Computational and Applied Mathematics Seminar

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Using multigrid reduction techniques for parallel-in-time integration

ABSTRACT:

The need for parallelizing in the time dimension and, thus, adding an additional layer of parallelism to a numerical algorithm is being driven by the rapid change in computer architectures towards systems with more, but not faster, processors. Future speedups will come through making use of this greater concurrency, not faster clock-speeds, which are stagnant. Various approaches for parallel-in-time integration have been explored resulting in both direct and iterative methods. Multigrid provides for some of the most powerful parallel-in-time approaches because of its optimal algorithmic scaling for both parallel communication and number of operations. The multigrid-reduction-in-time (MGRIT) algorithm which applies multigrid reduction techniques in the time dimension is an approach for exploiting parallelism in the time dimension that is designed to build on existing codes and time integration techniques. The key features of the method are its high degree of parallelism, its non-intrusiveness, and its optimality. Being a full approximation storage (FAS) multigrid scheme, i. e., a nonlinear version of multigrid, the MGRIT algorithm is suitable for solving linear as well as nonlinear problems. The corresponding open source code XBraid is flexible, allowing for a variety of time stepping, relaxation, and temporal coarsening options.

In this talk, we discuss practical and theoretical aspects of the MGRIT algorithm, including its excellent strong and weak parallel scalability, as well as its implementation in the XBraid library. While most of the research on MGRIT is proof-of-concept work with model problems, we also give an overview of the application areas in which MGRIT has demonstrated advantages over classical space-parallel time stepping.