Parallel and distributed computing

General Information

Number of ECTS Credits	
3	
Module code	
TSM_ProgAlg	
Valid for academic year	
2024-25	
Last modification	
2023-08-08	
Coordinator of the module	
Christoph Stamm (FHNW, christoph.stamm@fhnw.ch)	

Explanations regarding the language definitions for each location:

- Instruction is given in the language defined below for each location/each time the module is held.
- Documentation is available in the languages defined below. Where documents are in several languages, the percentage distribution is shown (100% = all the documentation).
- The examination is available 100% in the languages shown for each location/each time it is held.

	Lausanne			Lugano	Zurich		
Instruction					**X** E 100%		
Documentation					**X** E 100%		
Examination					**X** E 100%		

Module Category	
TSM Technical scientific module	

Lessons	
2 lecture periods and 1 tutorial period per week	

Entry level competences

Prerequisites, previous knowledge

- Procedural programming (C/C++ knowledge is helpful
- Algorithms and data structures
- Basic notion of complexity analysis and big-O notation
- Basic notions of concurrent programming (Threads)

Brief course description of module objectives and content

The objective of this module is to provide the student with an introduction to parallel computing and algorithms. Students learn to parallelize systems at three different levels: Shared memory systems, distributed memory systems, and heterogeneous shared memory systems. For all three systems, which can be part of a high-performance cluster, students learn the necessary parallelization techniques and a few classical parallel algorithms.

This course includes hands-on work to train students in the application of parallel programming techniques and the programming and analysis of parallel algorithms.

Aims, content, methods

Learning objectives and acquired competencies

By the end of the course, students will know:
- the most common heterogeneous parallel hardware infrastructures
- different ways to model and efficiently program these architectures
- how to assess the performance of parallel algorithms
- how to efficiently implement parallel algorithms
- how to choose the right parallel algorithm to solve a specific problem on a specific parallel architecture

Contents of module with emphasis on teaching content

Introduction (30%)

- Motivation and high-performance cluster model
- Basic concepts in parallel programming in C++
- Asymptotic analysis of parallel programs
- Performance metrics for parallel systems
- Decomposition and mapping techniques for load balancing
- Scalability of parallel systems

Shared memory systems (20%)

- Architectures of widely used multi-core systems
- Cache coherence in multiprocessor systems
- Parallel programming models (OpenMP)
- Parallel algorithms (numerical, sorting, graphs)

Distributed memory systems (30%)

- Architectures of distributed memory systems
- Communications models and communication costs
- Message passing paradigm (MPI)
- Collective operations and their costs
- Distributed algorithms (numerical, sorting)

Heterogeneous shared memory systems (20%)

- GPU architectures
- SIMD programming models (vectorization, SYCL)
- Matrix-vector and matrix-matrix multiplication
- GPU algorithms (numerical, image processing)

Teaching and learning methods

The most important basics are taught in theory lessons in face-to-face classes. In between, students work on the practical exercises at home and exchange information via online channels.

Literature

A. Introduction to Parallel Computing, Zbigniew J. Czech, Cambridge University Press, 2017
B. An Introduction to Parallel Programming, 1st edition, Peter Pacheco , Morgan Kaufmann Publishers Inc, 2011

Assessment

Certification requirements

Module does not use certification requirements

Basic principle for exams

As a rule, all the standard final exams for modules and also all resit exams are to be in written form

Standard final exam for a module and written resit exam

Kind of exam

written

Duration of exam

120 minutes

Permissible aids

Aids permitted as specified below:

Permissible electronic aids
No electronic aids permitted

Other permissible aids
A handwritten summary of a fixed number of pages given by the lecturer.

Special case: Resit exam as oral exam

Kind of exam

oral

Duration of exam

30 minutes

Permissible aids

No aids permitted