BigStorage

Storage-Based Convergence Between HPC and Cloud to Handle Big Data

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About us: Scientific Computing

- Analysis of parallel I/O
- I/O & energy tracing tools
- Middleware optimization
- Alternative I/O interfaces
- Data reduction techniques
- Cost & energy efficiency

We are an Intel Parallel Computing Center for Lustre
(“Enhanced Adaptive Compression in Lustre”)

BigStorage

- BigStorage is a European Training Network (ETN)
  - Main goal is to train future data scientists
  - Estimated demand in the 100,000s over the next few years
- Focus on performance and energy consumption
  - Backed by use cases
- Consortium with ten partners
  - Seven research centers/universities
  - Three large companies
- Three associated partners from industry
- 15 Early Stage Researchers (ESRs)

BigStorage…

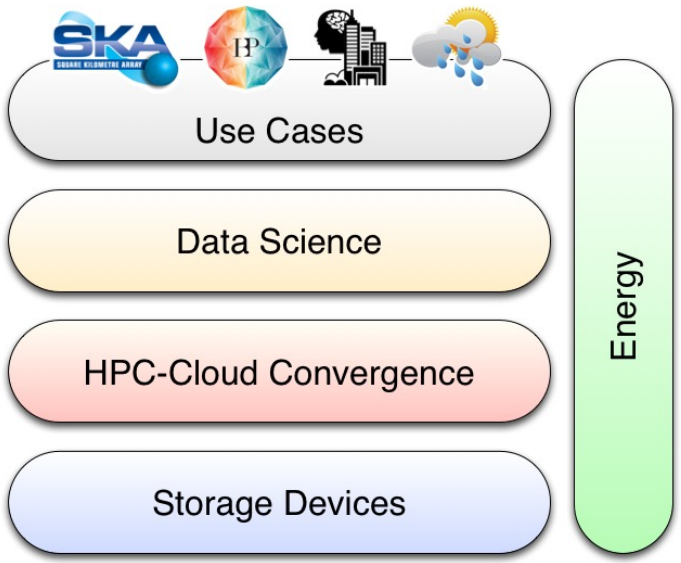
- Problems are addressed on different layers of the I/O stack
  - Applications that can exploit the data
  - Middleware for HPC and cloud environments
  - Infrastructure that provides compute and storage capabilities
- Appropriate techniques and algorithms have to be available
  - Areas include statistics, machine learning, visualization, databases and high performance computing
  - ESRs should be educated on different facets of data science

BigStorage…

Project overview

Data Science
- Modelling Big Data processing
- Energy-efficient analysis
- Data-driven decision making for Big Data applications

HPC-Cloud Convergence
- Applications
- Middleware, operating in the cloud and HPC environments
- Infrastructure for Storage and Computing



Storage Devices
- Storage acceleration
- Storage convergence
- Storage isolation

Energy
- Compression or de-duplication for storage footprint reduction
- Hints from application to storage system, enabling energy consumption reduction

- Split into four work packages and use cases
- Three work packages cover the whole I/O stack
  - Energy is a cross-cutting issue
  - Solutions are evaluated using use cases

BigStorage…

- Four use cases to evaluate developed solutions
  - Human Brain Project
  - Square Kilometre Array
  - Smart Cities
  - Climate Science
- Each use case is handled by a working group
  - Working groups consist of 3–4 ESRs and 1–2 advisors
  - Gathering requirements and extracting benchmarks

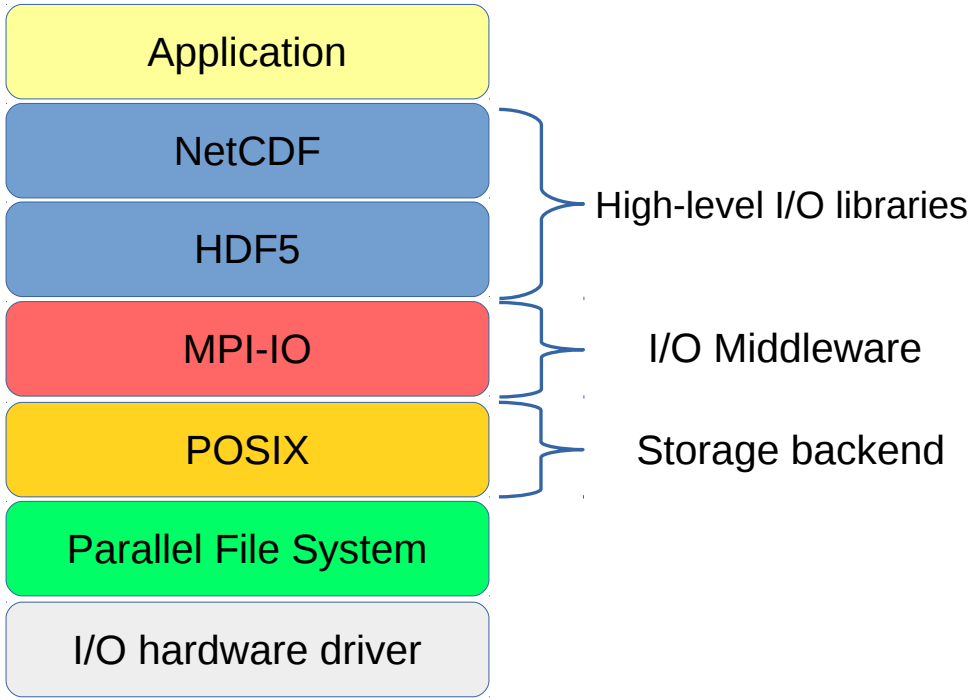
BigStorage…

- Activities to support training
- Training schools and workshops
  - Topics: big data, storage solutions, HPC, cloud, data science etc.
- Seminars
  - Topics: intellectual property, commercial exploitation of results, entrepreneurship etc.
- Additional language courses, scientific writing etc.
- Secondments and internships
  - Typically two secondments at other partners
  - Duration of 3–6 months

DKRZ

- Involved in HPC-cloud convergence and energy
  - Make use of cloud technologies for HPC workloads
  - Provide interface extensions to improve cost efficiency
- Leading the climate science working group
  - Analysis of I/O requirements for climate applications
  - Benchmark extraction for other interested parties
- Workloads: checkpointing/output, post-processing
  - Many climate applications still use serial I/O
  - Ensemble runs (tens to hundreds of model runs)
- Challenges
  - High volumes and exchangeability of data
  - Result analysis, interpretation, visualization
  - Data life cycle management

I/O stack



- Many climate science applications use CDI or NetCDF
  - Easy to change the underlying storage technology
- NetCDF is the de facto standard format
  - Export to NetCDF is a requirement
- Existing technologies have problems regarding scalability

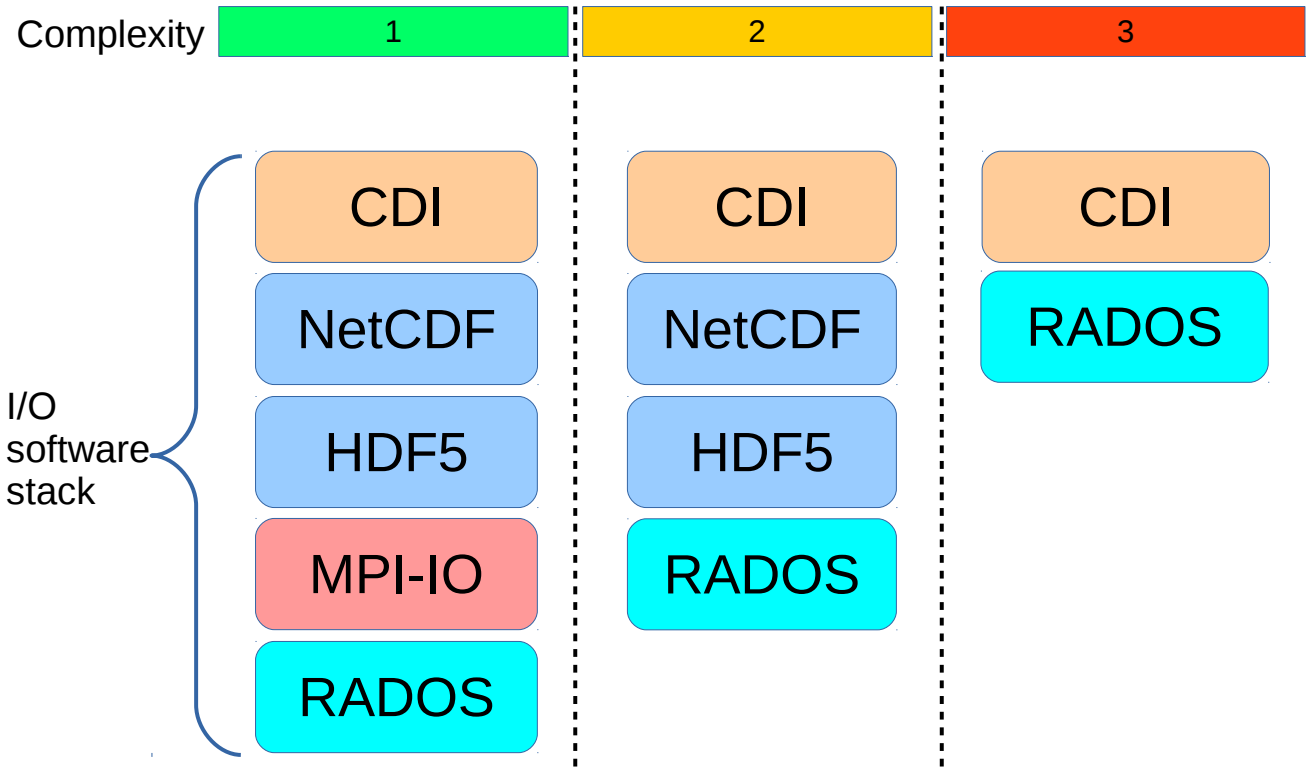
Data storage

- Data is typically stored in a parallel file system
  - HDF uses MPI-IO, which stores data in Lustre
  - Access to shared files has performance issues due to POSIX
  - Object stores provide sufficient functionality for MPI-IO
- Ceph is a storage platform
  - Provides block, file and object storage
  - No single point of failure
  - Resilient through replication
  - Scalable into the exabyte range

Data storage…

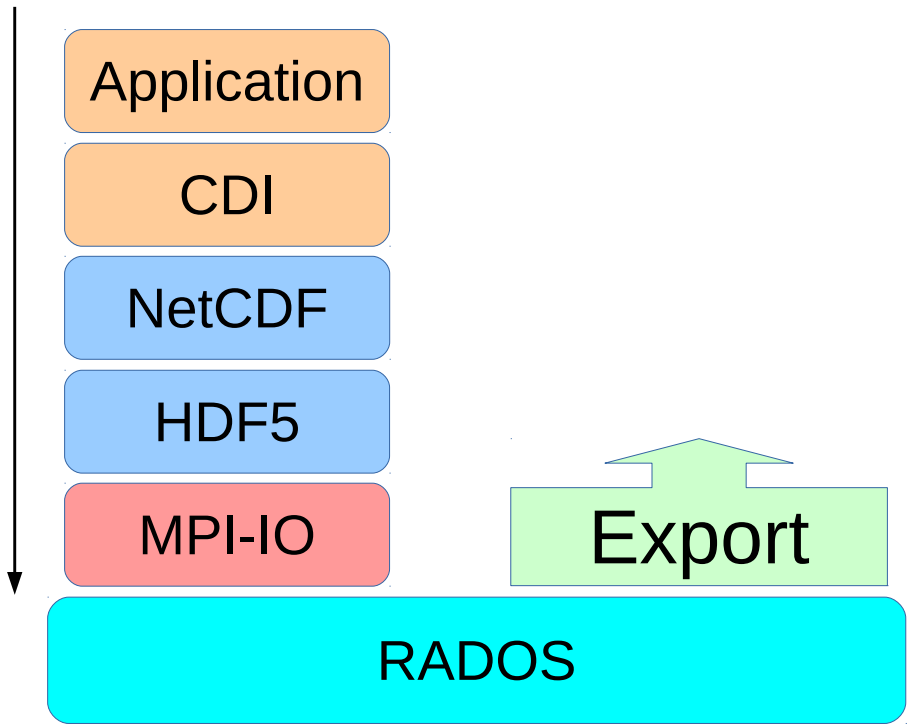
- Ceph consists of several components
  - RADOS (reliable, autonomous, distributed object store)
  - librados (direct access to RADOS)
  - radosgw (REST gateway with S3 and Swift compatibility)
  - RBD (reliable, distributed block devices)
  - CephFS (POSIX-compliant distributed file system)
- RADOS provides the basis with additional features built on top
  - Direct access if additional features are not required
  - Allows avoiding POSIX overhead

Data storage…



- RADOS can be integrated at different levels of the stack
  - Increasing difficulty from left to right
- Proof of concept: RADOS backend for MPI-IO

Data storage…



- Have to be able to export normal NetCDF files
  - Important for archiving and exchanging data
  - Might be as easy as `h5copy`

Summary

- BigStorage aims to train data scientists
  - Future demands are high
- Different facets of data science are taught
  - Applications, HPC and cloud middleware, storage infrastructure
  - Additional seminars and courses
- Climate applications use NetCDF
  - MPI-IO functionality can be provided by an object store
  - RADOS backend for MPI-IO allows avoiding POSIX overhead
- More information at
  - `http://bigstorage-project.eu/`
  - `https://wr.informatik.uni-hamburg.de/research/projects/bigstorage/start`