Bulldog

Boast ULtimately LeaDing to an Optimized Gysela

CEMRACS project 2016

Abstract

Modeling turbulent transport is a major goal in order to predict confinement problems in a tokamak plasma. The gyrokinetic framework considers a computational domain in five dimensions to look at kinetic issues in a plasma; this leads to huge computational needs. Therefore, optimization of the code is an especially important aspect, especially since GPUs and MICs coprocessors are foreseen as building blocks for Exascale systems. This project aims to evaluate the applicability of the BOAST approach for the Gysela code in order to separate a set of computation intensive kernelsfrom the main code, and address the optimization of these kernels on accelerators.

Context

Modeling turbulent transport is a major goal in order to predict confinement problems in a tokamak plasma. This aspect of first principle physics plays a key role in achieving the level of performance expected in fusion reactors as ITER (`http://www.itercad.org/`). The simulation and understanding of the turbulent transport in Fusion plasmas remains therefore an ambitious endeavour. The gyrokinetic framework considers a computational domain in five dimensions to look at kinetic issues in a plasma; this leads to huge computational needs. For example, large simulations using the semi-Lagrangian code GYSELA typically require thousands of cores during multiple weeks.

In this context, the optimization of the code is an especially important aspect, both to be able to access new physics (*e.g.* kinetic electrons in the case of GYSELA) and to prevent wasting resources. This is especially difficult since architectures expected to provide the required computing power in the future will most likely differ from current general-purpose CPU based architectures. This can for example be seen with the increase of accelerators such as GPUs and MICs in the top500 list of fastest computers. Multiple aims concerning the source code should therefore be targeted at once:

- performance
- portability (including portability of performance)
- maintability and readibility

These are very difficult to handle simultaneously. A solution could be to overhaul some computation intensive parts of the code in introducing well defined kernels. The API of these kernels remain to be defined.

BOAST [7, 8] (`https://github.com/Nanosim-LIG/boast`), is a metaprogramming framework to produce portable and efficient computing kernels for HPC application. It offers an embedded domain specific language to describe the kernels and their possible optimization. BOAST also supplies a complete runtime to compile, run, benchmark, and check the validity of the generated kernels.

The following project aims to evaluate the applicability of the BOAST approach for the Gysela code. It will focus on some of the most computation intensive kernels of the code: 1D and 2D advection kernels, but also on a 4D advection kernel.

Objectives

During the CEMRACS project, we intend to work on:

- Isolate advection kernels from the rest of the code
- Implement BOAST approach on each of these kernels
- Benchmark these kernels to demonstrate the gain BOAST can bring
  - on Intel Xeon Haswell architecture
  - on Intel MIC architecture
  - on Nvidia K80 GPGPU

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