

CSE 2550: Visualizing and Simulating Blockchains

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In order to understand the operations of the blockchain, several visualization tools were created. In this document, we examine a few tools that allow for simulating blockchains and visualizing real-time operations on existing blockchain systems.

1 TxStreet

TxStreet [2] is a live transaction and mempool visualizer featuring Bitcoin, Ethereum, Bitcoin Cash, Monero and Litecoin. It allows visualization of new transactions and blocks being created on the previously mentioned blockchain system.

The blocks are represented as buses and transactions are represented as people attempting to board the bus, and the size of a transaction is proportional to the size of the character representing it.



Figure 1: TxStreet: Overview of the System

Whenever a transaction is broadcast into a network, a new person is spawned. This visualizer follows the Maximal extractable value (MEV) approach to decide which transactions board the bus. In other words, the transactions with the highest fees board the bus first. All other transactions remain pending until they become the highest-fee transactions. The transactions with very low fees remain waiting for a long time (and have their own section in the visualization).



Figure 2: TxStreet: Low fee Transactions

For certain blockchains (e.g. ethereum), certain institutional smart contracts (like the one for USDT) are represented as houses that deliver transactions to the system. This allows differentiating between institutional transactions (coming from certain exchanges, stablecoins, decentralized autonomous organizations, rollups) and other transactions in the systems

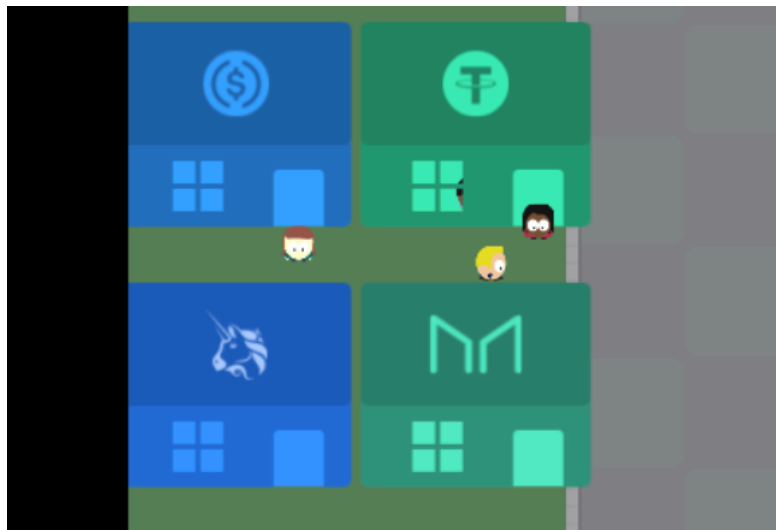


Figure 3: TxStreet: Institutional Sources

2 Blockchain Simulator

Blockchain Simulator[1, 3] is a tool that can simulate the behavior of Proof-of-Work (PoW) blockchains (e.g. bitcoin). It allows generating different network topologies and simulating the behaviour of real nodes and evaluate the outcomes of the distributed consensus in these network. It also allows visualizing and performing attacks on the network, like 51% or Eclipse attacks. In this tutorial we explore how we can create and configure a network, and visualize different interactions with nodes:

2.1 Creating a Network Topology

To create a new network topology, click on the topology menu and select Generate a new topology, then select your desired topology from the ones offered in the menu (traditional ones: e.g ring, star, mesh; and real-life models: e.g. Barabási-Albert, Bitcoin)

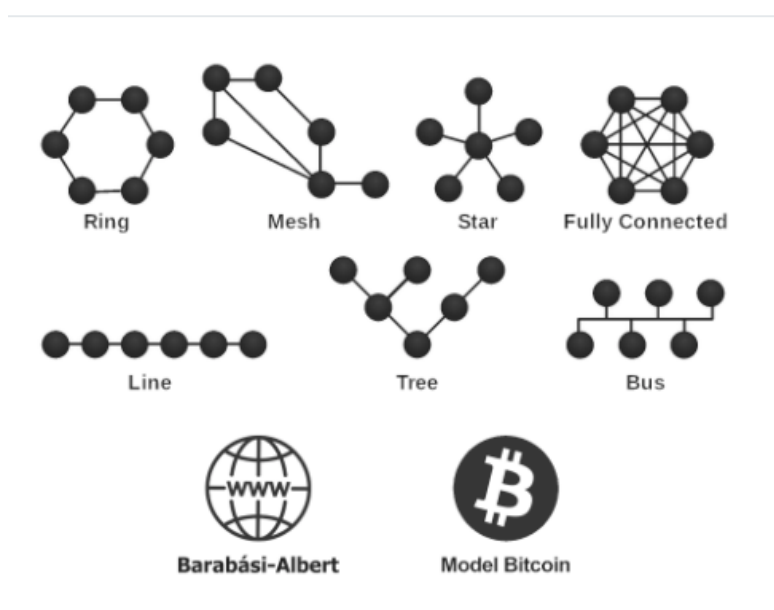


Figure 4: Blockchain Simulator: Topologies

A Menu will appear to allow you to configure the networking properties of the topology. Those properties are represented as a JavaScript Object that you can modify to correspond to your needs. You can set the latency values, bandwidth, the in-/out-degree of connectivity for nodes and so on.

```
{
  "Type": "Mesh",
  "Bidirectional": true,
  "Prevent duplicate connections": true,
  "Number of peers": 30,
  "Minimum number of outgoing connections": 1,
  "Maximum number of outgoing connections": 1,
  "Minimum power (hashes per second)": 1,
  "Maximum power (hashes per second)": 5,
  "Minimum downlink (megabytes per second)": null,
  "Maximum downlink (megabytes per second)": null,
  "Minimum uplink (megabytes per second)": null,
  "Maximum uplink (megabytes per second)": null,
  "Minimum latency (milliseconds)": 100,
  "Maximum latency (milliseconds)": 100,
  "Naming cycle": [
    "Aaron",
    "Adam",
    "Alan",
    "Albert",
    "Alex",
    "Alice",
    "Andrew",
    "Anthony",
    "Arthur",
    "Austin",
    "Ben",
    "Bill",
    "Bob"
  ]
}
```

Ln: 3 Col: 22

Figure 5: Blockchain Simulator: Network Configuration

2.2 Fine-Tuning Network Nodes

Each node can be fine-tuned to display certain behavior during the simulation. The webpage displays all nodes in the network and allows you to modify each individually with different properties. To perform this operation, select the node from the page and change its properties. You can set and edit their ingoing and outgoing network links to other nodes, their mining power, the type of blocks they produce, etc.

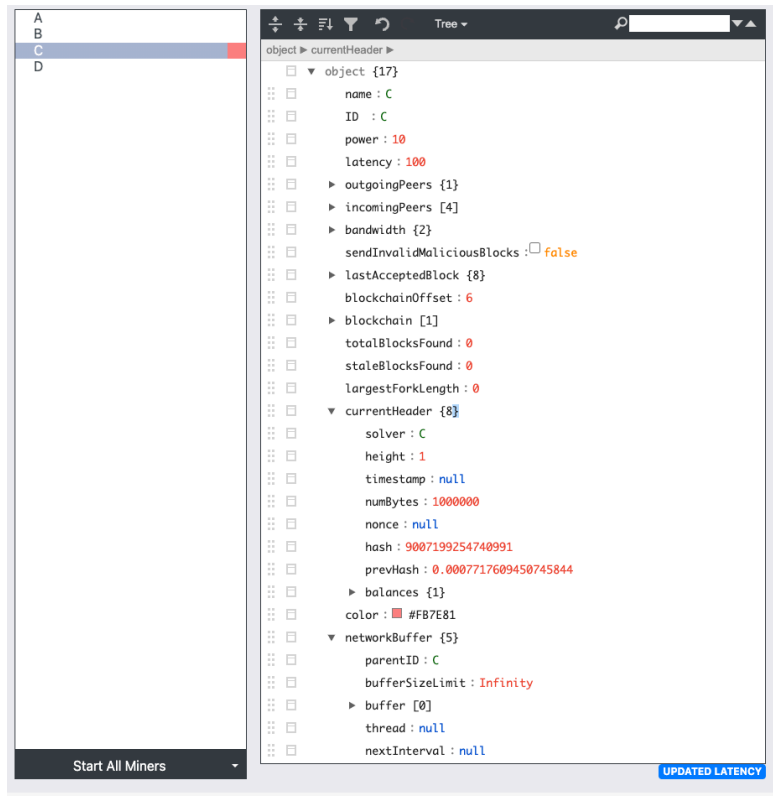


Figure 6: Blockchain Simulator: Node Configuration

The simulator also allows visualizing your current network and the links between different nodes.

3 Running the Simulation and Visualizing Node Interactions

Once the topology and nodes are configured, one can visualize the interaction between different nodes on the webpage. The nodes start flickering to represent block propagation during each for each node, and a graph represents the last block Accepted by each node.

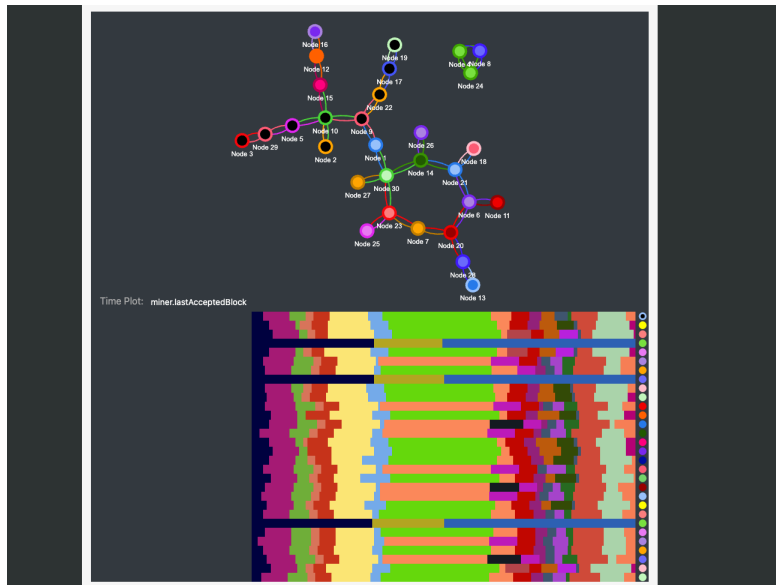


Figure 7: Blockchain Simulator: Block Propagation and Accepted Blocks

The simulation also provides full statistics on each node participating in the network and their contributions to the blockchain, as well as the number of forks they encountered.

| Refresh | Account balance | Power (%) | Power (H/s) | Blocks in flight (%) | Latency (ms) | Downlink (Mbps) | Uplink (Mbps) | In peers | Out peers | Block height | Total blocks | Stale blocks | Max fork length | |
|---------|-----------------|-----------|-------------|----------------------|--------------|-----------------|---------------|----------|-----------|--------------|--------------|--------------|-----------------|---|
| Node 1 | 0 | 0 | 1 | 1.204 | 0 | 100 | Infinity | Infinity | 2 | 2 | 48 | 0 | 0 | 2 |
| Node 2 | 2 | 3.571 | 3 | 3.614 | 0 | 100 | Infinity | Infinity | 1 | 1 | 48 | 2 | 0 | 3 |
| Node 3 | 0 | 0 | 3 | 3.614 | 0 | 100 | Infinity | Infinity | 1 | 1 | 48 | 2 | 2 | 3 |
| Node 4 | 3 | 5.357 | 2 | 2.409 | 0 | 100 | Infinity | Infinity | 2 | 2 | 8 | 3 | 0 | 1 |
| Node 5 | 2 | 3.571 | 4 | 4.819 | 0 | 100 | Infinity | Infinity | 2 | 2 | 48 | 3 | 1 | 3 |
| Node 6 | 3 | 5.357 | 3 | 3.614 | 0 | 100 | Infinity | Infinity | 3 | 3 | 48 | 4 | 1 | 2 |
| Node 7 | 0 | 0 | 2 | 2.409 | 0 | 100 | Infinity | Infinity | 2 | 2 | 48 | 0 | 0 | 2 |
| Node 8 | 1 | 1.785 | 2 | 2.409 | 0 | 100 | Infinity | Infinity | 2 | 2 | 8 | 1 | 0 | 1 |
| Node 9 | 3 | 5.357 | 3 | 3.614 | 0 | 100 | Infinity | Infinity | 3 | 3 | 48 | 3 | 0 | 3 |
| Node 10 | 1 | 1.785 | 1 | 1.204 | 0 | 100 | Infinity | Infinity | 4 | 4 | 48 | 1 | 0 | 3 |
| Node 11 | 2 | 3.571 | 3 | 3.614 | 0 | 100 | Infinity | Infinity | 1 | 1 | 48 | 3 | 1 | 2 |
| Node 12 | 4 | 7.142 | 4 | 4.819 | 0 | 100 | Infinity | Infinity | 2 | 2 | 48 | 5 | 1 | 3 |
| Node 13 | 2 | 3.571 | 3 | 3.614 | 0 | 100 | Infinity | Infinity | 1 | 1 | 48 | 2 | 0 | 2 |
| Node 14 | 6 | 10.714 | 3 | 3.614 | 0 | 100 | Infinity | Infinity | 3 | 3 | 48 | 6 | 0 | 2 |

Figure 8: Blockchain Simulator: Participation Statistics

Finally, for each node, a blockchain explorer is provided. It shows the current view a node has and allows you to compare it to other nodes and visualize possible forks in the network

```
Blockchain Explorer

Node 1:
{
  "solver": "NODE_9",
  "height": 38,
  "timestamp": 1698859192287,
  "numBytes": 1000000,
  "nonce": null,
  "hash": 0.005216213085416976,
  "prevHash": 0.00723321533689858,
  "balances": {
    "NODE_26": 1,
    "NODE_30": 3,
    "NODE_2": 1,
    "NODE_12": 2,
    "NODE_5": 2,
    "NODE_19": 1,
    "NODE_6": 3,
    "NODE_14": 4,
    "NODE_15": 2,
    "NODE_18": 2,
    "NODE_20": 2,
    "NODE_29": 1,
    "NODE_13": 1,
    "NODE_22": 1,
    "NODE_16": 2,
    "NODE_9": 3,
    "NODE_10": 1,
    "NODE_11": 2,
    "NODE_28": 1,
    "NODE_21": 1,
    "NODE_27": 1,
    "NODE_25": 1
  }
}

Miner Name Node 1 Block Number 38
```

Figure 9: Blockchain Simulator: Miner View of the Blockchain

References

- [1] Blockchain simulator. <https://simewu.com/blockchain-simulator/>, Nov 2023.
- [2] Txstreet.com: Blockchain transaction visualizer. <https://txstreet.com>, Nov 2023.
- [3] Simeon Wuthier and Sang-Yoon Chang. Demo: Proof-of-work network simulator for blockchain and cryptocurrency research. In *2021 IEEE 41st International Conference on Distributed Computing Systems (ICDCS)*, pages 1098–1101, 2021.