Proof of Authority Consensus Algorithms

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Outline

- Proof of * Algorithms
- Proof of Authority
  - Why PoA?
  - PoA in Ethereum
- Authority Round (AuRa)
- Clique

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Consensus Algorithms

Intro to Consensus Algorithms

- A method of ensuring everybody agrees on the current state of the blockchain
- Want to create a single source of truth
  - Ensure everyone knows I have X amount of Eth
- Challenges include:
  - Bad actors
  - Network latency
- Lots of different algorithms exist for establishing consensus

Proof of Work

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Proof of Steak

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Proof of Stake*

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Proof of Authority

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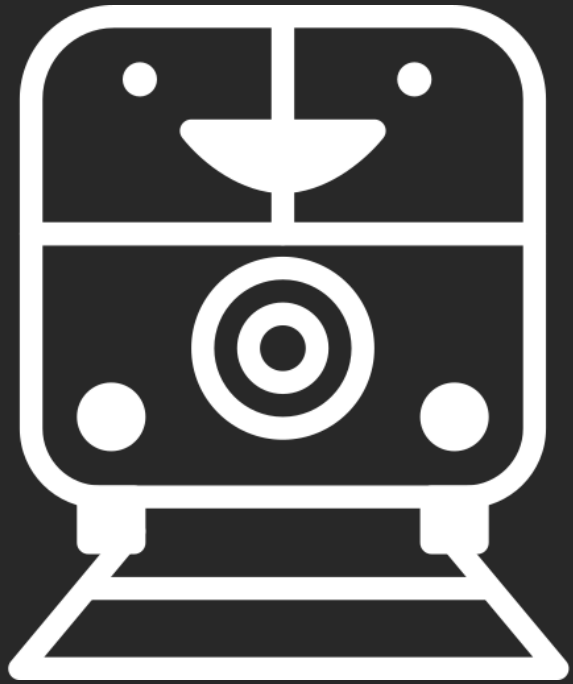
Proof of Authority

- Trusted set of nodes acting as validators
- Want to produce blocks at a reliable, fixed interval
- Don’t have adversarial conditions on network
- Potentially higher performance

PoA in Ethereum

- Ropsten is a PoW testnet
- No incentive to mine meant low hash rate
  - Lead to spam attacks on Ropsten back in early 2017
- Two different PoA networks were spun up in the aftermath of the Ropsten attacks



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Kovan

Authority Round

Rinkeby

Clique

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Authority Round

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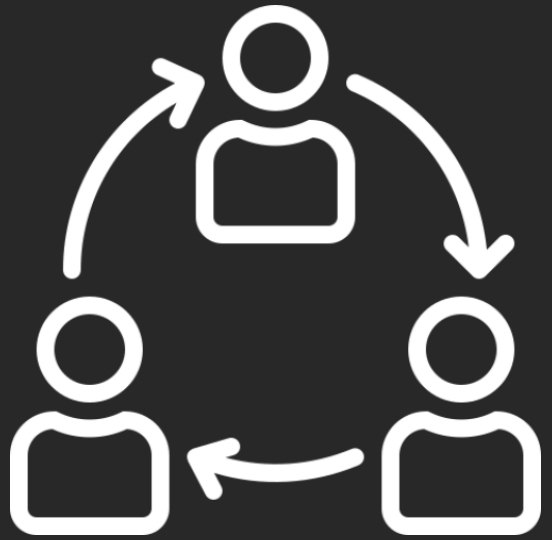
Authority Round (Aura)

- Round robin based algorithm
- Time is divided into discrete steps
- Every validator has an assigned slot to propose a block
- Configurable through a smart contract



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Authority Round: Idea

- Time is divided into discrete steps, where:
  - Step = Unix Time / Length of Step
    - Step 1 = 5 / 5
    - Step 20 = 100 / 5
- Each step has an assigned validator, chosen through:
  - Index = s *mod* n
    - Validators [s % n]
    - Validators [1 % 5] = Validators [1]

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Finality in Aura

- Aura provides the concept of finality
- Bitcoin and Ethereum only have probabilistic finality
  - “Might not be reverted, but let’s wait a few blocks just in case…”
- A block is finalized when more than half of the validators have built on top of it

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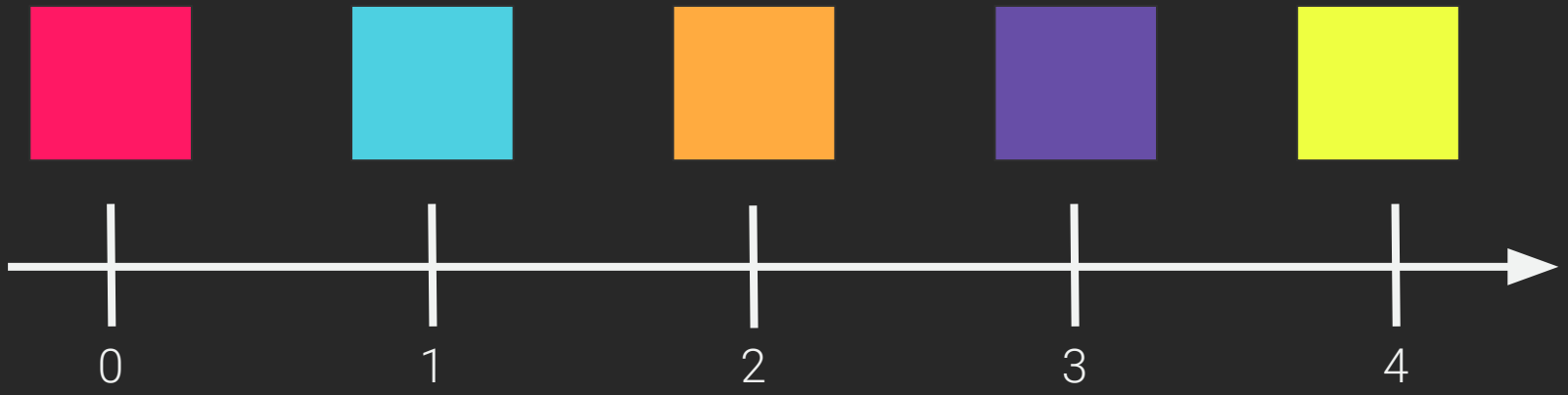

Finality in Aura

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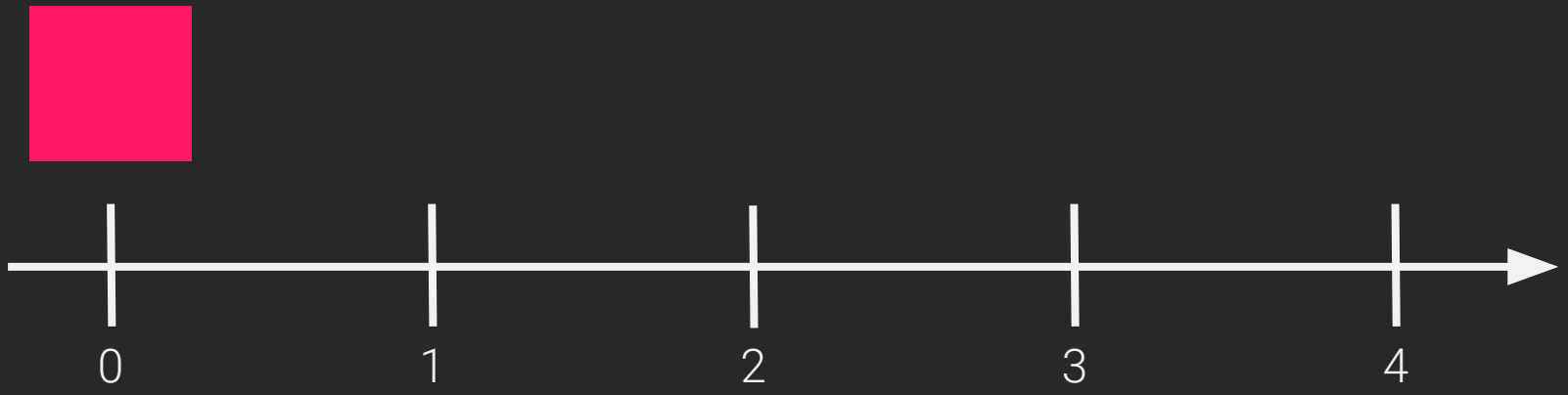

Finality in Aura

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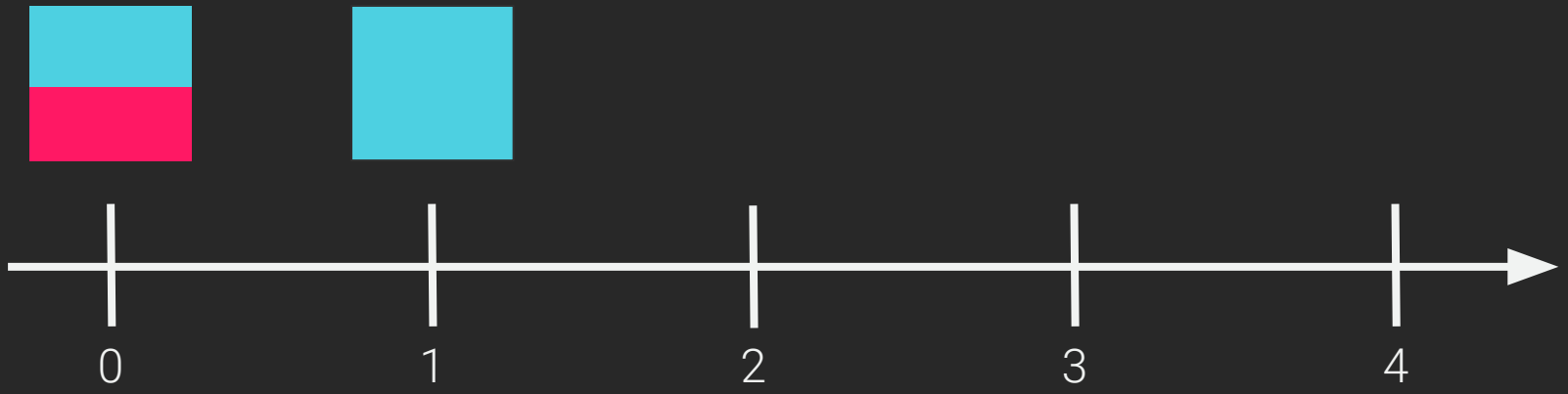

Finality in Aura

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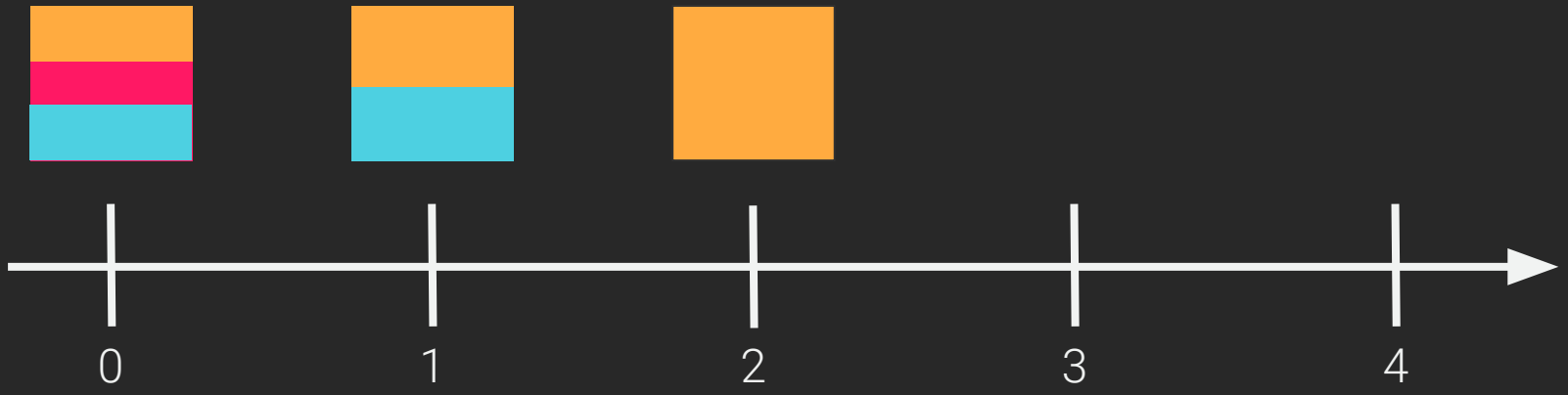

Finality in Aura

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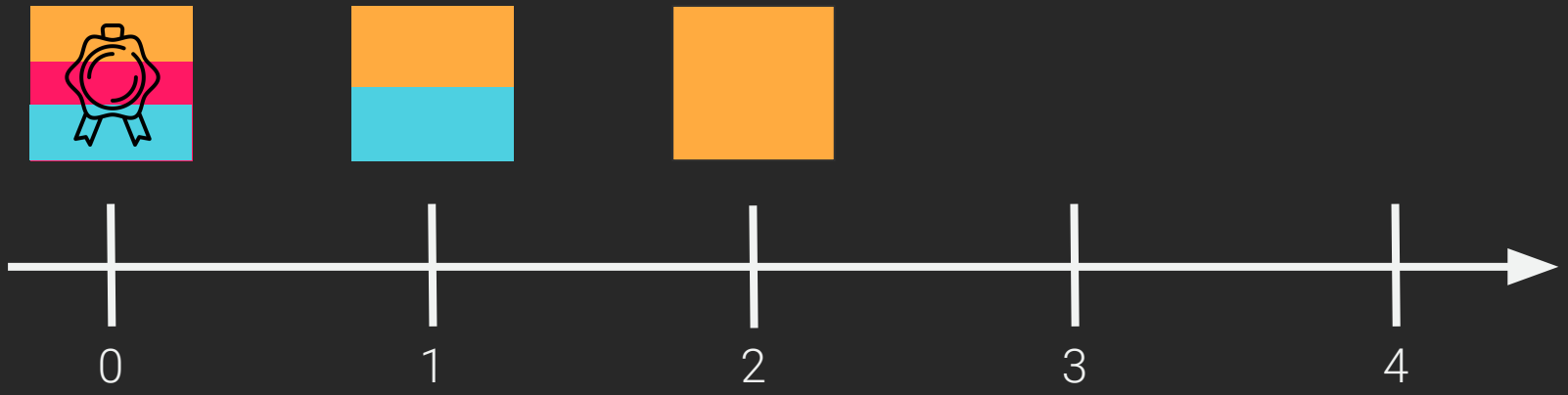

Finality in Aura

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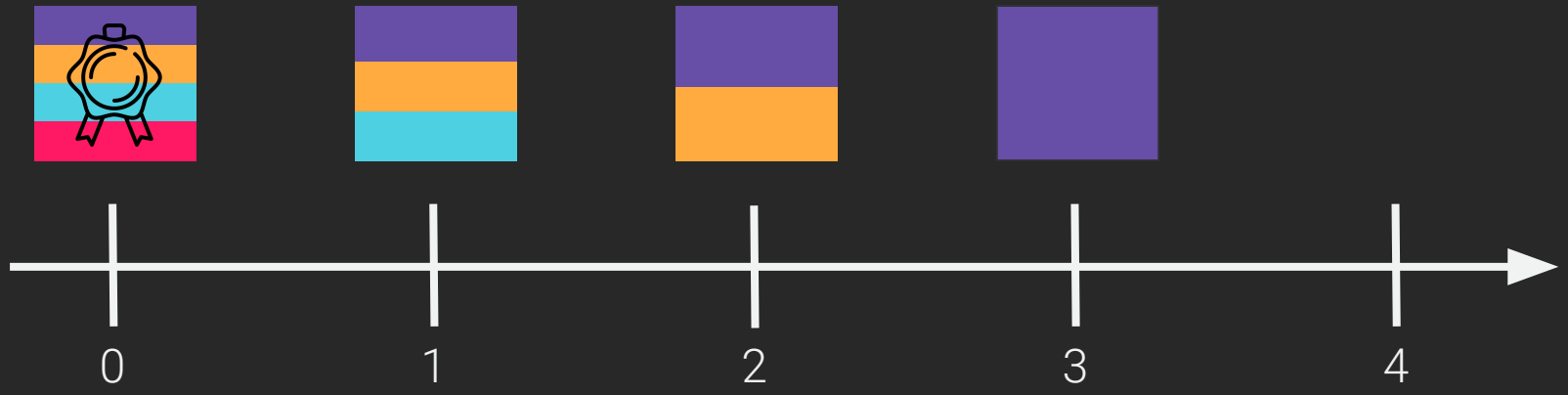

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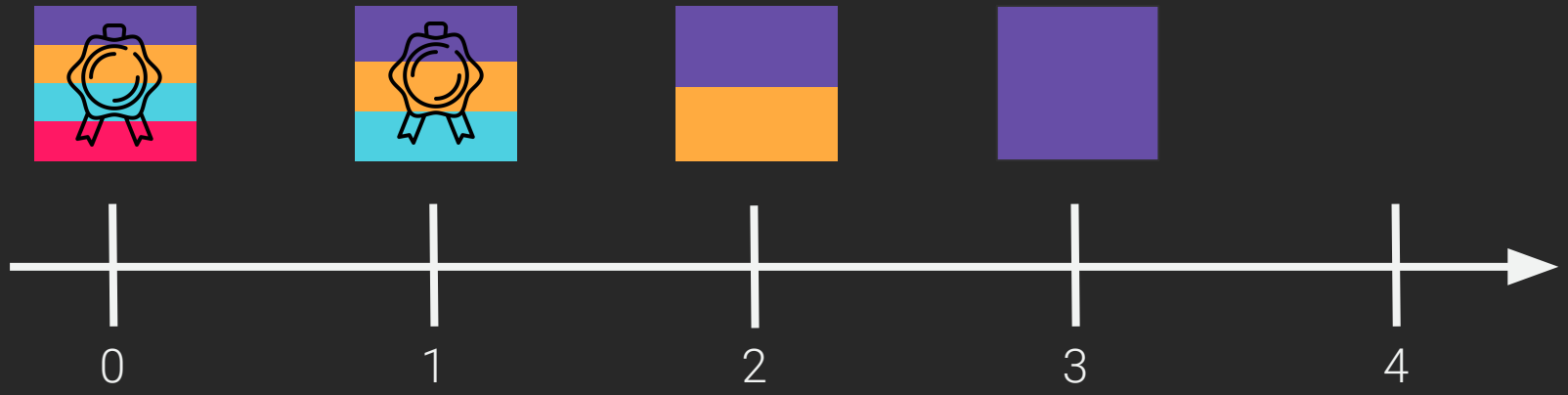

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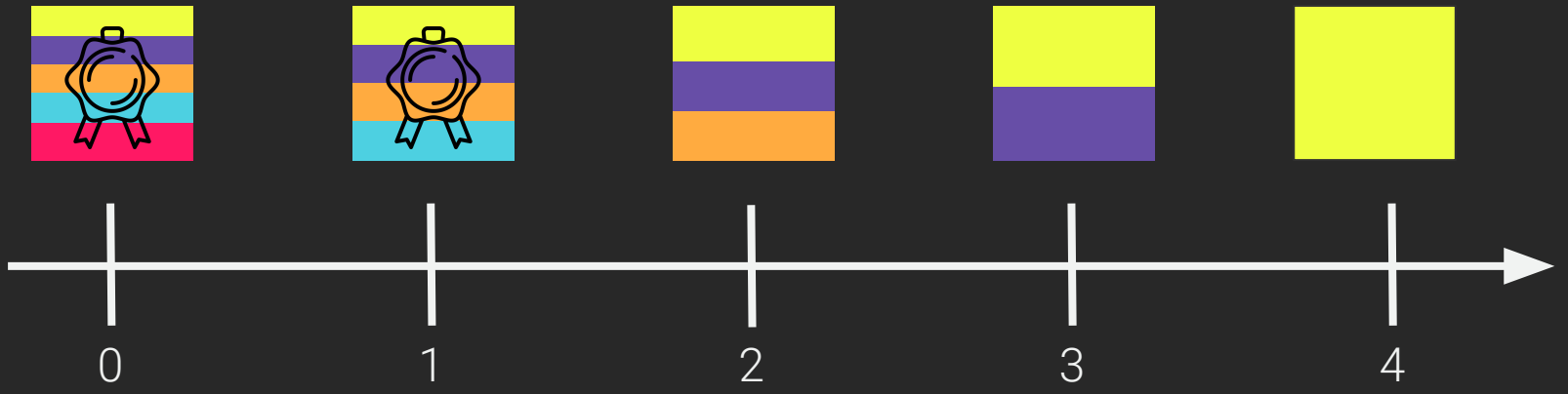

Finality in Aura

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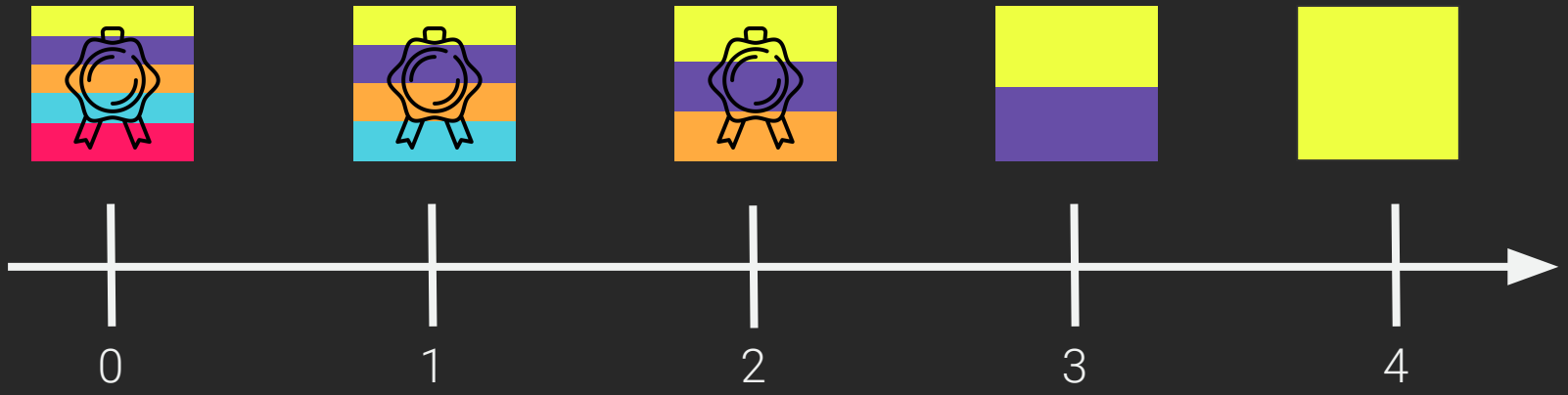

Finality in Aura

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Validator Set

- The set of validators can be defined in two ways:
  1. Chain Specification (*chain.json*)
  2. Smart Contract
- Epoch = Period of time with same validators

```
"validators" : {
    "multi": {
        "0": { "list": ["0xc6d9d2cd449a754c494264e1809c50e34d64562b"] },
        "10": { "list": ["0xd6d9d2cd449a754c494264e1809c50e34d64562b"] },
        "20": { "contract": "0xc6d9d2cd449a754c494264e1809c50e34d64562b" }
    }
}
```

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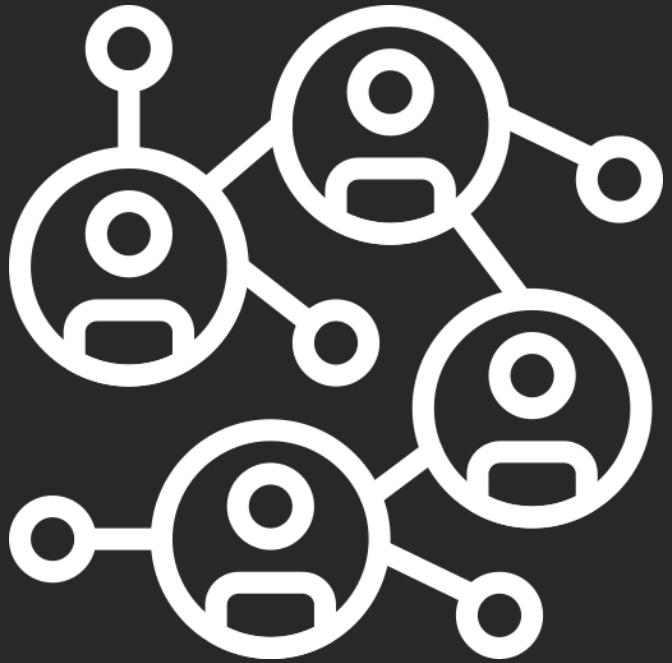
Clique

Background

- PoA consensus algorithm
- Defined in EIP-225 by Péter Szilágyi of Geth
- Also developed after Ropsten attacks
- Goal is to standardize PoA for Eth clients
- Used in Rinkeby and Goerli testnets



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Block Proposals

- Block proposals are a little less strict than they are with Aura
  - Have concept of INTURN and NOTURN validators
- After signing a block validators are not allowed to sign the next floor(SIGNER_COUNT / 2) + 1 blocks

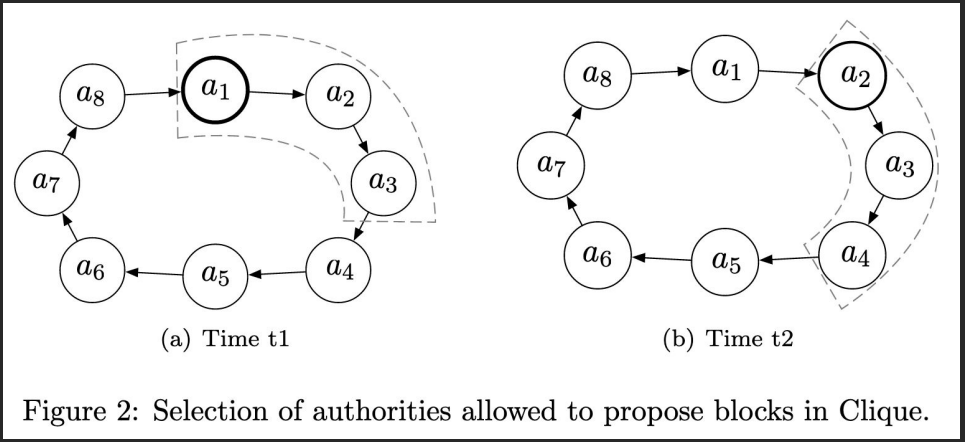

Figure 2: Selection of authorities allowed to propose blocks in Clique.

http://ceur-ws.org/Vol-2058/paper-06.pdf

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Choosing the Longer Chain

- Blocks have a higher difficulty depending on when they were made
  - DIFF_INTURN = 2
  - DIFF_NOTURN = 1
- Gives preference to chain built with INTURN validators

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Validator Set Changes

- Authorities vote for validator set changes
- For non-epoch transition blocks (from the spec)
  - Signers may cast one vote per own block to propose a change to the authorization list.
  - Only the latest proposal per target beneficiary is kept from a single signer.
  - Votes are tallied live as the chain progresses (concurrent proposals allowed).
  - Proposals reaching majority consensus SIGNER_LIMIT come into effect immediately.
  - Invalid proposals are not to be penalized for client implementation simplicity.

Epochs

- Smart contracts require state access
  - Need way to verify authorities without access to state
- An epoch block is a stateless transition
  - Contain no votes
  - Contain list of current authorities
  - All non-settled votes are discarded
- Can be used as a checkpoint for clients syncing the network
- Default is every 30,000 blocks

Pop Quiz!

```
signers: []string{"A", "B", "C"},
blocks:  []block{
  {signer: "A", voted: "C", auth: false},
  {signer: "B", voted: "C", auth: false},
},
```

Pop Quiz: Consensus Tests!

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```
// Three signers, two of them deciding to drop the third
signers: []string{"A", "B", "C"},
blocks:  []block{
  {signer: "A", voted: "C", auth: false},
  {signer: "B", voted: "C", auth: false},
},
results: []string{"A", "B"},
```

Pop Quiz: Consensus Tests!

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```
signers: []string{"A"},
blocks:  []block{
  {signer: "A", voted: "B", auth: true},
  {signer: "B"},
  {signer: "A", voted: "C", auth: true},
},
```

Pop Quiz: Consensus Tests!

parity

```
    // Single signer, voting to add two others (only
accept first, second needs 2 votes)
    signers: []string{"A"},
    blocks:  []block{
      {signer: "A", voted: "B", auth: true},
      {signer: "B"},
      {signer: "A", voted: "C", auth: true},
    },
    results: []string{"A", "B"},
```

Pop Quiz: Consensus Tests!

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```
signers: []string{"A", "B", "C", "D"},
blocks:  []block{
  {signer: "A", voted: "C", auth: false},
  {signer: "B", voted: "C", auth: false},
},
```

Pop Quiz: Consensus Tests!

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```
    // Four signers, consensus of two not being
enough to drop anyone
    signers: []string{"A", "B", "C", "D"},
    blocks:  []block{
      {signer: "A", voted: "C", auth: false},
      {signer: "B", voted: "C", auth: false},
    },
    results: []string{"A", "B", "C", "D"},
```

Pop Quiz: Consensus Tests!

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```
epoch:   3,
signers: []string{"A", "B"},
blocks:  []block{
  {signer: "A", voted: "C", auth: true},
  {signer: "B"},
  {signer: "A", checkpoint: []string{"A", "B"}},
  {signer: "B", voted: "C", auth: true},
},
```

Pop Quiz: Consensus Tests!

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```
    // Epoch transitions reset all votes to allow chain
checkpointing
    epoch:   3,
    signers: []string{"A", "B"},
    blocks:  []block{
      {signer: "A", voted: "C", auth: true},
      {signer: "B"},
      {signer: "A", checkpoint: []string{"A", "B"}},
      {signer: "B", voted: "C", auth: true},
    },
    results: []string{"A", "B"},
```

Pop Quiz: Consensus Tests!

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Questions?

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