Parallel, adaptive finite volume methods for mapped, multi-block domains

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Finite volume methods are widely used in applications for which the numerical discretization of the underlying model equations should exactly conserve mass, momentum, energy and other physical quantities whose evolution is governed by conservation laws. Discretizations of finite volume schemes on smooth, logically Cartesian grids is straightforward, and can have superior accuracy properties over more general unstructured meshes. However, uniform Cartesian meshes can be prohibitively expensive, especially in situations where the interesting dynamics occurs only in a fraction of the domain. In these cases, we wish to locally adapt the uniform grids to regions of interest.

In this talk, I will describe the ForestClaw project, a parallel adaptive code for finite volume methods in mapped, multiblock domains. Unlike traditional patch-based algorithms for mesh adaptation, ForestClaw uses adaptive quadtrees and can therefore take advantage of the regularity of the quadtree layout, making applications much simpler to develop. We can also take advantage of the high performance capabilities of our underlying quadtree code, making it possible to run on thousands of processors. I will describe the underlying parallel, multi-rate time stepping algorithm developed for this quadtree approach and provide examples from areas of natural hazards modeling, including the transport of volcanic ash, and tsunami modeling using the shallow water wave equations. Comparisons with an existing adaptive code AMRCLaw (LeVeque, et al.) based on the traditional patch-based algorithm will also be shown.

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