Look Inside™

# Lustre* consistency verification

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**Breakthrough Storage Performance**
**LUG 2014**

Oct 14 2014
Beijing, China

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# Outline

## Lustre* consistency issues

- Dangling reference, orphan object, repeated reference, …

## Lustre consistency framework

- FID-in-LMA, linkEA, parent FID for OST-object

## Lustre consistency verification tools - LFSCK

- OI scrub, layout LFSCK, namespace LFSCK

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# Lustre* consistency issues

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# Some Lustre* consistency issues

- Dangling reference: where did my file/data go?
  - Name entry references non-exist or invalid MDT-object.
  - MDT-object references non-exist or invalid OST-object (via its LOV EA).
- Orphan object: who consumed my space?
  - No name entry references the MDT-object.
  - No MDT-object references the OST-object.
- Repeated reference: why has my data been overwritten?
  - Multiple MDT-objects reference the same OST-object.
  - Multiple objects references the same block.
    - Backend local consistency verification tools, such as e2fsck for ldiskfs/extN, focus on that. Lustre will use them and put more effort on other distributed consistency issues verification.

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# Lustre* special consistency issues

- Object Index (OI)
  - OI is used for mapping the object's global FID to server backend local identifier (such as <inode#, generation#> for ldiskfs).
  - Lost the OI mapping will cause the object to be invisible when locate the object by FID.
  - Corrupted OI mapping may misguide the application to access some unexpected object and cause unpredictable result.
- FID-in-dirent (directory entry)
  - To accelerate traversing directory, the FID of the object that is referenced by the dirent is appended after the name in the dirent.
  - Lost the FID-in-dirent will cause additional reading FID from the object (maybe load from disk) when traverse the directory (READDIR).
  - Corrupted FID-in-dirent may misguide the application to access some unexpected object and cause unpredictable result.

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# Lustre* consistency framework

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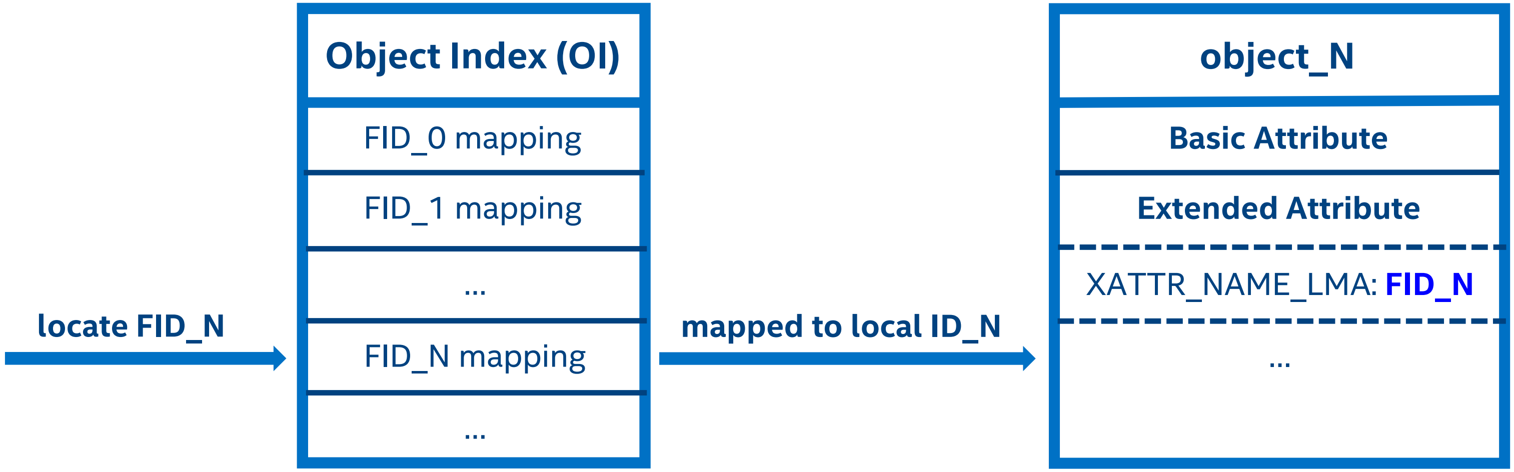
# FID-in-LMA

Lustre* object stores its FID in the XATTR_NAME_LMA extended attribute (EA) for related OI mapping consistency self-verification.

- To check whether the object found by the FID is the expect one or not. If NOT, the application will get -**EREMCHG** (-78).
- The FID-in-LMA can be used to rebuild the Lustre OI.



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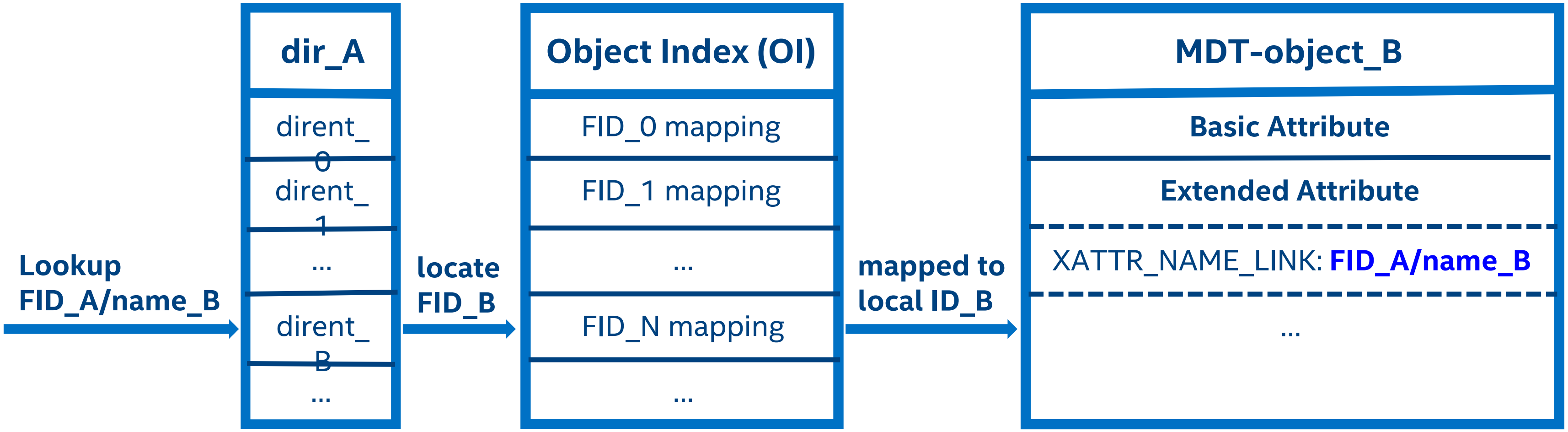
# linkEA

The MDT-object stores its position (in namespace) information (the name and the parent FID) as XATTR_NAME_LINK EA.

- To knows where the given MDT-object resides in the (original) namespace.
- The linkEA can be used to rebuild the Lustre* namespace.



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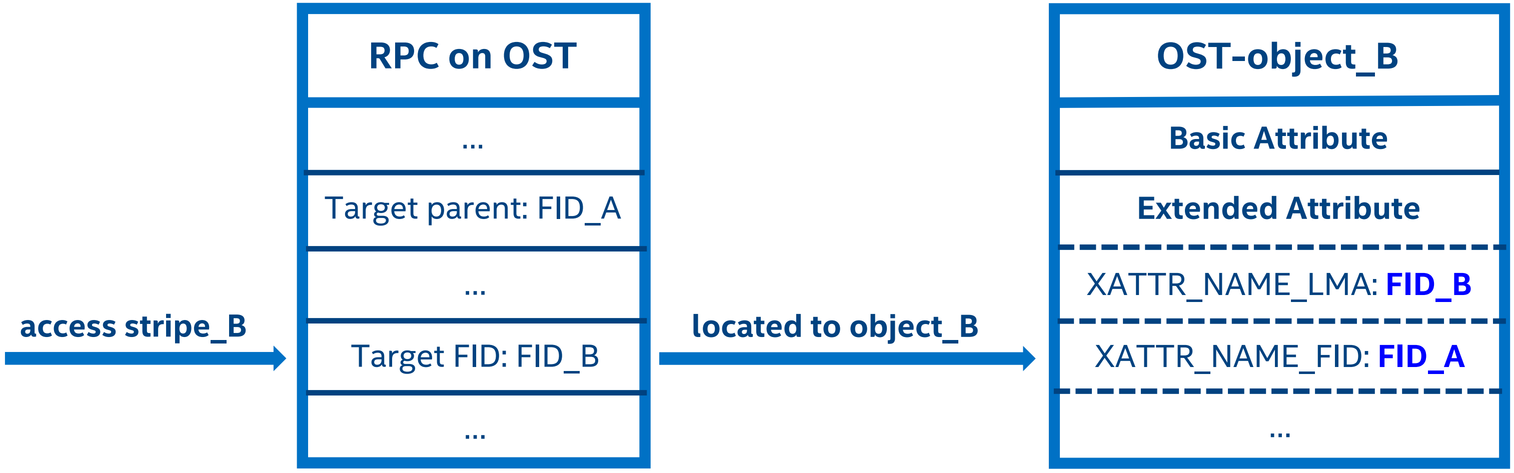
# parent FID for OST-object

The OST-object stores the FID of its parent MDT-object that references the OST-object as XATTR_NAME_FID EA.

- To check whether the OST-object to be operated belongs to the given target (MDT-object) or not.
- The parent FID for OST-object can be used to rebuild the MDT-object LOV EA.



# Lustre* consistency verification tools - LFSCK

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# New LFSCK goals

- Online verification
  - LFSCK routine verification with normal Lustre* services non-stopped.
  - Speed is controllable to avoid affecting normal services too much.
- Robust
  - Allow servers (MDT/OST) to join/exit the LFSCK dynamically.
  - Resume the LFSCK from the latest checkpoint (breakpoint).
- Scalable
  - LFSCK on thousands of servers in parallel, the aggregate verification speed will increase as the servers count increasing.
  - Support DNE (Distributed NamespacE) mode consistency verification.

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# LFSCK engines

LFSCK is driven by the LFSCK engines to verify the objects in the whole/partial system.

- Each Lustre* MDT/OST has a main engine.
  - All the main engines are equal, no central control-point.
  - All the main engines are relative independent.
    - Each main engine only verifies the objects in its own scope.
- Each main engine on MDT may has some assistant engine(s).
  - The main engine and the assistant engine(s) compose some asynchronous pipeline(s).
    - The main engine loads objects (from disk or network) and input the pipeline.
    - The assistant engine verifies the objects consistency from the pipeline output.

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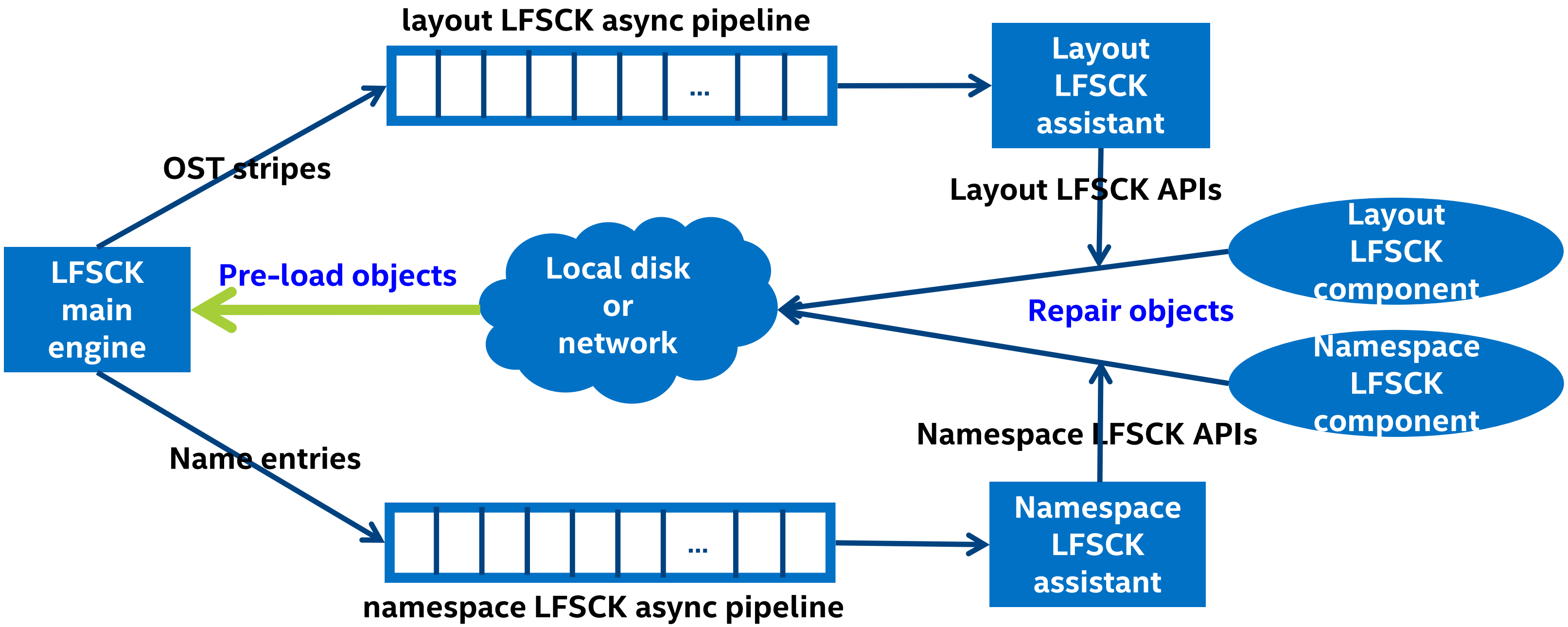
# LFSCK components

Every LFSCK component corresponds to one of the LFSCK verification types (OI scrub/layout LFSCK/namespace LFSCK). LFSCK uses the LFSCK component's APIs to verify the object.



# LFSCK component – OI scrub

## Special for ldiskfs-based backend to verify OI files.

- Basic principle
  - Trust FID-in-LMA if LMV EA is there.
  - Linearly scan all objects on the local device.
- Use cases
  - Re-create OI files totally
    - Some OI files are lost.
    - Split OI files to improve OI efficiency.
    - Shrink OI size to release the disk space occupied by empty FID mappings.
  - Re-build FID mappings after MDT file-level backup/restore
    - Backend local identifier (inode#/generation#) cannot be preserved when MDT file-level backup, but the FID mappings in OI are kept after the restoring.
  - Recover backend orphans on OST from /lost+found to Lustre* OI

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# LFSCK component – layout LFSCK

For regular striped file layout consistency between MDT and OST.

- Basic principle
  - For a regular file, the MDT-object references the stripes (OST-objects) via LOV EA; the OST-object back references the MDT-object via PFID EA.
  - The LFSCK on the MDT verifies the stripes in all MDT-objects' LOV EA.
  - The LFSCK on the OST records non-verified OST-objects that are orphans.
  - Share the same linear iterator as OI scrub used for scanning.
- Use cases
  - Guarantee that your data is written to the right OST-object(s).
  - Find the lost data via re-generating the lost or corrupted LOV EA.
  - Retrieve the lost space (occupied by the stale orphan OST-objects).

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# LFSCK component – namespace LFSCK

For local/global namespace consistency inside/among MDT(s).

- Basic principle
  - Traverse the namespace on MDT, for each name entry, check whether the referenced MDT-object has linkEA to back references the name entry.
  - Statistics the name entries that reference the same MDT-object to verify the MDT-object's nlink attribute.
  - Share the linear iterator, and plus namespace-based directory traversing.
- Use cases
  - Guarantee that the name entry references the right MDT-object.
  - Find the lost file/MDT-object via re-generating the name entry.
  - Retrieve the lost space (occupied by the stale orphan MDT-objects).
  - Guarantee that the nlink attribute matches the real name entries.
  - Verify FID-in-dirent, name hash for striped directory, and so on.

# User Interfaces – start LFSCK

```
lfsck_start <-M | --device {MDT,OST}_device> [-A | --all] [-c | --create_ostobj [on | off]]
            [-C | --create_mdtobj [on | off]] [-e | --error {continue | abort}] [-h | --help]
            [-n | --dryrun [on | off]] [-o | --orphan] [-r | --reset] [-s | --speed ops_per_sec_limit]
            [-t | --type check_type[,check_type...]] [-w | --window_size size]
```

options:

-M: device to start LFSCK/scrub on

-A: start LFSCK on all MDT devices

-c: create the lost OST-object for dangling LOV EA (default 'off', or 'on')

-C: create the lost MDT-object for dangling name entry (default 'off', or 'on')

-e: error handle mode (default 'continue', or 'abort')

-h: this help message

-n: check with no modification (default 'off', or 'on')

-o: repair orphan OST-objects

-r: reset scanning to the start of the device

-s: maximum items to be scanned per second (default '0' = no limit)

-t: check type(s) to be performed (default all)

-w: window size for async requests pipeline

# User Interfaces – stop LFSCK

```
lfsck_stop <-M | --device {MDT,OST}_device>
           [-A | --all] [-h | --help]
```

options:

-M: device to stop LFSCK/scrub on

-A: stop LFSCK on all MDT devices

-h: this help message

# User Interfaces – query LFSCK

- Query OI scrub
  - /proc/fs/lustre/osd-ldiskfs/${FSNAME}-MDTxxxx/oi_scrub
  - /proc/fs/lustre/osd-ldiskfs/${FSNAME}-OSTxxxx/oi_scrub
- Query layout LFSCK
  - /proc/fs/lustre/mdd/${FSNAME}-MDTxxxx/lfsck_layout
  - /proc/fs/lustre/obdfilter/${FSNAME}-OSTxxxx/lfsck_layout
- Query namespace LFSCK
  - /proc/fs/lustre/mdd/${FSNAME}-MDTxxxx/lfsck_namespace

# LFSCK project processing

Congratulations if you are using Lustre* 2.3 or newer!

- LFSCK 1 – OI scrub & object-table based linear iteration
  - Released in Lustre 2.3
- LFSCK 1.5 – FID-in-dirent & linkEA for local MDT
  - namespace LFSCK part1
  - Released in Lustre 2.4
- LFSCK 2 – layout LFSCK
  - Released in Lustre 2.6
- LFSCK 3 – LFSCK for DNE
  - Namespace LFSCK part2
  - To be released in Lustre 2.7
- ...

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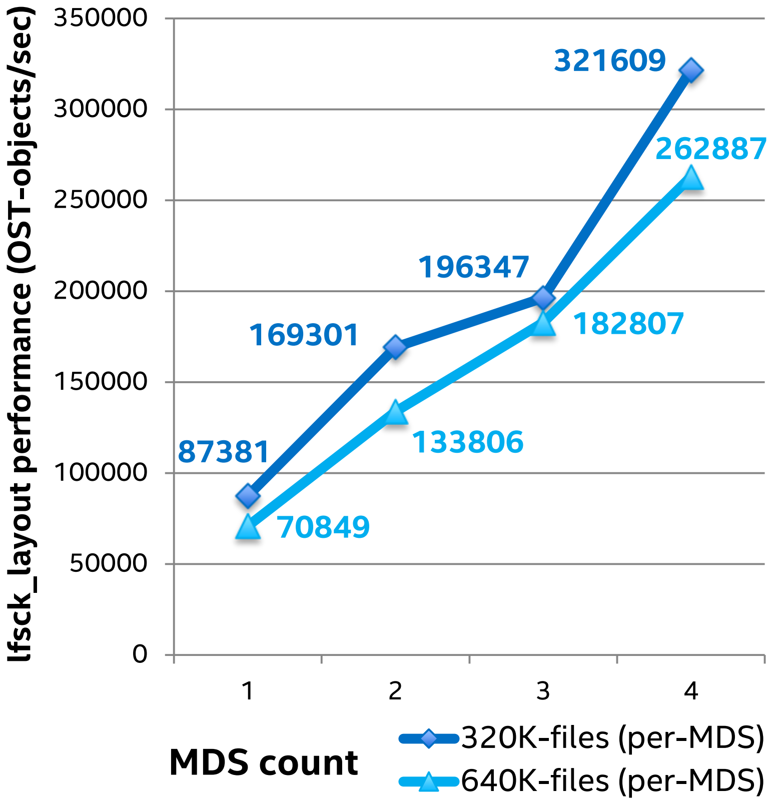
# LFSCK performance test environment

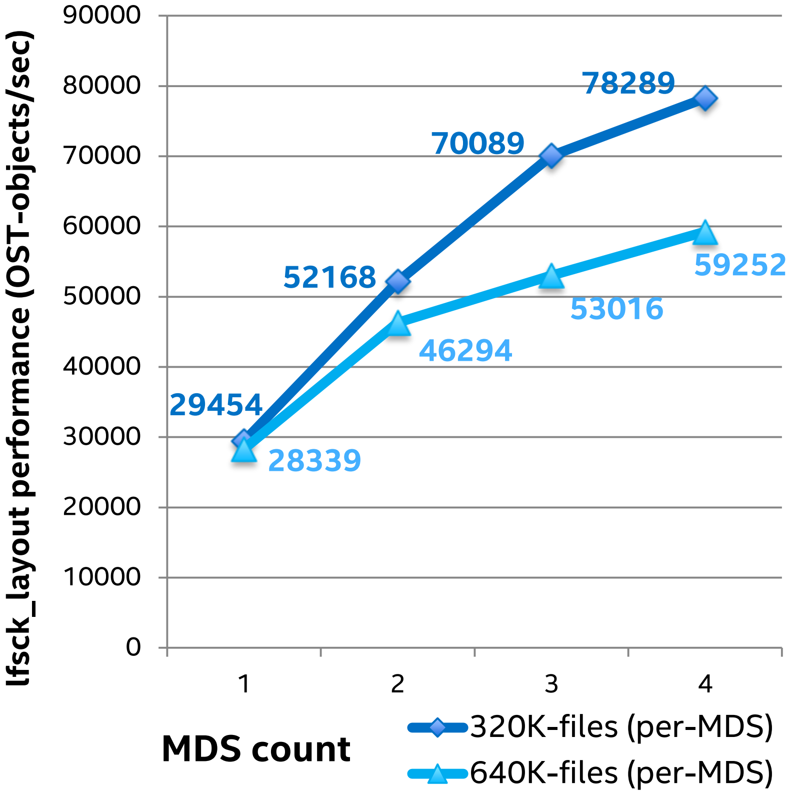
- CPU
  - 1 * Intel® Xeon® CPU E5620 @ 2.40GHz, 8 logic processors
- RAM
  - 32GB DDR3 RAM on each server (MDS/OSS) node
- Storage
  - 500GB 7200 rpm SATA disk on each server node
- Network
  - InfiniBand QDR
- Logic servers
  - 4 MDS nodes, 1 MDT per MDS
  - 4 OSS nodes, 2 OSTs per OSS
  - 1 client node, multiple mount points

# Layout LFSCK performance

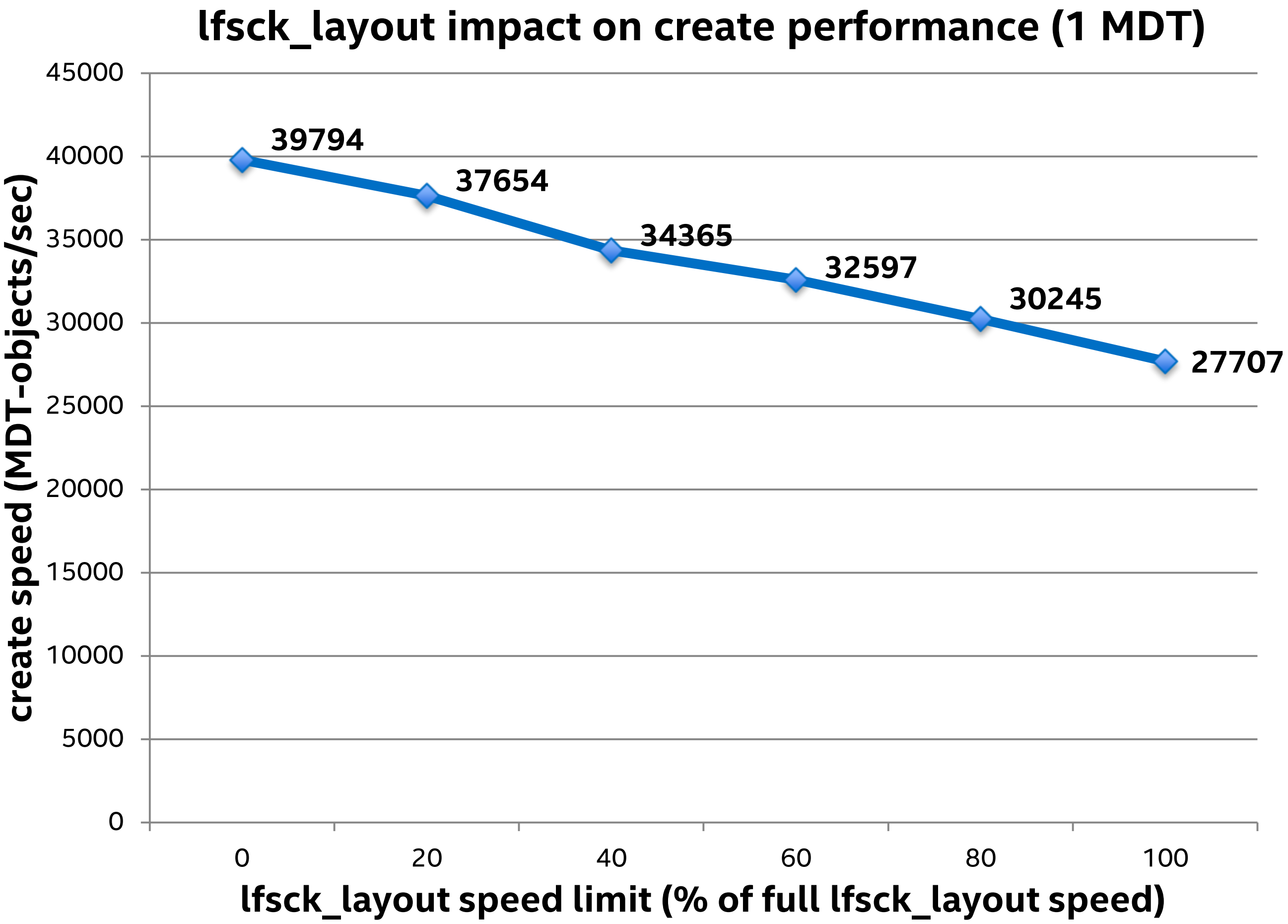
lfsck_layout routine check (bundle) performance under DNE



lfsck_layout repair dangling (bundle) performance under DNE



# Layout LFSCK impact on others



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