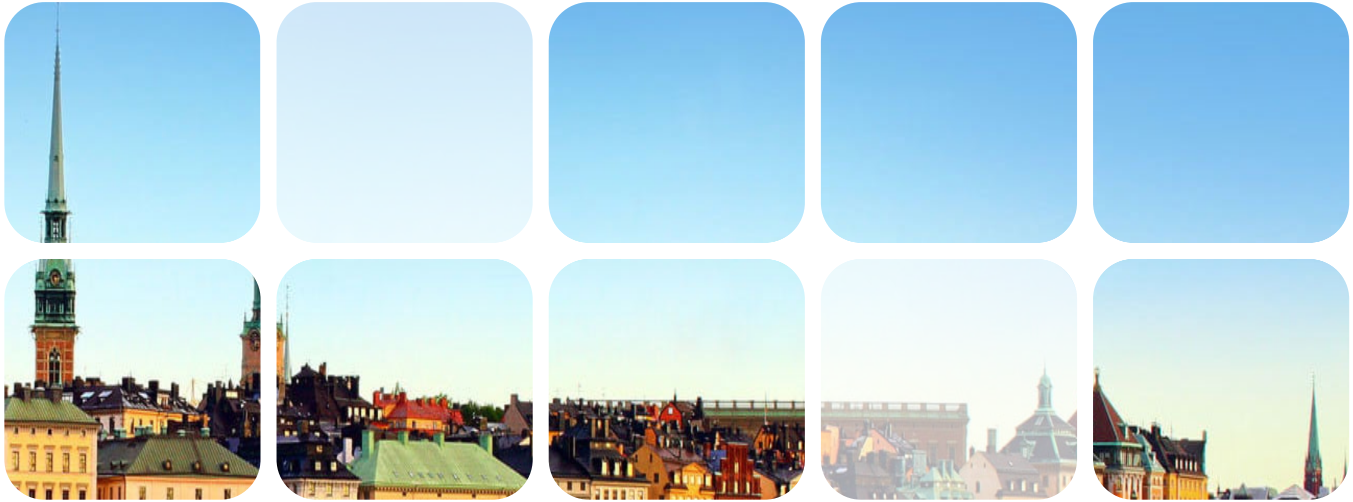

The Role of SSD Block Caches in a World with Networked Burst Buffers

CUG 2018

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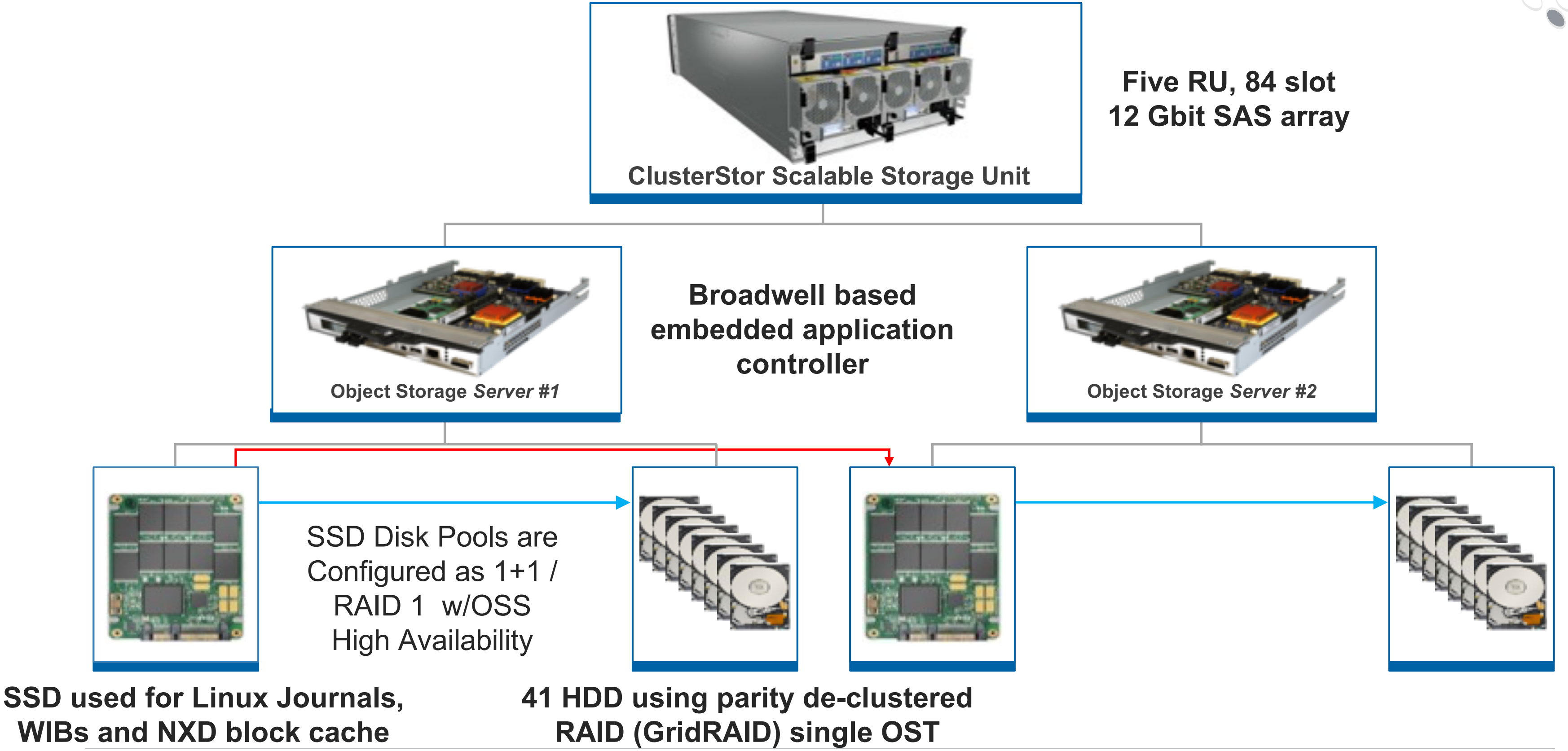
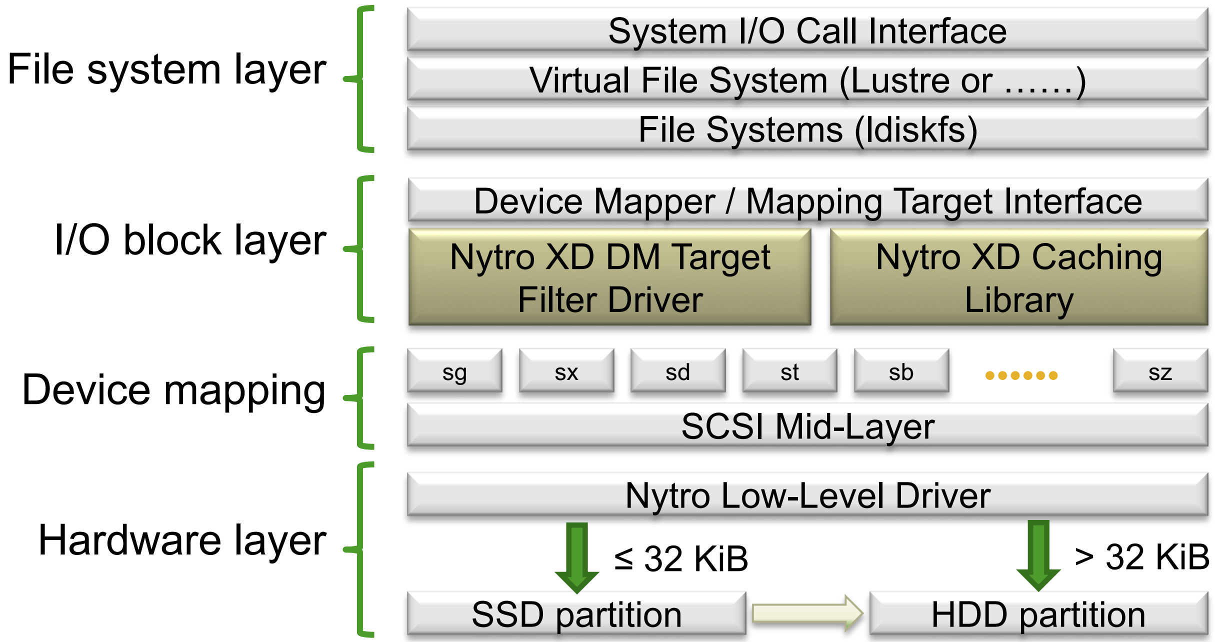
Agenda

- **Purpose**
  - HPC storage performance is under constant strain to deliver required performance
  - Modern I/O bound applications tend to be very complex with a mix of large sequential and smaller IOPS bound I/O
  - Examine the ability of NXD to improve application performance and manage a mixture of large streaming I/O in conjunction with small, random I/O.
- **Benefit**
  - Users with complex I/O workloads are always looking for solutions to the problem. NXD is potentially one of these solutions.
- **Experimental setup**
- **Results**
- **Summary**
- **Q&A**

NXD Hardware Components



NXD Software Architecture



NXD

- Filter driver implemented as device mapper target driver
- Core library compiled as a Linux kernel module with well defined APIs
- Work at the block layer be **transparent** to file system and applications
- Core caching function is an OS agnostic portable library with well defined interfaces
- Filter Driver intercept's IO and routes through Cache Management Library for Caching functions

Benchmarking Setup

- **Single ClusterStor L300N**
  - 82x Seagate 6TB Enterprise SAS HDDs
  - 2x Seagate (ST3200FM0033) SSDs
  - High speed interconnect (EDR IB or OmniPath)
- **16 Compute clients on IB or OPA**
- **Storage Software**
  - Lustre 2.7.19.12.x8-51 (user app tests run on Lustre 2.5.1)
    - End user app tests used Lustre 2.5.1
  - NXD Version 3.1.0.3 (2017.12.20)
    - End user app tests used NXD Version 3.0.10.3

Experimental Setup

1. **IOR sequential**

   IOR -b 32g -t 1m -F -k -m -e -v -v -C -i 5 -o $OUTFILE

2. **Mixed IOR**

   Sequential IOR: IOR -b 32g -t 1m -F -k -m -e -v -v -C -i 10 -o $OUTFILE

   Random IOR: IOR -b 280m -t 4k -F -k -m -e -v -v -C -i 10 -z -o $OUTFILE

3. **Concurrent IOR, increasing load of random**

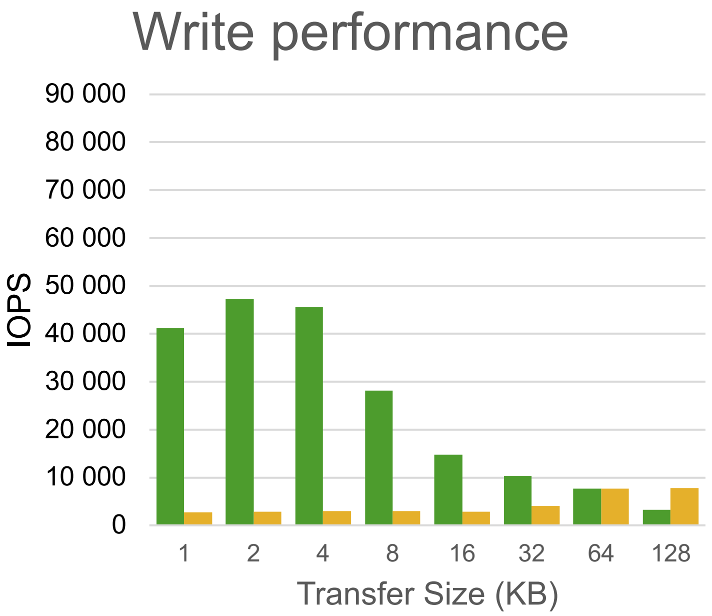
   Mixed IOR (above) with 32, 96, 160 and 224 I/O threads respectively

4. **SWMR**

   swmr write --niter 2500 --testdatafile $IN_FILE $OUT_FILE

NXD / ClusterStor L300N – Write/Rewrite, Aligned I/O

16 nodes, 64 processes total, 1x SSU, (2x SSDs vs. 82x HDDs) running Lustre 2.5.1

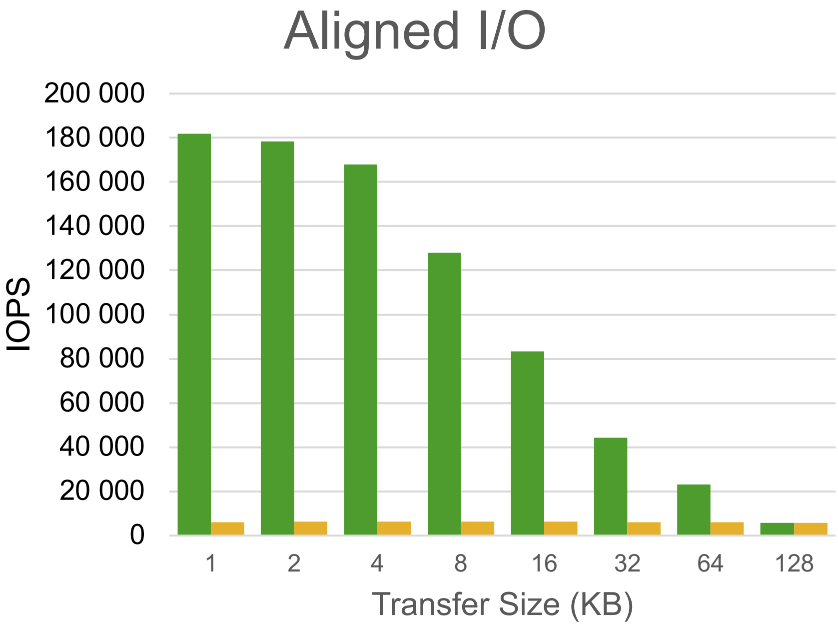


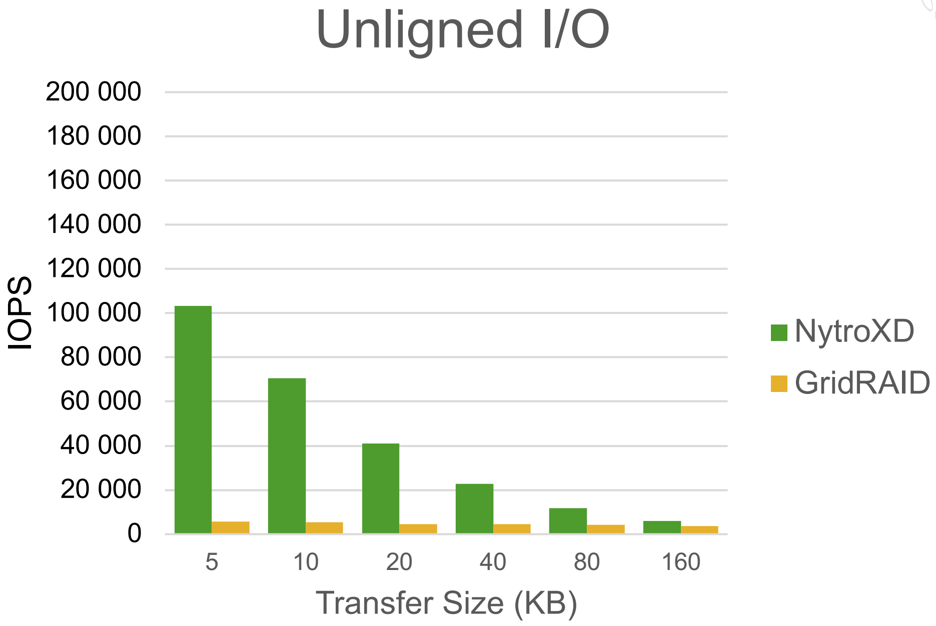
NXD / ClusterStor L300N – Write/Rewrite, Unaligned I/O

16 nodes, 64 processes total, 1x SSU, (2x SSDs vs. 82x HDDs) running Lustre 2.5.1

NXD / ClusterStor L300N – Read Performance

16 nodes, 64 processes total, 1x SSU, (2x SSDs vs. 82x HDDs) running Lustre 2.5.1



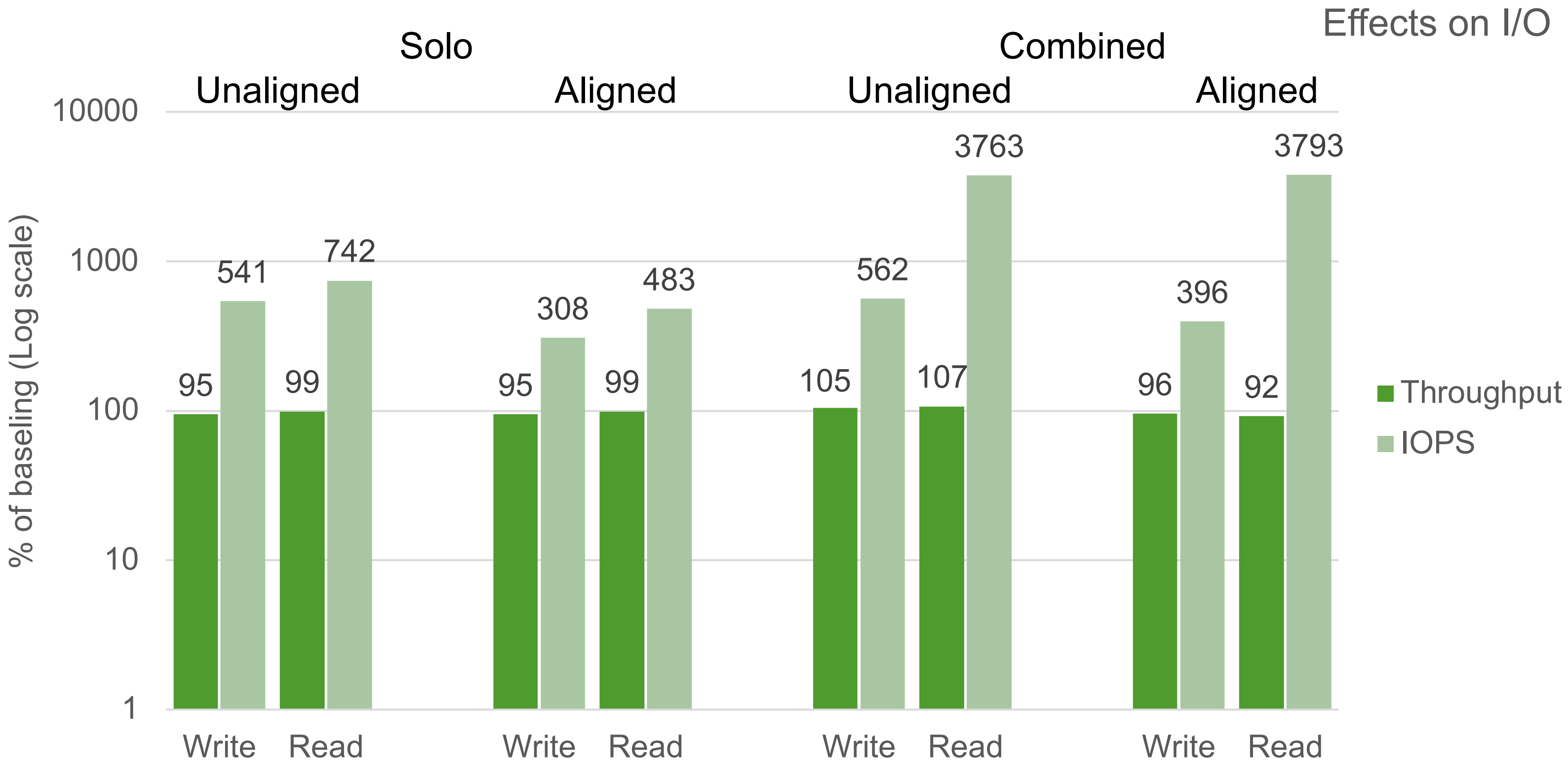


Experiment 1 – IOR Sequential

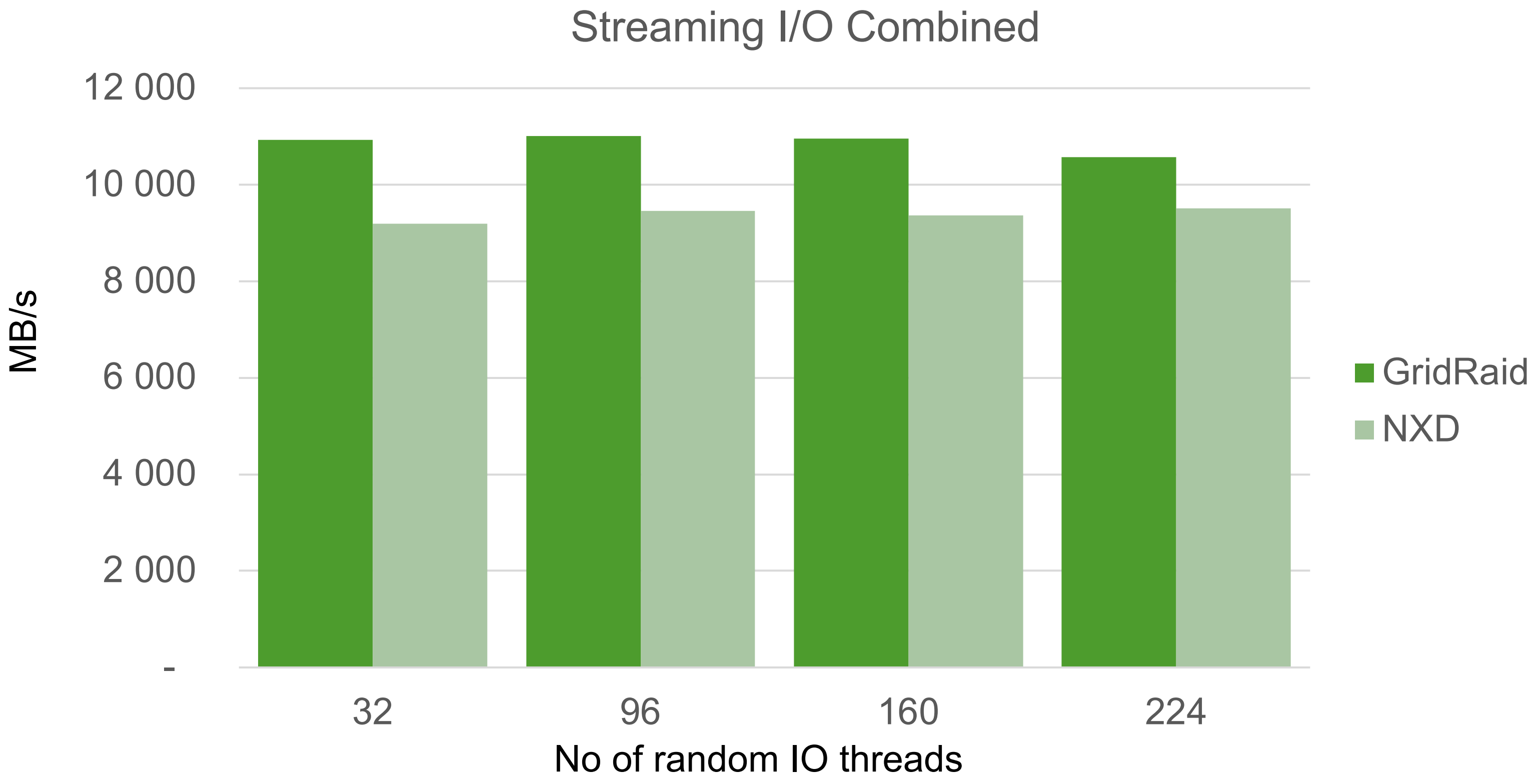
Pattern	NXD	Nodes	PPN	Procs	File Size (MB)	Transfer (KB)	Iterations	Write (MB/s)	Read (MB/s)	Write (MiB/s)	Read (MiB/s)
Sequential	**Disabled**	16	2	32	32,768	1024	5	**13,143**	**11,182**	**12,535**	**10,664**
Sequential	**Enabled**	16	2	32	32,768	1024	5	**13,014**	**11,154**	**12,411**	**10,637**

- No significant decrease in write or read performance
  - Small trend of slightly slower performance with NXD
- Mean impact over 5 iterations < 1%

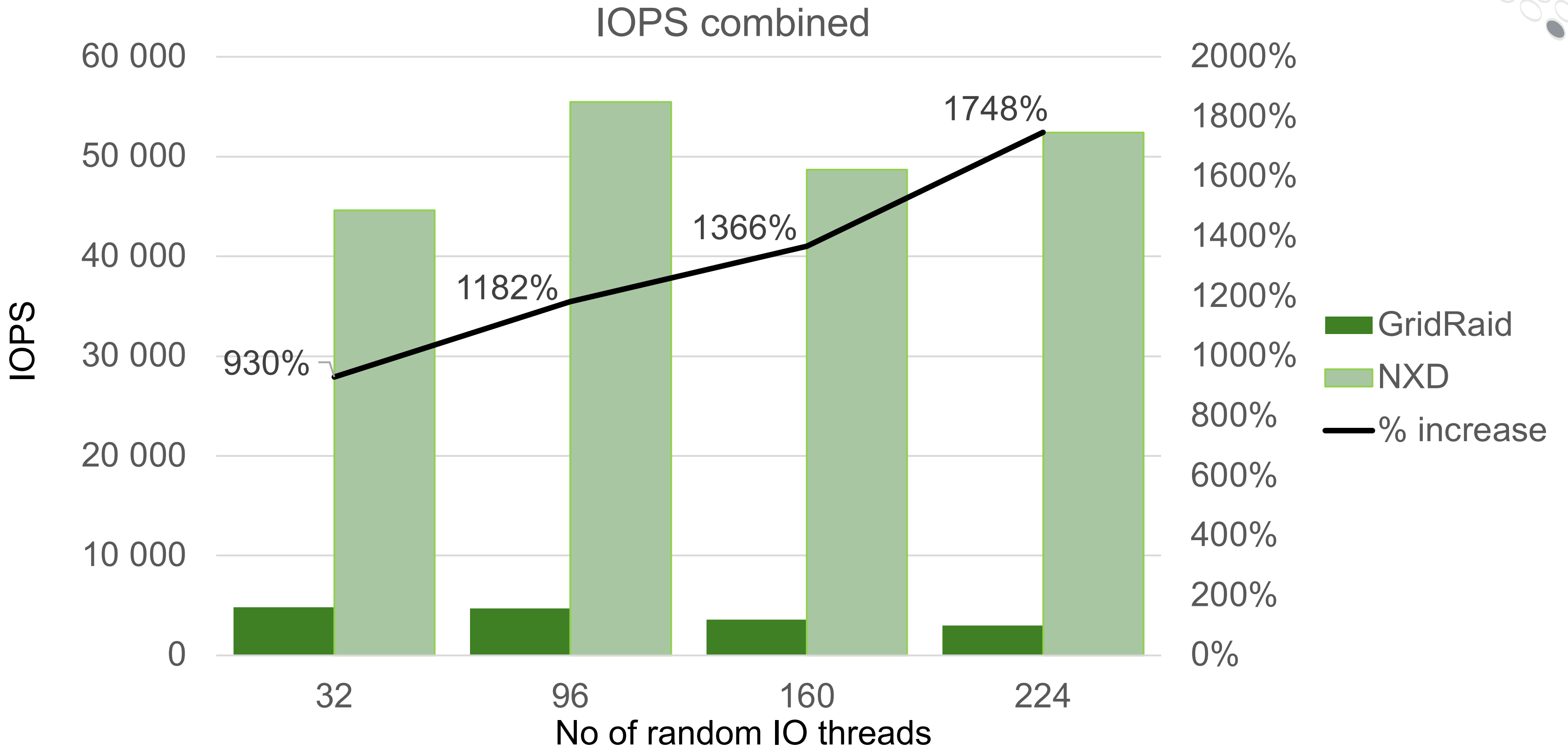
Experiment 2 – Mixed IOR



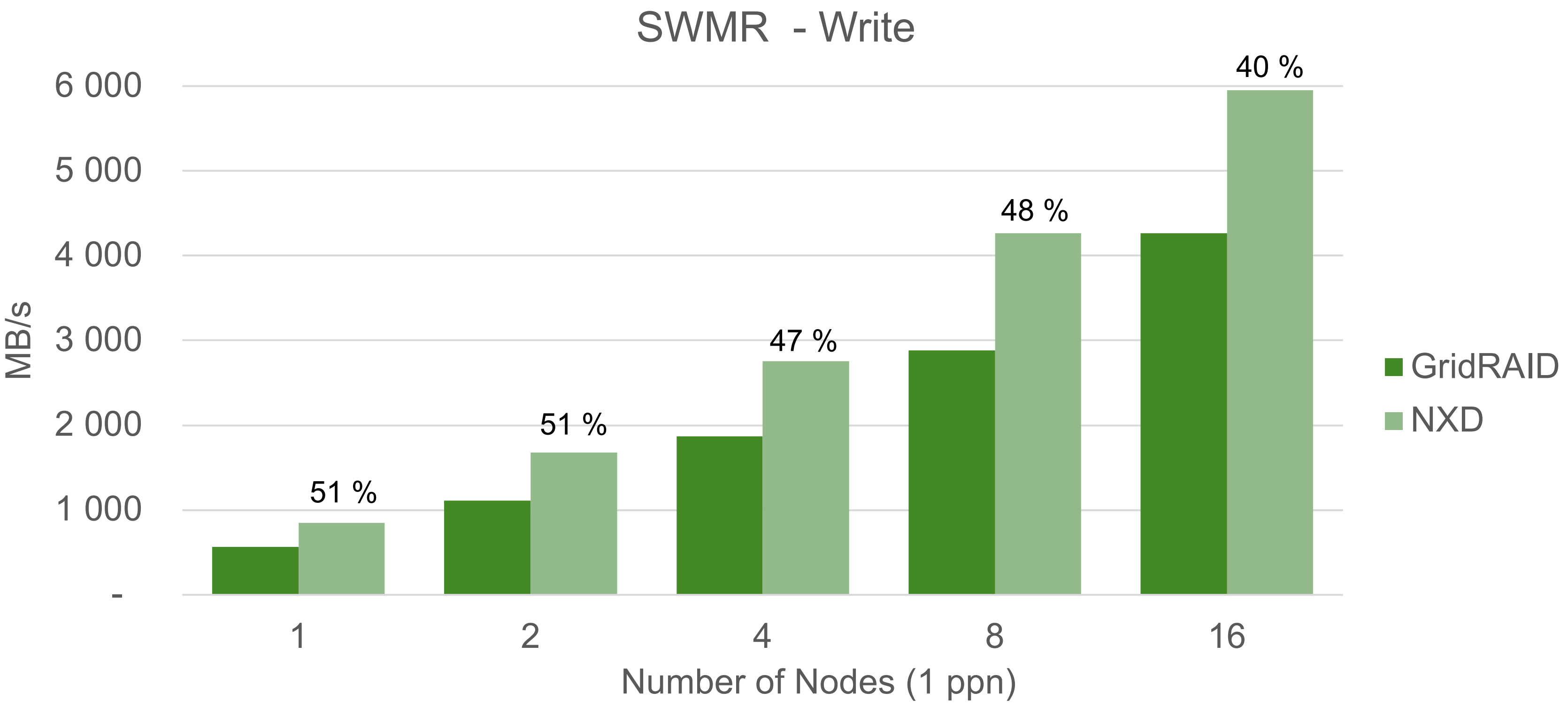
Experiment 3 – Concurrent IOR, Increasing Load of Random



Experiment 3 – Concurrent IOR, Increasing Load of Random



Experiment 4 – SWMR



Customer Test Runs – Production Codes and Data

Application	Work Load Type	Large Block Range	Small Block Range	NXD Impact	Overall CS Performance
Hydra (open source)	Write intensive Large block	4M-8M – 99.9%	< 4K – 0.1%	Minimal	No degradation
Hydra (open source)	Write intensive Large block	4M-8M – 99.9%	< 4K – 0.1%	Perf gain 2.6% to 6%	Tuning down StripeSize from 4M to 1M and the gains started showing up.
CDI-PIO (DKRZ)	Write intensive Mixed mode	1M – 90%	< 512K – 10%	Perf gain of 10%	Performance improvement with NXD enabled / Histogram OFF and StripeSize – 1M / RPC 512/7
FESOM (DKRZ)	Read intensive Small block	10% large reads	90% Small Read	Perf gain of 6%	Performance improvement with NXD enabled. No tuning, no pre-load
FESOM (DKRZ)	Read intensive Small block	10% random large block	90% small Read (mostly seq.)	Perf gain of 10% over a run of continuous 100 iterations.	CS performs around 10% Sample size is only 9GiB
IOR (open source)	2 seqential runs 2 random runs	4 MB for seq	4K for random	Read: 10x increase Write: 6x increase	No degradation
COSMO (open source)	Write intensive large blocks	1 MB	Mostly 4K	1% with stripe count 1 and stripe size 4m	No degradation over 7 runs

Conclusions

- **NXD is transparent to 100% streaming I/O**
- **NXD can preferentially enhance small block I/O by orders of magnitude with only a modest impact on sequential I/O during mixed I/O workloads**
- **Performance improvement is very application dependent**
  - Careful I/O pattern analysis is required for optimal tuning
  - Example: NXD improved `tar -c` on a large directory by 43% whereas `tar -x` was unaffected
- **Still limited field experience of NXD**
  - But the number of customers implementing NXD is growing rapidly

Q&A

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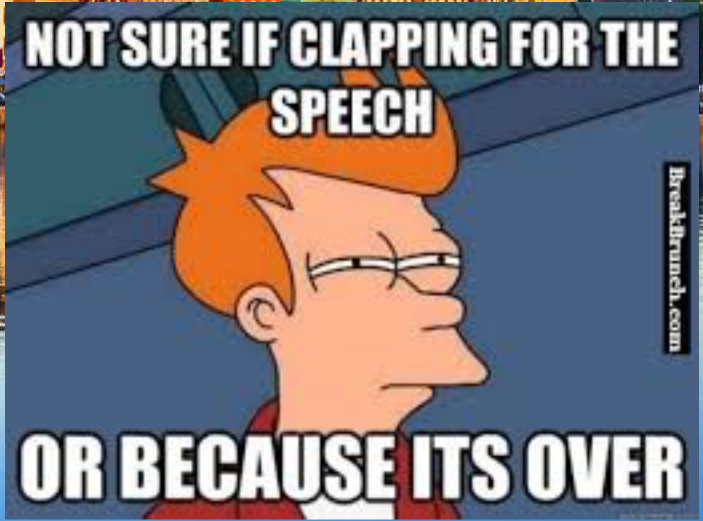

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