Cothority/ByzCoin

Elements from implementing a scalable blockchain

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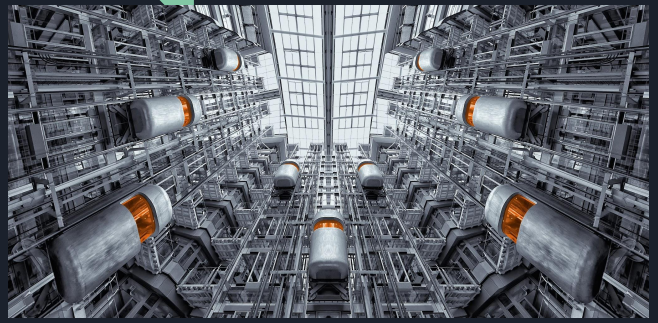
Overview

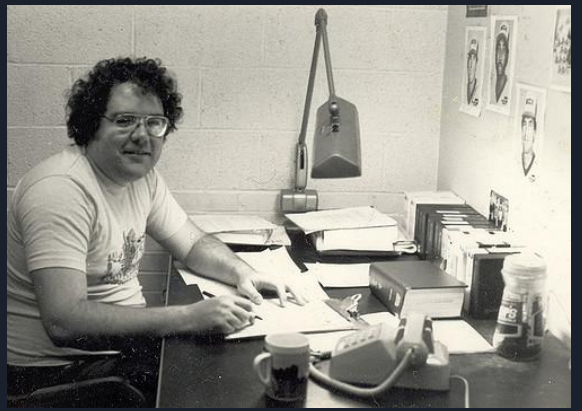
- **Presentation Cothority / Conodes**
- Our ByzCoin implementation
- Hands-on

Users of our Code



Industry /
Commercial

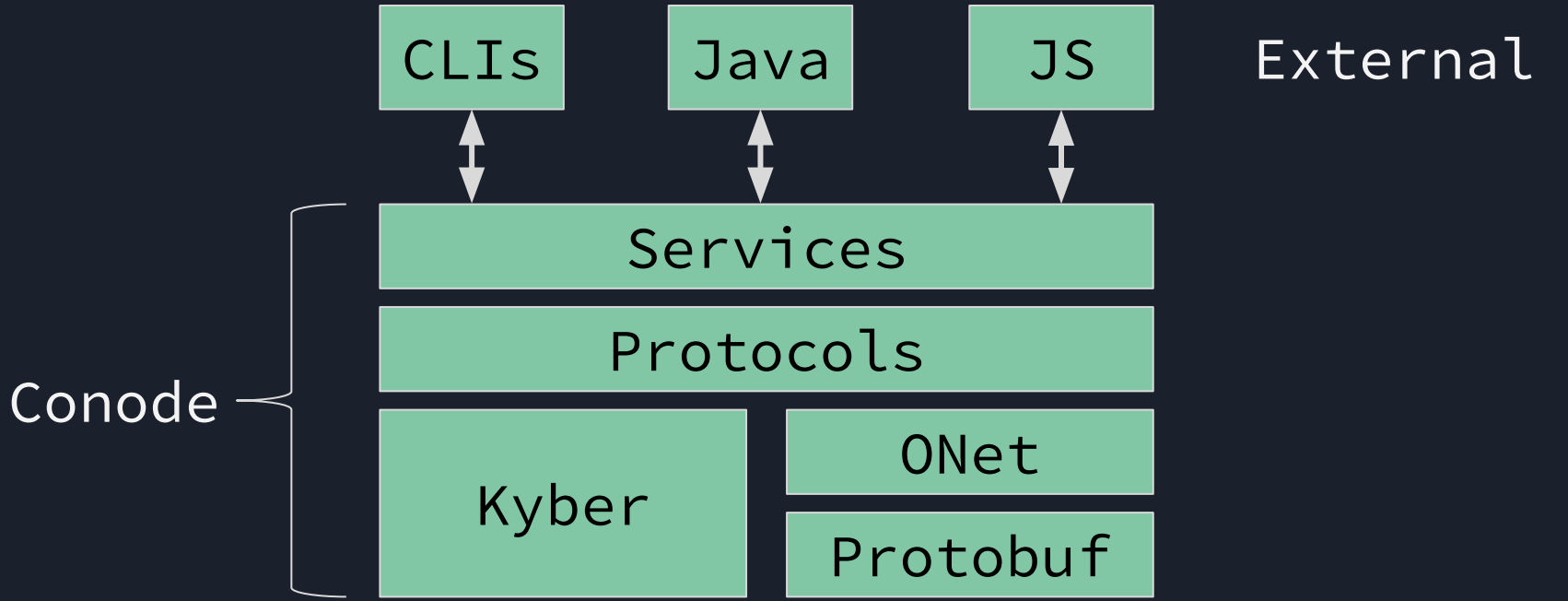
PhD / Researchers
Semester students



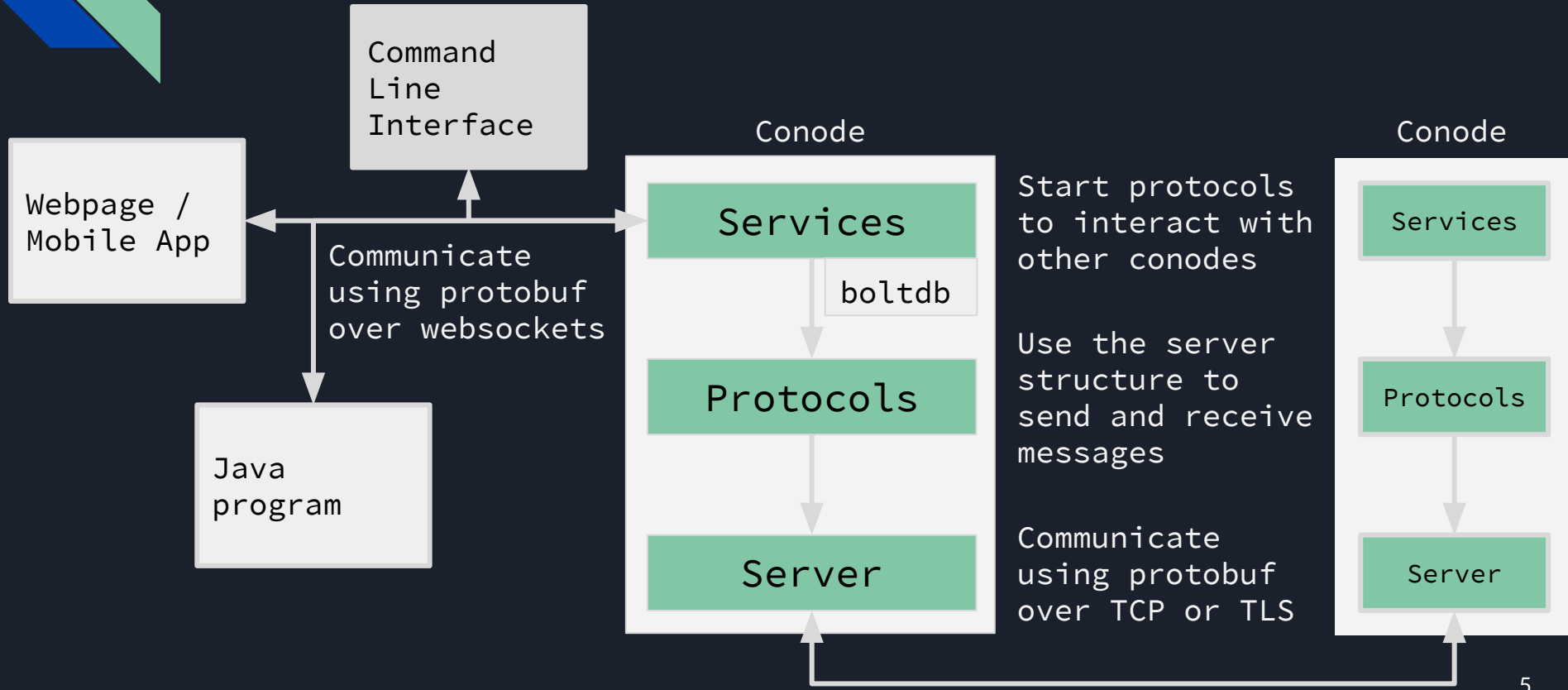
General
Public

Free as in Freedom

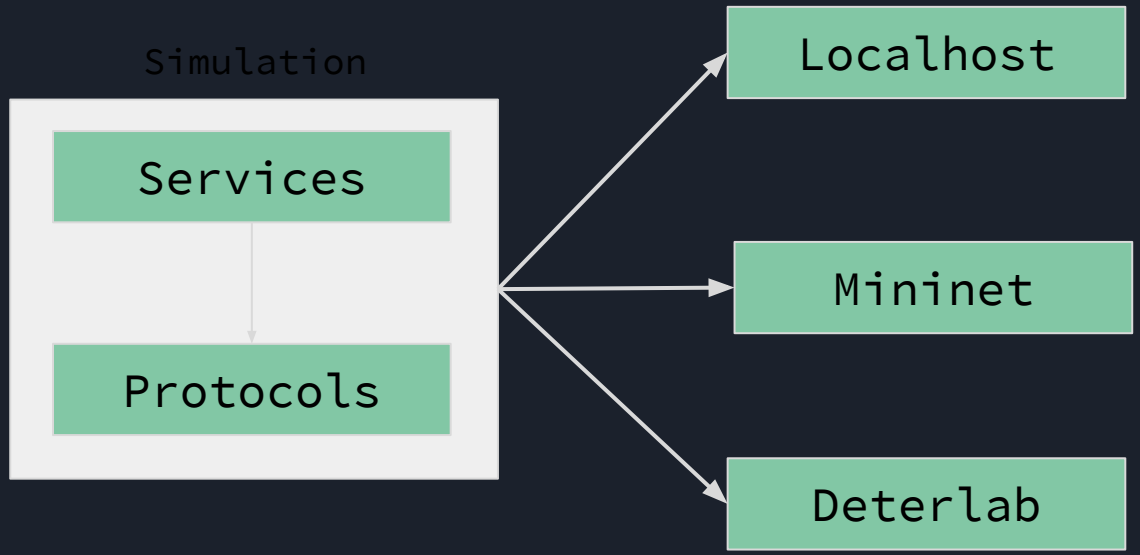
Library-overview - V2



ONet.v2

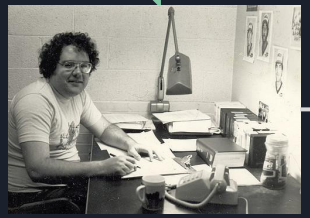

Command Line Interface
Webpage / Mobile App
Communicate using protobuf over websockets
Java program
Conode
Services
boltdb
Protocols
Server
Start protocols to interact with other conodes
Use the server structure to send and receive messages
Communicate using protobuf over TCP or TLS
Conode
Services
Protocols
Server

ONet.v2 - Simulations



Maximum nodes	Delay / Band-width control	Comments
100 - 200	No	Easy to setup
1’200 - 2’000	Yes - all connections	ICCluster reservation limits
30’000 - 60’000	Yes - only server-server	Sometimes difficult to get servers

Cothority.v2 - Where Does the Code Come from?



Creates throwaway code for paper → Researcher is happy → Populates paper_18_* repository

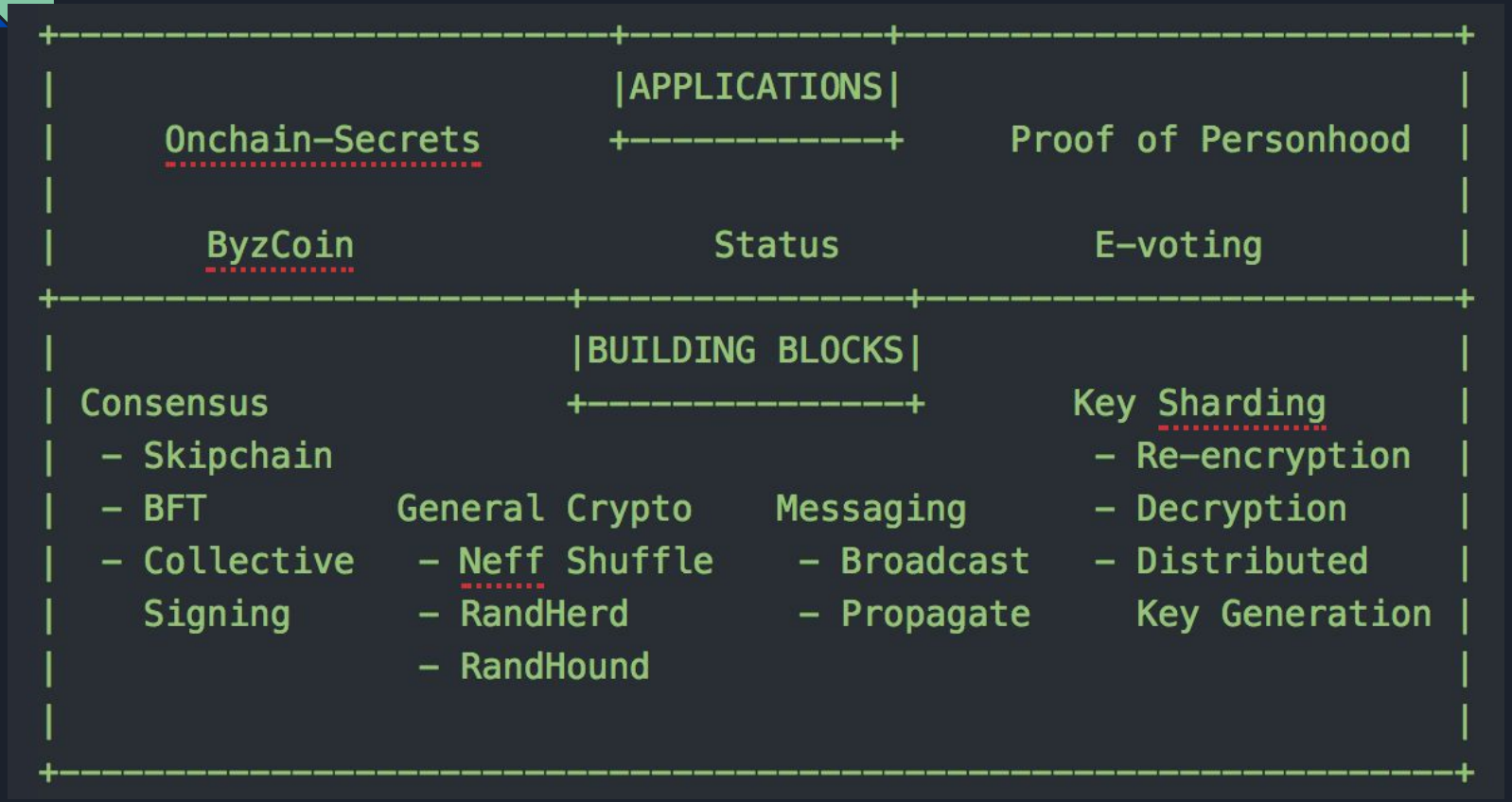
GPL Free Software

Free as in Freedom

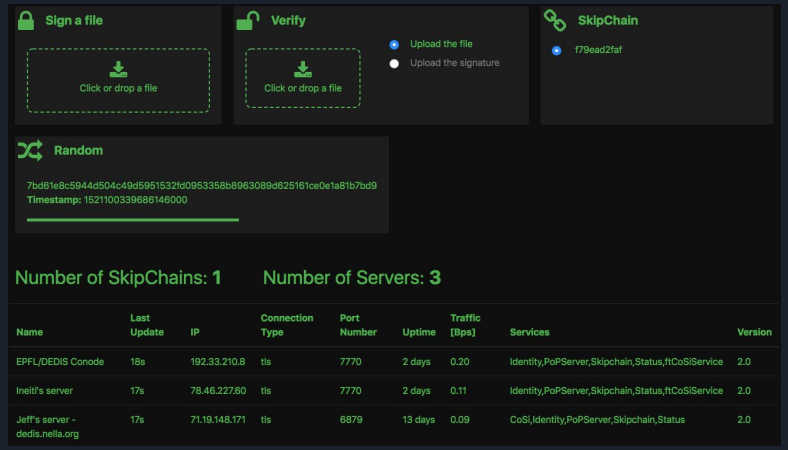
Semester student choses project and codes it again → Engineers clean code → Somewhat stable code in Cothority

Requests product based on existing code → Researchers and Engineers work hard to satisfy client → Stabilized code in Cothority

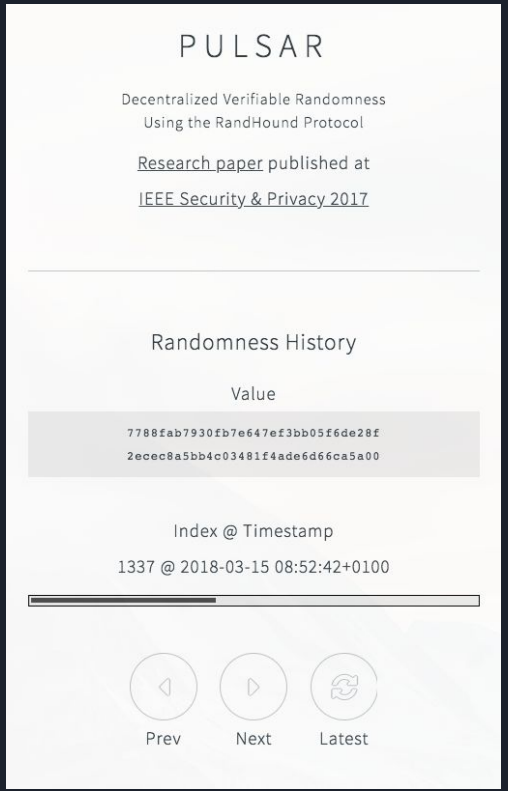
Cothority.v2 - Overview



Cothority.v2 - GUIs



http://status.dedis.ch



https://pulsar.dedis.ch

Cothority.v3 - Roadmap

- Implement sharded ByzCoin: Omniledger
- More testing in real-world deployments
- Add semi-permissioned onboarding for nodes: proof-of-personhood
- Add EVM contract to run Ethereum-compatible smart contracts
- Calypso encrypted storage on the blockchain

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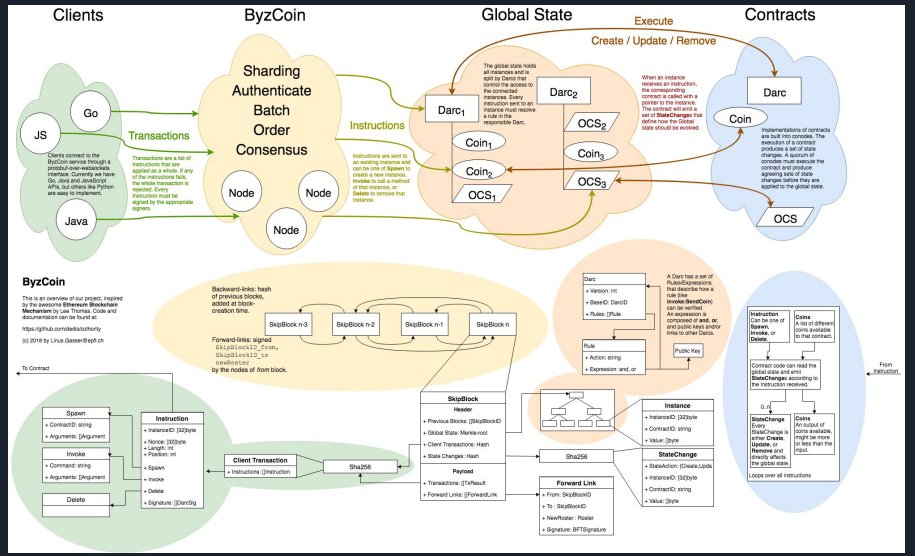
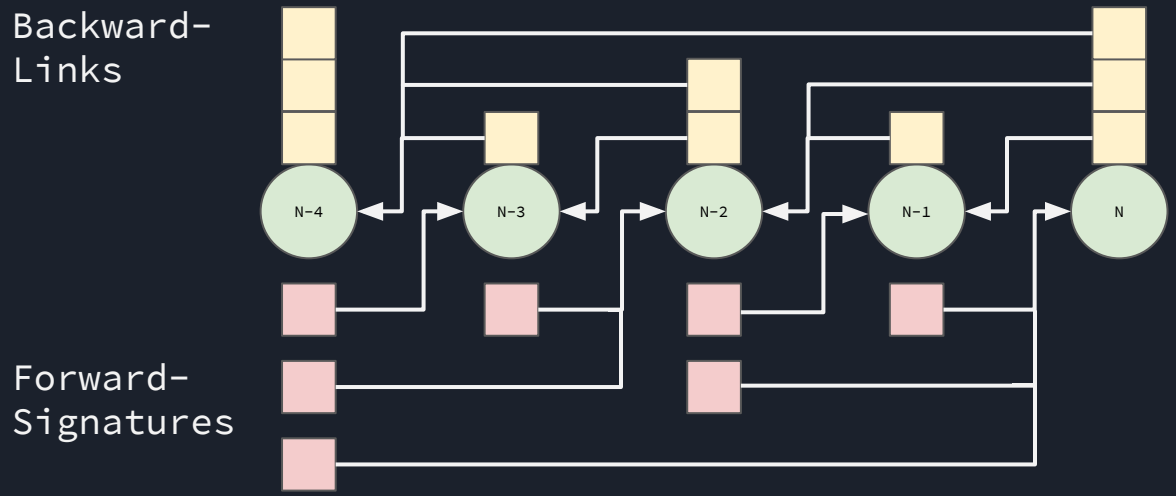
PhD paper -> usable software

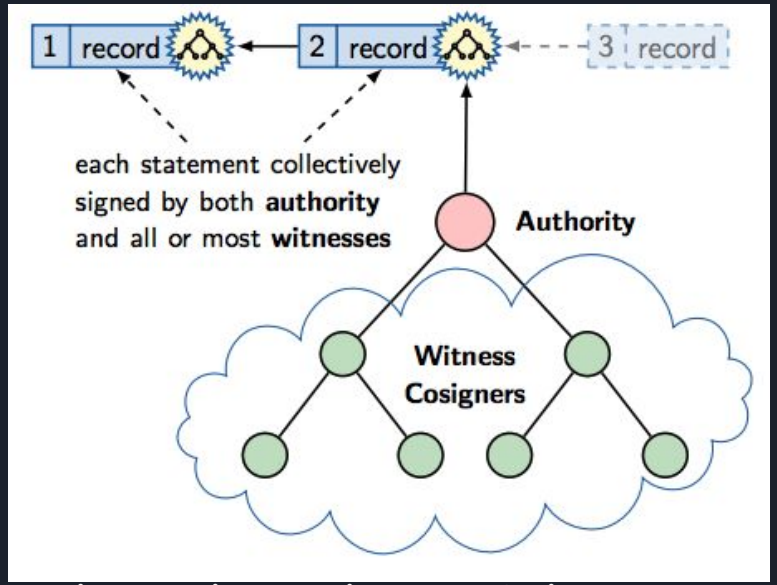
```
// verifyBlock is a simulation of a real block verification algorithm
// FIXME merge with Nicolas' code (public method in byzcoin)
func verifyBlock(block *blockchain.TrBlock, lastBlock, lastKeyBlock string)
bool {
        //We measure the average block verification delays is 174ms for an
average
        //block of 500kB.
        //To simulate the verification cost of bigger blocks we multiply
174ms
        //times the size/500*1024
        b, _ := json.Marshal(block)
        s := len(b)
        var n time.Duration
        n = time.Duration(s / (500 * 1024))
        time.Sleep(150 * time.Millisecond * n) //verification of 174ms per 500KB simulated
        // verification of the header
        verified := block.Header.Parent == lastBlock &&
block.Header.ParentKey == lastKeyBlock
        verified = verified && block.Header.MerkleRoot ==
blockchain.HashRootTransactions(block.TransactionList)
        verified = verified && block.HeaderHash ==
blockchain.HashHeader(block.Header)

        return verified
}
```



Base for ByzCoin - 1: skipchains



Base for ByzCoin - 2: ByzCoinX



Witnessing using ByzCoinX

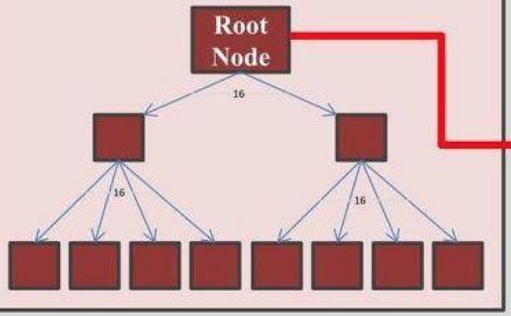
Two-round cosigning:
- prepare - verification of new block
- commit - creating final signature

If subleaders fail:
- rotate that sub-group, fast

If leader fails:
- all nodes must reach consensus on failure
- propose next node in list
- change is slow

Account storage contents Trie

A mapping between integer keys (KEC) and integer values (RLP)



Account, σ[address]

RLP data structure

nonce, $\sigma[address]_n$

scalar; the number of transactions sent from this address or, in the case of accounts with associated code, the number of contract-creations made by this account.

balance, $\sigma[address]_b$

scalar; the number of Wei owned by this address

storageRoot, $\sigma[address]_s$

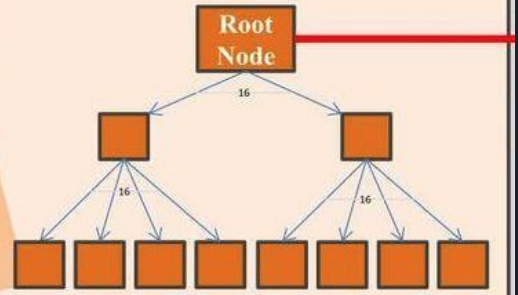
256-bit hash of the root node of a Merkle Patricia tree that encodes the storage contents of the account (a mapping between 256-bit integer values), encoded into the trie as a mapping from the Keccak 256-bit hash of the 256-bit integer keys to the RLP-encoded 256-bit integer values.

codeHash, $\sigma[address]_c$

Hash of the EVM code of this account - the code that gets executed should this address receive a message call; it is immutable and thus, unlike all other fields, cannot be changed after construction. All such code fragments are contained in the state database under their corresponding hashes for later retrieval.

World State Trie, σ

A mapping between addresses and account states. Stored as a merkle-partrica tree



Transaction, T

nonce, T_n

Scalar; the number of transactions sent by the sender

gasPrice, T_p

scalar; the number of Wei to be paid per unit of gas for all computation costs incurred as a result of execution of this transaction

gasLimit, T_g

scalar; the max amount of gas that should be used in executing this transaction. Paid before any computation is done, may not be increased later.

to, T_t

160-bit address of the message call's recipient or, for a contract creation transaction, Ø (zero bytes).

value, T_v

scalar; the number of Wei to be transferred to the message call's recipient or, in the case of contract creation, as an endowment to the newly created account

init, T_i

Contract creation transaction only; unlimited size byte array specifying the EVM-code for the account initialisation

data, T_d

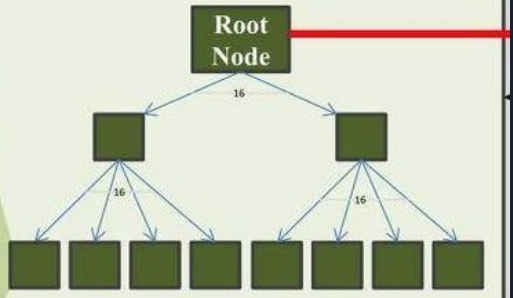
Message call transaction only; unlimited size byte array specifying the input data of the message call

v, r, s, T_w, T_r, T_s

Outputs from EDSCA signature of KEC(T_n, T_p, T_g, T_t, T_v, $(T_i$ or $T_d)$). T_w identifies sender.

Transaction Trie, T

A merkle-partrica tree of transactions to include



Transaction Receipts Trie

Index keyed trie

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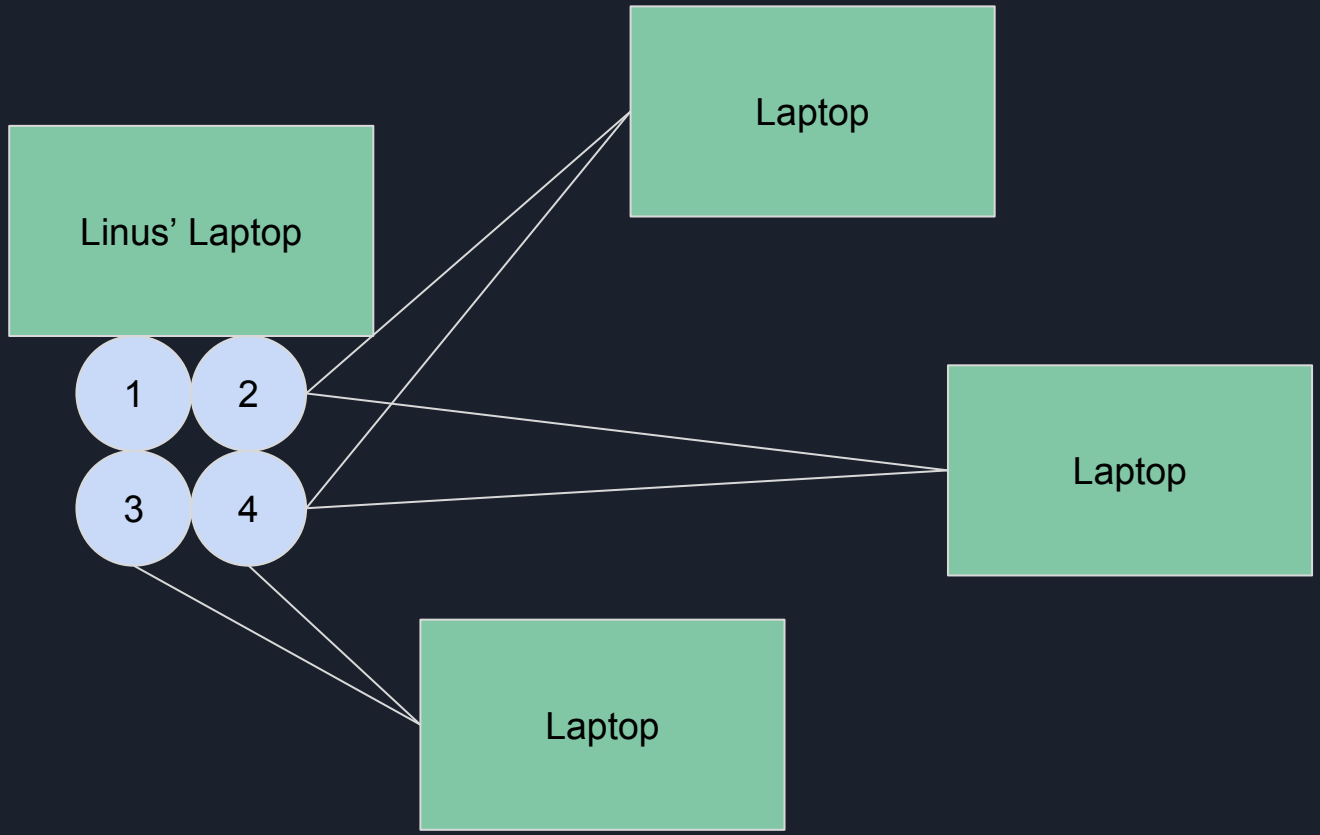
0 - Introduction

- There is a status page with more explanations here:
  - http://192.168.0.164:8000
- And a blockchain explorer:
  - http://192.168.0.164:8000/student_18_explorer/dist
- The following google-doc is used to exchange data:
  - https://docs.google.com/document/d/11WseidLI2pIE96aNzm-s_dxANaMvBDO0Xe2b73JygMY/edit?usp=sharing

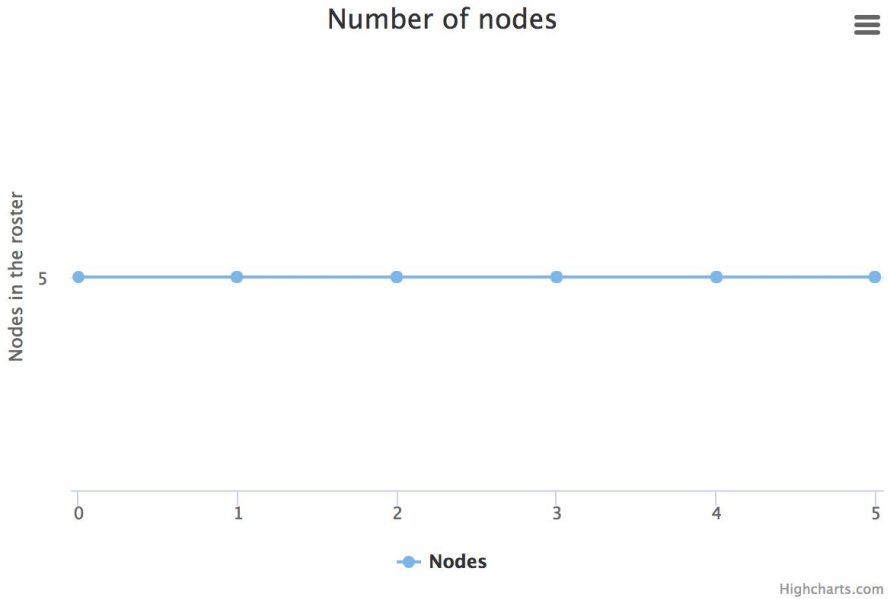
0 - Introduction to Docker Images

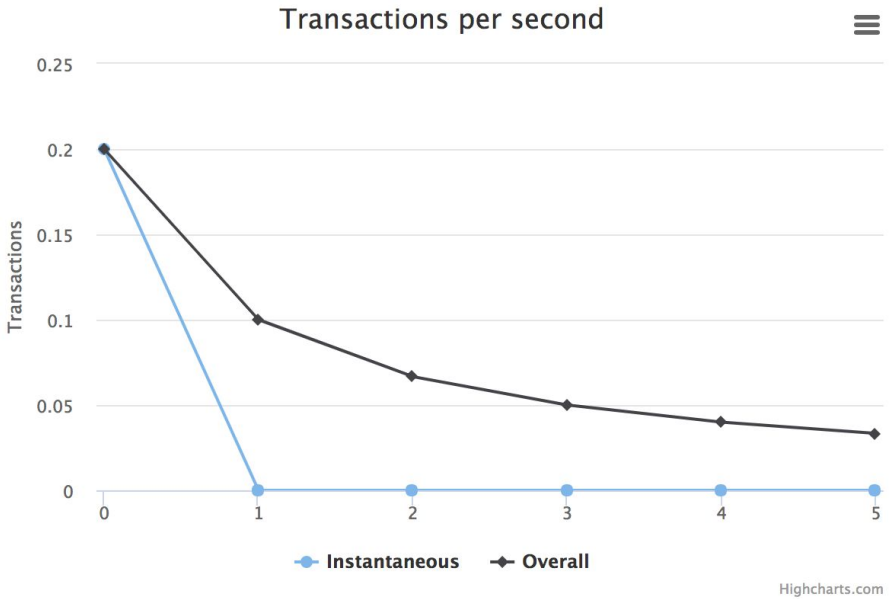
- You need a docker-installation from https://docker.com
- You'll be running two docker images:
  - dedis/mba-cothority - for the commands
  - dedis/mba-conode - for running your own server
- The commands for mba-conode will create a directory in ~/data
  - This directory will hold the private data of your conode
- Please copy your log-file from ~/data to the following directory at the end:
  - https://drive.google.com/drive/folders/1GWSvXOKOZSnTmWZ4G6Rbsrvl3zOy9r0j?usp=sharing

Network Overvice



http://192.168.0.164:8000





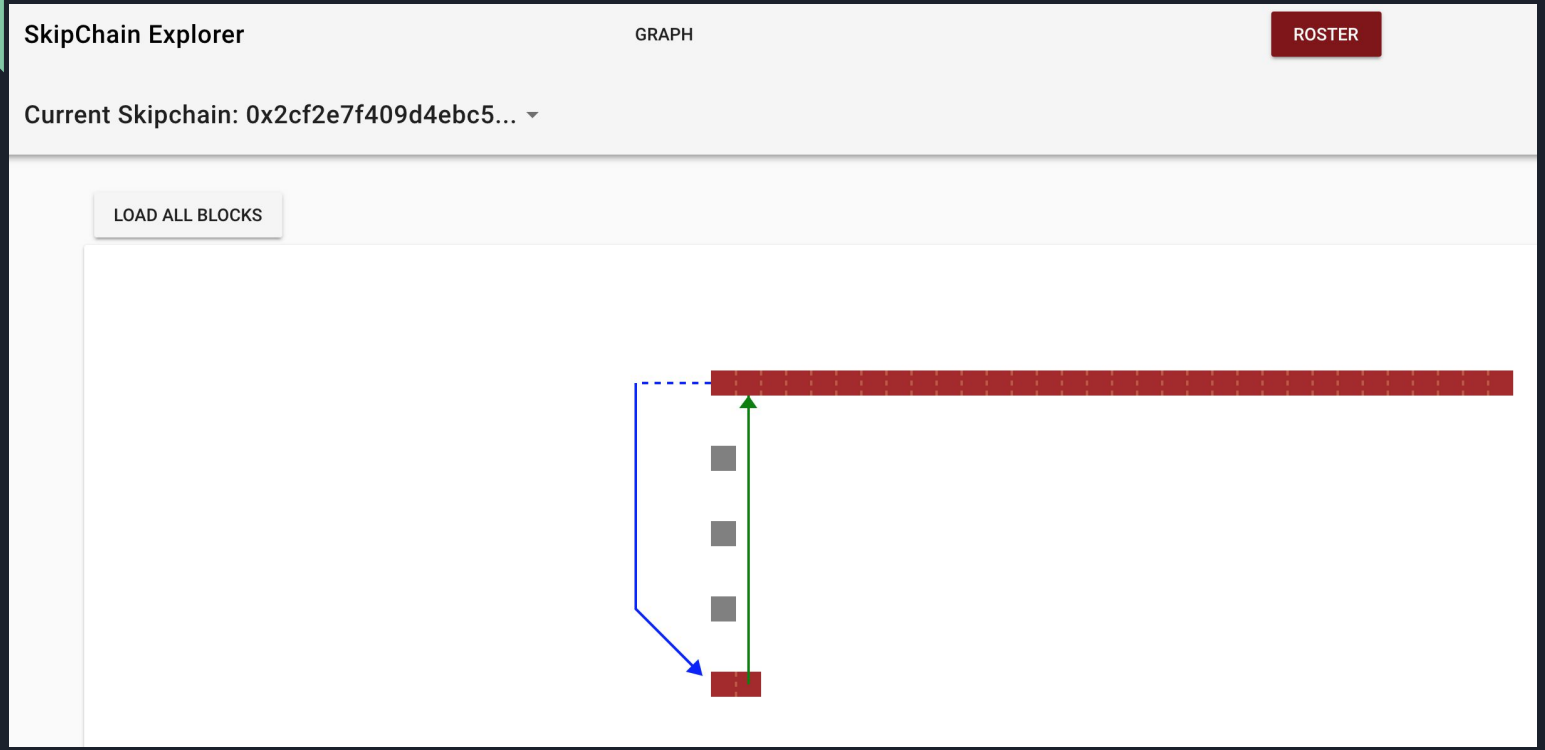
Here is a list of links:

- MBA Worksheet
- Presentation
- Directory for logs

```
Roster is:
 ok   - tls://192.168.0.42:7772 - Conode_1
 ok   - tls://192.168.0.42:7774 - Conode_2
 ok   - tls://192.168.0.42:7776 - Conode_3
 ok   - tls://192.168.0.42:7778 - Conode_4
FAIL - tls://192.168.0.42:7770 -
```

```
# blocks: 2
# backlinks: 1
block-size: 812
```

Blockchain Explorer



Google-Doc

MBA working document

Rules

Be nice - where nice is defined as making the demo as successful as possible with regard to showing off what the DEDIS/cothority can do.
If we have more than 10 participants, I want to have 90% passing.
Please help others. Two rules: 1. ask if they need help first, 2. don't touch their keyboards
Don't laugh when it breaks.

Participants

Please enter your name or pseudo here. For every exercise you completed, put an **X**. If you also made the bonus, put a **XX** in it.

#	Name / Pseudo	Ex 1	Ex 2	Ex 3	Ex 4	Ex 5	Ex 6	Ex 7
1								
2								
3								
4								

Keys for the Terminal

<ctrl+a> - start of the line
<ctrl+e> - end of the line
<ctrl+w> - delete to the left
<ctrl+k> - delete to end of line
<ctrl+r> - search in previous commands
<ctrl+c> - abort command or delete current command
<alt+right> - jump to next word
<alt+left> - jump to previous word
ZZ - save and quit vim
:q! - quit vim without saving

General Rules

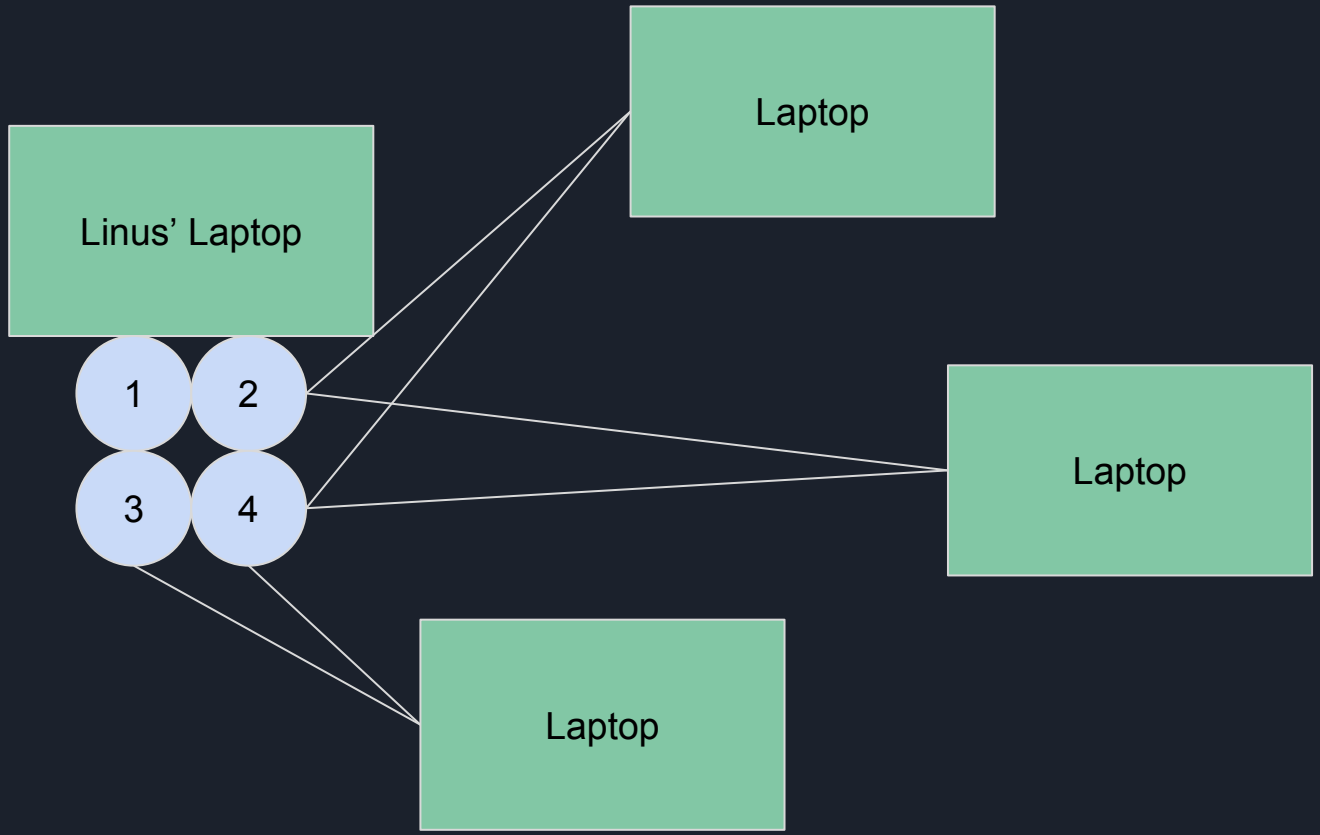
- Be nice - where nice is defined as making the demo as successful as possible with regard to showing off what the DEDIS/cothority can do.
- If we have more than 10 participants, I want to have 80% passing (Pareto principle).
- Please help others. Two rules:
    1. ask if they need help first
    2. don’t touch their keyboards
- Don’t laugh when it breaks, please.

1 - Contact a Conode

- Sign up: http://192.168.0.164:8000
- Download docker image from here: https://hub.docker.com/r/dedis/
- Run it using
  `docker run -ti -v ~/data:/conode_data dedis/mba-cothority`
- Get status from nodes on my computer:
  `status --group public.toml`

- Bonus: get status of node at `tls://192.168.0.164:7780`

1 - Contact a Conode

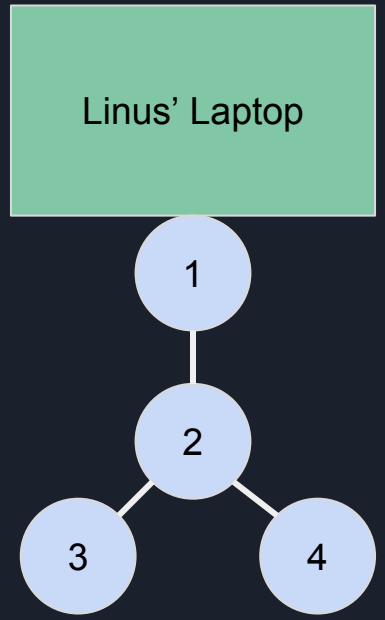


2 - Fault Tolerant Collective Signatures (ftCoSi)

- Still in dedis/mba-cothority docker container, run
  `ftcosi sign msg.txt > signature.json`
- Now this file is collectively signed by all the nodes in public.toml
- To verify it, use
  `ftcosi verify msg.txt < signature.json`

- Bonus: include conode at `tls://192.168.0.164:7780` and sign
- Bonus: verify file from other participant

ftCoSi Signature

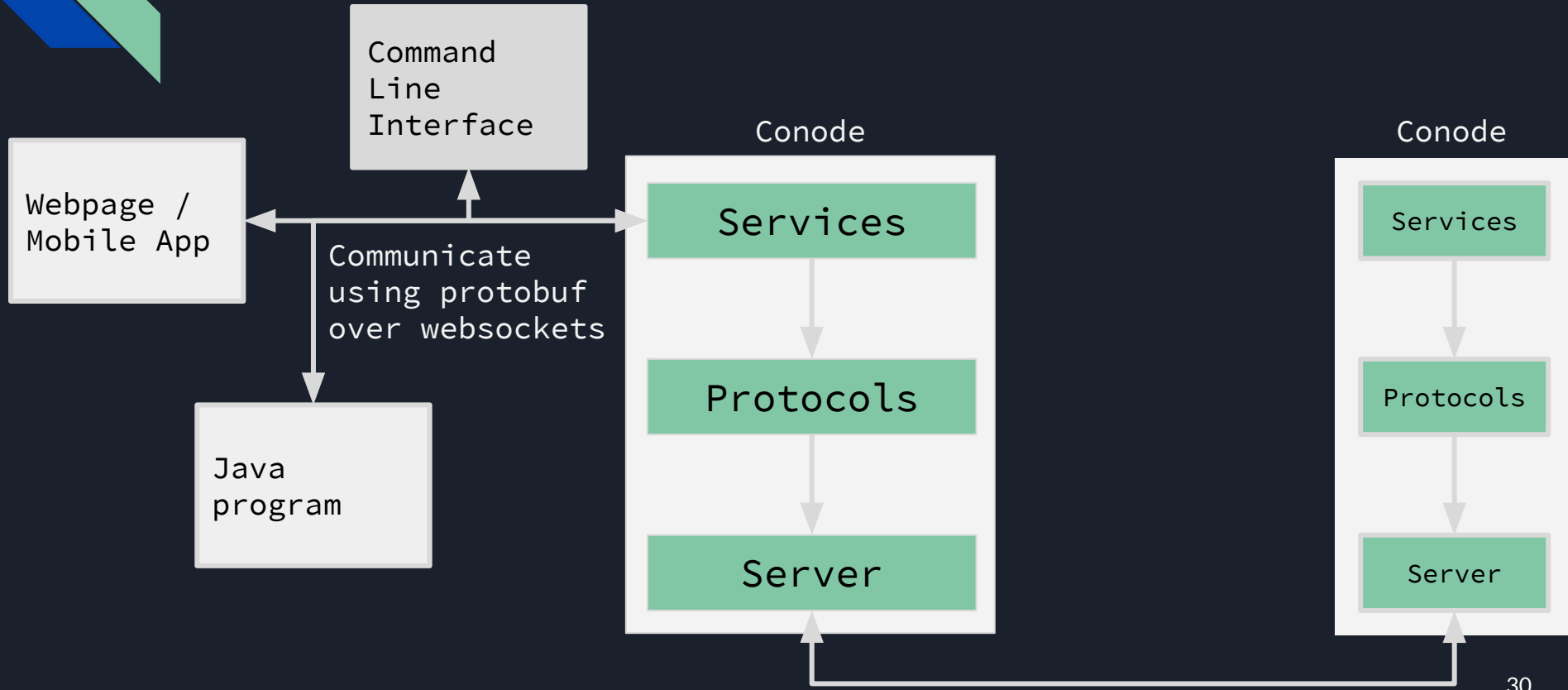


3 - Run a Conode

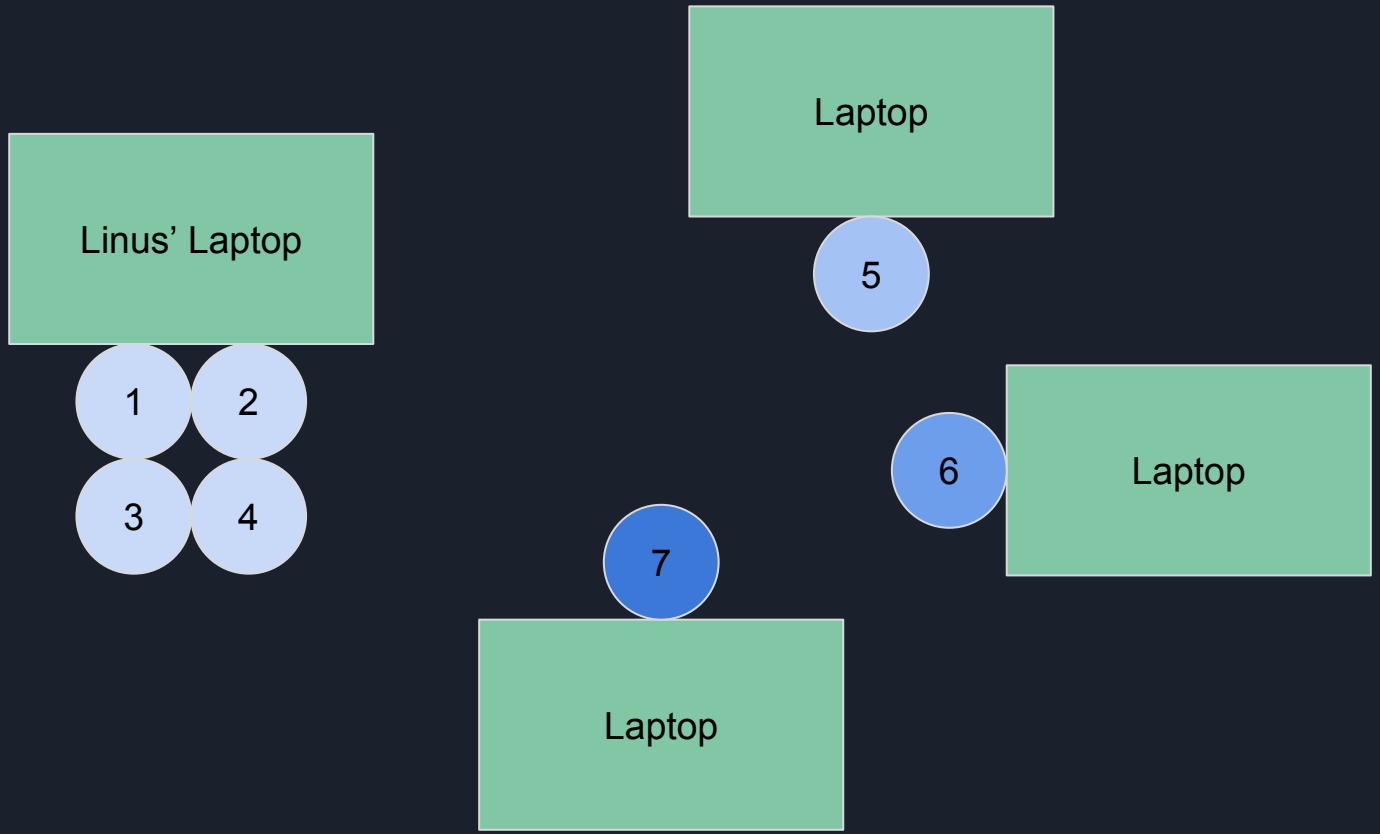
- Run the dedis/mba-conode docker image
  `docker run -ti -v ~/data:/conode_data -p 7770-7771:7770-7771 dedis/mba-conode`
- Make sure to enter your local IP address: 192.168.x.y:7770
- Test status from your dedis/mba-cothority container:
  `status --host <your_local_ip>:7770`

- Bonus: test the status of your neighbour's node

ONet.v2


Command Line Interface
Webpage / Mobile App
Communicate using protobuf over websockets
Java program
Conode
Services
Protocols
Server
Conode
Services
Protocols
Server

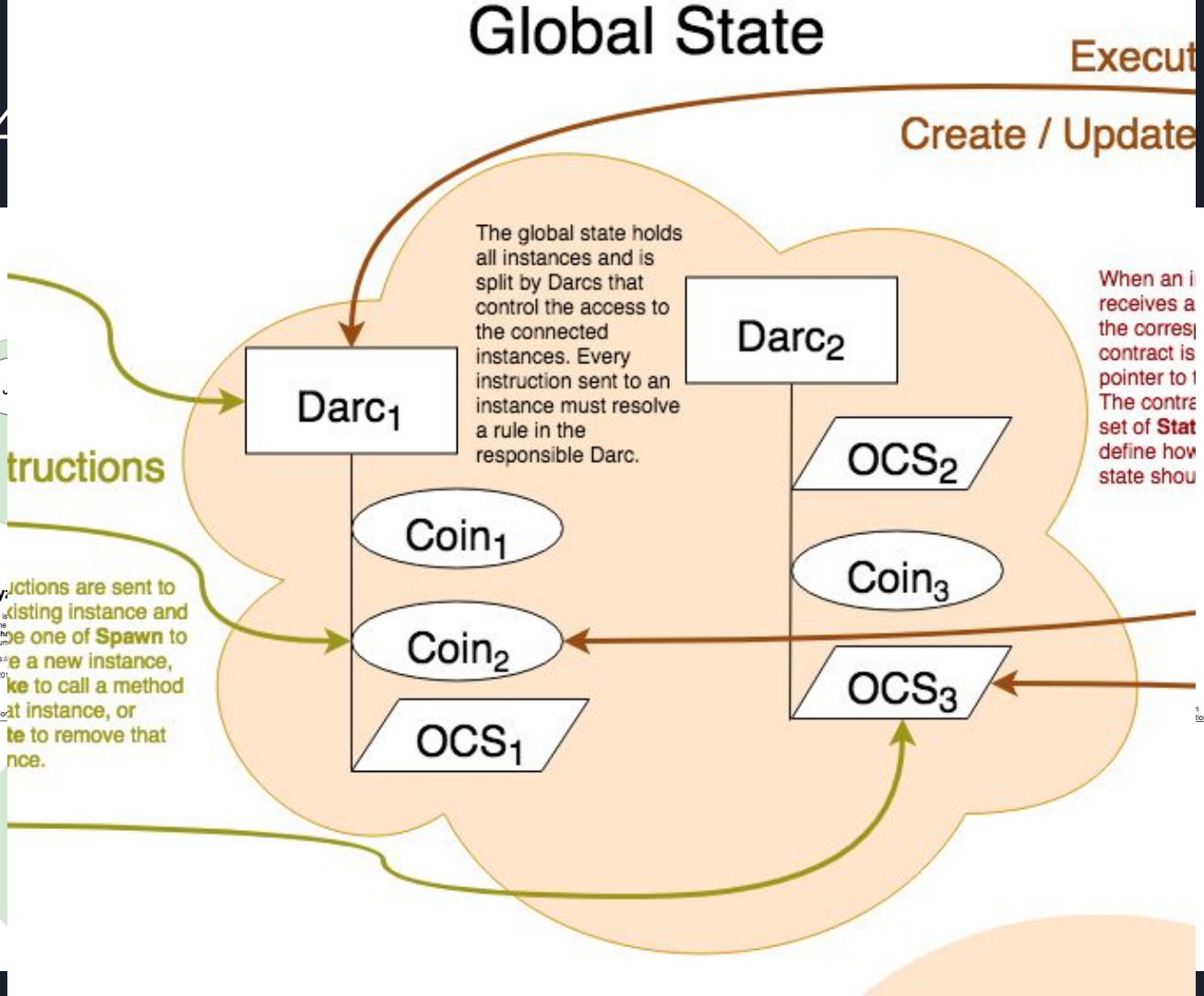
3 - Run a Conode



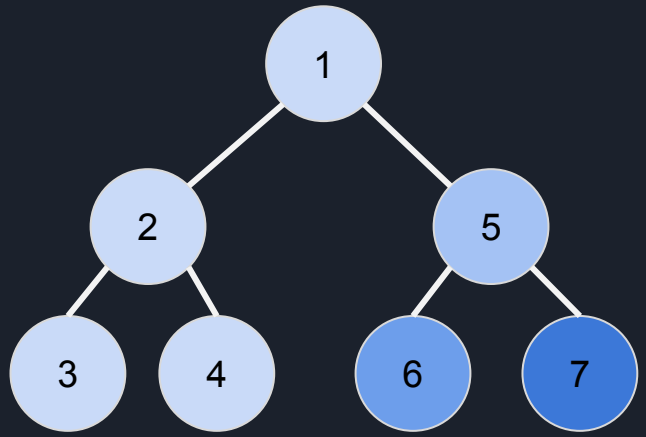
4 - Join ByzCoin Ledger

- Start by checking out the latest block from the local byzcoin ledger:
  `bcadmin show bc*cfg`
- Put the content of your `/conode_data/public.toml` -or- `~/data/public.toml` on the wiki and verify periodically if we included it:
  `bcadmin show bc*cfg`

- Bonus: set up your own byzcoin ledger with 3 other participants


Global State
Execut
Create / Update
The global state holds all instances and is split by Darcs that control the access to the connected instances. Every instruction sent to an instance must resolve a rule in the responsible Darc.
Darc1
Darc2
Coin1
Coin2
Coin3
OCS1
OCS2
OCS3
When an i
receives a
the corres
contract is
pointer to
The contra
set of Stat
define how
state shou
tructions
ctions are sent to
isting instance and
e one of Spawn to
e a new instance,
ke to call a method
t instance, or
te to remove that
nce.

4 - Join ByzCoin



4 - Joining ByzCoin - Ideally

According to the paper:

- Use a window of mined blocks to define the participants

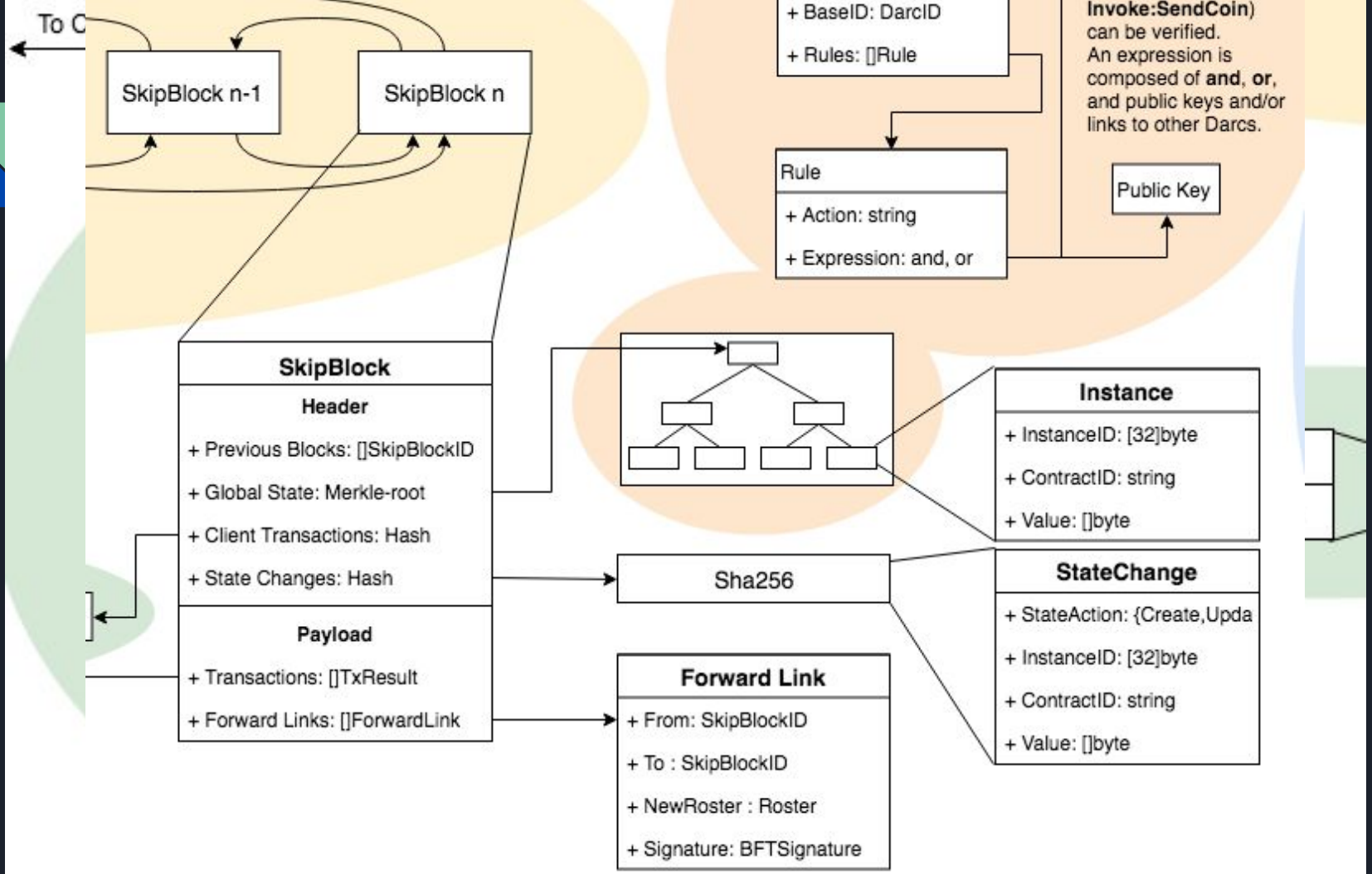
Latest idea:

- Use Proof-of-Personhood to allow nodes to enrol in the system
- Proof-of-Personhood allows us to restrict the number of nodes to one per person

5 - Open a Wallet and Transfer Coins

- First create your address:
  `wallet join bc-*.cfg`
- Now enter your public key in the google doc to get some coins
- Verify the coins with
  `wallet show`
- Transfer some coins to a public address -add-
  `wallet transfer 1000 -add-`

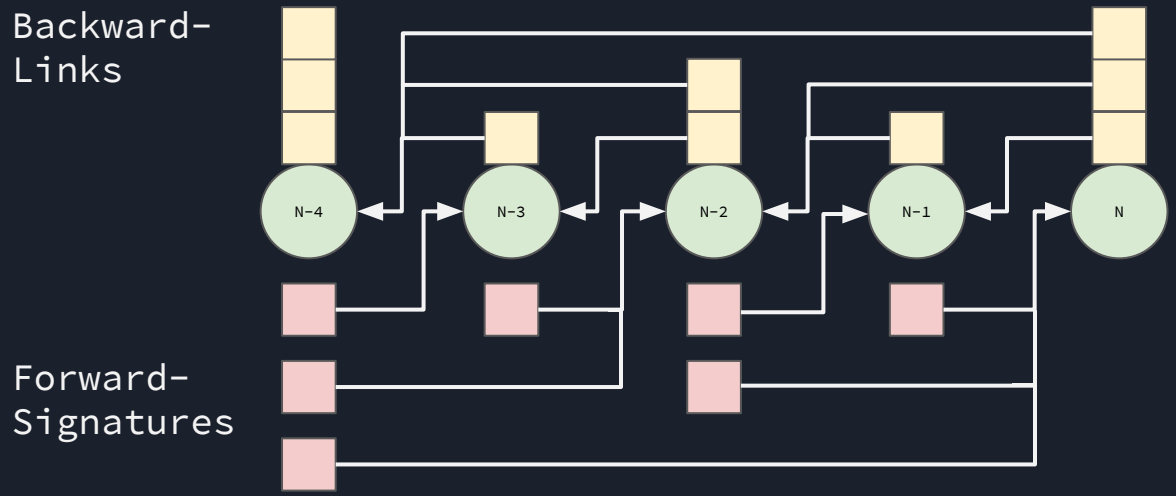
- Bonus: transfer coins to your neighbour(s)


To C
SkipBlock n-1
SkipBlock n
+ BaseID: DarcID
+ Rules: []Rule
Invoke:SendCoin)
can be verified.
An expression is
composed of and, or,
and public keys and/or
links to other Darcs.
Rule
+ Action: string
+ Expression: and, or
Public Key
SkipBlock
Header
+ Previous Blocks: []SkipBlockID
+ Global State: Merkle-root
+ Client Transactions: Hash
+ State Changes: Hash
Payload
+ Transactions: []TxResult
+ Forward Links: []ForwardLink
Instance
+ InstanceID: [32]byte
+ ContractID: string
+ Value: []byte
Sha256
StateChange
+ StateAction: {Create,Upda
+ InstanceID: [32]byte
+ ContractID: string
+ Value: []byte
Forward Link
+ From: SkipBlockID
+ To : SkipBlockID
+ NewRoster : Roster
+ Signature: BFTSignature

6 - Get a Proof of Your Coin Address

- On the status-website, open a javascript-console
  Mac OS X: <cmd><alt>j
- Type
  `proof`
  to see the proof of the configuration-contract. It contains:
  - links - skiplinks from the genesis block to the latest block

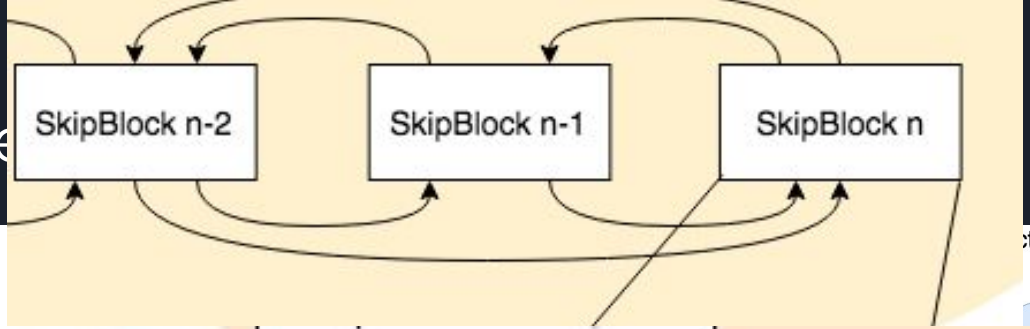
Base for ByzCoin - 1: skipchains



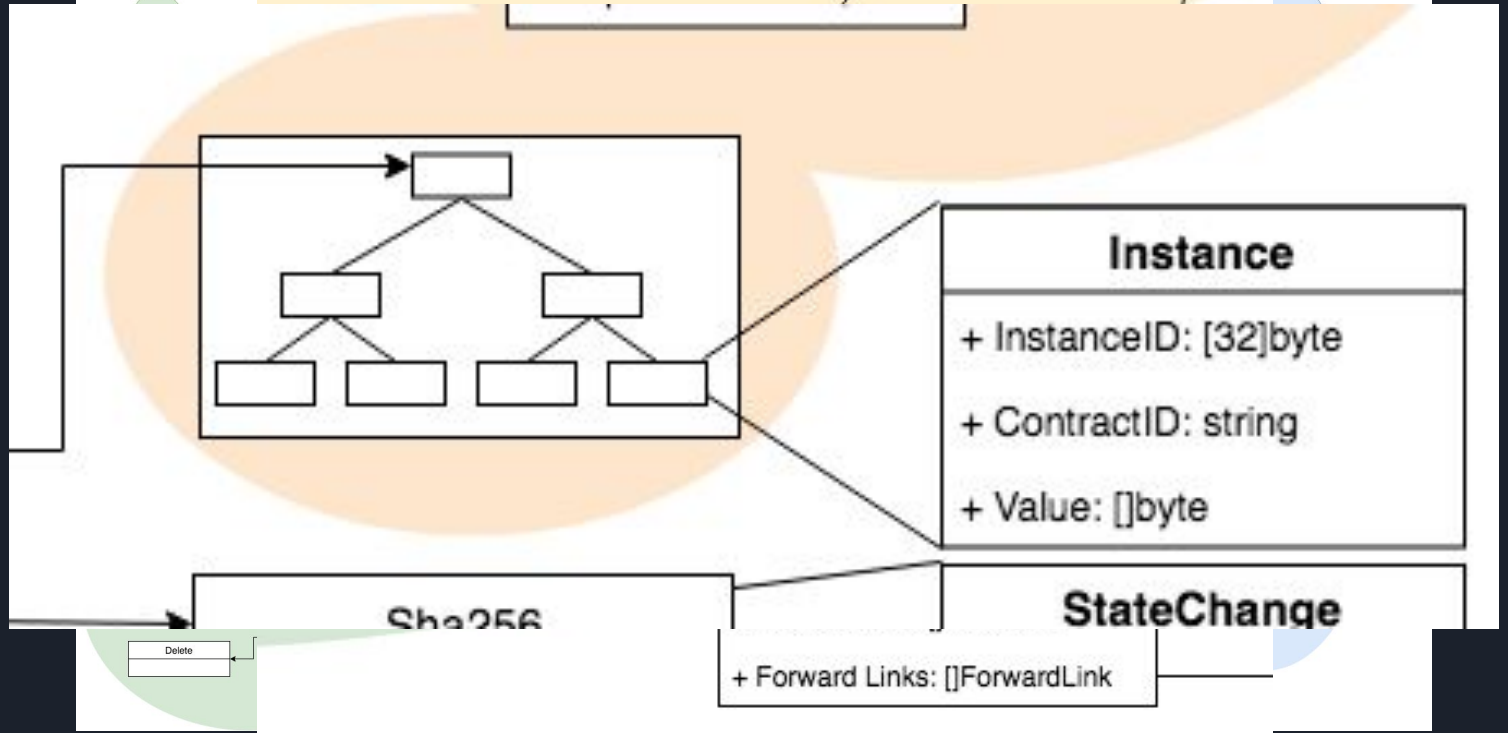
6 - Get a Proof of Your Coin Address

- On the status-website, open a javascript-console
  Mac OS X: <cmd><alt>j
- Type
  `proof`
  to see the proof of the configuration-contract. It contains:
  - links - skiplinks from the genesis block to the latest block
  - Latest block for the merkle-tree root hash of the state
  - Inclusion-proof of the instance in the merkle-tree root

6 - Ge


SkipBlock n-2
SkipBlock n-1
SkipBlock n

Clients


Instance
+ InstanceID: [32]byte
+ ContractID: string
+ Value: []byte
StateChange
+ Forward Links: []ForwardLink
Delete

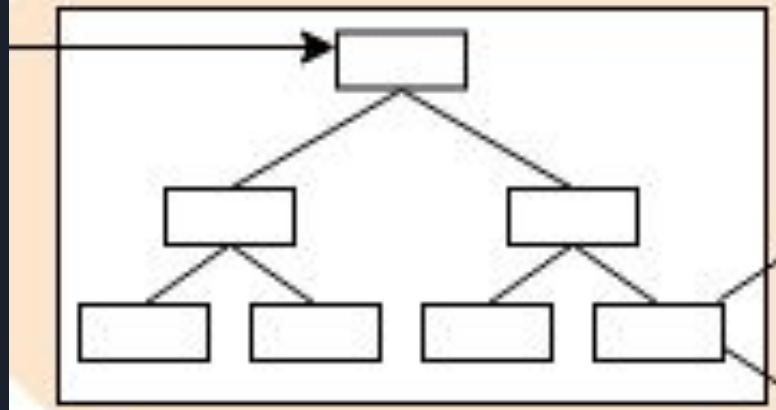
6 - Get a Proof of Your Coin Address

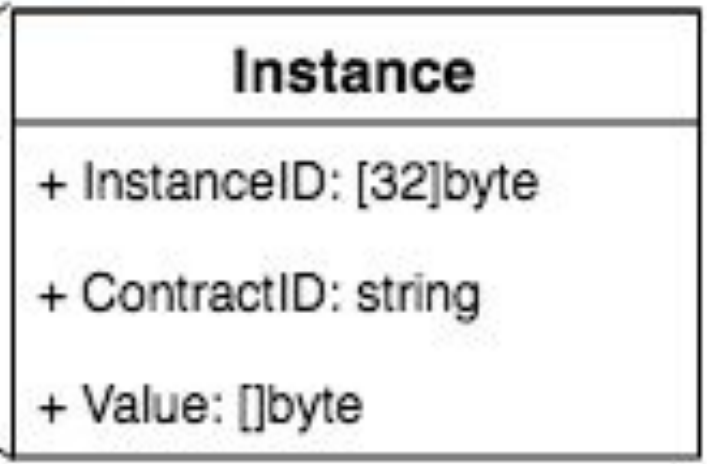
- First get the InstanceID of your coin:
  `wallet show --address`
- Get the proof of your coin-instance (for Firefox use ***then***):
  `mycoin = await bc.getProof(hex2iid("coinaddresshex"))`
- Convert the value of the proof to the coin-data:
  `coindata = value2coin(mycoin.instance.data)`
- And check if the data is correct

6. Get a Proof of Your Coin Address

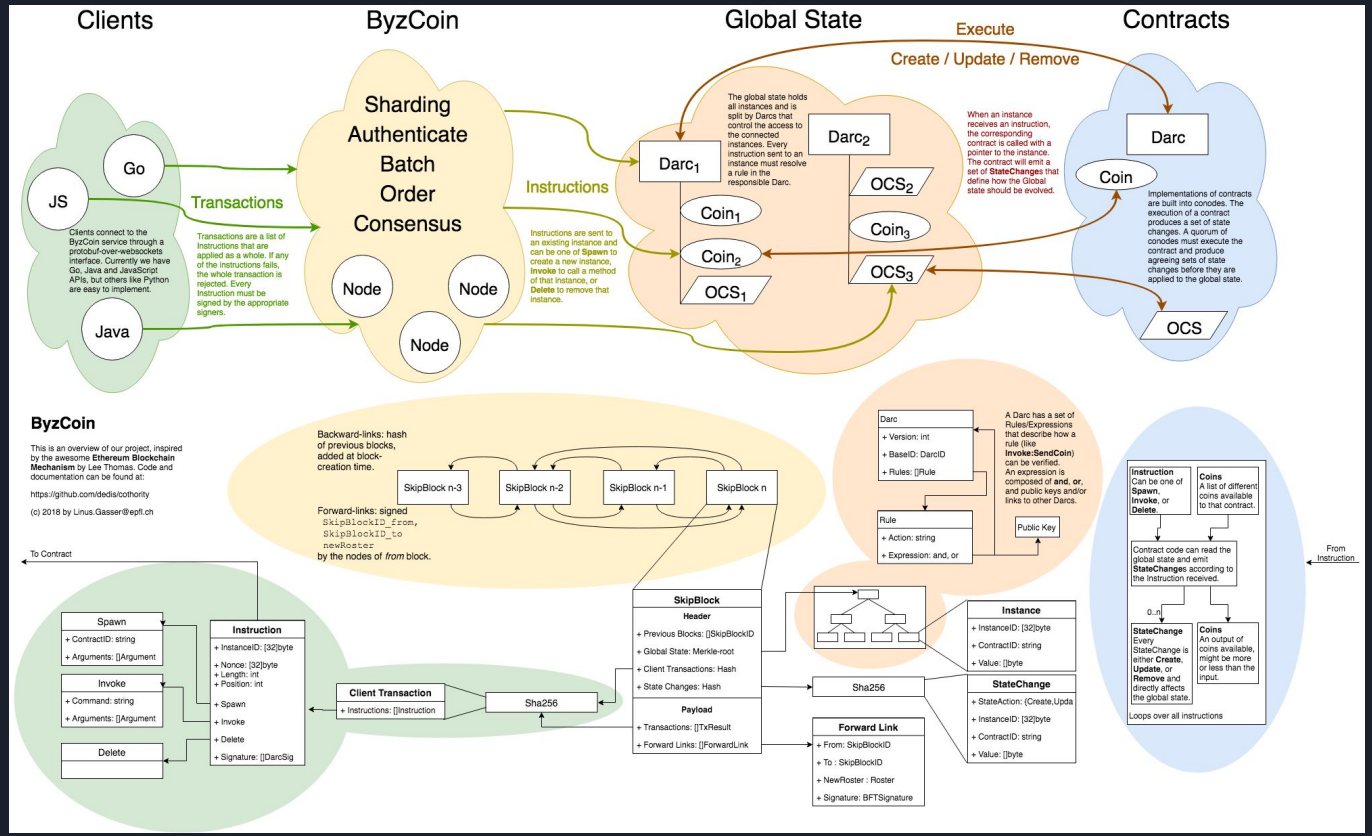
Shardin

Authentic





6 - Get a Proof of Your Coin Address



7 - The End

- Copy your logs to https://drive.google.com/drive/folders/1GWSvXOKOZSnTmWZ4G6Rbsrvl3zOy9r0j?usp=sharing
- Write issues / bug reports to https://github.com/dedis/cothority
- Contact us at dedis@epfl.ch
- Keep an eye on https://pop.dedis.ch