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A robust geometric multigrid solver within the WaLBerla framework

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Recently, more and more GPU HPC clusters are installed and thus there is a need to adapt existing software design concepts and algorithms to multi-GPU environments. We have developed a modular and easily extensible software framework called WaLBerla working on block-structured domains. It covers a wide range of applications ranging from particulate flows over free surface flows to nano fluids coupled with temperature simulations and medical imaging.

In this talk we report on our experiences to extend WaLBerla in order to support geometric multigrid algorithms for the numerical solution of partial differential equations (PDEs) on multi-GPU clusters. As building blocks we use a damped Jacobi or red-black Gauss-Seidel smoother, collocation coarse approximation (CCA) to compute the coarse grid stencils and standard or matrix-dependent intergrid transfer operators. CCA allows us to force a certain size of the coarse grid stencil and coincides with Galerkin coarsening, if both have the same number of stencil entries.

We discuss the object-oriented software and performance engineering concepts necessary to integrate efficient compute kernels into our WaLBerla framework and show that a large fraction of the high computational performance offered by current heterogeneous HPC clusters can be sustained for geometric multigrid algorithms.