Karlsruhe Institute of Technology

Challenges in making Lustre systems reliable

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STEINBUCH CENTRE FOR COMPUTING - SCC

Background and motivation

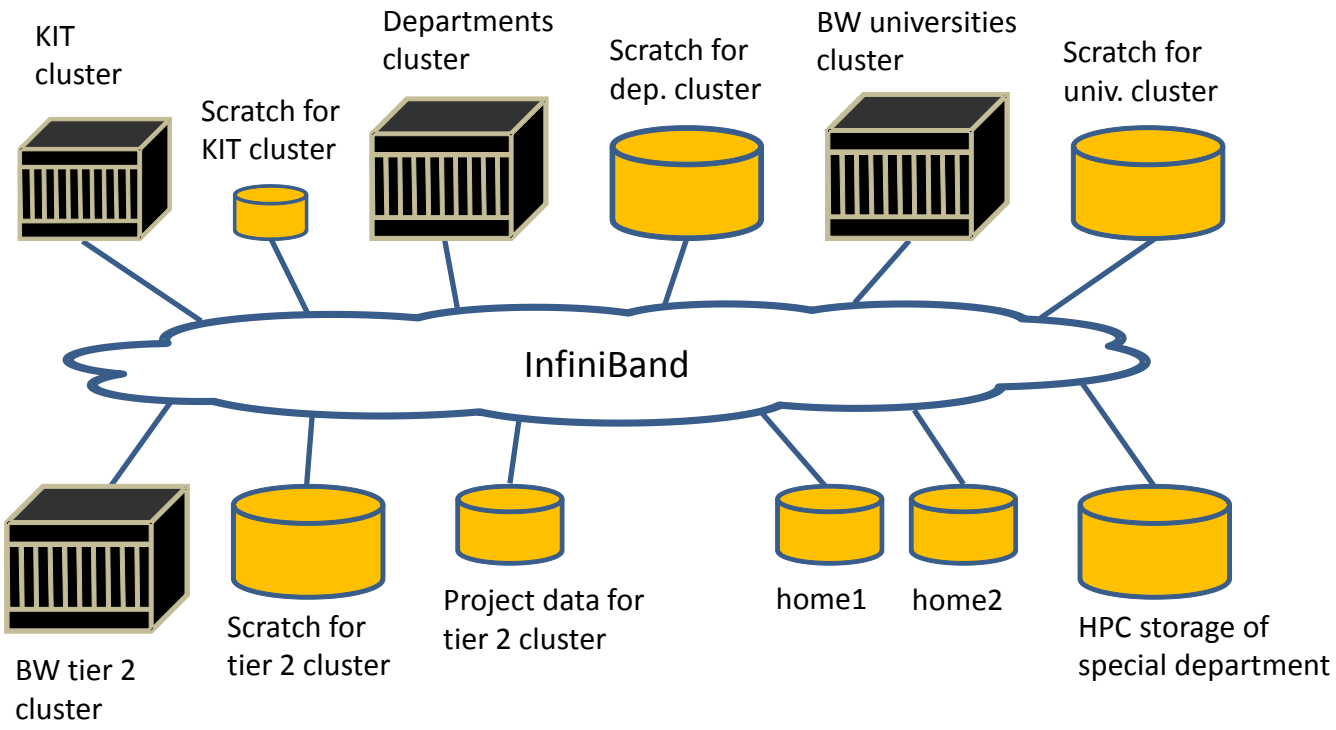
- Most of our compute cluster outages caused by Lustre
  - Probably this would be similar with other parallel file systems
- Even recently we had seen bad Lustre versions
  - Most bugs related to new client OS versions or quotas
- Frequent discussions with users about I/O errors
  - Often small changes allow to omit Lustre evictions
- We had silent data corruption caused by storage hardware
  - A huge damage needs restore of complete file systems

Overview

- Lustre systems at KIT
- Challenge #1: Find stable Lustre versions
- Challenge #2: Find stable storage hardware
- Challenge #3: Identify misbehaving applications
- Challenge #4: Recover from disaster

Lustre systems at KIT - overview

- Multiple clusters and file systems connected to same InfiniBand fabric
  - Good solution to connect Lustre to midrange HPC systems
  - Select appropriate InfiniBand routing mechanism and cabling
  - Allows direct access to data of other systems without LNET routers



Lustre systems at KIT - details

System name	hc3work	pfs2	pfs3
Users	KIT, 2 clusters	universities, 4 clusters	universities, tier 2 cluster
Lustre server version	DDN Lustre 2.4.3	DDN Lustre 2.4.3	DDN Lustre 2.4.3
# of clients	868	1941	540
# of servers	6	21	17
# of file systems	1	4	3
# of OSTs	28	2*20, 2*40	1*20, 2*40
Capacity (TB)	203	2*427, 2*853	1*427, 2*853
Throughput (GB/s)	4.5	2*8, 2*16	1*8, 2*16
Storage hardware	DDN S2A9900	DDN SFA12K	DDN SFA12K
# of enclosures	5	20	20
# of disks	290	1200	1000

Challenge #1: Find stable Lustre versions (1)

- Lustre 1.8.4 / 1.8.7 was running very stable
  - Needed to upgrade to version 2.x for SLES11 SP2 client support
- Lustre 2.1.[2-4] on servers was pretty stable
  - Clients with version 2.3.0 caused trouble, needed for SLES11 SP2
    - SLES11 SP2 clients with version 2.4.1 were stable
  - Needed to upgrade servers to 2.4.1 for SP3/RH6.5 client support
- Lustre 2.4.1 on servers caused some problems
  - Bad failover configuration caused outages (LU-3829/4243/4722)
  - Needed to disable ACLs after security alert (LU-4703/4704)
  - User and group quotas were wrong (LU-4345/4504)
- Lustre 2.5.1 clients on RH6.5 were bad
  - LBUGs and clients hanging in status evicted (LU-5071)

Challenge #1: Find stable Lustre versions (2)

- Lustre 2.4.3 on servers is stable
  - SLES11 SP3 clients with Lustre 2.4.3 cause no problems
  - RH6.5 clients with Lustre 2.5.2 are now stable, too
  - User and group quotas are still forged (LU-4345/4504/5188)
    - Not yet fixed in current maintenance release(?)
    - Objects on OSTs sometimes created with arbitrary UID/GID
    - Recommended way to fix bad quotas is hardly usable

- Choose stable maintenance release
- Stay with old stable versions
- Bad dependency: OS upgrade → new Lustre client version required → new Lustre server version required

Challenge #2: Find stable storage hardware

- We had silent data corruption on Infortrend and HP RAIDs
  - More details given at my talk at ELWS'11
  - Infortrend systems provided different data when reading twice
    - This happened once per year on 1 of 60 RAID systems
  - HP MSA2000 G2 had problem with cache mirroring
    - After PCIE link failed messages e2fsck sometimes showed corruption
- Some hardware features greatly improve stability
  - Features which reduce rebuild times
    - Declustered RAID or partial rebuilds using bitmaps
    - We have seen triple disk failures on RAID6 arrays multiple times
  - Features which detect silent data corruption
- High end storage systems are most likely more stable
- During procurements give stability features high weighting

Challenge #3: Identify misbehaving apps

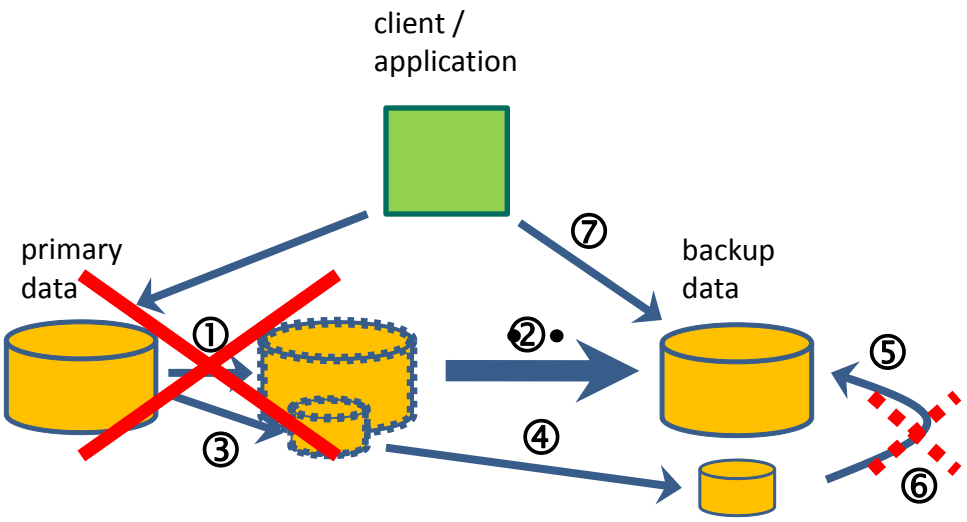
- Find out which file is causing an eviction
  - On version 2.x LustreError messages like this might appear:
    - LustreError: 45766:0:(osc_lock.c:817:osc_ldlm_completion_ast()) lov sub@...: [0 … W(2):[0, …]@[**0x200001ea7:0x18682:0x0**]]
  - Use FID and file system name to identify the badly accessed file
    - lfs fid2path pfs3wor4 [0x200001ea7:0x18682:0x0]
    - Unfortunately, sometimes only the root of the file system is reported
- Use performance monitoring to check what users are doing
  - For good instructions see Daniel Kobras' talk at LAD'12
  - E.g. this shows bad scratch usage of home directory file systems
  - Frequently users do not know how their I/O ends up on Lustre
- Enhancing misbehaving applications and reducing load stabilizes the file system and makes it more responsive

Challenge #4: Recover from disaster (1)

- A disaster can be caused by
  - hardware failure, e.g. a triple disk failure on RAID6
  - silent data corruption caused by hardware, firmware or software
  - complete infrastructure loss, e.g. caused by fire or flood
- Timely restore of 100s TB does not work
  - Transfer takes too long and rates are lower than expected
    - Bottlenecks often in network or at backup system
  - Metadata recreation rates can be limiting factor
  - We restored a 70 TB Lustre file system with 60 million files
    - With old hardware and IBM TSM this took 3 weeks

Challenge #4: Recover from disaster (2)

- Solution on other huge storage systems:
- Do not restore but switch on client or application to backup copy !



Note: Data created after last incremental snapshot is lost.

Backup:

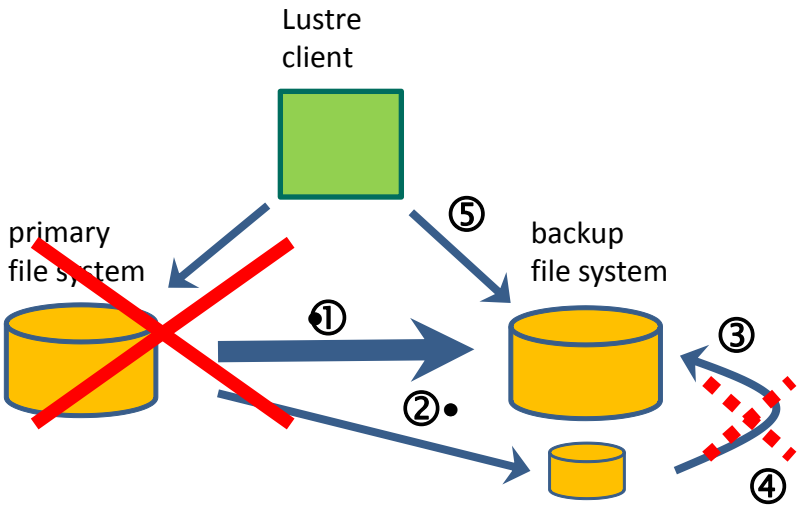
1. Complete snapshot
2. Transfer snapshot to backup system
3. Incremental snapshot
4. Transfer incr. snapshot
5. Install incr. snapshot on backup system

Disaster recovery:

6. Remove bad incr. snapshot if required
7. Redirect application or client to backup system

Challenge #4: Recover from disaster (3)

- Transfer previous solution to Lustre:
- rsnapshot uses rsync to create copy and creates multiple copies by using hard links for unchanged data



Note: Data created after last rsync is lost.

Backup:

1. Use rsnapshot (rsync) to transfer all data to backup file system
2. Use rsnapshot (hard links) to transfer new data
3. rsnapshot possibly removes old copies

Disaster recovery:

4. Use good rsnapshot copy and move directories to desired location
5. Adapt mount configuration and reboot Lustre clients

Challenge #4: Recover from disaster (4)

- Details of our solution
  - 3 file systems with permanent data (home, project, software)
    - Each holds production data of some groups and backup data of others
- Experiences
  - Did not yet need the disaster recovery on production systems
    - User requested restores have been done and are just a copy
  - Backup done twice per week on one client with 4 parallel processes
    - For 100 mill. files and with 5 TB snapshot data this takes 26 hours
  - In addition, we still use TSM backup
    - This allows users to restore by themselves
    - Alternatively, rsnapshot copies could be exported read-only via NFS

Challenge #4: Recover from disaster (5)

- Restrictions of the solution
  - Slow silent data corruption might pollute all backup data
    - Same problem for other backup solutions
    - We did not yet see this case, i.e. OSS go pretty fast in status read-only
  - Recovery does not work if both file systems have critical Lustre bug
    - Different Lustre versions on primary and backup file system might help
  - Using lustre_rsync instead of rsync would omit file system scans
    - We plan to investigate if and how this would work

Further information

- rsnapshot
  - http://www.rsnapshot.org
- All my talks about Lustre
  - http://www.scc.kit.edu/produkte/lustre.php
- roland.laifer@kit.edu