Linaro

connect
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SFO15-207: Storage and filesystem optimisations

Steve Capper
Yazen Ghannam

Presented by

Steve Capper
Yazen Ghannam

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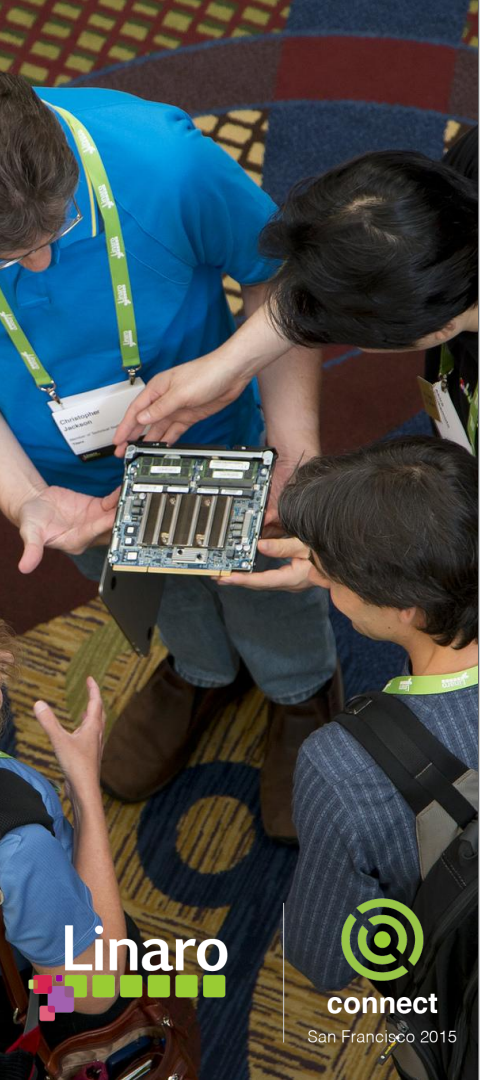
Event

SFO15



Agenda

1. Introduction
2. Where we are currently with:
   a. Ceph
   b. Linux kernel
   c. Hadoop FS (HDFS)
3. Future work
4. Q & A

Ceph

- Ceph is a distributed storage system written in cross-platform friendly C++.
- Ceph was introduced at the last Connect:
  - http://connect.linaro.org/resource/hkg15/hkg15-401-ceph-and-software-defined-storage-on-arm-servers/
- It did “just work” on ARM, but there were a couple of areas we were able to improve for AArch64.

Ceph - CRC32c

- Example: rados bench write for 60s on btrfs

```
28.61%  rados    [kernel.kallsyms]      [k] __copy_from_user
25.99%  rados    librados.so.2.0.0      [.] ceph_crc32c_sctp
19.13%  rados    libc-2.20.so           [.] memcpy
 2.43%  rados    [kernel.kallsyms]      [k] clear_page
 2.14%  rados    [kernel.kallsyms]      [k] _raw_spin_unlock_irqrestore
 0.85%  rados    [kernel.kallsyms]      [k] handle_mm_fault
 0.83%  rados    [kernel.kallsyms]      [k] __do_softirq
 0.78%  rados    [kernel.kallsyms]      [k] ioread32
 0.61%  rados    [kernel.kallsyms]      [k] __cpu_clear_user_page
 0.57%  rados    [kernel.kallsyms]      [k] get_page_from_freelist
 0.52%  rados    [kernel.kallsyms]      [k] dev_gro_receive
```

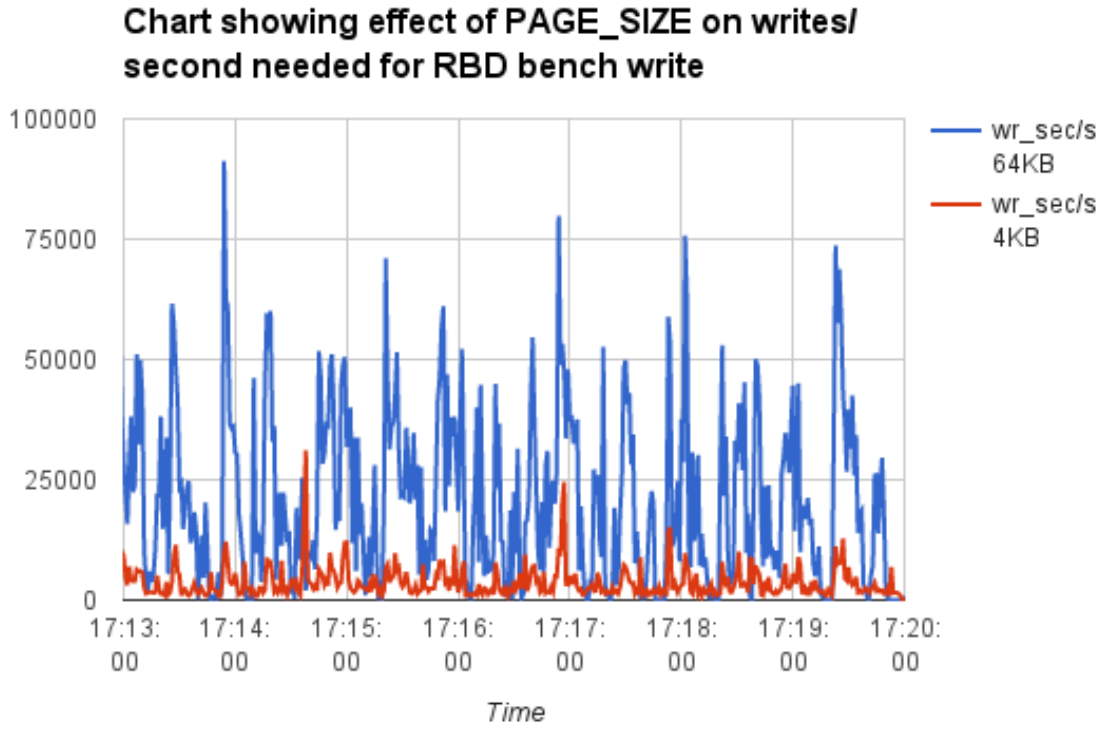
Ceph - CRC32c

- This was mentioned at last Connect, but as a quick recap...
- CRC32c (Castagnoli polynomial) code was accelerated using the AArch64 optional instructions.
- This is in Ceph v9.0.0.

Ceph - IO Analysis

- Having taken a look at the CPU cycle distribution with `perf`, we moved on to examine general IO.
- `sar` was used to get a general picture of things (disk, network, …).
- We drilled into block IO via `blktrace`.

Ceph - Effect of `PAGE_SIZE` on writes



Ceph - `PAGE_SIZE` effects on Journal

- The Journal assumed that `PAGE_SIZE` was a good value for the storage sector size.
- Thus for a system running with a 64KB `PAGE_SIZE` more IO was carried out.
- This has been fixed in upstream git commit:
  - 2eb096a FileJournal: Remove CEPH_PAGE_SIZE assumptions

Ceph - Patched FileJournal

```
Total (ceph.baseline.journal.out):
 Reads Queued:           0,     0KiB  Writes Queued:     68,395,      2,336MiB
 Read Dispatches:        0,     0KiB  Write Dispatches:    62,439,    2,302MiB
 Reads Requeued:         0            Writes Requeued:   19,847
 Reads Completed:        0,     0KiB  Writes Completed:    51,766,    2,302MiB
 Read Merges:            0,     0KiB  Write Merges:      13,985,   449,690KiB
 IO unplugs:        21,510            Timer unplugs:           0

Total (ceph.patch.journal.out):
 Reads Queued:           0,     0KiB  Writes Queued:     82,133,   660,698KiB
 Read Dispatches:        0,     0KiB  Write Dispatches:    84,269,   646,526KiB
 Reads Requeued:         0            Writes Requeued:   27,868
 Reads Completed:        0,     0KiB  Writes Completed:    65,163,   646,482KiB
 Read Merges:            0,     0KiB  Write Merges:      15,467,   123,500KiB
 IO unplugs:        18,502            Timer unplugs:           0
```

Ceph - `PAGE_SIZE` and Bufferlist

- I was advised to check out the Bufferlist.
- A 64KB `PAGE_SIZE` led to a ~ 10x increase in peak memory usage by the MetaData Server (MDS)!
- This has been fixed in:
  - 4524316 Common: Do not use CEPH_PAGE_SIZE when appending buffers in Ceph

Teuthology + Ceph-QA Suite

- We also wanted to ensure that Ceph worked on ARM. :-).
- The Ceph-QA suite is comprised of a **LOT** (~5500) tests.
- We spent time running through these tests.
- The Bufferlist patch in the previous slide was also found to help some of the tests pass.

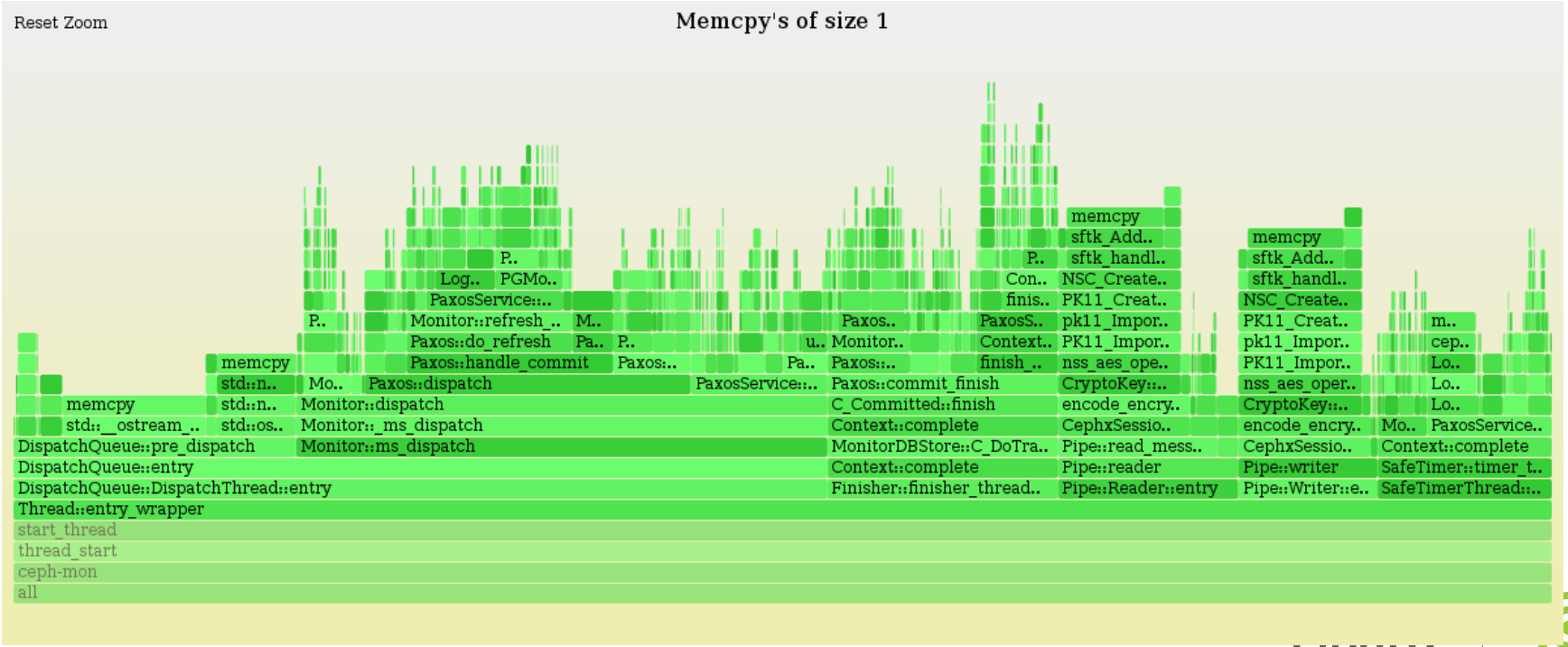
Linux Kernel - CRC32

- Both CRC32 and CRC32c checksums were implemented in 3.19 using optional AArch64 instructions.
- They are used extensively by btrfs and the Ceph kernel mode client code (rbd and cephfs).

Linux Kernel: Testing kprobes & uprobes

- AArch64 kprobes are being worked on by David Long at Linaro.
- AArch64 uprobes by Pratyush Anand at Redhat. uprobes requires kprobes.
- We analysed Ceph's memcpy size utilisation using early versions of uprobes:
  - https://wiki.linaro.org/LEG/Engineering/Storage/Ceph/ceph-memcpy

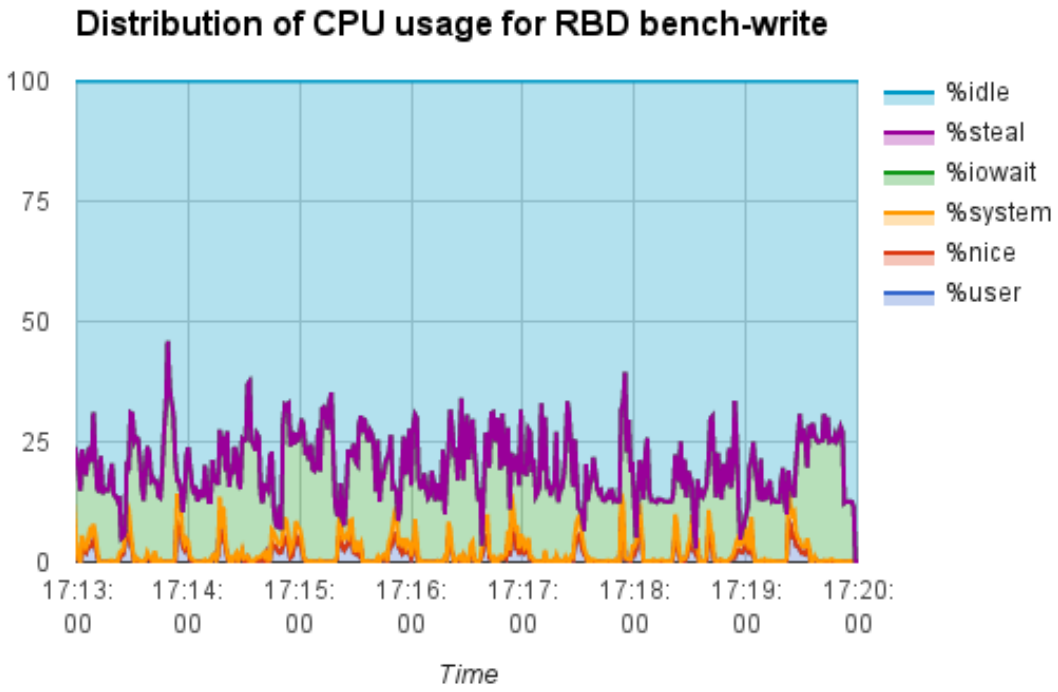
uprobes + perf + flame graphs



Hadoop HDFS

- More on Hadoop in the Hadoop session.
- Optimisation wise, we have CRC32c coded up by Ed Nevill for the Hadoop native library.
  - https://issues.apache.org/jira/browse/HADOOP-11660
- micro-benchmark speedups of ~11x found.
- This will make it into the Hadoop 2.8 release.

Ceph - CPU usage - Future work



Future Work

- We have kicked the tyres with Ceph, using dev boards.
- As higher spec AArch64 hardware becomes more readily available - one will be able to stress the CPU/Linux kernel even more and spot new areas of interest.

Future Work (2)

- Ceph utilises a collection of libraries, some notable ones:
  - tcmalloc (from the Google perf tools)
  - Boost
  - RocksDB
- These libraries could benefit from some analysis on AArch64.

Future Work (3)

- Investigate pipelined CRC32c implementation on Ceph and Linux Kernel.
- Hadoop is already using a pipelined implementation resulting in ~11x speedup vs ~4.5x speedup with single-issue implementation.

Thank you for your attention!

Any questions/comments?