Preconditioned Krylov subspace methods for solving high-frequency cavity problems in electromagnetics

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The numerical solution of Maxwell's equations in large unbounded domains may be carried out using the boundary element method, which reformulates Maxwell's equations as a set of integral equations defined on the surface of the scattering object. Method of Moments discretizations of boundary integral equations lead to very large dense linear systems. Fast iterative methods and robust preconditioning are mandatory to use for the solution.
In this talk we discuss the design of efficient preconditioned Krylov methods for this problem class. We cover numerical linear algebra aspects such as the choice of the iterative solver, the design of algebraic preconditioners including sparse approximate inverses, inverse-based multilevel incomplete factorization techniques, inner-outer schemes, symmetry-preserving strategies both for the iterative solver and for the preconditioner. We also present the characteristics of the parallel Multilevel Fast Multipole Algorithm (MLFMA) that we used. These numerical linear algebra tools have enabled us modelling a full aircraft and a tank on a moderate number of processors. The type of computation required makes it an ideal paradigm for large-scale scientific computing in general, as large amounts of data are handled, storage is often a limiting factor, codes may be very complicate, a hierarchy of parallelism is exhibited, and only algorithms with linear or almost linear numerical complexity are well suited to achieve the peak performance of modern computer systems. Identifying the best class of method with respect to good scalability with respect to the frequency of the problem, inherently parallelism, numerically stability is still an open research issue.