

CEA/EDF/INRIA Summer School 2022 – Hybrid and Asynchronous High-Performance Programming

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The main subject of this school is related to hybrid parallel programming (MPI+OpenMP) with the use of asynchronism to enhance the overall computing performance. Based on HPC (High-Performance Computing), the target courses aim at teach efficient asynchronous algorithms for current generations of supercomputers

Context

Nowadays the number of compute units has dramatically increased in supercomputer architectures. Even if the overall performance of such machines is still growing, exploiting the corresponding units becomes more and more complex. Indeed, exposing efficient parallelism on such a large number of cores is already tedious. One possible solution is to mix multiple parallel programming models like MPI and OpenMP to benefit from advantages of both worlds (performance and memory consumption). However various approaches exist to make such hybrid applications efficient: coarse-grain parallelism, correct resource placement, interoperability between different runtimes, asynchronous computing...

Goals

In this context, the summer school presents best practices to mix multiple programming models focusing on asynchronous computing and communications with MPI and OpenMP. This approach reduces concurrent memory accesses overhead, impact of network communications... Hands-on sessions will illustrate the main concepts on target supercomputer.

Prerequisites

Knowledge in MPI+OpenMP parallel programming.

Courses and Seminars

This summer school is divided into 3 courses and 3 seminars.

- **Course 1: Asynchronous MPI Communications**
 - Lecturer: *Anthony Skjellum* (University of Tennessee at Chattanooga)
 - Abstract: this first course focuses on overlapping communication with computation through the MPI interface. It presents available functions for such optimizations and it illustrates them on the target supercomputer.
- **Course 2: Asynchronous OpenMP threading/tasking**
 - Lecturer: *Matsuhisa Sato* (RIKEN-CCS)
 - Abstract: In order to complete the MPI asynchronous approach, this course highlights the task parallelism that enables such asynchronous behavior inside a shared-memory model. Hands-on session will be based on OpenMP tasking.

- **Course 3: Hybrid Placement**

- Lecturer: *Edgar Leon* (LLNL)
- Abstract: Expressing asynchronous operations in MPI and OpenMP is mandatory but not enough to enable high performance. Indeed, the interaction with the rest of the software stack is important. For example, the placement of threads/processes on computing resources can shape the overall performance. This course focuses on this subject.

This set of lectures/hands-on will be augmented with seminars from **Intel, ARM & Atos/Bull** focusing on emerging technologies and current/future challenges.