High-Performance Computing for Flow in Porous Media

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Abstract: Simulation of flow and transport processes in porous media provides a formidable challenge and application field for high-performance computing. Relevant continuum-scale models include partial differential equations of elliptic, parabolic and hyperbolic type which are coupled through highly nonlinear coefficient functions. The multi-scale character and uncertainties in the parameters constitute an additional level of complexity but provide also opportunities for high-performance computing.

This talk will first present an efficient solver for incompressible two-phase flow based on a fully-coupled discontinuous Galerkin approach which is comparable in efficiency (measured in accuracy per computation time) to simple cell-centered schemes but offers the opportunity to increase arithmetic intensity substantially in the assemble stage as well as the solve phase. For the fast solution of the arising linear systems a hybrid preconditioner based on subspace correction in the conforming finite element subspace is employed. Scalability and robustness of this preconditioner for the elliptic model problem and the full two-phase problem is investigated on a moderate number of processors.

In the second part of the talk the efficient implementation of high-order discontinuous Galerkin methods is discussed. Exploiting tensor product structure of basis functions and quadrature on hexahedral grids a substantial reduction in computational complexity can be achieved while at the same time allowing efficient use of SIMD instructions. Results on Intel Xeon and Intel Phi architectures will be presented.

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