
Los Alamos
NATIONAL LABORATORY
EST.1943

Evaluating Hardware Compression Offload in a Lustre File System

Mariana Hernandez

Mentors: Dominic Manno, Jarrett Crews, and Brian Atkinson

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Introduction

- Solid-state storage has inspired more efficient bandwidth tiers
- SSDs are now affordable
  - an increase in speed
  - reduction in capacity per device
- Compression is vital
  - This project focuses on compression out of several storage operation offloads

Introduction

- Current compression algorithms either
  - Reduce throughput, efficient compression
  - Good throughput, inefficient compression

- Offloaded compression to specialty hardware
  - High compression ratios and high throughput
  - Eideticom's NoLoad FPGAs
    - Programmable hardware for complex projects
    - Minimal impact on performance
    - High compression efficiency

Objective

- Determine feasibility of implementing NoLoad FPGAs in a production environment
  - ZFS
  - Lustre
- Show that compression done through the NoLoad FPGA could achieve GZIP levels of compression at or above LZ4 throughput

Test Setup

- ZFS implemented these compression algorithms
  - No compression
  - LZ4
  - GZIP
  - GZIP-NoLoad
    - Provided by custom Eideticom ZFS
- ZFS backed Lustre file system
  - 9 NVMe SSDs
  - 8+1 RaidZ1
  - Single combined Lustre OSS/MDS node

Test Setup

- CentOS 7.8
- ZFS 8.3
- Lustre 2.13.54
- 5.0.3 Kernel

When testing NoLoad kernel

- Custom kernel required patches for its FPGAs
  - 4 NoLoad CSP U.2s
  - Patches for the 5.3.1. kernel were provided by Eideticom
    - Unable to use 5.3.1. kernel due to incompatibility with ZFS and Lustre
  - Eideticom provided custom ZFS version with compression offloading handling

Method

Storage Throughput Benchmarks

- XDD ~ written data 30% compressible
  - Raw NVMe
  - ZFS
  - Lustre Client

Network Benchmarks

- ib_send_bw
  - Raw infiniband
- lnetselftest
  - Lustre network

Results – Baseline Benchmarks

ib_send_bw – 21363 MiB/s

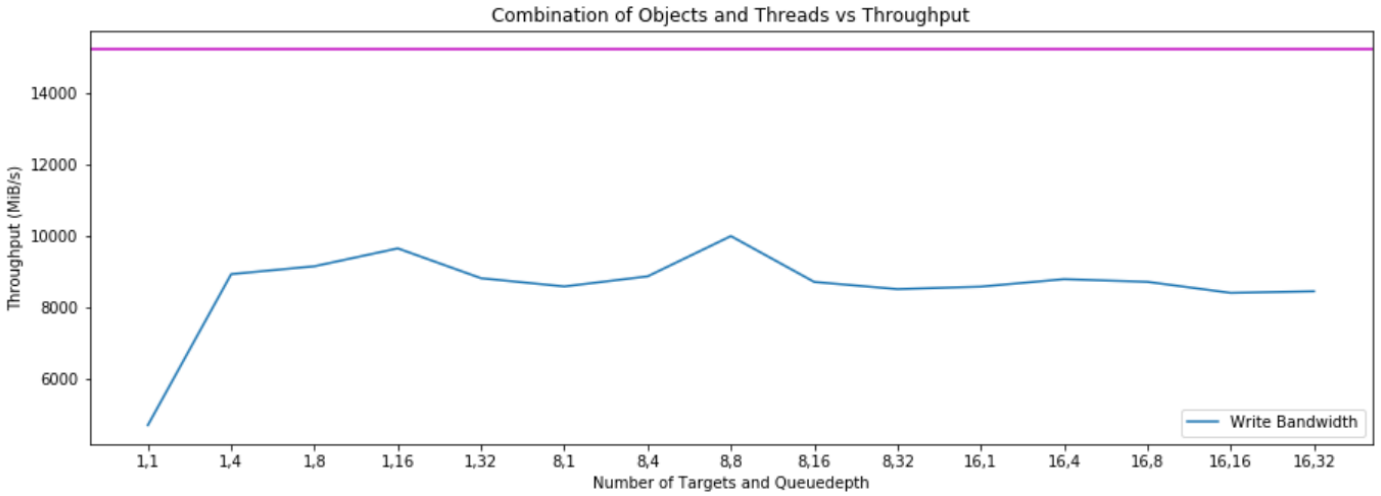
lnetselftest - 14314 MiB/s

Single NVMe - 1952.021 MiB/s

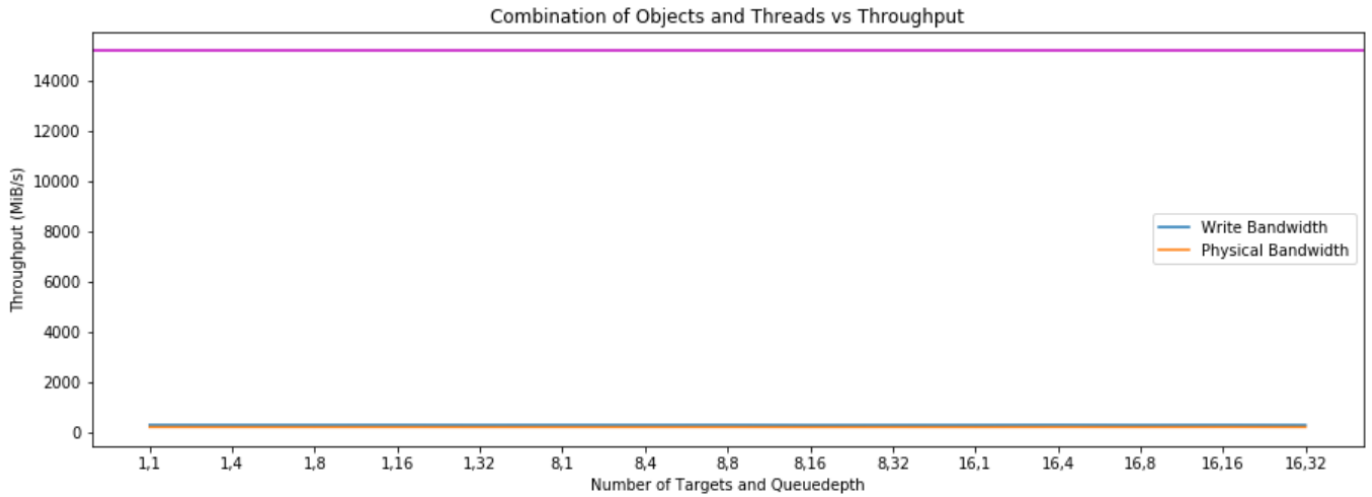
8+1 Raidz1 – 15200 MiB/s

Results – ZFS Performance

ZFS



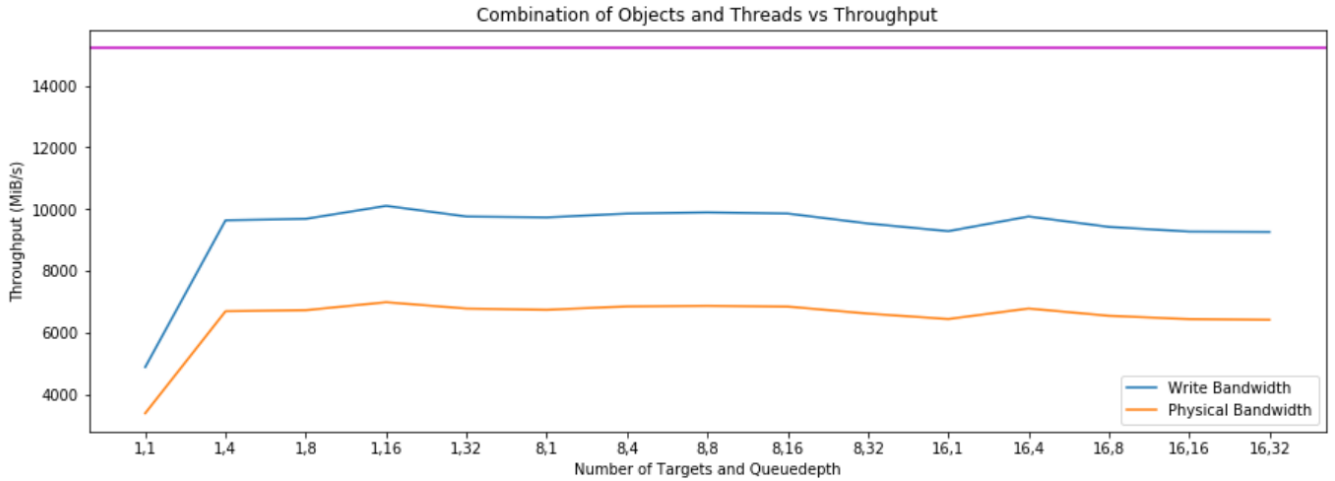
No compression



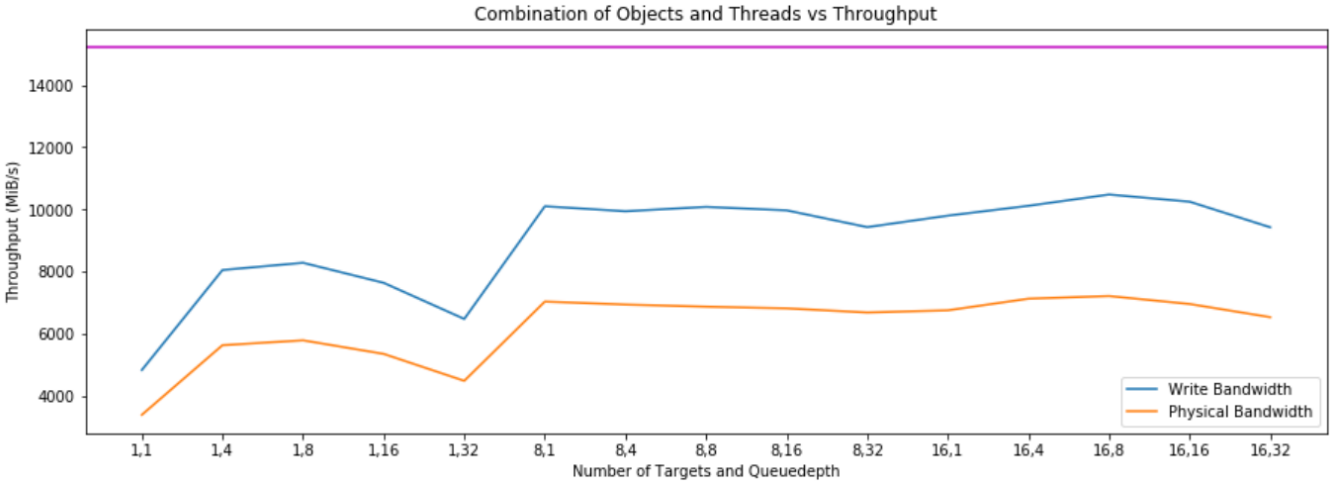
GZIP compression

Results – ZFS Performance

ZFS



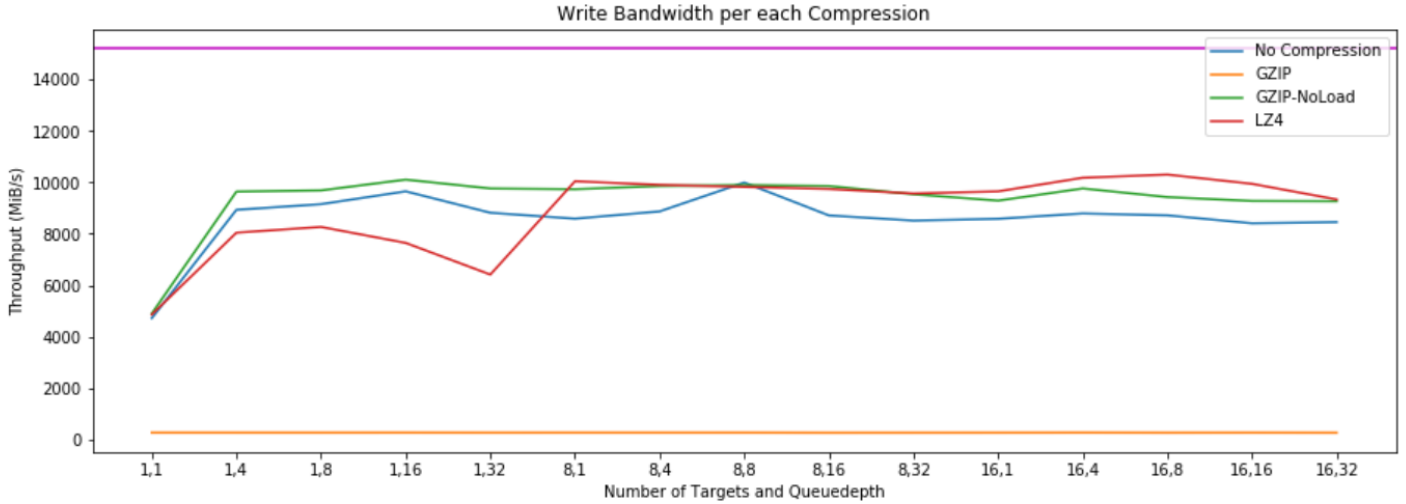
GZIP-NoLoad compression

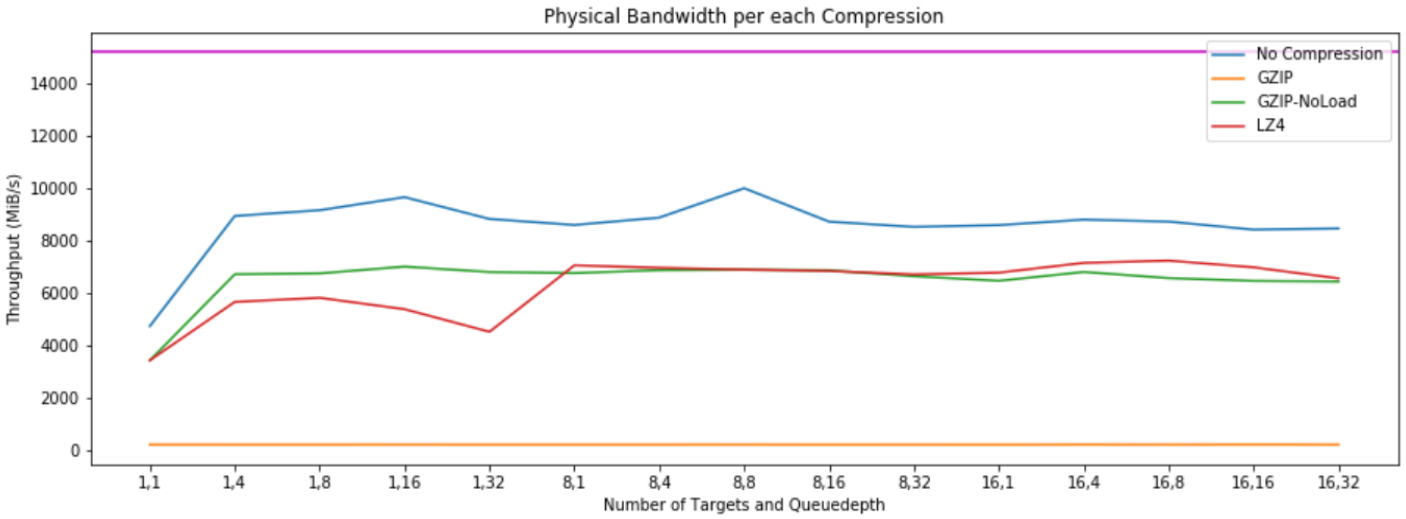


LZ4 compression

Comparing Compression on the Server

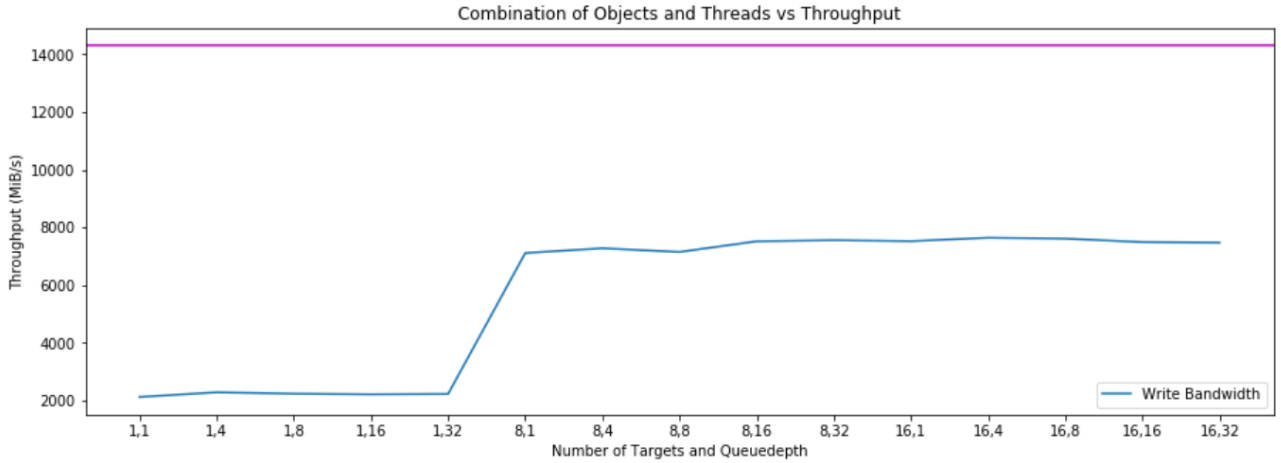
ZFS



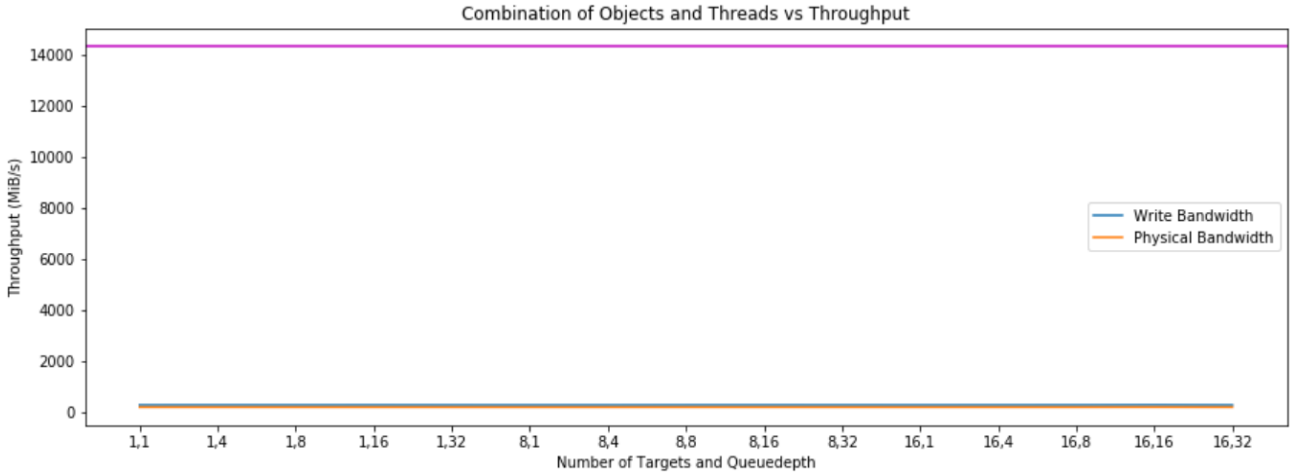


Results – Lustre Client Performance

Lustre Client



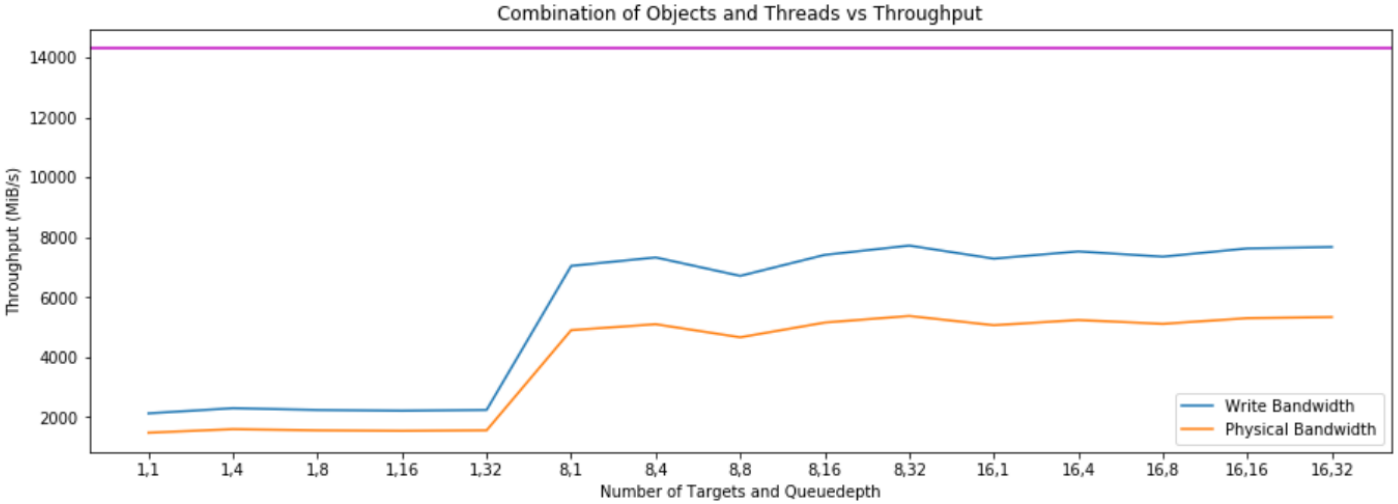
No compression



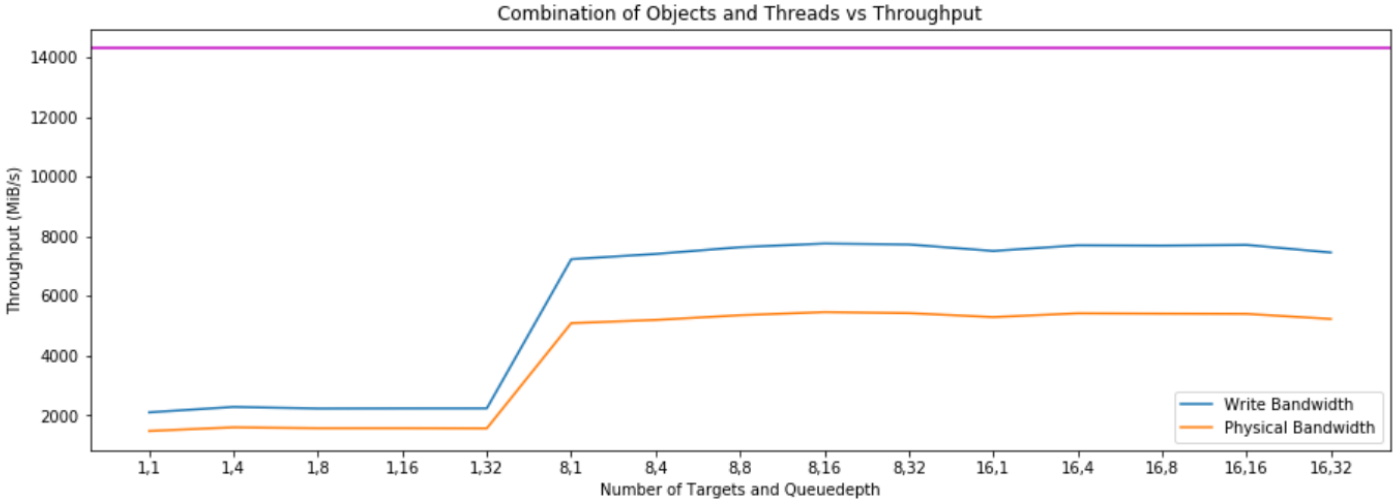
GZIP compression

Results – Lustre Client Performance

Lustre Client



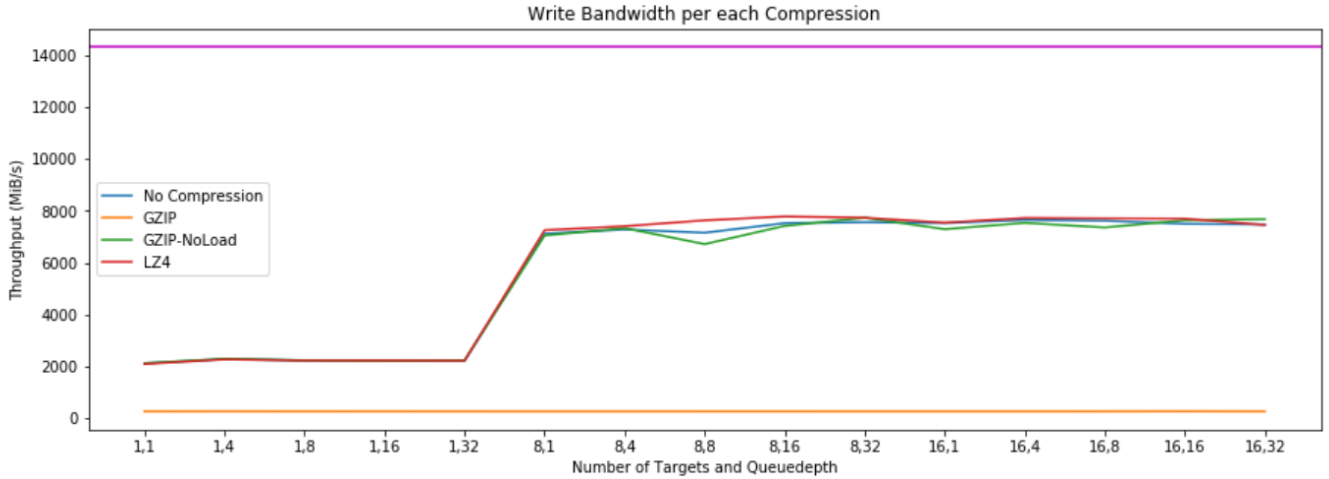
GZIP-NoLoad compression

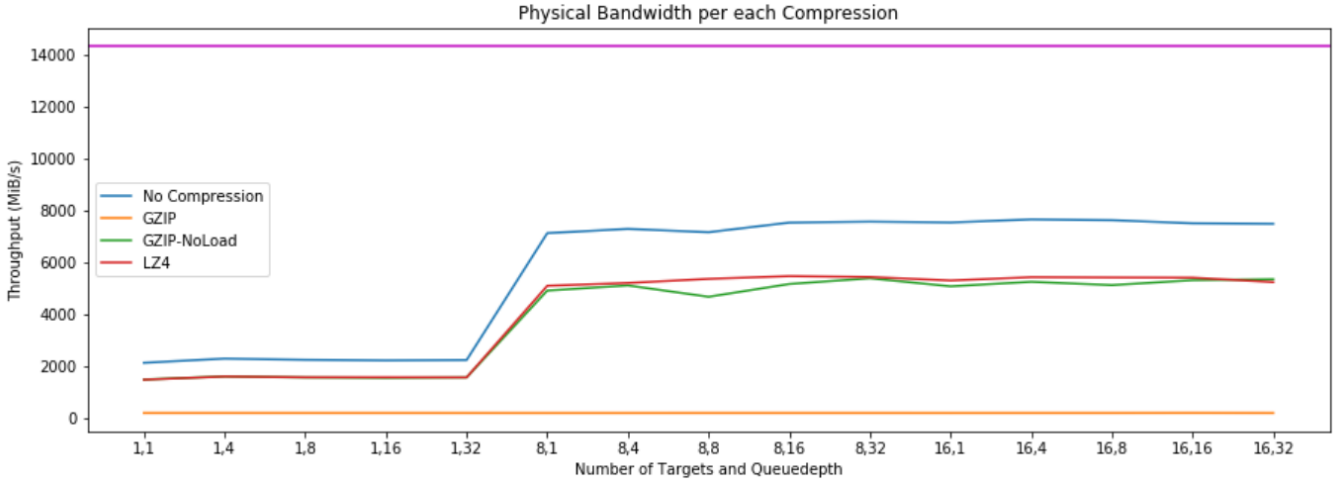


LZ4 compression

Comparing Compression on the Client

Lustre Client





Conclusion

- We have confirmed the viability of using Eideticom NoLoad devices to offload compression in ZFS and a ZFS-based Lustre filesystem.
  - A result from this is a high maintenance cost that should be further evaluated
- Lustre seems agnostic to the fact that we added NoLoads to offload compression
  - We plan to evaluate multiple Lustre clients to confirm we meet no compression performance provided by the server
- Multiple efforts to continue removing ZFS bottlenecks with NVMe devices.

Questions?

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