Whamcloud

Lustre Performance Yesterday, Today and Tomorrow

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Overview

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- Lustre continuously aims to improve performance, but it's hard to confirm because..
  - Many dependencies. (Not only Lustre version, but also kernel, OFED, Firmware version, etc.)
  - Need to understand test workload to see improvements
  - Same test workload, but it's tested by different users or different cluster (hardware)
  - Not all performance improvements mentioned on the Lustre roadmap (need to read changelog)
- Performance benchmark on same hardware with same configuration is important
  - Apples to apples testing with different Lustre branch
  - Tested three major Lustre versions (2.10.8, 2.12.2, and master)

We select and compare a number of interesting performance metrics on the different versions

Tested and Covered Workload

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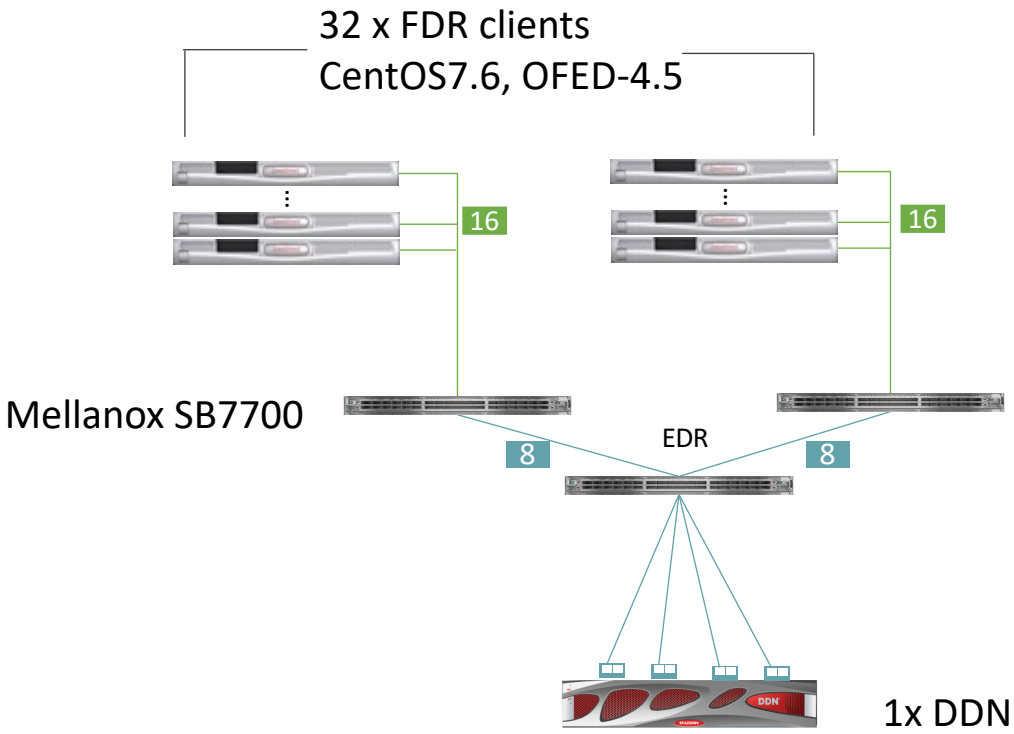
- General Lustre Performance Comparisons on Flash System
  - Aggregate Throughput
    - FPP (File Per Process), Strided SSF (Single Shared File) and Strided SSF Hard
    - 1MB IO Size on FPP and Strided and 47008 Byte IO size for Strided SSF Hard
  - Aggregate IOPS (4K Random Read)
  - Single OSS Performance
- Single Client Performance Comparisons
  - Single Thread
  - Single Client on High Network Bandwidth with Multi-rail
  - 4K Random Read IOPS
- Metadata Operations for Small Files

Benchmark Configuration



1x DDN AI400NV with 20 x 3.84TB SSD
Mixed 4 x OSS and MDS

- Test Conditions
  - Keep same version on both server and client
  - Same Lustre parameters on each tests

```
# lctl set_param obdfilter.*.brw_size=16
# lctl set_param osc.*.max_rpcs_in_flight=16
# lctl set_param osc.*.checksums=0
# lctl llite.*.max_read_ahead_mb=2048
```

  - Enable new features if it improves performance

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General Lustre Performance Comparisons on Flash System

Aggregate Throughput Comparison

FPP (File Per Process), Strided-SSF (Single Shared File), Strided-SSF-Hard

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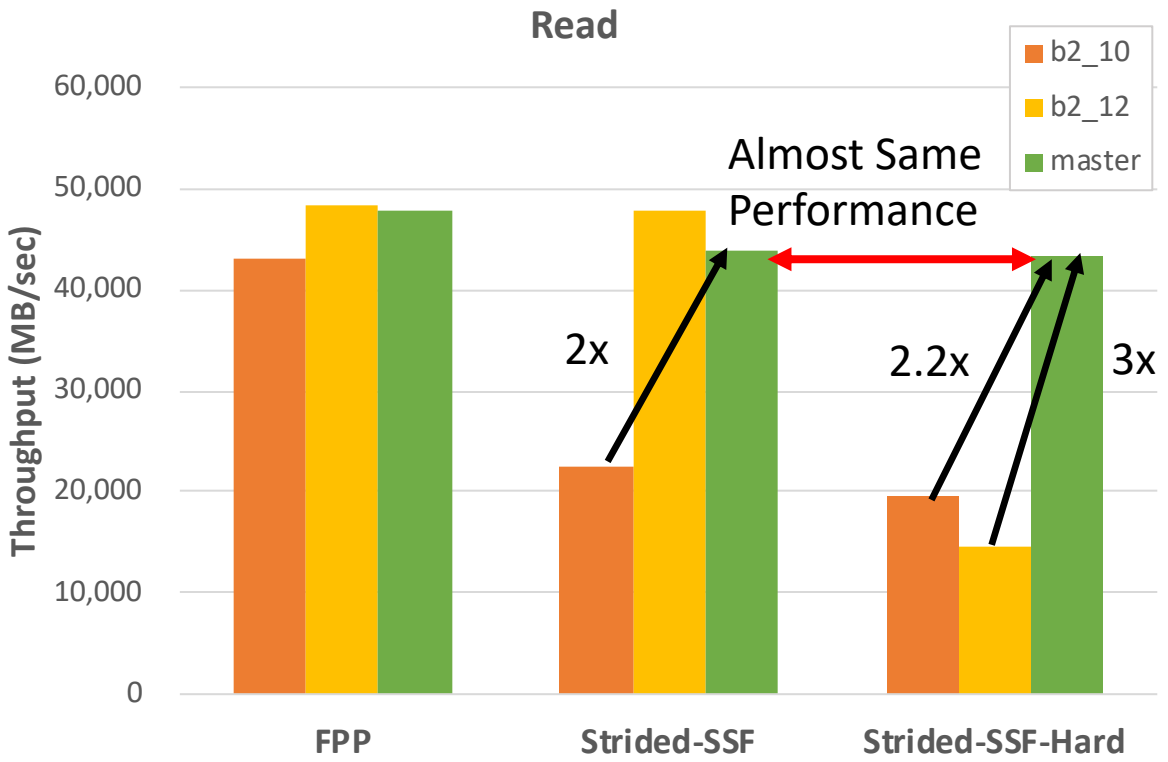
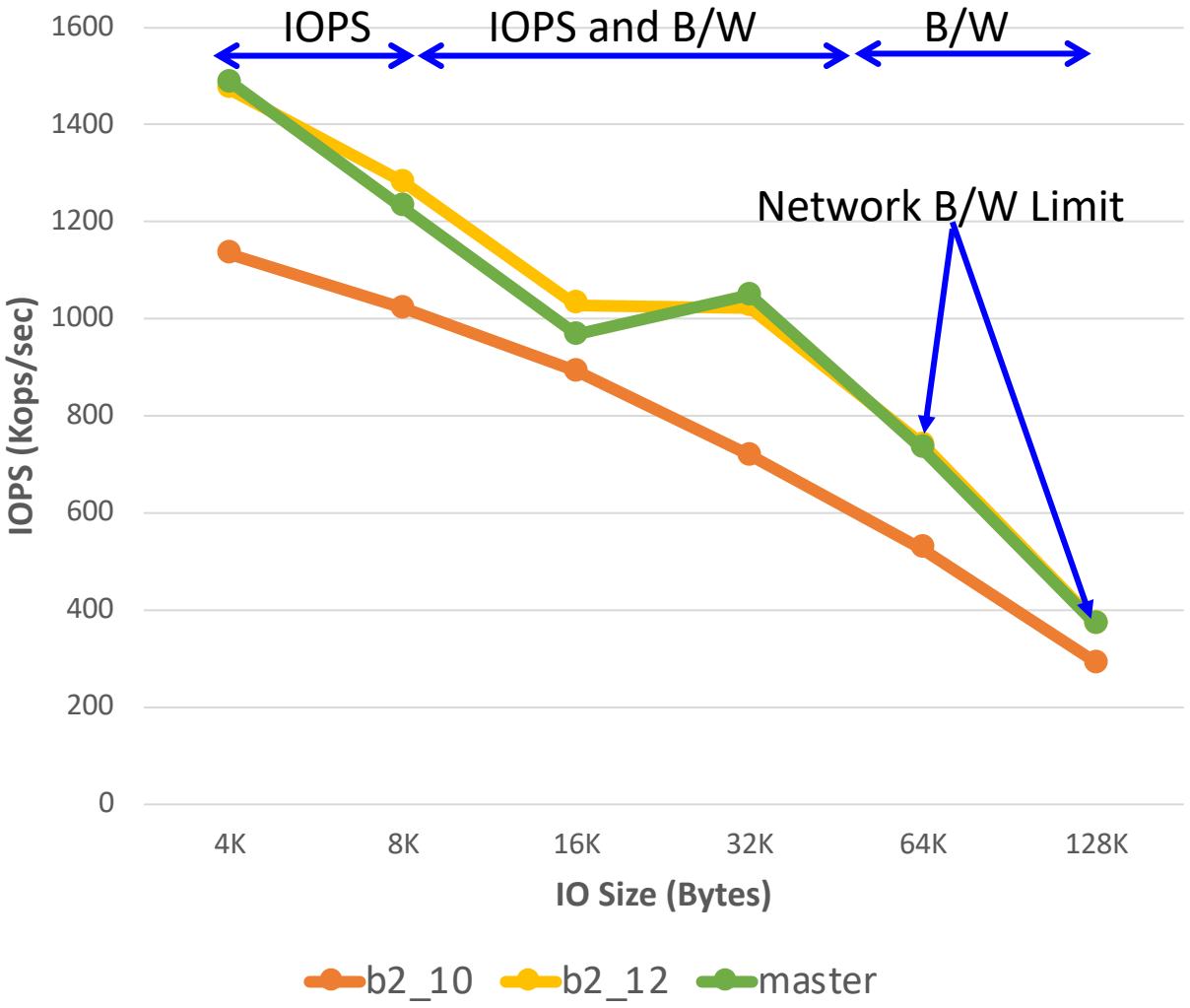
```
FPP:              ior -w/-r -s 6600 -i 1 -C -Q 1 -g -G 27 -k -e -t 1m -b 1m -F
Strided-SSF:      ior -w/-r -s 6600 -i 1 -C -Q 1 -g -G 27 -k -e -t 1m -b 1m
Strided-SSF-Hard: ior -w/-r -s 132000 -i 1 -C -Q 1 -g -G 27 -ke -t 47008 -b 47008
```



Aggregate IOPS (4K Random Read, O_DIRECT)



- Workload is `fio` with random O_DIRECT reads
  - Compare different IO sizes
- 1536 processes on 32 clients with random reads
- b2_12 and master 30% higher 4K IOPS vs. b2_10
- b2_12 and master branch saturate network
  - 4x IB-EDR bandwidth is 48GB/sec at 64K IO size

Single OSS Performance on Flash System
Heavy Concurrent Access N:1 (32 clients, 768 processes)

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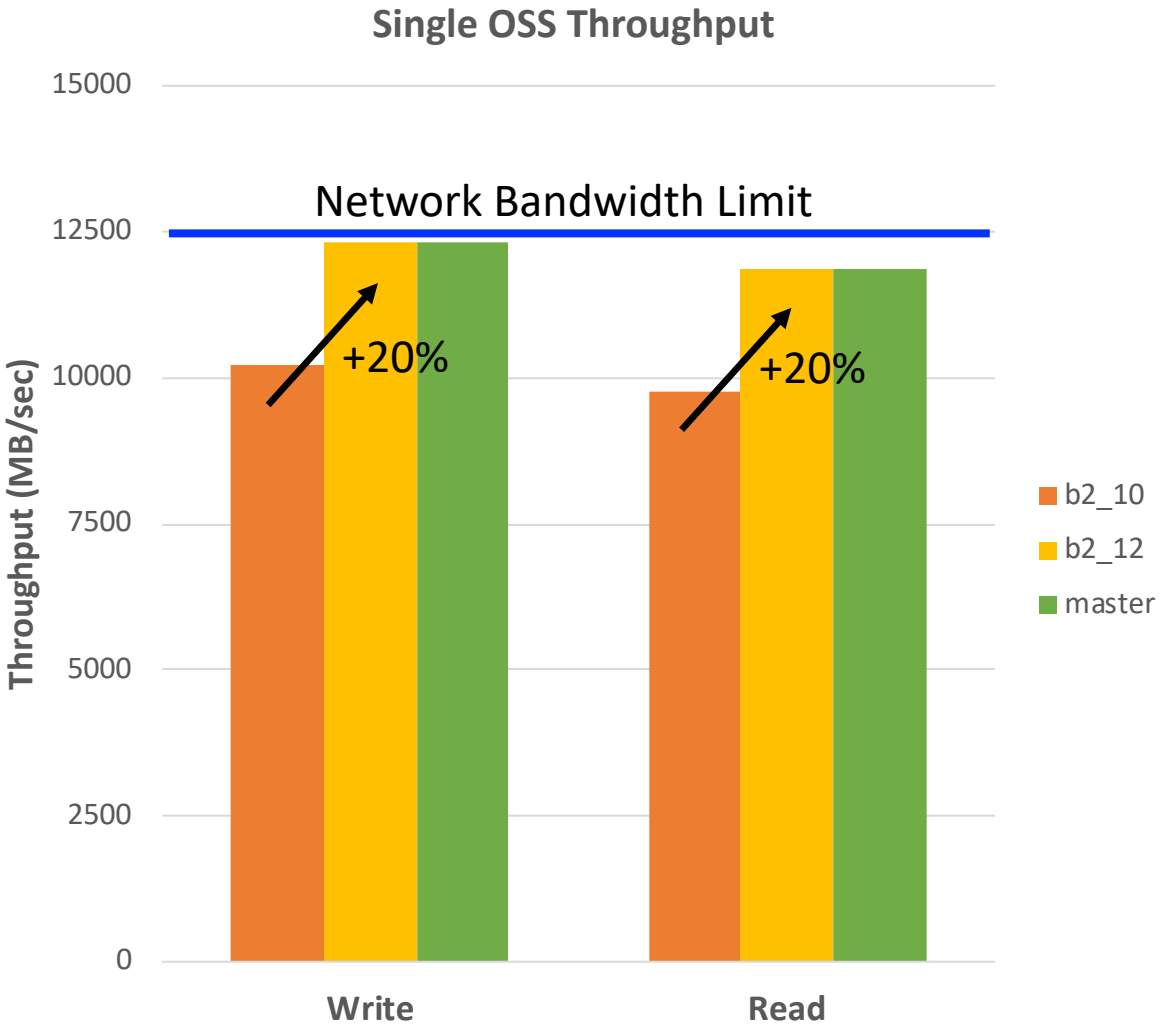

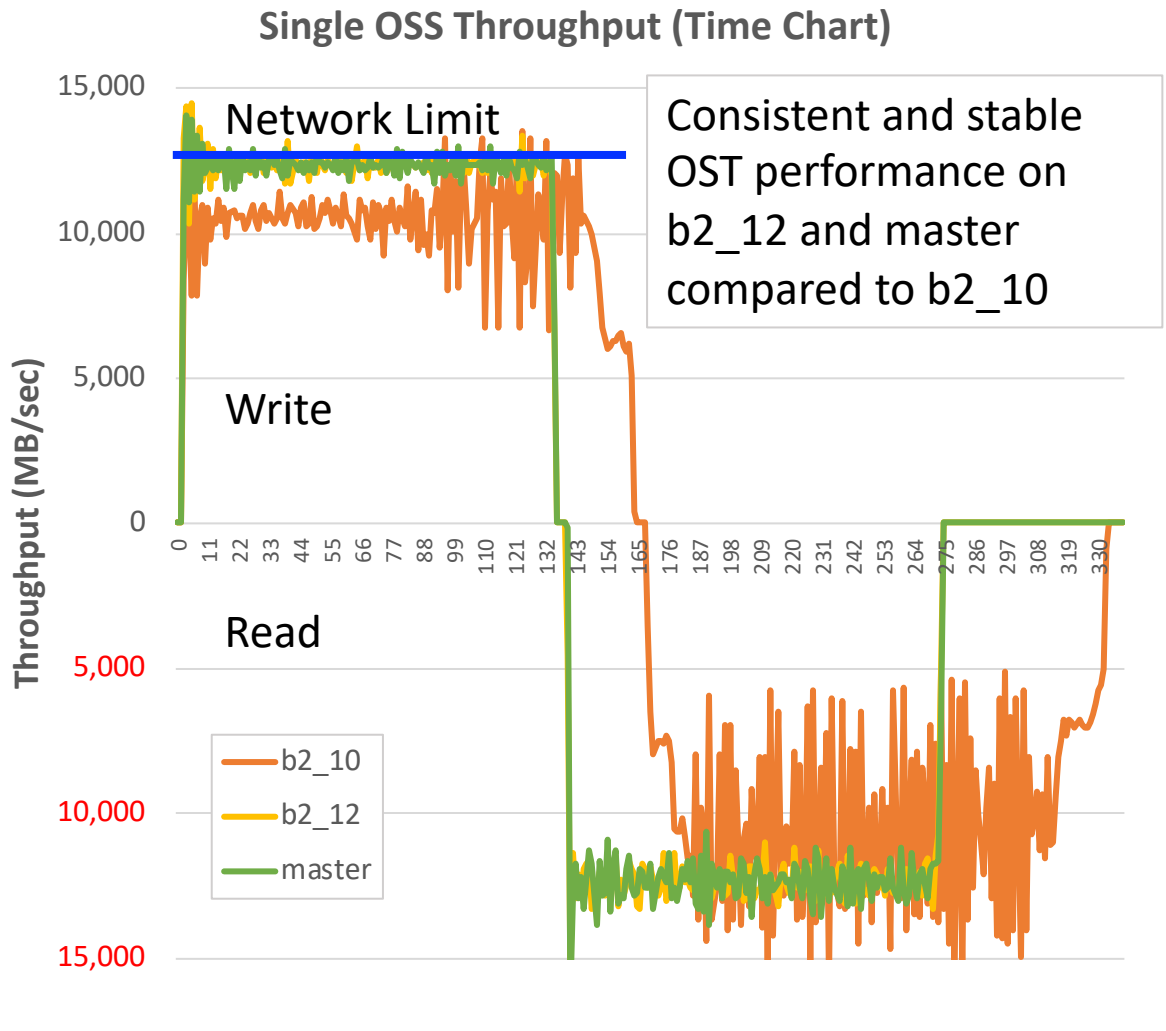

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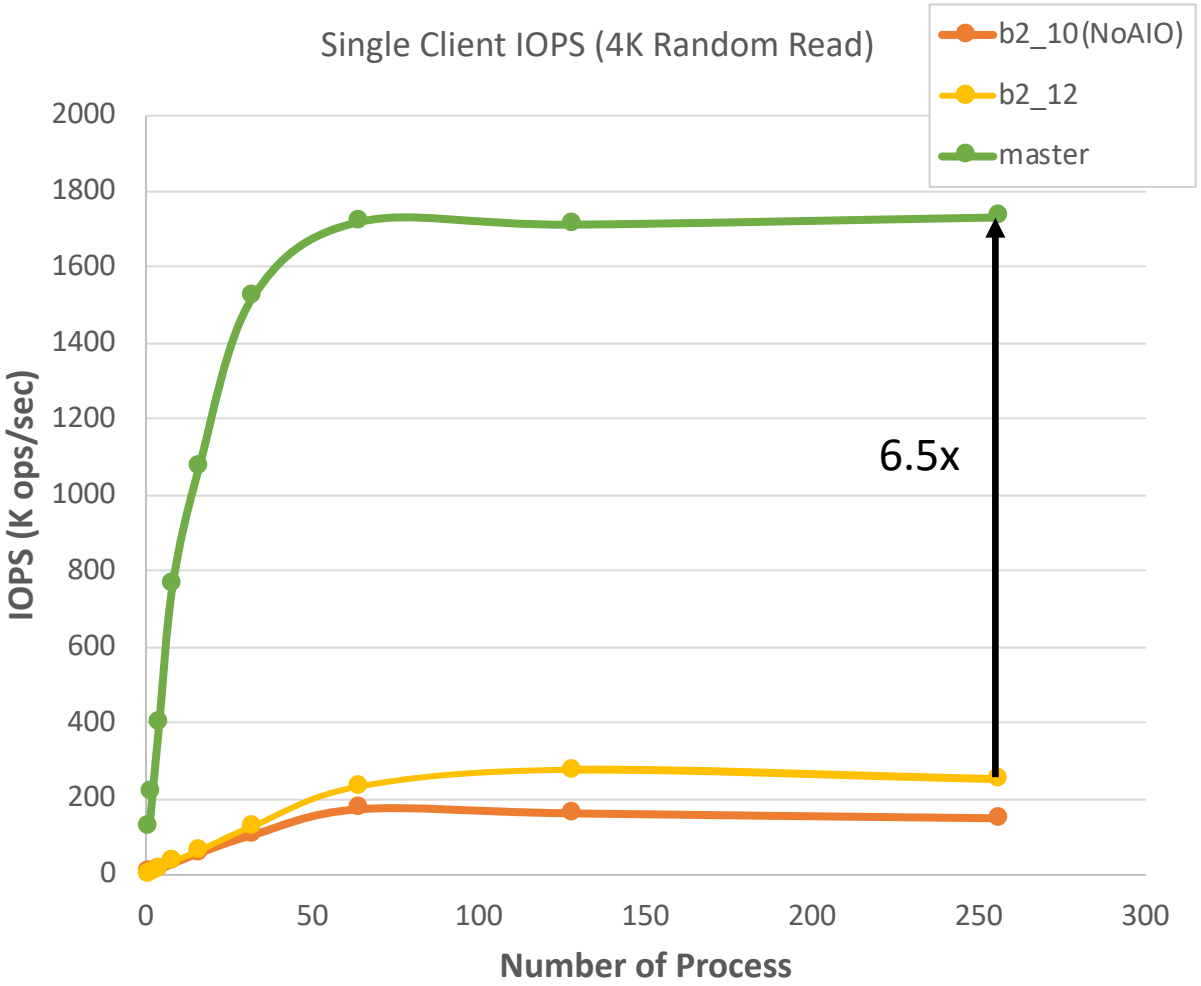
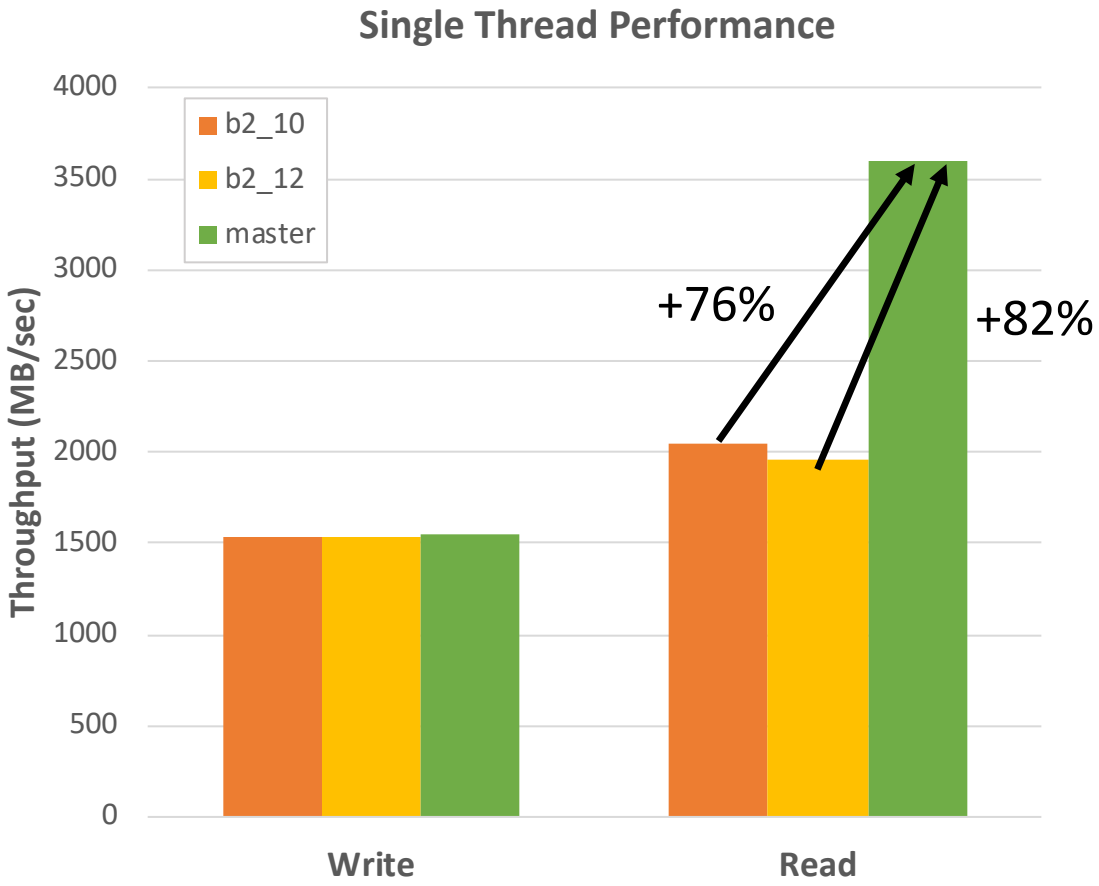
Lustre Client Performance Comparisons

Single client IOPS Scalability (4K random read, O_DIRECT/AIO)



- "fio" generates random O_DIRECT+AIO reads
  - Compare different number of processes on one client
- b2_10 doesn't allow O_DIRECT+AIO
- AIO works on b2_12 branch, but still "sync" mode
- master branch supports O_DIRECT+AIO
- master delivers 1.7M IOPS 4K random read on single client with sufficient storage performance

Single Thread Performance



- 1MB single stream to a large file

  ```
  # IOR -w (-r) -k -t 1m -b 384g -e -vv -o file
  ```

- Flashed cache between write and read
- Enabled Lustre file striping

  ```
  # lfs setstripe -c -1 –S 16M
  ```

- master 76-82% faster than 2.10/2.12 for read
- Write almost same speed on all branches

Single Client Performance with Multi-Rail

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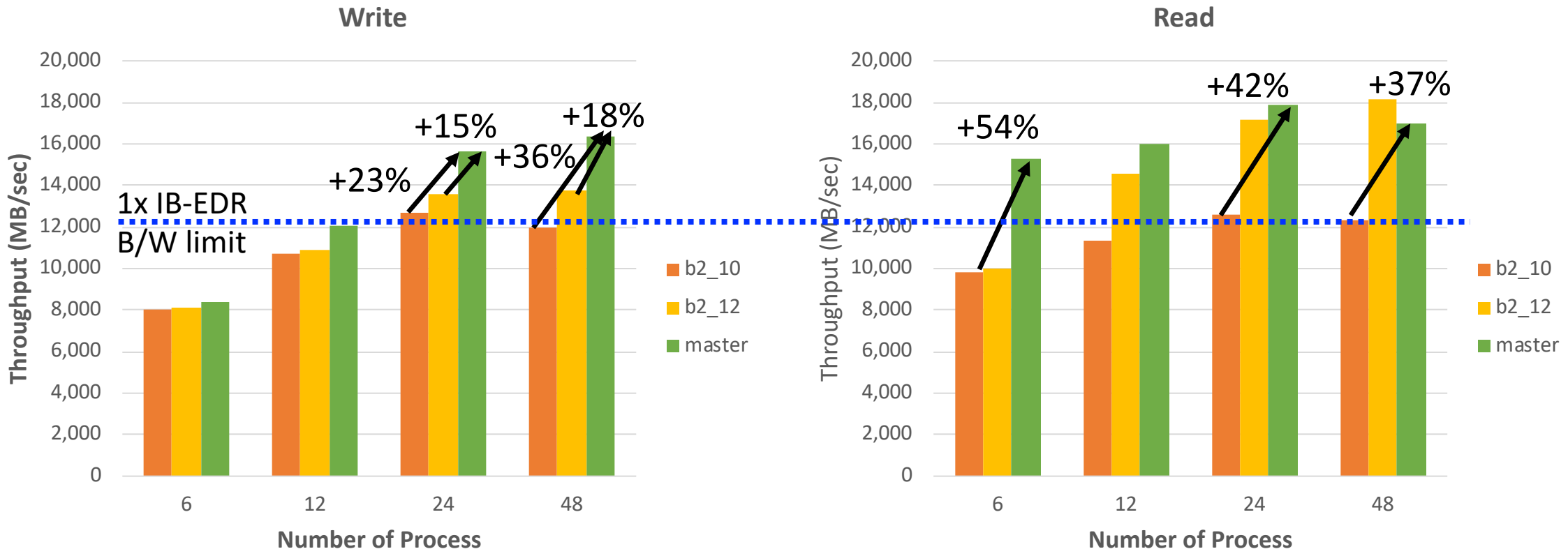
- High Bandwidth Network (2 x IB-EDR) Client with Lustre Multi-Rail
- File Per Process Workload (Aggregate 768GB files)
- Hidden Client performance bottleneck behind Single IB-EDR bandwidth



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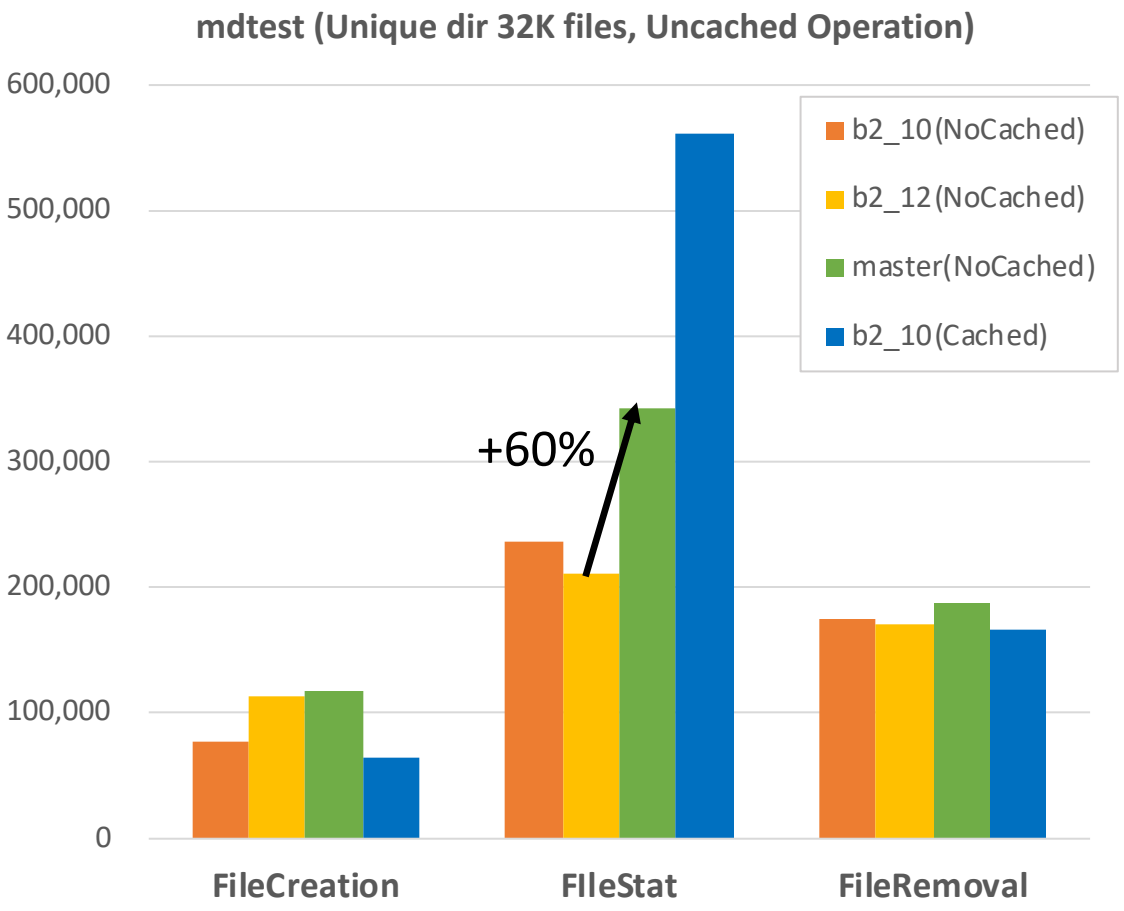
Lustre Metadata Operations

Metadata Performance
Small File with Non-Cached Operations



- Workload is `mdtest` with `create/stat/unlink`
  - 11.5M x 32K files in unique directories
- 32 clients 768 processes generate workload
- No Cache aware `mdtest`

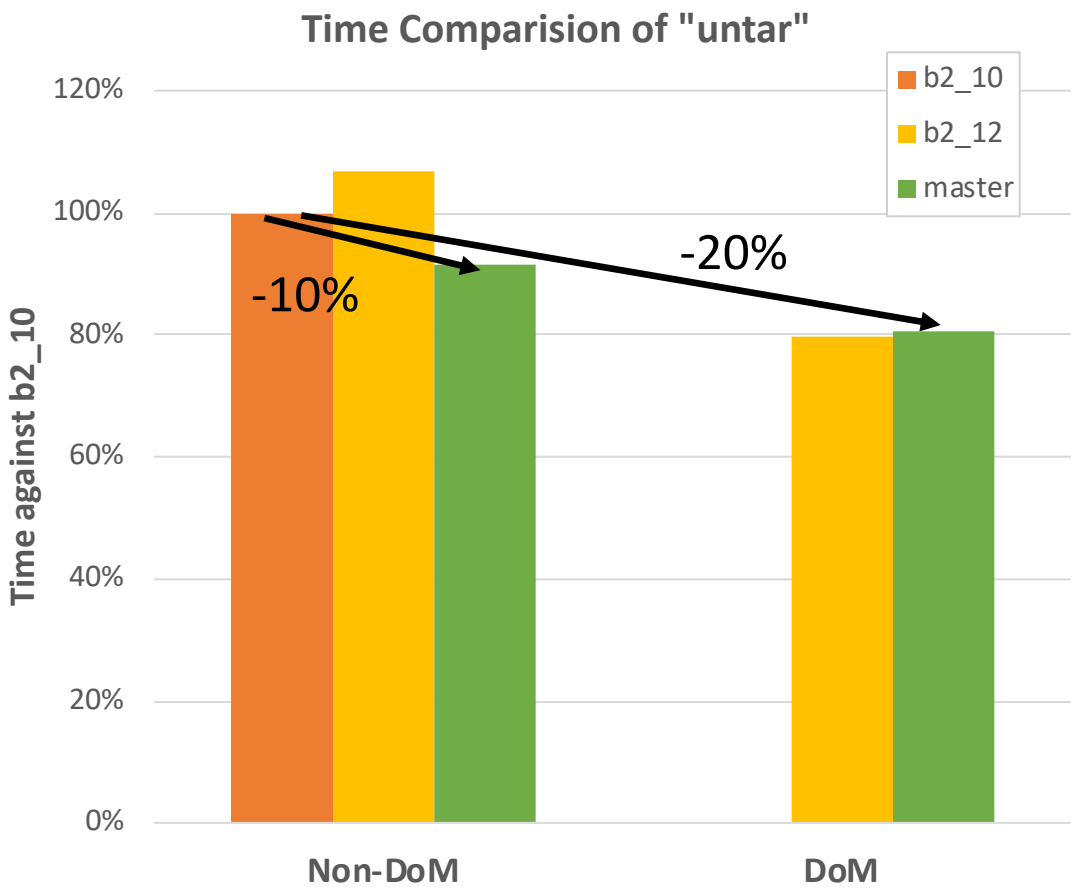
```
# mdtest -n15000 -Fvu -w 32k -e 32k -N24 -d /path
```

  - Client calls `stat()`/`unlink()` on remote created files.
  - Client cache at create is useless for next operations.
- Cache aware `mdtest`

```
# mdtest -n15000 -Fvu -w 32k -e 32k -d /path
```

  - Opencache can be valid for stat/unlink
  - Measured on b2_10 branch as a reference numbers
- master has 60% faster `stat()` than 2.10 and 2.12
- Unlink speed is almost same as cache aware mode

Single Client Small File Operation with DoM



- Speed “untar“ operation

```
# tar xzf /lustre/linux-5.3-rc8.tgz -C /lustre/out
```

- Enabled DNE2 in all branch

```
# lfs setdirstripe -c 4 /lustre/out
# lfs setdirstripe -c 4 -D /lustre/out
```

- DoM for less than 16M files

```
# lctl set_param lod.*.dom_stripesize=16777216
# lfs setstripe -L mdt -E 16M /lustre/out
```

- master branch improves untar operation by 10%
- DoM can provide another 10% time reduction

Conclusions

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- Apples to Apples comparison (different branch on same hardware) is very helpful
  - Tested major three branches (2.10.8, 2.12.2, and master) on same hardware
- master and b2_12 branch contains many performance improvements
  - Performance optimization for Flash system (both throughput and IOPS)
  - Client performance optimization (IOPS, bandwidth, reduced latency, remove overhead, etc.)
  - Metadata performance improvements for small files
- Future work
  - Add more performance metrics and different Lustre configurations (or hardware configurations. e.g. ethernet)
  - Found several performance bottlenecks in master that needs to be investigated

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Backup: Tested Lustre Branches

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- b2_10 at v2_10_8
  - 1e117a3 New release 2.10.8
- b2_12 at v2_12_2-150-g2e0e446bca
  - 2e0e446 Revert "LU-11816 lnet: setup health timeout defaults"
- master at v2_12_57-22-g9b6b5e4798
  - 9b6b5e4 LU-11011 osc: add preferred checksum type support
  - Added the patches for LU-12518 and LU-4198