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Extending Scalability of Collective IO Through Nessie and Staging

Parallel Data Storage Workshop

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Motivation

- Collective & Two-Phase IO proven beneficial
  - Relatively modest data volumes, 1-D, 2-D
- But….
- Trade-off of inter-node communication for data reorganization to save IO not always beneficial
  - Large datasets
  - 3-D domain decompositions particularly bad

Motivation

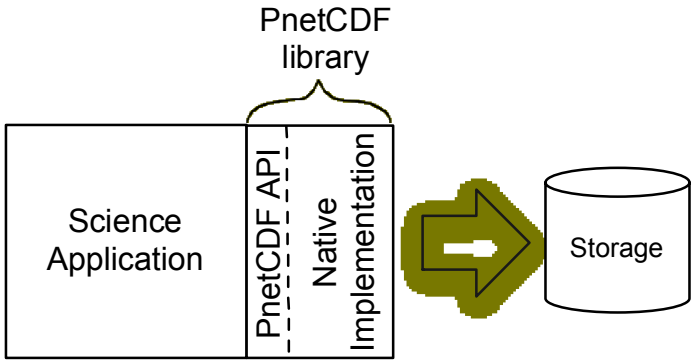
- **Problem: technique is central to some IO APIs**
  - **netCDF4, HDF5**
- **Problem: Changing IO techniques/file format may not be an option for some applications**
  - **CESM climate model is committed to netCDF file format**
- **Problem: Continued scaling of problem sizes and resolution making things worse**

Solution

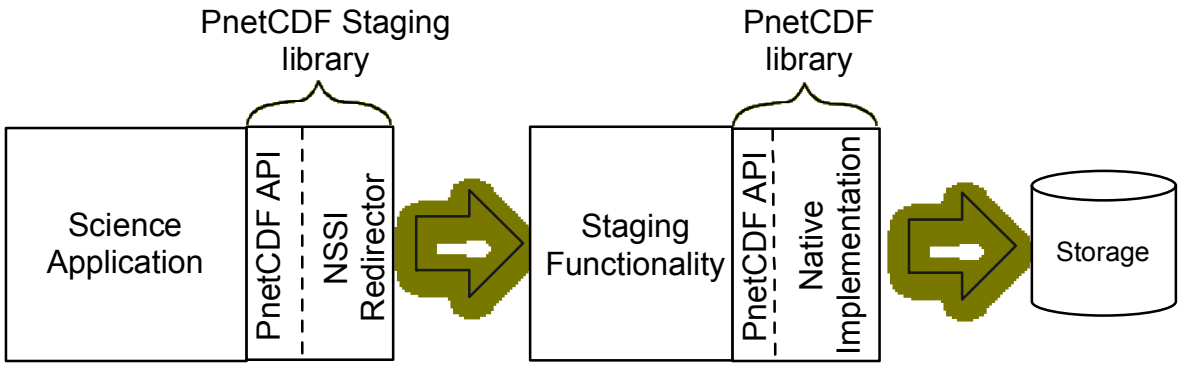
- Use efficient transport layer and data staging transparently in the IO stack
  - Re-implement native IO API (link-time compatible)
  - Ensure format on disk is identical
- Requirements
  - Efficient, portable transport layer
  - Staging area functionality to reduce time to completion

Solution Architecture

Native



Nessie



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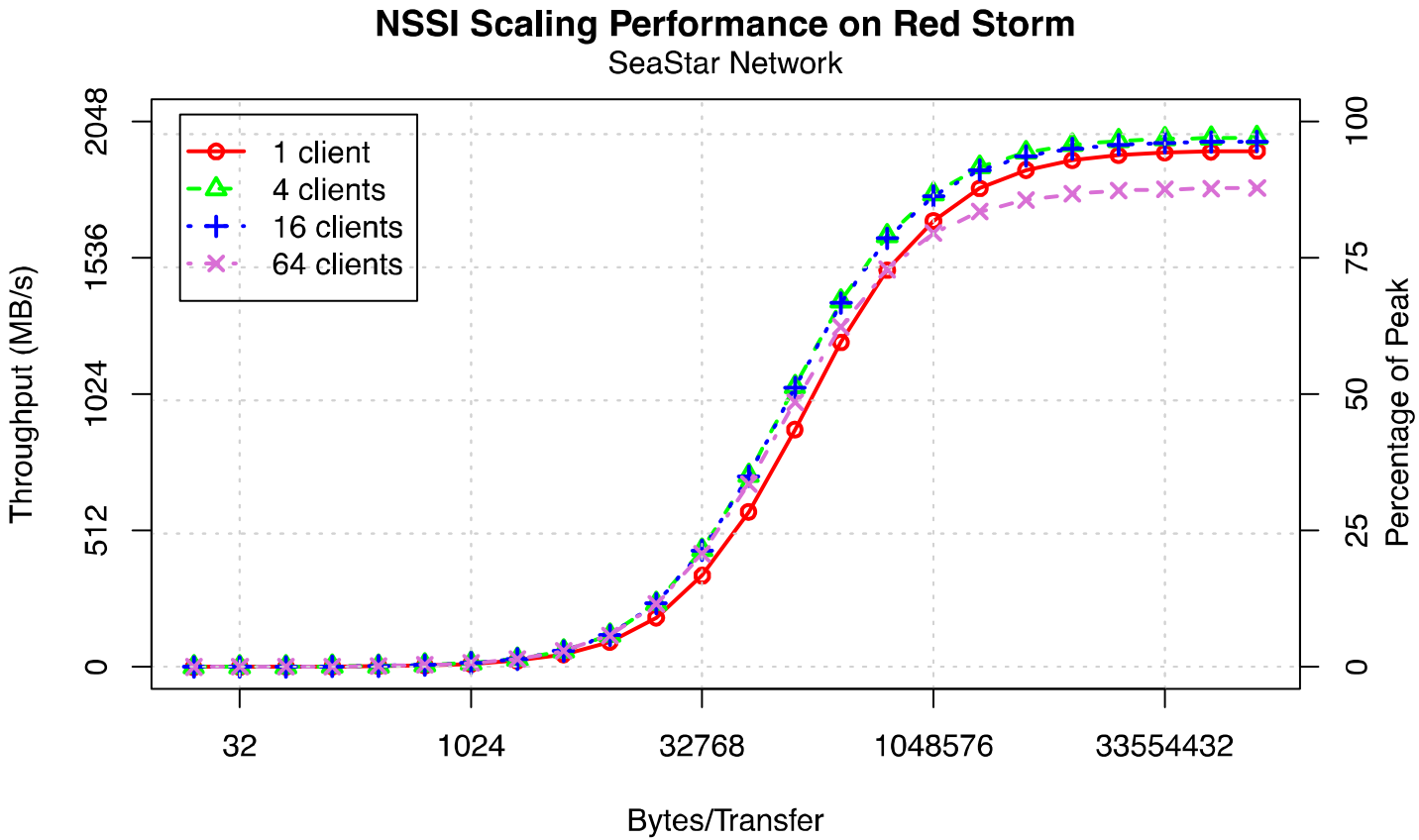
Nessie Transport Layer

- Network Scalable Services Interface (Nessie)
  - Originally developed for the Lightweight File Systems project
  - RPC-like asynchronous API layer supporting RDMA
  - Physical layer support
    - InfiniBand
    - Portals
    - Cray Gemini
  - Server-directed for bulk data
    - Writes: pull from client
    - Reads: push to client

Staging Functionality

- Collect data packets prior to writing to storage
  - Cache data chunks to afford other optimizations
- Perform data rearrangement
  - Perform partial data rearrangement like two-phase IO
- Use different techniques for writing to storage
  - Direct, Caching, Aggregation

Nessie Performance (Portals)



Performance of xfer_write_rdma on Red Storm

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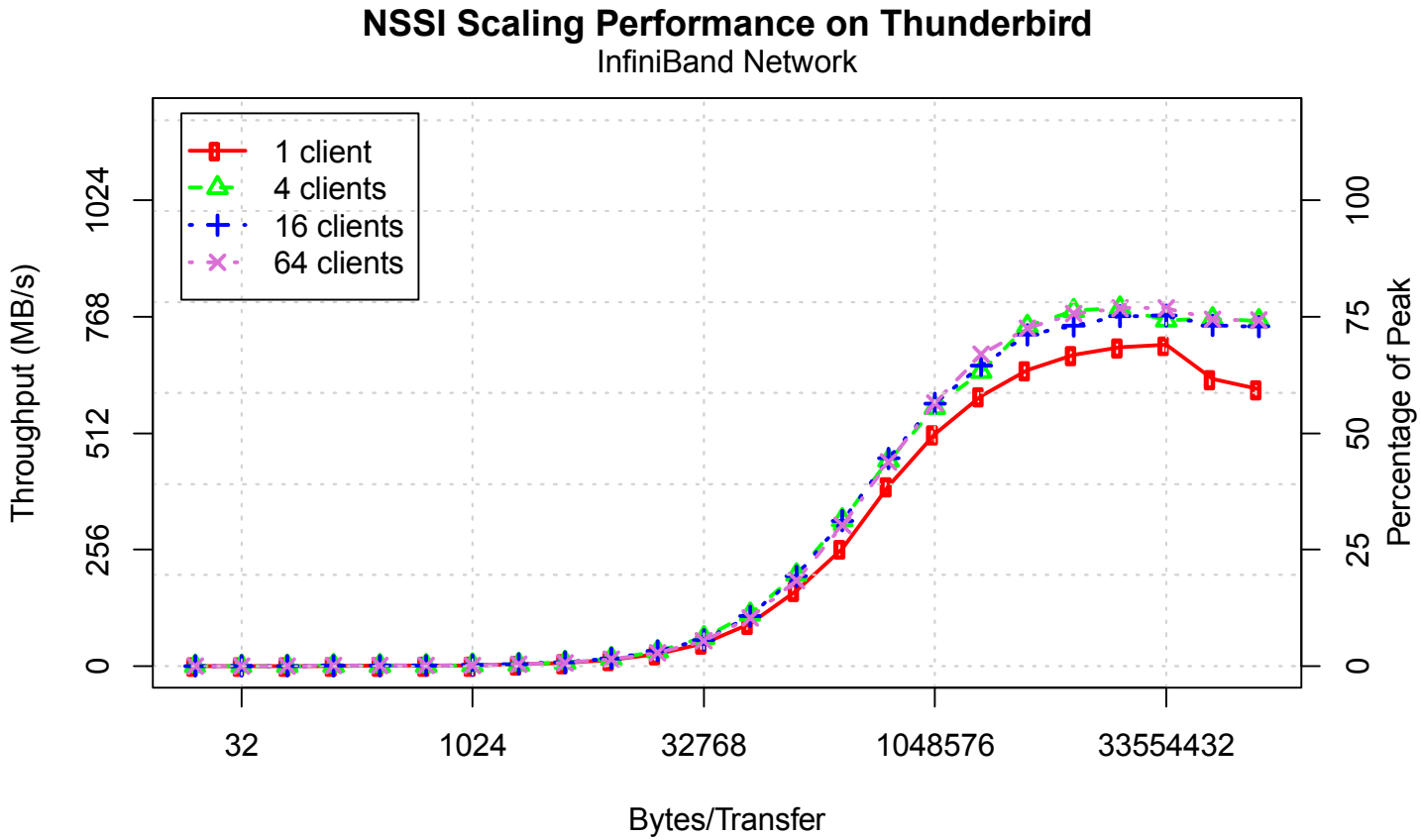
Nessie Performance (InfiniBand)



Performance of xfer_write_rdma on Thunderbird

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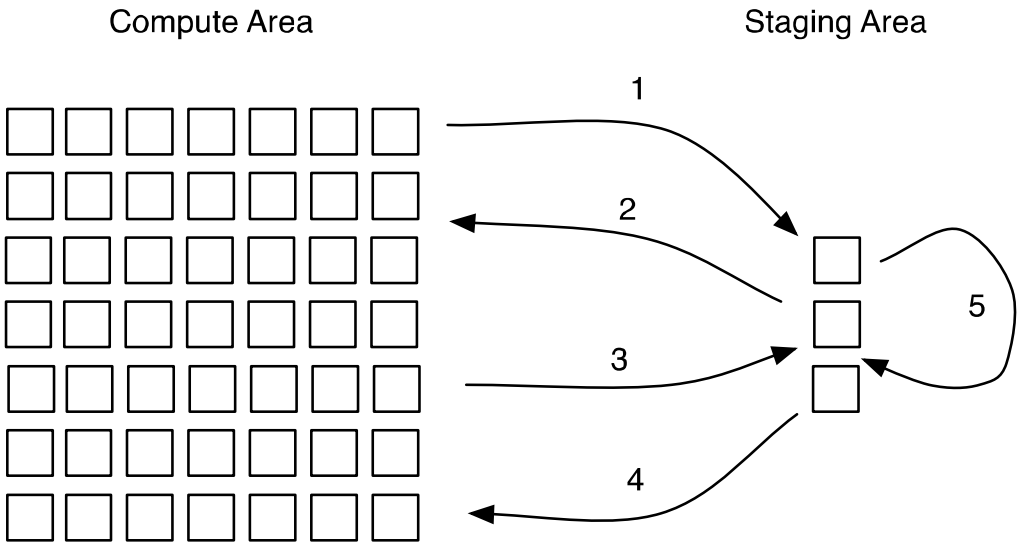
NetCDF Staging Operation

1. Initiate Request
2. Start data retrieval
3. Move data
4. Put completion/result
5. Process in staging area



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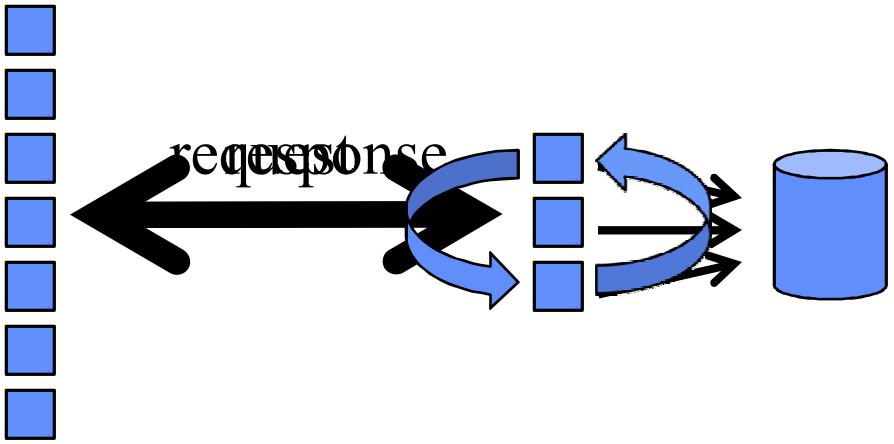
NetCDF Staging Functionality

- NetCDF4 and PnetCDF API supported
- Direct – synchronous with client calls
- Cache Independent – asynch with client calls
- Aggregate Independent – asynch with client calls, but aggregate data prior to writing (on node only)



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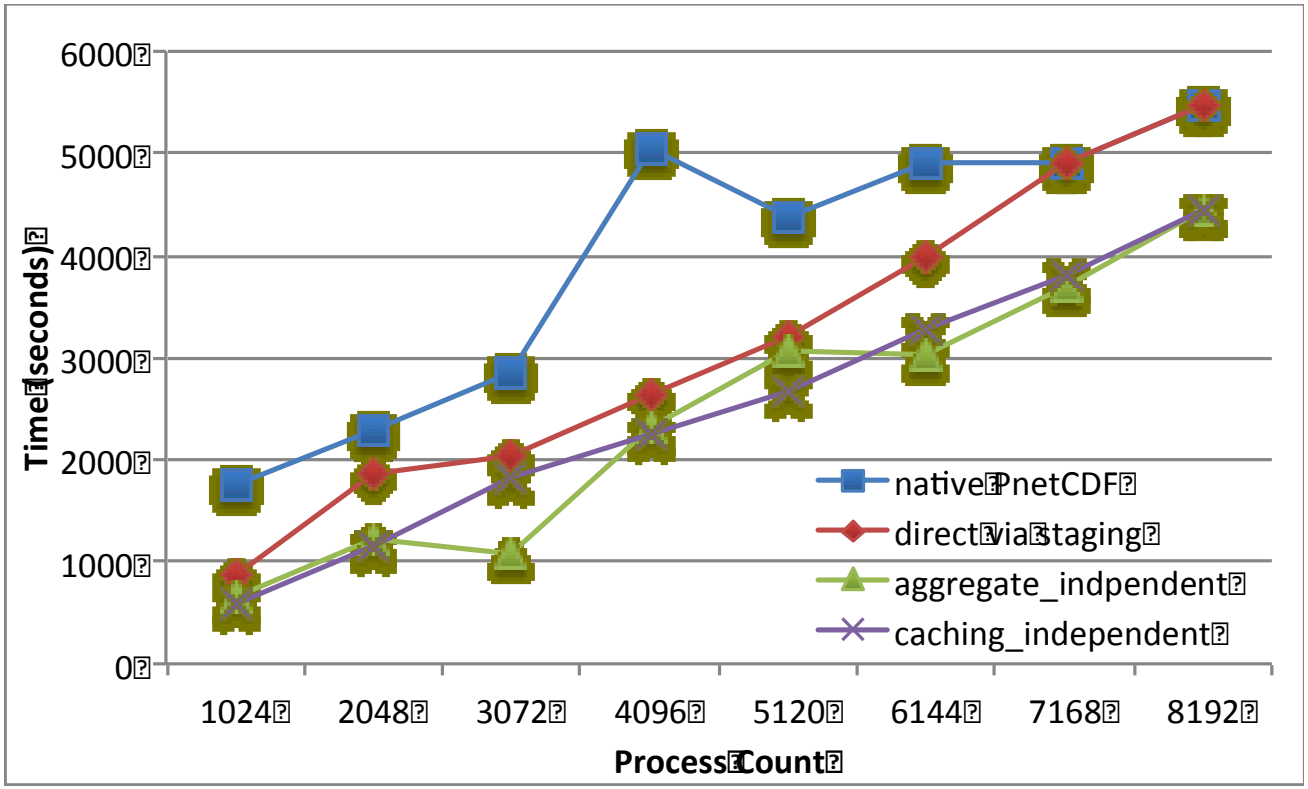
NetCDF Staging Functionality

- Untested functionality for this paper
  - Collective IO versions of cache and aggregate – like independent versions, but a maximal number of collective IO calls made for writing
  - Other data manipulation
    - Different implementation using Nessie for data analysis hosting

NetCDF Staging Performance



Testing on JaguarPF using S3D IO kernel

Current Status

- Nessie and NetCDF staging now part of Trilinos
  - Trios capability area
- Port to BlueGene underway
- Integration of accelerators for staging processing

Future Work

- Finish tests on RedSky to isolate Lustre issues
- Test collective IO routines
- Examine impact on reading performance

- For Nessie, other applications
  - 'In flight' data analysis routines
  - Transactions for resilience in data staging (see our poster!)
  - Hybrid, high level IO routine complications
    - Exodus + NetCDF