Towards high throughput composable multilevel solvers for implicit multiphysics simulation

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Location: SZE – JKK Ovális iroda

Abstract: Multiphysics problems present unique challenges for algorithms and software. The best methods are usually not known in advance and change with physical regime, problem size, and available hardware. The presence of disparate temporal scales often demand implicit or semi-implicit time integration. Multilevel methods are necessary for algorithmic scalability, placing new demands on hardware and the components necessary for extensible software. Composable libraries attempt to manage the complex design space by decoupling problem specification and reusable algorithmic components from the composition of a specific algorithm.

Implicit and IMEX solution methods for multiphysics problems are either monolithic (treating the coupled problem directly) or split (solving reduced systems independently). Software for monolithic multigrid is historically more intrusive, requiring a monolithic hierarchy instead of independent hierarchies, but the required number of iterations may be smaller due to coupling on all levels. I will describe tools developed in the PETSc library for composing algebraic solvers, including "multigrid inside splitting" and "splitting inside multigrid" using the same user specification, and application to multiphysics problems in glaciology, geodynamics, and plasma physics. I will also explore variants of methods and future directions for adapting implicit multilevel algorithms to deliver more "science per watt" by better utilizing emerging hardware, for which the relative cost of memory bandwidth and communication is increasing relative to floating point performance.