Timechain

A Time Synchronization Protocol based on Distributed Network

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Recap

- Research on Network Time Protocol
  - How it works
  - Security concerns
- Proposed Timechain
  - Blockchain for timekeeping
  - Demonstration

Agenda

- Background research
- Timechain
- Testing and Evaluation

Consensus Algorithm

- Preventing Byzantine faults:
  - Ensuring the proposed block in the chain generated by a node is legitimate
  - Preventing malicious users from successfully derailing the system

Consensus Algorithm

- Proof of Work (PoW)

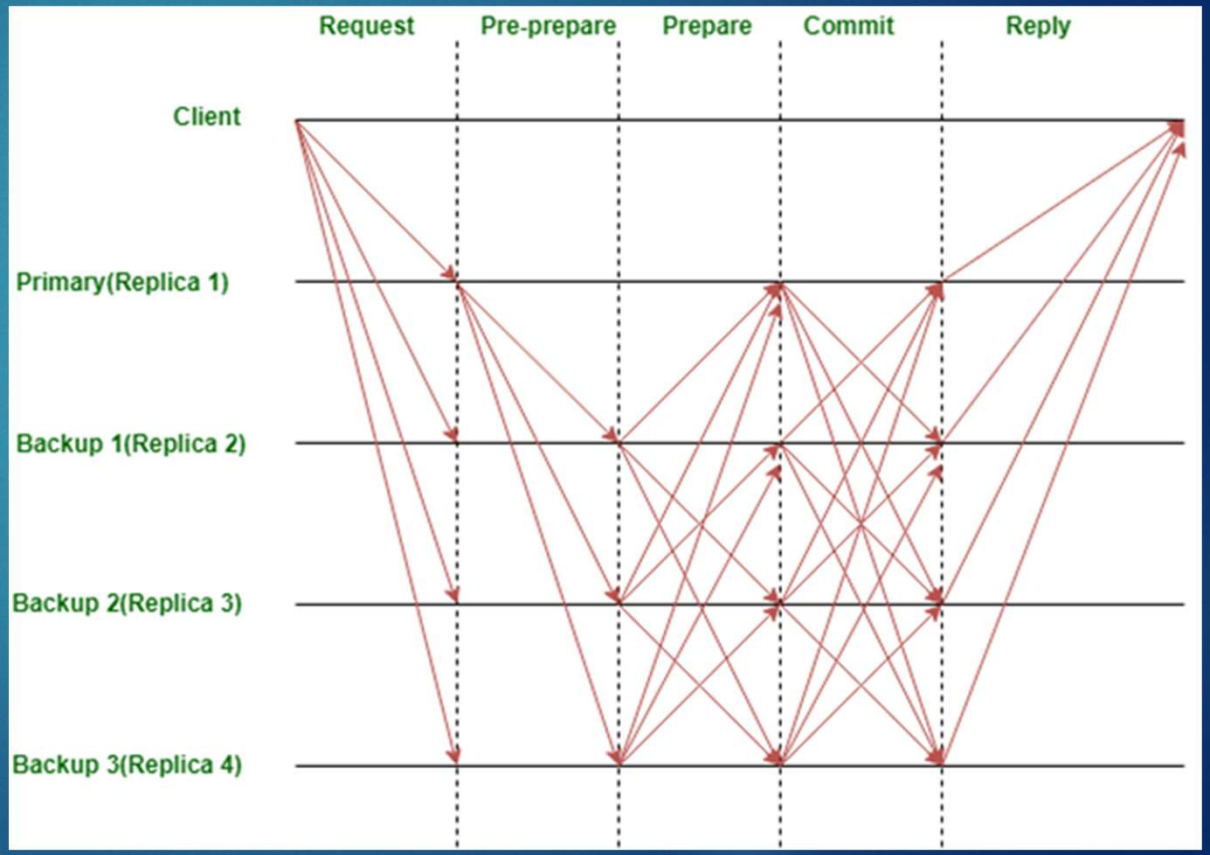
	Nonce	Hash
Block content	0001	888B19A43B151683C87895F6211D9F8640F97BDC8EF……
	0002	4FAC6DBE26E823ED6EDF999C63FAB3507119CF3CB……
	0003	446E21F212AB200933C4C9A0802E1FF0C410BBD75F……
	……	
	1234	03AC674216F3E15C761EE1A5E255F067953623C8B38……

Consensus Algorithm

- Proof of Stake (PoS)
  - Probability of creating a block depends on the amount of stake
  - Economic incentive

Consensus Algorithm

- Practical Byzantine Fault Tolerance (pBFT)



https://www.geeksforgeeks.org/practical-byzantine-fault-tolerancepbft/

Consensus Algorithm

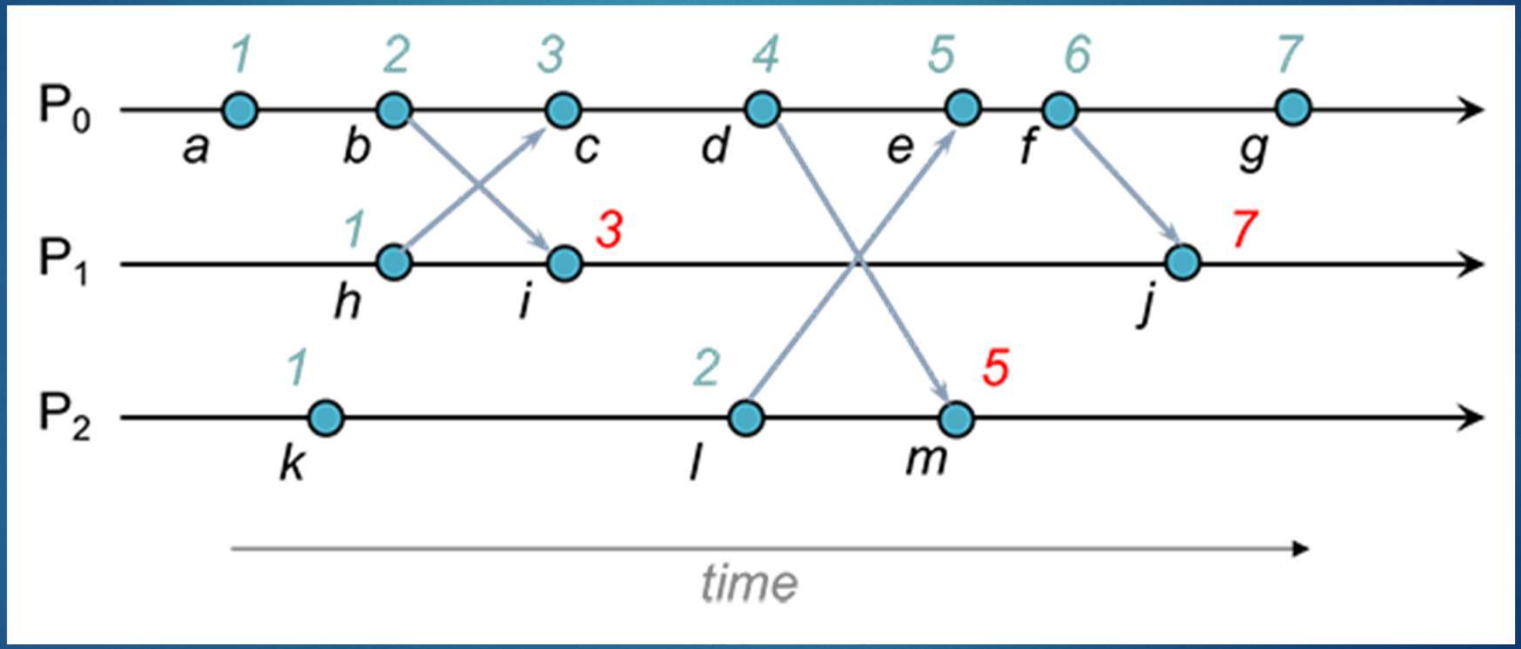
- Computational overhead
- Network overhead
- Fault tolerance
- Transaction finality
- Scaling

Timing Mechanisms

- Physical Time
- Logical Time

Timing Mechanisms

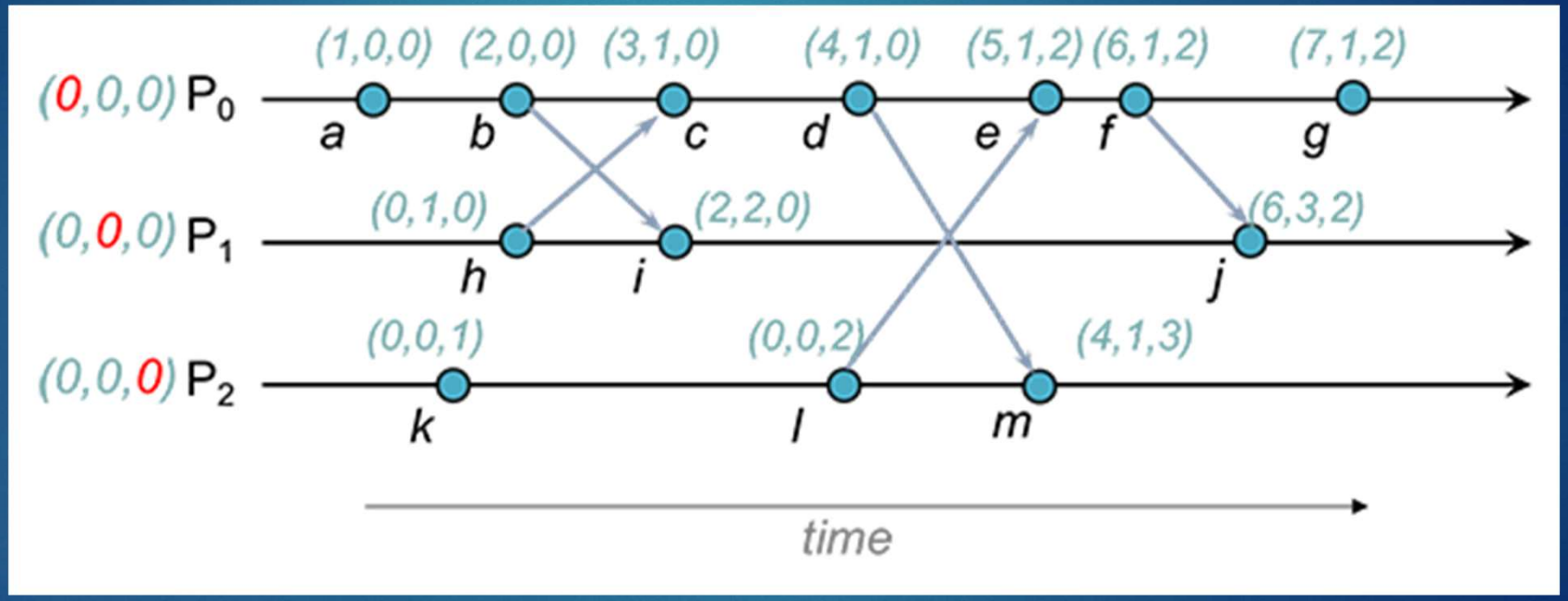
- Lamport Clock



https://www.cs.rutgers.edu/~pxk/417/notes/clocks/index.html

Timing Mechanisms

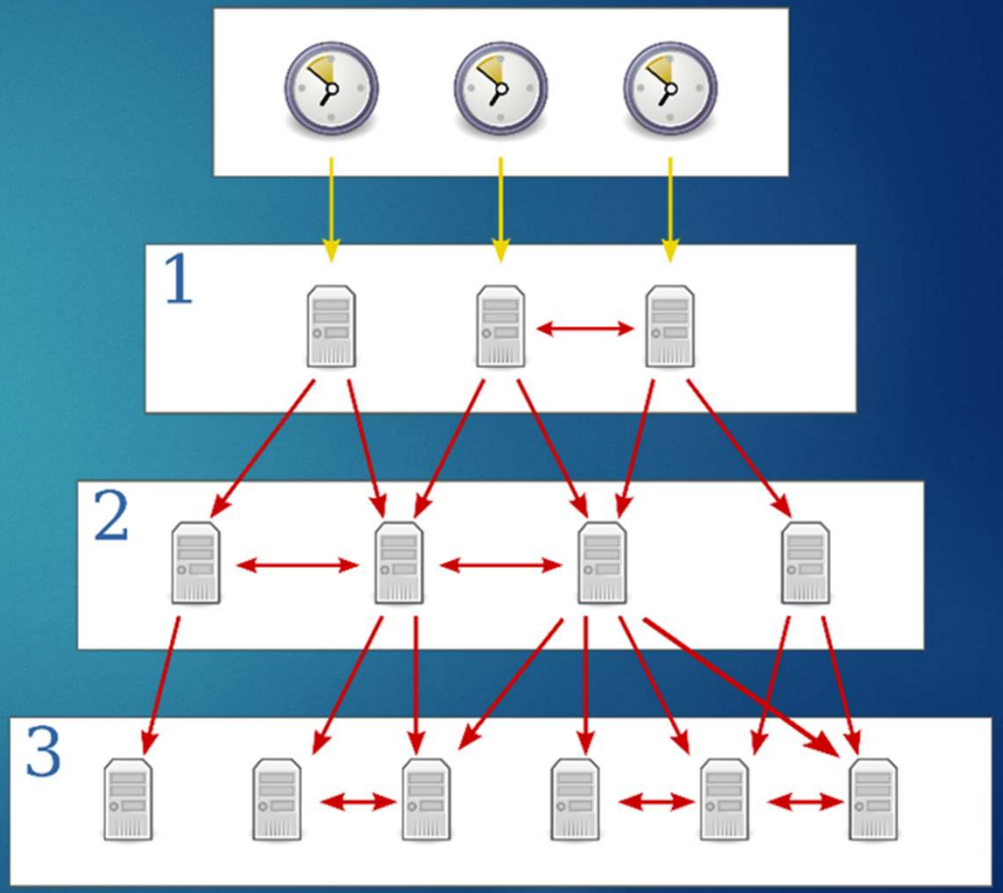
- Vector Clock



https://www.cs.rutgers.edu/~pxk/417/notes/clocks/index.html

Timing Mechanisms

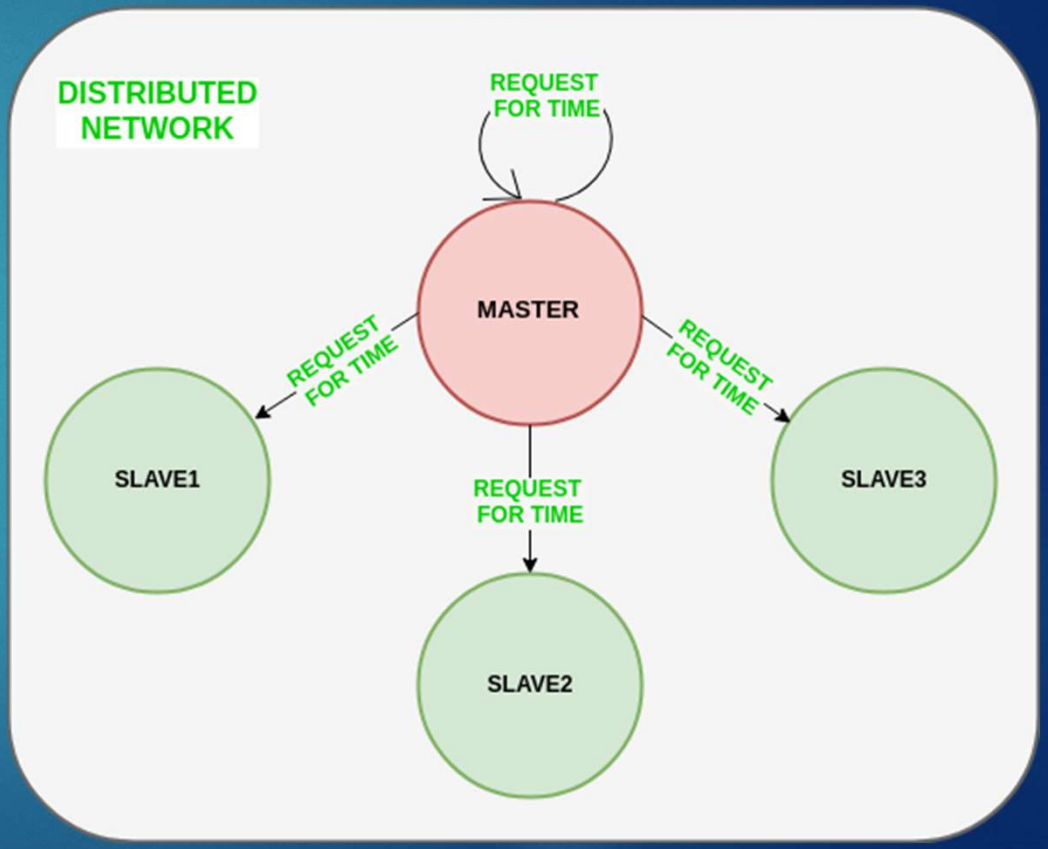
- Network Time Protocol
  - Real time



https://commons.wikimedia.org/wiki/File:Network_Time_Protocol_servers_and_clients.svg

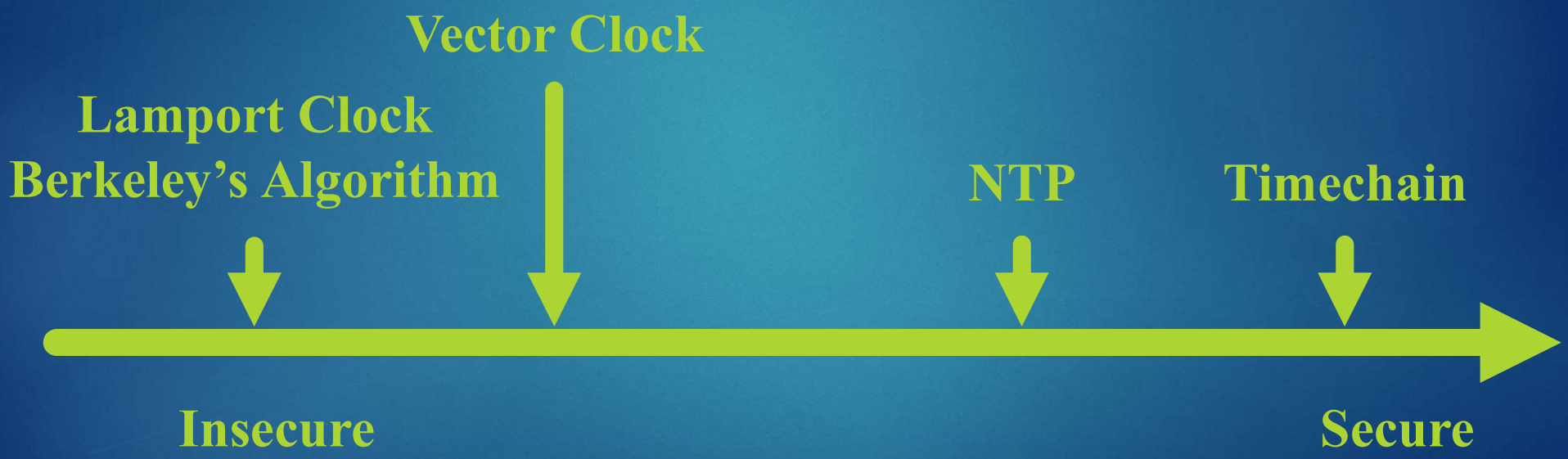
Timing Mechanisms

- Berkeley's Algorithm
  - No trustworthy time source

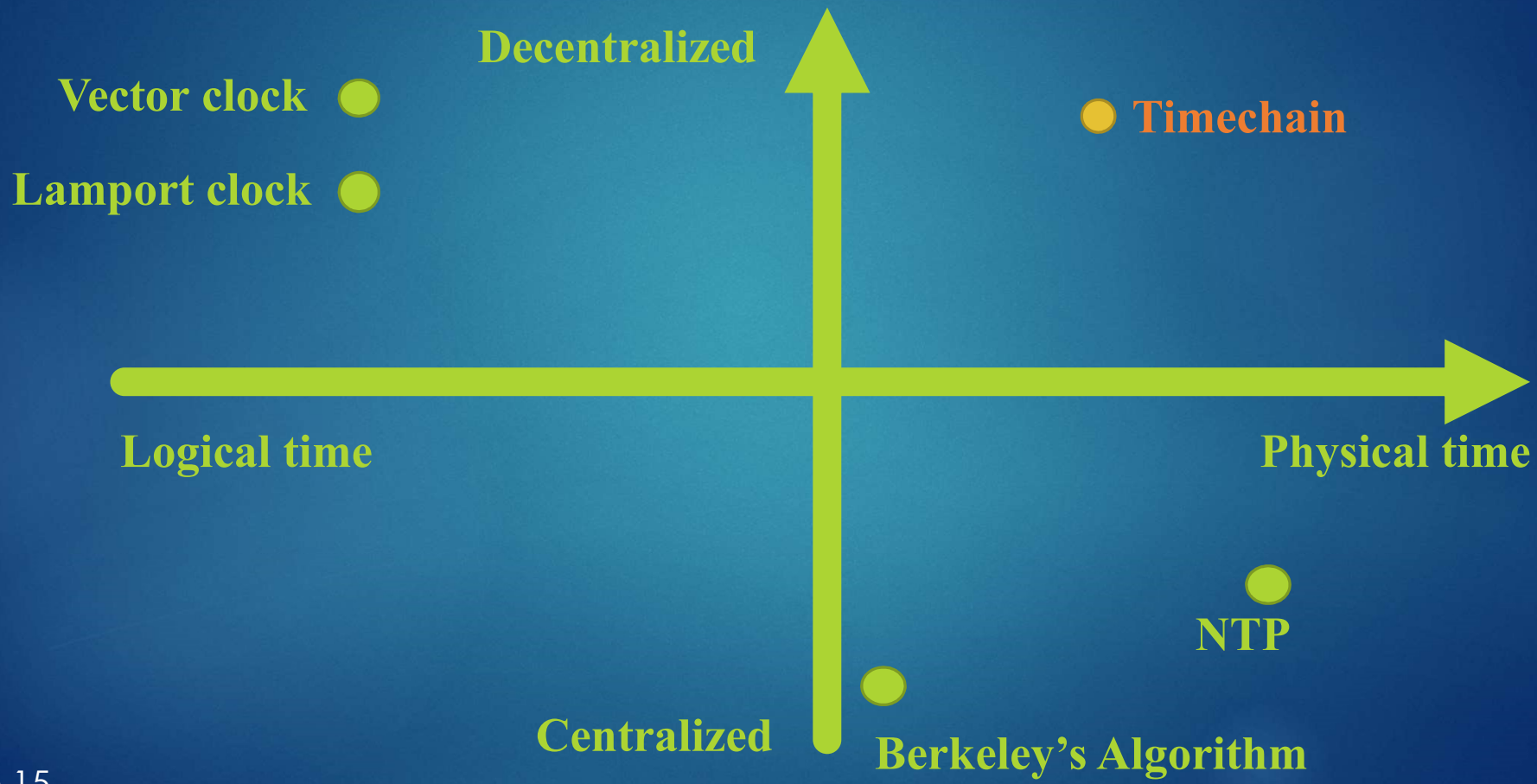


https://www.geeksforgeeks.org/berkeleys-algorithm/

Timing Mechanisms



Timing Mechanisms



NTP Clock Selection

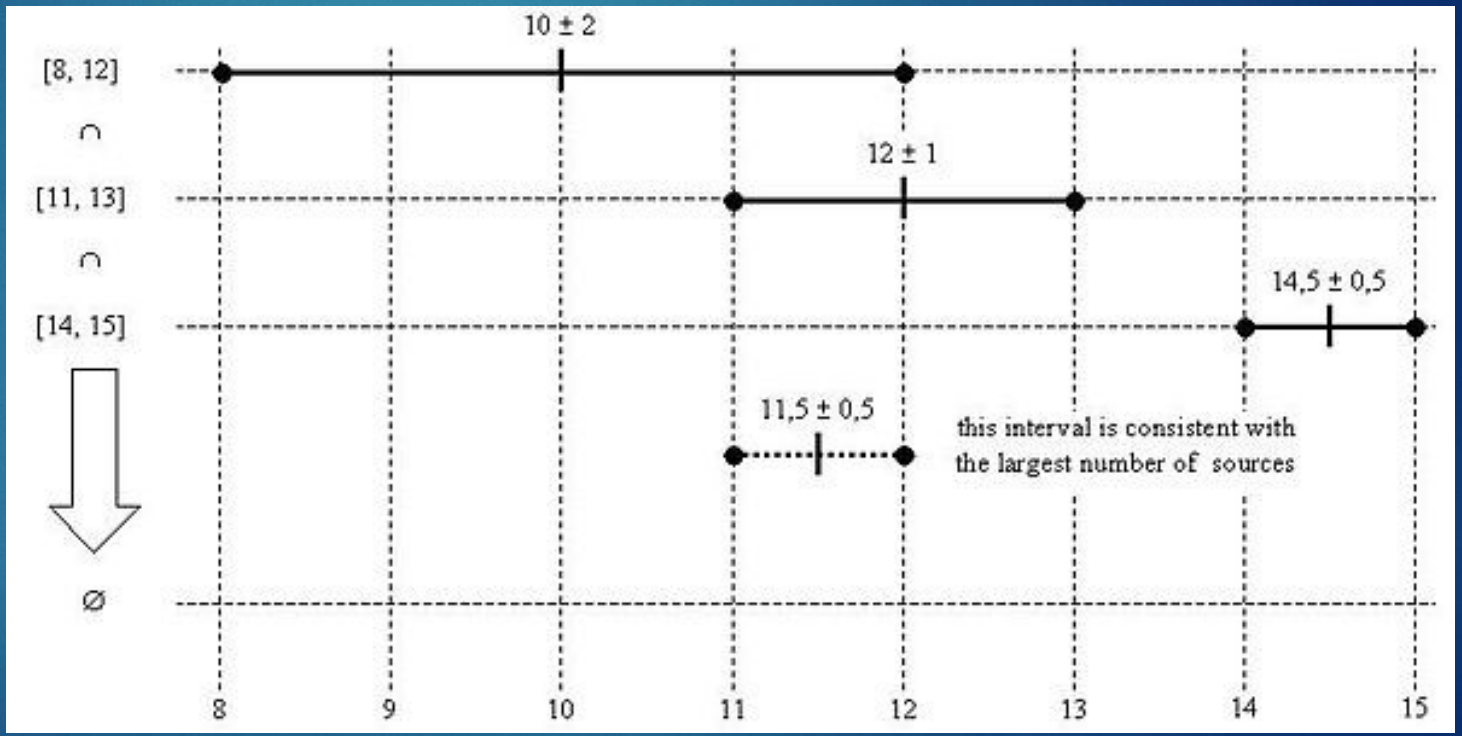
- Truechimers vs Falsetickers
- $[\theta_0 - \lambda, \theta_0 + \lambda]$
- θ_0: Measured offset
- λ: Root distance
  - ½ Round trip delay + root dispersion

NTP Clock Selection

- Marzullo's algorithm
  - intersection interval: the smallest interval containing points from the largest number of correctness intervals

NTP Clock Selection

- Marzullo's algorithm



https://en.wikipedia.org/wiki/Marzullo%27s_algorithm

Timechain

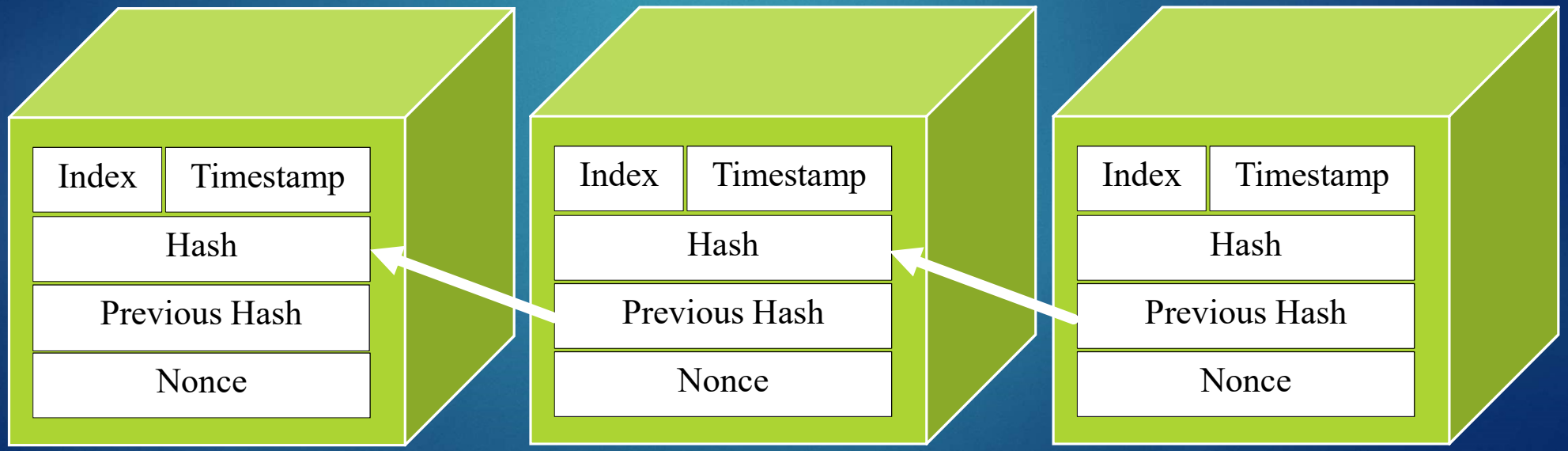
- Decentralized, distributed timekeeping
- Physical time + logical time

Consensus Algorithm

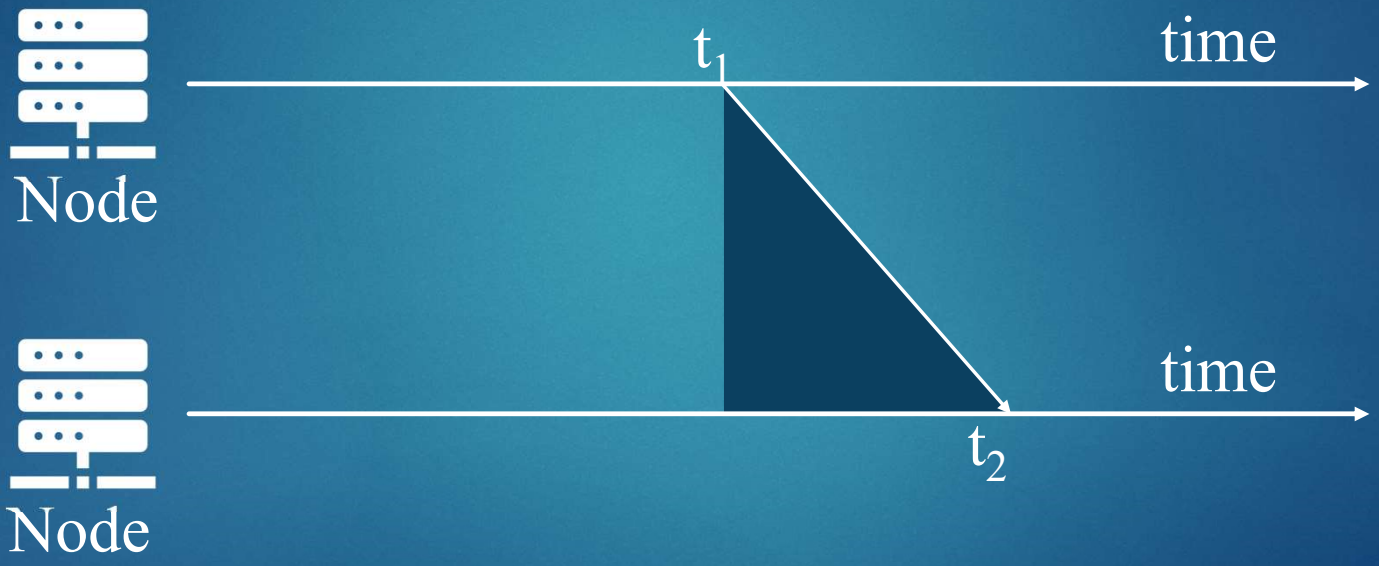
- Proof of Work (PoW)
  - Highly scalable
  - No stake
  - Better fault tolerance

Timechain

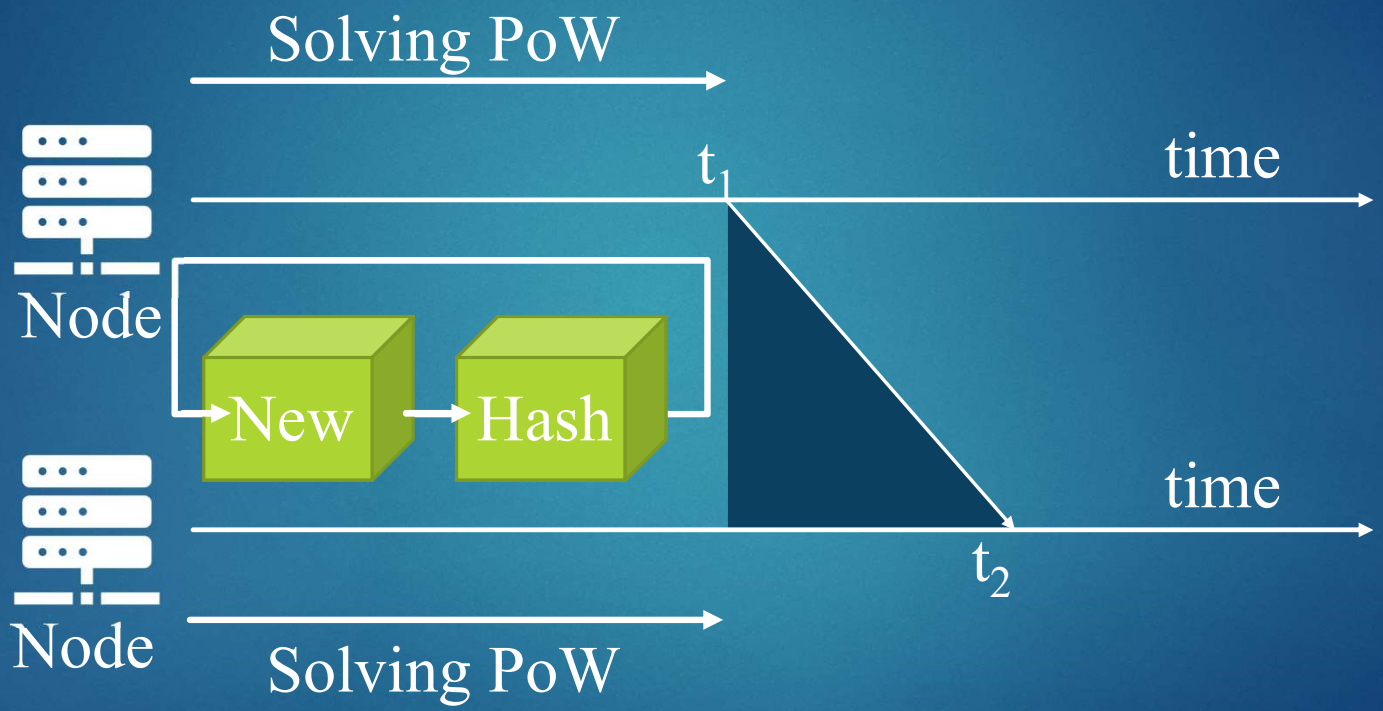
- Block



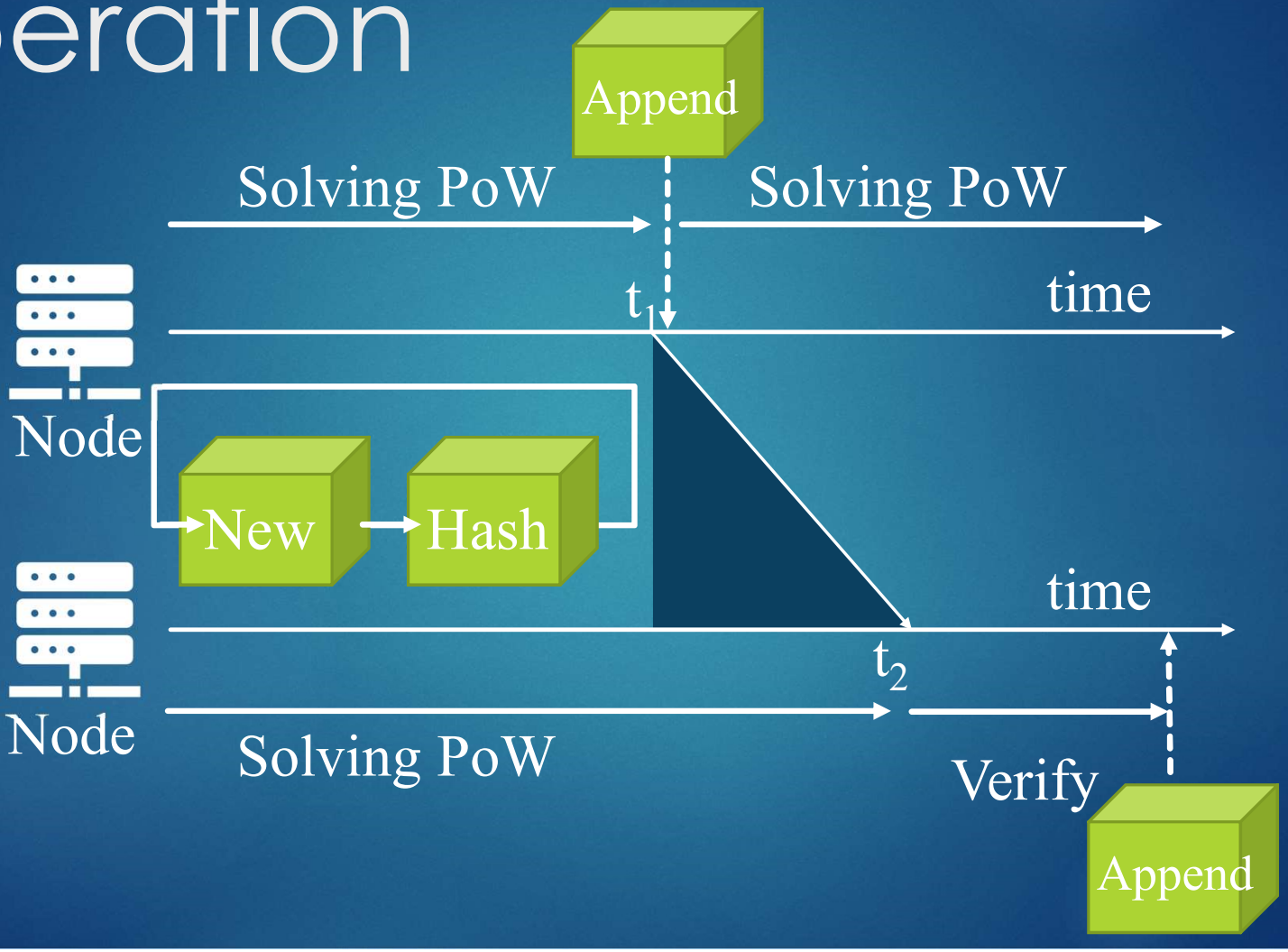
Operation



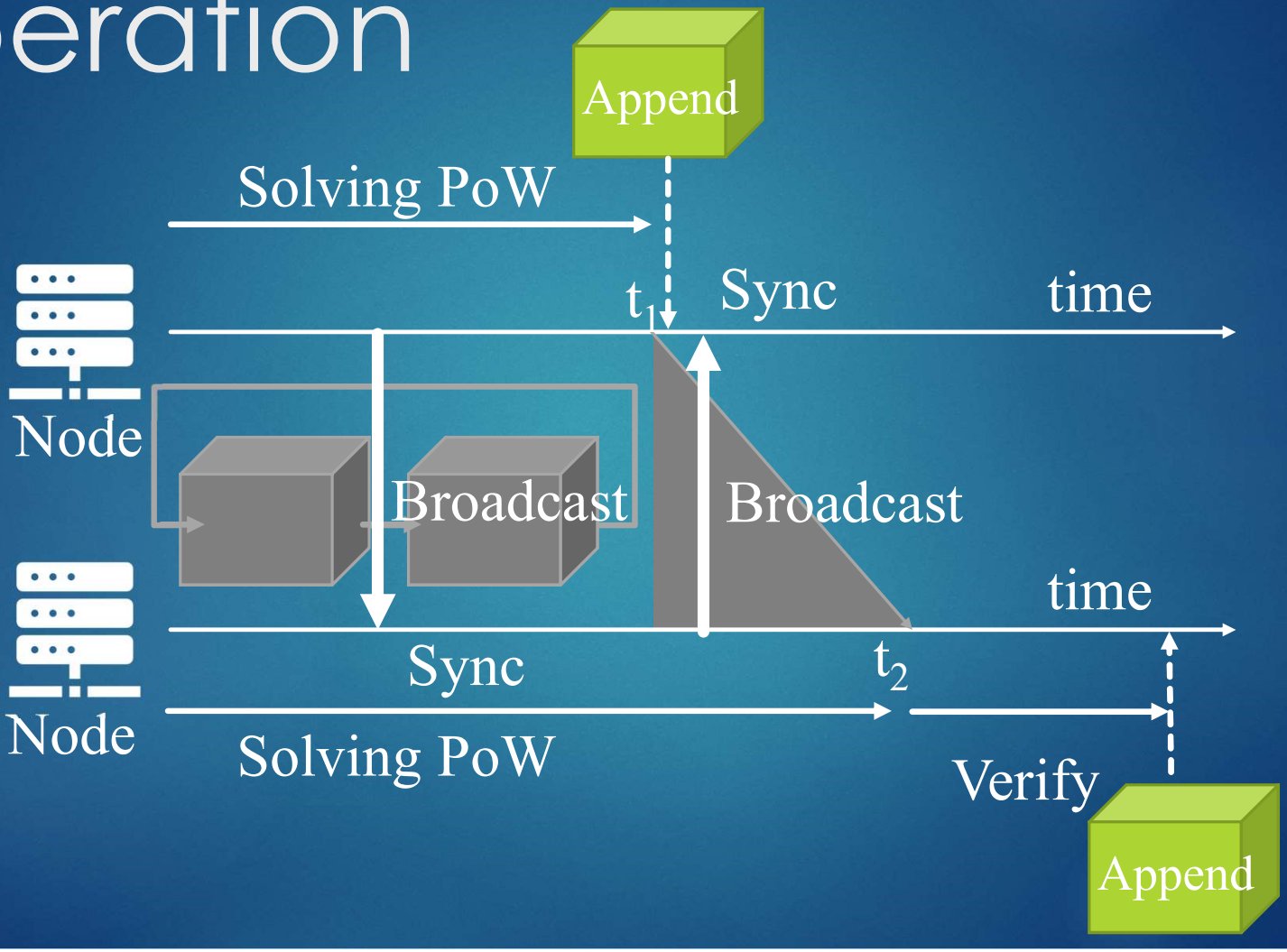
Operation



Operation


Append
Solving PoW
Solving PoW
time
t_1
Node
New
Hash
time
t_2
Node
Solving PoW
Verify
Append

Operation

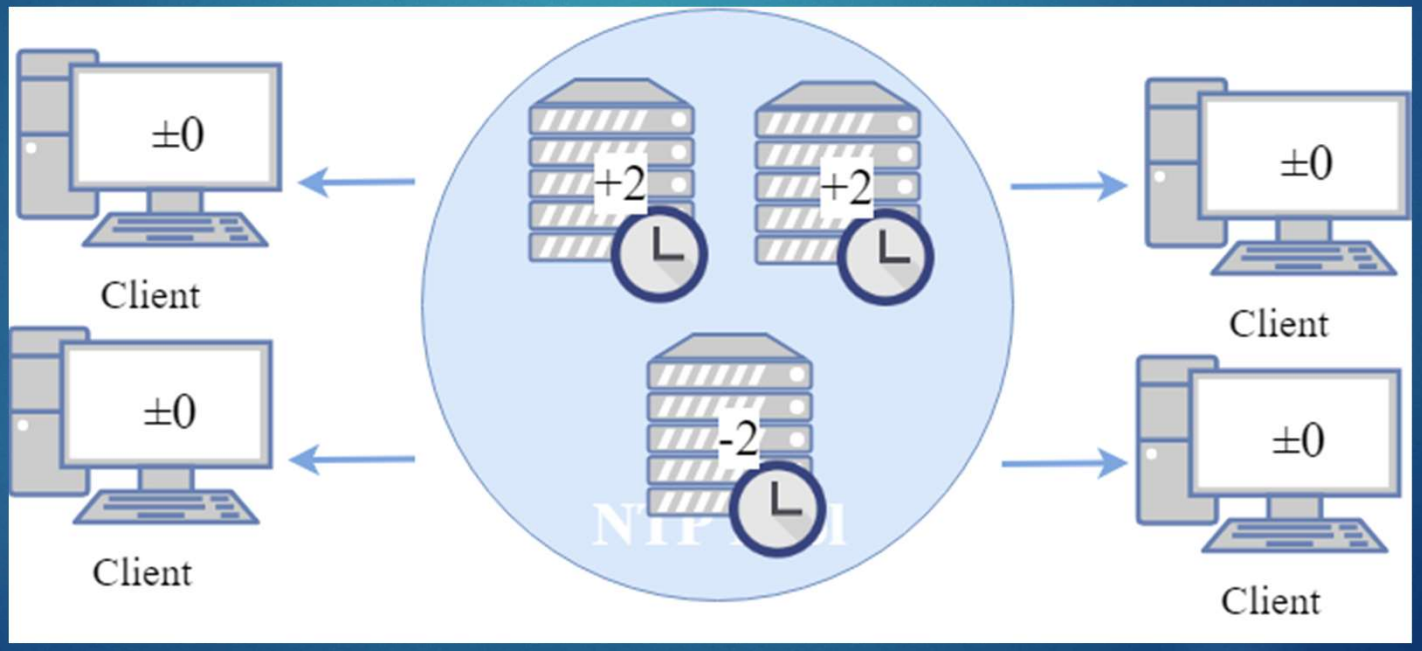

Append
Solving PoW
t_1
Sync
time
Node
Broadcast
Broadcast
time
Sync
t_2
Node
Solving PoW
Verify
Append

Implementation

- Deployed working instance on 7 machines
- Timechain vs NTP in clock selection
- How to choose a time among the blocks

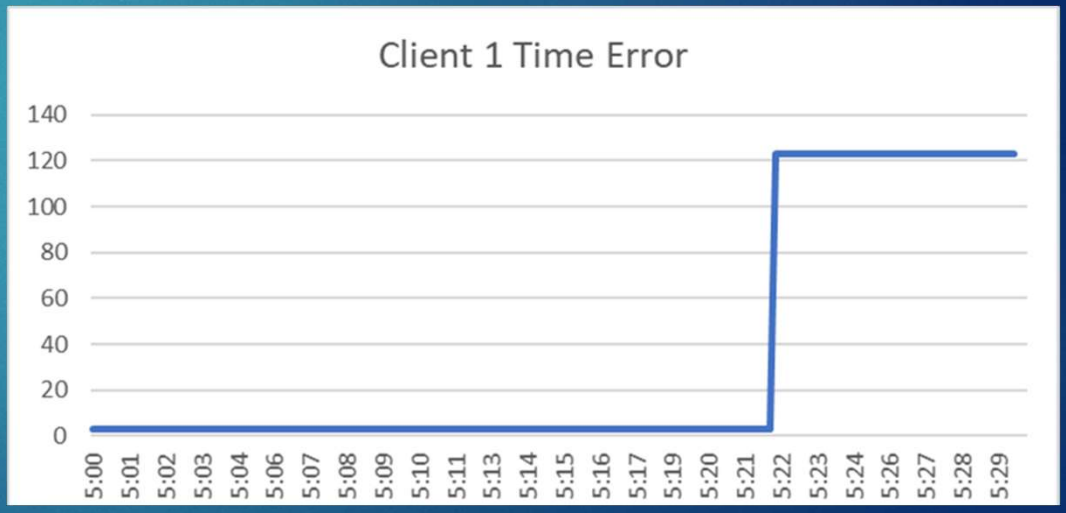
Implementation

- NTP Test:



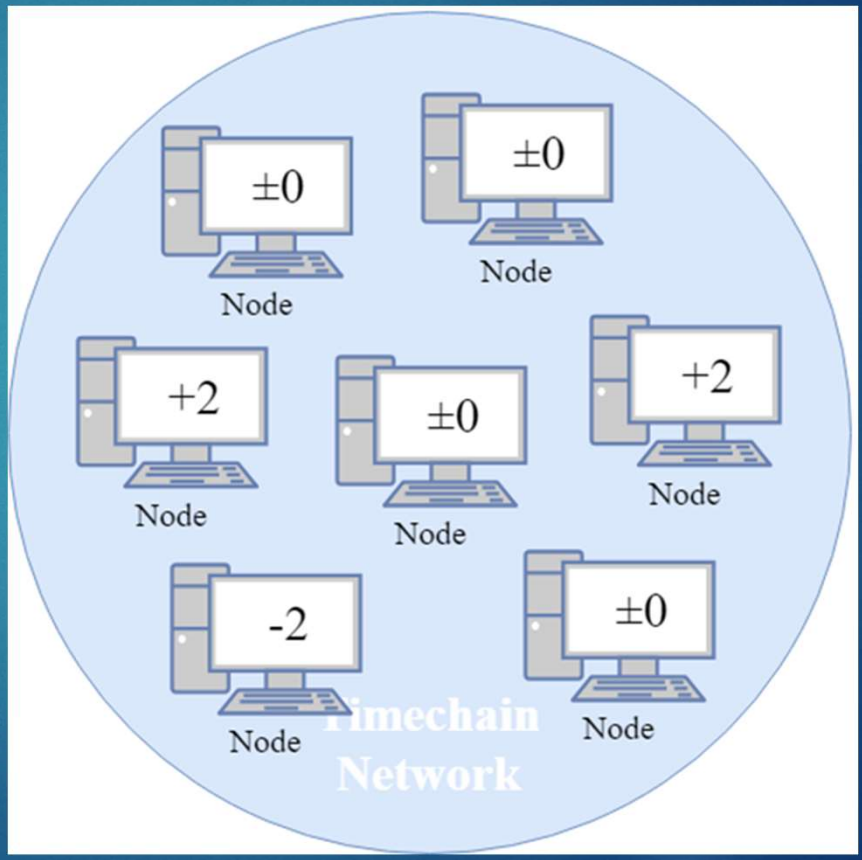
Implementation

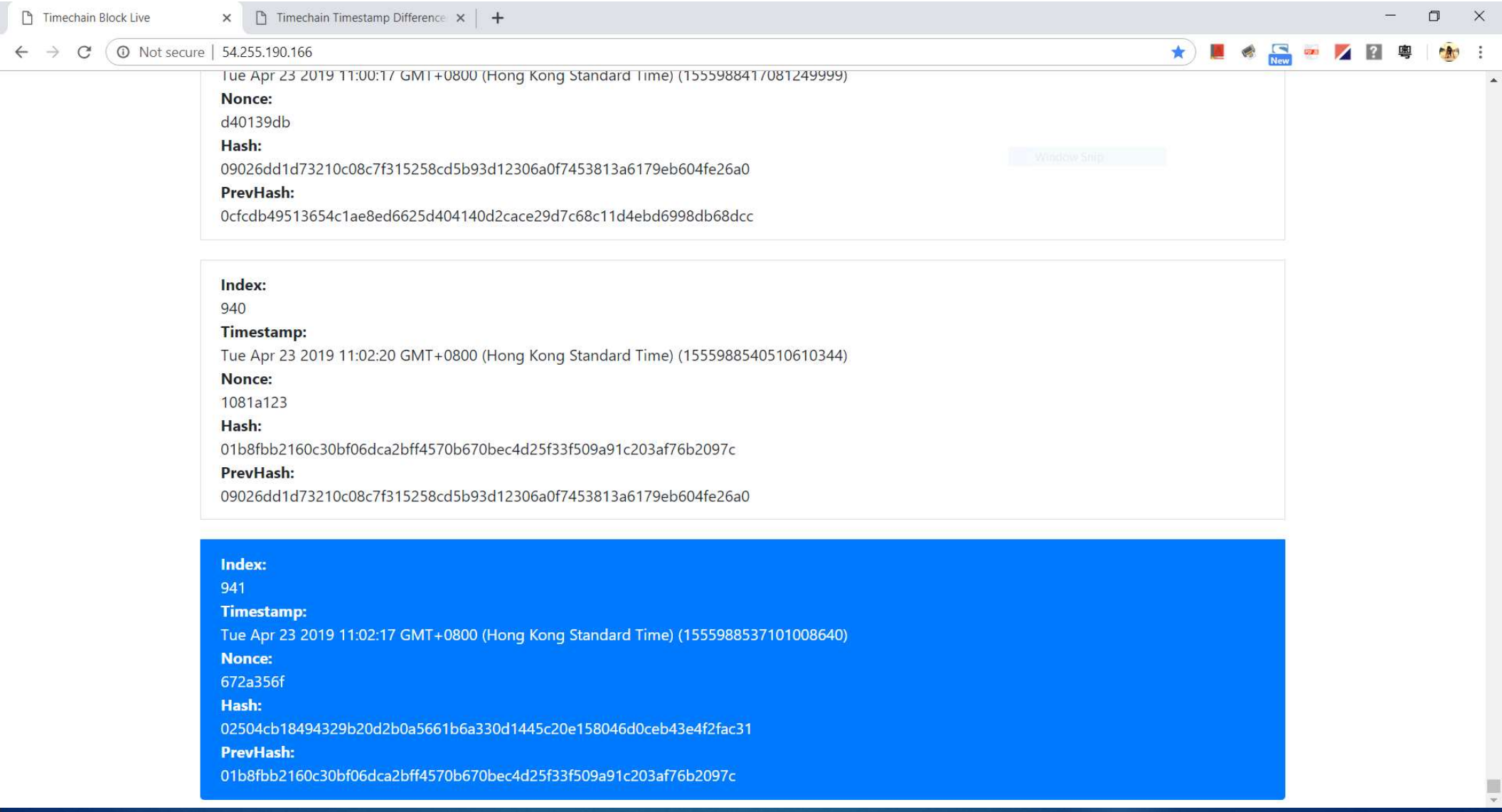
- NTP Test:



Implementation

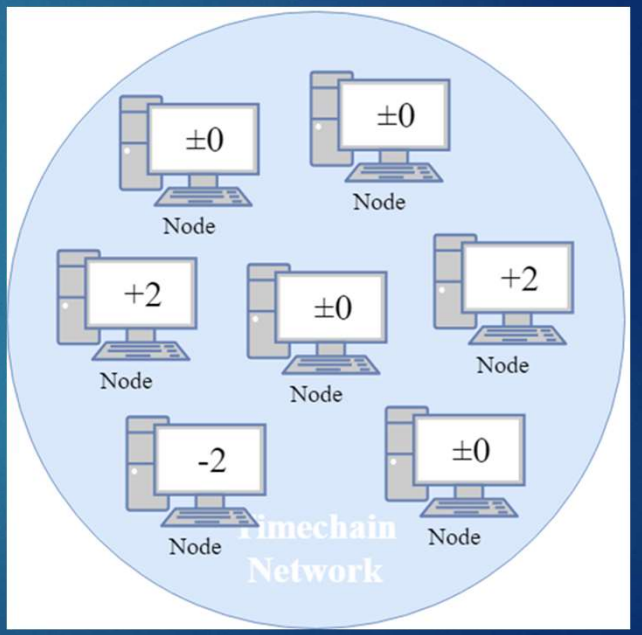
- Timechain Test:

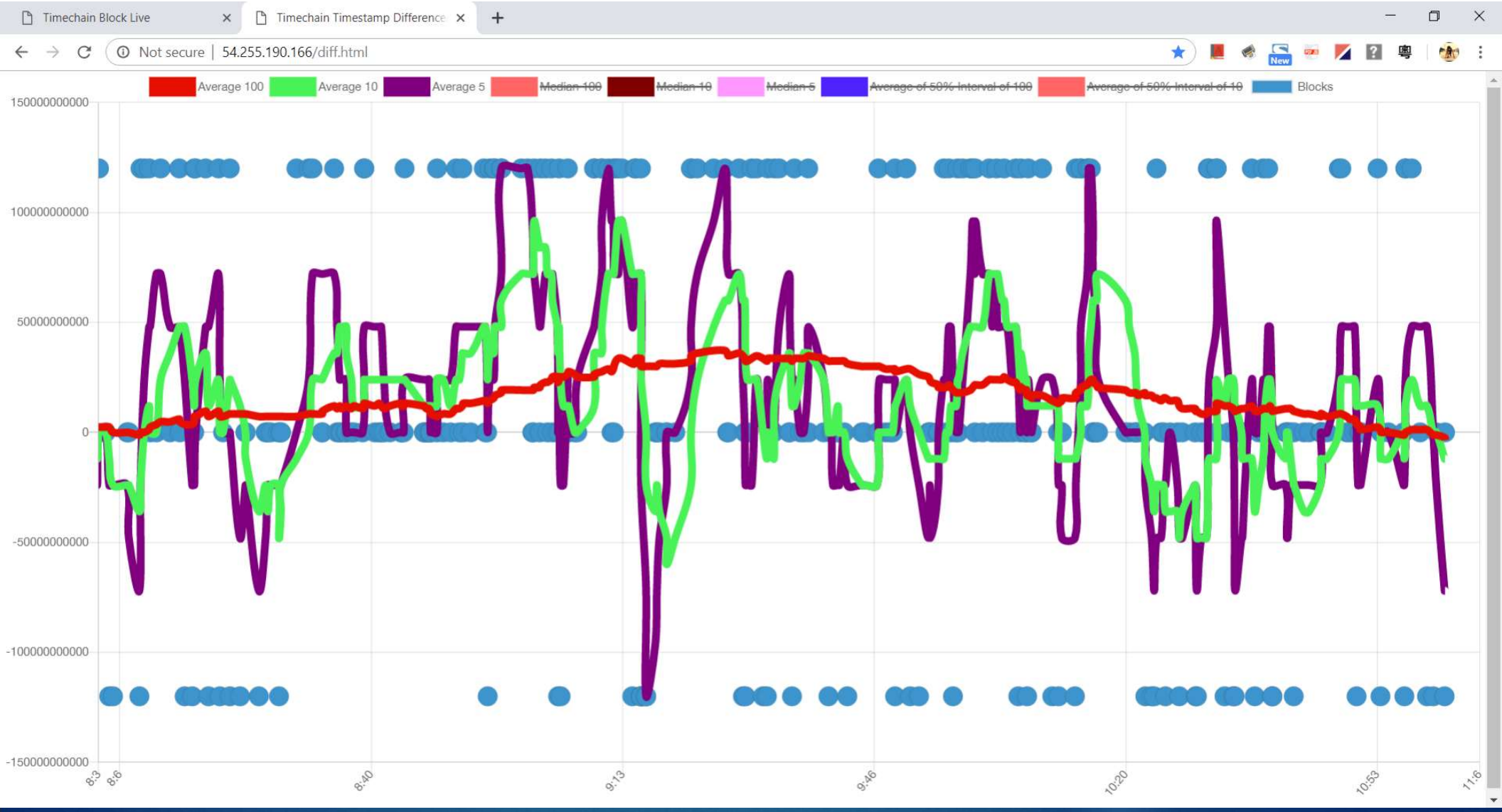



Timechain Block Live
Timechain Timestamp Difference
Not secure | 54.255.190.166
Tue Apr 23 2019 11:00:17 GMT+0800 (Hong Kong Standard Time) (1555988417081249999)
Nonce:
d40139db
Hash:
09026dd1d73210c08c7f315258cd5b93d12306a0f7453813a6179eb604fe26a0
PrevHash:
0cfcdb49513654c1ae8ed6625d404140d2cace29d7c68c11d4ebd6998db68dcc
Index:
940
Timestamp:
Tue Apr 23 2019 11:02:20 GMT+0800 (Hong Kong Standard Time) (1555988540510610344)
Nonce:
1081a123
Hash:
01b8fbb2160c30bf06dca2bff4570b670bec4d25f33f509a91c203af76b2097c
PrevHash:
09026dd1d73210c08c7f315258cd5b93d12306a0f7453813a6179eb604fe26a0
Index:
941
Timestamp:
Tue Apr 23 2019 11:02:17 GMT+0800 (Hong Kong Standard Time) (1555988537101008640)
Nonce:
672a356f
Hash:
02504cb18494329b20d2b0a5661b6a330d1445c20e158046d0ceb43e4f2fac31
PrevHash:
01b8fbb2160c30bf06dca2bff4570b670bec4d25f33f509a91c203af76b2097c

Choosing a Time

- Mean(n)
  - n: number of samples
  - $0\left(\frac{4}{7}\right) + 2\left(\frac{2}{7}\right) - 2 \times \left(\frac{1}{7}\right) = 0.285$ mins

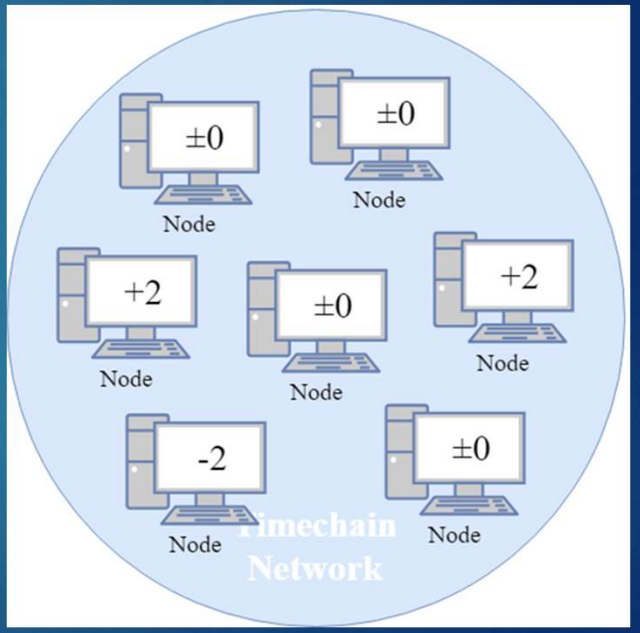


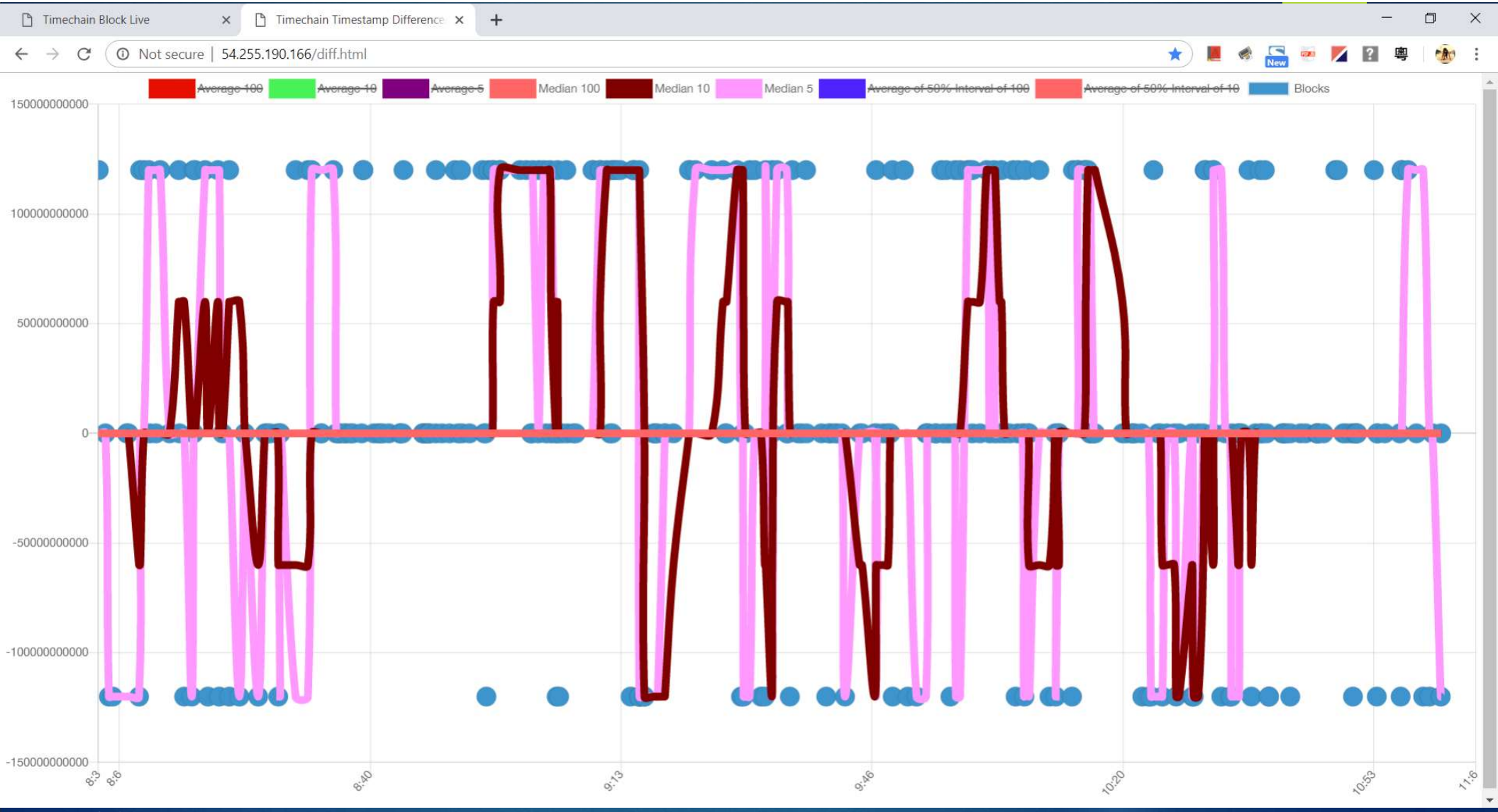


Captured at 4/23/2019 11:06am HKT

Choosing a Time

- Median(n)
  - n: number of samples





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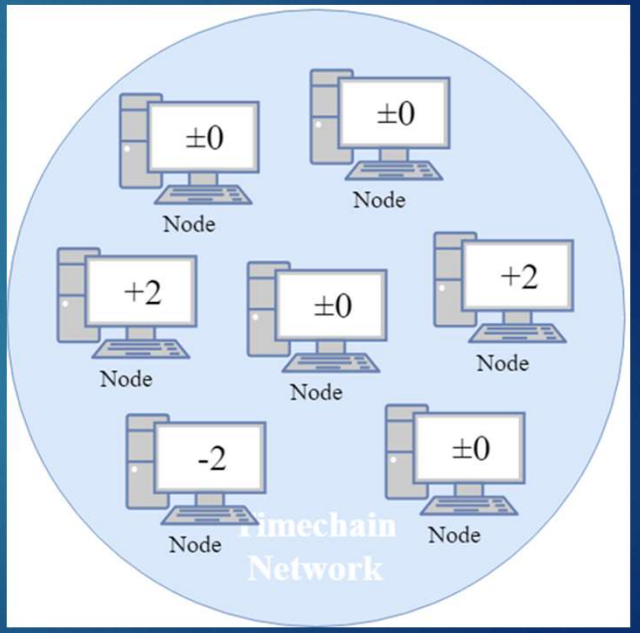
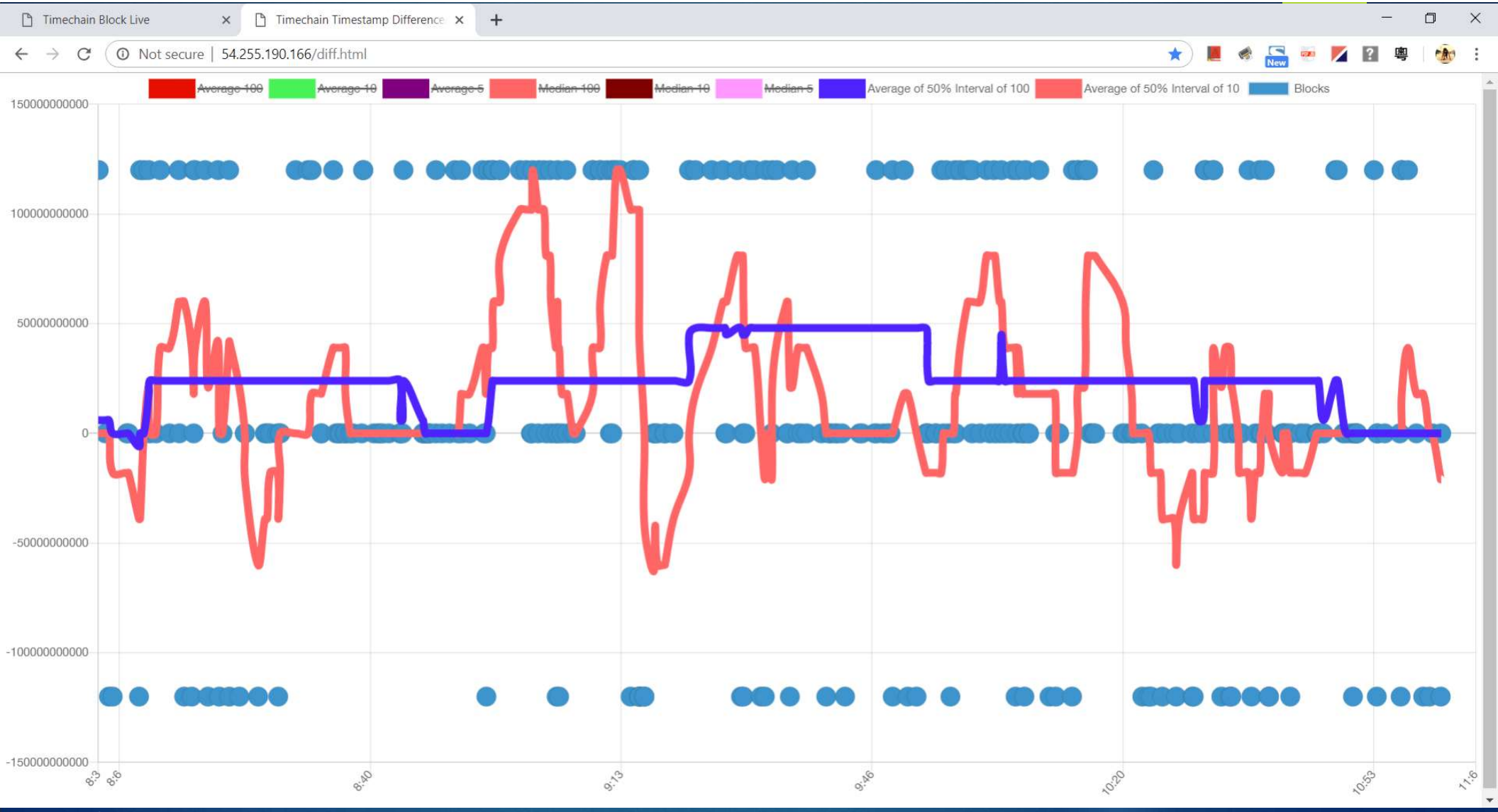
Choosing a Time

- Average of timestamps of nodes between 25th percentile and 75th percentile





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Conclusion

- Timechain capable to keep physical time and logical ordering
- There may exist better methods to computer a more accurate time
- Intended to provide a more creditable time source alongside with other timing mechanisms