Parallel monolithic implicit solver for compressible flows

Mariano Vázquez[*,†], Marta Pérez Larrañaga[*], Margarida Moragues[*] and Guillaume Houzeaux[*]

[*] Barcelona Supercomputing Center
Nexus I – Campus Nord UPC – Barcelona - Spain
mariano.vazquez@bsc.es - http://www.bsc.es

[†] IIIA - CSIC
Univ. Autonoma de Barcelona - Bellater
http://www.iiia.csic.es

ABSTRACT

This paper introduces a monolithic compressible flow implicit scheme, capable of scaling up to a few thousand processors. The scheme is programmed in Alya, the BSC in-house code for simulating multi-physics problems in supercomputers [1,2,3]. It is monolithic, assembling a global matrix for the delta form of the conservative unknowns linear momentum, density and total energy and solving the resulting linearized system. The linearized system is solved using a preconditioned GMRES iterative scheme. The non-linearity of the compressible Navier-Stokes set is sorted out using Newton-Raphson iterations, where the gradient of the discretized residual is computed analytically, including the stabilization terms. The space discretization scheme is based on the Finite Element Method, stabilized using a Variational Multiscale (VMS) method for compressible flows [4]. The paper assess several aspects of the strategy proposed, such as: GMRES preconditioners (RAS, Diagonal, linelet), low-Mach and supersonic behavior, high-aspect ratio meshes or local preconditioners (Van Leer, Choi - Merkle). This last point specially considered, showing the scheme's performance when the equations are stabilized using a Preconditioned VMS (PVMS) method [5]. Parallel scalability is assessed in a series of runs for tens of thousands MPI tasks for large-scale 3D problems.

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