Implementation of a Massively Parallel Hybrid Finite-Element/Finite-Difference Electromagnetic Solver in the NEVADA Framework

J.D. Kotulski*, M.F. Pasik, D.B.Seidel, and C.D. Turner
Sandia National Laboratories
P.O. Box 5800
Albuquerque NM 87185-1152 USA

This presentation describes the implementation of hybrid finite-element/finite-difference algorithms within the NEVADA framework for solving Maxwell's equations in the time domain. The NEVADA framework is an object-oriented time-domain finite-element framework implemented in C++ supported by the Department of Energy's Advanced Simulation and Computing Program (ASCI). The NEVADA framework forms the basis of the well-known h-adaptive finite-element shock-physics code ALEGRA. One of the main reasons for implementing our electromagnetic algorithms in the NEVADA framework was to facilitate coupling with other type of physics analysis.

The finite-element services of the NEVADA framework allowed us to rapidly implement both a conditionally stable coupled first-order and unconditionally stable second order Whitney edge-element based formulations originally developed in the VOLMAX code. Most of the effort involved in adding finite-element based electromagnetic algorithms to NEVADA related to the implementation of specialized communication for sub-cell models such as slots and wires.

To facilitate the implementation of finite-difference algorithms we extended the key NEVADA framework concept of a computation region to include one based on structured mesh topologies. We also extended the framework by encapsulating our proven structured communication plan algorithms and data structures developed for the QUICKSILVER code into general-purpose framework objects. The introduction of another new region type, a region controller (a "smart" container of regions which also encapsulates the necessary data and algorithms used to interconnect the regions) allowed us to implement both multi-block and massively parallel structured mesh capabilities.

In the presentation we will focus on how we further extended the framework communications objects and the controller region concept to support hybrid structured/unstructured mesh connections in parallel. The costs and benefits of the framework implementation will be compared/contrasted to the algorithm development efforts in the VOLMAX and QSVM codes. Practical applications of the implementation will be presented that demonstrate the hybrid capability and sub-cell algorithms.

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