PERFORMANCE ENHANCEMENT OF MAGIC FDTD-PIC PLASMA-WAVE SIMULATIONS USING GPU PROCESSING*

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Present day computers equipped with powerful graphics processing units (GPUs) show considerable promise of increased performance for the electromagnetic (EM) modeler. In order to determine the degree of performance gain achievable for electro-energetic physics computations, the MAGIC EM finite difference-time domain (FDTD) particle-in-cell (PIC) plasma code [1] is undergoing testing for parallel speedup on typical large scale plasma wave EM calculations using GPU processing. The results of the tests are expected to be of great interest to the EM community because MAGIC is widely employed and implements the methods common to many large scale applications. The performance data obtained will quantify the benefits of GPUs, and aid in selecting the proper system including GPUs potentially critical to effectiveness with EM/plasma codes where calculation times often run into days due to small zone and time step requirements. GPUs promise a relatively low cost boost leveraging the vast development driven by the computer game industry.

Our approach is to first develop simple models of major CPU-intensive code portions using the freely-available CUDA™ language for massively parallel high-performance computing. CUDA™ enables GPU processing using high-level languages (C and FORTRAN employed here) [2]. Our relativistic particle scheme also calls the C-based GPUlib [3].

The major challenge of this performance exercise is to recast the particle and field updates in MAGIC into vector forms such that large blocks of data are shipped to the GPU for processing in parallel. This of course requires non-dependent data elements during each GPU step of the time advance.

The CPU-intensive Lorentz equation particle update code portion is the starting point for this evaluation. Early results indicate a 12x speedup for standard kinematics of a 100k particle vector with 100k time steps on a Dell 64-bit quad-core processor with Windows Vista and a Quadro FX 3700 GPU (~$800 on the NVIDIA website). We are encouraged that MAGIC will benefit significantly from GPUs.

[1] B. Goplen, et. al., "User-configurable MAGIC for Electromagnetic PIC Calculations," Computer Physics Communications 87 (1995), (http://www.mrcwdc.com).
[2] http://www.nvidia.com/object/cuda_home.html#
[3] http://www.txcorp.com/products/GPULib/index.php

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