Introduction to Bitcoin and how it works

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What is it?

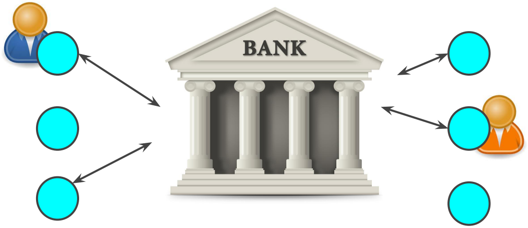
- Digital currencies
  - DigiCash (eCash), e-Gold, Liberty Reserve, ...
- Bitcoin is:
  - **a decentralized digital (crypto-)currency**
  - **a decentralized payment network**
  - **a technology**
    - software
    - a peer-to-peer network/protocol
    - an immutable public transaction ledger (aka blockchain)
    - a proof-of-work algorithm
    - a decentralized trustless platform using elliptic-curve cryptography (PKI)
    - a novel consensus mechanism
- Bitcoin introduced Blockchain technology to the world

Decentralized Digital CryptoCurrency

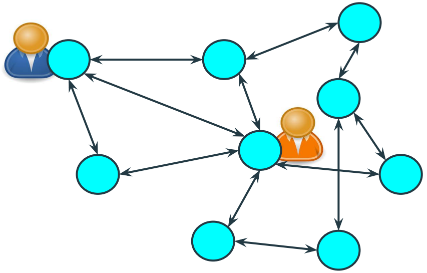
- bank creates/controls currency
- transfer of value via an institution
- higher and inter-institution fees
- 9.00 -15.00 Mon-Fri
- closed security model

- currency is created and distributed algorithmically
- direct transfer of value from A -> B
- no intermediaries and low fees
- global, 24/7, internet connection
- open security model

Centralized

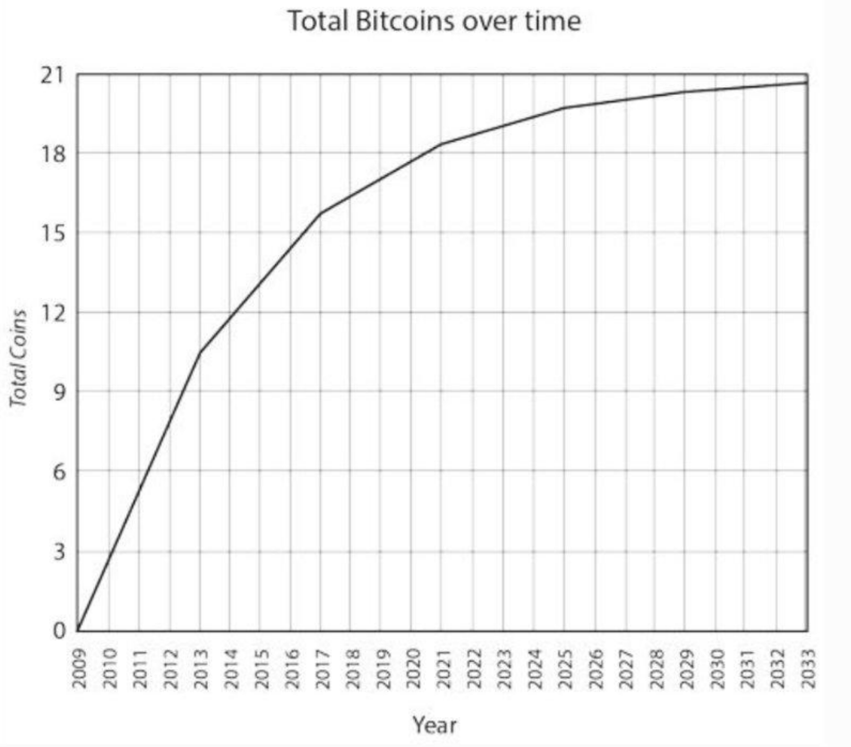


Decentralized



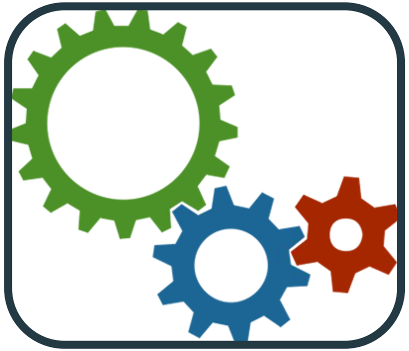
Currency characteristics (fixed supply)

- Bitcoin
  - 21 million
  - issued every ~10 minutes
  - 99% up to ~2036
  - deflationary
- Fiat currency (euro, dollars, etc.)
  - inflationary



Currency characteristics (transparent rules)

- Transparent rules
  - which transactions are valid?
  - how is ownership determined?
  - how are new coins distributed?
- Open source software
  - anyone can verify

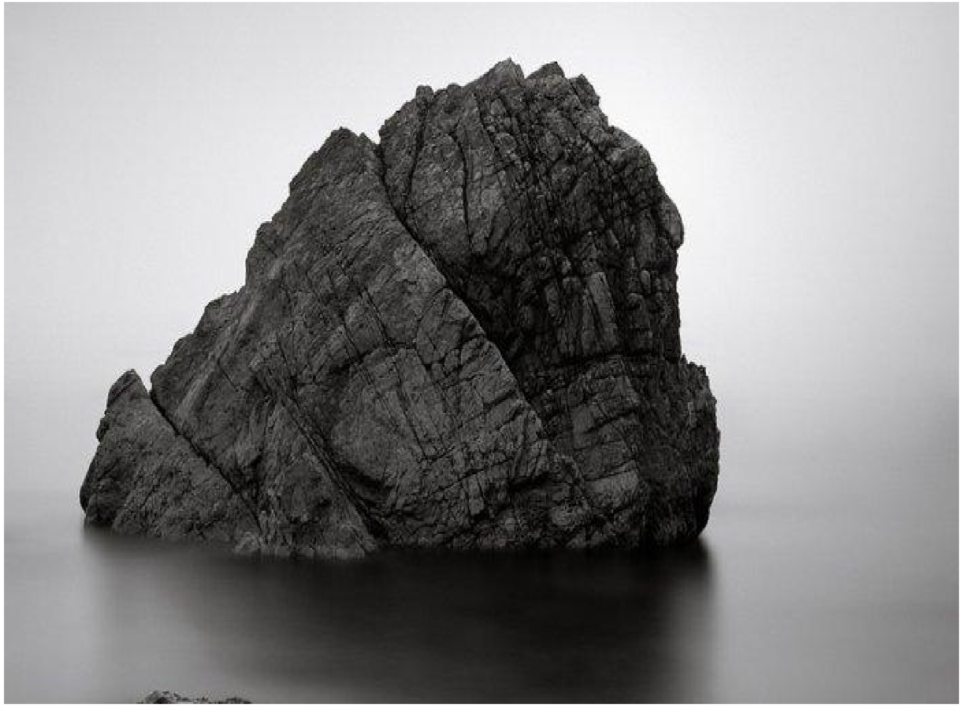


Currency characteristics (consensus-based)

- Valid rule set
  - majority governed
    - valid transactions
    - which transactions occurred
    - …
  - by supporting a specific version

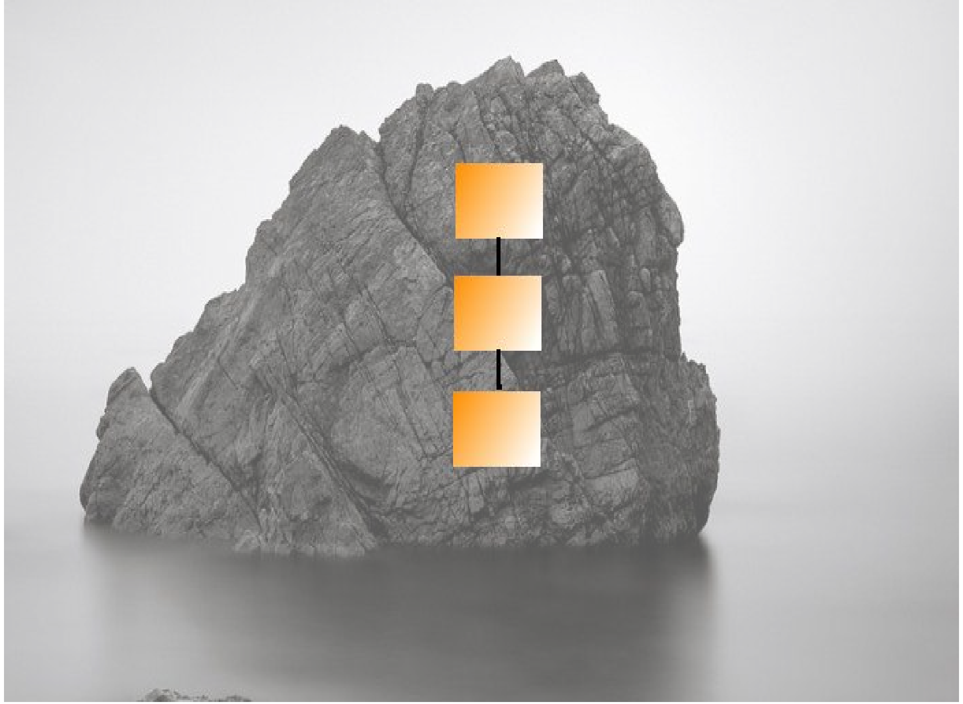
Currency characteristics (tx immutability)

- Immutable tx history / ledger
  - blockchain
    - chain of blocks
    - deeper -> safer



Currency characteristics (tx transparency)

- Public tx history / ledger
  - transparent transactions
  - auditable / verifiable



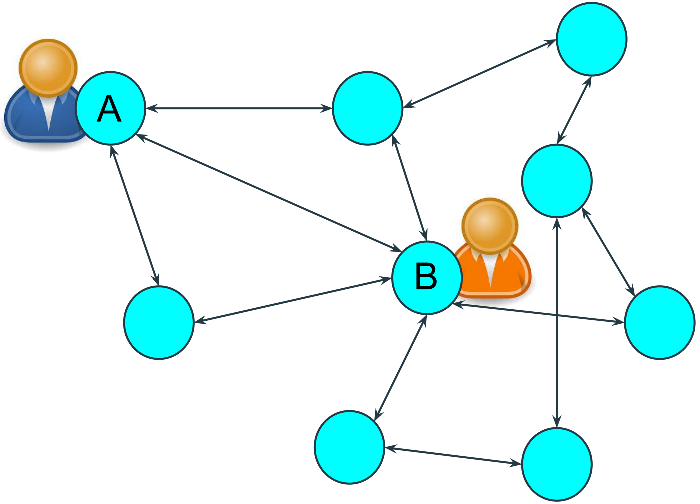
Main attributes

- Decentralized
    - State changes only after majority consensus
- Immutable
    - Append-only; no deletion or modifications allowed (w/o majority consensus)
- Transparent
    - Operations/data are available for all to see and verify
- Open
    - No barriers of entry; anyone can participate
- Secure
    - Strong cryptography ensures integrity of data stored

How it works

- Bird's eye view
  - peer-to-peer network (of)
  - bitcoin nodes (open source software)
  - run and secure the network
  - transaction history (aka blockchain)
    - immutability
    - transparency
- Why run a bitcoin node?
  - volunteerism
  - bitcoin rewards
- Mining
  - secures the network
  - the process of minting new coins

Decentralized



Next: Bitcoin/Blockchain Evolution

Blockchain Technology Evolution

- 2009: **Bitcoin** network was born
- 2010: First *real-value* transaction
- 2011: Silk Road accepts Bitcoin
- 2012
  - Television series ‘The Good Wife’
  - **Litecoin**
- 2013
  - US Financial Crimes Enforcement Network (FINCEN) “guidance report”
  - China bans Bitcoin
- 2014
  - Major online retailers (Overstock) start accepting Bitcoin
  - **Ethereum** (aka Blockchain 2.0)
  - US government auctions 29k Bitcoins
  - UK government classified Bitcoin as asset (no VAT)
- 2015
  - **Hyperledger project** (Linux Foundation)
  - NY Exchange invests in Coinbase
  - ~160.000 merchants accept Bitcoin
- 2016
  - Japan recognises Bitcoin as currency
  - Billions are invested by VCs and ICOs
- 2017
  - Bitcoin surpasses $240 billion in capitalization
  - Cryptocurrencies surpassed $0.5 trillion
  - 1500+ ATMs
  - Blockchain 3.0

- Thousands of blockchain and cryptocurrencies projects
- How disruptive is Blockchain technology?

Next: Use Cases

Bitcoin/Blockchain Applications

- **Remittances**
- **Payments**
- **Bank services for the unbanked**
- **Store of Value**
- **Digital Tokens**
- Decentralized Applications
- Micropayments
- Proof of Existence
- Smart Contracts
- Decentralized Autonomous Organizations
- Internet of Things / Machine to Machine
- Voting / Identity

Remittances

- €600 billion market
  - Western Union (15%)
  - MoneyGram
- High fees
  - depends on location
  - up to 15%
  - more for same day delivery
- Up to same day delivery
- Anywhere there is an agent
- Working hours
  - plus extended hours

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- Cryptocurrencies slowly gains momentum
- Costs cents irrespective of amount
  - In Bitcoin it has been quite high lately
- Takes minutes
  - in practice it is much faster
- Anywhere there is a connected machine
  - Internet (no need for permanent access)
- Anytime
  - 24/7
- No intermediaries, but…
  - bitspark.io
  - rebit.ph
  - bitpesa.co

Making/Receiving Payments

- Online
- Credit cards
  - 2%-6% + small flat rate
- Debit cards
  - 2%-3% + small flat rate
- Paypal
  - 2.9% + $0.30
- Cryptocurrencies
  - none
  - only the sender pays

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- Merchants can offer discounts for bitcoin
- Payment Processing
  - Coinbase, BitPay
- Point of Sale
  - Bitcoin PoS (android app)

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- Some major companies
  - Overstock
  - Microsoft
  - Dell
  - Expedia
  - Time Inc.
  - DISH Network
  - Newegg
  - Zynga
  - UK’s Theatre Tickets Direct
  - AirBaltic
  - CheepAir
  - …

- Do they keep their bitcoins?
- Can Bitcoin handle demand if widely adopted?

Be your own bank

- Bank services for the unbanked/underbanked
    - payments
    - remittances
    - micro-payments
    - donations
        - UN World Food Programme
    - … using Mobiles

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- Bank services for the banked
    - capital controls
    - censorship

Be your own bank

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  - capital controls
  - censorship

- Store of value (vs hyper-inflation)
  - gold
  - reserve currencies
  - bitcoin
    - deflationary
    - Latin/South America, China, Russia.

Digital Tokens

- represent/transfer real world value/asset
    - theater tickets
    - consultancy hours
    - authentication mechanism
    - stock markets’ shares
    - new currency
    - car ownership/key, house deeds, …

- open blockchain technology
    - immutability
    - transparency

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- Swedish National Land Survey (on trial)
  - immutability / transparency
  - automation of selling process
  - less paperwork (months -> days/hours)
  - more secure
- Nasdaq Composite Index
  - pre-IPO trading
  - equity shares on Bitcoin’s blockchain
- LetsTalkBitcoin.com (publishing platform)
  - LTBC token
  - Proof of Participation
  - token-based access
- Steem (social networking with rewards)
- StorJ (decentralized cloud storage)
- FoldingCoin (help scientists cure diseases)
- BitCrystals - Spells of Genesis game
- …

Bitcoin/Blockchain Applications

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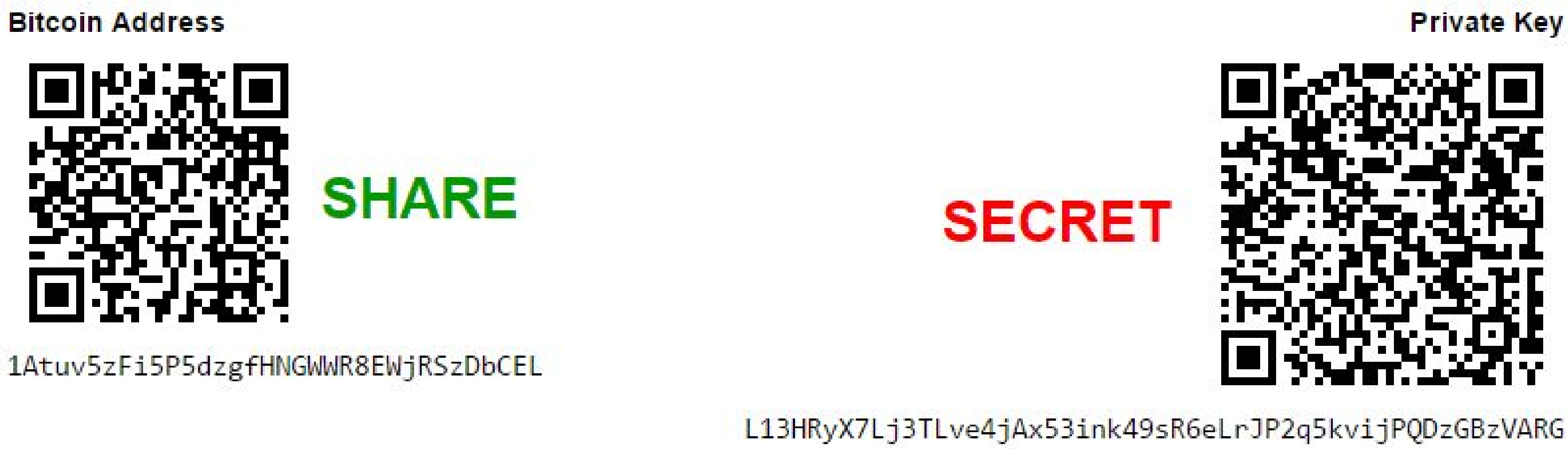
Next: Basic concepts / usage

Basic concepts (Bitcoin address / private key)



Bitcoin Address

1Atuv5zFi5P5dzgfHNGWWR8EWjRSzDbCEL

SHARE

Private Key

SECRET

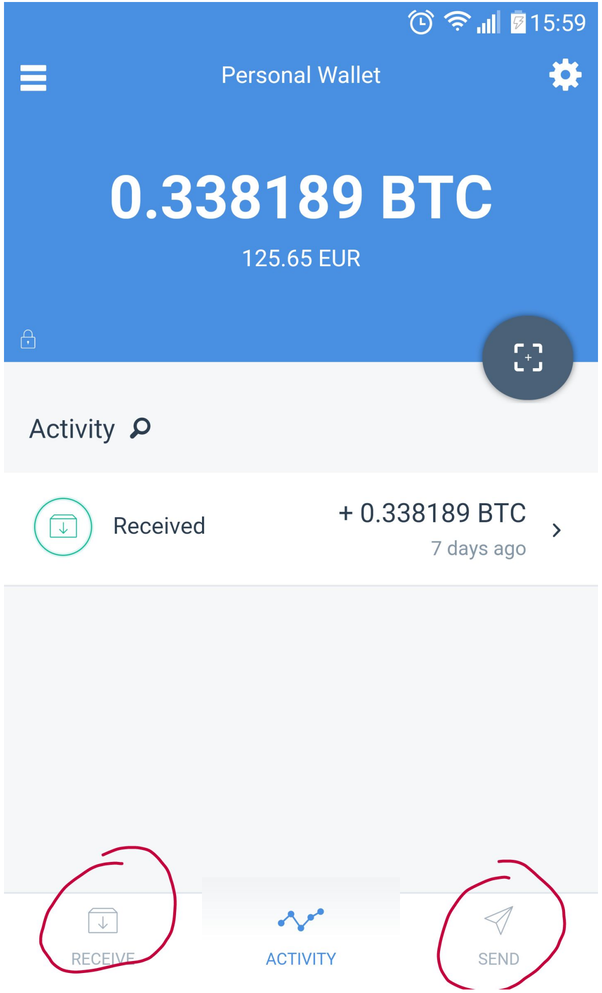
L13HRyX7Lj3TLve4jAx53ink49sR6eLrJP2q5kvijPQDzGBzVARG

Basic concepts (Bitcoin wallets)

- Wallet
  - manages bitcoin addresses (accounts)
  - can send (receive) bitcoins
- Types
  - desktop
  - mobile
  - online/web wallet
  - hardware wallet
- Wallet examples
  - Copay, Mycelium, ...
  - https://bitcoin.org/en/choose-your-wallet

Usage:

- Balance
- Activity
- Receive
- Send



0.338189 BTC

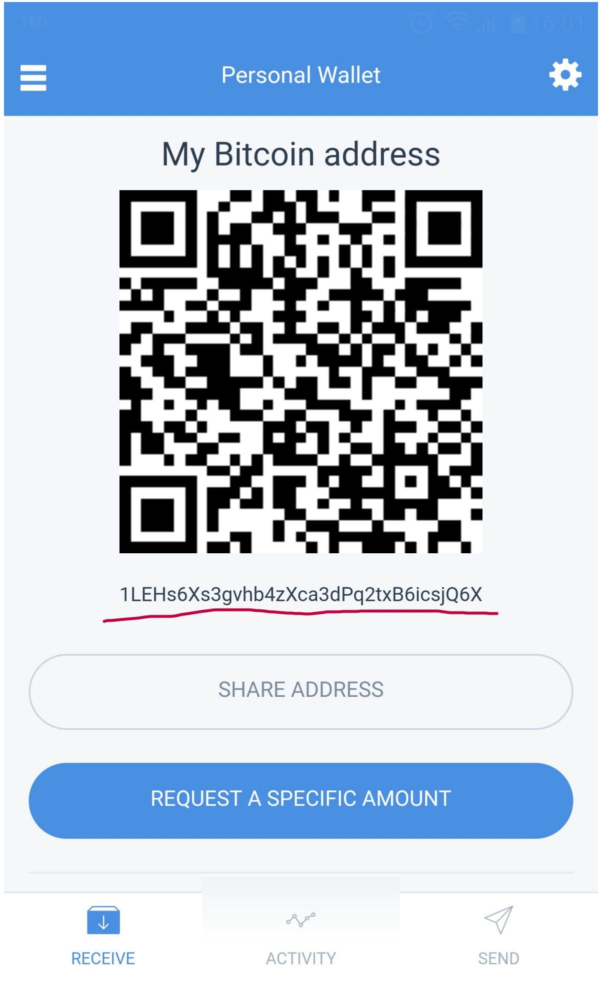
125.65 EUR

Activity

Received + 0.338189 BTC
7 days ago

Usage: receive bitcoins

- Provide address string, or
- QR code

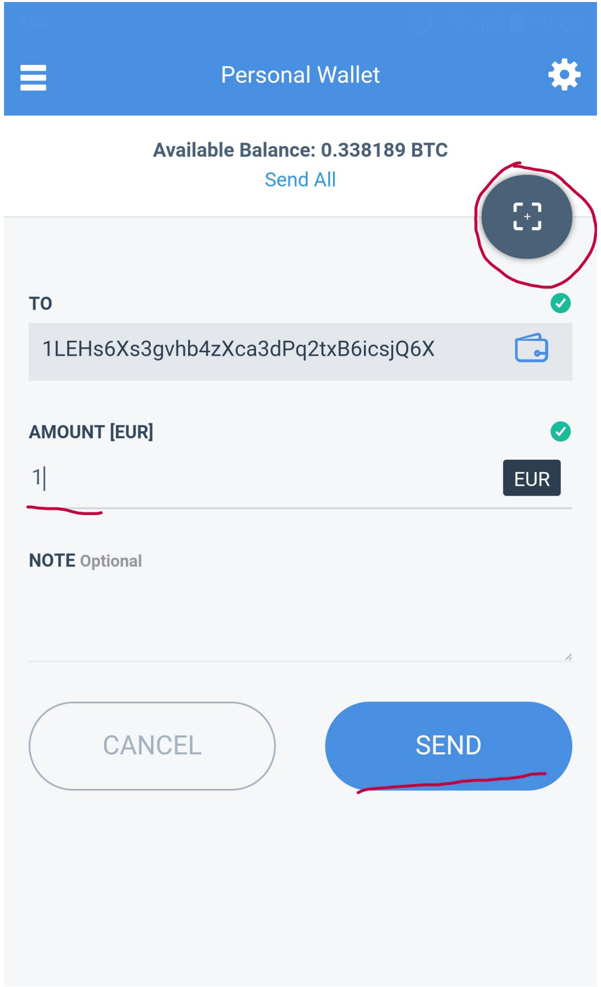


My Bitcoin address

1LEHs6Xs3gvhb4zXca3dPq2txB6icsjQ6X

Usage: send bitcoins

- To: (address / QR code)
- Amount: (in bitcoins or preferred currency)



Available Balance: 0.338189 BTC

TO

1LEHs6Xs3gvhb4zXca3dPq2txB6icsjQ6X

AMOUNT [EUR]

1

How it works

Agenda

The Story of a Transaction

From Transactions to Blocks

Mining

The Story of a Block and Nakamoto Consensus

Basic interaction with a node

Conclusions

The Story of a Transaction

Transaction Basics (1/4)

- Transactions specify the transfer of bitcoin ownership
- Zed transferred 1.5 BTC to 1Alice
- Alice wants to transfer 1 BTC to 1Bob

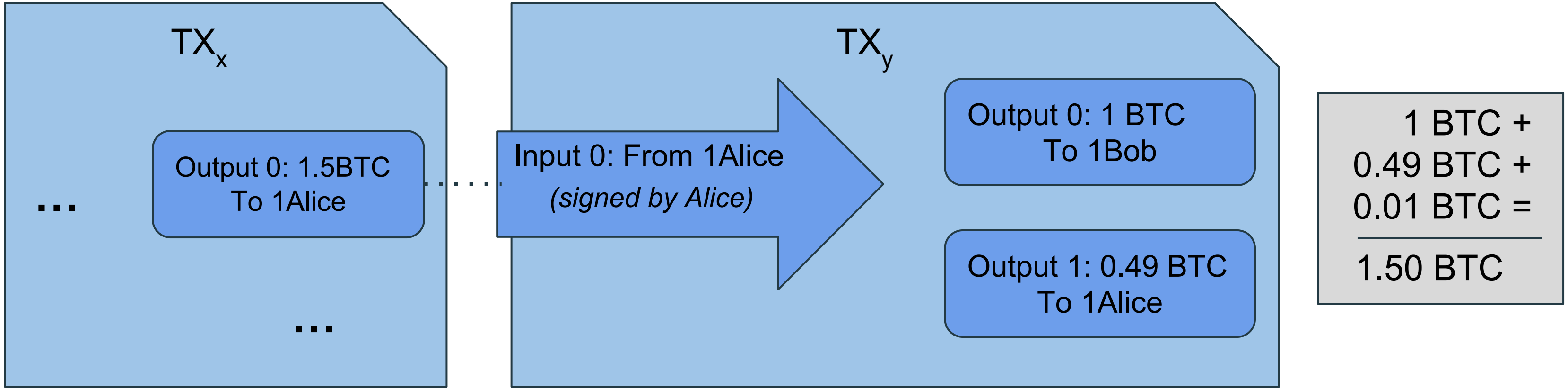
TX_x: 1Zed transfers 1.5 BTC to 1Alice

TX_y: 1Alice transfers 1 BTC to 1Bob

- 1Zed, 1Alice and 1Bob are short for the actual bitcoin addresses
- Alice has to prove that she is the owner of 1Alice
- Bob does not need to do anything

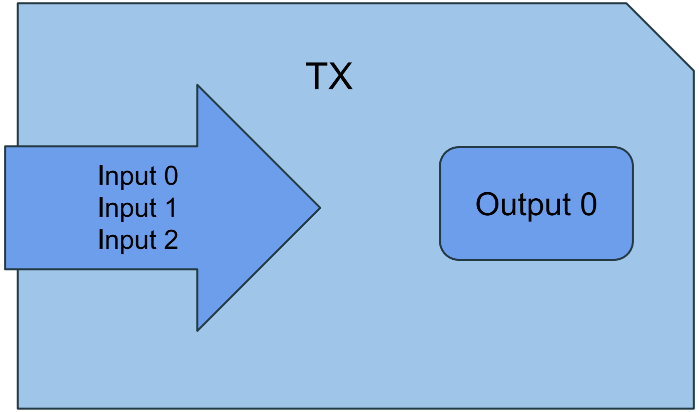
Transaction Basics (2/4)

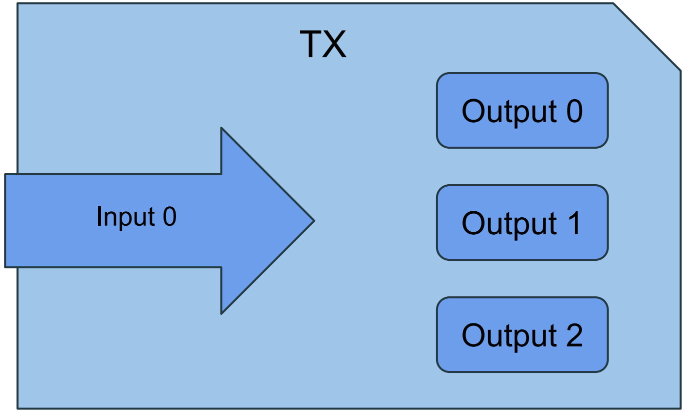
- Transactions can have many inputs and outputs
  - Input; address to get bitcoins from
  - Output; address to send bitcoins to
- When an input is used it is completely consumed
  - all the bitcoins that the TX contained need to be ***spent***.
- Total inputs - total outputs = transaction fee



Transaction Basics (3/4)

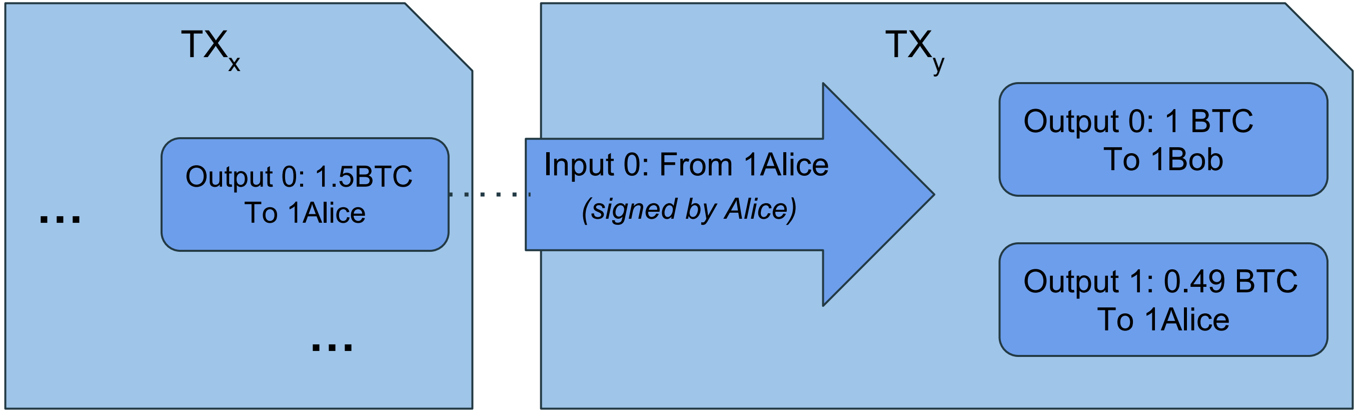
- A typical transaction
  - 1 inputs
  - 2 outputs (1 is *change* to the originating address)
- Other
  - N inputs - 1 output (e.g. aggregation of funds)
  - 1 input - N outputs (e.g. distribution of funds)



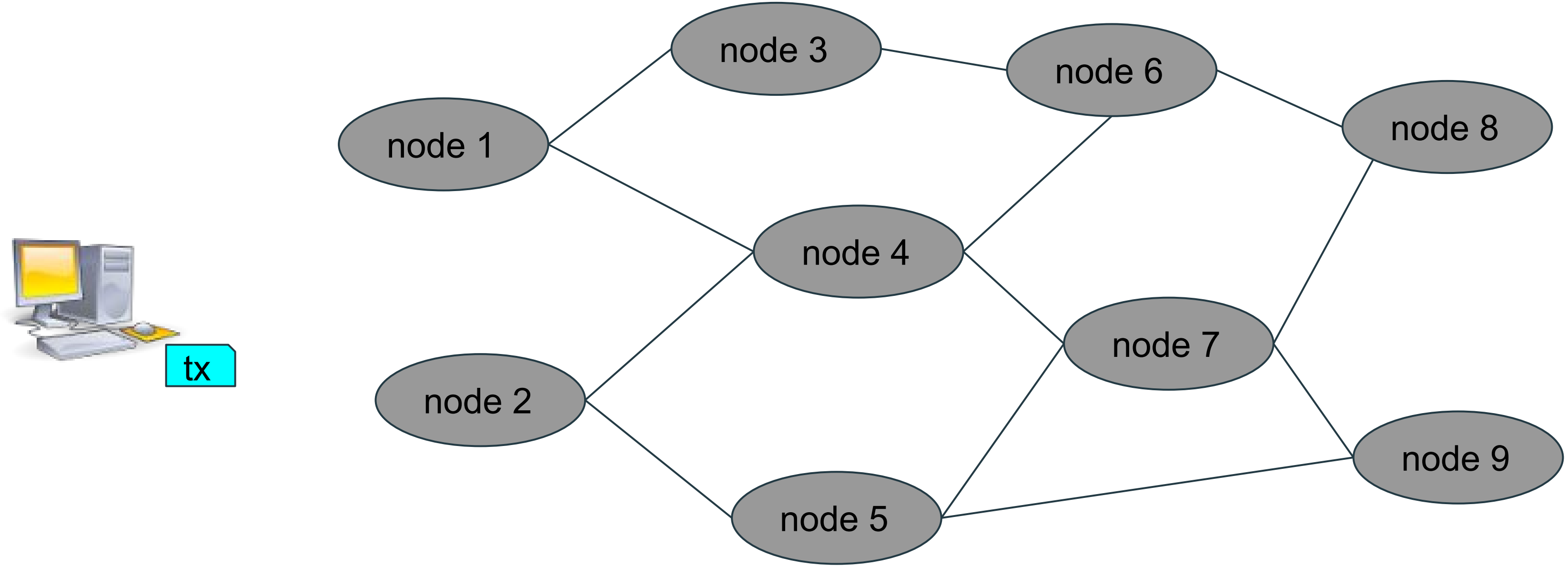


Transaction Basics (4/4)

- Alice creates TXy to send 1 BTC to Bob.
- What next?



Transaction Network Propagation



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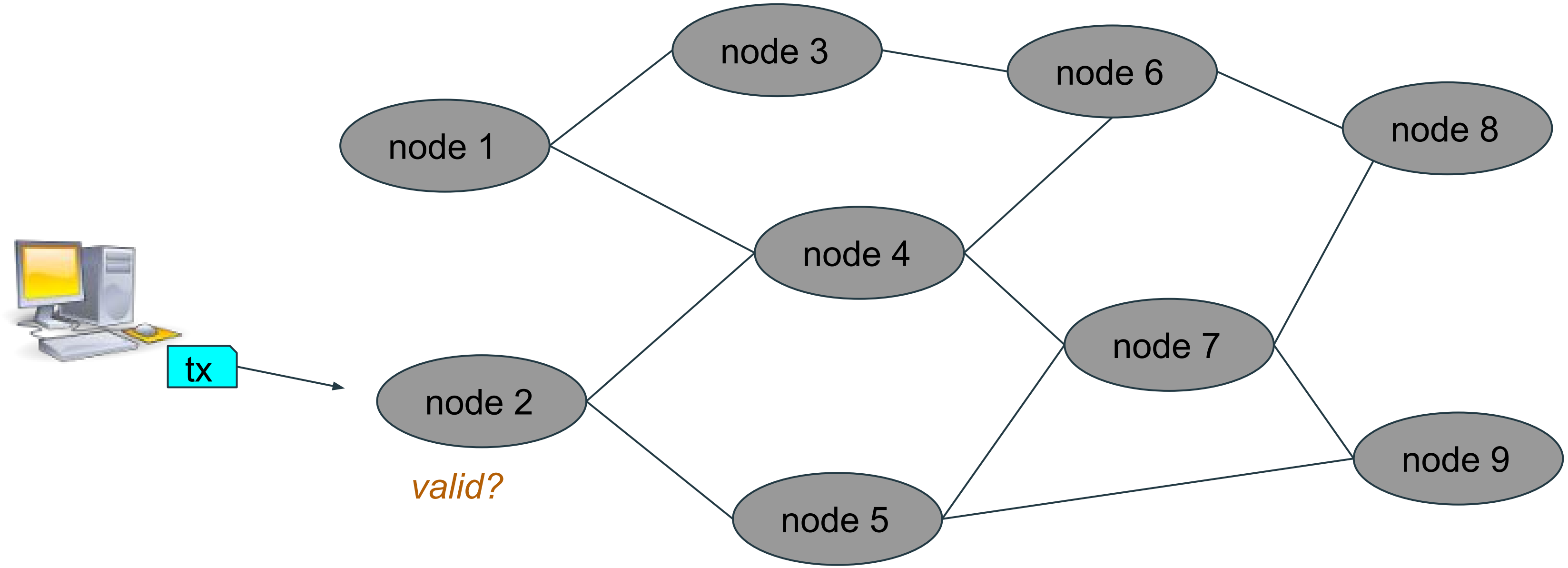

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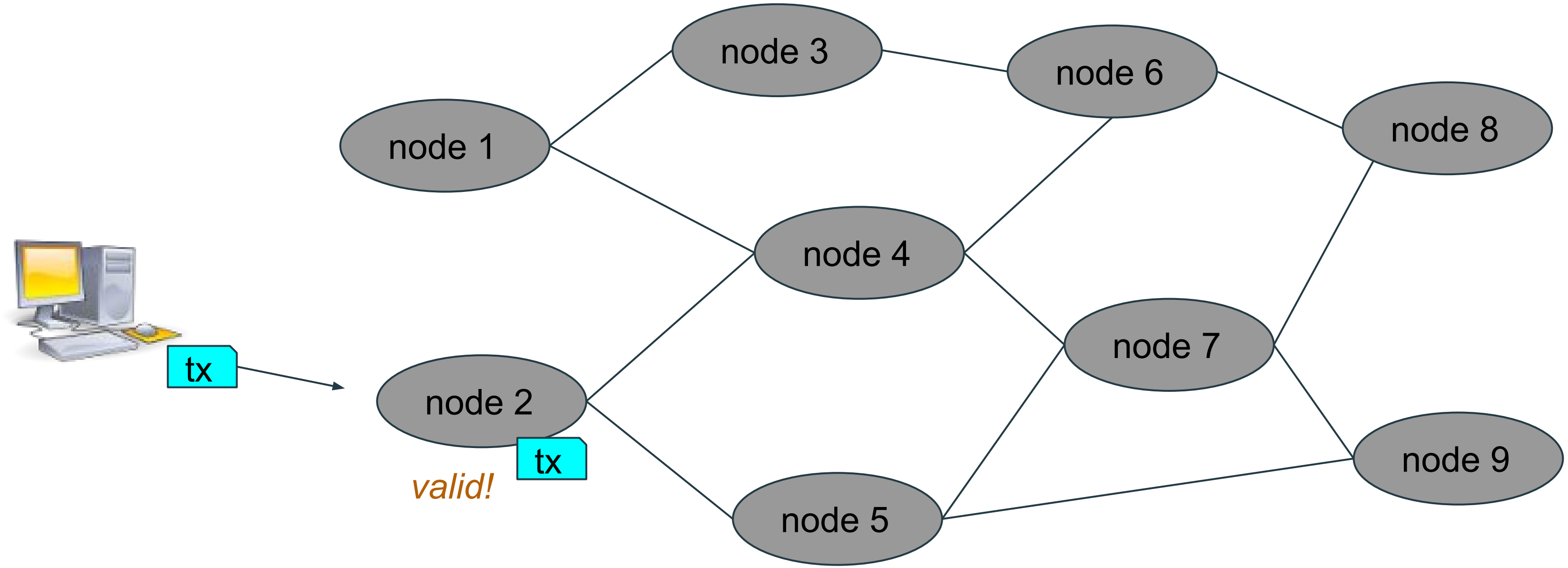

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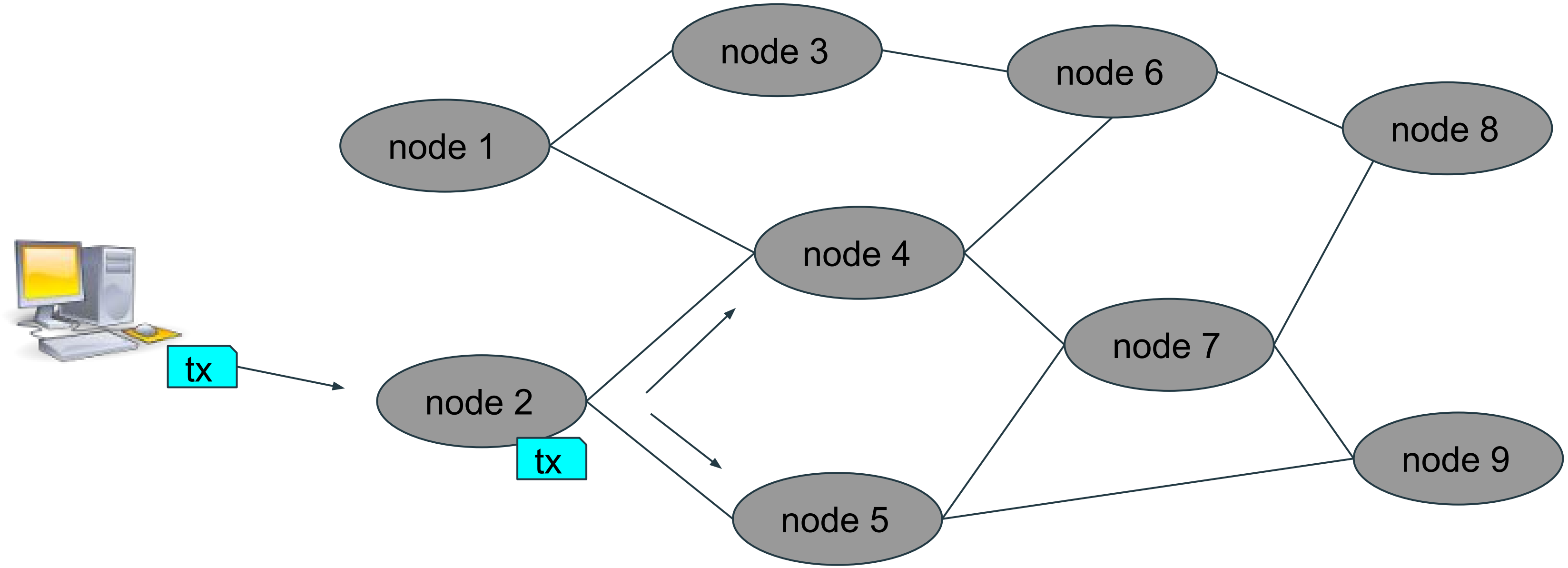

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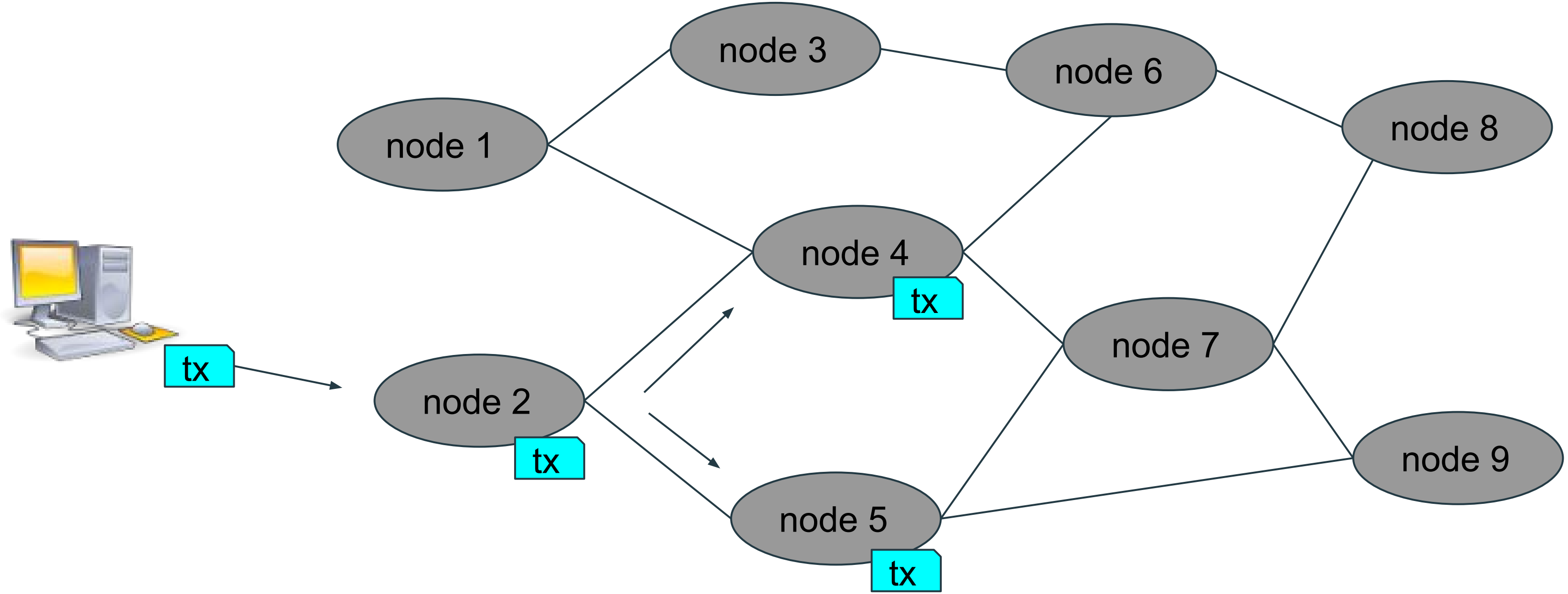

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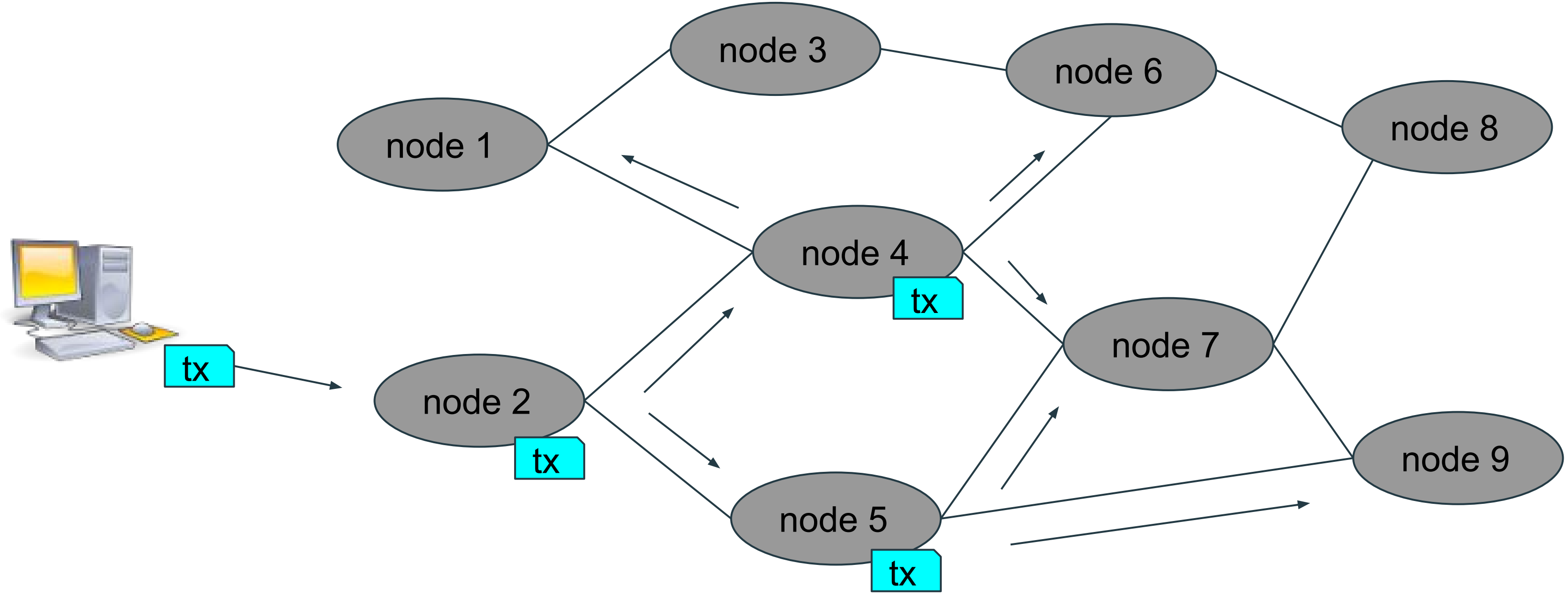

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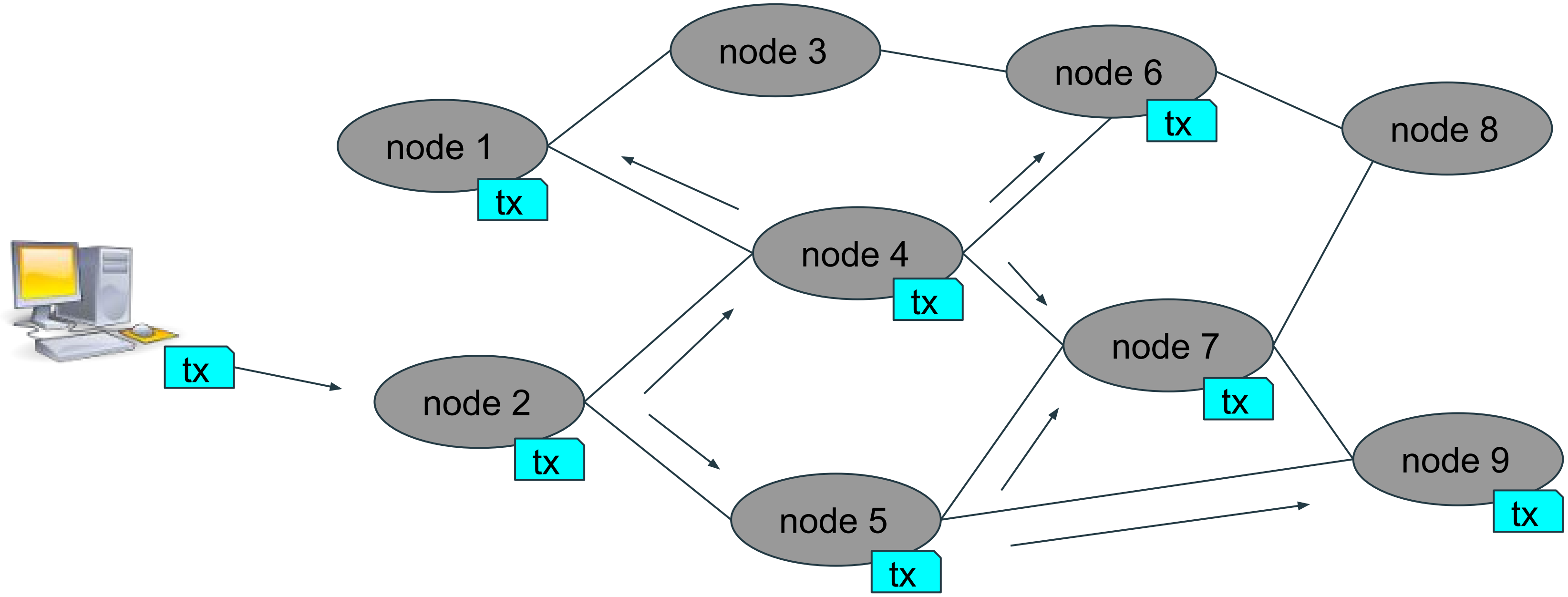

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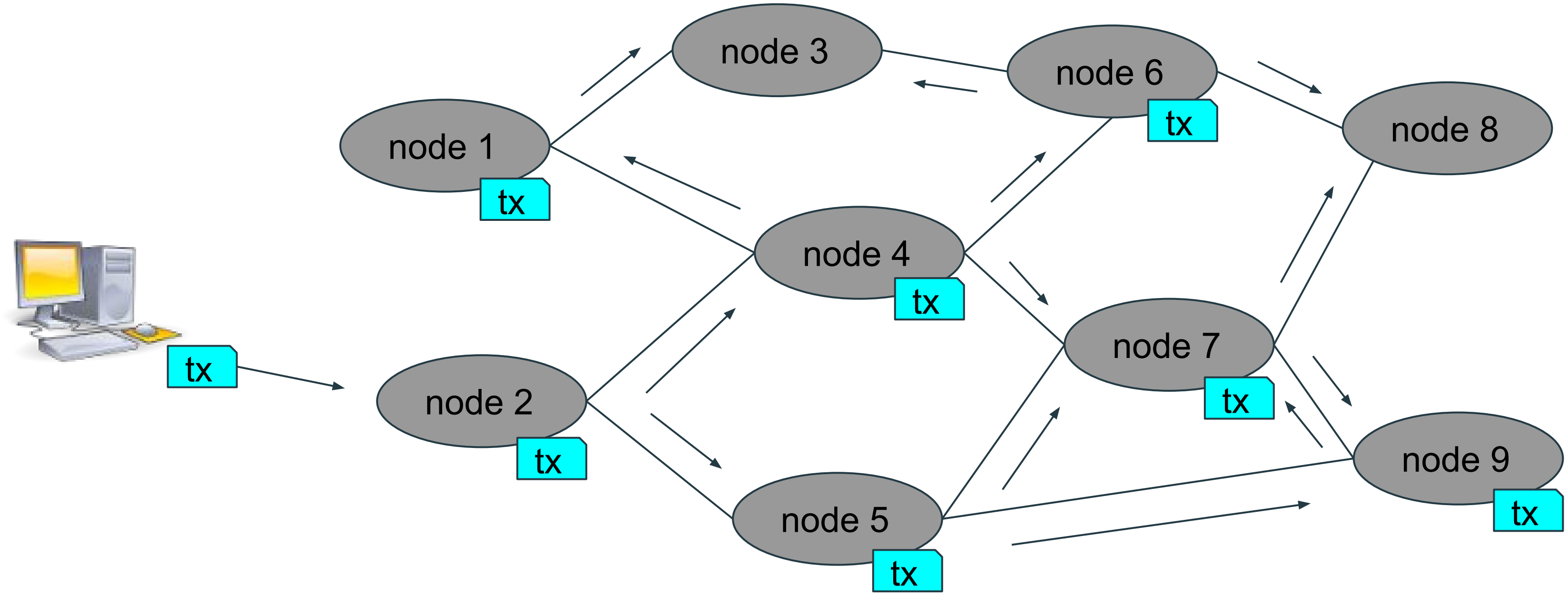

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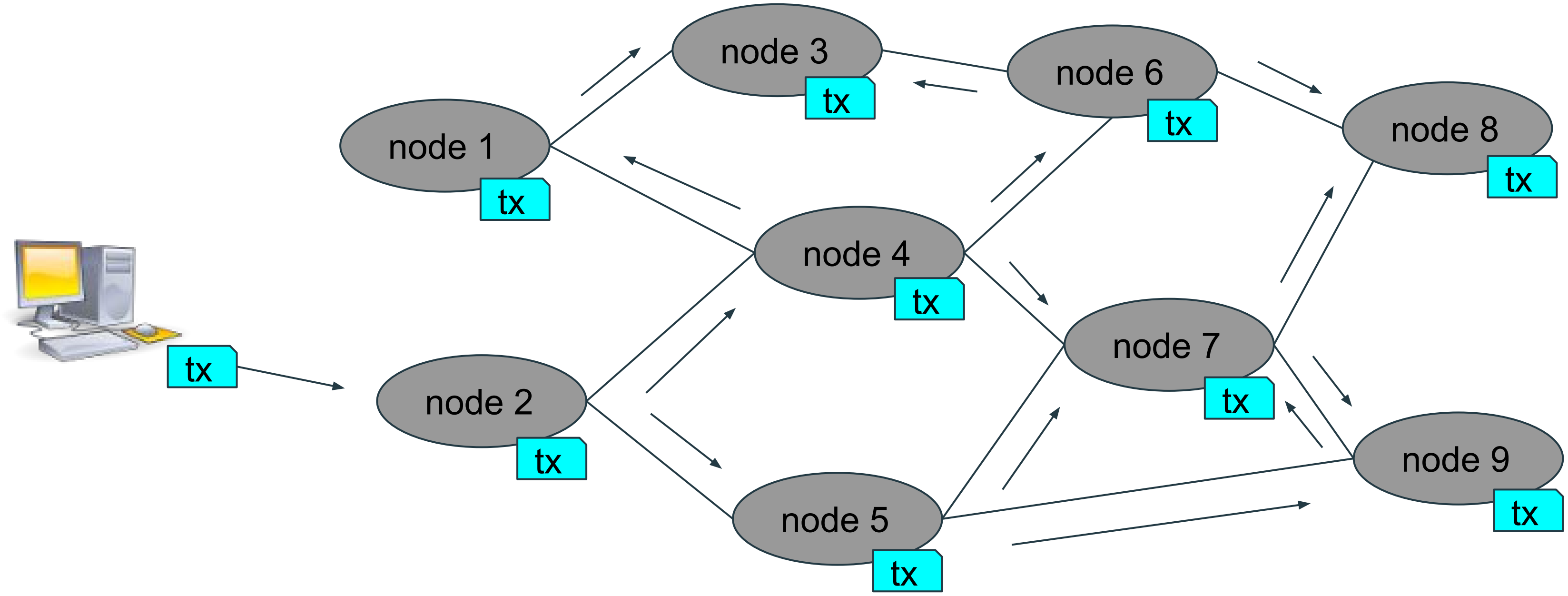

From Transactions to Blocks

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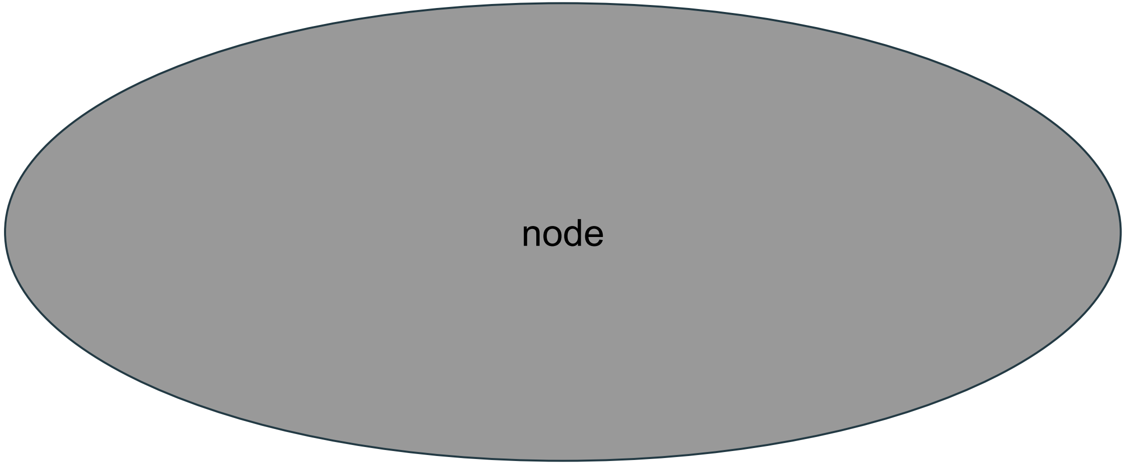

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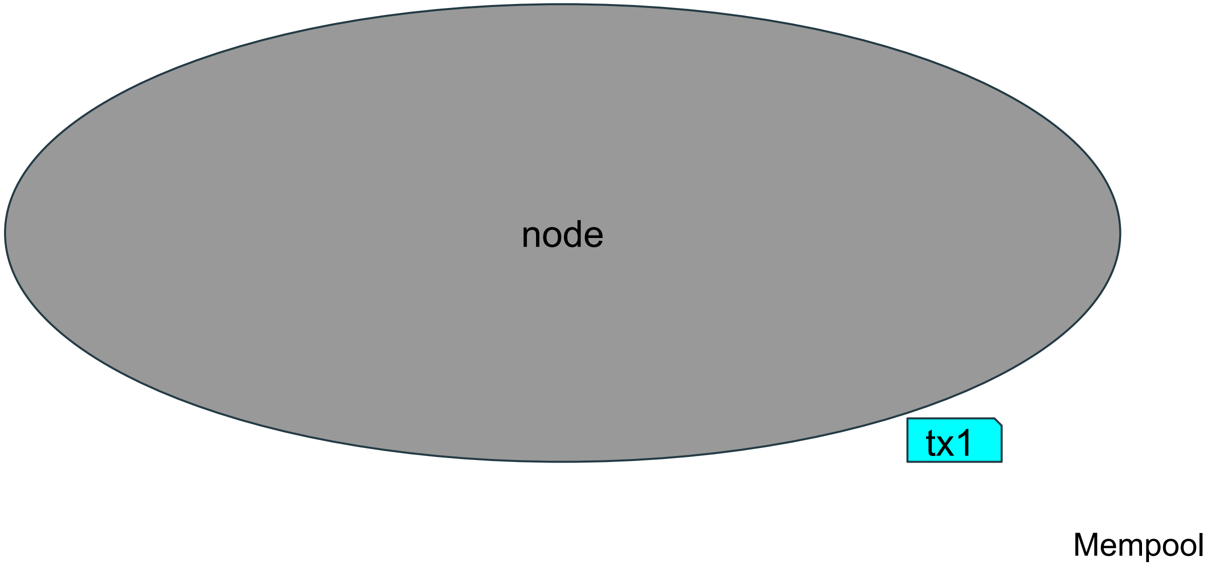

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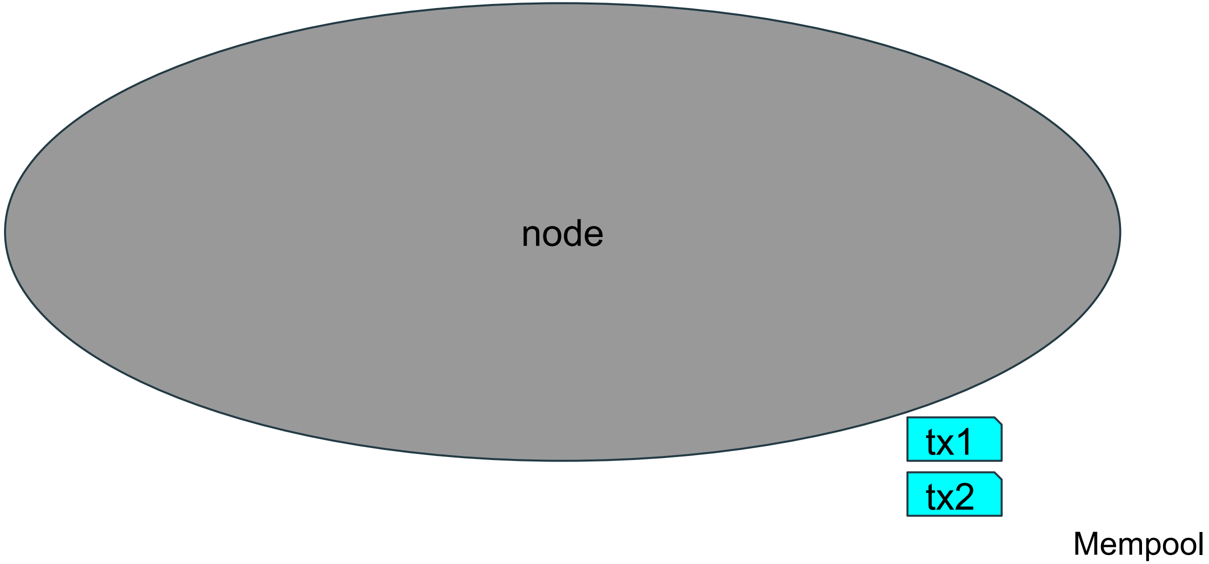

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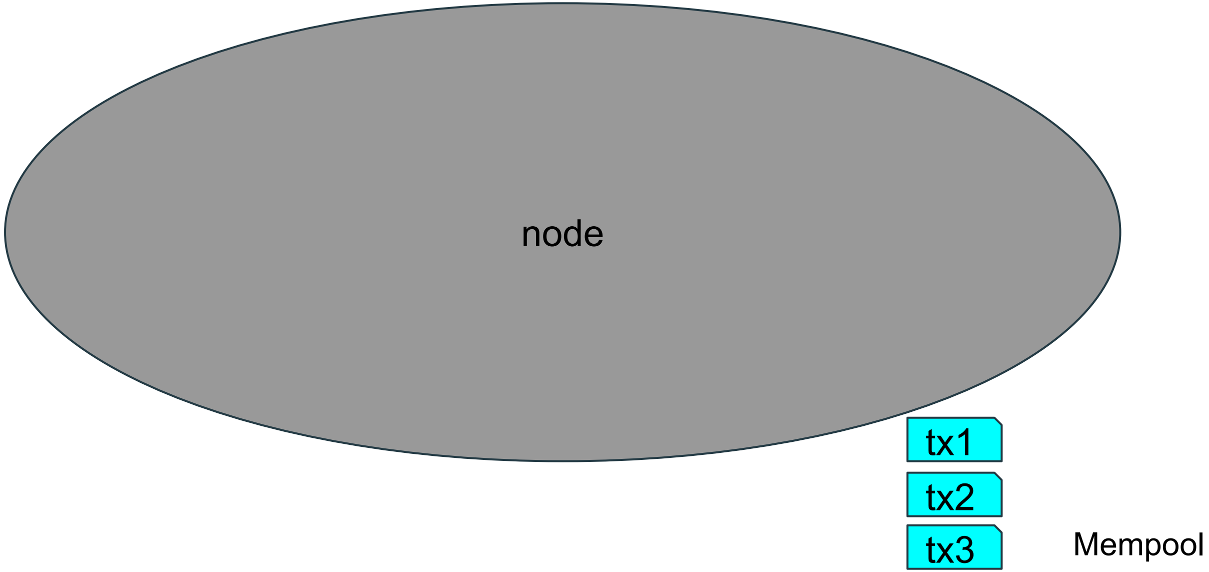

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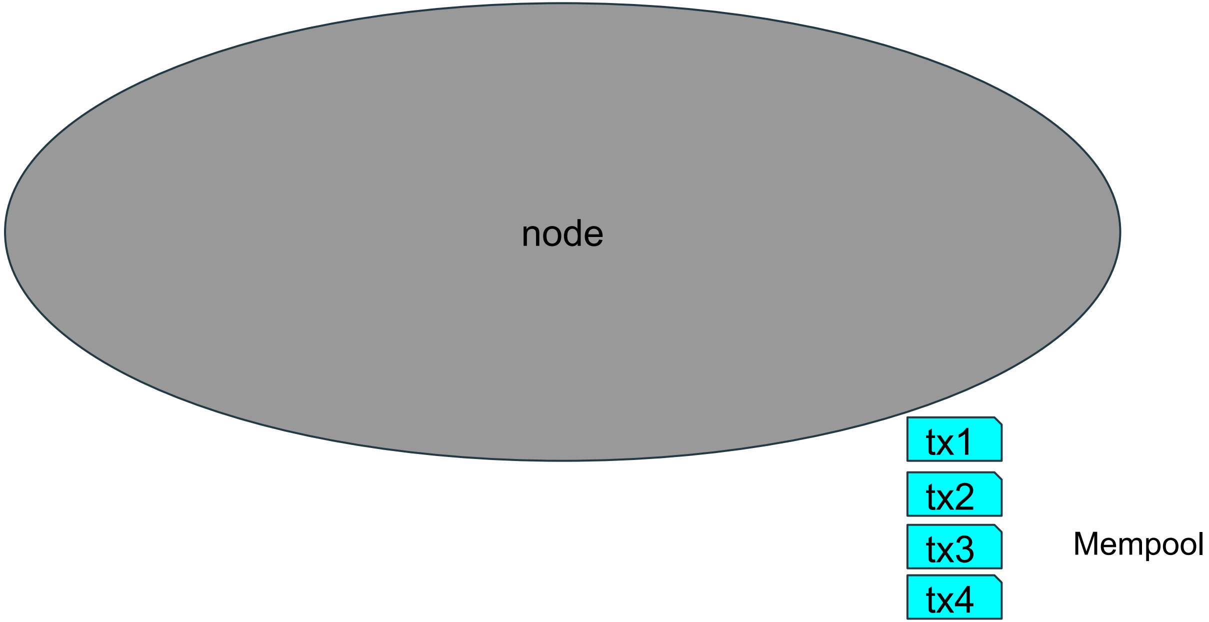

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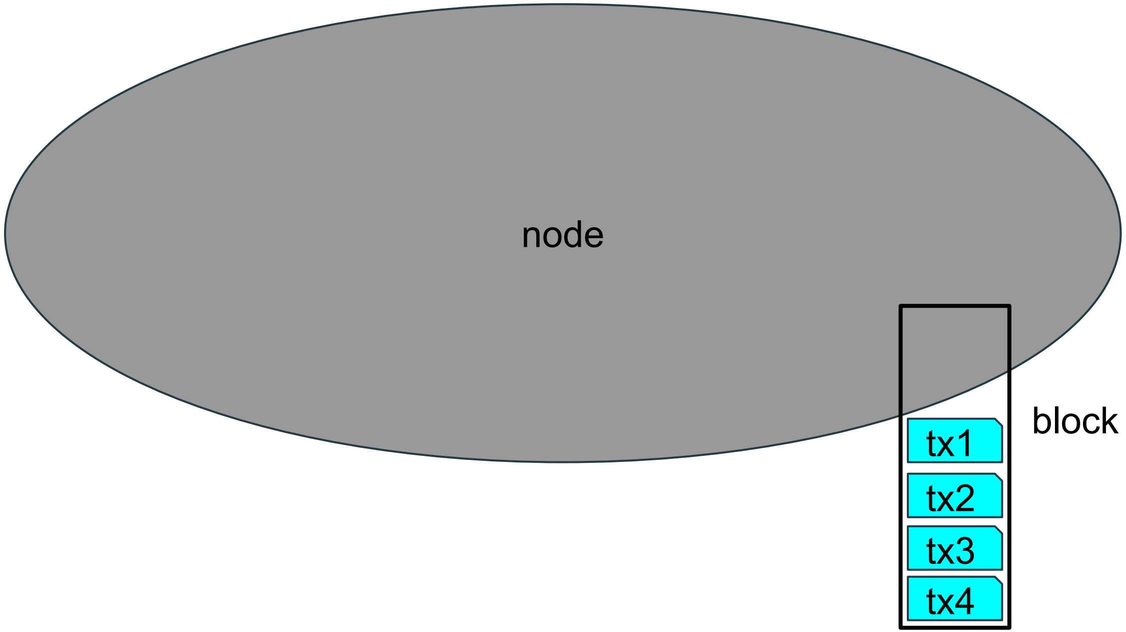

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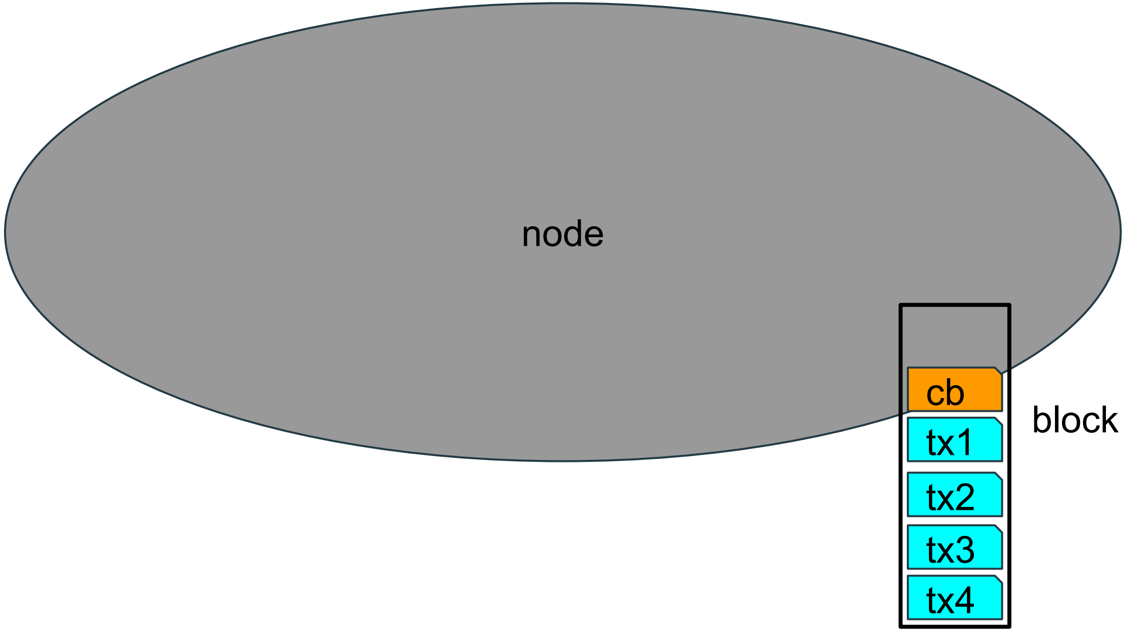

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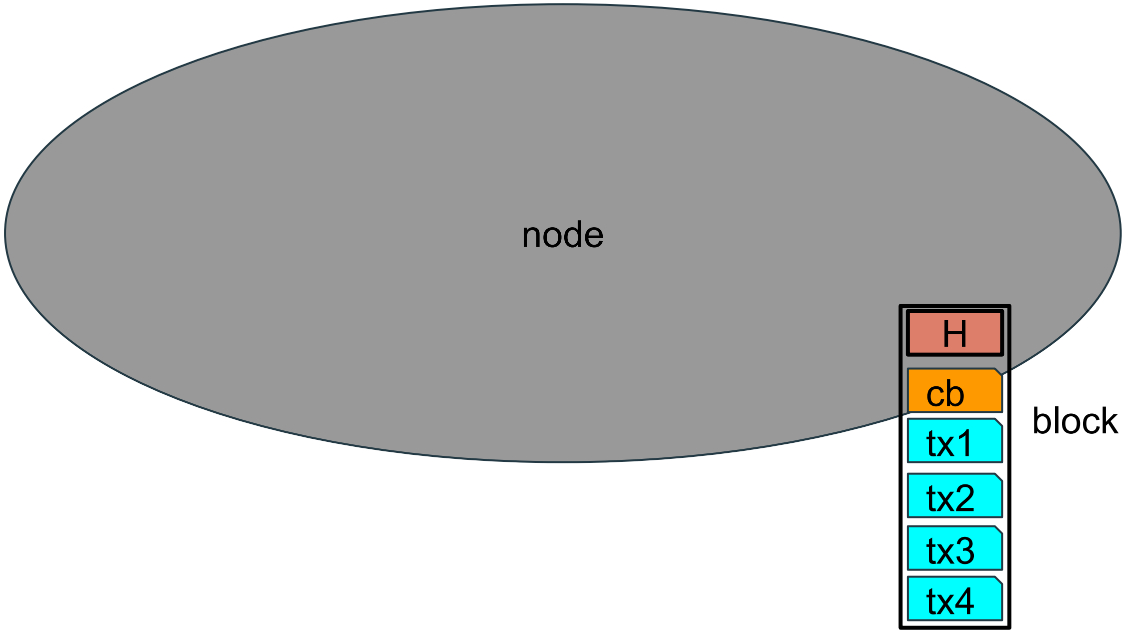


Mining

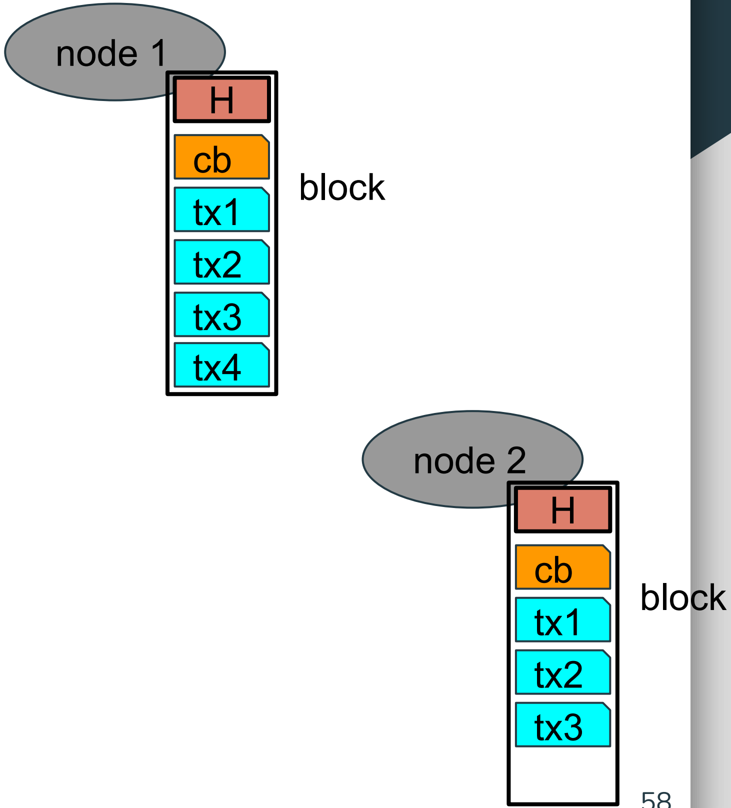
Mining a Block (1/4)

- Multiple nodes will get the transactions
- … and will create new blocks!
  - not identical

How do we avoid spam?

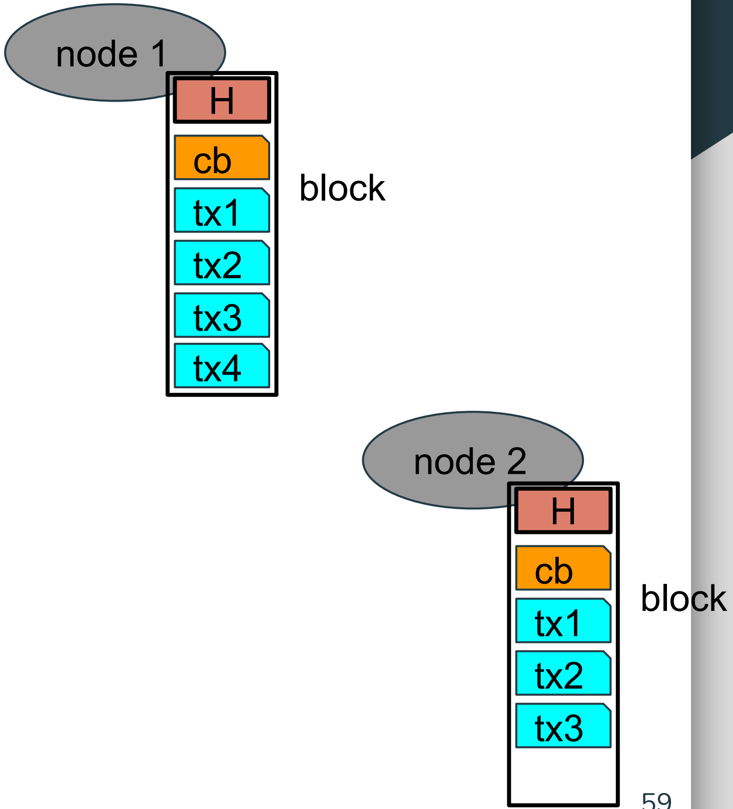
Which blocks are accepted by the network?

- Mining
  - Computational problem
  - Solutions requires work
- Proof-of-Work
  - difficult to calculate
  - trivial to validate



Mining a Block (2/4)

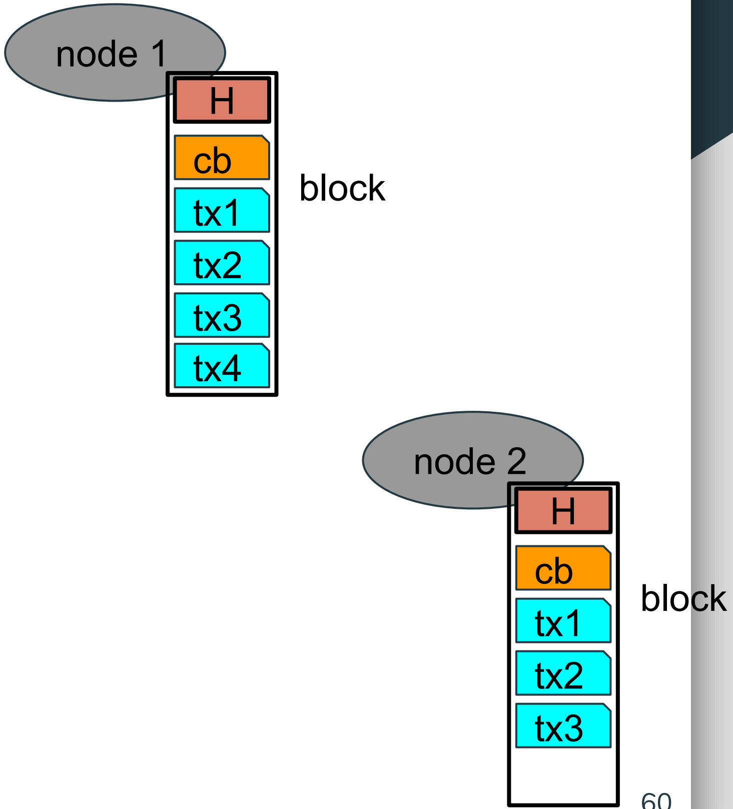
- Bitcoin’s Proof-of-Work puzzle
  - cryptographic hash* of the new block should be less than a given number
  - hash is random and thus it will take several attempts to find a proper hash
  - other nodes can validate with one attempt



* A cryptographic hash function is a hash function that takes an arbitrary block of data and returns a fixed-size bit string, the cryptographic *hash value*, such that any (accidental or intentional) change to the data will also change the hash value significantly.

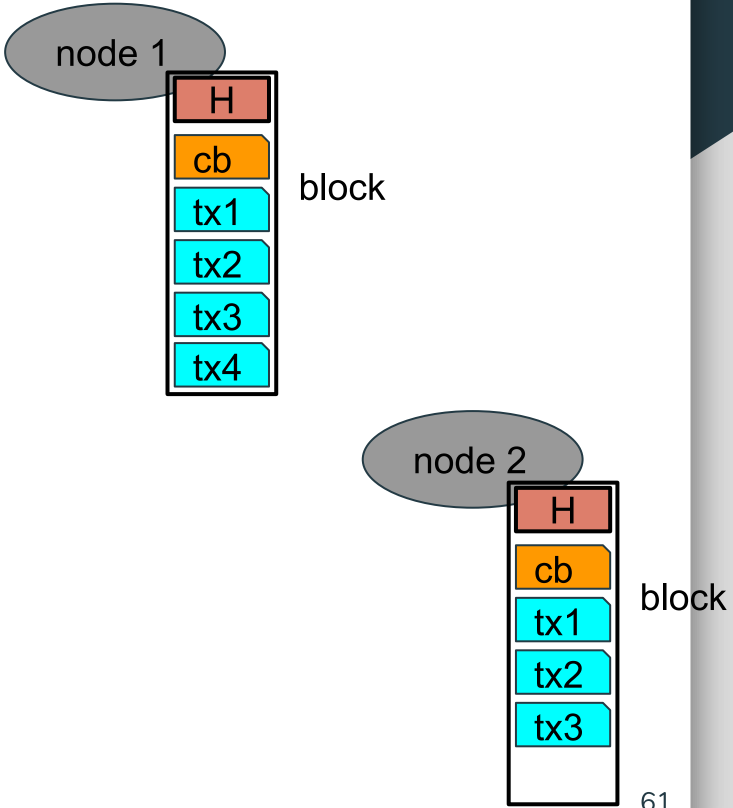
Mining a Block (3/4)

- The puzzle's difficulty automatically adjusts so that it requires approximately 10 minutes to solve
    - following the network's hashrate
- This *difficulty adjustment* happens every 2016 blocks
    - approximately 2 weeks
- The coinbase transaction is added by the miner
    - reward of 12.5 BTC to self
    - if the block is accepted he will get the reward.



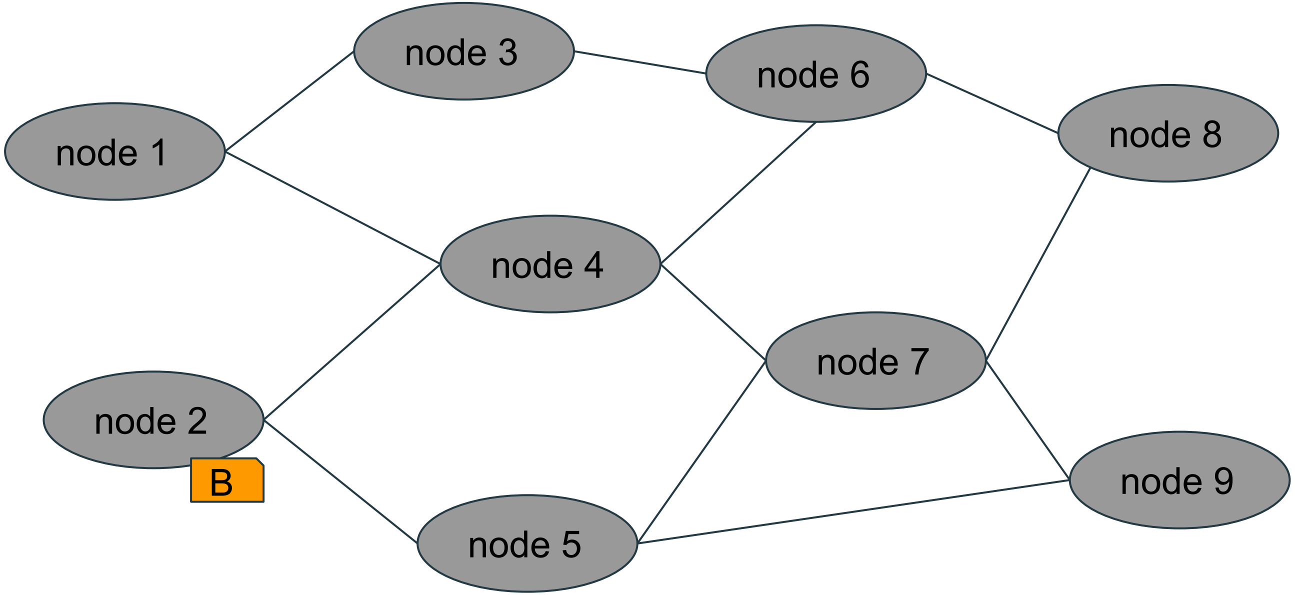
Mining a Block (4/4)

- Reward started at 50 bitcoins
  - It is halved every 210000 blocks
  - approximately 4 years
- All the TXs fees in a block are also awarded to the miner
- The header of a block contains
  - a link to the previously created block



The Story of a Block and Nakamoto Consensus

Block Network Propagation



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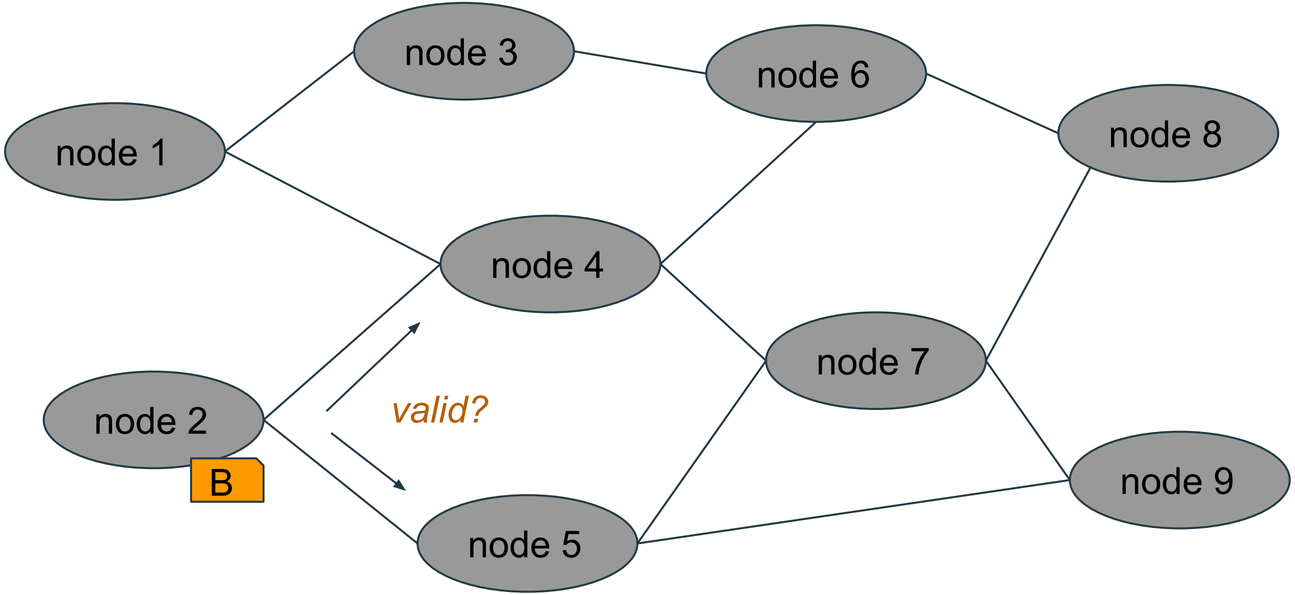

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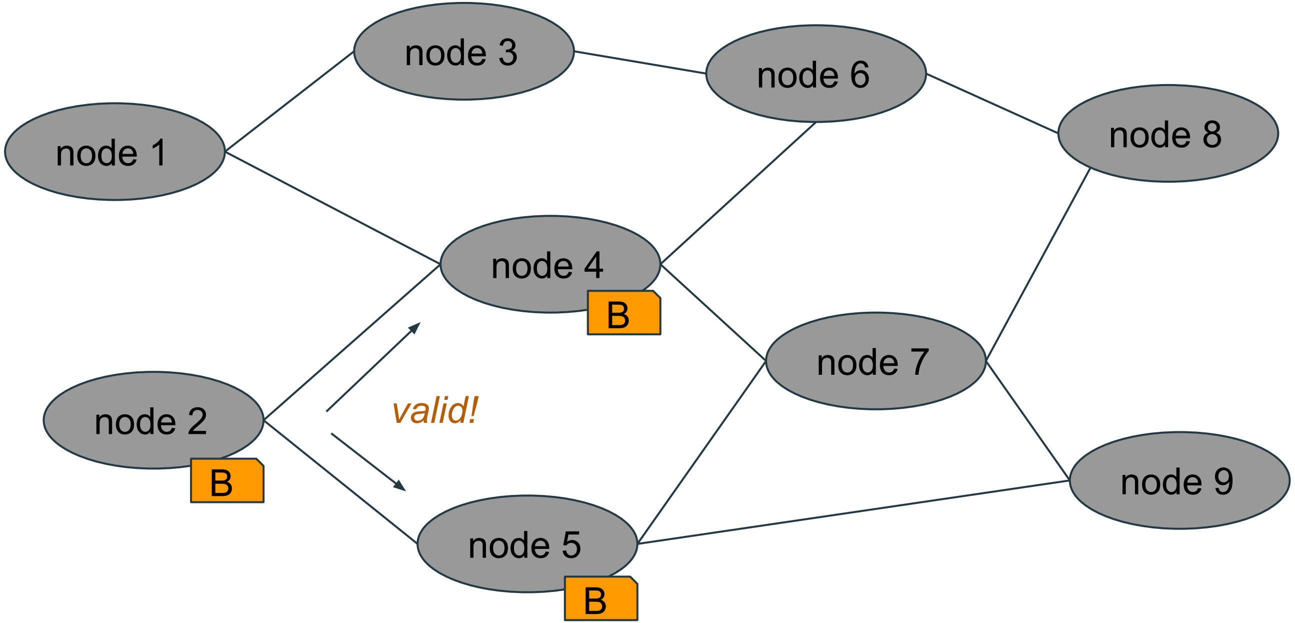

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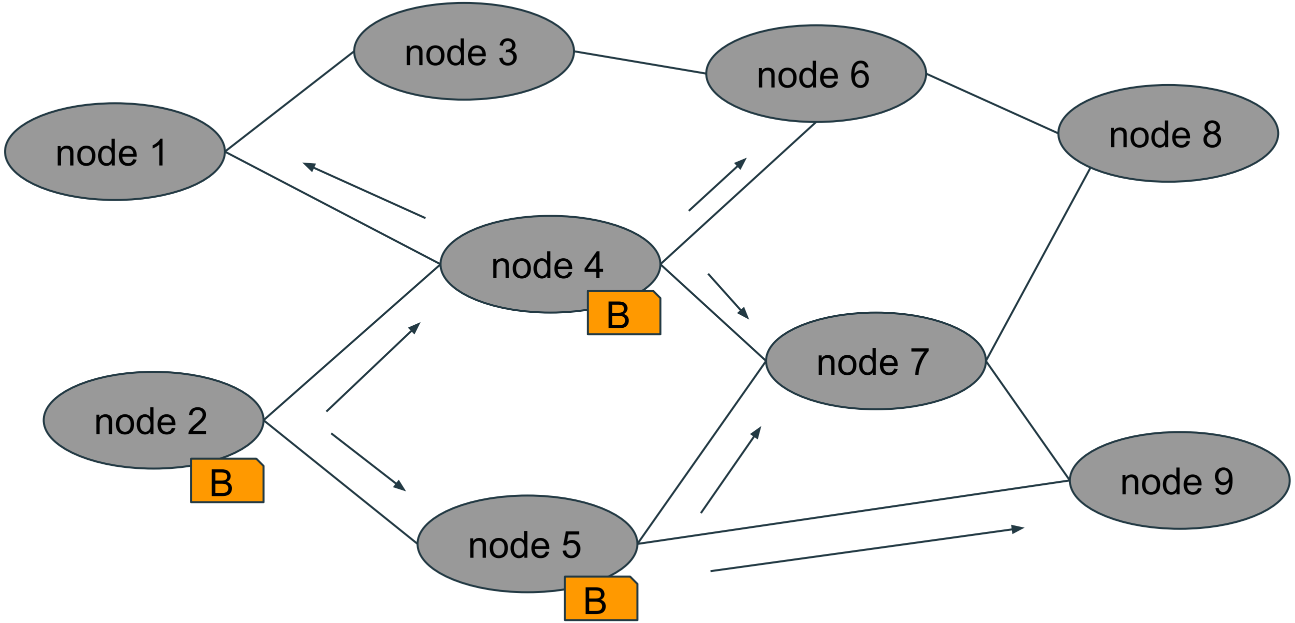
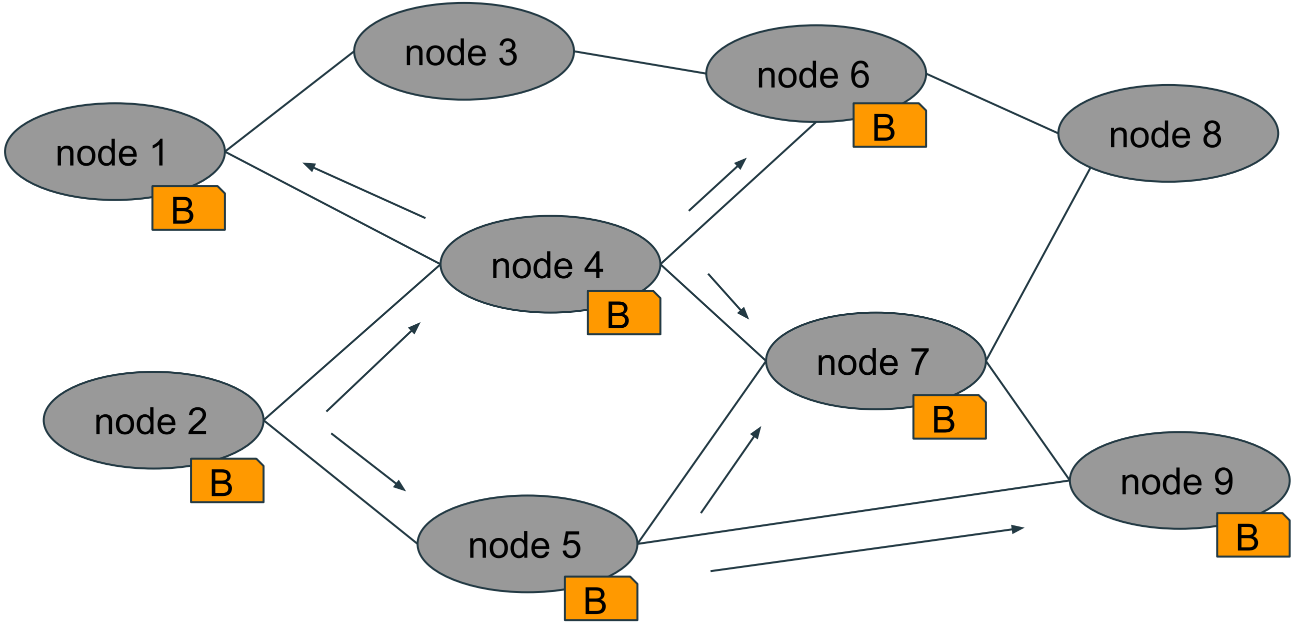
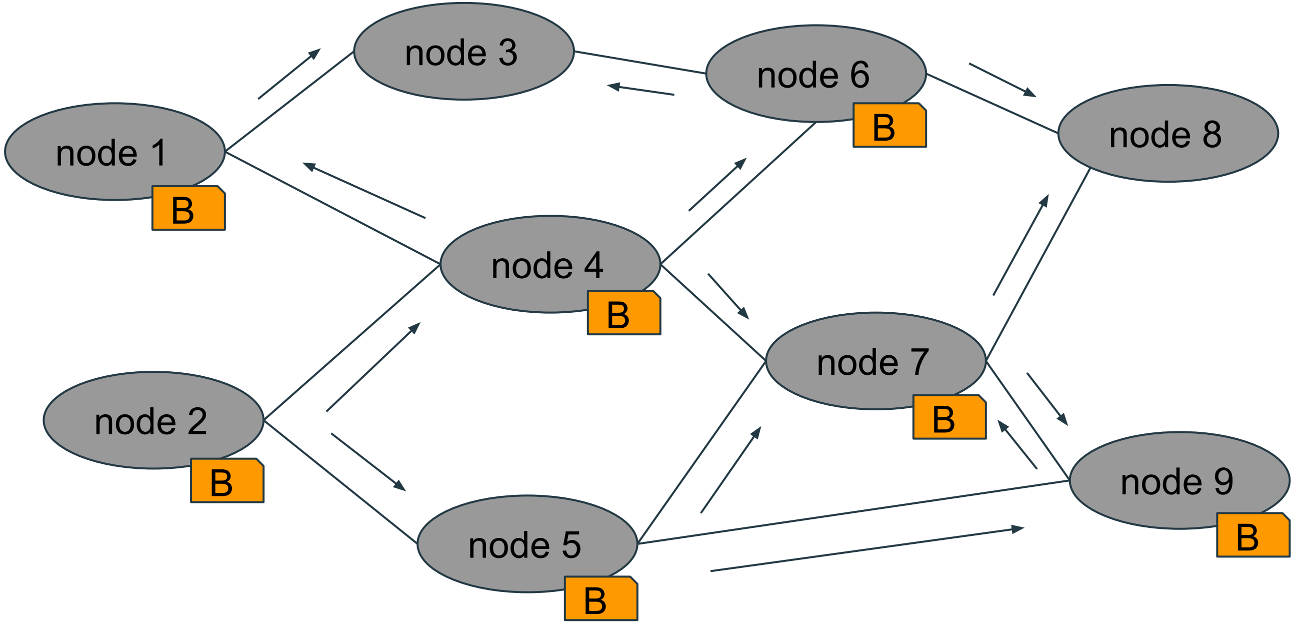


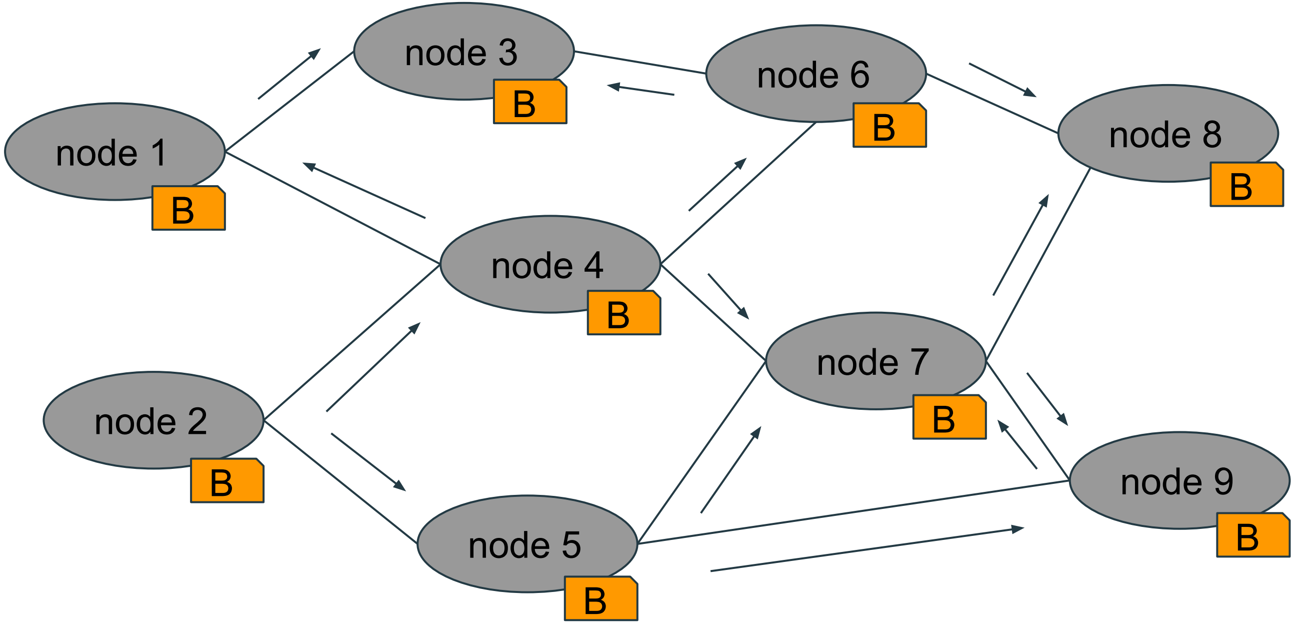
Block Network Propagation



Block Network Propagation



Block Network Propagation

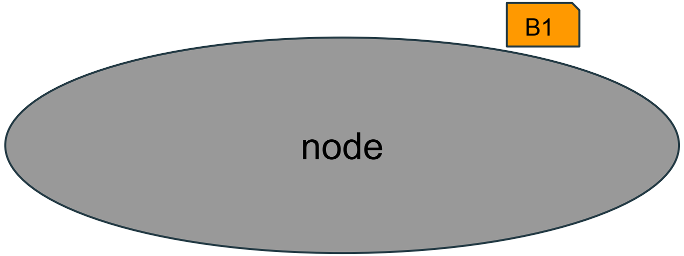


Forming a chain of Blocks (1/3)

- The new block is being added on top of the existing blocks
    - every ~10 minutes

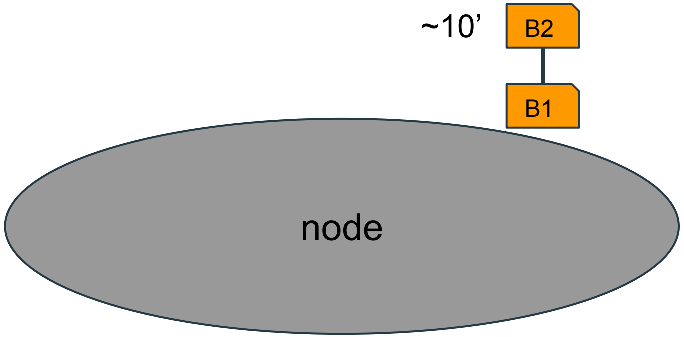
- This occurs on every single node

- Thus the network nodes have the same blocks



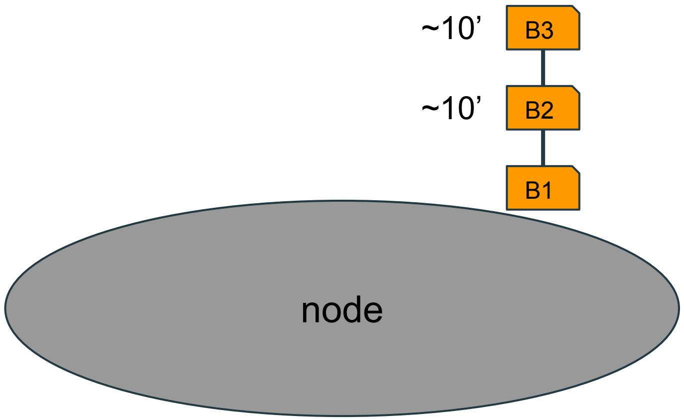
Forming a chain of Blocks (2/3)

- Blocks are linked with cryptographic hashes forming a chain of blocks
    - *Blockchain*.



Forming a chain of Blocks (3/3)

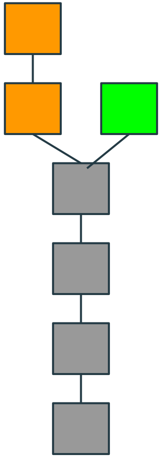
- When B1 is accepted by the network we say that a transaction on that block has one confirmation.
- When B3 is accepted we say that our transaction has 3 confirmations.
- The more confirmations the more final and secure a transaction is.



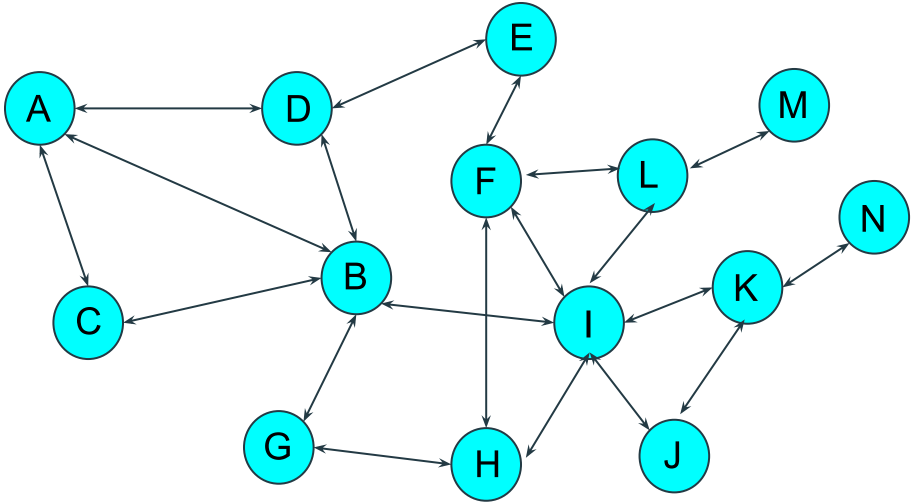
Nakamoto Consensus (1/2)

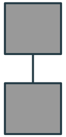
- Nodes receive blocks
  - construct blockchain in isolation
- Nakamoto consensus
  - fundamental contribution
  - how do different nodes come to agreement on what is the current state of the blockchain.
- If two blocks are found by two miners
  - two states
  - nodes continue chain based on the one they received first

- In Nakamoto consensus miners should **follow the longer chain** (the one with the most computation).
  - on next block miners will align and consensus is achieved.

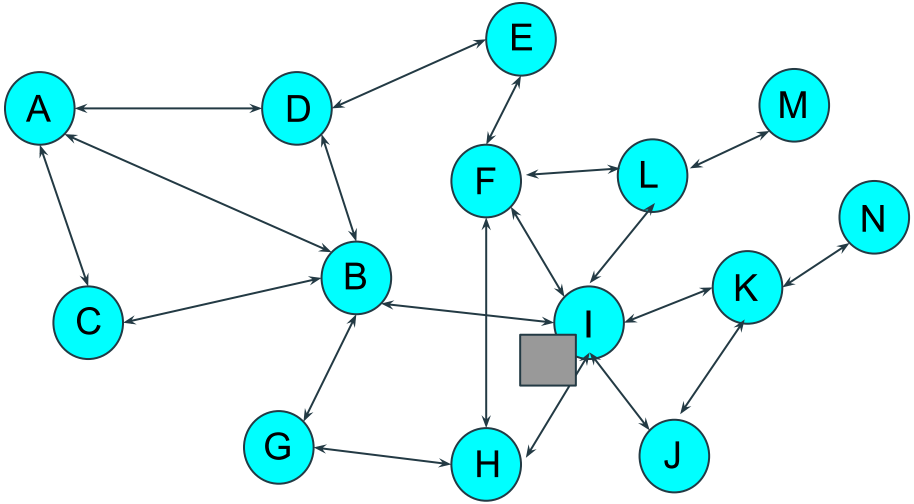


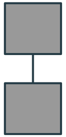
Nakamoto Consensus (2/2)



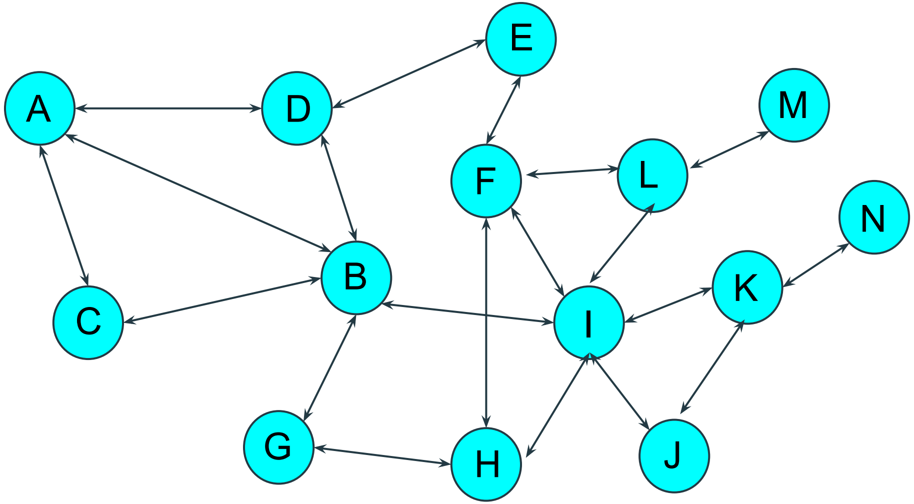


Nakamoto Consensus (2/2)

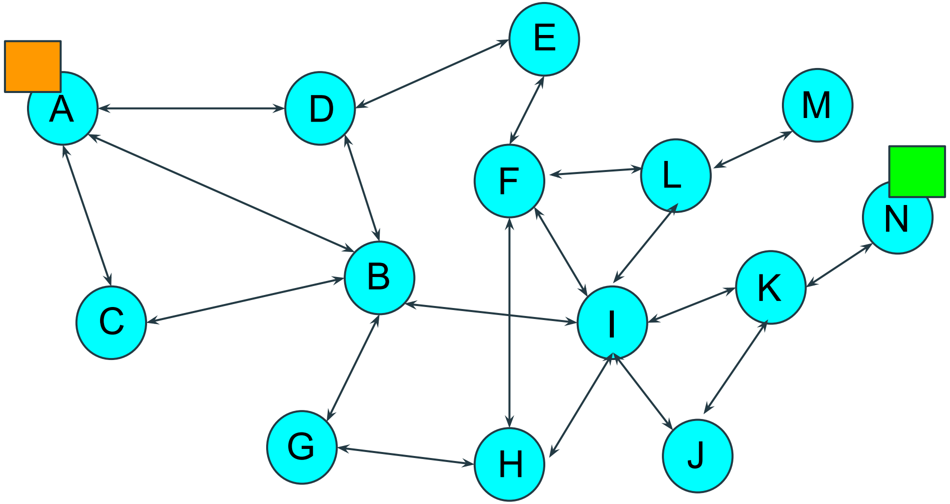




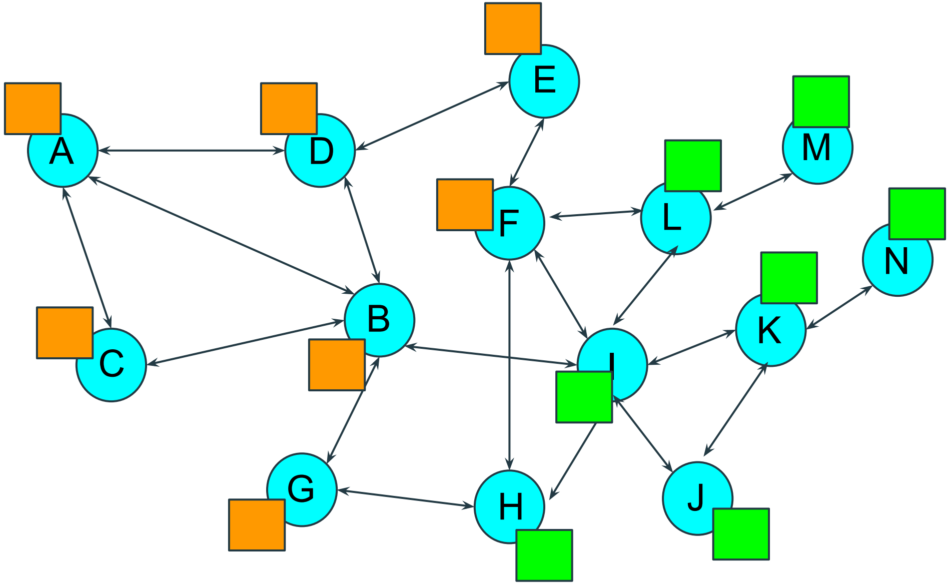
Nakamoto Consensus (2/2)



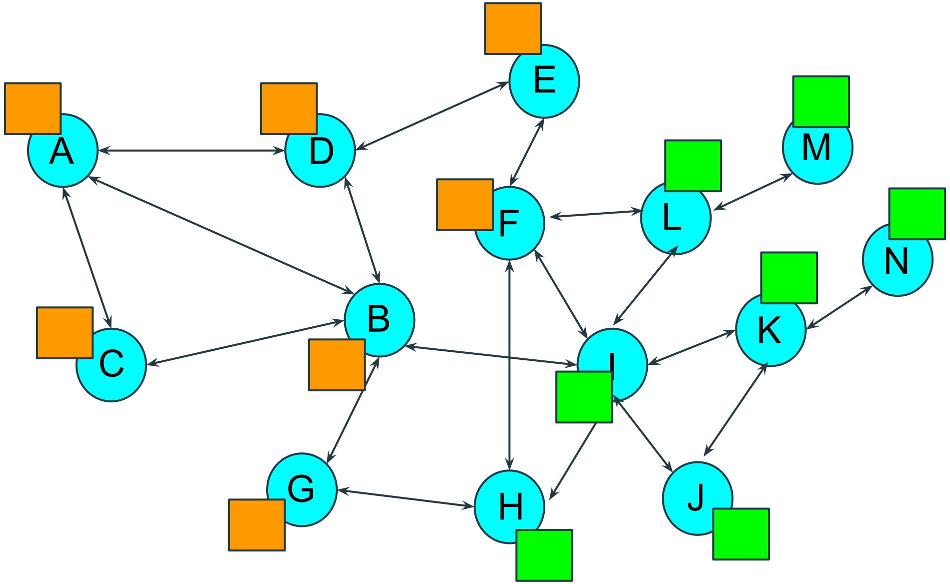
Nakamoto Consensus (2/2)

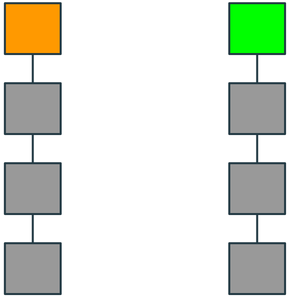


Nakamoto Consensus (2/2)

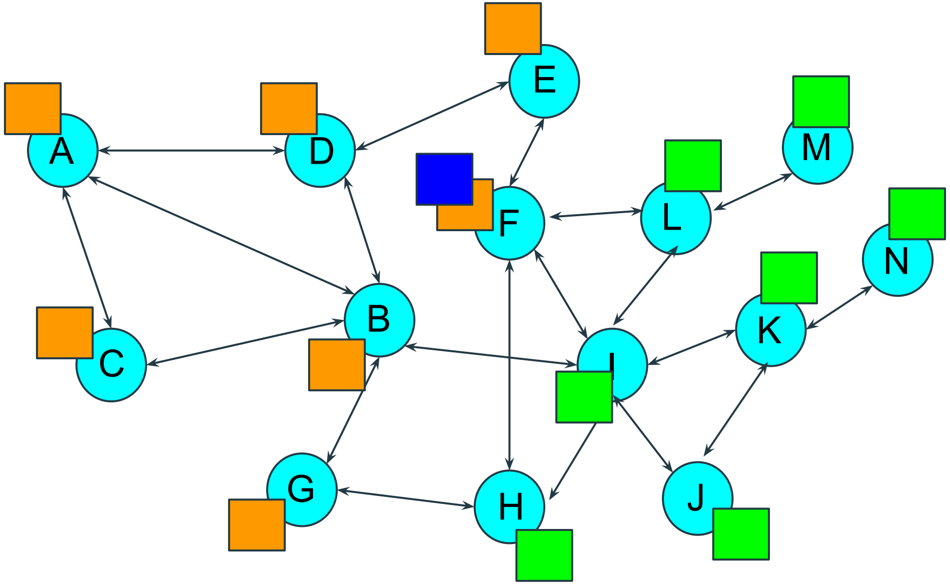


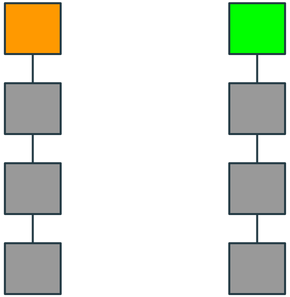
Nakamoto Consensus (2/2)



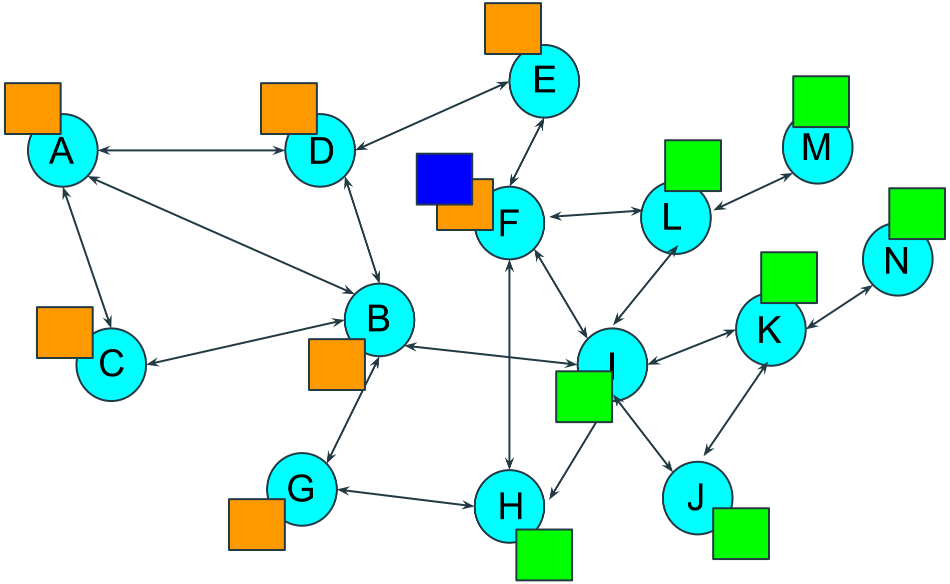


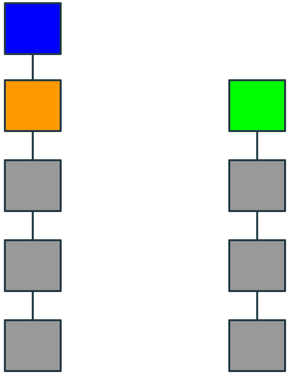
Nakamoto Consensus (2/2)



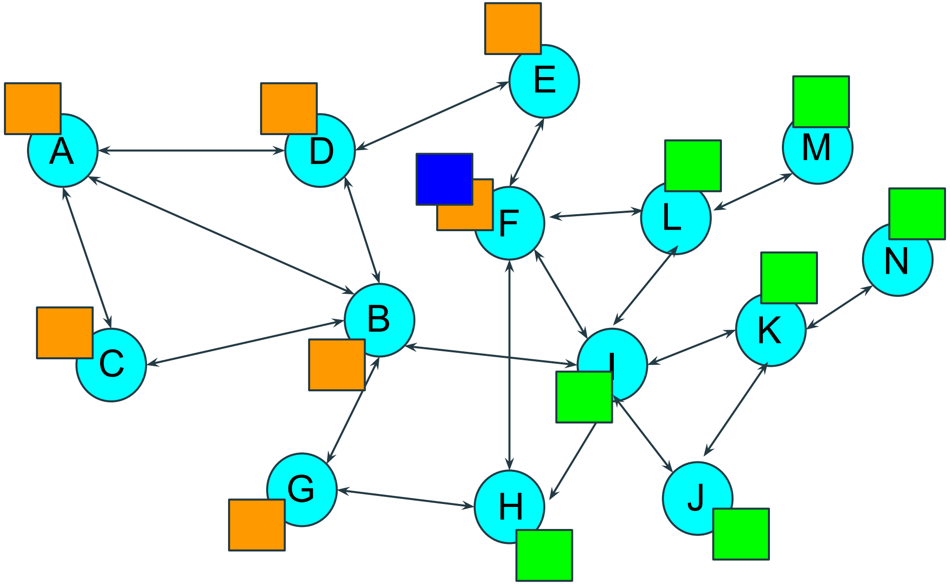


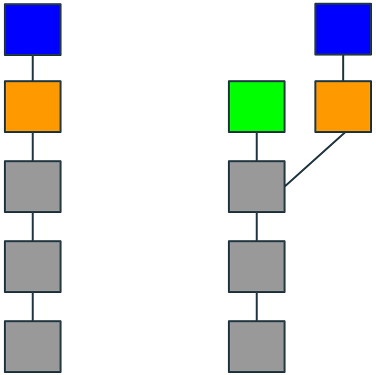
Nakamoto Consensus (2/2)



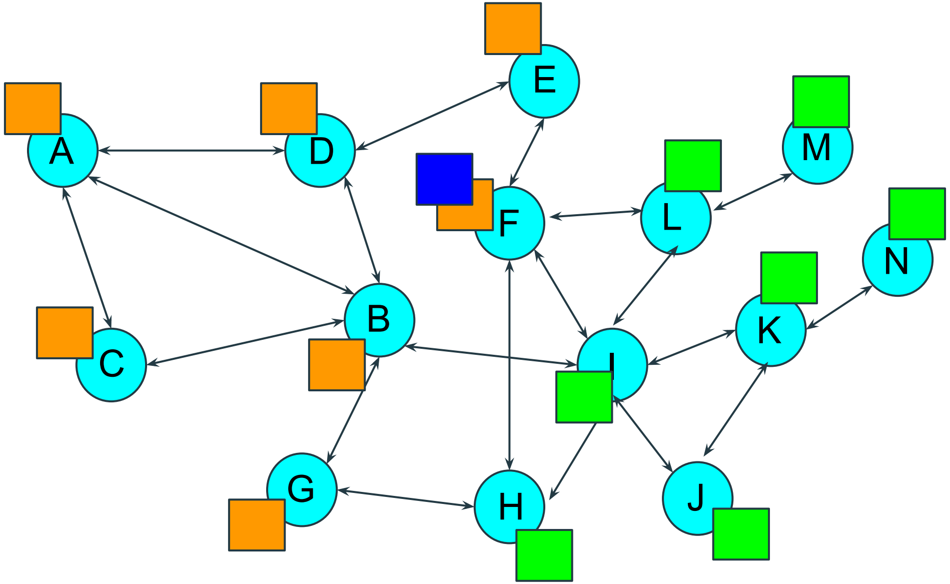


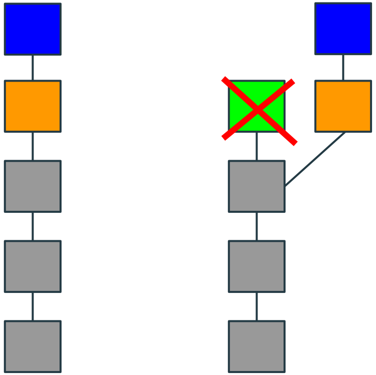
Nakamoto Consensus (2/2)





Nakamoto Consensus (2/2)



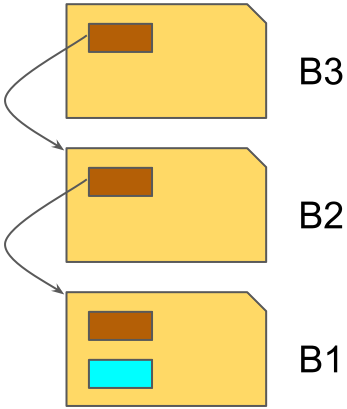


Blockchain and Trust (1/2)

- Blocks are linked together
  - hash of the previous block header

- If a Tx in B1 is tampered with it will be detected immediately by peers
  - since the hash of B1 will change

- An attacker will need to re-create all blocks
  - computationally infeasible
  - 51% attack

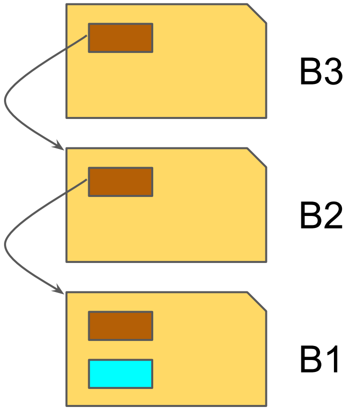


Blockchain and Trust (2/2)

- The block will be rejected and the attack will fail
  - since all peers have a copy of the blockchain they can detect tampering.

- When all hashes match across the whole chain all participants (nodes) know that they can trust their records, i.e. the system.

- Blockchain and Nakamoto Consensus achieve **trustless** interaction between participants.



Basic interaction with a node

Bitcoin software

The Bitcoin software includes several executables, one providing the core functionality and the other utility tools:

bitcoind:

The daemon server provides full peer functionality; includes a wallet. It provides a JSON-RPC API to talk to the node (ports: mainnet: 8332, testnet: 18332).

bitcoin-cli:

Provides a command-line interface to *talk* to the daemon server

bitcoin-qt:

Provides a graphical user interface to the Bitcoin peer and wallet (subset of the API as part of GUI but also provides a console for all calls)

bitcoin-tx:

Allows to create, parse or modify transactions

JSON-RPC API Calls (1/2)

```
$ ./bitcoin-cli help

$ ./bitcoin-cli getblockcount
1128802

$ ./bitcoin-cli getbalance
1.51815479

$ ./bitcoin-cli getnewaddress
mvBGdiYC8jLumpJ142ghePYuY8kecQgeqS

$ ./bitcoin-cli encryptwallet MyPaSsWoRd
wallet encrypted; Bitcoin server stopping, restart
to run with encrypted wallet. The keypool has been
flushed, you need to make a new backup.

$ ./bitcoin-cli walletpassphrase MyPaSsWoRd 120

$ ./bitcoin-cli backupwallet wallet.backup

$ ./bitcoin-cli importwallet wallet.backup
```

```
$ ./bitcoin-cli getinfo
{
  "version": 130100,
  "protocolversion": 70014,
  "walletversion": 130000,
  "balance": 1.51815479,
  "blocks": 1142660,
  "timeoffset": 0,
  "connections": 8,
  "proxy": "",
  "difficulty": 4898.829455242267,
  "testnet": true,
  "keypoololdest": 1480065505,
  "keypoolsize": 100,
  "paytxfee": 0.00000000,
  "relayfee": 0.00001000,
  "errors": ""
}
```

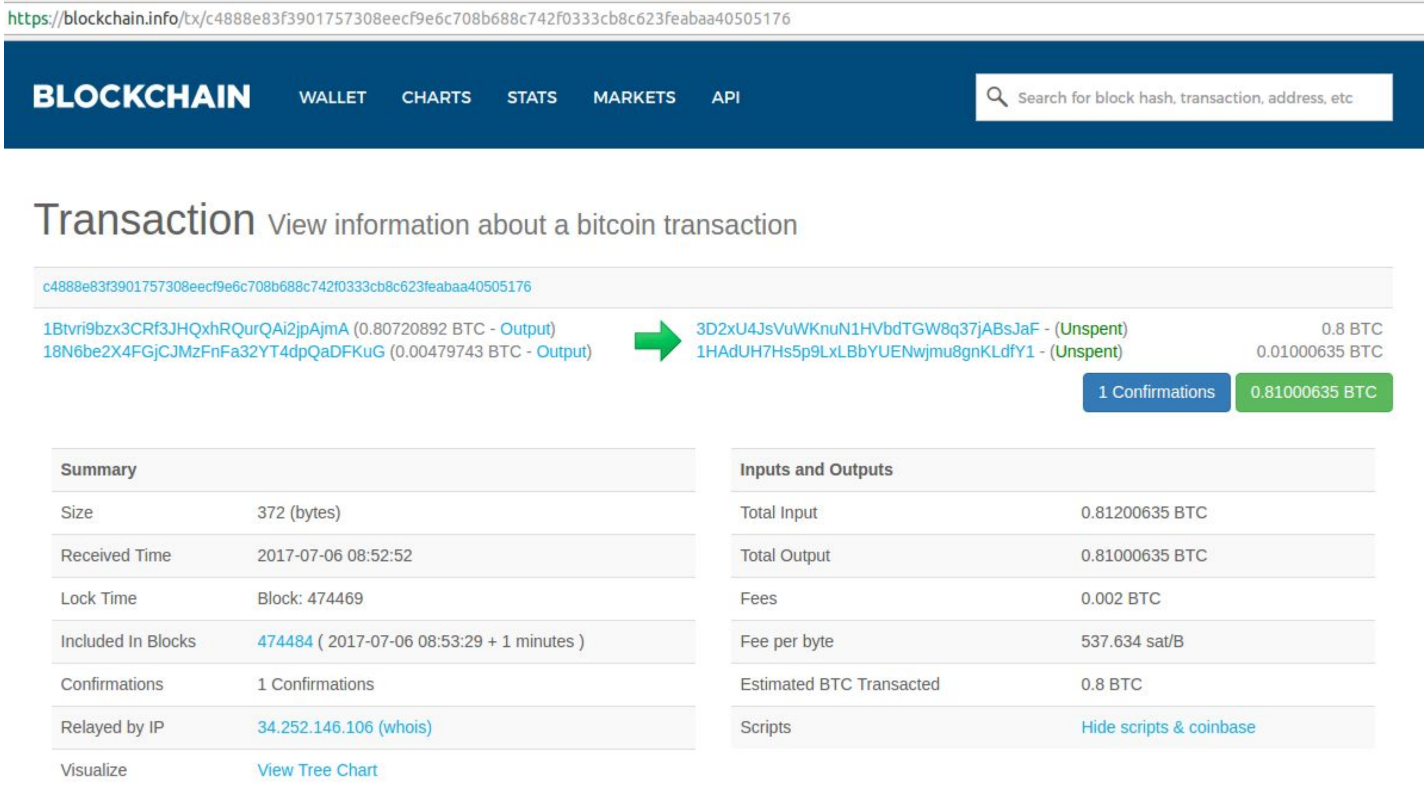
JSON-RPC API Calls (2/2)

```
$ ./bitcoin-cli sendtoaddress mvBGdiYC8jLumpJ142ghePYuY8kecQgeqS 0.01
Ff8322626c21c5bdfa1d27f75a55a1cb1d3b764bb34063f64b38f0803c370c08

$ ./bitcoin-cli listunspent 2
[
 {
    "txid": "30d98980c56a139438f0c969ca30d4be2c7f865d098b905362263c5daca2afa7",
    "vout": 0,
    "address": "mgs9DLttzvWFkZ46YLSNKSZbgSNiMNUsdJ",
    "amount": 1.01452015,
    "confirmations": 20183,
    ...
  }
  ...
]
$ ./bitcoin-cli listaccounts
{
  "": -1.01483854,
  ...
}

$ ./bitcoin-cli getaddressesbyaccount “”
[ “mvBGdiYC8jLumpJ142ghePYuY8kecQgeqS”, ... ]
```

Blockchain Explorer: Transaction Example



https://blockchain.info/tx/c4888e83f3901757308eecf9e6c708b688c742f0333cb8c623feabaa40505176

Transaction View information about a bitcoin transaction

c4888e83f3901757308eecf9e6c708b688c742f0333cb8c623feabaa40505176

1Btvri9bzx3CRf3JHQxhRQurQAi2jpAjmA (0.80720892 BTC - Output)
18N6be2X4FGjCJMzFnFa32YT4dpQaDFKuG (0.00479743 BTC - Output)

3D2xU4JsVuWKnuN1HVbdTGW8q37jABsJaF - (Unspent) 0.8 BTC
1HAdUH7Hs5p9LxLBbYUENwjmu8gnKLdfY1 - (Unspent) 0.01000635 BTC

1 Confirmations 0.81000635 BTC

Summary	
Size	372 (bytes)
Received Time	2017-07-06 08:52:52
Lock Time	Block: 474469
Included In Blocks	474484 (2017-07-06 08:53:29 + 1 minutes)
Confirmations	1 Confirmations
Relayed by IP	34.252.146.106 (whois)
Visualize	View Tree Chart

Inputs and Outputs	
Total Input	0.81200635 BTC
Total Output	0.81000635 BTC
Fees	0.002 BTC
Fee per byte	537.634 sat/B
Estimated BTC Transacted	0.8 BTC
Scripts	Hide scripts & coinbase

Greek Community

- Bitcoin and Blockchain Tech Meetup (Thessaloniki)
    - **http://www.meetup.com/BlockchainGreece-1/**

- Bitcoin and Blockchain Tech Meetup (Athens)
    - http://www.meetup.com/BlockchainGreece-0/
- Bitcointalk forum (Greek section)
    - https://bitcointalk.org/gr
- Blog
    - http://www.bitcoin-gr.org/
- Facebook
    - https://www.facebook.com/groups/bitcoin.gr/?fref=ts
- Slack
    - https://bitcoingreece.herokuapp.com
- https://weacceptbitcoin.gr/

Questions ?

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Linkedin:	https://www.linkedin.com/in/kkarasavvas
Twitter:	@kkarasavvas
Email:	kkarasavvas@gmail.com
Bitrated:	https://www.bitrated.com/kostas
Keybase:	https://keybase.io/kkarasavvas