Burst Buffer and File Level Redundancy

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File Level Redundancy (FLR) goals

Software, network, hardware all contribute to Lustre data unavailability

- FLR should provide redundancy to Lustre file system
  - HA is no longer necessary for OSTs
  - Possible to be deployed on lower cost commodity hardware
  - Configurable redundancy level on per-directory or per-file basis
- Based on Progressive File Layout (PFL)
  - A file replica is composed of one or more PFL components
- Superb I/O performance
  - Write is as fast as for non-FLR files
  - Aggregate read performance is scalable to the number of replicas
- POSIX compliance

FLR Development and Release Plan

Phase 0: Composite Layouts from PFL project (2.10)

Phase 1: Delayed writing mirroring - depends on Phase 0 (2.11)

Phase 2: Immediate write mirroring - depends on Phase 1

Phase 3: Integration with policy engine/copytool - needs Phase 1

Phase 4: Erasure coding for striped files - depends on Phase 2

FLR Development Status

Targeting to land Phase 1 to 2.11

Redundant read

- Data can be read from any available replica
- Client and layout policies to determine which replica to read

Write is partially redundant

- Lustre needs to pick one available replica to write
  - what if the just picked replica becomes unavailable?
- Data will be resynchronized among replicas asynchronously
- Not necessary to resync entire replica, FLR will synchronize modified components only

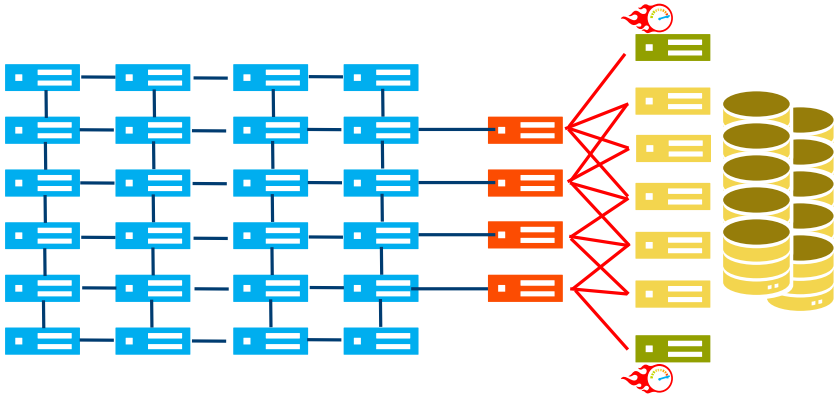
FLR DEMO

FLR use cases

FLR is a fundamental technology that multiple use cases can build upon:

- Multi-tiered storage with preferred read replica
  - SSD OSTs as the first tier and HDD OSTs as the second
  - HDD OSTs will be accessed only when the SSD OSTs are out of reach
  - Pre-stage data before job start for reads
- Burst buffer with preferred write replica
  - NVMe OSTs for fast checkpoint write for HPC
- Increase parallel read performance for many-client reads
- Play it for fun – what a nerd!

Burst buffer market landscape and requirements



- Checkpoint and restart
- File alignment and block alignment
- Staging and demand loading
- Protect from latency bound applications
- Out-of-Core I/O
- Data analysis support

- Several commercial offerings
- Start to be included as requirement in tenders

FLR Based Burst Buffer Solution

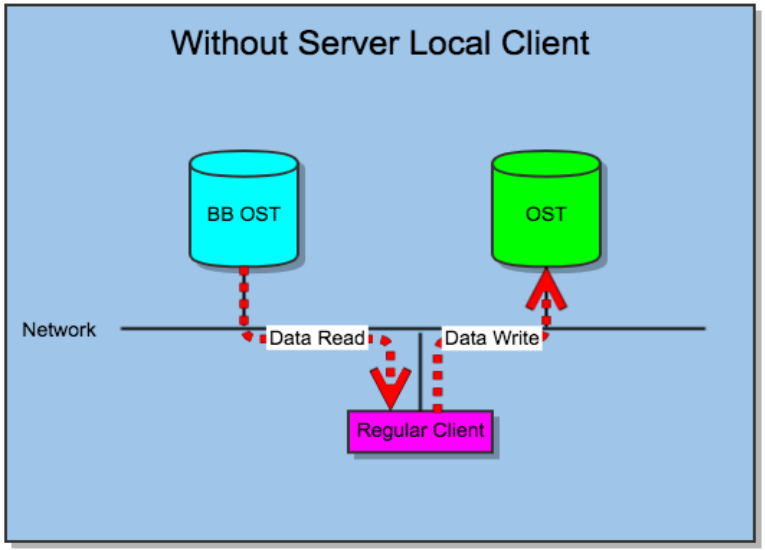
- Benefits of FLR based burst buffer
  - Based on existing mature and proven technology
  - Burst buffer as OSTs in Lustre file system
  - Unified name space, easier for data management
- Data first go to burst buffer OSTs, then migrates to secondary OSTs in background
  - Workload on computing nodes can proceed while data is migrated
- Request burst buffer space on demand, reclaimed by deleting replicas from BB OSTs
  - Highly efficient prestage if checkpoint data are already on burst buffer OSTs
- Burst buffer capacity should be at least three times checkpoint size
  - One checkpoint writing, one checkpoint "safe", one checkpoint migrating

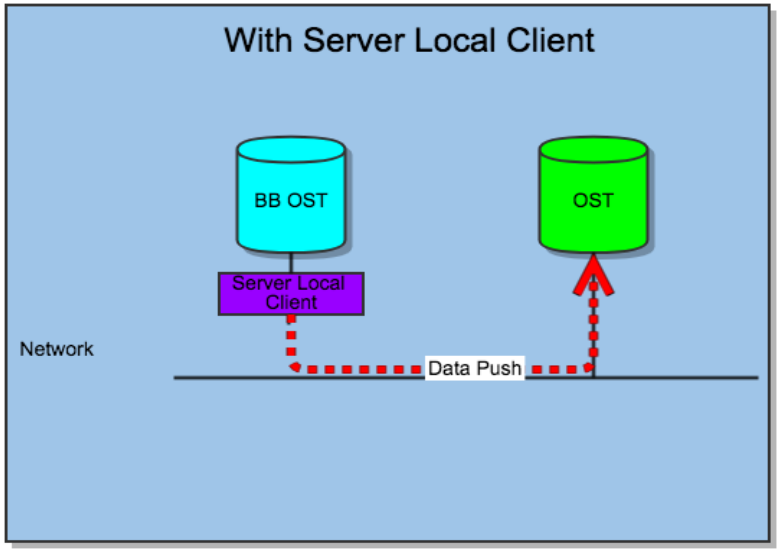
MDT Object Inventory (MOI) File

- Lustre depends on external databases for data management
  - Slow and painful access and update
  - Consistency between Lustre and database is always concerned
  - Limited by Lustre Changelog scalability
- Propose to maintain MOI files on MDTs that list all objects for each OST
  - MOI iteration to list all file FIDs for OSTs under recovery or evacuation
    - Should be as fast as reading a regular file on the MDT
  - No database needed for data management if iteration is fast and compact
    - Policy engine can still maintain in memory cache for optimization
  - Slight overhead on file creation and deletion

Server Local Client

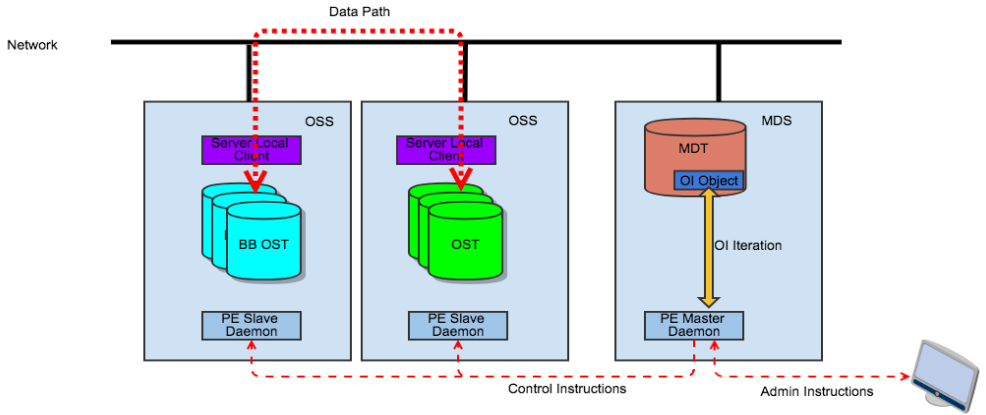
- High efficient data move engine between burst buffer and secondary OSTs
  - Use half of network bandwidth for data transfer, with minimum Lustre protocol overhead





Burst Buffer Policy Engine (PE)

- PE daemon for burst buffer running on each server node
  - No dedicated client node for PE
- Master daemon iterates MOI file
  - Get a list of files created/deleted on burst buffer OSTs
  - Instruct slave daemons for data move
- No database for PE
- Burst buffer command via PE master
  - Imperative data move
  - Burst buffer space monitoring
  - Prestage, etc



Conclusion and call to action

- The FLR technology will modernize Lustre
- Lustre will manage different storage tiers transparently for legacy applications
- Data protection/erasure code at filesystem level simplifies cloud adoption
- Data availability without HA software or multi-port storage
- Intel is supporting these innovations
- Feedback from FLR Phase 1 is welcome
- Intel is looking forward to FLR community adoption and contributions

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