Time-parallelism using inexact PFASST

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The "parallel full approximation scheme in space and time" (PFASST) introduced by Emmett and Minion in 2012 is an iterative, multilevel strategy for the temporal parallelization of ODEs and discretized PDEs. As the name suggests, PFASST is similar in spirit to a space-time FAS multigrid method performed over multiple timesteps in parallel. In benchmarks runs on 448K cores, the space-time parallel combination of PFASST with a parallel multigrid solver (PMG) already showed significantly better strong scaling than the space-parallel code alone.

The key for optimal parallel efficiency in PFASST is a suitable choice of coarsening strategies in space and time. Besides straightforward approaches like reducing the number of degrees-of-freedom and/or integration nodes, recent works focussed on the reduction of the spatial discretization order as well as inexact solves of systems arising in implicit steps on the coarse levels. This last concept can be extended to form an "inexact" PFASST algorithm (IPFASST), in which also on the finer levels only a limited number of multigrid cycles is performed. The iterative nature of IPFASST provides continuously improving initial guesses in each iteration, so that full solves can be replaced by inexact approximations of the solutions of the implicit systems on all levels, leading to significantly improved runtimes.

In this talk we present optimality and scalability results for a 3D heat equation benchmark. Along the building blocks of IPFASST, i.e. inexact single- and multi-level spectral deferred corrections, we demonstrate the impact of inexact solves and different coarsening strategies. In addition, we describe the extension of the code for the 3D viscous Burgers equation and show first results.