CROSS-TIER UNIFIED NAMESPACE

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What this talk is about

- Multi-tier integration
  - Scale-out object store / DAOS
  - Parallel File System (PFS) / Lustre
- Expose unified namespace to end users
- Efficient dataset migration

What this talk is not about

- Burst buffers or transparent caching
- DAOS internals
  - Ping me separately if you are interested in the open-source DAOS project
- A comparison between Lustre and DAOS
Targeted Storage Architecture

- **Compute Nodes**
- **Gateway Nodes**
- **DAOS Nodes**
- **Lustre OSS & MDS Nodes**
- **PFS Tier**

- **Scale-out Object Store Tier**
- **Dataset Migration**

- DAOS Protocol
- I/O Forwarding Protocol
- Lustre Protocol

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Distributed Async Object Storage

HPC Workflow

DAOS Storage Engine
Open Source Apache 2.0 License

3rd Party Applications
Rich Data Models
Storage Platform
Storage Media

Relaxed POSIX I/O
HDF5
Apache Arrow
SQL
...

PMDK
SPDK

SCM
NVMe

Control Plane
Data Plane

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Distributed Async Object Storage

3rd Party Applications
- Rich Data Models
  - Relaxed POSIX I/O
  - HDF5
  - Apache Arrow
  - SQL
  - ...
Unified Namespace Concept

Regular Lustre directories & files
- HDF5 Container
- DAOS POSIX Container
- DAOS MPI-IO Container

/mnt/prod
  ├── users
  │   └── Buzz
  │       └── .shrc
  │       └── moon.mpg
  ├── libs
  │   ├── mkl.so
  │   └── hdf5.so
  └── projects
      ├── Apollo
      └── Gemini
          └── Simul.out
              └── EA:CUUID

          └── Result.dn
              └── EA:CUUID

          └── Simul.h5
              └── EA:CUUID

          for file/dir with special extended attribute (EA)
What’s really stored in the PFS?

Regular Lustre directories & files
- HDF5 Container
- DAOS POSIX Container
- DAOS MPI-IO Container

```
/mnt/prod
  users
    Buzz
      .shrc
      moon.mpg
    mkl.so
    hdf5.so
  libs
  projects
    Apollo
    Gemini
      Simul.h5
      Result.dn
      Simul.out
      EA: CUUID
      EA: CUUID
      EA: CUUID
```

Empty file/dir!
Unified Namespace Implementation – POSIX IOF

- HDF5
- Apache Arrow
- Interception Library
- DAOS POSIX
- POSIX I/O Forwarding FUSE Daemon

Compute Node

- DAOS Client Library
- DAOS

Gateway Nodes

- POSIX I/O Forwarding Service
- Lustre Client
- Lustre
Use Case: Readdir Lustre Directory

1. readdir

2. lookup (intent=readdir)

3. getxattr

4. readdir results

DAOS

Lustre protocol

FUSE
demon

System call
Use Case: Readdir POSIX Container

1. readdir

2. lookup (intent=readdir)

3. getxattr

4. readdir (UUID)

5. readdir results

Application

IOF FUSE DAEMON

Lustre

DAOS

Lustre protocol

DAOS protocol

System call
Use Case: DAOS-aware I/O Middleware

1. getxattr
2. lookup (intent=getxattr)
3. return UUID
4. DAOS API (UUID)
Special File/Dir Representation

Regular Extended Attribute (EA)

- Portable
- Performance Impact
  - Extra EA fetch on every lookup
- Can't prevent Lustre file/dir from being created under the special directory

Special LOV EA

- Not Portable
- Minimal Performance Impact
  - No extra RPC
- Prohibit regular file/dir creation

---

```
Lustre Client                                MDTs
```

```python
fd = open(apollo/simul.out)
fgetxattr(fd, DAOS_EA)
```

```
Lustre Client                                MDTs
```

```python
fd = open(apollo/simul.out)
fgetxattr(fd, LOV_EA)
```
Specific data mover

- Format conversion
  - Middleware-dependent
  - Middleware-agnostic

- Explore how to use layout swap functionality

Integration with Lustre Client Container Image (CCI)

- Local /diskfs image mounted transparently on Lustre client
  - Written back to OSTs
  - High IOPS per client since MDTs not involved

- Accelerate migration of POSIX containers
Summary

Lustre change proposal

- Extend LOV EA
  - New layout type to point at external tier
  - Generic feature based on UUID
  - Can be integrated with any scale-out object stores
  - Opportunity to leverage layout swap functionality for cross-tier migration

- Effort tracked in LU-11376
  - Goal is to merge feature upstream
  - Feedback is welcomed!

Resources

- POSIX I/O Forwarding
  - https://github.com/daos-stack/iof

- DAOS
  - http://daos.io
  - https://github.com/daos-stack/daos

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