

Evaluating the Performance of Major Blockchain Platforms: An Empirical Analysis

Dartmouth Blockchain
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Abstract

The purpose of this paper is to provide an impartial academic analysis of the transactions per second (TPS) and time to finality (TTF) metrics of different blockchain networks, including SKALE, Solana, Fantom, Flow, Avalanche, Polygon, Ethereum, and Near. The study analyzed the technical process of gathering the information and sources used and presented the findings of the study. The TPS metric was computed using gas, byte, and compute methodologies, while the TTF metric was computed using epoch and block methodologies. The results showed that SKALE had the highest TPS and the fastest TTF compared to the other networks.

Introduction

Since the inception of Bitcoin in 2009, the blockchain and crypto industry has grown exponentially. The emerging technology has the potential to revolutionize the way we transact and store data. However, blockchain networks vary in their capabilities, and it is crucial to evaluate their metrics to determine their suitability for different use cases. This paper presents an analysis of the TPS and TTF metrics of different blockchain networks. The study aims to provide an impartial academic analysis of the metrics and not to endorse any particular blockchain network.

Technical Process and Sources

The study used gas, byte, and compute methodologies to compute the TPS metric. The gas methodology involved gathering data on the gas limit of a given blockchain, taking a mean transaction of the blockchain, and utilizing a blockchain's scanner to accrue information regarding the gas used by the transaction. The study then calculated how many of these transactions could have theoretically occurred in a given block using the gas limit and gas used metrics. The byte methodology was used for blockchains that do not utilize gas for users. The study repeated the gas methodology with how much data a given blockchain was engrossing using the metric "bytes." The compute methodology was used for blockchains that provide users with compute units or fuel to power transactions.

The study used epoch and block methodologies to compute the TTF metric. The epoch methodology was used for blockchains that utilize epochs to promote true transaction finality. The study utilized a certain percentage of node consensus or percentages of node consensus as well as block finality. For BFT to take effect, the network relied on the equation $((n-1) / (1/3))$ to validate the presence of benevolent nodes on the network and a minority malicious node, where 67% of nodes verifying a transaction equated to "irreversible finality." The study used the block methodology for other projects that provide the exact number of blocks that must be written to a given blockchain to achieve "irreversible finality."

Findings

Blockchain Network	Transactions Per Second (TPS) Rounded to the nearest whole number
SKALE	397
Solana	375
Fantom	85
Flow	60
Avalanche	49
Polygon	21
Ethereum	12
Near	6

The TPS metric showed that SKALE had the highest TPS with 397, followed by Solana with 375, Fantom with 85, Flow with 60, Avalanche with 49, Polygon with 21, Ethereum with 12, and Near with 6.

Blockchain Network	Time to Finality (TTF) Rounded to the nearest hundredth
SKALE	1.46 seconds
Fantom	1.76 seconds
Avalanche	1.9 seconds
Near	4.6 seconds
Solana	9.6 seconds
Polygon	4 minutes and 45 seconds
Ethereum	17 minutes and 5 seconds

The TTF metric showed that SKALE had the fastest TTF with 1.46s, followed by Fantom with 1.76s, Avalanche with 1.9s, Near with 4.6s, Solana with 9.6s, Polygon with 4m 45s, and Ethereum with 17m 5s.

Conclusion

The analysis of TPS and TTF metrics of different blockchain networks is critical in determining their suitability for various use cases. The study used gas, byte, and compute methodologies to compute the TPS metric and epoch and block methodologies to compute the TTF metric. The findings showed that SKALE had the highest TPS and the fastest TTF compared to the other networks. However, the study is not exhaustive, and there is a need for further research to comprehensively evaluate the different blockchain networks.

Technical process of gathering our information, and list of sources.

TRANSACTIONS PER SECOND

I. GAS METHODOLOGY

First, we gathered data regarding the 'Gas Limit' of a given blockchain. For many chains, this involved both utilizing their 'scanner' tools, as well as reaching out to developers native to the chain.

Secondly, we took a 'mean' transaction of the blockchain, typically this involved a native D.E.X. Given this transaction, we could utilize a blockchain's 'scanner' to accrue information regarding gas used by the transaction.

Third, we calculated how many of these transactions could have theoretically occurred in a given block using our 'Gas Limit' and 'Gas Used' metrics. However, this computation was more complex than it seems at face-value. 'Gas Limits' and 'Gas Used' often don't take into account stress on a given network - when 'Gas Used' will increase as fees to miners become prioritized. Considering gas limits are inherently logarithmic in terms of compute they allow for, our calculations take into account logarithmic blockchain performance capabilities.

Lastly, we take into account the amount of gas that can be utilized by a chain in a given second - regarding their blocks. For some chains, this involved more than one block-per-second, increasing the amount of gas utilized by a given blockchain on a per-second basis, while some chains write blocks much slower, decreasing the gas utilized on a per-second basis.

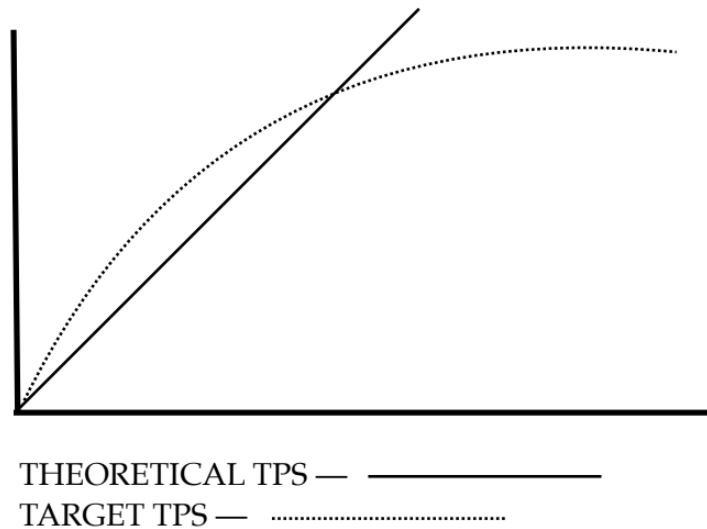
II. BYTE METHODOLOGY

Some blockchain's don't utilize gas for users, and instead either charge a set gas fee, or charge developers for user's fees. In this event, we repeated our structure above with how much data a given blockchain was engrossing - using the metric 'bytes'.

Each blockchain has a given 'Block Limit', in terms of how many bytes each block on the block chain could write to the network, allowing us to recreate our 'Gas Computations,' with 'Bytes'. Important to note regarding 'bytes', is that a 'mean' transaction will also incur data inflows from signatures, messages, assets, etc. For example, some smart contracts involve several different 'calling' methods that increase the 'byte' size of the transaction, lowering TPS realities.

III. COMPUTE METHODOLOGY

Some blockchains also provide users with ‘compute units’ or ‘fuel’ in order to power transactions. These compute ‘tools’ should be considered similar to ‘gas’, however, these metrics should always be double-tested against another standard, as ‘compute units’ can often be rate-limiters, acting as D.D.o.S. protection for certain blockchains. Regardless, ‘Compute Methodology’ can provide for realistic TPS, given security constraints limit a project’s technical capabilities.



TIME TO FINALITY

I. EPOCH METHODOLOGY

Multiple P.o.S. chains utilize ‘epochs’ in order to promote true, transaction finality. In these epochs, some chains utilize a certain percentage of node consensus, while others utilize percentages of node consensus as well as block finality.

To understand node consensus, many blockchain’s utilize a form of BFT that requires $\frac{2}{3}$ (67%) of nodes to verify a transaction before ‘solidifying’ the transaction as ‘irreversible.’

In order for BFT to take effect, the network relies on the following equation to validate the presence of ‘benevolent’ nodes on the network, and a minority ‘malicious’ node - $(\frac{n-1}{1/3})$. Hence where we observe 67% of nodes verifying a transaction equating to ‘irreversible finality’.

As for amassing $\frac{2}{3}$ of nodes validation, BFT networks rely on node connectivity to achieve true finality. Given nodes are in communication with each other, network effects create exponentially fast validation in a blockchain’s network.

```
neighbors struct {
    Nodes    []rpcNode
    Expiration uint64
}
```

Given a node on a given P2P network has 'k' neighbors, we could equate for how many 'pings' it would take for 2/3 of the available network to validate a transaction - also determining the length of time in a given 'epoch'.

II. BLOCK METHODOLOGY

Other projects either simplify the equation by providing the exact number of blocks that must be written to a given blockchain in order to achieve 'irreversible finality'. In this sense, a blockchain could equate the amount of time it takes for finality to be achieved through a given 'epoch' in terms of 'blocks' written to a blockchain.

The most popular of projects that achieves finality according to block time is 'Bitcoin', confirmations are based on blocks written to the underlying blockchain.

III. OTHERS

While testing TTF, a project may achieve 'finality' before the block is even written to the blockchain. It is important to note that in this event, Dartmouth Blockchain erred on the reference that these transactions weren't determinably 'finalized' or 'irreversible', given the efforts of or a group of malicious nodes.

Furthermore, it is worth noting that any given blockchain's 'irreversible finality' contains its own definition of both 'irreversible' and 'finality'. For several projects, users may access funds from a transaction in as little as one - or less - blocks, meanwhile, these transactions are not technically deemed 'irreversible' by the network itself. Lastly, given the contortion of enough compute/funds, it is difficult to actually deem any of these transactions truly 'irreversible'. With that being said, Dartmouth Blockchain would like to remind readers to operate and use crypto products at their own risk, as our findings may be inaccurate, incomplete, and change over time.

CALCULATION REFERENCES

With that being said, here is a simple overview of our calculations used to determine both TPS and TTF for our tested blockchains:

$$\text{gwei limit} = f(G) = (\log_2(G^-) / B(t)) / B^-$$

$$\text{compute limit} = f(C) = (C^- / B(t)) / C$$

$$\text{byte limit} = f(d) = (\log_2(d^-) / B(t)) / B^-$$

$$\text{compute-to-byte derivation} = c = C^- / c(d)$$

epoch derivation = $f(K) = (K / n(k)) / B(t)$ t = time — ∞ = limits

DISCLAIMER

Dartmouth Blockchain's metric-tests results are not final nor indicative of guaranteed performance. Although our tests varied by project, date, and time to guarantee a diversified and accurate data set - blockchain performance can vary *drastically* with some chains outperforming our statistical averages.

Secondly, blockchain performance can differ depending on upgrades to a project's technology or load usage. We recommend all readers to verify blockchain metrics for themselves in case of error or updated technological stacks.

For more information regarding exact metrics from our tests for individual blockchains, please feel free to reach out to us at any of our following media profiles:

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