

Parallel Programming Workshop

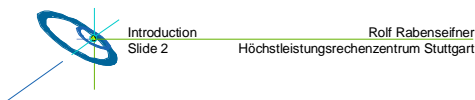
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University of Stuttgart
High-Performance Computing-Center Stuttgart (HLRS)
www.hlrs.de



Goals

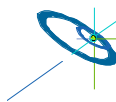
- **Overview**
 - on parallel programming models
 - on hardware architectures
 - on real HPC (high performance computing) platforms in Germany
- **Parallel programming**
 - on distributed memory systems with **MPI** (message passing interface)
 - on shared memory systems with **OpenMP**
 - advanced topics, domain decomposition ...
- **You should be able**
 - to make decisions:
 - which platform for **your application**
 - which programming model for **your application**
 - to parallelize **your application**
 - to use the documentation and advanced features in **your application**



Outline

This workshop is part of a 6-day course:

- 1st day (Monday), **Message Passing Interface (MPI-1, part 1)**
- 2nd day (Tuesday), **Message Passing Interface (MPI-1, part 2) and OpenMP**
- 3rd day (Wednesday), **MPI-2 and advanced MPI programming**
- 4th day (Thursday), **Advanced OpenMP programming and Vectorization**
- 5th day (Friday), **Domain Decomposition and Load Balancing**
- 6th day (additional day), **High Performance Fortran (HPF)**



Introduction
Slide 3

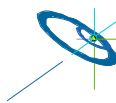
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Outline — 1st day (Monday)

Message Passing Interface (MPI-1, part 1)

- 9:00 **Introduction** [1] (talk)
- 9:10 **Parallel Architectures and Programming Models** [2] (talk)
- 10:10 **Coffee**
- 10:25 **MPI-1 – Introduction to the Message Passing Interface** [3+3a] (talk)
- 10:25 **Chap. 1 MPI Overview** (talk)
- 10:45 **Chap. 2 MPI Process model** (talk+practical)
- 12:00 **Lunch**
- 13:00 **Chap. 3 Messages and Point-to-Point Communication** (talk+practical)
- 14:15 **Coffee**
- 14:30 **Chap. 4 Non-Blocking Communication** (talk+practical)
- 15:45 **Coffee**
- 16:00 **Chap. 5 Derived Datatypes** (talk+practical)
- Writing Message-Passing Parallel Programs with MPI** [4] (only in the handouts)
- 17:00 **Parallel debugging** [5] (talk+practical)
- 17:30 **End**



Introduction
Slide 4

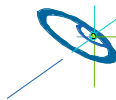
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Outline — 2nd day (Tuesday)

Message Passing Interface (MPI-1, part 2) and OpenMP

- 9:00 **Chap. 6 Virtual Topologies** [3, continued] (talk+practical)
- 10:10 **Coffee**
- 10:25 **Chap. 7 Collective Communication** (talk+practical)
- 11:00 **Coffee**
- 11:15 **Chap. 8 Other MPI-1 features** (talk)
- 11:40 **Heat conduction program, a parallelization example with MPI** [6] (talk)
- 12:00 **Lunch**
- 13:00 **OpenMP – Overview and execution model** [7+7a] (talk+practical)
- 14:00 **Coffee**
- 14:15 **OpenMP – Work sharing directives** (talk+practical)
- 15:15 **OpenMP – Data environment** (talk+practical)
- 16:00 **Coffee**
- 16:15 **OpenMP – Pitfalls** (talk)
- 16:45 **Assure – detection of OpenMP race conditions** [8] (talk; practical on 3/5 day course)
- 17:00 **Access to the federal high-performance computing-centers** [9] (talk, 2-day course only)
- 17:30 **End**



Introduction
Slide 5

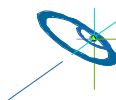
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Outline — 3rd day (Wednesday) — 3-day course only

MPI-2 and advanced MPI programming (3-day course)

- 9:00 **Access to the federal high-performance computing-centers** [9] (talk)
- 9:30 **MPI-2 overview** [10] (talk)
- 9:45 **MPI-2 parallel file I/O (basics)** [11] (talk+practical)
- 10:45 **Coffee**
- 11:00 **MPI-2 parallel file I/O (fileviews)** (talk+practical)
- 12:00 **MPI-2 parallel file I/O (access methods)** (talk)
- 12:30 **Lunch**
- 13:30 **MPI on hybrid systems / MPI + OpenMP** [23] (talk, 1h)
or **MPI-2 one-sided Communication** [12] (talk, 30min)
- 14:00 **Other MPI-2 chapters** [13] (talk)
- 14:30 **Coffee**
- 14:45 **Optimization of MPI applications** [14] (talk)
- 15:30 **MPI Performance Studies on Cray T3E and SGI Origin** [15] (talk)
- 15:45 **VAMPIR and other tools for performance analysis** [16, 17] (talk+practical)
- 16:30 **End**



Introduction
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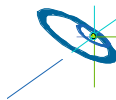
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Outline — 3rd day (Wednesday) — 5-day course only

MPI-2 and advanced MPI programming (5-day course)

- 9:00 **Access to the federal high-performance computing-centers** [9] (talk)
- 9:30 **MPI-2 overview** [10] (talk)
- 9:45 **MPI-2 parallel file I/O (basics)** [11+11a] (talk+practical)
- 10:45 **Coffee**
- 11:00 **MPI-2 parallel file I/O (fileviews)** (talk+practical)
- 12:00 **Lunch**
- 13:00 **MPI-2 parallel file I/O (access methods)** (talk+practical)
- 14:00 **Coffee**
- 14:15 **MPI-2 one-sided Communication** [12+12a] (talk+practical)
- 15:15 **Coffee**
- 15:30 **Other MPI-2 chapters** [13] (talk)
- 16:00 **Optimization of MPI applications** [14] (talk)
- 16:30 **Coffee**
- 16:45 **VAMPIR and other tools for performance analysis** [16, 17] (talk+practical)
- 17:10 **Application Support at HLRS** [18] (talk)
- 17:30 **End**



Introduction
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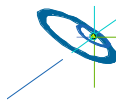
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Outline — 4th day (Thursday)

Advanced OpenMP programming and Vectorization

- 9:00 **OpenMP – Enhancements in OpenMP 2.0** [19] (talk)
- 9:30 **OpenMP – Cluster extensions** [20] (talk)
- 10:00 **Coffee**
- 10:15 **OpenMP – Tools** [21] (talk)
- 10:45 **OpenMP – Performance tuning and OpenMP** [22] (talk+practical)
- 12:00 **Lunch**
- 13:00 **MPI on hybrid systems / MPI + OpenMP** [23] (talk)
- 14:00 **Coffee**
- 14:15 **NEC SX-5 – Vectorization on NEC Supercomputers** [25] (talk)
- 15:15 **NEC psuite** [27] (online demonstration)
- 15:45 **Coffee**
- 16:00 **Hitachi SR8000 – Programming models, vectorization, Performance profiling and tuning** [29] (talk and online demo.)
- 16:45 **Virtual reality based visualization** [30] (talk and online demo in the "cave")
- 17:30 **End**



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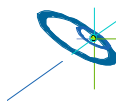
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Outline — 5th day (Friday)

Domain Decomposition and Load Balancing

- 9:00 **Domain decomposition of structured and unstructured grids** [31] (talk)
- 10:00 **Coffee**
- 10:15 **Load balancing** [32+32a] (talk+practical)
- 11:30 **Numerical libraries** [33] (talk)
- 11:50 **Parallel numerics (part1)** [34] (talk)
- 12:30 **Lunch**
- 13:30 **Parallel numerics (part2)** (talk)
- 14:15 **Coffee**
- 14:25 **Particle based domain decomposition** [35] (talk)
- 15:10 **Coffee**
- 15:20 **Object oriented parallel programming with C++** [36] (talk)
- 16:30 **End**



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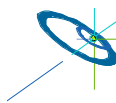
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Outline — 6th day (additional day)

High Performance Fortran (HPF)

- 9:00 **HPF, JaHPF and HPF-2 (part1)** [37+37a] (talk+practical)
- 12:00 **Lunch**
- 13:00 **HPF, JaHPF and HPF-2 (part2)** (talk+practical)
- 16:30 **End**



Introduction
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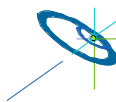
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Outline — Additional Presentations — online only

- (1:00) **Parallel Hardware Architectures / Which Parallel Programming Model is the best?** [2a] (talk)
- (1:00) **NEC HPC platforms** [24] (talk)
- (1:00) **NEC SX-5 – Shared Memory parallelization on NEC Supercomputers** [26] (talk)
- (0:45) **Hitachi SR8000 – Introduction and Hardware Architecture** [28] (talk)

http://www.hlr.de/news-events/events/2001/parallel_prog_fall2001/material/



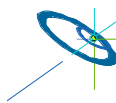
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H L R I S

Subjects

- Programming models
 - MPI and OpenMP
 - the major standards for parallel programming
- Tools
 - debugging, verifying the correctness
 - performance optimization
 - important for the development of parallel applications
 - commercial tools
 - but freely available via X11 for the users at most HPC centers
 - first touch with the exercises
- Parallel numerics
 - wide area
 - here only major topics in this area



Introduction
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H L R I S

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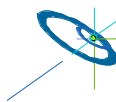
HLRS High-Performance Computing-Center (HLRS) at the University of Stuttgart
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ZHR Center for High-Performance Computing (ZHR) at Dresden University of Technology
www.tu-dresden.de/zhr/

ZAM Central Institute for Applied Mathematics (ZAM), Forschungszentrum Jülich
www.fz-juelich.de/zam/zam.html

EPCC Edinburgh Parallel Computing Centre www.epcc.ed.ac.uk/epcc-tec/

MSU Mississippi State University, High Performance Computing Lab www.cs.msstate.edu



Introduction
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