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Analysis of Blockchain Availability Based on Block Lag

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Analysis of the on-chain data for 4 networks (Bitcoin, Ethereum, Solana, Binance Smart Chain) to calculate some statitics over the block time (time between blocks being mined / inserted in the chain).

The data is taken from the Data Sets and processed using Pandas tools using Jupyter Notebook, published in the github project.

Why Block Lags Matter?

The goal for this analysis is to measure how well blockhain networks of different kind meet client expectations on availability and speed. This is not just defined by the mean statistics, as average block time and transactions per second. The distribution of these parameters is also important, and especially the corner cases of unexpectedly long lags in block times.

When the blockchain network does not add the new block for a long time, all applications that are elying on that network, efffectively stalled. It is equivallent to the program hangs on your computer. Blockchain clients, as wallets or DApps, can not execute transactions, make transfers or smart contract calls.

Too long time lag between the blocks is equivalent to the service outage of the blockchain network. Here we tried to measure how often this happens and how severe it is in different blockchains.

Here we consider outage when the next block does not appear in 10x time interval from the average block period. For example, if average period in Ethereum is 14 seconds, we consider 140 seconds as outage. This is calculated relative to the average values, because the expectations of the clients (both humans and applications) are adapted to the average block times, which are very different across blockchain networks.

Aggergated Statistics on Block Times

Here is the agregated statistics of the 4 blockchain networks under consideration:

Network	Average Block Time, sec	Median, sec	Max, sec
Ethereum Before POS	14.47	10	13013
Ethereum After POS	12.11	12	96
Bitcoin	573	400	463160
Binance Smart Chain	3	3	26276
Solana	0.56	0.5	122245

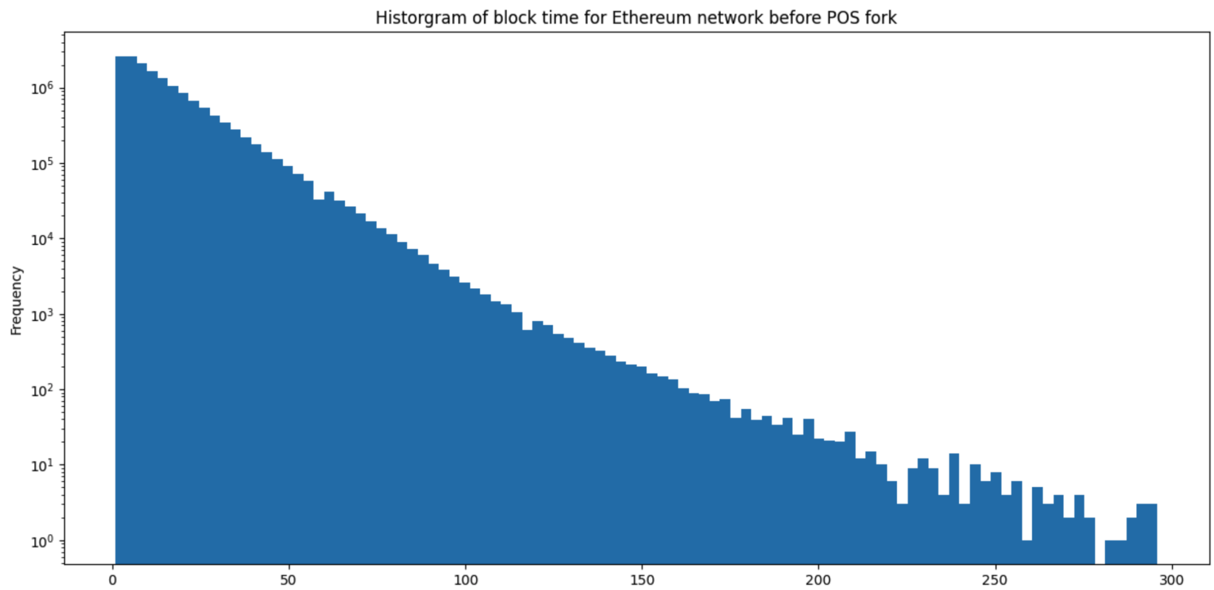
Ethereum is separated on 2 cases: before POS fork and after it, as statistics differs significantly.

The evident fact from the table is that the max time can significantly exceed the average figures and sometimes they also exceed hours and even days.

We next will investigate each chain separately and after will come back to SLA figures alltogether

Ethereum Before POS

The distribution of the block time in Ethereum Before POS (logarithmic frequency scale):



The hystogram in logarithmic scale looks very smooth and has almost linear slope for a range of 10..120 seconds per block.

It can be approximately modeled as of exponential decay:

```
Freq ~ A * exp ( -t * B )
```

Proof of work requires the guessing of crypto puzzle, which is a random guessing, which must follow the Binomial distribution. We see here the trail of this distribution with t >> average(t), average is approximately 14 seconds.

It means, that any POW consensys by-design assumes the outages, when the block time due to probabalistic reasons exceed some pre-defined value.

On this diagram, the 140 seconds (14 sec avg x 10 factor) lies in the middle, showing quite a lot of blocks, which took more time than that to mine.

There are also several blocks with the lag exceeding 300 sec:

```
ethereum[(ethereum['lag']>300)  & (ethereum['block']<15537393)]
```

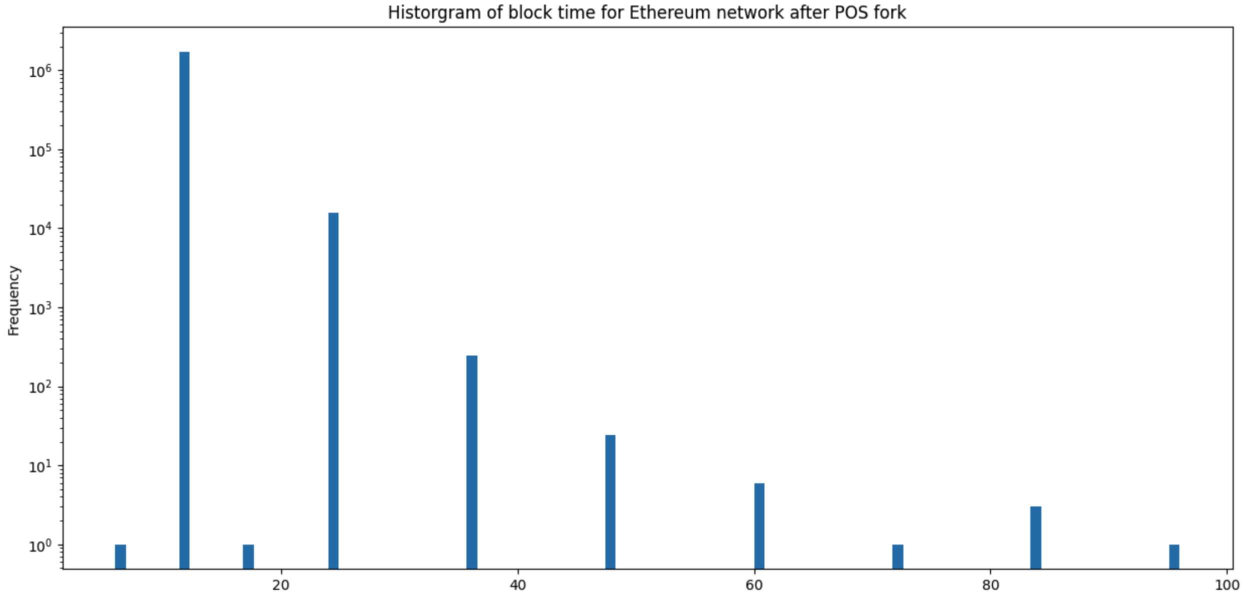
gives us the blocks with extreme block times:

```
block   lag
116522  13013
4301233 315
4319473 311
4332544 303
4335240 312
4362431 440
4367071 346
4367313 309
```

Good news, that all of them well in the past!

Ethereum After POS

The distribution of the block time in Ethereum After POS (logarithmic frequency scale):

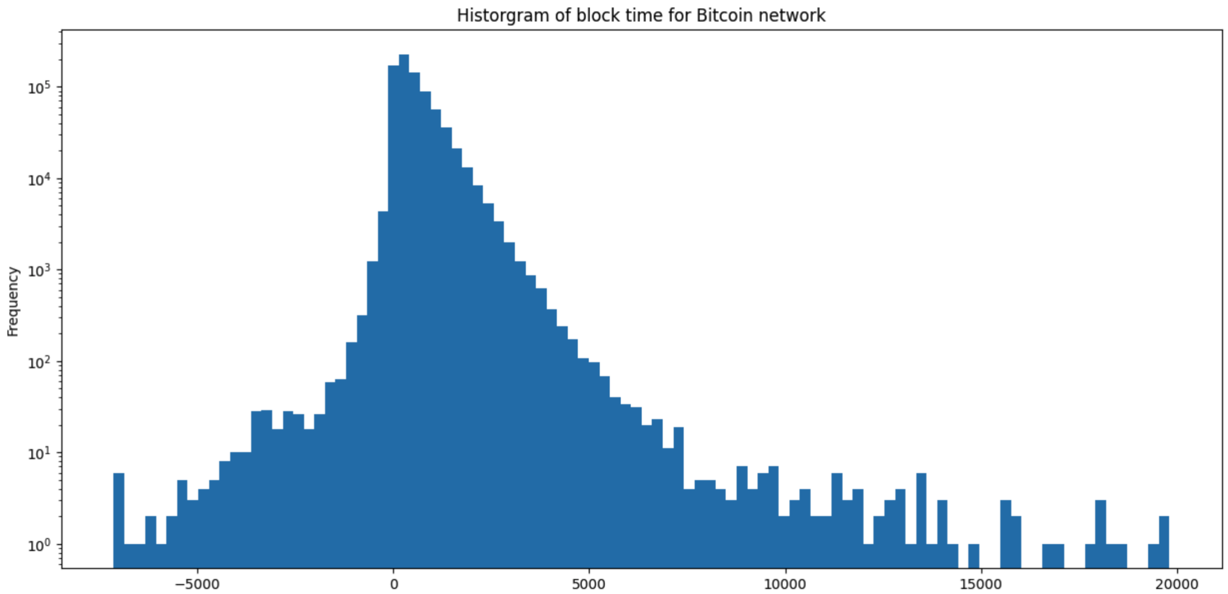


Here we see very discrete histogram, with block times of multiples of 6 and 12 seconds.

The maximum time is 96 = 12 * 8, minimum is 6 seconds.

Bitcoin

The distribution of the block time in Bitcoin (logarithmic frequency scale):



Bitcoin has similar POW type of block mining as Ethereum, thats why we see very similar slope towards large values.

Remarkable is quite significant negative range of block times. They originated from the fact, that we took block **mining time** as a timestamp, and not the actual time when the block was included in the blockchain. Mining times can be set well before the block was included in the chain in reality, that's why we see quite a lot of blocks with negative lags.

However they should not significantly affect the measurement of the block lags in a positive range, as their distribution falls much faster than positives.

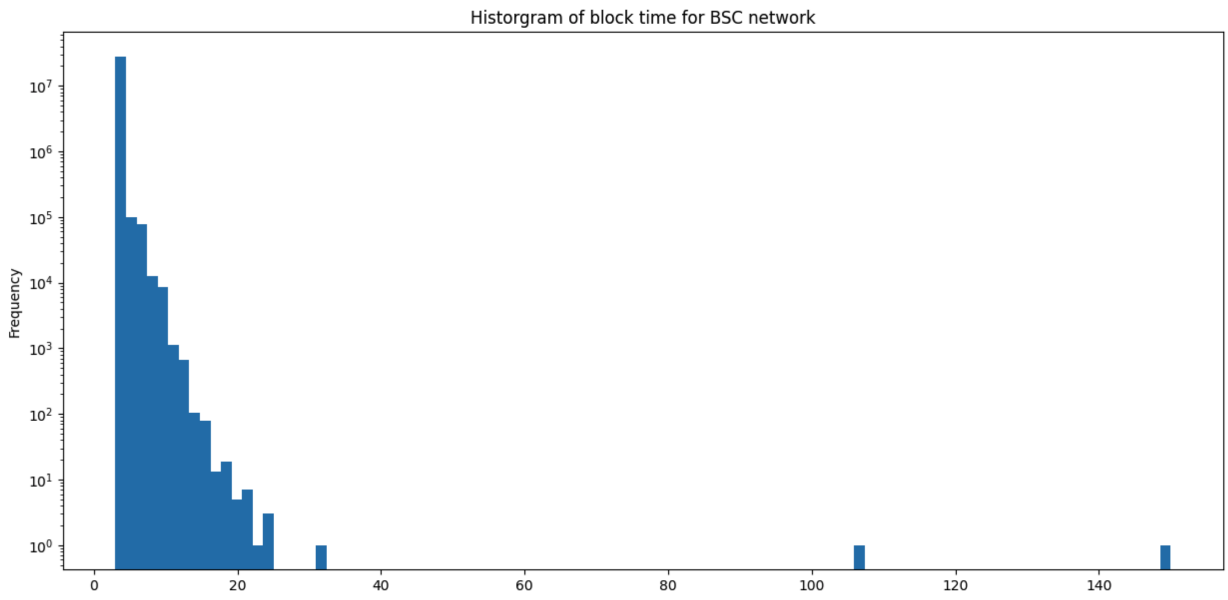
There are 151 blocks, which took more than 2 hours to mine, and some took more than 10 hours:

```
block   lag
15      87157
15324   90532
16564   90390
16592   73782
19722   37536
19724   47127
20189   60203
21438   38219
```

Note that these are all at the very beginning of the network... good times!

Binance Smart Chain

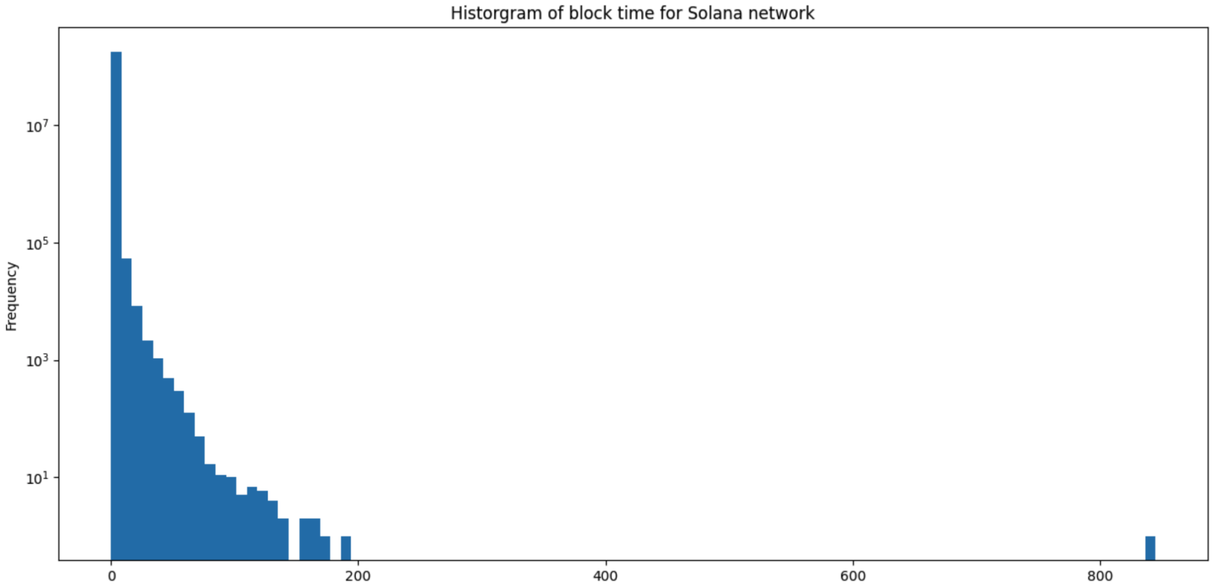
The distribution of the block time in Binance Smart Chain (logarithmic frequency scale):



BSC distribution falls pretty fast, and there are no much extremely long block times here.

Solana

The distribution of the block time in Solana (logarithmic frequency scale):



Solana is famous for the very fast block times... and long outages!

These are blocks that took over 10 minutes:

```
block   lag
1690557 24831.334
13391978        25279.000
16903262        30648.500
53180905        16415.334
53180945        845.000
53180946        3345.000
60912004        122245.500
66528004        71496.500
96542813        38793.000
131973978       8665.500
136512012       16029.000
153139236       33098.000
179526406       69544.500
```

And you see, they are sometimes close to the whole day (!) when the network effectively stalled.

Aggregated Availability Figures

The aggregated figures from the distributions are collected in the following table:

Network	Alert Block Time, sec	Availability %	Outage Time, Hours
Ethereum Before POS	140	99.83	109

Network	Alert Block Time, sec	Availability %	Outage Time, Hours
Ethereum After POS	120	100	0
Bitcoin	5700	99.19	1023
Binance Smart Chain	30	99.97	7.6
Solana	5	97.67	645

Binance Smart Chain and Ethereum After POS are favorites in terms of availability, very close to 100%. It means the high predictability of application performance.

Solana is probably the fastest and less predictable network with just 97 % of availability, which is not good even for centralised non-redundant systems (single server web-site).

Data Sets

The data for inter-block lags in seconds versus the block number are quieried from Bitquery datasets for 4 blockchains.

They are available in S3 public :

- Binance Smart Chain
- Ethereum Mainnet
- Bitcoin
- Solana Mainnnet

Jupyter Notebook

Jupyter notebook is in the github project. To run the code, you will need standard Jupyter labs installation, and download the datasets in data folder inside the prject

After that run

```
% jupyter-lab
```

and load notebook BlockhainTimes.ipynb