

Data Management on UL HPC



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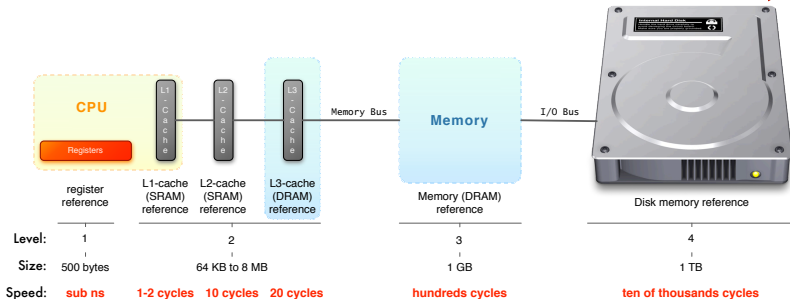


Summary

- 1 Data Storage on UL HPC
- 2 Storage Policy
- 3 Last Challenges
Effective Storage and Memory Management
Fault Tolerance

Local Data Storage

Larger, slower and cheaper



- SSD R/W: 560 MB/s; 85000 IOps **1000 €/TB**
- HDD (SATA @ 7,2 krpm) R/W: 100 MB/s; 190 IOps **100 €/TB**



Available File Systems

File Systems

Logical manner to store, organize, manipulate and access data.

- **Disk file systems:** ext4 (nodes), xfs (storage servers)
- **Network file systems:** NFS, SMB/CIFS
- **Distributed parallel file systems:** Lustre, GPFS, GlusterFS
 - ↪ data are striped over multiple servers for high performance.
 - ↪ generally add robust failover and recovery mechanisms



Shared storage on UL HPC

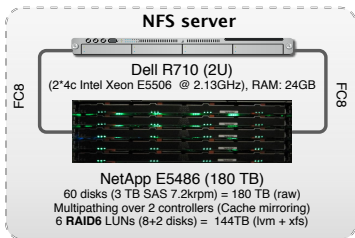
- All based on disk enclosure (Nexsan or NetApp)





NFS-based Storage on UL HPC

- Enclosures configured with xfs over LVM
- An attached server exports the volume over NFS



Effective capacity: 109 TB

- Only available on **Chaos**:
 - ↪ 1 Netapp Enclosure (109 TB):
 - ✓ \$HOME
 - ✓ \$WORK

- **Note:** all NFS shared storage of **Gaia** was replaced on March 2015 in favor of GPFS

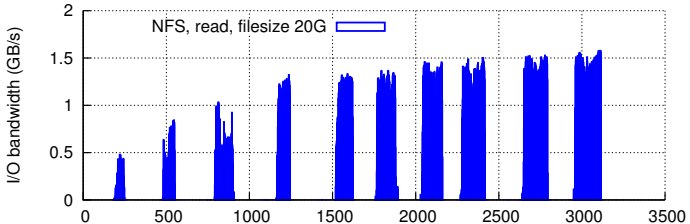


NFS Performances

● Remember that NFS-based storage **DOES NOT** scale

● In particular, adding a new enclosure:

- ↪ adding a new enclosure: **does not** improve the general performance
- ✓ un-like Lustre and GPFS





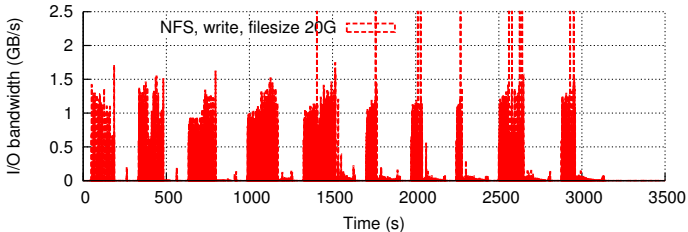
NFS Performances

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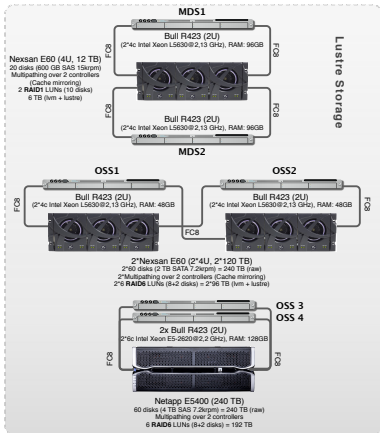
 - ↪ adding a new enclosure: **does not** improve the general performance

 - ✓ un-like Lustre and GPFS





Lustre Storage (Gaia)



Effective capacity: **347 TB**

- Scalable Parallel FS
 - ↳ \$SCRATCH
- Only available on **gaia**
- Current Layout:
 - ↳ 2 MDS servers,
 - ↳ 4 OSS servers,
 - ↳ 3 Nexsan E60 encl.
 - ↳ 1 Netapp E5400 encl.

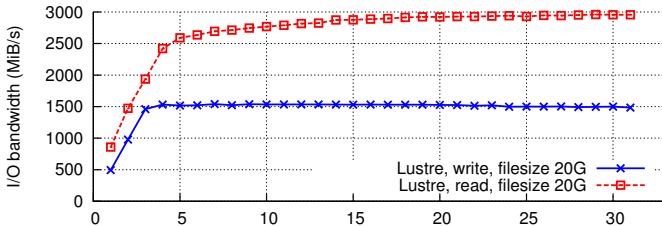


Lustre Performances

● Remember that Lustre-based storage DOES scale

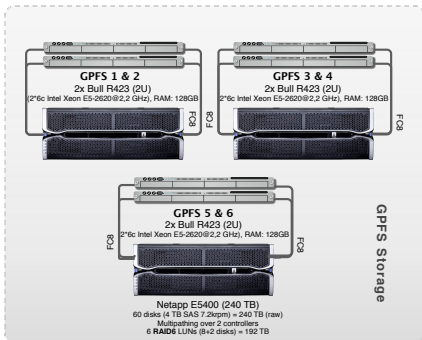
● In particular, adding a new enclosure:

- ↳ increase the global capacity accordingly
- ↳ **adds** the performance to the global perf. of the system
- ↳ Note: below measures were done **before** the recent extension





GPFS Storage (Gaia)



Effective capacity: **524 TB**

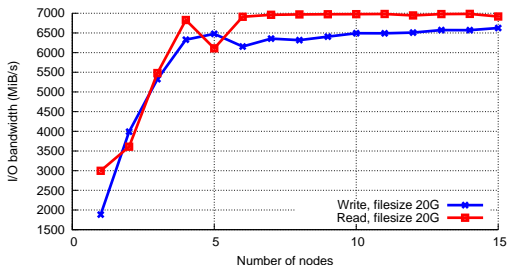
- Scalable Parallel FS
 - ↳ \$HOME
 - ↳ \$WORK
- Only available on **gaia**
- Current Layout:
 - ↳ 6 servers,
 - ↳ 3 Netapp E5400 encl.



GPFS Performances

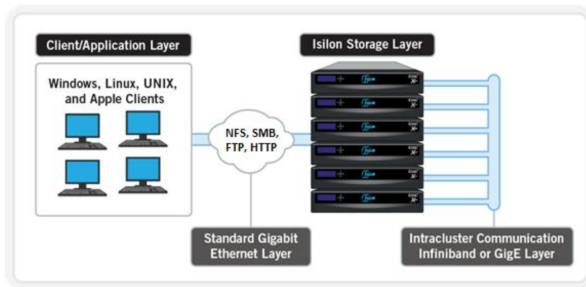
- Remember that GPFS-based storage DOES scale

- In particular, adding a new enclosure:
 - increase the global capacity accordingly
 - **adds** the performance to the global perf. of the system



Effective capacity: 1460 TB

- Mounting point on the **gaia** cluster: `/mnt/isilon`
 - ↳ Performance evaluation in progress
 - ↳ **Obj**: projects data go on it





UL HPC Backups

Total **Effective** (split) capacity: **1365 TB**

- Based on **bontmia** and **backupninja**
 - ↪ Backup Over Network To Multiple Incremental Archives
 - ↪ **ULHPC/puppet-bontmia** puppet module
- **NFS-based** targets:
 - ↪ **Chaos**: 1 Netapp Enclosure (130 TB) cartman
 - ↪ **Gaia**:
 - ✓ 1 Netapp Enclosure (130 TB) stan
 - ✓ 1 Nexsan Enclosure (189 TB): former `nfs.gaia`
- **GlusterFS-based** targets (**Gaia** only) (916 TB)
 - ↪ **highlander** server exports the volumes
 - ✓ **bertha** and the others Certon are storage enclosures



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Multi-Tier Environment

Tier-structure of storage space

- 1 **Tier-1** (GPFS): high performance, high reliability
↳ put there frequently processed data only
- 2 **Tier-2** (Certons): low performance
↳ storage and backup disks (\simeq archiving)
- 3 **Tier-0** (LUSTRE): Scratch
↳ ultra high performance, (potentially) low reliability



Storage Policy

- \$HOME (**NFS** or **GPFS**) is under a regular backup policy.
- \$WORK (**NFS** or **GPFS**) is **not** backed up
 - ↪ Avoid massive parallel writes under NFS
 - ↪ Use cdw to quickly change your current directory to \$WORK
- \$SCRATCH (**Lustre** *) is **not** backed up
 - ↪ designed for **temporarily need**, with fast I/O
 - ↪ Use cds to quickly change your current directory to \$SCRATCH
 - ↪ **On Chaos, \$SCRATCH is /tmp thus NOT Shared**

Directory	Max size	Max #files	Backup
\$HOME	50 GB	500.000	YES
\$WORK	3 TB		NO
\$SCRATCH	10 TB		NO



Project Management

- In case the regular storage limits **do not** match your expectations
 - ↳ quotas extension for project folders can be granted
 - ↳ this comes with additional fees

Project Storage Request Form

Contact: joanna.smula@uni.lu

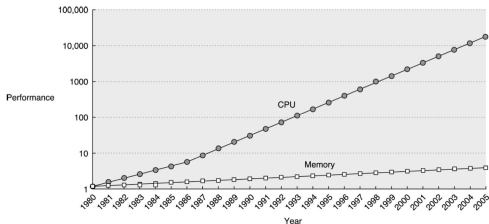


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Memory bottleneck



- A regular computing node have at least 2GB/core RAM
 - ↳ Do 12-24 runs fit in the memory?
 - ↳ If your job runs out of memory, it simply crashes
- Use fewer simultaneous runs if **really** needed!
 - ↳ **OR** request a big memory machine (1TB RAM)
 - \$> oarsub -t bigmem ...
 - ↳ **OR (better)** explore parallization (MPI, OpenMP, pthreads)



Understanding Your Storage Options

Where can I store and manipulate my data?

- **Shared storage**

- ↪ NFS – **not scalable** $\simeq 1.5$ GB/s (R) $\mathcal{O}(100$ TB)
- ↪ GPFS – **scalable** $\simeq 6$ GB/s (R) $\mathcal{O}(500$ TB)
- ↪ Lustre – **scalable** $\simeq 5$ GB/s (R) $\mathcal{O}(400$ TB)

- **Local storage**

- ↪ local file system (/tmp) $\mathcal{O}(200$ GB)
 - ✓ over HDD $\simeq 100$ MB/s
 - ✓ over SSD $\simeq 400$ MB/s
- ↪ RAM (/dev/shm) $\simeq 30$ GB/s (R) $\mathcal{O}(20$ GB)

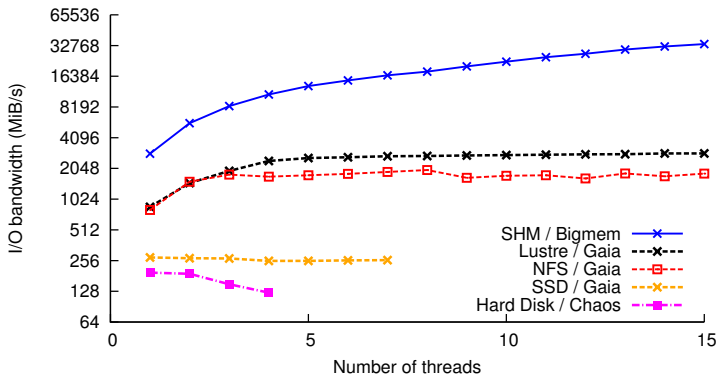
⇒ **In all cases:** small I/Os really **kill** storage performances



Storage performances

- Based on IOR or IOZone, reference I/O benchmarks

Read

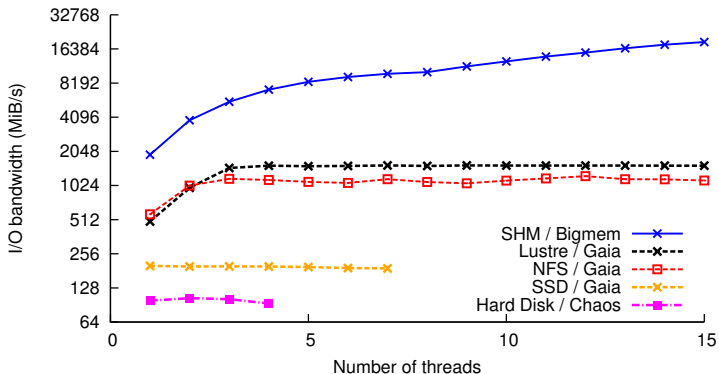




Storage performances

- Based on IOR or IOZone, reference I/O benchmarks

Write





Speed Expectation on Data Transfer

<http://fasterdata.es.net/>

- How long to transfer **1 TB** of data across various speed networks?

Network	Time
10 Mbps	300 hrs (12.5 days)
100 Mbps	30 hrs
1 Gbps	3 hrs
10 Gbps	20 minutes

- **(Again)** small I/Os really **kill** performances
 - ↪ **Ex:** transferring 80 TB for the backup of ecosystem_biology
 - ↪ same rack, 10Gb/s. 4 weeks → 63TB transfer...



Speed Expectation on Data Transfer

<http://fasterdata.es.net/>

Data set size

10PB	166.67 TB/sec	33.33 TB/sec	8.33 TB/sec	2.78 TB/sec
1PB	16.67 TB/sec	3.33 TB/sec	833.33 GB/sec	277.78 GB/sec
100TB	1.67 TB/sec	333.33 GB/sec	83.33 GB/sec	27.78 GB/sec
10TB	166.67 GB/sec	33.33 GB/sec	8.33 GB/sec	2.78 GB/sec
1TB	16.67 GB/sec	3.33 GB/sec	833.33 MB/sec	277.78 MB/sec
100GB	1.67 GB/sec	333.33 MB/sec	83.33 MB/sec	27.78 MB/sec
10GB	166.67 MB/sec	33.33 MB/sec	8.33 MB/sec	2.78 MB/sec
1GB	16.67 MB/sec	3.33 MB/sec	0.83 MB/sec	0.28 MB/sec
100MB	1.67 MB/sec	0.33 MB/sec	0.08 MB/sec	0.03 MB/sec
	1 Minute	5 Minutes	20 Minutes	1 Hour

Time to transfer

Legend:

Requires less than 100Mbps throughput

Requires between 100Mbps and 10Gbps throughput

Requires between 10Gbps and 100Gbps throughput

Requires more than 100Gbps throughput

Note: Kilo, Mega, etc. are in SI units. E.g. 1KB is 1000 bytes, not 1024 bytes



Speed Expectation on Data Transfer

<http://fasterdata.es.net/>

Data set size

1XB	34.72 TB/sec	11.57 TB/sec	1.65 TB/sec	385.80 GB/sec
100PB	3.47 TB/sec	1.16 TB/sec	165.34 GB/sec	38.58 GB/sec
10PB	347.22 GB/sec	115.74 GB/sec	16.53 GB/sec	3.86 GB/sec
1PB	34.72 GB/sec	11.57 GB/sec	1.65 GB/sec	385.80 MB/sec
100TB	3.47 GB/sec	1.16 GB/sec	165.34 MB/sec	38.58 MB/sec
10TB	347.22 MB/sec	115.74 MB/sec	16.53 MB/sec	3.86 MB/sec
1TB	34.72 MB/sec	11.57 MB/sec	1.65 MB/sec	0.39 MB/sec
100GB	3.47 MB/sec	1.16 MB/sec	0.17 MB/sec	0.04 MB/sec
10GB	0.35 MB/sec	0.12 MB/sec	0.02 MB/sec	0.00 MB/sec
	8 Hours	24 Hours	7 Days	30 Days
	Time to transfer			

Legend:

Requires less than 100Mbps throughput

Requires between 100Mbps and 10Gbps throughput

Requires between 10Gbps and 100Gbps throughput

Requires more than 100Gbps throughput

Note: Kilo, Mega, etc. are in SI units. E.g. 1KB is 1000 bytes, not 1024 bytes



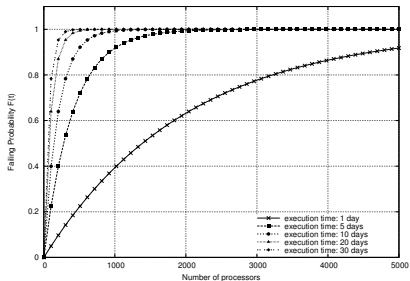
Fault Tolerance

- Cluster maintenance from time to time



Fault Tolerance

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- Reliability vs. Crash Faults in Distributed systems





Fault Tolerance

- Cluster maintenance from time to time
- Reliability vs. Crash Faults in Distributed systems
- Fault Tolerance general strategy: checkpoint/rollback
 - ↪ assumes a way to save the state of your program
 - ↪ hints: OAR `-signal -checkpoint -idempotent...`, BLCR
 - ↪ combine best-effort jobs with checkpointing (<http://git.io/c-dn1A>)



Thank you for your attention...

Questions?

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