Performance Report

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1.0 Purpose

This program was written to implement a simple blockchain with a tamper-proof ledger and mining through the use of a cryptographic hash puzzle for the purpose of gathering data to compare the efficiency of solving hash puzzles with different difficulty settings and numbers of threads.

2.0 Requirements

There are no further requirements to run this experiment outside of what is typically required to run a Go program.

2.1 Background Knowledge

- **Bitcoin**
    - Bitcoin is a system initially proposed by Satoshi Nakamoto in a white paper published in 2008. It effectively functions as a ledger, serving as a decentralized database for transactions of the system's currency "Bitcoins". Transactions are stored in blocks which are then linked together, similar to a linked list data structure. Miners mine blocks by solving cryptographic puzzles, and the first miner to propose a block and have it verified by a majority of other miners gets the block reward, consisting of bitcoins. It has several key features, however for this project only a couple are necessary to know: the cryptographic hash puzzle and the tamper proof ledger.
    - What is the hash puzzle? Say there is a hash with inputs H and n and output h(H|n). H is the previous block's hash. A miner will then hash H with n's, nonces, until the output hash h(H|n) has a certain number of leading zeroes according to the difficulty level.
    - Why is the ledger tamper proof? Say there are blocks 1-4. In order to change a transaction in block 2, a miner will then have to solve the cryptographic puzzle for that block, block 3, and block 4, all while there are other people making the blockchain longer and longer, making it near impossible for a single machine to replace real transactions with false ones.

- GOMAXPROCS limits the number of operating system threads that can execute code at the same time.

3.0 Instructions

To run this program, first clone the git repository. Then, type "go run *.go" into the terminal line. The program will then give a brief description of how the program works and ask the

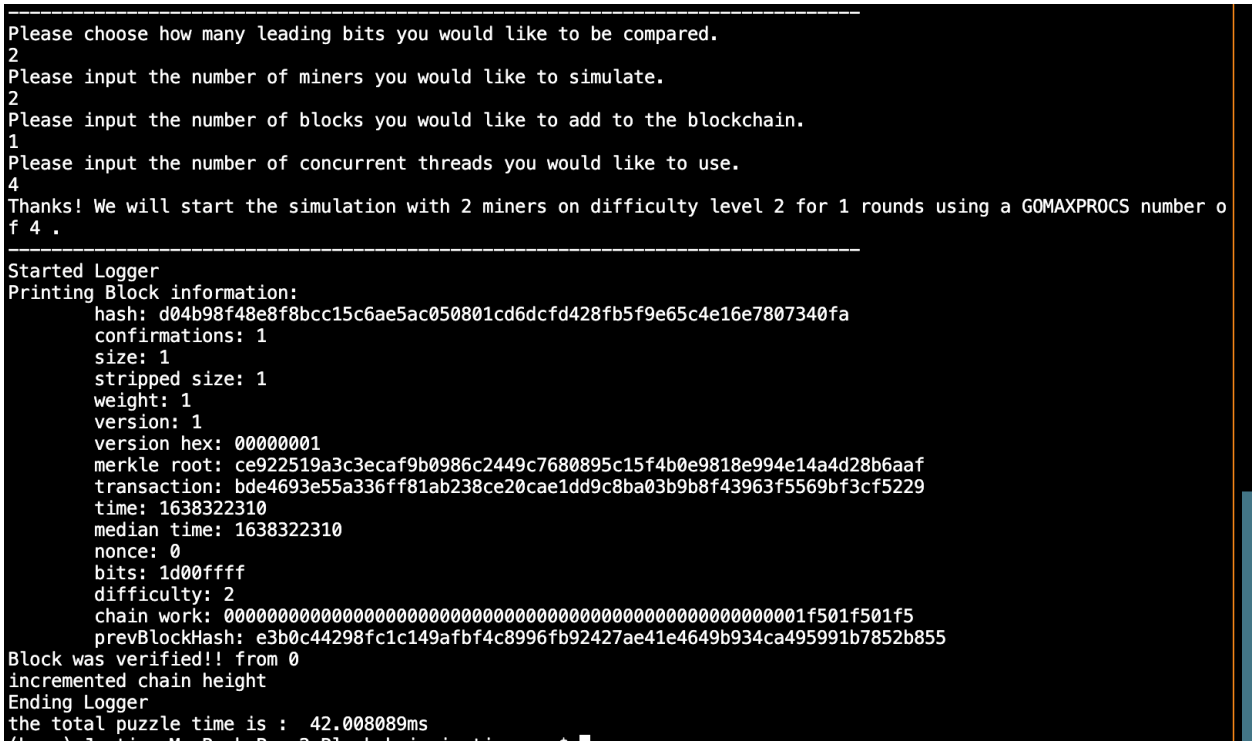
user to type an integer input for each of the following: (1) difficulty level, (2) number of miners in the system, (3) number of blocks added to the chain, and (4) number of concurrent threads used.

To gather enough data for analysis, run the program several times. The description of input used in this experiment is described further in 4.2 Data Analysis.

4.0 Output

The output consists of the information for the first block containing the relevant fields mirrored from Bitcoin's repository. Additionally, one the user enters the desired information, the logger will start running and output when a block is verified, when the blockchain height increases, and when the logger finishes running. Once the logger ends, the total puzzle time is given in milliseconds.

4.1 Code Output



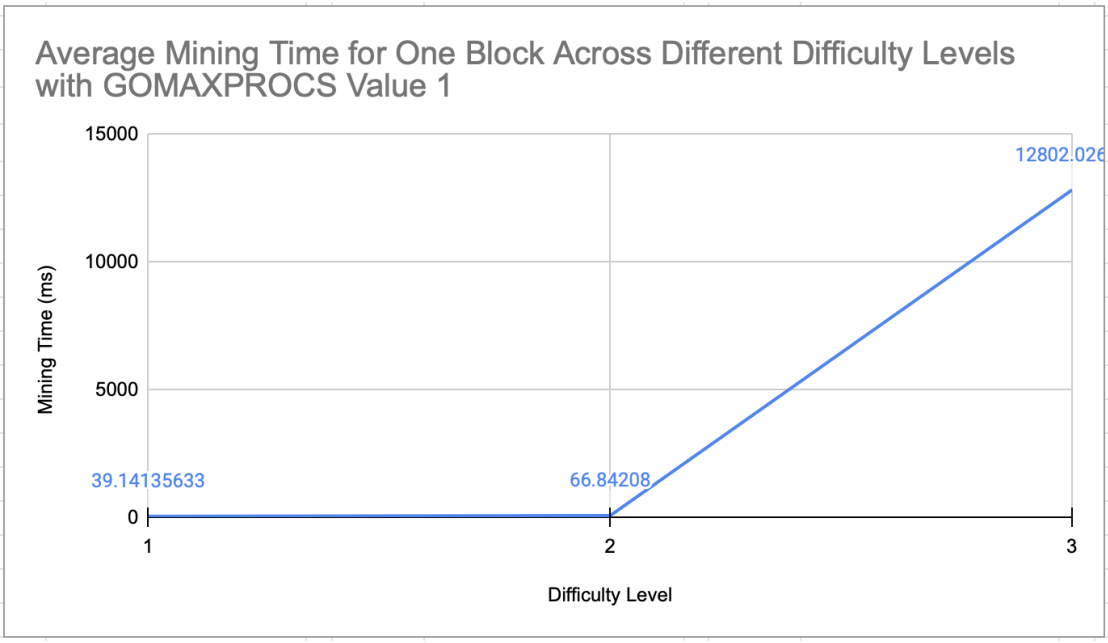
4.2 Data Analysis

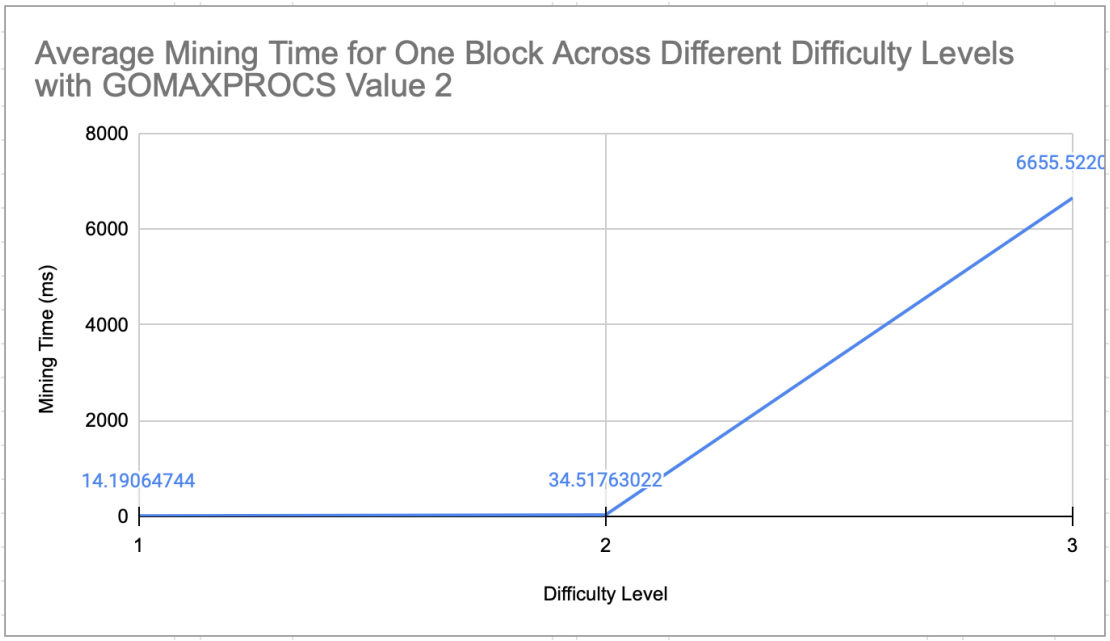
This project investigates the difference in mining time for one block between systems with different difficulty levels and systems with different GOMAXPROCS values. To maintain consistency, the tests were always run on a system with two miners mining for a chain with length one. Data was collected by running the program nine times for each combination of GOMAXPROCS numbers up through eight and difficulty levels up through three. Because of the runtime when using difficulty levels higher than three, it was not feasible to perform the experiment on higher difficulty levels while gathering enough data to draw meaningful conclusions. The collected data was then put into a Google Sheet for creation of charts.

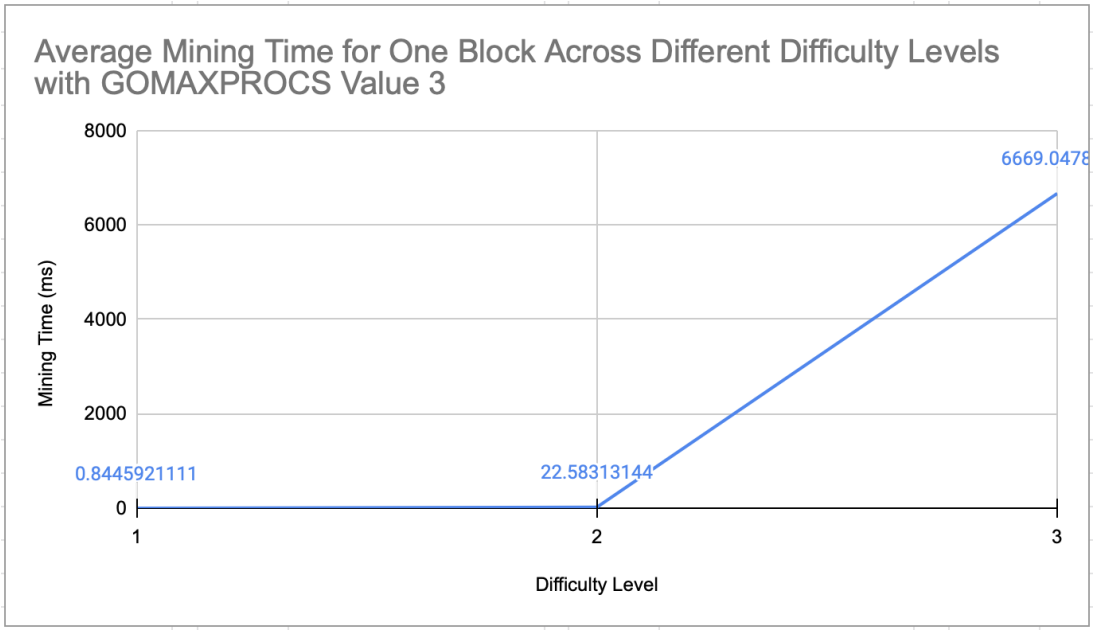
4.3 Discussion of Results

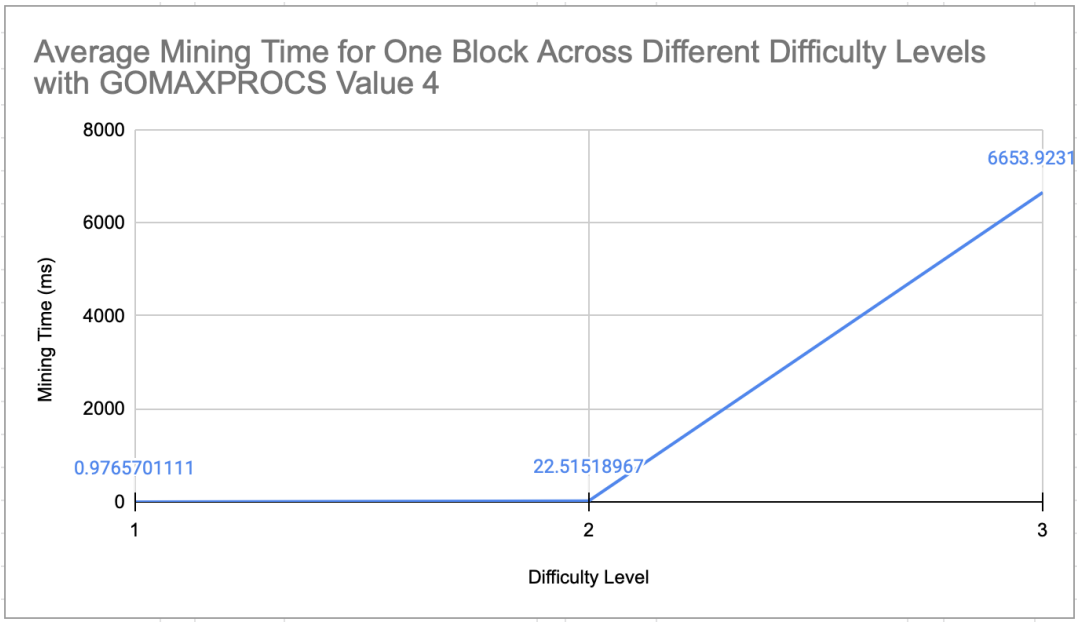
4.3.1 Difficulty Level vs. Time

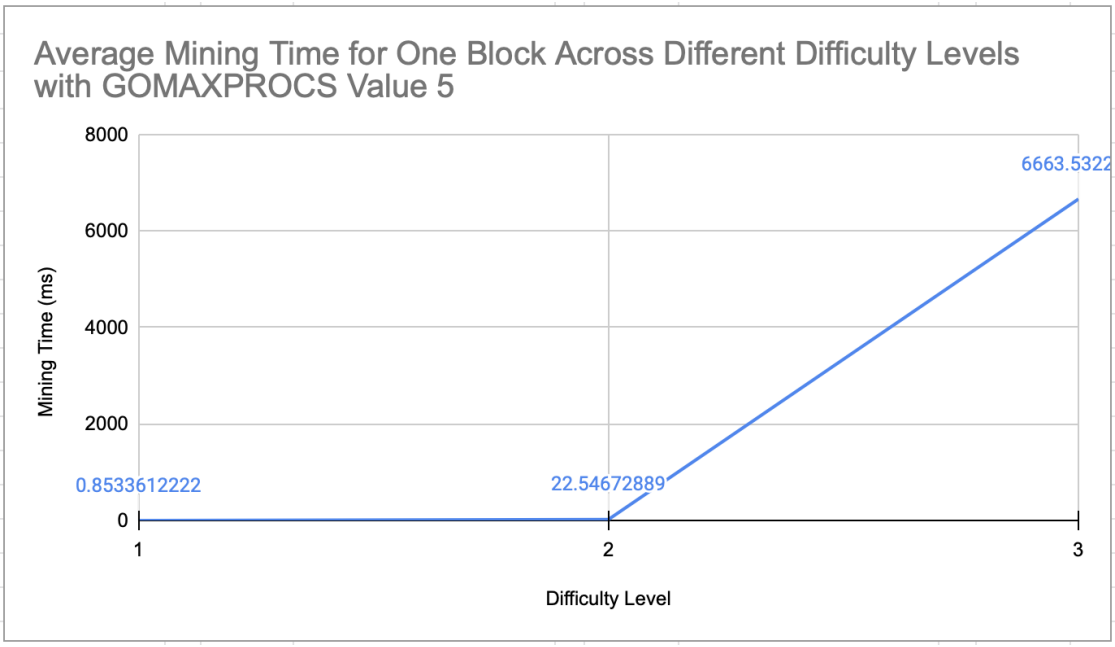
Overall, the results indicate that the relationship between difficulty level and mining time for systems with two miners using any GOMAXPROCS value follows a similar trajectory to a parabola. Using nine repetitions to find the average runtime for each difficulty level may result in error due to a small sample size, however it was the most feasible number of repetitions for this execution of the experiment as the data had to be manually transferred to a spreadsheet. Figures are included for each GOMAXPROCS value, however the same trend is followed for each and the graphs appear almost identical, save for the data labels describing the actual mining time value.

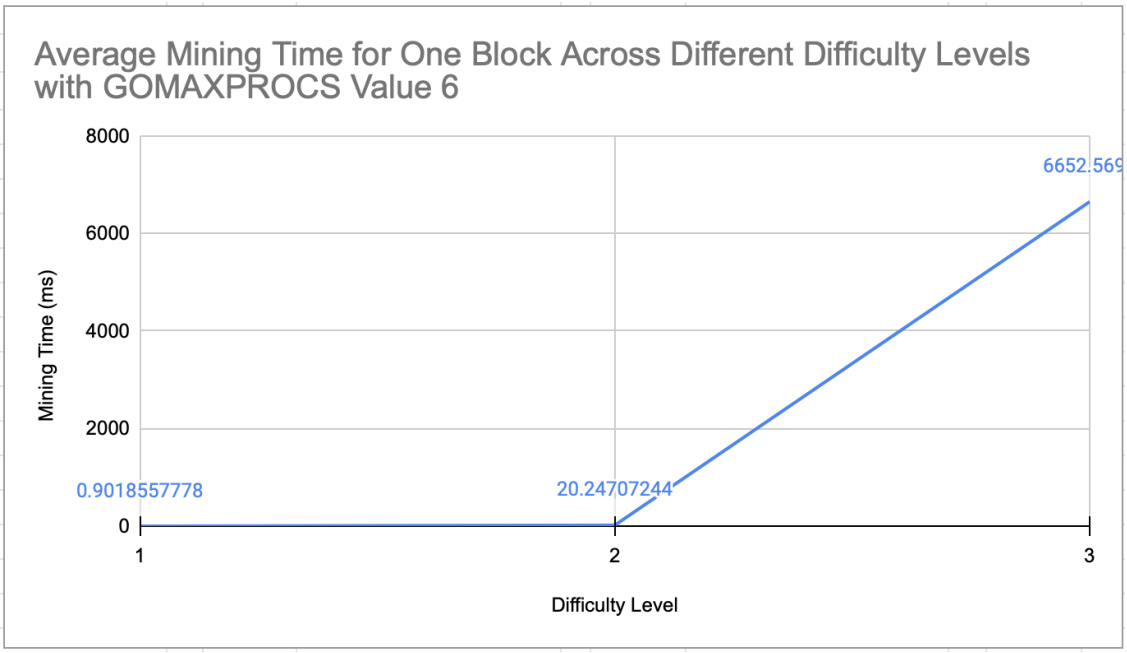


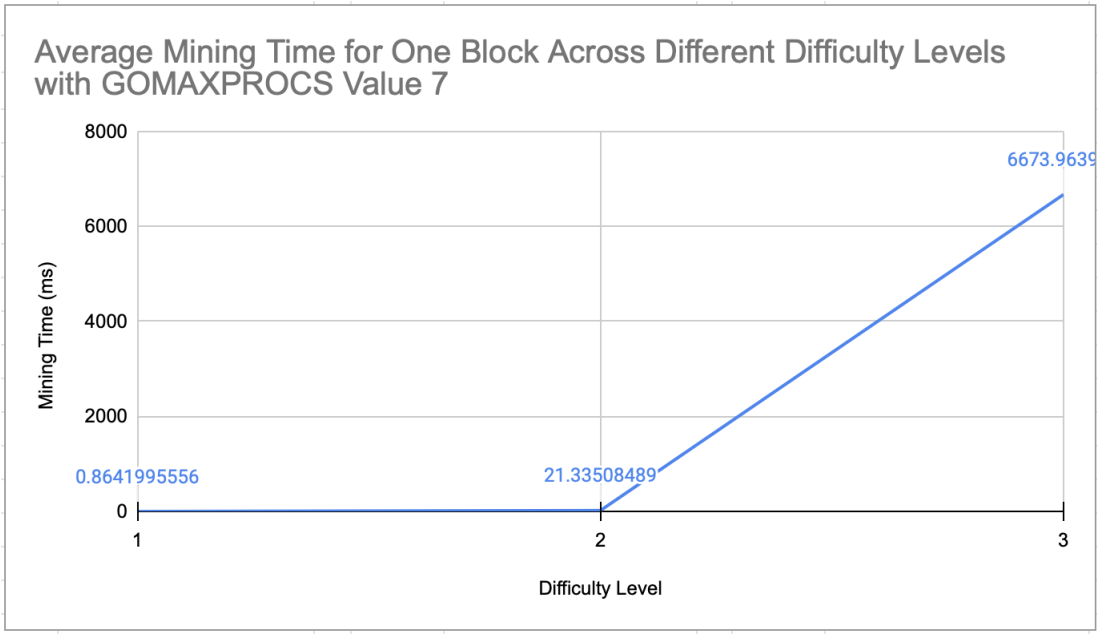

Average Mining Time for One Block Across Different Difficulty Levels with GOMAXPROCS Value 2
8000
6000
4000
2000
0
Mining Time (ms)
6655.5220
14.19064744
34.51763022
1
2
3
Difficulty Level

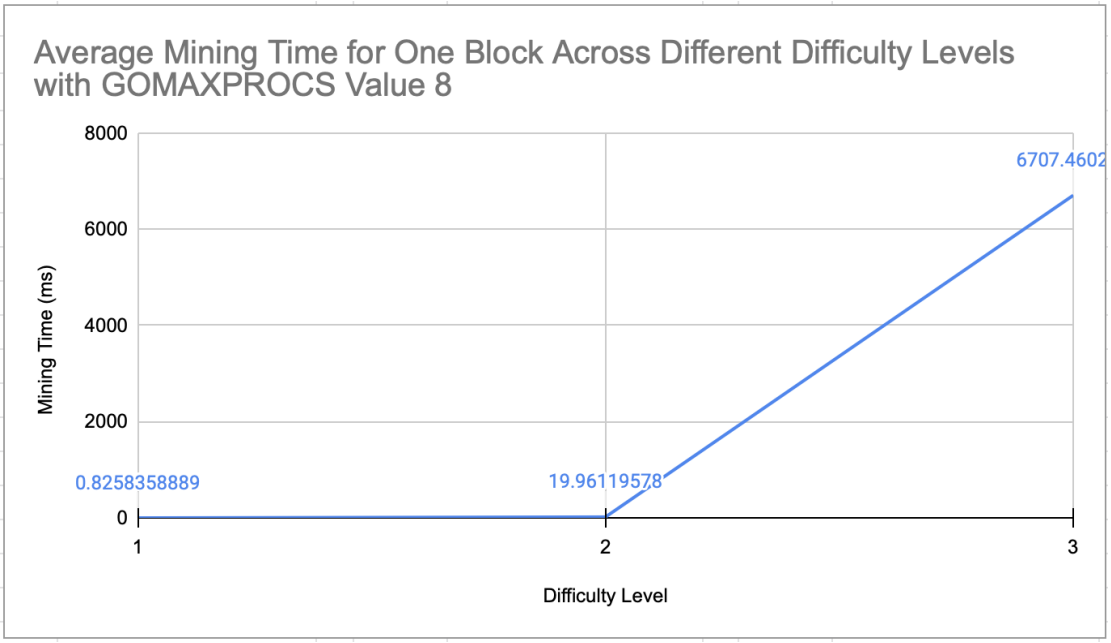

Average Mining Time for One Block Across Different Difficulty Levels with GOMAXPROCS Value 3
8000
6000
4000
2000
0
Mining Time (ms)
6669.0478
0.8445921111
22.58313144
1
2
3
Difficulty Level


Average Mining Time for One Block Across Different Difficulty Levels with GOMAXPROCS Value 4
8000
6000
4000
2000
0
Mining Time (ms)
6653.9231
22.51518967
0.9765701111
1
2
3
Difficulty Level

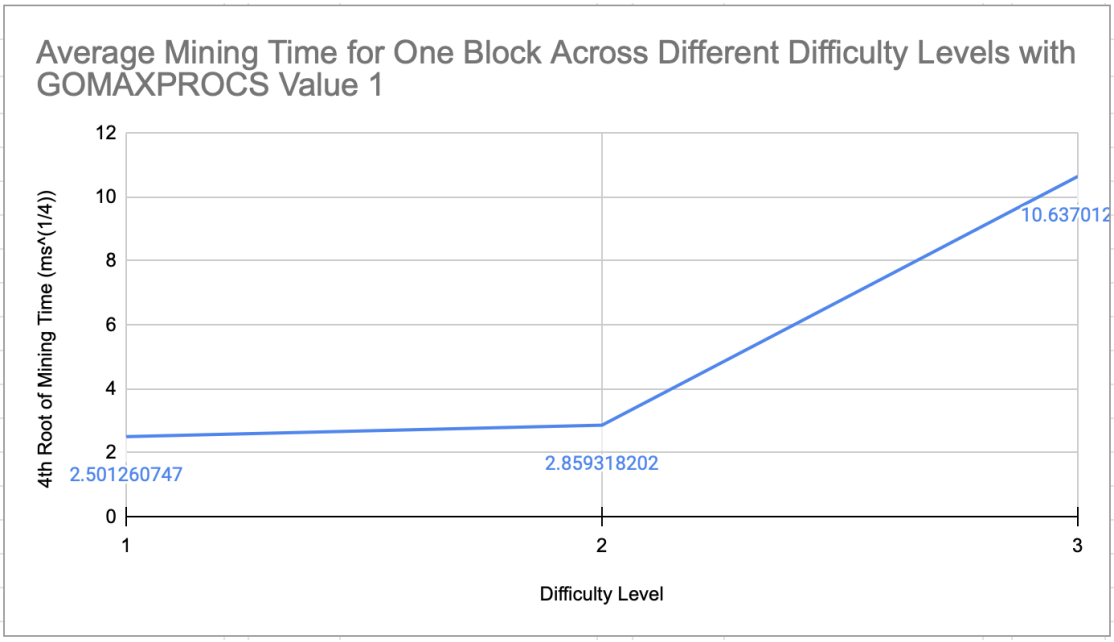

Average Mining Time for One Block Across Different Difficulty Levels with GOMAXPROCS Value 5
8000
6000
4000
2000
0
Mining Time (ms)
6663.5322
22.54672889
0.8533612222
1
2
3
Difficulty Level


Average Mining Time for One Block Across Different Difficulty Levels with GOMAXPROCS Value 6
8000
6000
4000
2000
0
Mining Time (ms)
6652.569
0.9018557778
20.24707244
1
2
3
Difficulty Level

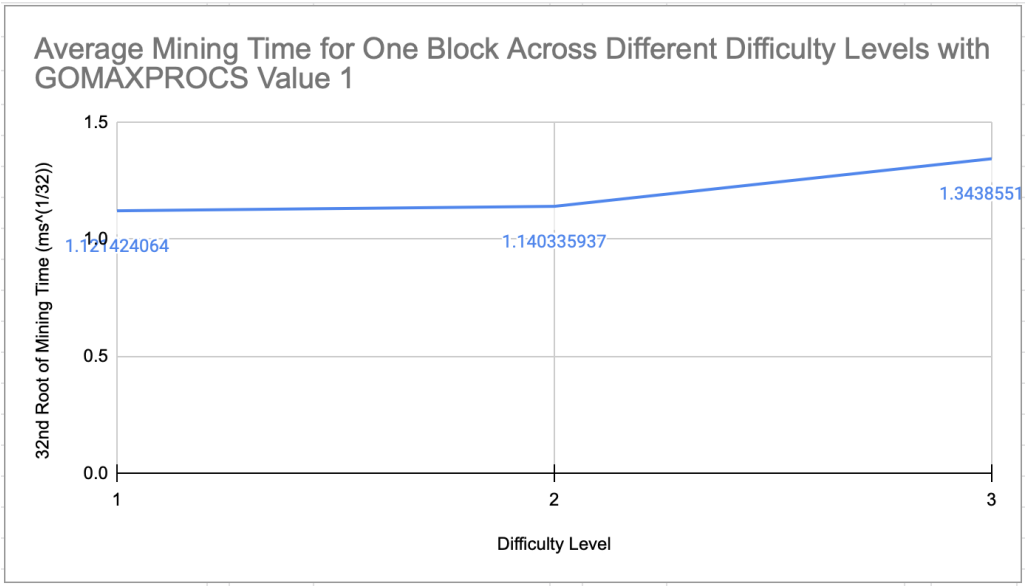

Average Mining Time for One Block Across Different Difficulty Levels with GOMAXPROCS Value 7
8000
6000
4000
2000
0
Mining Time (ms)
6673.9639
0.8641995556
21.33508489
1
2
3
Difficulty Level



Because there is such a large increase in mining time between difficulty levels two and three, graphing the fourth root of the mining time can more clearly show the trajectory between the difficulty levels. Because this still shows a roughly parabolic relationship, it implies that difficulty level and mining time are related to each other through a large exponent number.

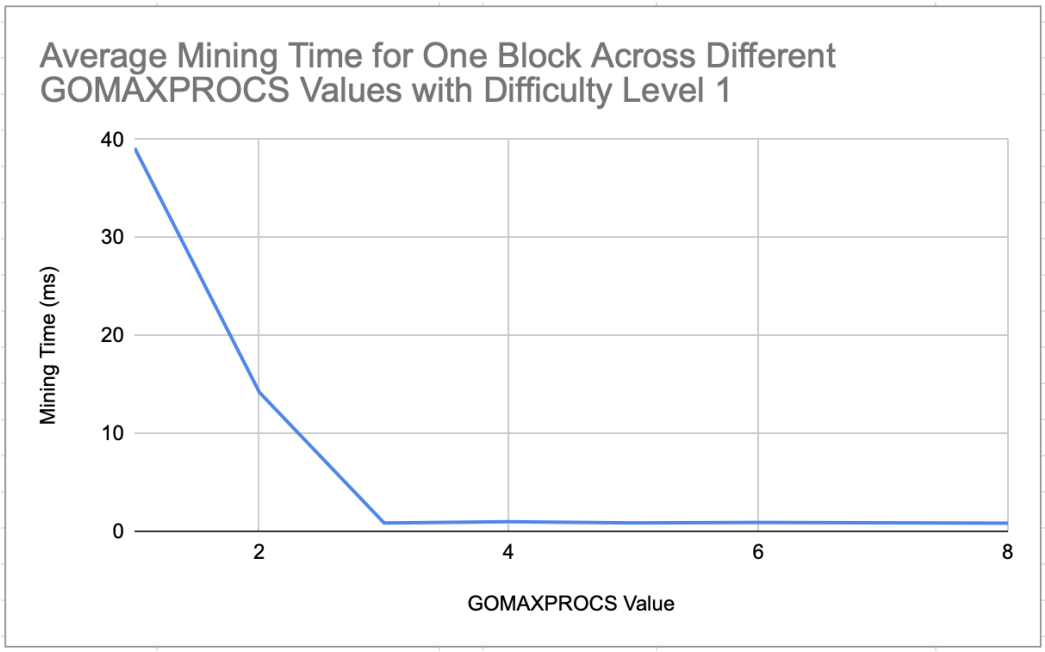


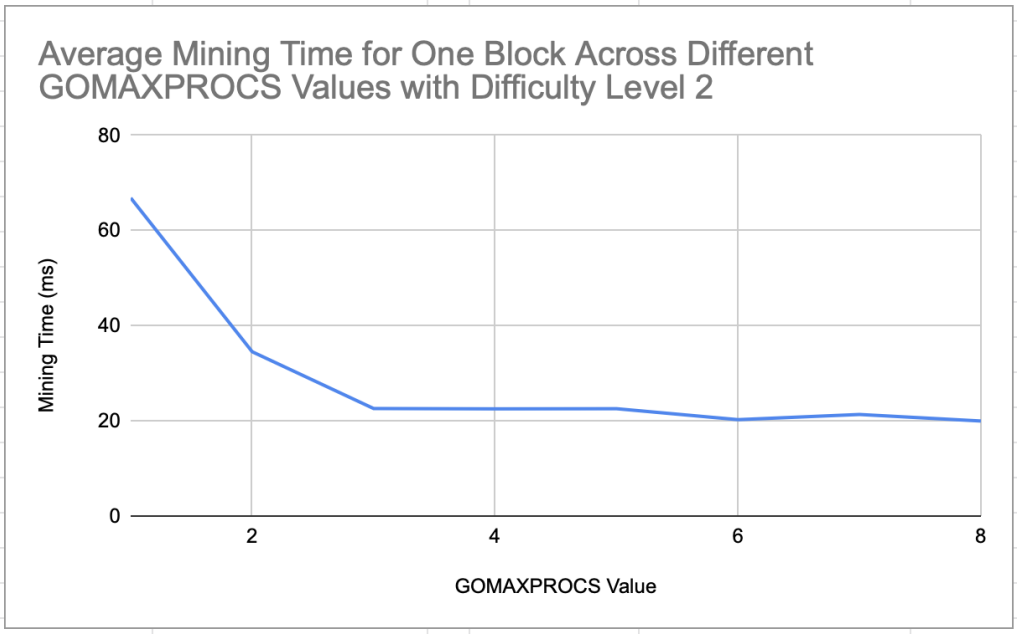
After raising the mining time to a power of 1/32, there appears to be an almost linear relationship with difficulty level, implying that mining time is related to difficulty level raised to the power of 32. More testing would be necessary to definitively assert this relationship.



4.3.2 GOMAXPROCS Number vs. Time

The figures below illustrate the average mining time for one block across different GOMAXPROCS values with difficulty level remaining constant. Consistently for difficulty levels one and two, there is a significant increase in efficiency between GOMAXPROCS values of one, two, and three, but after that point there is no significant gain from using more threads.





Slightly differently from difficulty levels one and two, the significant difference in mining time is only present between GOMAXPROCS values one and two for the figure below.