A Coupled DD-FEM and ADM/CG-FFT BEM for Antenna Arrays

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Finite Element Method-Domain Decomposition (FEM-DD) methods have been proven very efficient and effective numerical techniques for the analysis of Maxwell's equations. Among other advantages, it suffices to stress their parallelization ability, ability to systematically couple different numerical methods into hybrid schemes, efficient exploitation of geometrical redundancies and symmetries, and relaxing meshing and adaptive meshing strategies. On the other hand, in light of the recent fast integral equation developments, see for example MLFMA, AIM, p-FFT, etc., Boundary Element Methods (BEM) are best suited for the fast analysis of unbounded problems.

This paper attempts to modularly couple the two approaches, FEM-DD & BEM. The result is a very robust, accurate and efficient method for unbounded electromagnetic problem analysis. The method is extremely efficient when repeating structures are involved in the computational domain. The FEM-DD is coupled with BEM using DD concepts. In other words, the FEM-DD and BEM coupling are viewed as another domain level in the domain decomposition. Overall, this is a 2-level DD where the inner level of the DD is the FEM-DD and the outer level DD is the coupled FEM-DD and BEM problem. The method is non-conforming, thus it allows for maximum exploitation of geometry repetitions, local adaptation schemes and efficient structured BEM solvers. For example, because the FEM and BEM meshes are non-conforming, we propose using a regular quadrilateral discretization for the BEM mesh that can be accelerated using a highly-efficient CG-FFT approach. For structures with repeating elements, the Array Decomposition Method (ADM) will be combined with CG-FFT to further reduce the computational cost. In essence, the discretized BEM apertures can be treated as the efficient interaction of multiple structures, which can in turn be accelerated using a multi-dimensional FFT framework. Overall, the method is variational and free of internal resonances. Various solutions strategies will be proposed.

New results of the coupled FEM-DD and BEM will be given. Comparisons with other methods, convergence curves, and computational statistics will be presented in order to demonstrate the accuracy, efficiency, and versatility of the method. Results on challenging real-world radiation and scattering problems such as very large antenna arrays will be presented as well.