IX.2329 / IX.2429 – Introduction to High Performance Computing and Quantum Computing

General information

Module Title: Introduction to High Performance Computing and Quantum Computing
Module ID: IX.2329 / IX.2429
Module leader: Maria TROCAN
ECTS: 5
Average amount of work per student: 120 hours, including 42 hours supervised
Teamwork: yes
Keywords: HPC, QC, AWS, Multi-thread, Multi-process, Vectorization, Qbit, QiSkit

Presentation

The use of scientific computing software allows industrial players to simulate experiments that would be too expensive, too long, too complicated or even impossible to implement in practice:

- Expected performance during the installation of wind turbines,
- Resistance of the subsoil prior to the construction of new buildings,
- Evolution of the environment in the short (weather) or long (climate) term,
- Damage to passengers in the event of an accident,
- Optimization of mechanical structures to meet a set of constraints,
- Simulation of quantum interactions between particles,
- Interaction between molecules and proteins.

The amount of calculations to be performed is often too large to allow these simulations to be implemented without taking into account the specificities of the computers used (type of processor, type of network, number of machines, etc.). In addition to strong skills in the application field (physics, weather, etc.), the implementation of this software requires strong skills in software development and applied mathematics and a good knowledge of hardware.

The objective of this course is to allow students to have a first experience in the field of High Performance Computing (HPC) and Quantum Computing (QC).

Educational objectives

By the end of this module, students will have an understanding of the hardware and software technologies implemented in HPC. They will have a first programming experience to take advantage of a parallel and distributed architecture. They will understand the link between the algorithm and the material characteristics. The main concepts of Quantum Computing will also be discussed.

Finally, students will understand the contributions of the cloud for HPC and will have a first experience of implementation in quantum computing.

Prerequisite

None

Content/Program

Concepts

- Multi-threaded programming with OpenMP
- Multi-process programming with MPI

- Implementing Compute Infrastructure in the AWS Cloud
- x86 processor architecture
- Using a QISKIT Quantum Computing Architecture

Tools used

- The teacher/speaker will use the following tools: gcc/clang, openMP, MPI, QISKIT.
- By the end of the module, learners will have learned how to design and develop applications using the following tools: gcc/clang, openMP, MPI, AWS.

Pedagogical methods

Learning methods

4 sessions of 3 hours of lessons, 10 supervised project sessions, each of 3 hours.

Evaluation methods

The evaluation of this module is based on the supervised sessions of the project, through their code and reports.

Language of work

This module is taught entirely in English, the students' productions can be in English or French, as desired.

Bibliography - Webography

1. https://franknielsen.github.io/HPC4DS/
2. https://qiskit.org/textbook/ch-states/introduction.html