A research published in the Journal of Computational Physics was executed at the BSC

Barcelona, 29 June 2011.-*Parallel direct Poisson solver for discretisations with one Fourier diagonalisable direction* is the title of the research which counted with the collaboration of the the Barcelona Supercomputing Center (BSC). All the numerical tests presented in this paper have been carried out on the MareNostrum supercomputer of the BSC.
R. Borrell, O. Lehmkuhl, F. X. Trias and A. Oliva, from the Heat and Mass Transfer Technological Center (CTTC) of the Polytechnic University of Catalonia (UPC), are the authors of this paper published in the Journal of Computational Physics. In the context of time-accurate numerical simulation of incompressible flows, a Poisson equation needs to be solved at least once per time-step to project the velocity field onto a divergence-free space. Due to the non-local nature of its solution, this elliptic system is one of the most time consuming and difficult to parallelise parts of the code. In this paper, a parallel direct Poisson solver restricted to problems with one uniform periodic direction is presented. It is a combination of a direct Schur-complement based decomposition (DSD) and a Fourier diagonalisation. The latter decomposes the original system into a set of mutually independent 2D systems which are solved by means of the DSD algorithm. Since no restrictions are imposed in the non-periodic directions, the overall algorithm is well-suited for solving problems discretised on extruded 2D unstructured meshes. The load balancing between parallel processes and the parallelisation strategy are also presented and discussed. The scalability of the solver is successfully tested using up to 8192 CPU cores for meshes with up to 10^9 grid points. Finally, the performance of the DSD algorithm as 2D solver is analysed by direct comparison with two preconditioned conjugate gradient methods. For this purpose, the turbulent flow around a circular cylinder at Reynolds numbers 3900 and 10,000 are used as problem models.

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