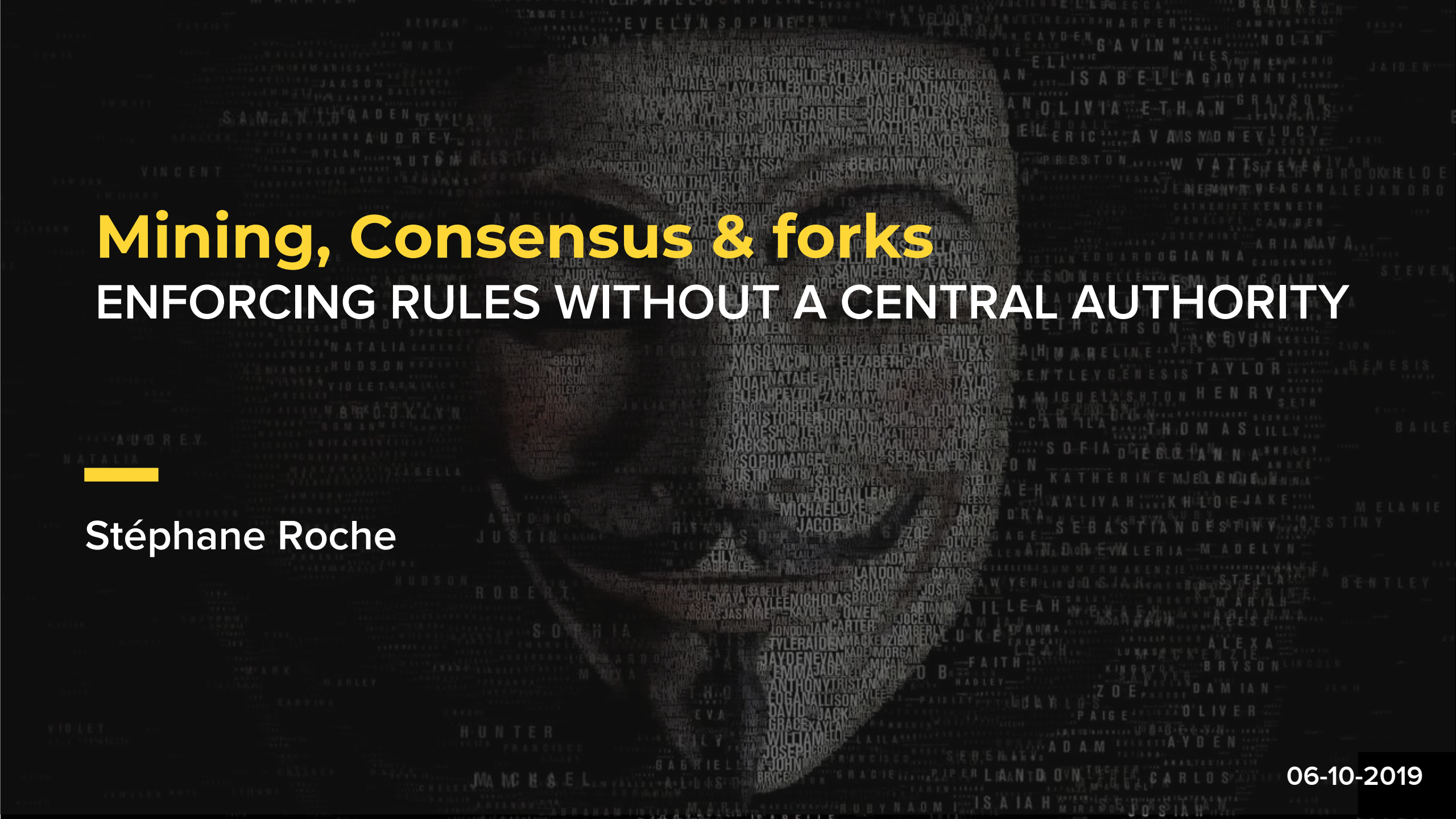

Mining, Consensus & forks

ENFORCING RULES WITHOUT A CENTRAL AUTHORITY

Stéphane Roche

06-10-2019

CREATIVE COMMONS

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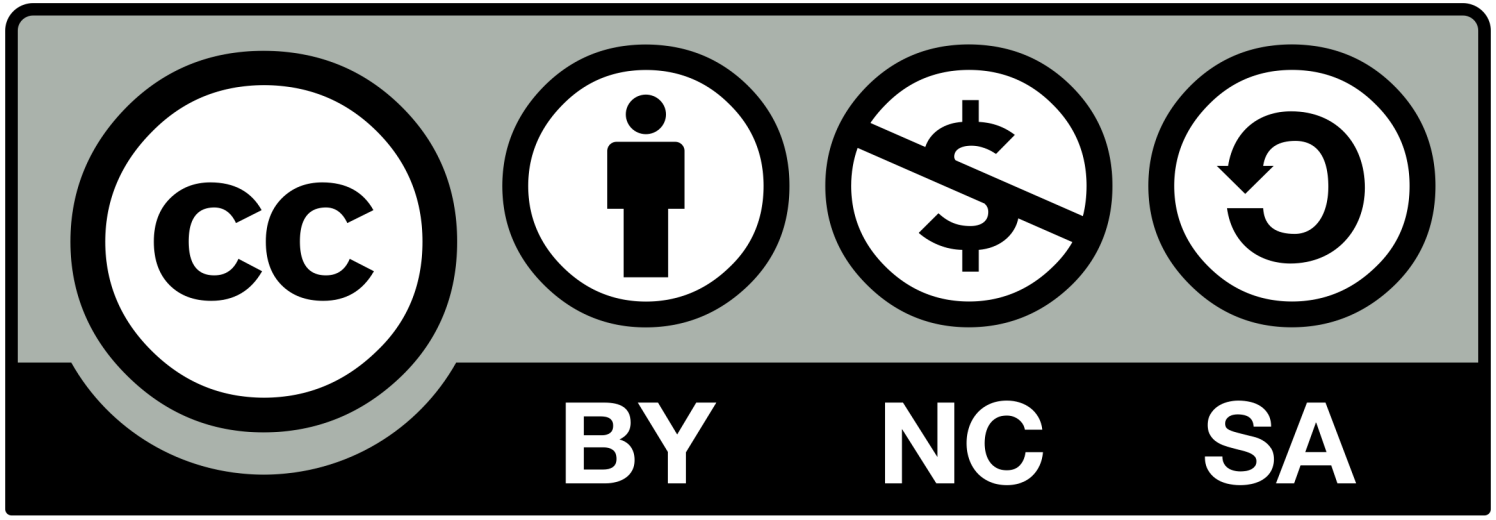


ABOUT STEPHANE

2015

Work at Ledger - hardware wallet company

2016–2017

Work on Ethereum

- Learn and play
- Co-found non-profit organization Asseth
- Contribute to the ERC20 Consensys smart contracts
- Dether.io

2017–2019

Found Bitcoin Studio

Focus on Bitcoin education

Consultant at Chainsmiths

https://www.bitcoin-studio.com
@janakaSteph on Twitter
bitcoin-studio@protonmail.com

OUTLINE

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

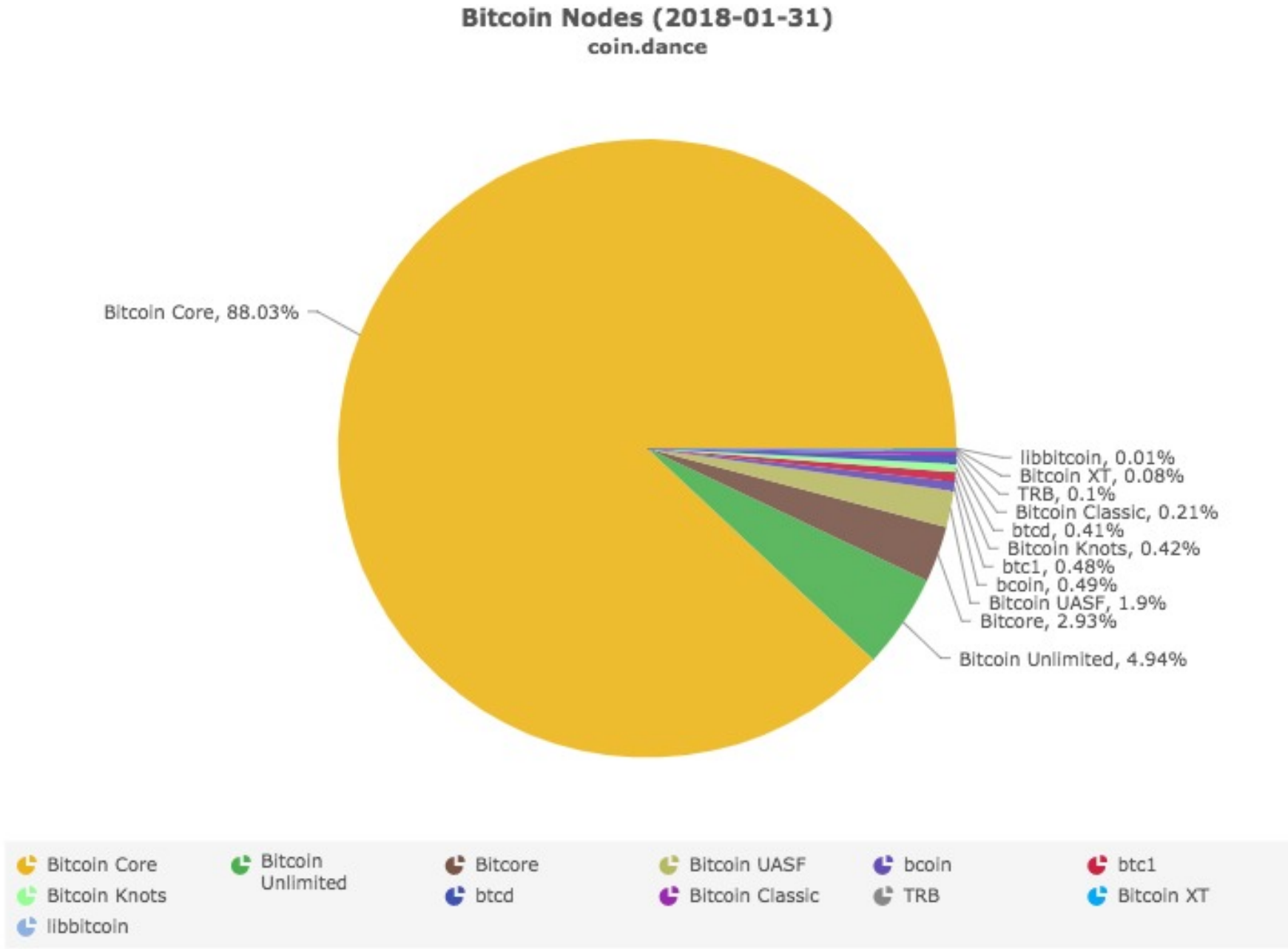
1 THE BITCOIN NETWORK

PROTOCOL & IMPLEMENTATIONS

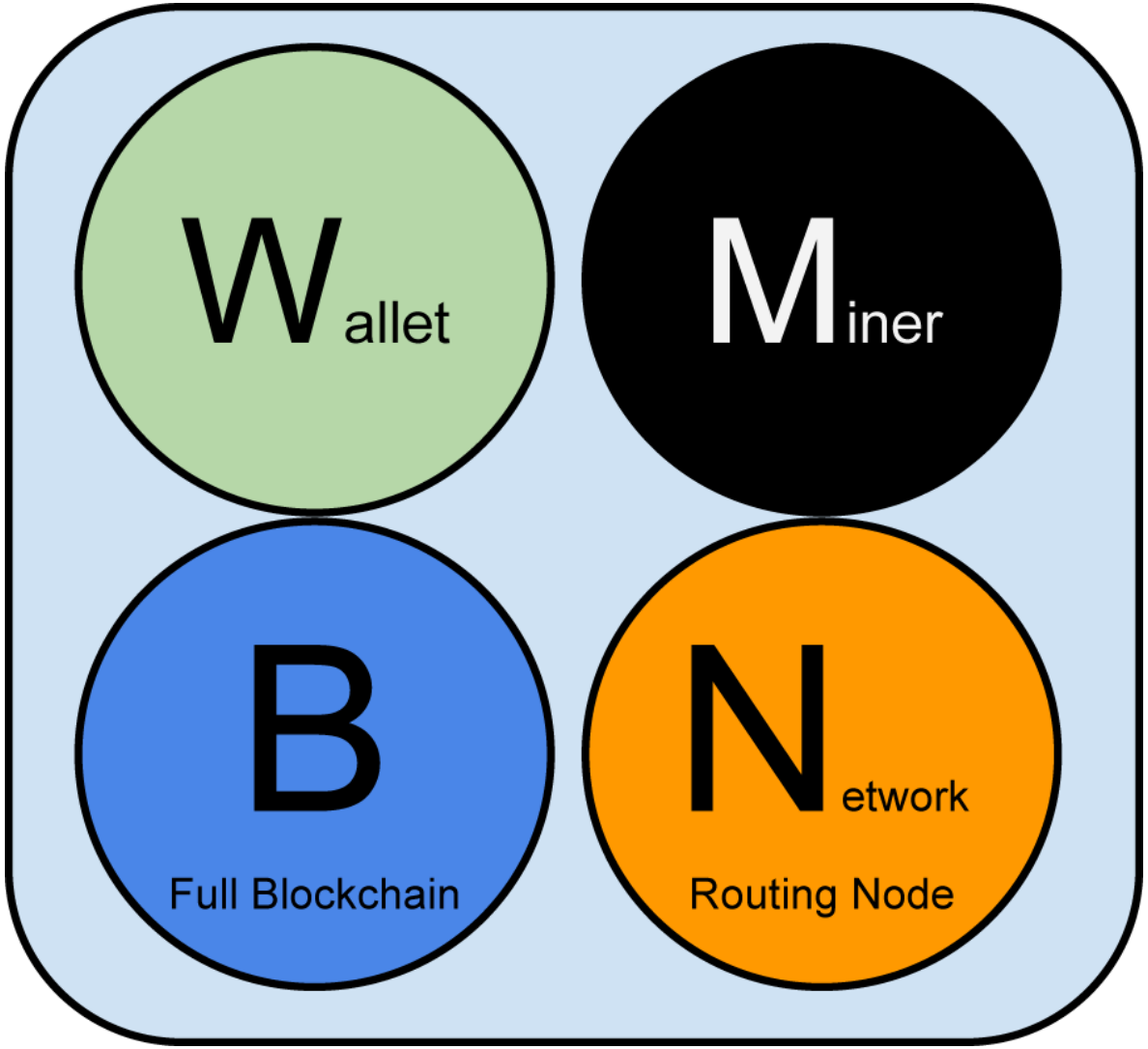
- BIPs are a set of specifications that affects Bitcoin in general, not a specific implementation

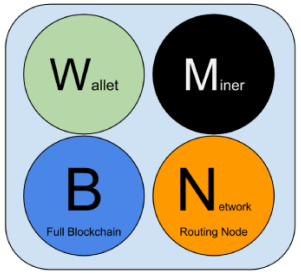
- But ultimately, the reference client is the specification
  - The Bitcoin protocol is specified by the behavior of the reference client
  - Consensus is determined by the software that the majority of the network runs
  - Consensus is not determined by a natural language specification

- And a few other implementations
  - Btcd (Go)
  - BitcoinJ (Java)
  - Bcoin (Javascript)
  - Parity-bitcoin (Rust)
  - ...


Bitcoin Nodes (2018-01-31)
coin.dance
Bitcoin Core, 88.03%
libbitcoin, 0.01%
Bitcoin XT, 0.08%
TRB, 0.1%
Bitcoin Classic, 0.21%
btcd, 0.41%
Bitcoin Knots, 0.42%
btc1, 0.48%
bcoin, 0.49%
Bitcoin UASF, 1.9%
Bitcore, 2.93%
Bitcoin Unlimited, 4.94%
Bitcoin Core
Bitcoin Unlimited
Bitcore
Bitcoin UASF
bcoin
btc1
Bitcoin Knots
btcd
Bitcoin Classic
TRB
Bitcoin XT
libbitcoin

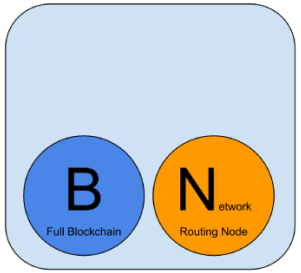
The four functions of a node





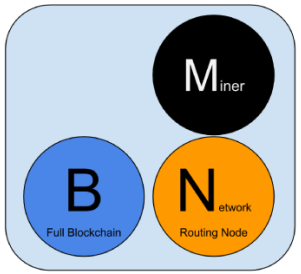
Reference Client (Bitcoin Core)

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



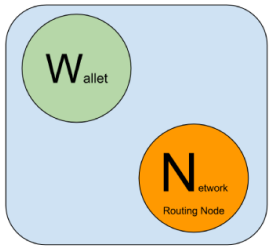
Full Block Chain Node

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



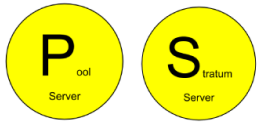
Solo Miner

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.

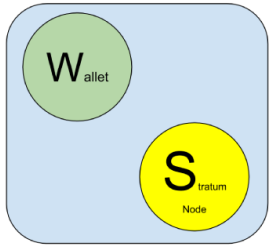


Pool Protocol Servers

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

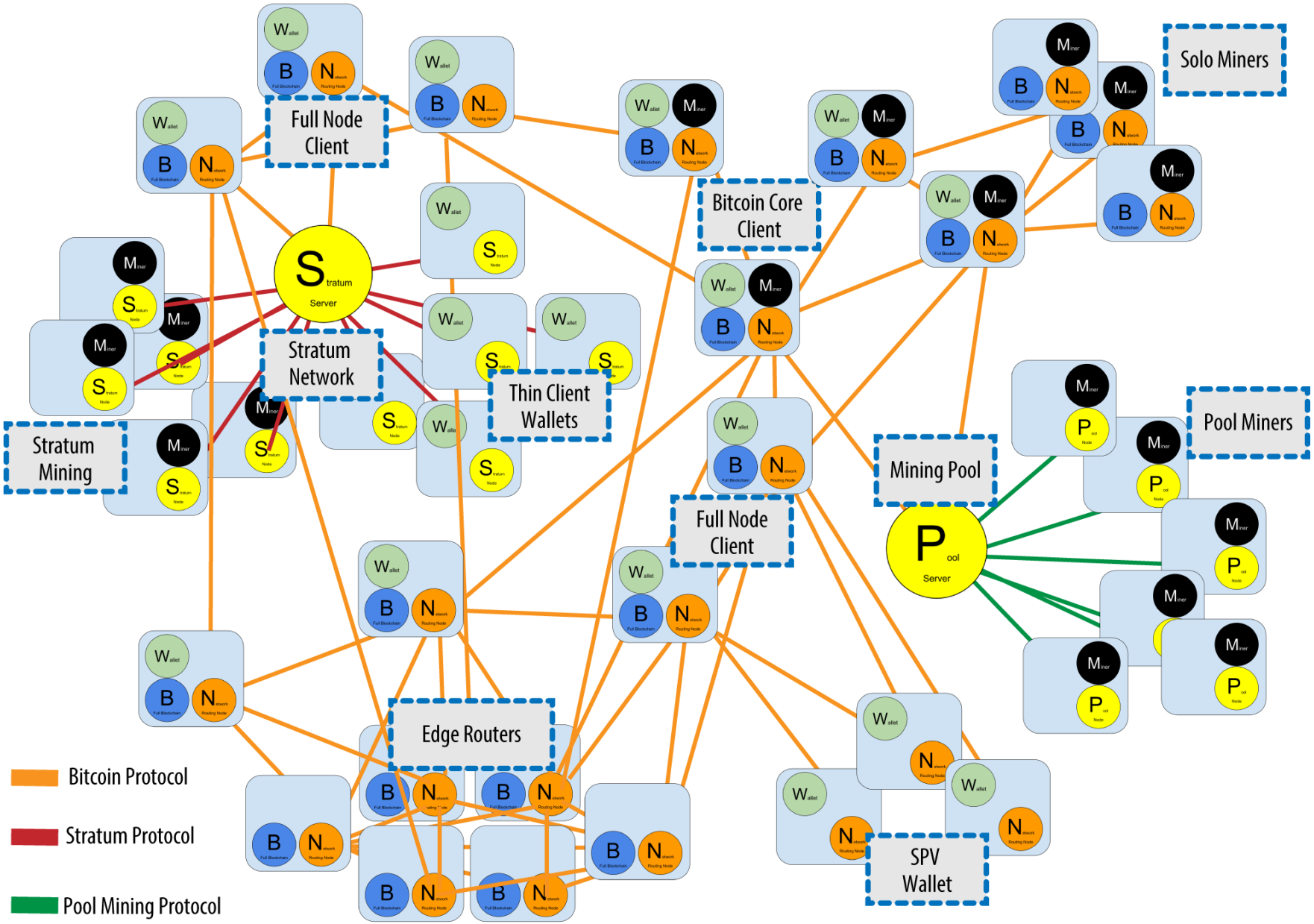
Mining Nodes

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.


Solo Miners
Full Node Client
Bitcoin Core Client
Stratum Server
Stratum Network
Thin Client Wallets
Stratum Mining
Pool Miners
Mining Pool
Pool Server
Full Node Client
Edge Routers
SPV Wallet
Bitcoin Protocol
Stratum Protocol
Pool Mining Protocol

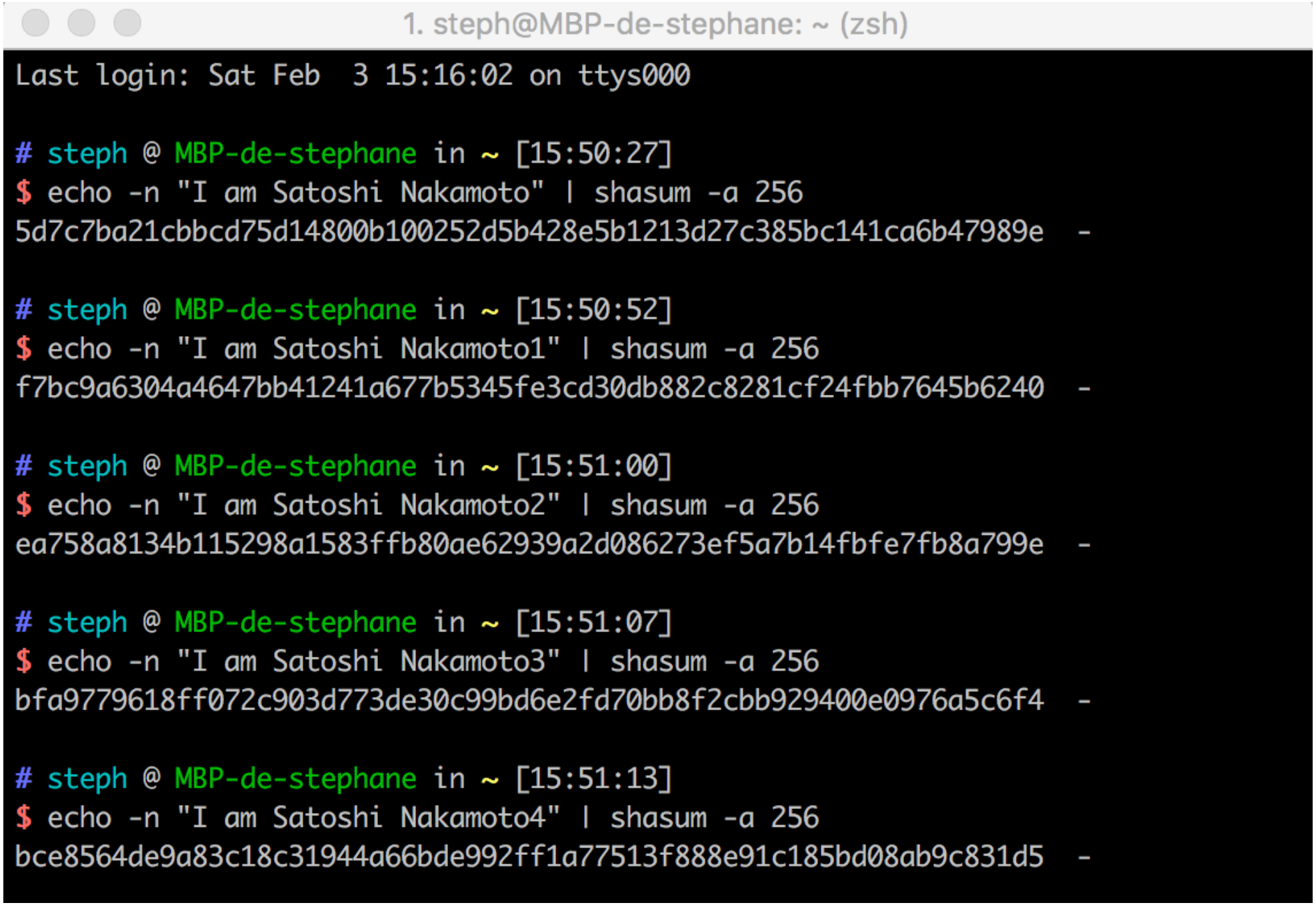
RECAP

- Multiple software implementations
- Multiple node functionalities / roles
- Each node has its own view of the blockchain and the network

2 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*


1. steph@MBP-de-stephane: ~ (zsh)
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

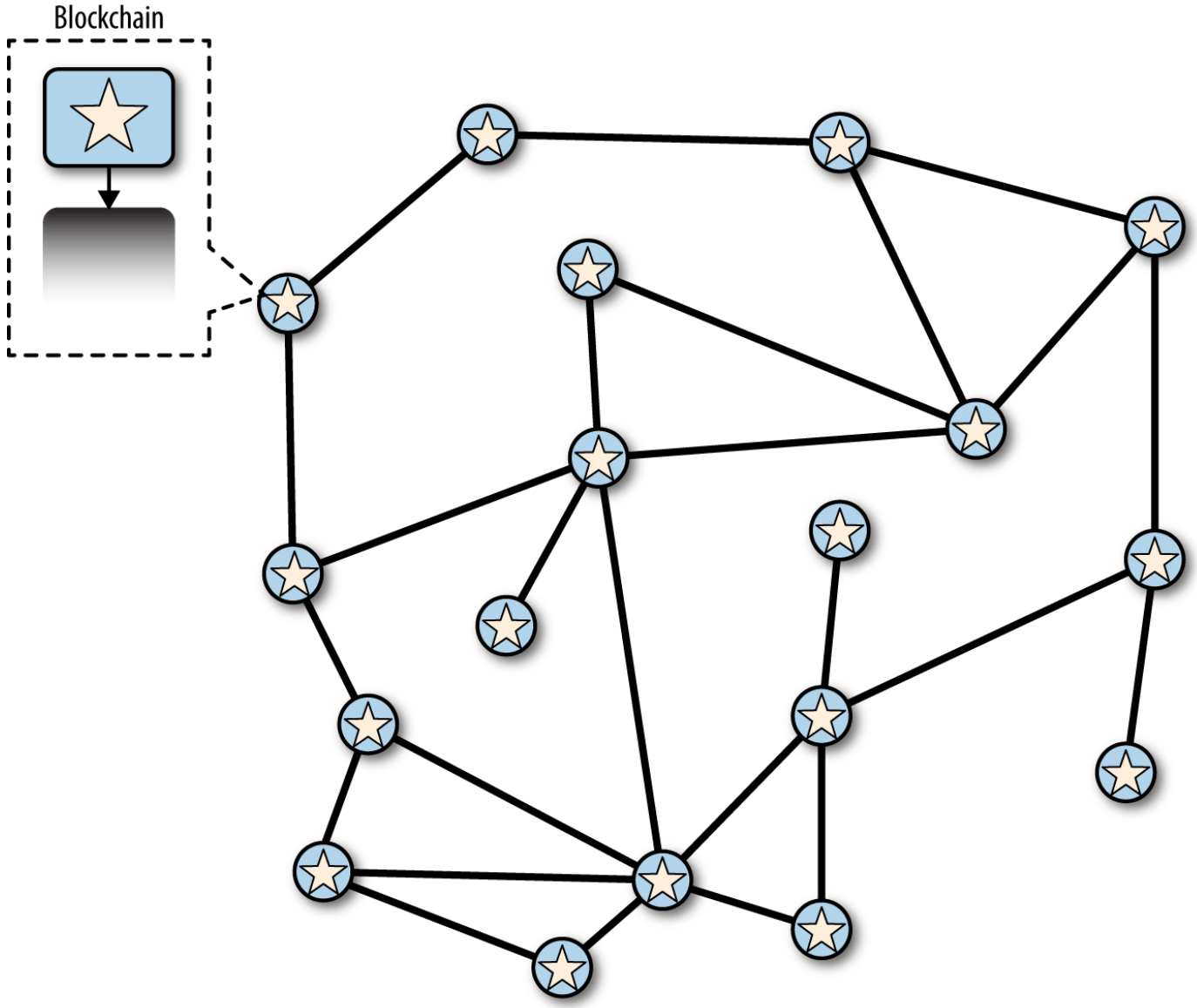
NATURAL FORKS

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

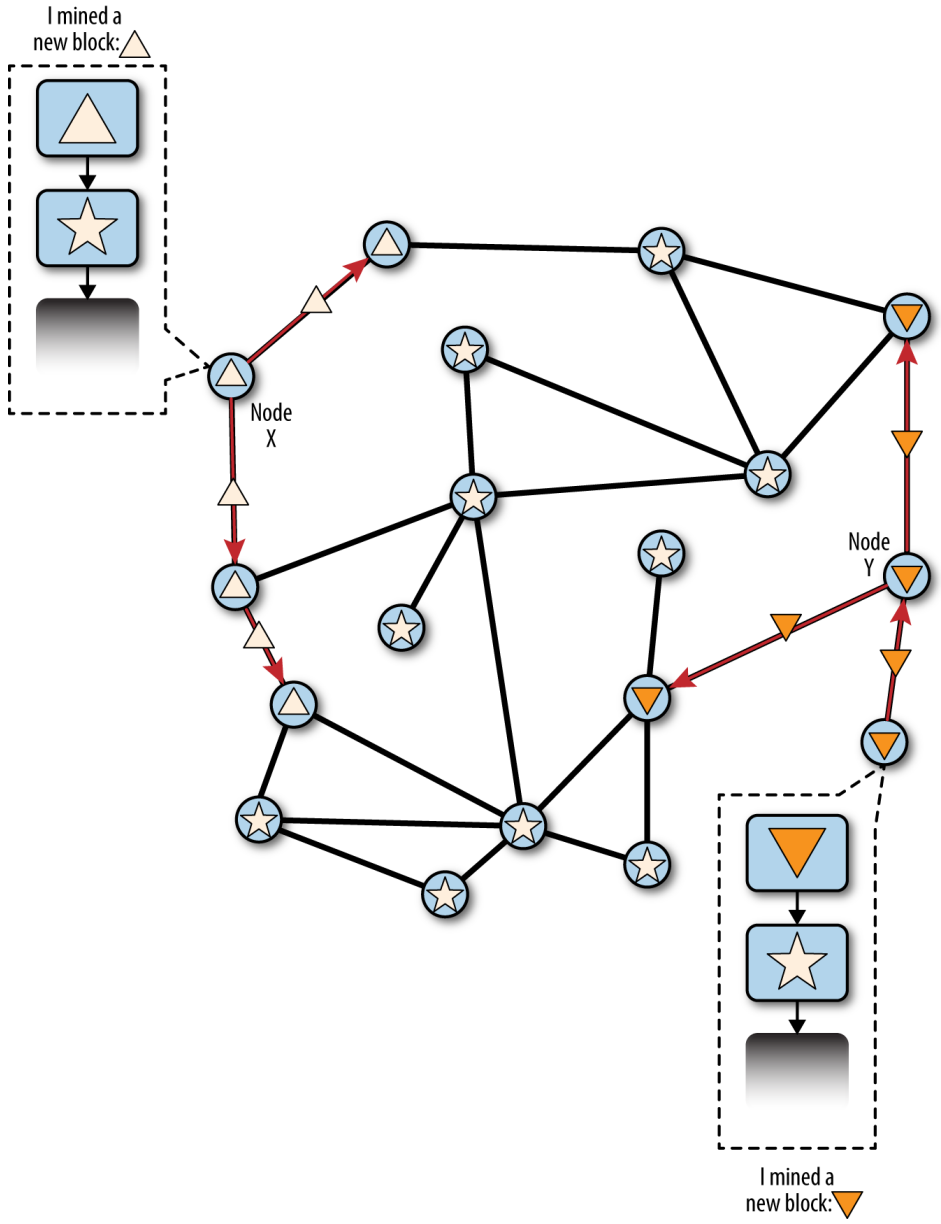
- Occurs naturally as a result of transmission delays

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

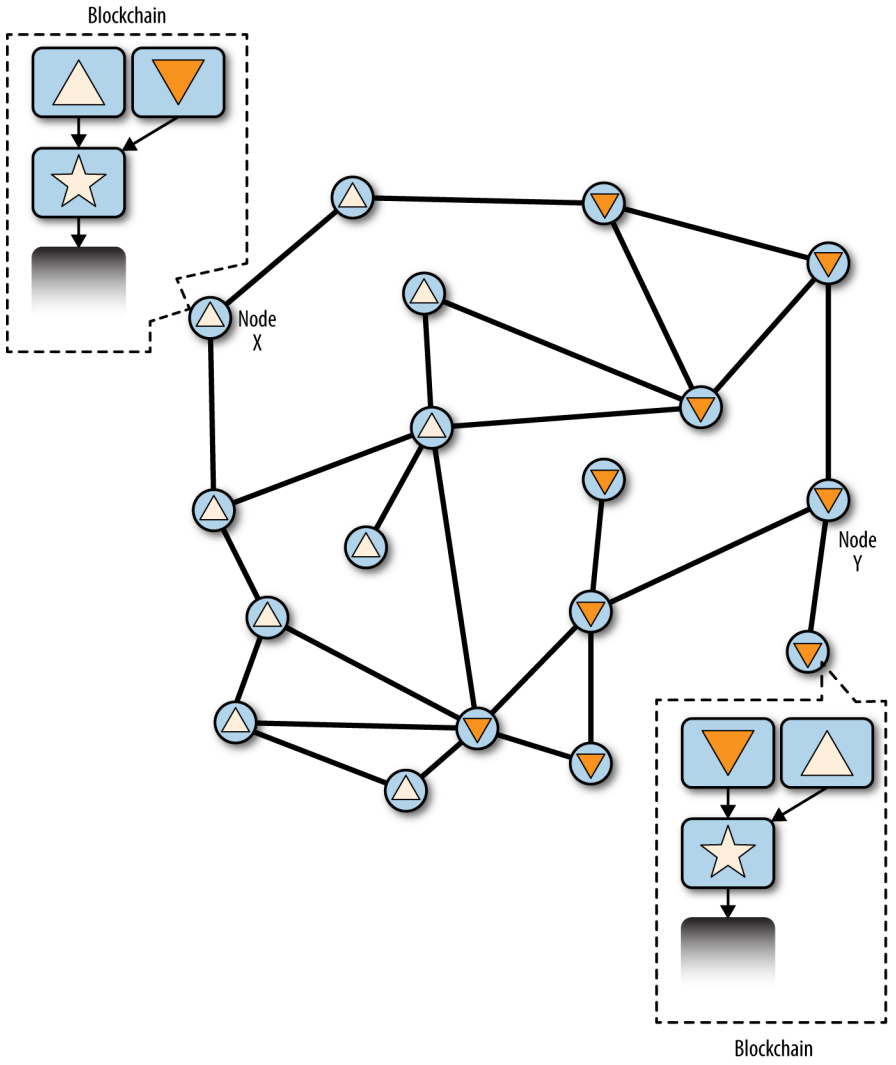
Before the fork—all nodes have the same perspective



Blockchain fork event: two blocks found simultaneously

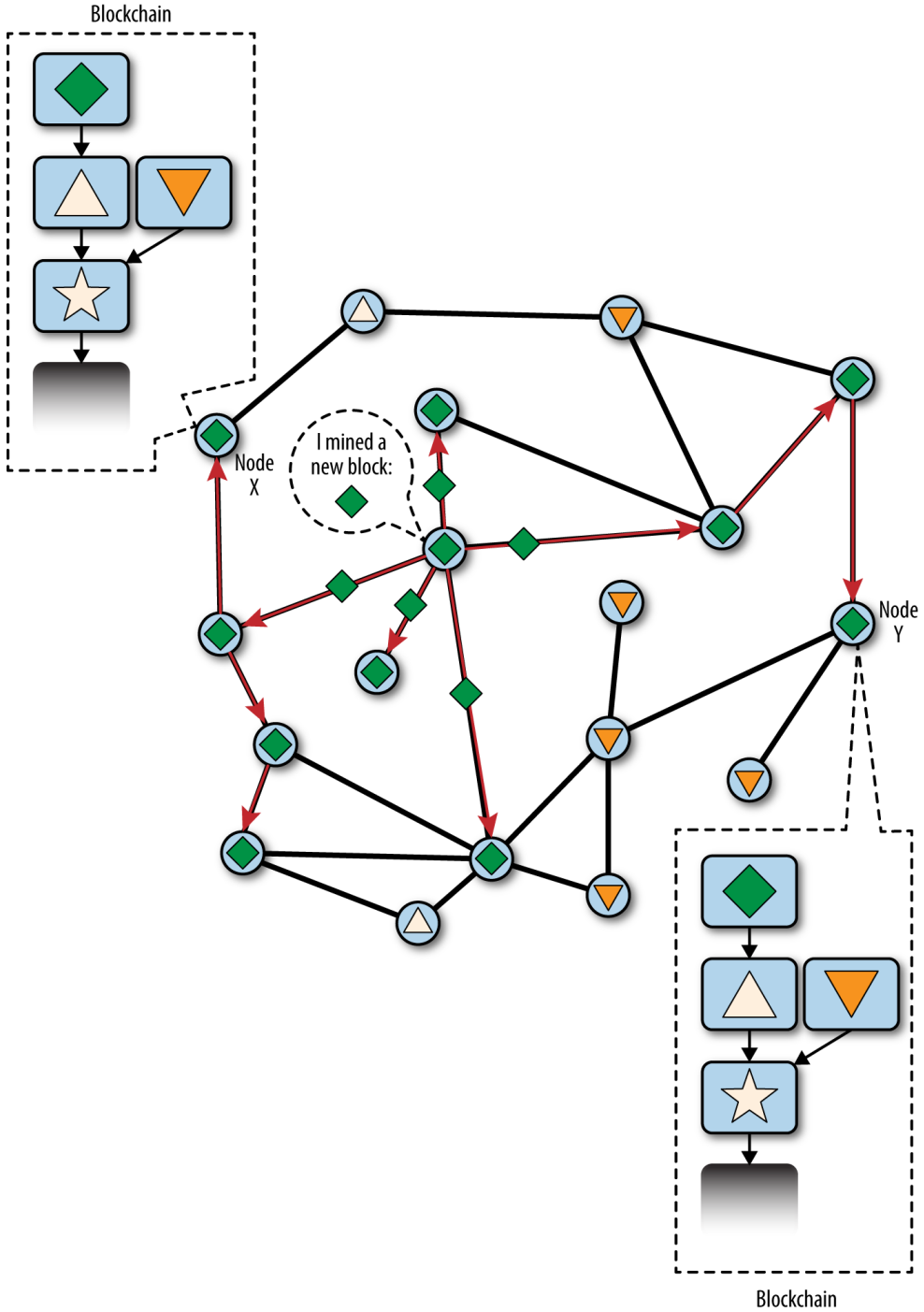


Blockchain fork event: two blocks propagate, splitting the network

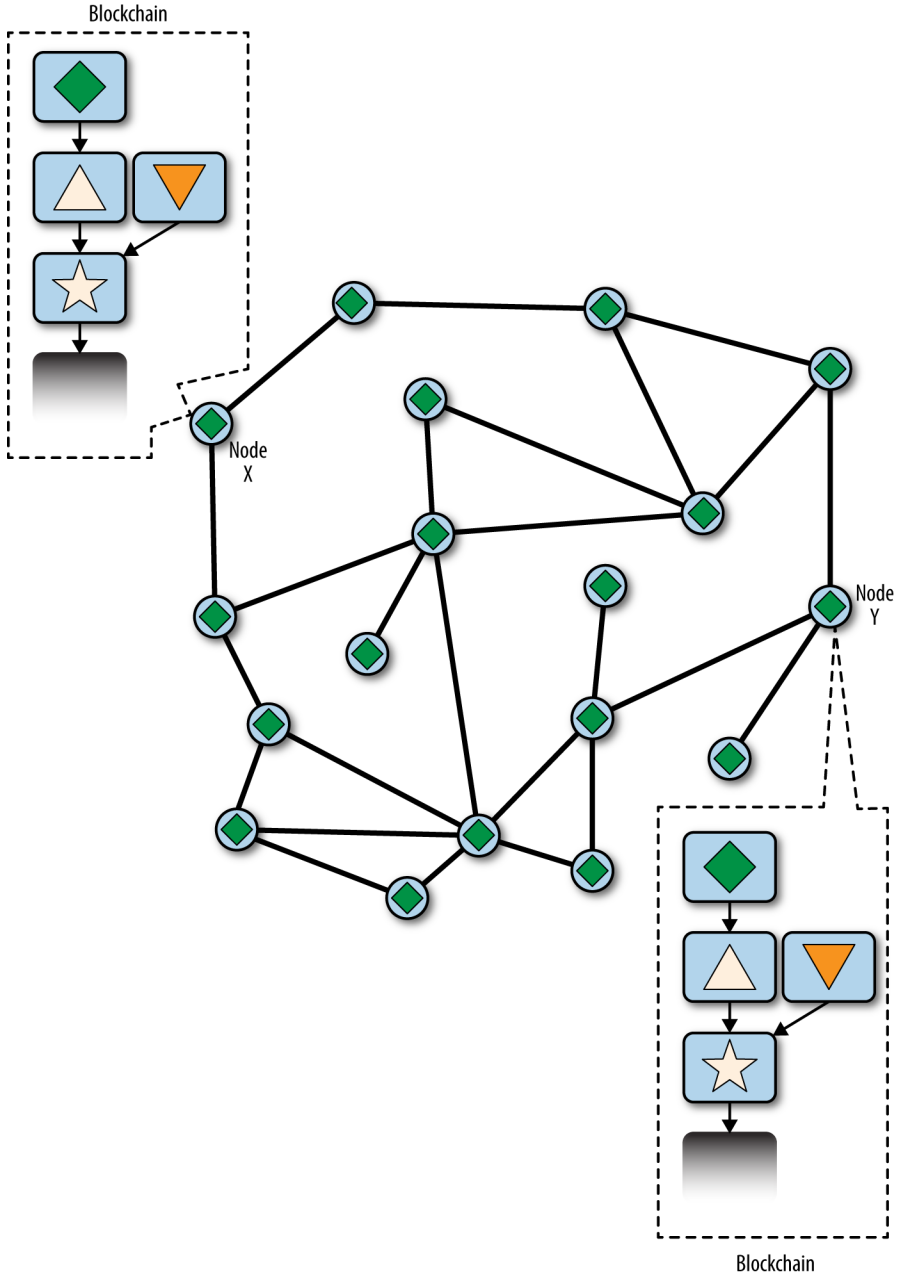


A new block extends one fork, reconverging the network

- 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

4

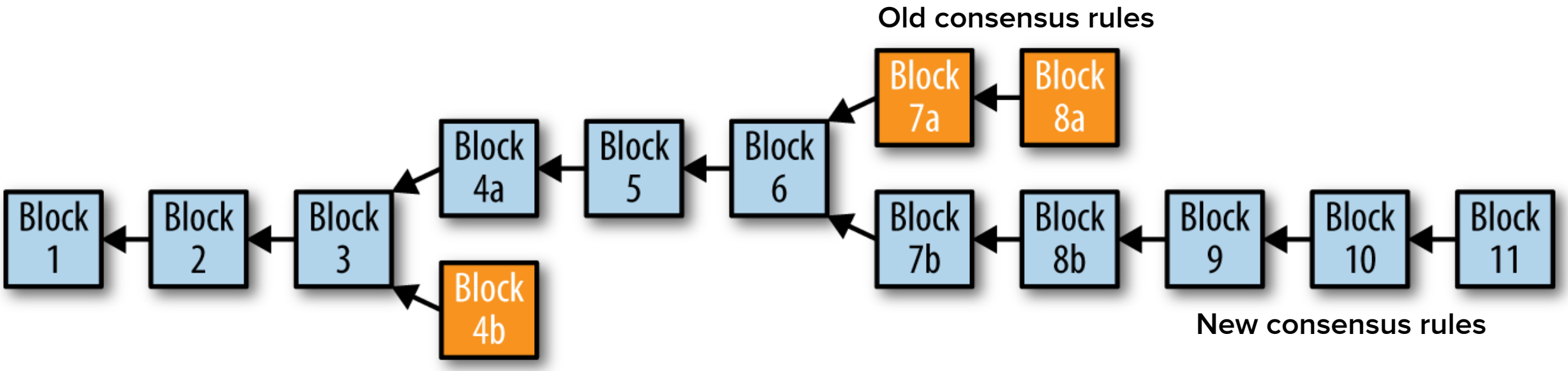
Hard Fork

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

FOUR STAGES

Software fork

Network fork

Chain fork

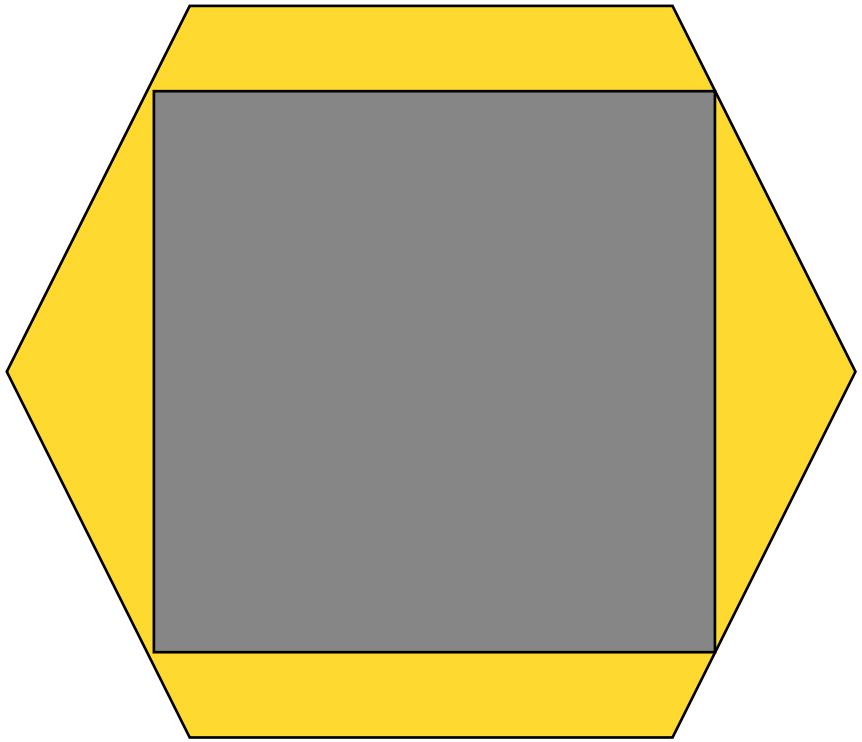
Mining fork

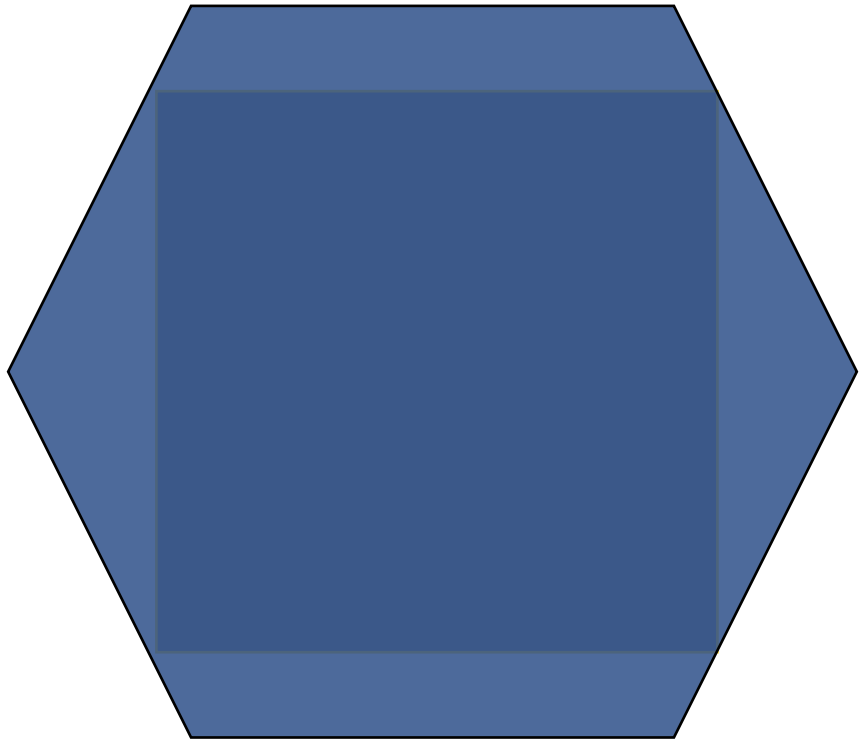
5

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