CS765: Introduction to Blockchains, Cryptocurrencies and Smart Contracts

HW1 (Simulation of a P2P Cryptocurrency Network)

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Question 2

- We say safely assume in a network events occur randomly and independently over time with an average constant rate
- Let λ be the transaction generation rate per unit time. In a small interval δ, the probability of a transaction occurring is:

$$P(\text{Transaction in } \delta) = \lambda\delta$$

- Thus, the probability that no transaction occurs in time x (divided into n small intervals of size δ) is:

$$n\delta = x$$
$$P(X > x) = (1 - \lambda\delta)^n$$

- Taking the limit $\delta \to 0$ (i.e., $n \to \infty$):

$$P(X > x) = \lim_{n\to\infty} (1 - \lambda x/n)^n = e^{-\lambda x}$$

- Differentiating gives the **Probability Density Function (PDF)**:

$$P(X = x) = \lambda e^{-\lambda x}$$

- Thus, interarrival times is the mean of the Distribution:

$$T_{tx} = E[I] = \frac{1}{\lambda}$$

Question 5

- Lets Investigate why queuing delay is realted inversely proportional to Link speed
- As queuing delay is sampled from exponential distribution

$$P(X = x) = \lambda e^{-\lambda x}$$

- This means

$$\mu = 1/\lambda = \frac{96kbps}{c_{ij}}$$
$$\lambda = \frac{c_{ij}}{96kbps}$$

- rate of packets from the queue is proportional to the link speed
- This is done because more the link speed less the packet queuing time

Question 8

Visualization and Insights :

Fraction of blocks generated by types of Nodes:

Ratio of the number of blocks generated by each type of nodes in the Longest Chain of the tree to the total number of blocks it generates.

Hight Hash Power	Block Fraction
True	0.92
False	0.08

Fast Node	Block Fraction
True	0.64
False	0.36

High Hash Power	Fast Node	Block Fraction
True	True	0.50
True	False	0.38
False	True	0.08
False	False	0.04

This clearly shows that number of Blocks generated are heavily influenced by Hashing Power than Network speed of the node

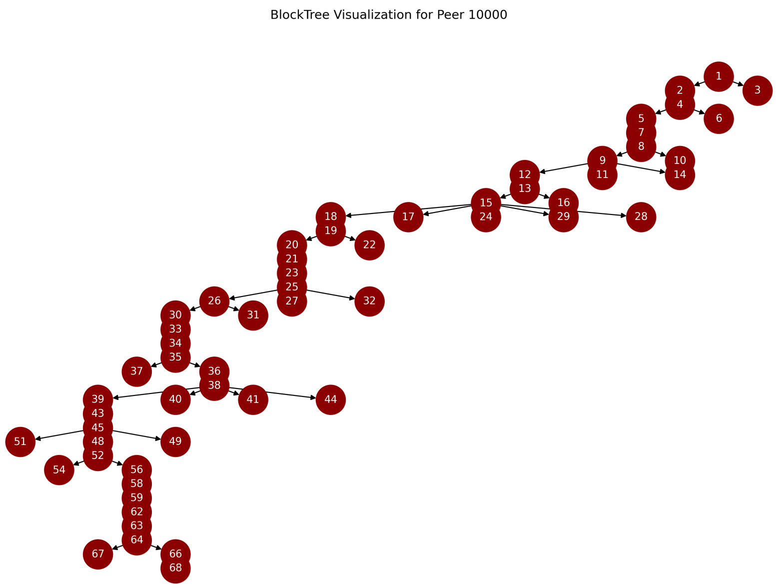
Analysis of the Tree Based on Various Parameters

For all the trees analyzed below, the following parameters remain constant:

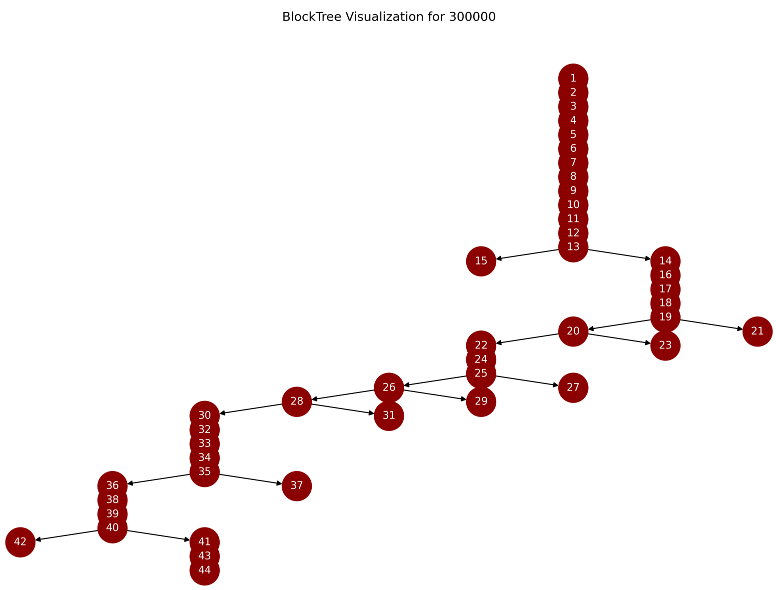
$$n = 20, \quad z_0 = 40, \quad z_1 = 40, \quad T_{tx} = 10s$$

We now examine how varying T_x, the mean inter-block arrival time, affects the tree structure:

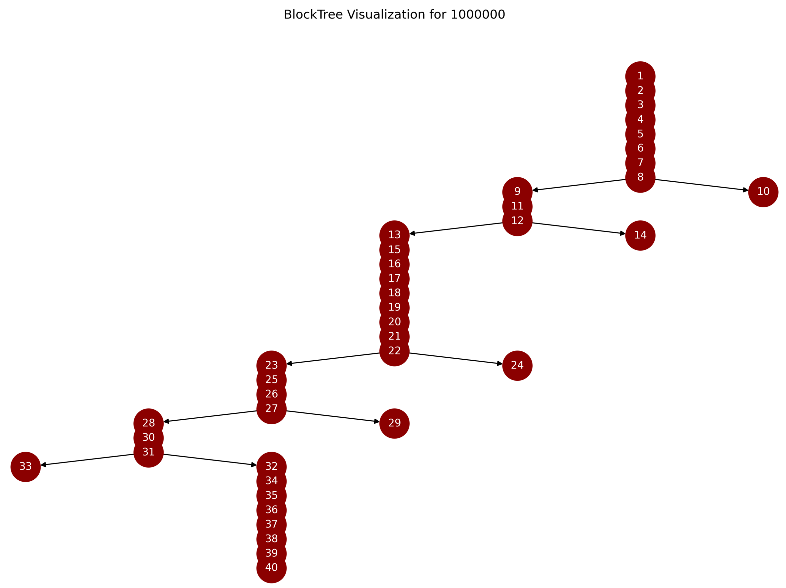
1. $T_x = 10s$**:** When T_x is very small and comparable to network delay, a significant number of forks are created due to frequent block arrivals.



2. $T_x = 300s$**:** At this value, T_x is moderately larger than the network delay. While forks still occur, they are less frequent compared to the scenario where $T_x = 10s$.



3. $T_x = 1000s$**:** With a very large T_x relative to network delay, almost all forks are eliminated, as block arrivals are sufficiently spaced out.



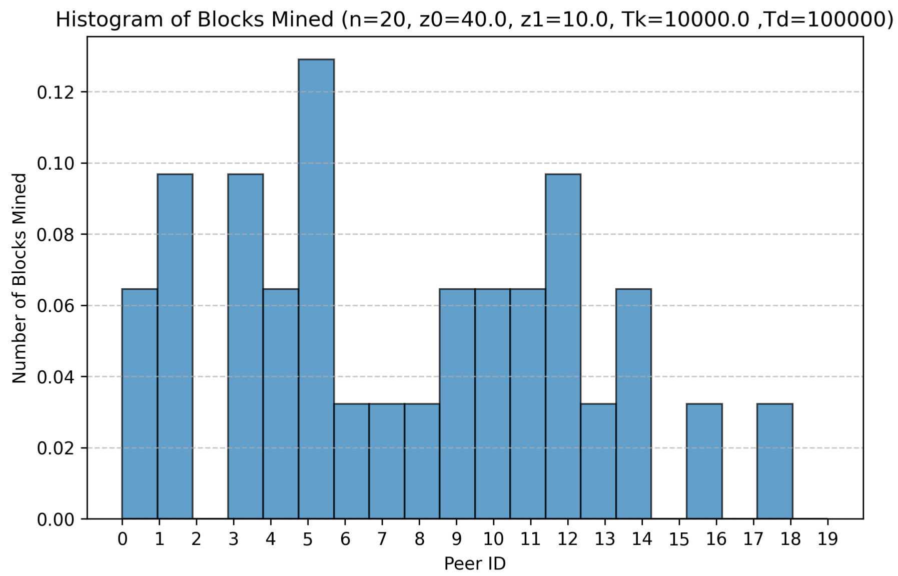
Analysis of the Fraction mined by peers on Various Parameters

Let's analyze how the fraction of blocks mined by each peer changes with varying hashing power. The following parameters remain constant:

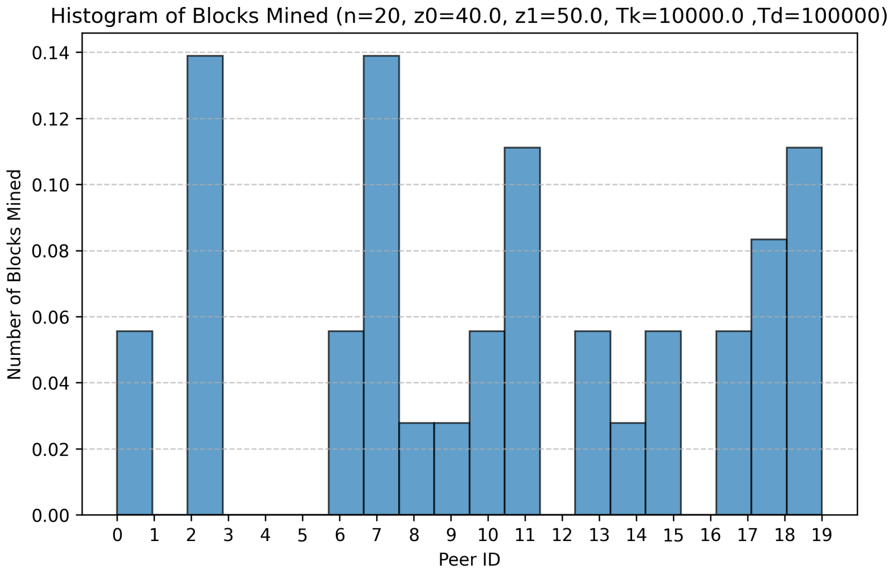
$$n = 20, \quad z_0 = 40, \quad T_{tx} = 10s, \quad T_x = 600s$$

We consider different values of z_1, which represents the number of peers with lower hashing power:

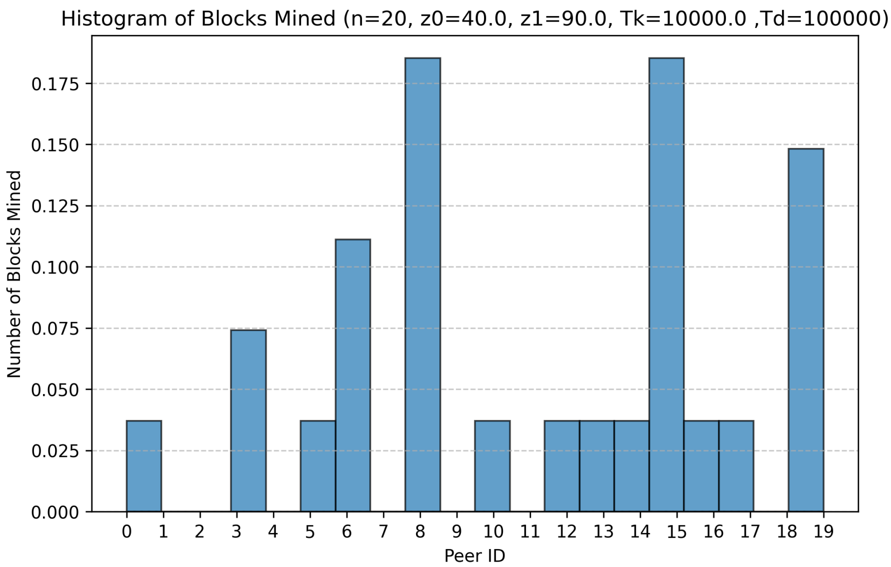
1. $z_1 = 10$: Since only a small fraction of peers have lower hashing power, the distribution of mined blocks is nearly uniform across all peers.



2. $z_1 = 50$: With an equal number of high and low hashing power peers, the distribution of mined blocks becomes skewed, favoring the peers with higher hashing power.



3. $z_1 = 90$: Since the majority of peers now have lower hashing power, a small subset of high-hashing peers mines a disproportionately large fraction of the blocks.



Analysis of Longest chain on Various Parameters

Let's analyze how the length of the longest chain changes when varying the number of peers in the network while keeping the following parameters fixed:

$$z_0 = 20, \quad z_1 = 30, \quad T_{tx} = 2s, \quad T_x = 100s$$

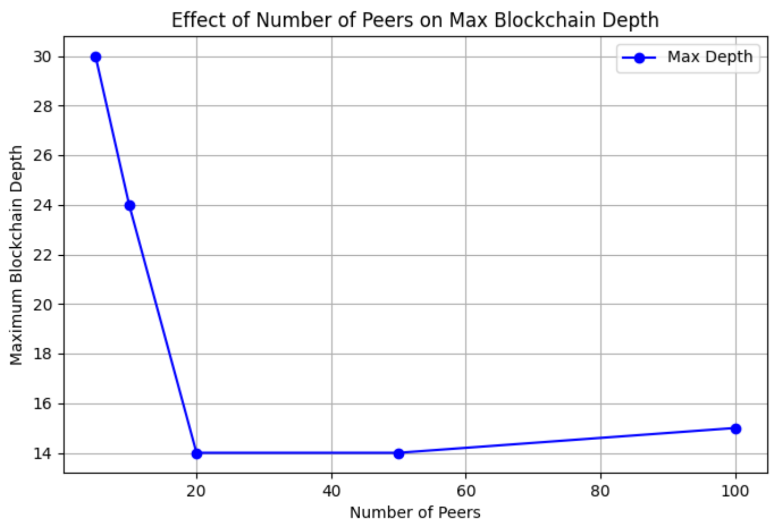


Figure 1: Effect of number of peers on the longest chain length

As the slowPerc increases, the time required for blocks to propagate across the network also increases. This results in more forks being created. Consequently, a significant portion of hashing power is wasted on competing forks rather than contributing to the main chain. As a result, the length of the longest chain decreases.

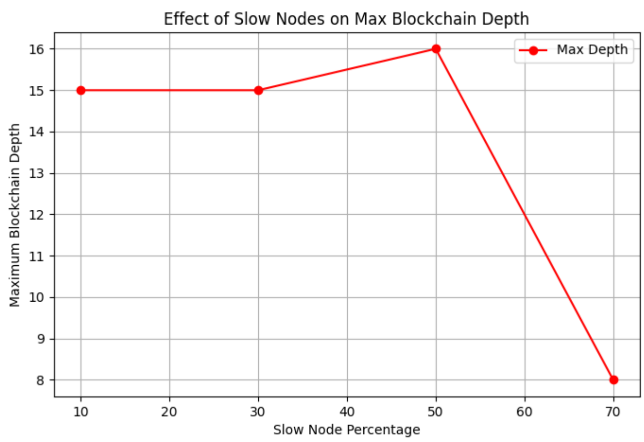


Figure 2: Effect of number of peers on the longest chain length

We can see when slowPerc is 70 we have maximum depth of 8 although number of blocks created are 75!