Snapping Snap Sync:
Practical Attacks on Go Ethereum Synchronising Nodes

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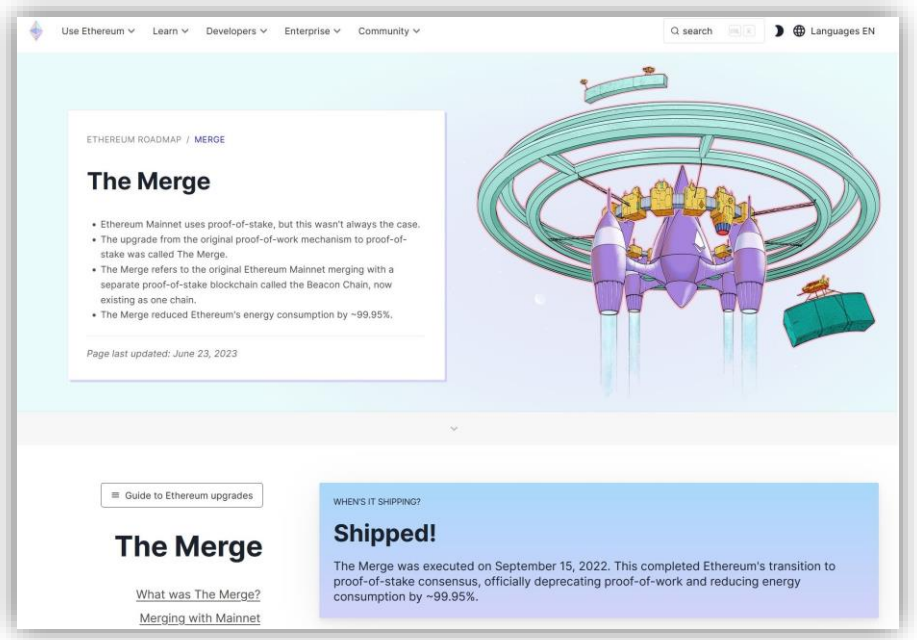
  - 80% of all the nodes, before the Merge
- The Merge: switch from proof-of-work (PoW) to proof-of-stake (PoS)
  - Sept 2022



ethereum.org

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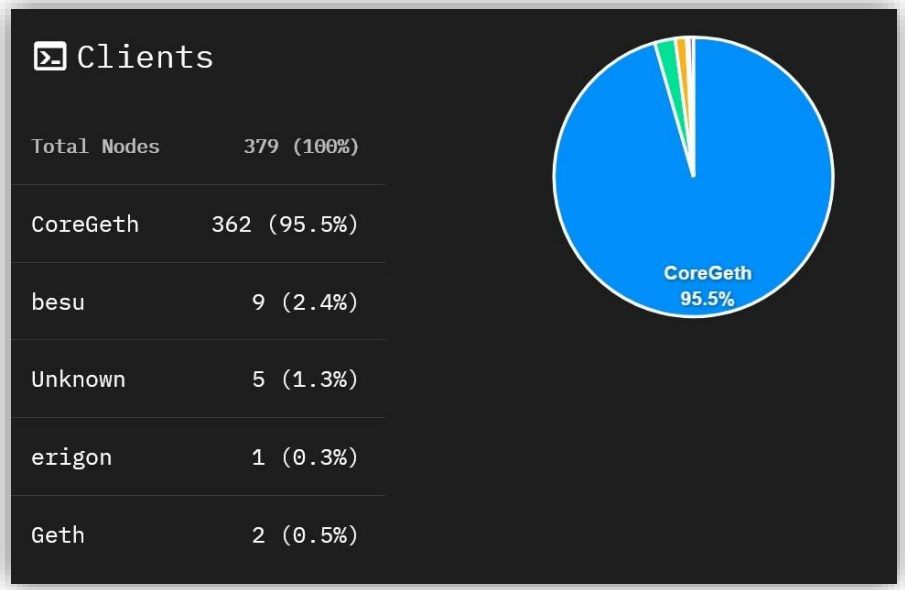

etcnodes.org

What is Ethereum?

- PoW still in use:
  - Ethereum Classic (ETC)
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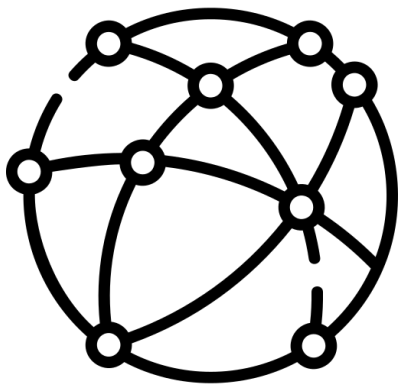
- We have found attacks on Go Ethereum nodes which apply to PoW

Peer-to-Peer Network

- Distributed system



Peer-to-Peer Network

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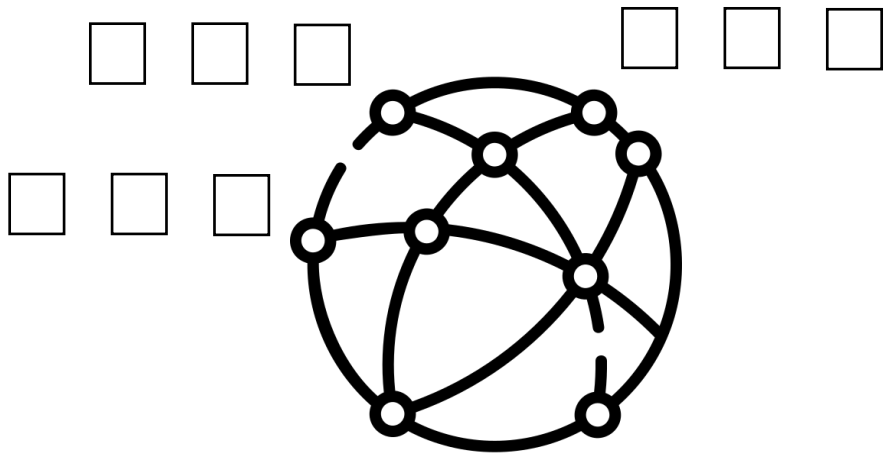

Peer-to-Peer Network

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  - Account balances
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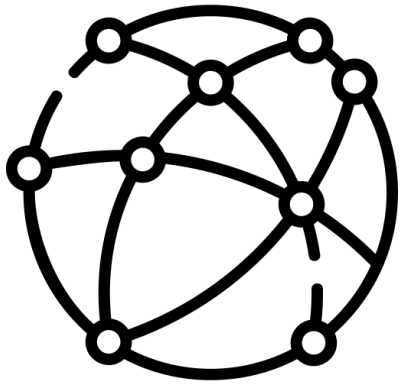

Peer-to-Peer Network

- Distributed system
- Every node has the blockchain
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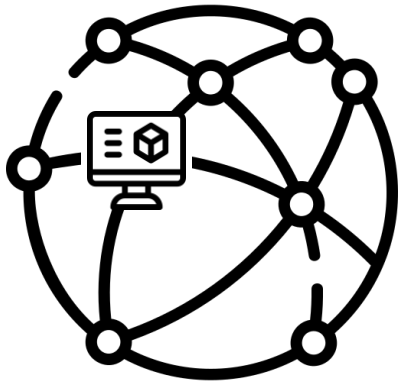
- Ethereum client
  - Creates, propagates and verifies blocks
  - Propagates, verifies, executes transactions
  - Overall, manages the Ethereum blockchain and state



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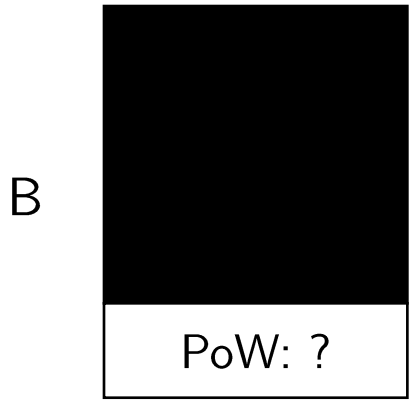

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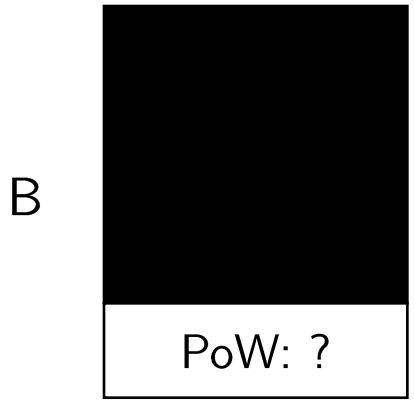

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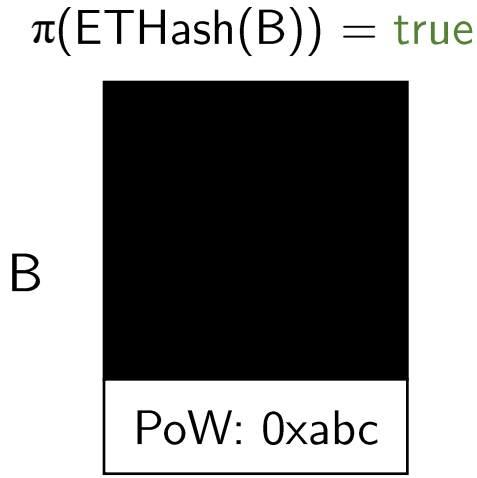

Proof of Work

- A block needs a PoW in order to be valid
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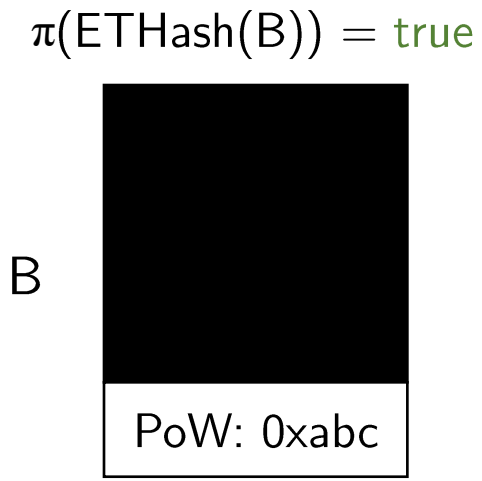
- Evidence that computational effort has been put into the block creation



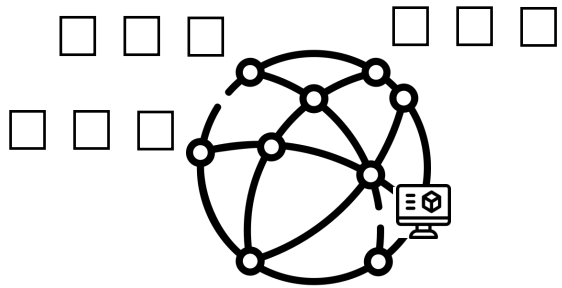
Longest chain rule

- Assumption:
  the majority of the computational power is held by honest nodes

- Consequence:
  the longest chain is the honest chain

Synchronisation process

- A new node joins the network



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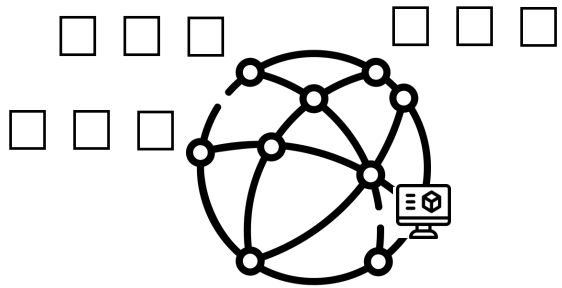

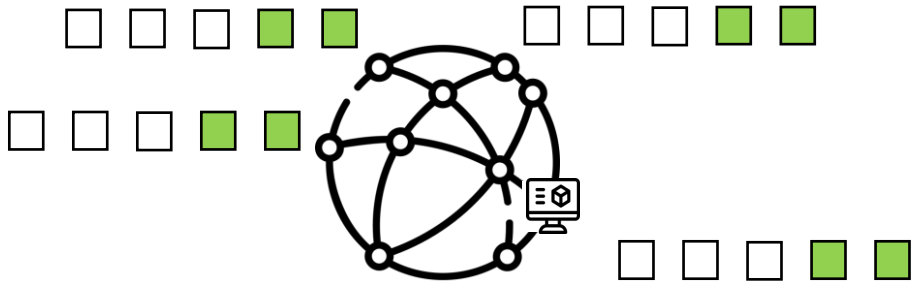

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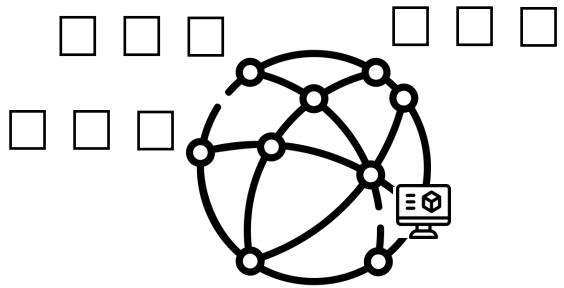

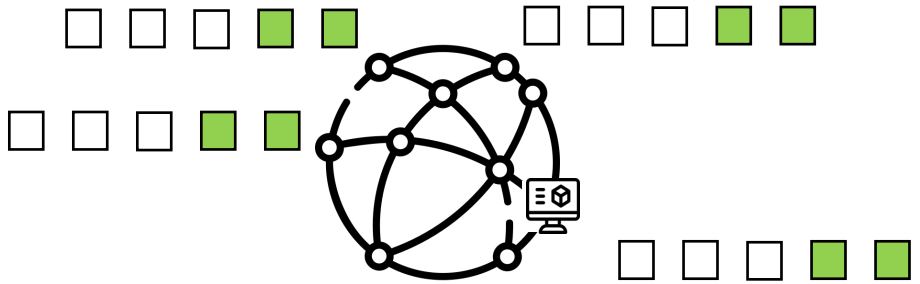

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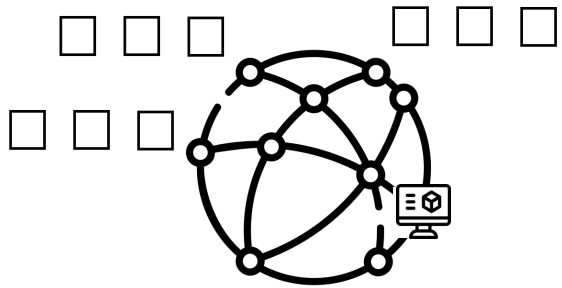
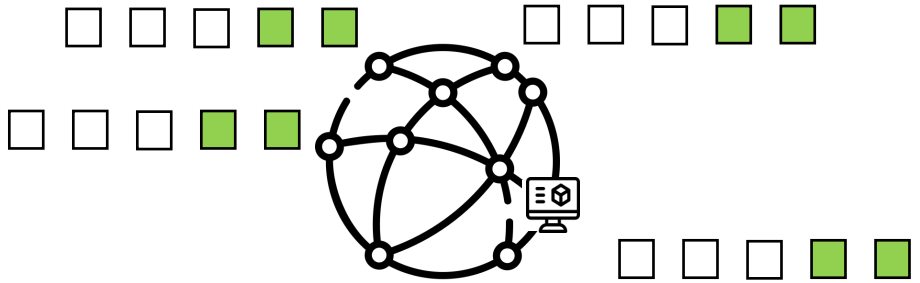
- Go Ethereum solution
  - Verify one PoW in every 64 blocks
  - Random choice





Intro to the attacks

- Our attacks target synchronising nodes

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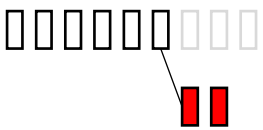
- Our attacks target synchronising nodes
- Take a victim node onto a malicious fork
- Arbitrarily modify the Ethereum state
  - Account balances
  - Smart contracts

Account	Balance
Alice	20 $
Eve	10 $



Account	Balance
Alice	20 $
Eve	1000 $

Cashing Out

Account	Balance
Alice	20 $
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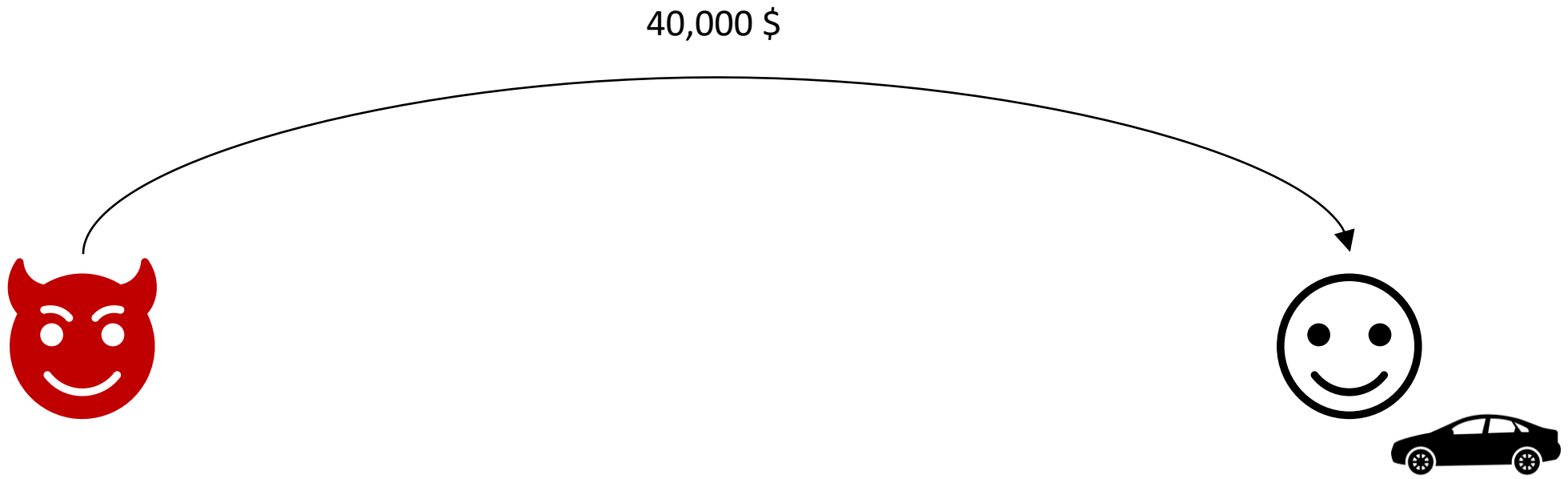

Account	Balance
Alice	20 $
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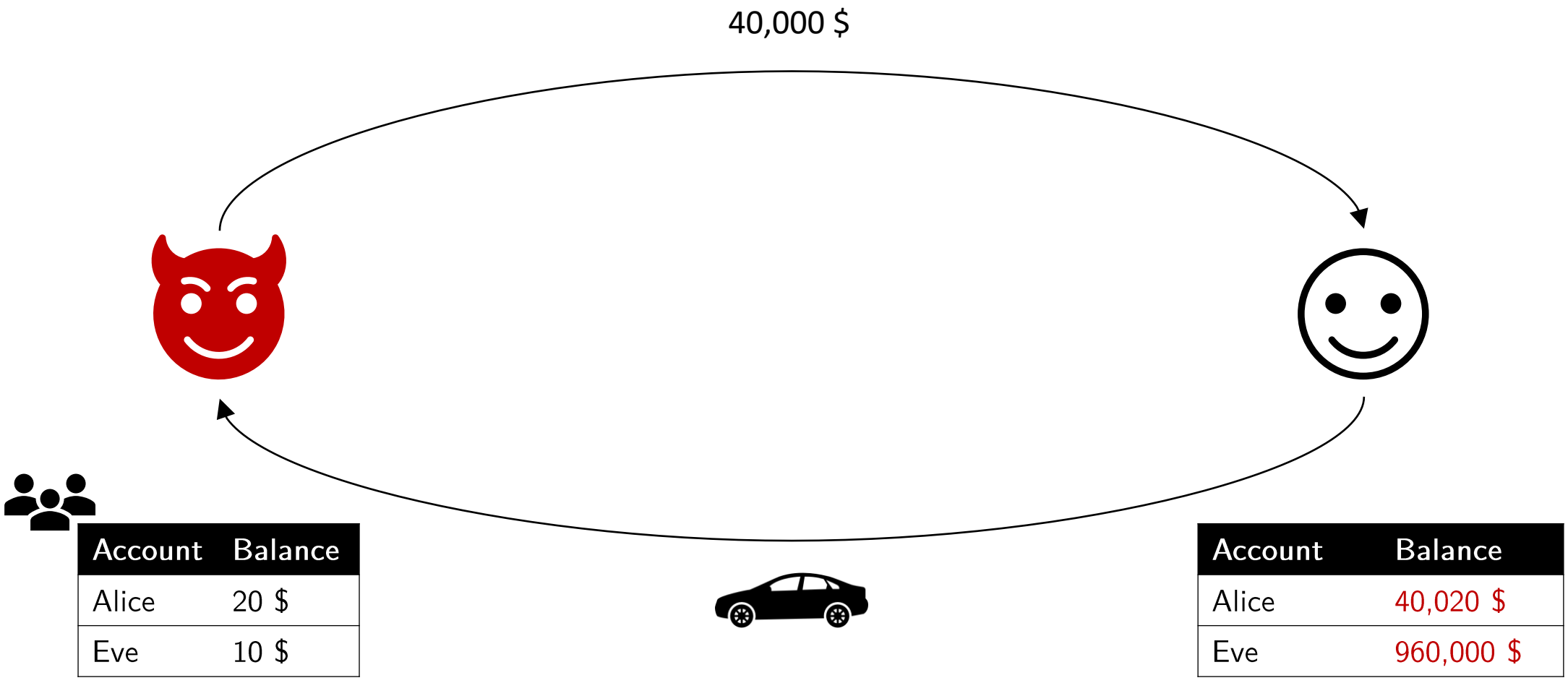
Account	Balance
Alice	40,020 $
Eve	960,000 $

Cashing Out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Attack 1: Adversarial Model

- Fraction of the total mining power: 1.6%
- 2 malicious peers in the victim's peer-set
- Victim still has to sync

Attack 1: Security Issues

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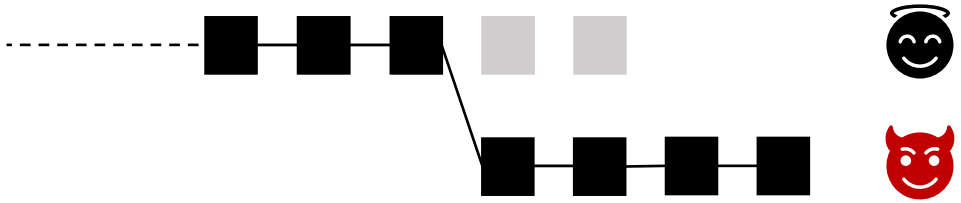
- The random PoWs to verify are chosen by using math/rand
- A synchronising node leaks information about its PRNG's outputs

- Consequence: an attacker can recover the seed
  and build a longer chain than the honest one

Attack 1: Execution

- While $\mathcal{V}$ downloads blocks, $\mathcal{A}$ creates new ones



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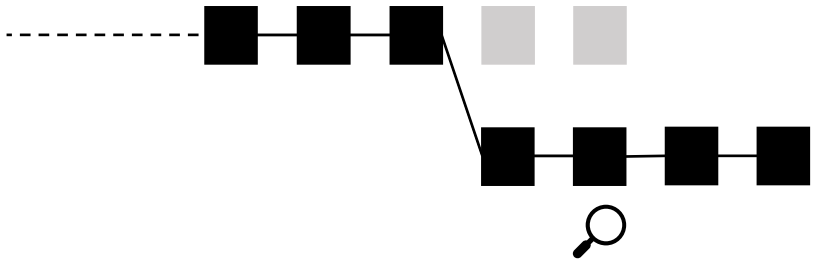
- While $\mathcal{V}$ downloads blocks, $\mathcal{A}$ creates new ones
- $\mathcal{A}$ knows which blocks $\mathcal{V}$ will verify and computes PoWs only for those



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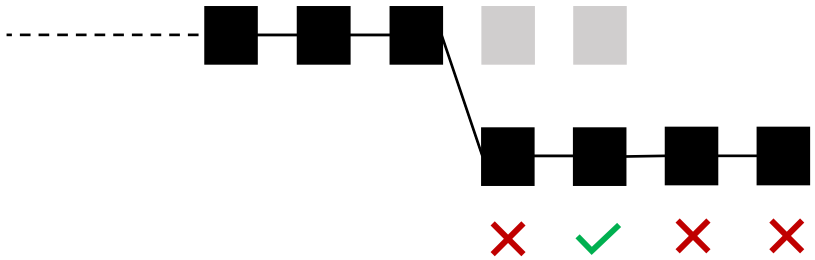

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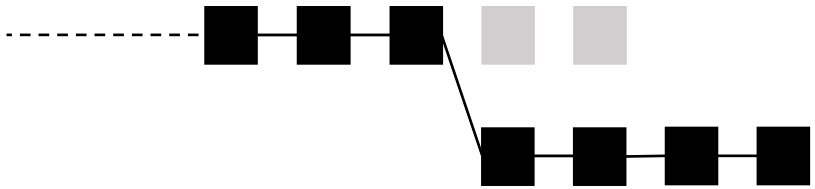

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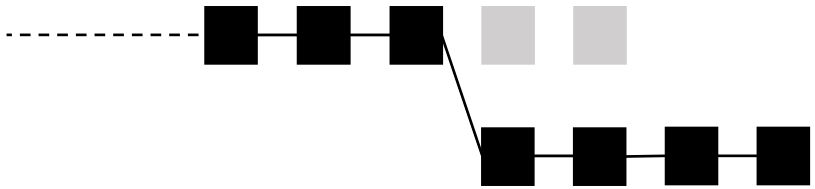
  - $R_A \geq \frac{R_H}{64} \Rightarrow \frac{R_A}{R_H} \geq \frac{1}{64} \approx 1.6\%$



Attack 2: Adversarial Model

- Fraction of the total mining power: 0.23%
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Interestingly enough, this attack is enabled by the countermeasure to another attack

Attack 3: Combining both flaws

- We can build a unique attack exploiting both flaws

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- We can build a unique attack exploiting both flaws
- Outcome: divert the victim onto a malicious chain at a surprisingly low cost
  - 5 GPU for Ethereum
  - 1 GPU for Ethereum Classic

Attack 3: Adversarial Model

- Fraction of the total mining power: 5.5×10^{-7}
- 2 malicious peers in the victim's peer-set
- Victim still has to sync

Coordinated Disclosure

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  - Contacted after the Merge
  - Vulnerabilities no longer part of their bug bounty program

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  - Collaborative team of developers
- EthereumPoW
  - No reply despite multiple attempts to contact them

Conclusion: A lack of security awareness

- Usage of a weak PRNG for a security-critical operation
- Closing a vulnerability opens a new one
- Web3 is a new, dynamic environment

Thanks for listening

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