Solving Very Large Scattering Problems Using a Parallel PWTD-Enhanced Surface Integral Equation Solver

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The computational complexity and memory requirements of multilevel plane wave time domain (PWTD)-accelerated marching-on-in-time (MOT)-based surface integral equation (SIE) solvers scale as $O(N_t N_s \log^2 N_s)$ and $O(N_s^{1.5})$; here N_t and N_s denote numbers of temporal and spatial basis functions discretizing the current [Shanker et al., *IEEE Trans. Antennas Propag.*, 51, 628-641, 2003]. In the past, serial versions of these solvers have been successfully applied to the analysis of scattering from perfect electrically conducting as well as homogeneous penetrable targets involving up to $N_s \approx 0.5\times10^6$ and $N_t \approx 10^3$. To solve larger problems, parallel PWTD-enhanced MOT solvers are called for. Even though a simple parallelization strategy was demonstrated in the context of electromagnetic compatibility analysis [M. Lu et al., in *Proc. IEEE Int. Symp. AP-S*, 4, 4212-4215, 2004], by and large, progress in this area has been slow. The lack of progress can be attributed wholesale to difficulties associated with the construction of a scalable PWTD kernel.

Recently, we developed a new parallel PWTD kernel that leverages an advanced hierarchical and provably scalable spatial, angular, and temporal load partitioning strategy [Y. Liu et. al., in *URSI Digest*, 2012]. Here, we adopt this new PWTD kernel to solve time domain electric, magnetic, and combined field SIEs pertinent to the analysis of scattering from perfect electrically conducting objects; all SIEs are discretized using standard RWG spatial basis and testing functions, and shifted Lagrange temporal interpolators. Just like in parallel frequency domain FMM-accelerated SIE solvers, “far-fields” are evaluated using the parallel PWTD scheme; classical “near-field” computations and the actual MOT operation also are performed in parallel. The interplay between the PWTD and classical code components calls for CPU versus memory trade-offs that are quite different from those encountered in frequency-domain FMM-accelerated SIE solvers. These trade-offs and related implementation details, which render this new PWTD-enhanced MOT-SIE solver highly scalable on up-to thousands of cores, will be presented at the meeting. The solver has been used to analyze transient electromagnetic scattering from canonical and real-world targets involving up to 10 million spatial unknowns, realizing vast efficiency improvements over its predecessors.