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VISA Research

FLYCLIENT

SUPER LIGHT CLIENT FOR CRYPTOCURRENCIES

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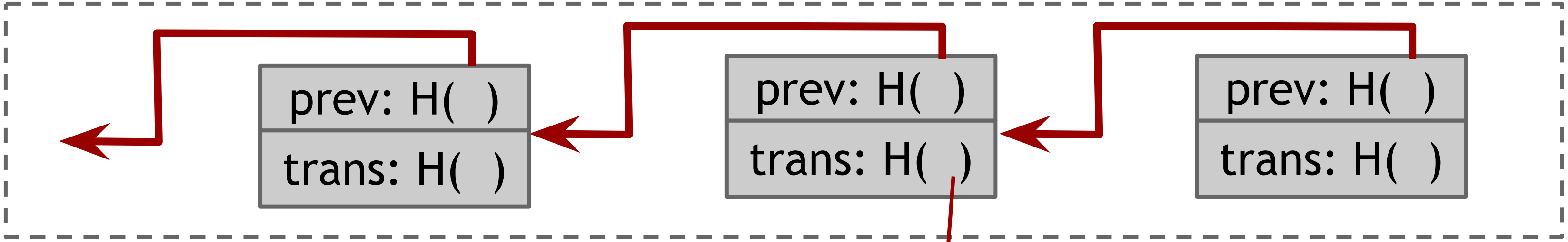
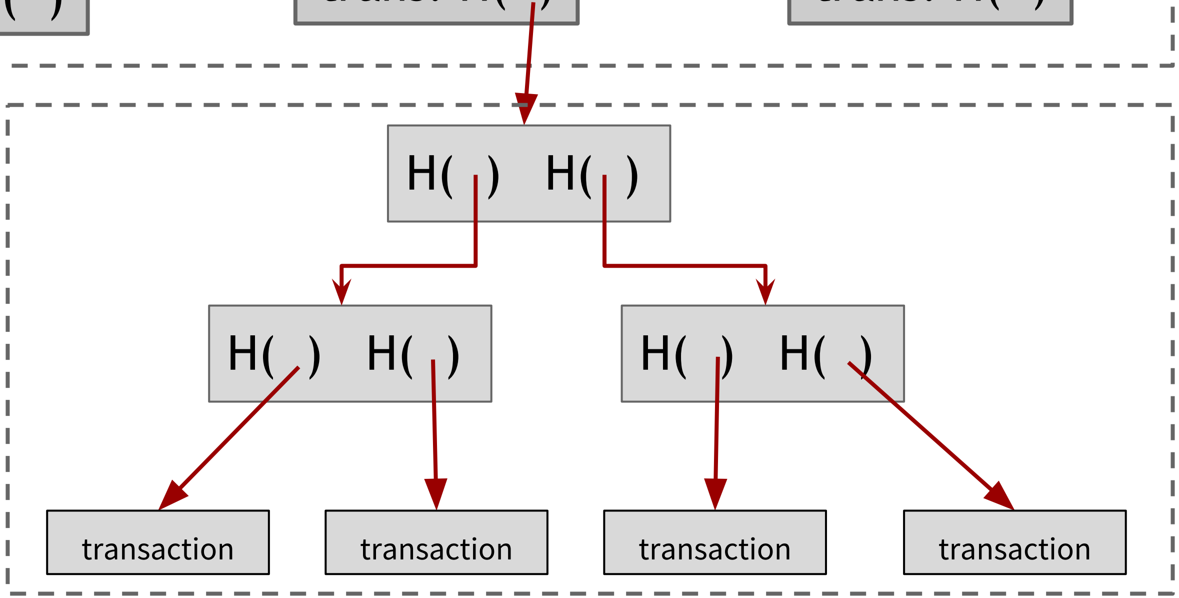
Recall: Bitcoin blockchain format

Hash chain of blocks

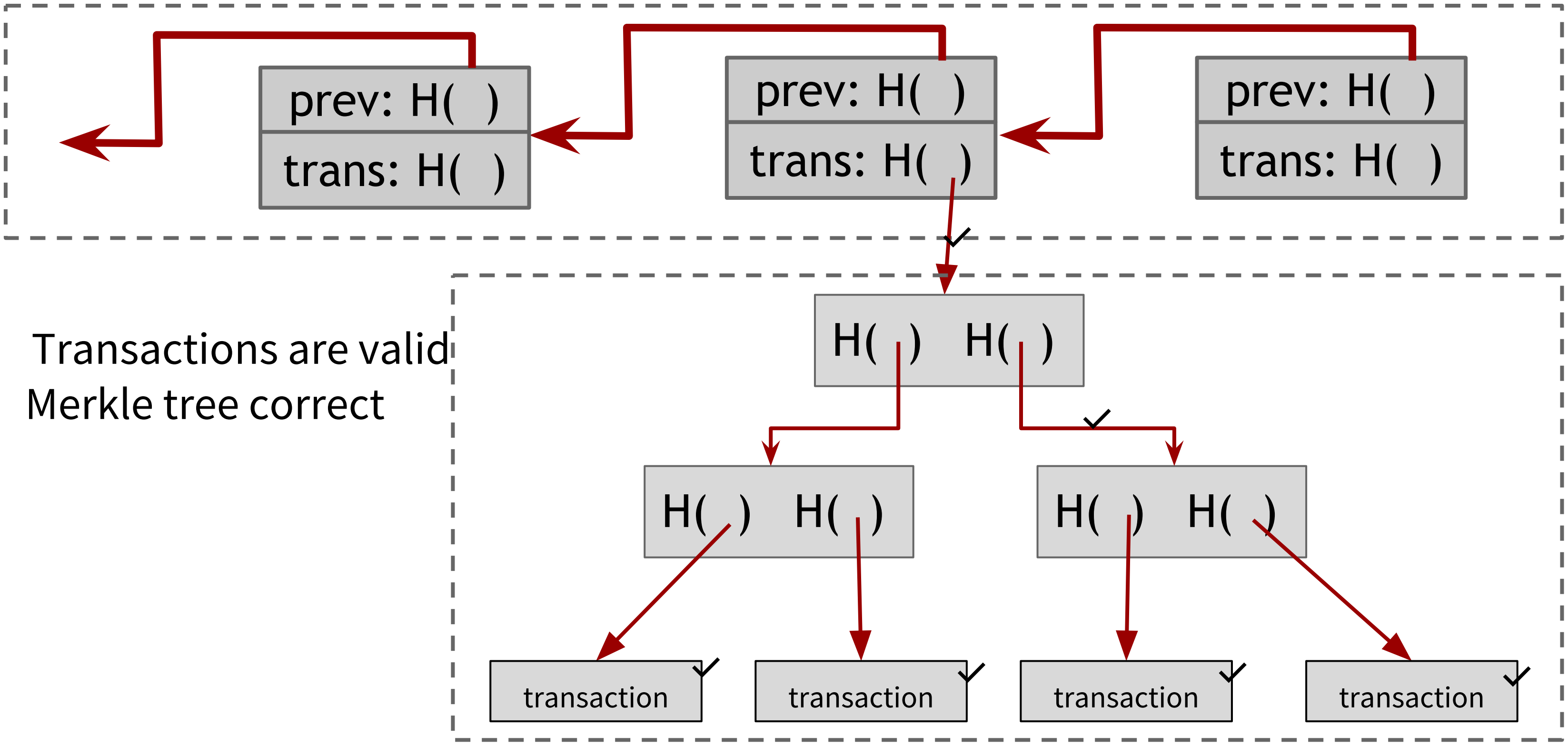


Hash tree (Merkle tree) of transactions in each block



Validity of a blockchain

Hash chain of blocks



1. Transactions are valid
2. Merkle tree correct

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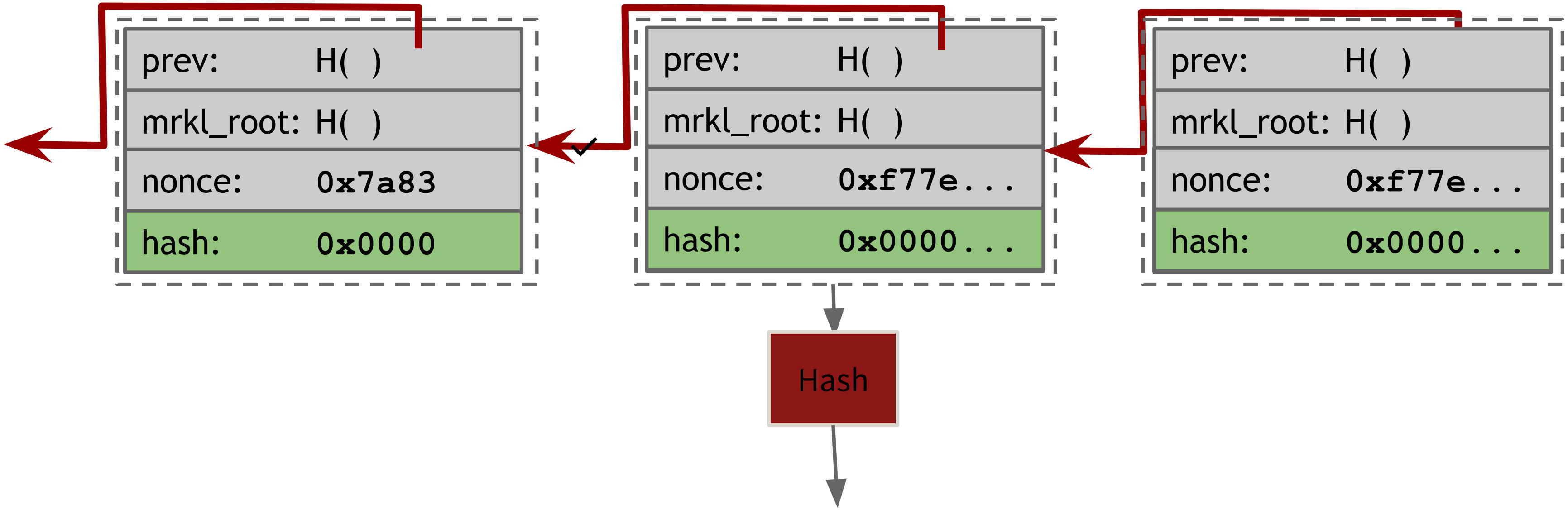
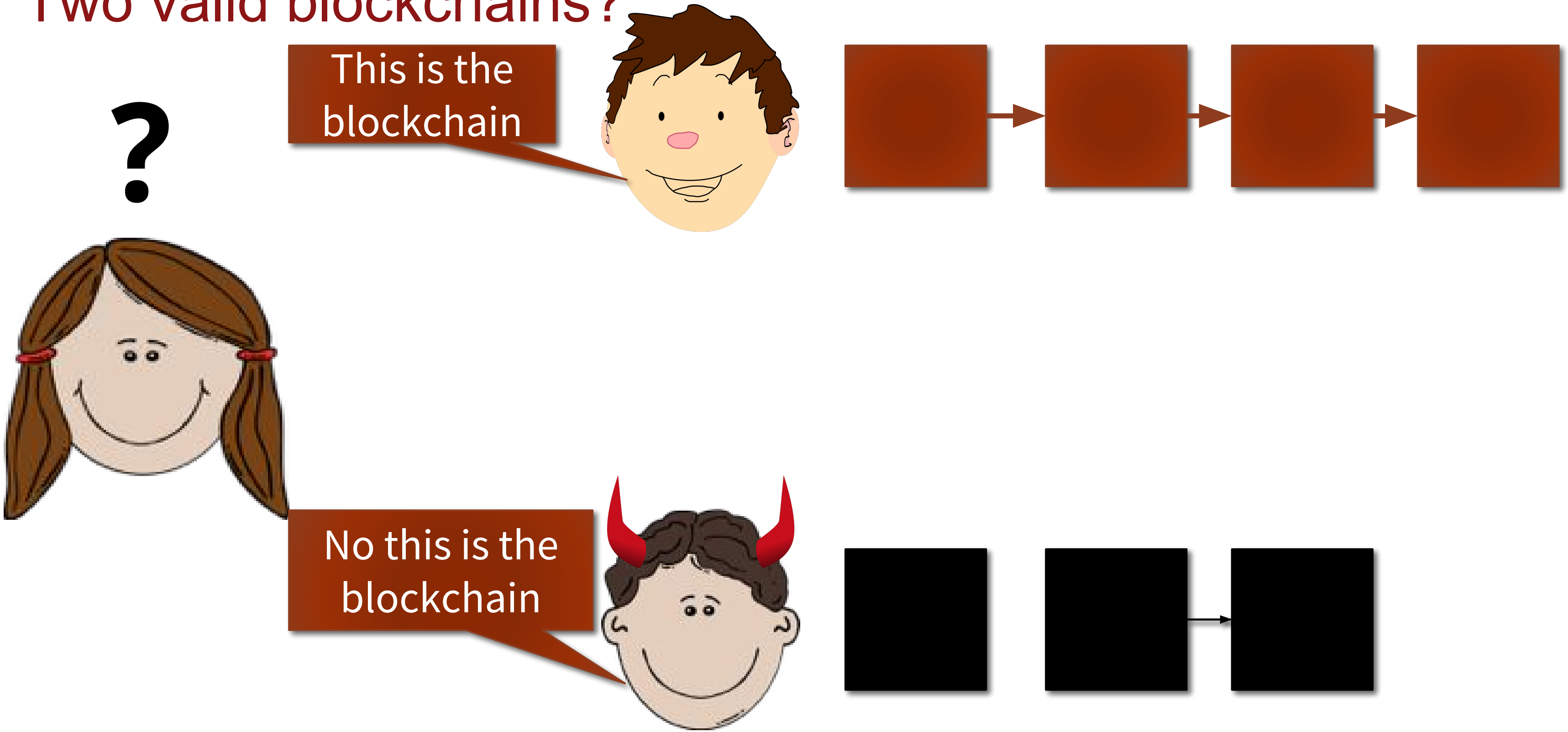
3. Validity of a block header



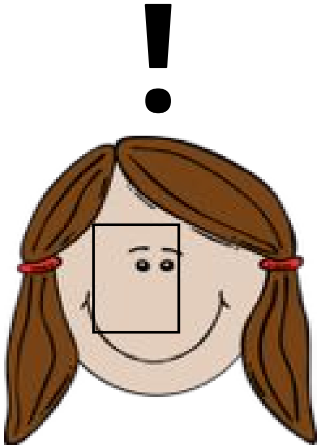
≤ 00000000000000001FB8930000000000000000000000000000000000000000000000

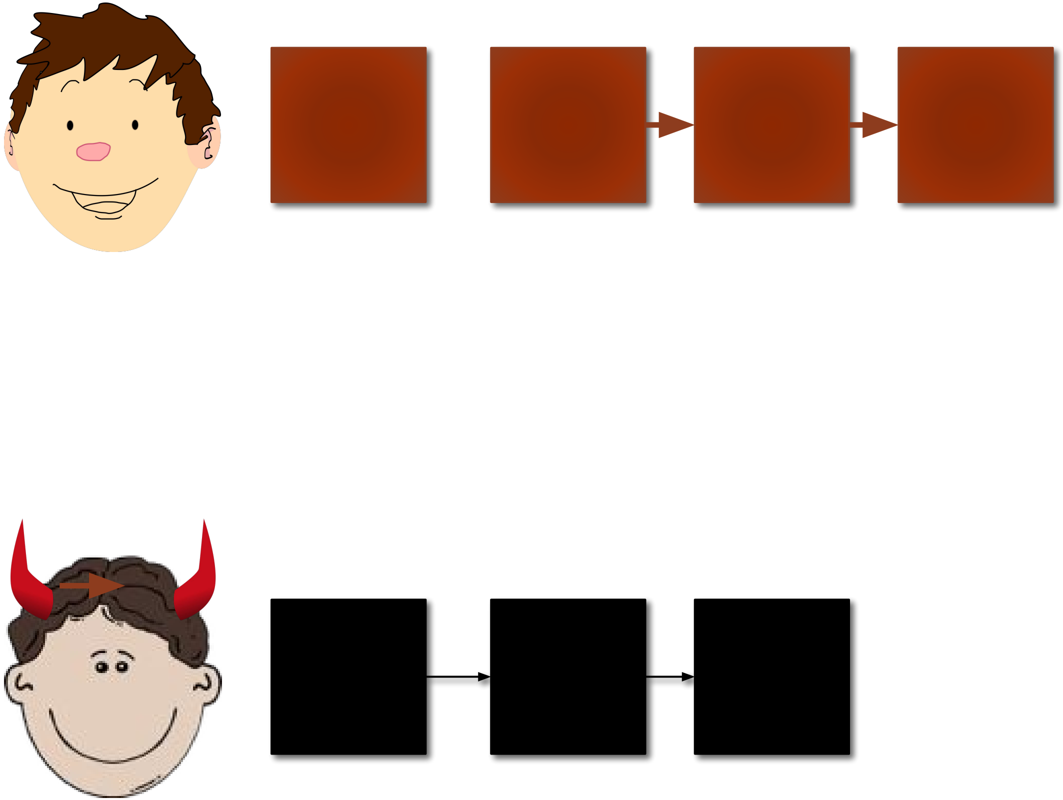
70+ leading zeroes required… ✓

Two valid blockchains?



Longest chain rule





Take the longest chain!
Harder to produce.

Proof of work conjecture

- Honest mining is a dominant equilibrium strategy
- The majority of miners act rational

- Implies that longest chain follows the rules of the network

- Sleeping beauty property: You can always distinguish honest and honest chains after being offline

- Does not (necessarily) hold for proof of stake

- As long as one of the nodes you are connected to is honest you will find the best chain

Blockchain size: A growing problem

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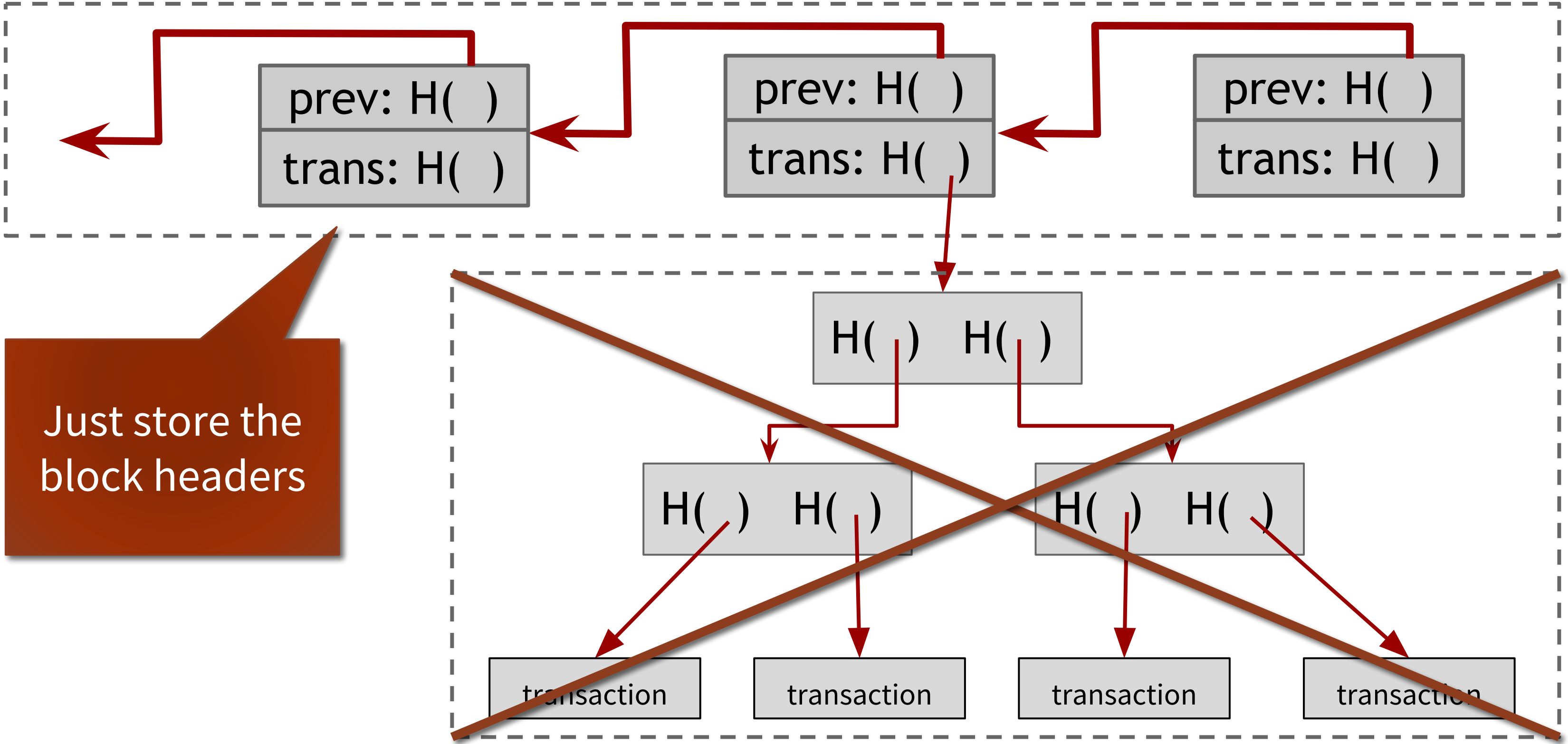
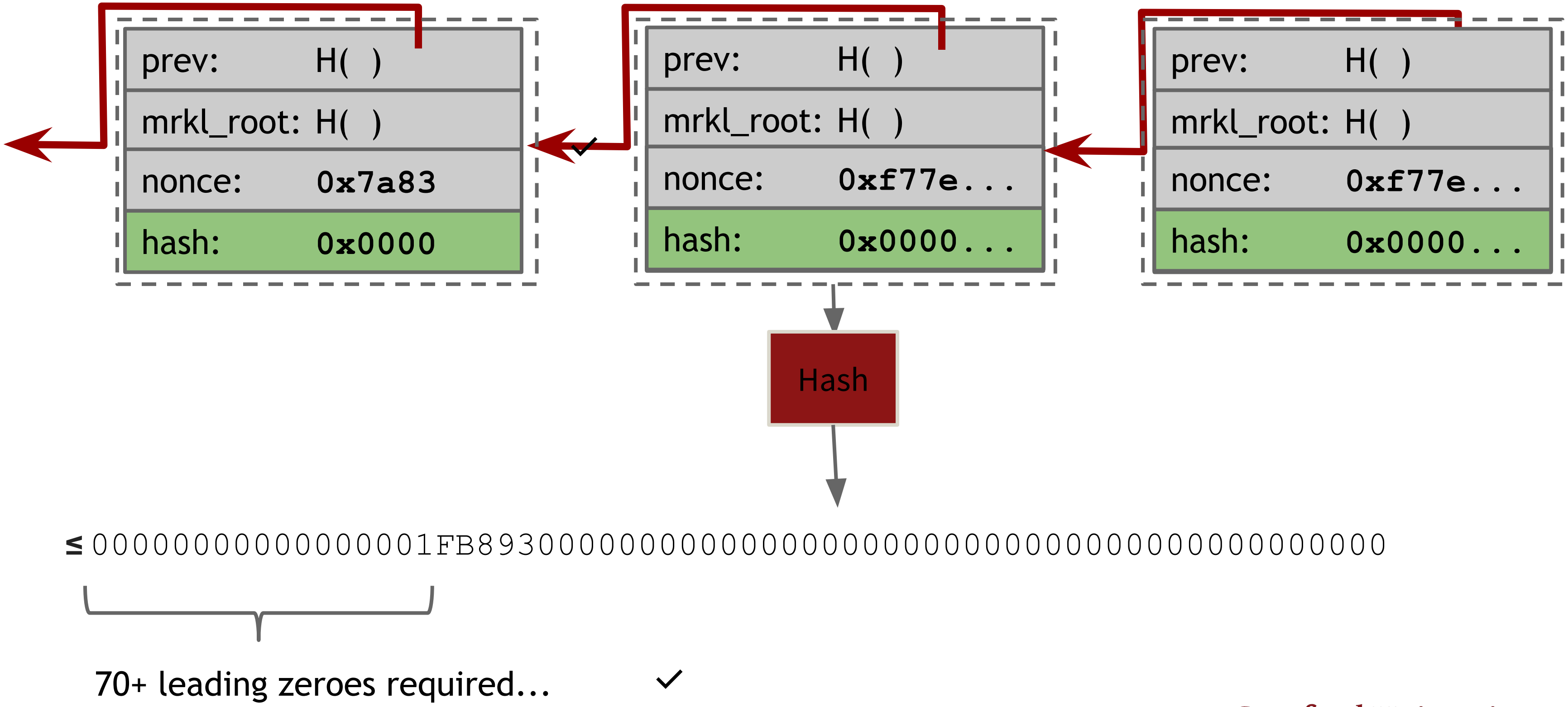
Simple Payment Verifying Client (Satoshi 2008)

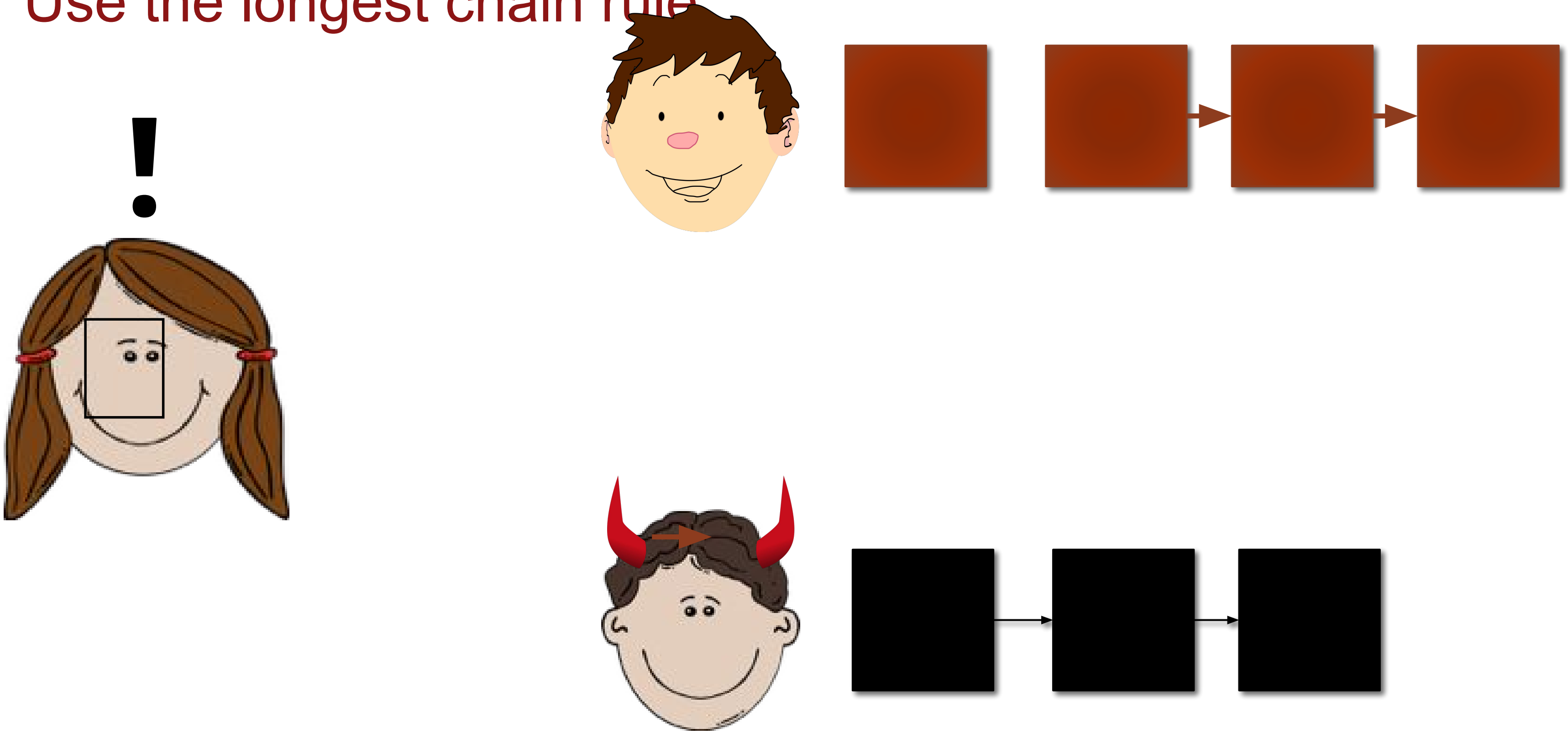


Just store the block headers

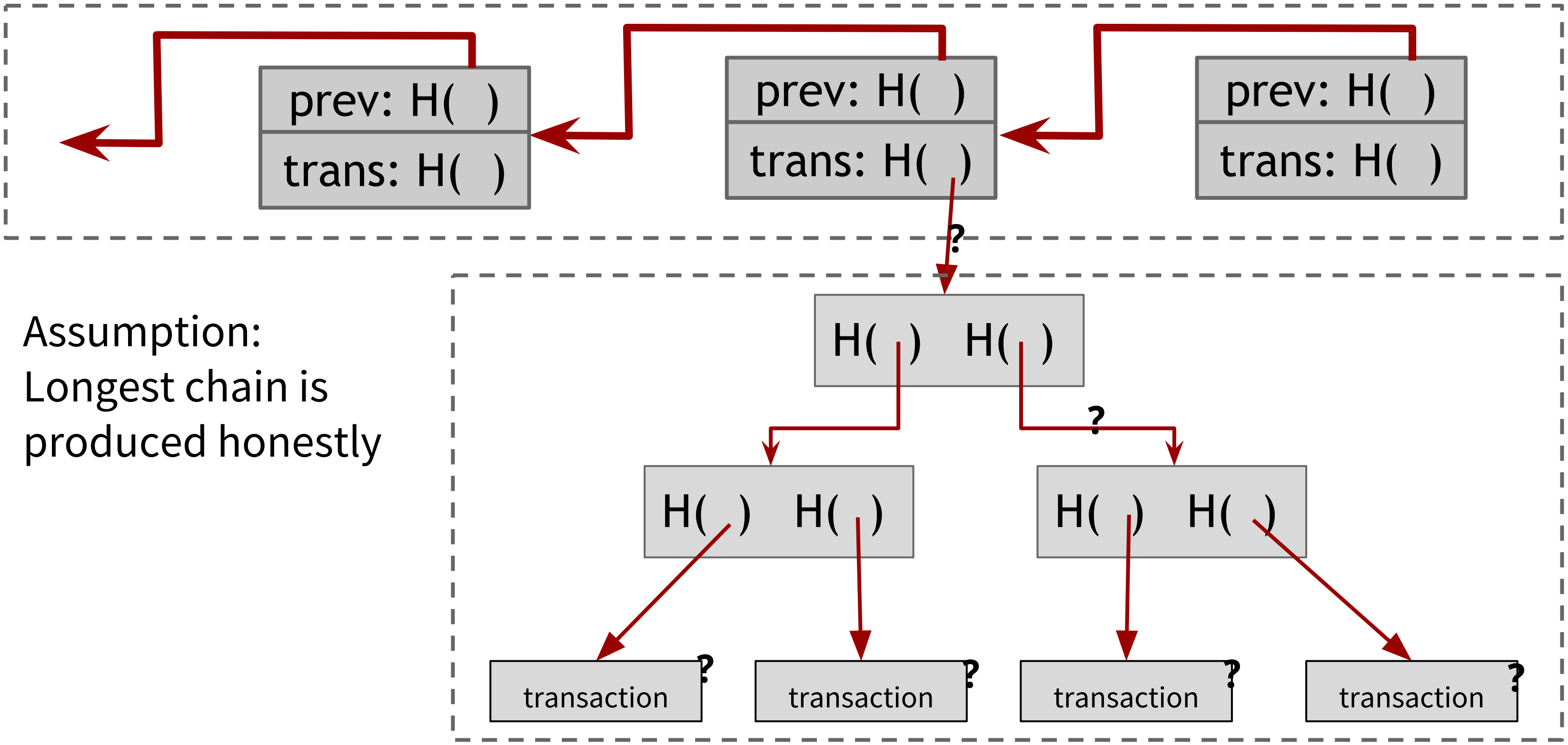
Verify block headers



Use the longest chain rule

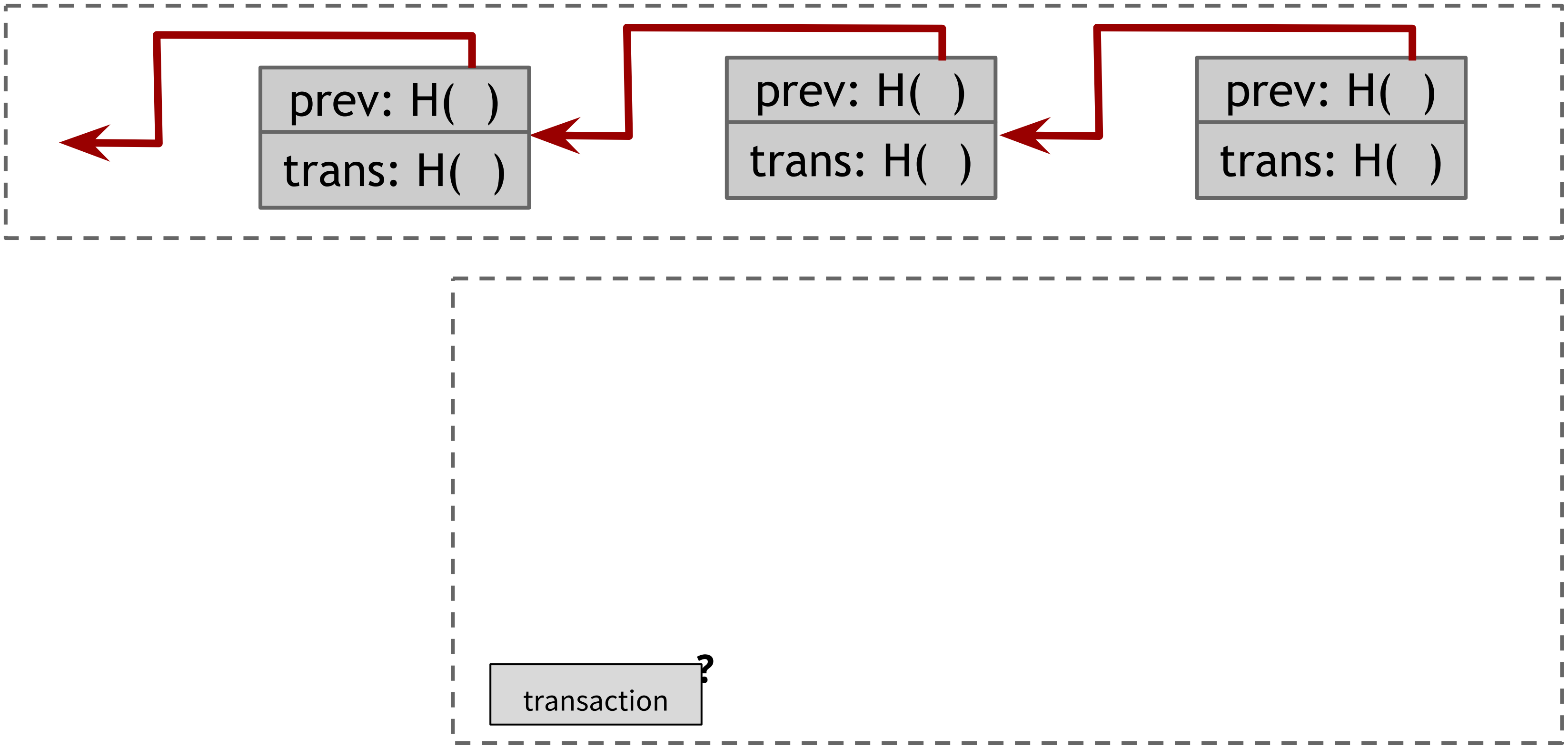


Can’t verify all transactions (but that’s ok)

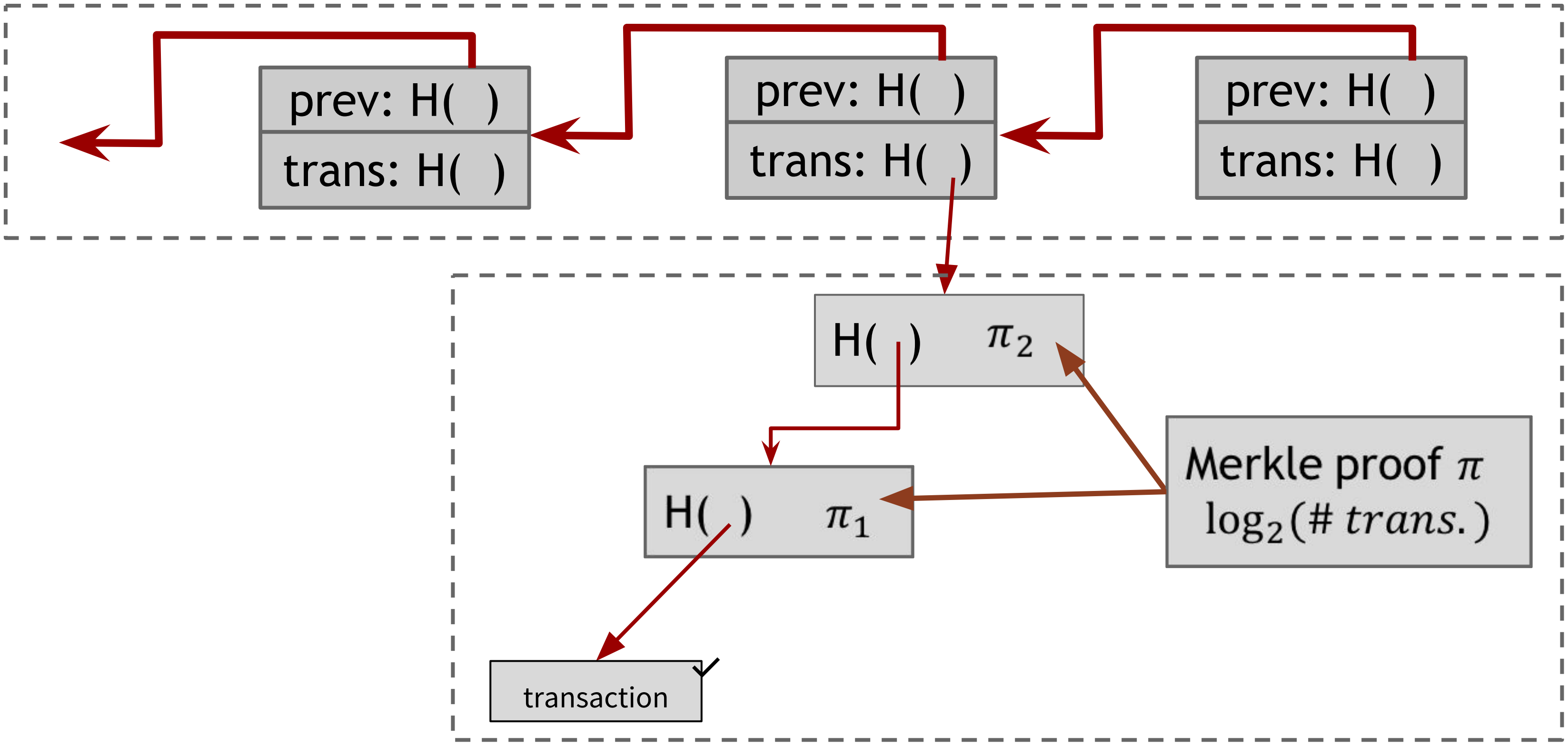


Assumption:
Longest chain is
produced honestly

Can verify specific transactions (with help)



Can verify specific transactions (with help)



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SPV Properties and Problems

- Can determine the longest chain
- Can verify transaction inclusion
- Does not grow with #transactions
- 80 bytes * #blocks (Bitcoin)
- 508 bytes * #blocks (Ethereum)
- Sufficient for sidechains and swaps

- Can't verify all transactions
- Grows with #blocks
- Less block time-> larger SPV client
- 40 MB in Bitcoin
- 2.2 GB in Ethereum
- Especially bad for multi-chain clients

Sublinear SPV-Clients: SNARKs

- SNARK or CS-Proof/CIP/STARK (Micali 91, Ben-Sasson et al. 17)
  - Constant size non-interactive proof that chain has length X
  - Circuit verifies full blockchain
  - Not practical for prover
  - SNARKs closer to being practical but trusted setup

Sublinear SPV-Clients: NiPoPoWs

- Kyriasis, Miller, Zindros 17
- Based on Kiayias, Lamprou, Stouka 16 and Back et al. 14

- Insight: If I want to find x such that H(x) has n 0s then I will find 2 x’ such that H(x’) has n-1 0s, 4 x’’ such that H(x’’) has n-2 0s …

- Best quality proof of work indicates quality of whole chain

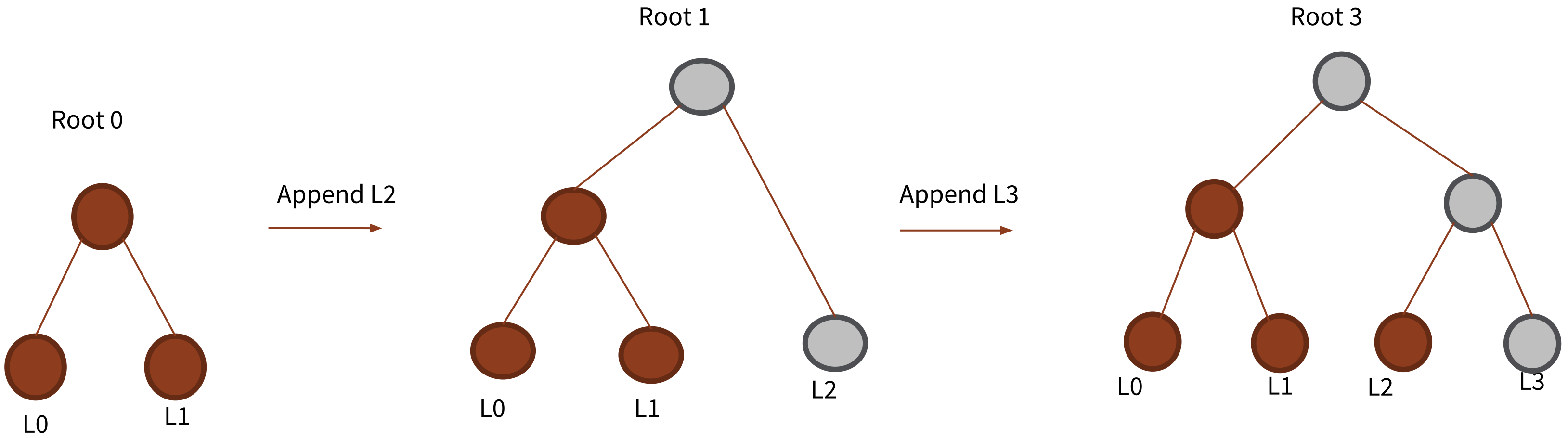
- Use a skiplist to point to proofs with less proofs of work

- O(log(n)*log(log(n))) proof size

NiPoPoW bribery attack

- High quality blocks do not give extra reward
- But they are important for NiPoPows[1]
- Bribe ~~honest~~ rational miners to throw away super high quality blocks
- Main chain “looks” worse which makes fooling SPV client easier
- Does not violate NiPoPow’s security proof because honest mining and not rational mining is assumed
- Motivates search for different NiPoPows

Merkle Mountain Ranges (Todd 16)



Log(n) inclusion proofs
Log(n) updates
nth tree commits to kth tree k<n
Log(n) difference proofs

Flyclient: A different approach to super-light clients

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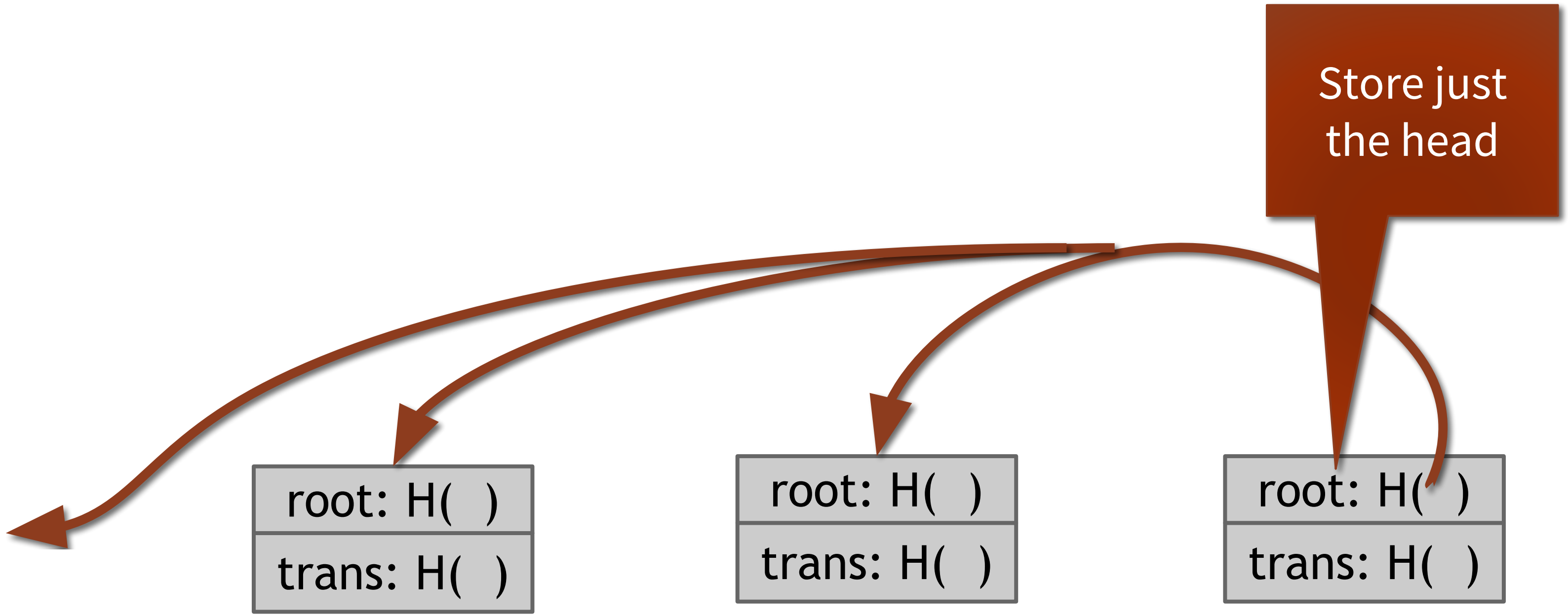
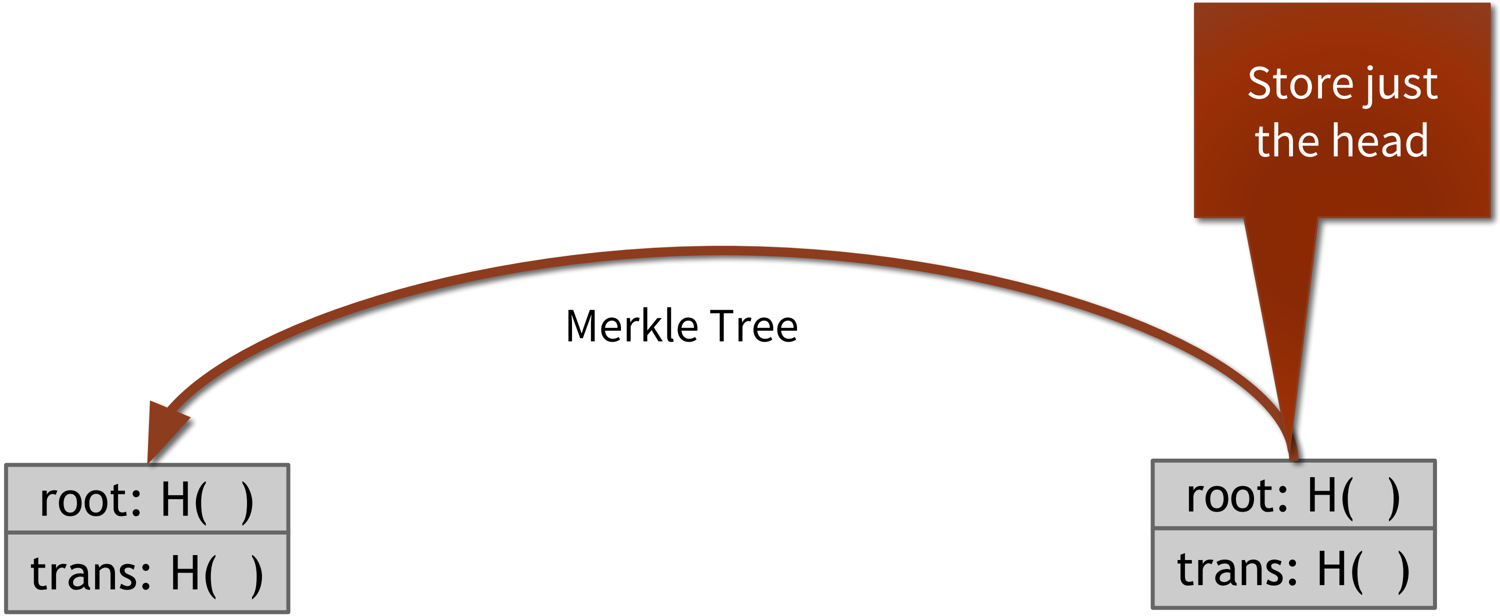
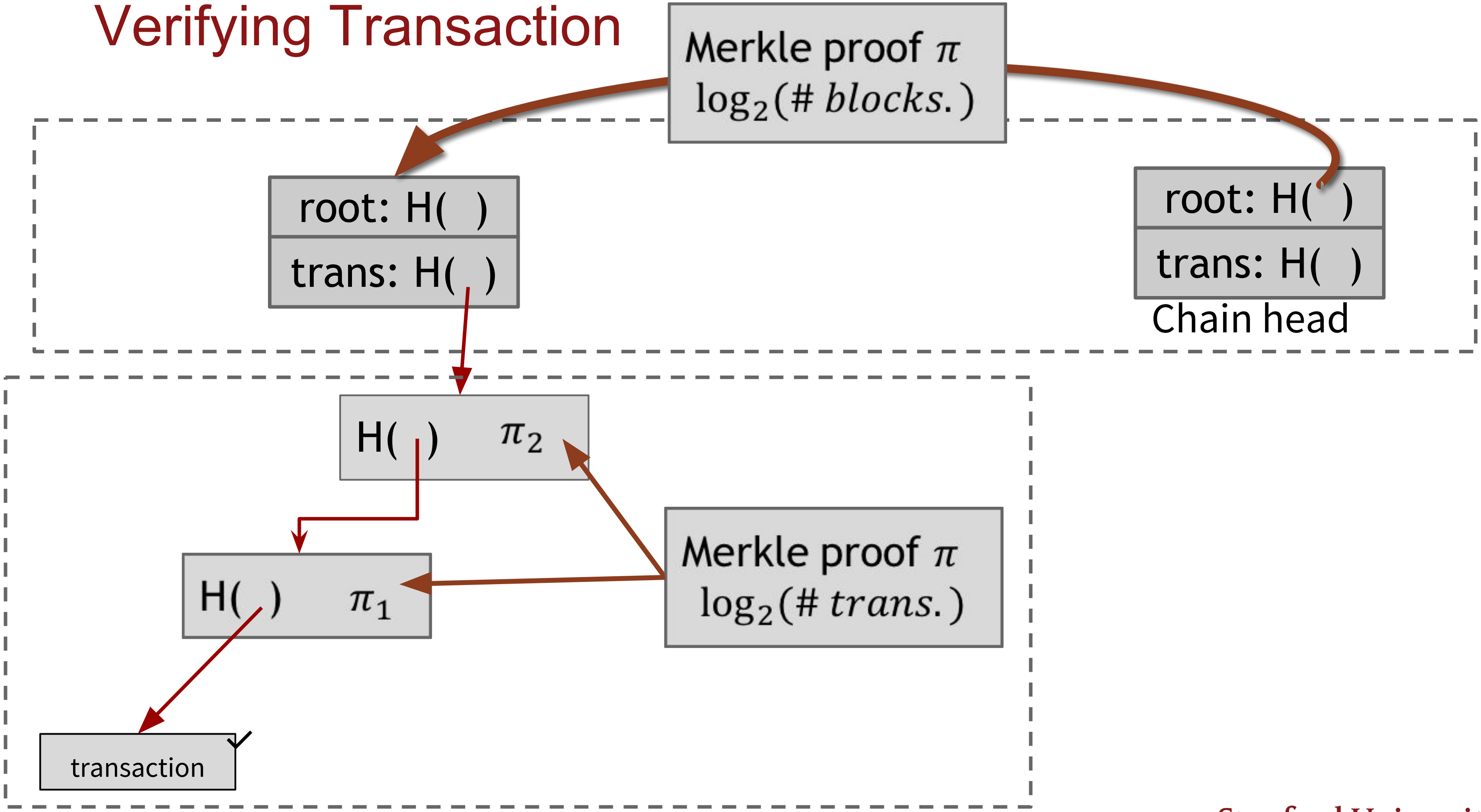


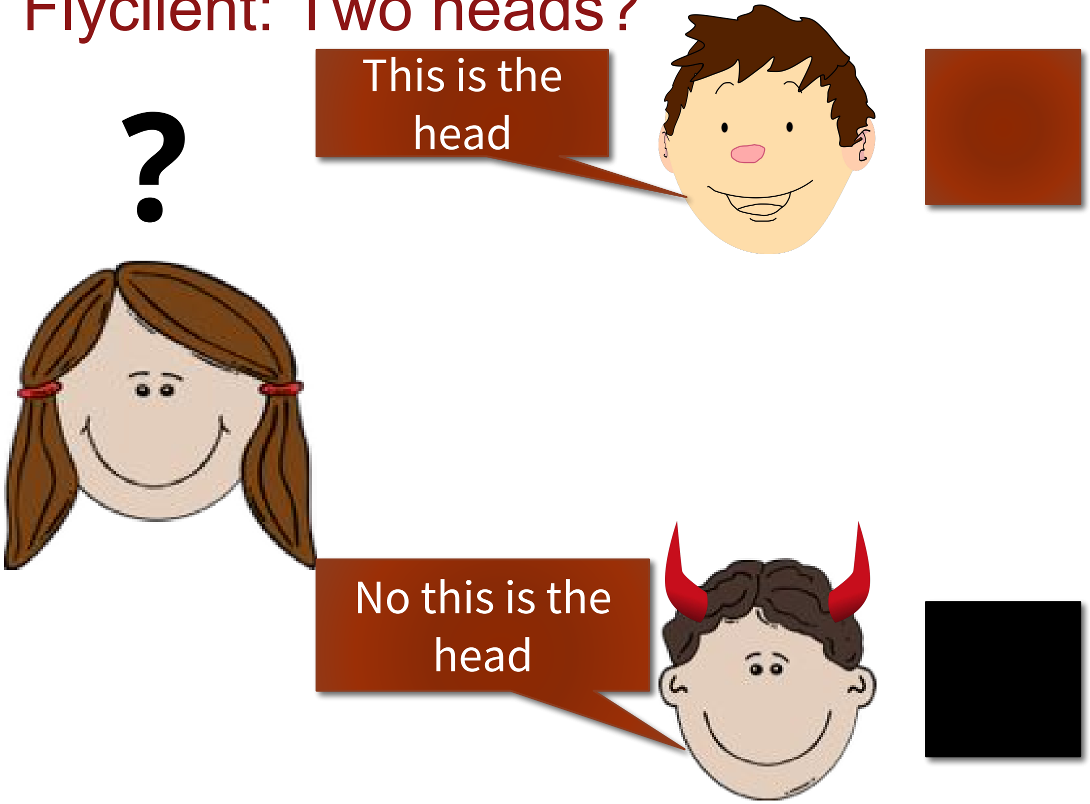
Flyclient: A different approach to super-light clients



Verifying Transaction



Flyclient: Two heads?



Assumption:
At least one chain is honest

Other one has at most a c fraction of the mining power
Ex: c=1/3

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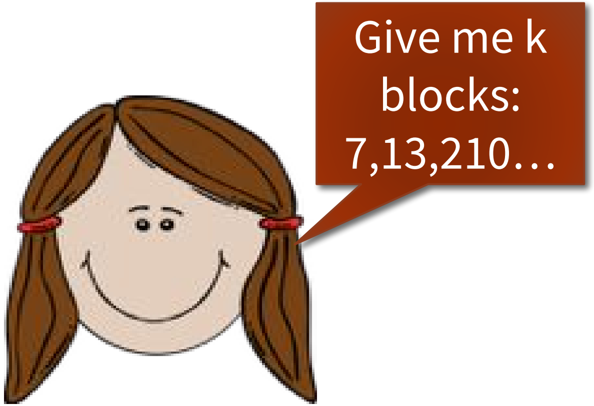
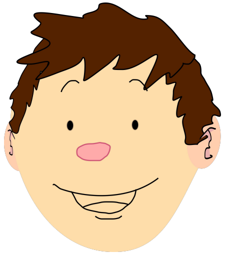
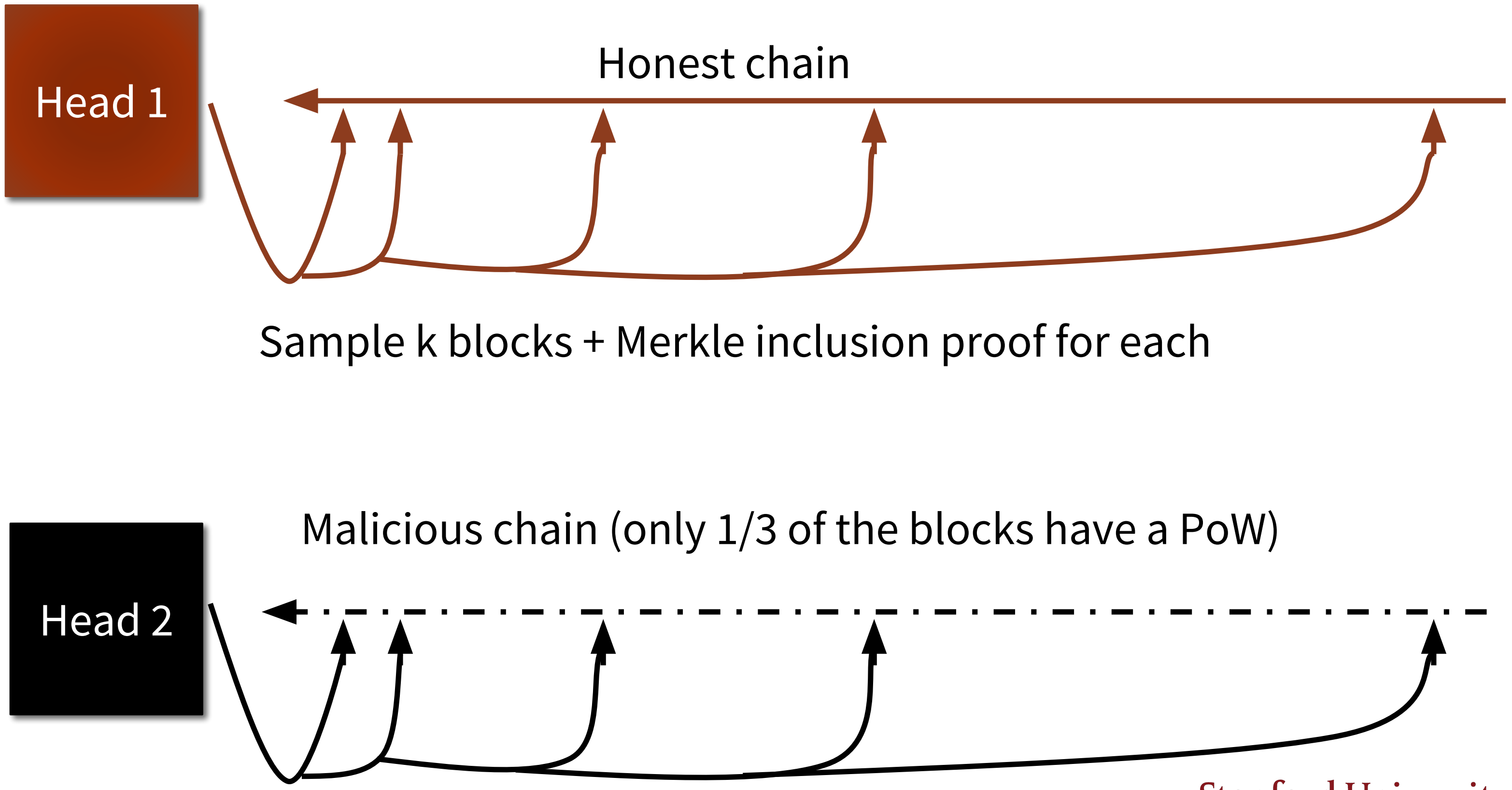
Flyclient Strawman 1





Flyclient Strawman 1: sample constant # of blocks



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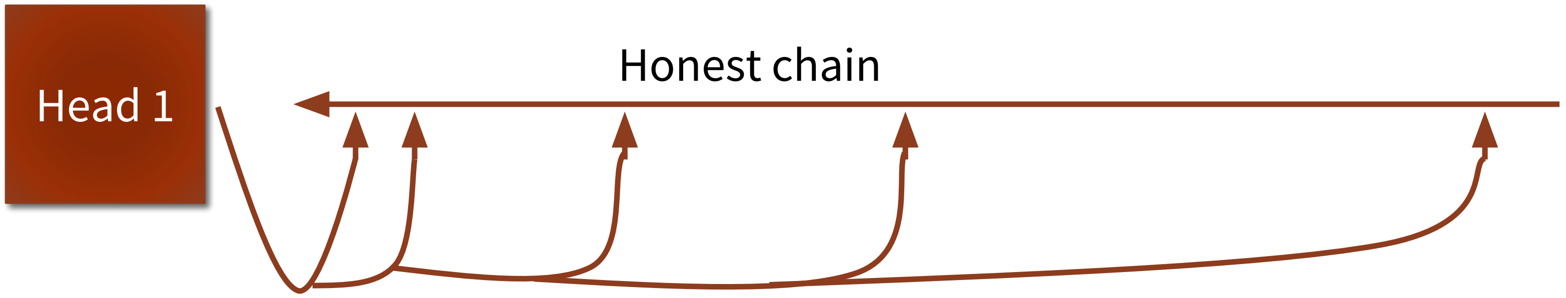
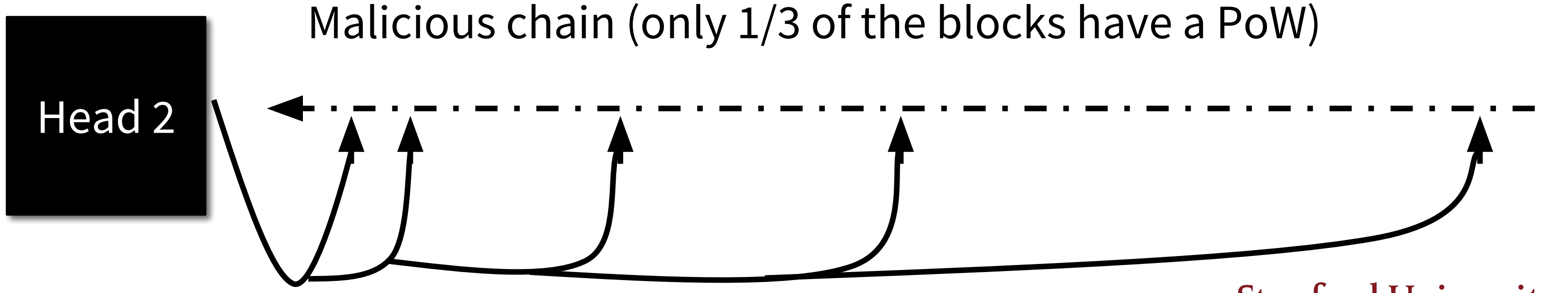


k samples and $\frac{1}{3}$ mining power →Advers. wins with $\frac{1}{3}^k$

$$k = 81 \rightarrow P[Cheating] < 2^{-128}$$



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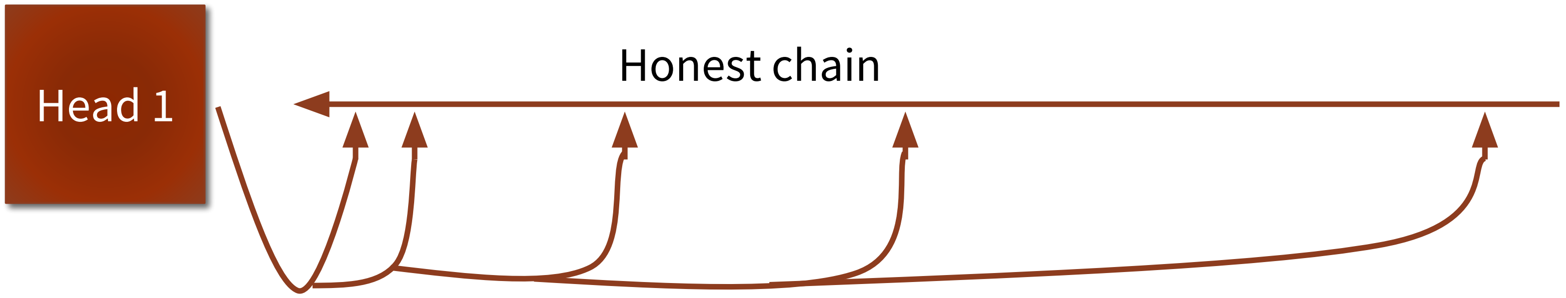

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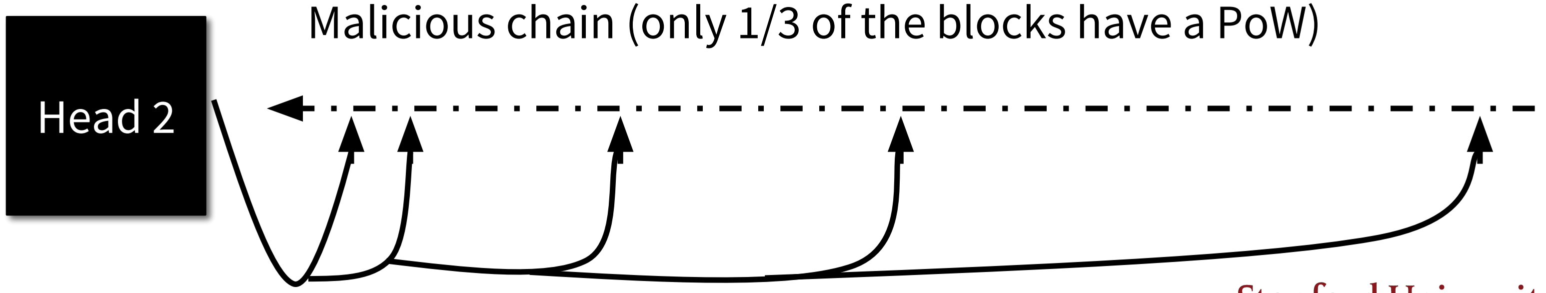

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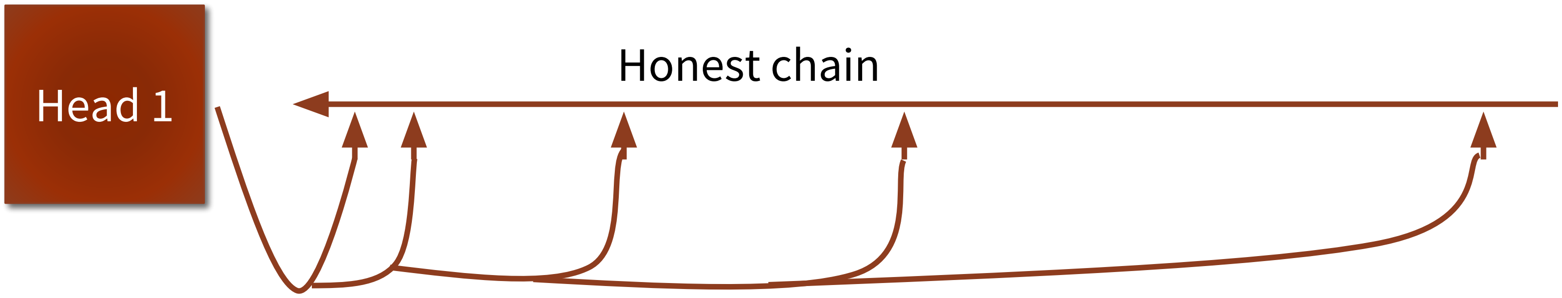

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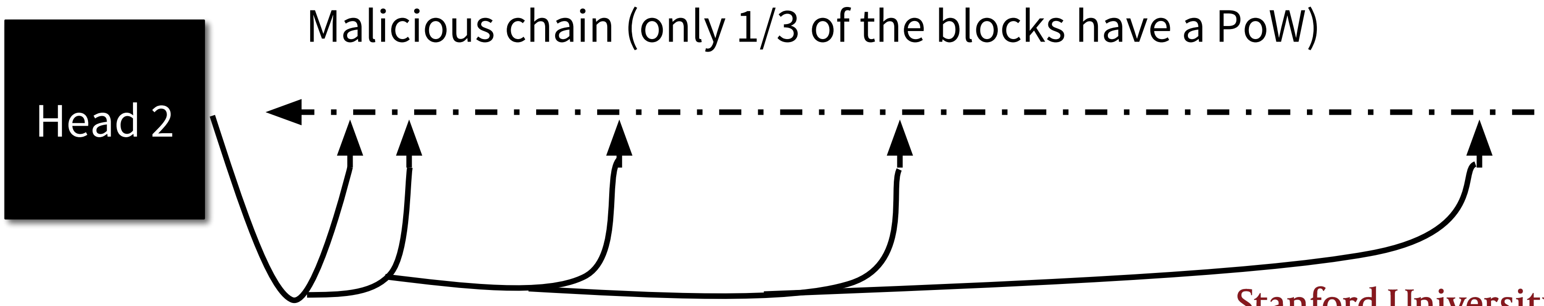
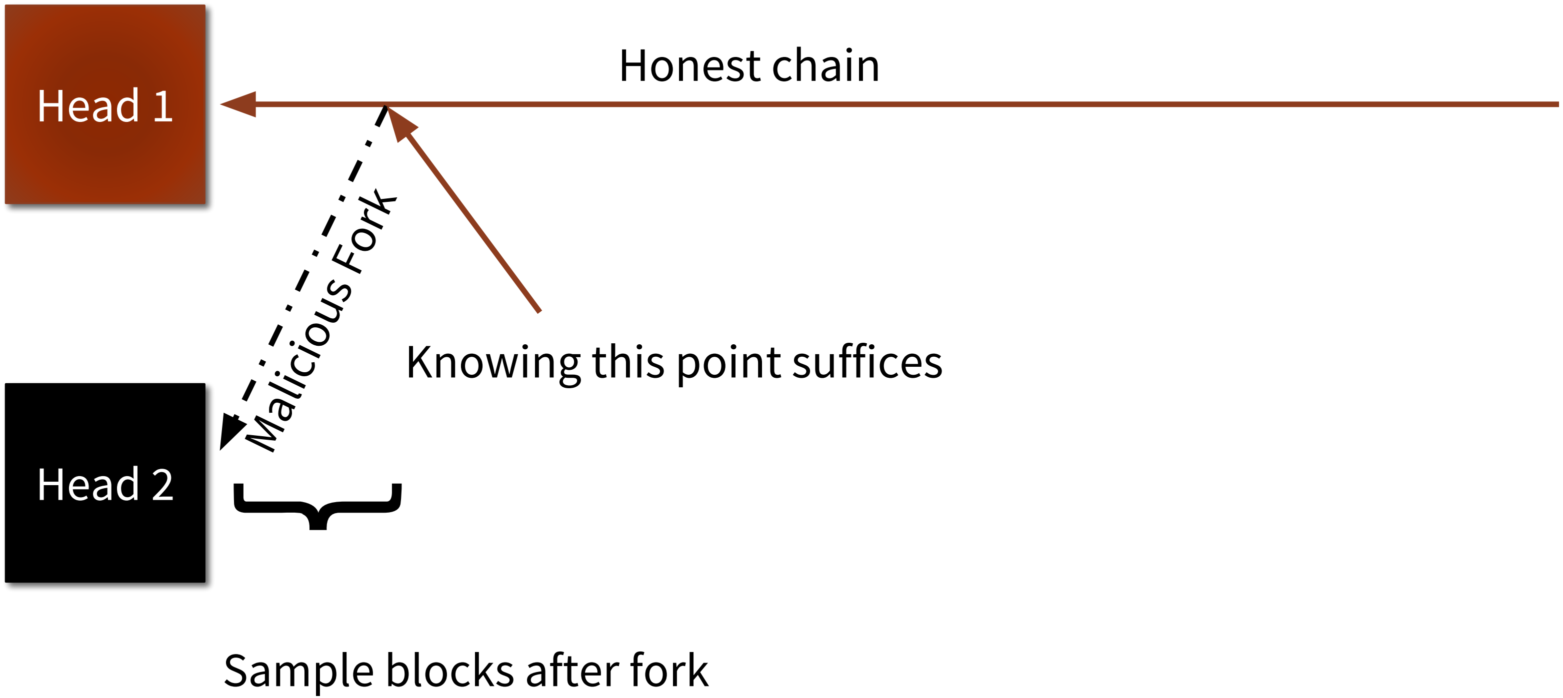
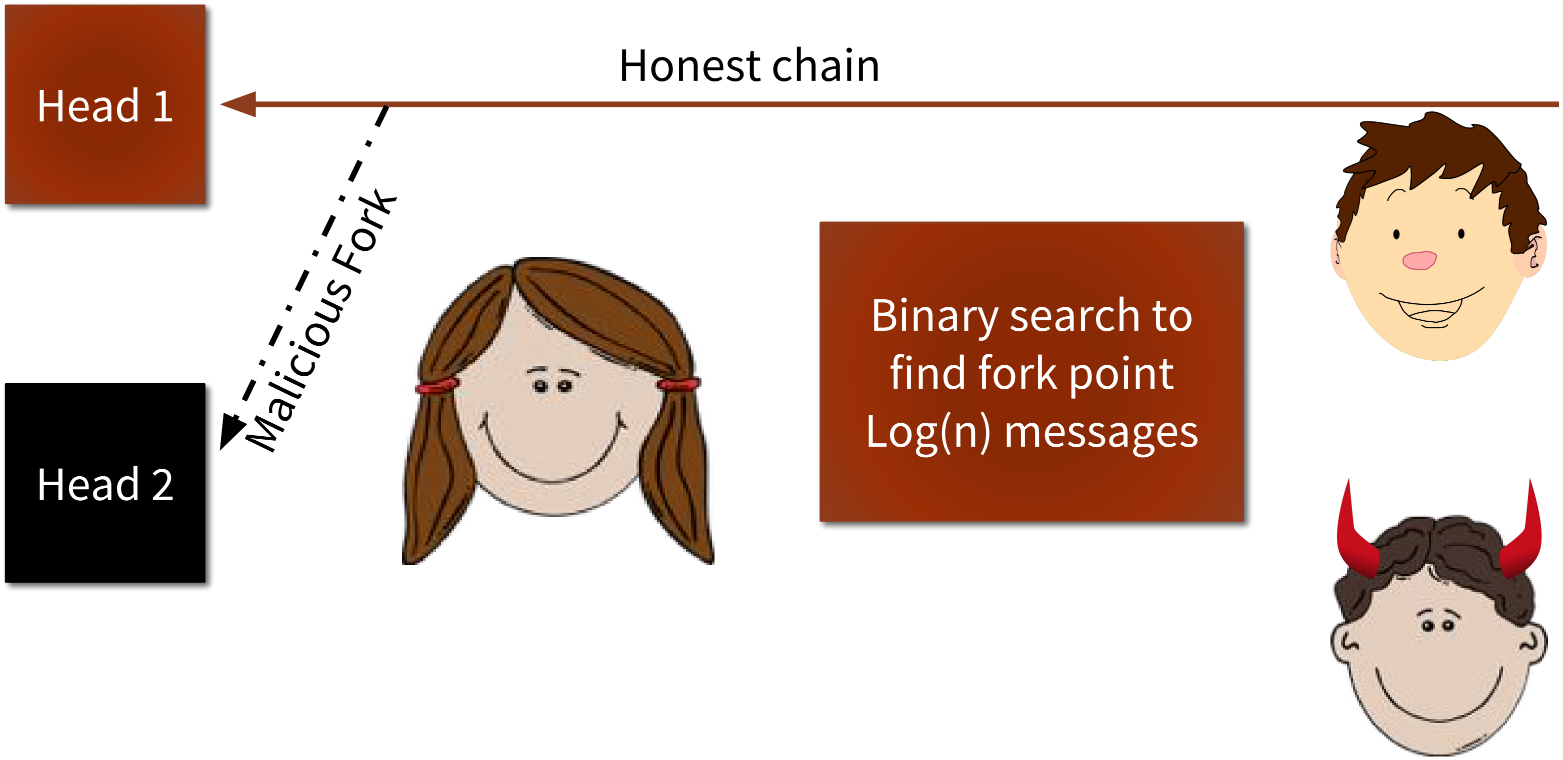


Flyclient Strawman 1 problem: Forking

Flyclient idea: Find Fork Point



Flyclient Strawman 2: Interactive Binary Search



Flyclient Strawman 2: Interactive Binary Search

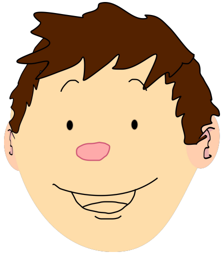
Head 1

Honest chain

Malicious Fork

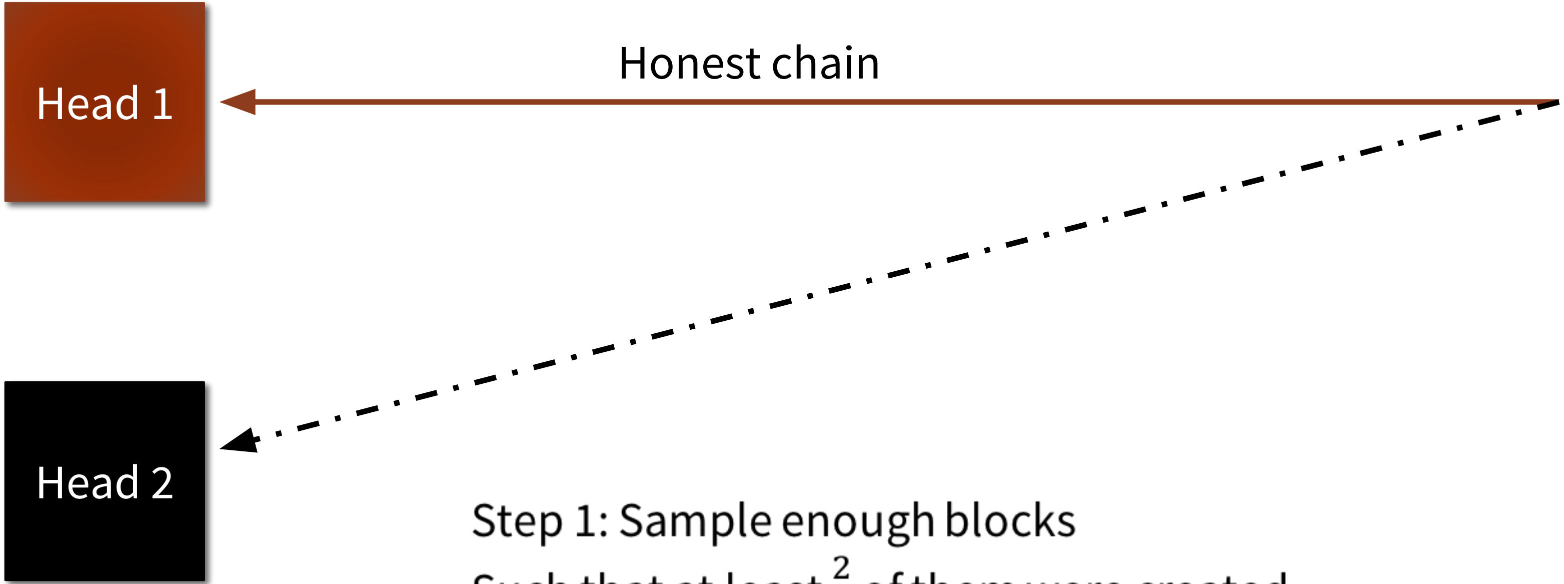
Head 2

Binary search to
find fork point
Log(n) messages



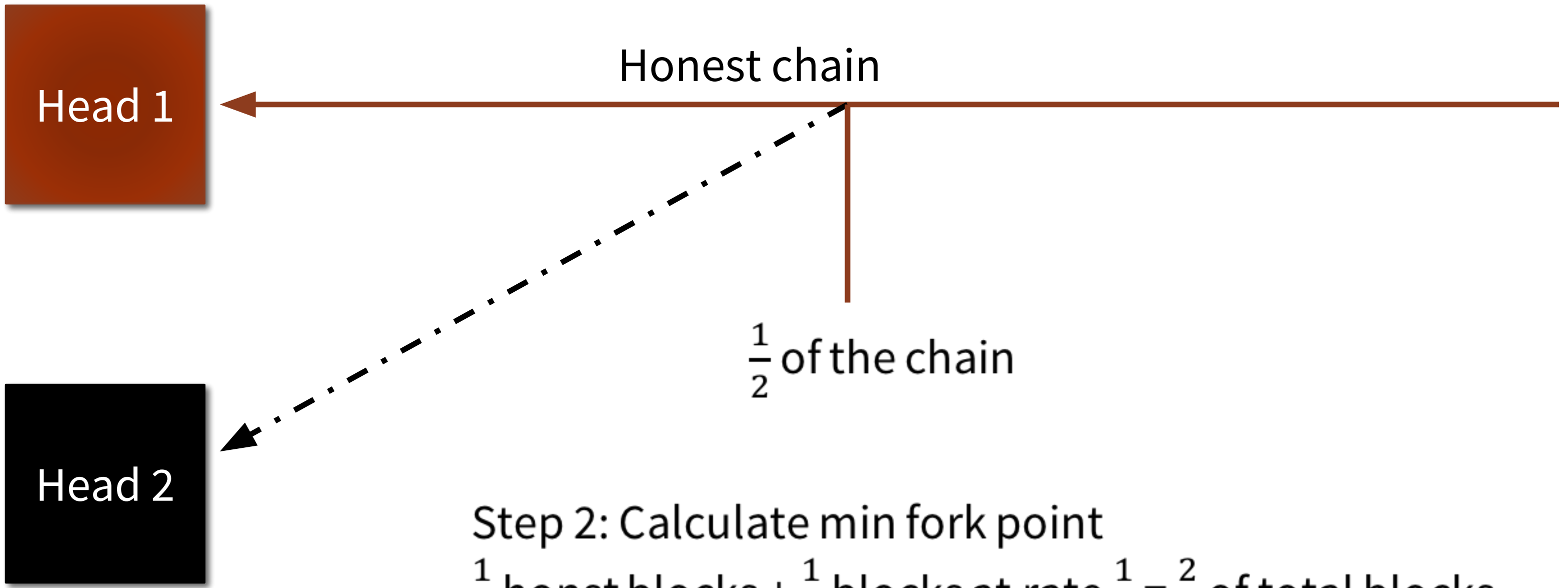
Works but two provers may
not want to interact

Flyclient: Idea bound forking point



Step 1: Sample enough blocks
Such that at least $\frac{2}{3}$ of them were created

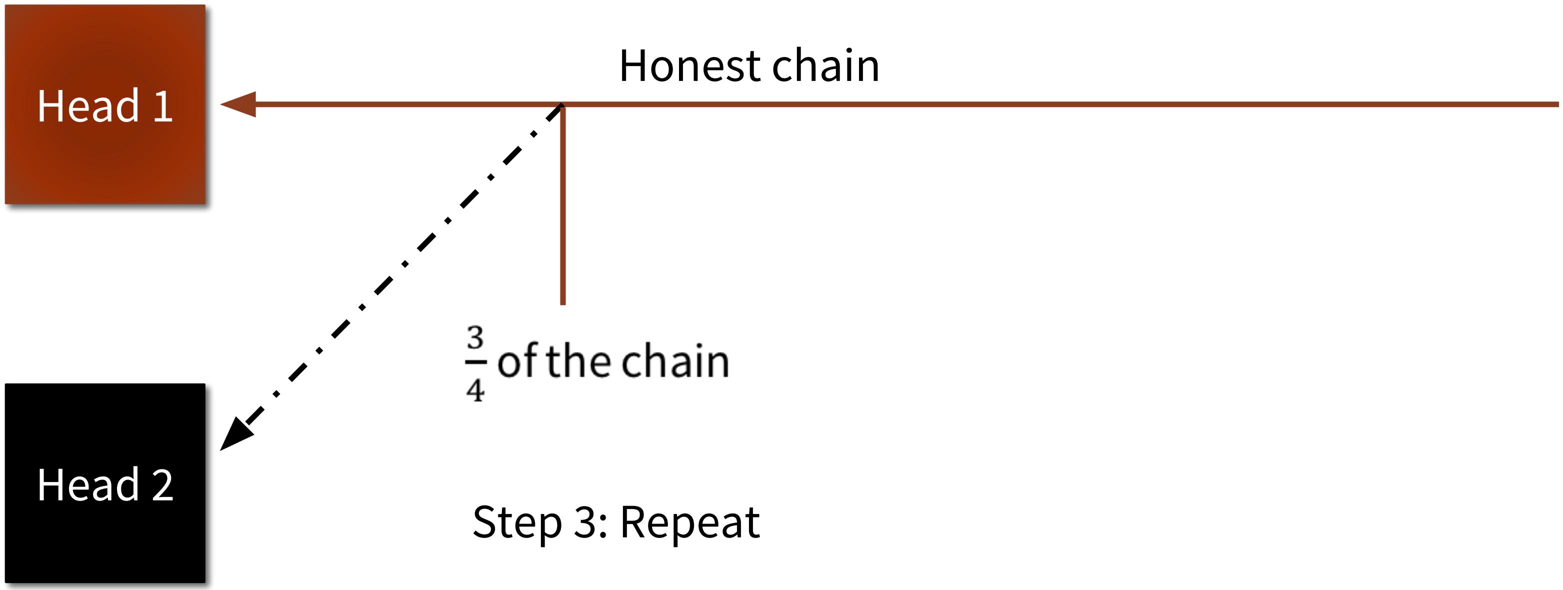
Flyclient: Idea bound forking point



Step 2: Calculate min fork point

$\frac{1}{2}$ honst blocks + $\frac{1}{2}$ blocks at rate $\frac{1}{3} = \frac{2}{3}$ of total blocks

Flyclient: Idea bound forking point



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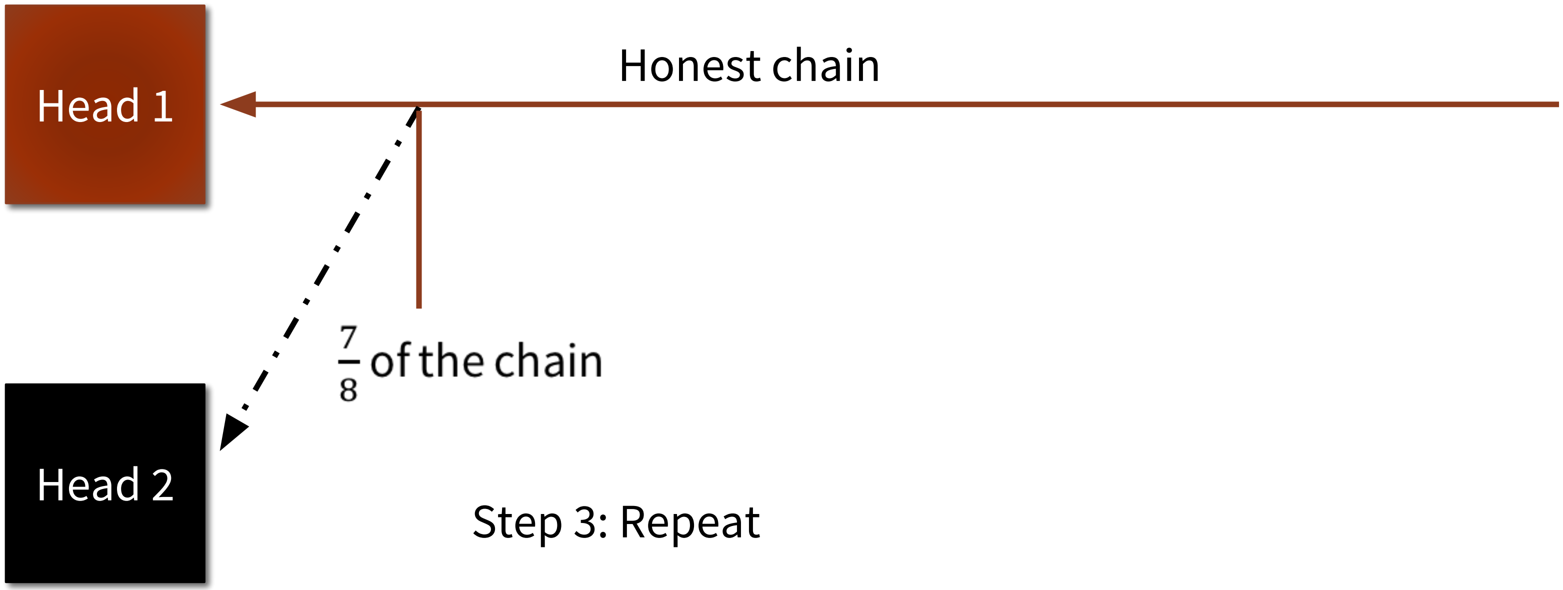
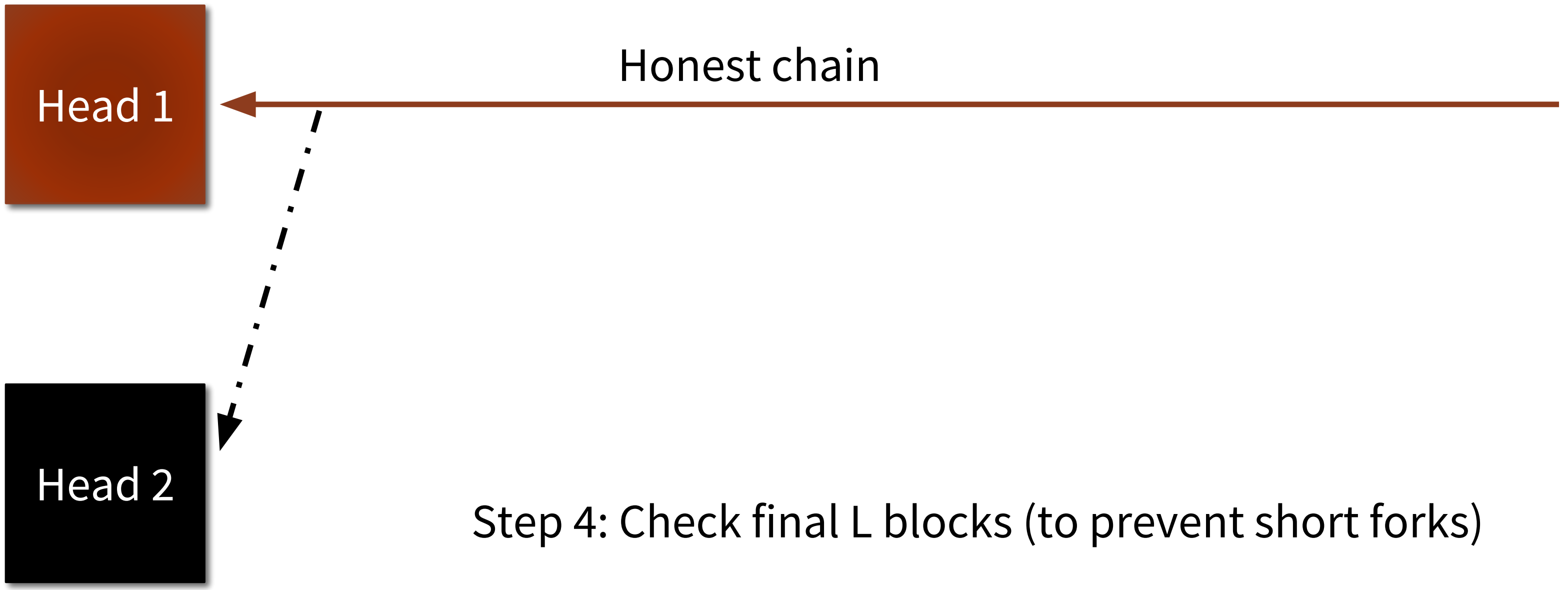


Step 3: Repeat

Flyclient: Idea bound forking point



Step 4: Check final L blocks (to prevent short forks)

Flyclient Analysis

- In each interval check k blocks, k independent of chain length n
- k dependent on attacker strength
- Check log(n) intervalls
- For each block do log(n) merkle inclusion proof
- O(log(n)^2) overall
- For n=1000000->

Non Interactive Flyclient

- Verifier just requests random blocks
- Get randomness from hash function and chain head (Bonneau et al. 15)
- Also known as the Fiat-Shamir heuristic
- 2^{-128} soundness not needed because new hash -> new head -> new PoW
- Create proof once and reuse
- Simulation: <3 MB for Ethereum instead of 2.2GB

Thanks

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