Lustre* 2.8 and Beyond

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Development Process Changes

Features are not necessarily be tied to specific releases

- Versions and features listed here are only targets and not guaranteed

Feature/component landings will be more "all or nothing"

- Still possible to land independent functional parts of a feature
- Avoids landing only a few (otherwise useless) patches of a feature

More focus on testing patch series before landing

- Whole patch series to be landed via merge commit after testing

Improved focus on documentation, comments, man pages

- Make the code easier to understand and maintain in the future

Overview of Features

Features at or near completion

- LFSCK Phase 4 - Performance Improvements
- DNE Phase 2 Striped Directories - Asynchronous Commits
- Client IO Simplification and Speedup

Features starting early development

- Multiple metadata-modifying RPCs (multi-slot last_rcvd)
- First generation Intel Omni Path Fabric / Dynamic LNet Configuration 2
- ZFS* Enhancements
- Protocol Documentation
- Data on MDT Prototype (DoM)
- Progressive File Layout Prototype (PFL)

LFSCK Phase 4 (Intel/OpenSFS 2.8)

LFSCK performance improvements (Phase 4)

- Improve object iteration, don't load objects unnecessarily
- Avoid a full scrub if only a few objects are found inconsistent
  - Tunable, launch full scrub if more than 60 errors within 60s
- Limit DLM locking to only affected name instead of whole directory
- Predict locking based on recent history
  - LFSCK doesn't lock by default, only lock & reverify on inconsistency
  - If errors recently seen LFSCK locks objects before doing checks
- Improved logging of LFSCK-detected inconsistencies

LFSCK Phase 4 is the final phase of this project

http://wiki.opensfs.org/images/3/3c/LFSCK_Performance_SolutionArchitecture.pdf

http://cdn.opensfs.org/wp-content/uploads/2013/04/Zhuravlev_LFSCK.pdf

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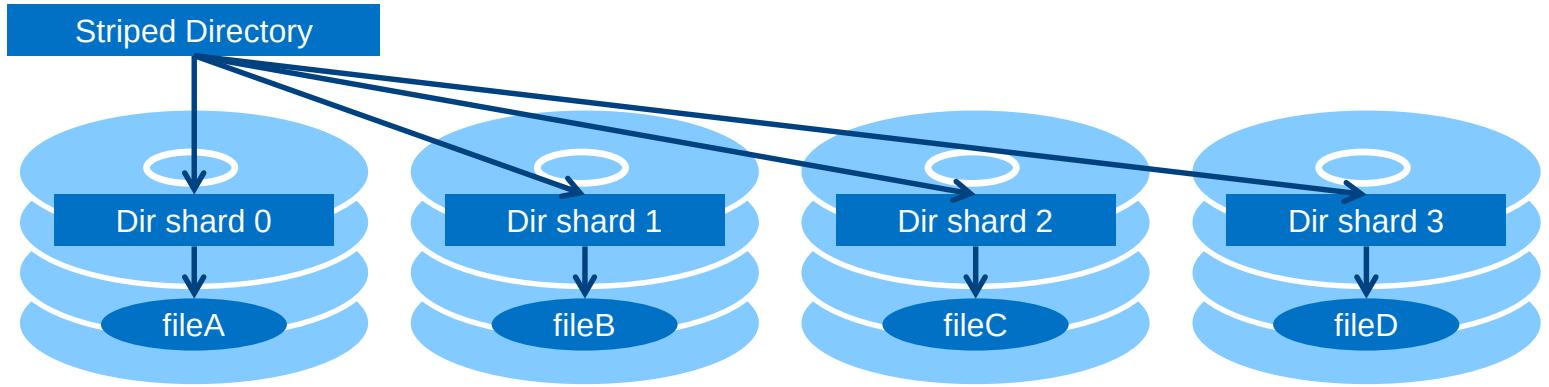
DNE Phase 2 Striped Directories (Intel/OpenSFS 2.8)

Spread a single directory across multiple MDTs

- Reduce contention, improve performance for large directories
- Directory layout + name hash locates slave MDT directory entry
- Directory shard on each MDT independent (lock, lookup, modify)
- Inode created on the same MDT as name entry
- Tool to migrate directories from one MDT to another

DNE Phase 2 Async Commits is the final phase of this project



DNE 2 Asynchronous Commit (Intel/OpenSFS 2.8)

Change ***within*** MDT (mkdir, rmdir, rename) **never** synchronous

DNE remote/striped directory create synchronous in 2.4-2.7

- Cross-MDT rename() or link() weren't working (returned -EXDEV)

Async commit implements distributed DNE recovery

- Each target (master/slave) writes a full redo log of all updates
- If *any* target commits a change it can be replayed on *all* involved targets
- Ensures all-or-nothing semantic for namespace-visible changes
- Reduced latency for remote/striped directory creates
- Allow rename() and link() to work correctly across MDTs
- Foundation for future features (e.g. cross-MDT mirrored objects)

http://wiki.opensfs.org/images/f/ff/DNE_StripedDirectories_HighLevelDesign.pdf

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Client IO Cleanup/Speedup (Intel/OpenSFS 2.8+)

Clean up CLIO code and interfaces

- Simplify complex internal locking code
- Replace old ioctl interfaces with proper methods
- Remove non-functional interop code for WinNT and MacOS
  - Remove extra abstraction layer complexity and overhead
- Remove access to LOV internals throughout code
  - Preparation for handling of more complex file layouts (e.g. PFL)

Client Performance Improvements

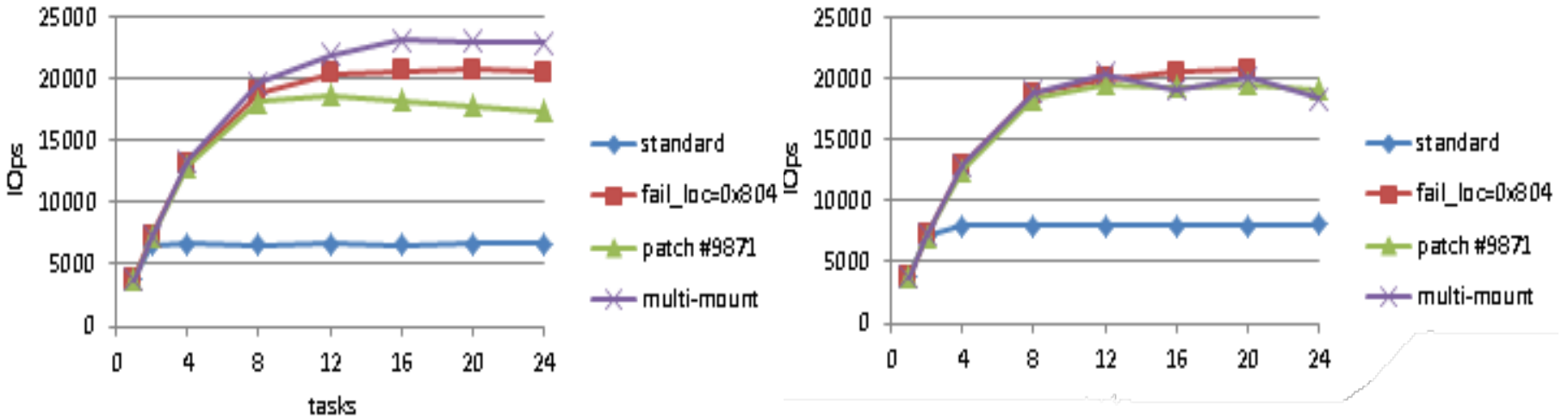
- Larger RPC sizes for improved allocation and disk IO
- Single-threaded IO performance improvements

http://wiki.opensfs.org/images/b/b7/CLIOSimplificationDesign_HighLevelDesign.pdf

Client Metadata RPC Scaling (Bull/Intel 2.8)
(aka multi-slot last_rcvd)

Currently limited to one modifying RPC (+close) per client
- last_rcvd slot on MDT for each client to reconstruct reply
- Many concurrent clients limited by MDS performance

Dynamic log on MDT for multiple saved RPC replies per client
- Each metadata-modifying RPC has a separate tag/index
- Single client multi-threaded create/unlink performance improved



https://jira.hpdd.intel.com/browse/LU-5319

Intel® Omni-Path Architecture Gen 1 (Intel 2.8)
Dynamic LNet Config Phase 2 (Intel 2.9)

LNet support for Intel Omni-Path host fabric interface (HFI)

- Next generation interconnect from Intel
- Compatible with OFED verbs interface
- May need LNet o2iblnd tuning for best performance

Improved Dynamic LNET Config

- Per-NI tunables instead of per-LND
- Auto-tune parameters based on network interface type
  - Optimize for Mellanox*, Intel® True Scale HCA, and Intel® Omni-Path HFI

ZFS Enhancements (Intel, 2.8+)

Changes for ZFS OSD (2.8)

- 1MB+ ZFS blocksize (IO performance)
- Read IO optimization (IO performance)
- ZIL support for fast sync (IO & metadata performance)

Changes to core ZFS code (2.10?)

- Parity declustering (availability)
- Distributed hot spares (availability)

Protocol Documentation (Intel/OpenSFS)

Document the PTLRPC wire structures, message flow, states

- POSIX operations (mount, open, close, setattr, create, unlink, etc)
- MDS state handling (connect, disconnect, FLD, SEQ, PING, etc)
- IO operations (read, write, truncate, setattr, grant)
- OSS state handling (precreate, orphan cleanup, destroy, etc)
- Quota management
- OUT distributed updates (DNE, LFSCK, Async Commit)

http://wiki.opensfs.org/Contract_SFS-DEV-005

Data on MDT Prototype (Intel/OpenSFS)

Efficiently store small files on the MDT(s)

- Avoid OST BRW RPC + disk seek + OST lock for each file access
- Use small-file optimized MDT storage (RAID-10/SSD/NVRAM)
- Avoid RAID-5/6 read-modify-write for small writes

Space usage on MDT(s) managed by quota

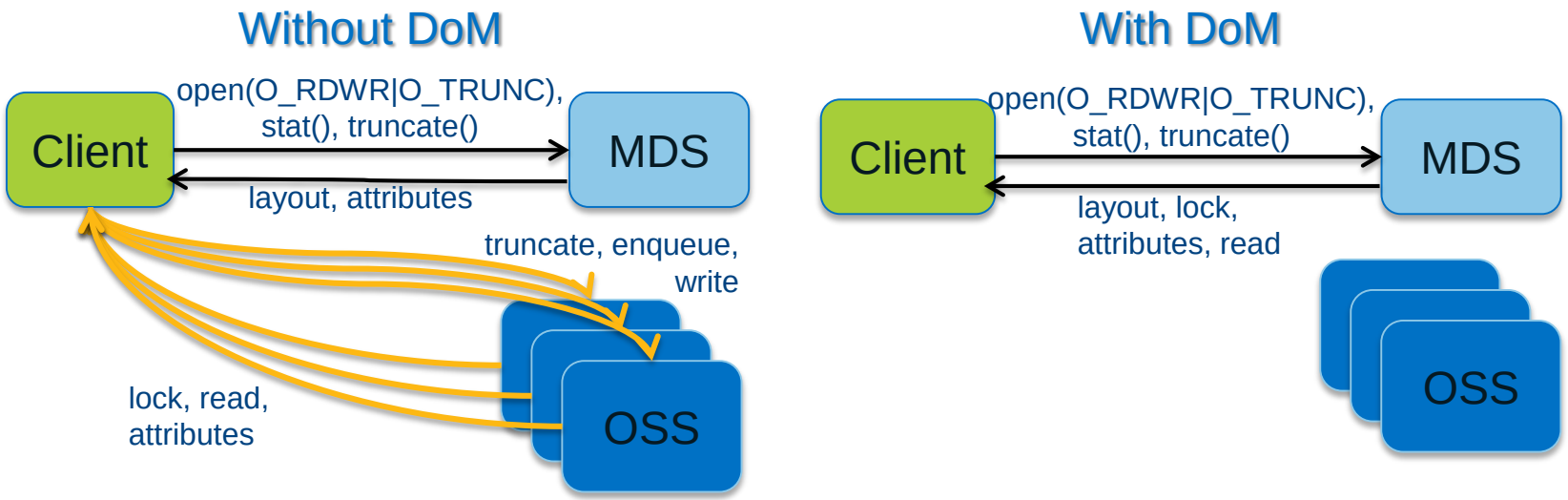
Small files are determined by the file layout

- Maximum MDT file size can be specified by min(user, admin)
- Typically expected to be <= 1MB, dependent on MDT space

Complimentary with DNE 2 striped directories

- Scale small file IOPS horizontally with multiple MDTs

Data on MDT Implementation



DoM layout chosen at file creation time like files on OSTs

- Can't do it after write because objects are allocated at open()
- Default DoM striping on subdirectories inherited by newly created files

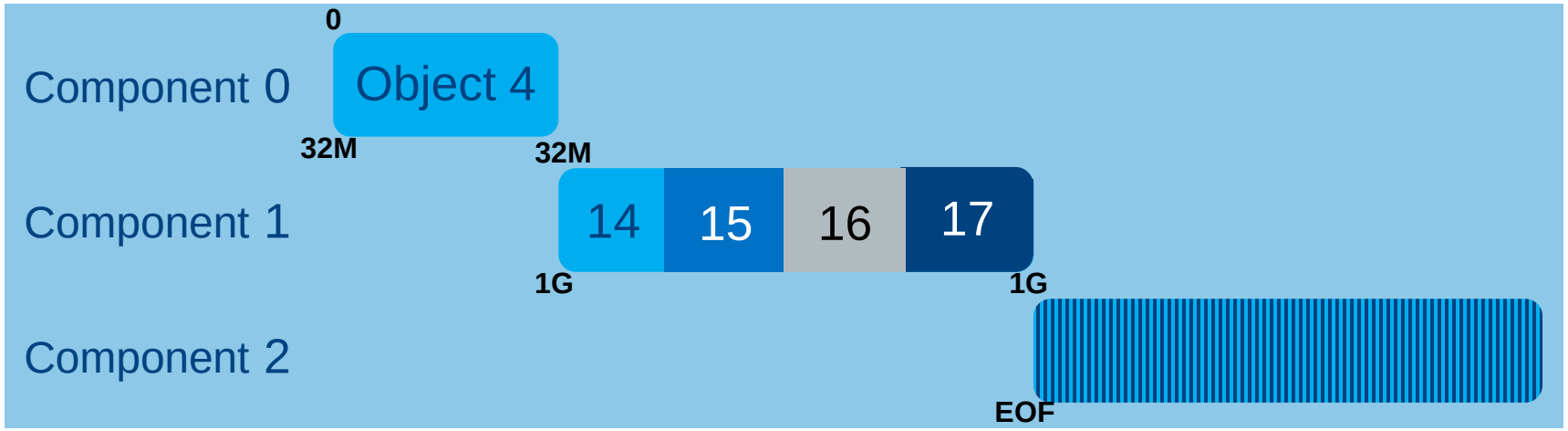
http://cdn.opensfs.org/wp-content/uploads/2014/04/D1_S10_LustreFeatureDetails_Pershin.pdf

http://wiki.opensfs.org/images/b/be/DataonMDSDesign_HighLevelDesign.pdf

Progressive File Layout Prototype (Intel/ORNL)

Allow compound layouts for regular files

- Component layouts describe one or more extents of a file
- Layout extents do not overlap for PFL files
- Start with few stripes, increase stripe count as file size increases
- Balance lower overhead vs. performance and space balance



Miscellaneous features

Code cleanups (Cray*/Intel®/ORNL)

- Remove dead code and useless wrappers
- Update to match upstream kernel coding style
- Port patches to/from upstream kernel
- Clean up or eliminate server kernel/ldiskfs patches

Project Quotas (DDN*)

- Allow quota tracking on subtrees independent of UID/GID

Network Authentication and Encryption (Bull*/IU*/Seagate*)

- Kerberos user/node authentication, RPC encryption
- Shared Secret Key node authentication, RPC encryption

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