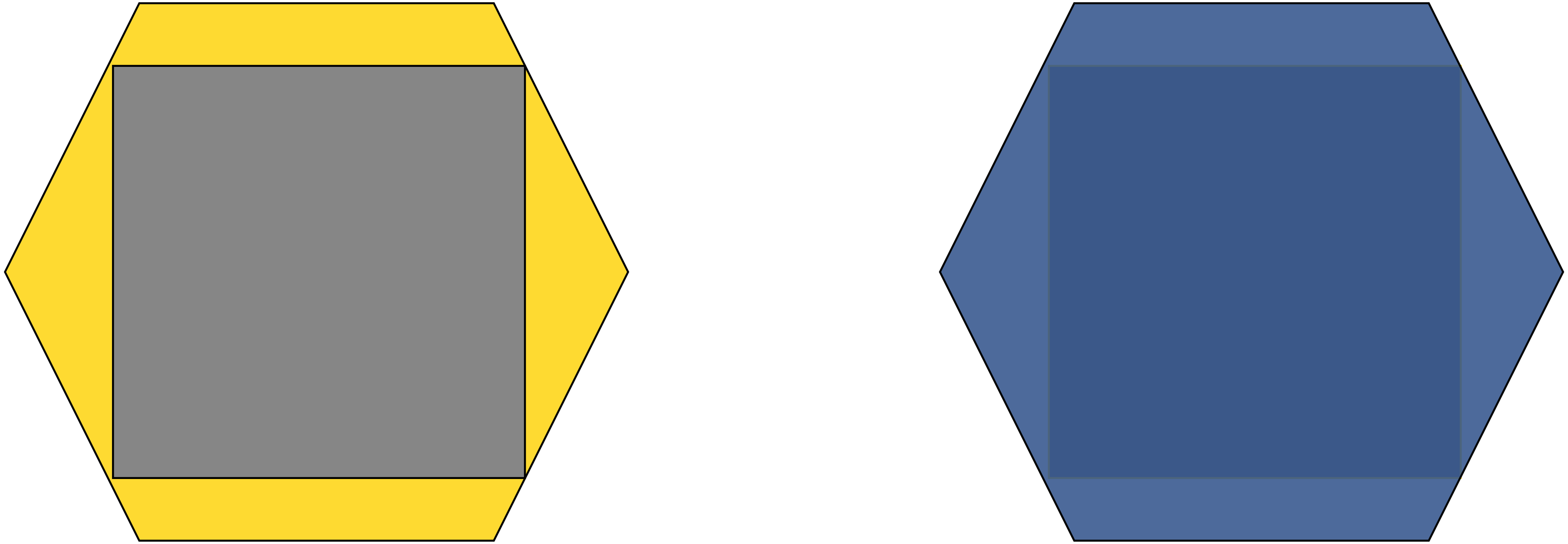
- Not backward-compatible: upgraded nodes must consider tx and blocks created under the old rules as invalid

- Forward-compatible: non-upgraded nodes must consider tx and blocks created under the new rules as valid

- The new rules can only limit what is valid, constrains the consensus rules (mostly re-interpretation of NOP opcodes)

- Requires a majority of the miners upgrading to enforce the new rules (not 100%)

If consensus rules were shapes



SOFT FORK SIGNALING AND ACTIVATION

- Miners signal readiness
- New rules activated after a threshold

- IsSuperMajority / BIP-34
    - Block version as an integer
    - Used for the version 2, 3 (BIP-66 / Strict DER) and 4 (BIP-65 / CLTV) upgrades

- BIP-9
    - Block version as a bit field
    - Much more flexible
    - Used for CSV and associated BIPs 68, 112, 113

CRITICISMS OF SOFT FORKS

- Technical debt

- Validation relaxation

- Irreversible upgrades (without Hard Fork)

CONCLUSION

- Decentralized consensus made by:
  - Independent nodes following a set of rules
  - Mining process (which is part of the rules)

- A blockchain/coin is defined by the sum of its consensus rules

- Consensus software development is difficult and tricky

- Soft or Hard Fork = tradeoffs