National Competence Centar Montenegro

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Parallel computing course

Parallel computing is essential for solving numerical problems that are too hard for sequential programs. During this course, distributed computing and parallel processing will be introduced to the students and industry partners, as well as performance indicators of parallel programs. In the second part of training, students will be familiarized to the fundamentals of parallel programming with multicore HPCs using shared memory and distributed memory architecture with OpenMP and MPI. After adoption of parallel programming essentials, lectures will cover all steps of decomposition of serial program and their transformation into parallel; recognize parallelization and communication potential problems.

After this course, attendees will be able to speak about models and classification of parallel computers, analyze parallel program complexity and efficiency, recognize the possibility of parallelization according given infrastructure and develop simple parallel program.

Program:

- **Welcome and introduction**
- **NCC Montenegro – short presentation**
- **Distributed computing systems**
    - Distributed computing system architecture

- Parallel computers and HPC's

- **Parallel Computing Overview**
  - What Is Parallel Computing?
  - Why Use Parallel Computing?
  - Who Is Using Parallel Computing?
  - Parallel Computer Memory Architectures
    - Shared Memory
    - Distributed Memory
    - Hybrid Distributed-Shared Memory
  - Parallel program performance metrics (execution time, acceleration and efficiency)
  - Amdahl's law
  - Load imbalance
  - Load balancing algorithms
- **Hands-on : C (renewal), access to HPC, SLURM**
- **Programming models**
  - **OpenMP**
    - Basics, Threading, Loop parallelism and other worksharing constructs, Data sharing, Task work sharing…
    - Examples
  - **MPI (message passing interface)**
    - Basics of message passing, Point-to-point communication, Collective communication …
    - Examples
  - **Hybrid MPI+OpenMP parallel programming**
    - Why go hybrid?
    - Examples
- **Examples of parallel programming from practice (cooperation with NCC Germany or industry partners)**
- **Defense of student papers**

Course duration: 5 x 90 minutes

Course material

Literature

- S. Tanenbaum and M. van Steen, Distributed Systems: Principles and Paradigms, 2nd Edition, Pearson Education. Inc., 2007.
- Barney, Introduction to Parallel Computing, Lawrence Livermore National, 2012.
- T. Rauber and G. Rünger, Parallel Programming for Multicore and Cluster Systems, Springer, 2010.

Additional material

- https://www.openmp.org/specifications/
- https://www.mpi-forum.org/docs/
- https://hpc.llnl.gov/training/tutorials/introduction-parallel-computing-tutorial
- https://fz-juelich.de/SharedDocs/Termine/IAS/JSC/EN/courses/2021/mpi-intro-2021-1.html
- https://www.cs.purdue.edu/homes/ayg/book/Slides/
- https://hpc.llnl.gov/training/tutorials/introduction-parallel-computing-tutorial