Abstract

In the present thesis, a hybrid numerical method is presented for the solution of very large and complex radiation and scattering electromagnetic problems, which combines the Finite Element Boundary Integral (FEBI) technique and the Multilevel Fast Multipole Method (MLFMM) with the Uniform Geometrical Theory of Diffraction (UTD). The presented hybrid approach is referred to as FEBI-MLFMM-UTD method and it combines for the first time a local method, a global fast Integral Equation (IE) method, and ray optical asymptotic techniques. The hybridization with UTD is performed in both the Boundary Integral Method (BIM) part, where the Green's function and the incident field are appropriately modified for Combined Field Integral Equation (CFIE), as well as within the matrix-vector multiplications in the various levels of the MLFMM part by approximating ray optical terms of the Green's function with far-field expressions suitable for MLFMM interactions. This results in modification of the translation procedure using a far-field approximation of the translation operator for ray optical contributions. In each case, the Green's function and the incident field are modified according to superposition of all received field contributions. Dielectric regions of FEBI objects are handled efficiently through conventional combination of BIM with the Finite Element Method (FEM), which does not affect the hybridization with UTD. Further, postprocessing near-field computations in the proposed hybrid method are accelerated using MLFMM combining near-field and far-field MLFMM translations for optimum performance. Near-field translations are performed from source groups including currents to receiving groups including nearby observation points, whereas far-field translations are performed for each far-away observation point at the coarsest level on which far-field condition is still satisfied. The optimum level for far-field translations is found for each observation point in the initialization step in a worst-case sense using its shortest distance to the MLFMM domain of the currents. In both domains ray optical contributions due to the presence of UTD objects are taken into account according to hybridization of MLFMM with UTD. In addition, far-field scattering computations are performed by applying Near-Field to Far-Field Transformations (NFFFTs) in the postprocessing stage based on planar near-field scanning techniques. Particularly, the scattered ray optical electric field is first computed in a scanning plane in the near-field region of the involved objects using the postprocessing MLFMM and it is then transformed into far-field regions using plane wave expansions. Direct field contributions are evaluated directly in the far-field of the involved objects using conventional fast techniques and the total far-fields are found by superposition. In the UTD part, double diffracted ray optical fields at arbitrarily oriented straight metallic edges are included using scalar diffraction coefficients of standard UTD. Using the hybrid FEBI-MLFMM-UTD method large scale problems including arbitrarily shaped and electrically large objects can be handled very efficiently saving a large amount in computation and memory requirements, which is demonstrated very clearly with numerical examples.