Extending adaptive sparse grids for stochastic collocation to hybrid architectures

Advanced Dynamically Adaptive Algorithms for Stochastic Simulations on Extreme Scales

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Abstract

We are developing an adaptive sparse grid library tailored for emerging architectures that will allow the solution of very large stochastic problems. Fundamental to this research is the extension of mature mathematics from the academic study of stochastic simulations into algorithms that can enable uncertainty quantification for realistic complex systems of large scales. New algorithms have been built that decouple the hierarchal structure of sparse grid generalized polynomial chaos so that expansion coefficient generation and interpolation operations can be done using fast methods that are independent of the ordering of sparse grid data. These algorithms fit well into an architecture that streams computation through a memory hierarchy in single instruction multiple thread (SIMT) execution mode. We demonstrate the scaling properties of our SIMT algorithms for coefficient transformation and interpolation code for non-adapted sparse grids across a hybrid 16-node system using a MPI plus CUDA parallelization approach. We show how these algorithms can be incorporated into our prototype implementation of a serial adaptive sparse grid library for both bounded and unbounded sparse grids, thereby extending this library to hybrid node systems.