H-MATRIX SOLVER APPLIED TO COUPLED FEM-BEM AEROACOUSTICS SIMULATIONS

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Abstract. Wave propagation phenomena intervene in many different aspects of systems design at Airbus. They drive the level of acoustic vibrations that mechanical components have to sustain, a level that one may want to diminish for comfort reason (in the case of aircraft passengers, for instance) or for safety reason (to avoid damage in the case of a payload in a rocket fairing at take-off). Numerical simulations of these phenomena plays a central part in the upstream design phase of any such project. Airbus Central R&T has developed over the last decades an in-depth knowledge in the field of Boundary Element Method (BEM) for the simulation of wave propagation in homogeneous media and in frequency domain. To tackle heterogeneous media (such as the jet engine flows, in the case of acoustic simulation), these BEM approaches are coupled [1] with volumic finite elements (FEM). We end up with the need to solve large (several millions unknowns) linear systems of equations composed of a dense part (coming for the BEM domain) and a sparse part (coming from the FEM domain). In collaboration with Inria Bordeaux Sud-Ouest, we have implemented a task-based H-matrix [2] solver on top of the runtime engine StarPU [3]. This solver provides excellent parallel performance when dealing with BEM dense matrices (a sequential version is available as open-source [4]). It has been recently extended to FEM sparse matrices, using ideas coming from the field of sparse direct solvers (such as nested dissection or symbolic factorization), allowing us to treat large coupled FEM-BEM linear systems using the same methods for both the dense and the sparse matrices. We expect that these advances will permit to tackle the simulation of aeroacoustics problems at the highest acoustic frequencies (between 5 and 20 kHz, upper limits of human audition) while considering the whole complexity of geometries and phenomena involved.

Keywords: Wave propagation, Linear Algebra, H-matrix, Task-based Programming, Parallelism, HPC.

Mathematics Subject Classifications (2010): 76Q05, 78M10, 78M15.

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