Bribe-resilient NIPoPoWs

Changing Blockchain Macroeconomic Policy through Soft Forks

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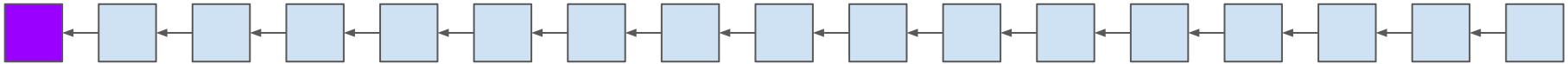
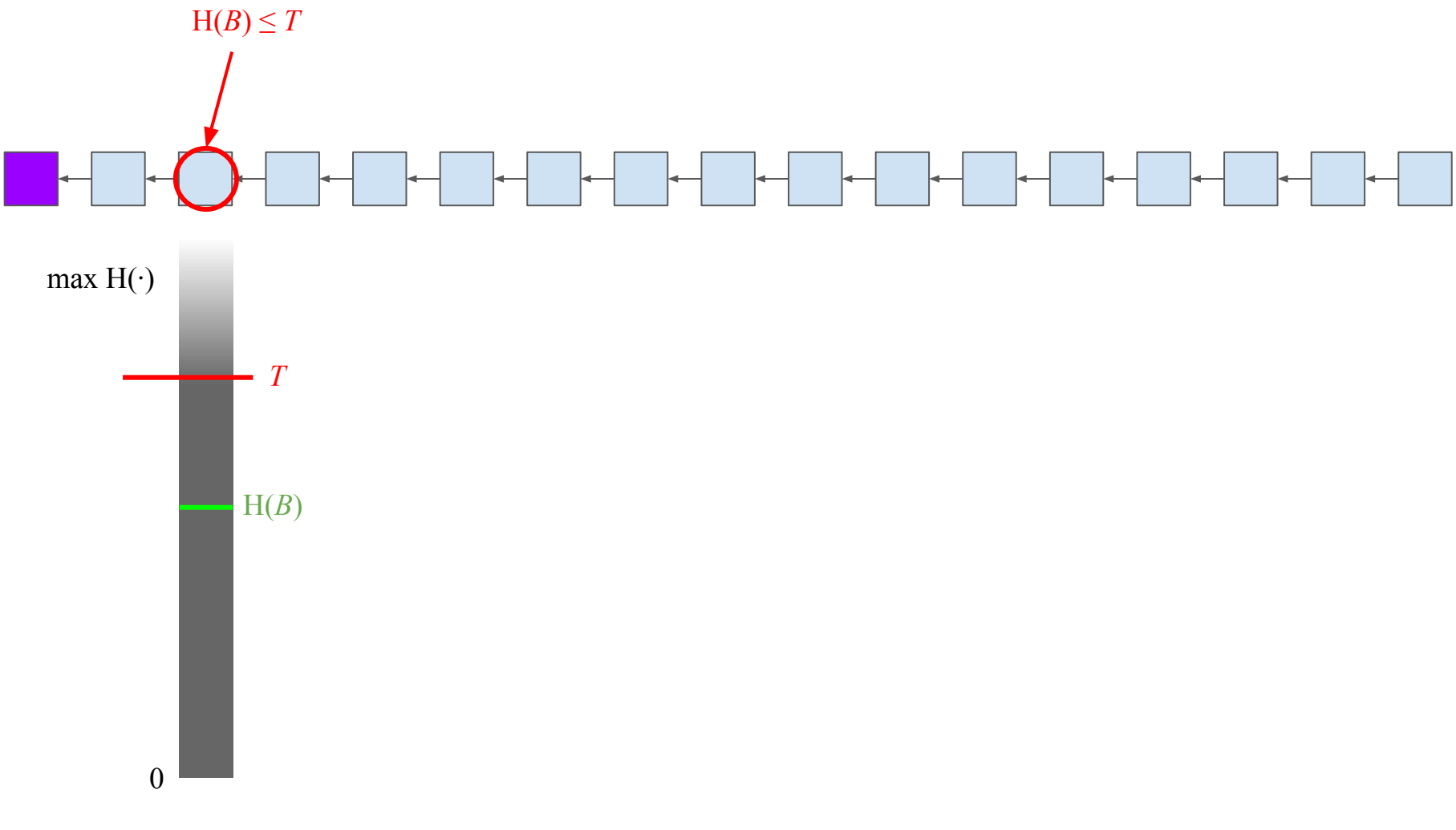
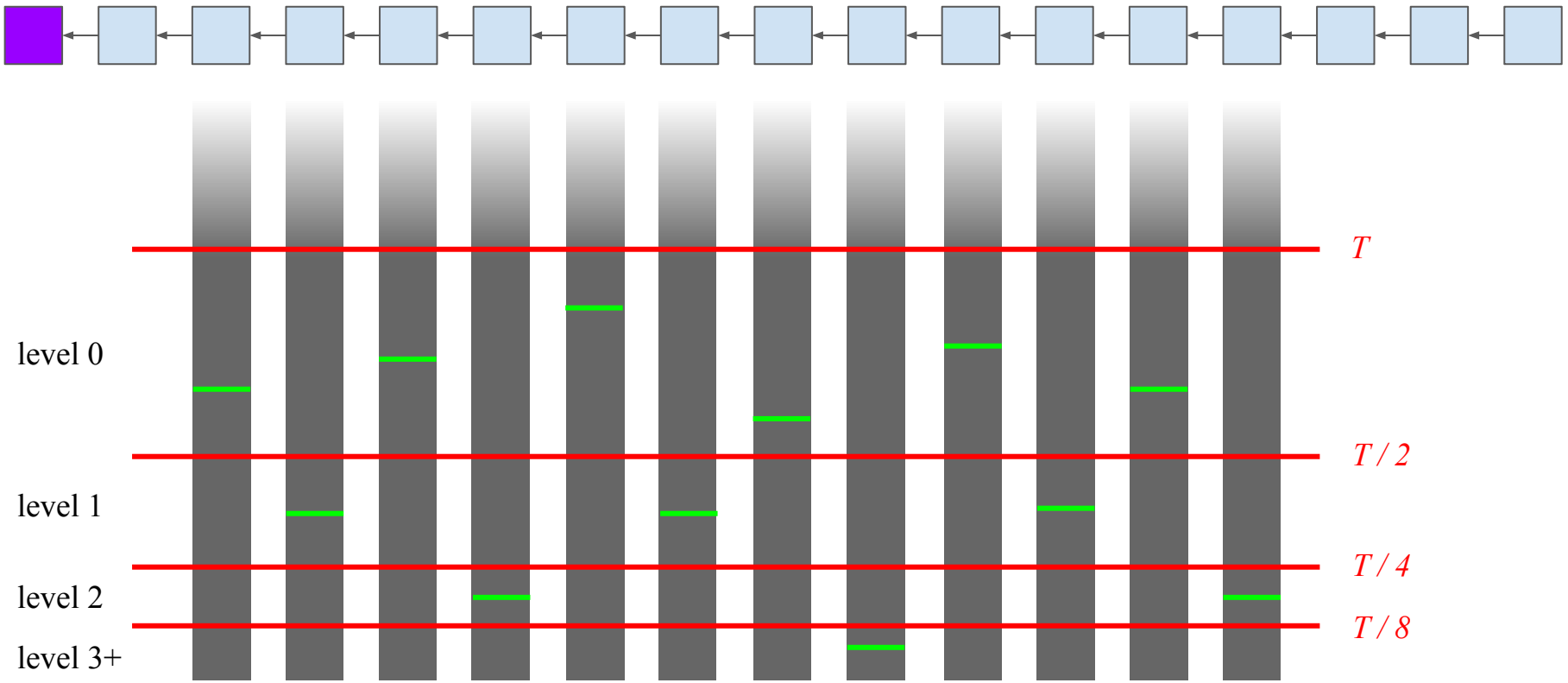
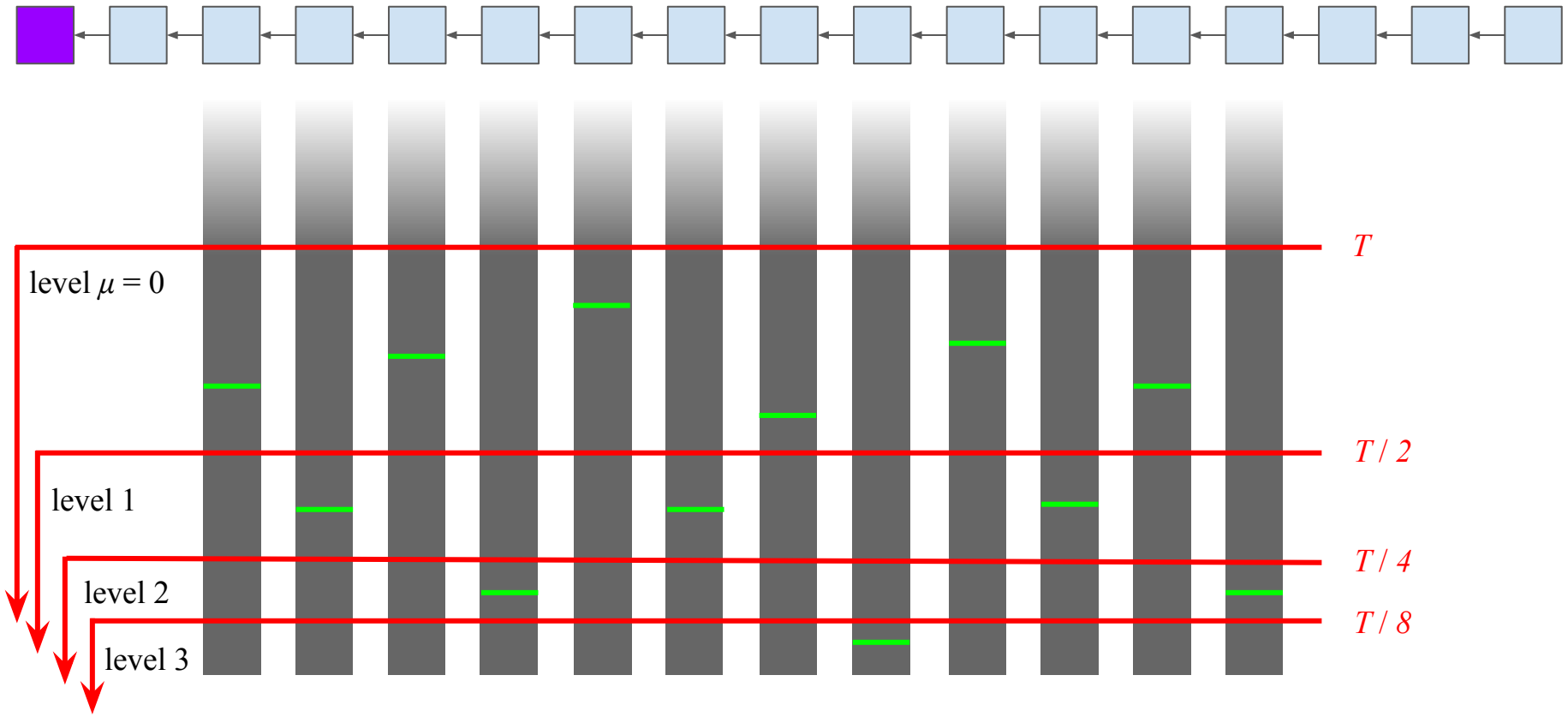
Superblocks

- Superblocks allow the construction of superlight clients
- Superlight clients are exponentially more efficient light clients
- They are built on top of NIPoPoWs = Non-Interactive Proofs of Proof-of-Work

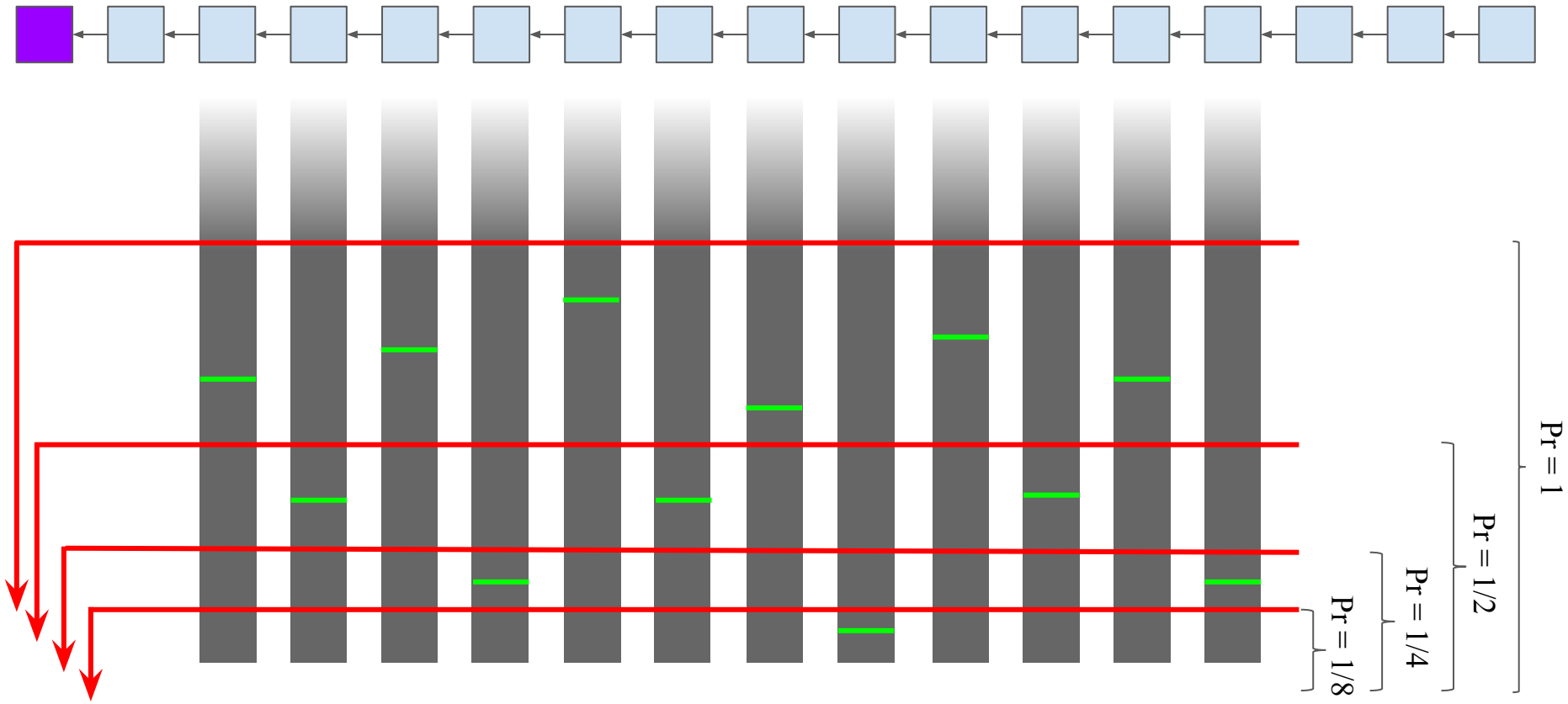


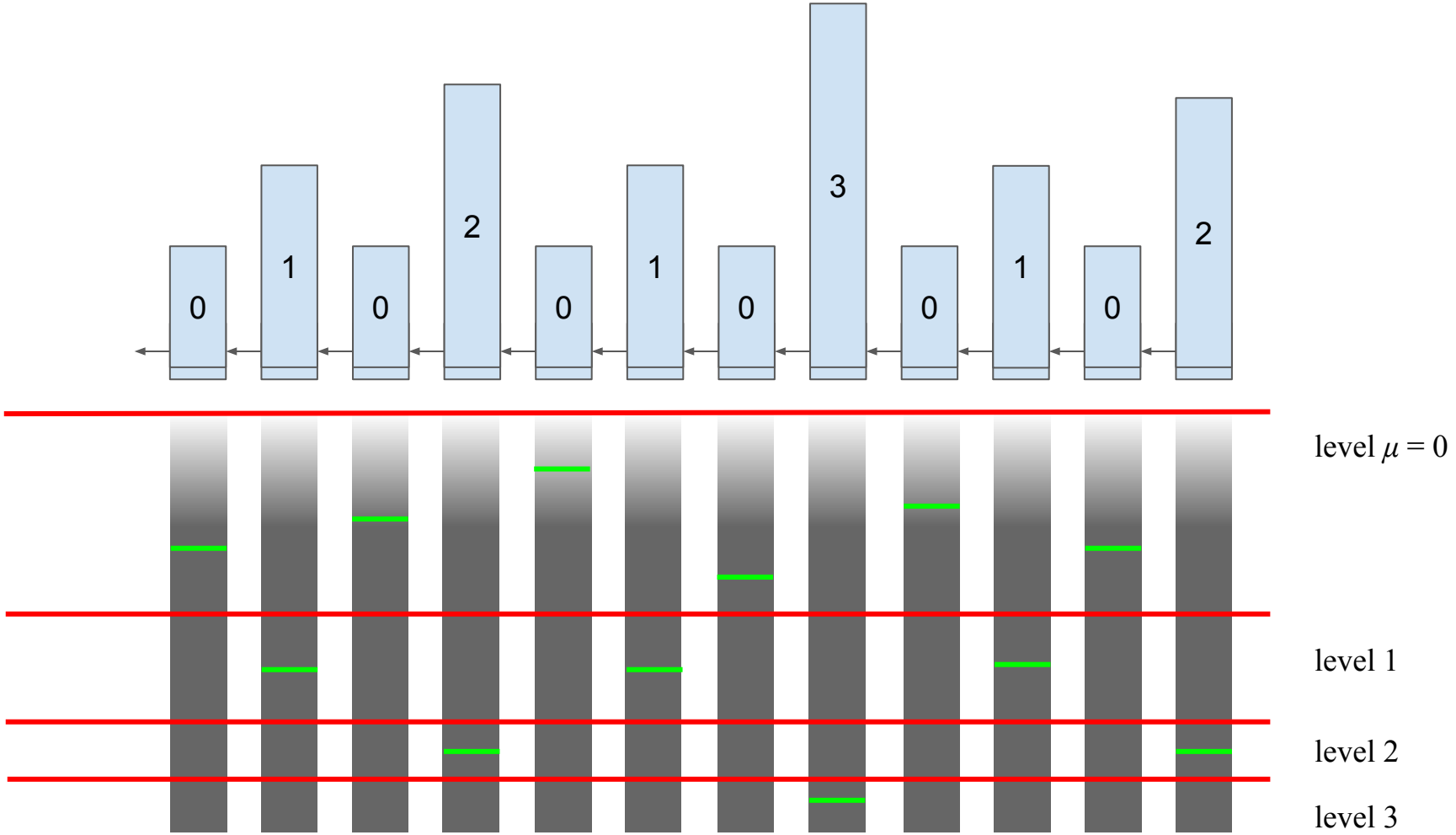

H(B) ≤ T
max H(·)
T
H(B)
0


level 0
level 1
level 2
level 3+
T
T / 2
T / 4
T / 8


level $\mu = 0$
level 1
level 2
level 3
T
$T / 2$
$T / 4$
$T / 8$

$$\Pr[\mathrm{H}(B) < T/2^{\mu} \mid \mathrm{H}(B) < T] = 1 / 2^{\mu}$$

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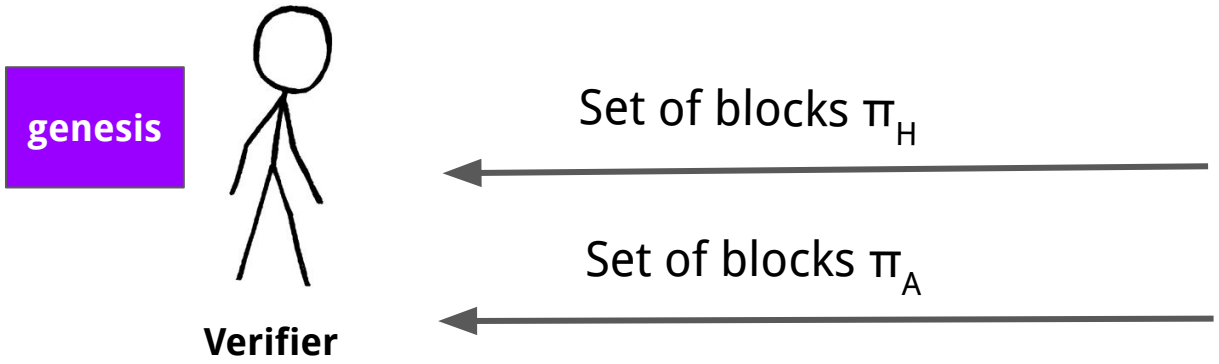
1
0
2
level $\mu = 0$
level 1
level 2
level 3

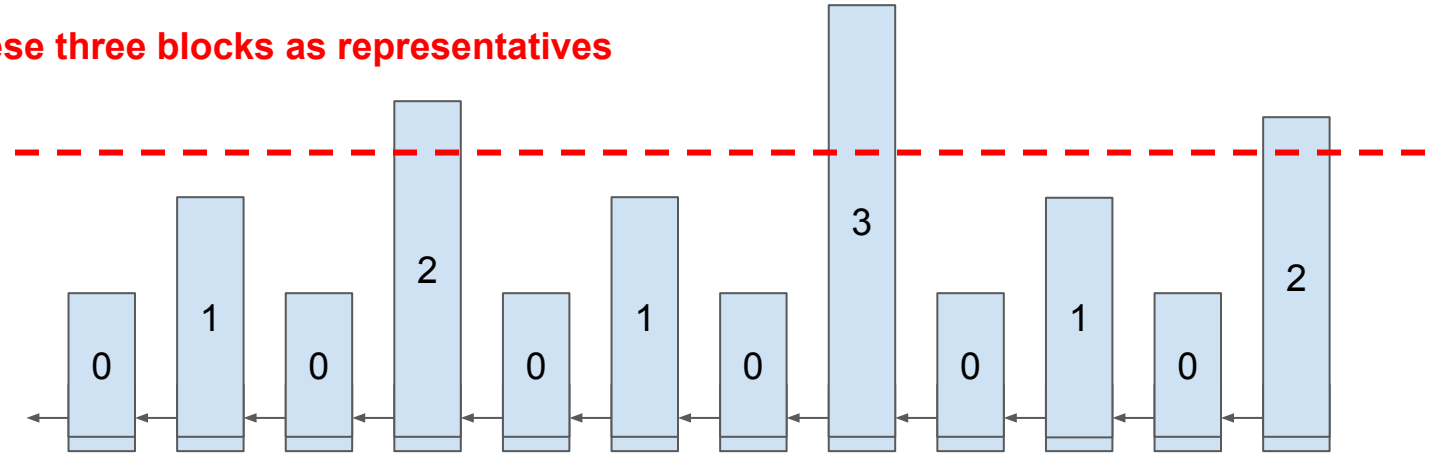
Proofs

- Verifier wants to deduce most recent $k = 6$ blocks of honest chain
- Pick highest μ with at least $m = 128$ μ-superblocks
- Proof with most μ-superblocks wins



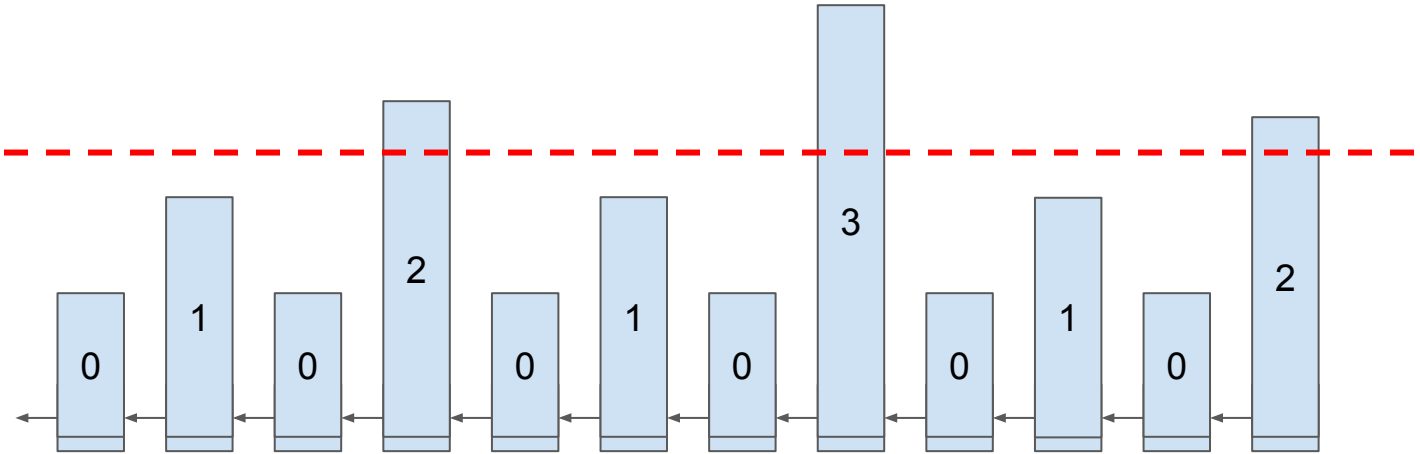
Does π_H have more μ-superblocks than π_A?

just send these three blocks as representatives



Bribing attacks against superblocks -- withholding

- NIPoPoW protocols are secure in the cryptographic/backbone model
- What about incentives? Rational model
- NIPoPoWs can allow the transfer of large amounts of money
- A simple bribing attack can break the protocol:
  - Adversary pays rational miners to *withhold* superblocks
  - If block reward is R, adversary pays rational miner R+ε to *withhold* superblock
  - This *biases* the chain of honest parties to have fewer superblocks per blocks
  - The same attack applies in simple Bitcoin, but is *much* more expensive
- Incentive attack discovered by Benedict Bünz et al. from Stanford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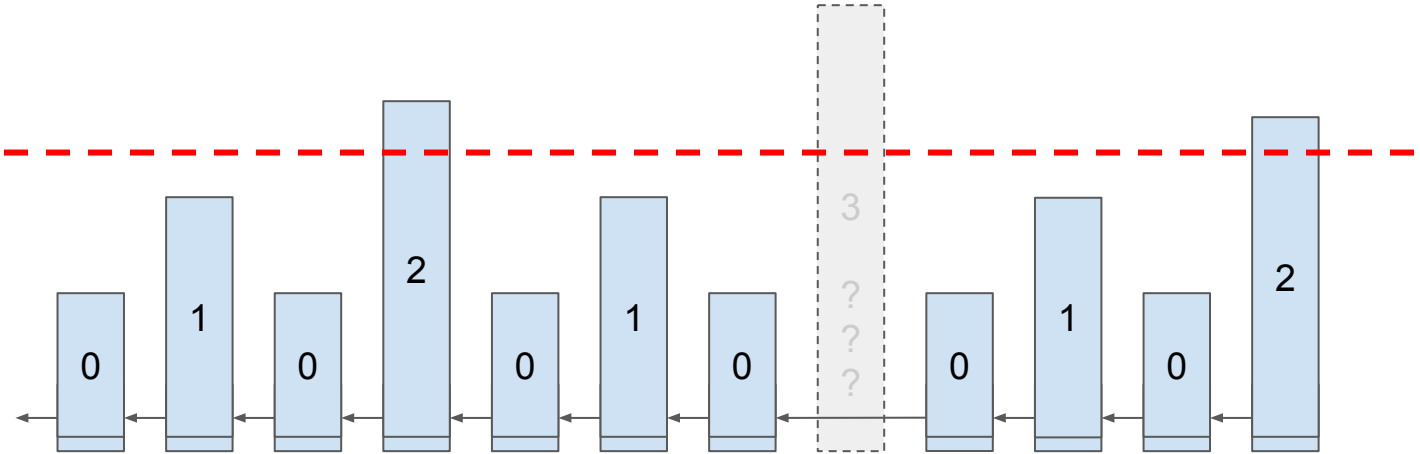
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2

Reason for bribing attacks

- Bitcoin is also susceptible to bribing attacks
- If `block reward * k << value transferred`
- But superblocks get same reward as regular blocks
- Withholding m superblocks allow adversary to hide μ-superchain at any level
- Superblock bribing attack stems from all blocks having the same reward
- Can we change the reward of blocks?

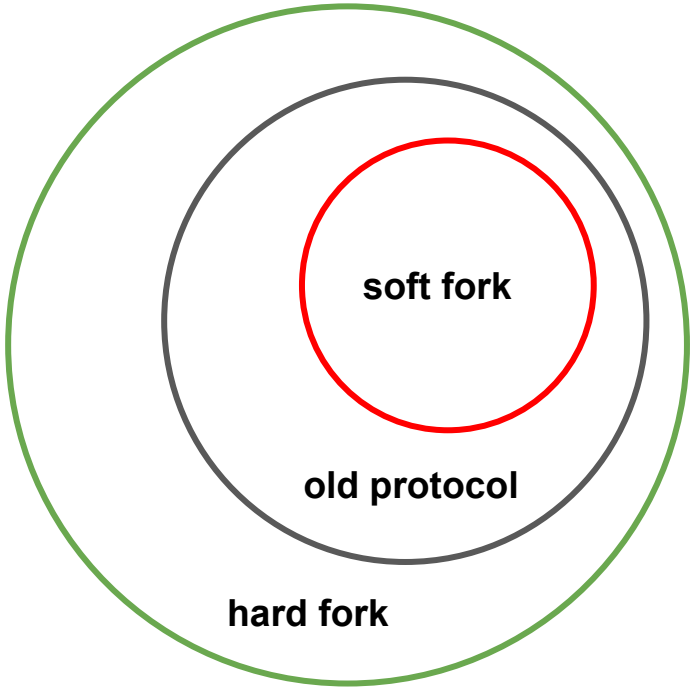
Idea! Superblocks should pay out more

- If simple block reward is R, then μ-superblock should be rewarded with 2^{μ} R
- That way, superblock bribes cost the same as regular bitcoin bribing

Review: Hard and soft forks

Soft fork

- **Reduces** the validity language
- txs / blocks that were valid are now invalid
- All old invalid txs / blocks are still invalid
- Old miners **accept** new-style txs / blocks
- New miners **reject** some old-style txs / blocks



How to soft fork?

- Seems difficult to make blocks pay out *more* with a soft fork…
- After all, why would unupgraded miners accept blocks paying out more as valid?
- Approach: Pay out exactly the same as before
- Use a *smart contract beneficiary** to receive these payouts
- Miners themselves get paid only later
- **Require** valid blocks to pay out to **this** smart contract only

* this idea was pioneered by SmartPool

Conditions for paying out

- Smart contract must have enough money to perform payout
- Lower reward of regular block so that superblocks can be paid out

Example schedule:

- Regular block reward R’ becomes 1/10 of old block reward R
- μ-superblocks receive 2^{μ} R’

With a few minor adjustments:

- μ-superblocks are only rewarded after the first m
- R drop to a half every time a power of 2 blocks have passed

Conditions of applicability

Expectation of payment must be upper-bound by previous policy:

```
old average payment per block
                >=
new average payment per block
```

What happens if contract becomes bankrupt?
No problem, wait until it receives more rewards, pay debts later

```
contract SuperBlocks {
  uint256 constant public R = 0.5 ether;
  uint256 constant public m = 128;
  mapping(address => uint256) balances;
  mapping(uint256 => bool) blockClaimed;
  mapping(uint256 => uint256) muCount;

  function () external payable {
    // just accept the payment
  }

  function claimBlock(int blockNumber, int realMu, int claimedMu) {
    // must be called within a 256-block window
    uint256 blockHash = blockhash(blockNumber);
    // require miner to annotate block by including a first tx
    require(getBlock(blockNumber).transactions[0].sender == msg.sender);
    require(!blockClaimed[blockNumber]);
    // check superblock level of block
    require(blockHash >> realMu == 0);
    require(blockHash >> (realMu + 1) > 0);
    require(claimedMu <= realMu);
    muCount[realMu]++;
    require(muCount[claimedMu] >= m);
    blockClaimed[blockNumber] = true;
    // allocate reward
    balances[msg.sender] += R * 2^claimedMu;
  }

  function withdraw(uint256 amount) {
    require(amount >= balances[msg.sender]);
    balances[msg.sender] -= amount;
    msg.sender.send(amount);
  }
}
```

Other applications

Blinded mining

- Reward miners for later revealing a hidden commitment in a block
- Useful building block for variable difficulty NIPoPoWs
- (Superblock level is hidden until block becomes confirmed)

Other applications

Smooth emission

- Block rewards half every 4 years on bitcoin
- There are other schedules for other coins
- This sudden change in rewards has chaotic influence on the economy
- Some coins emit “smoothly”
- i.e., change the amount of reward per block slowly
- We can change a sudden emission coin to a smooth emission coin with a soft fork
- The smart contract acts as a low-pass filter

Non-applications

Difficulty bombs

- Increase difficulty of blocks
- While it is possible to do with a soft fork in this manner, it is insecure

Other applications

Ensuring availability -- online miners

- Require miners to answer questions about data in block
- Only after, say, 1000 blocks of availability, reward miner
- If block data is withheld and proof of it can be presented, remove miner reward

Thank you! Questions?

HELLENIC REPUBLIC
National and Kapodistrian
University of Athens

INPUT | OUTPUT

References

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