Building a Parallel Cloud Storage System using OpenStack’s Swift Object Store and Transformative Parallel I/O

or

Parallel Cloud Storage as an Alternative Archive Solution

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Overview

- Our project consists of bleeding-edge research into replacing the traditional storage archives with a parallel, cloud-based storage solution.
- Used OpenStack’s Swift Object Store cloud software.
- Benchmarked Swift for write speed and scalability.
- Our project is unique:
  - Swift is typically used for reads
  - We are mostly concerned with write speeds
Tools/Software

- Swift
- FUSE
- S3QL
- PLFS
Typical Swift Setup

- Auth Node
- Proxy node
- Storage nodes
- Internet
Swift Component Servers

- **Swift-proxy**—Serves as the proxy server to the actual storage node. Ties all components together.

- **Swift-object**—Read, write, delete blobs of data (objects).

- **Swift-container**—Lists and specifies which objects belong to which containers.

- **Swift-account**—Lists the containers of Swift.
S3QL

- Full-featured Unix filesystem.
  - E.g.: /mnt/s3ql_filesystem/

- Stores data online using backends:
  - Google Storage
  - Amazon S3(Simple Storage Service)
  - OpenStack

- Favors simplicity.

- Dynamic capacity.
Parallelization via N-N and N-1-N

- PLFS is LANL’s own approach to parallelized data storage.
- Appears as an N-1 write(left), but actually is an N-1-N write(right).
How the Four Applications Interact

Application

PLFS

FUSE

S3QL

Swift
Baseline Performance Testing

Single Node Tests
Baseline Test Setup

- Wrote a script to write various block and file sizes
- Wrote 1GB, 2GB, and 4GB files
- Tested multiple configurations
  - Single write to a single file system
  - Single write to single PLFS mounted file system
  - 3 separate writes to 3 file systems simultaneously
- Graphed the results to watch trends
Found Ideal Block Size

Write Speed on Single S3QL Mount

- 4GB File Size
- 2GB File Size
- 1GB File Size

Block Size (kB)

Speed (MB/s)
Discovered FUSE Limitations
Local Parallelization Increased Performance
Baseline Performance
Testing was Successful

- We found an ideal block size.
- Single node parallelization is efficient
- FUSE is a limiter in our setup
- Single write performance was in line with normal cloud storage performance (~25-30MB/s)
Target Performance Testing

Parallelization Benchmarking and Scalability
Target Performance Testing
Used Multiple Nodes

- Used Open MPI for parallelizing tests across the whole cluster.
- Tested performance scaling from 1 to 5 hosts.
- We were able to get 40 processes running at once because each host contained 8 cores.
N to N Write Tests had Interesting Results

- Immediate performance improvement with adding nodes even with a small number of processors per node
- Also noticed spikes of increased performance at each number of processes that was a multiple of the number of hosts we were using
- Stable, didn't break the S3QL mounts to the Swift containers
2-3 Host Test Results

N to N 2 Host Write Speed

N to N 3 Host Write Speed
4-5 Host Test Results

N to N 4 Host Write Speed

- 5 M3 Tile Size
- 2.5 MB File Size
- 5 MB File Size
- 10 MB Tile Size

Host 1
Host 2
Host 3
Host 4

N to N 5 Host Write Speed

- 5 M3 Tile Size
- 2.5 MB File Size
- 5 MB File Size
- 10 MB File Size

Host 1
Host 2
Host 3
Host 4
Host 5
Our Tests Show Cloud Storage Scales Well

- Performance scales linearly as you increase the number of hosts being used for MPI
Read speeds are fast but don't tell the whole story

- Incredibly fast due to caching
- Scales very well as you increase the number of hosts being used
More work needs to be done with PLFS and S3QL

- PLFS performance results were similar to N to N performance results but added enough instability to the S3QL mounts that many failures prevented a complete set of tests.
Cloud Storage is a Viable Option for Archiving

- Parallel cloud storage is possible and has good scalability in the N to N case.
  - Linear as nodes were added

- More work will need to be done to get PLFS working without breaking the S3QL mounts.
Future Work and Conclusion

Further research possibilities of cloud parallelization
Future Testing

• Test write performance impacts of increased S3QL cache sizes.

• Test CPU load impact of S3QL uncompressed vs the default LZMA compression

• Test swift tuning parameters to handle concurrent access for added stability of PLFS testing.
Other File Systems That Could Be Tested

- Test GlusterFS and Ceph as alternative cloud solutions to swift
Why is Cloud Storage a Viable Archive Solution

- Container management for larger parallel archives might ease the migration workload.
- Many tools that are written for cloud storage could be utilized for local archive.
- Current large cloud storage practices in industry could be utilized to manage a scalable archive solution.
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Questions?