Multigrid Reduction in Time: A flexible and scalable approach to parallel-in-time

†*Jacob B. Schroder[1], R. D. Falgout[1], Tz. V. Kolev[1], U. M. Yang[1], V. Dobrev[1], A. Petersson[1], M. Lecouvez[1], B. O'Neill[2], B. Southworth[2], S. Friedhoff[3] and S. P. MacLachlan[3]

[1]Lawrence Livermore National Laboratory, USA
[2]University of Colorado at Boulder, USA
[3]University of Cologne, Germany
[4]Memorial University, Canada

*Presenting author: schroder2@llnl.gov
†Corresponding author: schroder2@llnl.gov

Abstract

The need for parallel-in-time algorithms is currently being driven by the rapidly changing nature of computer architectures. Future speedups will come through ever increasing numbers of cores, but not faster clock speeds, which are stagnant. Previously, increasing clock-speeds could compensate for traditional sequential time stepping algorithms when the problem size increased. However this is no longer the case, leading to the sequential time integration bottleneck and the need to parallelize in time. In this talk, we examine an optimal-scaling parallel time integration method, multigrid reduction in time (MGRIT) [1, 2, 3]. MGRIT applies multigrid to the time dimension by solving the (non)linear systems that arise when solving for multiple time steps simultaneously. The result is a versatile approach that is nonintrusive and wraps existing time evolution codes. MGRIT allows for various time discretizations (e.g., Runge-Kutta and multistep) and for adaptive refinement/coarsening in time and space. Nonlinear problems are handled through full approximation storage (FAS) multigrid. Some recent theoretical results, as well as practical results for a variety of problems will be presented, e.g., explicit/implicit time integration, nonlinear diffusion and compressible Navier-Stokes.

LLNL-ABS-681149

Keywords: Parallel-in-time, multigrid-reduction-in-time (MGRIT), parareal, multigrid

References

[1] R. D. Falgout, S. Friedhoff, Tz. V. Kolev, S. P. MacLachlan, and J. B. Schroder. (2014) Parallel Time Integration with Multigrid. *SIAM J. Sci. Comput.* **36**, pp.C635-C661. LLNL-JRNL-645325.

[2] R. D. Falgout, A. Katz, Tz. V. Kolev, J. B. Schroder, A. Wissink, U. M. Yang. (2015) Parallel Time Integration with Multigrid Reduction for a Compressible Fluid Dynamics Application. *Lawrence Livermore National Laboratory Technical Report* LLNL-JRNL-663416.

[3] R.D. Falgout, S. Friedhoff, Tz.V. Kolev, S.P. MacLachlan, J.B. Schroder and S. Vandewalle. (2015) Multigrid Methods with Space-Time Concurrency. *SIAM J. Sci. Comput.* (submitted). LLNL-JRNL-678572.