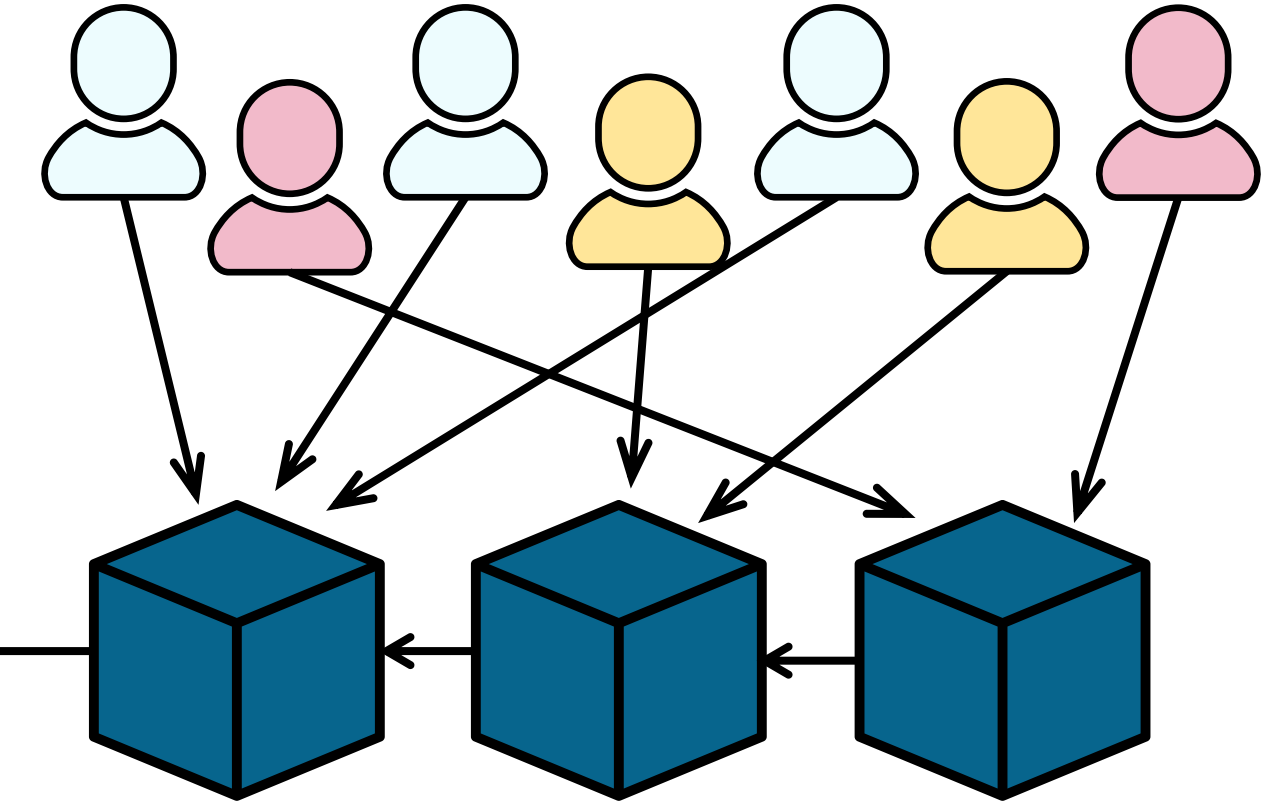
Ethereum Proof-of-Stake Consensus Layer: Participation and Decentralization

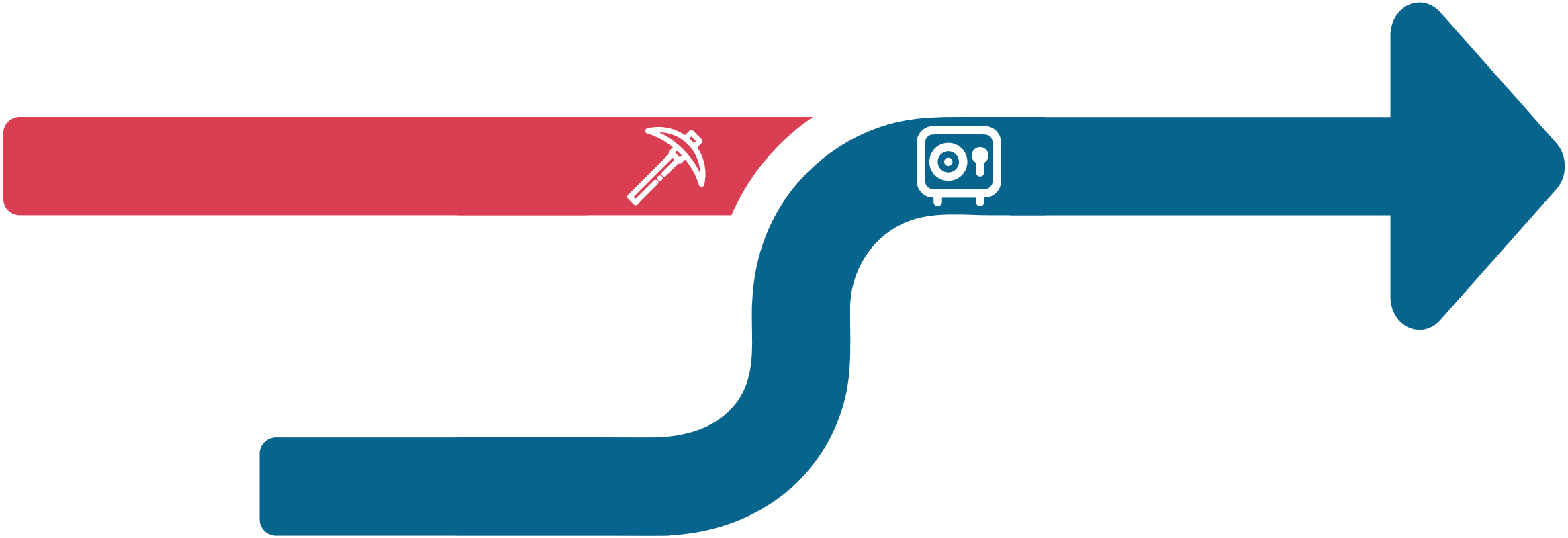


Dominic Grandjean, **Lioba Heimbach**, Roger Wattenhofer

ETH Zurich

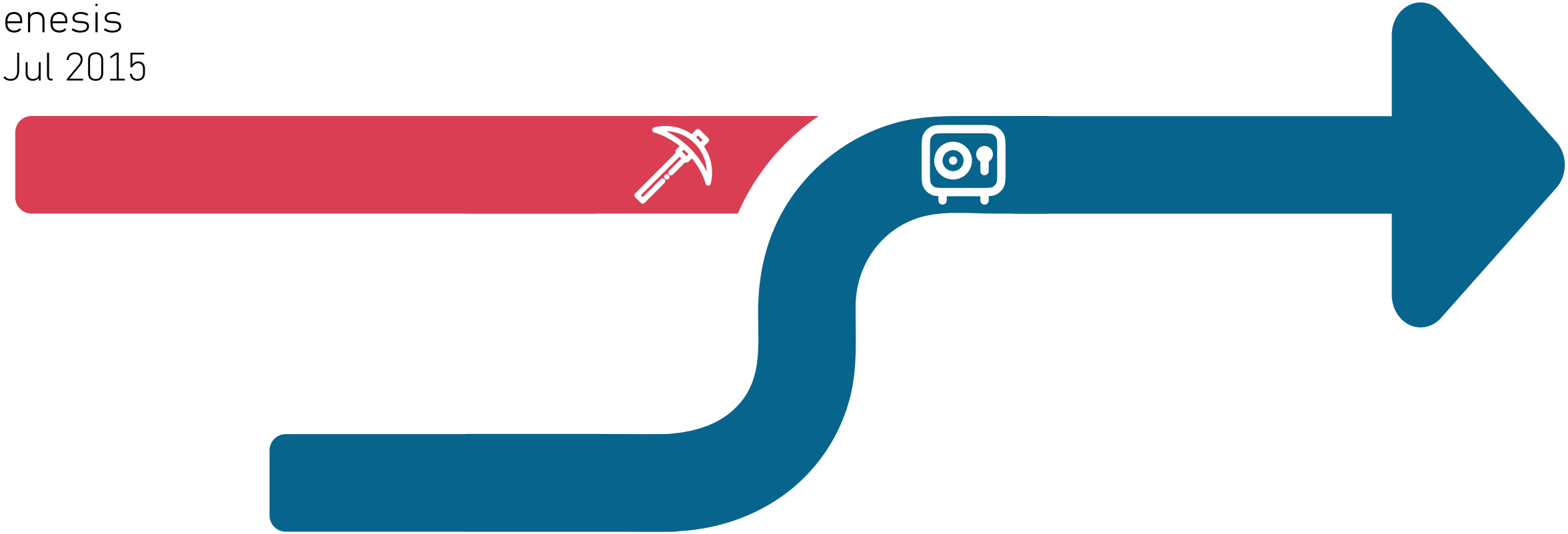
CoDecFin@FC

Ethereum history



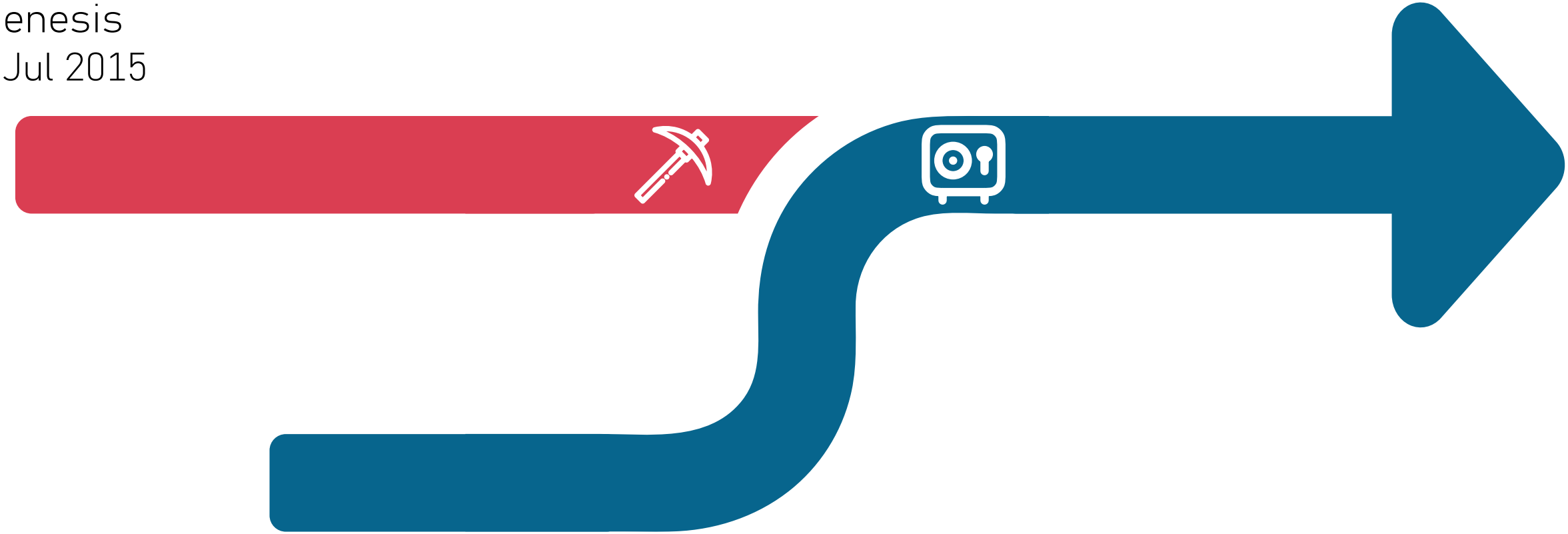
Ethereum history

Genesis
30 Jul 2015



Ethereum history

Genesis
30 Jul 2015

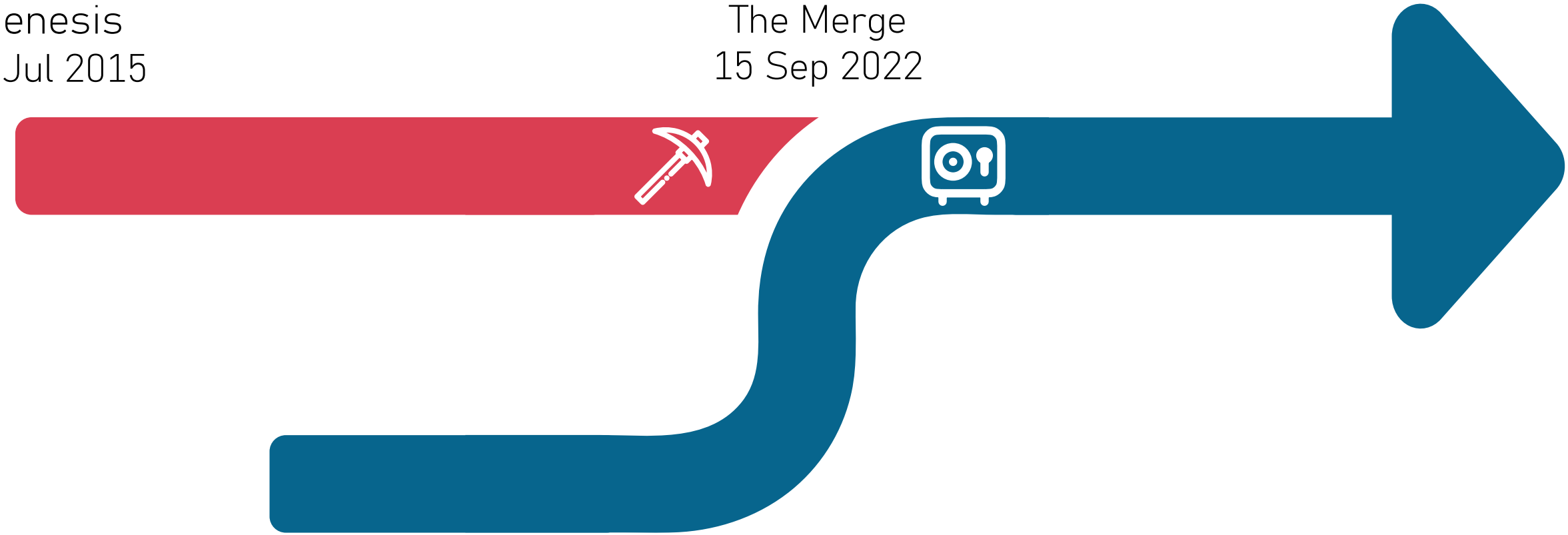


Beacon Chain launch
1 Dec 2020

Ethereum history

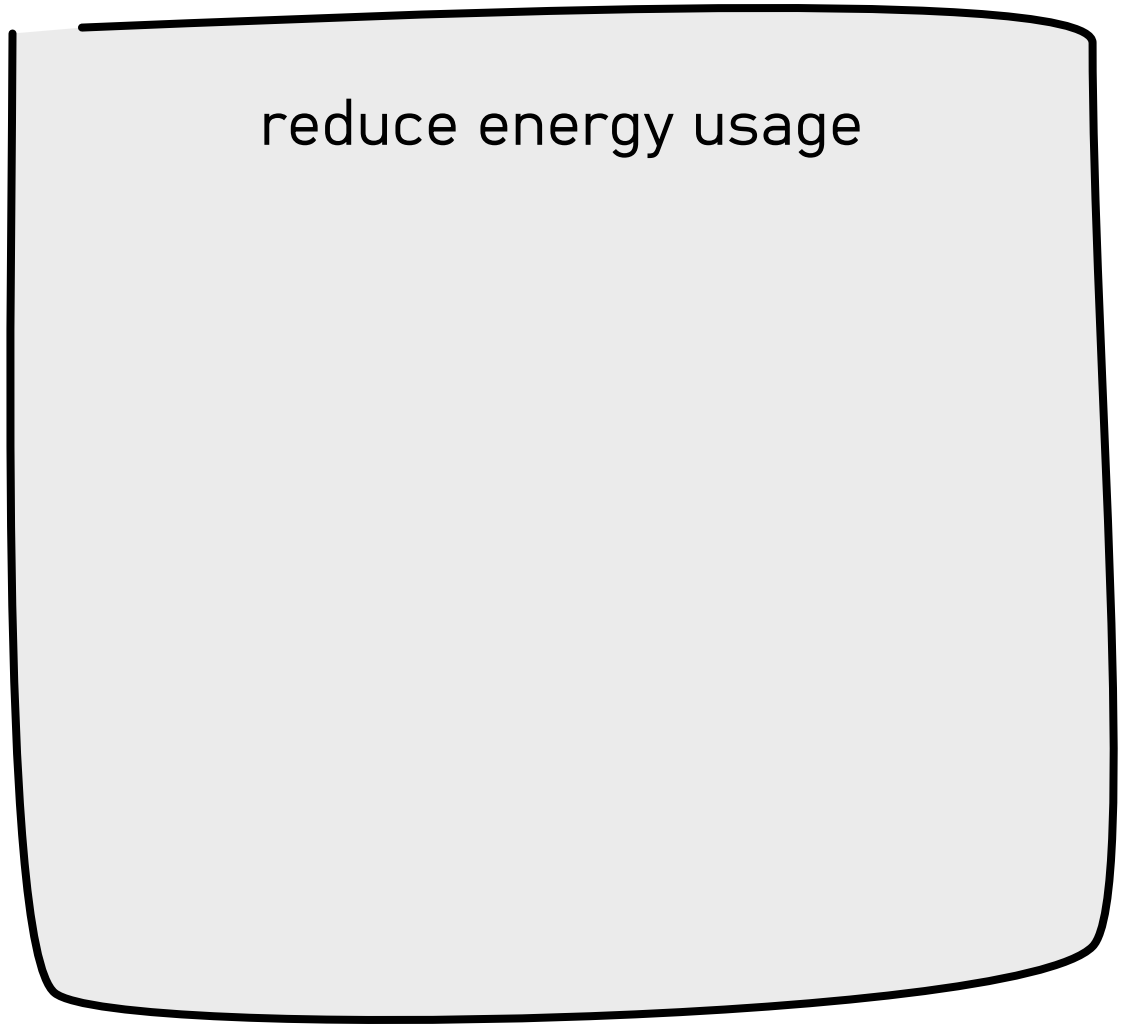
Genesis
30 Jul 2015

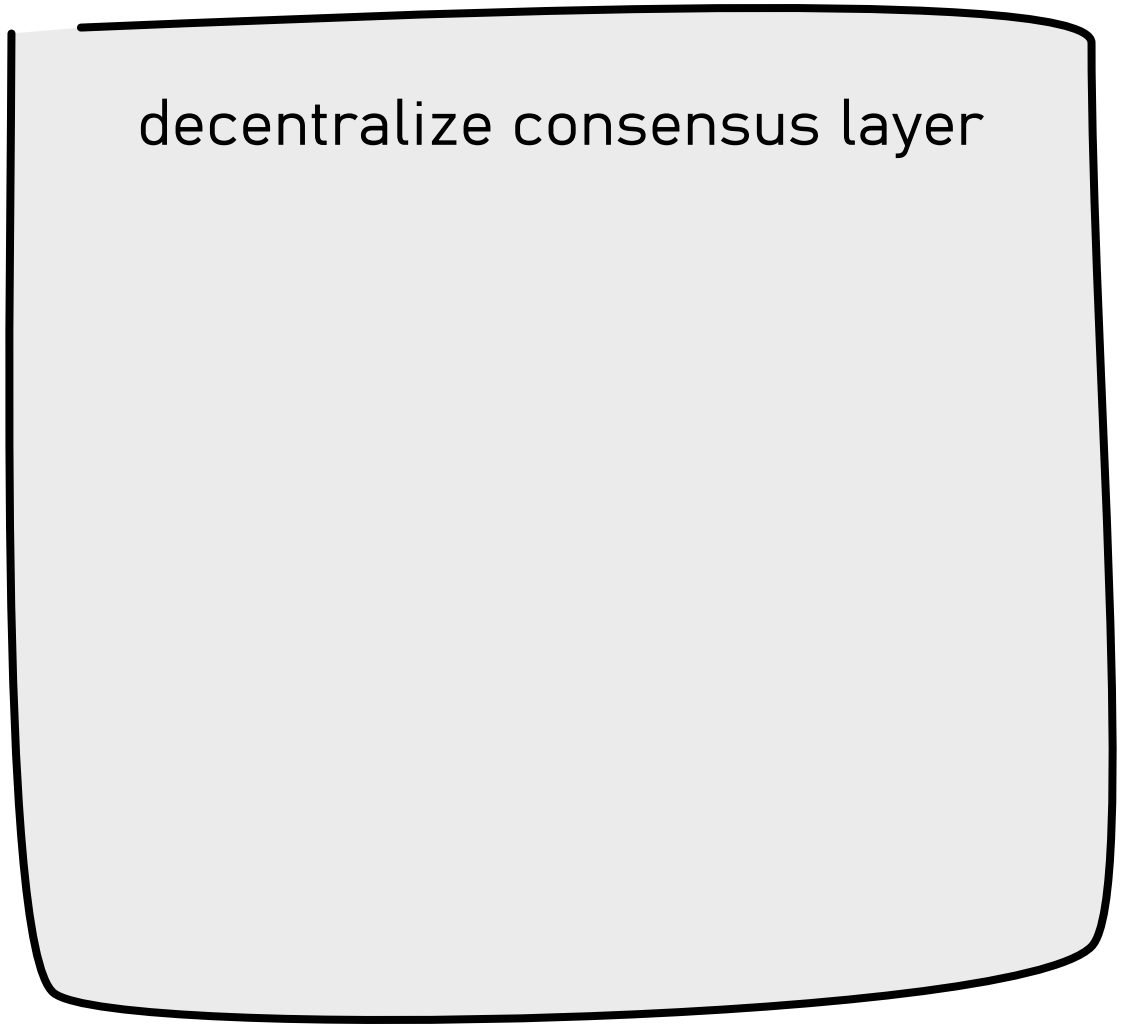
The Merge
15 Sep 2022



Beacon Chain launch
1 Dec 2020

PoS Goals





PoS Goals

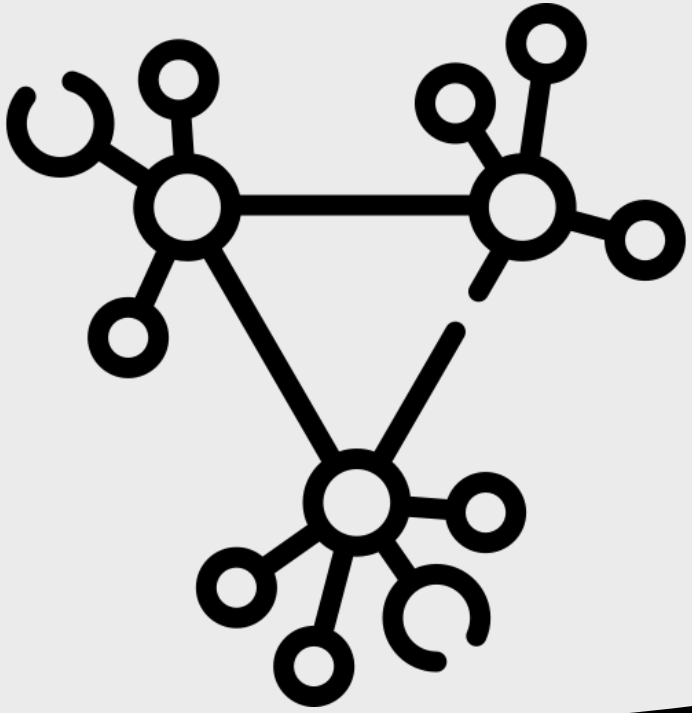
reduce energy usage

decentralize consensus layer

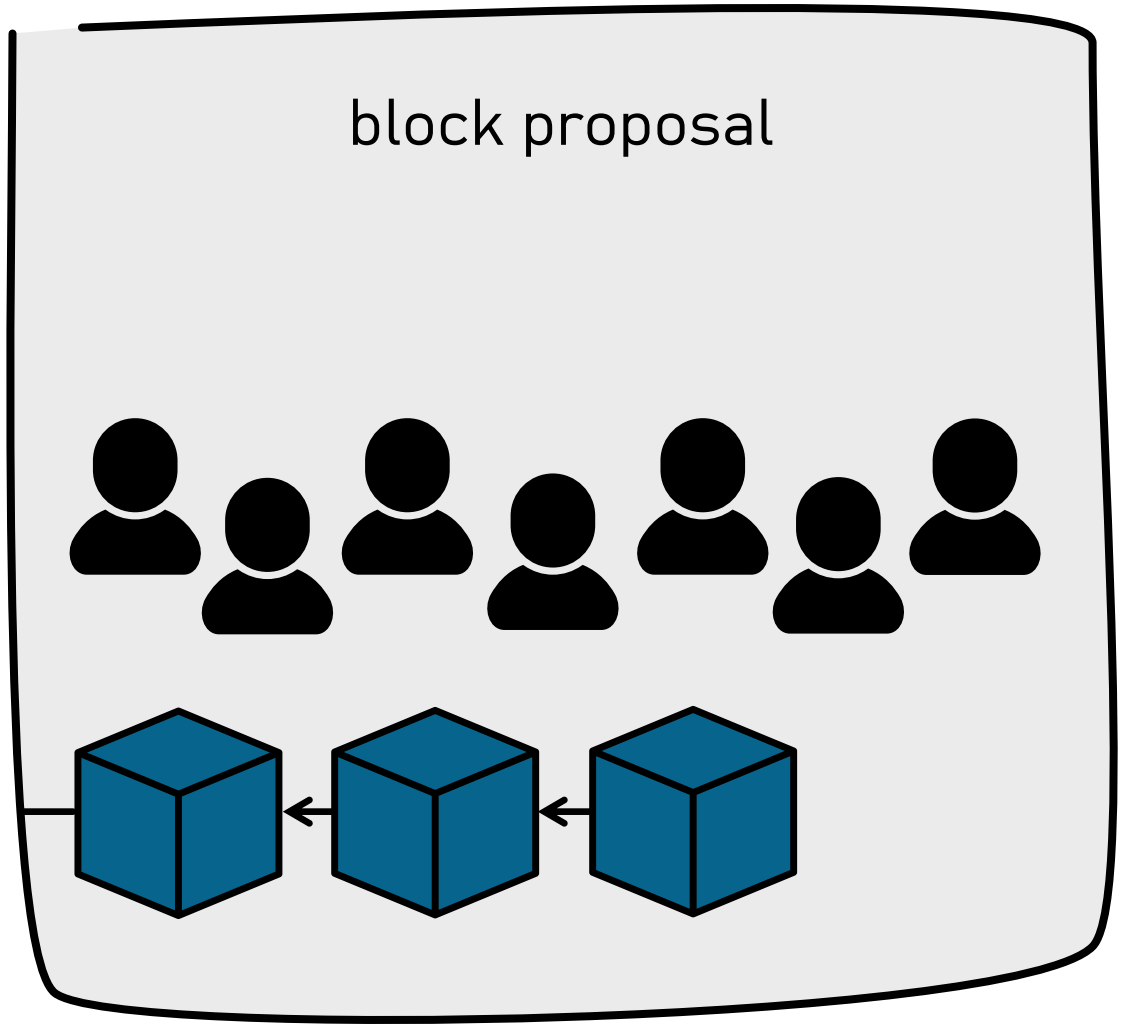
PoS Goals

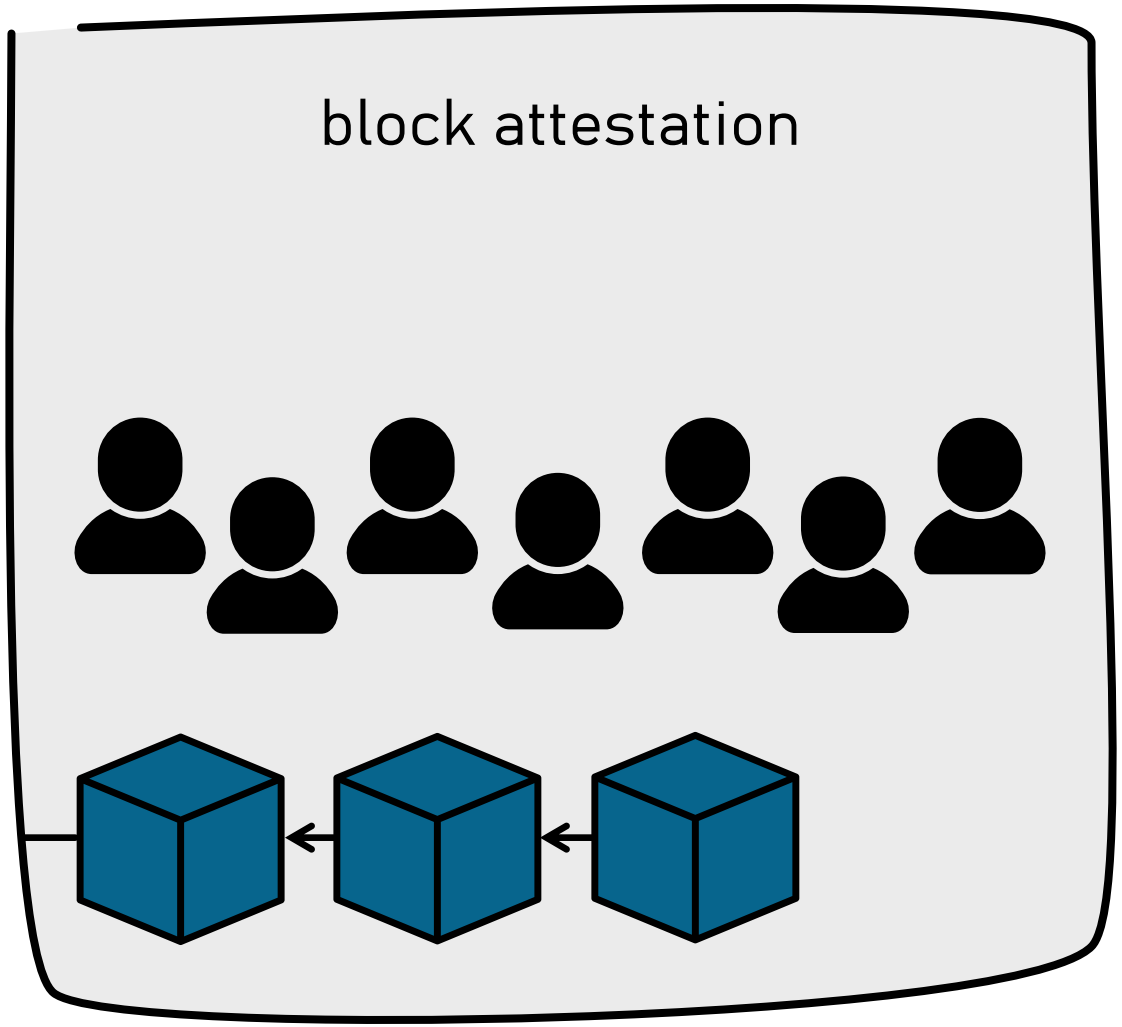
reduce energy usage

decentralize consensus layer

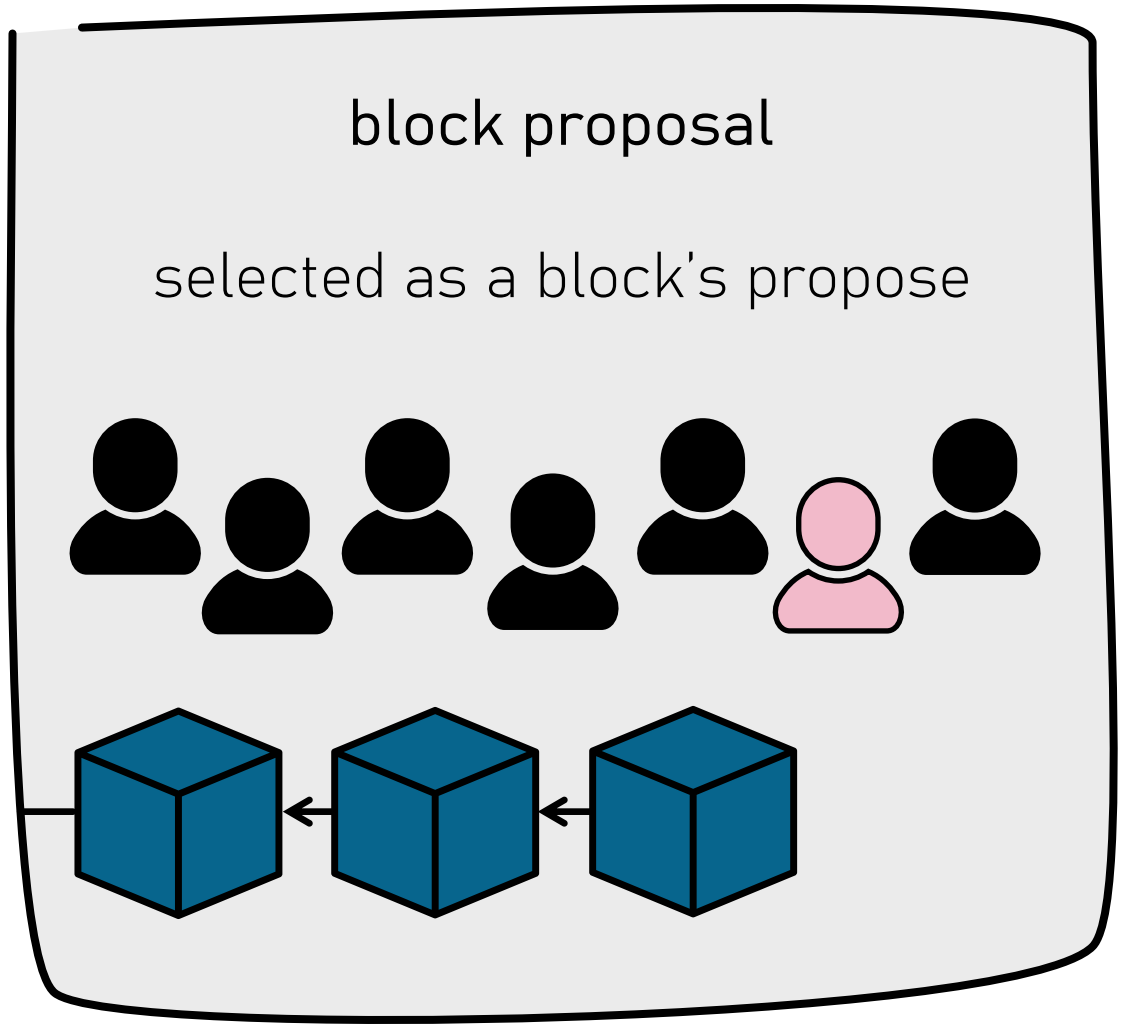


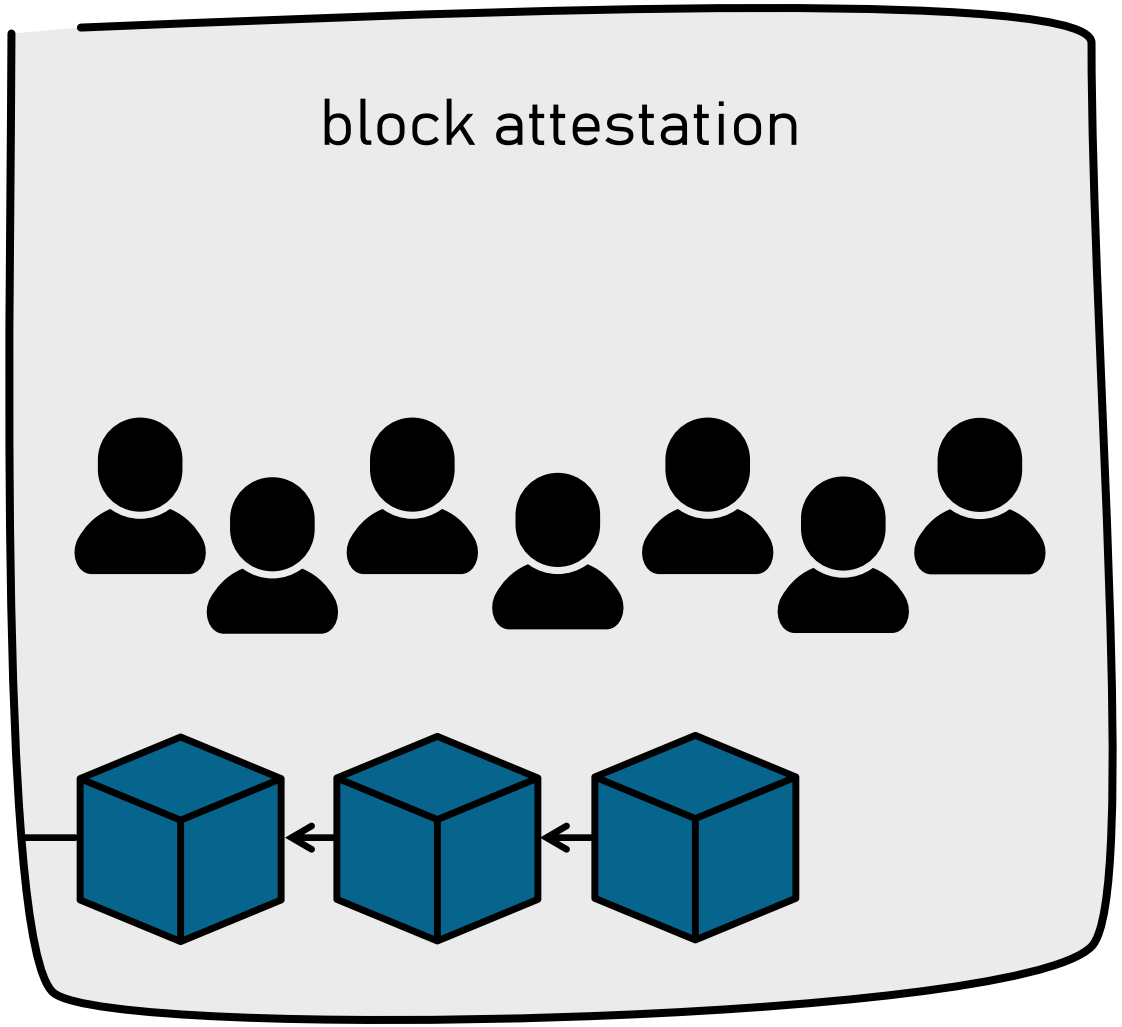
Validator duties



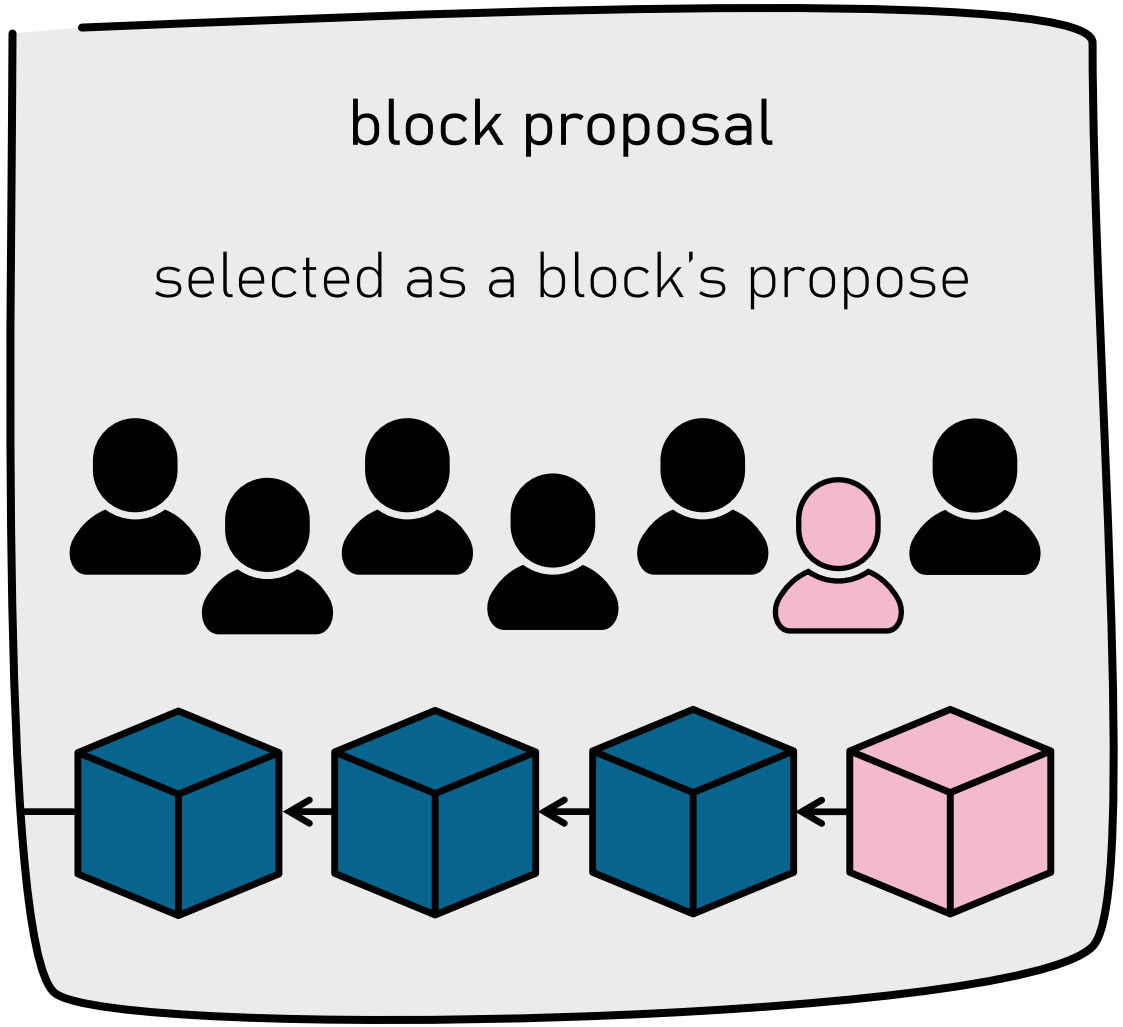


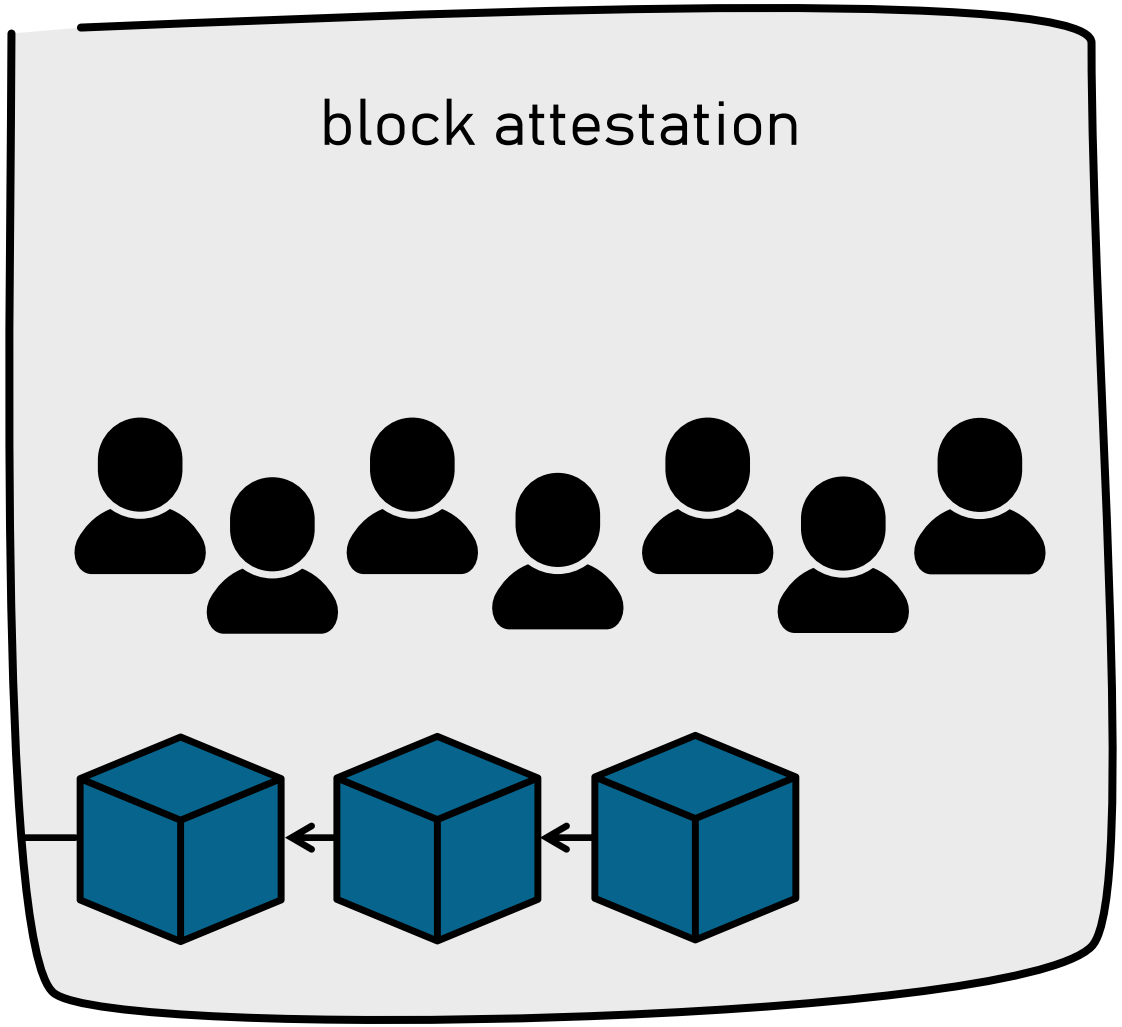
Validator duties



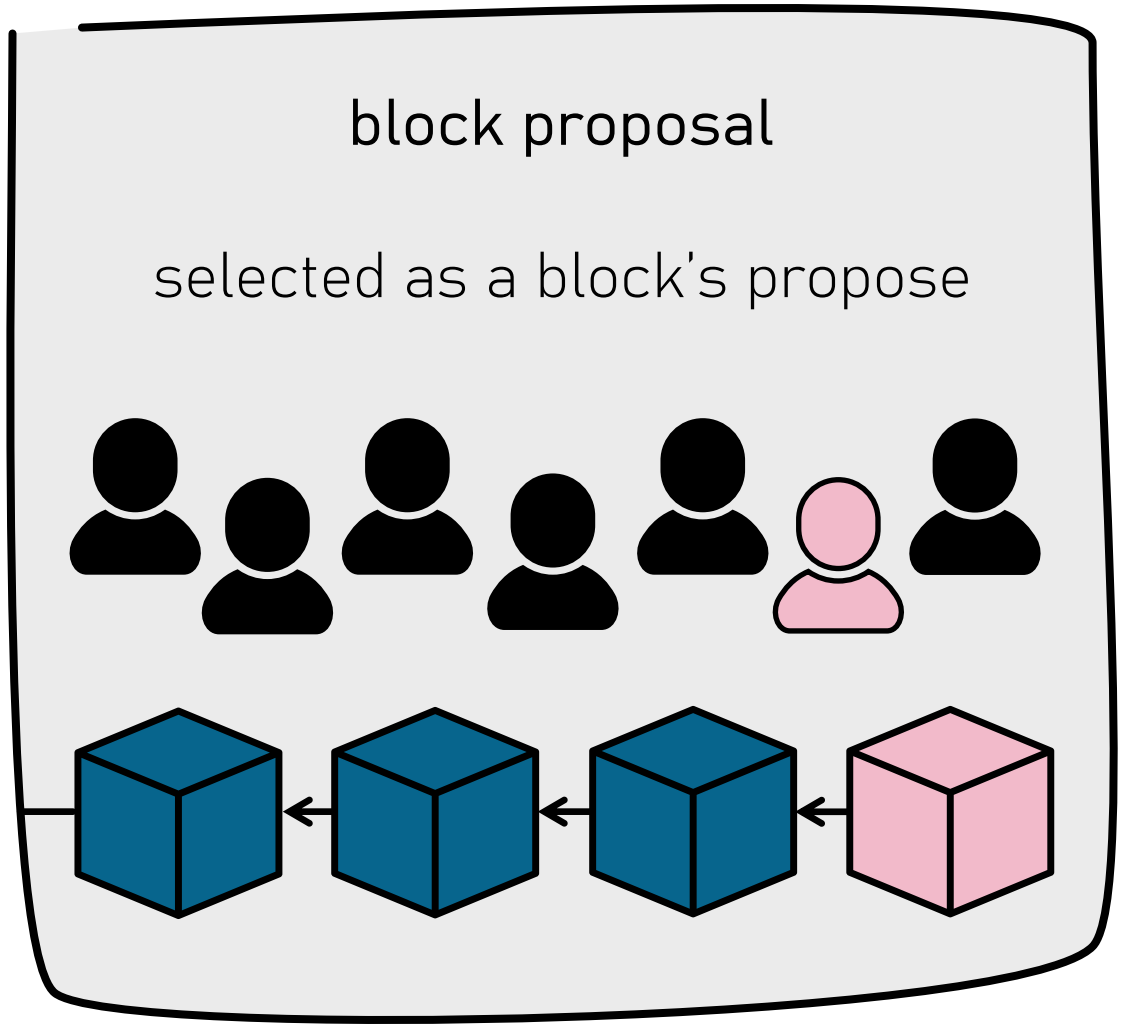


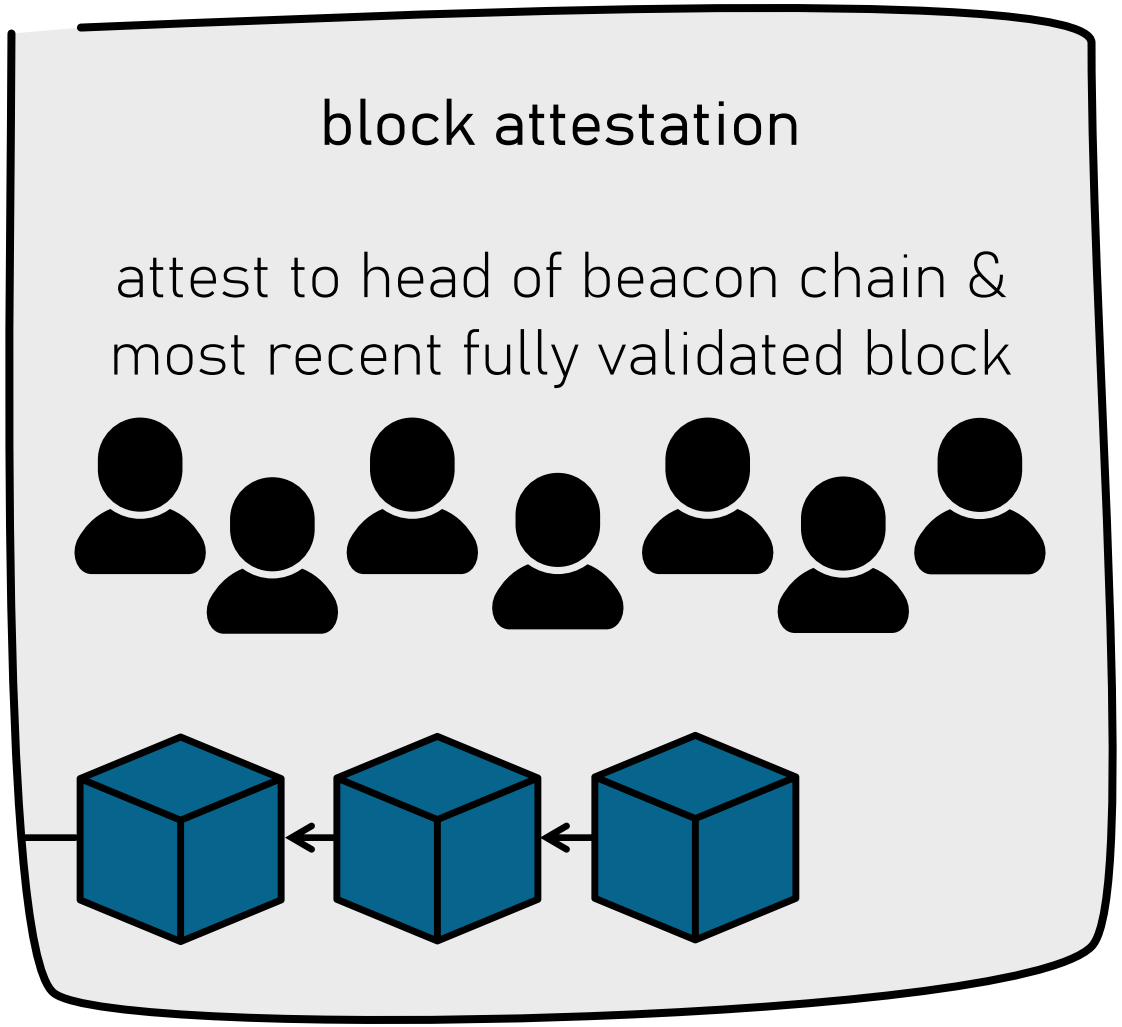
Validator duties



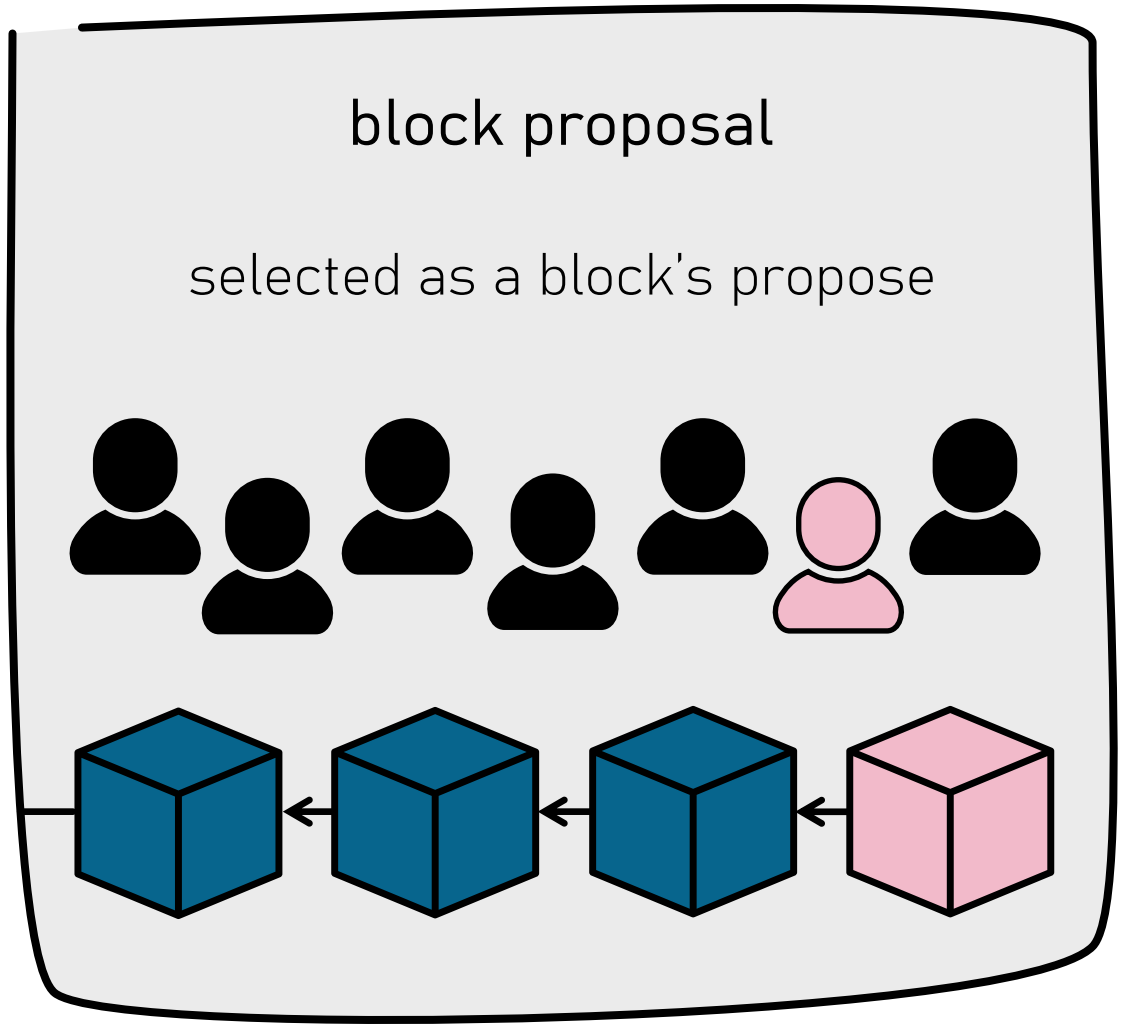


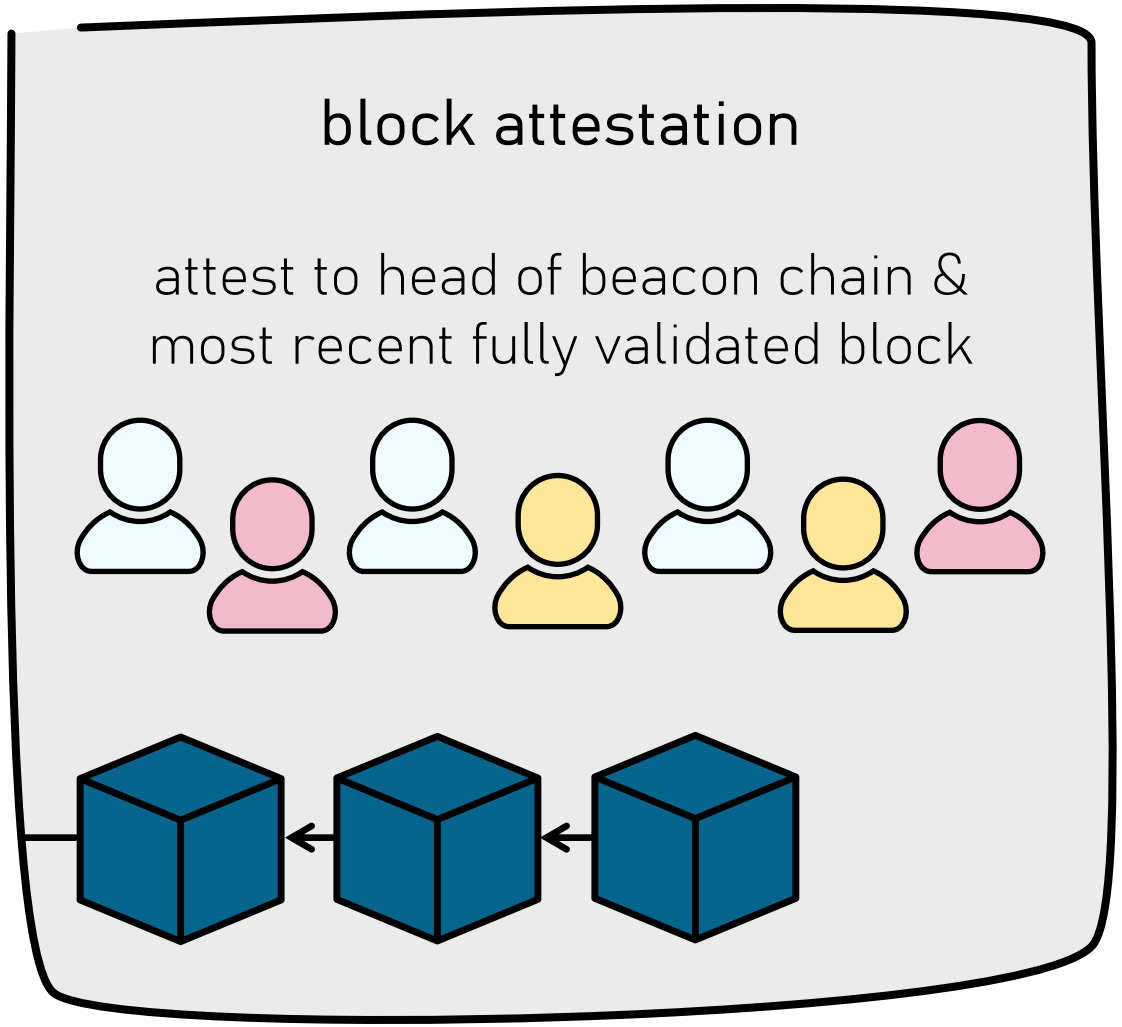
Validator duties



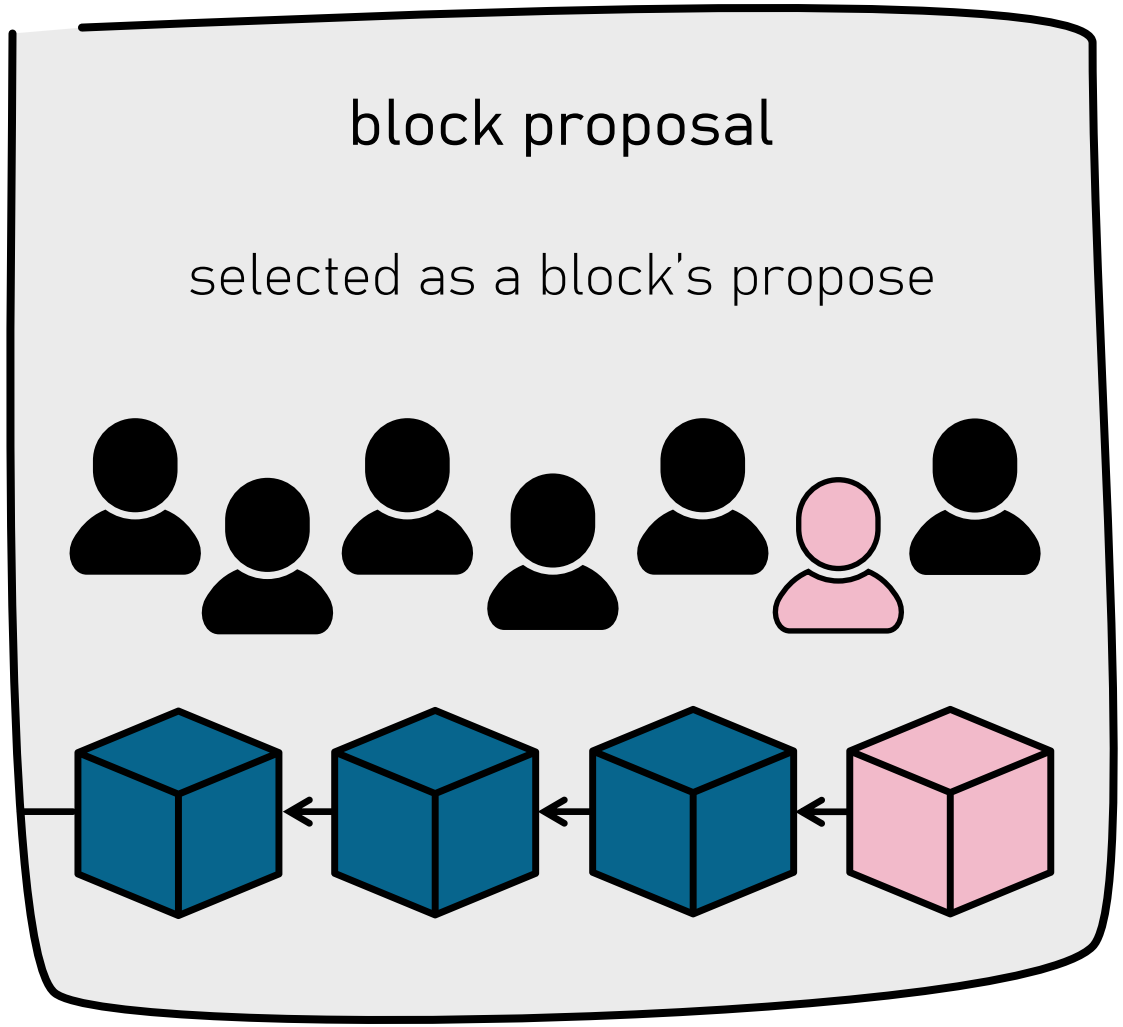


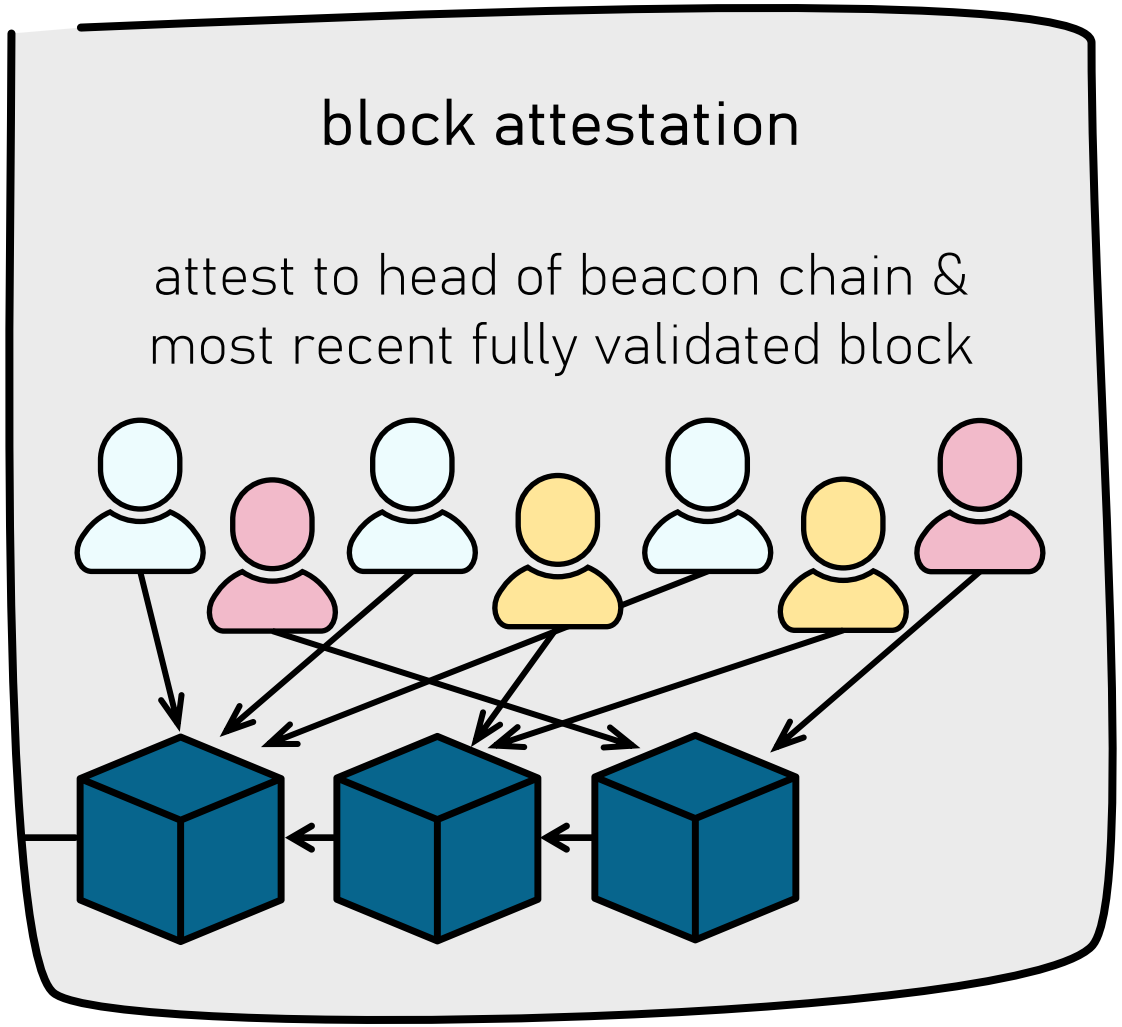
Validator duties



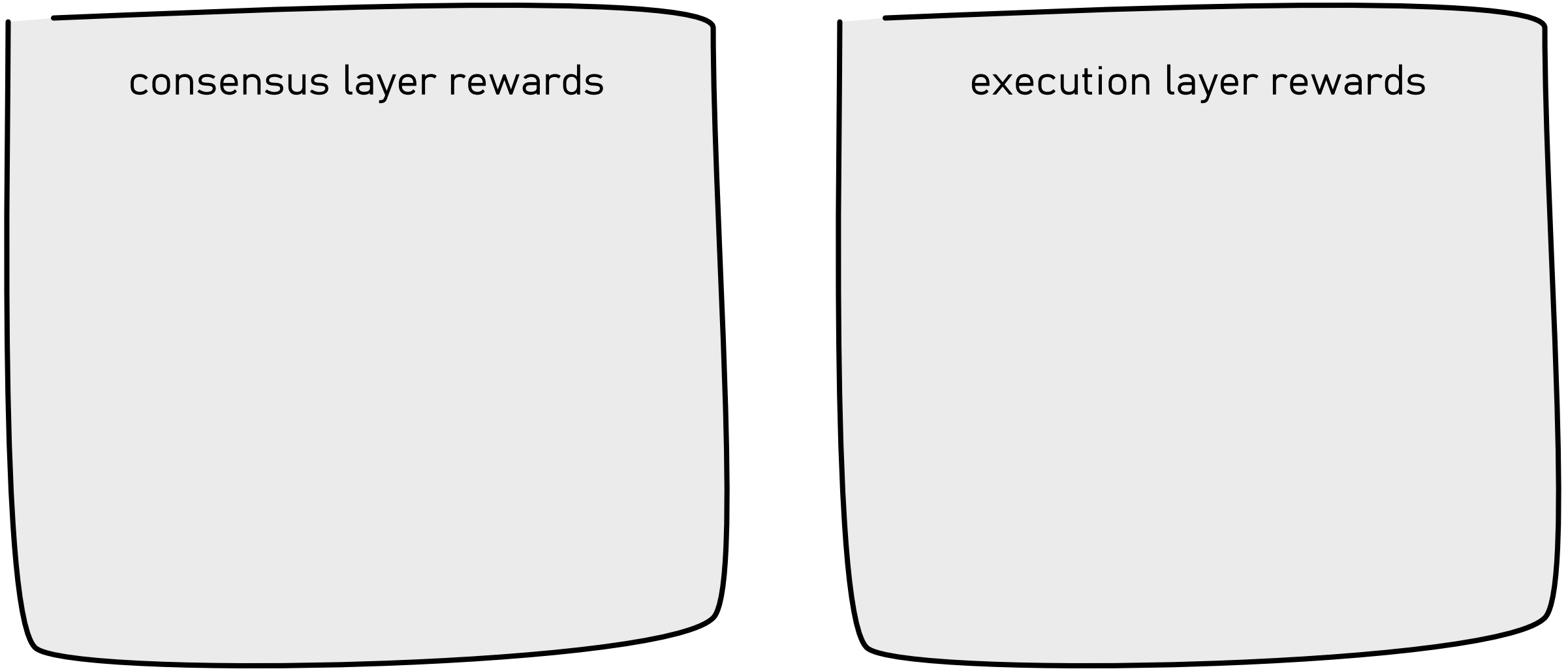


Validator duties





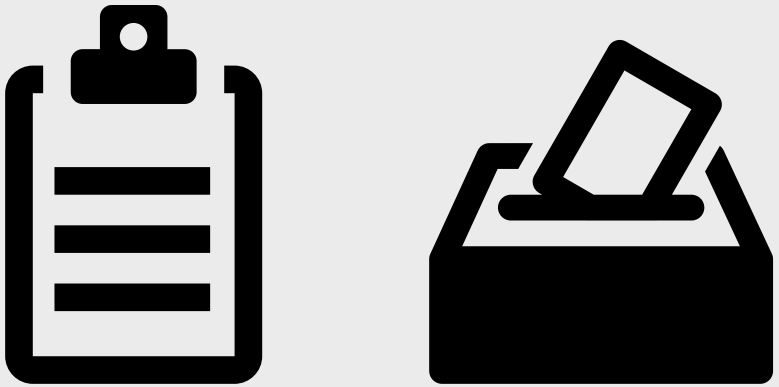
Rewards



Rewards

consensus layer rewards

fixed rewards for
validator duties

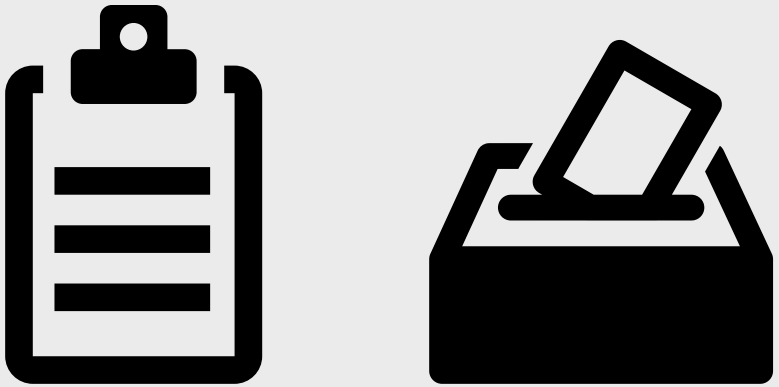


execution layer rewards

Rewards

consensus layer rewards

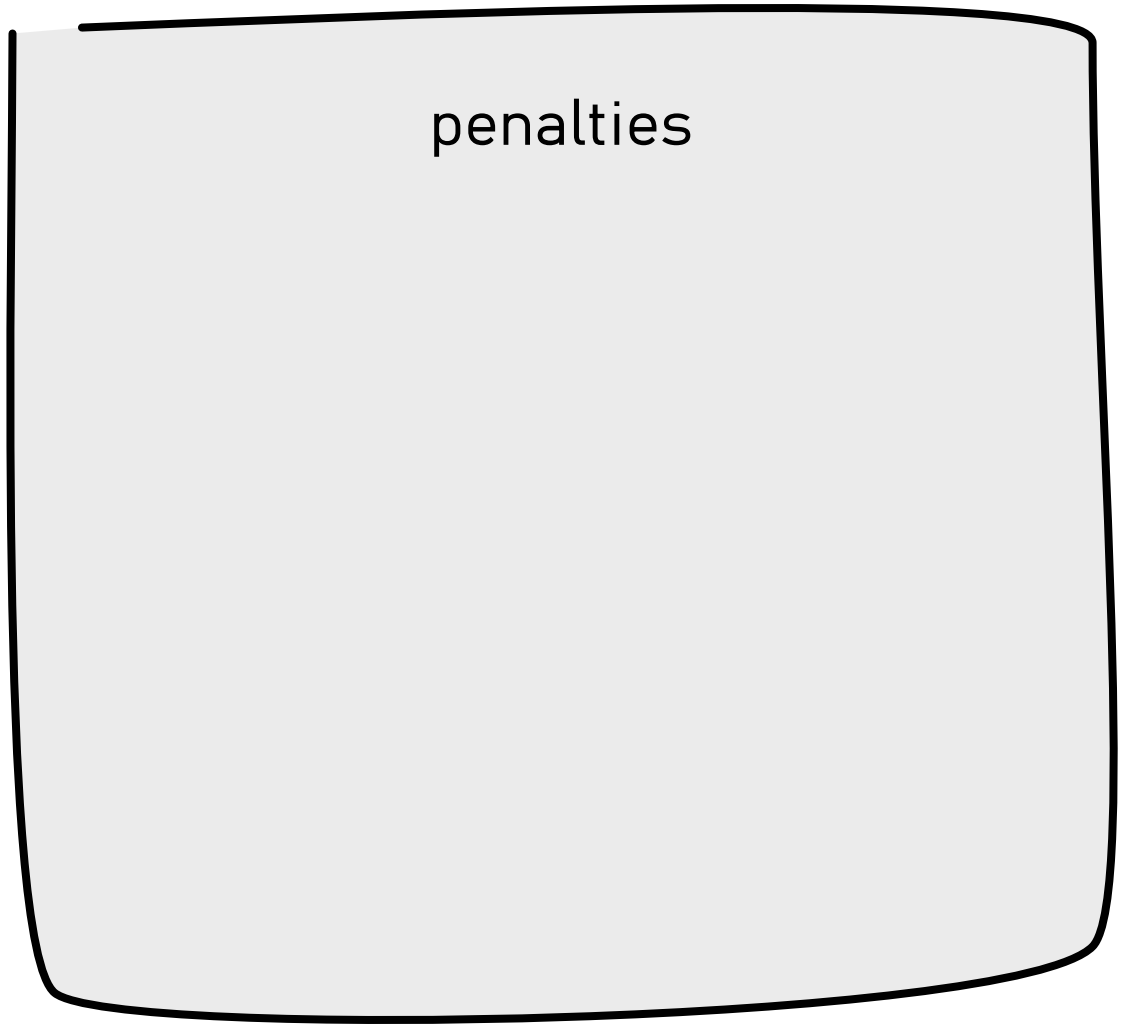
fixed rewards for
validator duties

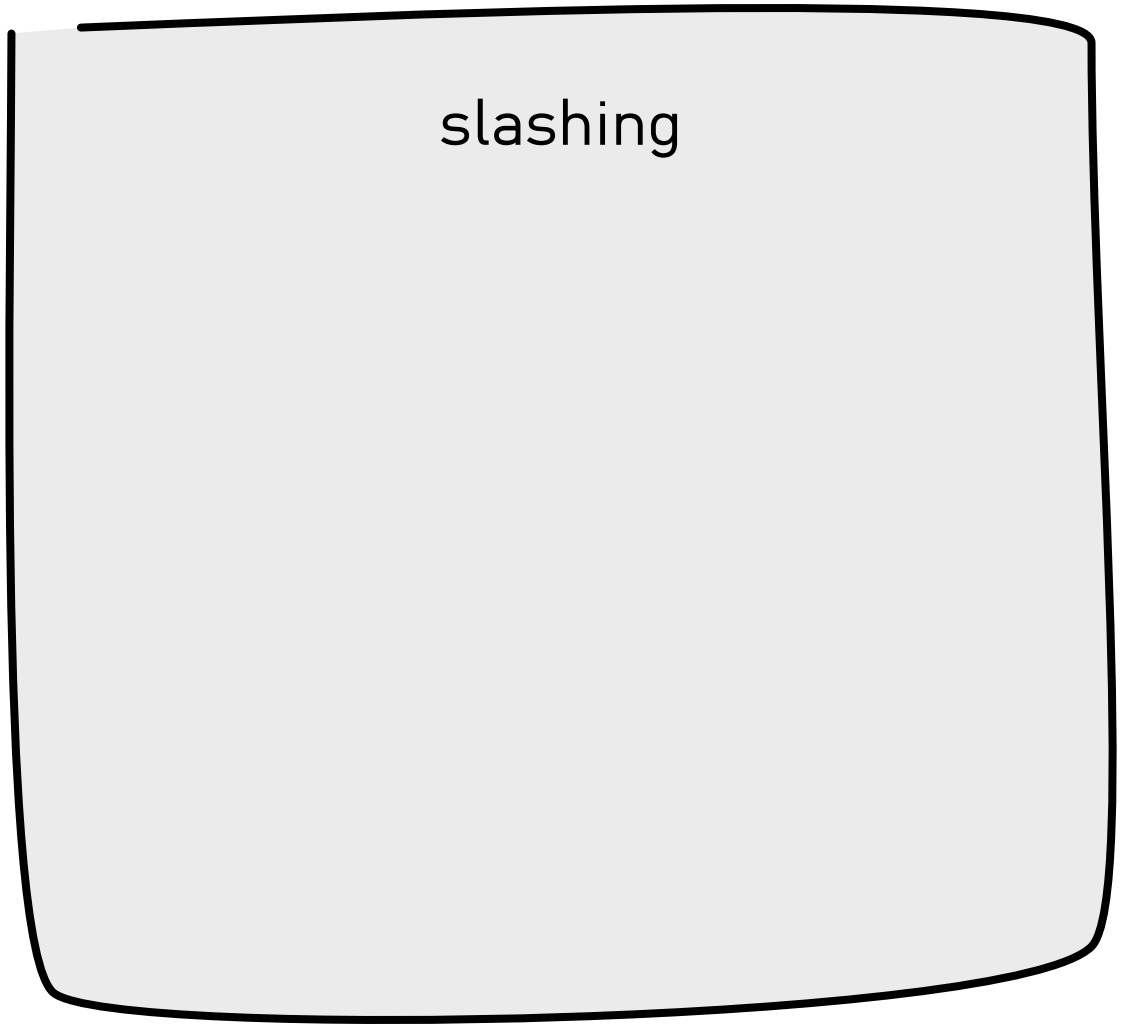


execution layer rewards

variable rewards from
transaction fees

Penalties and slashings





Penalties and slashings

penalties

missing source and target votes

slashing

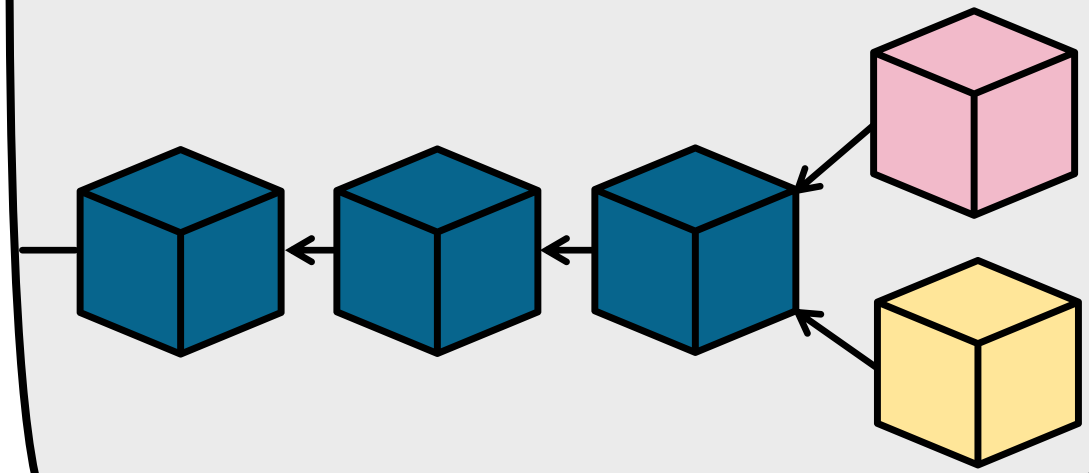
Penalties and slashings

penalties

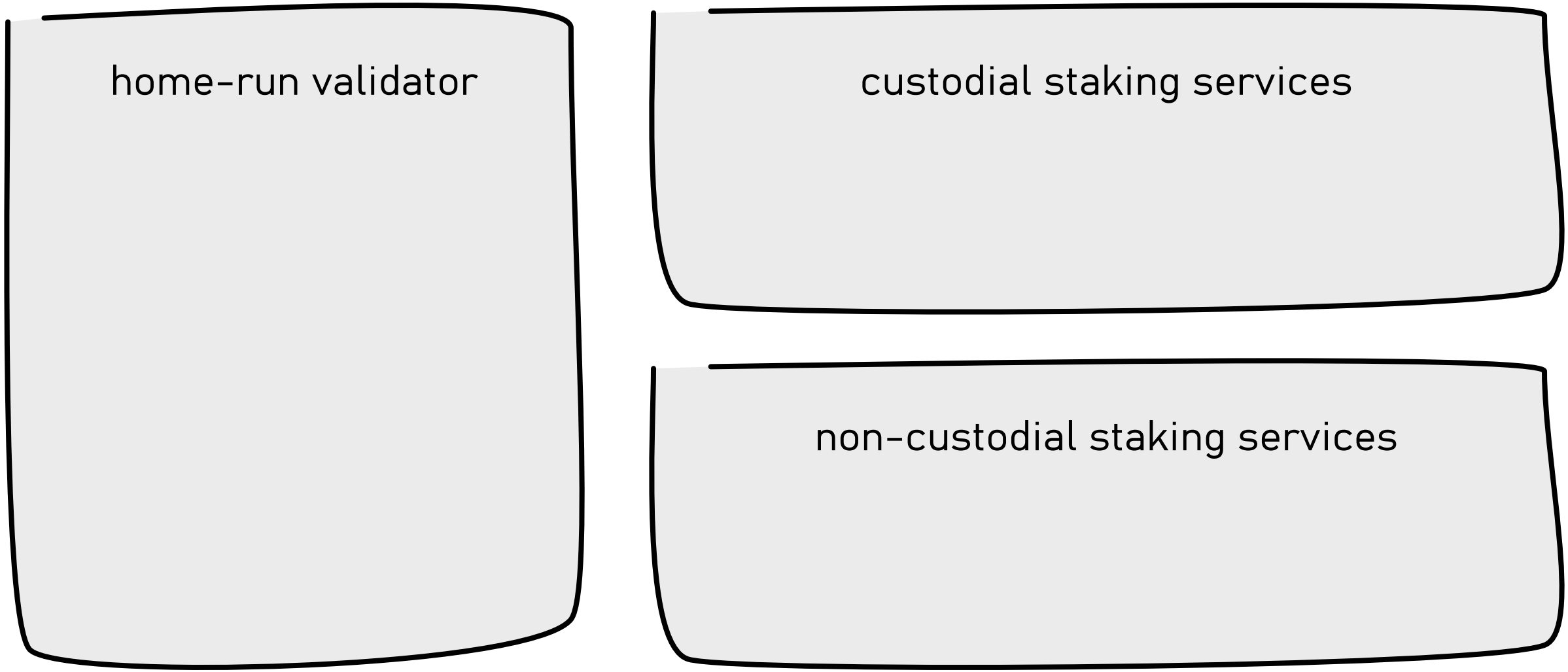
missing source and target votes

slashing

dishonest proposal or attestation

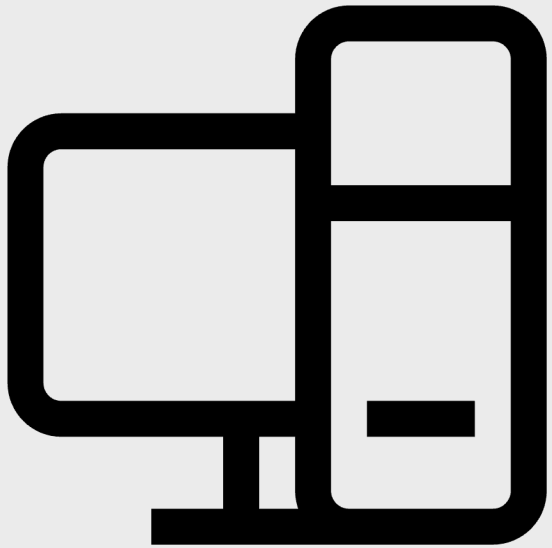


Staking services



Staking services

home-run validator

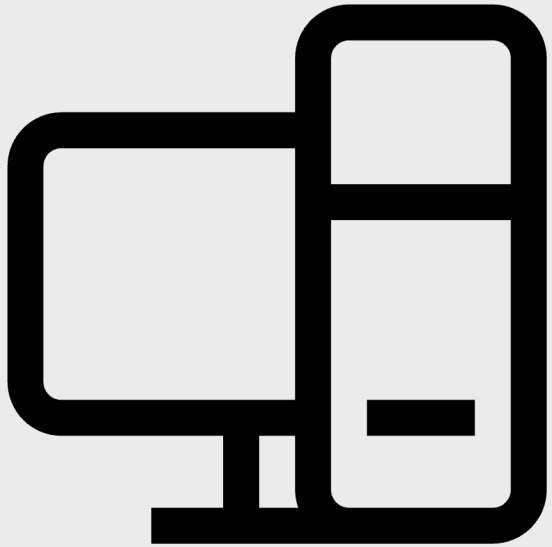


custodial staking services

non-custodial staking services

Staking services

home-run validator

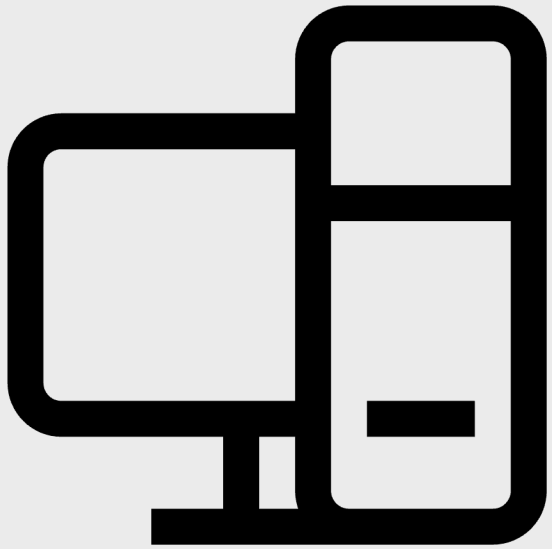


custodial staking services

non-custodial staking services

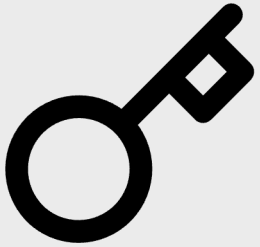
Staking services

home-run validator



custodial staking services

non-custodial staking services



Ethereum PoS Consensus Layer

participation

validator landscape

decentralization

performance

Ethereum PoS Consensus Layer

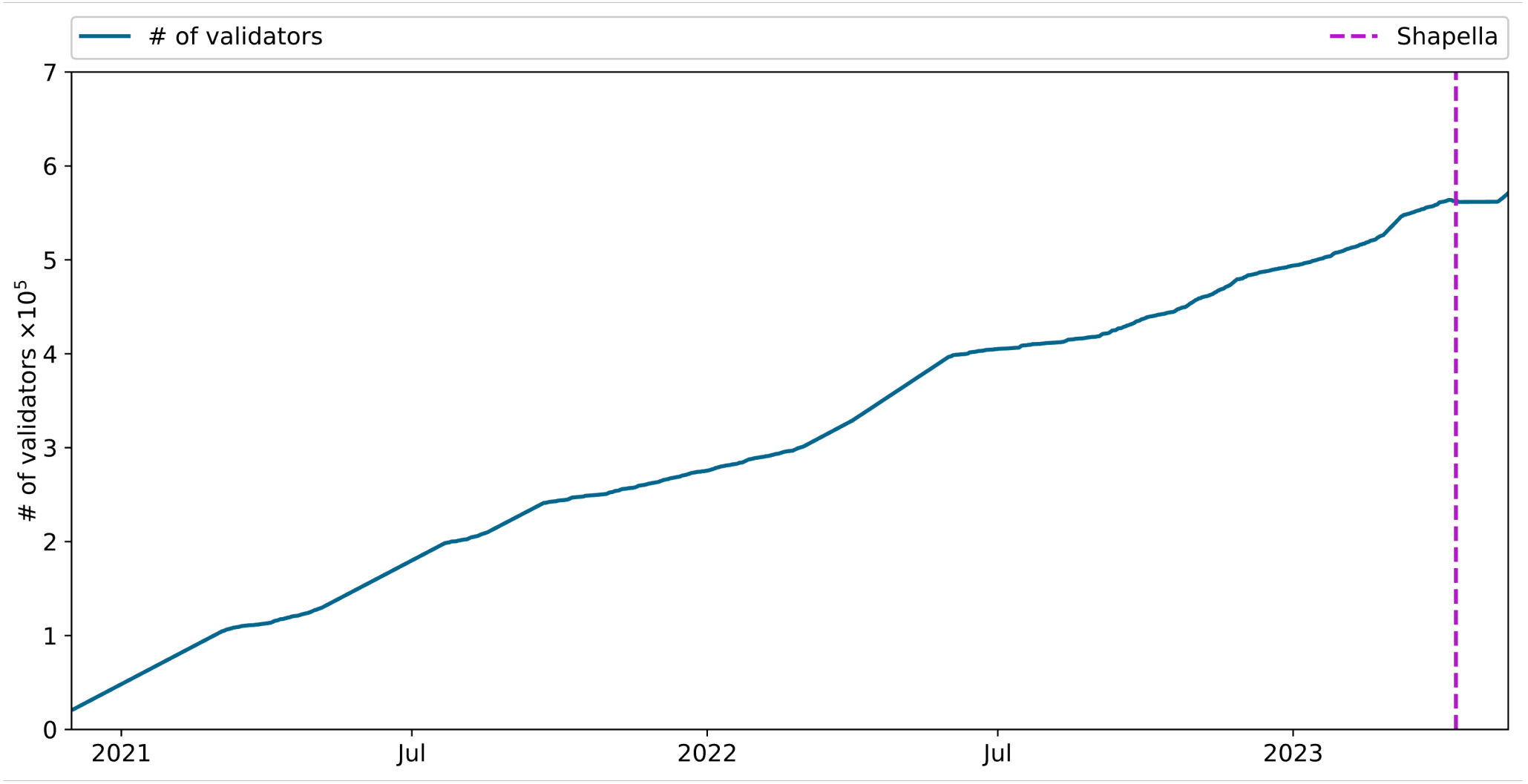
participation

validator landscape

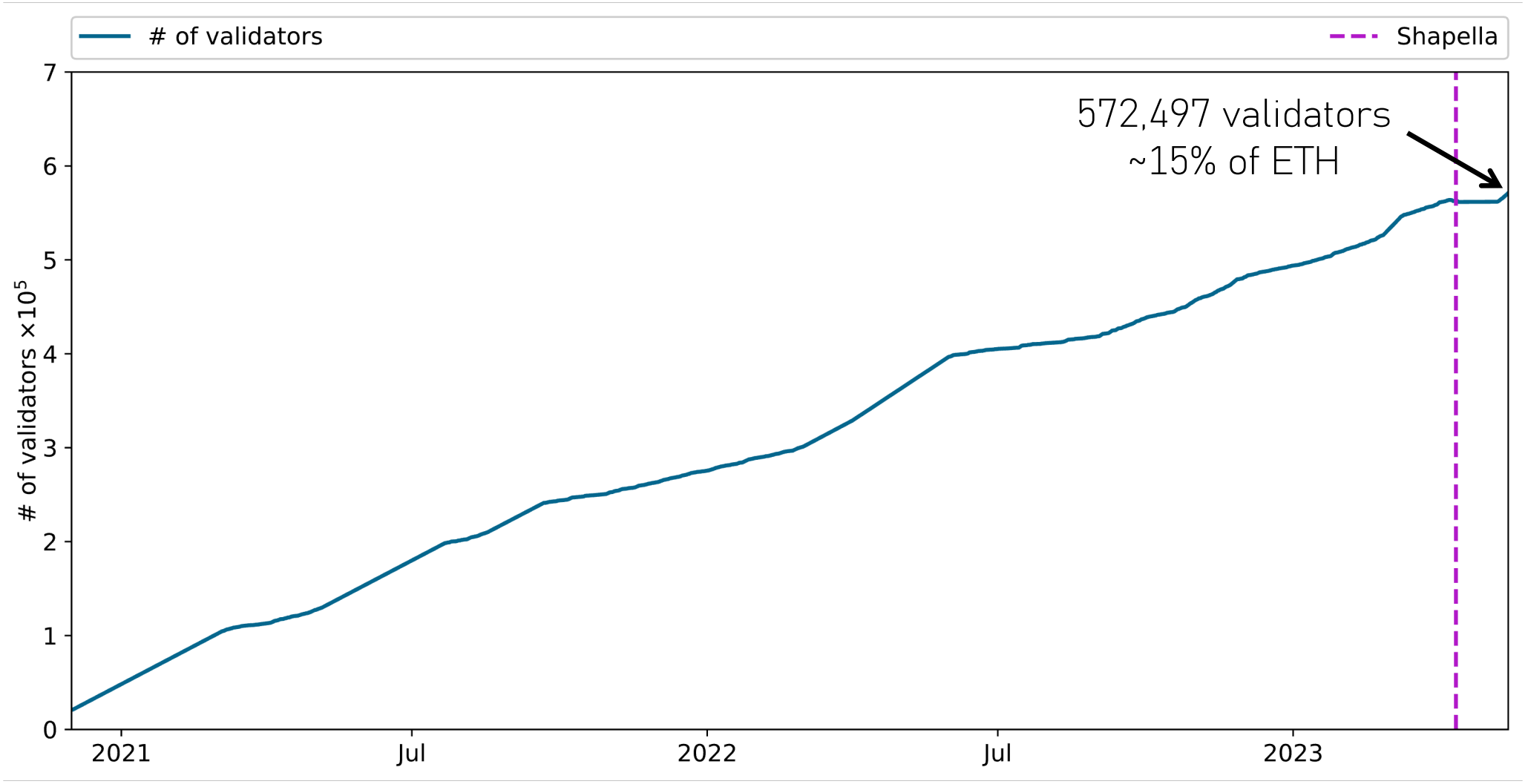
decentralization

performance

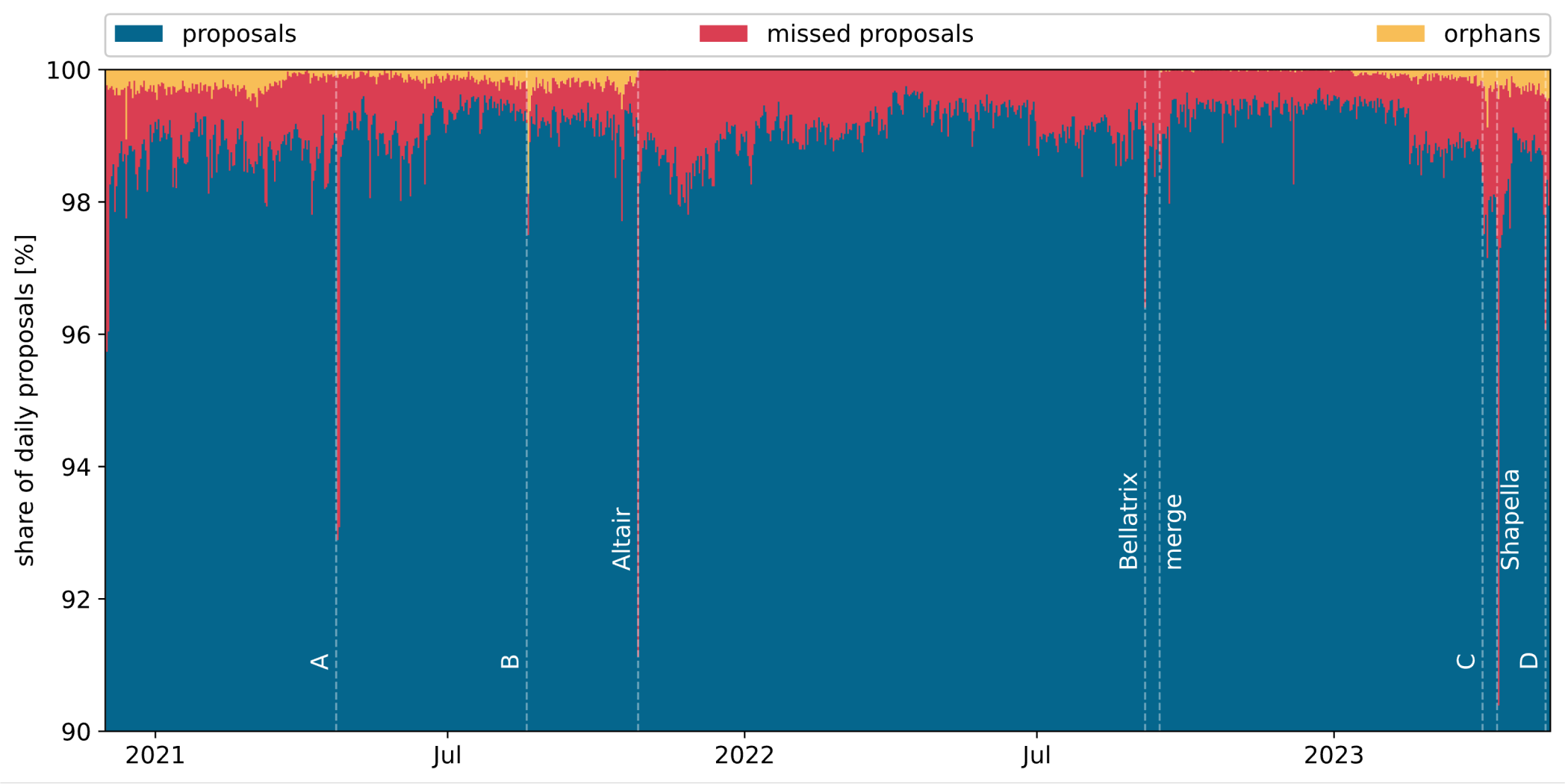
Network size



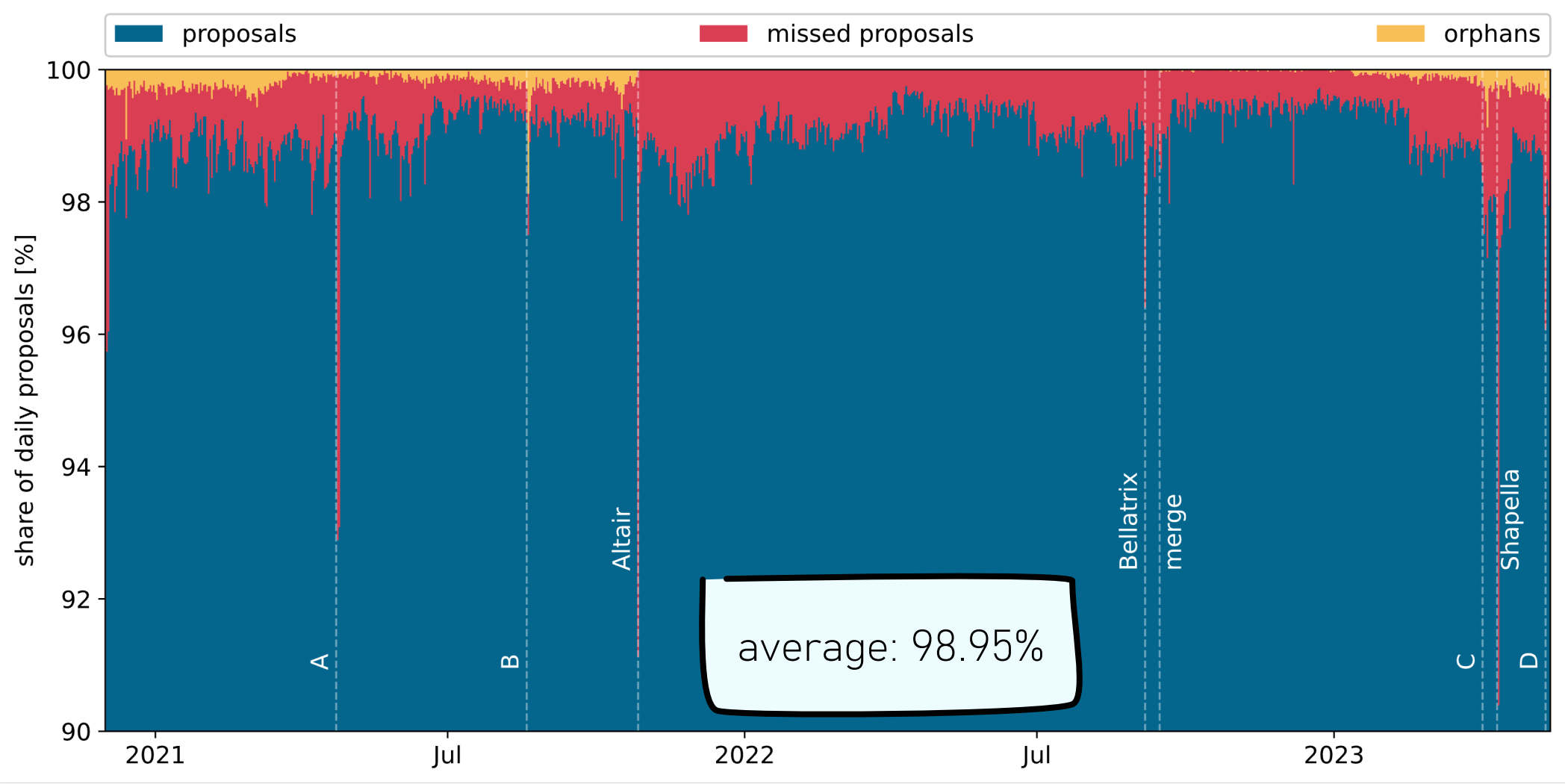
Network size



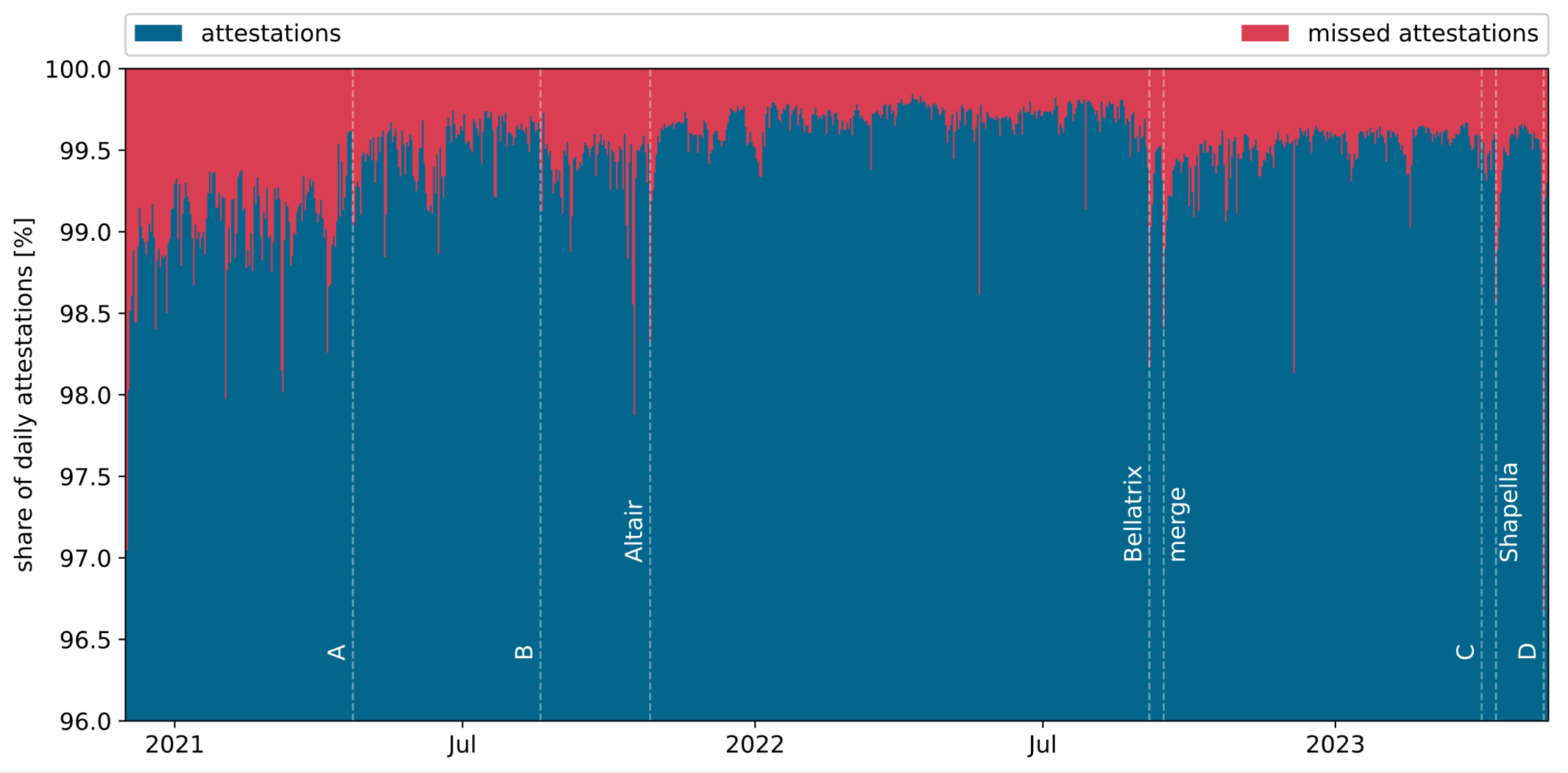
Proposals


proposals
missed proposals
orphans
100
98
96
94
92
90
share of daily proposals [%]
A
B
Altair
Bellatrix
merge
C
Shapella
D
2021
Jul
2022
Jul
2023

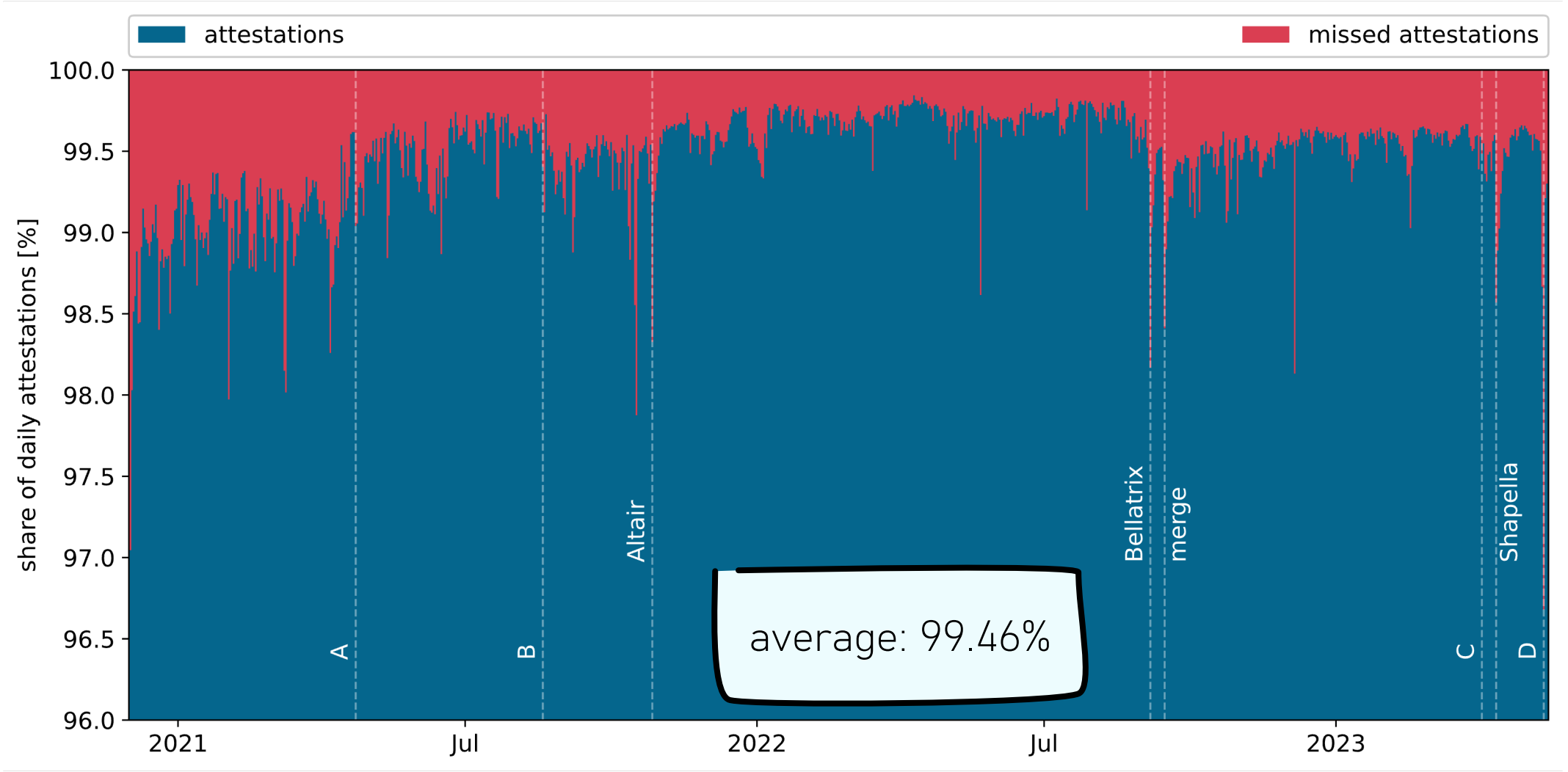
Proposals


proposals
missed proposals
orphans
share of daily proposals [%]
100
98
96
94
92
90
2021
Jul
2022
Jul
2023
A
B
Altair
Bellatrix
merge
C
Shapella
D
average: 98.95%

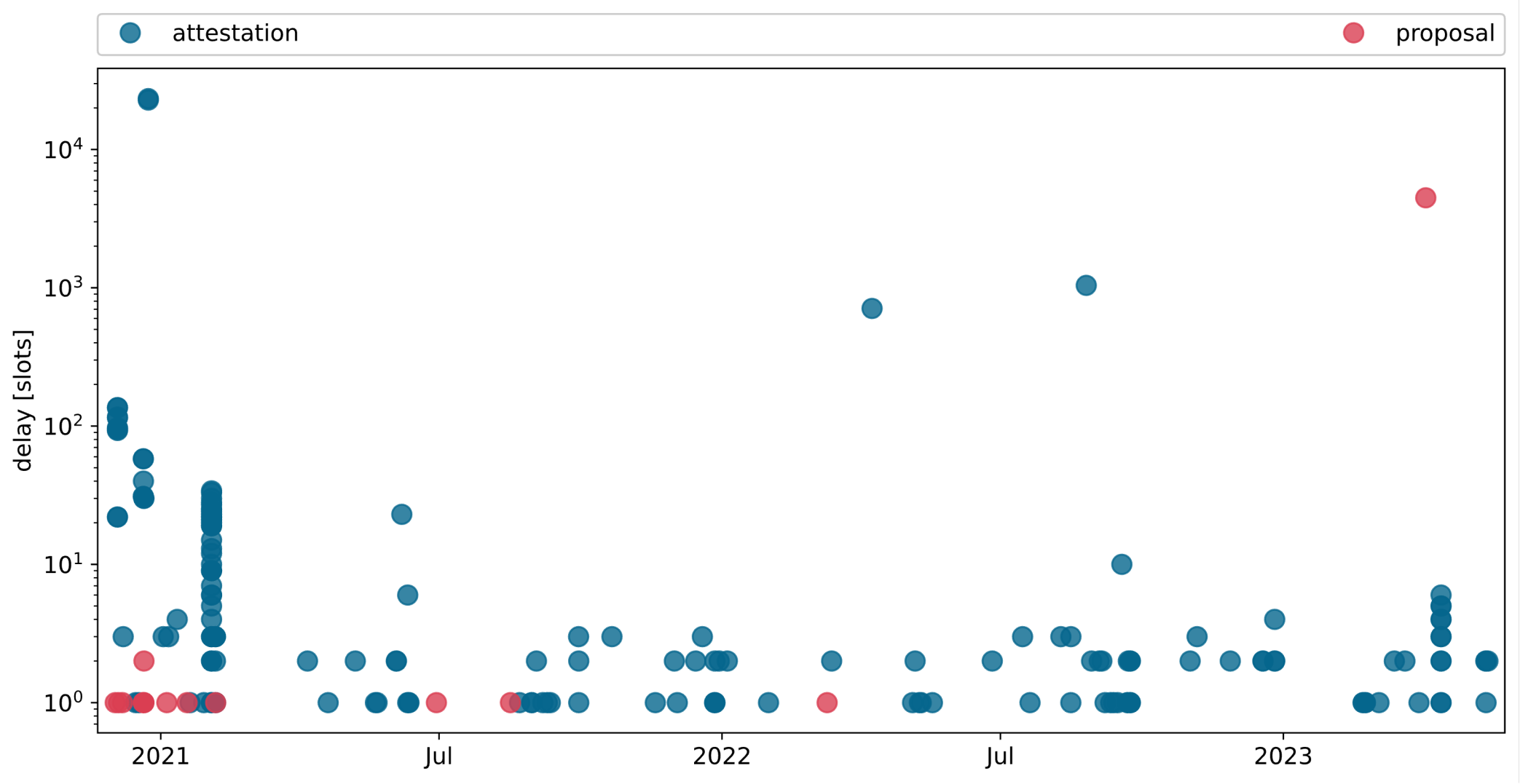
Attestations



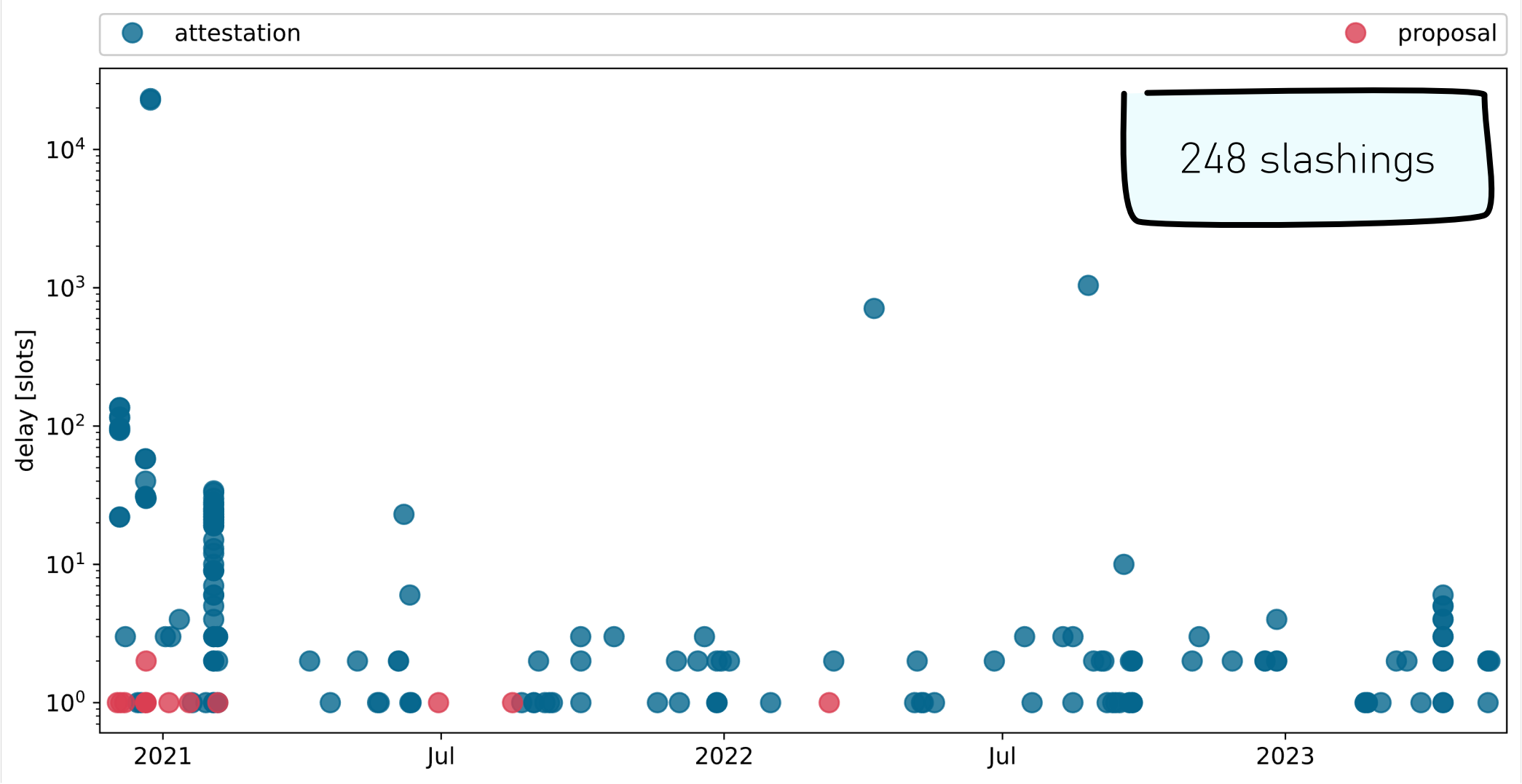
Attestations



Slashings


attestation
proposal
delay [slots]
10^4
10^3
10^2
10^1
10^0
2021
Jul
2022
Jul
2023

Slashings


attestation
proposal
248 slashings
delay [slots]
10^4
10^3
10^2
10^1
10^0
2021
Jul
2022
Jul
2023

Ethereum PoS Consensus Layer

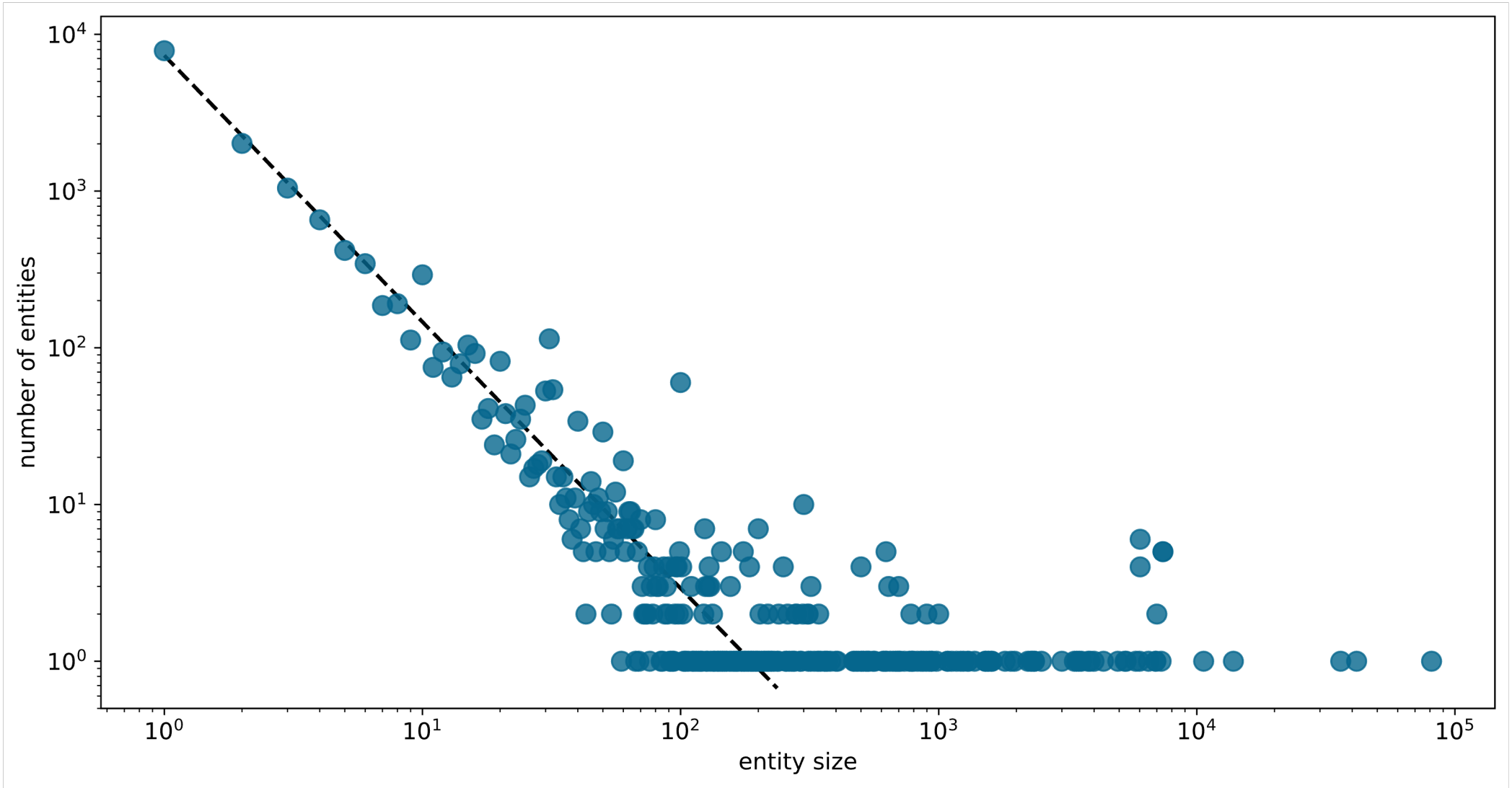
participation

validator landscape

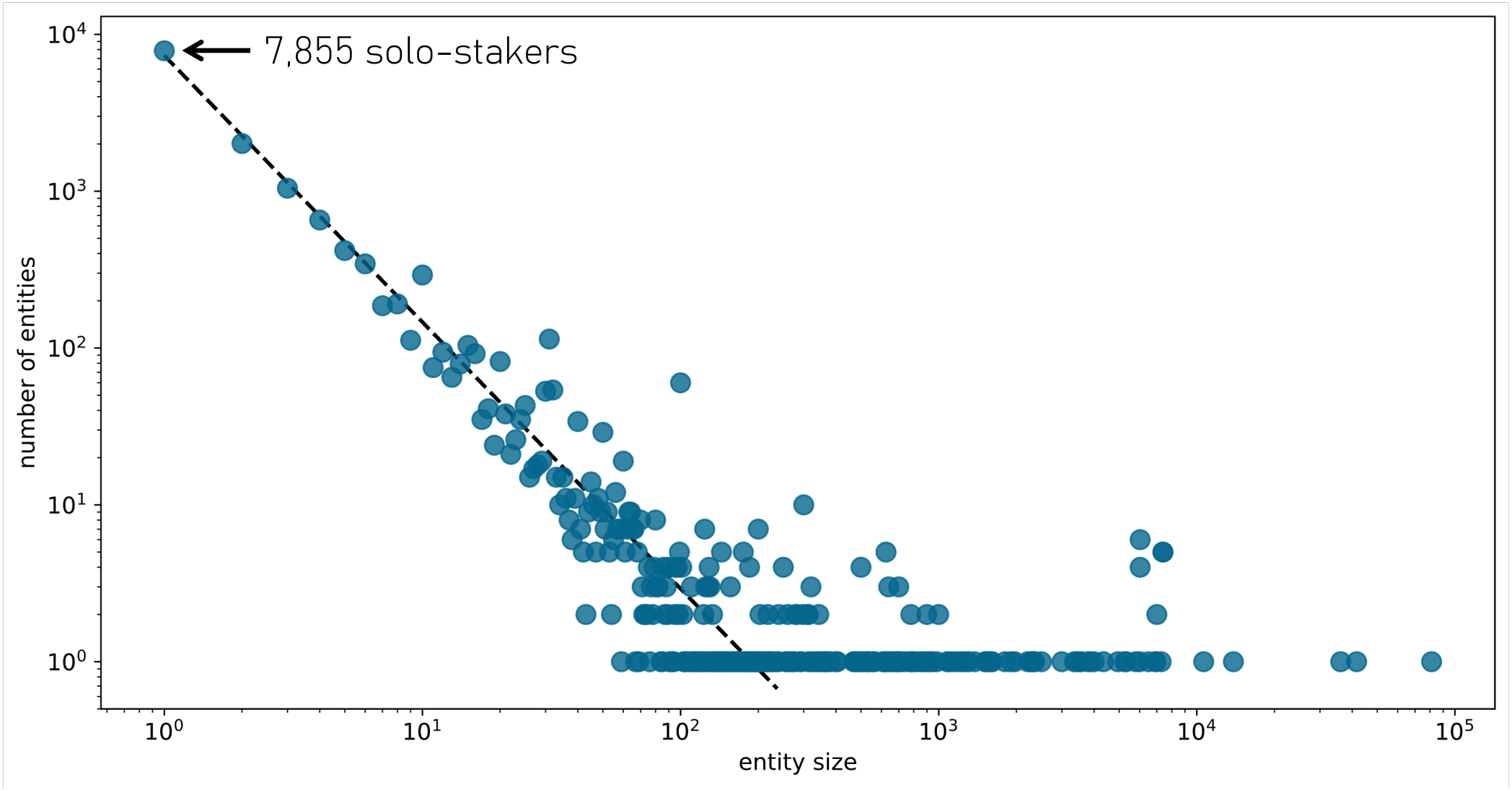
decentralization

performance

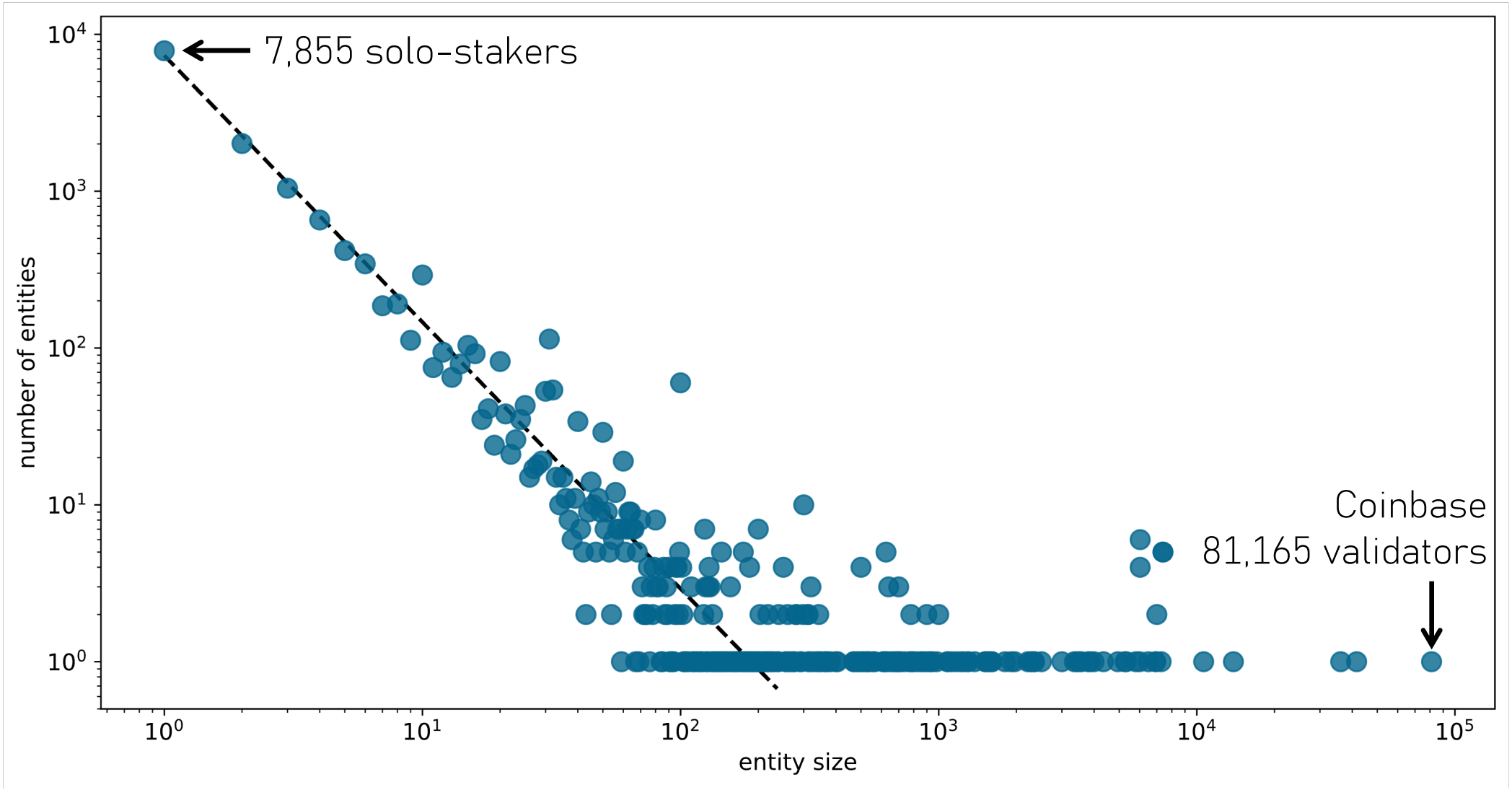
Entity size



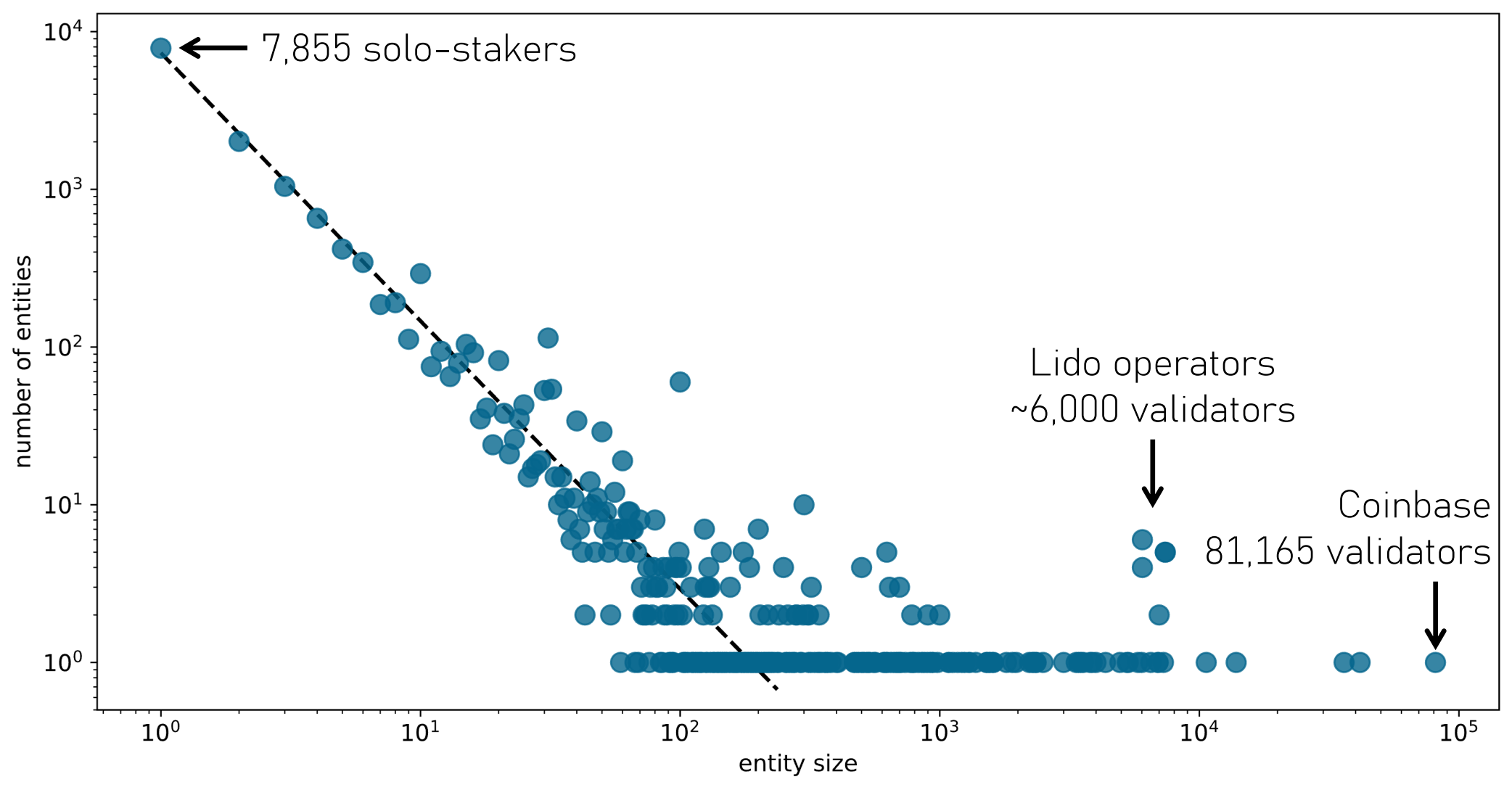
Entity size


7,855 solo-stakers
number of entities
entity size
10^0
10^1
10^2
10^3
10^4
10^5

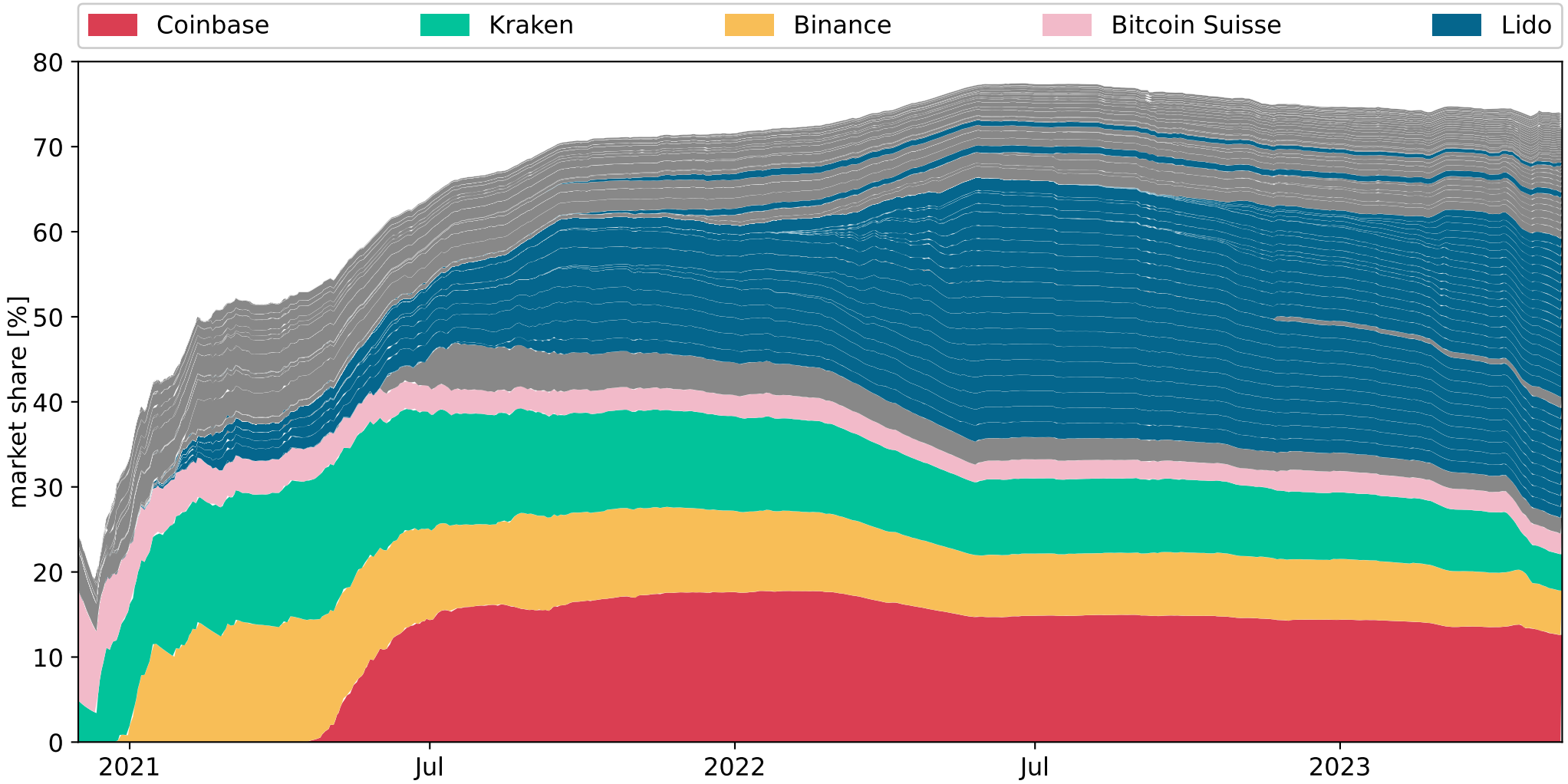
Entity size


7,855 solo-stakers
Coinbase
81,165 validators
number of entities
entity size
10^0
10^1
10^2
10^3
10^4
10^5

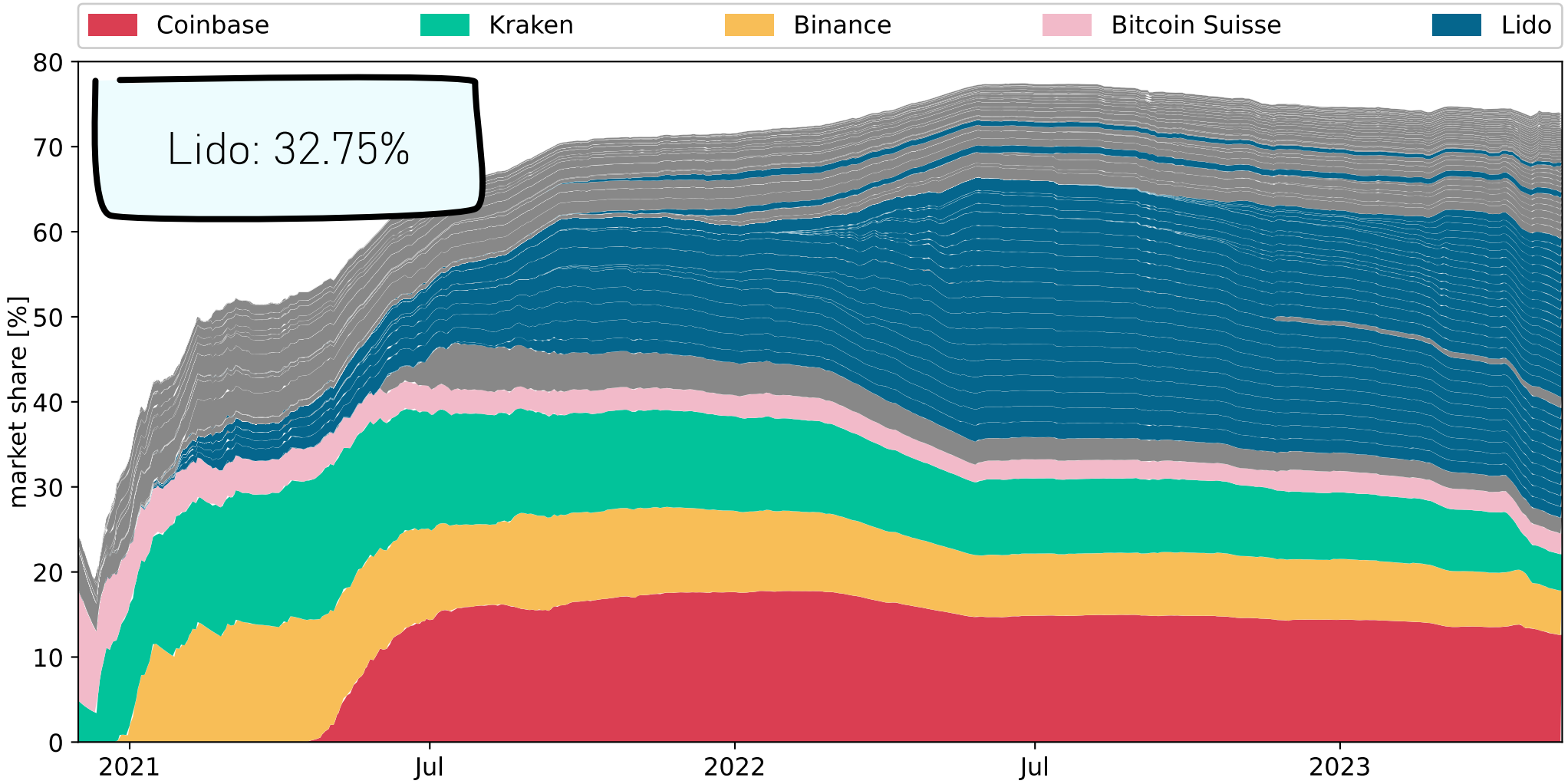
Entity size


7,855 solo-stakers
Lido operators
~6,000 validators
Coinbase
81,165 validators
number of entities
entity size
10^0
10^1
10^2
10^3
10^4
10^5

Market share by entity



Market share by entity



Ethereum PoS Consensus Layer

participation

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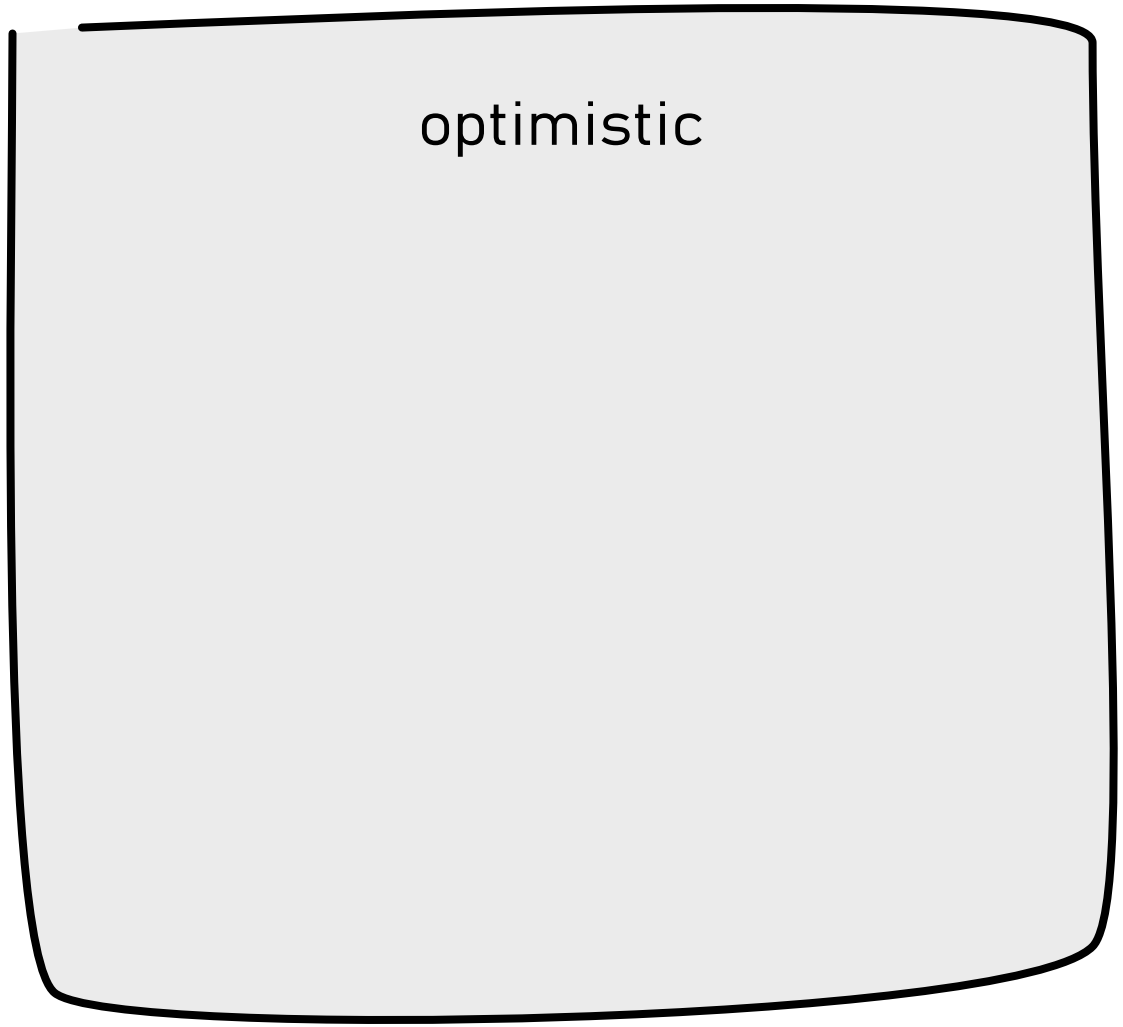
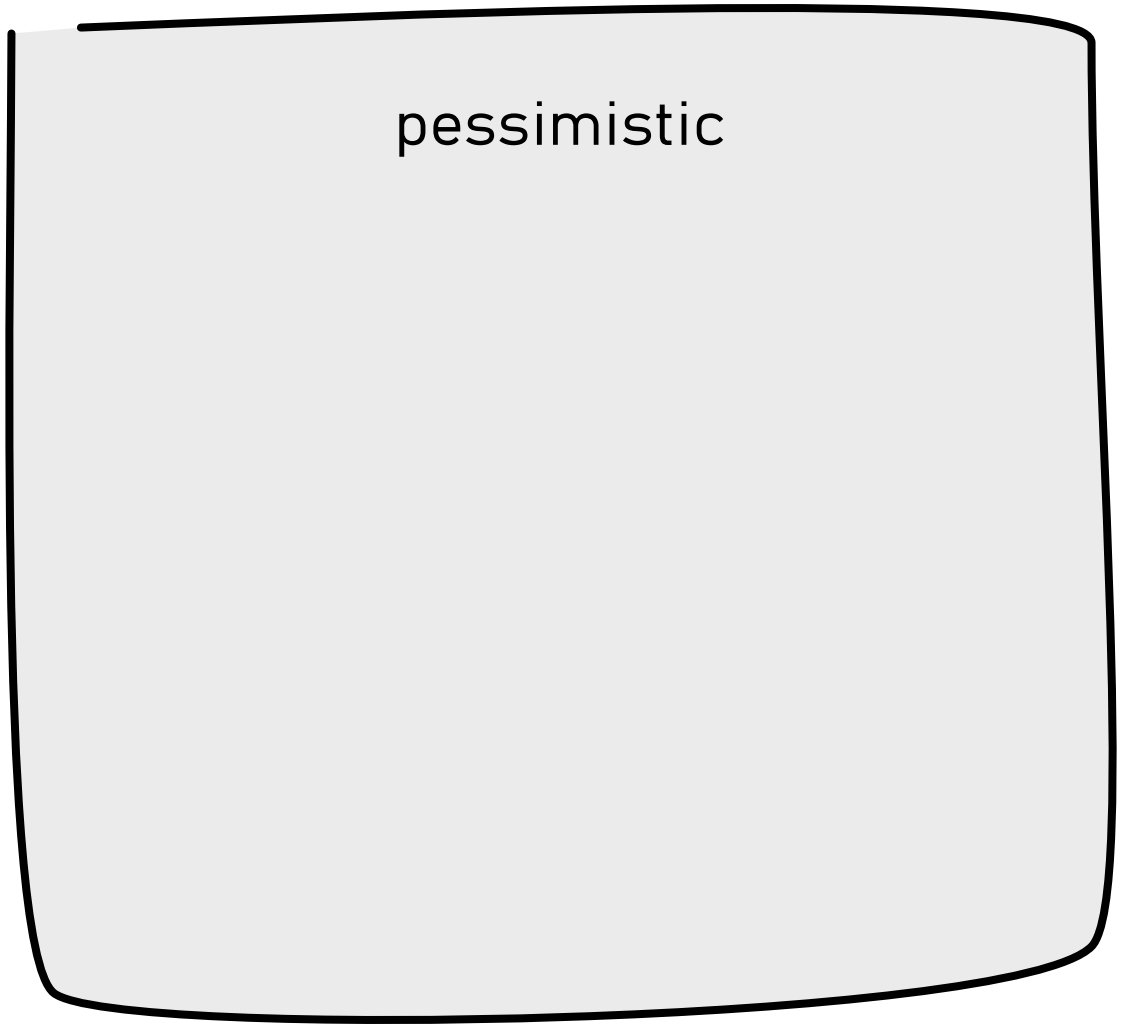
performance

Vantage point





Vantage point

optimistic

one operator one entity

pessimistic

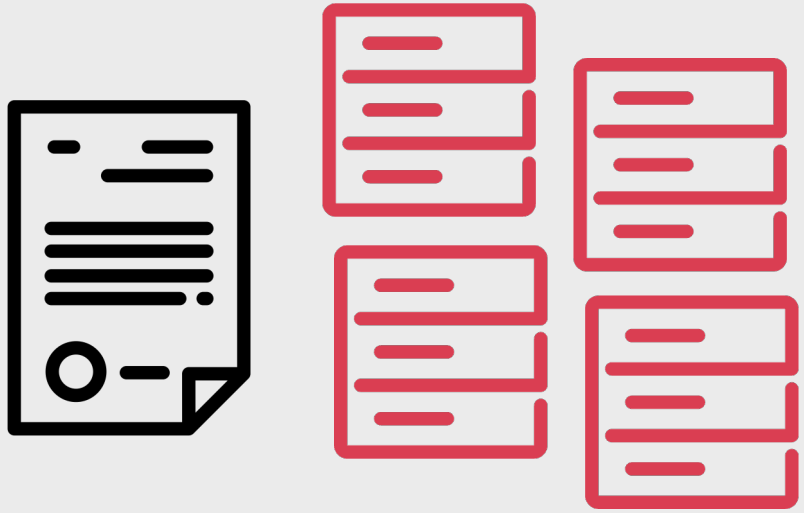
Vantage point

optimistic

one operator one entity

pessimistic

one staking service one entity



Decentralization measures

Nakamoto coefficient

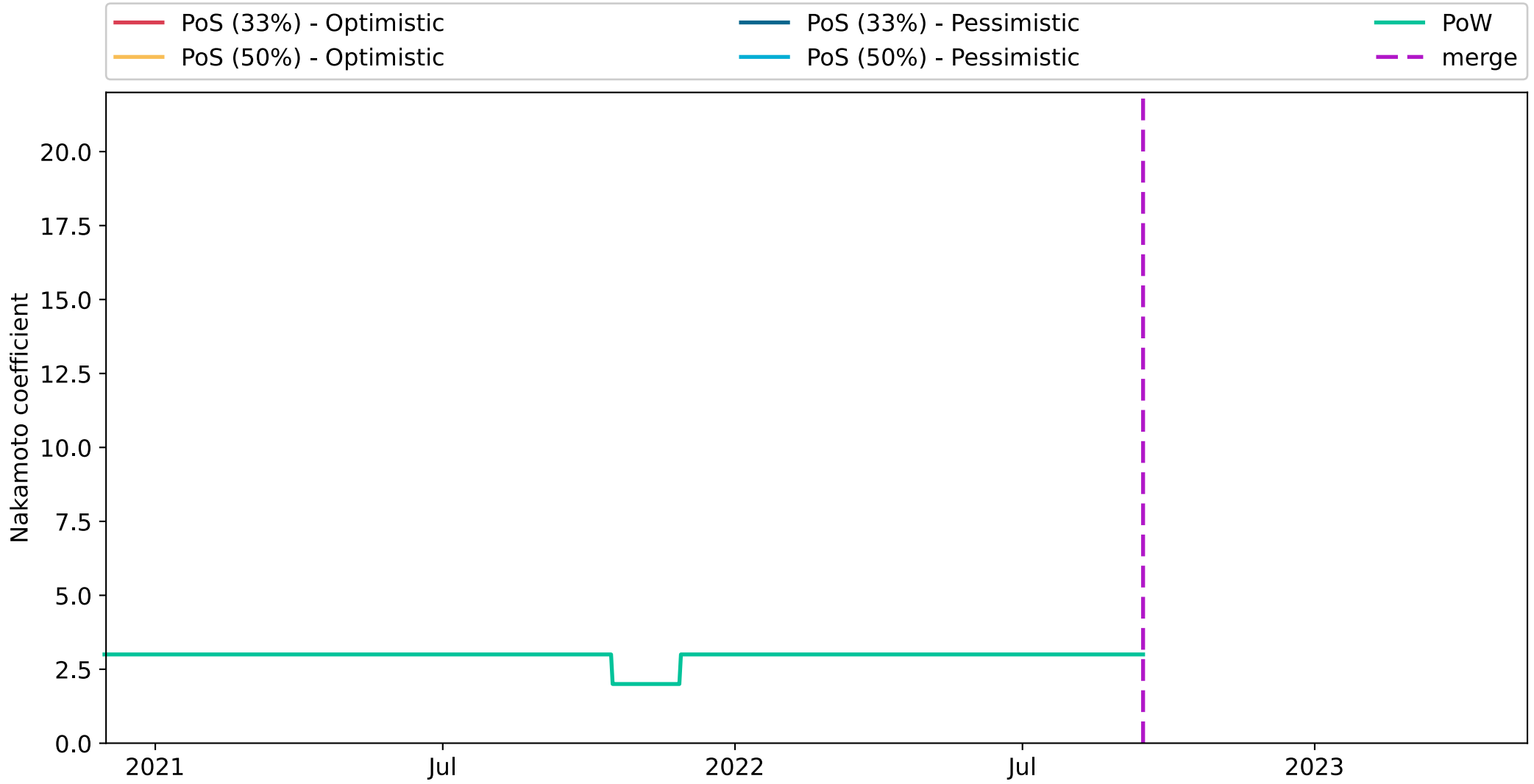
number of entities that need to be compromised by an adversary to disrupt the blockchain's network

PoW
>50% to disrupt system

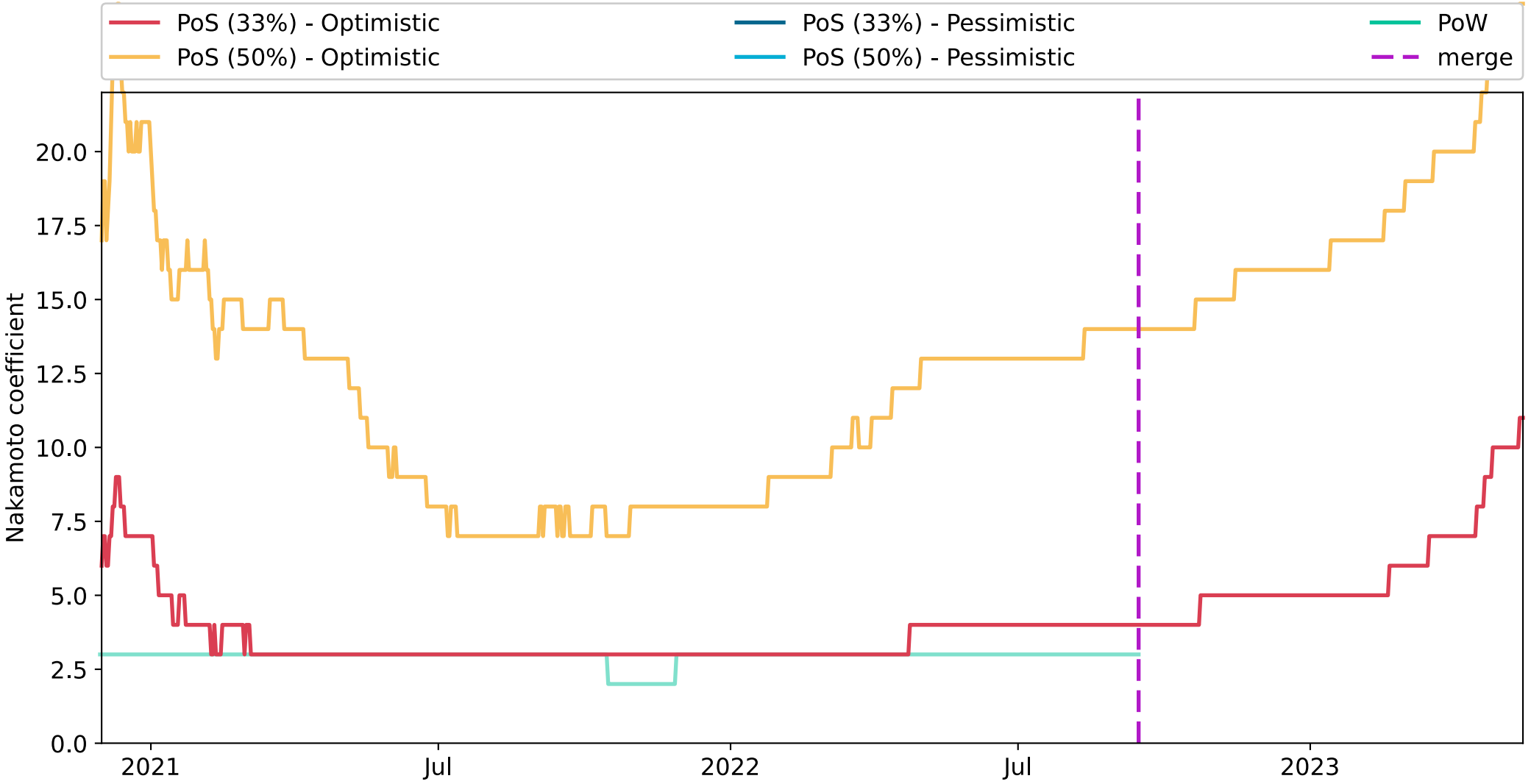
PoS
>33.3% to stall system
>50% to break safety properties

Herfindahl-Hirschman Index

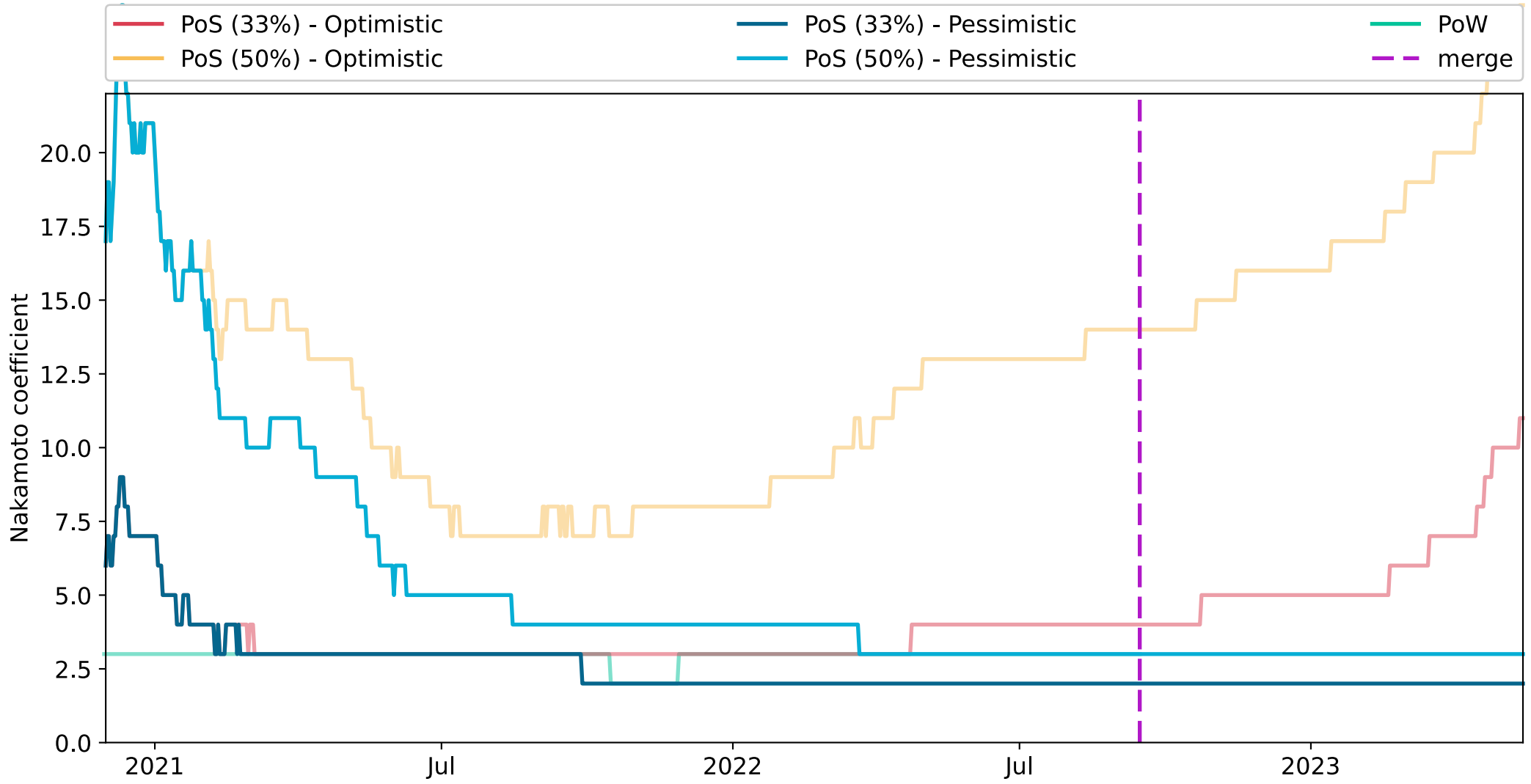
Nakamoto coefficient



Nakamoto coefficient



Nakamoto coefficient



Decentralization measures

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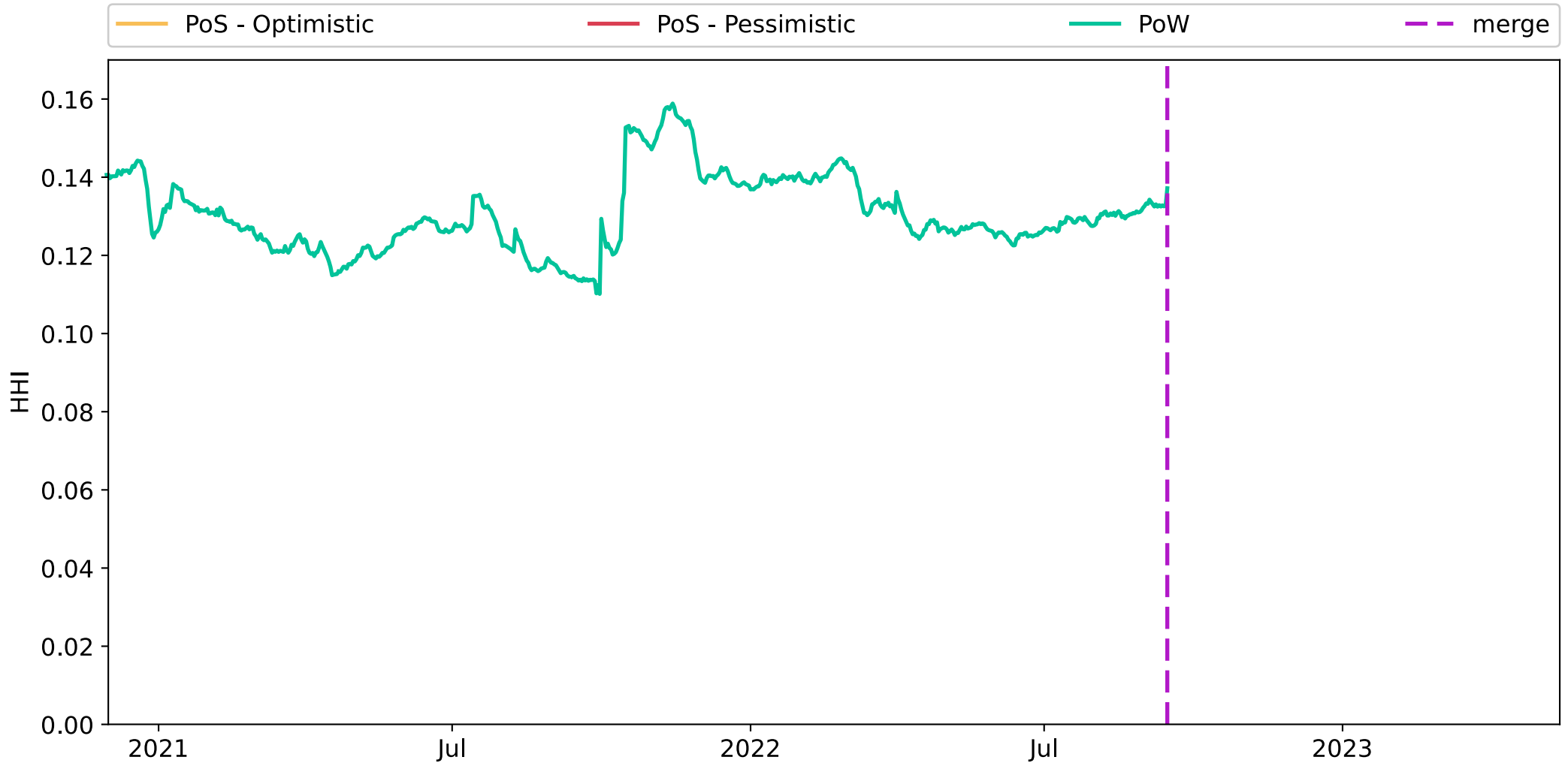
PoS
>33.3% to stall system
>50% to break safety properties

Herfindahl-Hirschman Index

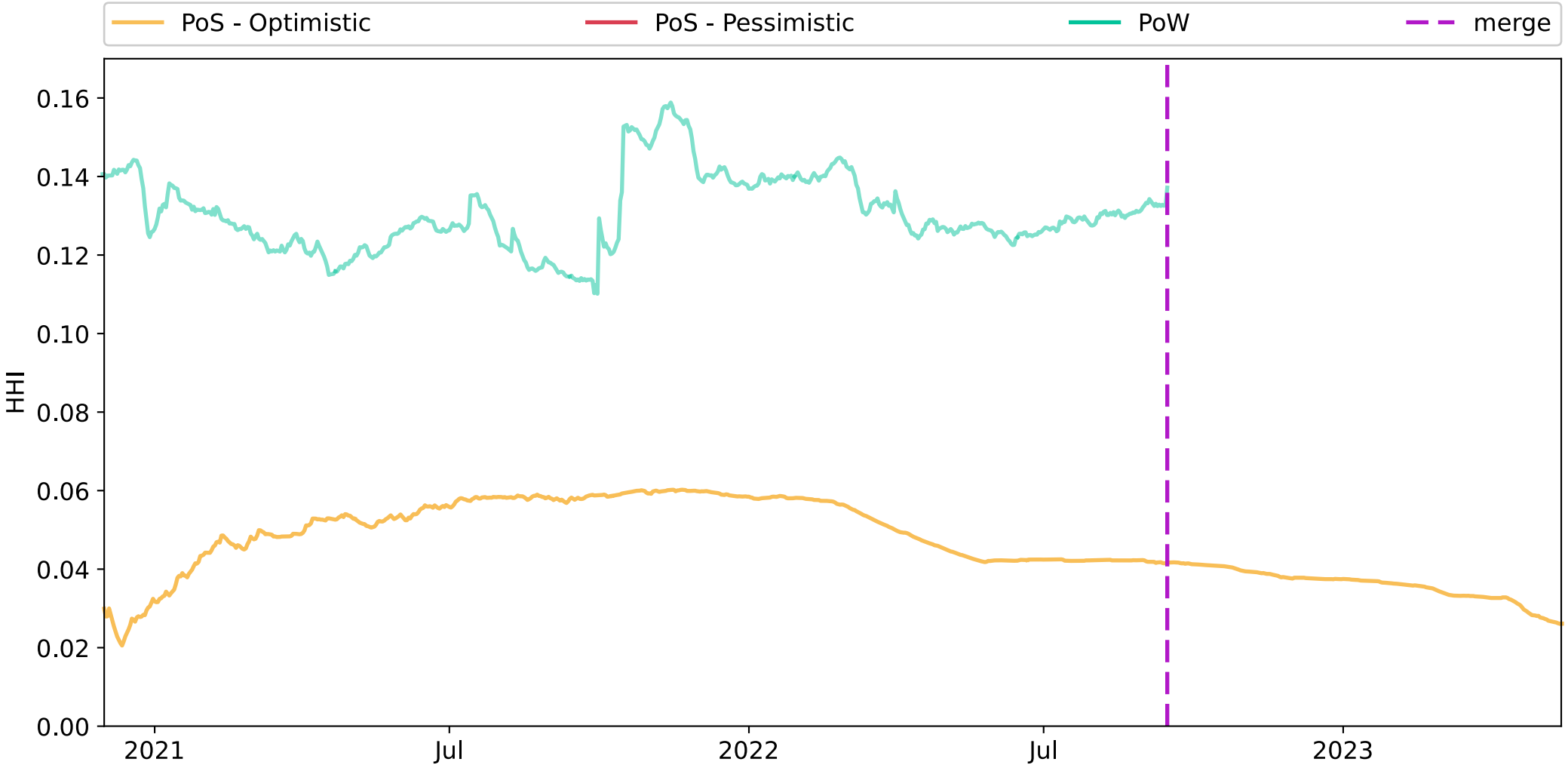
measure of market concentration

ranges between 0 (competitive market) and 1 (monopolized market)

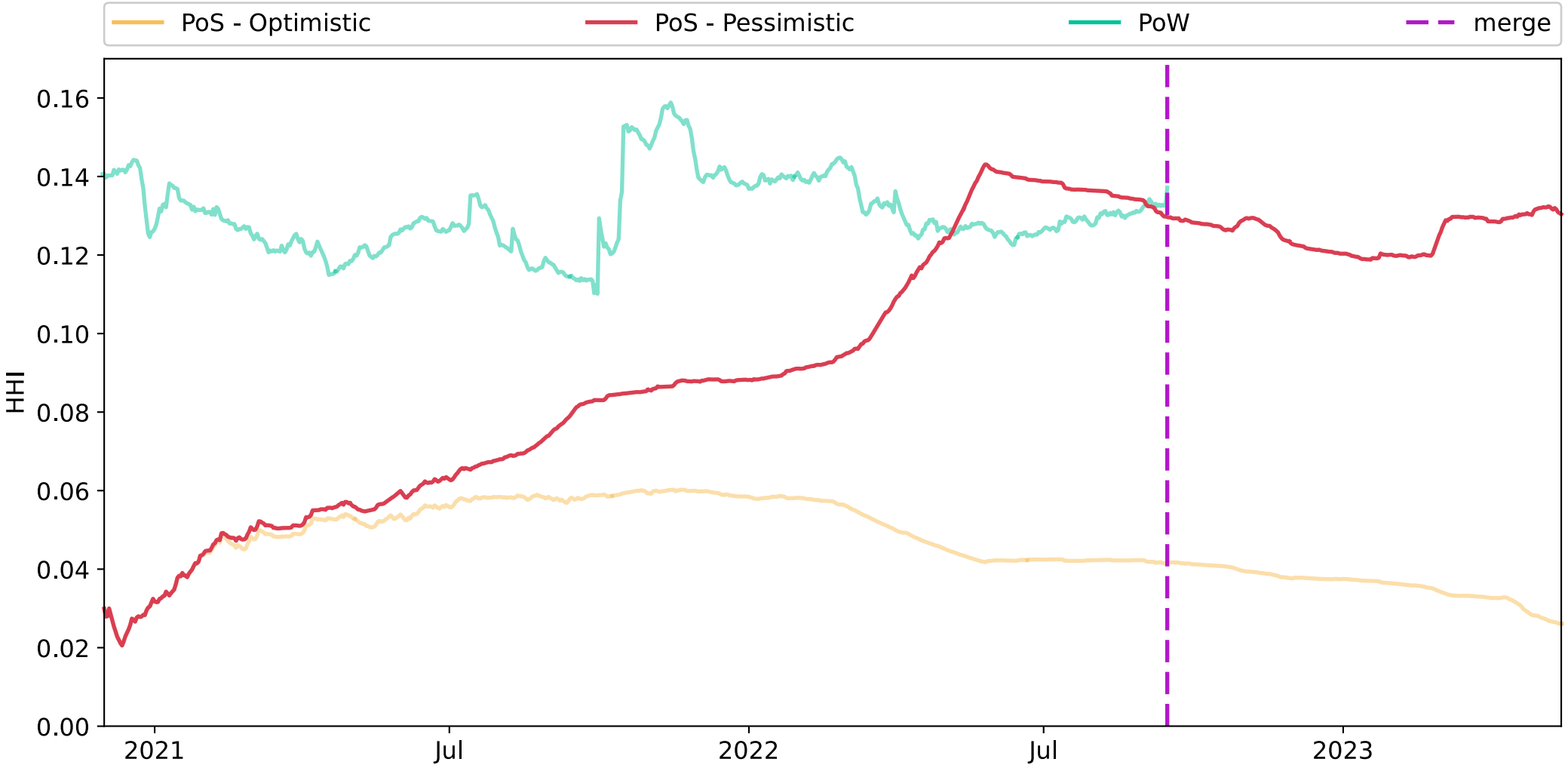
Herfindahl-Hirschman Index (HHI)



Herfindahl-Hirschman Index (HHI)



Herfindahl-Hirschman Index (HHI)



Ethereum PoS Consensus Layer

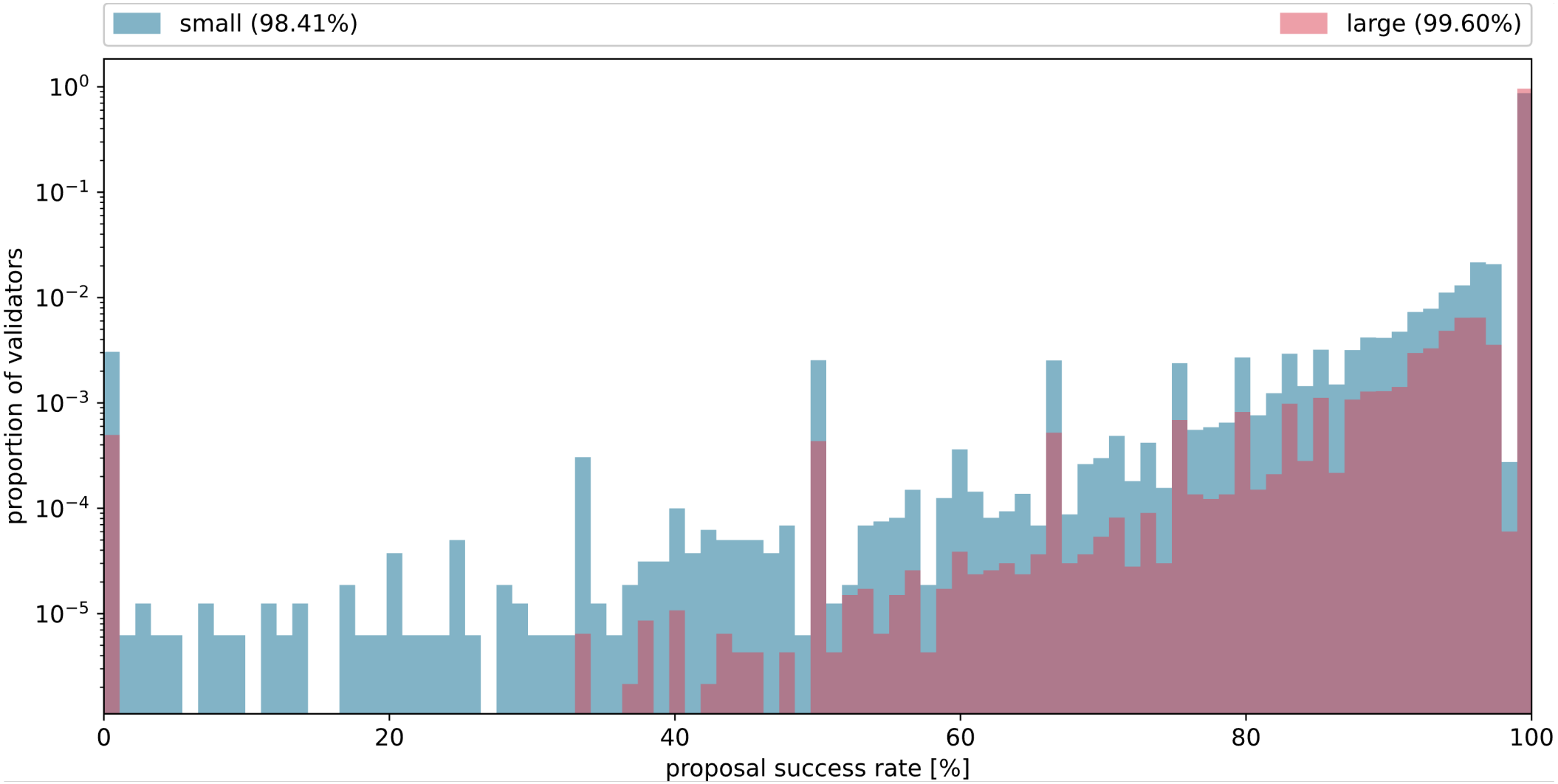
participation

validator landscape

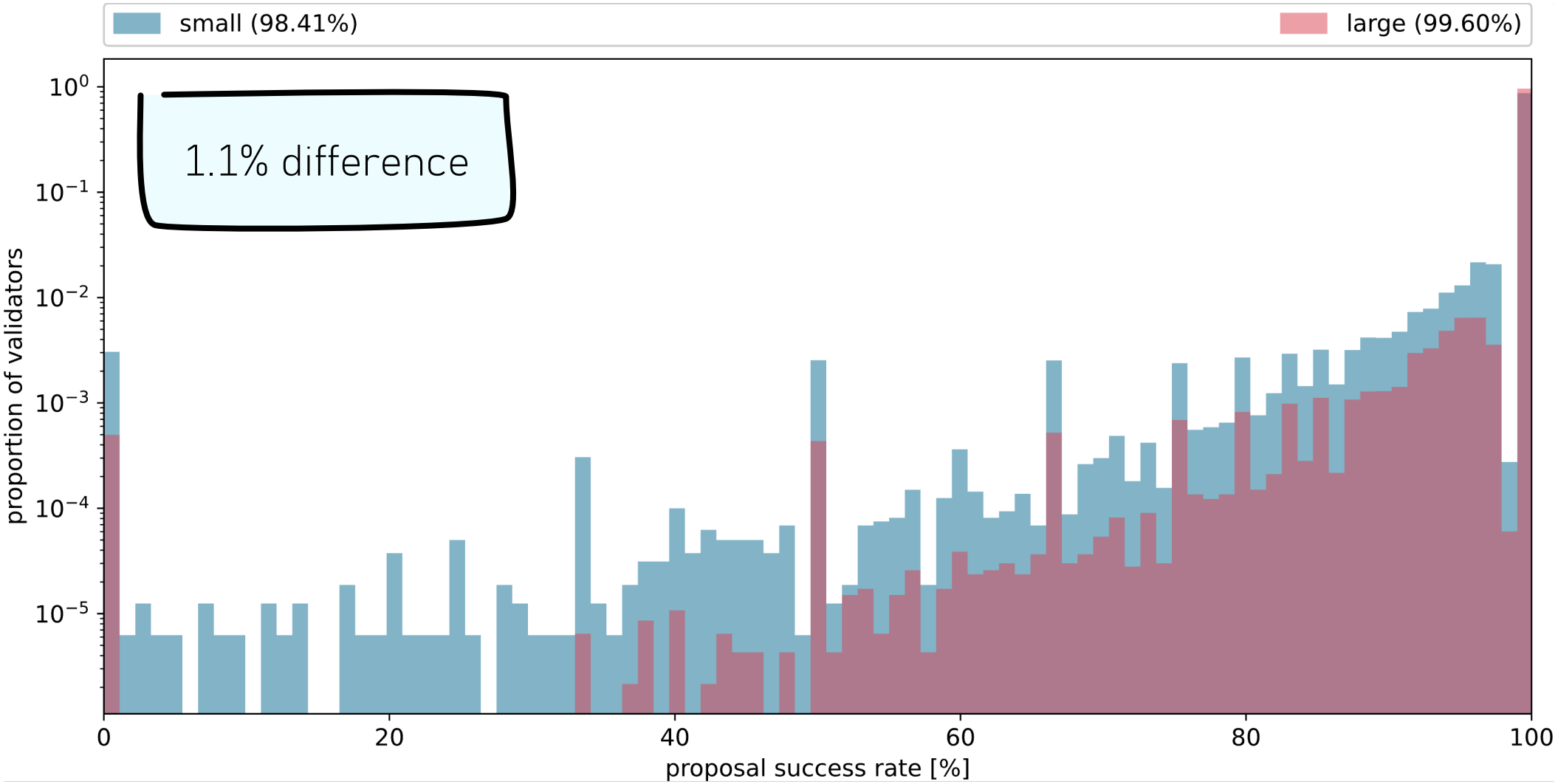
decentralization

performance

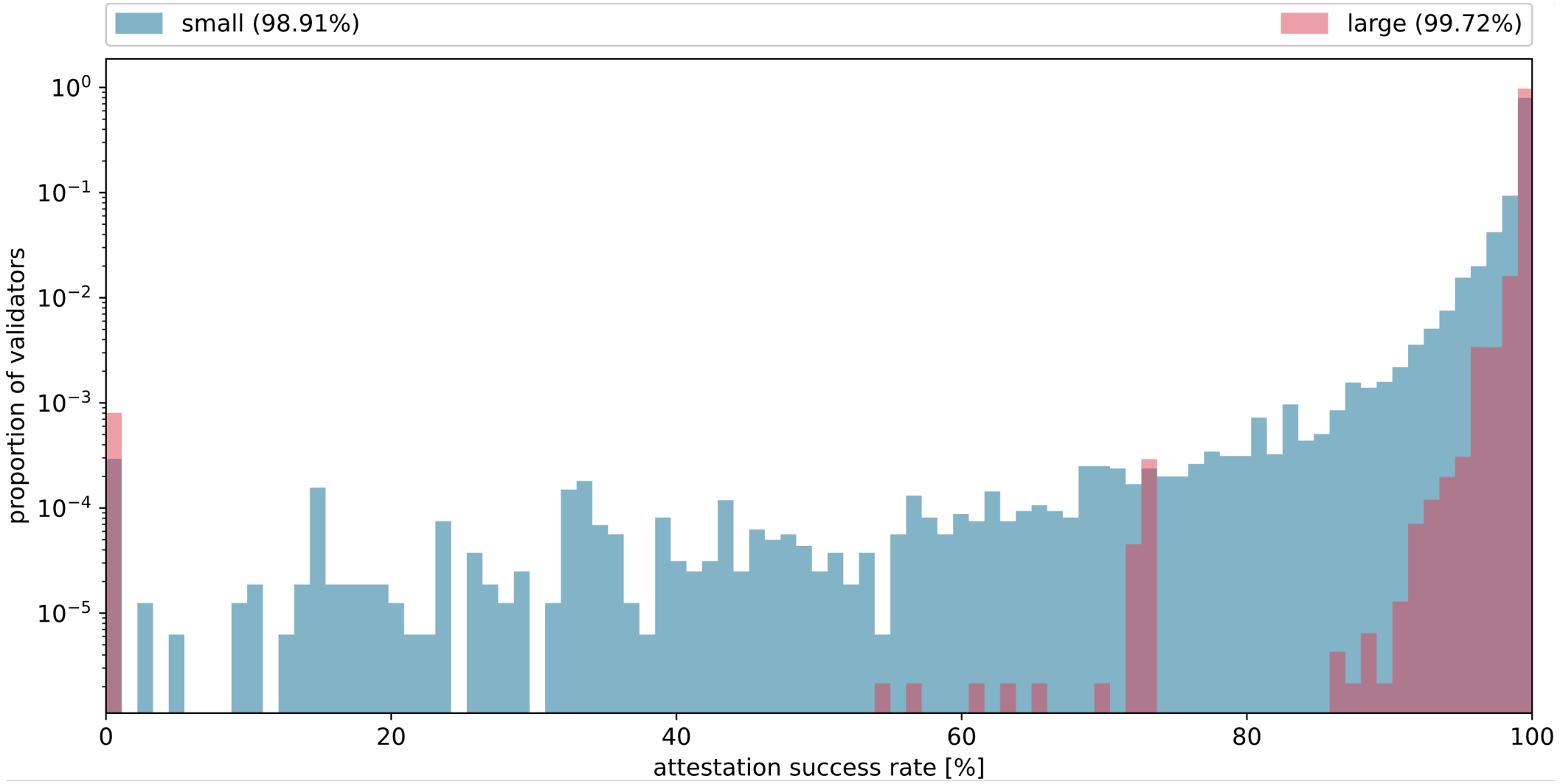
Proposal success rate



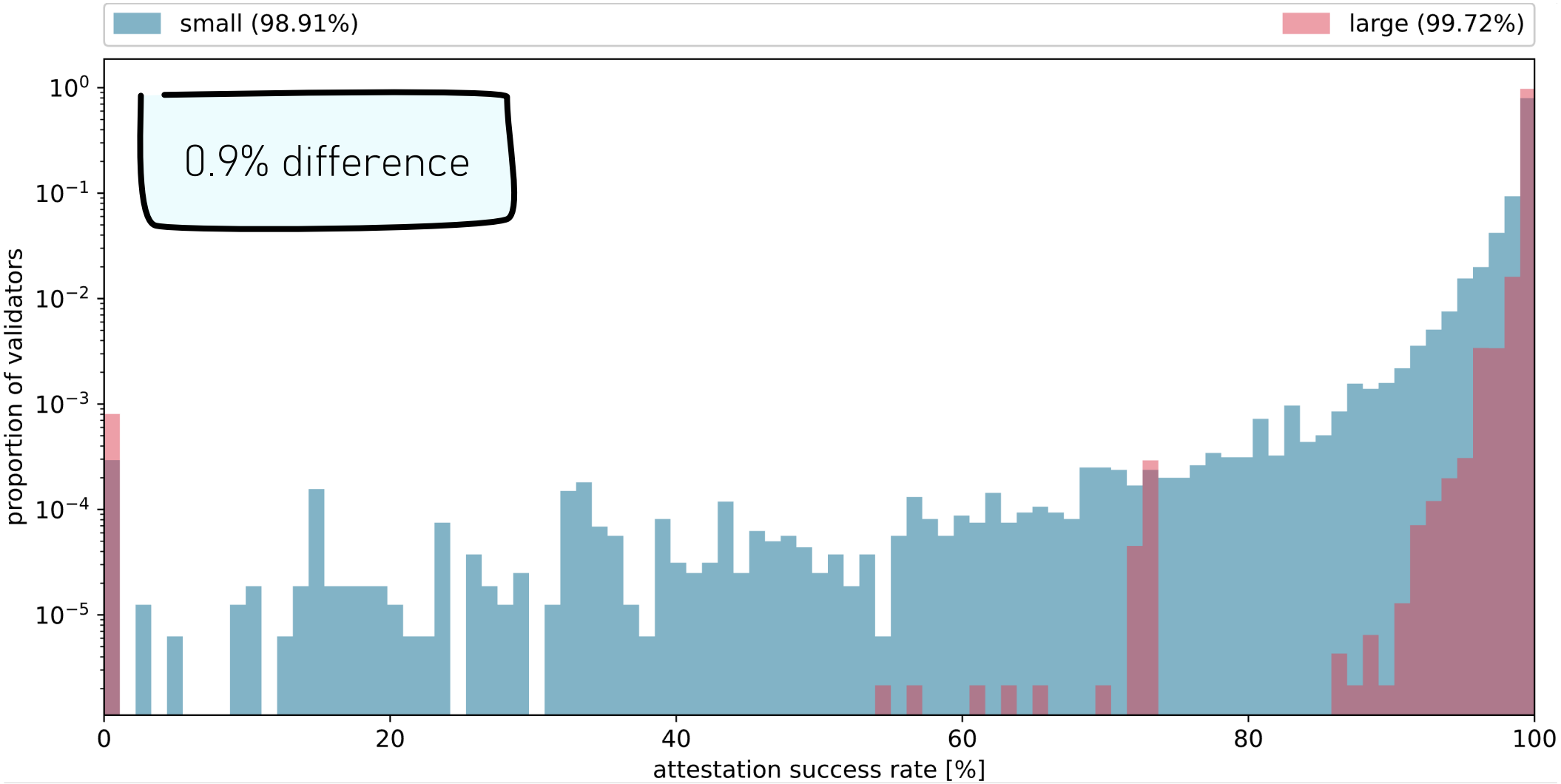
Proposal success rate



Attestation success rate

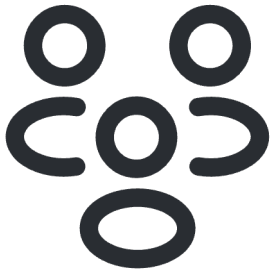


Attestation success rate



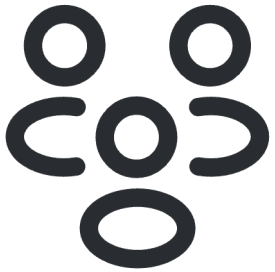
Conclusion

Conclusion

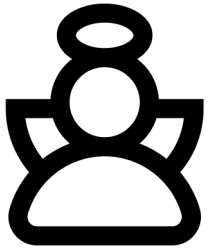


high participation

Conclusion

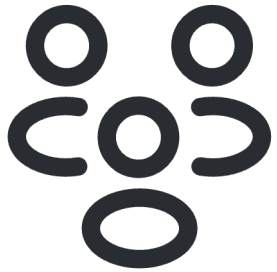


high participation

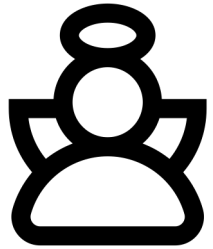


good behavior

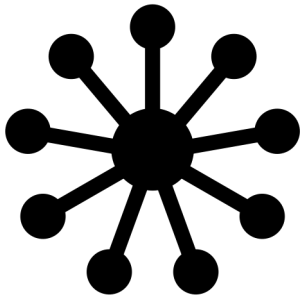
Conclusion



high participation

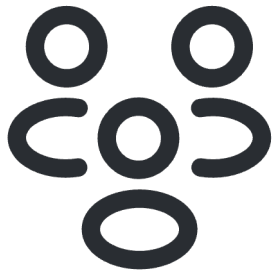


good behavior

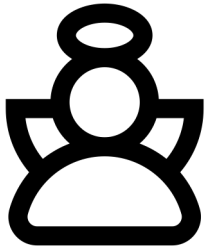


no significant increase
in decentralization

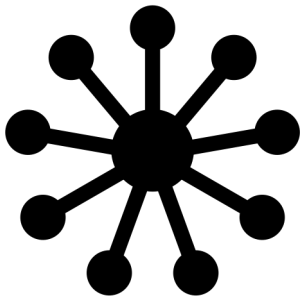
Conclusion



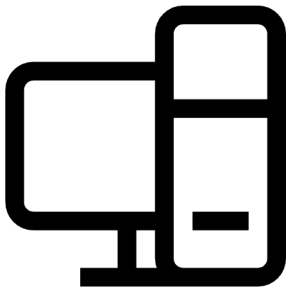
high participation



good behavior

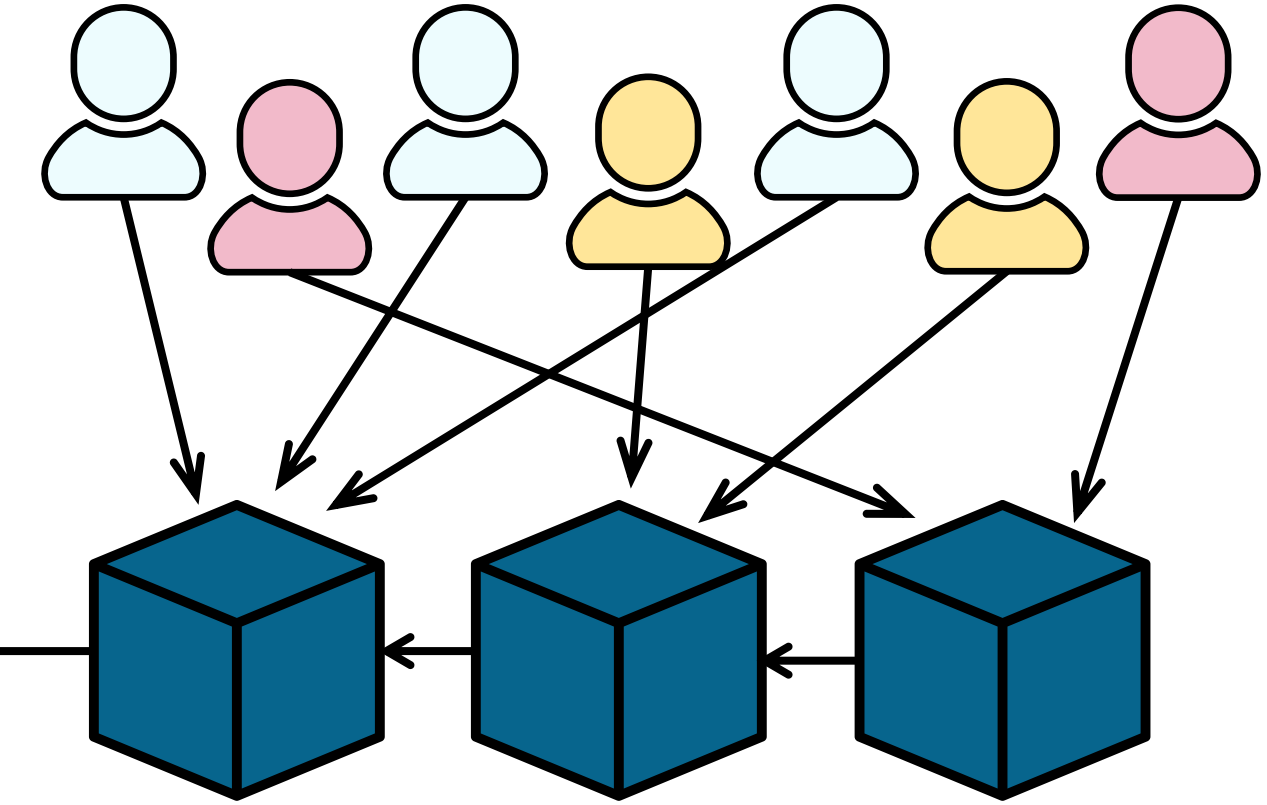


no significant increase in decentralization



challenges of solo stakers

Ethereum Proof-of-Stake Consensus Layer: Participation and Decentralization



Questions?

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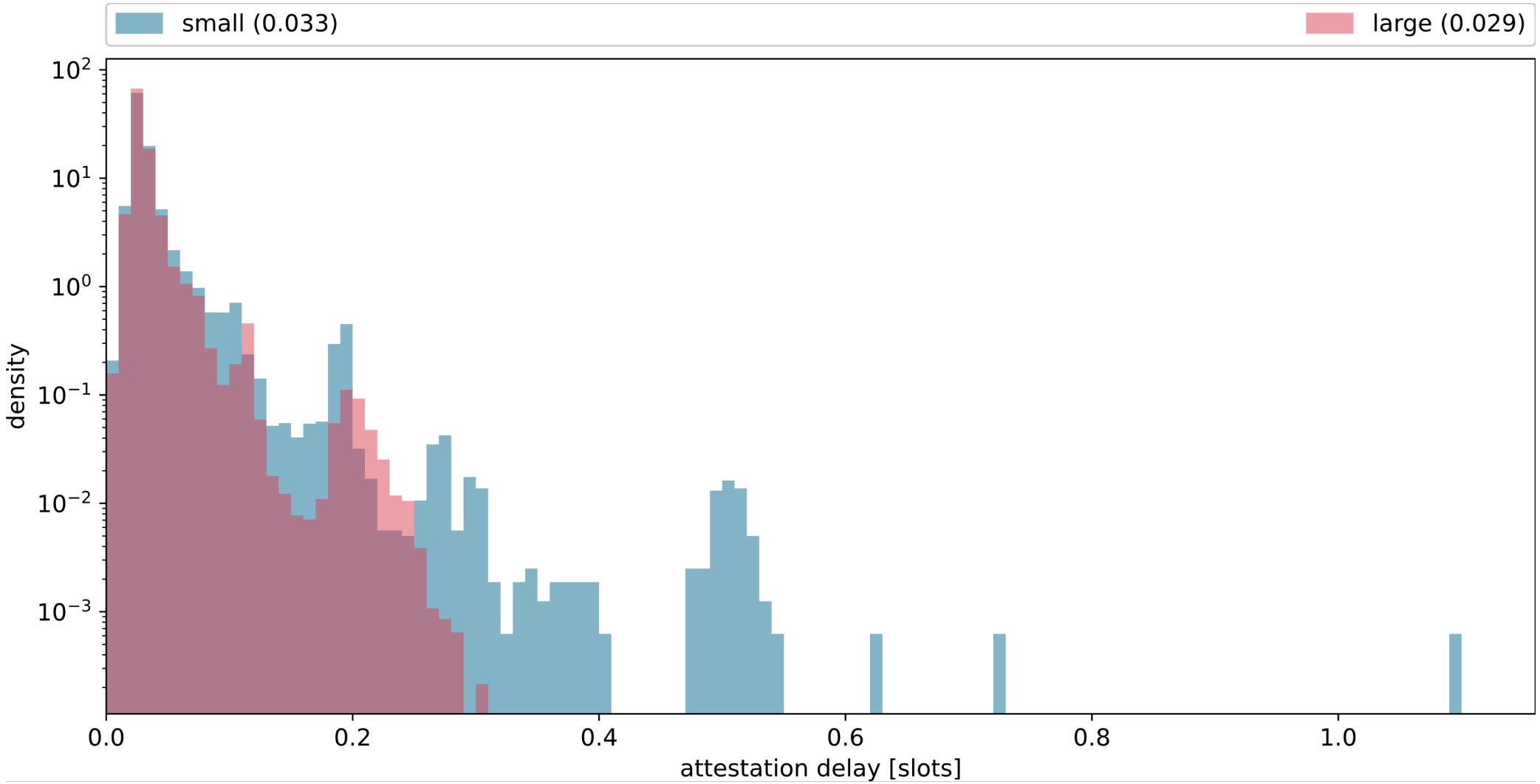
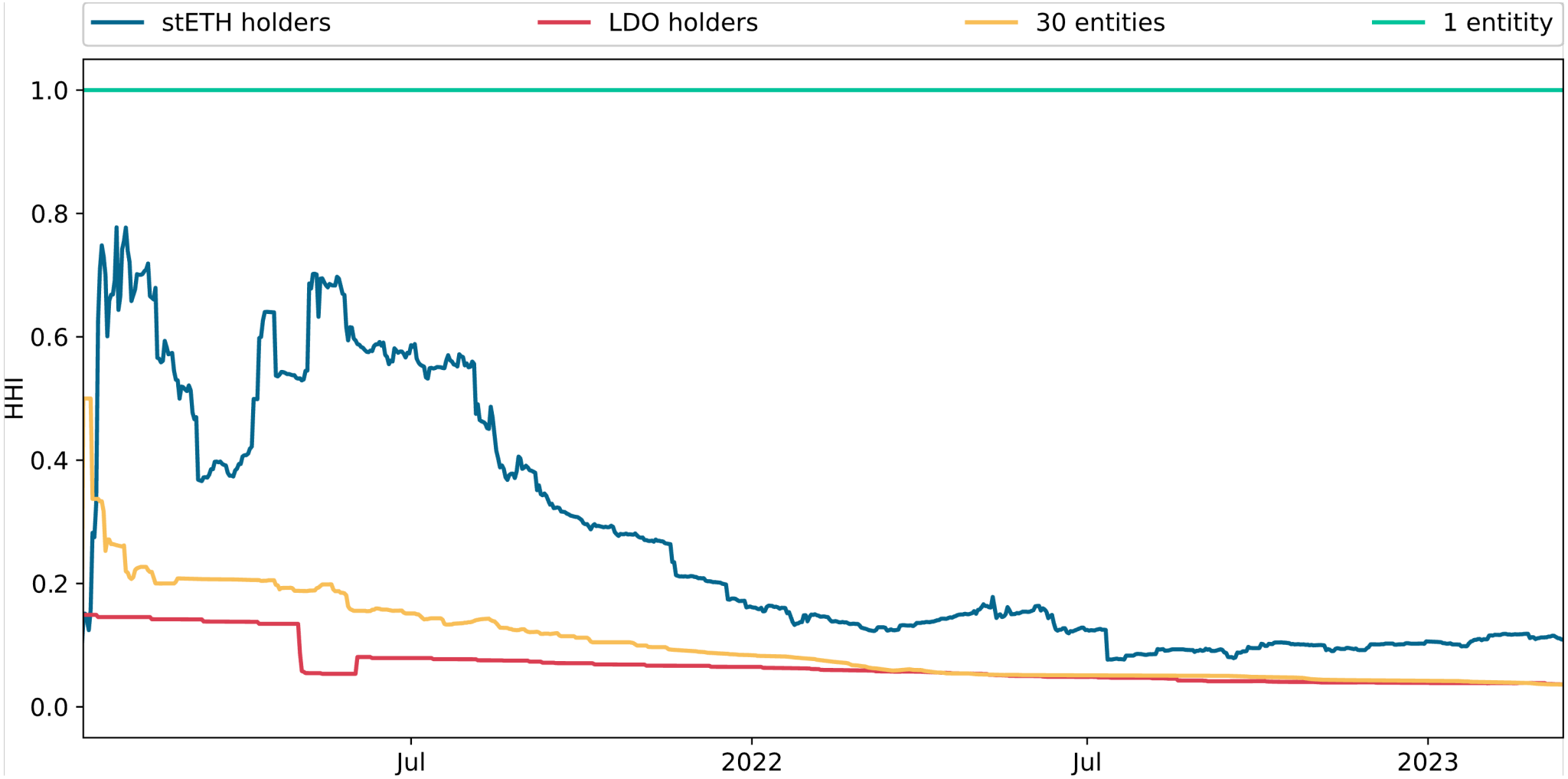
Attestation delay



Lido decentralization



Lido operator market share