Direct Domain Decomposition Method Finite Element Boundary Element Hybrid (D^3M-FEBE)

Nash Lochner and Marinos N. Vouvakis
Department of Electrical and Computer Engineering,
University of Massachusetts, Amherst, MA, 01003, USA

Finite Element Boundary Element (FEBE) hybrids aim to combine FEM's versatility in modeling complicated structures and materials with the BEM's innate ability to model unbounded fields. Unfortunately, the linear resultant system of equations is harder to solve because of the different nature of the unknown quantities i.e. both fields and currents. This leads to conditioning problems that without resorting to elaborate preconditioning method, it ultimately slows-down the hybrid .

Among others, a remedy to this problem is to eliminate the FEM unknowns by invoking the Schur-complement of the FEM submatrix (outward looking formulation). This corresponds to forming the interior (FEM) numerical Dirichlet-to-Neumann (DtN) Map, and then combining it to the exterior integral equation typically EFIE or CFIE. Because the Schur-complement is evoked (which could be thought of as a form of preconditioner), the conditioning of the resultant system is better. Computing the interior numerical DtN map amounts to inverting or factorizing the FEM matrix which can be efficiency done only for small to moderate size problem. For large problems very good memory efficient direct sparse matrix solver is needed.

Recently, our group has shown that direct solvers for general FEM electromagnetic computations can be produced with the direct domain decomposition methods (D^3M). D^3M was found to outperform state-of-the-art 'black-box' direct solver libraries in terms of memory and parallel speed-up (J. Moshfegh D. Makris and M. N. Vouvakis, Direct domain decomposition method (D3M) for finite element electromagnetic computations, 2016 IEEE (APSURSI)) . It is the aim of this paper to use those efficient D^3M solver to obtain (via factorization and forward-backward substitution) the interior (FEM) numerical DtN map of the FEBE hybrid. The method will be formulated for 2D and 3D unbounded problems with complex metallic and dielectric geometers. Efforts that employ both geometry and mesh partitioning will be undertaken. Results on canonical but also more complex problems will be presented.