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3-D Wave Propagation Simulation using Multi GPU

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Three-dimentional ground motion simulation is one of the key techniques for a seismic hazard evaluation using hybrid method. In the method, high frequency component which is rather random process is simulated by stochastic Green's function method. On the other hand, low frequency component is calculated by deterministic method such as FDM (finite difference method) and FEM (finite element method) assuming a source and underground structure model. Though the information technology drastically improve the capacity of computer (calculation and memory resources), it is still a bottleneck of hazard calculation because the practical model is rather large scale.

To solve this situation, we have introduced GPGPU (General purpose computing on graphics processing units) which is the technique of using a GPU to perform computation in applications traditionally handled by the CPU. Aoi et al. (2009, SSJ fall meeting) showed that FD calculation using GPGPU showed very high performance. They developed the FD code based on second-order velocity-stress formulation with staggered-grid using CUDA (Compute Unified Device Architecture). By using small model which has 16.7 million grids (255x256x256), they examined the benchmark test by comparing the performance with single CPU (Altix4700 (Itanimu2, 1.66 GHz)) and single GPU (Tesla D870 on Asterism Power AQ232), and showed that the computation time was reduced to 1/17.8.

Simulations using more realistic and much larger model are required for hazard evaluation and the computational capacity of single GPU is insufficient. Though the typical global memory install on a GPGPU board is 1 to 4GB, a practical simulation requires several dozens GB memory. Therefore a multi GPU calculation is essential for an application to reliable hazard evaluation. In this paper, we extend out FD code for single GPU to multi GPU using MPI (Message-Passing Interface) and examined the performance test for parallel computing. We divided the model along the vertical direction and assigned each dived region to a GPU. Values of neighboring regions are necessary for the FD calculation at the grids which are close to another region. In such a case, values are obtained by communication between two GPUs. Because direct communications are not available, values are once transmit to main memory and send to the target GPU using MPI. Calculation time using 4 GPUs (Tesla D870 install in Asterism Power AQ232) is reduced by the factor of 1/3.1 which corresponds to the performance of about 50 cores of CPU. This result implies a large potential of GPGPU as the low-price platform of large scale simulation.

Keywords: GPGPU, Multi GPU, parallel computing, ground motion simulation, FDM, seismic hazard evaluation