Investigations of Load Balancing, Communications, and Scalability in Parallel MLFMA[†]

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We report our efforts to implement efficient and scalable parallelizations of the multilevel fast multipole algorithm (MLFMA), iterative solvers, and preconditioners. In order to solve very large problems of computational electromagnetics (CEM) that accurately model their real-life counterparts, we explore all possible advances in the areas of both solution algorithms and computer hardware. In this respect, MLFMA has been the solution algorithm of our choice due to its reduced computational complexity and memory requirement. In the area of hardware selection, we prefer parallel clusters of relatively inexpensive computing platforms. The combination of these two choices results in a need to parallelize the MLFMA solver on parallel computers. This nontrivial task requires a careful approach to the parallelization.

The ultimate goal in the parallelization is to achieve efficiency and scalability. For this purpose, we consider different load-balancing and communications strategies for different parts of the algorithm. We also study the effect of network speed on the scalability for different computing platforms that have nonidentical network communication speeds.

We consider load balancing in every step of MLFMA in order to minimize the memory and computation time required by each processor. As for communications, even though we consider each instance of data transfer from one processor to another, we particularly focus on the "translations" part of the algorithm, where most of the communications are required and performed. Since the communications due to the translations directly influence the scalability of the algorithm, we examine them in detail. For this purpose, communications required by the translations at different levels of the multilevel algorithm are separately investigated. We perform measurements of actual communication times on different parallel platforms. We use optimization strategies to minimize the communication costs established by actual measurements.

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