CMPSC 390
Decentralization

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Credit: Authors of "Bitcoin and Cryptocurrency Technologies"

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Decentralization in Bitcoin

1. **Who maintains the ledger?**
2. **Who has authority over which transactions are valid?**
3. **Who creates new bitcoins?**
4. Who determines how the rules of the system change?
5. How do bitcoins acquire exchange value?

Decentralization in Bitcoin

Peer-to-peer:

Open to anyone, low barrier to entry.

Mining:

Open to anyone, but inevitable concentration of power often seen as undesirable.

Updates to software:

Core developers trusted by community, have great power.

Distributed Consensus

The protocol terminates and all correct nodes decide on the same value.

This value must have been proposed by some correct node.

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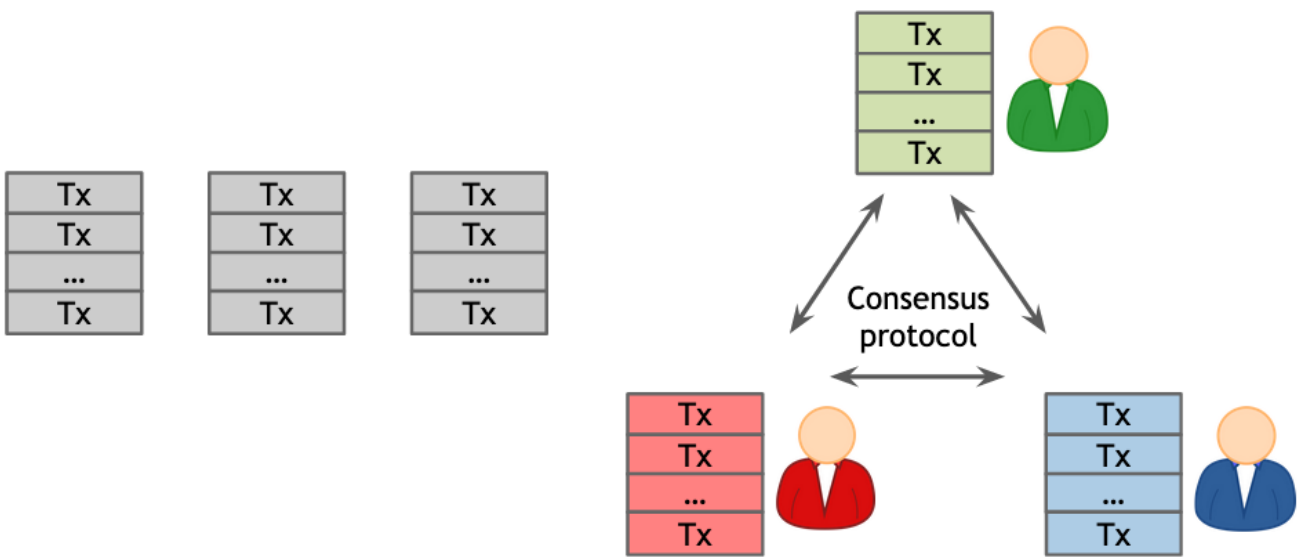

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- Network is imperfect:
  - Not all pairs of nodes connected.
  - Faults in network.
  - Latency.

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- Theory is still catching up.
- But theory is important, can help predict unforeseen attacks.

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Embraces randomness:

- Does away with the notion of a specific end-point.
- Consensus happens over long time scales - about one hour.

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Every block contains hash of the block it extends.

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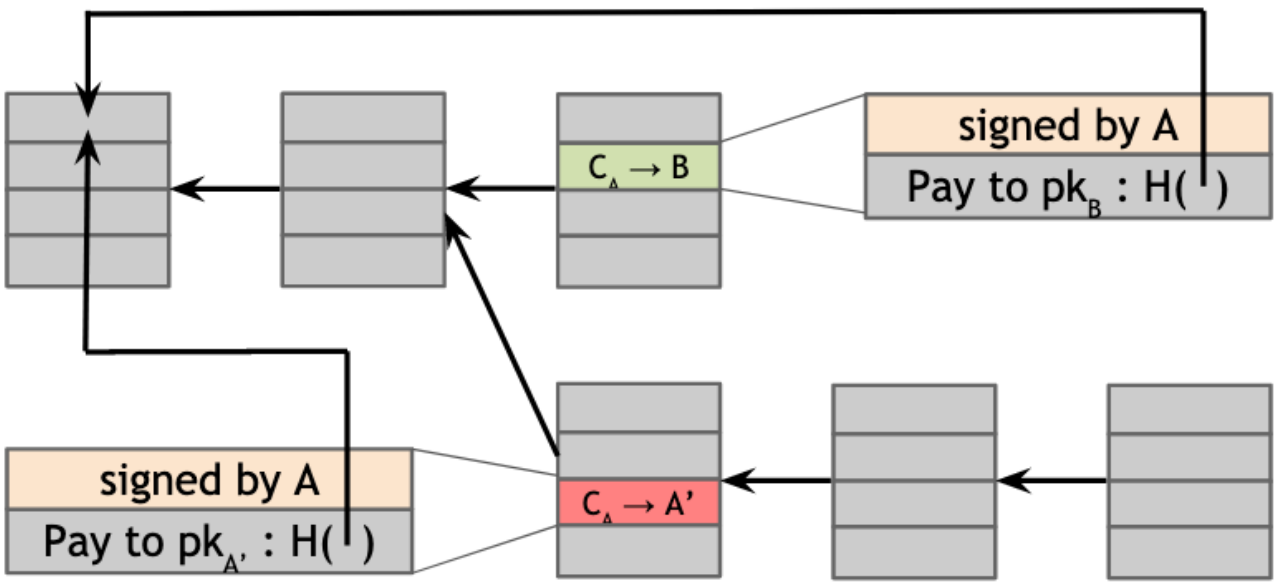
5. Nodes express their acceptance of the block by including its hash in the next block they create.

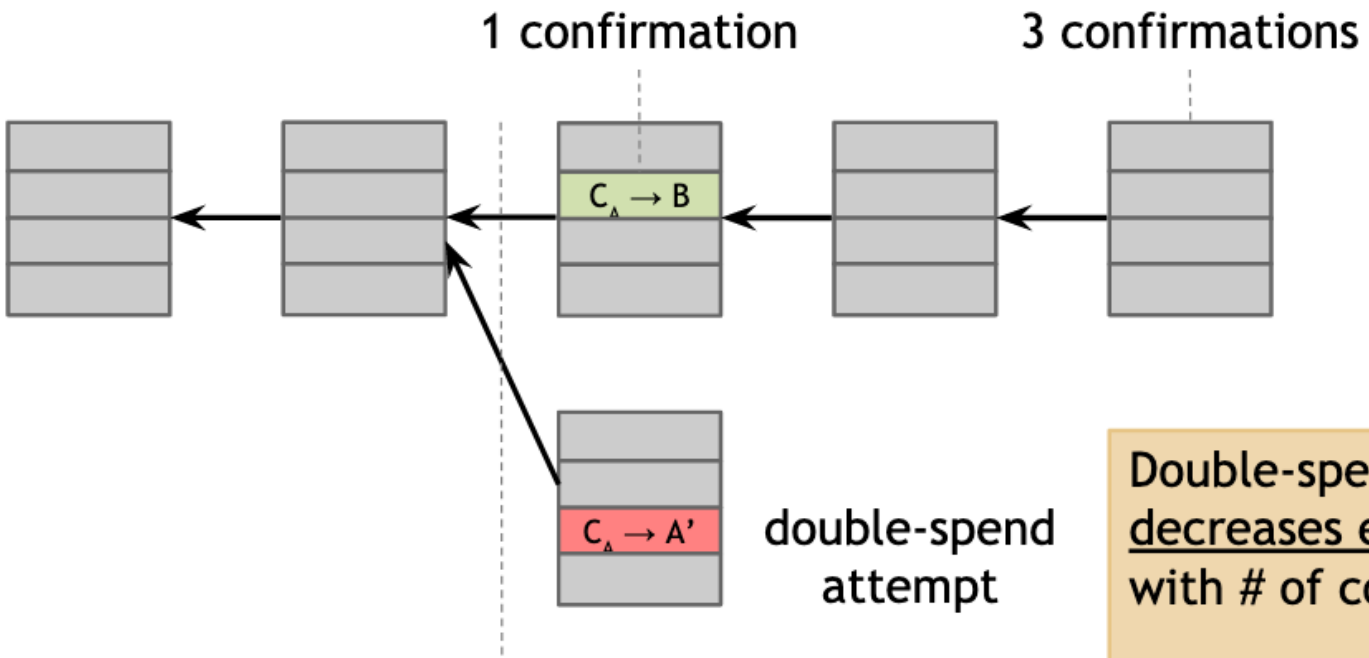
Malicious node?



Double-spending attack

Honest nodes will extend the longest valid branch

From merchant's point of view



Double-spend probability decreases exponentially with # of confirmations

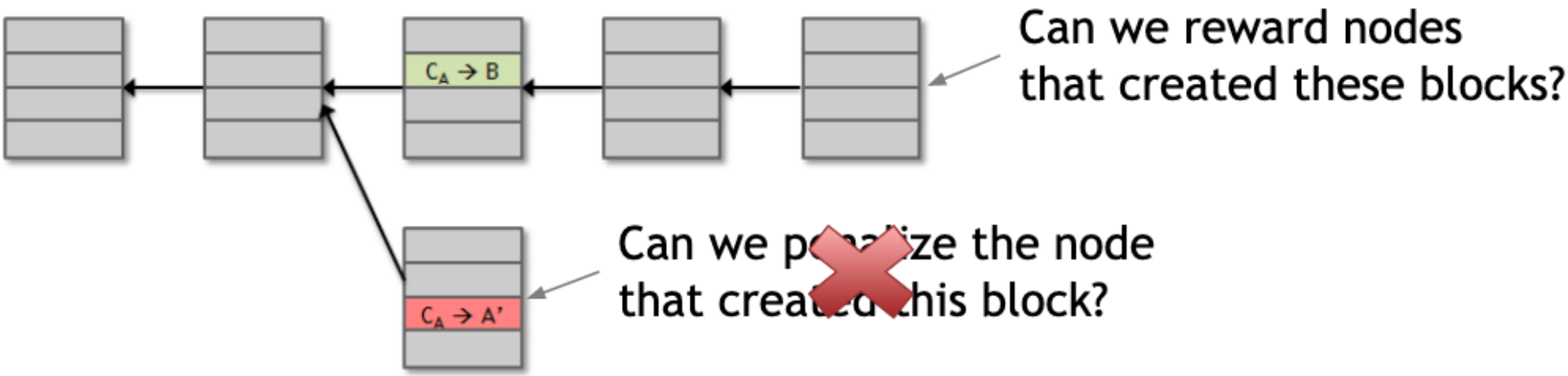
Most common heuristic: 6 confirmations

Summary

- Protection against invalid transactions is cryptographic, but enforced by consensus.
- Protection against double-spending is purely by consensus.
- You are never 100% certain a transaction is in consensus branch. Guarantee is probabilistic.

Assumption of honesty is problematic

Can we give nodes incentives for behaving honestly?



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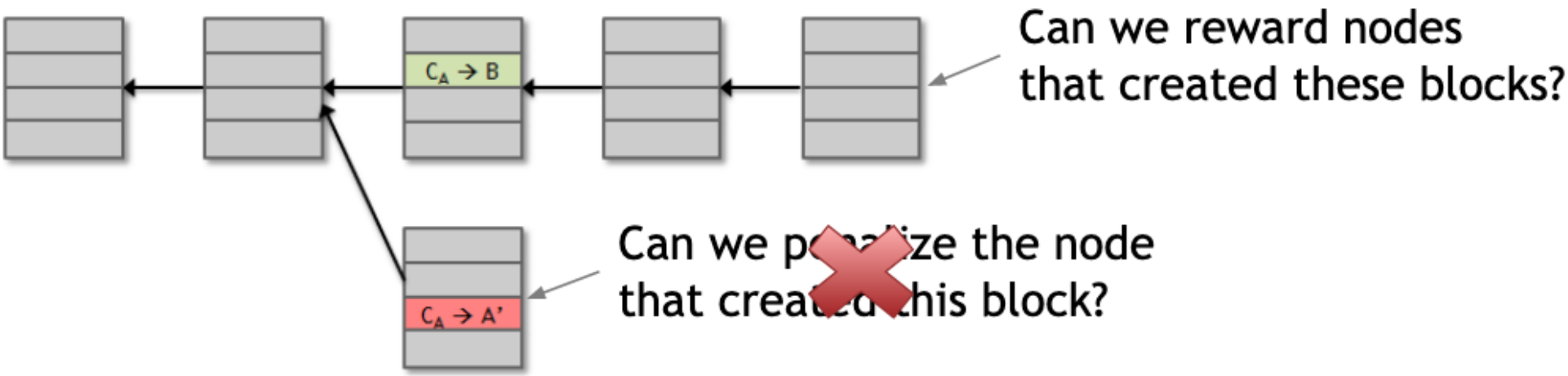

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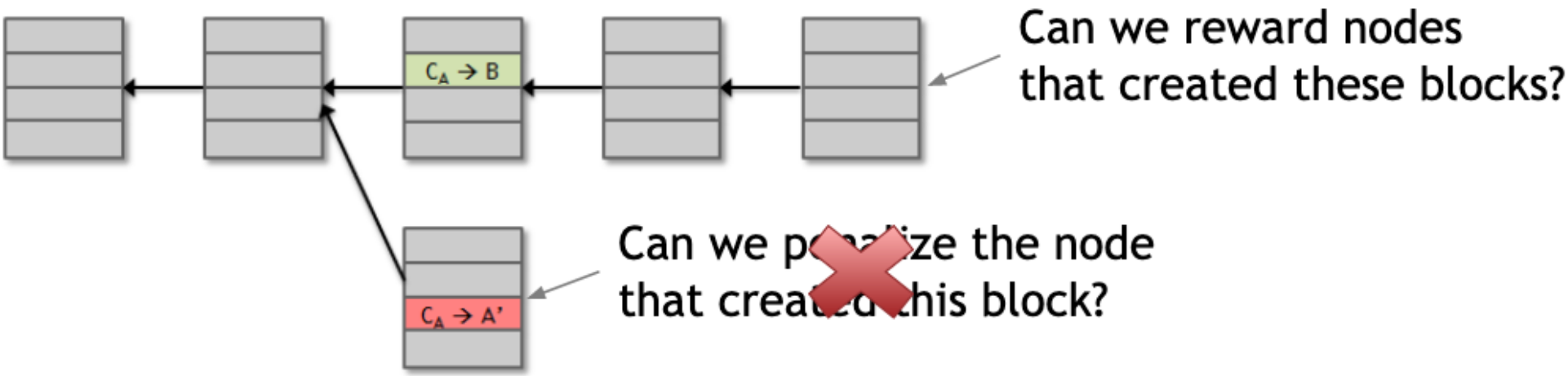

Everything so far is just a distributed consensus protocol ... but now we utilize the fact that the currency has value.

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Creator of block gets to:

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Block creator gets to "collect" the reward only if the block ends up on long-term consensus branch!

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- Purely voluntary, like a tip.

Remaining Problems

We still need to answer:

1. How to pick a random node?
2. How to avoid a free-for-all due to rewards?
3. How to prevent Sybil attacks?

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To approximate selecting a random node:

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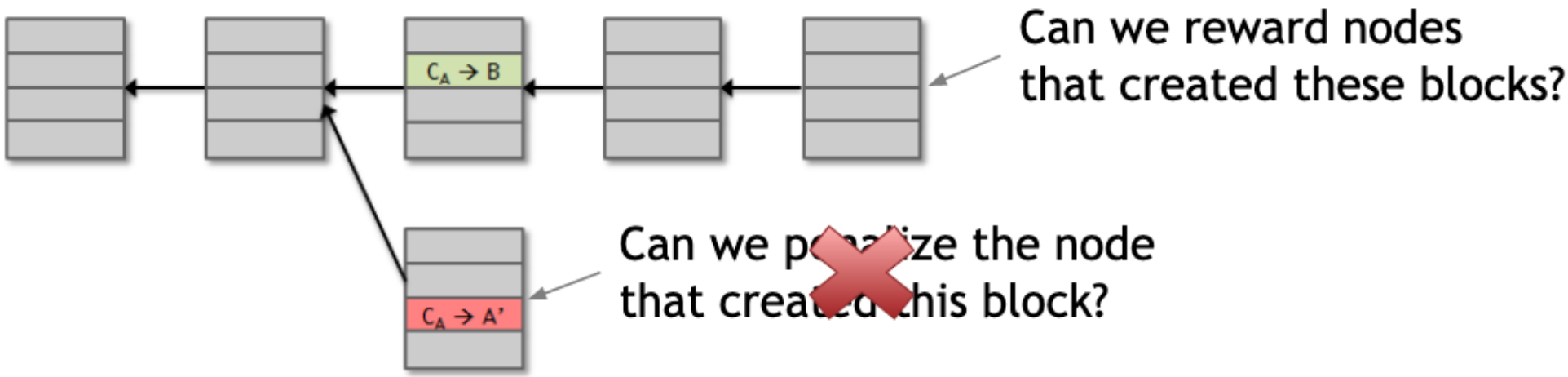
In proportion to computing power: *proof-of-work*.

In proportion to ownership: *proof-of-stake*.

Hash Puzzles

To create a block, find nonce such that:
$H(nonce||prev\_hash||tx||...||tx)$ is very small or
$H(nonce||prev\_hash||merkleRoot < target$.



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Property 3: Trivial to verify.

Nonce must be published as part of block.
Other miners simply verify that $H(nonce prev_hash tx \ldots tx) < target$

Summary

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1. Value
2. State
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Next time:

- How do we get from consensus to currency?
- What else can we do with consensus?