Proof of Space

Murat Osmanoglu

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(SpaceMint)

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  - unused disk space is available on many personal computers
  - most mining is currently done by specialized ASICs, and they have no use other than Bitcoin mining. No such devices required for PoSpace
- a simple idea can be applied to Bitcoin to avoid 'mining pools' : instead of applying the hash function to a nonce directly, it will be applied to the signature of the nonce (similar idea can be adapted to SpaceMint)

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Prover

Verifier

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F of size N

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	⟸	
	⟹	At any time later, verifier initialize a proof
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- we demand that verifier is highly efficient in both phases, and prover is highly efficient in the execution (generating the proof) and in the access to F

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- we demand that verifier is highly efficient in both phases, and prover is highly efficient in the execution (generating the proof) and in the access to F
- be careful; a cheating prover can delete F after initialization

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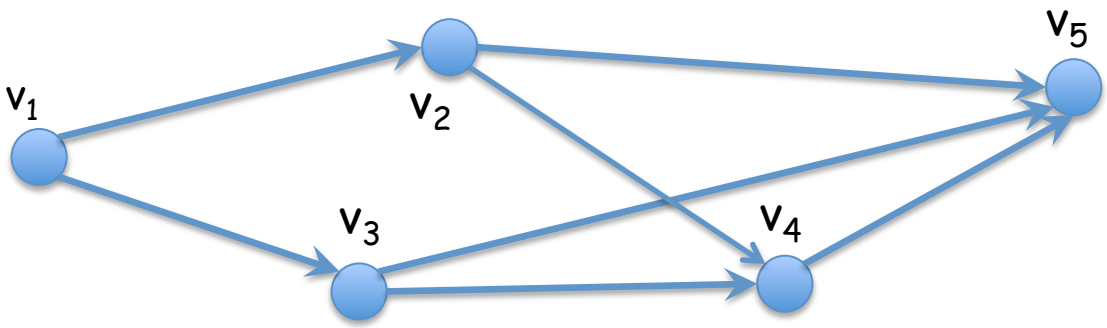
Graph Pebbling

- consider a directed acyclic graph $G = (V\ E)$



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Graph Pebbling

- consider a directed acyclic graph $G = (V\ E)$
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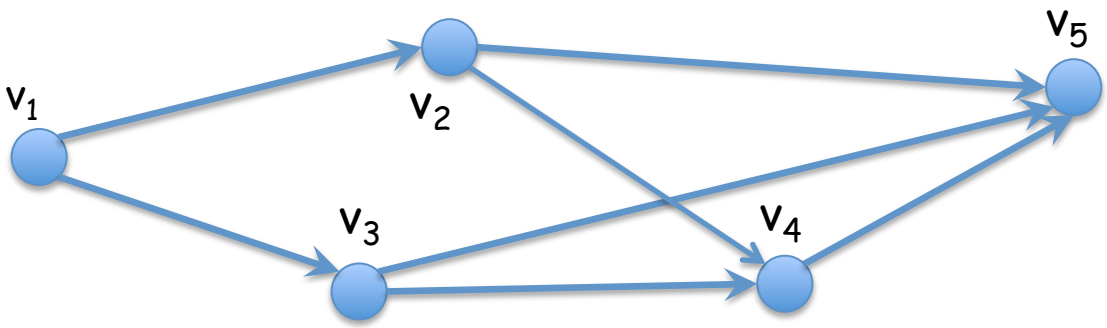

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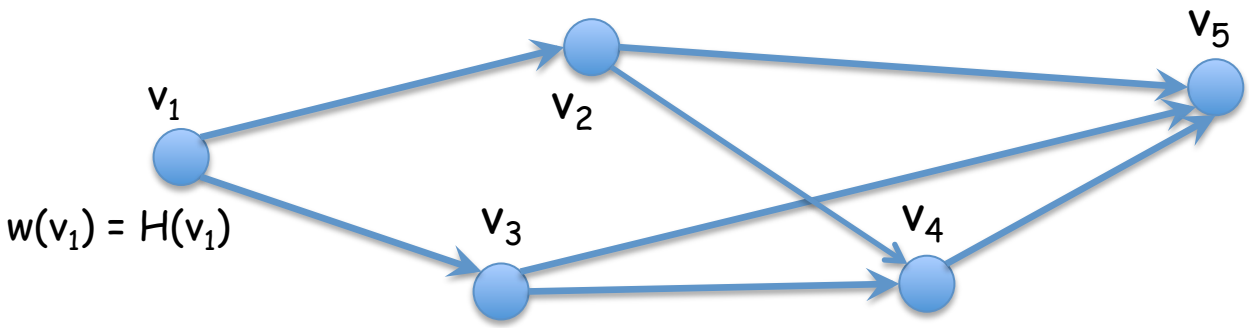

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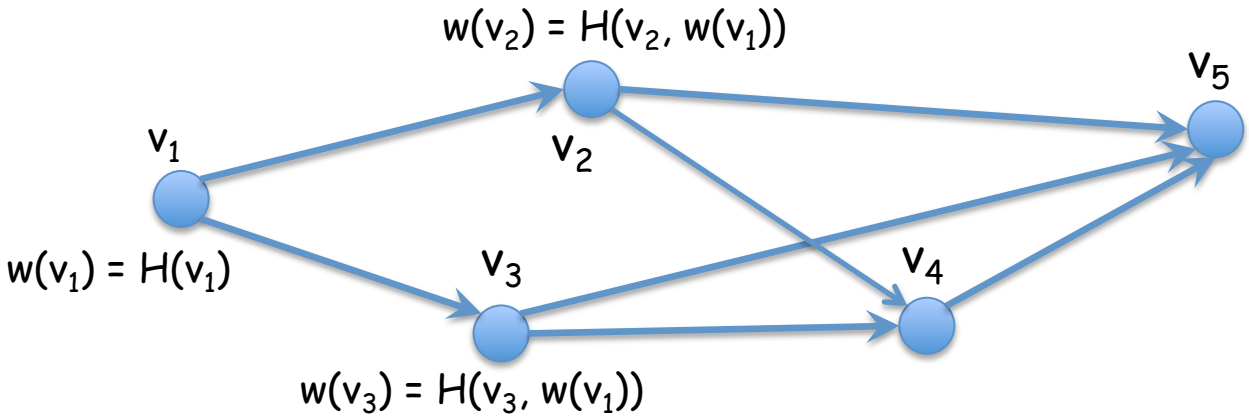

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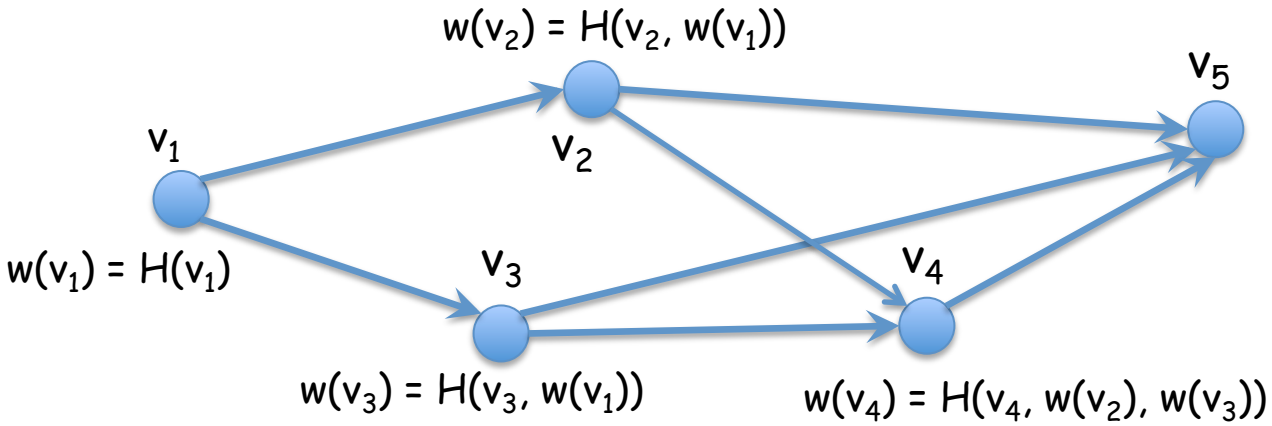

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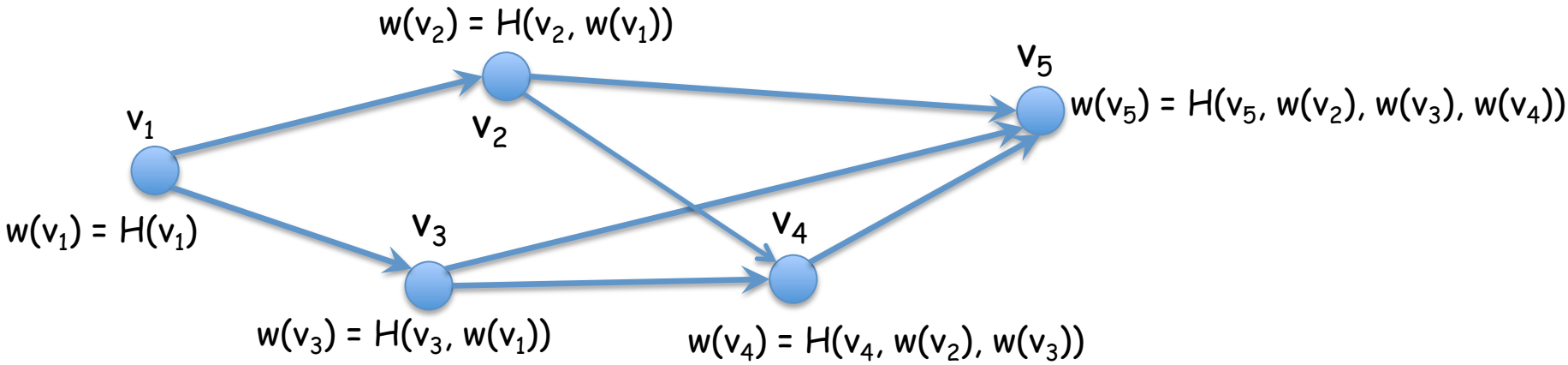

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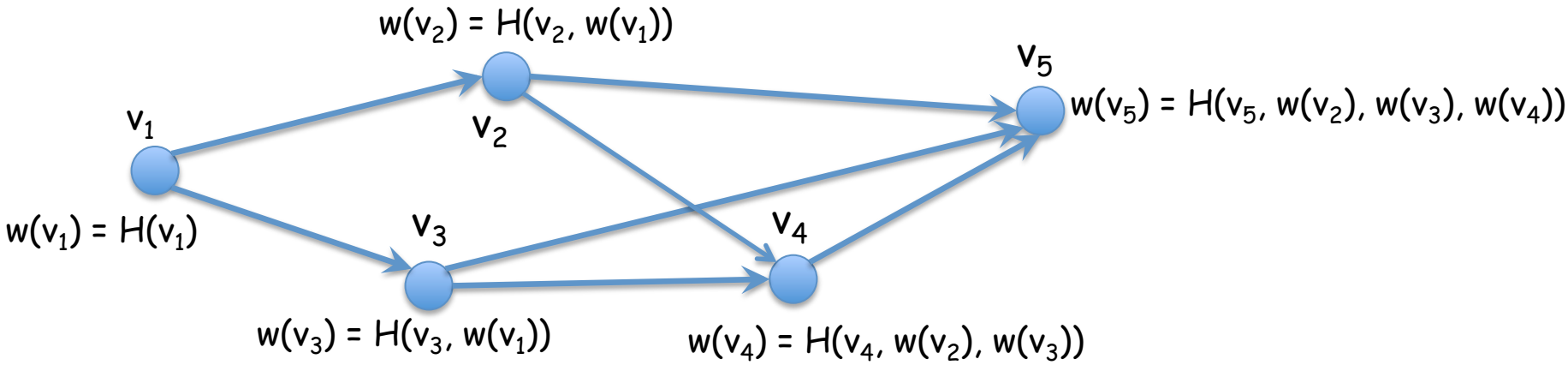

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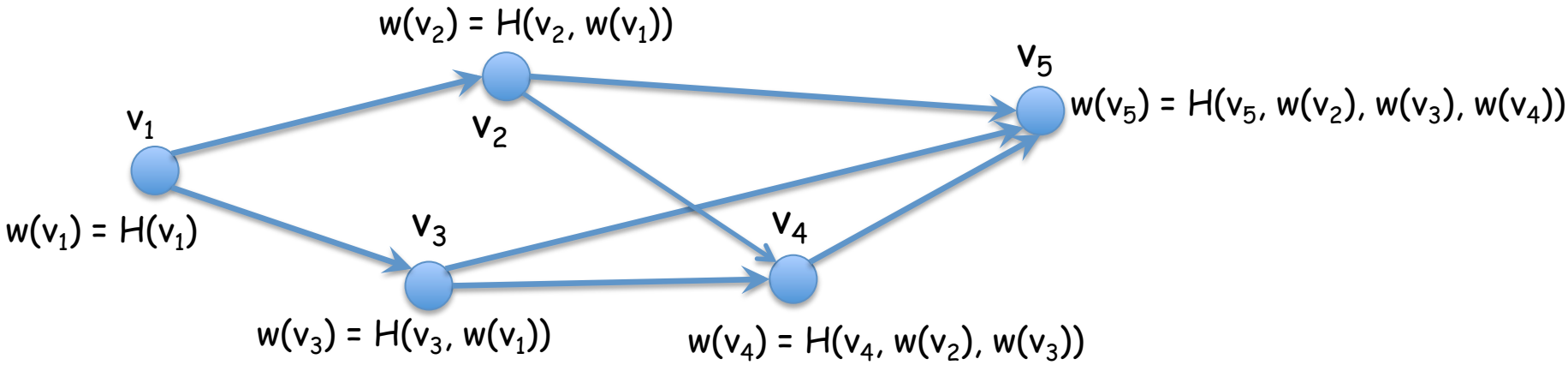

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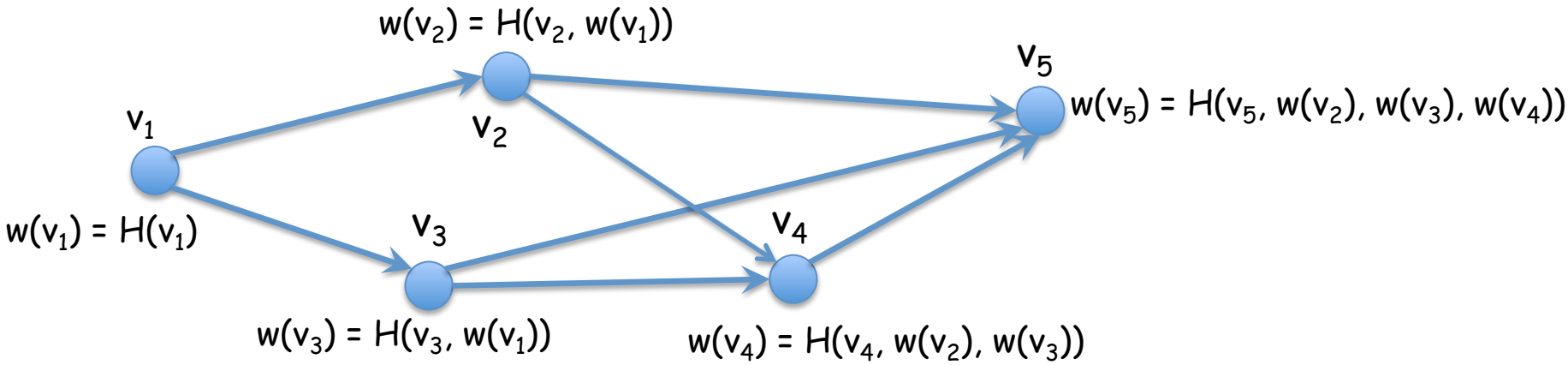

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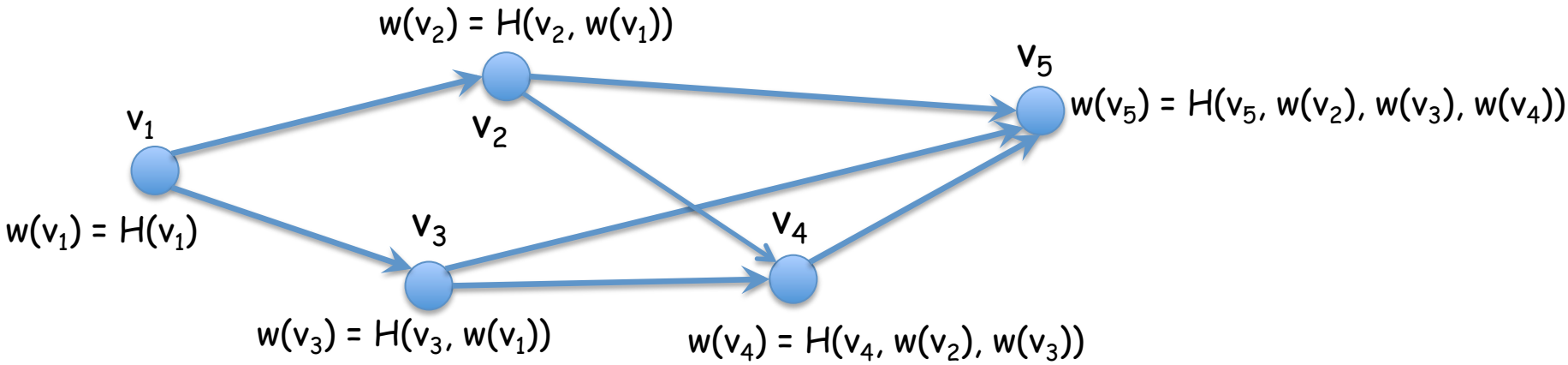

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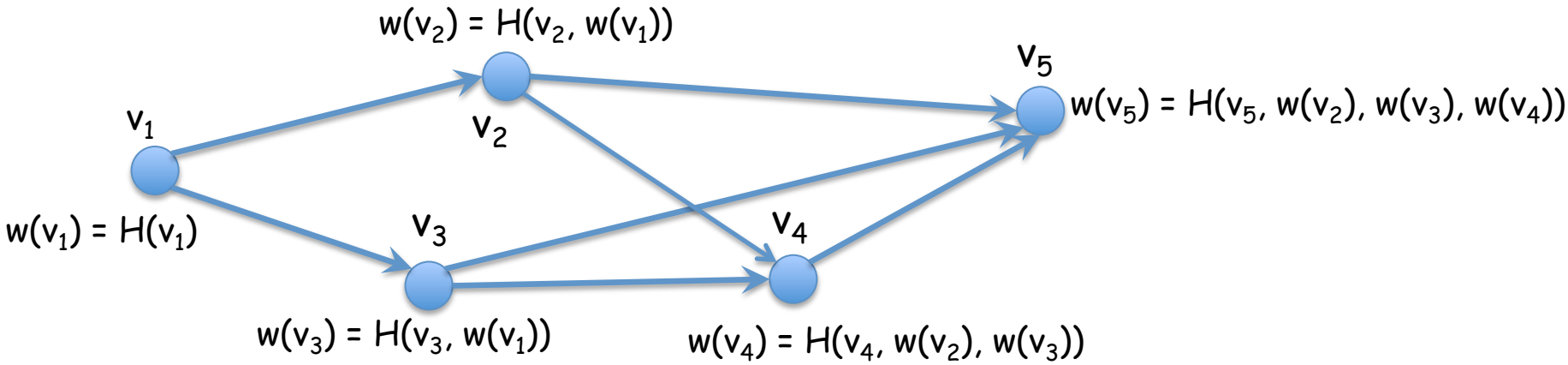

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- Verifier accepts if A is compatible with λ

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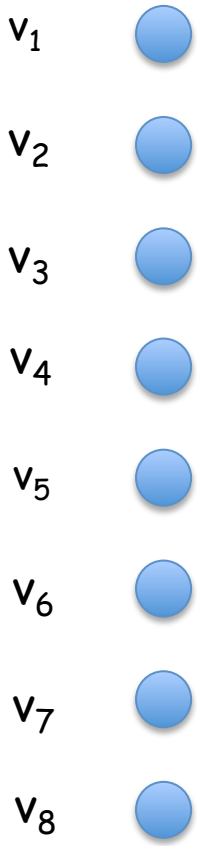
Hash Trees for Graph Pebbling



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Hash Trees for Graph Pebbling

v_1 x_1

v_2 x_2

v_3 x_3

v_4 x_4

v_5 x_5

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v_7 x_7

v_8 x_8

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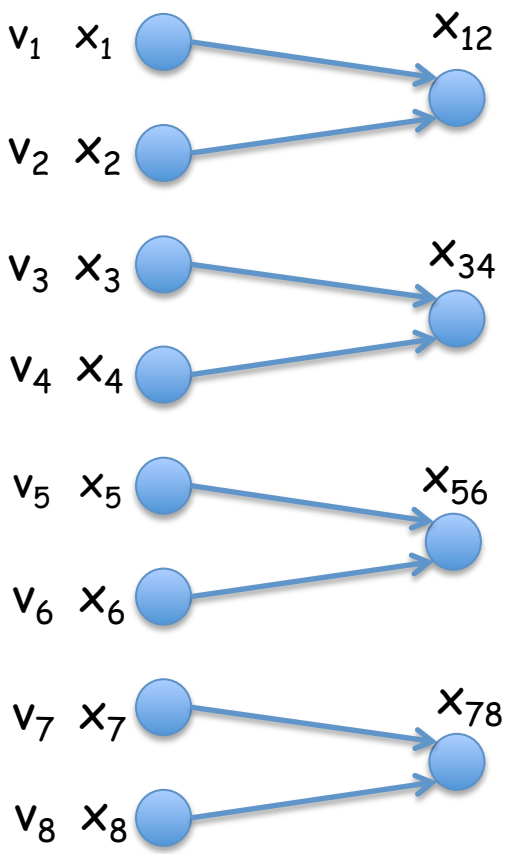

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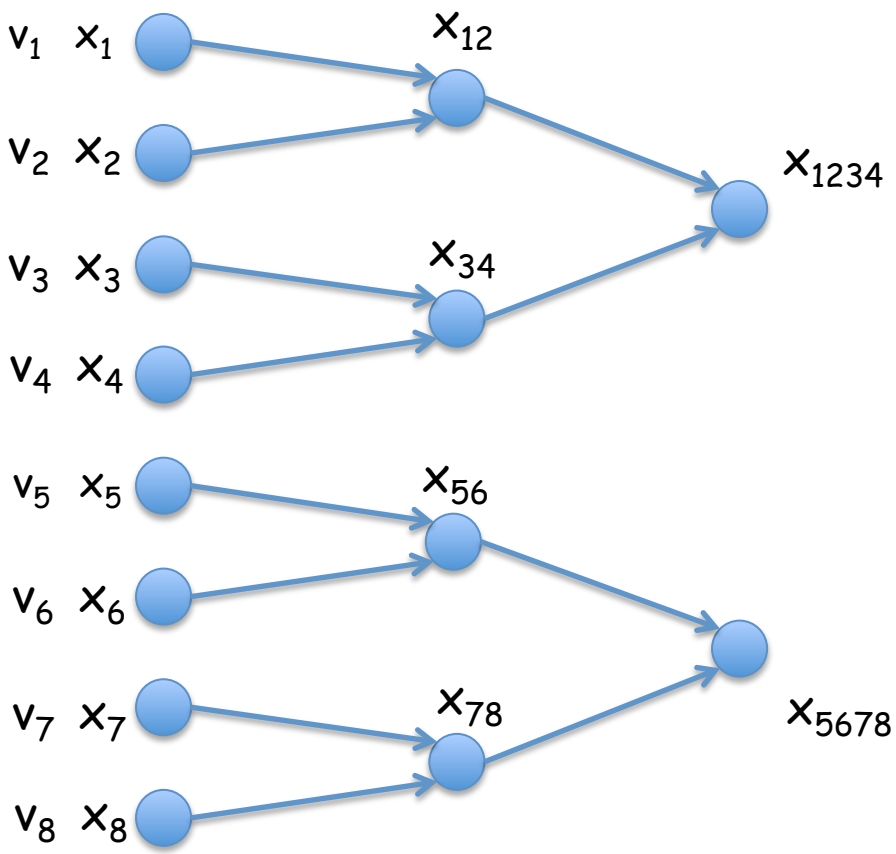

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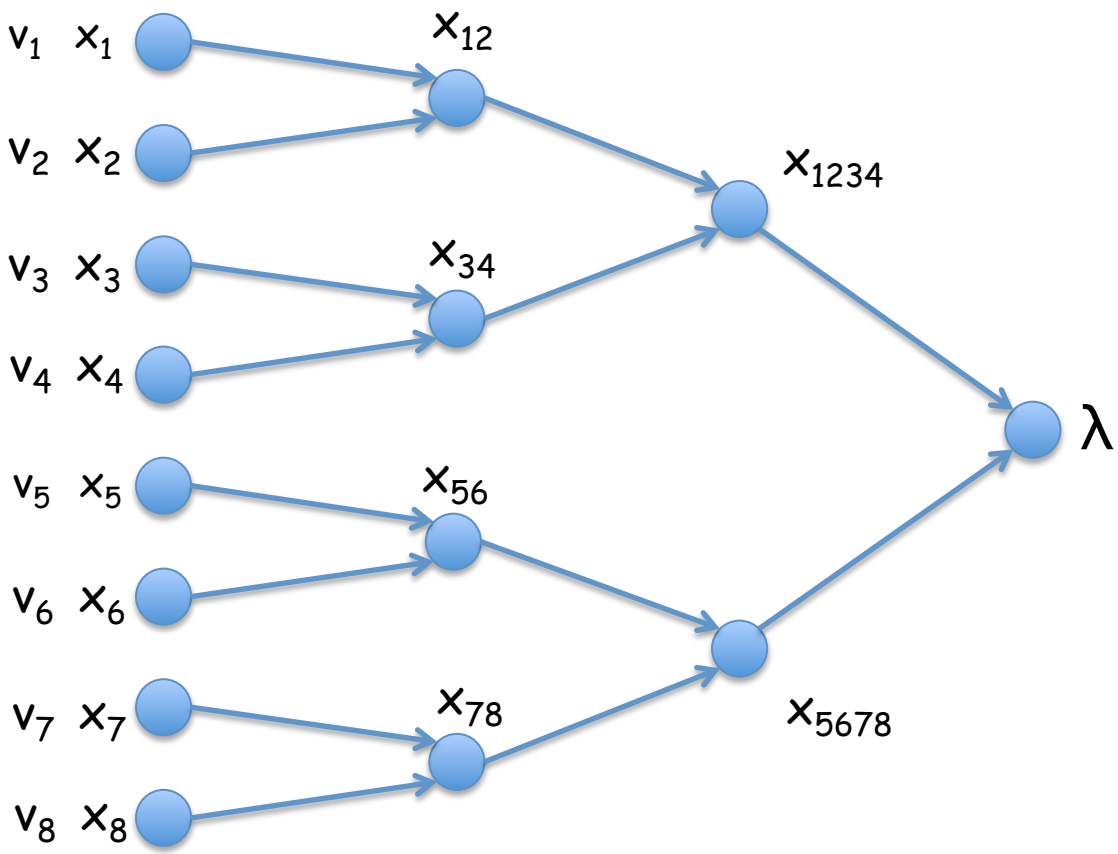

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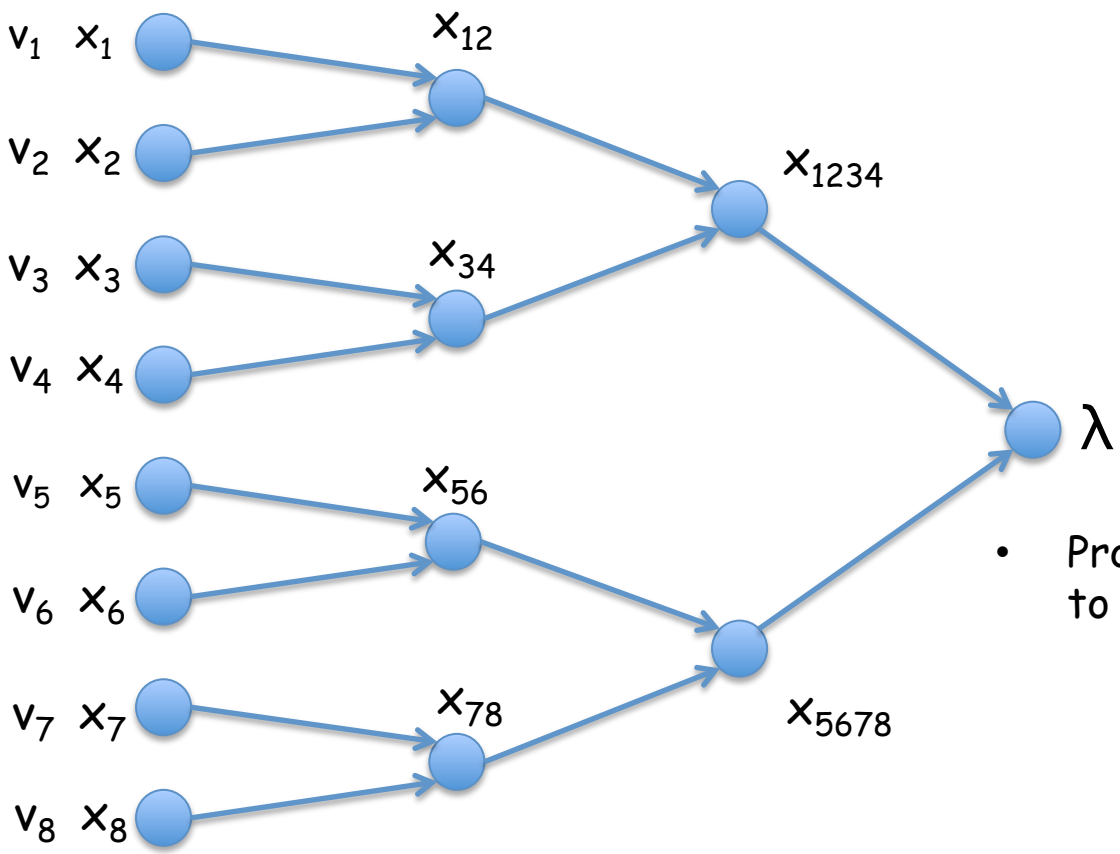

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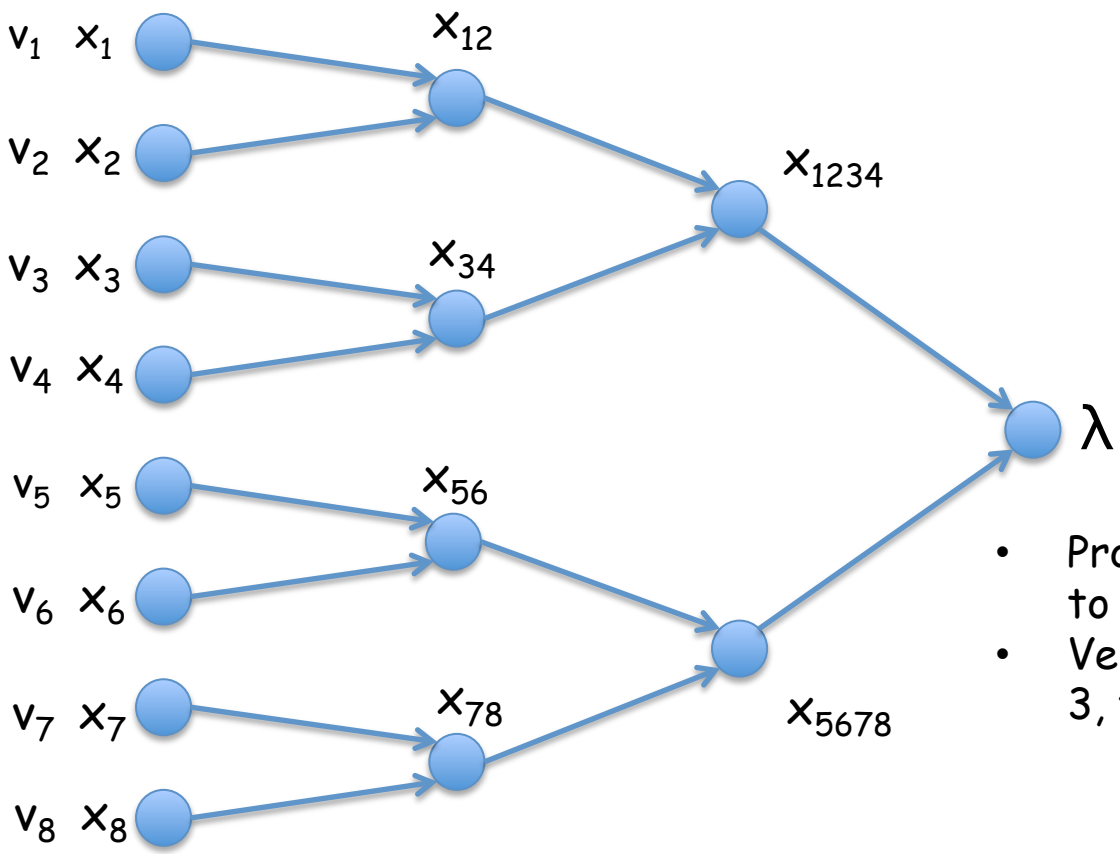

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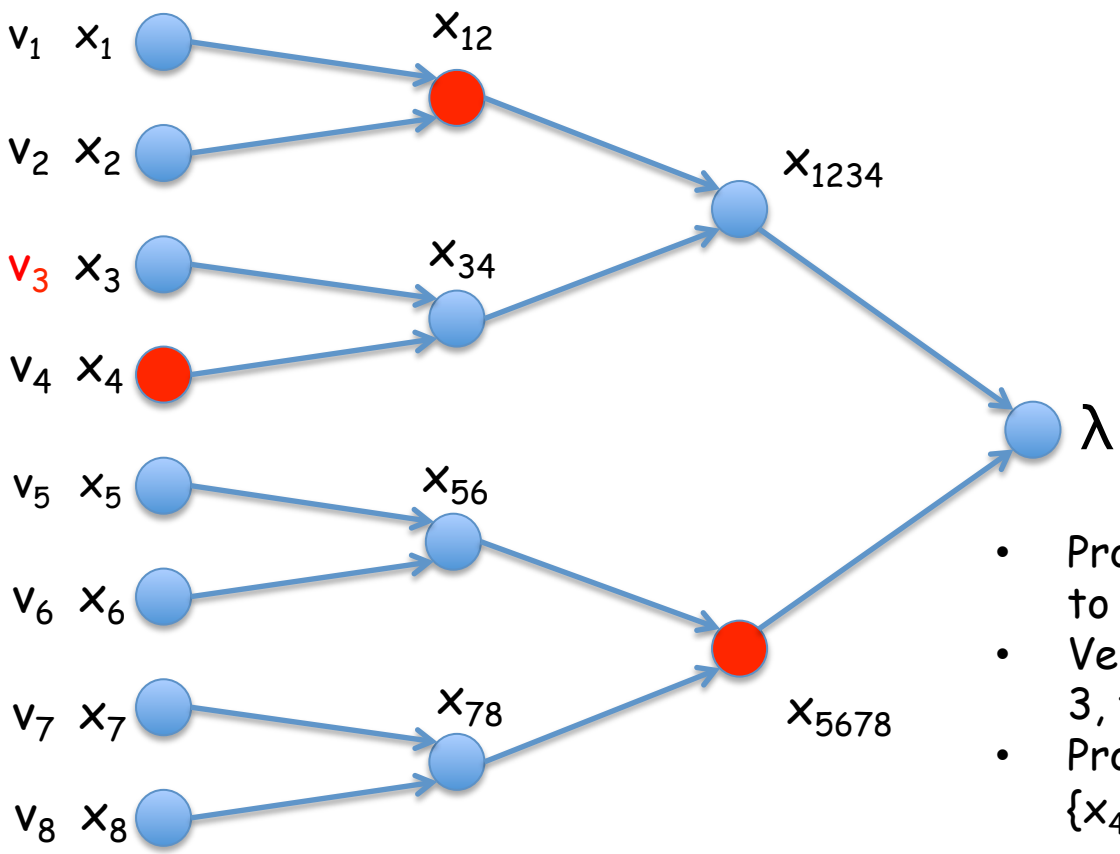

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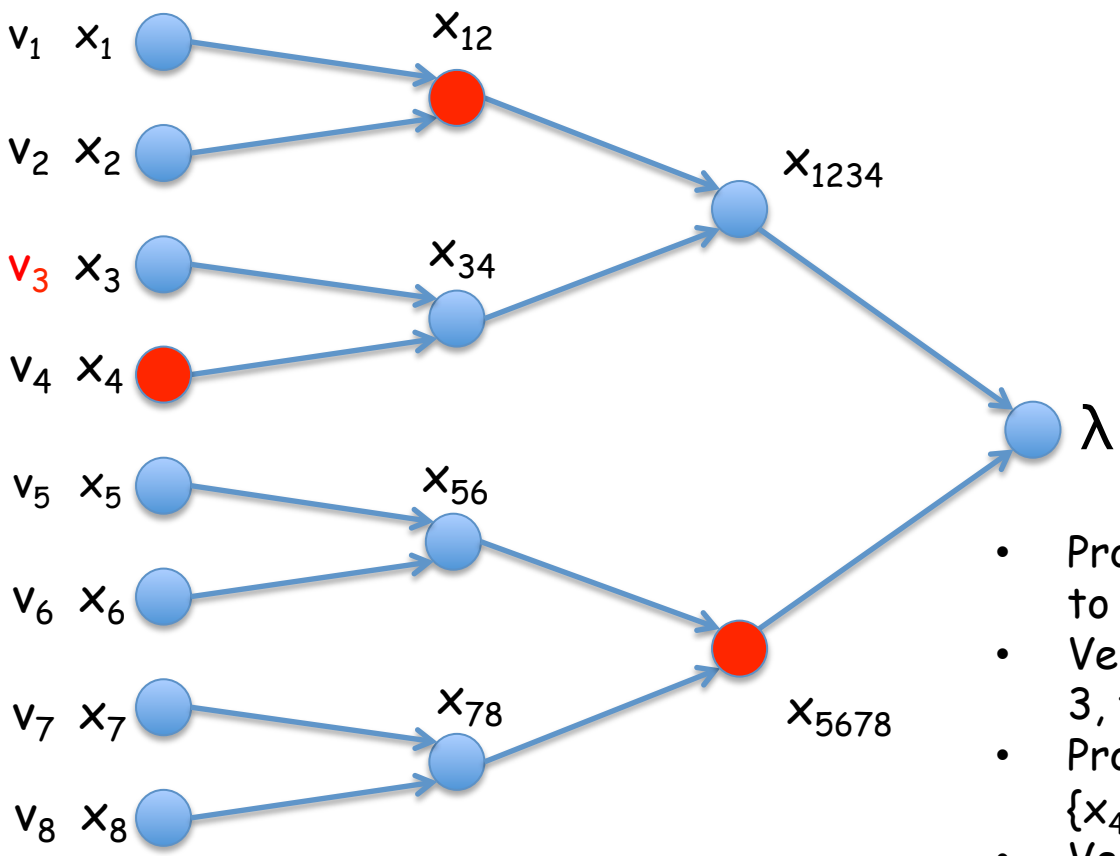

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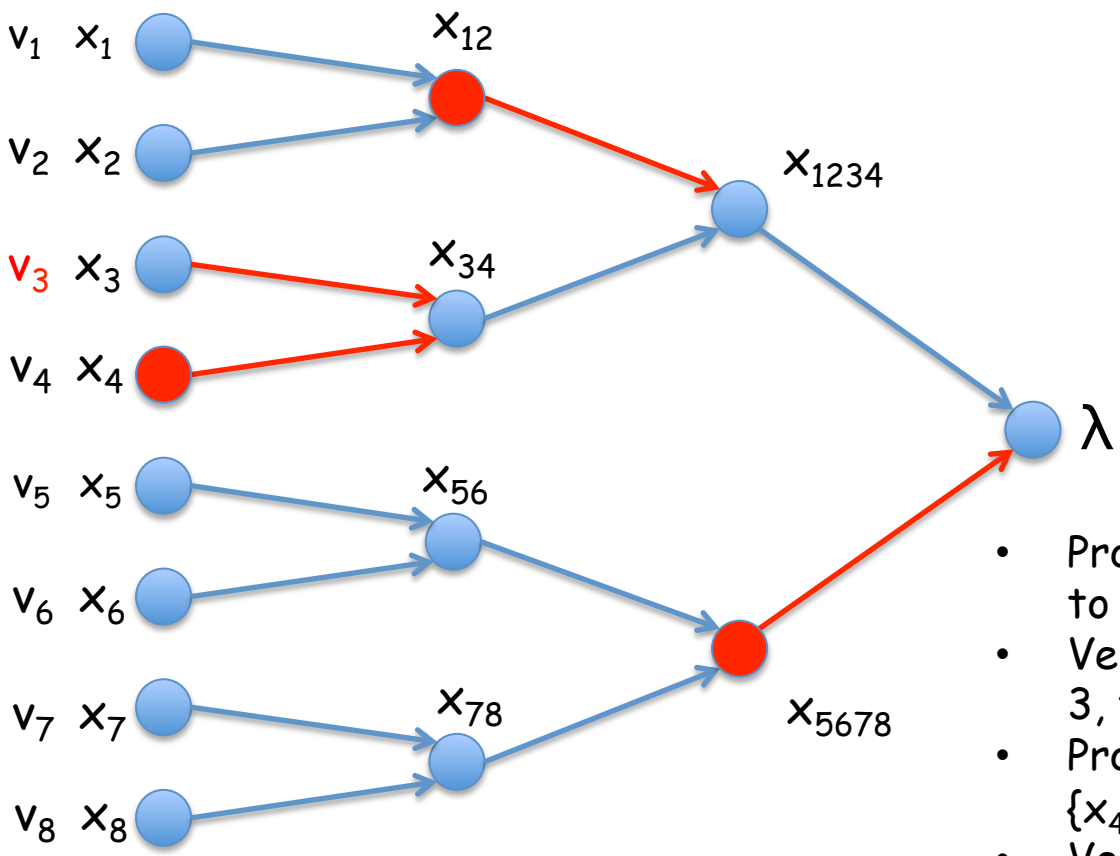

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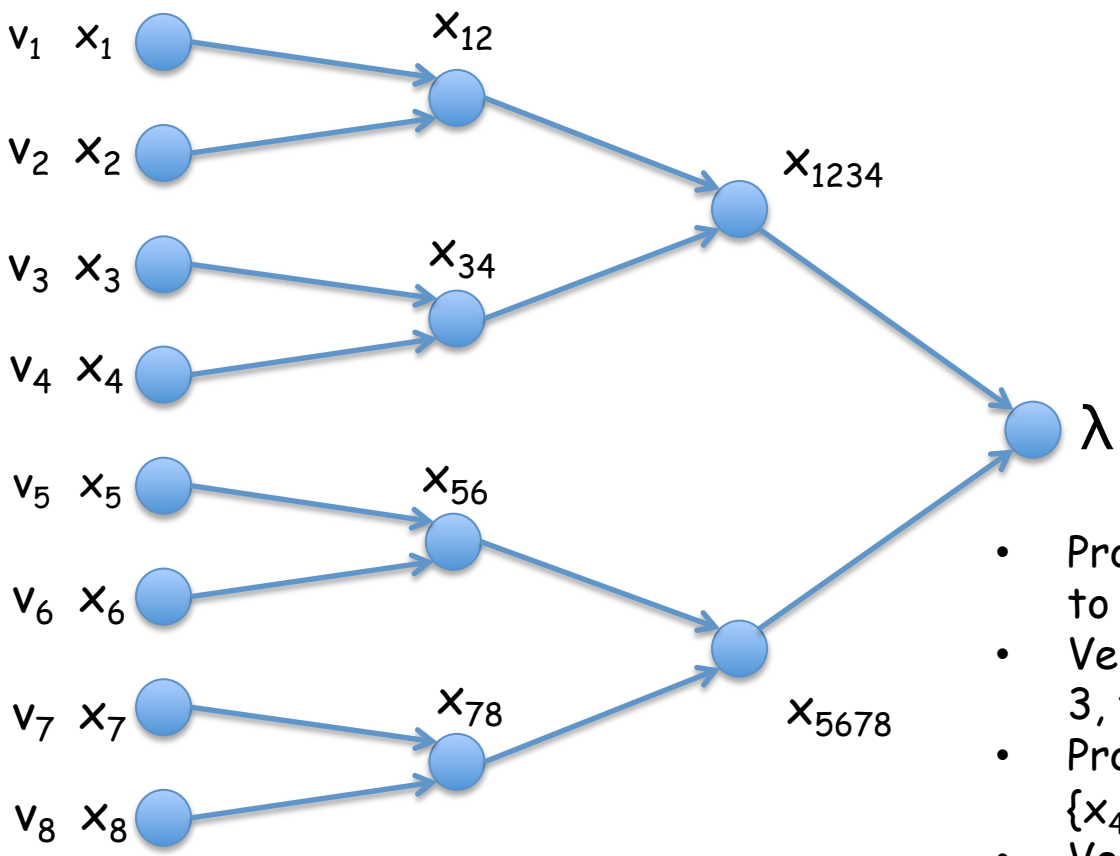

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If H is collusion-resistant, then prover must keep all the data to be able to provide valid proof

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- nothing-at-stake : if mining is computationally cheap, then miners can mine on multiple chains, or try to create many different blocks with a single proof

  slows down consensus

  gives chance to cheating miners to get a greater reward

  enables double-spending attacks by someone controlling less than 50% of the space

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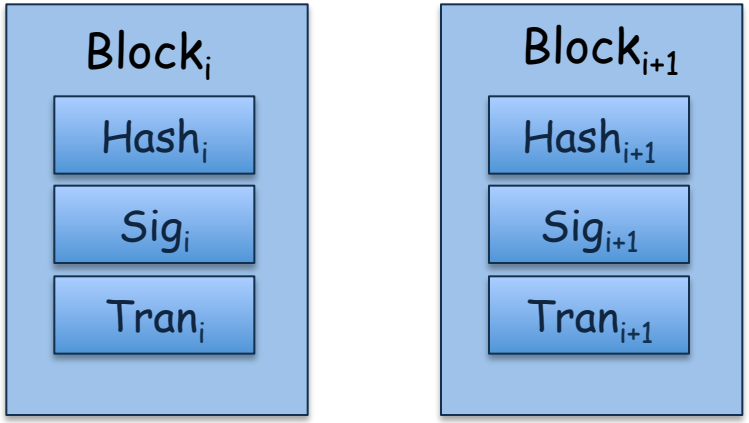
Construction



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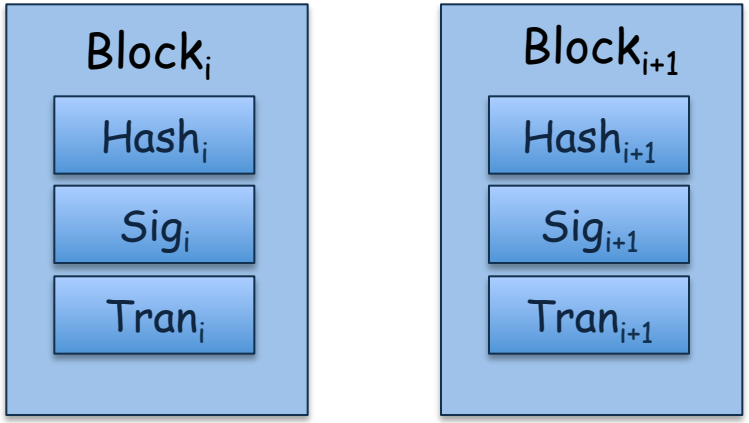

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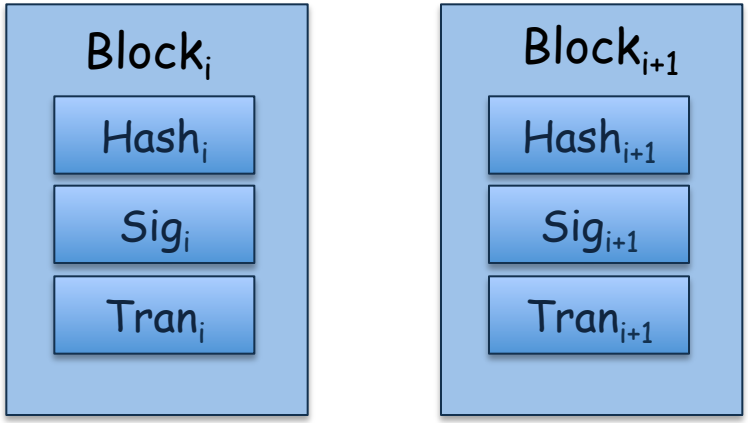

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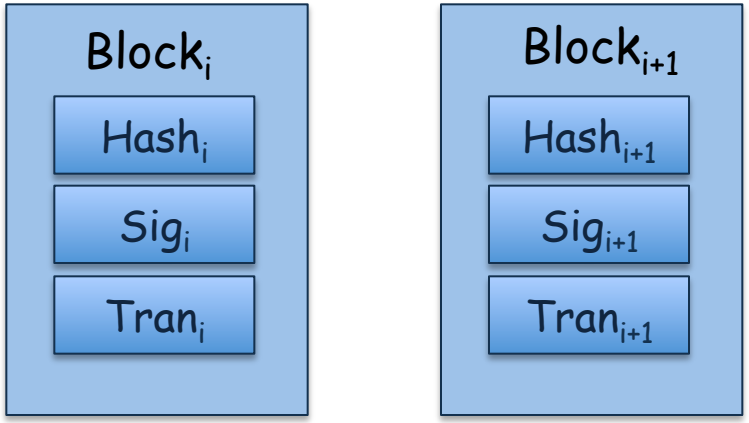

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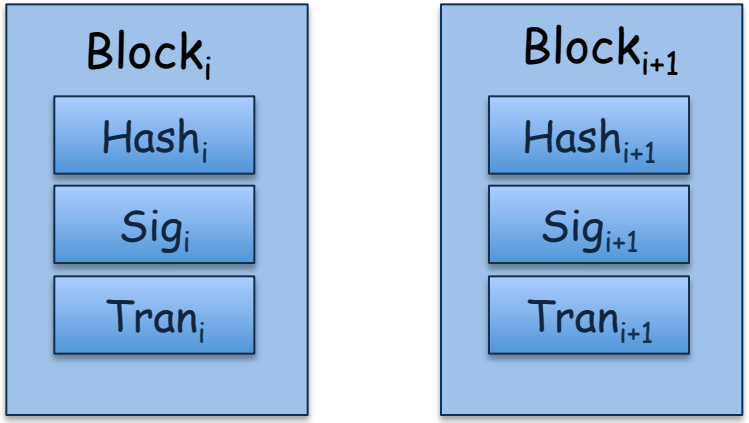

$Hash_i$: current block index i

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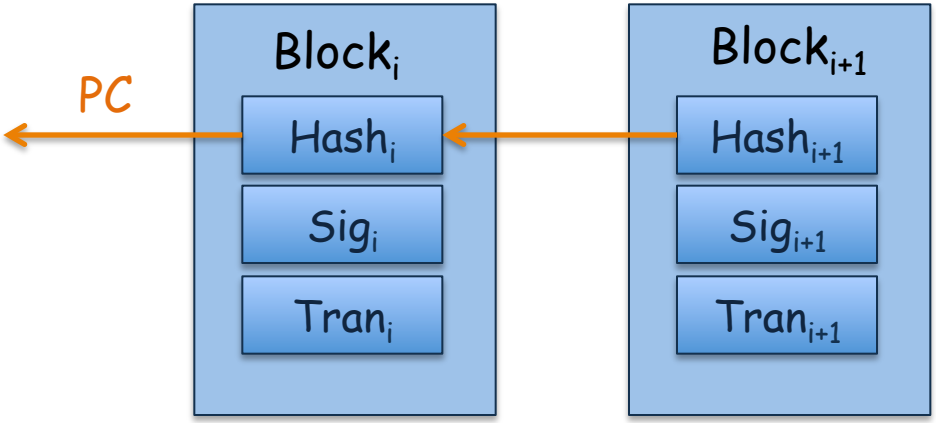

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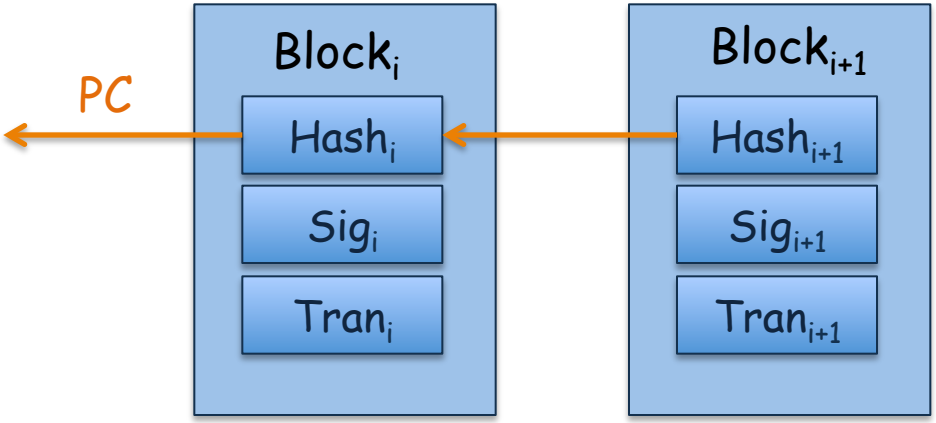

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miner's signature on Hash$_{i-1}$
a space proof that contains pk

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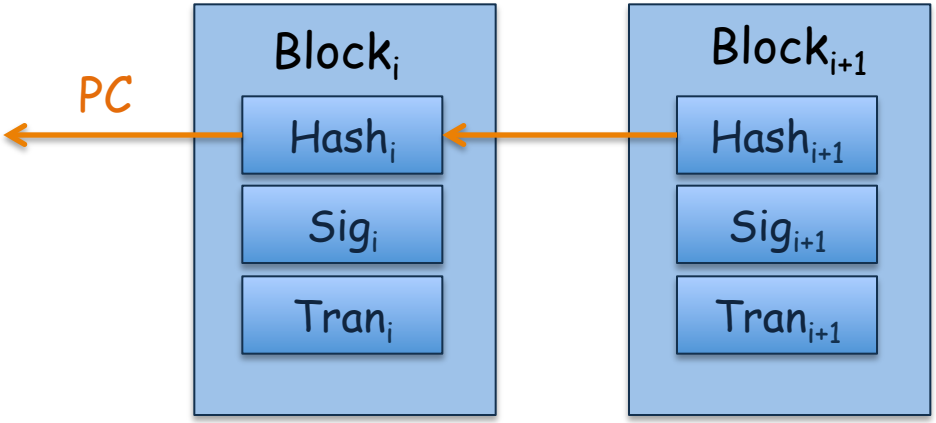

Hash$_i$: current block index i
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Proof of Space
(SpaceMint)

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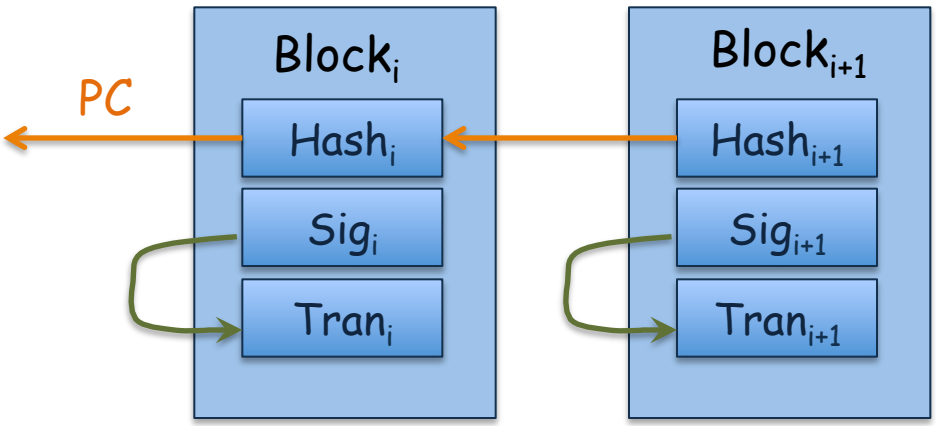

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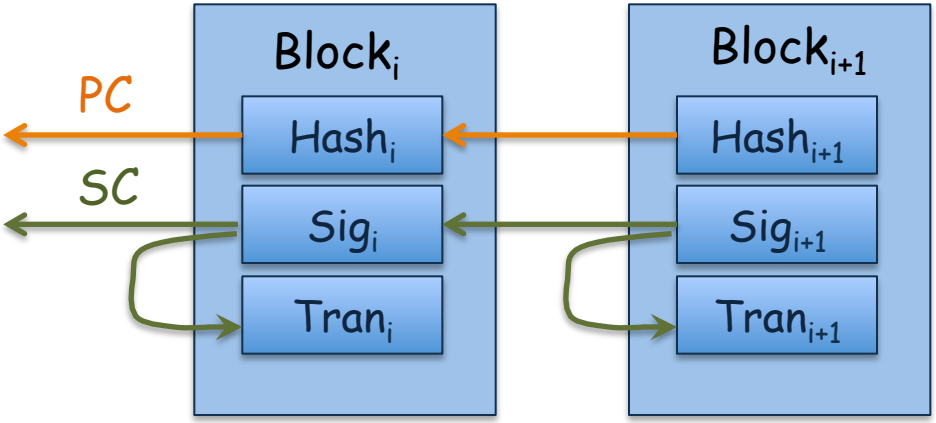

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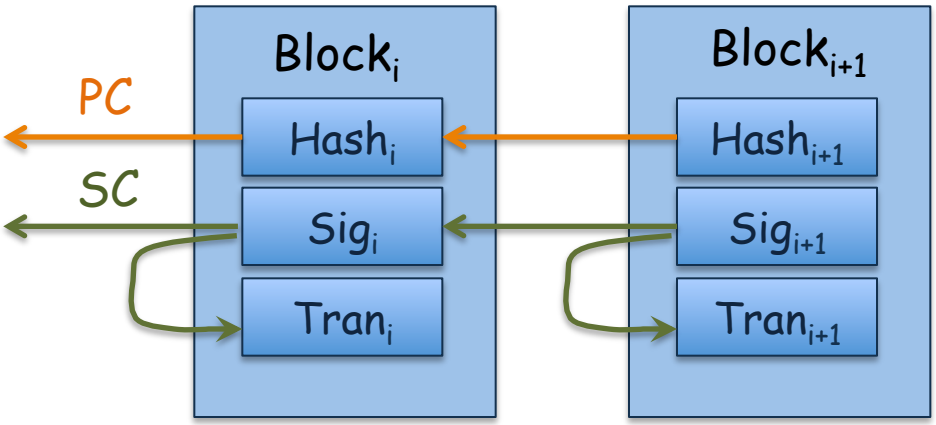

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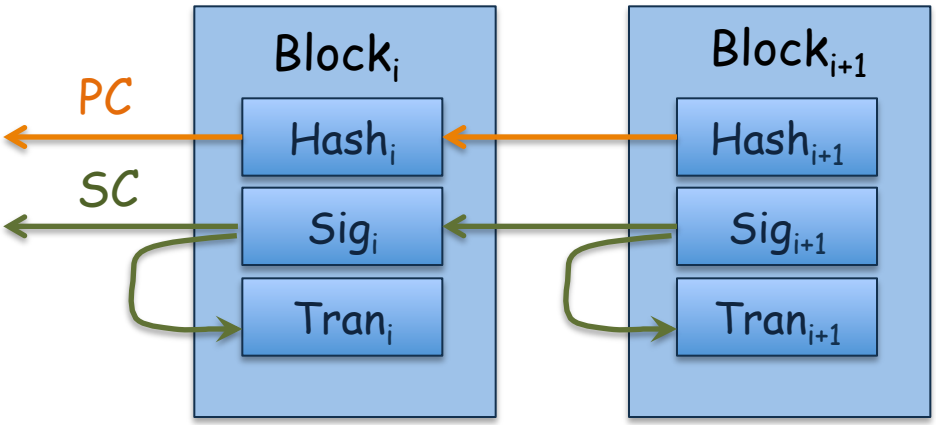

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- Once an honest miner adds a new block to the chain, the transactions up to this block cannot be changed, even by someone that holds all secret keys of the miners that added all the previous blocks.

Proof of Space
(SpaceMint)

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    prf is the proof indicating that two blocks of same index signed by the same signer
- For regular payments; all signatures must be valid, any subsequent transaction must be used only one time in the blockchain(double-spendin), and the sum of the input values should be at least the sum of the output for the acceptance of tx

Proof of Space
(SpaceMint)

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  - [illegible]
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How do we create this challenge ?

(i-1)th block can be used to derive that challenge, but it can slow down the consensus.

- there may be many chains; rational miners can create different challenges for different chains, and try to create proofs for different chains since it is easy to do it

Derive the challenge from the hash of block i – Δ

- the probability of multiple chains surviving for more than Δ blocks decreases exponentially

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For a set of valid proofs $\pi_1=(pk_1,\lambda_1,c_1, a_1),\ldots, \pi_m=(pk_m,\lambda_m,c_m, a_m)$, $Q(\pi_i)$ should be defined in a way that the probability that π_i has the best quality among $\pi_1,\ldots, \pi_m$ corresponds to ith miner's fraction of the total space in the network, which is

$$N_i / (N_1 + \ldots + N_m)$$

where N_i is the space committed to λ_i

Proof of Space
(SpaceMint)

Nothing-at-Stake

Proof of Space
(SpaceMint)

Nothing-at-Stake

- Grinding:

Proof of Space
(SpaceMint)

Nothing-at-Stake

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  - the challenge is derived the hash of block i – Δ, and for any challenge there is a single proof. Besides, the protocol imposes a penalty via the penalty transactions (half of the reward for bad block is given to the creator of the penalty transaction, and other half is diminished)