GPU Accelerated Parallel Computing in Nuclear Problems

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Graphic processing unities (GPU) are high performance parallel co-processors with applications that have become very popular in other fields out of the computer graphics field. Such fact is due to emerging tools and frameworks that facilitate their programming. The main responsible element in this feature is The Compute Unified Device Architecture (CUDA) [1].

This progress report aims at informing our colleagues about our recent research related to GPU accelerated parallel computing applied to nuclear problems.

In former works, the Monte Carlo (MC) based simulations in neutron transport using GPU have been investigated [2].

Our recent researches, which involve 2 D.Sc. (COPPE/UFRJ) and 2 IC students (IEN/CNEN), focus on 2 problems: i) the nuclear core reload problem and ii) atmospheric dispersion of nuclear material.

As to the first problem, there are two main objectives: i) accelerate existing reactor physics simulation by means of GPU and ii) investigate and develop GPU accelerated optimization meta-heuristics, such as Genetic Algorithms (GA) and Particle Swarm Optimization (PSO).

As the reactor physics code is written in Fortran programming language, in this research, we investigate the use of other development tools such as the PGI Fortran and Fortran CUDA [3].

Meta-heuristics are written in C code and use standard CUDA-C libraries. The investigation of possible parallel topologies such as fine- or coarse-grained is also the focus of our research.

In the application, the atmospheric dispersion of radionuclide for use in NPP releases is considered. The simulations involve source term and wind field calculations, plume transport, radioactive material diffusion and dose predictions. Such simulations are time-consuming (many seconds for a simple problem) and it is estimated that the use of GPU may accelerate hundreds of times.

The sequential programs are originally written in Fortran, so, two approaches are being considered: i) to use Fortran CUDA and ii) to re-write parts of the code in CUDA-C.

To analyze the programs in order to find out where the bottlenecks are, some tools like Intel Parallel Studio [5], which is able to debug and analyze multithreading parallel applications, is being used.

Due to the modular architecture of the sequential program, the problem can be handled in two distinct parts: i) parallelism of the Wind Field calculations (under development) and ii) parallelism of plume transport (to be investigated further).

This research is not in an advanced phase and some investigations and developments are still in course. As soon as possible, some publications will be prepared and submitted to international journals.

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