Distributed Parallel–Adaptive Implementation of Asynchronous Spacetime Discontinuous Galerkin Methods with Application to Seismic Simulation

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Abstract

The asynchronous Spacetime Discontinuous Galerkin (aSDG) method [1] is a powerful solution scheme for hyperbolic systems. It features unconditional stability, conservation over every spacetime cell, linear computational complexity, and support for arbitrarily high-order elements. However, its most promising advantages are compatibility with an extremely powerful and dynamic form of adaptive spacetime meshing and a highly favorable algorithmic structure for parallel computation. Serial adaptive aSDG solvers typically outperform conventional solvers running in parallel on large clusters, especially for multi-scale problems or problems with rapidly evolving domain geometry; cf. recent work on dynamic fracture [2]. Recent success with parallel–adaptive implementations on shared memory platforms bodes well for a more ambitious implementation intended for large-scale distributed supercomputers. In particular, the asynchronous and latency-tolerant features of our parallel–adaptive software architecture might be particularly well suited for implementation on exascale platforms.

This presentation describes the architecture and initial results from our work on a distributed parallel–adaptive aSDG implementation. We begin with a review of the design of our shared-memory implementation, emphasizing our reasons for abandoning the domain decomposition method and introducing a round-robin strategy for parallel task assignment. Then we describe various modifications required to extend our strategy to distributed systems, including nested round-robin schemes for multi-host platforms. We present preliminary performance and scaling efficiency studies and demonstrate an application of the parallel–adaptive aSDG method to a seismic simulation problem in which we model off-fault damage as a random field of explicit small-scale fractures. This approach is expected to deliver physically more realistic behaviour than typical smeared models in which, for example, a continuum plasticity model represents the bulk response of damaged rock. We close with a discussion of directions for continuing development, including integration of our parallel code with new spacetime meshing capabilities for problems defined in 3d×time.

References:

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