Lustre on ZFS

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Introduction

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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://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 $\leq$ 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
* Multiple OSD types (ZFS/Idiskfs) 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 & Idiskfs
• MGS can run on ZFS
• Ilog functionality now landed
• MDD, LOD, OSP, quota landings underway

Will test commits to master branch with ZFS and Idiskfs
Preliminary Performance Results (1/384 scale)

Stonewalling IOR FPP Writes
2 OSTs (6x 8+2 RAID6 SAS)

Stonewalling IOR FPP Reads
2 OSTs (6x 8+2 RAID6 SAS)
Preliminary Performance Results (1/12 scale)

Stonewalling IOR FPP Writes
64 OSTs (192x 8+2 RAID6 SAS)

Stonewalling IOR FPP Reads
64 OSTs (192x 8+2 RAID6 SAS)
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

Metadata Targets (MDT)
- ZFS Mirror SSD/JBOD

Metadata Servers (MDS)
- Today: 1 + backup
- MDS 1
- MDS 2

Object Storage Servers (OSS)
- OSS 768
- OSS 0
- OSS 1
- OSS 2
- OSS 3
- OSS 764
- OSS 765
- OSS 766
- OSS 767

Object Storage Targets (OST)
- 68PB raw
- 55PB usable
- 72 TB OST size
- 1152 TB Scalable Unit
- ZFS on 3x Hardware RAID-6
- 8+2 nearline SAS

96k Compute Nodes

768 IO Nodes

1.5M cores

1.5TB/s

0.5-1TB/s

= failover