Mesh partitioning in presence of strong coefficient heterogeneity

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This presentation focuses on mesh-partitioning in OPM’s Flow reservoir simulator.

Domain decomposition and weighted graph partitioning schemes.

Experiments on alternative strategies.
The current domain decomposition strategy of Flow uses an edge-weighted graph partitioning scheme.
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\[ \Omega \rightarrow G = (V, E) \]
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Graph partitioning problem:

\[ \min_C \sum_{e \in C} 1 \]

\[ |G_1| \approx |G_2|. \]
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Edge cut: 

\[ J(C) = \sum_{e \in C} 1 \]

\( J(C) \) approximates the communication cost.
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Heterogenous geological properties of the reservoir and wells motivates edge-weights in the partitioning scheme.

Transmissibility:

\[ T_{ij} = \left( \frac{1}{t_i} + \frac{1}{t_j} \right)^{-1} \]

\[ t_i = \frac{\vec{c}_i K_i \vec{n}_i}{||\vec{c}_i||^2} \]
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Weighted Edge cut:

\[ J(C) = \sum_{e \in \mathcal{E}} \omega_e \]
A weighting strategy based on cell-face transmissibility yield very heterogenous edge-weights.

Transmissibility weights:
\[ \omega_e = T_e \]

Logarithmic weights:
\[ \omega_e = \log T_e \]

Uniform weights:
\[ \omega_e = 1 \]
The edge-weights have a positive impact on the numerical effectiveness of the simulator.
When considering overall performance the impact of edge-weights are not necessarily positive.
Transmissibility edge-weights results in higher communication volume than logarithmic and uniform edge-weights.
In summary, mesh partitioning greatly effects the parallel performance for problems with heterogeneity.

Including edge-weights in the graph partitioning scheme impacts the numerical performance and the parallel efficiency of Flow.