Coupled Storage System for Efficient Management of Self-Describing Data Formats

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Project Description

- CoSEMoS's goal is to rethink the **architecture of storage systems**
  - DFG project to improve performance and data management
  - Built upon JULEA: Modern C11 code, available as open source
  - Currently in its second year with a funding period of 2019–2022
- JULEA provides a **flexible storage framework**
  - Contains necessary building blocks for storage systems
  - Facilitates rapid prototyping and evaluation
- Runs in **user space** and has **few dependencies**
  - Kernel code increases complexity and fragility significantly
  - Possible to use on clusters without root access

Problem Statement

- **Self-describing data formats (SDDFs)** widely used to exchange data
  - Structural information is encoded in the files themselves
  - Files can be accessed and interpreted without prior knowledge

1. **Weak treatment of different types of metadata**
   - Two different types of metadata
     - **File system metadata** is stored on the metadata servers
     - **File metadata** (for example, attributes or additional annotations) is stored within SDDF files on the data servers
   - Strict separation of metadata leads to inefficient file access
2. **Static I/O semantics**
   - Strict consistency and coherence semantics due to POSIX
   - Static approaches are unable to satisfy all requirements
3. **Inefficient data placement**
   - Hierarchical structuring of different hardware is used
   - Data movement across storage tiers is an expensive operation
   - Hardware is available, new approaches need to be developed

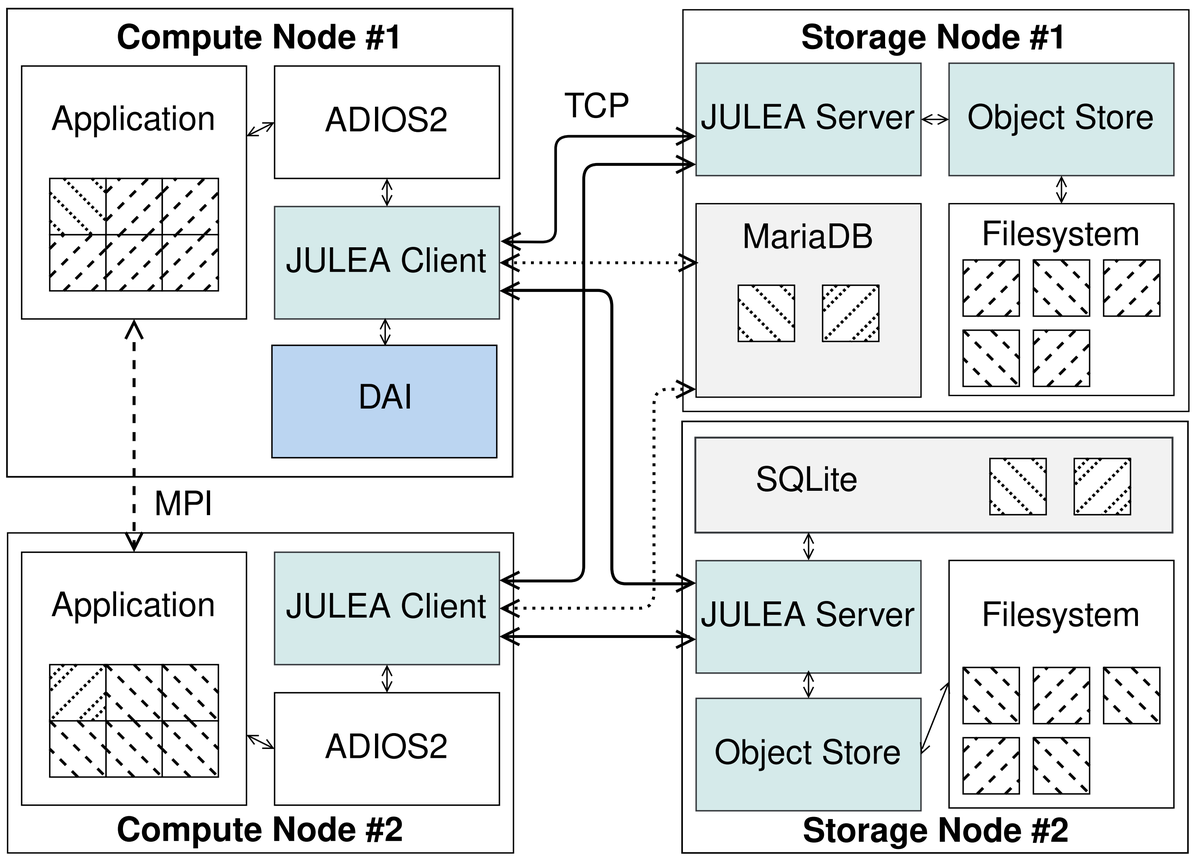
Objectives

1. **Global metadata management**
   - Closely **couple storage system and self-describing data formats**
     - All metadata handled by metadata servers
     - Optimize metadata accesses using database technologies
   - Novel data management approaches via a data analysis interface
     - Query file metadata across multiple files in a unified way
2. **Adaptable I/O semantics**
   - Possible to dynamically adapt semantics
     - Provide appropriate interfaces for applications and libraries
     - Specify **requirements regarding atomicity, consistency etc.**
3. **Intelligent storage selection**
   - Use structural information for **informed data placement decisions**
     - Improve performance by optimizing data placement
   - Different parts of self-describing files can be put on different tiers

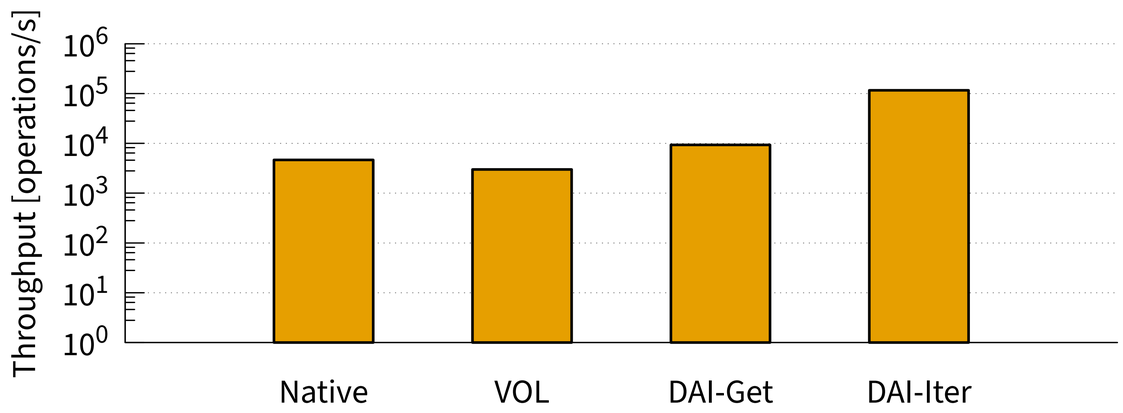
Partners

- German Climate Computing Center (Prof. Dr. Thomas Ludwig)
- Intel (Johann Lombardi)
- Max Planck Institute for Meteorology (Uwe Schulzweida)

Architecture and Evaluation



- JULEA (**turquoise**), database (**gray**) and data analysis interface (**blue**)



- Use case: Reading all attributes from an HDF5 file
  - Native HDF5 and JULEA VOL plugin are inefficient due to API overhead
  - DAI-Get: Fetch attributes separately, DAI-Iter: Iterate over attributes
- DAI-Get and DAI-Iter approaches offer **speedups of 2 and 25**, respectively

Work Packages

- WP1: **Application Interface**
  - T1.1 SDDF Interface ✔
  - T1.2 Application Requirements and Semantics ⧖
  - T1.3 Data Analysis Interface ⚙
- WP2: **Storage Tier Selector and Global Metadata Manager**
  - T2.1 Database Backend ✔
  - T2.2 Database Client ✔
  - T2.3 Metadata Backend Selection ⧖
  - T2.4 Data Storage Tiering ⚙
- WP3: **Evaluation and Dissemination**
  - T3.1 Compatibility Tests ⧖
  - T3.2 Case Study ⧖
  - T3.3 Workshop Organization ⚙

Acknowledgements and Links

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- https://cosemos.de/
- https://github.com/julea-io