



Parallel Processing

WS 2017/18

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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:** Monitoring, Analysis und Control of parallel and distributed Systems
- ➔ **Mentor** for Bachelor Studies in Computer Science with secondary field Mathematics
- ➔ **E-mail:** roland.wismueller@uni-siegen.de
- ➔ **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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0271/740-4047
H-B 8405

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



Damian Ludwig
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0271/740-2533
H-B 8402

- ➔ Capability systems
- ➔ Compilers
- ➔ Programming languages



Alexander Kordes
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0271/740-4011
H-B 8407

- ➔ Automotive electronics
- ➔ In-car networks
- ➔ Pattern recognition in car sensor data



Lectures/Labs

- ➔ Rechnernetze I, 5 LP (every summer term)
- ➔ Rechnernetze Praktikum, 5 LP (every winter term)
- ➔ Rechnernetze II, 5 LP (every summer term)
- ➔ Betriebssysteme I, 5 LP (every winter term)
- ➔ Parallelverarbeitung, 5 LP (every winter term)
- ➔ Verteilte Systeme, 5 LP (every summer term)
 - ➔ (will be recognised as Betriebssysteme II)
- ➔ Client/Server-Programmierung, 5 LP (every winter term)

Teaching ...



Project Groups

- ➔ e.g., tool for visualization of algorithms
- ➔ e.g., infrastructure for analysing the Android market

Theses (Bachelor, Master)

- ➔ Topic areas: mobile platforms (iOS, Android), sensor networks, parallel computing, pattern recognition in sensor data, security, ...
- ➔ e.g., static information flow analysis of Android apps

Seminars

- ➔ Topic areas: web technologies, sensor networks, pattern recognition in sensor data, ...
- ➔ Procedure: block seminar
 - ➔ 30 min. talk, 5000 word seminar paper



- ➔ **Lecture + practical Labs:** 2+2 SWS, 5 LP
 - ➔ Tutor: Matthias Bundschuh
- ➔ **Date and Time:**
 - ➔ Mon. 12:30 - 14:00, H-F 001 (Lect.) or H-A 4111 (Lab)
 - ➔ Thu. 16:00 - 17:30, ???????? (Lect.) or H-A 4111 (Lab)
- ➔ **Information, slides, and announcements:**
 - ➔ in the WWW: <http://www.bs.informatik.uni-siegen.de/lehre/ws1718/pv/>
 - ➔ annotated slides (PDF) available; maybe slight modifications
 - ➔ updated slides will normally be published at least one day before the lecture
 - ➔ code examples are installed locally on the lab computers in `/home/wismueller/PV`



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



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
- ➔ Prerequisite for admission: active attendance to the labs
 - ➔ i.e., qualified attempt for all main exercises
- ➔ Application:
 - ➔ fix a date with my secretary Mrs. Syska
 - ➔ via email (regina.syska@uni-siegen.de)
 - ➔ or personally (H-B 8403, in the morning)
 - ➔ application at the examination office



For Computer Science Students

- ➔ Please note the **deadlines** of the examination office:
 - ➔ filing of the **“Personalbogen”**: **10.11.2017**
 - ➔ filing of the **“Mentorengenehmigung”**: **23.11.2017**
 - ➔ without the “Mentorengenehmigung” you cannot enroll for examinations in non-obligatory courses!
 - ➔ **enrollment for written exams: 04.12. - 21.12.2017**
 - ➔ you can unsubscribe up to one week before the exam
 - ➔ (oral exams: no deadline for enrollment)
- ➔ Deadlines are earlier just in the winter term 2017/18
 - ➔ in January, the campus management system will be replaced!
- ➔ Other students (esp. business informatics, teaching):
 - ➔ please inform yourself at your examination office!

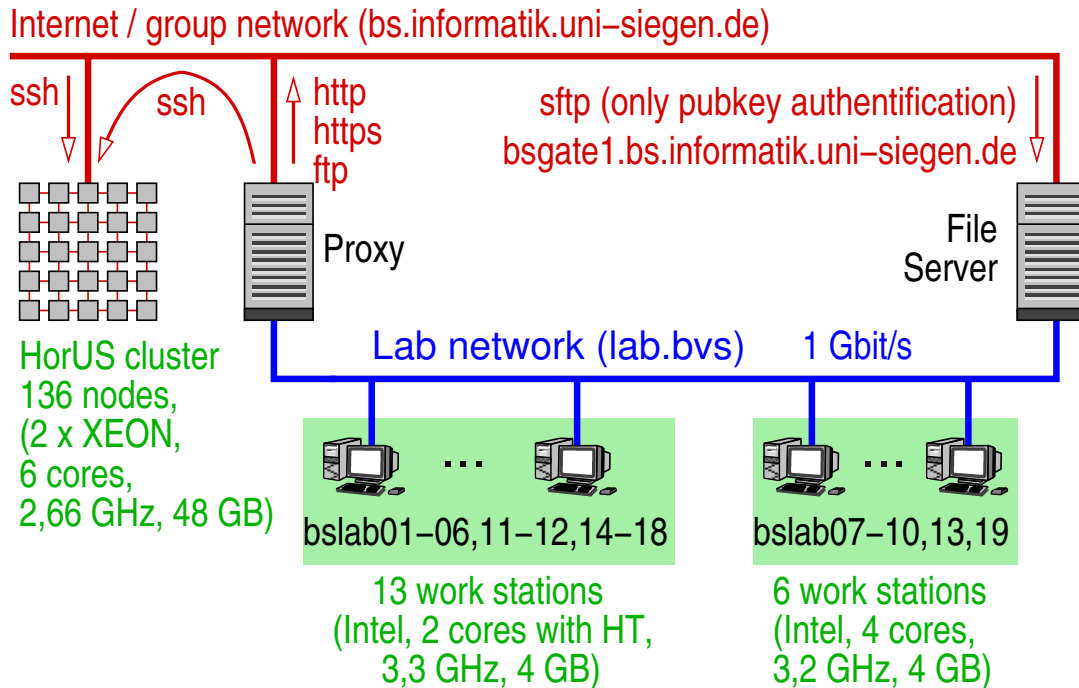
Organisational Issues regarding the Labs



- ➔ User regulations and key card application form:
 - ➔ <http://www.bs.informatik.uni-siegen.de/lehre/ws1718/pv/>
 - ➔ please let me sign the key card application form and then deliver it directly to Mr. Kiel (AR-P 209)
- ➔ **Start of labs: 02.11.**
 - ➔ introduction to the computer environment (Linux)
 - ➔ emission of login credentials
 - ➔ please pay attention to the user regulations in the WWW!
- ➔ Programming in C/C++



- ➔ Linux-PCs, private IP network, but `ssh` access to HorUS cluster



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



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

Preliminary Time Table of Lecture (V) and Labs (Ü)



| Date | Monday | Date | Thursday |
|--------|----------------------------|--------|-------------------------|
| 09.10. | V: Motivation, Parallelism | 12.10. | V: Parallel Computers |
| 16.10. | V: Programming Models | 19.10. | V: Design, Organisation |
| 23.10. | V: Performance | 26.10. | V: C Tutorial |
| 30.10. | V: POSIX Threads | 02.11. | Ü: PThreads (Quicksort) |
| 06.11. | V: OpenMP | 09.11. | Ü: PThreads (Quicksort) |
| 13.11. | V: OpenMP | 16.11. | Ü: PThreads (Quicksort) |
| 20.11. | Ü: OpenMP Tutorial | 23.11. | Ü: OpenMP (Jacobi) |
| 27.11. | V: OpenMP | 30.11. | Ü: OpenMP (Jacobi) |

Light blue: open lab hours

Dark blue: Tutorials or delivery deadlines



| Date | Monday | Date | Thursday |
|--------|-----------------|--------|----------------------|
| 04.12. | Ü: Sokoban | 07.12. | Ü: OpenMP (Jacobi) |
| 11.12. | V: MPI | 14.12. | Ü: OpenMP (Jacobi) |
| 18.12. | V: MPI | 21.12. | Ü: OpenMP (Sokoban) |
| 08.01. | V: MPI | 11.01. | Ü: OpenMP (Sokoban) |
| 15.01. | Ü: MPI Tutorial | 18.01. | Ü: OpenMP (Sokoban)) |
| 22.01. | V: Optimization | 25.02. | Ü: MPI (Jacobi) |
| 02.02. | Ü: MPI (Jacobi) | 01.02. | Ü: MPI (Jacobi) |

Light blue: open lab hours

Dark blue: Tutorials or delivery deadlines

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 Rüniger: *Parallele Programmierung*. 2. Auflage, Springer, 2007.
 - ➔ architecture, programming, run-time analysis, algorithms



- ➔ 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