Parallel Processing

WS 2020/21

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Parallel Processing

WS 2020/21

0 Organisation

About Myself

- Studies in Computer Science, Techn. Univ. Munich
  - Ph.D. in 1994, state doctorate in 2001
- Since 2004 Prof. for Operating Systems and Distributed Systems
- **Research:** Secure component based systems; Pattern recognition in network data; Parallel and distributed systems
- **Mentor** for Bachelor Studies in Computer Science with secondary field Mathematics

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- **Tel.:** 0271/740-4050
- **Room:** H-B 8404

- **Office Hour:** Mo., 14:15-15:15 Uhr

About the Chair “Operating Systems / Distrib. Sys.”

Andreas Hoffmann

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H-B 8405

- E-assessment and e-labs
- IT security
- Web technologies
- Mobile applications

Damian Ludwig

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H-B 8402

- Capability systems
- Compilers
- Programming languages

Hawzhin Hozhabr Pour

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H-B 8411

- Machine learning
- Pattern recognition in car sensor data
- Anomaly detection

Teaching

Lectures/Labs

- Rechnernetze I, 5 LP (Bachelor, every summer term)
- Rechnernetze Praktikum, 5 LP (Bachelor, every winter term)
- Rechnernetze II, 5 LP (Master, every summer term)

- Betriebssysteme I, 5 LP (Bachelor, every winter term)
- Parallel processing, 5 LP (Master, every winter term)
- Distributed systems, 5 LP (Master, every summer term)

Teaching ...

Project Groups

- e.g., recording and analyzing car sensor data
- e.g., outlier detection in car sensor data

Theses (Bachelor, Master)

- Topic areas: secure virtual machine, parallel computing, pattern recognition in sensor data, e-assessment, ...

Seminars

- Topic areas: IT security, programming languages, pattern recognition in sensor data, ...
- Procedure: block seminar
  - 30 min. talk, 5000 word seminar paper

About the Lecture

- **Lecture + practical Labs:** 2+2 SWS, 5 LP
  - Tutor: Felix Breitweiser (felix.breitweiser@uni-siegen.de)
- **Date and Time:**
  - **No presence teaching in this semester!**
  - The lecture will be provided digitally via moodle
  - The lab will also be organized via moodle
- **Information, slides, and announcements:**
  - In the WWW
    - `http://www.bs.informatik.uni-siegen.de/lehre/pv/`
    - annotated slides (PDF) available; maybe slightly modified
  - Screen casts available in moodle

About the Lecture ...

Learning targets

- Knowing the basics, techniques, methods, and tools of parallel programming
- Basic knowledge about parallel computer architectures
- Practical experiences with parallel programming
- Knowing and being able to use the most important programming models
- Knowing about the possibilities, difficulties and limits of parallel processing
- Being able to identify and select promising strategies for parallelization
- Focus: high performance computing

About the Lecture ...

Methodology

- Lecture: Basics
  - theoretical knowledge about parallel processing
- Lab: practical use
  - practical introduction to programming environments
  - “hands-on” tutorials
  - **independent programming work**
  - practical skills and experiences
  - in addition: raising questions
  - different parallelizations of two representative problems
    - iterative, numerical method
    - combinatoral search

Examination

- Oral examination (about 30-40 min.)
  - subject matter: lecture and labs!
  - examination also covers the practical exercises

- Application:
  - first, apply online via unisono
    - **at least** one week (better: a few weeks) in advance
    - note that you first must have your mentor's approval (**deadline**: see web page of the examination office!)
  - then, fix a date with my secretary Mrs. Syska
    - via email (`regina.syska@uni-siegen.de`)
    - or personally (H-B 8403, in the morning)

Registration for “Course Achievement” (Studienleistung)

- Prerequisite for admission to the exam:
  - active attendance to the labs
  - i.e., qualified attempt for all (i.e., 4) main exercises
- You have to register in unisono for the “Course Achievement” (Studienleistung) 822120-SL until **end of January**!
  - independent from the registration to the course and the lab!
  - the best is to do it right now!

Organisational Issues regarding the Labs

- In this semester, you will have to do the assignments at home
- Programming is done in C/C++
- Ideally, you need a Linux-PC with the GNU-compilers (`gcc/g++`)
  - however, Windows with `MSVC` will also work
- In addition, you need to install MPI, preferrable MPICH
  - see `https://www.mpich.org/downloads`
- You also get an account on the high performance computer HoRUS, accessible via SSH (`hpc.zimt.uni-siegen.de`)
  - 136 nodes, each with two Intel XEON processors (2 * 6 cores), 2.66 GHz, 48 GB RAM
- Four major assignments
  - code must be submitted via moodle in due time

Contents of the Lecture

- Basics
  - Motivation, Parallelism
  - Parallel Computers
  - Parallelization and Data Dependences
  - Programming Models
  - Design Process
  - Organisation Forms for Parallel Programs
  - Performance Considerations
- Parallel Programming with Shared Memory
  - Basics
  - POSIX Threads
  - OpenMP

Contents of the Lecture ...

- Parallel Programming with Message Passing
  - Approach
  - MPI
- Optimization Techniques
  - Cache Optimization
  - Optimization of Communication

Time Table of Lecture and Labs

- First three weeks: only lectures, no lab
- Then: lectures and lab
- Last two weeks: only lab
- Due dates for the major assignments:
  - 03.12.: Quicksort using PThreads
  - 07.01.: Jacobi using OpenMP
  - 28.01.: Sokoban using OpenMP
  - 11.02.: Jacobi using MPI

Consultation hours

- Online meetings using the `zoom` video conference system
  - see the documentation in the WWW
  - only for questions on the lecture / the lab
- For the lecture: **Mon., 12:00 - 12:30** (or longer, if necessary)
- For the lab: **Thu., 14:00 - 15:00** (or longer, if necessary)
- Links and access information for the zoom meetings are published in moodle!

General Literature

- Currently no recommendation for a all-embracing text book

- Barry Wilkinson, Michael Allen: *Parallel Programming*. internat. ed, 2. ed., Pearson Education international, 2005.
  - covers most parts of the lecture, many examples
  - short references for MPI, PThreads, OpenMP
- A. Grama, A. Gupta, G. Karypis, V. Kumar: *Introduction to Parallel Computing*, 2nd Edition, Pearson, 2003.
  - much about design, communication, parallel algorithms
- Thomas Rauber, Gudula Rünger: *Parallele Programmierung*. 2. Auflage, Springer, 2007.
  - architecture, programming, run-time analysis, algorithms

General Literature ...

- Theo Ungerer: *Parallelrechner und parallele Programmierung*, Spektrum, Akad. Verl., 1997.
  - much about parallel hardware and operating systems
  - also basics of programming (MPI) and compiler techniques
- Ian Foster: *Designing and Building Parallel Programs*, Addison-Wesley, 1995.
  - design of parallel programs, case studies, MPI
- Seyed Roosta: *Parallel Processing and Parallel Algorithms*, Springer, 2000.
  - mostly algorithms (design, examples)
  - also many other approaches to parallel programming

Literature for Special Topics

- S. Hoffmann, R.Lienhart: *OpenMP*, Springer, 2008.
  - handy pocketbook on OpenMP
- W. Gropp, E. Lusk, A. Skjellum: *Using MPI*, MIT Press, 1994.
  - the definitive book on MPI
- D.E. Culler, J.P. Singh: Parallel Computer Architecture - A Hardware / Software Approach. Morgan Kaufmann, 1999.
  - UMA/NUMA systems, cache coherency, memory consistency
- Michael Wolfe: *Optimizing Supercompilers for Supercomputers*, MIT Press, 1989.
  - details on parallelizing compilers