Strategic Peer Selection Using Transaction Value and Latency

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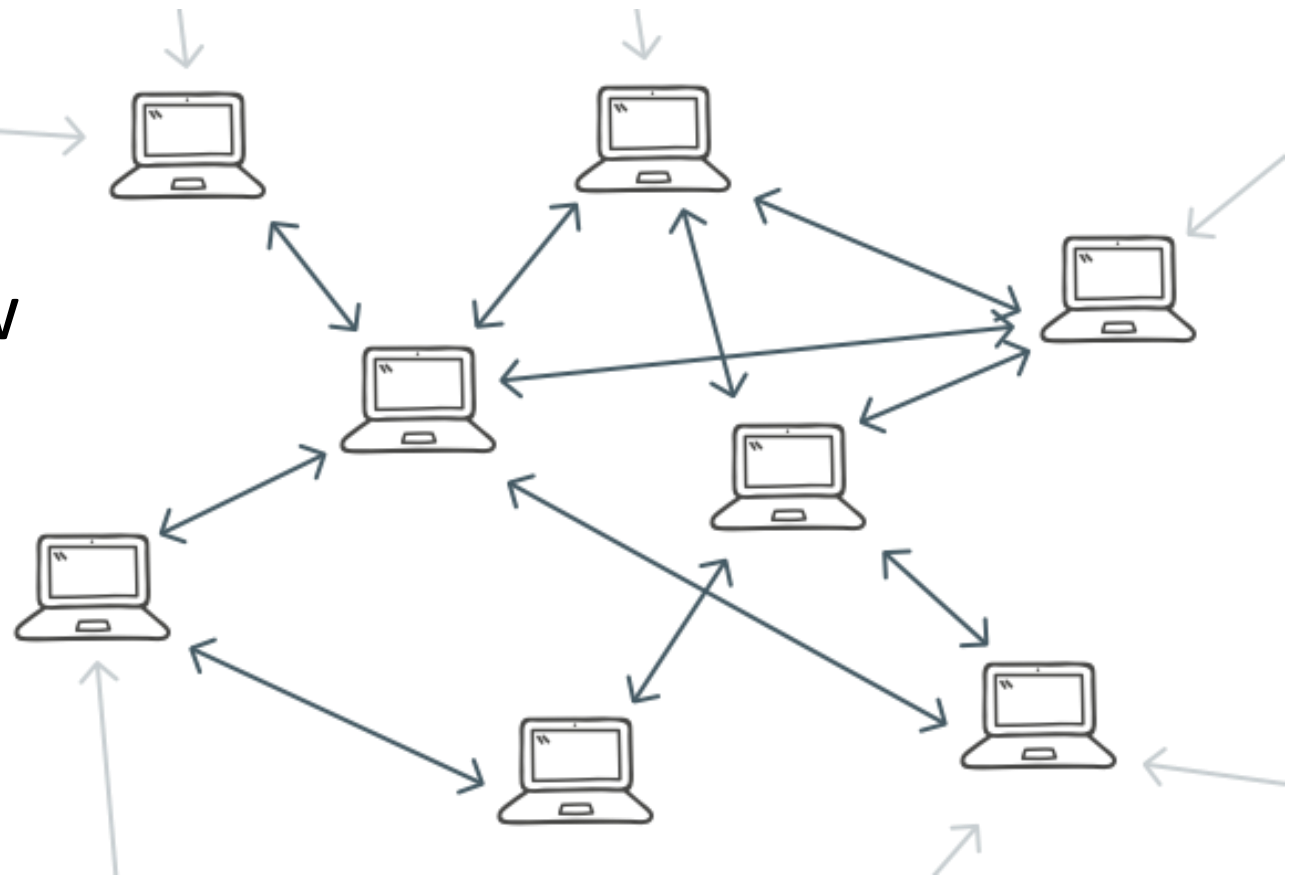
Outline

- Peer-to-Peer Networks
- Why Peer Selection Matters?
  - MEV
- Strategic Peer Selection
  - Latency Based
  - Transaction Value and Latency Based
- Objective Formalization
  - Time-based Ordering Protocols
  - Leader-based Protocols
- MEV-Peri Algorithm
- Evaluation
  - Transaction Flow Estimation

P2P Networks

- Each node in the network has only local view of the network.
- No node has complete view of all the pending transactions.
- Blocks are propagated with higher priority, and are often serialized, allowing for most nodes to have complete view of the state.



Why Peer Selection Matters?

- Need to know about the latest state...

But also,

- Pending transactions create profitable opportunities.
- MEV = Value captured by inserting, reordering or censoring pending transactions.
- A strategic agent wants to ideally
  - Know about all such transactions.
  - Listen to these transactions at the earliest.

MEV, A Growing Industry...

$674,300,932
Total Extracted MEV

$6,930,451
Last 30 days Extracted MEV

$113k
Last 24h Extracted MEV

Default Peer Selection

- Choose peers that are compatible
- Choose peers that are willing to serve
- Keep peers that are *stable*
- For discovering peers, rely on information from other peers (hardcoded), or from a past session

- But, no enforced way of peer selection

Strategic Peer Selection

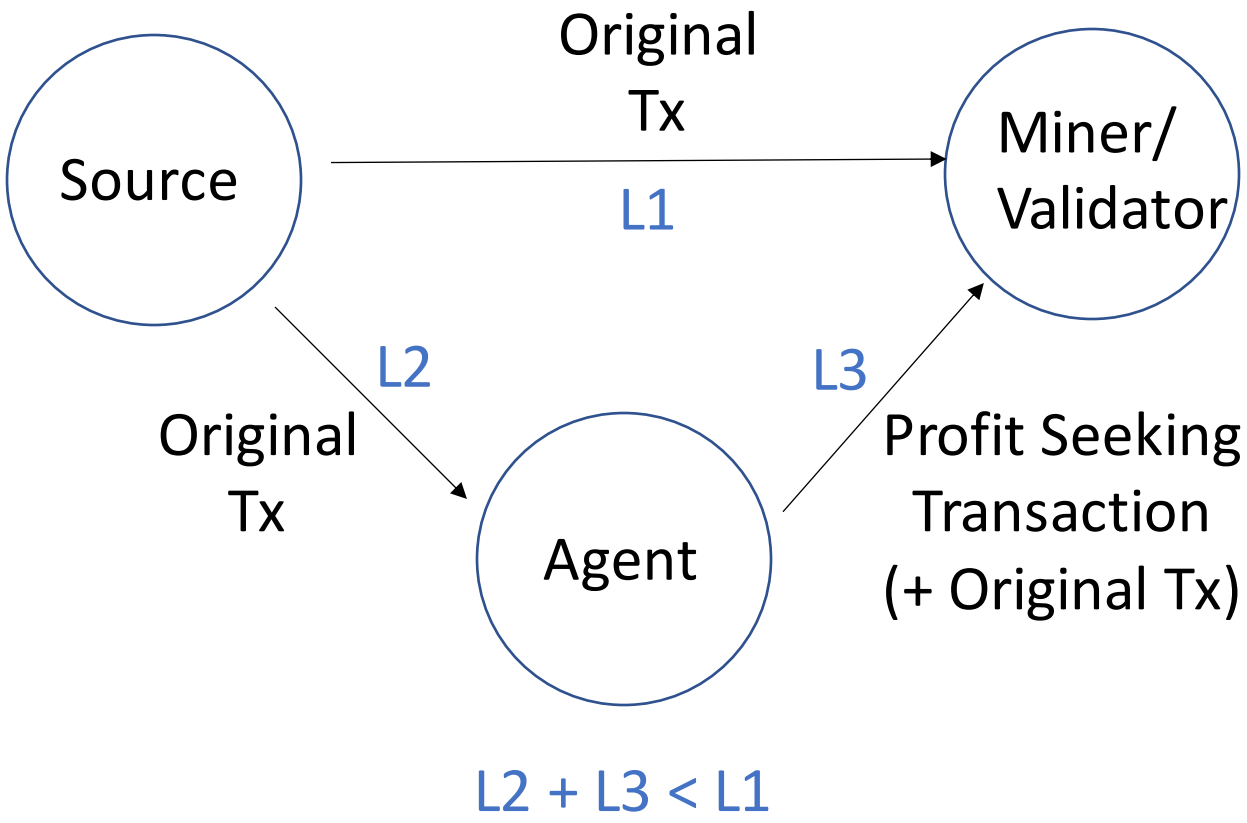
- Optimize for peers that help with profitable opporunities
- Peering algorithm should work based off the local view of the network

Latency-based Peer Selection

Tang, Weizhao, Lucianna Kiffer, Giulia Fanti, and Ari Juels. "Strategic Latency Reduction in Blockchain Peer-to-Peer Networks." arXiv preprint arXiv:2205.06837 (2022).

- Defined the notion of triangular latency
- Optimizing Peer Selection in general is NP-Hard
- Peri : Efficient and Local peering algorithm for optimizing triangular latency
- Can be combined with paid relay services like Bloxroute to further improve their latency advantage

Triangular Latency



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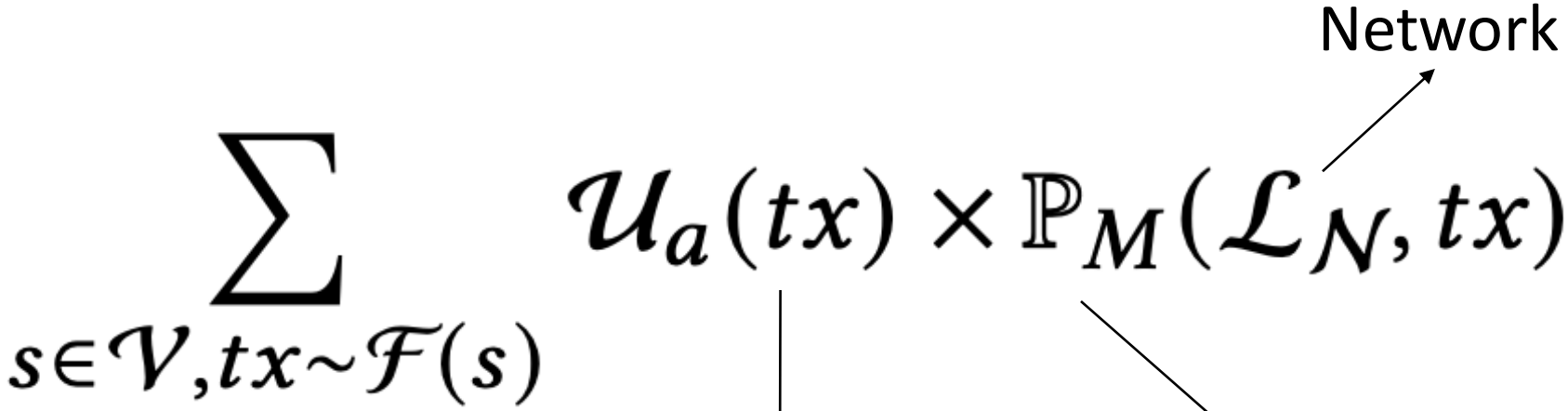
Transaction Value and Latency-based Peer Selection (This Work)

- Change the objective from latency optimization to profit optimization
- Latency is important, but the value derived from the transactions is now also important
- Intuition : Some peers may be fast, but may not be the ones gossiping valueable transactions
- Adapt the Peri algorithm for optimizing peer selection into the algorithm "MEV-Peri"

Objective Formalization

- Strategic Agent: *a,* Set of P2P nodes *V*



Time-based Ordering Protocols

- Committee : C, Network: *N*, Netowork with agent : *N'*

$$\mathbb{P}_{FCFS}(\mathcal{L}_{\mathcal{N}}, tx) = [\![\sum_{c \in C} [\![(\mathcal{L}_{\mathcal{N}}(s,c) > \mathcal{L}_{\mathcal{N}'}(s,c))]\!] \geq \gamma \times |C|]\!]$$

Protocol Parameter: Fraction of committee nodes that receive frontrunning transaction first

where,

$$[\![X]\!] = \begin{cases} 1, & \text{if } X \text{ is true} \\ 0, & \text{otherwise} \end{cases}$$

$$\underset{\mathcal{P}}{\operatorname{argmax}} \sum_{s \in \mathcal{V}, tx \sim \mathcal{F}(s)} \mathcal{U}_a(tx) \times \mathbb{P}_{FCFS}(\mathcal{L}_{\mathcal{N}}, tx)$$

Leader-based Ordering Protocols

- Strategic Agent: *a*

$$\mathbb{P}_{leader-based}(\mathcal{L}_{\mathcal{N}}, tx) = e^{-\lambda * (\Delta t)}$$

Protocol Parameter:
Inter-block time

where Δt is given by,

$$t - t_0 + \mathcal{L}_{\mathcal{N}}(s, a) + \mathcal{L}_{\mathcal{N}}(a, leader)$$

MEV-Peri Algorithm

Input: Network: $\mathcal{N} = (\mathcal{V}, \mathcal{E})$, Peer budget: n, Replacement Ratio: r;

Output: Optimal Peer Set: $\mathcal{P}^*$;

Requires: $1 \leq n \leq |\mathcal{V}|$, $0 < r < 1$;

$\mathcal{P} \leftarrow \texttt{random}(\mathcal{V}, n)$;

for *epoch = 1,2,...* **do**

  Sleep(epoch period);

  $\phi \leftarrow$ Init Score Map;

  for $p \in \mathcal{P}$ **do**

    $\phi(p) \leftarrow \texttt{score}(p)$;

  end

  $\mathcal{P} \leftarrow \mathcal{P} - \texttt{least}(\phi, r)$;

  $\mathcal{P} \leftarrow \mathcal{P} \cup \texttt{random}(\mathcal{V}, r)$;

end

$$\texttt{score}(p) = \sum_{\text{observed } tx} [\mathcal{U}_a(tx) \times (TS(tx) - TS_p(tx))]$$

Adapted from Peri : Tang, Weizhao, Lucianna Kiffer, Giulia Fanti, and Ari Juels. "Strategic Latency Reduction in Blockchain Peer-to-Peer Networks." arXiv preprint arXiv:2205.06837 (2022).

Evaluation

- Evaluation on mainnet is expensive:
  - P2P network does not propagate invalid transactions
  - Each valid (profit-seeking) transaction incurs significant fees
- Evaluate on a simulated P2P network
  - Need Latencies : Generate using Scale Free Graph Model (Hub and Spokes network)
  - Need Utility of each transaction and the distribution of these transactions across source nodes

Transaction Flow Estimation

- Use MEV as the utility function
- Estimate MEV : Average MEV bribe per transaction in Flashbots bundles (https://blocks.flashbots.net/)
- Attribution to a source node: Spawn 12 geographically distributed nodes, collected 116m unique transactions. Attribute the transaction source to the node that first observed the transaction

Transaction Flow Estimation

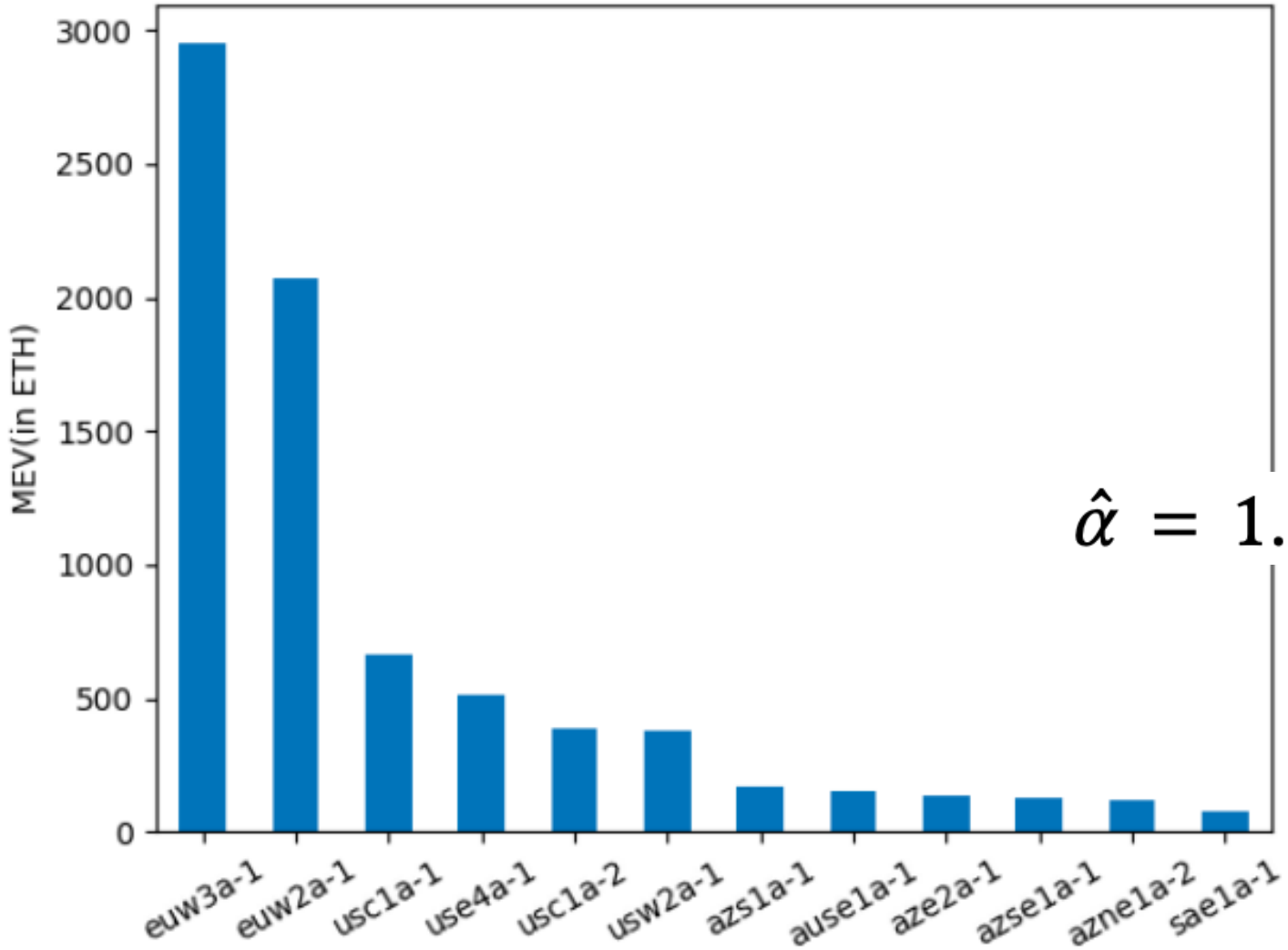
$$PDF(x) = \frac{x^{-\alpha}}{\zeta(\alpha, x_{min})}$$

where

$$\zeta(\alpha, x_{min}) = \sum_{n=0}^{\infty} (n + x_{min})^{-\alpha}$$

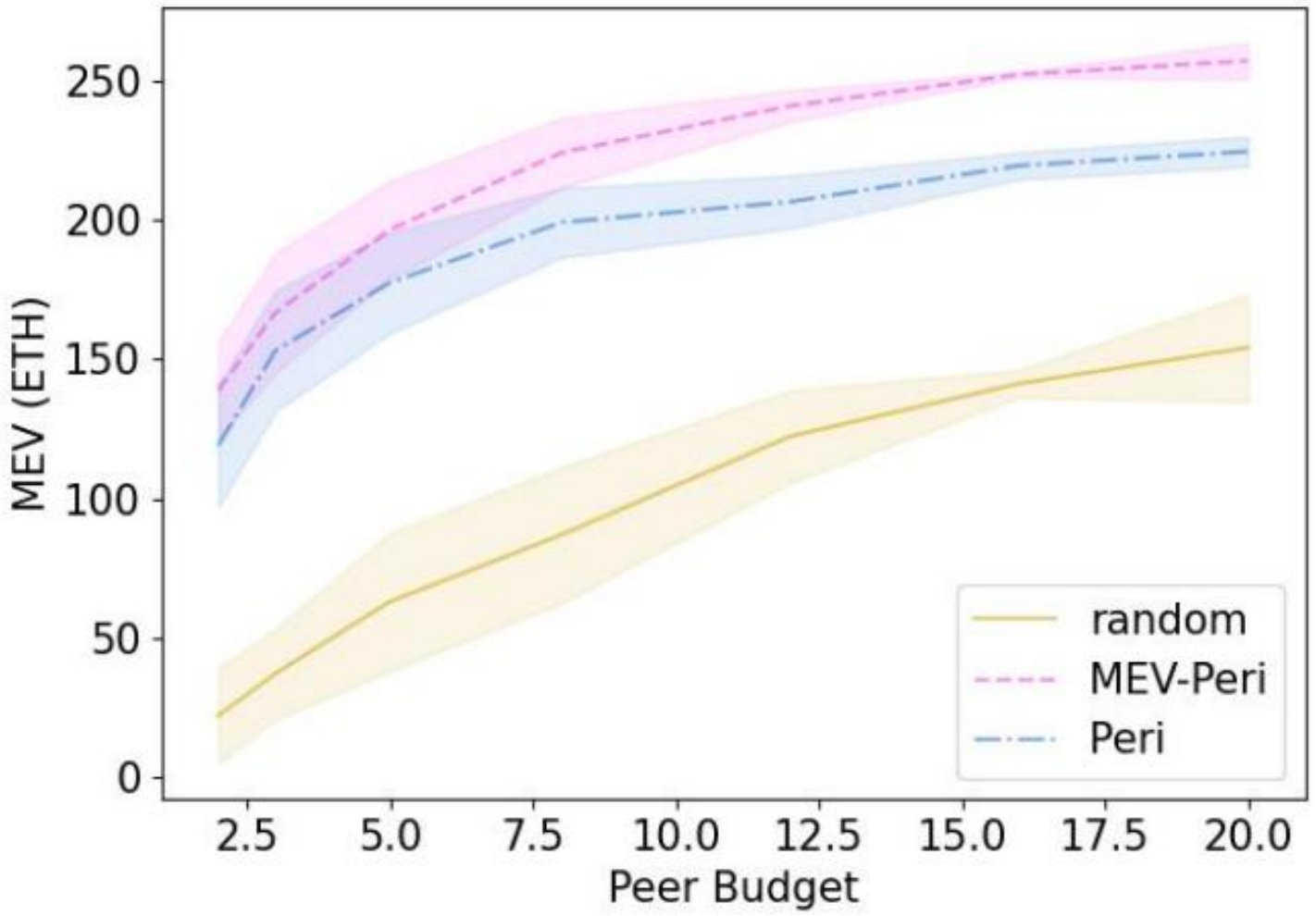
$$\hat{\alpha} = 1 + n \left(\sum_{i=1}^{n} ln \frac{x_i}{x_{min} - 1/2} \right)^{-1}$$

Evaluation: Transaction Flow



$$\hat{\alpha} = 1.72 \pm 0.20$$

Evaluation: MEV-Peri



- Epochs : 800
- Replacement Ratio : 25%
- Number of P2P nodes: 1000
- Size of Committee: 100
- γ = 0.5

Conclusion

- Peers can be chosen strategically in a P2P network
- Proposed and formalized the objective of choosing peers based on transaction value and latency
- Proposed the MEV-Peri algorithm which is efficient and local
- Evaluated MEV-Peri algorithm against baseline of random peering and algorithm that only exploits latency information