Task based parallelization of electromagnetic scattering problems

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Figure 1: *Surface currents on an aircraft model from a boundary element simulation with around 2 million unknowns.*

Required qualifications

The successful candidate must have previous experience in (advanced) parallel programming with threads and/or MPI, awareness of performance issues, and some familiarity with (parallel) numerical algorithms.

Project summary

In industry, simulations of electromagnetic scattering are performed to evaluate for example the design and placement of antenna for aircrafts, communication with satellites, and the operation of medical equipment. These problems can be discretized with boundary element methods, resulting in a discrete problem with millions or billions of unknowns. Efficient simulation methods are based on fast multipole type (FMM) approximations. The size of the problem warrants distributed parallel implementation both in order to fit the problem into the memory and to gain computational speed. Implementations in the literature are typically MPI-based [5, 3, 1]. However, a typical target architecture is a cluster of multicore computers. In this case, a hybrid parallelization using threads and MPI could prove advantageous for scaling purposes [6]. To hardcode an FMM algorithm using threads and MPI is non-trivial and suggests a large investment in time for a company. An interesting alternative is to use a task based approach [8], which hides the complexity of the parallel implementation from the programmer, while still providing high performance through a cleverly designed run-time system that executes tasks asynchronously, while respecting data dependencies. Successful implementations exist already for shared memory or shared memory + GPU [2, 4, 7]. The aim of the project is

- to develop a task-based prototype 3-D FMM hybrid implementation,
- to provide ease of parallel implementation for similar applications,
- to develop run-time strategies for distributed performance,
- to provide inter-model/inter-method comparisons for decision support.

The project will be carried out in close collaboration with the Swedish company E-field `http://www.efieldsolutions.com/`, part of the ESI group, who develop software for industrial electromagnetic simulation. Associated with this project, we also have an international collaboration with the Antenna and EMC Lab at the Politecnico di Torino and Istituto Superiore per le Telecomunicazioni "Mario Boella" in Italy.

References

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