



Lustre/Idiskfs Metadata Performance Boost

DataDirect Networks Japan, Inc.

Shuichi Ihara

Shilong Wang

2017/10/05

Why is metadata performance important?

▶ **Lustre is general purpose filesystem for Big data**

- 1 Million files per job are quite common with life science application
- AI/Machine learning type of workload requires small file access with low latency. Metadata performance is one of key factors of it.
- Lustre metadata performance has been performing well.

▶ **Vertical and Horizontal scale**

- 28 (and 32) CPU cores/socket is available Today.
- DNE helps Horizontal scale out Metadata, but needs to understand your single MDS metadata performance first.

Challenges on Lustre metadata performance

▶ **Lustre metadata is complex and very sensitive**

- Latency on many layers (CPU, network, disks, kernel..) affects Lustre metadata performance.
- Deep analysis and Maximizing single Metadata server performance is important for efficient MDS configuration.

▶ **Consistent Metadata benchmark is not simple**

- There are many dependencies between each lustre version. (Kernel support changes, OFED, Hardware configuration, etc)
- mdtest is common benchmark tool. MDS-survey is useful and good start, but it's limited layer to test. Eventually, End-to-End requires to understand full Lustre metadata performance.

What's Lustre metadata performance Today?

Benchmark Configuration

Forces on single MDS and MDT testing

▶ 1 x MDS

- 1 x CPU Socket
 - Intel Skylake Processor (Platinum 8160, 2 1GHz, 24 CPU cores)
 - 96GB DDR4 Memory
 - FDR Infiniband
- Lustre-2.10.1

▶ 1 x MDT

- 4 x Toshiba RI SSD(RAID10)
- DDN SFA7700X

▶ 4 x OSS and 40 x OST with DDN SFA14KXE

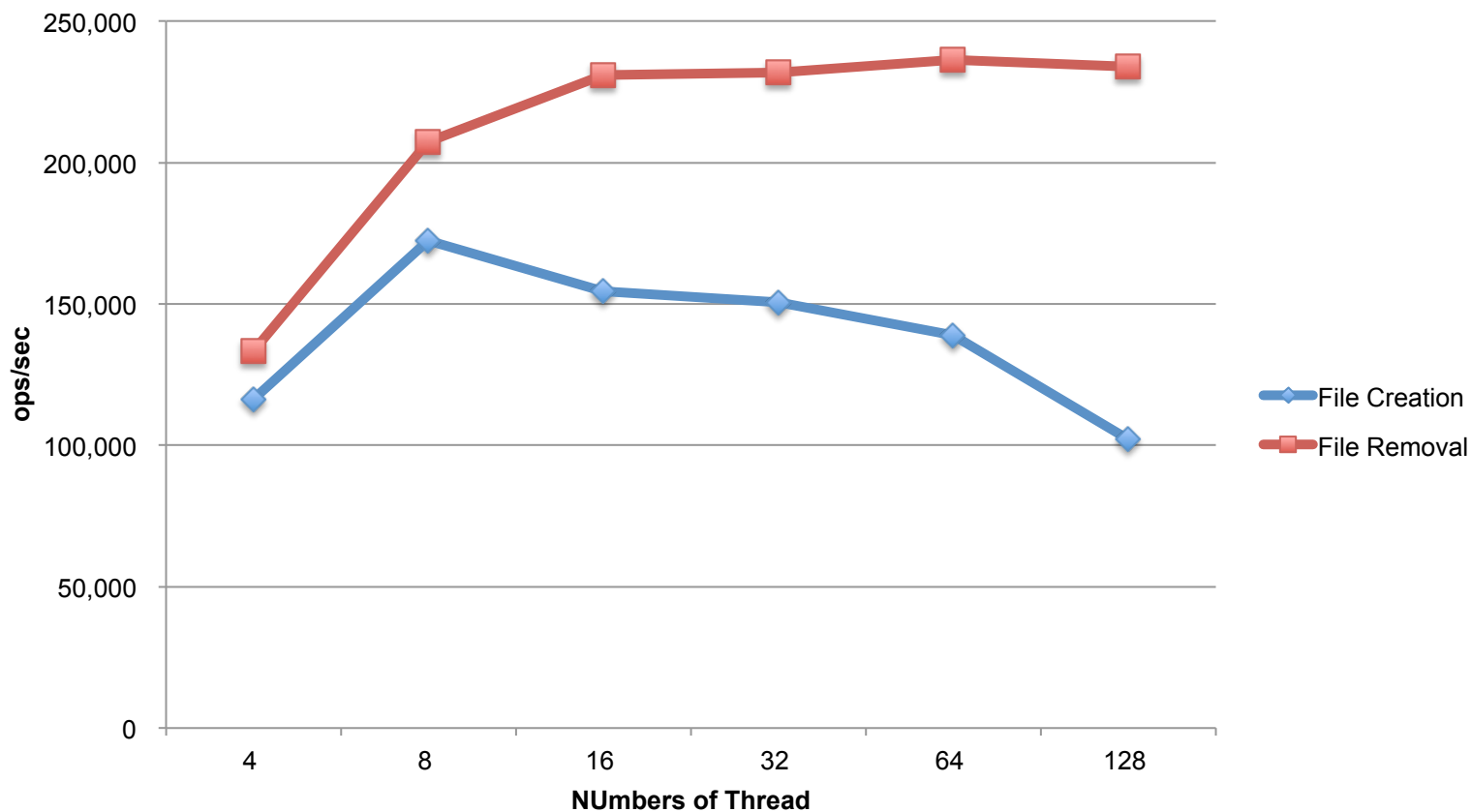
▶ 32 x Client

- 2 x E5-2650v4
- 128GB DDR4 Memory
- FDR Infiniband
- Lustre-2.10.1

MDS-Survey

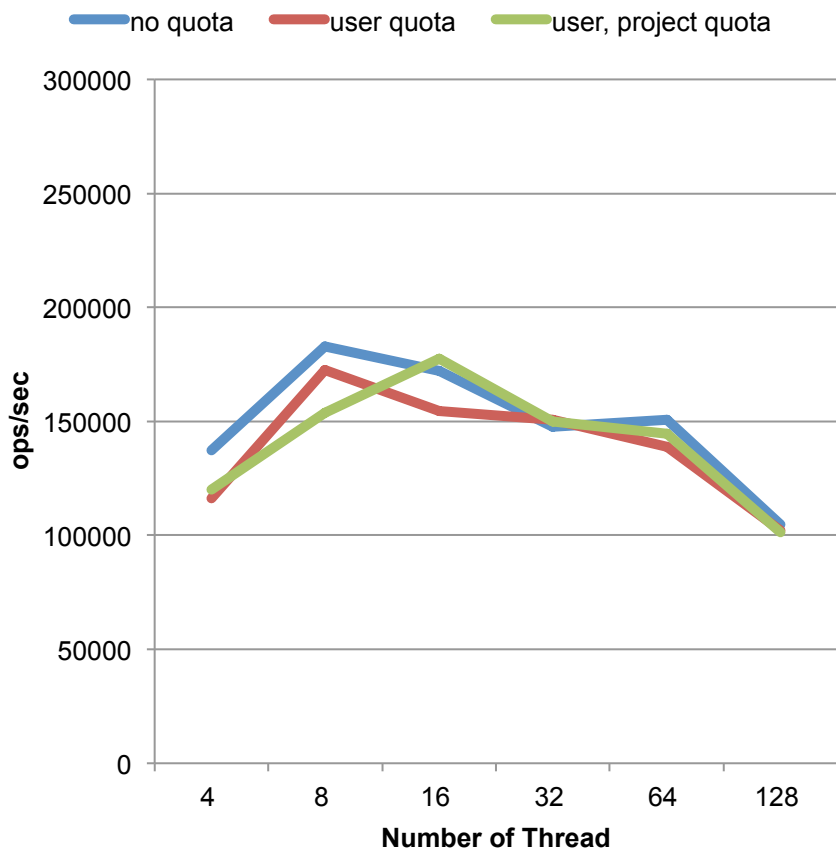
RHEL7.3/Lustre-2.10/ldiskfs

MDS-Survey(File Creation and Unlink)
RHEL7.3/Lustre-2.10.1RC/ldiskfs (Quota Enabled)

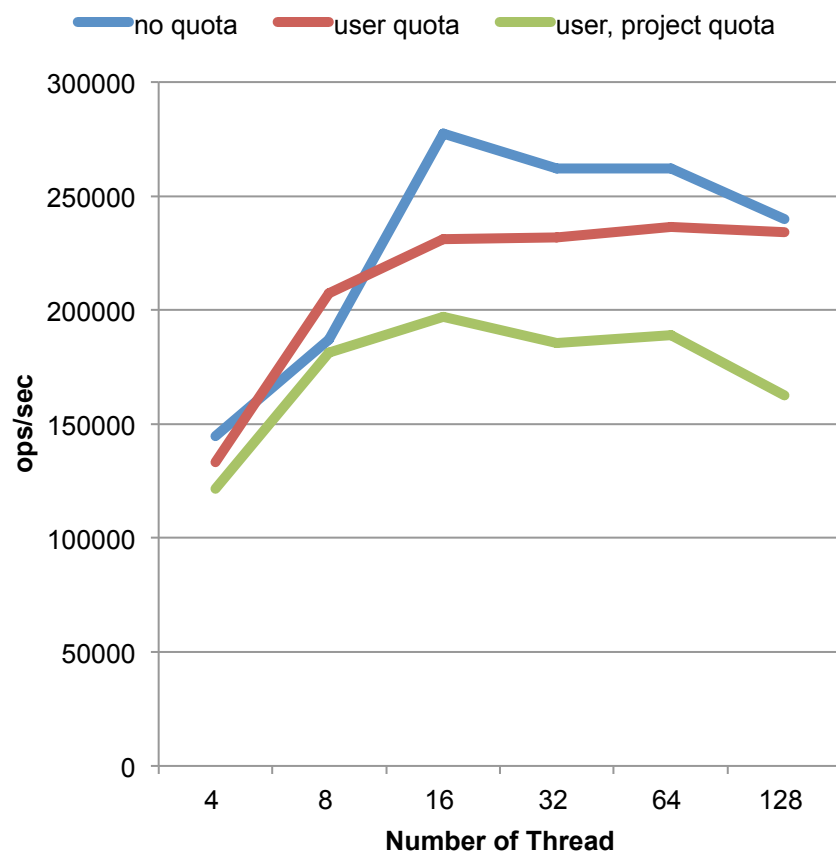


Metadata Performance impacts with Enabling Quota(RHEL7.3/Lustre-2.10.1)

mds-survey(creation)



mds-survey(unlink)



New metadata performance limit on Lustre/ldiskfs

Lustre/ldiskfs has been performing metadata rate, but new high-end CPUs expose next level performance limit.

▶ **File creations under heavy concurrency**

- Many threads create files to a MDT simultaneously
- Scalability problem on Many CPU core system

▶ **Quota scalability**

- Lustre Quota scalability was hidden by other limitation
- Will hit quota scalability issue when lustre metadata performance improves
- New quota accounting (e.g. project quota) introduced additional performance impacts

A problem on File creation under concurrency

► Profiled with perf-tools during mdtest to ldiskfs/ext4

- Collected CPU costs for all functions in ext4 and jbd2
- Found heavy lock contentions on group spinlock

FUNC	TOTAL_TIME(us)	COUNT	AVG(us)
ext4_create	1707443399	1440000	1185.72
_raw_spin_lock	1317641501	180899929	7.28
jbd2__journal_start	287821030	1453950	197.96
jbd2_journal_get_write_access	33441470	73077185	0.46
ext4_add_nondir	29435963	1440000	20.44
ext4_add_entry	26015166	1440049	18.07
ext4_dx_add_entry	25729337	1432814	17.96
ext4_mark_inode_dirty	12302433	5774407	2.13

- Same contentions exist in the upstream kernel

Fix lock contentions in upstream kernel

► Fixed and merged upstream kernel (4.14)

Wang Shilong (2):

ext4: cleanup goto next group

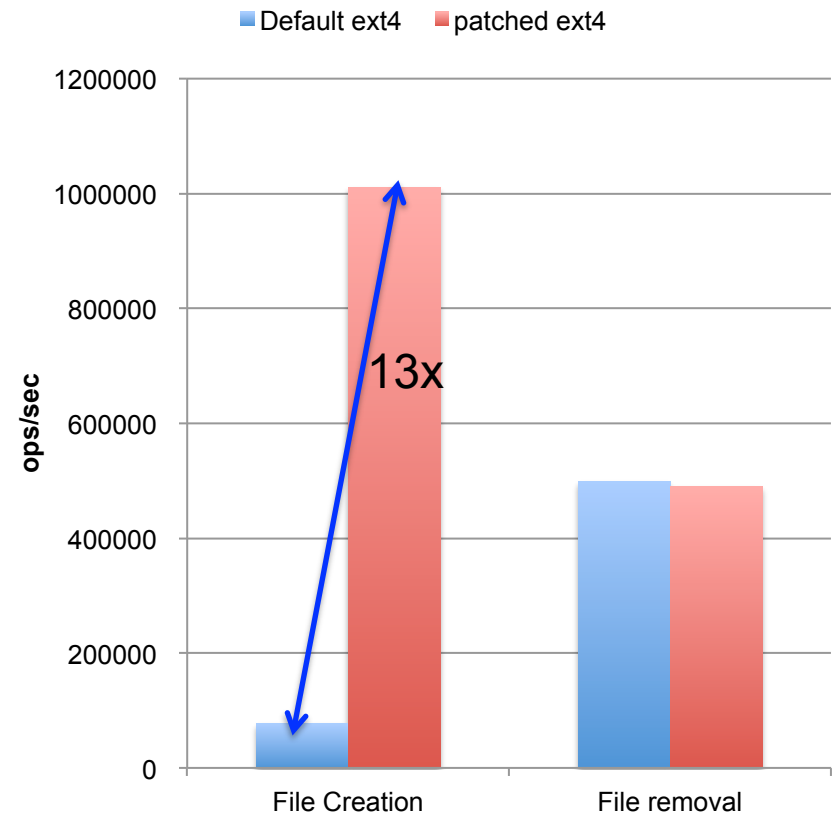
ext4: reduce lock contention in

__ext4_new_inode

► 13x performance improvement on file creation

- Run mdtest to ext4 directly
- Unique directory operations
- Quota disabled

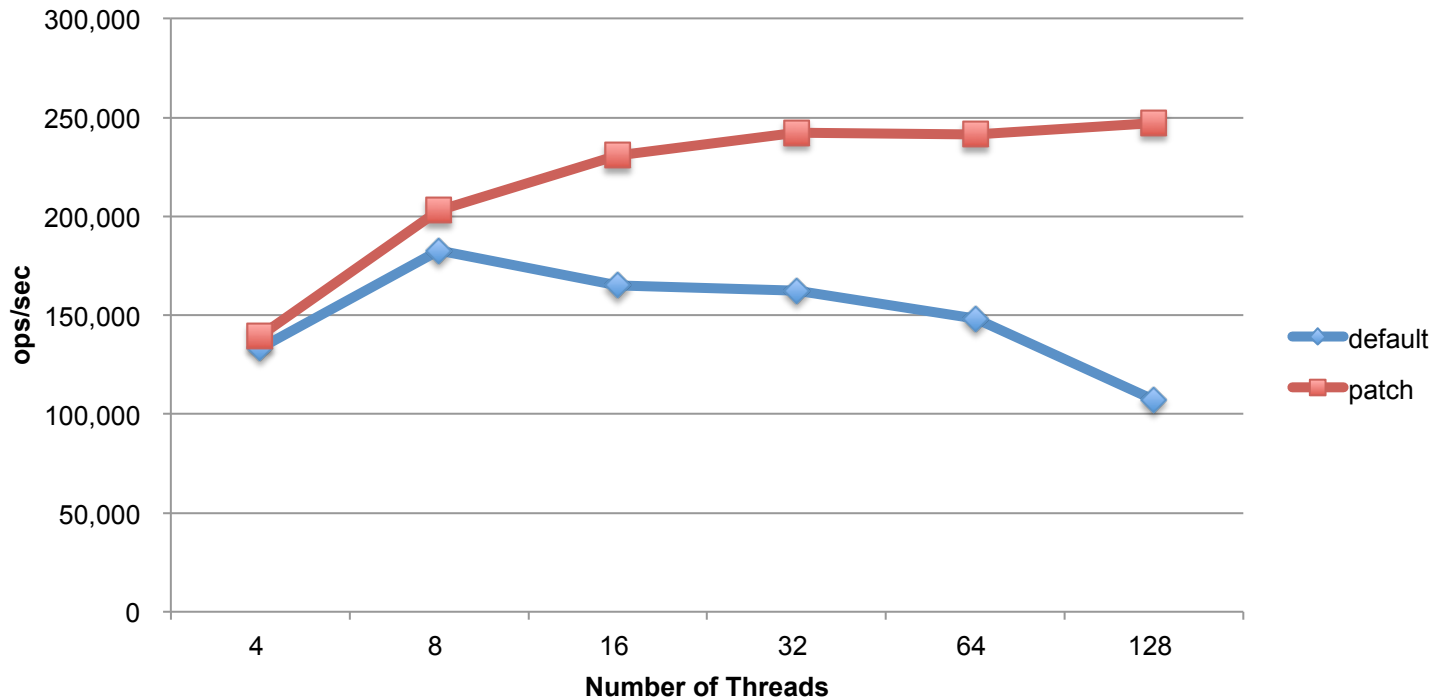
mdtest to ext4 (linux-4.13-rc5)



mds-survey on patched Idiskfs

- ▶ **LU-9796: speedup file creation under heavy concurrency**
- ▶ **Ported patches to Idiskfs for RHEL7 kernel**

**File Creation :mds-survey on Idiskfs
1 x MDS and 1 x MDT(2 x RAID1 SSD)**

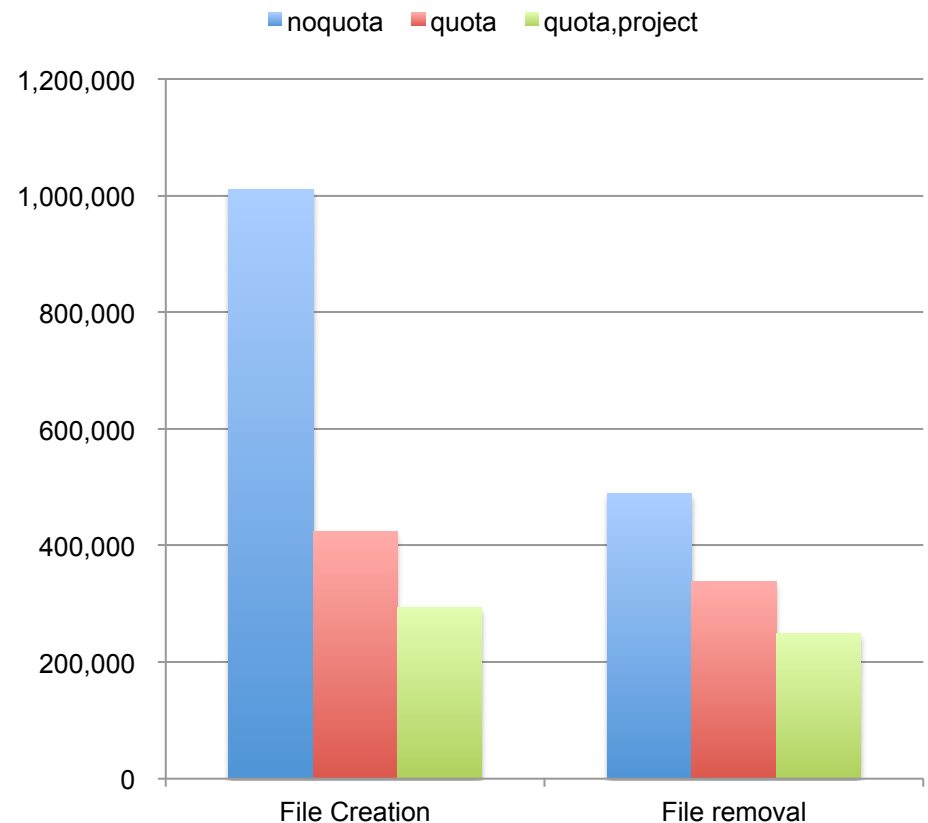


Quota scalability problem

► File creation/unlink affects performance when quota enabled

- Same behaviors on RHEL7 and upstream kernel
- Project quota introduced additional performance penalty

mdetst to ext4 (linux-4.13-rc5)

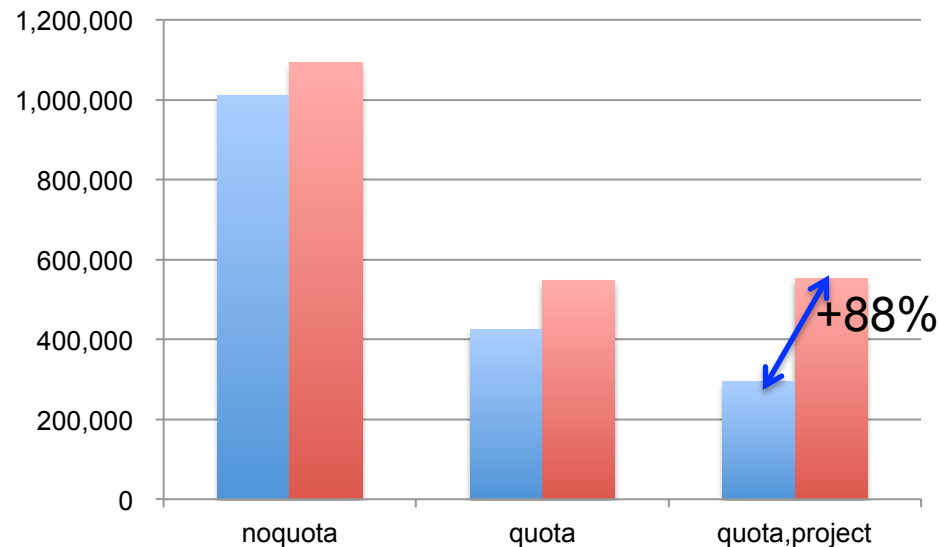


Quota scalability improvements in Ext4

- ▶ **New quota scaling patch introduced in upstream kernel**
 - Tested new Jan Kara's quota scaling patches (merged in 4.14)
 - Huge performance gains when quota enabled

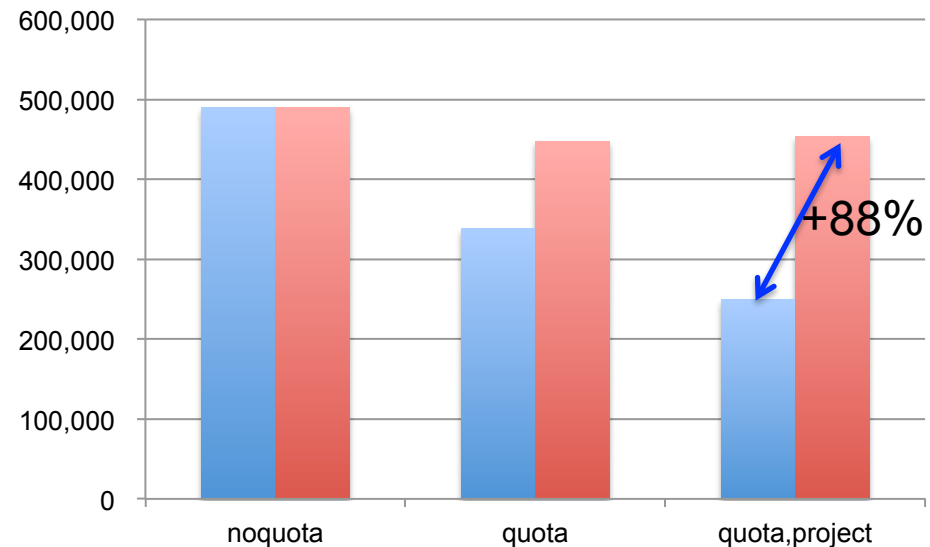
File Creation

■ default ■ quota_scaling



File Removal

■ default ■ quota_scaling

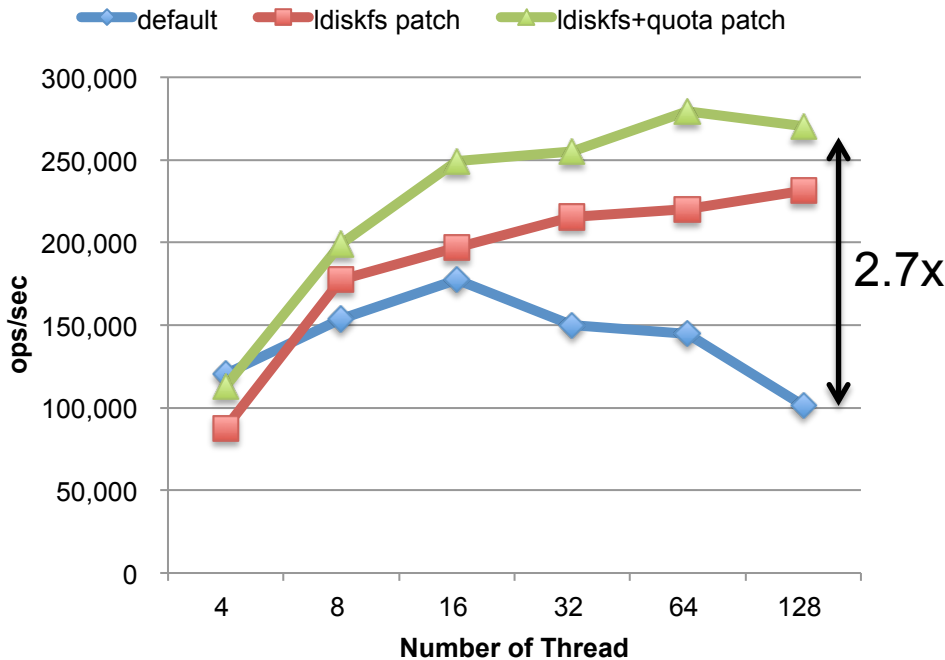


Performance results

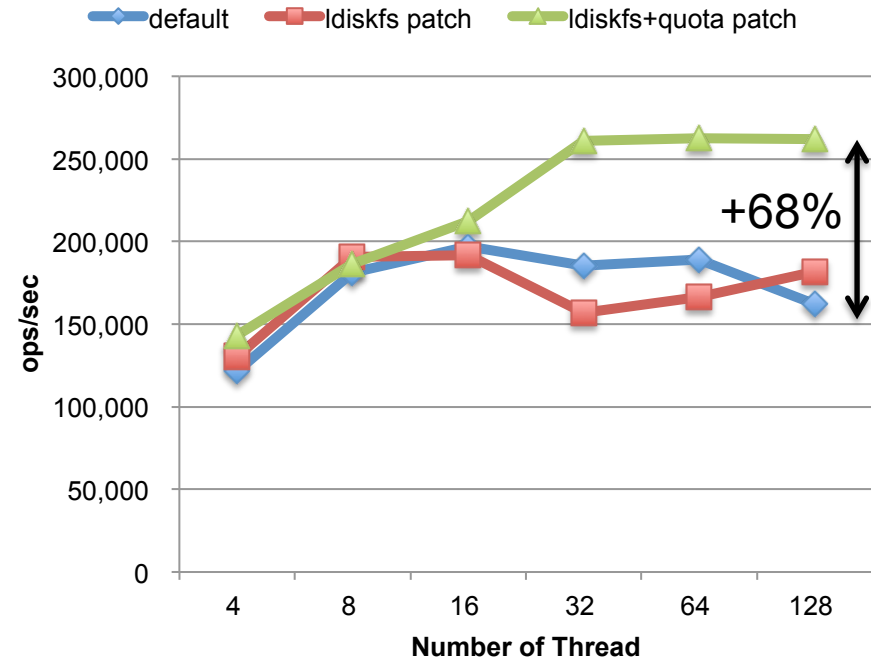
Quota scaling for Lustre

- ▶ Experimentally ported quota patches to RHEL7 kernel for Lustre server (LU-10034: Quota scaling for Lustre)
- ▶ User/Group and Project quota enabled

mds-survey(File Creation)



mds-survey(File removal)

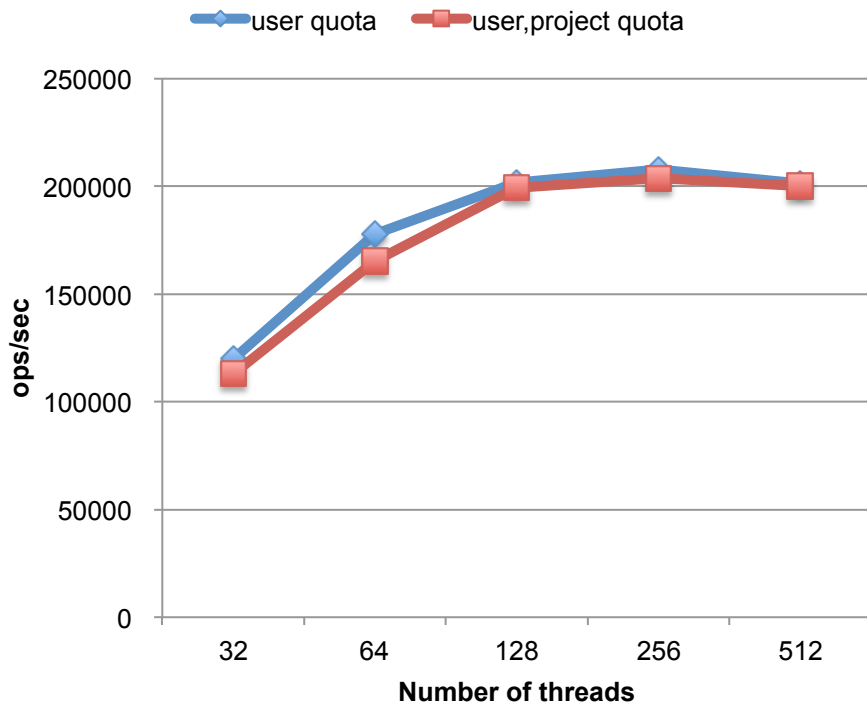


End-to-End Lustre Metadata Performance

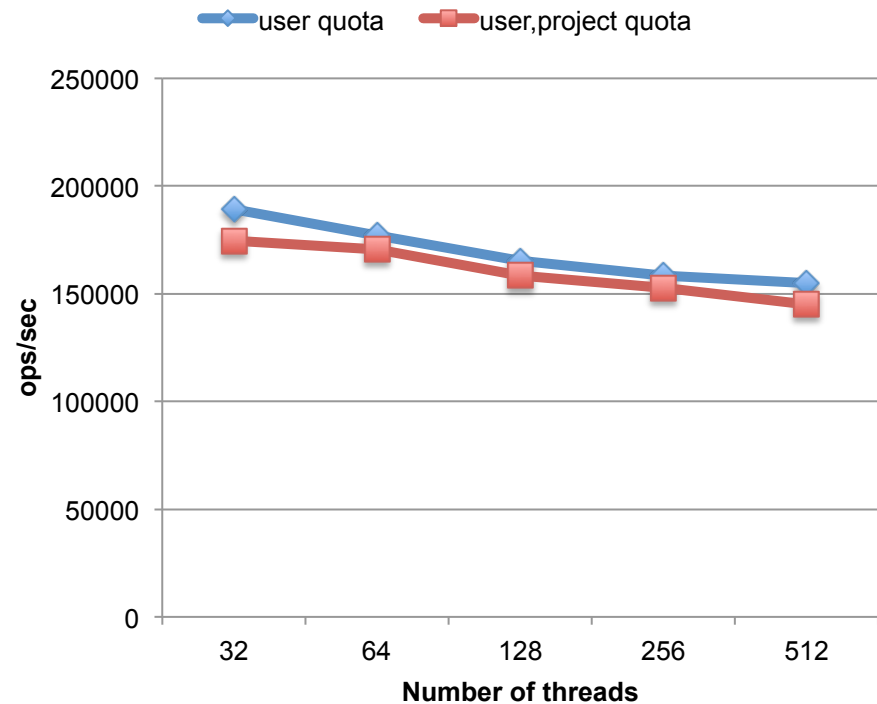
mdtest (1.28M files, unique directories)

- ▶ Applied ext4's contention fix and quota scaling patch against RHEL7 kernel
- ▶ mdtest from 32 clients to single MDS/MDT

mdtest(File creation)



mdtest(File removal)



Additional metadata performance efforts

- ▶ **LU-7251 osp: do not assign commit callback to every handle**
 - Reduction and optimization of cancel RPCs
 - Improved unlink operations
- ▶ **LU-9840 lod: add ldo_dir_stripe_loaded**
 - Performance improvements on file creation to single shared directory
- ▶ **LU-9972 performance regression on rmdir**
- ▶ **LU-10005 osp: cache non-exist EA**
 - Performance regression for non-root MDT

Conclusions

- ▶ **Evaluated Lustre-2.10 metadata performance on new hardware and exposed new performance limits.**
- ▶ **Fixed contention problem at inode allocation and tested ext4 quota scaling patch.**
- ▶ **Demonstrated 200K file creation and 150K unlink per second on single MDT with full quota accounting.**
- ▶ **Need further investigation on Lustre unlink performance.**
- ▶ **Will test even more CPU cores to maximize single metadata performance.**

17

Thank you!

