COMPUTATIONAL GAS DYNAMICS IN A WIDE RANGE OF MACH NUMBER ON HETEROGENEOUS CLUSTER ARCHITECTURE

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The specific features of numerical method for gas dynamics problems are considered in this paper. The viscous flows are considered in a wide range of Mach number. The numerical method is based on conservation laws applied on unstructured heterogeneous mesh with further integration on complex cluster architectures. Mesh generating software is non-commercial GPL-licensed, namely GMSH and Salome. Boundary layers are meshed by prisms or with hexahedra with further adaptation to tetrahedral using prisms. Application of unstructured mesh allows one to perform calculation of geometrically complex 3D objects with strict conservation properties, unlike immersed boundary methods. The developed numerical method includes multiple flux solvers (Godunov’s, HLLC, Roe-Fix, AUSM, etc.), first and second order spatial approximation, explicit, semi-implicit or implicit first order time schemes. The heterogeneous computational environment developed by the authors is used in order to perform computations. The program is written for heterogeneous cluster architecture under UNIX OS using OOP C++ with CUDA extension. The main computational module is an NVIDIA GPU. Main advantage of the GPU utilization is the increase of the efficiency of a single computational module, thus greatly decreasing load on the cluster’s interconnect. A wide range of problems is used for verification of the developed computational complex. Subsonic internal swirling flow in a pipe and hypersonic flow problems with different body shapes are considered. All results on these problems had a good agreement with reference data. Benchmarking performance was conducted on subsonic and hypersonic problems, the lesser result was chosen. Explicit method has almost linear acceleration on 5 GPUs. Fully implicit method has 76% of linear acceleration on the same 5 GPUs cluster. The performance of implicit method on five GPUs is about 3.4 TFLOPS, estimated by the nvprof program.