Dissertation Defense

Deterministic and stochastic acceleration techniques for Richardson-type iterations

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Abstract: The next generation of computational science applications will require numerical solvers that are both reliable and capable of high performance on projected exascale platforms. In order to meet these goals, solvers must be resilient to soft and hard system failures, provide high concurrency on heterogeneous hardware configurations, and retain numerical accuracy and efficiency. This work focuses on the solution of large sparse systems of linear equations, for example of the kind arising from the discretization of partial differential equations (PDEs). Specifically, the goal is to investigate alternative approaches to existing solvers (such as preconditioned Krylov subspace or multigrid methods). To do so, we consider stochastic and deterministic accelerations of relaxation schemes. On the one hand, starting from a convergent splitting of the coefficient matrix, we analyze various types of Monte Carlo acceleration schemes applied to the original preconditioned Richardson (stationary) iteration. These methods are expected to have considerable potential for resiliency to faults when implemented on massively parallel machines. In this framework, we have identified classes of problems and preconditioners that guarantee convergence. On the other hand, we consider Anderson-type accelerations to increase efficiency and improve the convergence rate with respect to one level fixed point schemes. In particular, we focus on a recently introduced method called Alternating Anderson-Richardson (AAR). We provide theoretical results to explain the advantages of AAR over other similar schemes presented in literature and we show numerical results where AAR is competitive against restarted versions of the generalized minimum residual method (GMRES) for problems of different nature and different preconditioning techniques.

Monday, April 2, 2018, 1:00 pm
Mathematics and Science Center: W306

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