ZFS*: Metadata Performance

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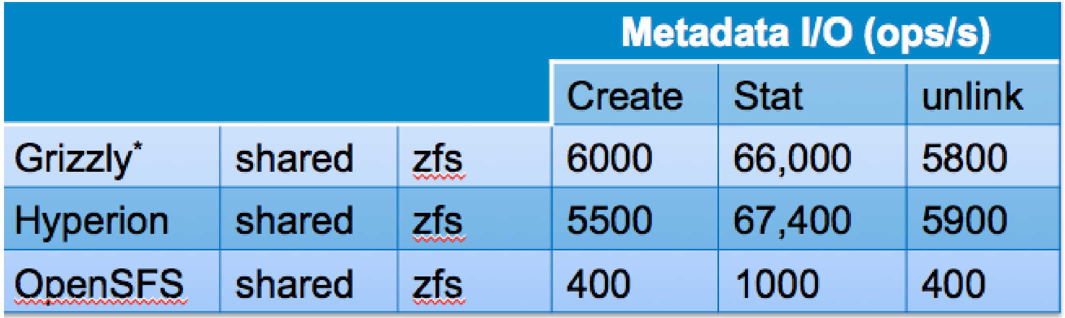
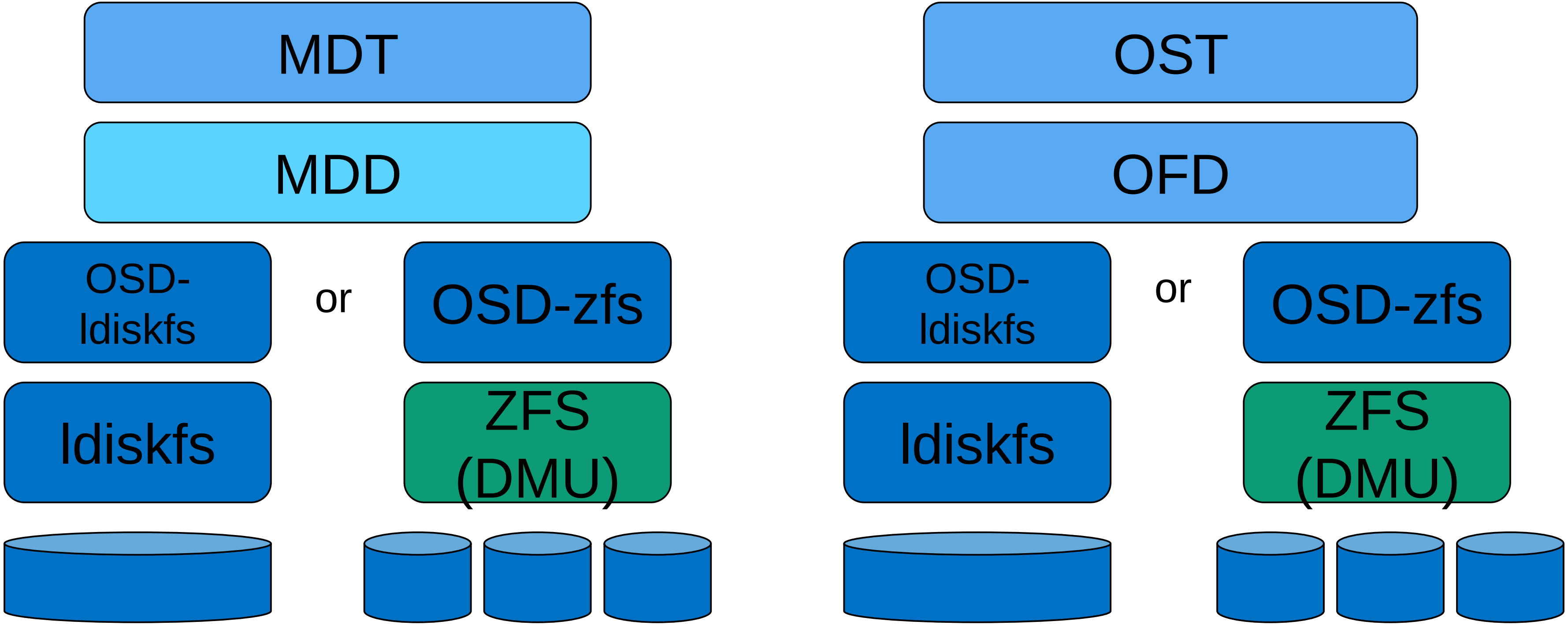
ZFS metadata performance

- Initial focus on correctness, can now focus on performance
- Performance often reported to be below expectations
- Internal benchmarks confirm this



			Metadata I/O (ops/s)		
			Create	Stat	unlink
Grizzly*	shared	zfs	6000	66,000	5800
Hyperion	shared	zfs	5500	67,400	5900
OpenSFS	shared	zfs	400	1000	400

Lustre* on ZFS - Server Layering



MDT

MDD

OSD-ldiskfs or OSD-zfs

ldiskfs

ZFS (DMU)

OST

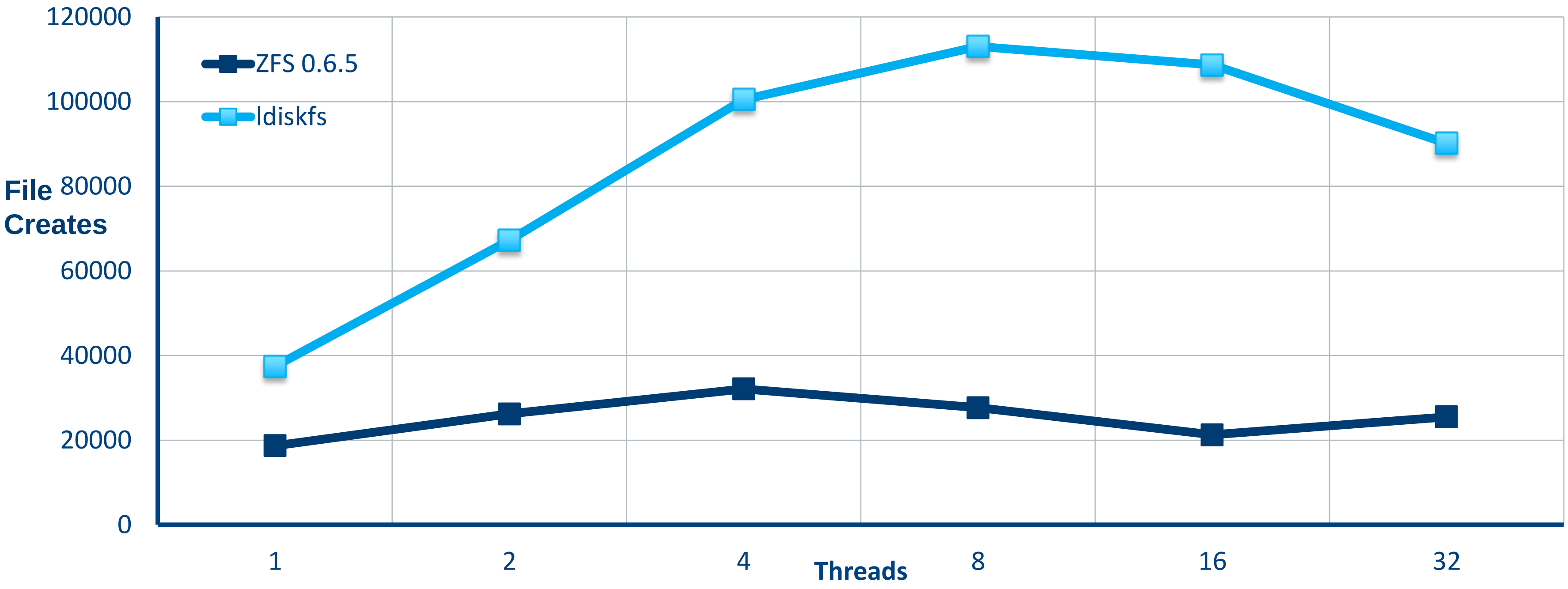
OFD

OSD-ldiskfs or OSD-zfs

ldiskfs

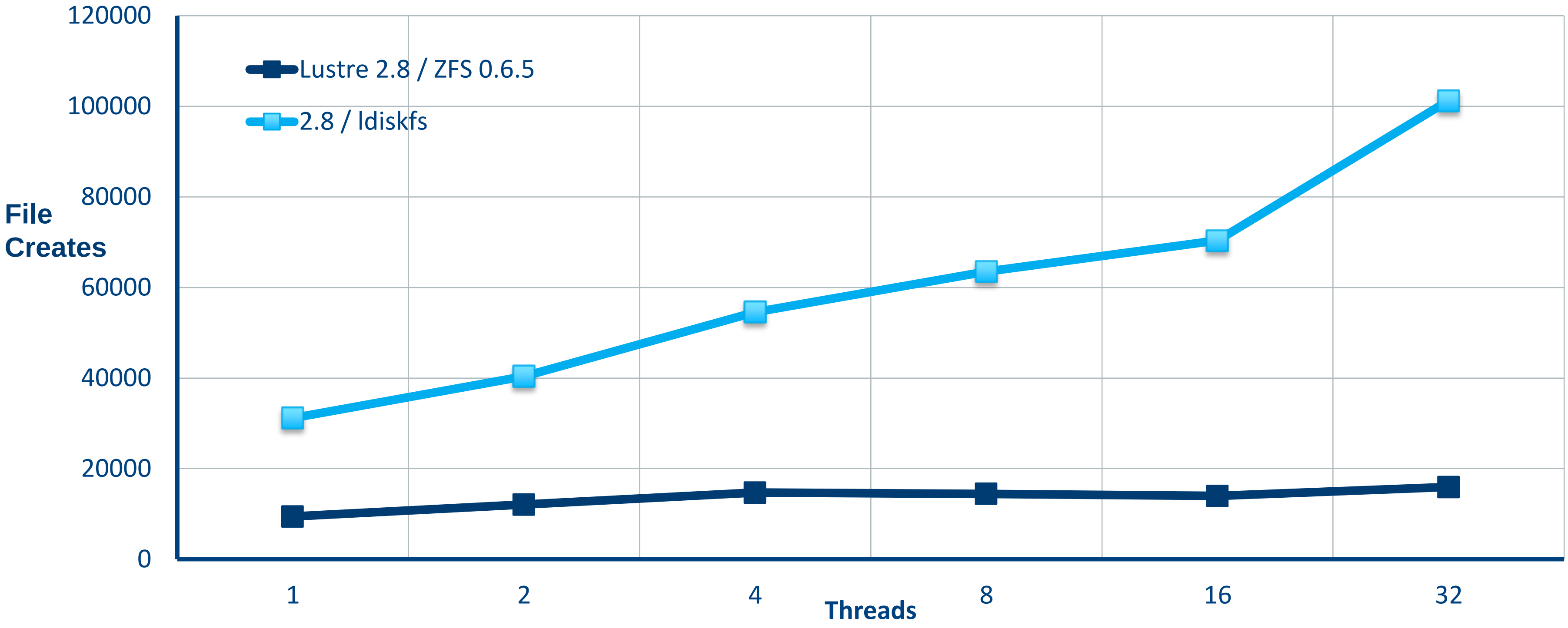
ZFS (DMU)

ZFS vs ldiskfs: 1M creates, directory/thread



Hardware specification on slide 22

Lustre: mds-survey



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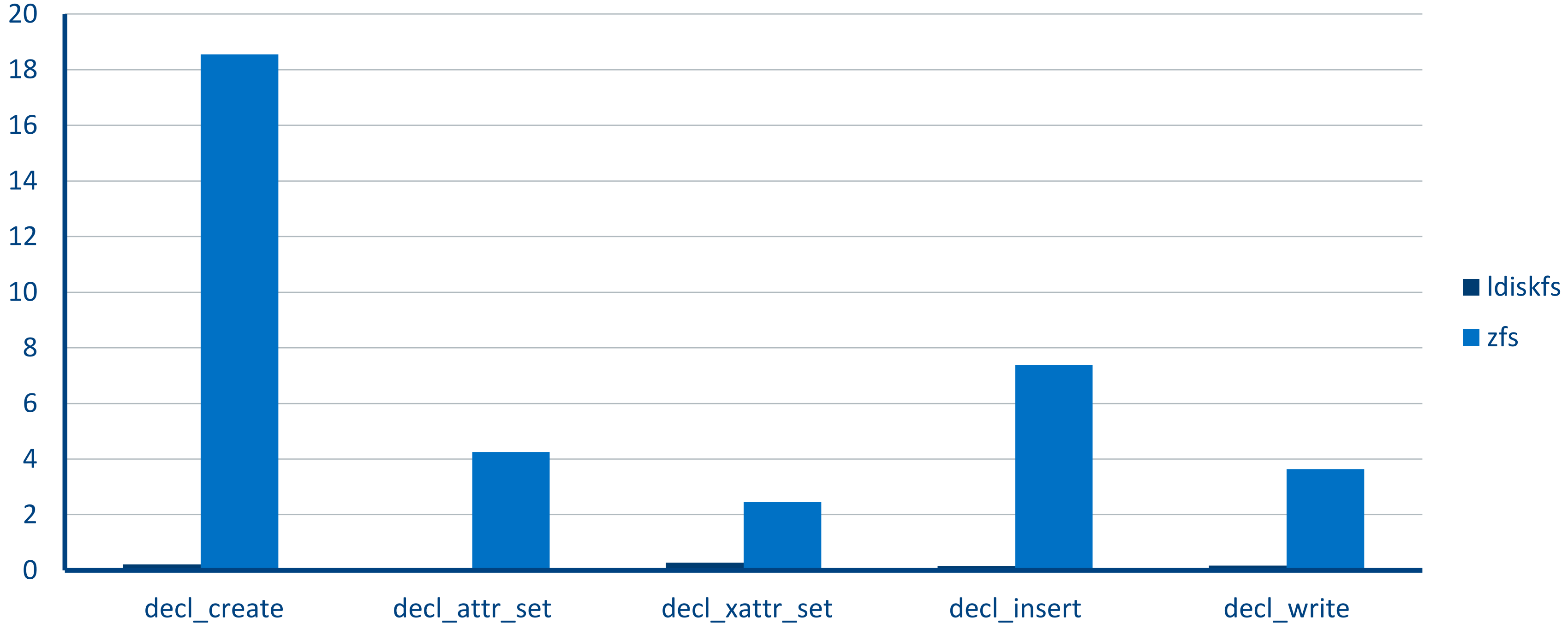
Declaration time: ZFS vs ldiskfs

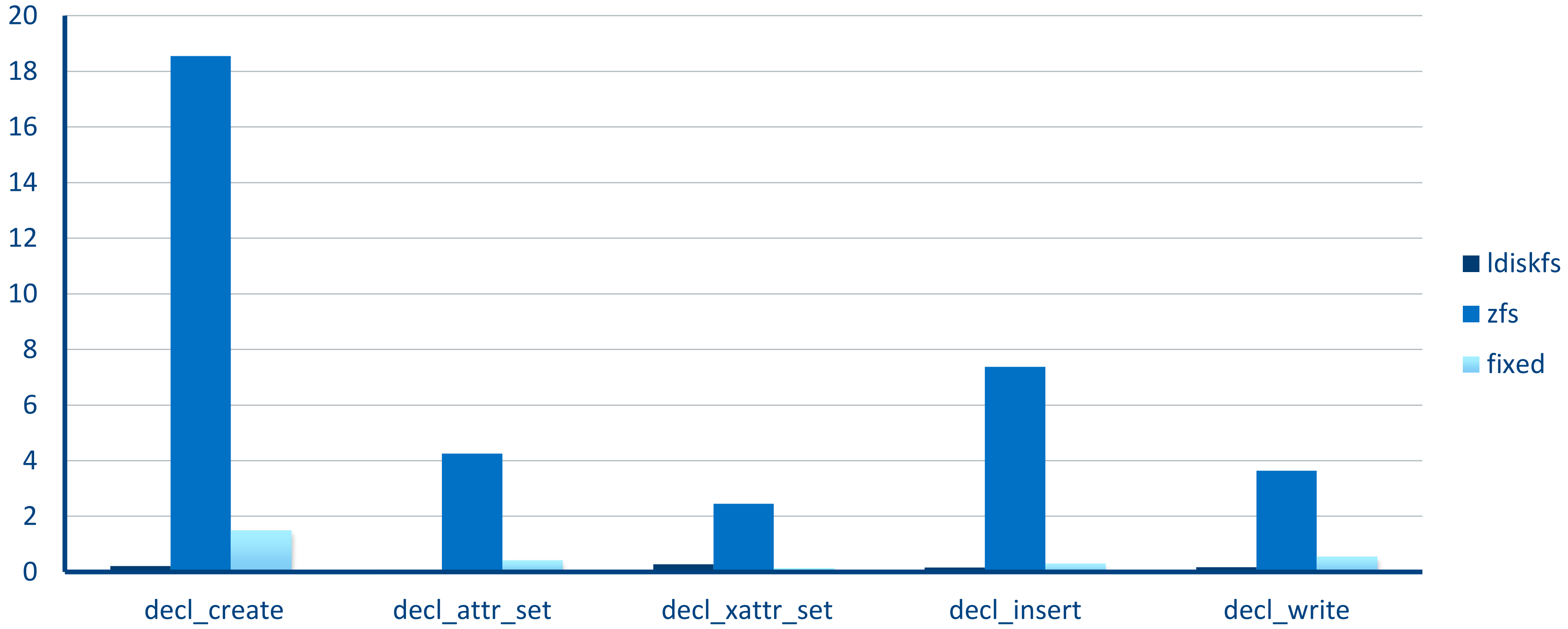


Hardware specification on slide 22

Declarations: expensive

- The more specific, the more expensive
  - dmu_tx_hold_zap() does lookup if name specified
  - dmu_tx_count_write() may check few blocks
  - few calls to dbuf_find()
  - few ZIOs allocated and destroyed with no real need
  - say, 100K / second
- Lustre uses very specific declarations
  - – Which is not required

Declaration time: fixed in LU-7898, landed to 2.9



Hardware specification on slide 22

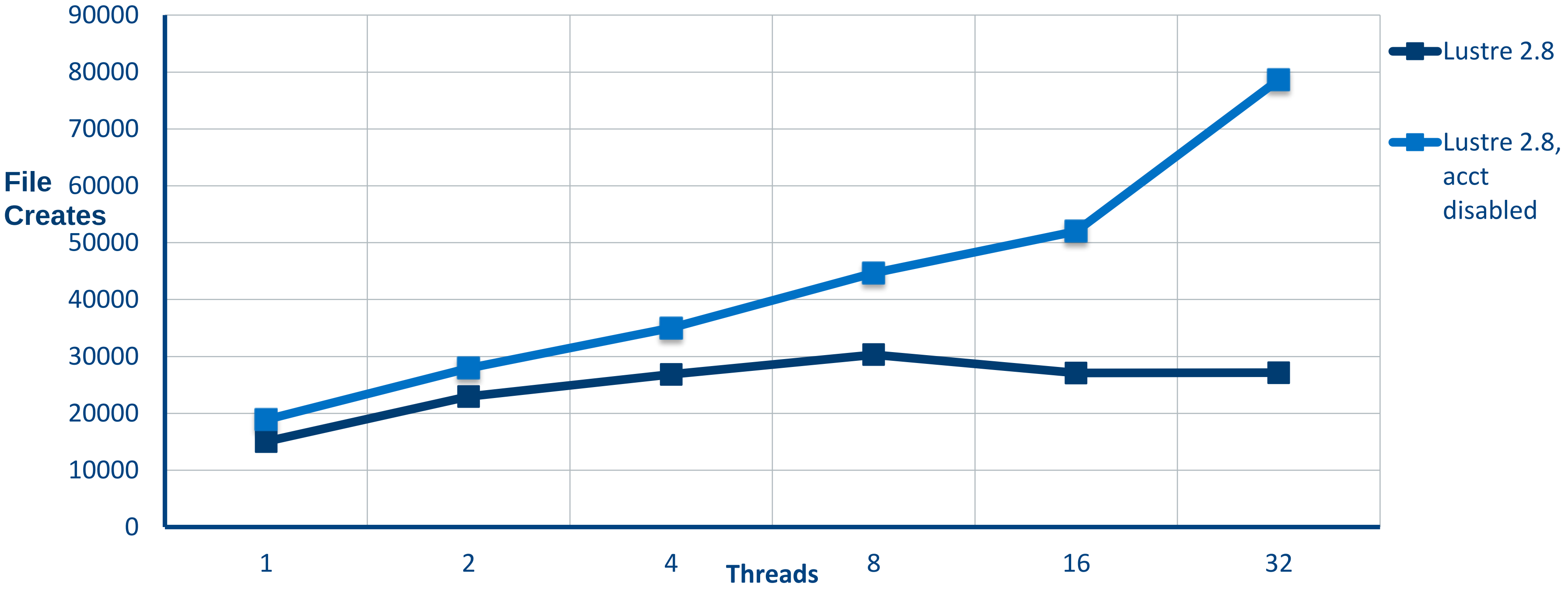
ZFS: large dnodes

- zfs 0.6.5 supports 512 bytes dnodes
- all EAs Lustre need (LMA, LinkEA, LOV, VBR) do not fit
  - Extra 2 4K blocks are allocated (so called *spill block* + redundant copy)
  - 8+ GBs to write to create 1M files
- Large dnode patch landed to ZFS master (for inclusion in 0.7 release)
  - Dnode size can vary: 0.5K to few K
  - 1 GB to write to create 1M files
  - Half head seeks to access files (no need to read spill block)

Dnode accounting (ZFS dnode quota)

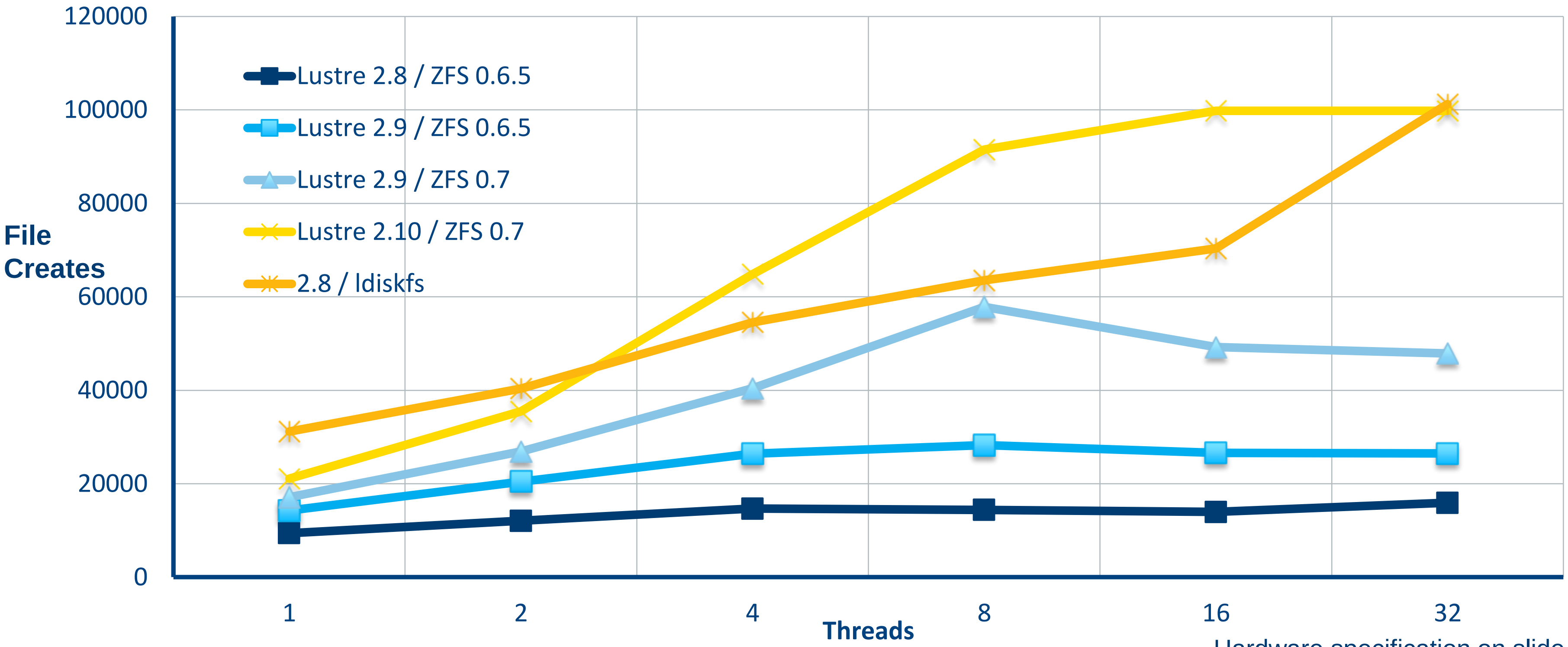
- ZFS didn't support dnode accounting
- Lustre implements own primitive schema to support file quota
  - Doesn't scale well
  - Update 2 accounting files on every file creation – very expensive
- Intel created patch to add native dnode accounting to ZFS (LU-2435)
  - Accounting is implemented in the syncing thread
  - Updates accounting file once
  - Almost ready for landing

Dnode accounting: performance estimation



Hardware specification on slide 22

Lustre: step by step (mds-survey)



Hardware specification on slide 22

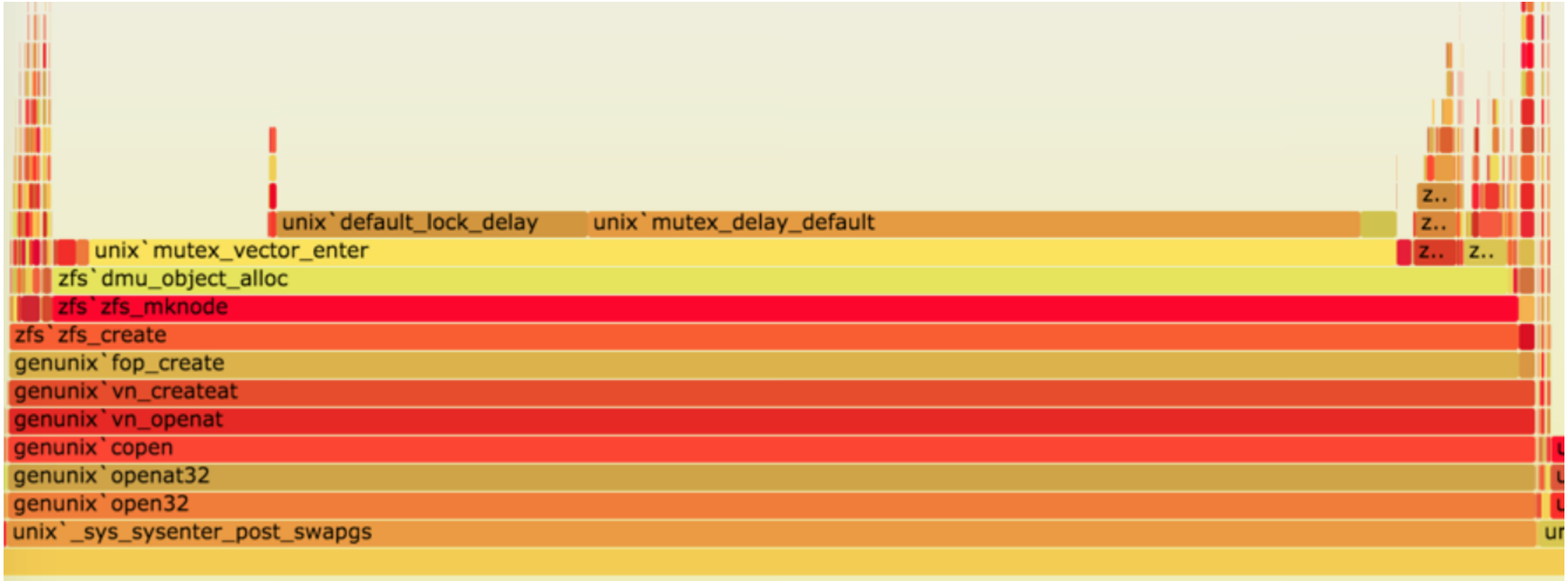
ZFS: more optimizations coming

- Active collaboration with upstream ZFS community
- Special thanks to Matt Ahrens @ Delphix who identified multiple bottlenecks
- Few experiments made to see potential improvement
  - Graph in a few slides

DMU object allocation

- dmu_object_alloc() serializes all object allocations with a single mutex
- Rescan every few thousand allocations
  - to reuse potentially freed dnodes
  - so-called *revisit problem*
- Every allocation looks up dbuf in the global hash table
- Then allocate and fill in-core structures from dbuf
- Summary:
  - very expensive
  - doesn't scale

ZFS: profiling with FlameGraph



ZFS: object allocation

- Possible improvement:
  - Smarter revisit algorithm to skip recently allocated dnodes
  - Concurrent allocation with metadnode broken into chunks
  - Cache last used dbuf to improve single-thread performance

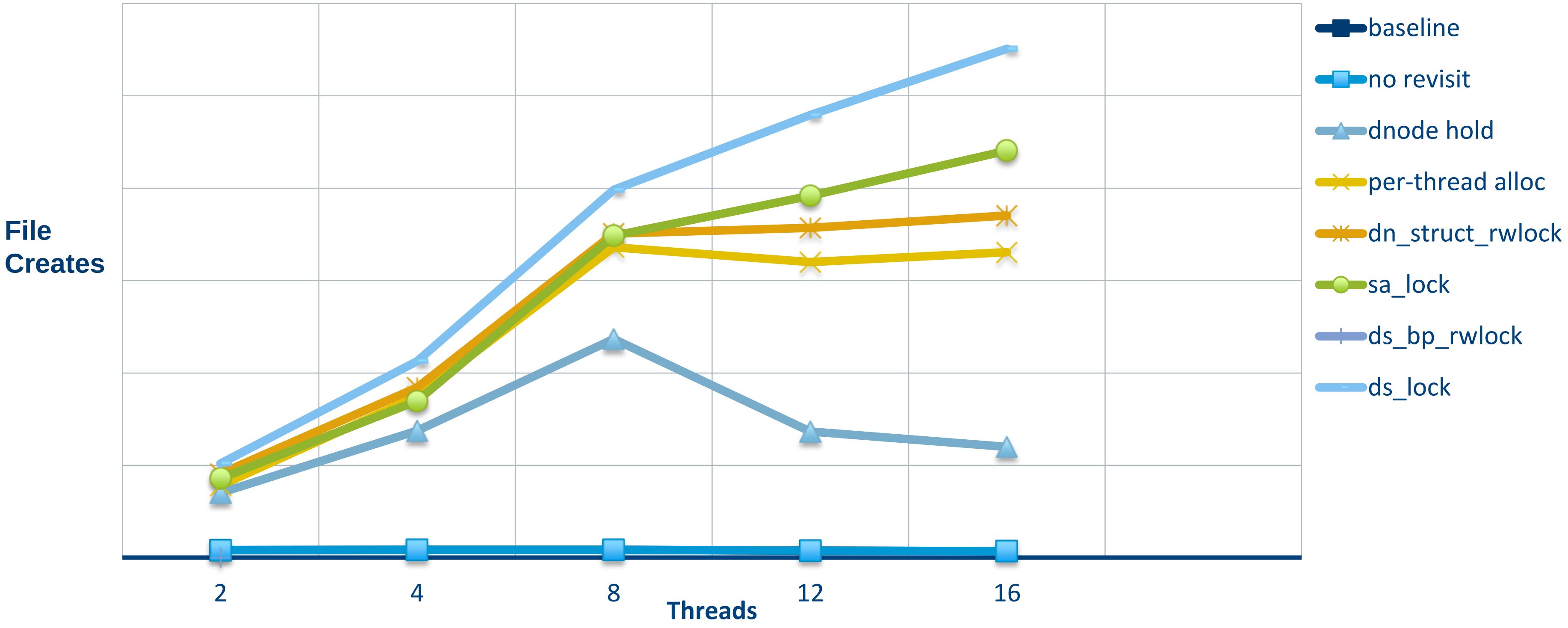
Look at the source

- DMU API uses dnode numbers instead of dnode_t *
  - Even internally
- Results in many dbuf lookups
- Doesn’t scale well with cores
- Lustre file create needs 14 lookups at least (even with all the fixes to Lustre)
- Options:
  - global dnode cache – additional locking
  - local per-cpu/transaction – additional lookups

ZFS: possible improvements

- dn_struct_rwlock
  - Used to access dnode fields, taken mostly shared
- sa_lock
  - Used to map specific set of EAs into a number encoding this set
  - Doesn’t need to be exclusive
- ds_bp_rwlock
  - Used for debugging, can be disabled
- ds_lock in dnode_setdirty()
  - Use multilist

ZFS: performance estimations



Summary

- Lustre 2.9 improves metadata performance with ZFS
  - 2x in some cases using same ZFS 0.6.5.7
  - ZFS 0.7 and Lustre 2.10 should bring ZFS in line (or even ahead) of ldiskfs
- Significantly better numbers are expected in the future
  - As ZFS gets fixes for the problems discussed above

Test configuration

- 2 x Intel(R) Xeon(R) CPU E5-2660 v2 @ 2.20GHz – 20 cores
- 64GB RAM
- 3 x 500GB local SATA HDD 7200 RPM
- CentOS 7.2.1511
- 3.10.0-327.28.2.el7 kernel (RHEL7)
- No remote clients, just local MDS testing (mds-survey script)

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