Lustre on ZFS

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September, 24 2012

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Lustre on ZFS Benefits

Can leverage many ZFS features in Lustre 2.4

- Robust code with 10+ years maturity
- Data checksums on disk + Lustre checksums on network
- Online filesystem check/scrub/repair - *no more e2fsck!*
- Scales beyond current filesystem limits (object count/size, filesystem size)
- Easier management of many disks, commodity JBODs without RAID hardware
- Integrated with flash storage cache (L2ARC read cache)
- Optional data compression on disk can improve real-world IO performance

Other features will need extra effort to work with Lustre

http://en.wikipedia.org/wiki/Zfs

http://zfsonlinux.org/lustre.html

Lustre on ZFS Implementation

On-disk format is ZFS compatible

- Can mount MDT/OST with Linux ZFS filesystem module
- Simplifies debugging/maintenance/upgrades

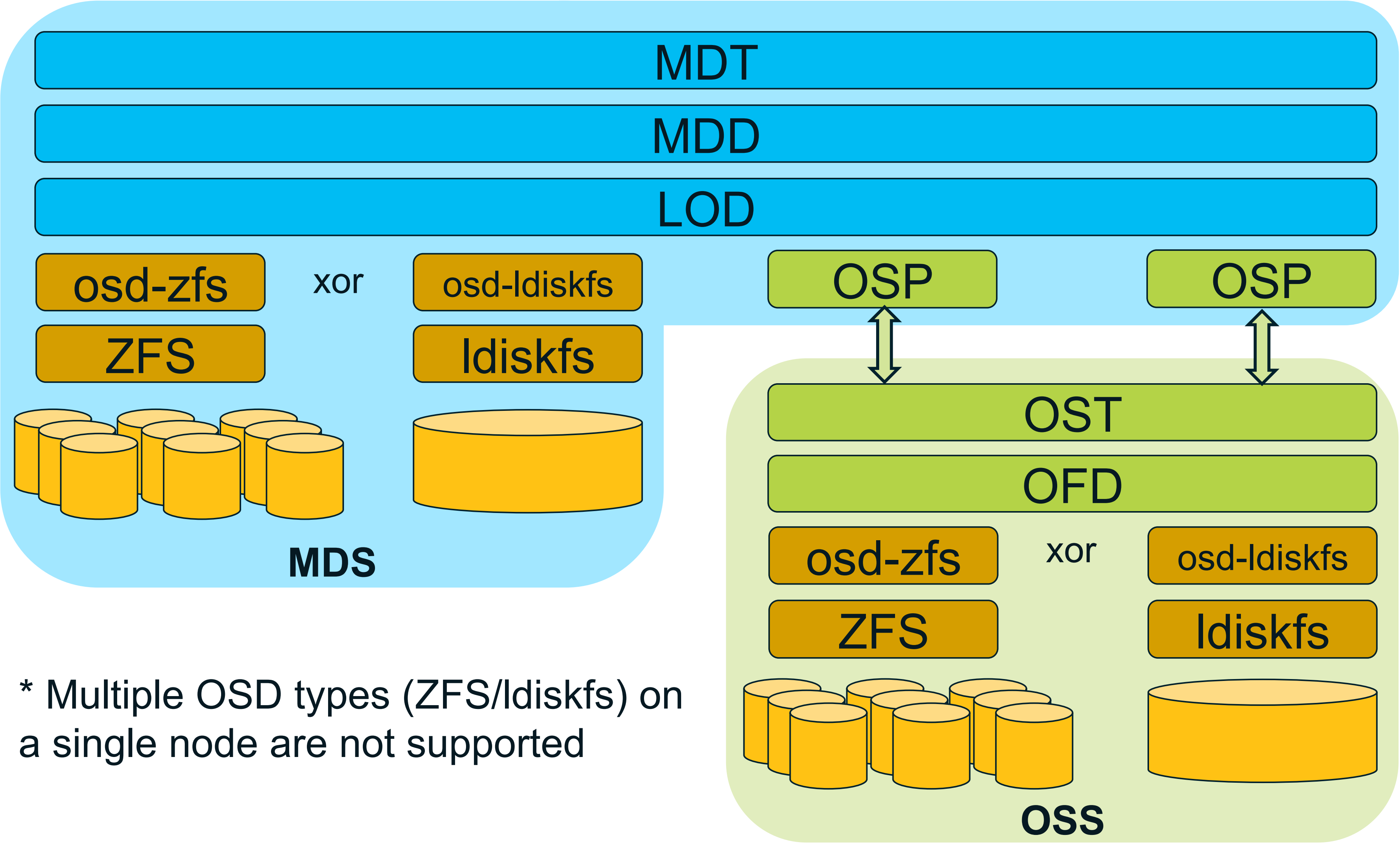
Network protocol independent of backing filesystem

- Fixed some hard-coded assumptions on client
  - Assumed maximum object size was 2TB (ext3 limit, fixed in 2.3)
  - Assumed OST blocksize <= PAGE_SIZE when reserving space

New Object Storage Device (OSD) module

- Integrates with ZFS Data Management Unit (no FUSE/VFS)
- Access ZFS transactions/features directly from Lustre

Updated MDS/OSS Module Layering



* Multiple OSD types (ZFS/ldiskfs) on a single node are not supported

Lustre Architectural Changes

Remove usage of VFS APIs

- Only access storage via OSD API

Clean up layering of MDS and OSS stacks

- Abstract MDS-to-OSS operations via OSD API
- Simplifies DNE design and implementation

Fix some longstanding MDS/OSS recovery issues

- MDS drives object destroy, avoids client failure issues

Allows ZFS support to co-exist with ldiskfs

- Potential for Btrfs OSD in the future, when it is faster/stable

Development Status

Feature development finished on Orion branch

- OSD API implemented for ZFS and finished for ldiskfs
- OST, MDT, MGT use only OSD API to access storage devices
- LOD/OSP are OSD API replacements for LOV/OSC
  - OSP proxies operations, transactions for remote OST storage
- Quota accounting and enforcement restructured for ZFS

Code has been under testing at LLNL for past year

- Development/testing clusters
- Scale testing up to ½ of Sequoia system (384 OSTs)
- Recent early deployment on ½ of Sequoia system

Landing Status

ZFS OST functionality landed for 2.3 (for testing only)

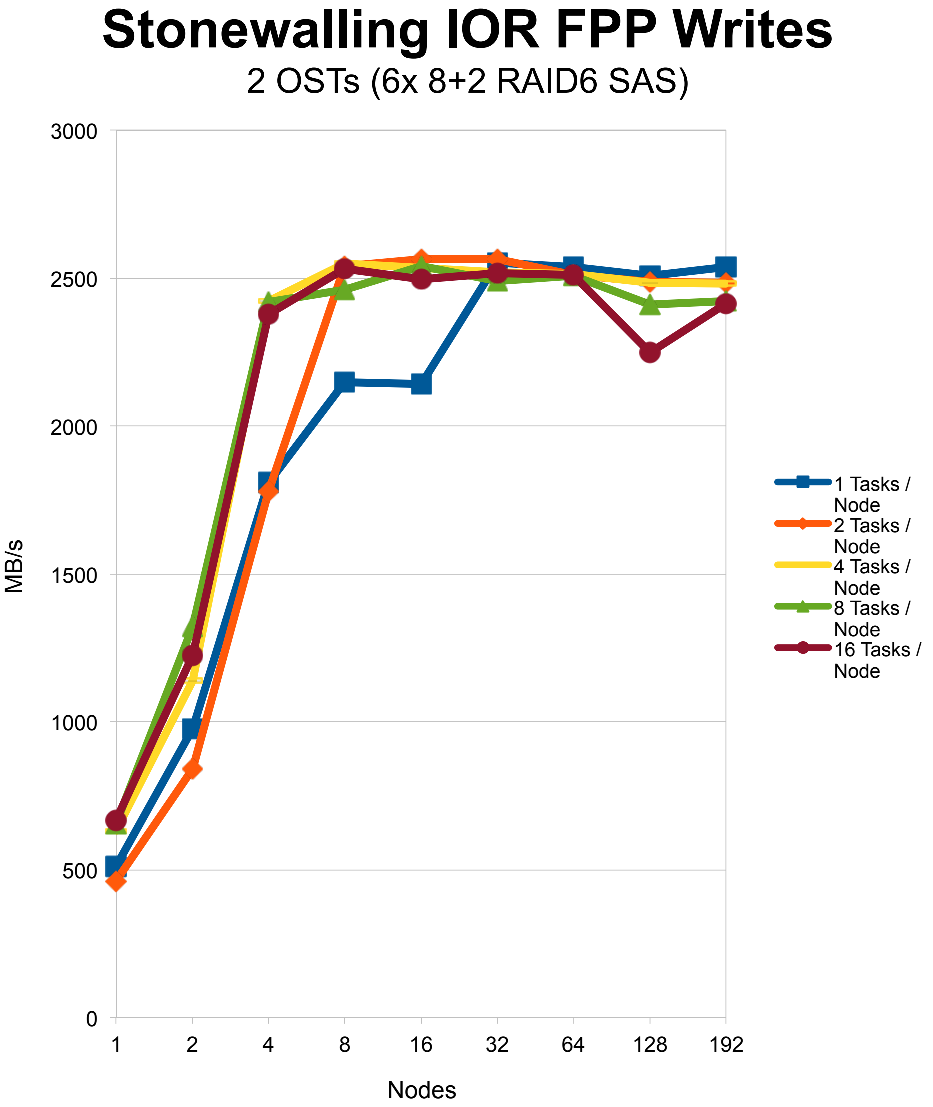
- Basic utilities support to format, mount ZFS OST filesystem

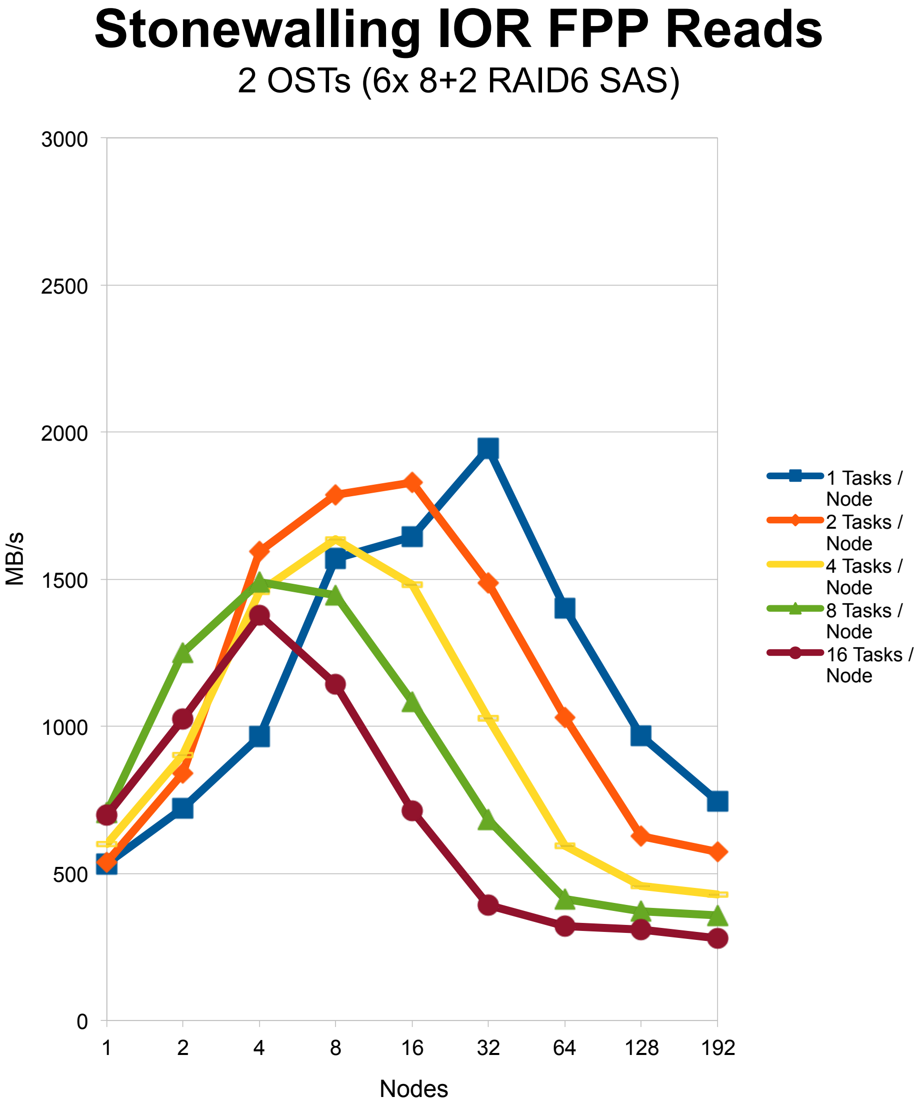
Work underway to land remaining Orion changes to master

- Utilities cleaned up for consistency between ZFS & ldiskfs
- MGS can run on ZFS
- llog functionality now landed
- MDD, LOD, OSP, quota landings underway

Will test commits to master branch with ZFS and ldiskfs

Preliminary Performance Results (1/384 scale)

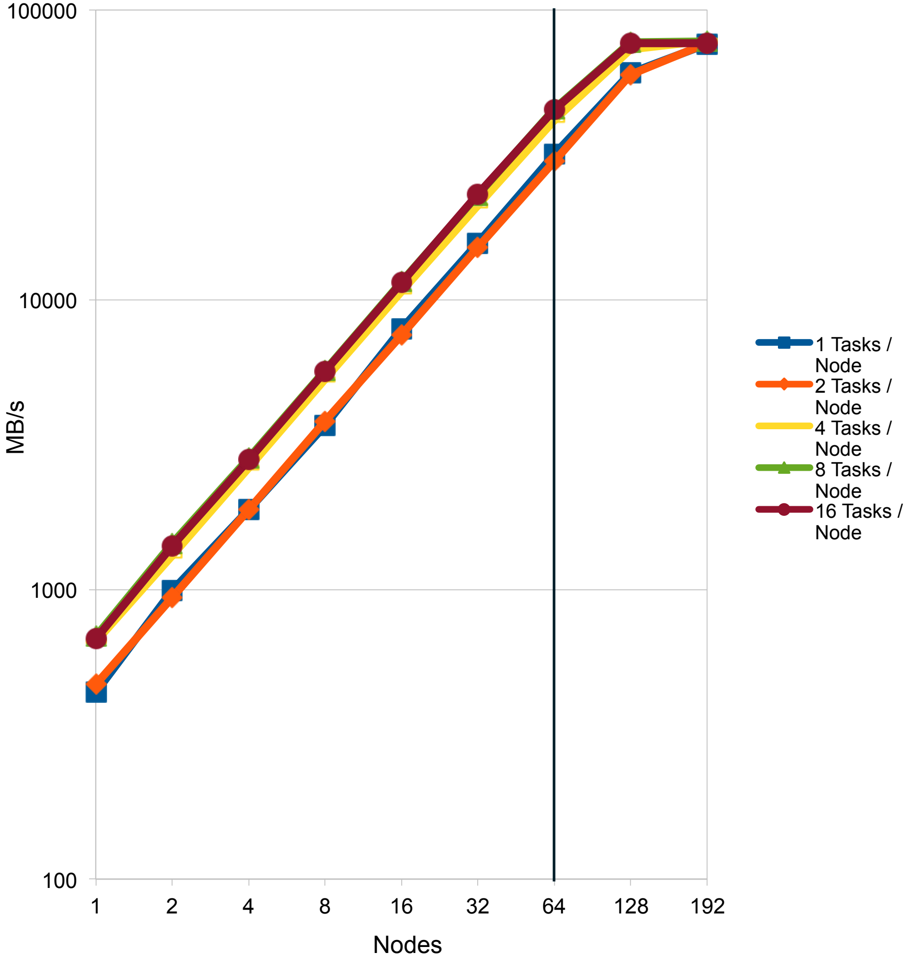




Preliminary Performance Results (1/12 scale)

Stonewalling IOR FPP Writes

64 OSTs (192x 8+2 RAID6 SAS)



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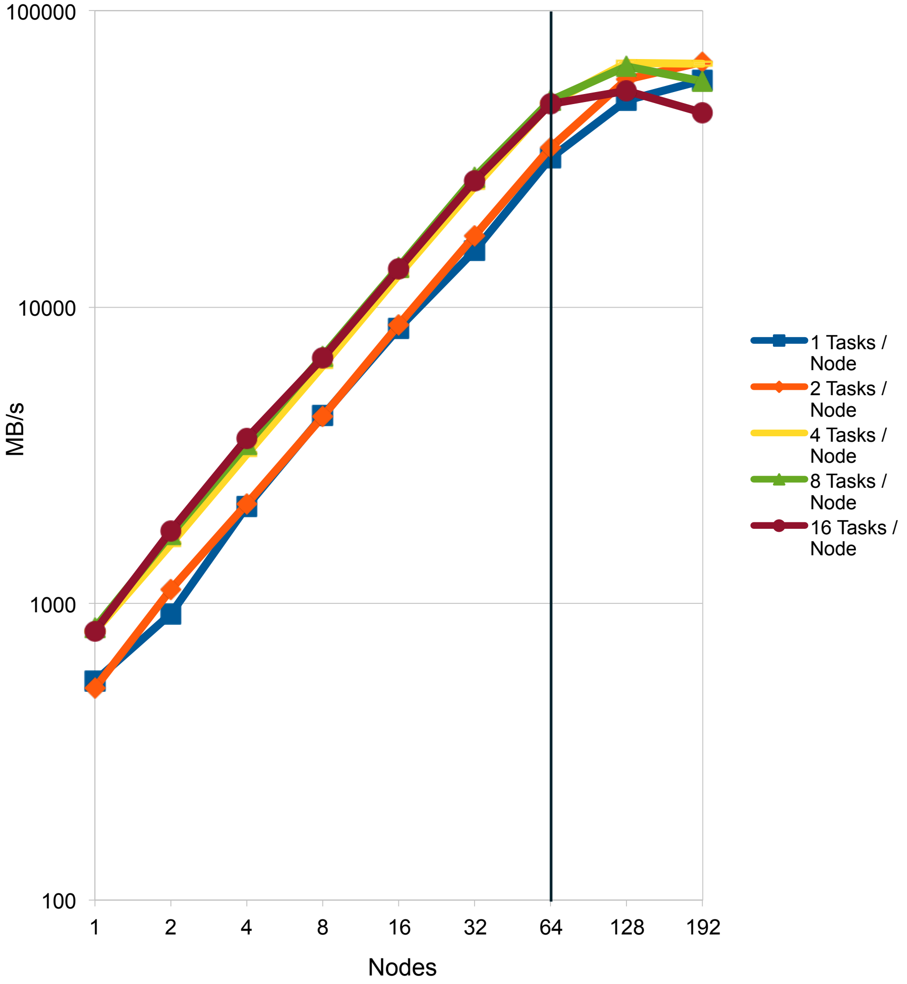


Future Lustre/ZFS Development

ZFS object iterator for online LFSCK

Performance investigation and tuning

- Allow up to 1MB ZFS block size to match Lustre RPC size
- osd-zfs ZFS Intent Log (ZIL) flash write cache integration
  - Allow fast synchronous IO operations
  - Avoid need to wait for full ZFS transaction commit

ZFS fault management and automatic hot-sparing

Longer term - better Lustre integration

- Snapshot support (synchronization, namespace visibility)
- Common network/disk checksum

Operational Changes

Relatively few operational changes for ZFS

- Can create ZFS pool/dataset manually, or via mkfs.lustre
- Recommend one target per pool, MGS always in separate dataset

```
mkfs.lustre ... --backfstype=zfs test-mgs/mgs mirror /dev/sda /dev/sdb
mkfs.lustre ... --backfstype=zfs test-mdt0/mdt0 mirror /dev/sdc /dev/sdd
mkfs.lustre ... --backfstype=zfs test-ost0/ost0 raidz2 /dev/sd[a-j] raidz2 /dev/sd[k-t]
:
mount -t lustre test-ost0/ost0 /mnt/ost/ost0
```

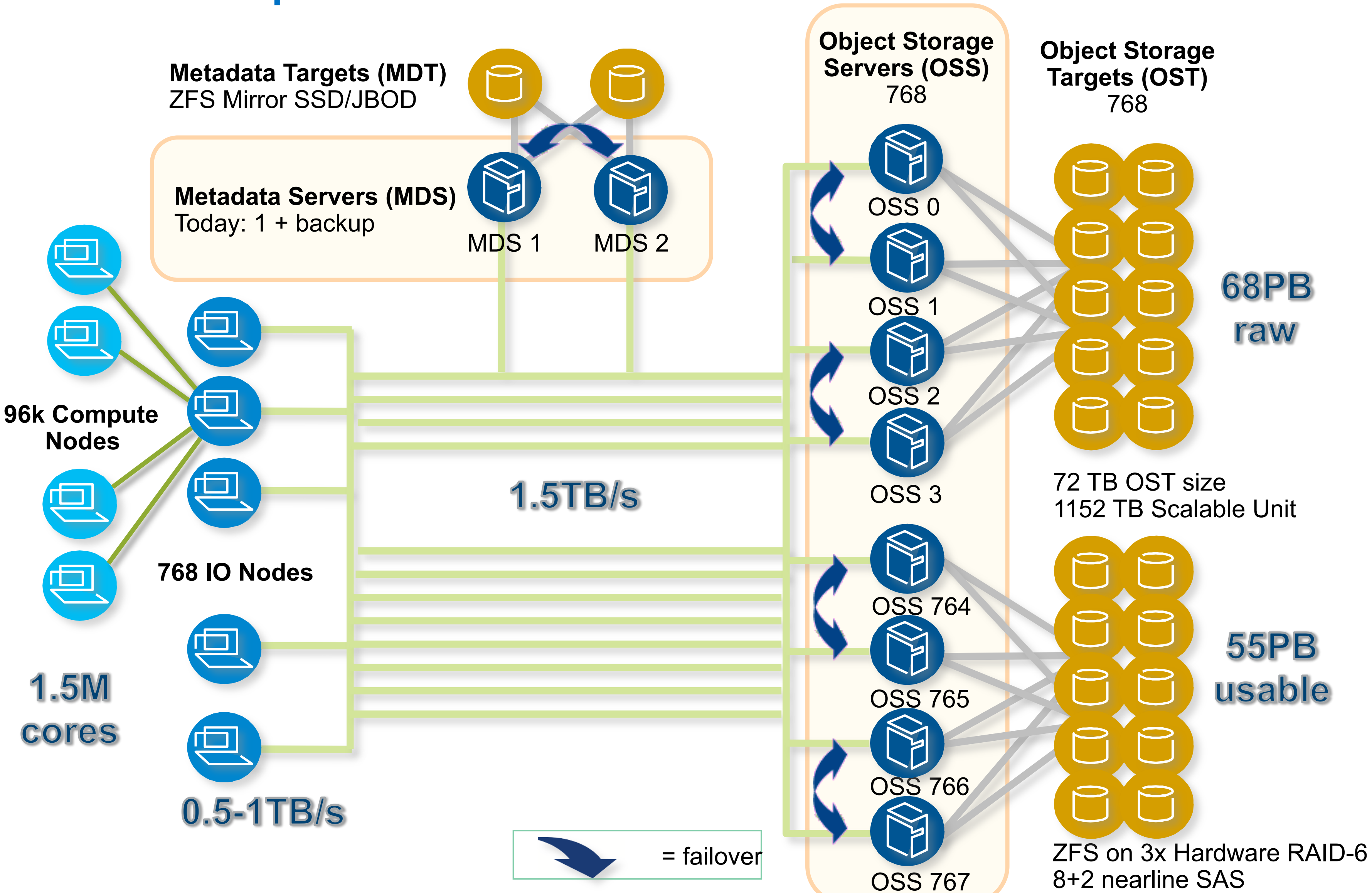
statfs/df blocks/inodes, quota data is not totally accurate

- Copy-on-write semantics make this impossible

No lfsck support for ZFS filesystems yet

Thank You

LLNL Sequoia Lustre Architecture



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