Introduction to distributed file systems. OrangeFS experience

LVEE Winter

Linux Vacation / Eastern Europe

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Outline

1. Introduction
2. Species of distributed file systems
3. Behind the curtain
4. OrangeFS
5. Summary

Introduction

Why one needs a non-local file system?

- a *large* data storage
- a *high performance* data storage
- *redundant* and highly available solutions

There are dozens of them: 72 only on wiki[1], more IRL.

Focus on *free software* solutions.

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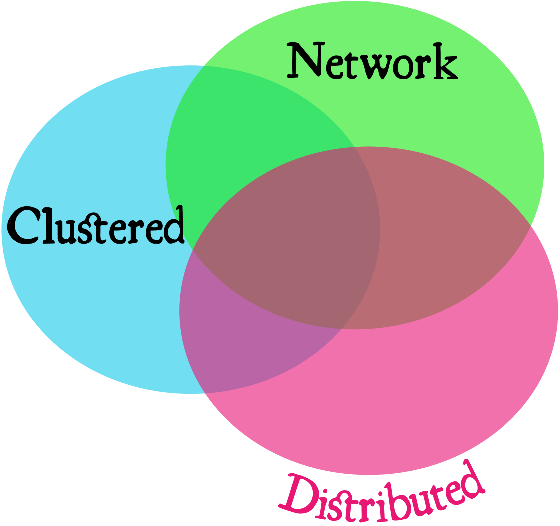
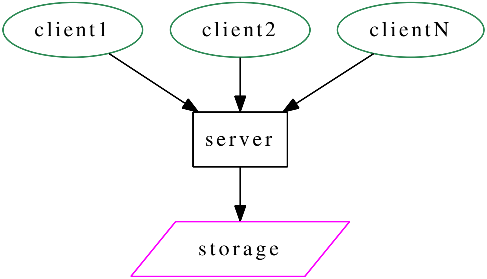
Species of distributed file systems



Terminology is ambiguous!

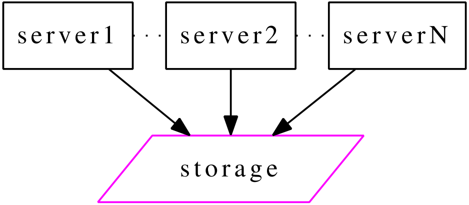
Network file systems



A single server (or at least an appearance) and multiple network clients.

Examples: NFS, CIFS.

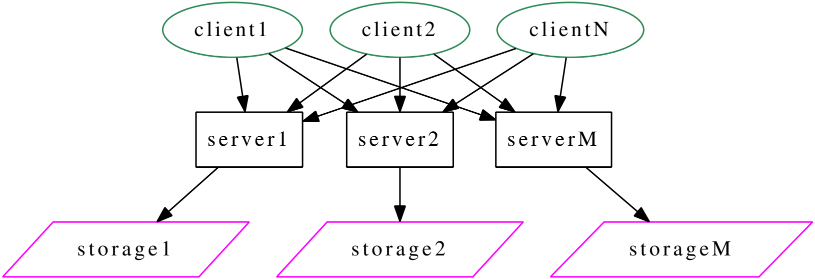
Clustered file systems



Servers sharing the same local storage (usually SAN[2] at block level).
shared storage architecture.

Examples: GFS2[3], OCFS2[4].

Distributed file systems



“Shared nothing” model, independent servers.
intelligent server architecture.

Examples: pNFS[5], AFS[6].

Parallel file systems

- Parallel access from clients to (all) servers
- Parallel R/W to the same data file
- Mitigate bandwidth and latency bottlenecks
- Fields of use: HPC and high-end business applications

Examples: Lustre[7], OrangeFS[8], Ceph[9].

Fully parallel file systems:

- Parallel data ***and*** metadata access
- Very important for large directories

Examples: OrangeFS[8], Ceph[9], FhGFS[10].

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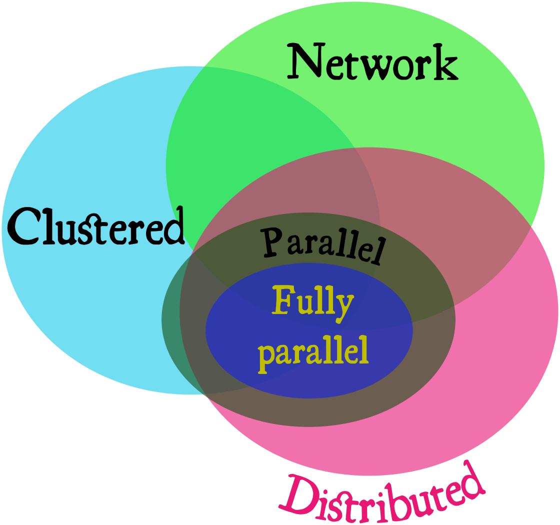

High Availability

Do not confuse High Availability and Fault Tolerance:

- FT: zero downtime
- HA: small downtime ($\sim$ min)

Data FT approaches:

- data replication (e.g. in Ceph[9])
- disk level redundancy (usually RAID 5/6)

Service HA:

- heartbeat
- pacemaker

Example of reliability: Lustre[7] is used on $\sim 50\%$ of Top-500[11] systems, including the fastest one: Titan.

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HPC stuff

- Parallel solutions are highly preferred
- Infiniband[12] support
  - Lustre[7], OrangeFS[8], FhGFS[10]
  - Do not use IP over IB!
- MPI[13] I/O support
  - Usually ROMIO[14] interface
  - Lustre[7], OrangeFS[8], NFS
- Tasks optimization

POSIX compliance and FS features

POSIX was designed for local FS with serial I/O interfaces, thus it hinders parallel access.

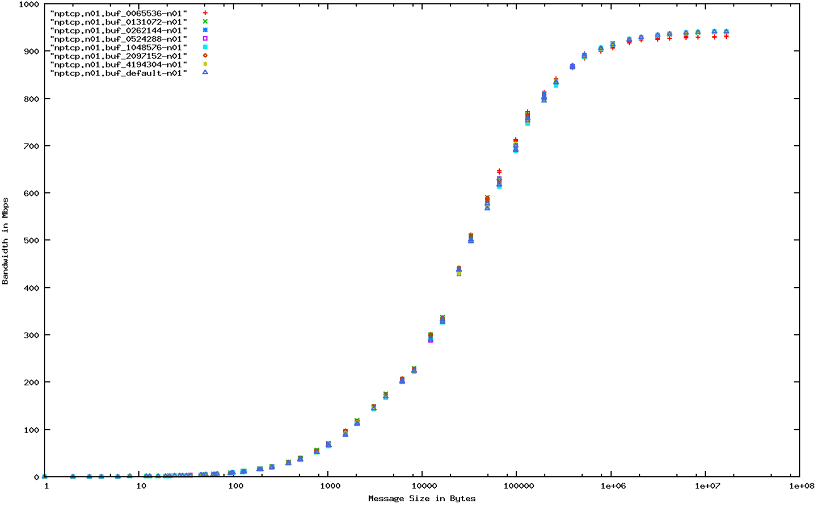
Most common issues:

- file locks
- special files
- quota support
- acl support
- hardlinks
- mmap
- I/O usually do not follow POSIX (strictly)

Setup considerations

- Know your workload
- What POSIX features do you need?
- Is MPI needed?
- Is HA needed?
- Choose locality type
- Choose security level

Network performance



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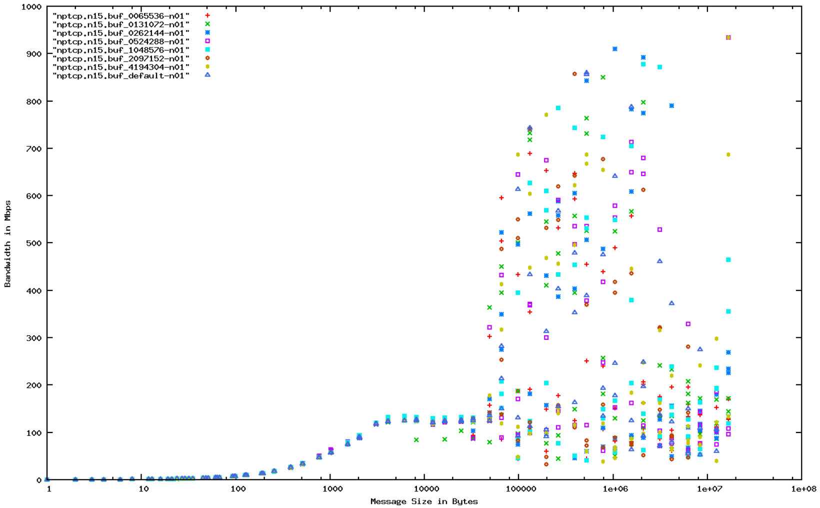

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OrangeFS

Procs:

- Scalable parallel FS
- Good MPI I/O support
- HA support
- Reasonable performance on large directories
- low CPU load with high network I/O
- configurable data distributions
- native IB[12] support
- pNFS[5] support

Cons:

- no hardlinks or special files
- no unlink(), locks
- no quota
- is not suitable for $HOME
- support for kernels $\geq$ 3.4 is on the way

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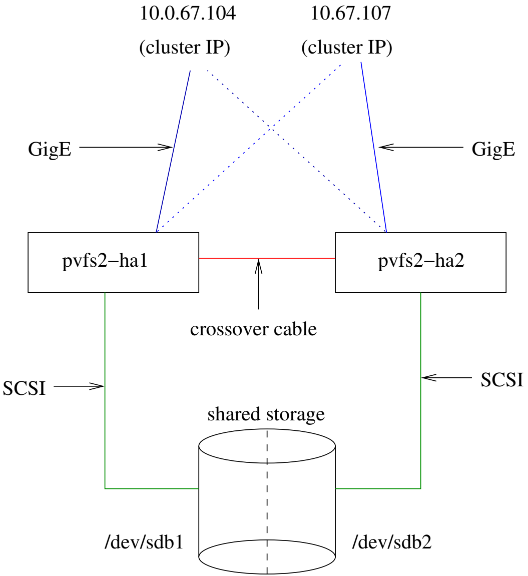
OrangeFS HA support



OrangeFS Benchmarks

	Server CPU	Client CPU	I/O, MB/s
GlusterFS	1.23	4.35	30
OrangeFS	0.11	0.48	95

- 15 nodes, 1 Gbit/s
- 1 : 15 servers setup
- Node: 2 x Xeon5450, 32 GB RAM, 54 MB/s HDD

Summary

- There is no universal solutions
- Understand your workload
- You’ll have very peculiar issues with any FS
- But these problems are usually solvable

- Good thing to look at for:
  - HPC: Lustre[7], OrangeFS[8], pNFS[5]
  - Data storage: Ceph[9], Lustre[7]

- Always send your patches!

Thank you for your attention!

NFS vs GFS2 vs OCFS2

Disclaimer:

Graphs aren’t mine! But they correlate well with our general experience. Our systems are in production now and old data were not saved.

Figures are taken from Giuseppe Paternò’s “Filesystem comparision: NFS, GFS2, OCFS2”[15]

Note: GFS2 is deprecated now, because only:

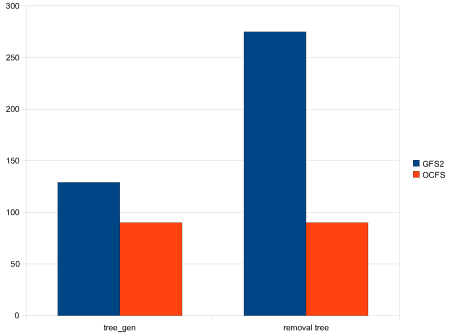
- up to 16 nodes are supported[16]
- up to 25 TB storage[16]

NFS vs GFS2 (generic load)

Nodes	I/O rate NFS (MB/s)	NFS avg transfer rate (MB/s)	I/O rate GFS (MB/s)	GFS avg transfer rate (MB/s)
2	21	2	43	2
6	11	6	46	4
10	8	6	45	5
14	0.5	0.1	41	8

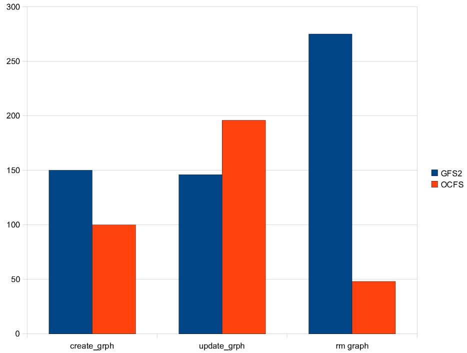
GFS2 vs OCFS2

Standard tree generation



(operation timings in Seconds)

Graph structure generation

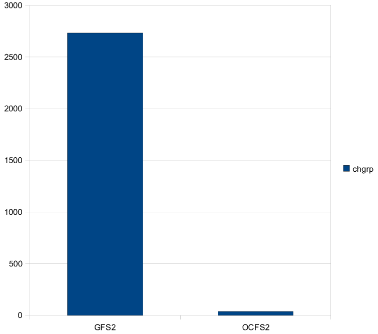


(operation timings in Seconds)

GFS2 vs OCFS2

Change group (chgrp)

42 mins
Vs
37 secs



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Operation needed to share data across the working group

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