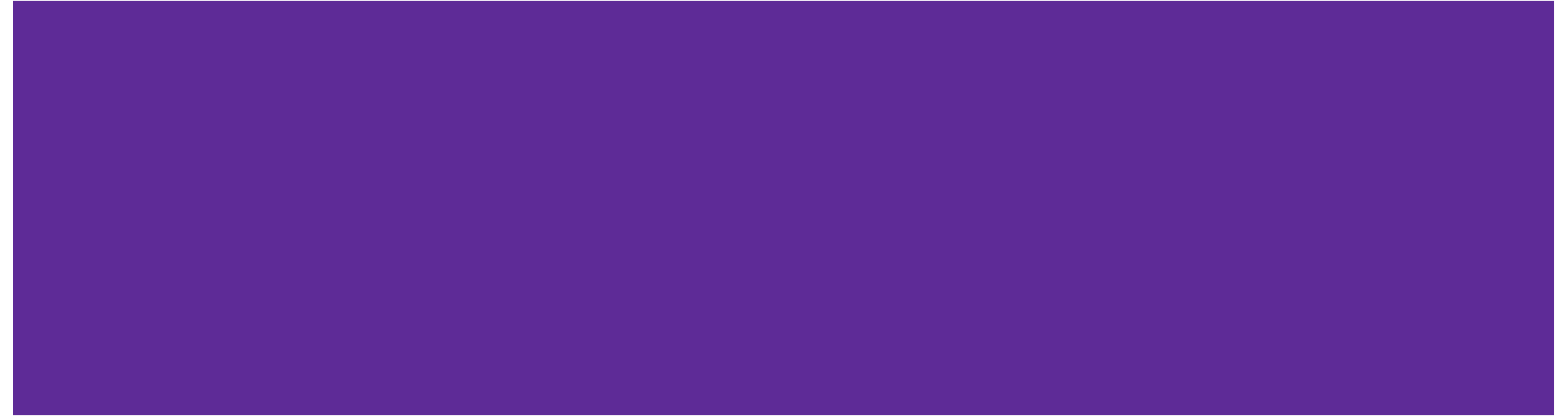


Optimizing fee estimation via the mempool state

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Some history



Time to confirm: 1h

Max fee: 456sat/b (~\$5.47 USD/tx)

Avg fee: 58.25sat/b (~\$0.70 USD/tx)

500

400

300

200

100

0

480000

480500

481000

481500

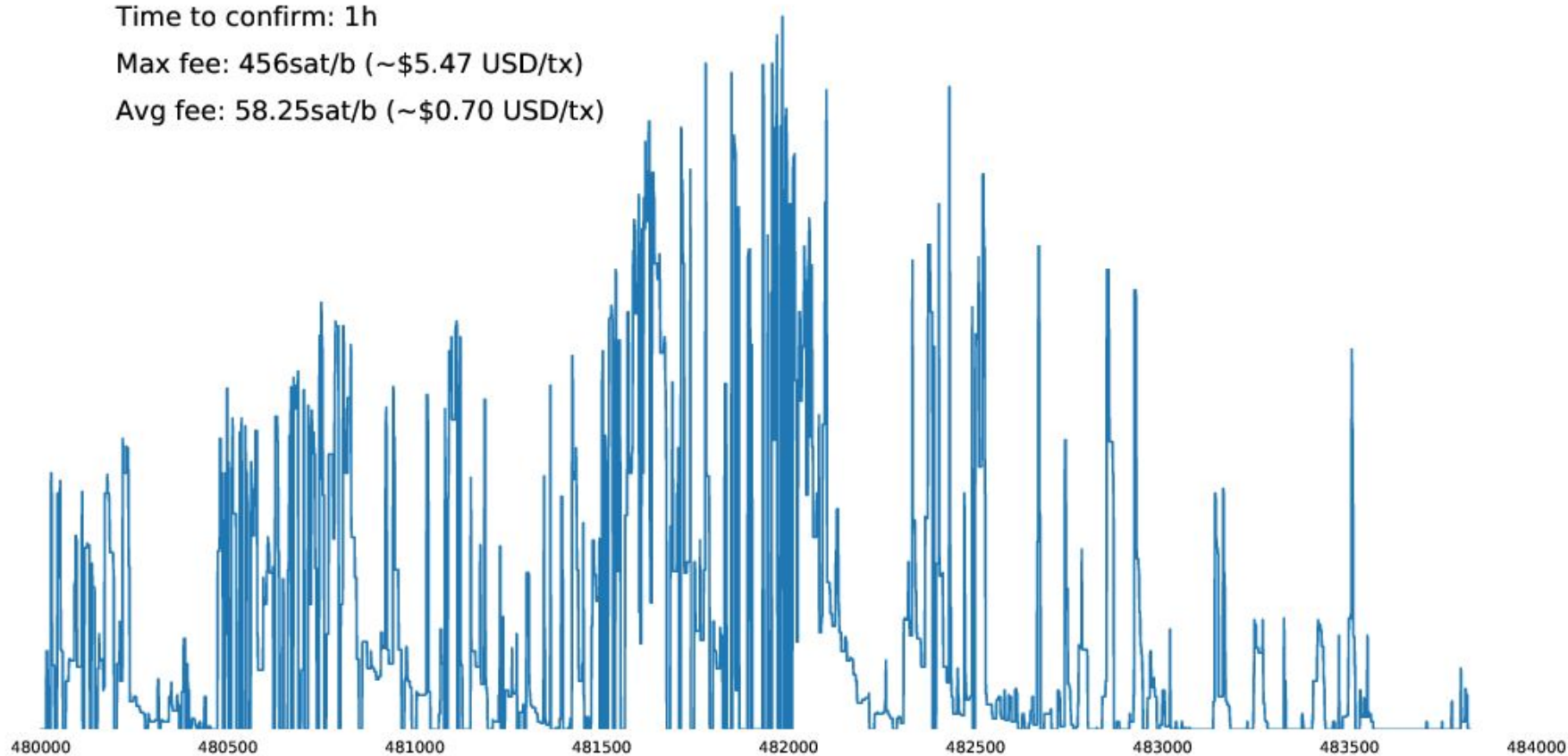
482000

482500

483000

483500

484000



Time to confirm: 2h

Max fee: 386sat/b (~\$4.63 USD/tx)

Avg fee: 36.62sat/b (~\$0.44 USD/tx)

500

400

300

200

100

0

480000

480500

481000

481500

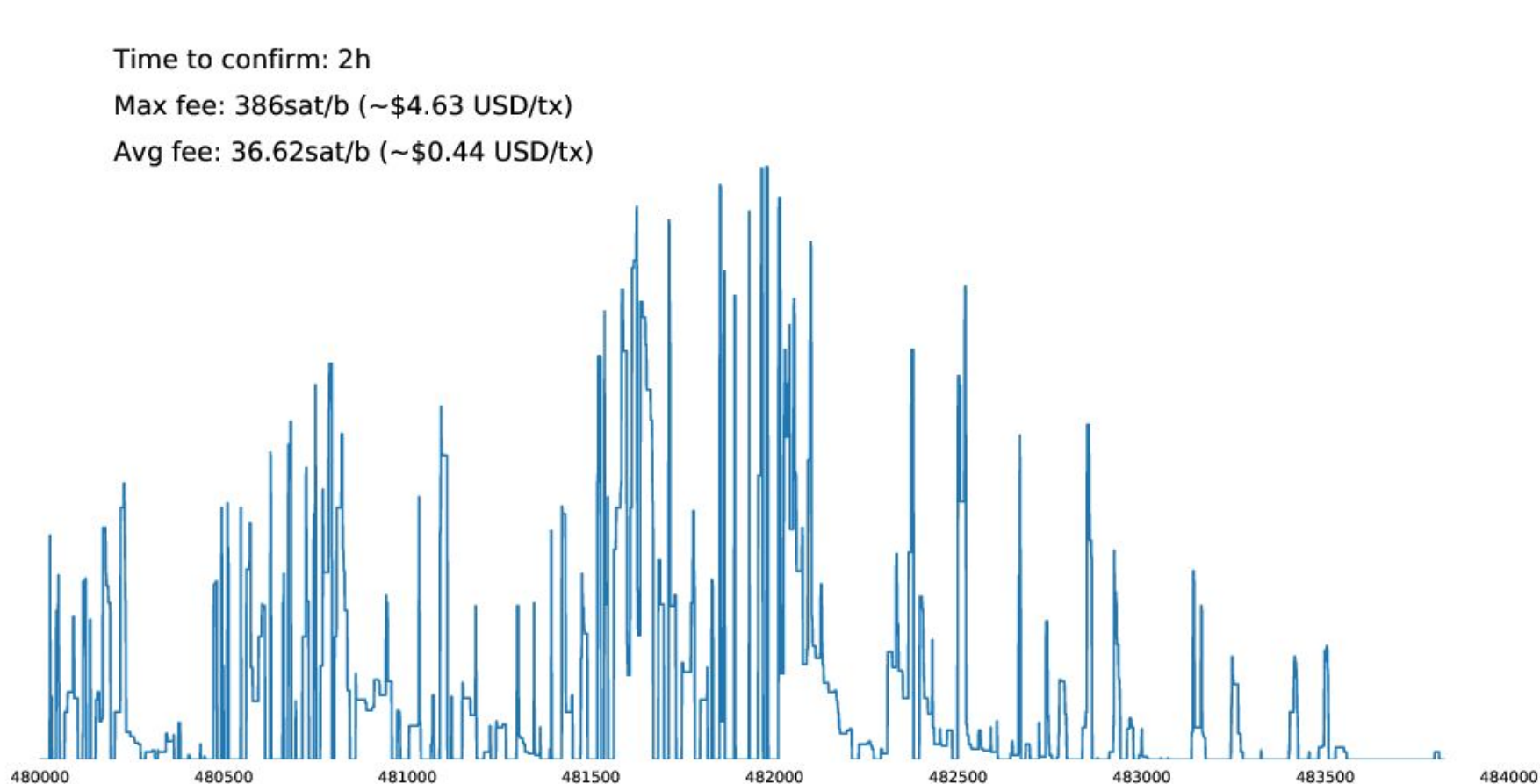
482000

482500

483000

483500

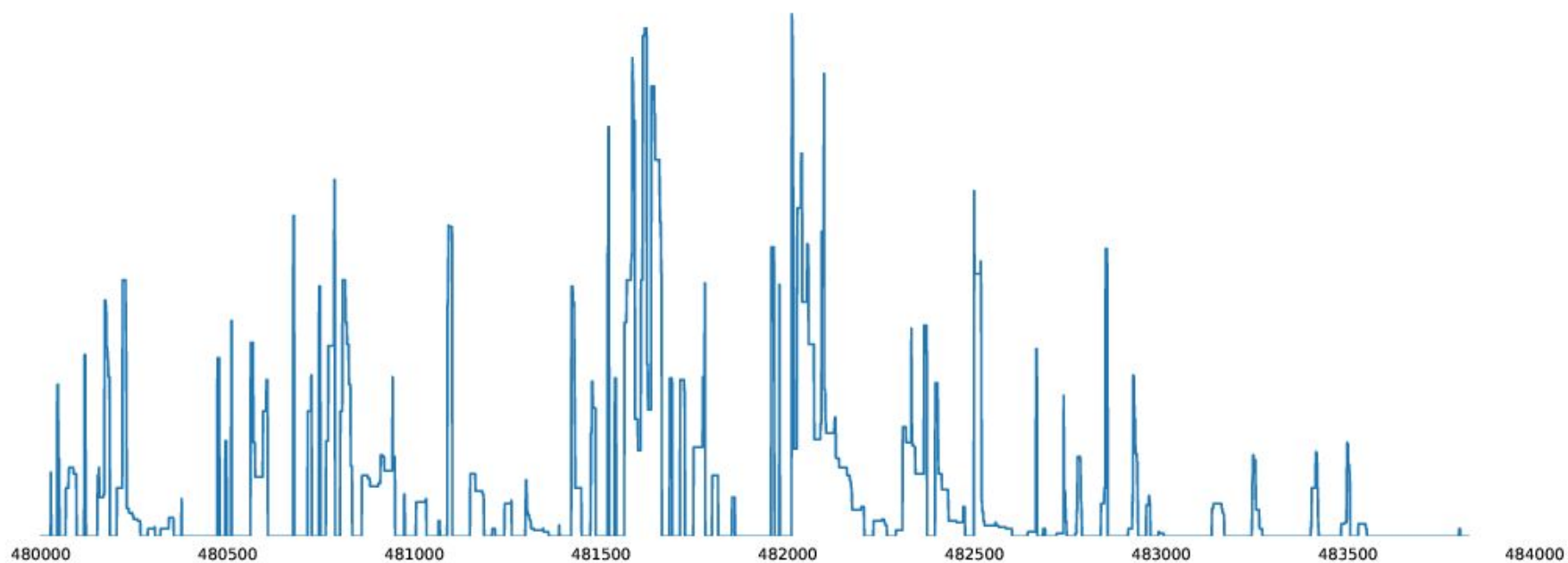
484000



Time to confirm: 3h

Max fee: 334sat/b (~\$4.01 USD/tx)

Avg fee: 24.29sat/b (~\$0.29 USD/tx)



Time to confirm: 4h

Max fee: 325sat/b (~\$3.90 USD/tx)

Avg fee: 17.16sat/b (~\$0.21 USD/tx)

500

400

300

200

100

0

480000

480500

481000

481500

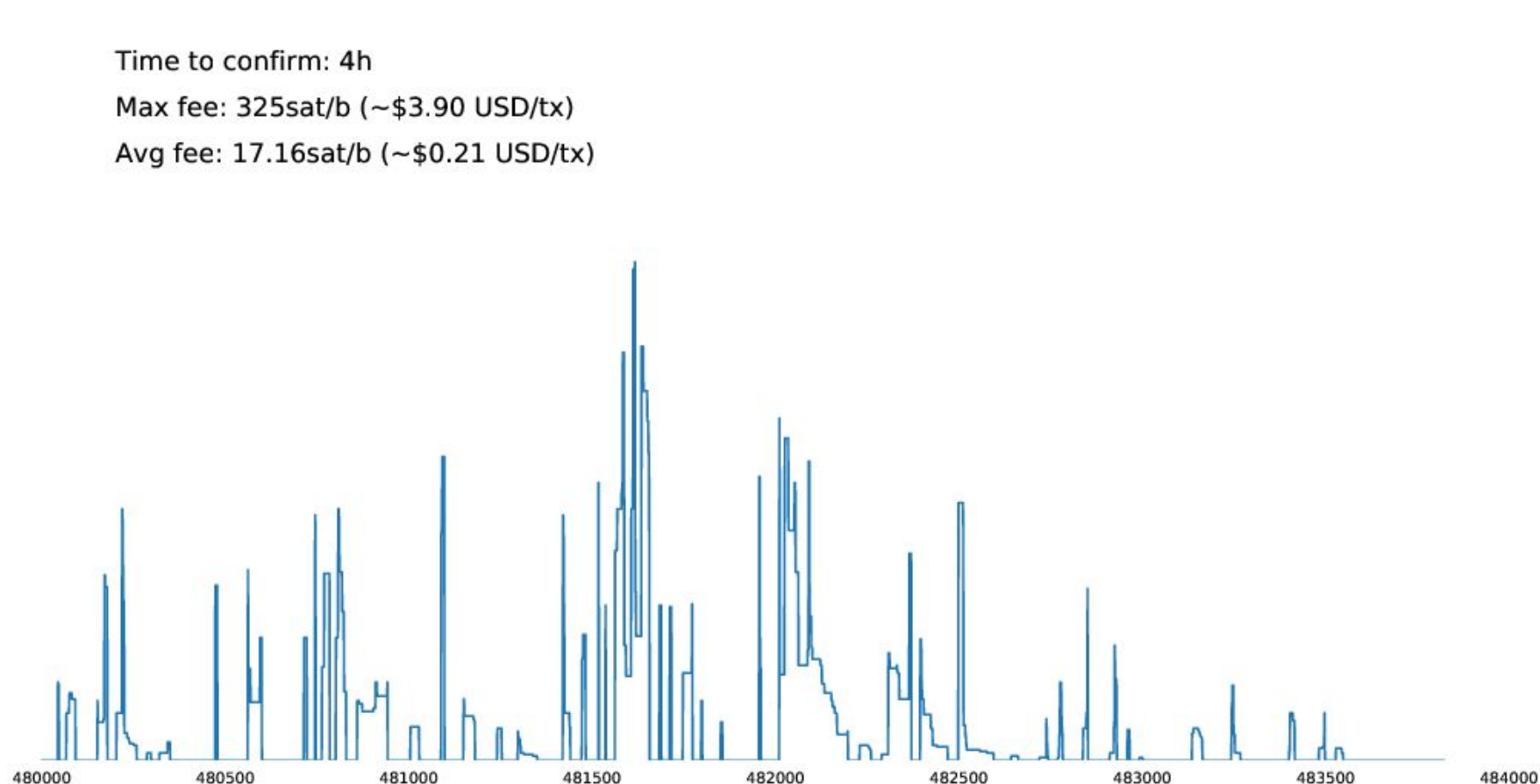
482000

482500

483000

483500

484000



Time to confirm: 5h

Max fee: 320sat/b (~\$3.84 USD/tx)

Avg fee: 12.45sat/b (~\$0.15 USD/tx)

500

400

300

200

100

0

480000

480500

481000

481500

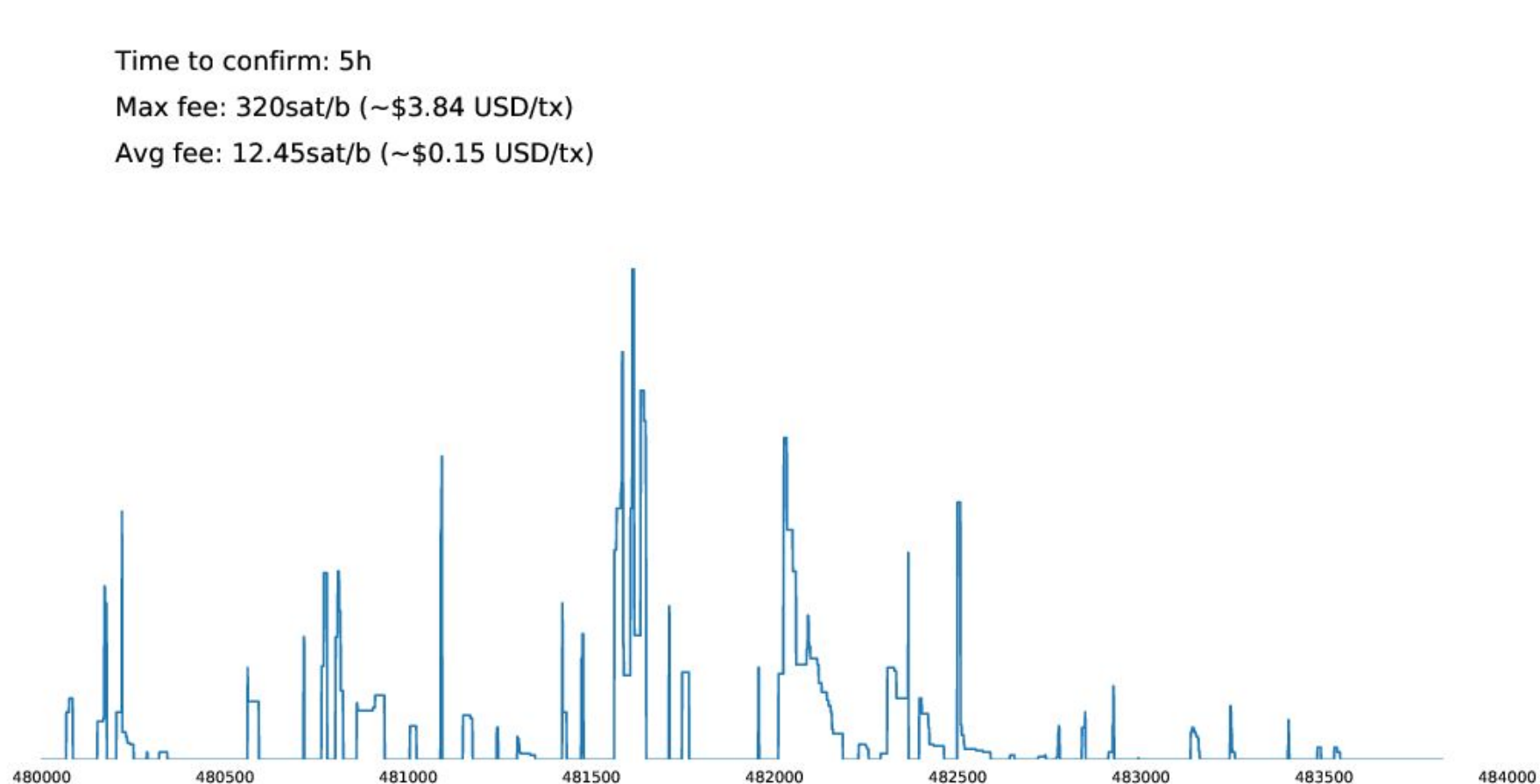
482000

482500

483000

483500

484000



Time to confirm: 24h

Max fee: 62sat/b (~\$0.74 USD/tx)

Avg fee: 1.02sat/b (~\$0.01 USD/tx)

500

400

300

200

100

0

480000

480500

481000

481500

482000

482500

483000

483500

484000

50

60

55

50

45

40

35

30

25

20

15

10

5

0

Current fee estimation method



Bitcoin Core

As of Bitcoin Core 0.15, fee estimation has been upgraded.

- Two modes: conservative and economic.
- For t block target, find a fee rate based on the most recently mined blocks, with the following success rates:
 - 60% at half of t (e.g. 3 for $t=6$), and
 - 85% at t , and
 - (conservative mode only) 95% at $2t$.

Bitcoin Core

The new fee estimator is much better at reacting to large volatility in tx throughput, but ignores the mempool.

Mempool optimization



Mempool optimization

We can use the mempool to react faster to sudden changes in the mempool:

- We can optimize (decrease) the fee to a given point in the next imagined block, say the 5% point.
- Precision depends on time until next block is mined and other factors.
- We can safely under-estimate and later RBF-bump.

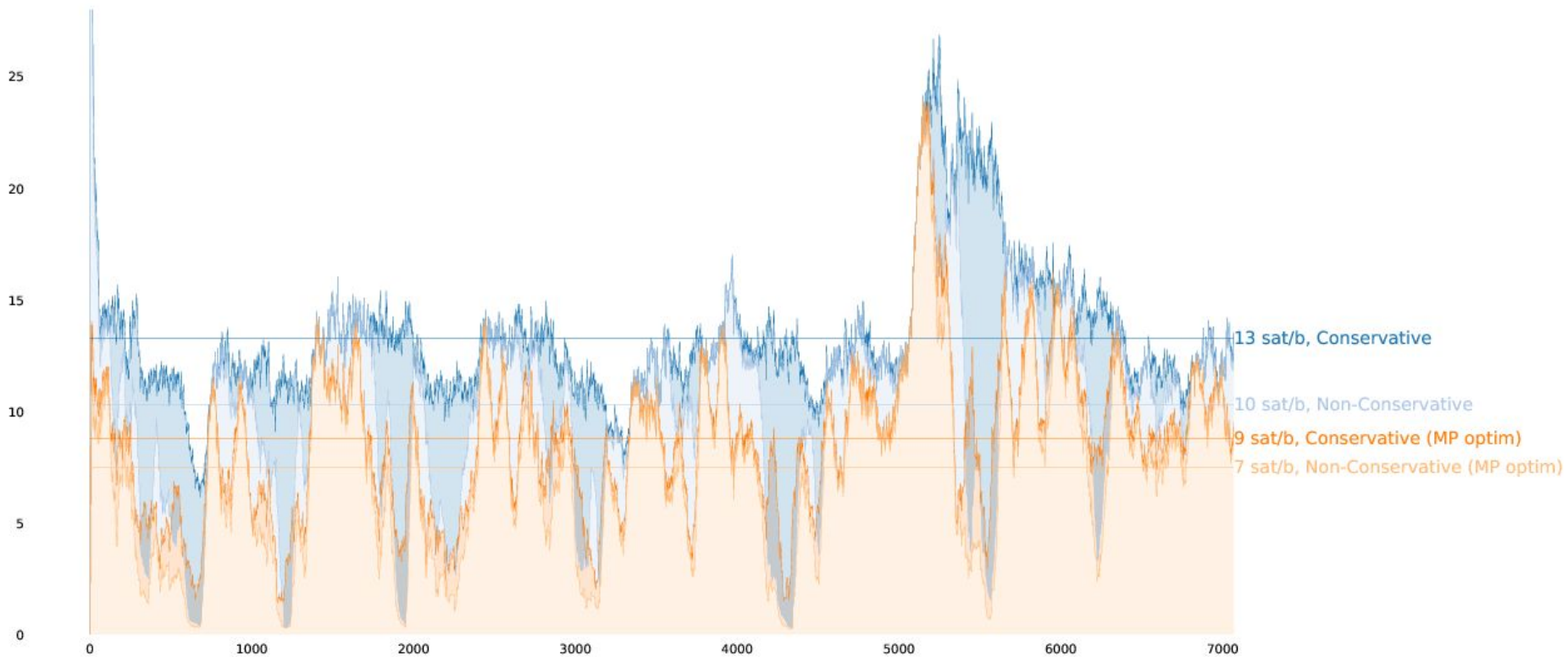
Mempool optimization

We can do the opposite as well...

- We can assume that we must wait at least $\Sigma(\text{mempool weight above our fee rate}) / 4,000,000$ blocks before our transaction is mined at the given fee rate.
- If this is higher than our target, we may want to use a higher fee rate.
- This can be gamed, and is not considered further.

Results (overestimations by mode)





100

80

60

40

20

0

0

1000

2000

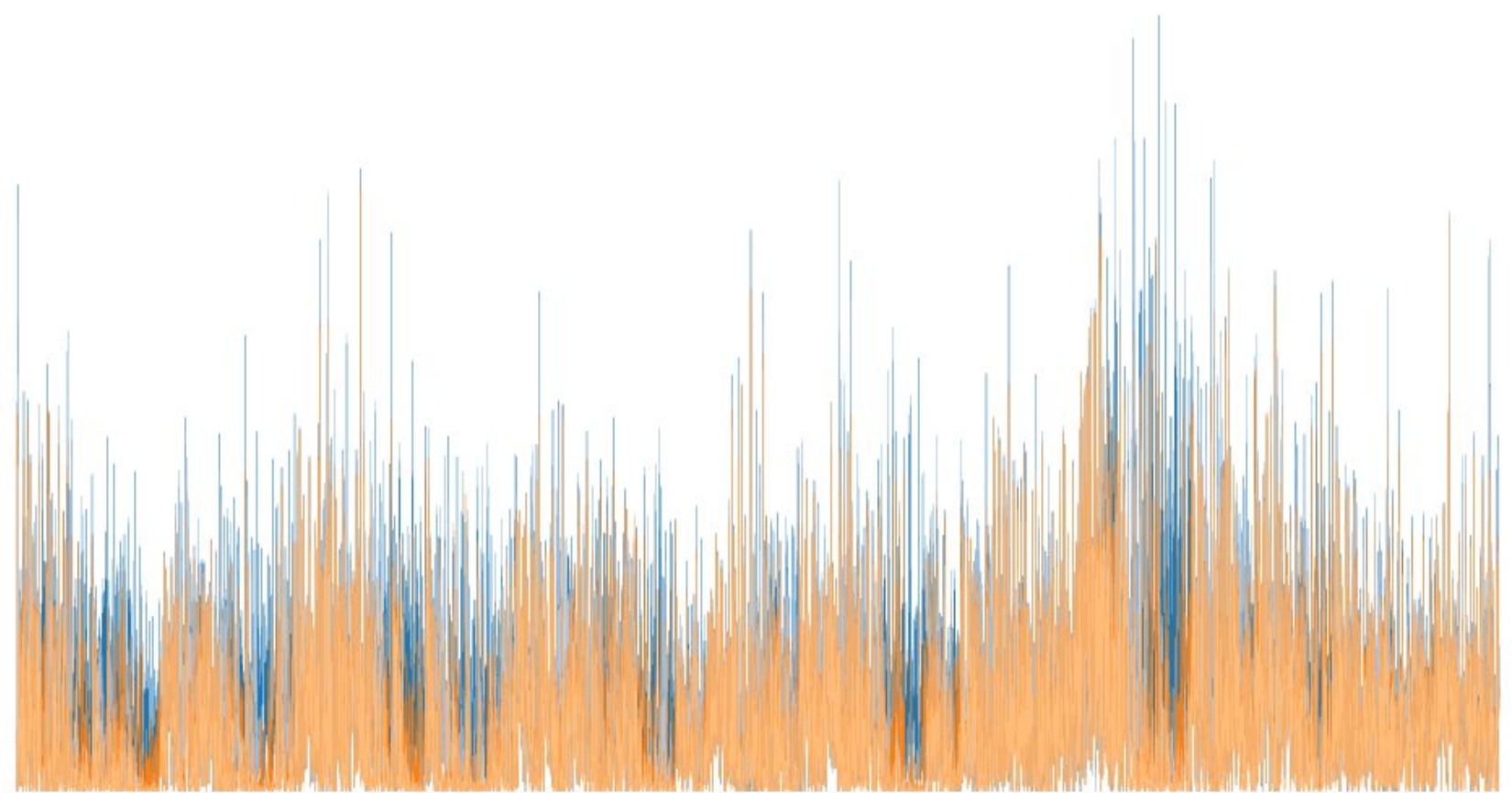
3000

4000

5000

6000

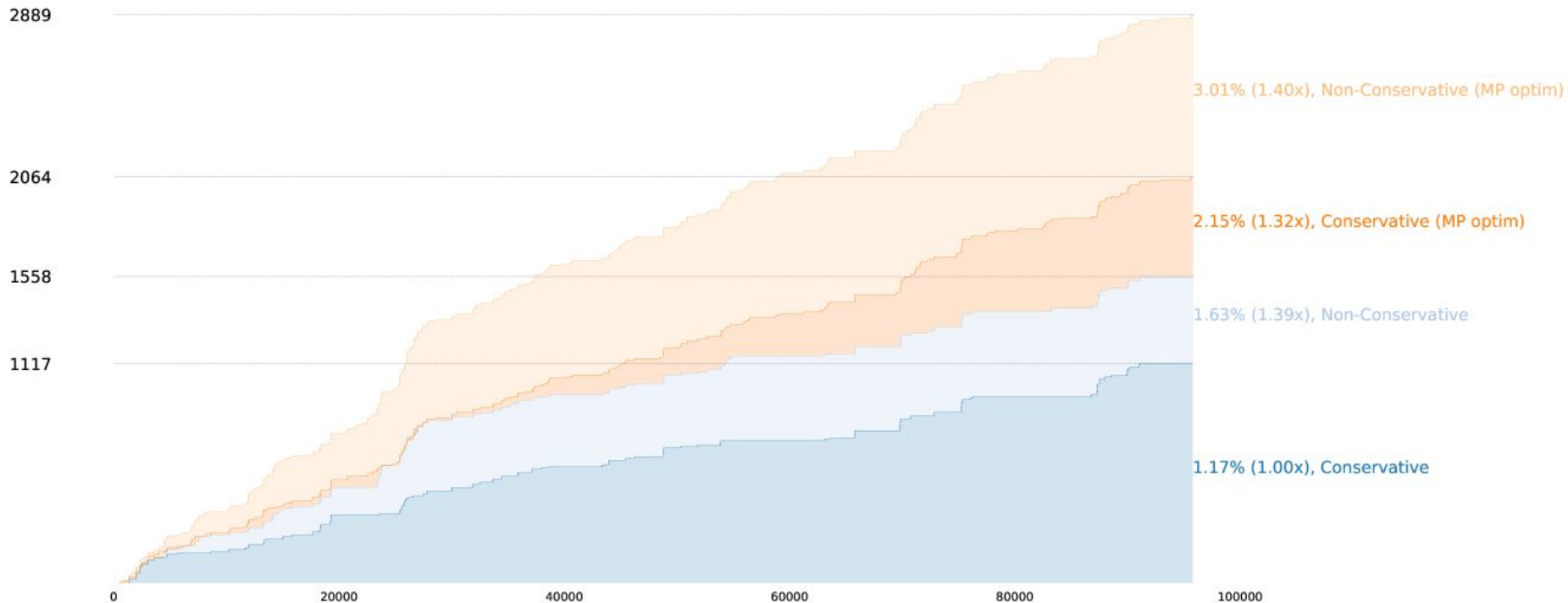
7000



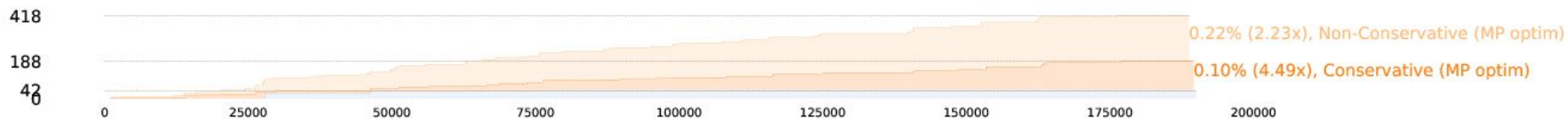
Underestimation rates



Underestimations after 1 block (t=1)



Underestimations after 2 blocks (t=1)



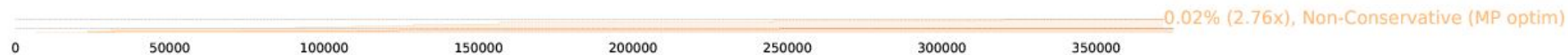
Underestimations after 3 blocks (t=1)

163
58



Underestimations after 4 blocks (t=1)

53



Underestimations after 5 blocks (t=1)



Underestimations after 10 blocks (t=1)

10



RBF-bumping



Replace-By-Fee (RBF)

- Around since Bitcoin Core 0.12
- Easier to use with 0.14: **bumpfee** command
- Method:
 - broadcast a transaction which is marked RBF (default off)
 - bump its fee by creating a **new** transaction which spends the same inputs, but has a higher fee rate (outputs can change)

Estimating fee delta with optimization

A transaction can be bumped at any time by looking at the mempool and calculating the minimum fee rate to get into the next t blocks:

- $\text{Excess} = \Sigma(\text{weight of mempool tx above our fee rate}) - 4,000,000t.$
- If < 0 , we are good.
- If > 0 , we have to wait longer than t .

Estimating fee delta with optimization

- The exact fee we need:
 - order txs by descending fee rate
 - grab fee rate of tx at $4,000,000t - \alpha$
 - Want: fee rate *slightly over* above, if $<$ some threshold
- We can "tune" our transaction repeatedly while waiting for the next block(s), until it's time to be mined ($t=1$) or we hit our threshold and need to wait longer.

Estimating fee delta with optimization

Benefits, assuming threshold = the block-only estimator result (or slightly above it):

- 100% safe (never gives insane fees unless Bitcoin Core does so itself, due to threshold)
- more precise, and will tell the user exactly when the transaction is expected to be mined (with some error...)
- cheaper (up to 80% in cases where mempool drops rapidly)

Thank you

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