A multi-GPU accelerated solver for the three-dimensional two-phase incompressible Navier-Stokes equations

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The use of graphics hardware for general purpose computations allows scientists to enormously speed up their numerical codes. We presently investigate the impact of this technology on our computational fluid dynamics solver for the three-dimensional two-phase incompressible Navier-Stokes equations, which is based on the level set technique and applies Chorin's projection approach. To our knowledge, this is the first time, that a two-phase solver for the Navier-Stokes equations profits from the computation power of modern graphics hardware. As part of our project, a Jacobi preconditioned conjugate gradient solver for the pressure Poisson equation and the reinitialization of the level set function of our CPU based code were ported to the graphics processing unit (GPU). They are implemented in double precision and parallelized by the Message Passing Interface (MPI). We obtain speedups of 16.2 and 8.6 for the Poisson solver and the reinitialization on one GPU in contrast to a single CPU. Our implementation scales close to perfect on multiple GPUs of a distributed memory cluster. This results in excellent speedups of 115.8 and 53.7 on eight GPUs of our cluster. Furthermore our whole multi-GPU accelerated solver achieves an impressive speedup of 69.6 on eight GPUs/CPUs.
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