Communication-Efficient LDPC Code Design for Data Availability Oracle in Side Blockchains

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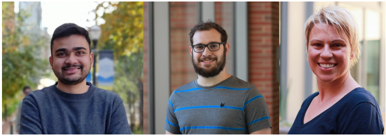
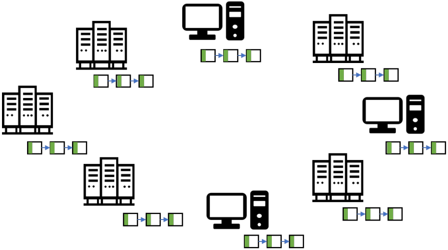


Side Blockchains

- Blockchain systems suffer from low transaction throughput



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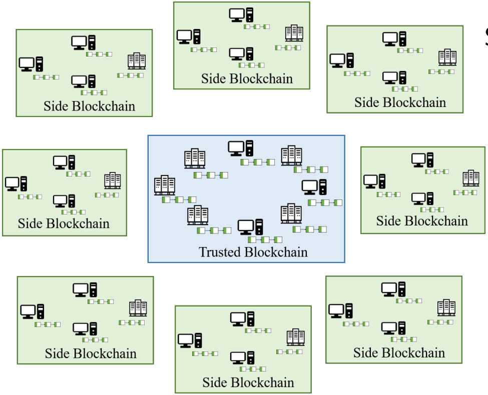
- To improve the transaction throughput, they run Side Blockchains



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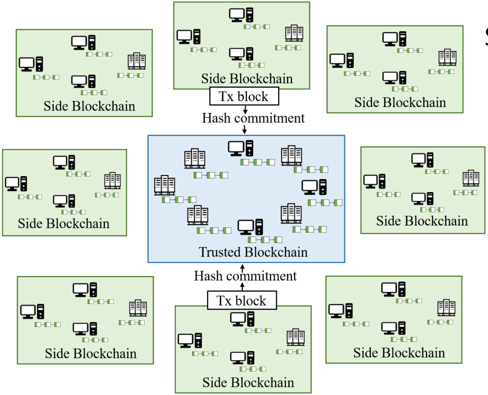

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- Push hash commitment of their block to the trusted blockchain

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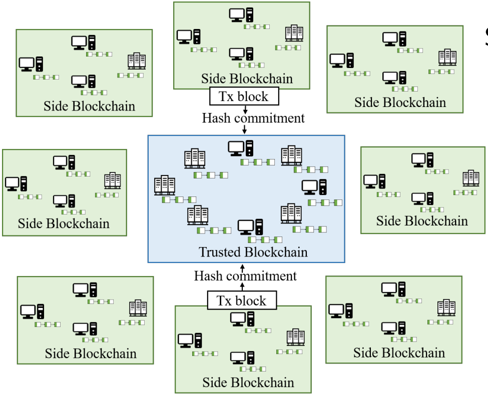

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- Side blockchains make commitments in parallel

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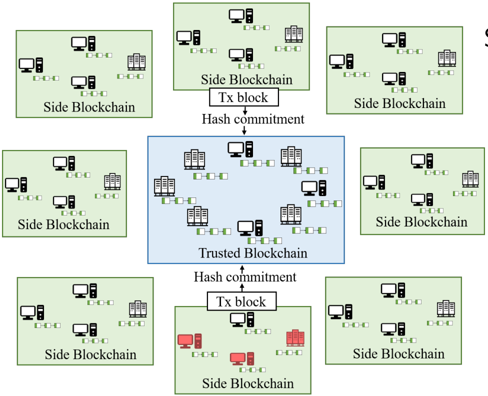

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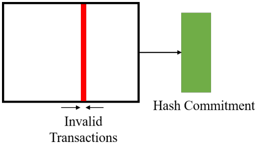
Issue: Side Blockchains with a majority of dishonest nodes are vulnerable to data availability attacks [Sheng '20]

Data Availability (DA) Attack in Side Blockchains

Adversary creates an invalid block



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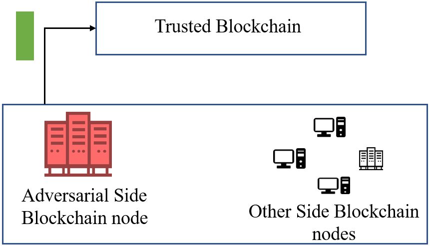

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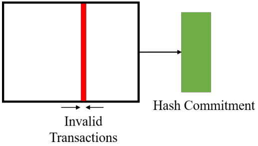

Adversarial Side Blockchain node:

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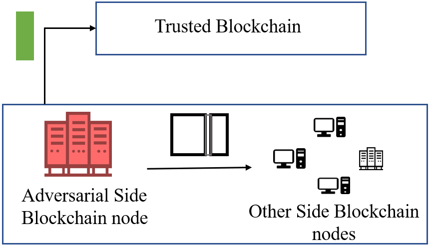

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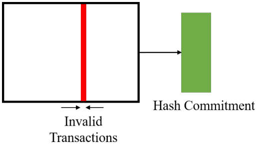
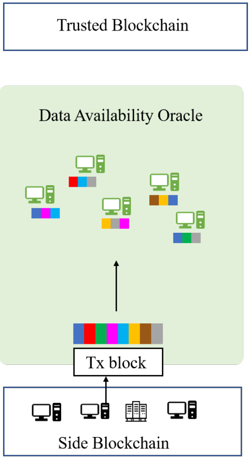


Adversarial Side Blockchain node:

- Pushes hash commitment to the trusted blockchain
- Full block not available to other side blockchain nodes

Solution using a Data Availability Oracle

An oracle layer was introduced to ensure data availability [Sheng '20]



Oracle layer goal

- Collectively and efficiently store chunks of the Tx block (to guarantee availability)

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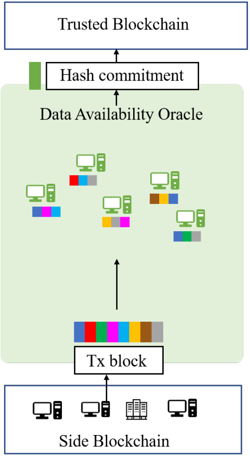

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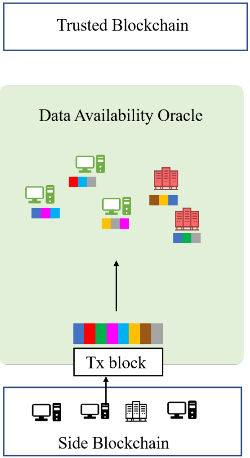

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- Push the Tx block's hash commitment iff the block is available
- Oracle nodes can be malicious (honest majority)

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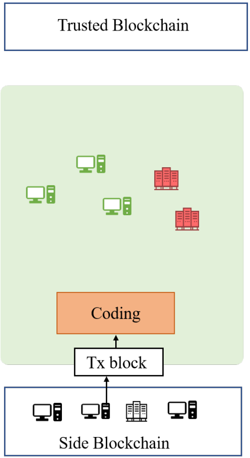

- Transaction block: chunked and coded

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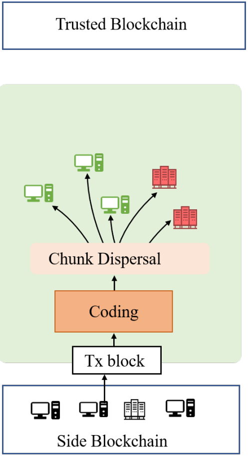

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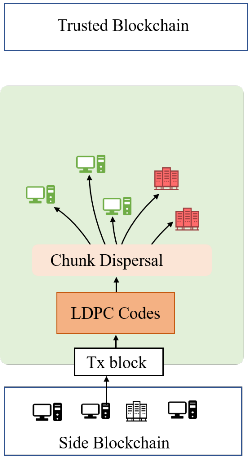

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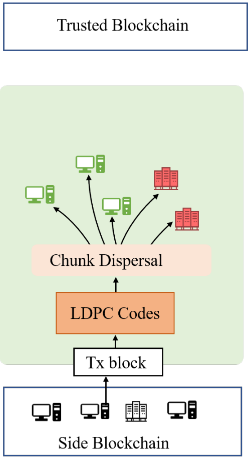

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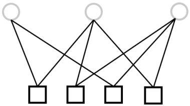
Issues with LDPC codes: small stopping sets (SS)



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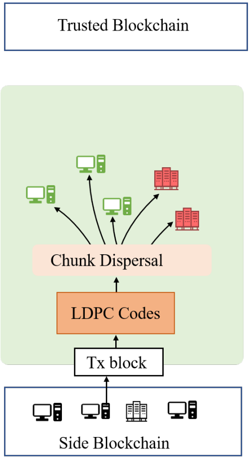

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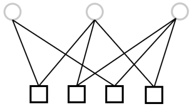

- If VNs corresponding to a small stopping set are hidden from the oracle nodes, original block cannot be decoded back by a peeling decoder

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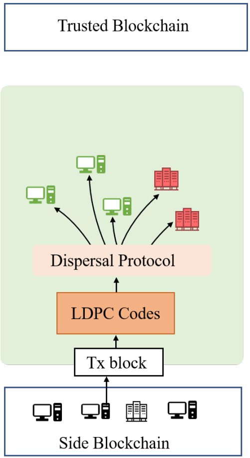

Dispersal Protocol

- Rule about which oracle node stores which coded chunks

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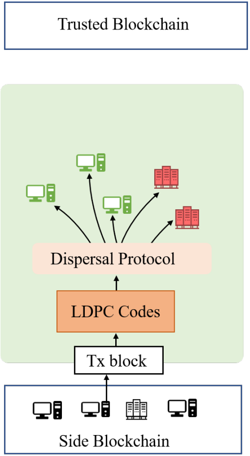

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- Sufficient coded chunks sent to each oracle node such that SS failure cannot occur

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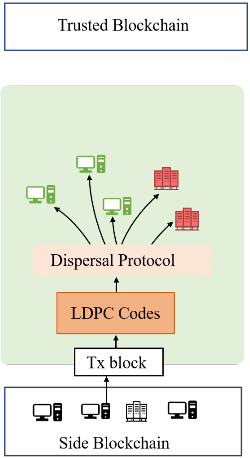

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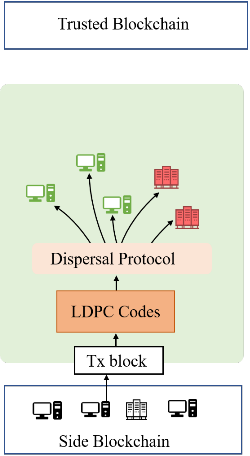

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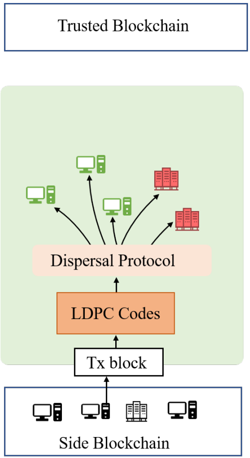

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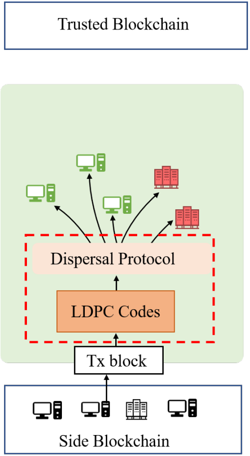

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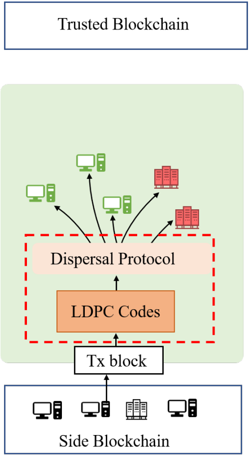

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Our work: Co-design of LDPC codes and a tailored dispersal protocol to significantly lower the communication cost.

Dispersal Protocol Design

Our dispersal strategy is a two step protocol

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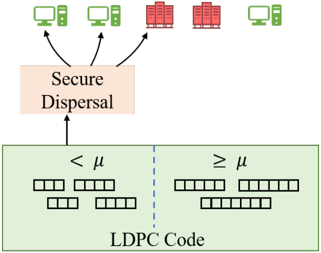

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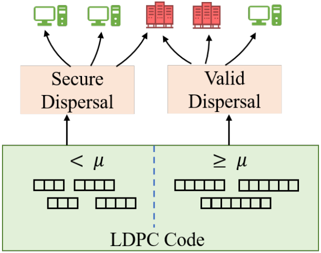

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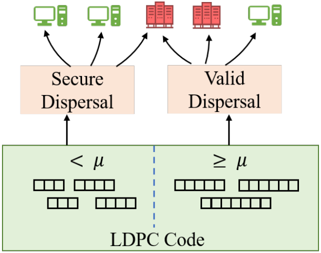

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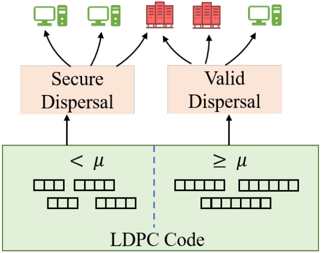

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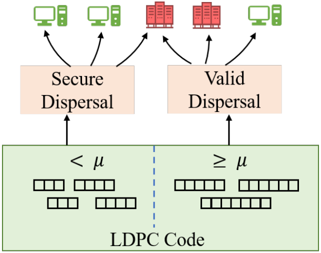

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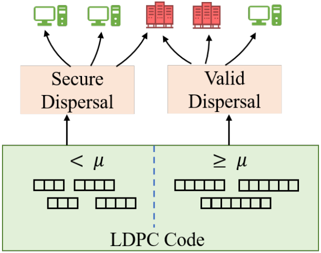

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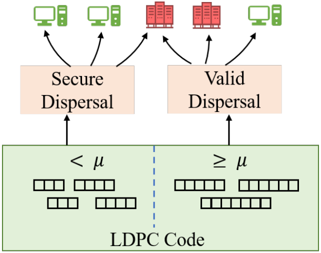

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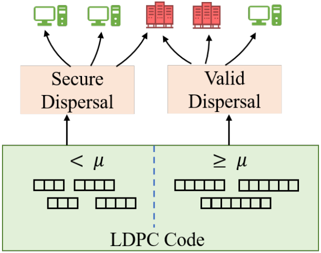

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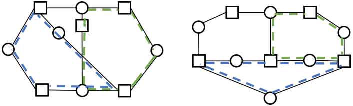
-Modify the PEG algorithm [Xiao '05]

Dispersal-Efficient (DE)-PEG Algorithm

- SSs are made up of cycles [Tian '03]



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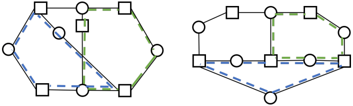

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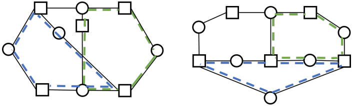

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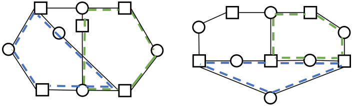

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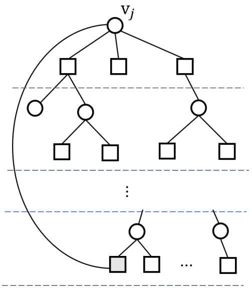

All CNs exhausted

DE-PEG Algorithm
For each VN v_j
Expand Tanner Graph in a BFS fashion
If $\exists$ CNs not connected to v_j
- Select a CN with min degree not connected to v_j

Else *(new cycles created)*
- Find CNs most distant to v_j
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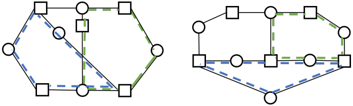

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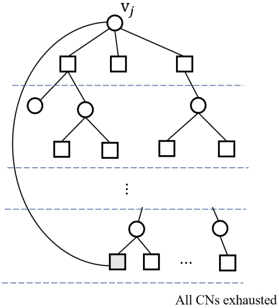

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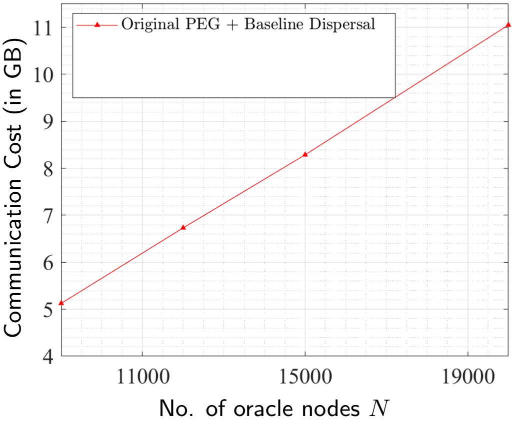
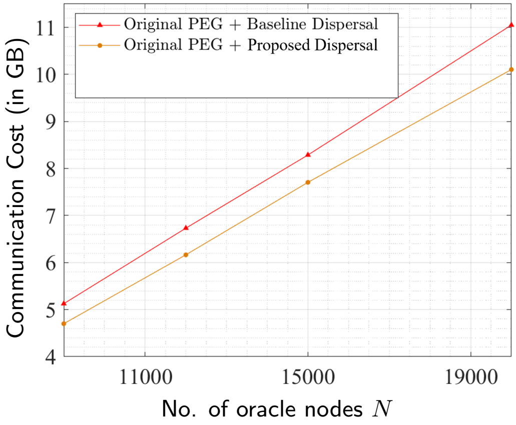
Simulation Results

Communication Cost achieved by different coding schemes and dispersal strategies



Simulation Results

Communication Cost achieved by different coding schemes and dispersal strategies



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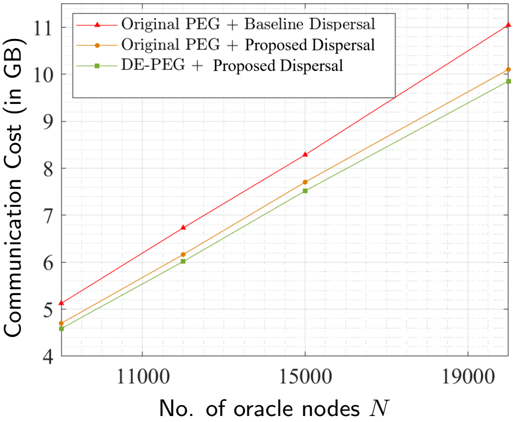

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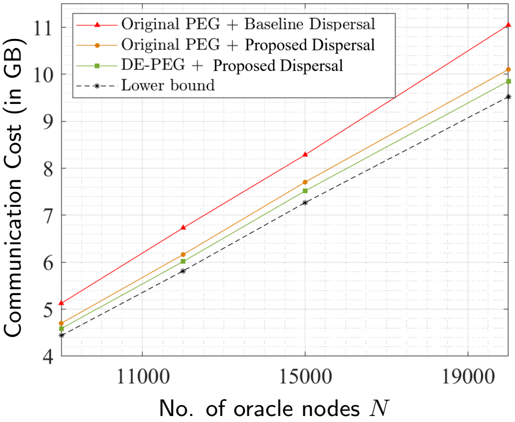

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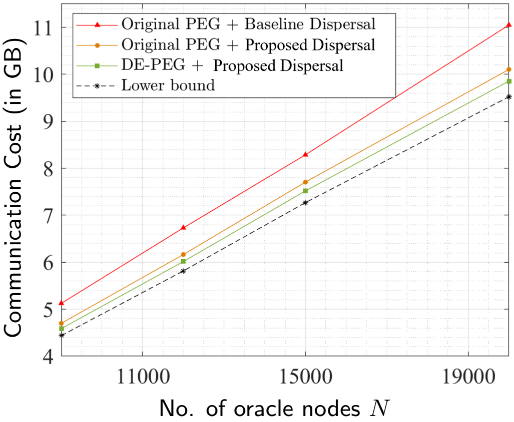

Co-design of the DE-PEG algorithm and the proposed dispersal protocol reduce the communication cost

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