High Performance Computing

„Vorbesprechung“: Planning, kick-off

Jesper Larsson Träff
Sascha Hunold
traff@par. … hunold@par. …
Institute of Computer Engineering, Parallel Computing, 191-4
Treitlstrasse 1-3, 5. Stock (DG)

Sprechstunde: By email-appointment

The takeaway

Lecture:
Tuesday, 9:00-11:00, FAV 1-INF (c.t.)

Project hand-in mid-January
Machine accounts October (new HPC server: "hydra")
Oral Exam: 22.1-26.1.2024. Sign up in TISS

Up-to-date information in TUWEL (via TISS sign-up/sign-off), communication via TUWEL (discussion forum)

What is this about: Efficient use of parallel computer systems

- What is High Performance Computing (HPC)?

- A topical overview of the "field":

- Systems
- (Applications)
- Measuring performance
- Interfaces&Algorithms
- Benchmarks, tools, libraries, algorithms
- (File systems, parallel I/O)
- (Linear algebra, solvers, graph processing)
- (Resilience, fault tolerance)
- (Energy models)
- (Machine learning, Analytics, "Big data")

Content/outline this year:

1. Introduction, overview (what is?). MPI recap

2. Measuring performance, MPI Benchmarking

3. Interfaces and algorithms: Advanced MPI, implementing MPI collectives: 5 lectures
4. (Research topics in MPI and related)

5. Libraries, Benchmarks, Tools
6. (MPI+X programming and models)

Formalities

Lecture with exercises and programming project (VU), in English

This year:
Jesper Larsson Träff, Sascha Hunold
Research Group Parallel Computing

4.5 ECTS = 112.5 hours of work

Breakdown:
- Lectures: 1.5 ECTS
- Exercises+Project: 2.0 ECTS
- Presentation&Exam: 1.0 ECTS

- Participation MANDATORY
- Credit/grade based on Project + oral exam/presentation (half-half)

Detailed ECTS breakdown

- Planning, intro ("Vorbesprechung"): 1h
- Lectures: 15 x 2h = 30h
- Preparation: 15 x 2.5h = 22.5h
- Exercises&Project: 50h
- Exam, including preparation: 9h

Total: 112.5h = 4.5 ECTS

Lectures:

Tuesday, 9:00 (c.t) – 11:00. Mandatory, active participation
Here: FAV 01.

Sign-up in TISS and TUWEL (deadline 16.10)

Sign-out if you don't follow the lecture (till 6.11)

"Sprechstunde": By appointment

Email (Jesper Larsson Träff): traff@par.tuwien.ac.at

Material on TUWEL

- Script: "Lectures on Parallel Computing"

  Basics of parallel computing, theoretical models, concrete shared memory programming with OpenMP and distributed memory programming with MPI

- Script: "Algorithms for Collective Communication"

  Abstract communication networks, algorithms for collective operations on such networks

Partly relevant for this years lecture

Both scripts in active development, feedback much appreciated (to Jesper Larsson Träff)

Detailed plan (subject to change)

03.10.2023: Preliminaries and Introduction
10.10: HPC Overview
17.10: HPC Overview, MPI Recap
24.10: MPI Recap
31.10: The Roofline model in use
7.11: Advanced MPI 1/5: Algorithms
14.11:Advanced MPI 2/5:
21.11: Advanced MPI 3/5
28.11: Advanced MPI 4/5
5.12: Advanced MPI 5/5
12.12: Profiling
19.12: Benchmarks
9.1.2024: TBA
16.1: TBA

System access

Project

22-26.1.20: Exam days

Getting system access: 13.10 (deadline TBA, end-October)

- Getting access to systems, ssh public key, everyone must submit
- Necessary for the project

Hand-in (latest):

- Late October (TBA)

Follow instructions in TUWEL on how/what to hand in!!

Exercises: Optional

- Everyone must do
- On paper, more "theoretical" stuff

This goes for all of this course

Project: 7.11 – 16.1.24

- Can be done in groups of ≤3
- Project on/with MPI: Implementing application/algorithm efficiently, testing, running (on real HPC cluster), benchmarking

Hand-in:
- Project 0: Getting system access (ssh-key), late October
- Project 1: Mid/End January 2024

LaTeX template will be available.
Follow instructions in TUWEL on how/what to hand in!!

Exam

- Oral exam based lecture material & project
- Individual
- Exam ca. $\frac{1}{2}$ hour
- Last full January week, 22.-26.1.2024 (sign up from 2.1.2024, end 16.1.2024, sign off 19.1.2024, see TISS)

Credits/Grading

- Active participation

- Hand-in of project, exercises optional
- Oral examination on lecture material/projects (ca. ½ hour)

Grade based on written hand-ins and exam

Doing project in group:

- Active collaboration, "3*100%", NOT "2*33%"
- All members get same grade (unless blatantly different)
- All members must understand all aspects of solutions

Don't forget to evaluate the course (TISS, after end of lecture)

Credits/Grading

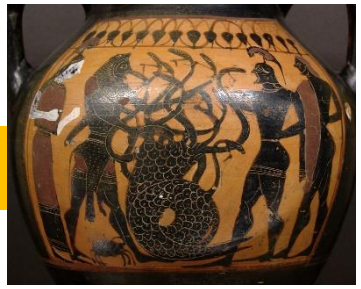
NOTE:

- You only learn by doing exercises&project by yourself (in the group).
- Copying from somewhere ("plagiarism", ChatGPT) will result in grade 5
- Discussion with other groups encouraged, but hand in your own solution

Grade weight: 1/2 project, 1/2 oral exam

Both must be passed (≥50% project points)

New HPC server "hydra"



- 36 Compute nodes, dual-rail Intel Omnipath
- 2 48 Port H1048-OPF switches

Total 1152 cores/MPI processes

Intel Xeon 6130F ("skylake"), 2.1GHz, 2x16 cores, 96GByte main memory/node

Use with "slurm" from head node

System access

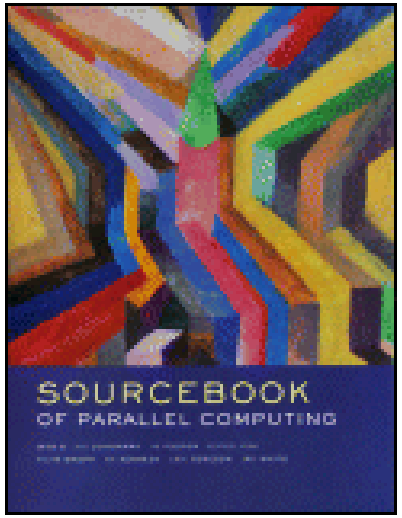
Get machine account via TUWEL (need ssh-key, see instructions)
exercise

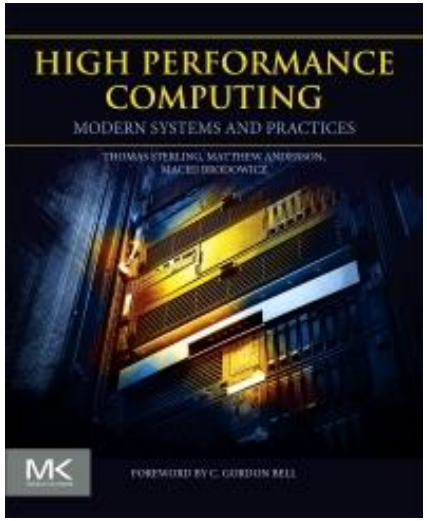
Deadline: late October 2023 (TBA)

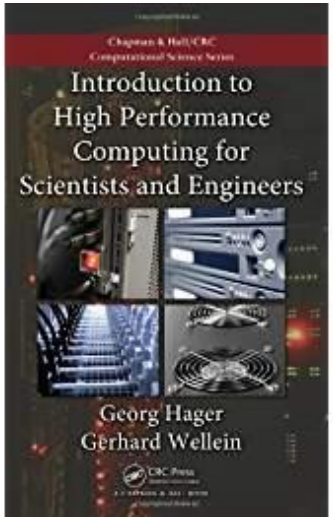
Material, books

Slides, scripts and additional papers/material available from TUWEL

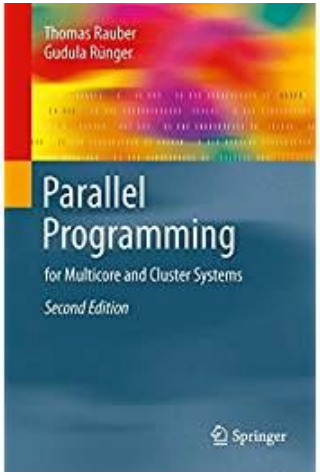
No good overview book of the field; most useful Hager&Wellein

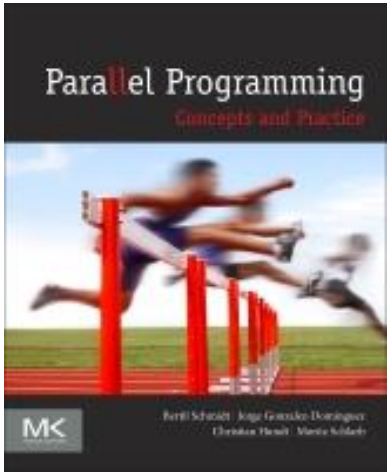


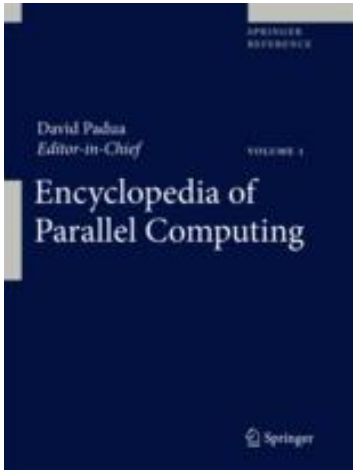




General background

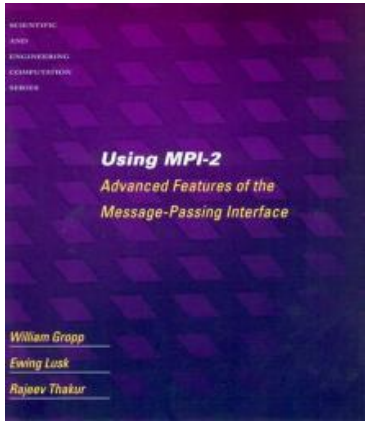


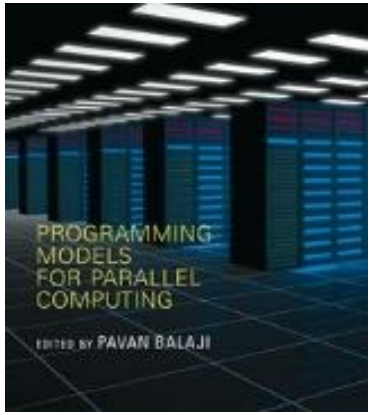


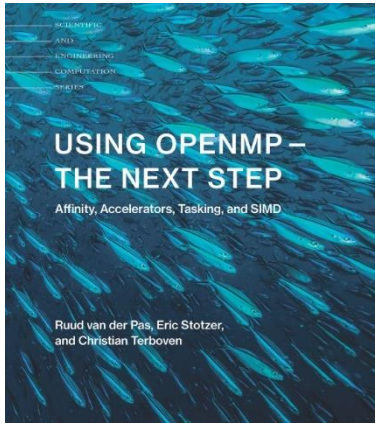


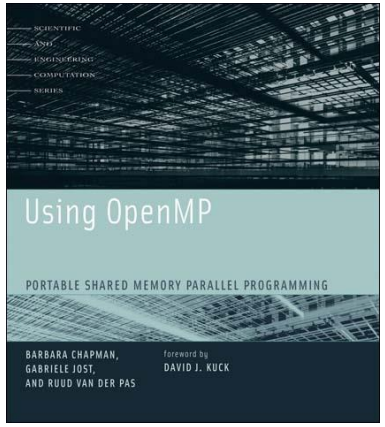
New:
TU Wien "Lectures on Parallel Computing" script, available via TUWEL

MPI, OpenMP usage, programming models, …









Follow-up

- Projects (6.0 + 6.0 ECTS)
- Seminars in WS23, WS24, …
- Seminar WS23, TBA, Vorbesprechung November 19th 2023, TBA
- Parallel Algorithms (WS24: VU, 3.0 ECTS)
- Advanced Multiprocessor Programming (WS24: VU, 4.5 ECTS)
- Master's Thesis (30.0 ECTS)

Some HPC related Master's thesis projects (Träff)

- (MPI) datatype normalization (and performance)
- (MPI) datatypes as DAGs
- Efficient (MPI) datatype equivalence checking
- Dynamic programming for collective communication schedules
- Better irregular collective algorithms
- Multi-lane collectives
- …

Some HPC related Master's thesis projects

- (MPI) datatype normalization (and performance)
- (MPI) datatypes as DAGs
- Efficient (MPI) datatype equivalence checking
- Dynamic programming for collective commun

19.10 11:15 in Treitlstrasse 1-3 seminar room 1st floor

TI Research presentations, see https://ti.tuwien.ac.at/institute/teaching/ti-research-presentations

Vienna Scientific Cluster trainings (OpenMP, MPI, …): http://typo3.vsc.ac.at/research/vsc-research-center/vsc-school-seminar/