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Many-core parallelization of AMG*

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Abstract

We developed our algebraic multigrid solvers (AMG) with special focus on cardiac electromechanics with the goal of simulating one heart beat as fast as possible. The overall systems consist of the bidomain equations (elliptic + parabolic pde, non-linear coupling via an ode system) [2] coupled with non-linear elasticity. The simulation bases on unstructured 3D meshes with anisotropic, inhomogeneous material coefficients. Besides choosing the AMG components such that the overall runtime is minimized, we needed a highly efficient MPI + OpenMP parallelization with an additional acceleration on GPUs. The presentation will focus on all the little improvements necessary to achieve very good strong speedup on 4096 CPU cores [1] such that one coupled system with 11 Mill. degrees of freedom can be solved in less than one second. The parallelization for many-core processors as NVIDA GPUs results in further speedup between 5 and 30 depending on the subtasks. In order to reduce the data transfer between accelerator memory and CPU memory in the non-linear solvers, we had to redesign the interfaces and data structures in the whole medical simulation code according to plain data structures and flexible solver steps. Although this parallelization has been done in CUDA [2] the future development will use pragma driven parallelization in OpenACC (GPU) and/or OpenMP 4.0 (Intel Xeon Phi) in order to have one code for all current (and future) many-core hardware.

Key words: many-core parallelization, algebraic multigrid, bidomain equations, elasticity

Mathematics subject classifications (2010): 65N55, 65Y10, 74-04, 65F08

References

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