Preconditioners for large geometries

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A preconditioner accelerates the convergence of iterative methods while solving sparse linear systems. Mostly, these sparse linear systems come from solving Partial Differential Equations (PDE) using the Finite Element Method. This study investigates the performance of 42 different preconditioner methods in order to determine the most suitable preconditioner that solve three PDE cases.

The PDEs chosen in this study calculate four general physical characteristics: Heat Conduction equation, Steady Navier-Stokes equations, Linear Elasticity equations with displacement and pressure boundary conditions.

The Multiphysics Object-Oriented Simulation Environment (MOOSE) framework which is built using PETSc and libMesh, is used to solve the PDEs mentioned. The effectiveness of the calculations depends on the configuration of the input files in where preconditioners are also set.

Different running combinations of preconditioners, PDEs, and units of execution are involved. A variety of setups consisting of OpenMP threads, and Message Passing Interface (MPI) processes to apply parallelisation are also considered to do the benchmarking which is conducted on an HPC-cluster called Cumulus (65 general worker nodes, each one has 32 CPU cores of spec-Intel(R) Xeon(R) CPU E5-2683 v4 @ 2.10GHz; and 512GB of RAM.

All nodes connected to each other via a FDR Infiniband network.).

By performing these benchmarks, we are able to find the execution time, memory usage and accuracy of each combination.

From the compiled data, we are able to find the most efficient preconditioners and parallelisation schemes to simulate alike multi-physic phenomena to solve multiple PDEs.