Evaluation of DoM/DNE scaling performance in Lustre

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Metadata EXA scaling challenges

• How many MDS servers do we need?
  - DoM increase space needs.
  - Do more MDS servers mean more performance

• Does moving to NVME devices make sense?

• What setup makes the most sense?
  - DNE Phase 1
    • Create directories on a specific remove MDT
  - DNE Phase 2
    • Enables deployment of striped directories on multiple MDS nodes
  - DNE Phase 3
    • Grow organically across MDTs
Testing Parameters

• Internal testbed cluster
  - 6 and 24 clients (Tyan B8026T70AV16E8HR / Dell PowerEdge R6415) tested
    • 7 ranks per node
  - DDN 14k mapped to 6 OSS each with 2 OSTs
  - 38 MDS servers (Dell PowerEdge R6415) with 1 NVME device 732.4G

• Directory setup (DNE2+)
  - lfs setdirstripe -c $mdt -i -1 $OUTDIR
  - lfs setdirstripe -D -c $mdt -i -1 $OUTDIR
  - lfs setstripe -c $OSTCOUNT --pool capacity $OUTDIR
  - lfs setstripe -L mdt -E 64K -E -1 $OUTDIR (DoM testing)

• Using lustre 2.14.51 from a few weeks ago. ZFS backend.
benchmarks

• mdtest
  - DNE2 shared directory testing (-g option to remove inherited striping)
    • $OUTPUT and test-dir.X-0 will be striped across several MDTs. Directories under test-dir.X-0 will be mapped randomly to one MDT of the striping set.
  - Zero size files, DoM and non-DoM testing of 32K files
  - 100K files created per node
  - mdtest -n $file_per_dir -g -i 3 -p 30 -N 1 ‘-w 32736 -e 32736’ -d $OUTDIR
  - Ran with 7 ranks per node.
Shared directory performance

MDS scaling (fnv1a64 Hash) [ directory operations ]

- Directory creation
- Directory stat
- Directory removal

Ops/sec

MDT count

0  5  10  15  20  25  30  35  40
File performance for zero size files

![Graph showing file performance for zero size files.](image-url)
File performance using OSTs

MDS scaling (fnv1a64 Hash) [ 32K files ]

- File creation
- File stat
- File read
- File removal

Ops/sec

MDT count

0 5 10 15 20 25 30 35 40

Ops/sec vs MDT count graph showing performance trends for different file operations.
DoM file performance

MDS scaling (fnv1a64 Hash) [32K DoM files]

- File creation
- File stat
- File read
- File removal

Ops/sec

MDT count

0 5 10 15 20 25 30 35 40

0 50000 100000 150000 200000 250000
Reason for results

• `lfs getdirstripe mdtest_tree.X.0` will show they are all mapped to the same MDT
  - Rank of 7 saturates data transfer to a single MDT.
  - Parallelization only from multiple client nodes.
    • Need many clients to get the most out of it.

• Next set of `mdtest` results are with unique directories per rank
  - Confirmed with `lfs getdirstripe mdtest_tree.X.0` they are mapped to random MDT in the striping set.
  - With 7 ranks on 9 clients we out number the MDT count.
Unique directory performance

MDS scaling (fnv1a64 Hash) [directory operations]

- Directory creation
- Directory stat
- Directory removal

Ops/sec vs MDT count
File performance for zero size files

MDS scaling (fnv1a64 Hash) [ 0K files ]

<table>
<thead>
<tr>
<th>Operations/sec</th>
<th>MDT count</th>
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<tbody>
<tr>
<td>File creation</td>
<td></td>
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<tr>
<td>File stat</td>
<td></td>
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<tr>
<td>File read</td>
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<td>File removal</td>
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</tbody>
</table>
File performance for 32k files

MDS scaling (fnv1a64 Hash) [32K files]
File performance for 32k DoM

MDS scaling (fnv1a64 Hash) [32K DoM files]
Giving DNE3 a test run

• DNE3 is new auto striping across MDTs feature
  - Files or directories get moved to other MDTs when limit is reached.
    • Ease of administration.
  - Ticket LU-11025. Landed to 2.14

• MDS setup for our testing.
  - lctl set_param mdt.*.enable_dir_auto_split=1
  - lctl set_param mdt.*.dir_split_delta=1
  - lctl set_param mdt.*.dir_split_count=15000

• Same mdtest script as before using shared directories.
DNE3 directory operations results

MDS DNE3 scaling (fnv1a64 Hash) [directory operations]

- Directory creation
- Directory stat
- Directory removal

Ops/sec vs MDT count
DNE3 file operations performance

MDS DNE3 scaling (fnv1a64 Hash) [32K DoM files]

Ops/sec

MDT count

File creation
File stat
File read
File removal
Conclusions

• DNE 2 Directory operations
  - Stats scale well
  - Directory creation putters out at 16 but continues to scale
  - Directory removal flat lines after 16 MDTs

• DNE2 File operations
  - All setups (0 size, DoM, OST based) behave the same. What is best DoM size?
  - File removal flat lines at 16 MDTS
  - The rest flat lines at 4 MDTs

• DNE3 (Time limit only allowed DoM 32K file + directory testing)
  - Directory operations
    • Log raise to 4 MDT and flattened for removal and stats. Creates did have an improvement at a slower rate
    • Performance worst than DNE2 by a large margin.
  - Better file read but everything else performs worst then DNE2 setup. Stats degrade.
Acknowledgements

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