Improving I/O Bandwidth With Cray DVS Client-Side Caching
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Agenda – DVS Client-Side Cache

- Introduction
- Motivation
- Interfaces
- Design
- Results
- Summary
- Q & A
Introduction

- Computational capabilities of large-scale HPC systems continue to improve
Introduction

- Filesystem performance, scale, and I/O bandwidth are not increasing at the same rate
- I/O is increasingly becoming the bottleneck to application performance
- New technologies are having to be adopted to bridge this gap
  - Burst Buffers – Datawarp
  - I/O forwarders
Cray DVS

- Cray Data Virtualization service
- I/O Forwarder
  - Via HSN
- Transparent Access
  - Filesystems
  - Datawarp Accelerator
- In-kernel – high performance
- Highly Scalable
- Tunable
Motivation

- DVS can drive I/O at network bandwidth
  - Maintain I/O throughput over the network

- Similar performance concerns of distributed parallel filesystems
  - Network Latency
    - Increased for Subset of I/O
      - Small
      - random
      - repeating
    - Disproportionate cost
DVS Client-Side Caching

- **New option for DVS**
  - Available in CLE 6.0UP04 release

- **Mitigate Potential Bandwidth issues with I/O subset**
  - Improves I/O bandwidth
  - Reduce network latency costs
  - Lowers overall network traffic
  - Decreased load
    - DVS servers
    - Backing filesystems
    - Storage
Interfaces

- Existing DVS ‘cache’ mount command option
  - Now provides ‘w’ write option instead of only readonly ‘ro’
    - mount –t dvs –o rw,cache…
    - /pfs /dvsmnt dvs rw,cache…

- **DVS_CACHE** environment variable and IOCTL commands
  - Application control of caching as necessary
  - DVS_CACHE=on / DVS_CACHE=off

- **Cray Datawarp WLM job scripts**
Design

- Implemented as a write-back type of cache
- Application writes target local in-memory cache
  - Low latency & high throughput writes
  - Aggregation of data to be written back to servers
    - More optimal amount of data to be written
    - Lower number of total network transactions
  - Local caching of data read or written
- Close-to-open coherency
- Cache page write-back heuristics
Linux VFS Address Space

- Utilizes Linux kernel page cache
  - Kernel maintains memory utilization
  - Cache control interfaces
- Local DVS filesystem `address_space_operations`
  - `write_begin()`
  - `write_end()`
  - `writepage()` & `writepages()`
Close-to-open Coherency

- Similar model as used by NFS
- Reads only guaranteed to see file data available on the server at file open time
- File write data cached not guaranteed to be written back to storage until file close time
- Does not imply newer data won’t be read or written back
- 4kb kernel page size granularity
DVS Inode Attribute Handling

- Possible inode attributes and cached data more current on client than server
  - Change from existing DVS model
  - Prevent local client inodes from picking up stale server attributes
- Metadata operations handled normally
- Writes and implicit size changes take effect at page writeback
Results

- Increased bandwidth for small file I/O
  - 10x IOR increase
  - 100x IOPERF increase
  - TOPNET – HDF5 – 664 seconds to 114 seconds
  - Customer TOPNET benchmark – 58 to 34 minutes
  - Nastran to DataWarp – 9:55 to 6:51
Summary

- DVS client-side cache mitigates a potential downside of a network I/O forwarder.
- Provides a new tier of file data storage in local high-speed memory on compute nodes.
- Optimized writeback of aggregated data decreases file system access latency and network and server load.
- Benchmark testing show bandwidth increases of 100x.
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CUG.2017.CAFFEINATED COMPUTING
Redmond, Washington May 7-11, 2017