A Flexible Multiscale Technique for Electromagnetic Simulation

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In computational electromagnetics, problems in which the structures span a large number of wavelengths and geometrical scales are important for a variety of applications. For such multiscale problems, to obtain a certain accuracy, the discretization of the problem domain is usually dominated by both the minimum wavelength and the fine geometrical details, which results in an extreme expensive overhead of computer resources. In the work, we develop a flexible multiscale technique, which allows for a free bridging of different scales in simulations.

A brief review of the multiscale technique is as follows. First, the total problem is divided into a number of subdomains according to their characteristics of scales and local wavelengths. For each subdomain, the discretization is controlled by its own characteristics. To acquire the required accuracy, the most efficient numerical method is chosen for each subdomain. The available methods included are the FDTD and ADI-FDTD improved to second-order accuracy, the pseudospectral time-domain (PSTD) method, discontinuous Galerkin method (DGM) and so on, spanning from second-order to spectral accuracy. A stable and flexible boundary matching scheme is constructed for the communication between adjacent subdomains. Unlike the usual matching, the flexible one allows for hanging nodes appearing on the boundary so that the mesh generation for each subdomain can be independent.

This multiscale technique brings about several orders of improvement on the cost of computational time and memory, making possible the engineering analysis of large-scale problems that were previously out of the reach of computer resources.