FROM RESEARCH TO INDUSTRY

LUSTRE SERVER ON KERNEL 4.12.8

LUG 2018 – Argonne, USA | Gaël DELBARY

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TOPICS

- Flash CEA project
- Hardware Storage (for this analysis)
- Performance recorded
- Analysis
- Lustre build on kernel 4.12.8
- Results with kernel 4.12.8

FLASH CEA PROJECT

- Flash Parallel Filesystem (Q1 2019) for the next exascale supercomputers

- Target:
  - First store storage level (same Lustre FS as STORE) with Lustre Pool
  - 1 TB/s in write sequential (5% of times)
  - Mounted by all supercomputers
  - Data migration with RobinHood (via lfs migrate)
  - Hide complexity to end users

- Usage:
  - Checkpoint restart files (mostly sequential writes)
  - Final files (mostly sequential writes)
  - Data post-processing (sequential writes + random read)

FLASH CEA PROJECT

- Flash required?
- Reasons:
  - Low footprint (limit to 5 racks)
  - Random read
  - High write throughput
- External things to monitor:
  - Weight (density is not light)
  - Power (SSDs consume energy)
- Collaboration with many vendors
- Focus on write throughput
- Goal: optimize Lustre write sequential throughput on a given hardware

HARDWARE STORAGE

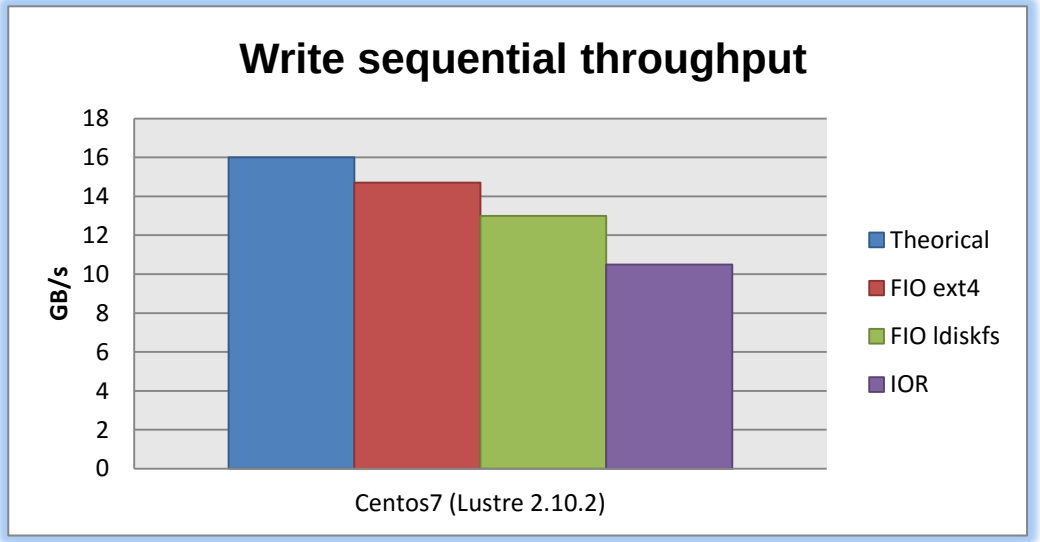
- Use case for this topic: embedded platform
- DDN SFA14KXE with SFAOS 11.0 GA
  - Broadwell processors
  - 512 GB of RAM
  - Infiniband Mellanox EDR
  - QEMU inside for Embedded
- 1x Declustered RAID pool (20x SSD HGST SS200)
  - 2x hotspares
  - 18x usable disks (RAID5 inside)
  - Theorical write sequential throughput (~16GB/s)
- Tested configuration: 1 VM (OSS inside)
  - 90 GB of RAM
  - 8x CPU cores (16 virtual with hyperthreading)
  - 2x EDR Infiniband card (Full Bandwidth: 24 GB/s)

PERFORMANCE RECORDED

- Commons parameters:
  - Device formated with no lazy initialization
  - CentOS 7.3 (ioscheduler: deadline, tuned profile: network-latency)
  - MOFED 4.2.1
  - Lustre 2.10.2 (ldiskfs backend)
  - Lustre clients tuning (no checksums)
  - FIO (direct=1, ioengine=libaio, iodepth=1)
  - IOR 3.0.1 (8 EDR clients)

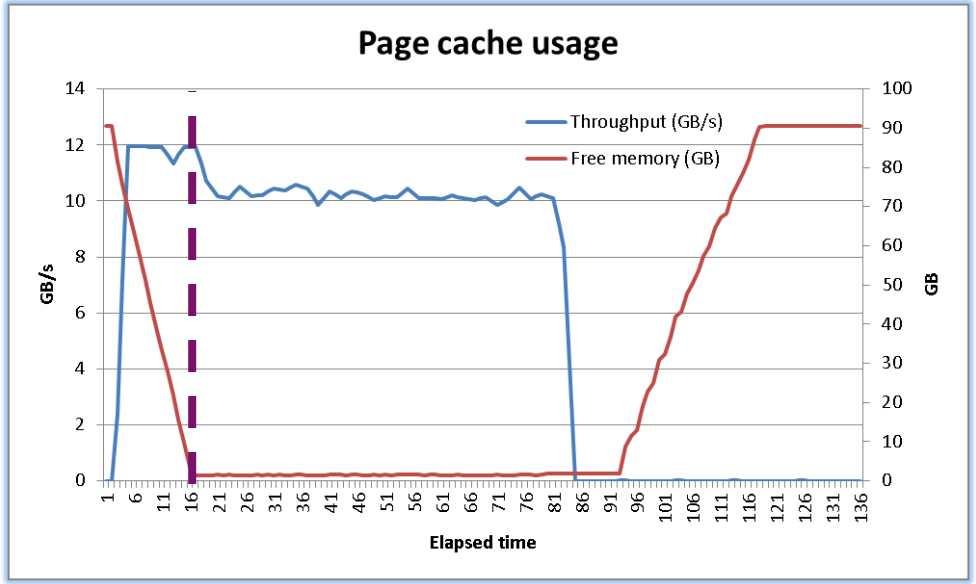
PERFORMANCE RECORDED

- Goal remember: close to 12 GB/s (full fill one EDR interface) with IOR
- Bandwidth lost:
  - 8% Theorical vs Ext4
  - 11% Ext4 vs Ldiskfs
  - 19% Ldiskfs vs IOR
- IOR bottleneck?
  - EDR bottleneck: 12 GB/s
  - Still 12,5% IOR vs EDR

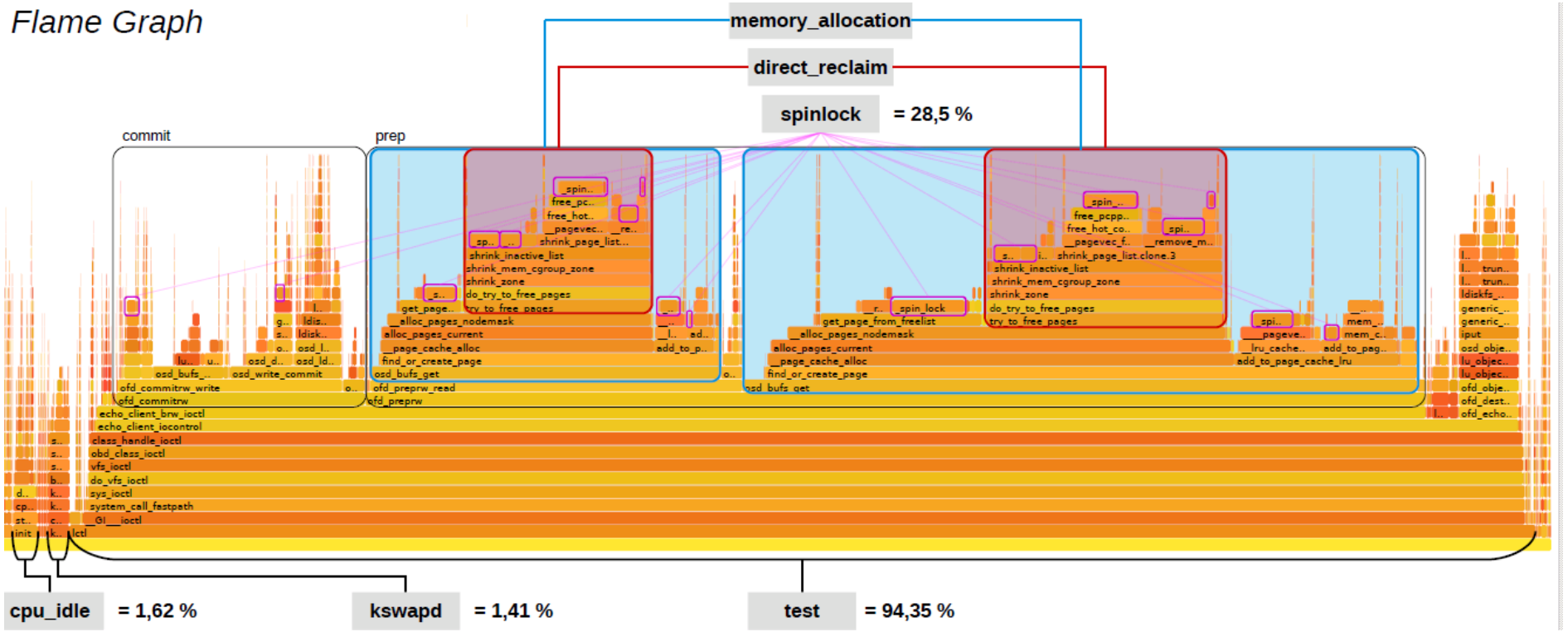


PERFORMANCE ANALYSIS

- Not EDR bottleneck, lnet_selftest (write) = 11,7 GB/s
- OSS Load is pretty low
- Kswapd is 100% CPU => memory reclaim?
- Behavior: full throughput until kswapd starts its job
- Need a quick profiling



LUSTRE PROFILING



LUSTRE PROFILING

- Not enough free pages available => switch to direct reclaim mode
- Direct reclaim mode is “time” expensive (due to spin_lock mechanism)
- 1/3 times in memory allocation through page cache
- This time could be use to run I/O
- What we have benchmarked in reality?
  - The speed of writing data in page_cache and flushing in the backend disks
  - Means page cache throughput limits to 10,5 GB/s (on this VM and on this hardware)?

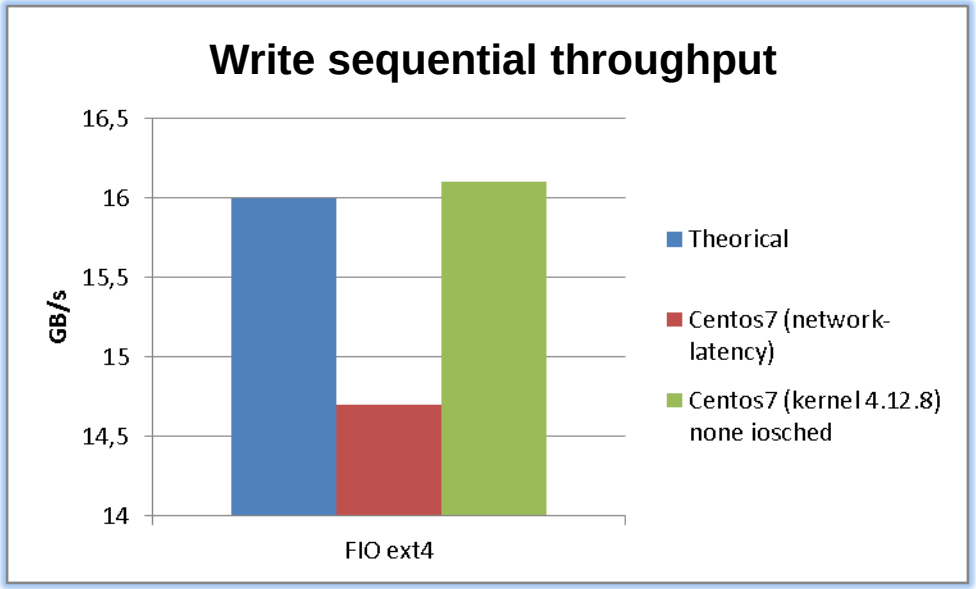
IMPROVEMENTS TO STUDY

- Bypass page_cache for Lustre OSD-layer: need big stuff in Lustre (discussion with Intel)
- Improve page_cache mechanism in Kernel: a delicate topic (seems nobody wants to do some modifications)
- What we try to do: decrease the latency to lower layer to expect benefits in throughput
  - Layer retained: io scheduler
  - From kernel 3.13, full io bypass scheduler exists
  - To get latest modifications to ext4, try 4.12.8 kernel (current version when we did tests)

KERNEL 4.12.8 PERFORMANCE

- io scheduler=none
- Performance is closed to the disks backend
- Improvements are amazing

- Jump to port Lustre on this kernel (4.12.8) (ldiskfs backend)



LUSTRE ON KERNEL 4.12.8

- 2 main jobs (ldiskfs backend):
  - Ldiskfs (34 patches, ~ 8655 lines)
  - Osd-ldiskfs
- LU-9558 to support Lustre “Client” Layers on kernel up to 4.13 (nice job)
- Process: build and fix errors until success (slow but give results…)
- Simplification: disable features that not build and not critical (gss, project quota, ext4 encryption)
- Ldiskfs current build process (main steps):
  - Copy of ext4 sources from current kernel to a temporary folder
  - Apply some patches for the current kernel (through series folder)
  - Sed “ext4” by “ldiskfs”

LUSTRE ON KERNEL 4.12.8: LDISKFS PATCHES

- Exists for Redhat/CentOS kernel (3.10.x), a bit old for 4.12.8!
- Exists for Suse kernel (4.4.x), interesting because difference is less than previous
- Create a custom series based on Suse ldiskfs patches
- First pass was done with patches for Suse kernel on kernel 4.12.8
  - 10/34 patches have success with no modification
  - 13 patches to modify
- Good surprise: some ldiskfs features has been landed in ext4 vanilla kernel (thanks to people that does this work): some patches are useless (11, that's huge)
- Final verification and round-trip with Redhat kernel series (sometimes 4.12.8 is closed to 3.10 for some ldiskfs features)

LUSTRE ON KERNEL 4.12.8: OSD LDISKFS

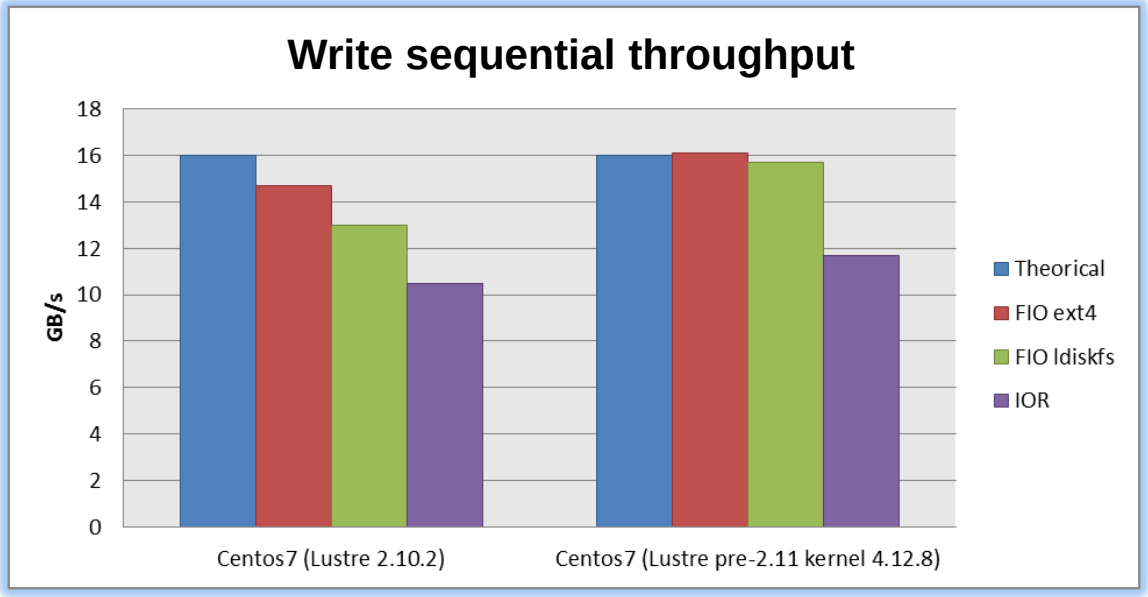
- Ldiskfs build pass for 4.12.8 kernel, osd-ldiskfs part?
- No surprise, failed on build, minor modifications needed:
  - “PAGE_CACHE_SHIFT” doesn’t exist anymore, just renamed in “PAGE_SHIFT”
  - Same way for “mutex_lock” (mechanism still exists, another way to do the job with “inode_unlock”)
  - Inode struct has changed, new way to do xattr operations. “i_op->*xattr” is gone. “__vfs_*xattr” is an alternative
- Not too much hard job, kernel commits help to understand the new way
- 3 new patches for osd-ldiskfs (222 lines)

LUSTRE ON KERNEL 4.12.8: MOMENT OF TRUTH

- Full Lustre rebuild (--disable-quota --disable-gss --with-o2ib=yes) with MOFED 4.2.1
  - OST format step: Pass
  - Ldiskfs mount: Pass
  - Lustre mount: Crash (Null pointer)
- Crash analysis:
  - “ext4_dir_operations” struct changes in kernel 4.12.8
  - Operation vector “.iterate” moved to “.iterate_shared”
  - “osd_scrub.c” and “osd_handler.c” want “.iterate”
- Fix was done through a patch in ldiskfs tree (no modification in osd part)
- This lustre version is used on a flash filesystem mounted on a lab supercomputer from 4 months with no crash. (that’s not sufficient to proove its stability…)

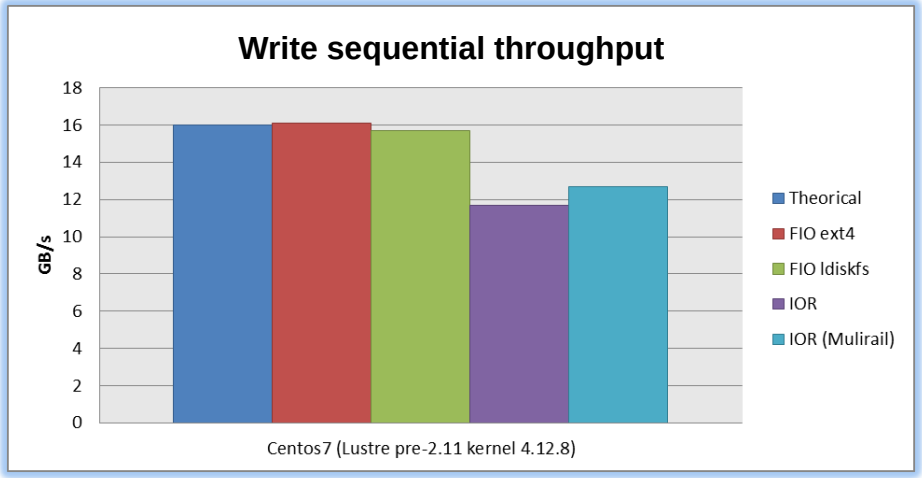
LUSTRE ON KERNEL 4.12.8: PERFORMANCE

- Ldiskfs throughput is very close to ext4
- IOR is around 11,7 GB/s, the EDR interface is full filled
- Page_cache behavior has disappeared or offset?
- Multirail bench to remove limit to 12 GB/s?

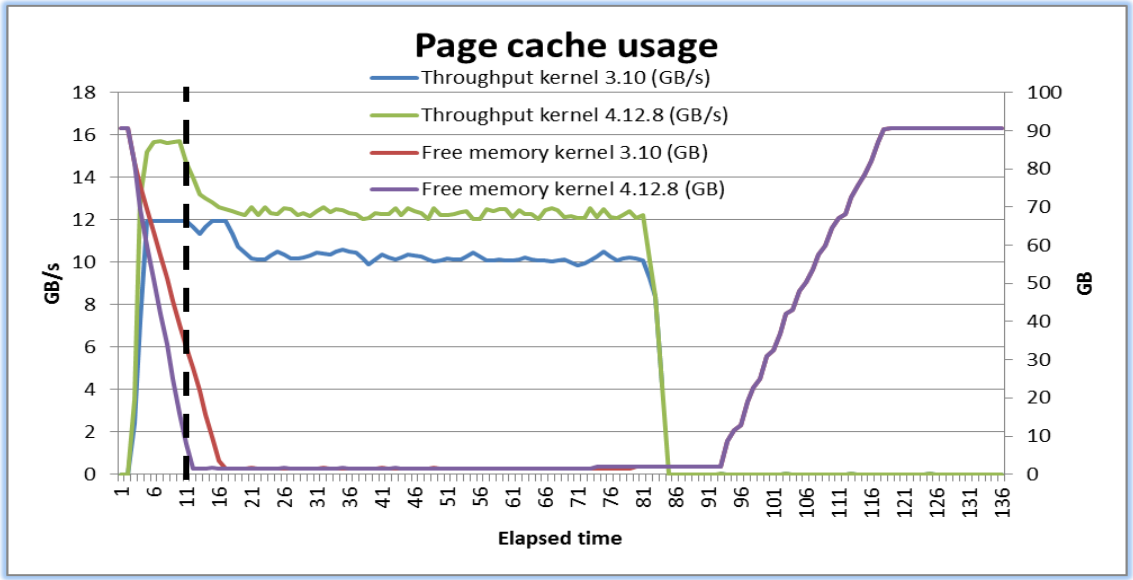


LUSTRE ON KERNEL 4.12.8: FINAL PERFORMANCE

- 2x EDR interfaces on the OSS
- 8x clients
- Result: 12,7 GB/s
- Where is the bottleneck?
- Page_cache again?



LUSTRE ON KERNEL 4.12.8: FINAL PERFORMANCE



- Page_cache behavior has just shifted to upper value
- Peek performance (15,7 GB/s) close to backend until memory reclaim occurs
- Quick explanation (to be confirmed): server memory bandwidth is reached during memory reclaims

SUMMARY

- Page_cache usage has impact on Lustre performance
- A workaround is to reduce latency in some layer:
  - to flush quicker data on disks
  - Effect will be to liberate memory pages soon
  - Memory allocation will be faster
  - I/O throughput will increase
- For example: NVMe disks (latency gain) but cost is high (now)
- Best performance (with low latency disks) will need a full page_cache bypass
- TODO:
  - Add patches to LU-10942 (cleaning in autoconf, add “define” in lustre source for the kernel 4.12.8)
  - Add support for features (GSS, Project Quota) not working yet
  - Add support for next Redhat 8 kernel

Questions?

Commissariat à l'énergie atomique et aux énergies alternatives
Centre de Saclay | 91191 Gif-sur-Yvette Cedex
T. +33 (0)1 69 08 60 00

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Etablissement public à caractère industriel et commercial | R.C.S Paris B 775