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Particle Accelerator Simulations on GPUs or/and Intel Xeon Phi (MIC)

Masters Thesis

Introduction

Object Oriented Parallel Accelerator Library (OPAL) is an open source tool for charged-particle optics in accelerator structures and beam lines, and is built from the ground up as a parallel application. OPAL runs on your laptop as well as on the largest HPC clusters available today, the relevant parts of OPAL is shown in Fig.1. The algorithm to compute self-consistently the scalar

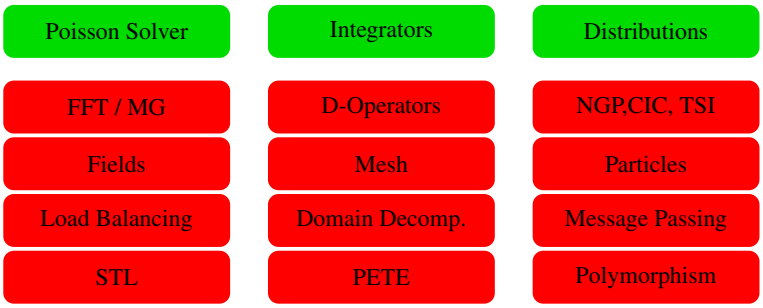

Figure 1: The relevant parts of OPAL

potential is based on the particle in cell (PIC) method, in the electrostatic approximation i.e. all temporal derivatives (∂_t) in Maxwell's equations are zero. In an appropriate frame of reference, the resulting Poisson problem is solved using spectral methods (FFT), on a regular 3-dimensional, body fitted mesh.

Details can be found in [1], the used splitting scheme is also illustrated in Fig. 2.

Description of the task

The complete algorithm of the FFT based electrostatic PIC has to be translated into CUDA, OpenCL or adapted to run on Intel Phi. As an option, the Monte-Carlo part of OPAL used in the particle matter interaction, can be parallelized. The present parallel algorithm is a plain C++ code complemented by MPI for communication.

In a first step, the algorithm shall be adapted to run on a single GPU or Intel Phi. In a second step, the algorithm is to be extended to multiple GPUs or Intel Phis. The communication among the

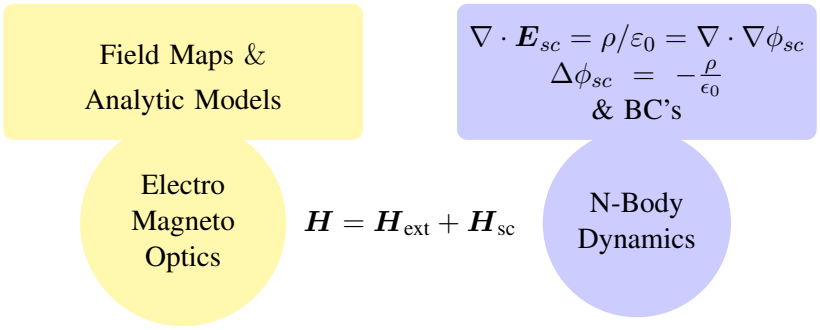

Figure 2: The splitting of the Hamiltonian results in ...

multiple accelerators has to be implemented by the Message Passing Interface (MPI). The target machine are Tödi at CSCS, a Cray XK7 and an Intel Xeon Phi development system, consisting of 60 x86 based cores at 1.052GHz, 4 hardware threads per core, so in total 240 cores are available.

Requirements

- Good knowledge in C++.
- Some knowledge of particle in cell is an advantage.
- The attendance of a parallel computing course is very useful.
- Willingness to work in an interdisciplinary environment at PSI & ETH.

Deliverables

The work is to be documented in a short and concise thesis written in LaTeX. It must be written such that it is intelligible to a fellow-student. The code should be written as clean as possible. It must be complemented by a short user's guide.

Presentation

At the end of the thesis, the work is to be presented in a talk. The date of the talk will be determined later.

Contacts

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Literature

[1] A. Adelmann, P. Arbenz, et al., J. Comp. Phys, 229 (12): 4554 (2010)
doi: 10.1016/j.jcp.2010.02.022

June 14, 2013 A. Adelmann & P. Arbenz