Student Cluster Competition 15 Team

TUMuchPhun

from the Technical University of Munich

SCC15 – The Challenge

»In this real-time, non-stop, 48-hour challenge, teams of undergraduate and/or high school students assemble small clusters at SC15 in the Palazzo, and race to complete a real-world workload, across a series of applications, and to impress HPC-industry judges. In the competition, teams of six students partner with vendors to design and build cutting-edge clusters, from commercially-available components, and work with application experts to prepare for the competition. With a catch! - Clusters must not exceed the 3120-watt power limits (26 amps at 120 volts). « — SCC15 Website

Michael Zellner
- graduated at upper vocational school to eventually study computer science at TUM
- has worked at the Leibniz Supercomputing Center as specialist for systems integration

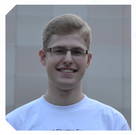
▶ post-processing expert

Sharru Möller
- started studying computer science as a pupil
- is giving algorithm courses as a tutor
- HPC knowledge of astronomic simulations

▶ energy management expert

Gregor Matl
- studying Computer Science and Mathematics
- won the German Federal Contest in Informatics
- competed in the International Olympics in Informatics (IOI) in Taiwan

▶ competitive programming expert

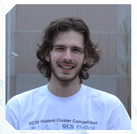


Daniel Gallenberger
- studying computer science and mathmatics as secondary subject
- has experience in game programming and the design of hardware architectures

▶ MILC & WRF expert

Felix Thimm
- studying Computer Science at the TUM with focus on High Performance Computing
- is enthusiastic about the challenge

▶ Trinity & HPL expert



Felix Späth
- has written his bachelors thesis on in-situ multi-node visualization of tsunami simulations
- wrote a tsunami simulation for coprocessors and an interactive java application

▶ showcase expert

HPC at the Technical University of Munich

- neighbor of the Leibniz Supercomputing Centre (LRZ), which hosts the 2x3 PFLOPS SuperMUC
- at Bachelors level seminars and courses with focus on HPC are offered, e.g. on molecular dynamics simulation and tsunami simulation
- at Masters level there are lectures on Parrallel Programming and Scalability as well as many seminars, e.g. optimization of a shallow water code
- course Programming of Supercomputers for the international CSE Master Programm
- LRZ offers training of PhD-level and postdoc researchers. The respective courses, including an introduction to Xeon Phi programming, are also open to TUM students.

Keys to Win
- half a year of intense tuning and refinement
- utilize diverse proficiencies of team members
- exploit many-core parallelism on Xeon Phi processor
- maximize computational performance per Watt
- create stunning visualizations of vast amounts of data

▶ *Phun on Phis!*

Preparing for the Challenge
- biweekly team meetings at the TUM and the Leibniz Computing Center (LRZ)
- training on the LRZ's Xeon Phi Cluster under competitive conditions
- expert support from RSC professionals and access to the actual machine
- pizza-fueled hackathons
- coaching from PhD students and HPC experts *Sebastian Rettenberger* and *Roland Wittman*

▶ we are prepared for every scenario!

Visit out Partners!
- ▶ RSC at booth 2513
- ▶ LRZ at booth 2328

Find us on

@TUMuchPhunSCC15

The Applications

LINPACK Benchmark
- solving vast systems of linear equations is the most important benchmark for supercomputers
- we studied a variety of optimization strategies with support from our hardware sponsor RSC

▶ Pure computational power will be required!

Trinity: RNA Sequencing
- RNA processing has crucial medical application, e.g. to determine customized medications for diseases like HIV
- we are running the application on our host node since the Xeon Phi nodes run into trouble executing java

▶ A puzzle for our host node to unravel!

MILC: Quantum Simulation
- designed to study nature's strong force by simulation the interaction of fermions
- compilation for Xeon Phis went smoothly

▶ *»That I understand what holds the core of the world together«* — Goethe's Faust

HPC Repast: Zombie Invasion
- simulates a deadly zombie invasion in a 2D space
- agent based large-scale simulation model
- competition hosts the 2.0 modified zombie version
- we have developed a parser to visualize the output

▶ Will humanity survive?

WRF: Weather Forecasting
- utilizes more than 50GB of detailed geological data for accurate weather calculation
- building every single component of the application for Xeon Phis proved to be a challenge - but now it's done!

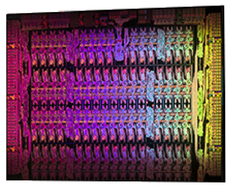
▶ Taking SCC15 by storm!

Mystery Application
- is unknown to the teams prior to the competition
- we set up a training session for building a completely new code to prepare for this challenge

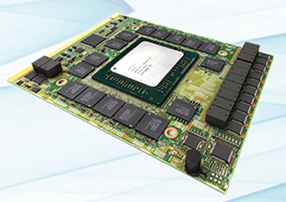
▶ No mystery will remain unsolved!

based on

RSC PetaStream®



Processor
- Intel® Xeon Phi™
- 61 cores / 244 threads
- 1.238 GHz
- 352 GB/s peak memory bandwidth
- 30 MB shared cache



Compute Node
- Intel® Xeon Phi™ 7120A/P
- One compute chip
- 16 GB of RAM
- 64 Gbps IO bandwith
- Linux µOS

Compute Module
- 2x4 compute nodes
- Over 200 Gbps external IO bandwith
- Direct liquid cooling of all components
- Integrated node management
- Effective DC 400V power system

Overall Performance
- ▶ 488 cores / 1952 hardware threads
- ▶ > 1.2 TFLOPS peak performance
- ▶ 128 GB of RAM
- ▶ 2.4 TB SSD HARD Drive DC S3710
- ▶ 3030 W (3120W allowed)

Energy Efficiency
- energy consumption is the limiting factor in this competition

▶ an Intel® Xeon Phi™ system ranked #1 in the GREEN500 ranking of 2012 and Xeon based systems constitute the top ten ever since

RSC Group: Our Hardware Sponsor
- founded in 2009 in Russia
- hardware vendor with focus on energy efficient solutions
- largest project: prototype of a 10 TFLOPS-range supercomputer at the Russian Academy of Science (RAS)

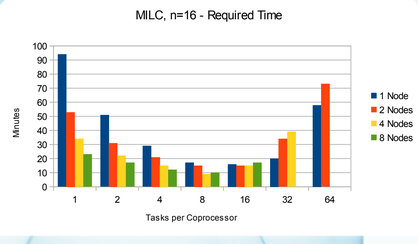
▶ provides cutting edge hardware and broad experience

Visualization

WRF Simulation
- We create weather simulations using our own pipeline, involving WRF, Paraview, Blender and custom-made import scripts.

▶ Many single rendered pictures are used to create animated videos.

Performance Tuning



MPI Organization
- We have analyzed the Runtime of MILC depending on the number of nodes and tasks

▶ The performance is maximized for n = 16 with 16 tasks per coprocessor – for n =32 the optimum is depending on the number of nodes.

Sponsored by:

GCS Gauss Centre for Supercomputing

IGSSE TUM International Graduate School of Science and Engineering

RSC Inspiring innovations www.rscgroup.ru