Lawrence Livermore National Laboratory

ZFS on Linux for Lustre
SC10
November 16, 2010

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This work performed under the auspices of the U.S. Department of Energy by
Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344

LLNL-PRES-461795

ZFS Overview

- Developed by Sun (now Oracle) on Solaris
- Combined filesystem, logical volume manager, RAID
- Copy-on-write
- Built-in data integrity
- Intelligent scrubbing and resilvering
- Very large filesystem limits

Lustre Overview

- Massively parallel distributed file system
- Major Components
  - Metadata Server (MDS)
    - Servers Metadata Target (MDT)
  - Object Storage Servers (OSS)
    - Server Objects Storage Targets (OST)
  - Clients

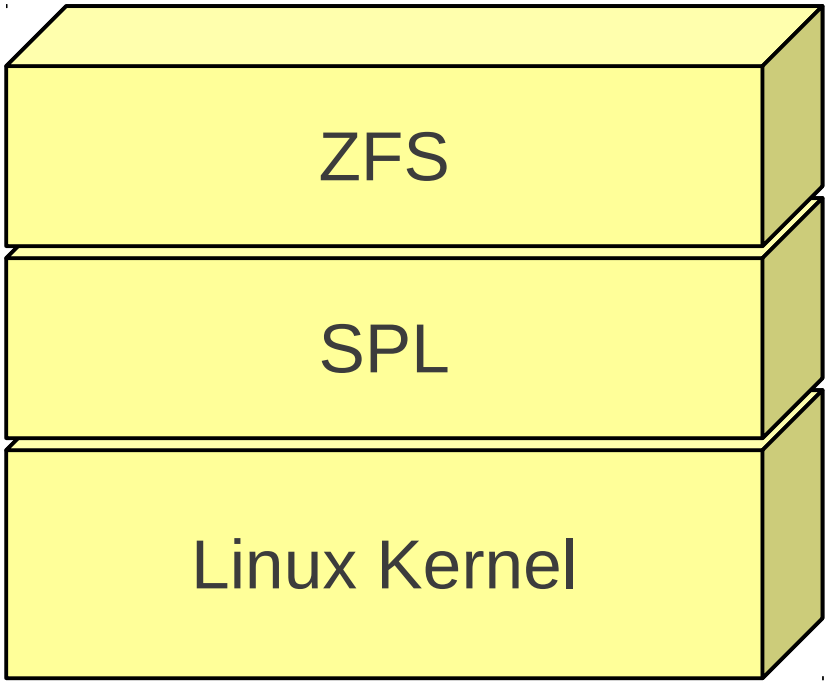
LLNL's Reasons for porting ZFS

- Lustre servers currently use ext4 (ldiskfs)
  - Random writes bound by disk IOPS rate, not disk bandwidth
  - OST size limits
  - fsck time is unacceptable
  - Expensive hardware required to make disks reliable
- Late 2011 requirement:
  - 50PB, 512GB/s – 1 TB/s
  - At a price we can afford

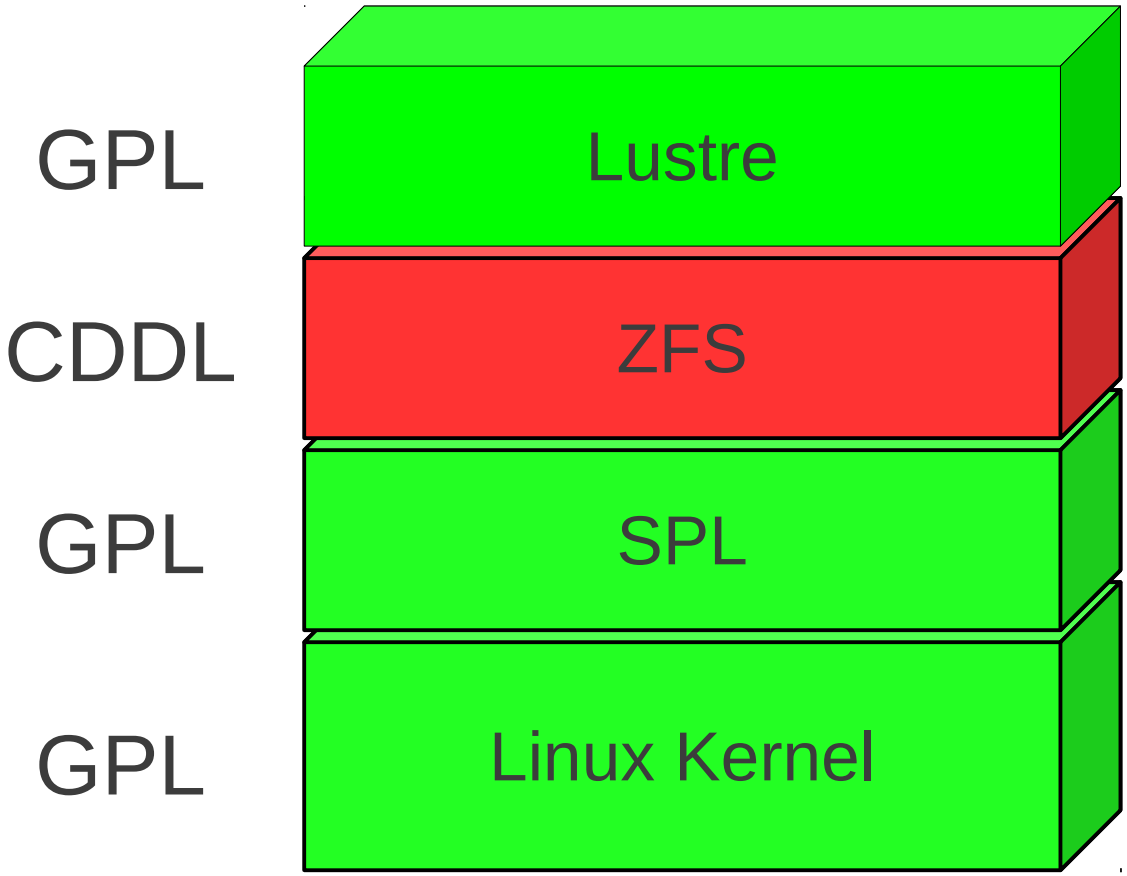
ZFS's Benefits

- COW sequentializes random writes
  - No longer bound by drive IOPS
- Single volume size limit of 16 EiB
- Zero fsck time. On-line data integrity and error handling
- Expensive RAID controllers are unnecessary

Solaris Porting Layer
Linux/ZFS Glue

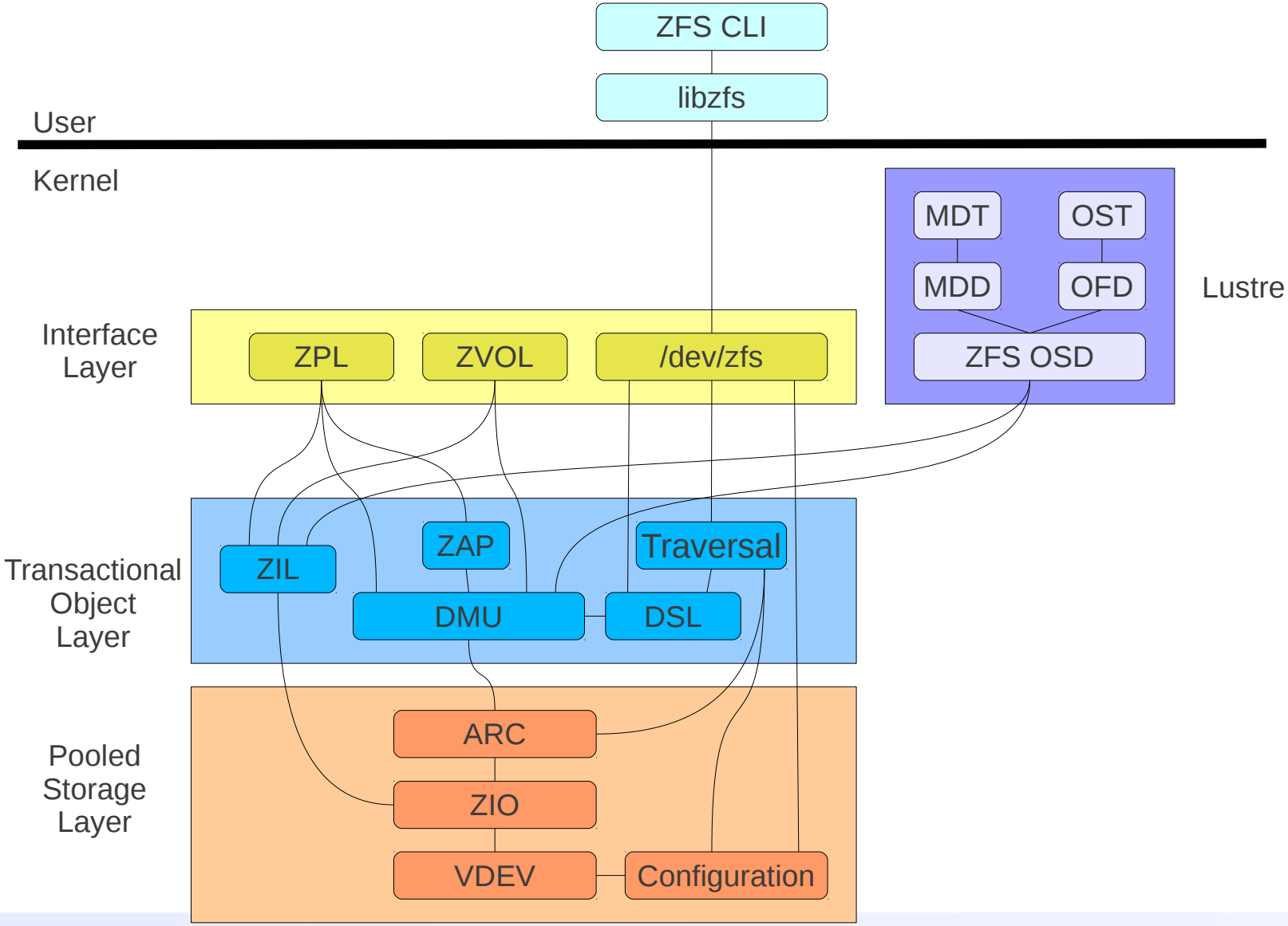


Licensing Issues

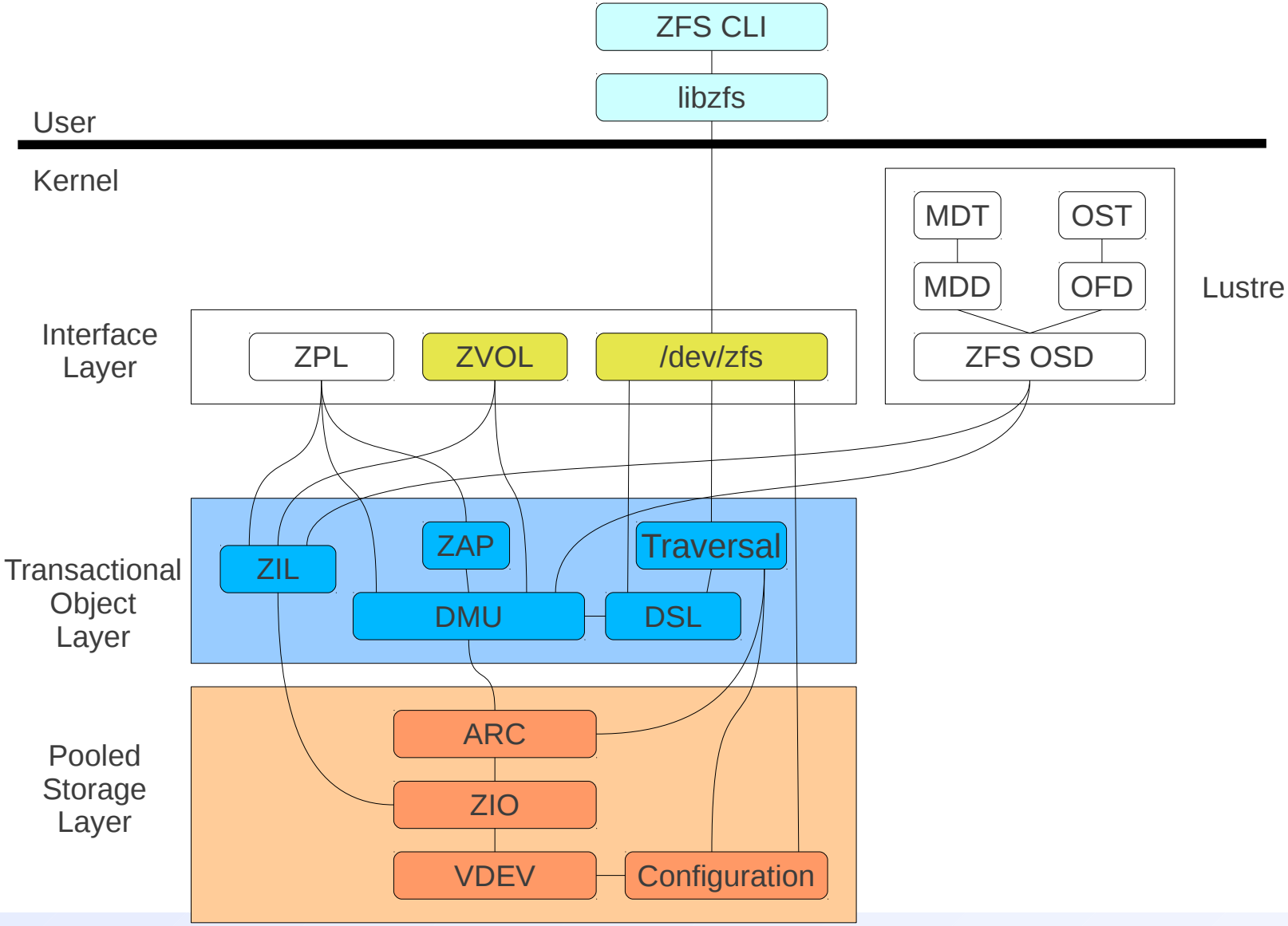


CDDL = Common Development and Distribution License
GPL = (Gnu) General Public License

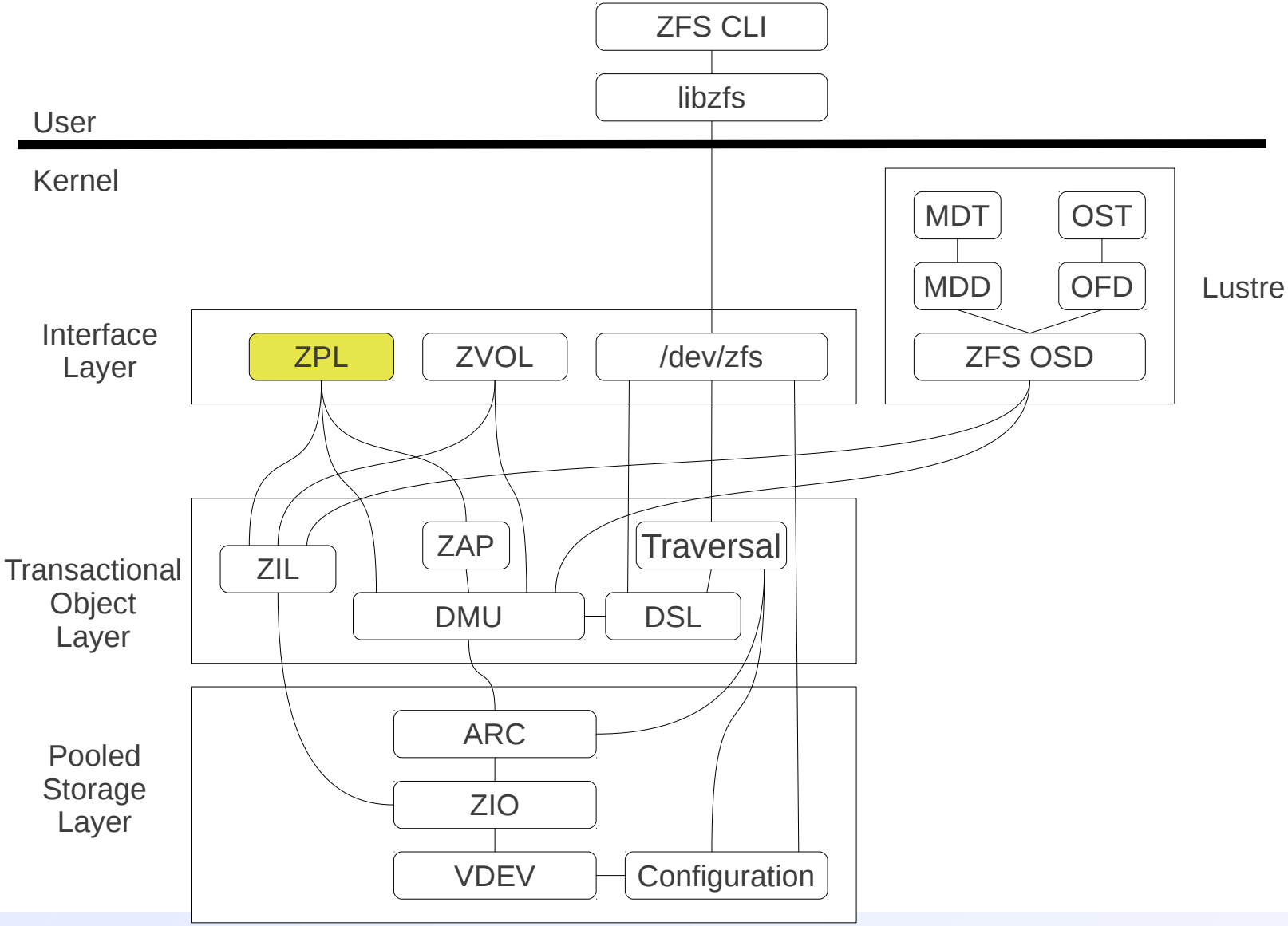
ZFS and Lustre Components



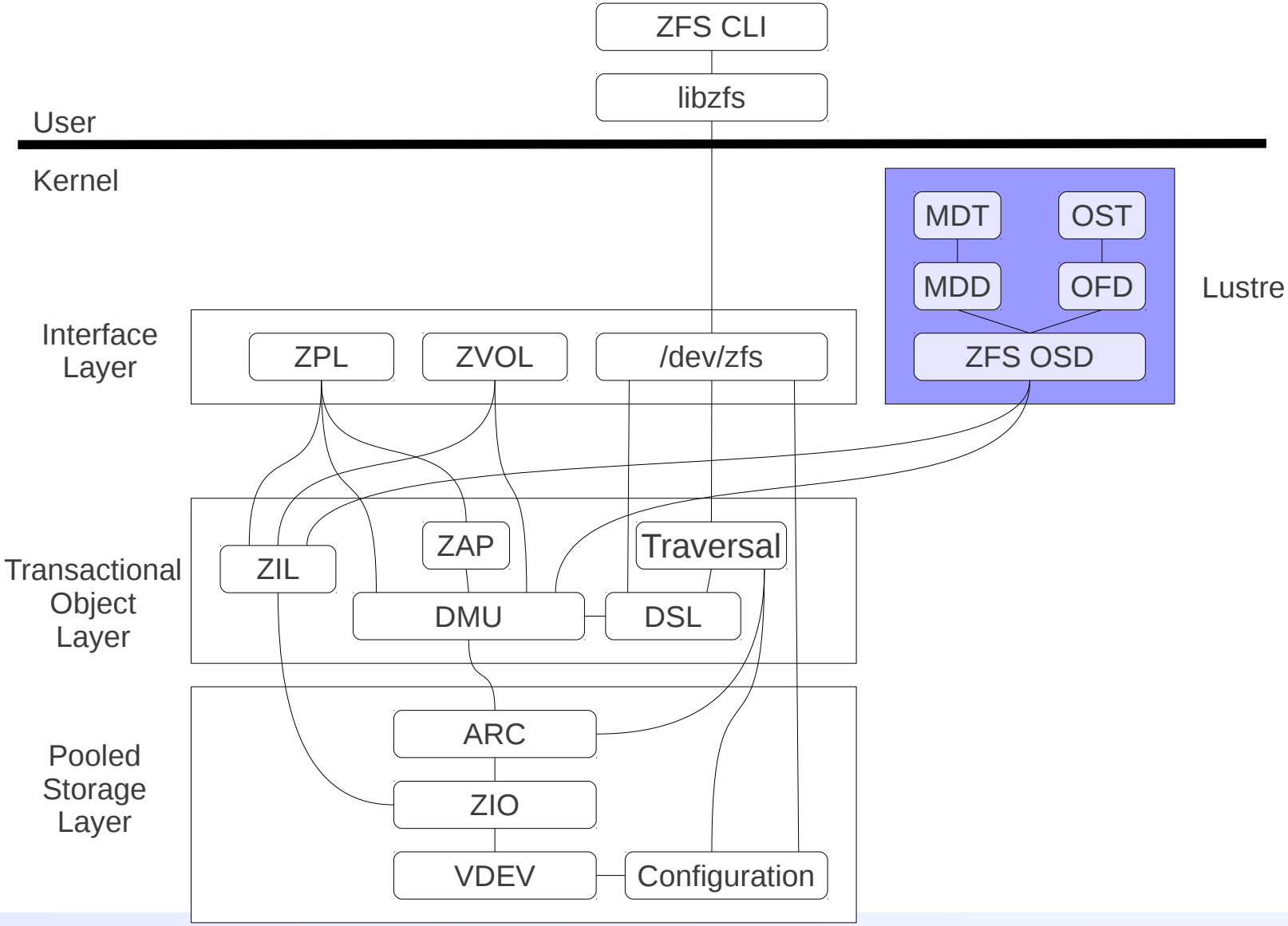
Ported by LLNL



Beta Port by KQInfotech



Under Development by Oracle



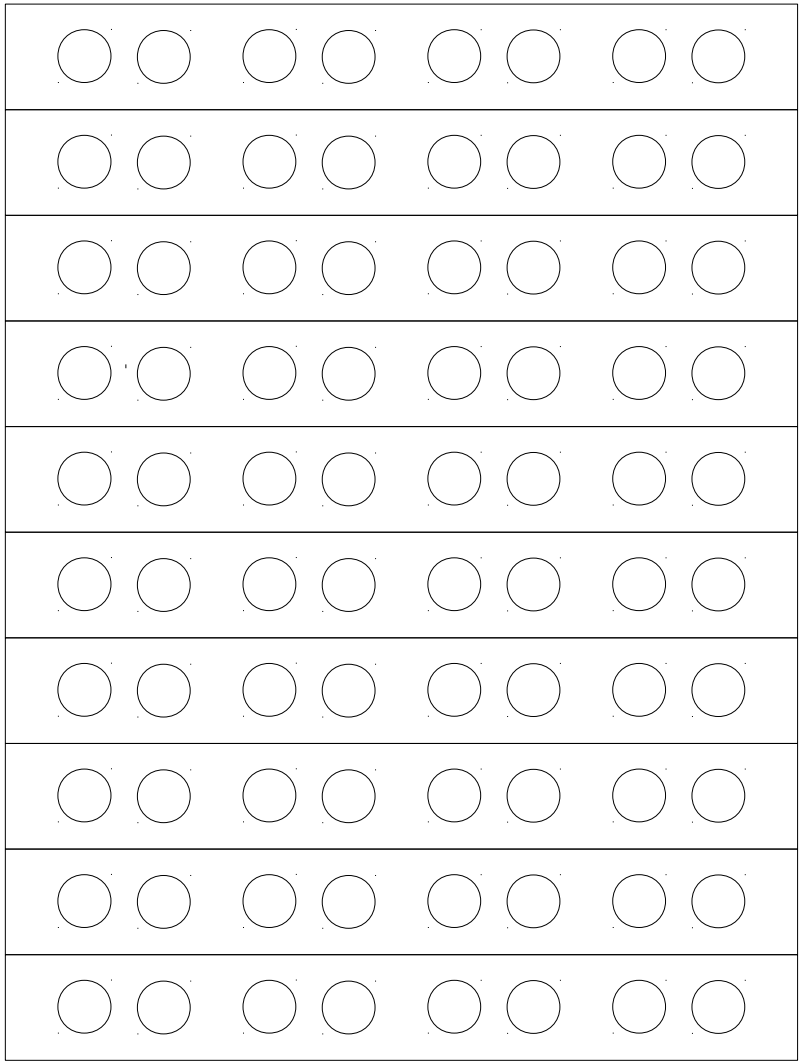
Proposed OSS Hardware

- “Scalable Unit” is 1½ racks
- 10x 4U disk enclosure (40U total)
  - 60 disks in each enclosure
- 8x 2U Linux server nodes (20U total)

SAS Link Count

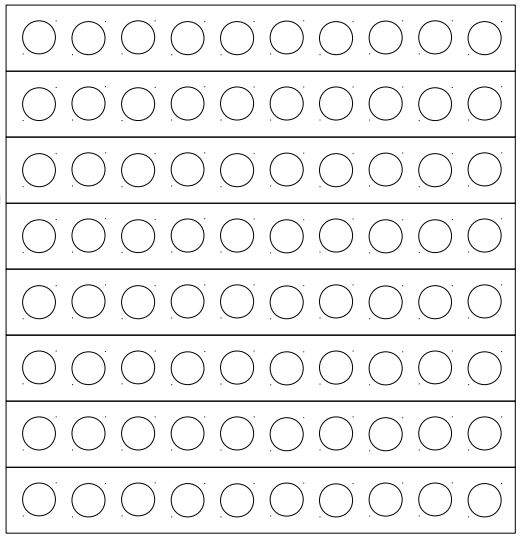
80 4-lane SAS Links
96 GB/s

10 60-bay disk enclosures
8 SAS Ports Each



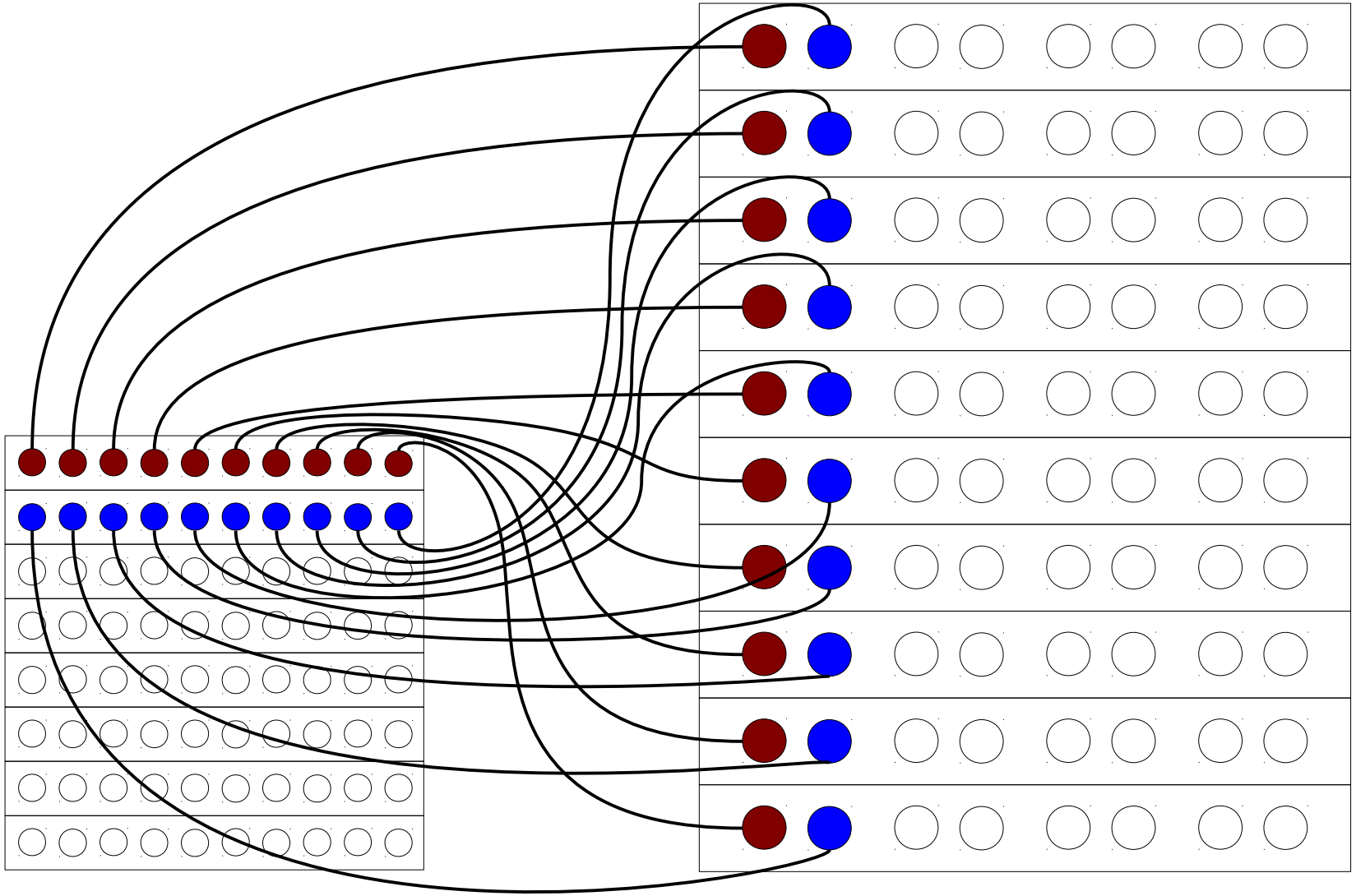
40U
(4U each)

8 OSS Nodes
10 SAS Ports Each

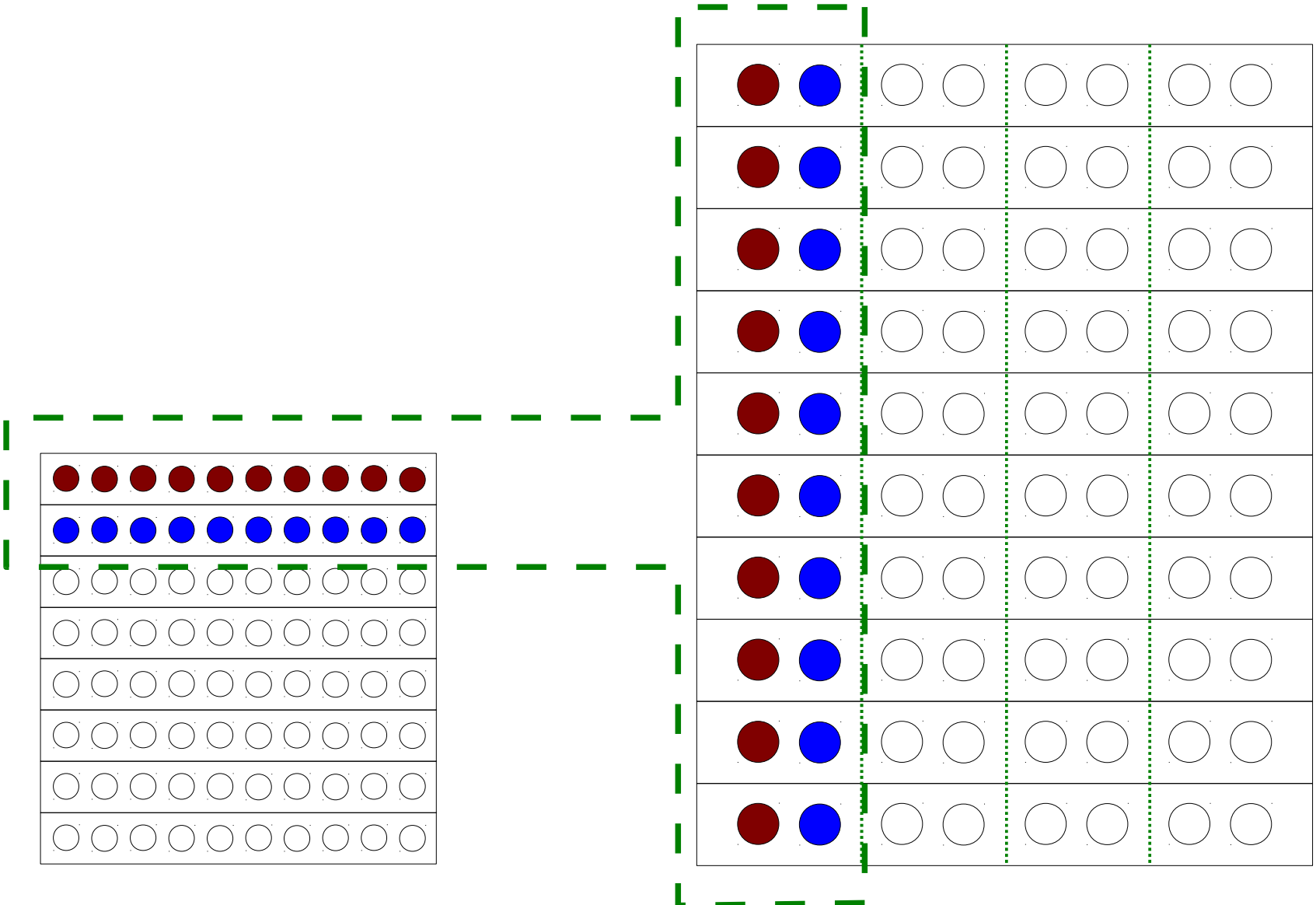


20U
(2U each)

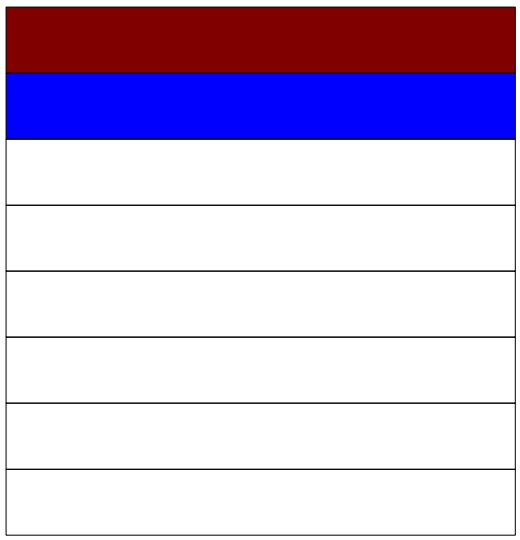
SAS Links from first two OSSs

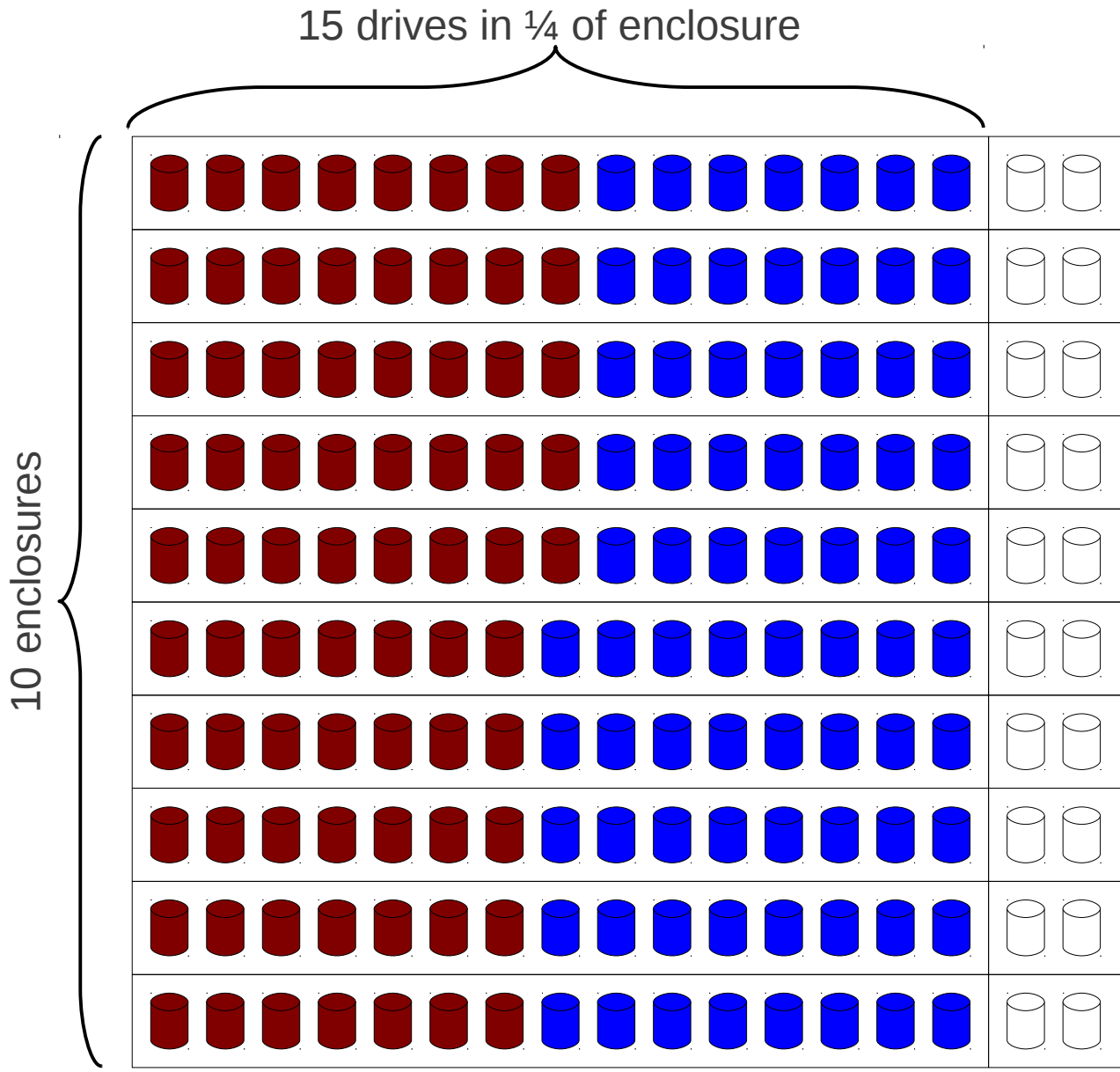


Each pair of OSS split ¼ of disks. OSS can serve as failover for partner.

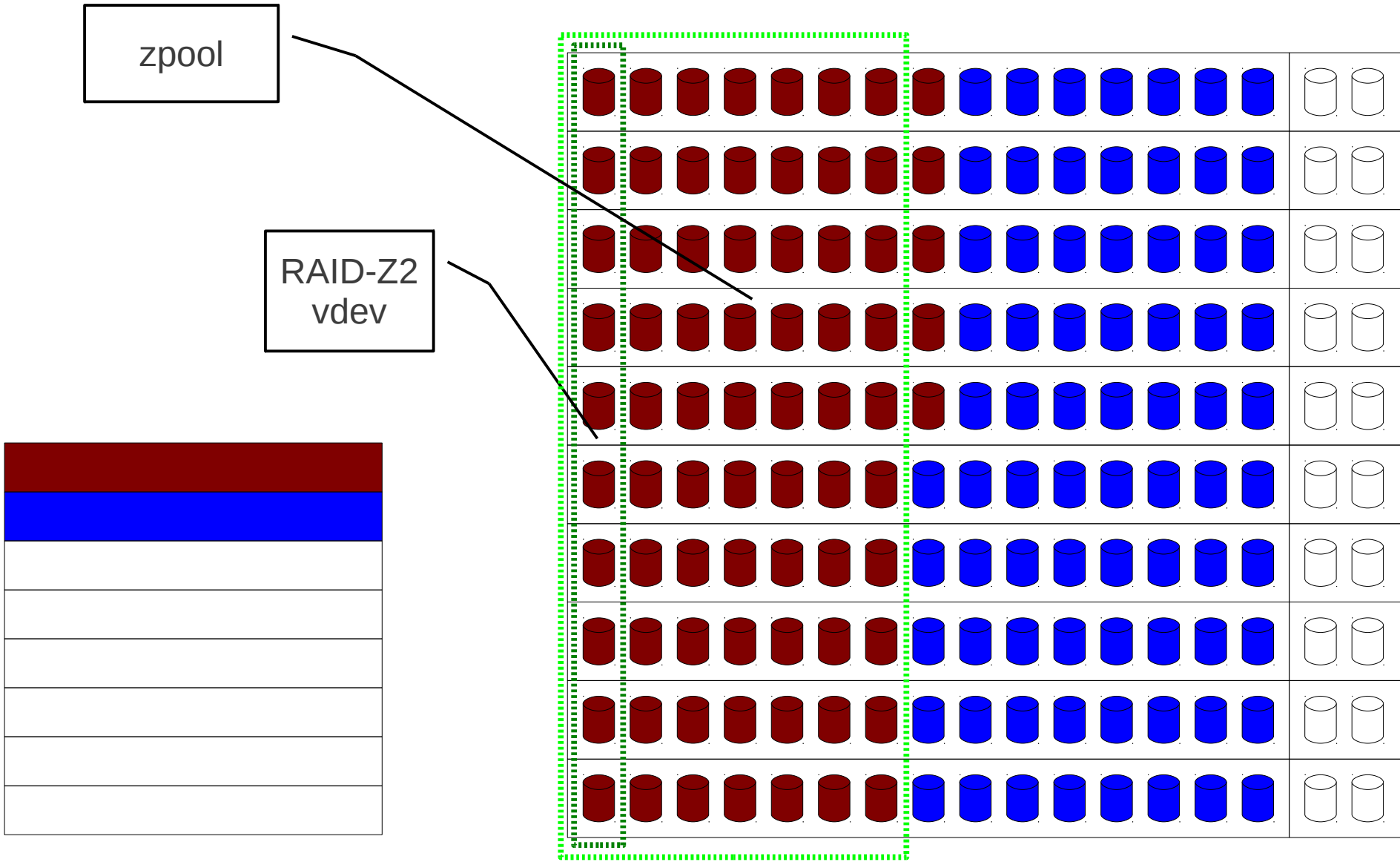


Each OSS sees 150 drives, uses 75

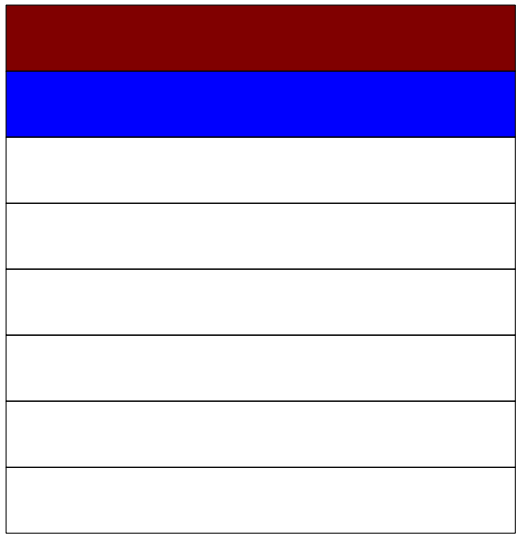


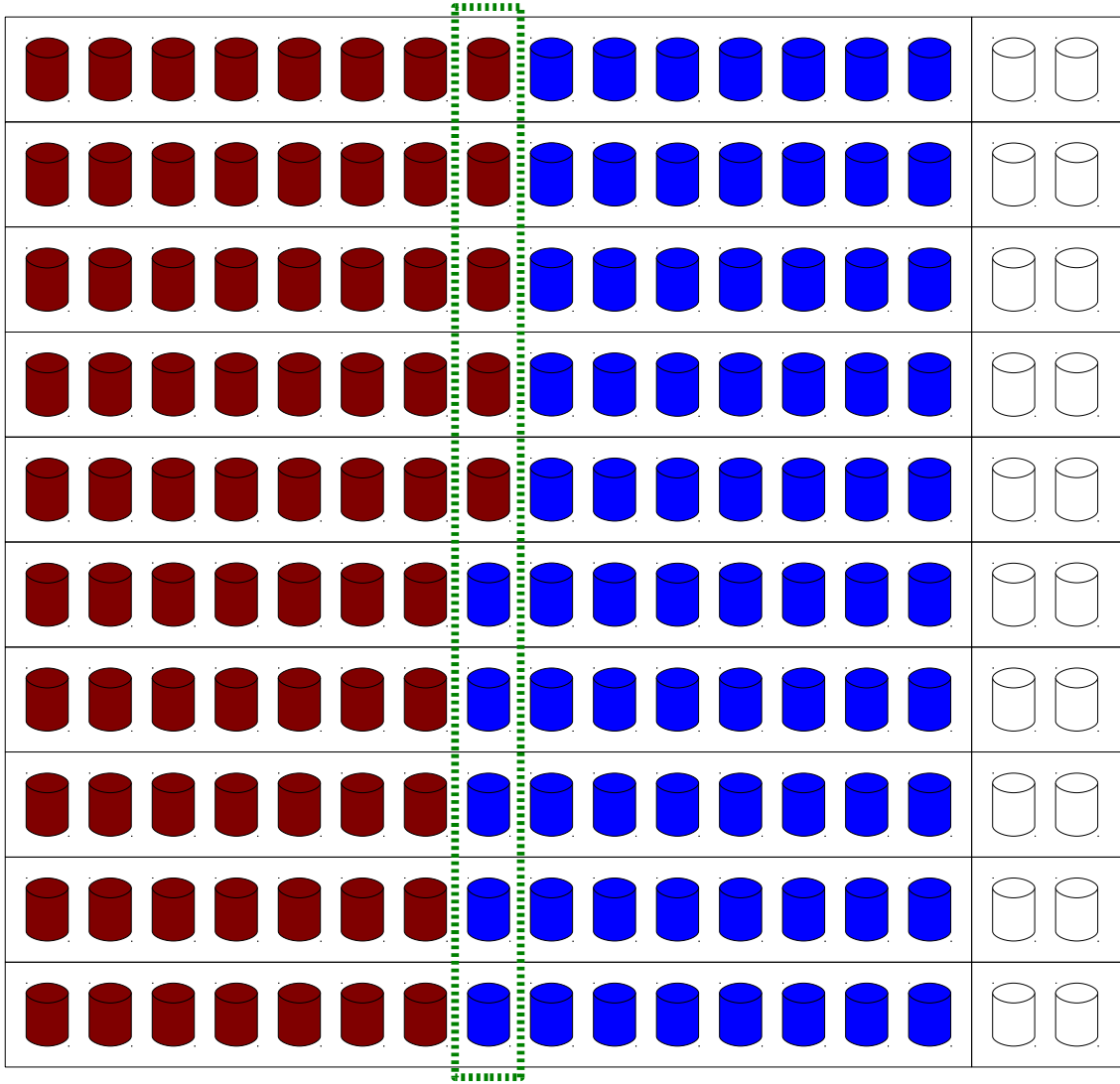


Each OSS has 7 10-disk zpools
70 disks each for normal use



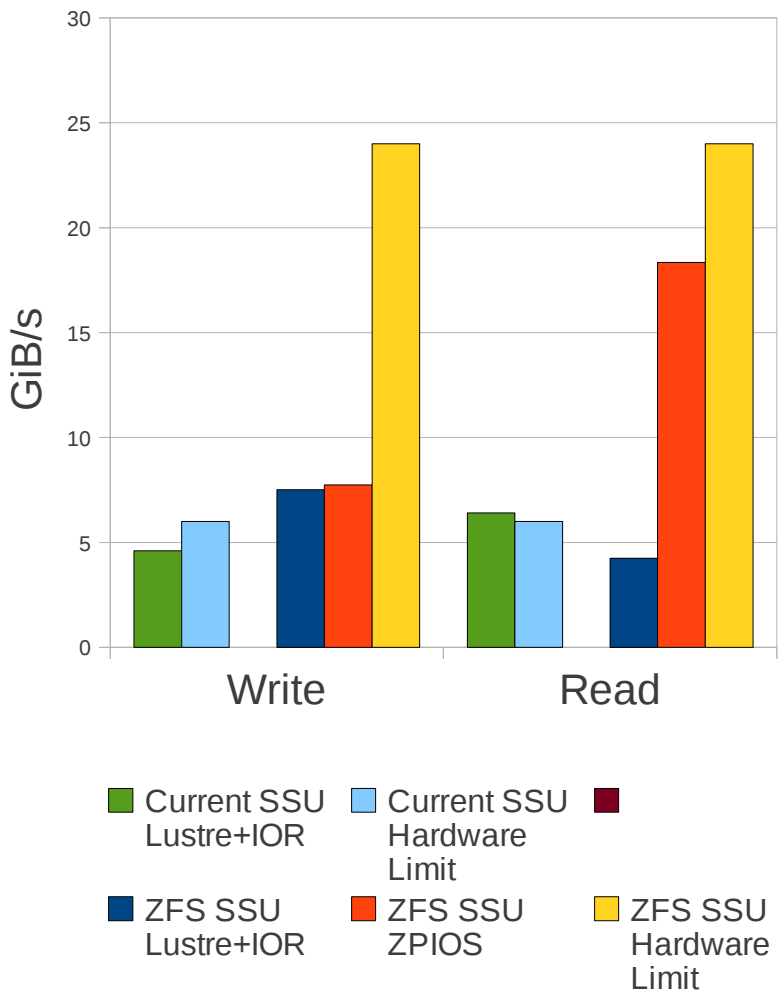
5 disks left over for each OSS
SSDs – ZIL? L2ARC?





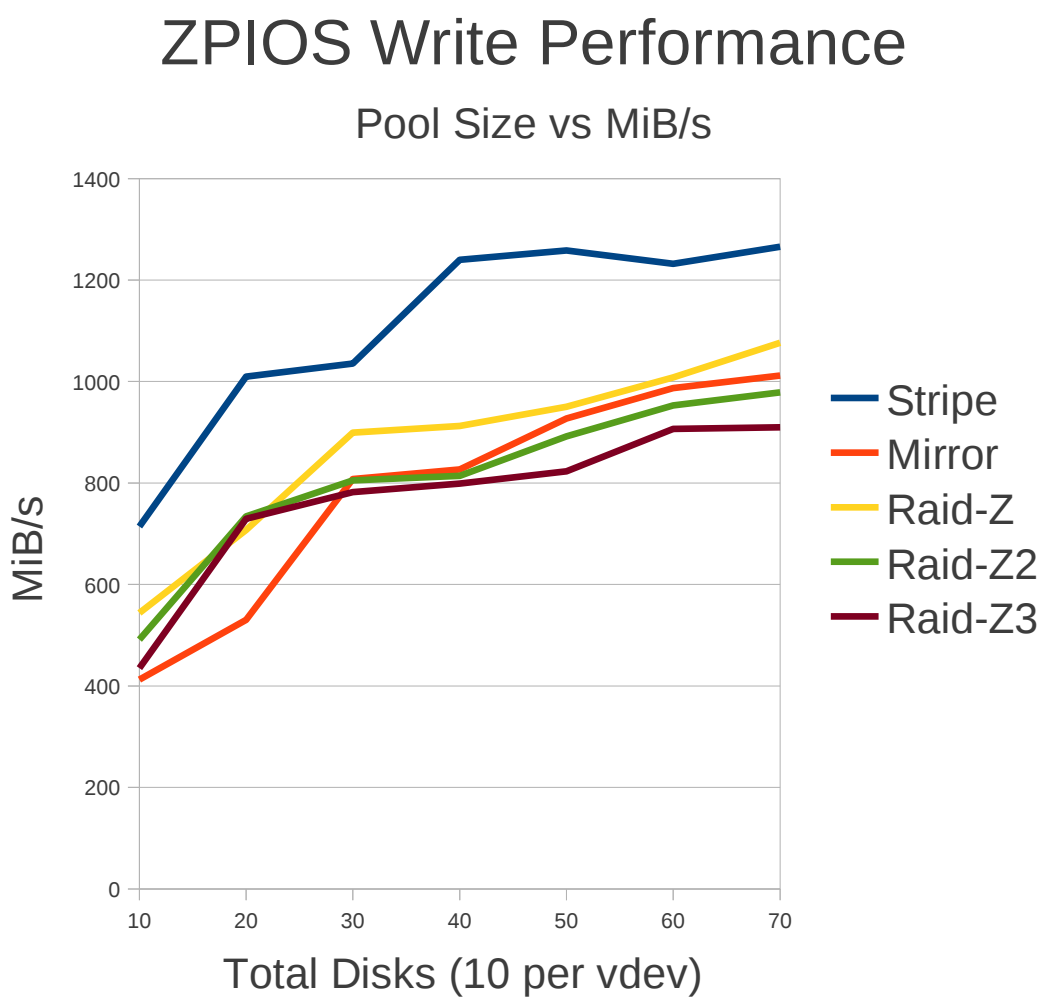
Prototype ZFS/Lustre Filesystem

ZFS Performance Comparison



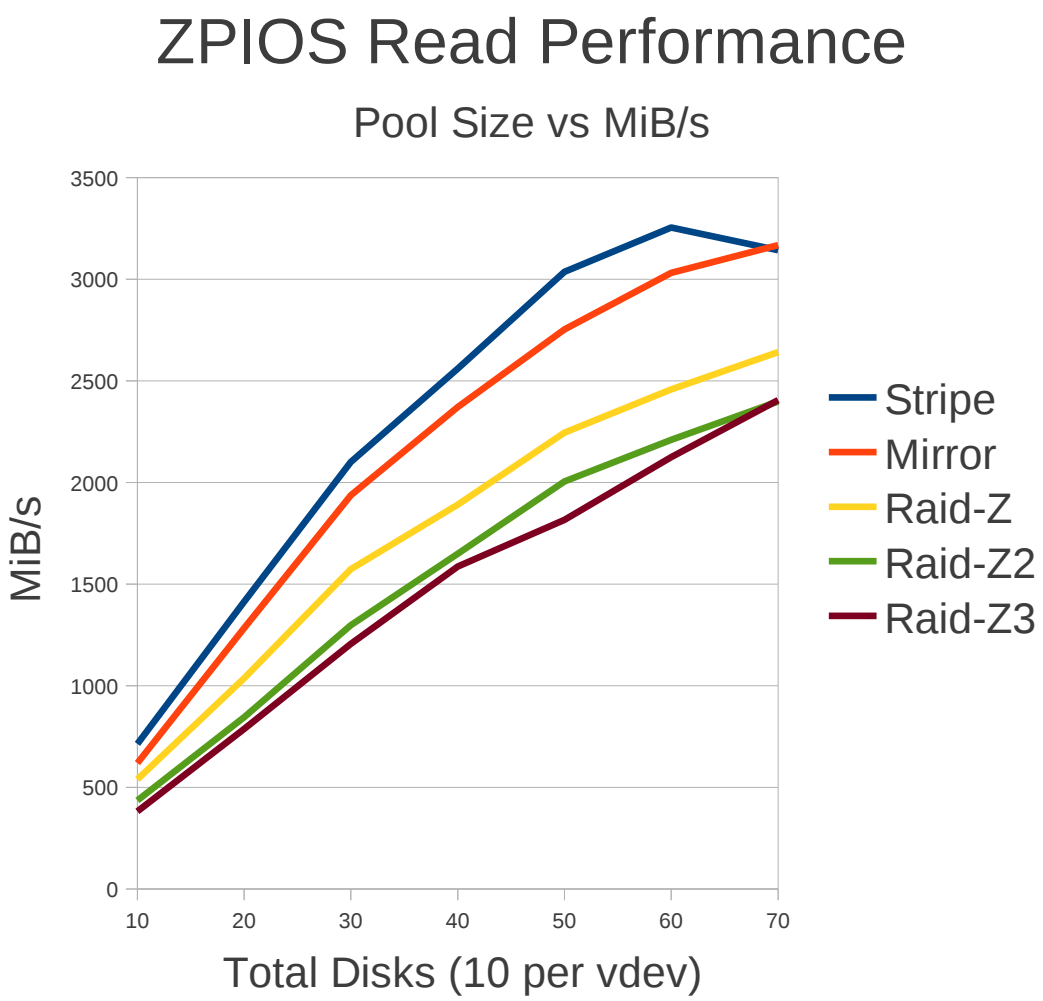
- Same number of drives
- SATA vs SAS disk
- RAID-Z2 vs RAID-6
- Write Performance is Limited by the ZFS Port
- Read Performance is Limited by Lustre/CPU
- ZFS is unoptimized, this can all be improved!

Single Node Write Performance



- Random 1MiB writes, from 128 threads, to 4096 objects
- 60 MiB/s per disk for small pools (10 disks)
- Limited by taskq when scaled up
- This is fixable

Single Node Read Performance

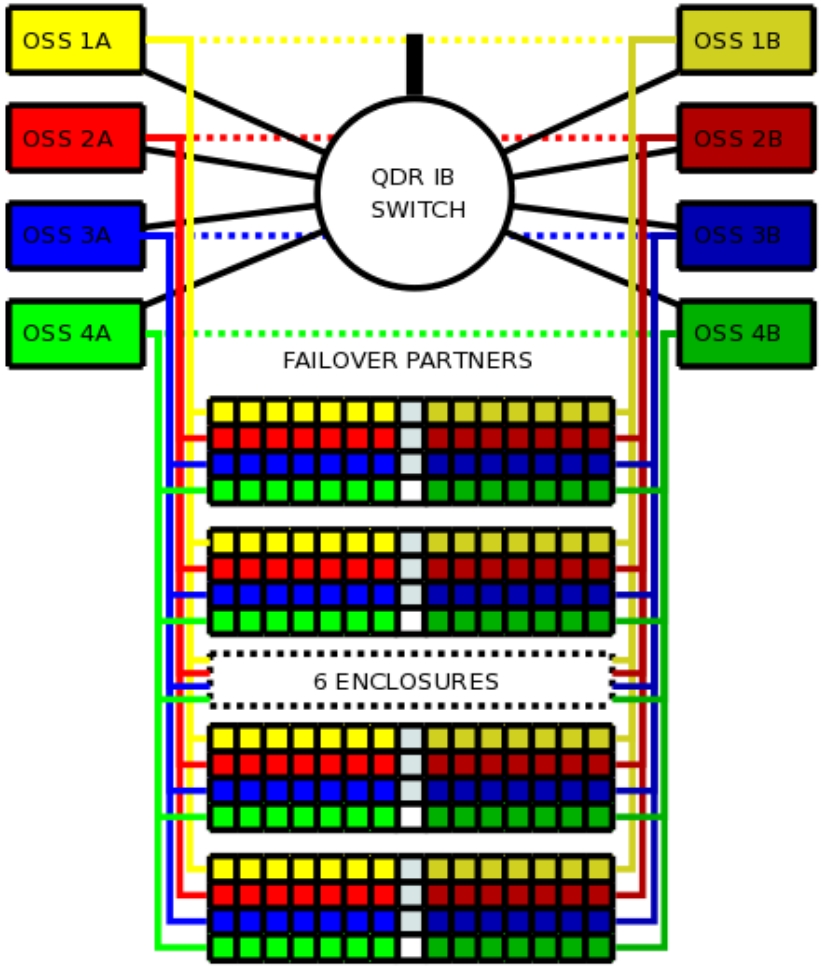


- Random 1MiB reads, from 128 threads, to 4096 objects
- Prefetch disabled
- Scales very well
- 50-60 MiB/s per disk even for large pools
- >90% CPU utilization when using 70 disks
- Can be optimized

More Information

- ZFS & SPL
  - http://zfsonlinux.org
    - Mailing Lists
    - Download software
    - Documentation
- Lustre support for ZFS (a.k.a., “KDMU branch”)
  - LLNL testing internally
  - Publicly available late 2011

OSS SSU



- 8 Linux hosts
- 10 60-bay SAS enclosures
- 560 2TB SATA drive
- 40 SSDs (ZIL, L2ARC)
- 8 QDR Infiniband adapters
- 8 dual-port 10-GigE adapters