Novel Algorithms for Ultra Scale Electromagnetic Problems in the Supercomputing Era

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Abstract

The need for increasing fidelity and accuracy in mission-critical electromagnetic applications have pushed the problem sizes toward extreme computational scales. Therefore, there is a large premium placed on the investigation of parallel and scalable integral equation simulators, a particularly useful class of computational electromagnetics, to meet this demand. This dissertation will focus on three interrelated areas: i) quasi-optimal, well-conditioned integral equation based domain decomposition methods, ii) geometry-adaptive, multi-scale discontinuous Galerkin boundary element methods, and iii) high-performance and scalable algorithms to reduce the computational complexity of extreme-scale simulations with the aid of parallel

computing architectures.

This dissertation will first develop the mathematical underpinnings of a geometry-adaptive, integral equation domain decomposition method. Then the parallelization technique will be discussed along with many numerical experiments to profile its performance. Finally, two real-world applications will be discussed that demonstrate the utility of a high performance-enabled solution. First, a solution to the challenging problem of the solution and prototyping of antennas on large platforms will be discussed. Finally, the code will be used to solve a channel modeling problem that has many important applications for the fifth generation (5G) of wireless telecommunication.