

Domain Decomposition in Scattering and Radiation Applications Based on Higher Order FEM-MoM Modeling

Milan M. Ilic¹, Branislav M. Notaroš² and Dragan Olcan³

¹University of Belgrade/Colorado State University

²Colorado State University

³University of Belgrade

The growing demand for full-wave computational tools that can handle simulations of larger and more complex electromagnetic (EM) problems has recently led to rapid development of novel domain decomposition (DD) algorithms. These algorithms allow splitting of the original, large, problem into a number of smaller ones, which can be analyzed independently, and then stitched together by some sort of local or integral boundary conditions, yet yielding in the process a rigorous solution of Maxwells equations for the problem. This way, the computational burden can be tremendously reduced. Among a variety of possible and existing DD algorithms, we address those based on the three-dimensional (3-D) finite element method (FEM) in the frequency domain. The FEM very efficiently deals with problems consisting of inhomogeneous and complex objects. When coupled with a boundary integral (BI) technique, which introduces an exact termination to numerically truncate and close the FEM computational domain, it yields powerful and versatile FE-BI hybrids, e.g. (Li and Jin, *IEEE Trans. AP*, Vol. 49, No. 12, 2001). Some algorithms explicitly combine FEM volumetric modeling with solutions of surface integral equations (SIEs) based on the method of moments (MoM), e.g., (Ilic, Djordjevic, Ilic, and Notaroš, *IEEE Trans. AP*, Vol. 57, No. 5, 2009), and such hybrids are hence referred to as FEM-MoM techniques. However, all existing, hybrid and other, FEM-based DD tools appear to be low-order (small-domain) techniques. In general, it is well established that the higher order (large-domain) computational approach, which utilizes higher order field/current basis functions defined on large curvilinear geometrical elements can substantially enhance the accuracy and efficiency of EM modeling.

In this work, we demonstrate the applicability of our novel higher order hybrid finite element method-method of moments (FEM-MoM) domain decomposition method for (3 D) EM modeling of antennas and scatterers (Ilic and Notaroš, *IEEE AWPL*, Vol. 8, 2009). We introduce some novel extensions of the method which include even more effective partitioning. The new DD method incorporates our previous work in the hybrid FEM-MoM methodology (Ilic, Djordjevic, Ilic, and Notaroš, *IEEE Trans. AP*, Vol. 57, No. 5, 2009), where a hybridization of FEM and MoM techniques, both in the framework of the higher order large-domain modeling, is reported.

A characteristic example, out of a variety of scattering and radiation application examples to be presented, is a 2-D finite array of lossless coated cubical dielectric scatterers. We analyze the monostatic radar cross section (RCS) of the array as a function of frequency. The results obtained by the higher order FEM-MoM-DD are compared with the reference MoM solution (Djordjevic and Notaroš, *IEEE Trans. AP*, Vol. 52, No. 8, 2004). We observe that the higher order hybrid FEM-MoM-DD solution accurately matches the reference MoM solution, and that it quickly converges when the structure is p-refined and the number of unknowns increased. The new method requires approximately 63% less memory and 74% less computational time than the reference MoM solution in this example, while maintaining the same accuracy throughout the complete given frequency span.