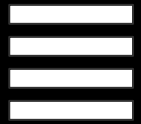
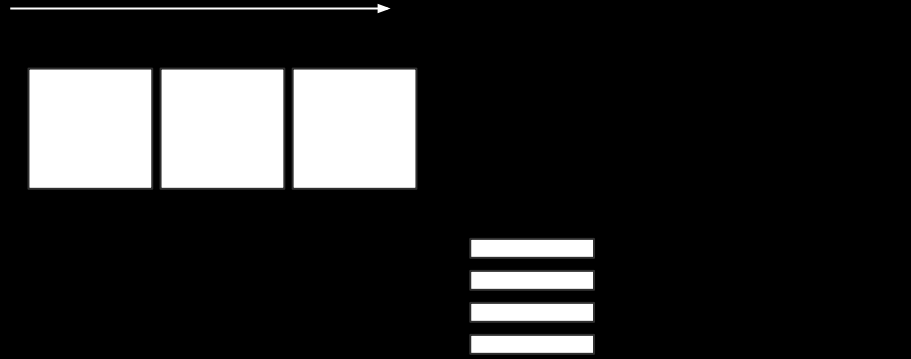
Blockchain consensus abstractions

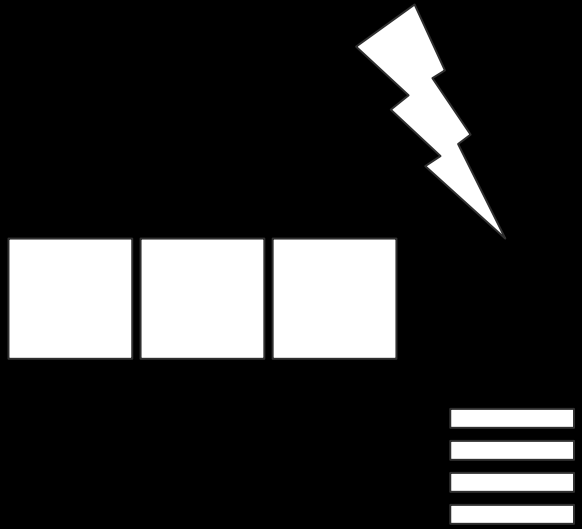
Peter Czaban
peter@parity.io

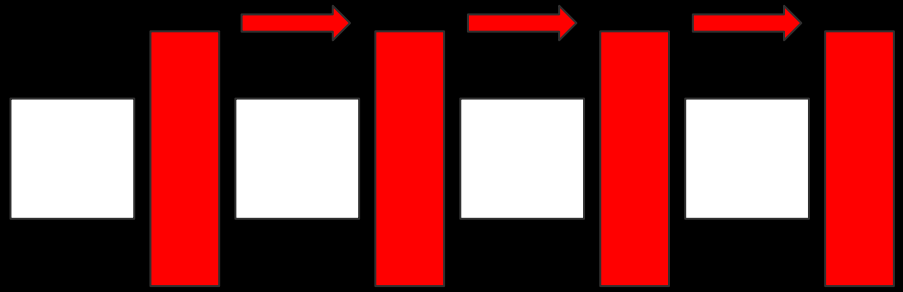
Replicated state machine

- Replicas
- State
- State transition rules
- Instructions
- Primary





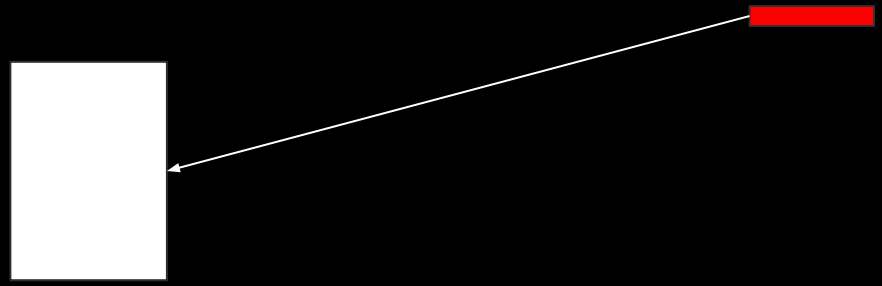

Sealing



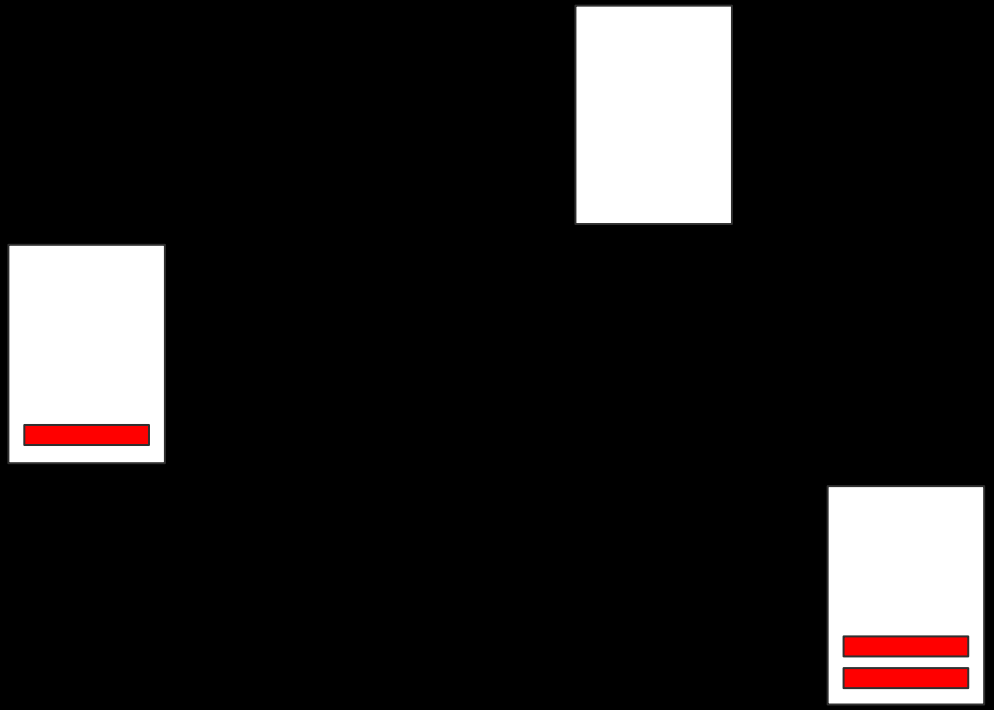
Chain without consensus

- Transaction submission
- Transaction broadcast
- Block building
- Block broadcast
- Block verification

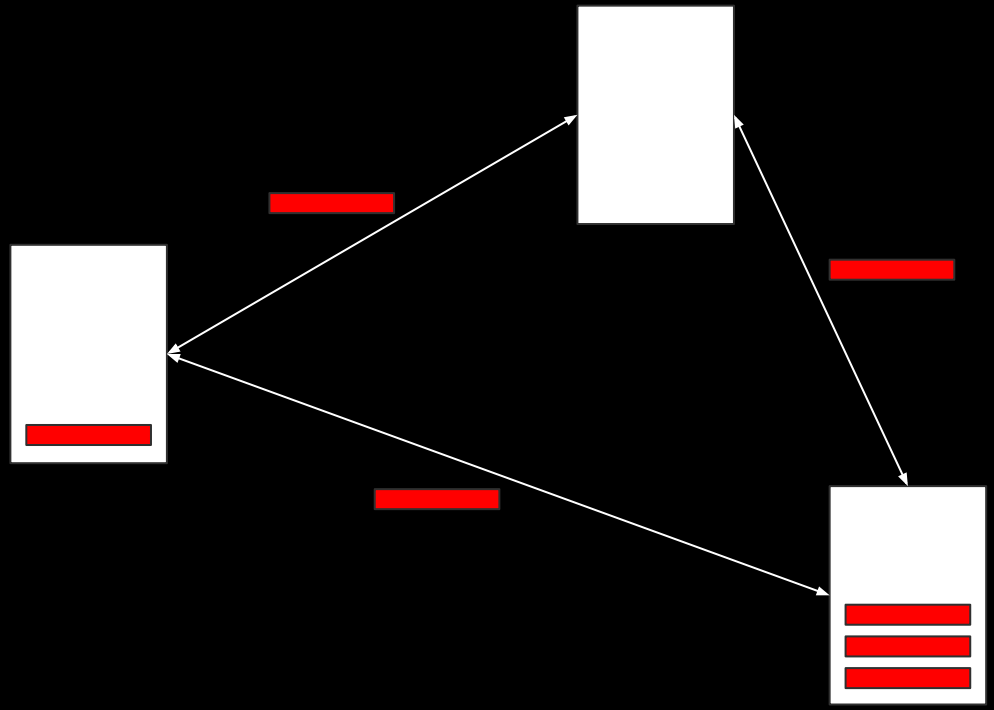
Transaction submission



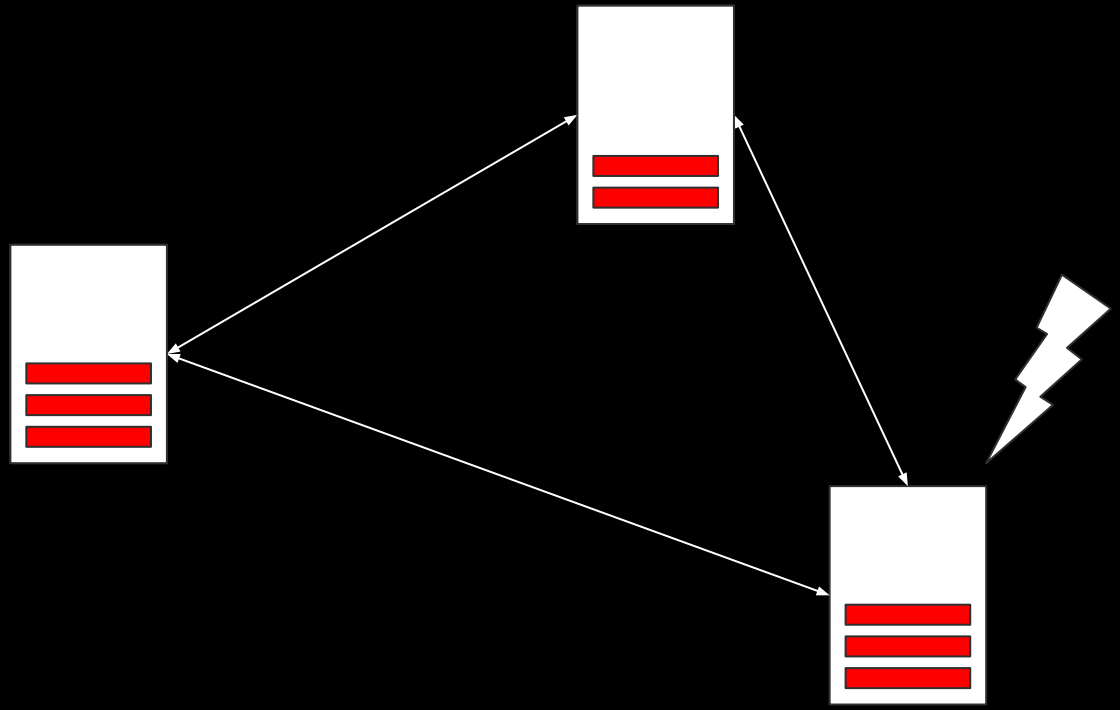
Transaction submission



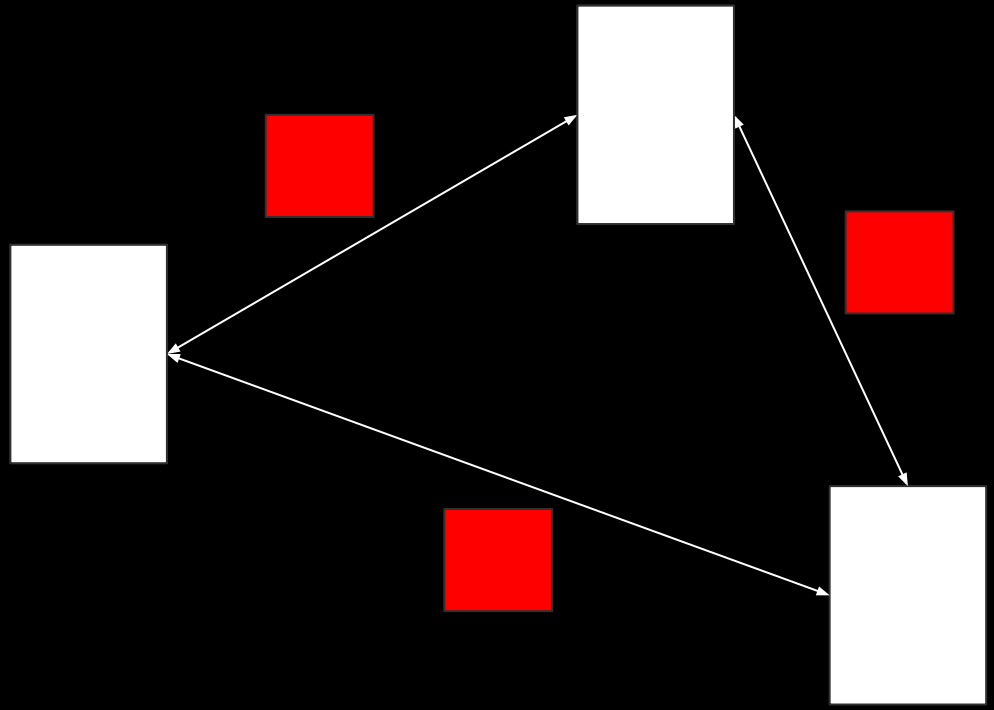
Transaction broadcast



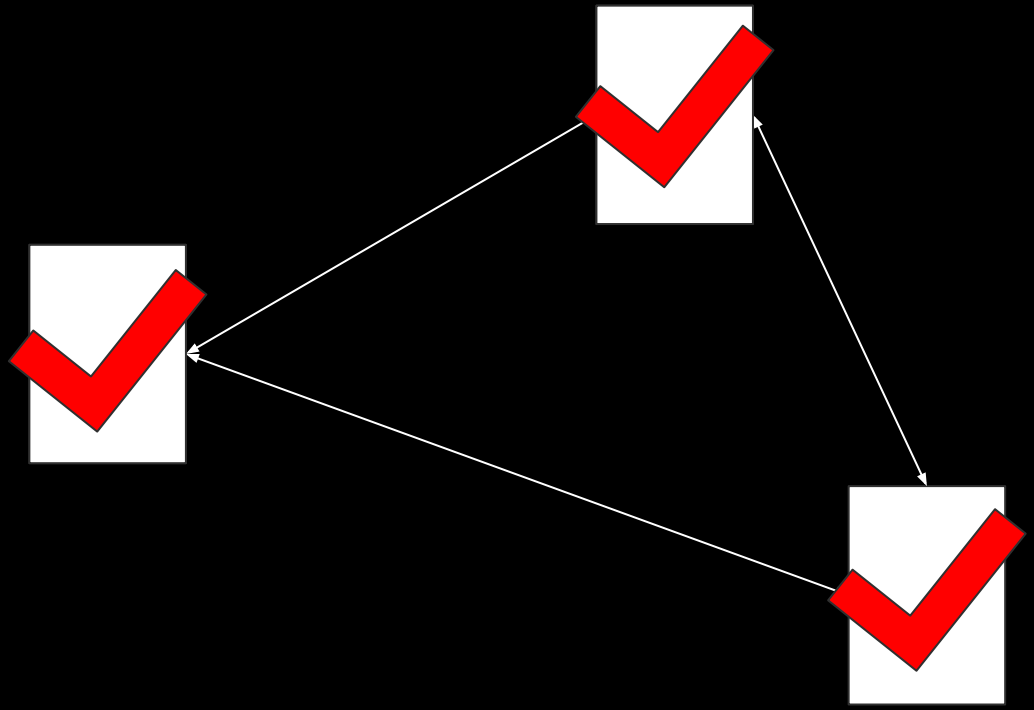
Block building



Block broadcast



Block verification



Parity implementation

- Standard Ethereum RPC interface
- 2000 tx/s
- Low footprint
- Robust networking
- Chain specification in json format

Consensus Engine abstraction

- Header seal generation
- Header seal verification
- Chain scoring rule

Additional:

- Block sealing trigger
- Proposal stashing
- Message broadcast and handling
- Additional transaction verification
- Additional state handling at open or close

Common features

- Generated header is accepted by all
- It is eventually possible to generate a header
- There is an eventual ordering over valid chains
- Views are changed on every block

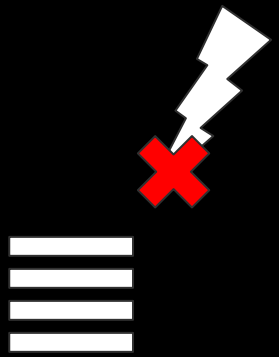
Chain scoring

- PoW: `difficulty`
- Height chain scoring: `height`
- Popular chain scoring: `const * height + length(signers)`

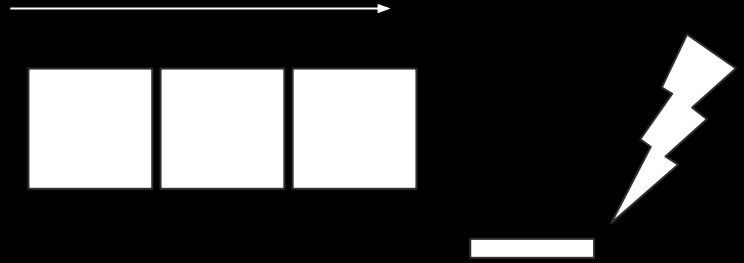
Current Engine implementations

- Ethash
- Null Engine
- Instant Seal
- Basic Authority
- Authority Round
- Tendermint
- Abab

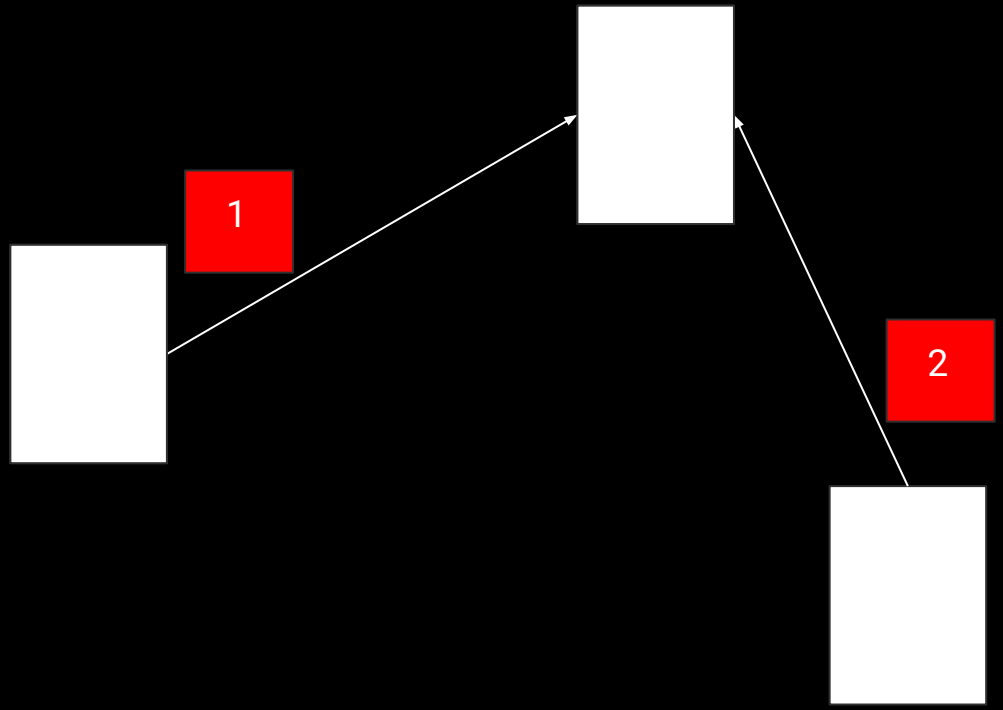
Null Engine



Instant Seal



Instant Seal



Validator engines

- Basic Authority
- Authority Round
- Tendermint
- Abab

Validator set abstraction

- Membership check
- Draw based on nonce
- Total count

Optional:

- Report malicious behaviour
- Report benign misbehaviour

Validator set

- Immutable
- Part of state

```
contract ValidatorSet {

     function getValidators() returns (address[]) {}

     function reportMalicious(address validator) {}

     function reportBenign(address validator) {}

}
```

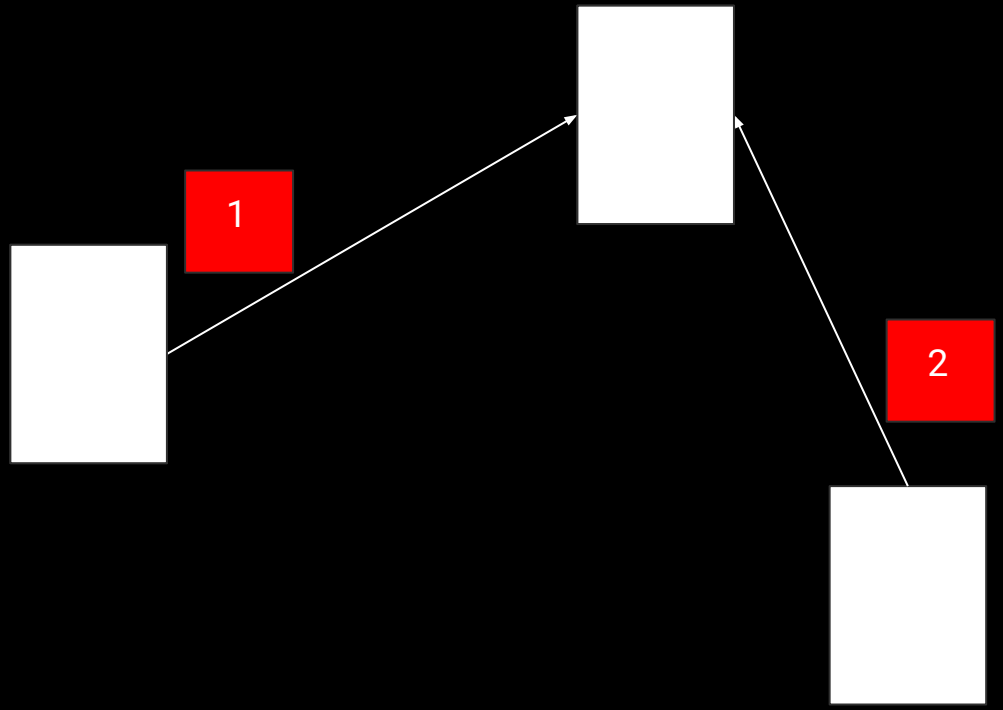
Stateful validator set

- Majority support
- Proof of Stake

Validator reporting

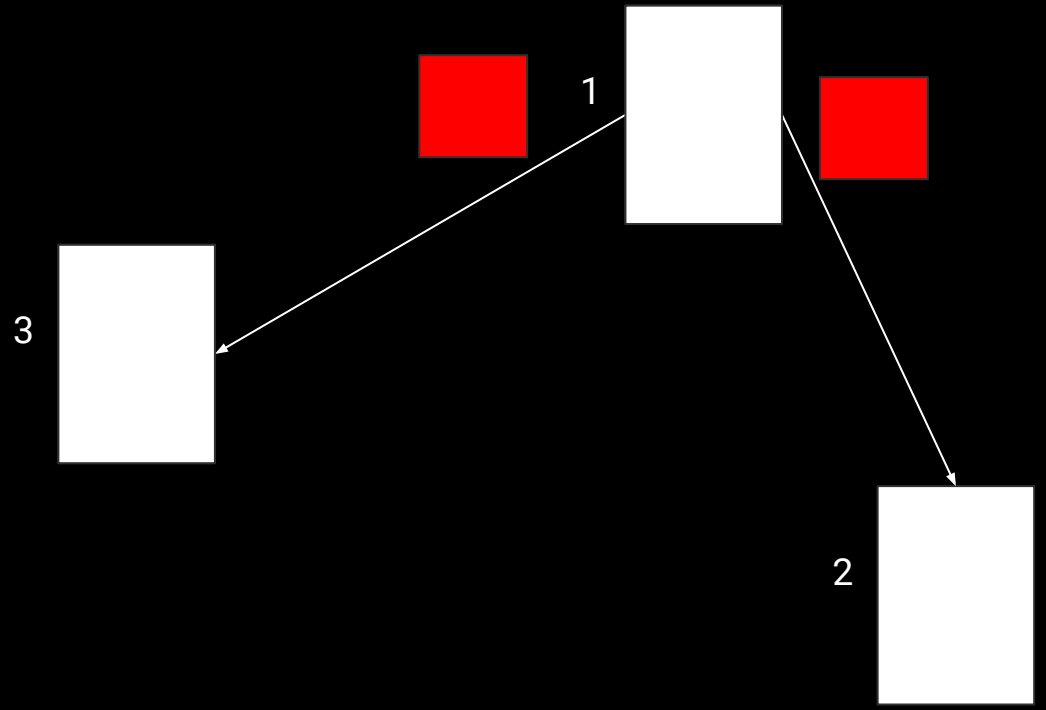
- Engine decides when
- Slashing, kicking, call to action
- Rejecting blocks without report

Basic Authority

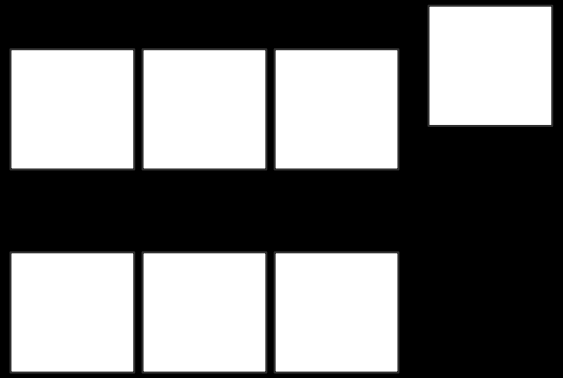


0x123…
0x321…
0x231…

Authority Round and Ethash

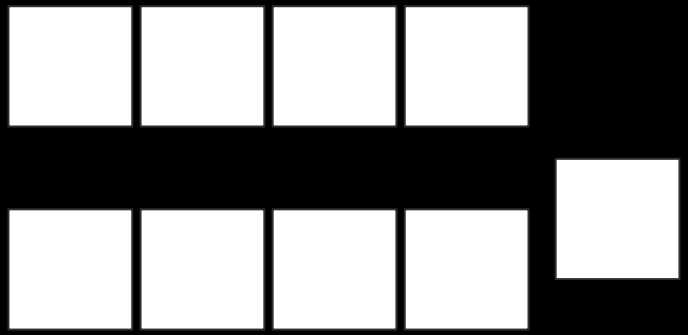


Authority Round partition

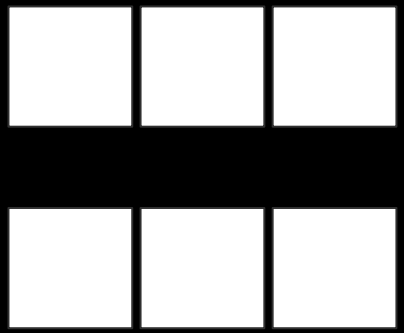


View = 1

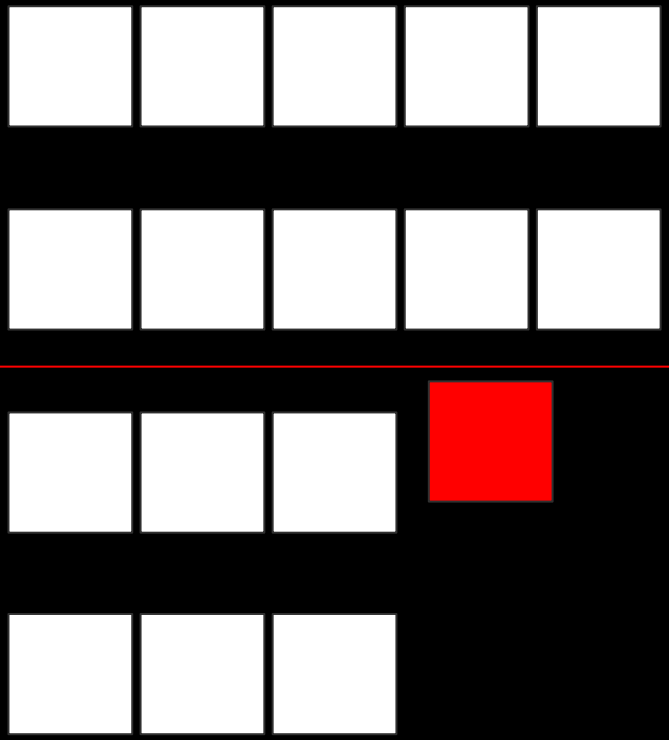
Authority Round partition



View = 2

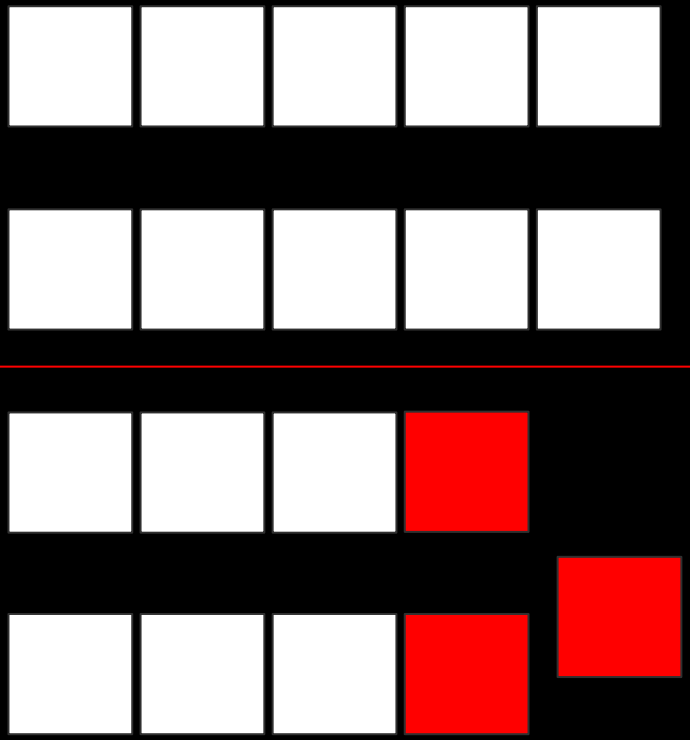


Authority Round partition



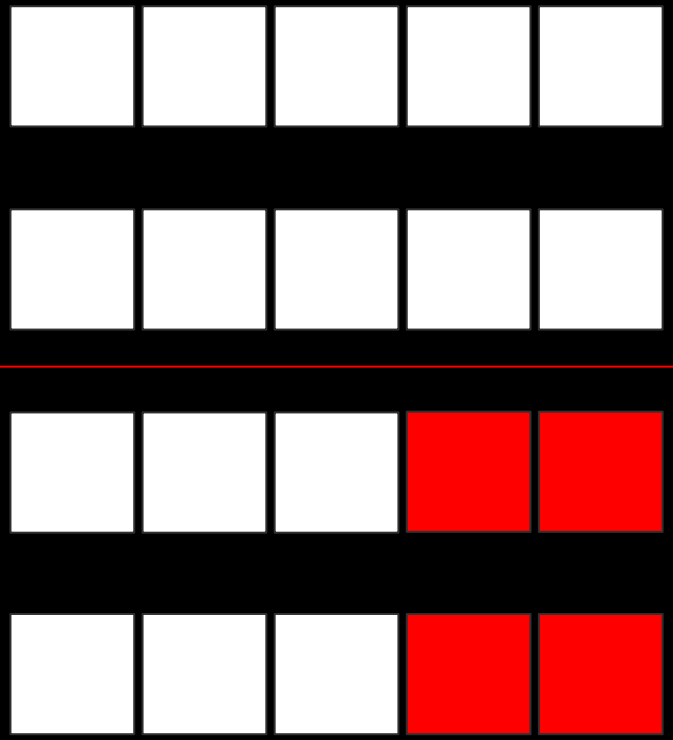
View = 3

Authority Round partition



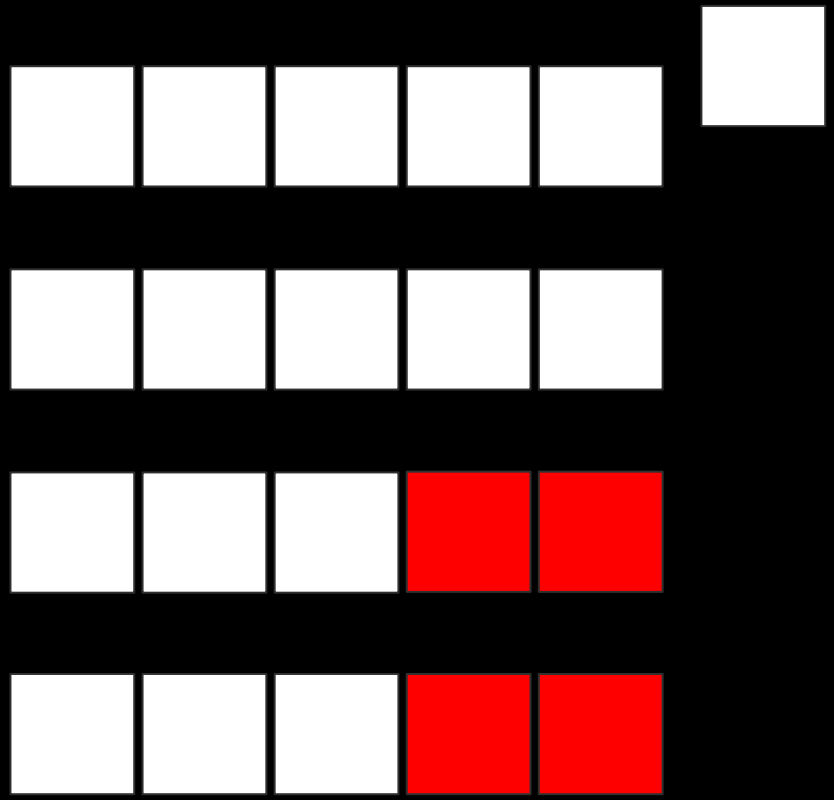
View = 4

Authority Round partition



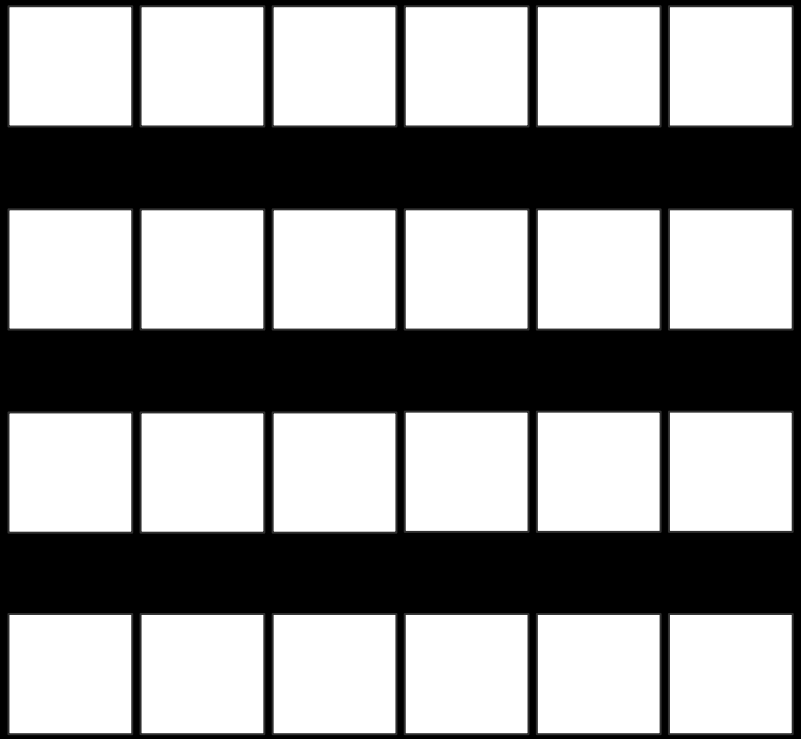
View = 4

Authority Round partition

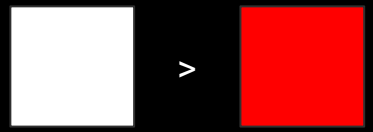


View = 5

Authority Round partition



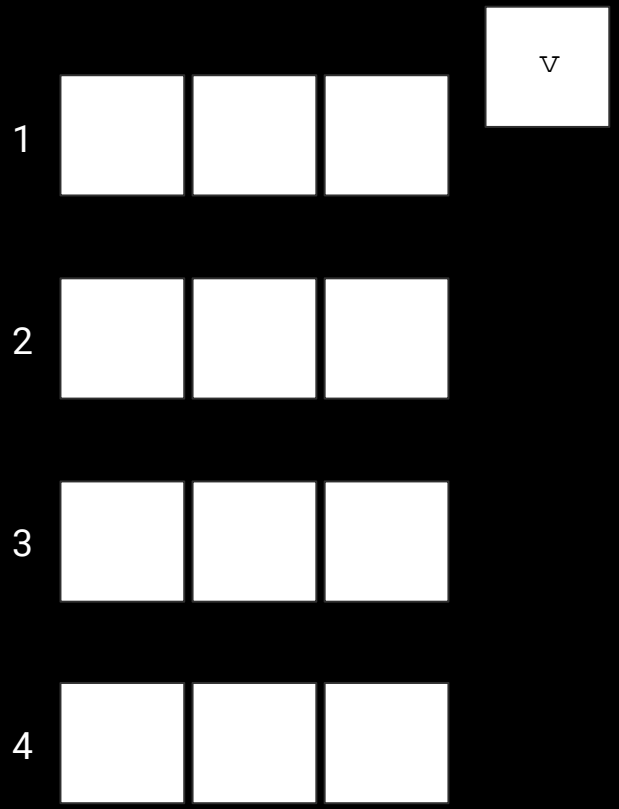
View = 5



Tendermint

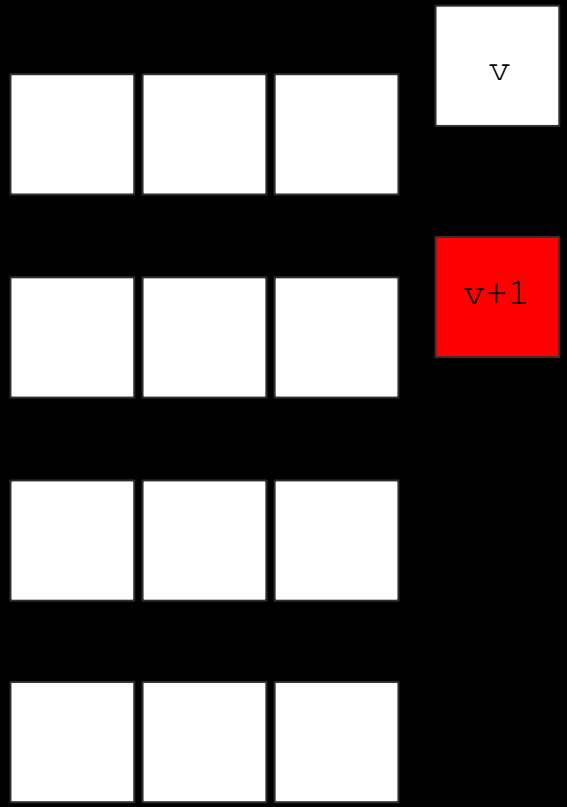
Propose -> Prevote -> Precommit -> Commit

Failure with chain scoring



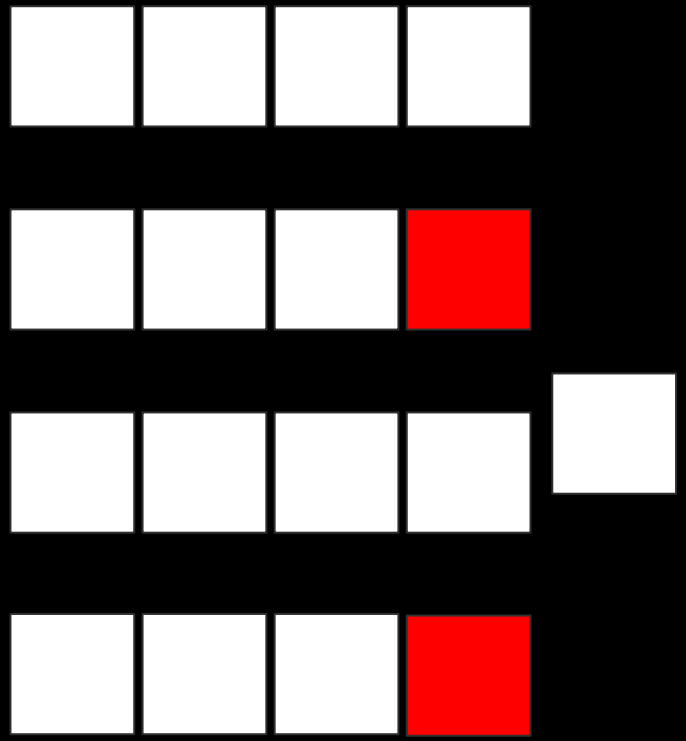
View = v

Failure with chain scoring



View = v+1

Failure with chain scoring



View = 1

Abab

- Maintains safety
- Improves speed / bandwidth
- Inspired by Zyzzyva and Aardvark

Abab

1. Primary issues a proposal
2. Replica responds with a vote
3. After ⅔ of votes are gathered the block is committed

Abab

1. Primary issues a proposal
2. Replica did not receive a valid proposal within timeout
3. Replica issues a view change message
4. Next primary receives ⅓ view changes
5. Next primary issues a proposal with new view signatures

Future directions

- Validator set contract implementations
- Various chain scoring + consensus implementations
- Threshold signatures
- Other state machines
- Extending the interface

Implement your own

- Messaging and seal format
- Internal state machine
- Chain scoring
- Validator set modification rules