Determining Optimal Incentive Policy for Decentralized Distributed Systems Using Reinforcement Learning

APPENDIX

A. Model Formulation

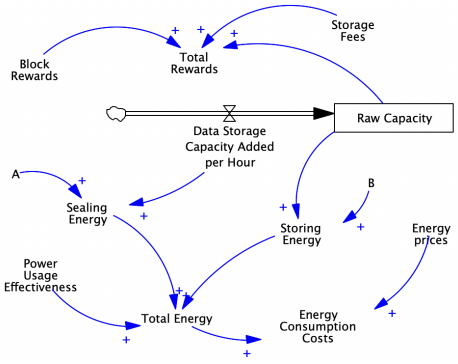

Fig. 1: Filecoin System Modelling[a]

[a] The plus-signs in the figure indicate a positive correlation between the different variables.

The system dynamics of the Filecoin model can be better expressed through the equations used in the Stock and Flow Diagram presented in Fig. 1.

- **Power Usage Effectiveness**: Static Value (1.57)
- **Sealing Energy**: A[1]*Data Storage Capacity Added per Hour
- **Total Energy**: (Sealing Energy+Storing Energy)*Power Usage Effectiveness
- **Energy Consumption Cost**: Total Energy*Energy prices
- **Energy Prices**: Constant Value
- **Storing Energy**: B*Raw Capacity
- **Data Storage Capacity Added per Hour**: Randomly Generated using the RANDOM NORMAL function in VenSim: RANDOM NORMAL(0 , 2.49187e+15 , 1.25776e+15 , 2.06549e+14 , 0)
- **Block Reward**: Constant Value
- **Total Rewards**: (Raw Capacity*Storage Fees) + Block Rewards
- **Storage Fee**: Constant Value
- **Raw Capacity**: Data Storage Capacity Added per Hour

B. Data Analysis

C. RLlib Training Parameters

- num_worker: 2
- num_envs_per_workers: 2
- train_batch_size: 4000

[1] A is a constant: 3.42e-08

TABLE I: Descriptive Statistics of the Energy Price per kWh in Different Countries

Summary: Energy Price per kWh in US$	
Mean	0.162154
Std	0.081045
Min	0.005000
25%	0.094000
50%	0.163000
75%	0.211500
Max	0.344000

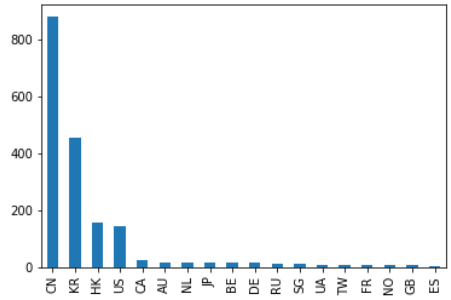

Fig. 2: Geographic Distribution of Filecoin Miners[b]

[b] Countries with less than 5 miners are not represented in the plot, but are taken into account in the implementation.

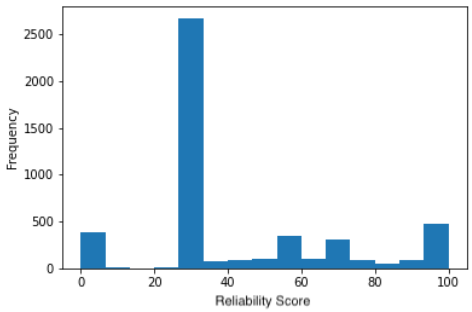

Fig. 3: Distribution of Filecoin Miners' Reputation Scores

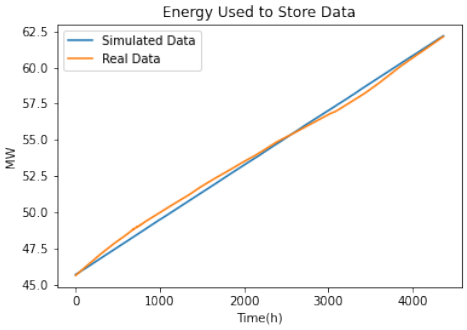

Fig. 4: Comparison of the Data Storage of the Filecoin System and System Simulation

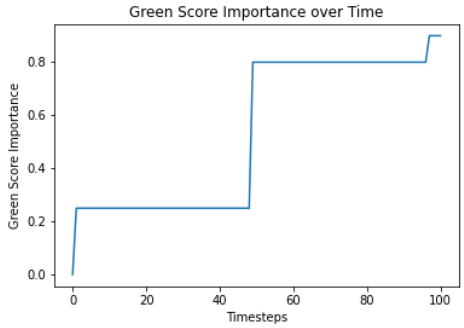

Fig. 5: Green Score Importance over Time

- sgd_minibatch_size: 4000
- num_sgd_iter: 1
- lr: 0.00001

By setting the number of workers and environments to 2, we end up with a total of 4 environment replicas used to gather rollouts. We set the batch sizes to 4000 to keep the iteration time small.