Parallel Processing

Winter Term 2025/26

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Parallel Processing

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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; Using generative AI for teaching; Parallel and distributed systems
- Head of Examination Board Computer Science

- **E-mail:** roland.wismueller@uni-siegen.de
- **Tel.:** 0271/740-4050
- **Room:** H-B 8404
- **Office Hour:** Mo., 14:15-15:15

About the Chair "Operating Systems / Distrib. Sys."

Andreas Hoffmann
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0271/740-4047
H-B 8405

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

Felix Breitweiser
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0271/740-4719
H-B 8406

- Operating systems
- Programming languages
- Virtual machines

Sven Jacobs
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0271/740-2533
H-B 8407

- E-assessment and e-labs
- Generative artificial intelligence
- Web technologies

Teaching

Lectures/Labs

- Rechnernetze I, 6 CP (Bachelor, summer term)
- Rechnernetze Praktikum, 6 CP (Bachelor, winter term)
- Rechnernetze II, 6 CP (Master, summer term)

- Betriebssysteme und nebenläufige Programmierung, 6 CP (Bachelor, summer term)
- Parallel processing, 6 CP (Master, winter term)
- Distributed systems, 6 CP (Bachelor, winter term)

Teaching ...

Project Groups

- e.g., secure cooperation of software components
- e.g., concepts for secure management of Linux-based thin clients

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 words paper)
- Master: attend the lecture “Scientific Working” beforehand!
  - block course end of Feb. / beginning of March

Notes for slide 6:

A note on external Master theses: The right to give you a topic for a Master thesis lies with the University only!

This means, if you want to do a thesis at an external company or research institute, you **first** have to find a professor who will supervise you, and then, if she or he is interested, the professor may define a topic together with the company.

Please have a look at our handout on conducting external theses![a]

[a] https://www.eti.uni-siegen.de/dekanat/pruefungsamt/dokumente/studienganguebergreifend/externe-abschlussarbeiten-eti_en.pdf

About the Lecture

Lecture

- Mon., 12:15-13:45, H-C 8326
- on Tue., 14.10., 21.10., 28.10. and 04.11. also in the lab slot: 10:15-11:45, H-C 8326

Practical labs

- Tue., 10:15-11:45, PC lab room H-C 4111 (and at home)
  - some exercises rely on software / hardware in the lab room
- Tutor: Felix Breitweiser (felix.breitweiser@uni-siegen.de)
  - for questions, help, and discussion of solutions

About the Lecture ...

Information, slides, and announcements

- See the WWW page for this course
- http://www.bs.informatik.uni-siegen.de/lehre/pv/
- Annotated slides (PDF) available; maybe slightly modified

Moodle course

- https://moodle.uni-siegen.de/course/view.php?id=23366
- For students arriving late:
  - screen casts of the lectures until mid November
- Screen casts with tutorials on exercises / tools
- Submission of lab assignments

About the Lecture ...

Learning targets

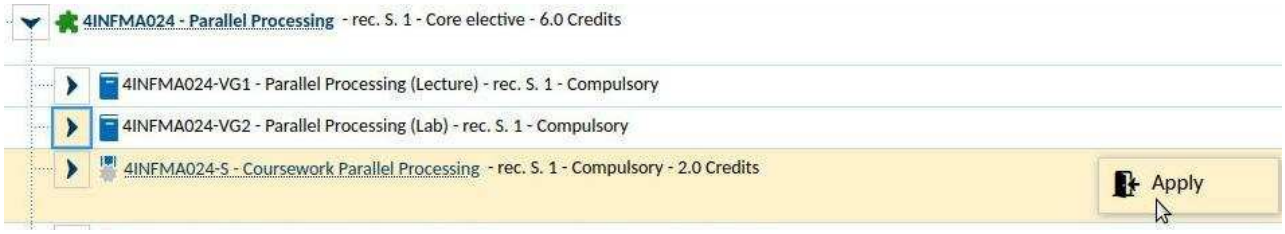
- Knowing the basics, techniques, methods, and tools of parallel programming
- Basic knowledge about parallel computer architectures
- **Practical knowledge/experience with parallel programming**
- Knowing and being able to use the most important programming models
- Knowing about the possibilities,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

Methodology

- Lecture: Basics
  - theoretical knowledge about parallel processing
  - practical introduction to programming environments
  - “hands-on” tutorials
- Lab: practical use
  - **independent programming work (lab + homework!)**
    - programming language: C++
  - practical skills and experiences
    - in addition: raising questions
  - main task: parallelization of two representative problems
    - iterative, numerical method (Jacobi, Gauss/Seidel)
    - combinatoral search (Sokoban)

Registration for Course Achievement (Studienleistung)

- Passing the course requires successful completion of the lab:
  - i.e., qualified attempt for all mandatory exercises
- You must register for ‘4INFMA024-S Coursework Parallel Processing’ in unisono **before you can submit a solution**! (do it right now!)
  - independent of the registration to the course and the lab!
  - if you cannot complete the course: **deregister** again!



Notes for slide 11:

If you are not registered for the course achievement, you will not be able to submit any solutions in the Moodle plattform (the corresponding section will not be available in Moodle).

Since data is transferred between unisono and Moodle only about once a week, you should register way in advance!

Requirements for passing the Course Achievement

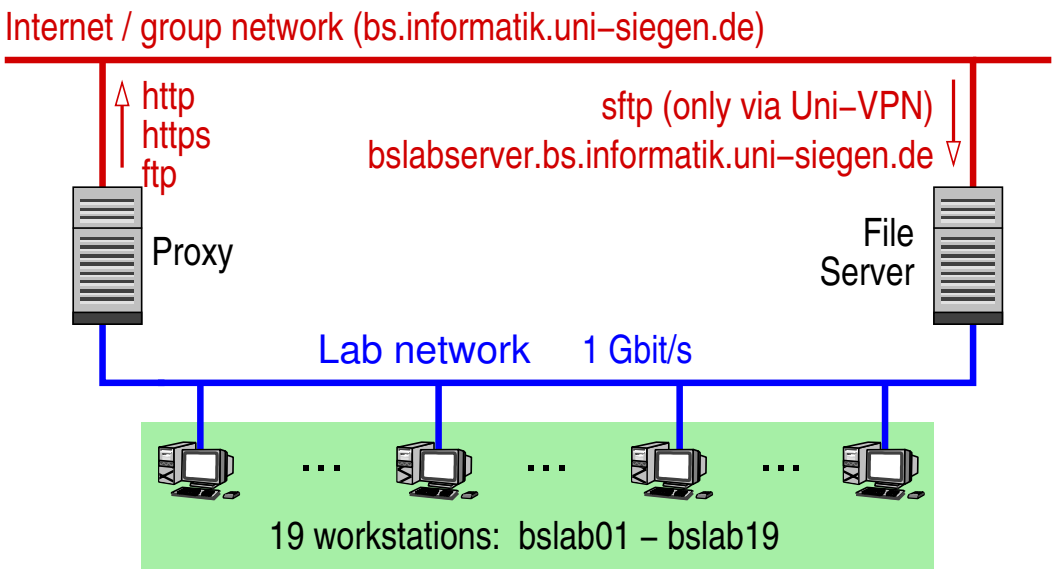
- Eight exercise sheets
  - each with 1-2 mandatory exercises of different weight (1-3)
  - **it'll be hard work!**
    - 6 LP = 180 hours, that is 60 h presence (lecture + lab), **60 h homework**, 60 h preparation for exam
  - solve exercises in the lab (H-A 4111) and at home!
  - solutions must be submitted via Moodle in due time
    - requirement for passing: at least **serious** attempt
    - codes must at least compile and execute in the lab
    - sometimes, additional answers / materials are required
    - **do not copy!** (both will get 0 points)
- Grading: yes/no
- You need at least 12 out of 16 possible points to pass

Organisational Issues Regarding the Labs

- Assignments should be done in the lab (H-A 4111), but can / should also be prepared at home
- Ideally, you have a Linux-PC with the GNU-compiler (g++)
  - Windows with MSVC will not work for all exercise sheets
- In addition, you should have MPI installed, preferrable MPICH
  - see https://www.mpich.org/downloads
- User regulations and key card application form:
  - http://www.bs.informatik.uni-siegen.de/lehre/pv
  - please let me sign the key card application form and then deliver it directly to Mr. Kiel (AR-P 209)
  - by using the lab computers you accept the user regulations (see web page)
- **First lab hour**: Tue. 11.11., H-A 4111

Computer Environment in the Lab Room H-A 4111

- Linux-PCs, private IP network, but sftp access via VPN



Intel Core Ultra 7, 8+12 cores, 5.2/4.6 GHz, 32 GiB RAM

+ RTX 4060, 3072 cores, 1.8 GHz, 8 GiB RAM

Examination

- Written examination (60 minutes)
  - open book exam
  - electronic exam, computers provided by university
  - subject matter: lecture and labs!
    - examination also covers the practical exercises
- Application via unisono
  - **at least two weeks before the exam date (hard deadline!)**
    - exam date is published via unisono and course web page

Contents of the Lecture

- Repetition / Foundations
  - C/C++ for Java programmers
  - Threads and synchronisation
  - C++ threads
- Basics of Parallel Processing
  - Motivation, Parallelism
  - Parallelization and Data Dependences
  - Parallel Computers
  - Programming Models
  - Organisation Forms for Parallel Programs
  - Design Process
  - Performance Considerations

Contents of the Lecture ...

- Parallel Programming with Shared Memory
  - Basics
  - OpenMP
- Parallel Programming with Message Passing
  - Approach
  - MPI
- Optimization Techniques
  - Cache Optimization
  - Optimization of Communication

Time Table of Lecture and Labs

- Until November, 4^{th}: only lectures (Mon. + Tue.)
  - no lab (but home work)
- Then: lectures (Mon.) and lab (Tue. + home work)
- Last three weeks: only lab (Tue. + home work)
- Prospective due dates for the assignments:
  - 11.11.: Exercise sheet 1
  - ... (see web page)
  - 03.02.: Exercise sheet 8

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