Transmissibility-based pre-coarsened partitioning for OPM Flow

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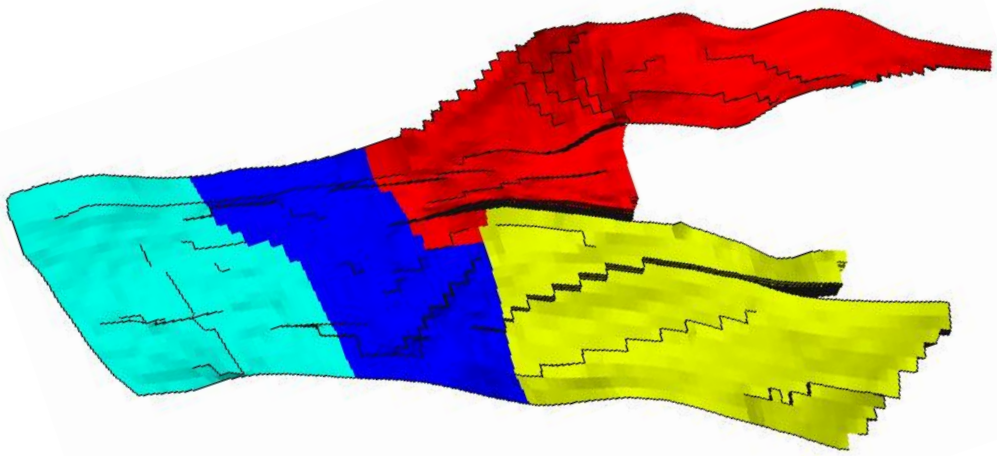
OPM summit - April 2026



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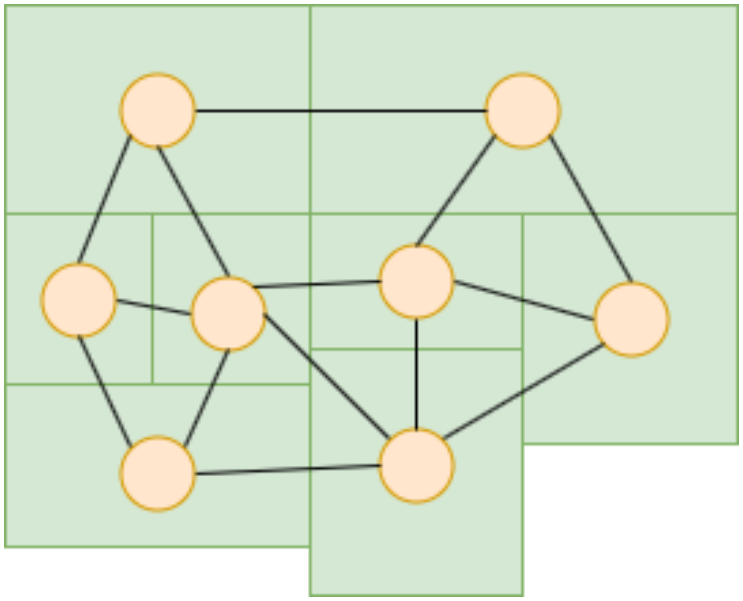
Low communication overhead and heterogeneity-awareness are conflicting partitioning goals

Universal partitioning goals:

1. **Computational load balance.**
2. **Total communication volume minimization.**



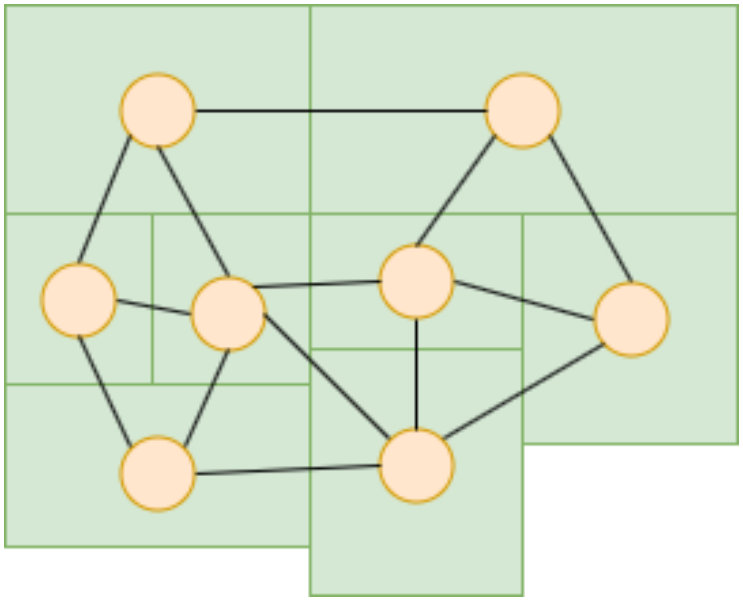
Low communication overhead and heterogeneity-awareness are conflicting partitioning goals

Universal partitioning goals:

1. **Computational load balance.**
2. **Total communication volume minimization.**

Reservoir specific partitioning goals:

1. **Wells.**
2. **Heterogeneity-awareness (preconditioner quality).**



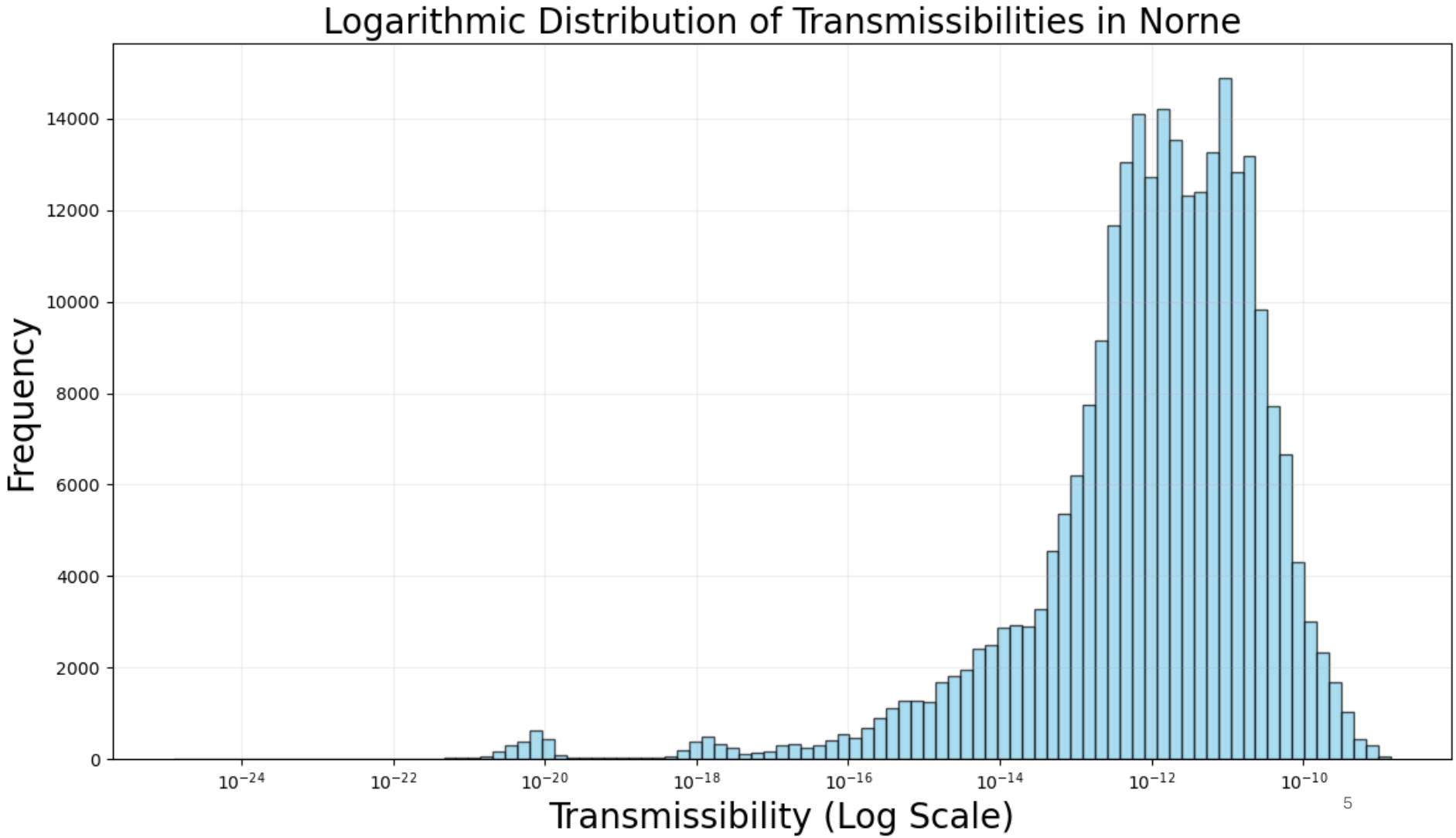
The three-step partitioning strategy includes transmissibility by coarsening the partitioning graph

Step 1: Calculate lower threshold for large transmissibilities and divide connections into weak and strong.

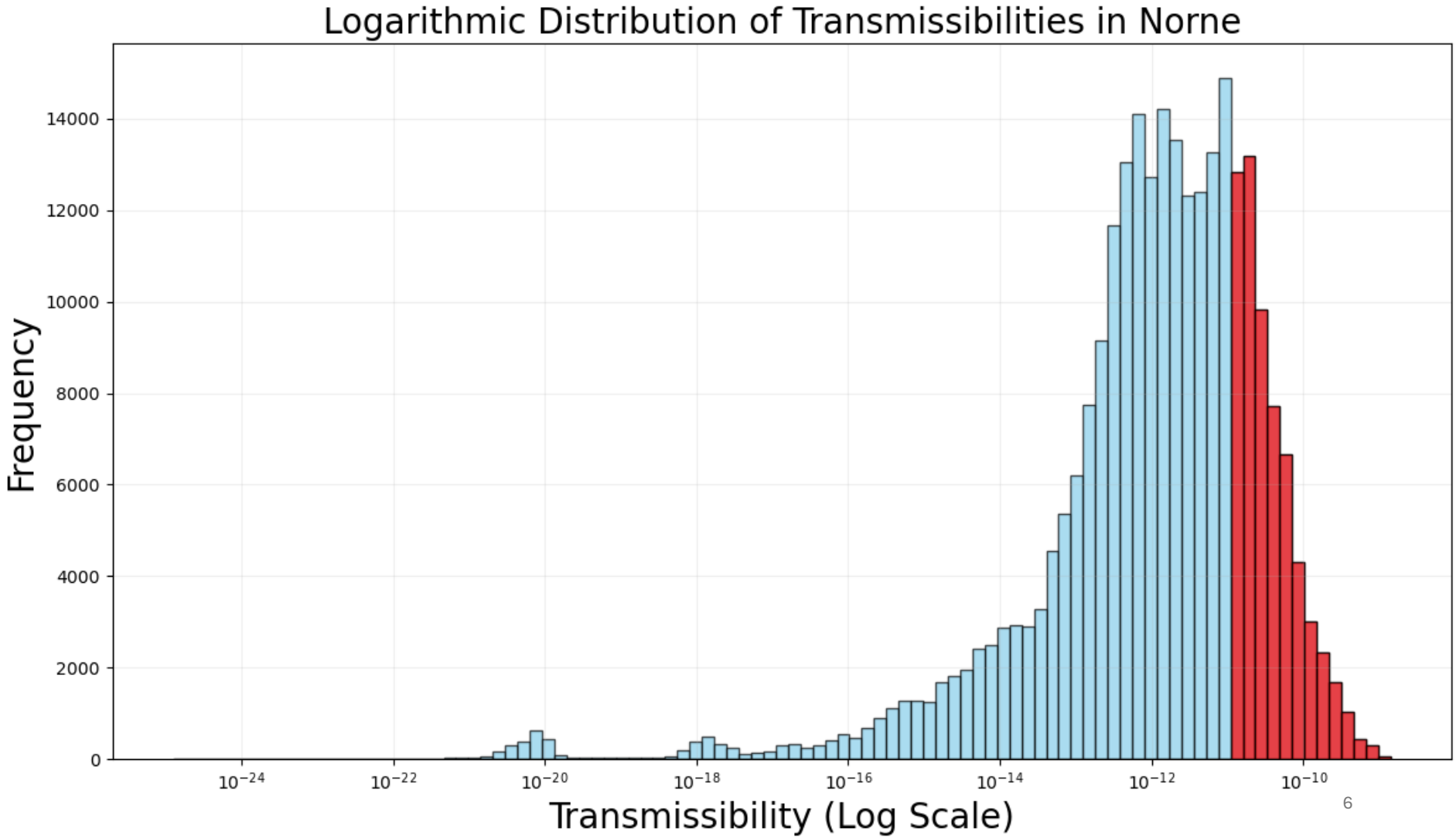
Step 2: Use strong transmissibilities to coarsen the partitioning graph.

Step 3: Partition the coarsened graph.

Step 1: Find a lower threshold for large transmissibilities

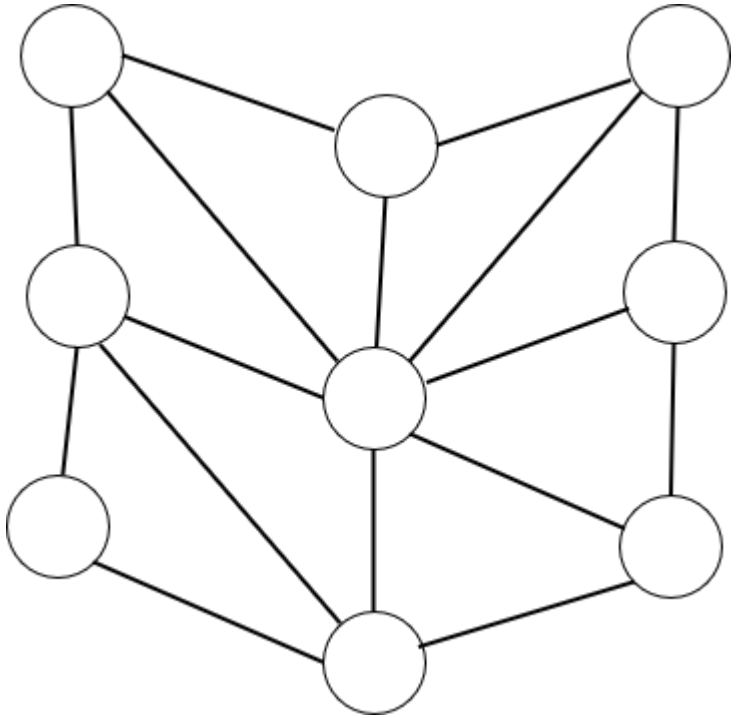


Step 1: Find a lower threshold for large transmissibilities



Step 2: Coarsen the partitioning graph

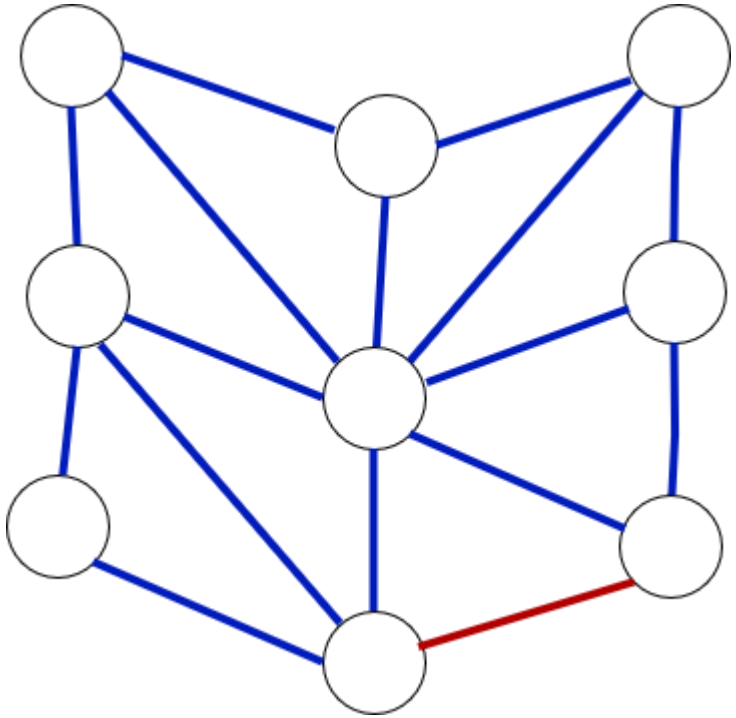
Pre-coarsening strategy:



Step 2: Coarsen the partitioning graph

Pre-coarsening strategy:

Find strong connections in the graph representation of the reservoir mesh.

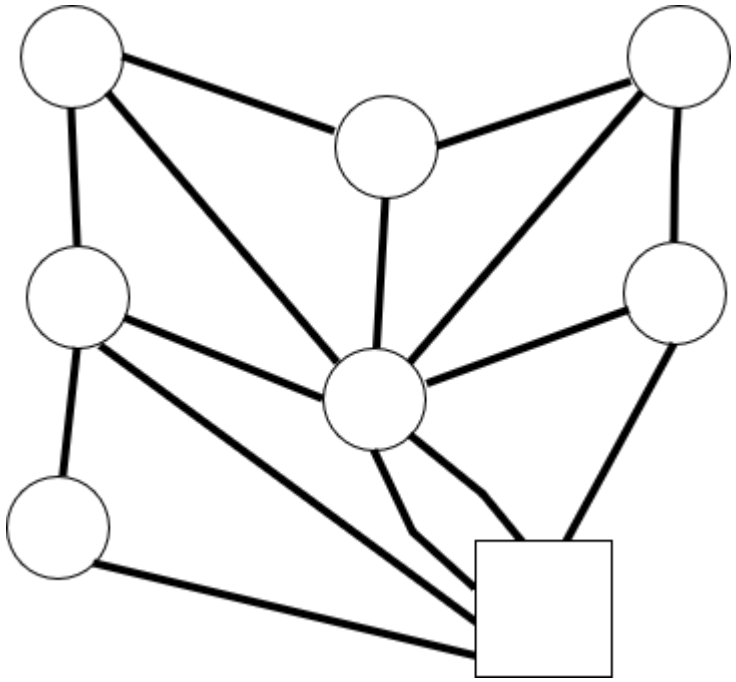


Step 2: Coarsen the partitioning graph

Pre-coarsening strategy:

Find strong connections in the graph representation of the reservoir mesh.

Merge strongly connected nodes.



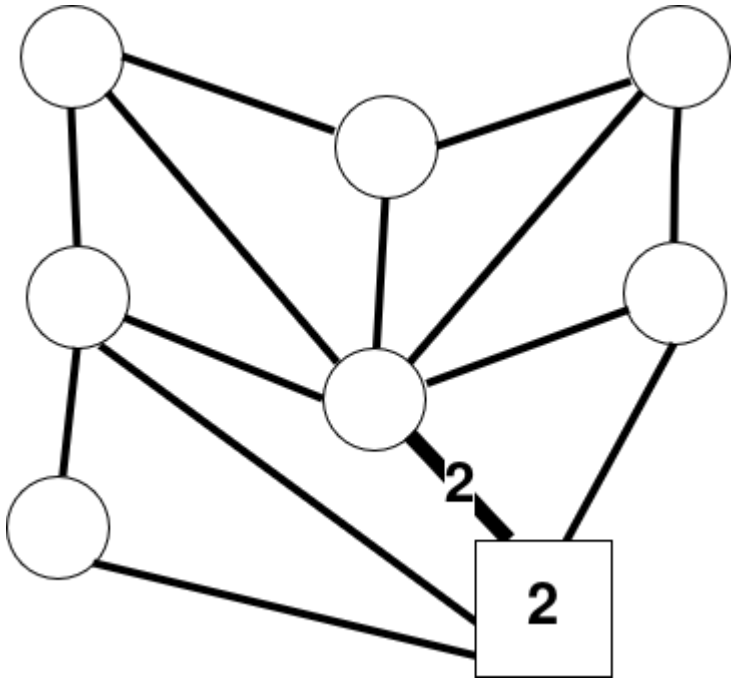
Step 2: Coarsen the partitioning graph

Pre-coarsening strategy:

Find strong connections in the graph representation of the reservoir mesh.

Merge strongly connected nodes.

Give node- and edge-weights to the coarse graph.



Step 2: Coarsen the partitioning graph

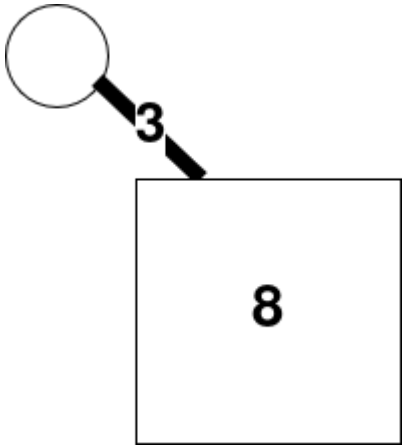
Pre-coarsening strategy:

Find strong connections in the graph representation of the reservoir mesh.

Merge strongly connected nodes.

Give node- and edge-weights to the coarse graph.

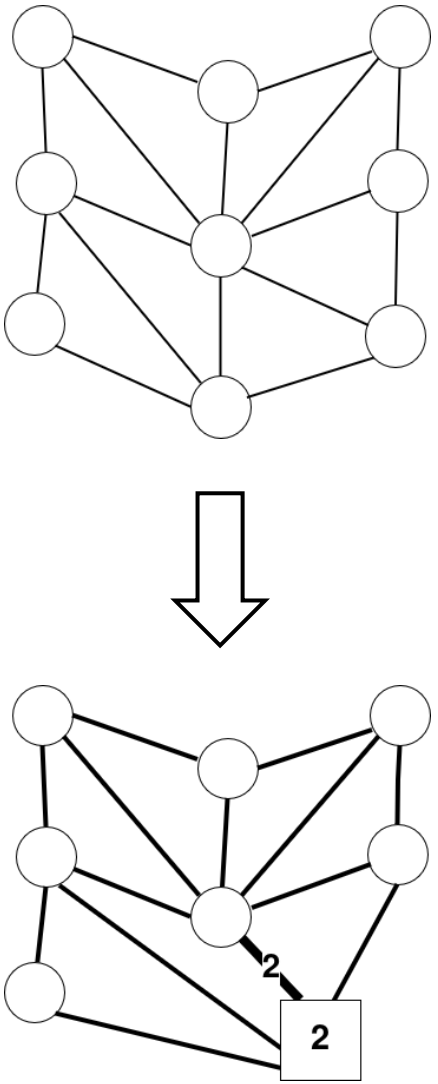
The maximal size of merged nodes needs an upper limit.



Step 3: Partition the coarse graph

Graph weights are integers. Zoltan is therefore no longer necessary.

The coarse graph is smaller and therefore faster to partition.



Implementation in Flow

New Flow Parameters:

--partition-method=zoltanCG
--coarse-partition-threshold: Parameter between 0 and 1.
--coarse-partition-max-node-size: Integer that limits max node size in coarse graph.

Works with other options:

--allow-distributed-wells=true/false
--serial-partitioning=true/false
--edge-weights-method=uniform/transmissibility

Testing new partitioning strategy on two reservoir models

Model	Size (cells)	--coarse-partition-threshold	--coarse-partition-max-node-size
Norne	44431	0.9	100
Black-oil	1 million	0.7	100

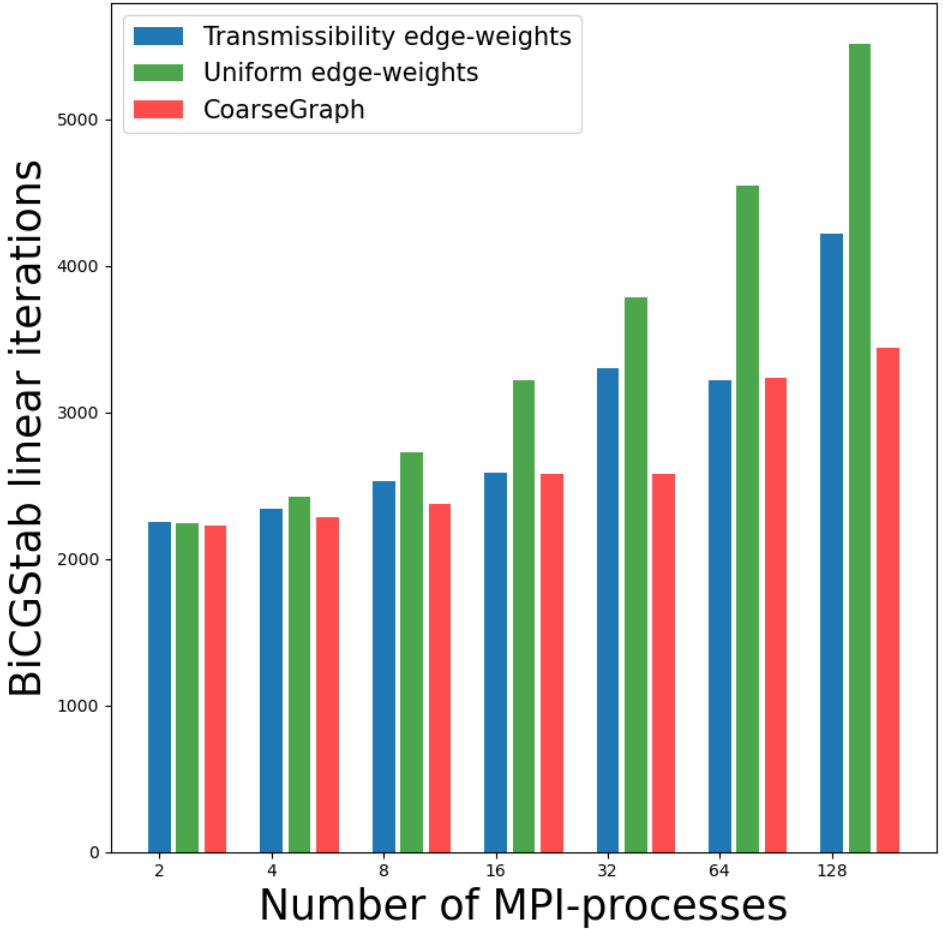
Other parameters:
--allow-distributed-wells=true
--serial-partitioning=true

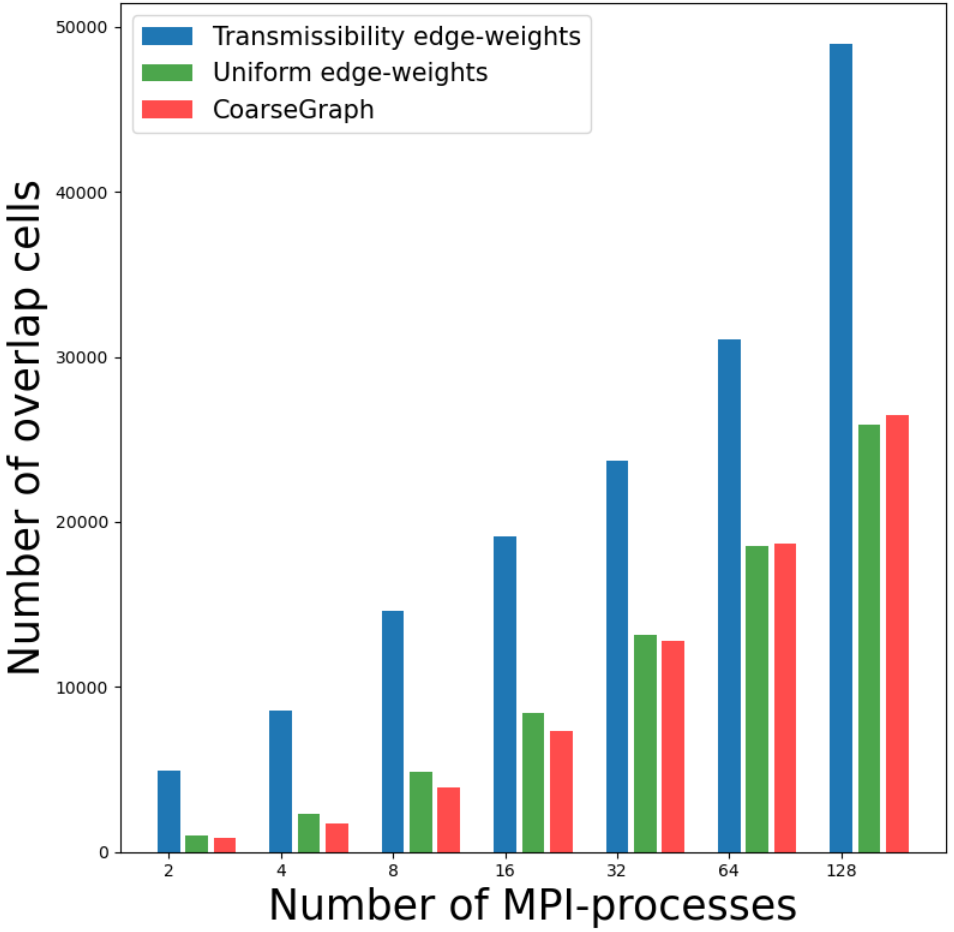
- All others: Default

Hardware:
- Dual Kunpeng920-6428 64 core processor

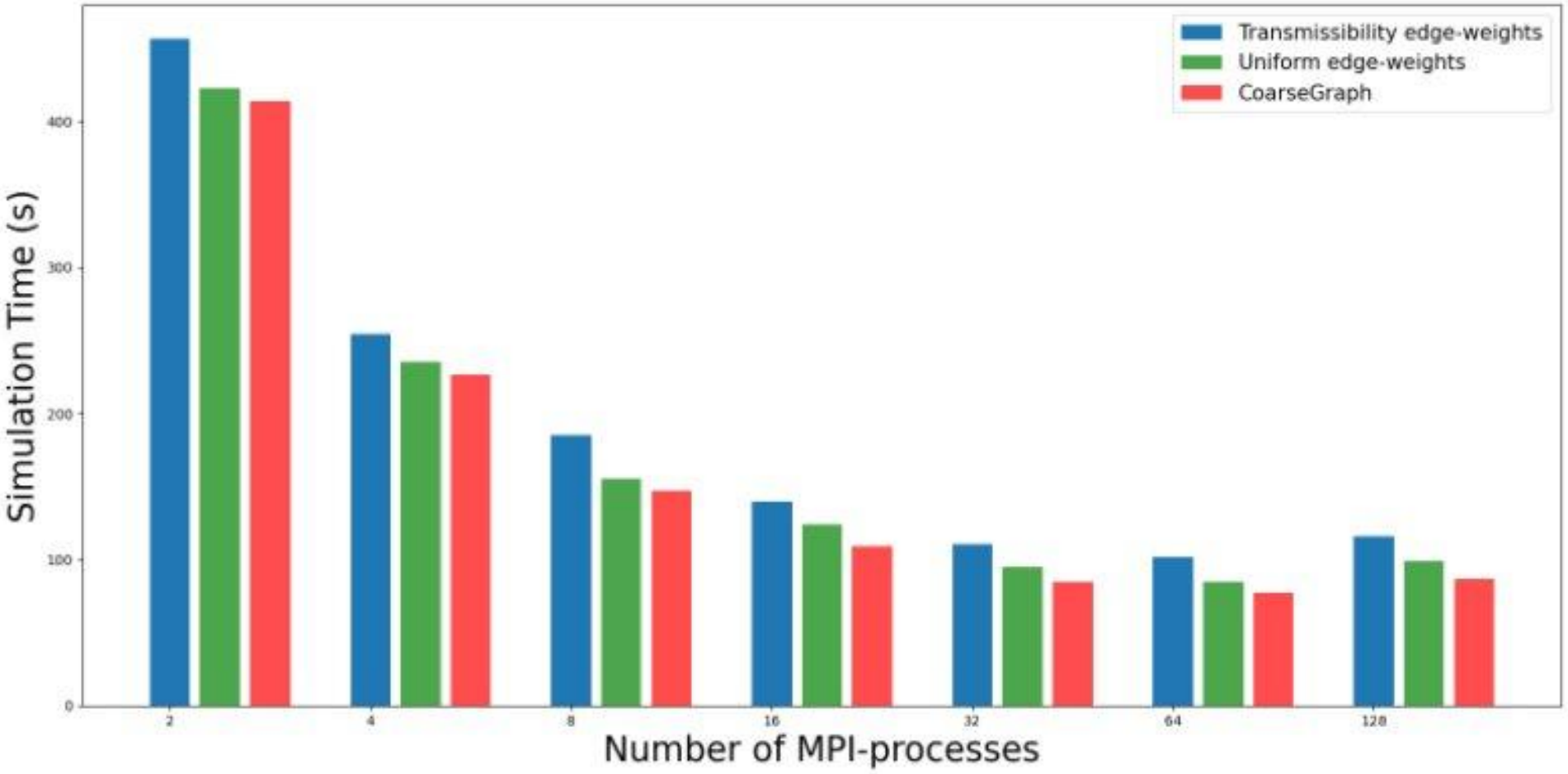
Flow version:
- 2025.10

The new partitioning strategy results in less iterations and better partitioning quality on the Norne model

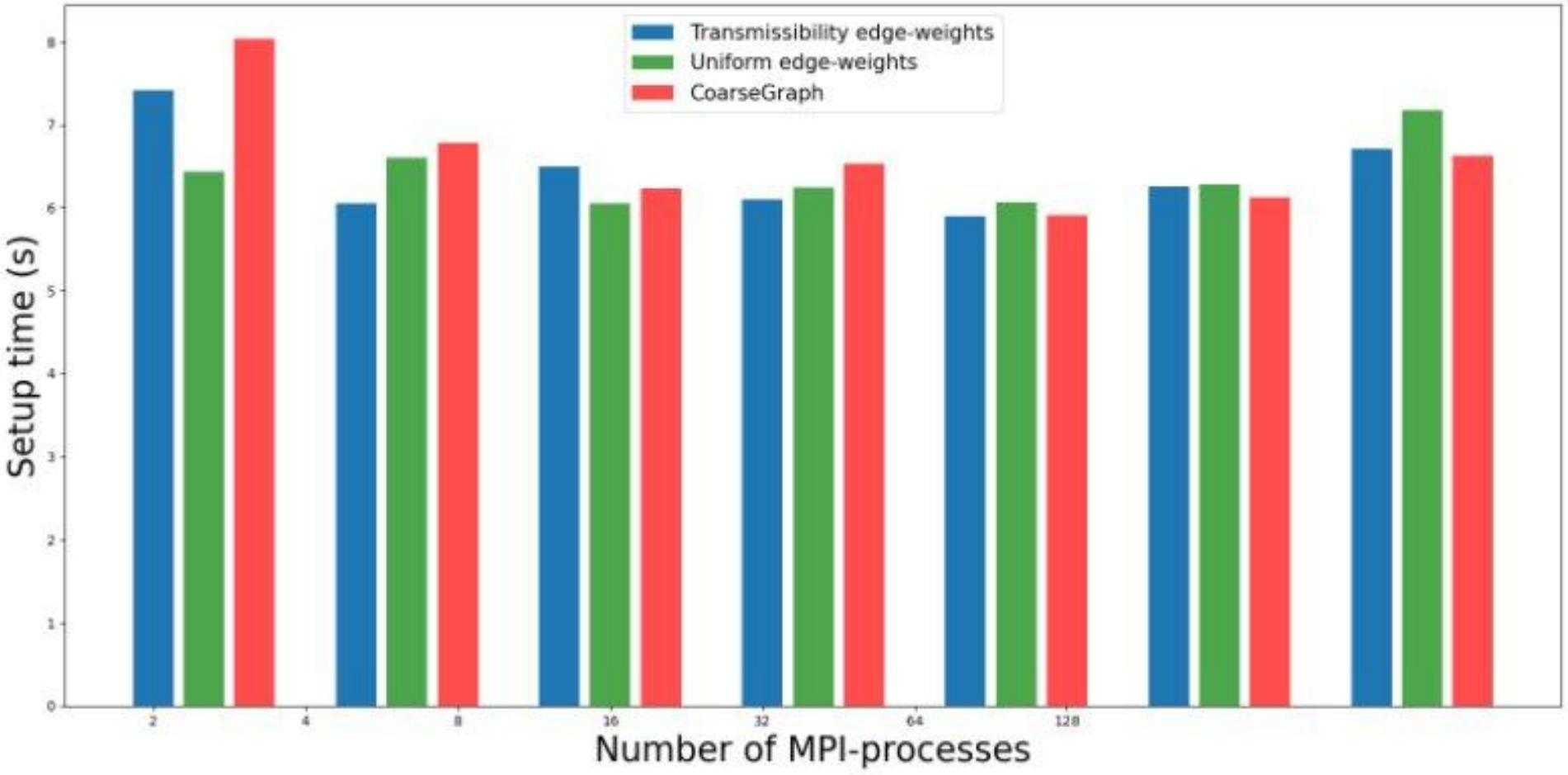




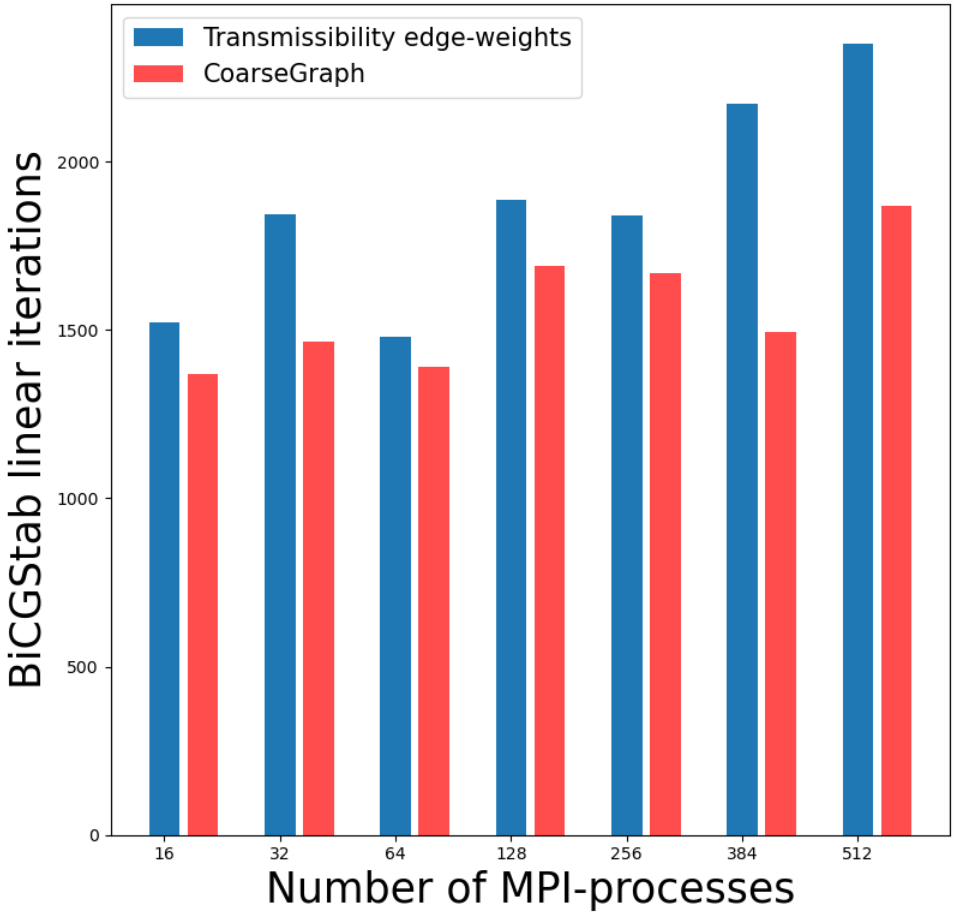
The new partitioning strategy results in lower execution time on the Norne model

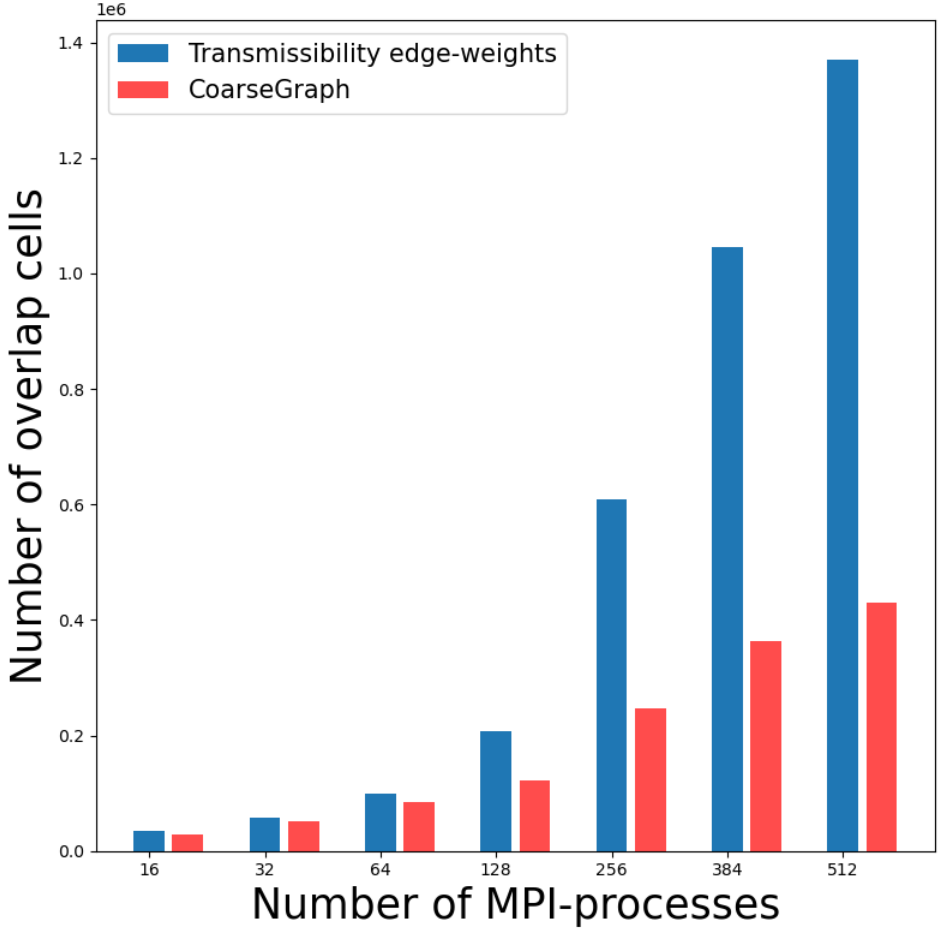


The new partitioning strategy does not increase setup time significantly for the Norne model



The new partitioning strategy results in less iterations and better partitioning quality on the black-oil model





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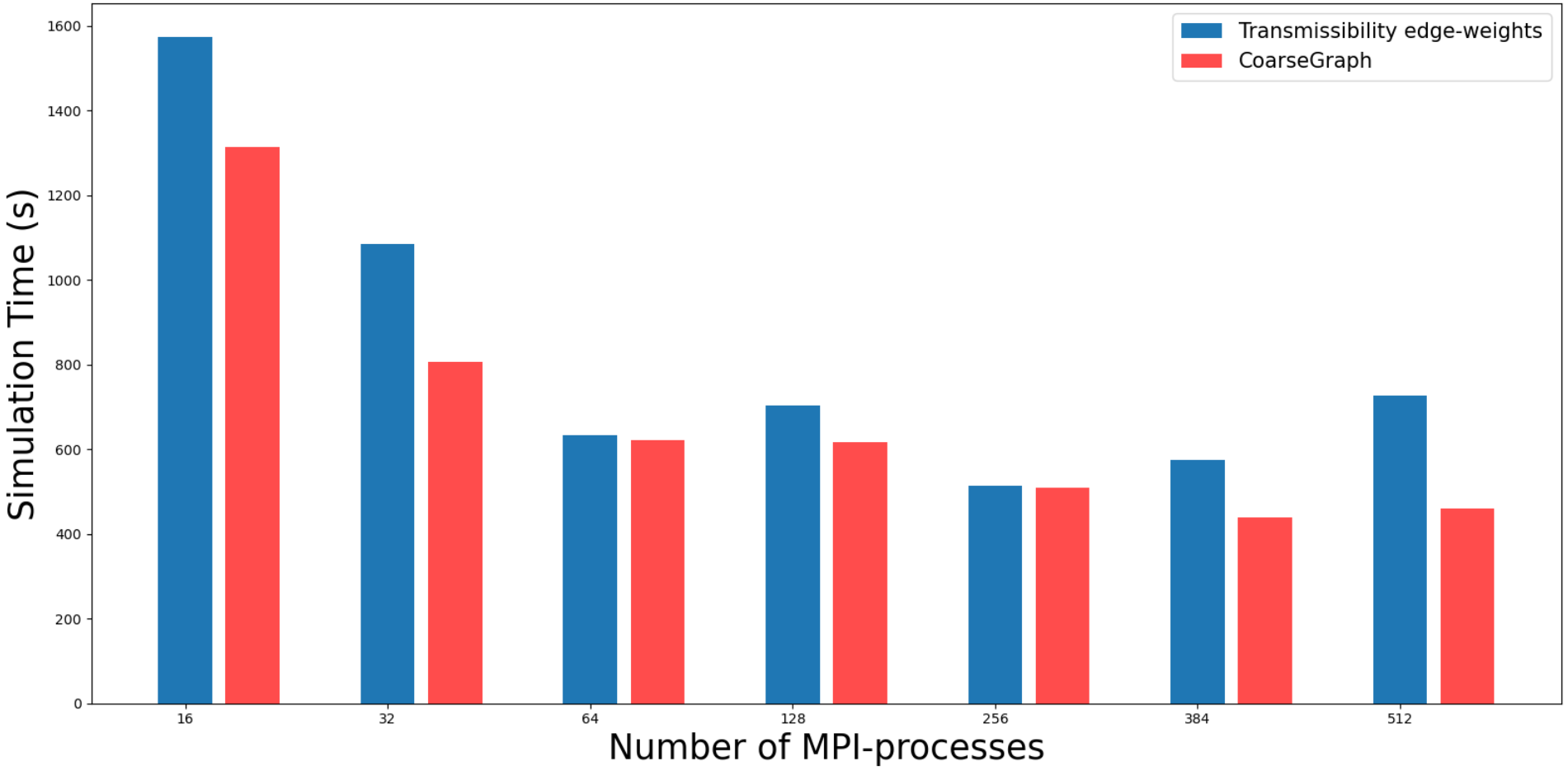
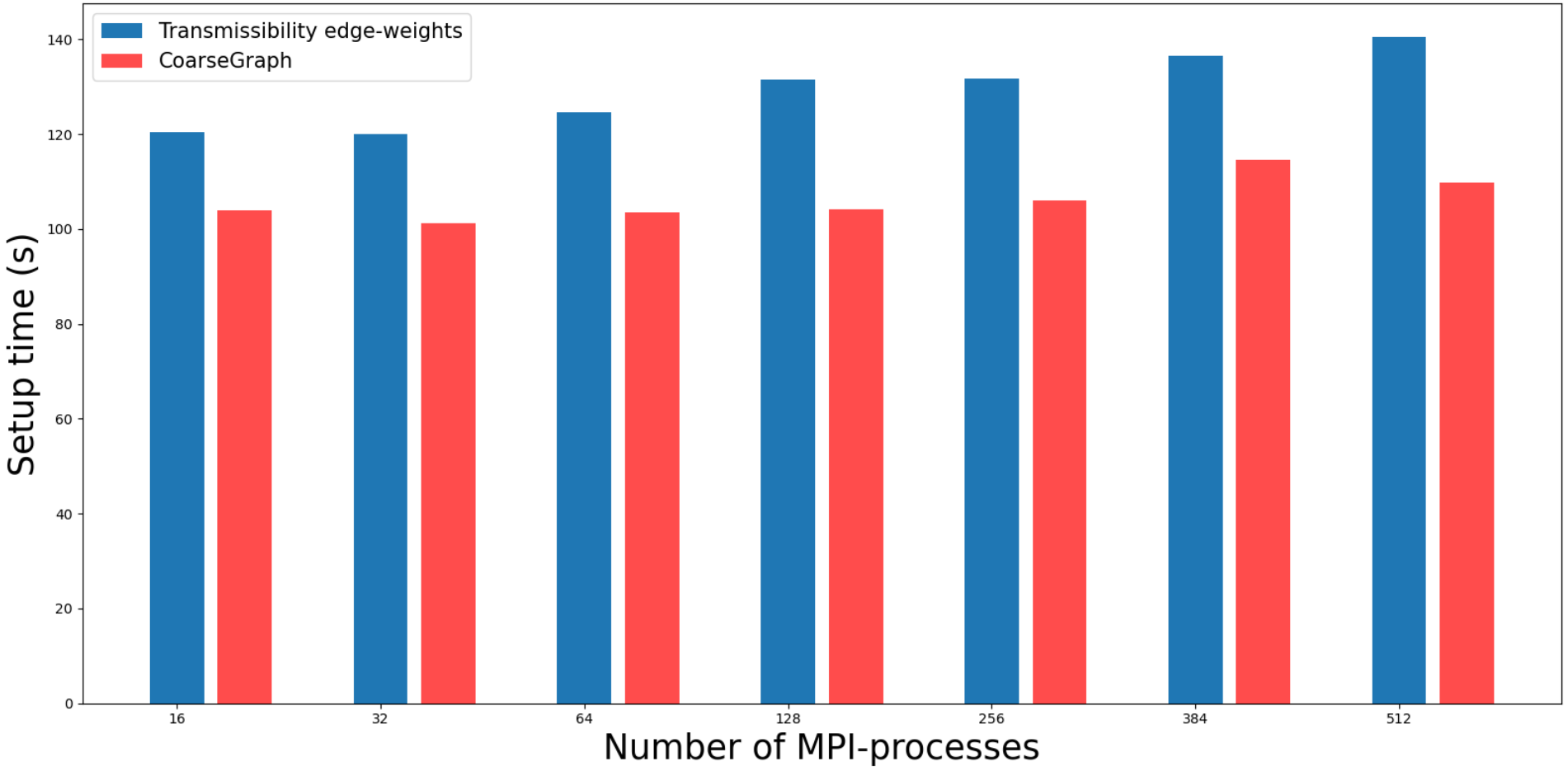


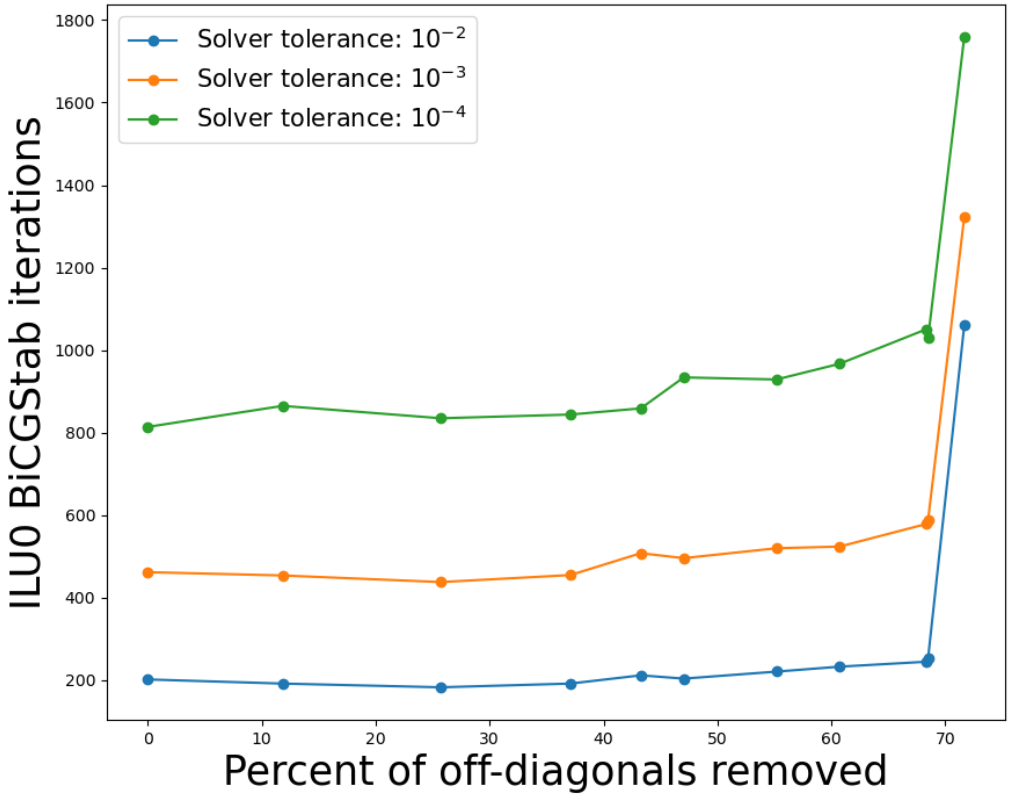
The new partitioning strategy reduces setup time for the black-oil model



Removing off-diagonals associated with the smallest transmissibilities in the preconditioner matrix leads to modest increase in linear iterations for the black-oil model

Experiment:

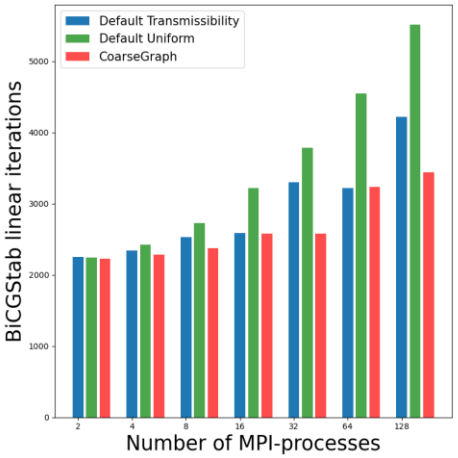
- 10 linear systems.
- Solved with ILU0-preconditioned BiCGstab.
- Remove **X%** of off-diagonals in preconditioner matrix.
- Record iteration count.

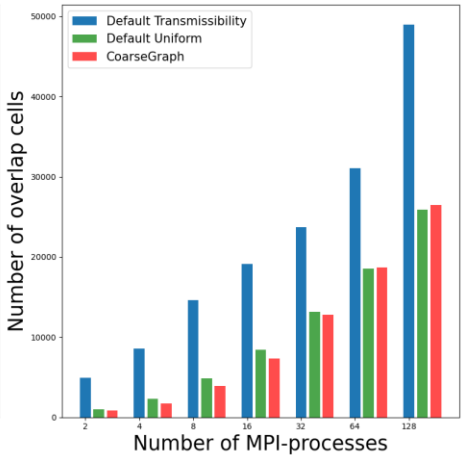


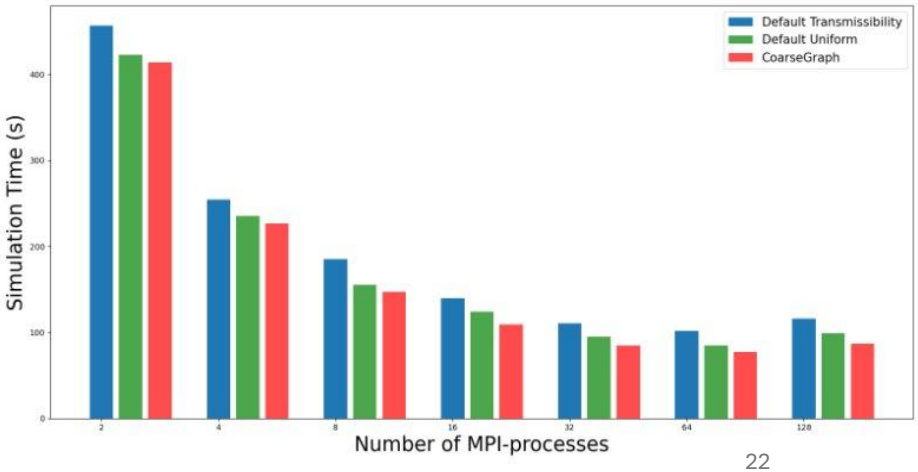
In summary, the transmissibility-based coarse graph partitioning strategy combines communication overhead minimization and heterogeneity-awareness

An alternative partitioning strategy has been implemented and tested.

The new coarse graph partitioning strategy achieves improved parallel performance on relevant reservoir models.







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