CSE446: Blockchain & Cryptocurrencies

Lecture – 8: Bitcoin-2

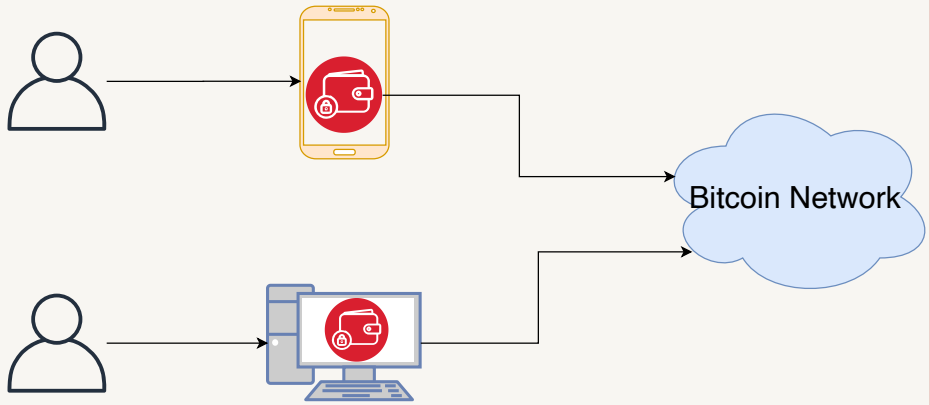
Inspiring Excellence

Agenda

- Bitcoin components
  - Users
  - Node & Network

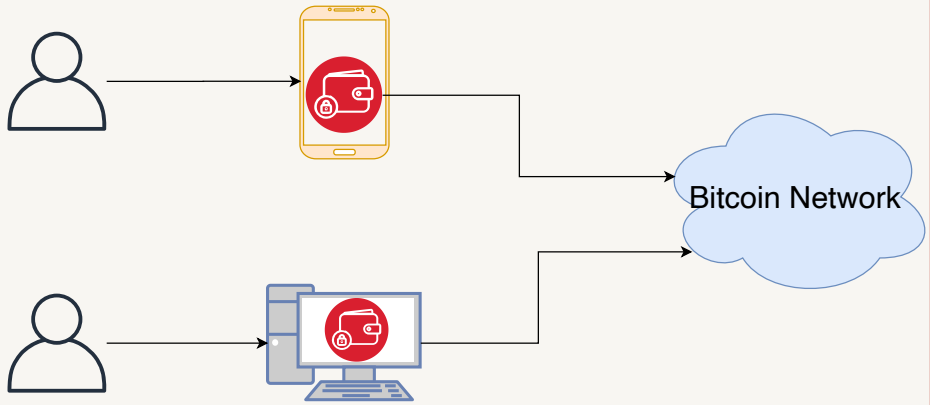
Bitcoin (hot) wallet

- A Bitcoin wallet is a collection of private keys
  - might be used to manage those keys and to make transactions on the Bitcoin network
- It is the entry point for any general users to interact with the bitcoin network
- Can be utilised in a PC, in any smart-device such as a mobile phone or tablet
- Also known as hot wallets as they are always connected to the network
- Examples: Exodus, Electrum, Mycelium



Bitcoin (hot) wallet

- Private keys are kept in encrypted (with a password) formats to ensure their security
- If password is forgotten, there is no way to recover funds attached to that private address
  - unlike other password enabled services, there is no account recovery option
- Strong usability issue
- Advantageous for daily trading or continuous usage
- Less secure (e.g. prone to malware attack)



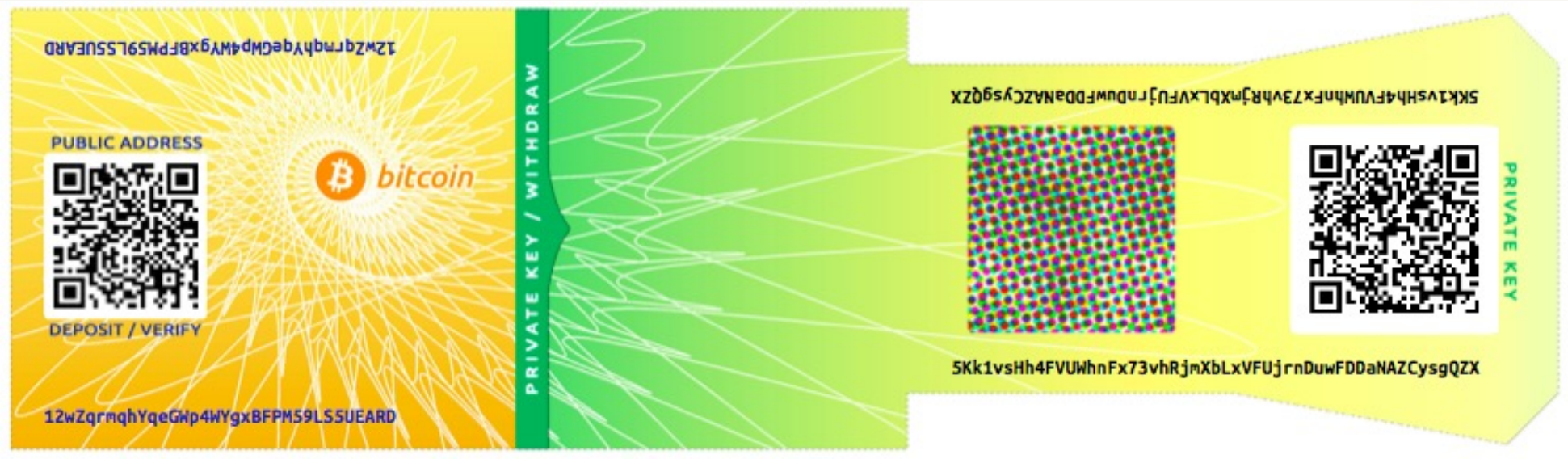
Cold wallet: paper wallet/cold wallet

- Paper wallets are bitcoin private keys printed on paper
  - might include the corresponding bitcoin address for convenience, but this is not necessary because it can be derived from the private key
- They are a very effective way to create backups or offline bitcoin storage, also known as *cold storage/wallet*

Cold wallet: paper wallet/cold wallet

- As a backup mechanism, a paper wallet can provide security
  - against the loss of key due to a computer mishap such as a hard-drive failure, theft, or accidental deletion
  - store it offline in a secret & secure place, even in a bank vault
- As a "cold storage" mechanism, if the paper wallet keys are generated offline
  - never stored on a computer system
- Hence, they are much more secure against hackers, keyloggers, and other online computer threats

Cold wallet: paper wallet/cold wallet



https://raw.githubusercontent.com/bitcoinbook/bitcoinbook/develop/images/mbc2_0410.png

Hardware wallet

- A **hardware wallet** is a special type of bitcoin wallet which stores the user's private keys in a secure hardware device
- They have major advantages over standard software wallets:
  - private keys are often stored in a protected area of a microcontroller, and cannot be transferred out of the device in plaintext
  - immune to computer viruses that steal from software wallets
  - can be used securely and interactively, as opposed to a paper wallet which must be imported to software at some point
  - much of the time, the software is open source, allowing a user to validate the entire operation of the device

https://www.ledgerwallet.com/images/products/lns/ledger-nano-s-fold-medium.png

https://en.bitcoin.it/w/images/en/d/de/Trezor-tx.jpg

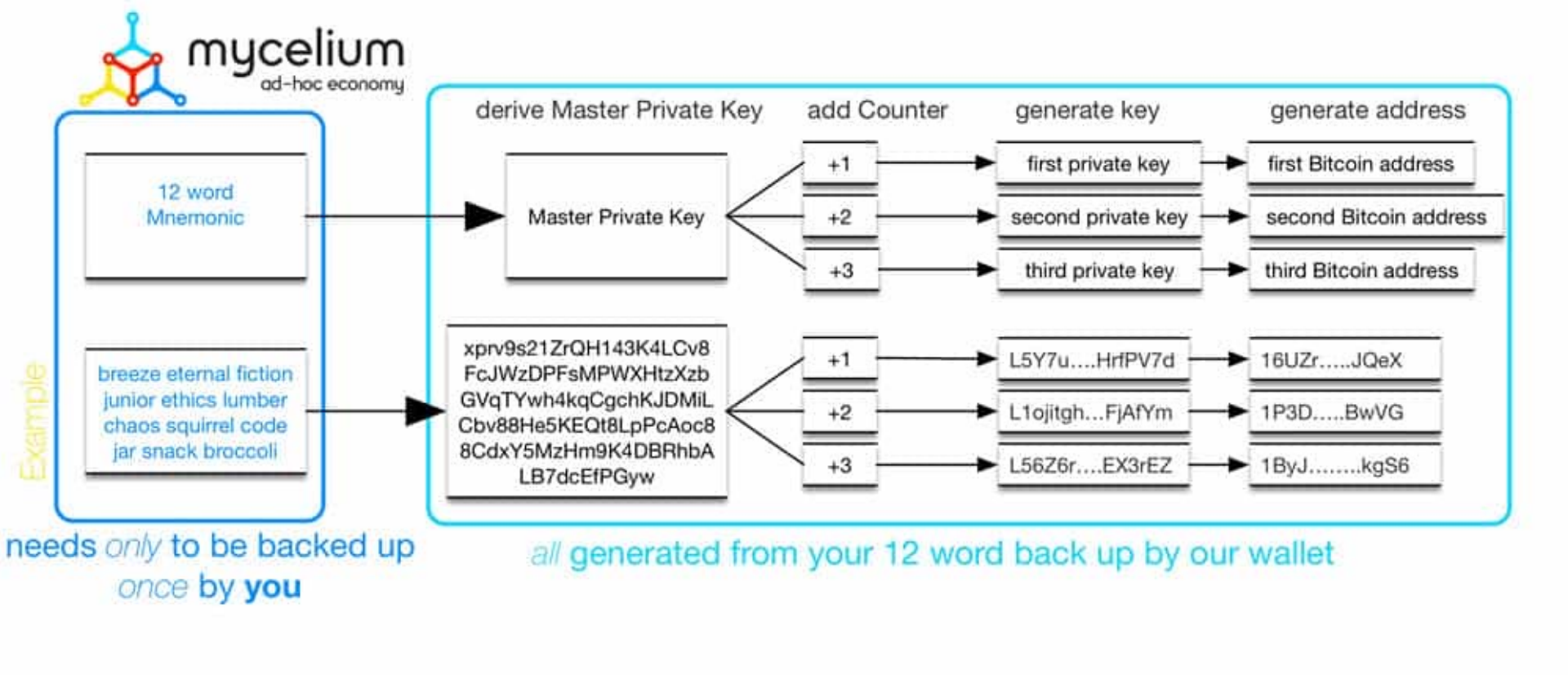
HD wallet

- A Hierarchical Deterministic (HD) is a key creation and transfer protocol which allows creating child keys from a parent key in a hierarchical way
  - Wallets using the HD protocol are called HD wallets
  - The single starting parent key is known as a seed
- The seed allows a user to easily back up and restore a wallet without needing any other information

HD wallet

- Seeds are typically serialised into human-readable words in a **Mnemonic** phrase
- A mnemonic phrase, mnemonic recovery phrase or mnemonic seed is a list of words which store all the information needed to recover a Bitcoin wallet
- Such Mnemonic words must be stored securely and must never be typed on any website

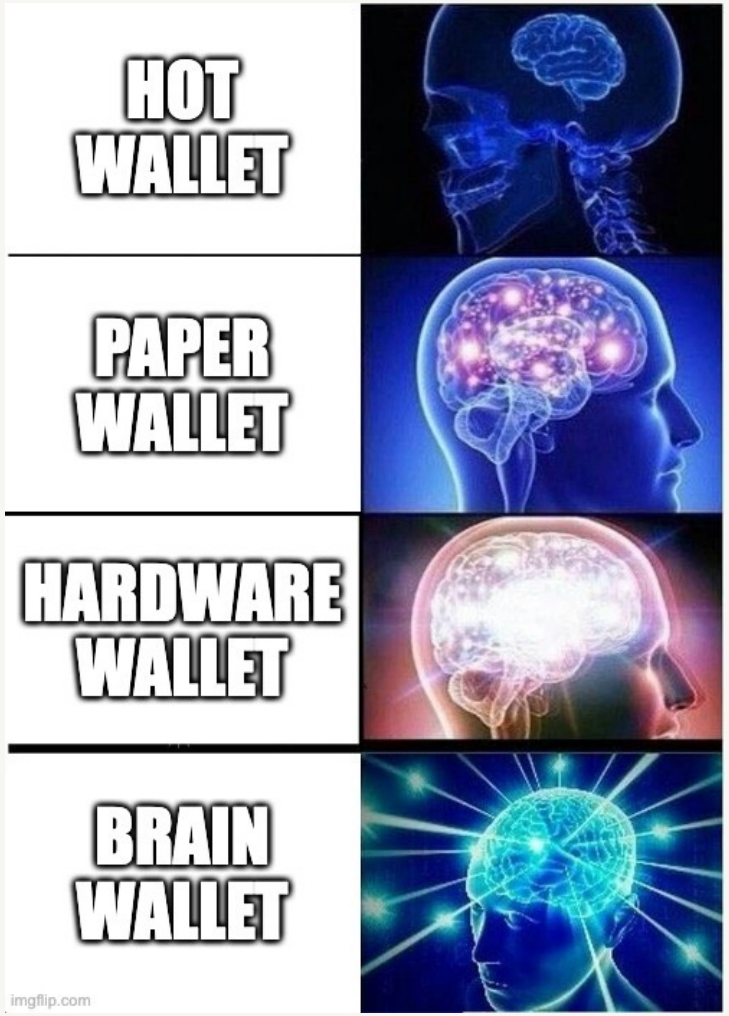
HD wallet



https://coinsutra.com/wp-content/uploads/2017/07/HD_Wallets.jpg

Brain wallet

- A brain wallet refers to the concept of storing Bitcoin’s private key in one's own mind by memorising a seed phrase
- If the seed is not recorded anywhere, the Bitcoins can be thought of as being held only in the mind of the owner
- If a brain wallet is forgotten or the person dies or is permanently incapacitated, the Bitcoins are lost forever
- Using memory techniques allow them to be memorised and recalled easily



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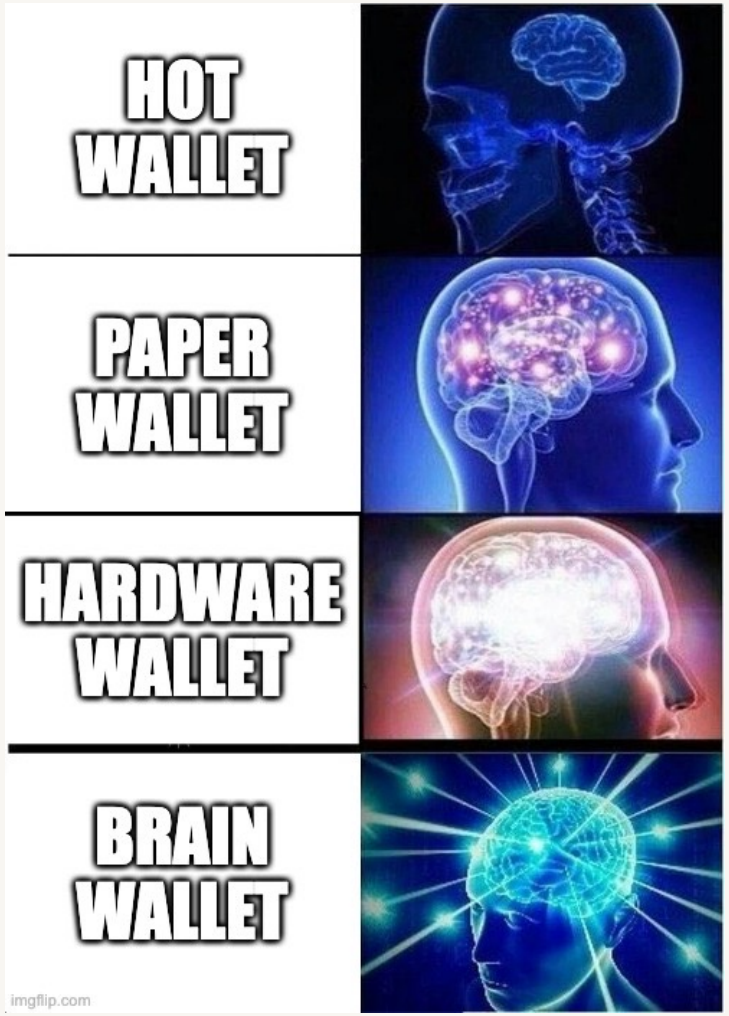
Brain wallet

- Private keys will be generated from a seed => random words known as passphrase
- Use the passphrase to generate a private key
  - E.g. hashing the passphrase
- Then generate the public key from the private key using a standard algorithm
- The passphrase needs to be securely created, otherwise an adversary could easily guess
- If the passphrase is long, it will be difficult to memorise



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Brain wallet

- To memorise a seed with this method you must invent a story which hits the words as "keynotes”
- Let the key phrases are the following
  - witch collapse practice feed shame open despair creek road again ice least
- “Imagine going through a room and seeing your sister dressed as a **witch**, playing the jenga boardgame until the tower **collapses** and so on”

Custodial wallet

- Let other people / companies store your bitcoins / cryptocurrencies for you
- No access to the private key, coins can only be used through a certain interface / website
- Very common within most exchanges
    - The money is sent to the exchange, the account on the platform has now a new balance which can be traded or paid out
- However: Very dangerous!
- Many exchanges got hacked, users lost their funds. Be careful!

Bitcoin Node & Network

- All nodes are connected to a common p2p network
- Every node runs a bitcoin implementation (bitcoind, bcoin, etc.)
  - implementations are open source
- Anyone can freely join the network
- Nodes do not have to trust the network!
- Everybody assumes that neighbours may lie (byzantine behaviour)
- Every node receives messages, acts on them and passes these messages to its known neighbours according to protocols
  - malicious nodes can suppress messages and behave beyond protocols rules

Bitcoin Node & Network

BITNODES

Bitnodes estimates the relative size of the Bitcoin peer-to-peer network by finding all of its reachable nodes.

REACHABLE BITCOIN NODES

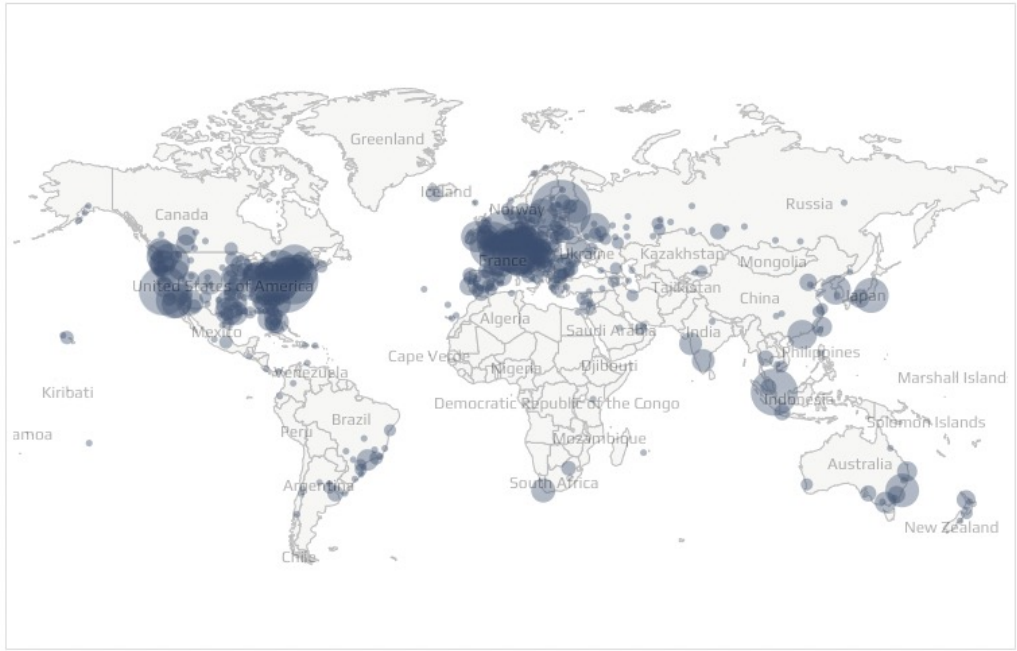
Updated: Sun Oct 16 23:47:43 2022 +06

15038 NODES CHARTS

IPv4: -2.4% / IPv6: -0.1% / .onion: +14.9%

Top 10 countries with their respective number of reachable nodes are as follows.

RANK	COUNTRY	NODES
1	n/a	8177 (54.38%)
2	United States	1905 (12.67%)
3	Germany	1383 (9.20%)
4	France	442 (2.94%)
5	Netherlands	381 (2.53%)
6	Canada	308 (2.05%)
7	Finland	241 (1.60%)
8	United Kingdom	218 (1.45%)
9	Russian Federation	177 (1.18%)
10	Singapore	143 (0.95%)



Map shows concentration of reachable Bitcoin nodes found in countries around the world. LIVE MAP

https://bitnodes.io/

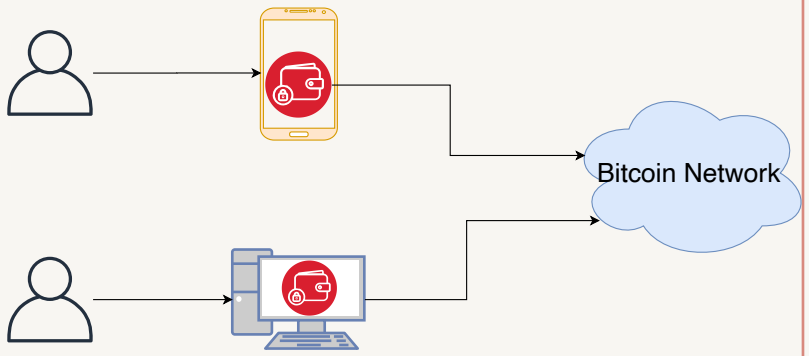
Live map available: https://bitnodes.io/nodes/live-map/

Bitcoin Node

- Bitcoin has four types of nodes:
  - Wallet node
  - Light node
  - Full node
  - Miner node

Bitcoin Node types: wallet node (user)

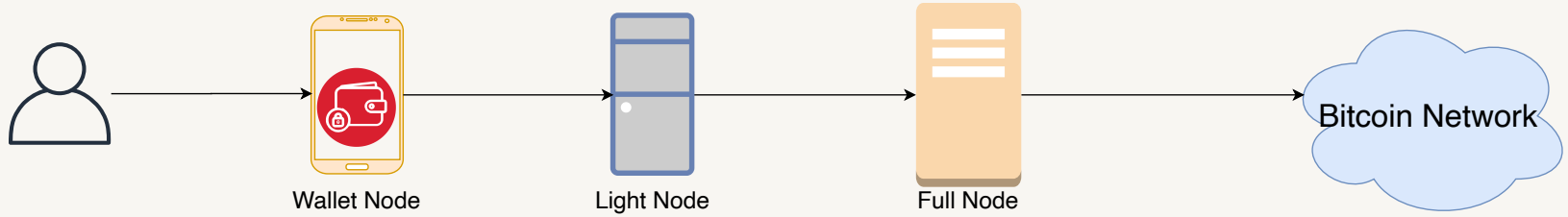
- The wallet owner owns different private keys
- He is the owner of all stored currencies on these addresses
- He sends money by signing and publishing new transactions to a connected light node, full node or miner node



Bitcoin Basics- Gallersdörfer, U., Holl, P., & Matthes, F. (2020). "Blockchain-based Systems Engineering". Lecture Slides. TU Munich.

Bitcoin Node types: light node (software)

- The light node can act as a relay for transactions of one wallet owner
- It validates whether a single transaction of the wallet owner was executed correctly
- The light node also requires a full node to connect to the network
- Almost no relevance in practice today
- Today, centralised services are used to create transactions



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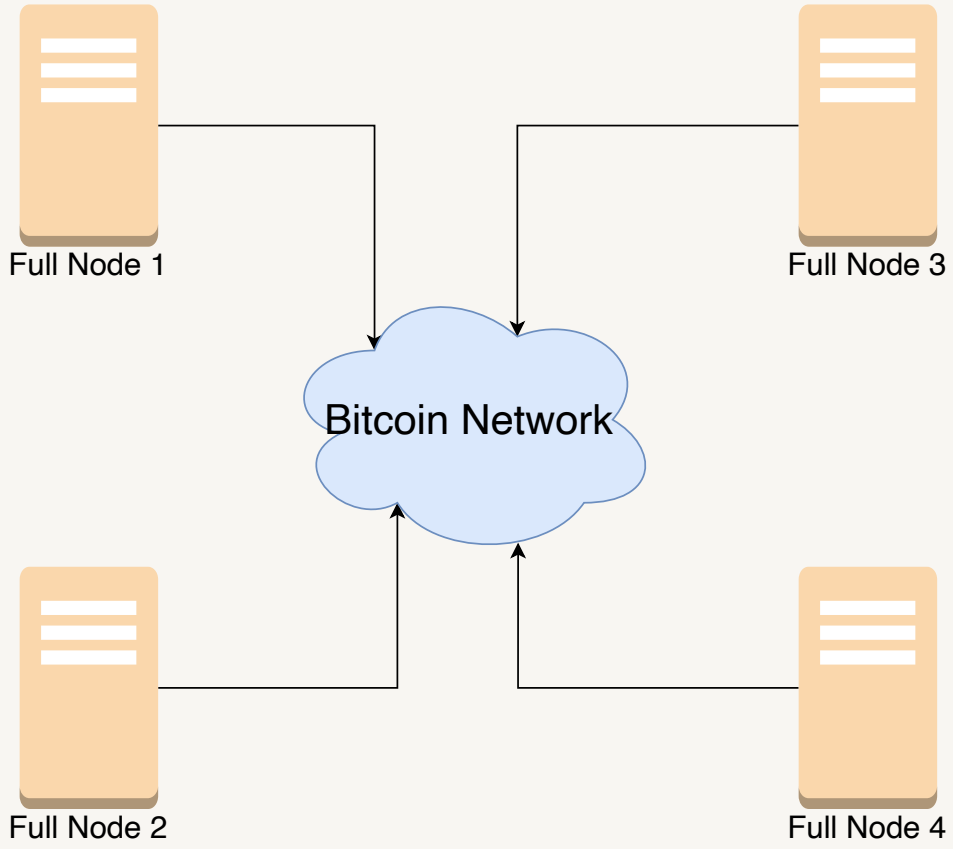
Bitcoin Node types: full node (software)

- The full node maintains the complete blockchain
- Its record of the chain is complete
  - it contains every single transaction and block until the genesis (first) block
- Is connected to other full nodes and exchanges information
- Namely:
  - Validates every transaction and block it receives
  - Relays all new transactions and blocks



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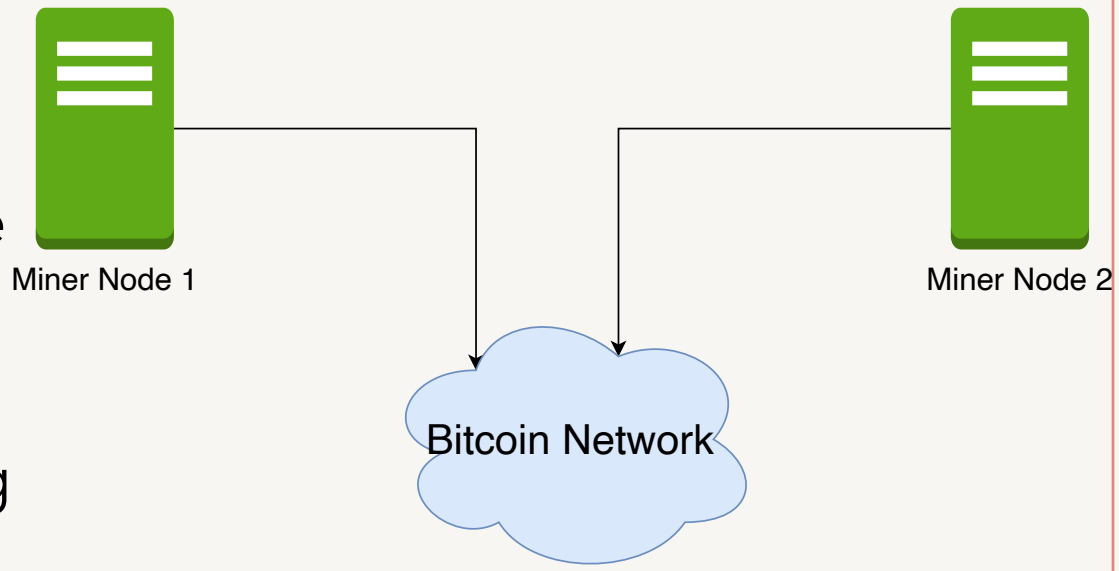
Bitcoin Node types: miner node (software)

- The miner needs the same record as a full node in order to work properly
- It also is connected with other nodes and maintains the network
- Additionally, the miner is responsible for creating new blocks by trying to solve the mining puzzle
- The miner gets rewarded for creating new blocks



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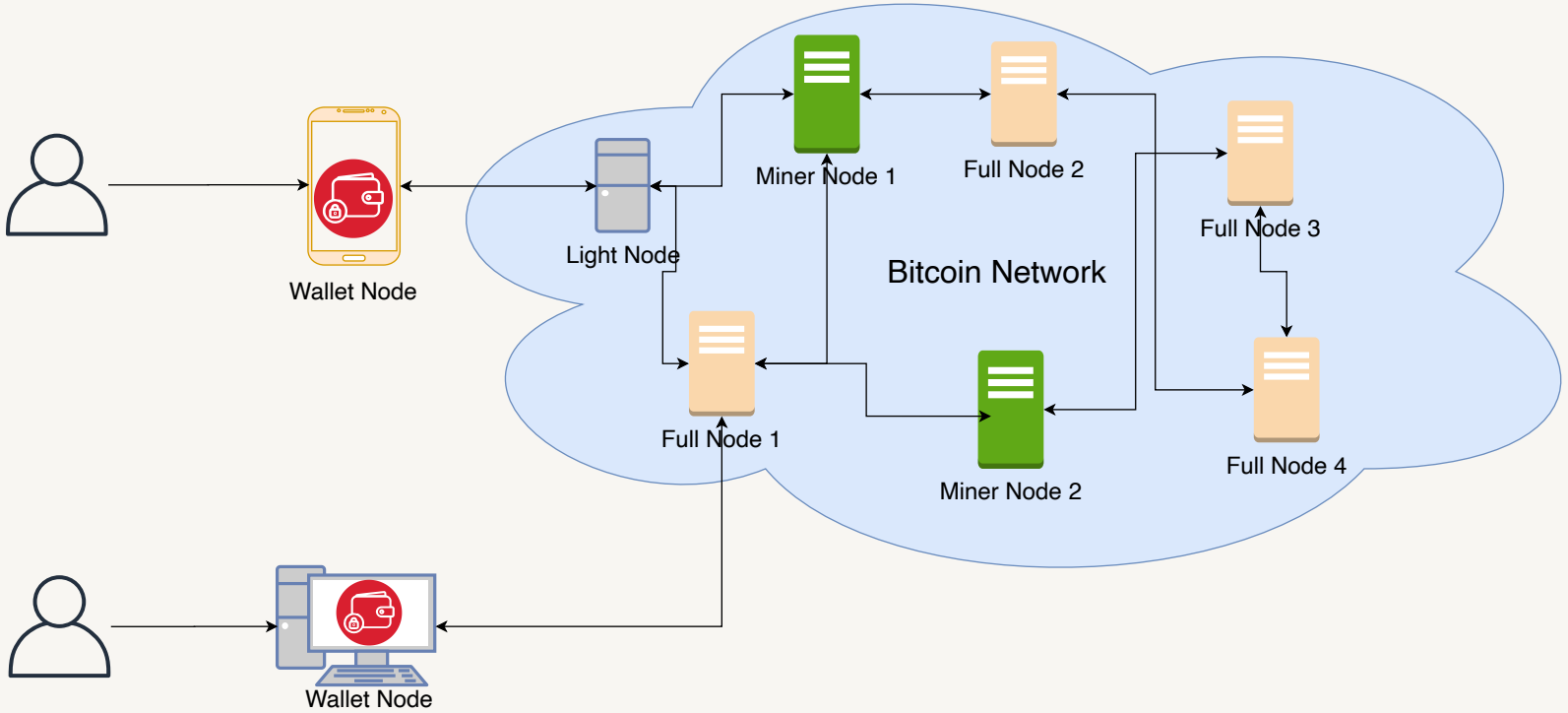
Bitcoin network



Bitcoin P2P network

- Bitcoin nodes communicate in a decentralised fashion, meaning that no single entity or node is superior, all nodes are equal
  - Ad-hoc protocol (runs on TCP port 8333)
  - Ad-hoc network with random topology
- New nodes can join at any time
- Forget non-responding nodes after 3 hr

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Bitcoin P2P network

- To communicate, they need to have clear rules
  - How to find other nodes (bootstrapping)
  - How to send and receive transactions
  - How to send and receive blocks
  - How to sync the blockchain
- The basic network uses a peer-to-peer gossip protocol for
  - Node discovery, node status maintenance
  - Messages about new blocks or transactions

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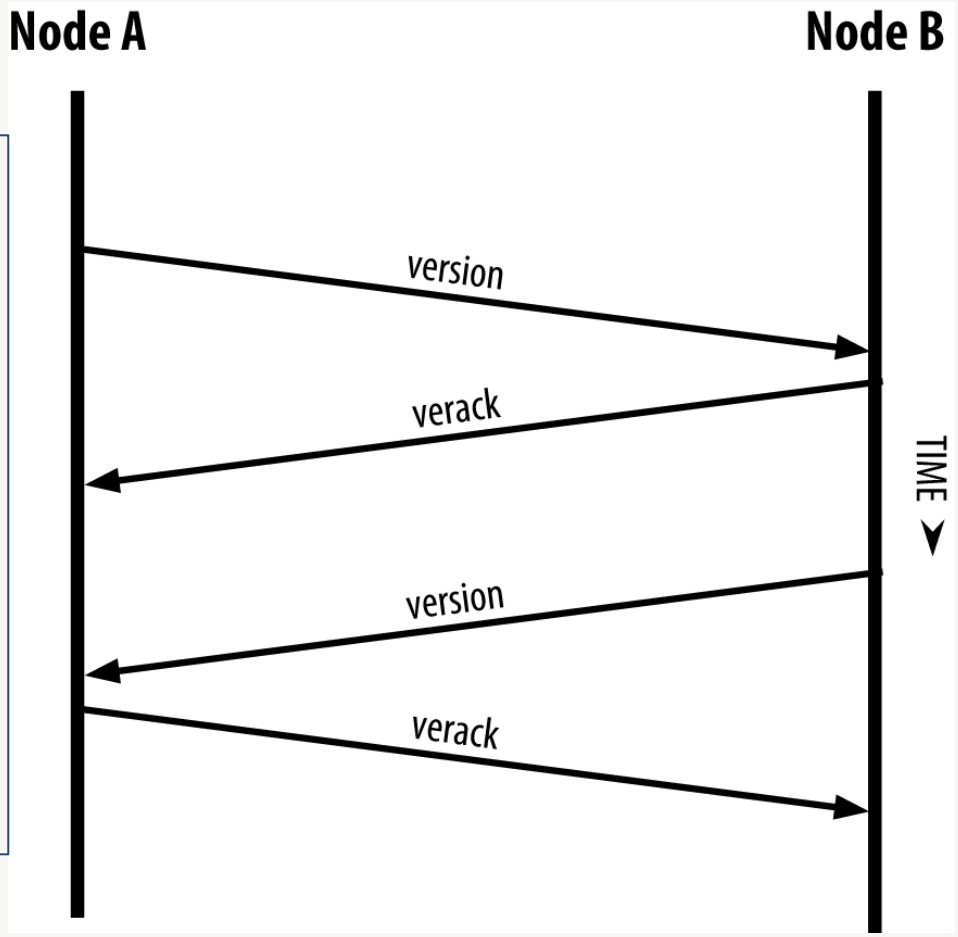
Node discovery/bootstrapping

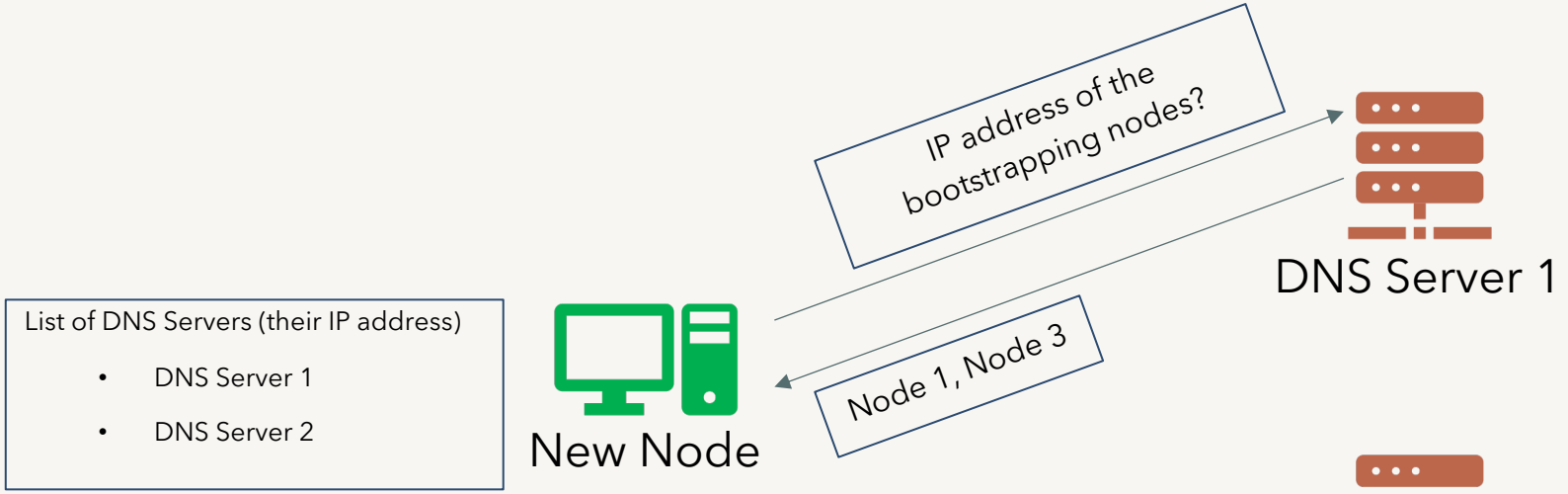
- Adding a new node into the network is called bootstrapping
- The new node needs to discover other nodes in the network to connect to the P2P network
- How does it know who to connect to?
  - Hard-coded DNS-services which offer IP-addresses of nodes
  - Hard-coded seed addresses (last resort)
  - Command-line provided addresses
  - Text-file provided addresses

Node discovery/bootstrapping

- The first message to another Bitcoin peer is the version message
- Using version each node check if the other node is compatible
- If compatible, the other node sends the version acknowledgement (verack) message

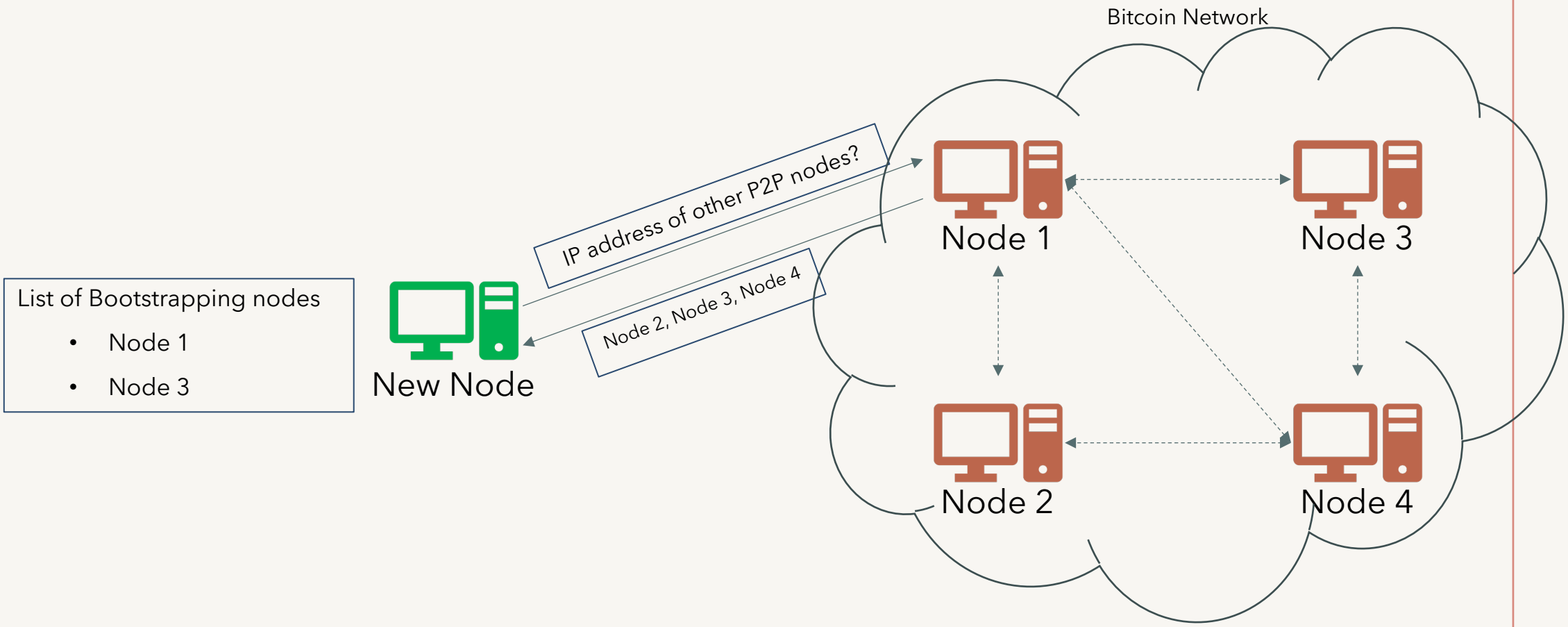


Node discovery/bootstrapping

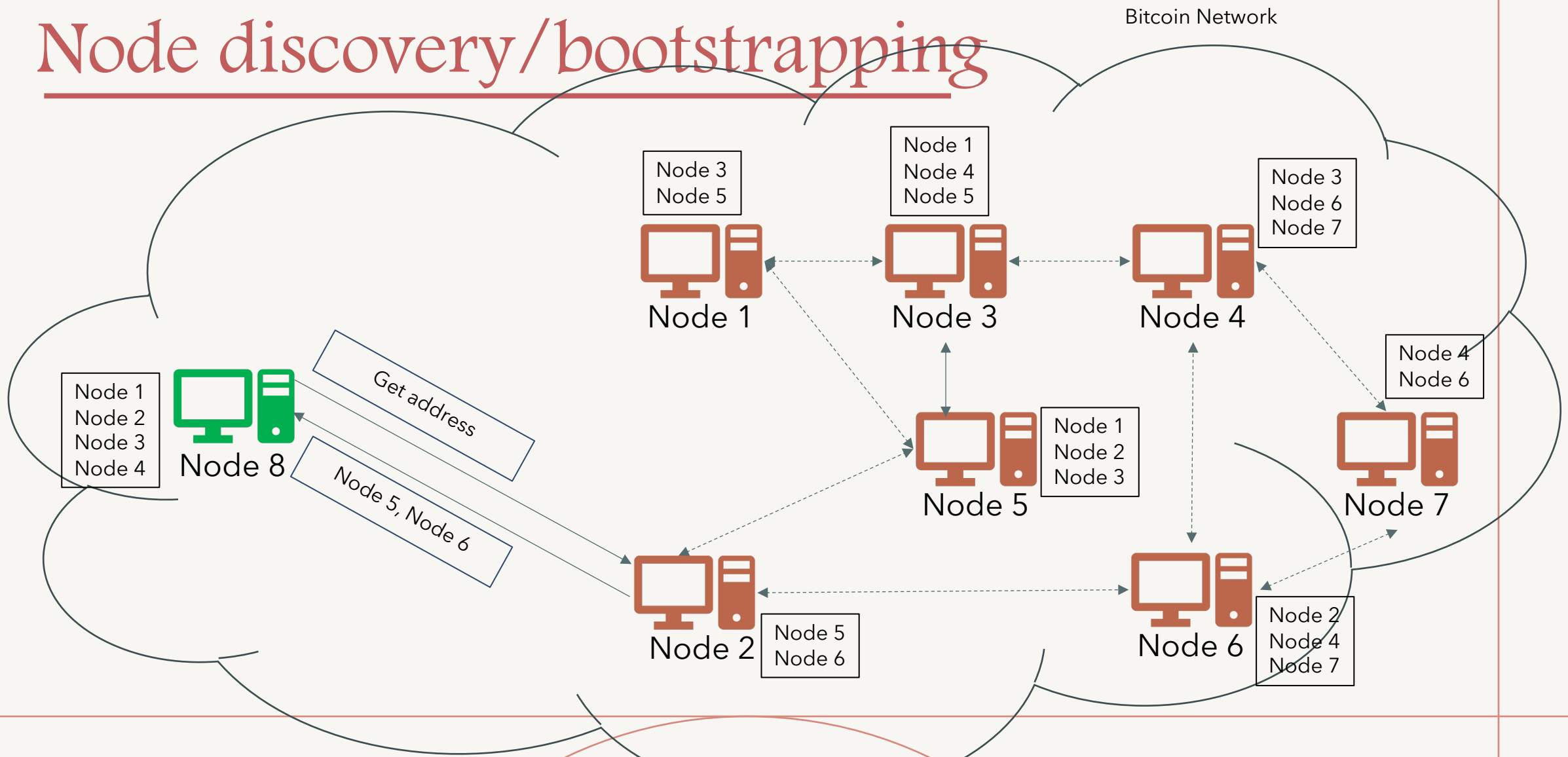


These DNS seeds (servers) provide a static list of IP addresses of stable bitcoin nodes

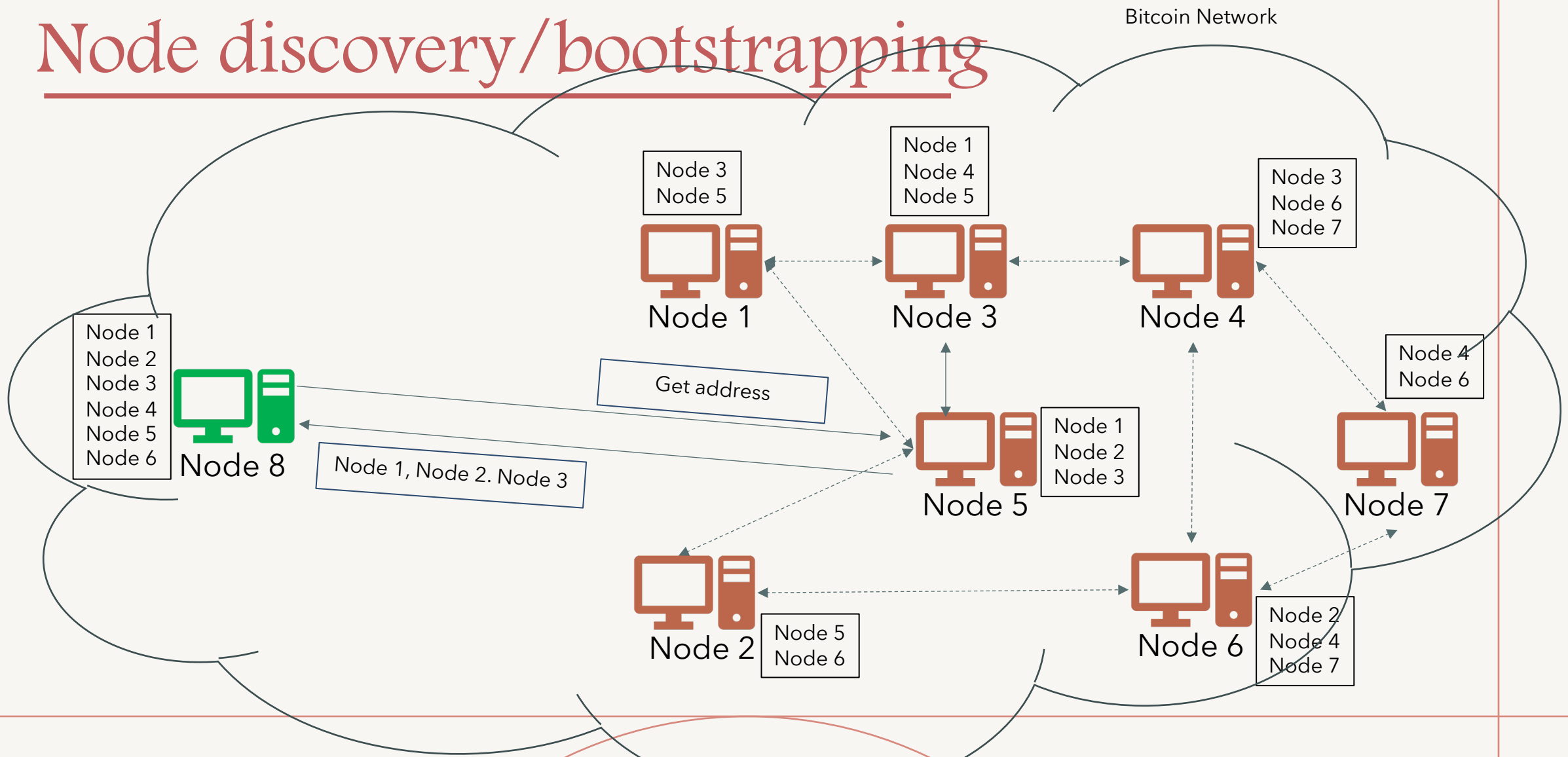
Node discovery/bootstrapping



Node discovery/bootstrapping



Node discovery/bootstrapping




THANK YOU
QUESTIONS?