Parallel Fast Higher-Order Solution of Large-Scale Scattering Problems via MLFMA Accelerated Locally Corrected Nystrom Discretization of the Electric Field Integral Equation: Study of Accuracy and Efficiency

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High precision solution of 3D large-scale scattering problems are attainable most efficiently via multi-level fast multipole algorithm (MLFMA) accelerated solution of higher order (HO) surface integral equations. Among them, the HO method of moments (MoM) (R. Graglia, et.al., IEEE Trans. Antennas Propag., 45, 329-342, 1997) and Locally Corrected Nystrom (LCN) method (L. Canino, et.al. Comp. Physics, 146, 627-663, 1998) have gained interest since they provide solutions of arbitrary orders within the same implementation. HO MoM however is not as well suited to be accelerated by the MLFMA compared to LCN since it provides an element-based discretization as opposed to the LCN's point-based discretization (W. C. Chew, et.al. (ed.) Norwood, MA: Artech House, 2001).

Construction of MLFMA accelerated HO LCN method impose formidable challenges since it requires all stages of the numerical scheme to maintain desired precision. Examples include HO representation of the model's surface, numerical integration of EFIE kernel functions, partitioning of the near interactions for local corrections and regular quadrature rule handling, setting up the near range and orders of expansions in MLFMA translators as well as iterative solution of the matrix equation using GMRES or CG methods.

Parallelization of the scheme for distributed memory multiprocessors introduces additional complexity to the method. This is because in a parallel implementation of the algorithm each stage of the method should be split among all of the processors as evenly as possible. Even neglecting a simple task such as processing the mesh and allowing it to be fully executed on each processor creates either computational or memory bottlenecks or both and severely limits the size of the models that can be handled by a particular multiprocessor machine.

In this work the outline of parallel implementation of HO solution of the EFIE via MLFMA accelerated LCN is given and its efficiency and accuracy is studied as a continuation to the work published in (Shafieipour, et.al., ACES Conf. 2013). The study is done on the problem of radial dipole field scattering on perfectly conducting sphere modeled exactly via cube-to-sphere analytical mesh mapping ensuring the elimination of solution error arising from geometrical approximations.