Novel, Highly Efficient Domain Decomposition Techniques for the Finite Element Computation of Electromagnetic Fields:

Application to Large-Scale Phased-Array Antennas and Photonic Crystal Problems

Jian-Ming Jin
Center for Computational Electromagnetics
Department of Electrical and Computer Engineering
University of Illinois at Urbana-Champaign

Numerical discretization of large-scale electromagnetic problems often results in a large system of linear equations involving millions or even billions of unknowns, whose solution is very challenging even with the most powerful computers available today. In this talk, we present two new computational techniques for numerical analysis of such large-scale electromagnetic problems. The first technique is based on the frequency-domain finite element method (FEM) combined with a nonoverlapping domain decomposition algorithm. In this method, a computational domain is first decomposed into many subdomains and the field inside each subdomain is formulated using the FEM. The field continuity is enforced explicitly along the edges shared by more than two subdomains and implicitly at the interfaces between two subdomains through the use of Lagrange multipliers. The enforcement of the field continuity couples all the subdomain problems and forms a much smaller global interface problem. The second technique is developed for the time-domain FEM analysis of electromagnetic problems and is based on Huygens' principle. This method computes both electric and magnetic fields in a leapfrogging manner and couples the fields in different subdomains through alternating applications of the surface equivalence principle. In this talk, we apply both methods to the simulation of large finite arrays such as phased-array antennas and photonic crystals to demonstrate the efficiency and capability of the methods.