

Matrix Equation Decomposition and Parallel Solution of Systems Resulting from Unstructured Finite Element Problems in Electromagnetics

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Finite element modeling has proven useful for accurately simulating scattered or radiated electromagnetic fields from complex three-dimensional objects whose geometry varies on the scale of a fraction of an electrical wavelength. An unstructured finite element model of realistic objects leads to a large, **sparse**, system of equations that needs to be solved efficiently with regard to machine memory and execution time. Both factorization and iterative solvers can be used to produce solutions to these systems of equations. Factorization leads to high memory requirements that limit the electrical problem size of three-dimensional objects that can be modeled. An iterative solver can be used to efficiently solve the system without excessive memory use and in a minimal amount of time if the convergence rate is controlled.

This paper will discuss a number of topics related to the parallel creation and solution of matrices resulting from large unstructured problems, in the context of an electric finite element code running on the Cray T3D located at the Jet Propulsion Laboratory. The JPL code, named PHOEBUS, has been used to obtain solutions for systems with nearly three-quarters of a million unknowns.

One of these topics is mesh vs. matrix partitioning. The code running at JPL decomposes the finite element matrix in

row slabs, as compared with the usual strategy of decomposing the mesh. Another topic is the iterative solver, in this case a quasi minimum residual method. An examination of the computational kernel, a sparse matrix dense vector multiply, is given, and the issue of solving for a single right hand side vs. multiple right hand sides (possibly a block of right hand sides) is discussed. Another question related to the iterative solver is parallel methods or preconditioning, such as using an incomplete Cholesky factorization or a sparse approximate inverse.