Optimization of data movements in a particle physics SYCL code

Internship Proposal for Master 2 or Engineer Last Year

Abstract

This internship falls within a collaboration between IJCLab (Orsay, France) and PDS (for Parallel and Distributed Systems) team of Telecom SudParis (Palaiseau, France), dealing with sustainable heterogeneous parallel programming.

The trainee will port to SYCL some components of the ACTS particle physics software library, improving the runtime performance thanks to GPUs exploitation. He will especially focus on the profiling and optimization of data movements between the processor and the accelerator.

Requirements

- Fluent with some imperative and/or object language (C++, Fortran, Python...).
- Familiar with parallel and GPU programming.
- Used to Linux.

Keywords

SYCL, C++, GPU, ACTS, Track reconstruction, Particle physics.

Location

In compliance with the constraints related to COVID, the internship will take place at IJCLab, IT department, in Orsay, as well as at Télécom Sud-Paris, PDS team, in Palaiseau.

Supervisors

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Scientific & technical context

In the field of scientific computing, the hardware has an approximate life span of 5 years, where an application will typically serve for 20 or 30 years. We are in a period where each new generation of hardware is very different from the previous one, and the scientific community does not have the human resources to constantly readapt its applications. This leads us to look for software solutions that promote a better sustainability of the software.

Among the recent hardware innovations, the emergence of accelerators (GPUs) raises questions about data exchanges between them and general processors (CPUs), as well as about the relevance of grouping accelerators in dedicated hosts. The answers are expected to be highly application-dependent.

This issue applies to the ACTS software library, to which IJCLab researchers and engineers contribute. The library is dedicated to the analysis of data from CERN's Large Hadron Collider (LHC), in particular the reconstruction of particle trajectories from measured point deposits.

Work to be done during internship

After studying the ACTS use cases selected by the IJCLab team, as well as the SYCL technology, the trainee will port to SYCL the relevant parts the code, and ensure that the physical results remain valid.

In a second step, the trainee will execute and compare several use cases and/or several GPU models. Each time, he will profile the data exchanges between processor and accelerator, and compare the ACTS behavior under these different conditions. He will also evaluate the portability and functionality of the profiling tools themselves.

Finally, the trainee is expected to propose and implement portable code improvements, especially regarding data exchanges, with the help of the PDS team.

PHD opportunity

A PhD may be envisaged afterwards, supervised by the same teams, about the optimal placement of accelerators in a computing cluster, and the trade-off between data transfer and full filling of these accelerators. For what type of applications is it preferable to distribute them in all compute nodes ? For which type of applications is it preferable to gather accelerators in dedicated nodes (GPU as a Service) ?

Gratification & ZRR

The CNRS pays 591.51 euros gross per month for internships. In addition, IJCLab being ZRR, the reception of the trainee is subject to the approval of the defense official.

Links

- SYCL (https://www.sycl.tech/)
- ACTS (https://acts.readthedocs.io/)
- IJCLab, Service Développement (https://www.ijclab.in2p3.fr/pole-ingenierie/informatique-2/)
- Telecom SudParis, Equipe ACMES (https://samovar.telecom-sudparis.eu/spip.php?rubrique127)