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Scientific Computing
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The group Scientific Computing conducts research and development on high performance storage systems. We develop HPC concepts and apply them to simulation software with a focus on earth system models.

We are an Intel Parallel Computing Center for Lustre. (“Enhanced Adaptive Compression in Lustre”)
High Performance Storage Systems

- Data reduction
  - **SCIL**: Application-specific, lossy compression
  - Lustre: File system, adaptive lossless compression
  - BigStorage: Energy-efficient data reduction

- Performance
  - I/O monitoring and optimization (15:15)

- I/O interfaces
  - **JULEA**: Flexible storage framework for HPC (15:35)
  - ESDM: Earth system data, HDF5
SCIL

- **Scientific Compression Interface Library (SCIL)**
  - Design of quantities, tools, compression chain
  - HDF5 plug-in for transparent use
- **Domain-specific compression (ratio > 10 : 1)**
  - Investigate metrics allowing to define accuracy per variable
  - Design user-interfaces for specifying accuracy
  - Develop a methodology for identifying the required accuracy
  - Implement compression schemes exploiting this knowledge
- **Evaluation on synthetic and scientific data (ECHAM, Isabel)**
- **Part of WP2 of the AIMES project**
  - [https://wr.informatik.uni-hamburg.de/research/projects/aimes/start](https://wr.informatik.uni-hamburg.de/research/projects/aimes/start)
Accuracy quantities:

absolute tolerance: compressed can become true value ± absolute tolerance
relative tolerance: percentage the compressed value can deviate from true value
relative error finest tolerance: value defining the absolute tolerable error for relative compression for values around 0
significant digits: number of significant decimal digits
significant bits: number of significant decimals in bits

Performance quantities:

compression speed: in MiB/s or GiB/s, or relative to network or storage speed
decompression speed: in MiB/s or GiB/s, or relative to network or storage speed

Supplementary quantities:

fill value: a value that scientists use to mark special data points
SCIL

Application

NetCDF4
+ Quantities support

HDF5
+ Quantities support
+ SCIL Filter

SCIL Tools

SCIL C-API

ZFP

SZ

...
JULEA provides a flexible storage framework
- Contains necessary building blocks for storage systems
- Facilitates rapid prototyping and evaluation
- Many projects implement basic functionality from scratch

Runs completely in user space and has few dependencies
- Easy to debug and develop
- Possible to use on clusters without root access

Feedback and contributions are always welcome
- First projects using it are running already
- https://github.com/wr-hamburg/julea
JULEA...
HPC Concepts and Infrastructure

- Domain-Specific Languages
  - GGDMML: Definition and manipulation of grids
  - FortranTestGenerator: Unit tests with capture and replay
- Energy efficiency
  - ArduPower: Open Source, based on Arduino
- Compiler optimizations
  - DasTool: Translation from OpenMP to MPI-3 RMA (14:50)
  - MPI-Checker: Static analysis for MPI
- Spack: Software management for supercomputers
DasTool

- Tool to automatize parallelization code modification
  - Probably not as effective as handwritten code ...
  - ... but no knowledge of MPI required by user

- Workflow:
  1. Exchange compiler calls by tool wrapper
  2. Rebuild application
  3. Adapt problem size to utilize additional nodes
  4. Run application as usual

Figure: Pass integration, based on [1]
HPC Education

- PeCoH: Performance engineering and HPC certification (14:30)
- Lectures about high-performance computing and high-performance I/O
- Seminars and software labs in cooperation with geoscience

- Student Cluster Competition
  - Fifth year in a row
  - Visit us at booth B-1366
  - Follow us on Twitter: @UHH_ISC_SCC
  - Vote for us: https://uhh.de/scc18
[1] Adrian Sampson. LLVM for Grad Students. 