

MuCoSim Seminar WS22/23

Prof. Gerhard Wellein / Dr.-Ing. Jan Eitzinger



- Professorship for High Performance

Some facts

2 Professors
22 staff members
6 PHD students

- NHR@FAU

N

Operate multiple HPC clusters:
1650 compute nodes
220 GPUs

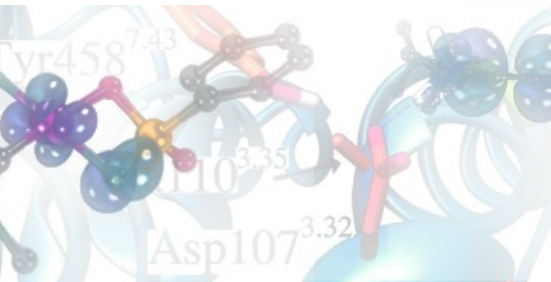
- HPC group at RRZ

 High Performance Computing

Teaching and training

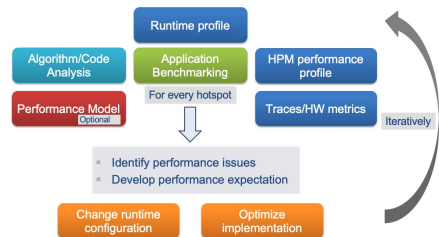
Research

Develop Open-Source tools

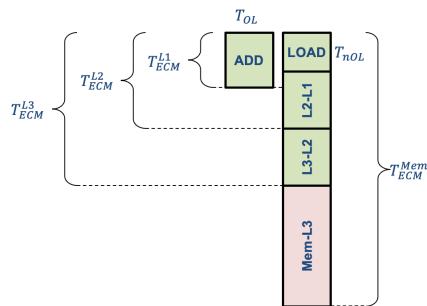
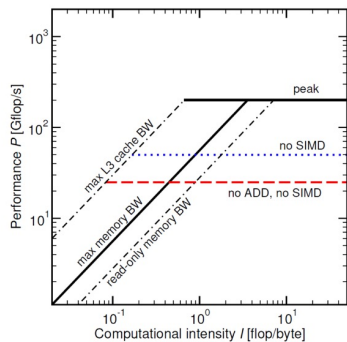


Research focus

Performance Engineering



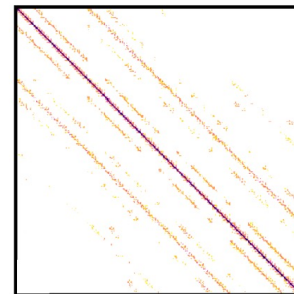
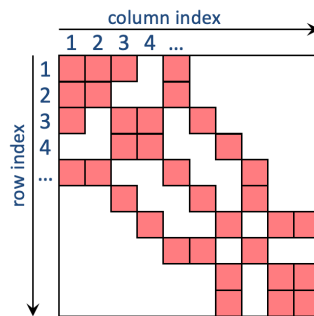
Performance Modeling



Performance Tools



Hardware-Aware Building Blocks for Sparse Linear Algebra



Topic of Seminar

- Seven Dwarfs:
 - numerical methods that are important for science and engineering
 - defined by similarity in computation and data movement
- Mini-Apps / Proxy Apps
 - Self-contained code that is simple to build and run
 - Simple to understand and maintain
 - Still mimics the performance behavior of critical kernels from real applications

The Landscape of Parallel Computing Research: A View from Berkeley



*Krste Asanovic
Ras Bodik
Bryan Christopher Catanzaro
Joseph James Gebis
Parry Husbands
Kurt Keutzer
David A. Patterson
William Lester Plishker
John Shalf
Samuel Webb Williams
Katherine A. Yelick*

Electrical Engineering and Computer Sciences
University of California at Berkeley

Technical Report No. UCB/ECS-2006-183
<http://www.eecs.berkeley.edu/Pubs/TechRpts/2006/ECS-2006-183.html>

December 18, 2006

Your task

- Pick one of the proxy-apps representing a Dwarf
- Decide if you want to look at CPU or GPU platform
- You will document all your steps and results in a Markdown Performance Logbook (we will provide a template)

Phase 1

- Learn about the Dwarf background and applications
- Get familiar with the proxy-app and build it
- Perform extensive application benchmarking
- Create a runtime profile

Your task cont.

Phase 2

- Instrument the hotspots of the proxy-app using LIKWID markers
- Perform hardware performance profiling with likwid-perfctr
- Document and analyze the results
- In the ideal case you come up with a sound explanation what aspect of the hardware limits the performance
- Investigate what ideal performance you would expect

- You have to give a **short talk about Phase 1** in beginning of the semester
- A **second talk** in the second semester half with results from Phase 2
- Finally you have to prepare a **report** (6-8 pages)

Overview seven Dwarfs

1. Dense Linear Algebra (BLAS, ScaLAPACK)
2. Sparse Linear Algebra (SpMV, SuperLU)
3. Spectral Methods (FFT)
4. N-Body Methods (MD)
5. Structured Grids (PDE Stencil solver)
6. Unstructured Grids (FEM or FVM on Tetraeder mesh)
7. Monte Carlo (Quantum Monte Carlo)

Possible proxy-apps

- **Cloverleaf**: Structured stencil code implemented in Fortran (OpenMP and CUDA versions available)
- **MD-Bench/MiniMD/CoMD**: Molecular dynamics implemented in C (OpenMP and CUDA versions)
- **MiniFE**: Unstructured Grids implemented in C++
- **SWFFT**: HACC FFT implemented in C++ (MPI)
- **Quicksilver**: Monte Carlo Particle Transport implemented in C++ (OpenMP and CUDA versions)

Possible proxy-apps cont.

- **Lulesh**: Unstructured Lagrangian Explicit Shock Hydrodynamics in C++ (MPI, OpenMP, CUDA, and many more)
- **POT3D**: Solar Physics simulation code in Fortran (MPI and OpenACC GPU versions)
- **SPH-EXA**: Smooth particle hydrodynamics solver (SPH) for Astrophysics and Cosmology in C++ (MPI/OpenMP and GPU CUDA)
- **LBM D2Q37**: Lattice Boltzmann Computational Fluid Dynamics in C (MPI and GPU CUDA available)

Preliminary Schedule

- **17.10.** Introduction
- **24.10.** Selection of topics and fix dates for talks
- **31.10./07.11.** LIKWID and Benchmarking Intro + Presentation of Tealeaf (T. Gruber)
- **14.11.** Lecture on Roofline model (Prof. Wellein)