Parallel Adaptive Mesh Refinement on Overlapping Grids

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Adaptive mesh refinement (AMR) is a technique that adds fine grid patches to regions of the computational domain where more resolution is needed such as near shocks and detonations. AMR can dramatically speed up a computation and/or enable simulations with a much higher effective resolution compared to uniformly refining the grid. Overlapping grids (also known as Chimera or overset grids) are used as a flexible approach to cover a complex geometry with a set of overlapping structured grids. In recent work (Henshaw and Schwendeman, JCP, 2008) we have developed the capabilities for parallel adaptive mesh refinement on overlapping grids. The parallel AMR components have been developed as part of the Overture software toolkit. The parallel implementation is flexible so that each base grid within the overlapping grid structure and its associated refinement grids can be independently partitioned over a chosen set of processors. A modified bin-packing algorithm is used to specify the partition for each grid so that the computational work is evenly distributed amongst the processors. All components of the AMR algorithm such as error estimation, regridding, and interpolation are performed in parallel. The parallel AMR time-stepping algorithm is validated by solving a simple linear advection-diffusion equation and the (nonlinear) reactive and non-reactive Euler equations. Numerical results are presented for both equations to demonstrate the accuracy and correctness of the parallel approach. The problem of planar shock diffraction by a sphere is considered as an illustration of the numerical approach for the Euler equations and a problem involving the initiation of a detonation from a hot spot in a T-shaped pipe is considered to demonstrate the numerical approach for the reactive case.