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Introduction to Lustre and Best Practices

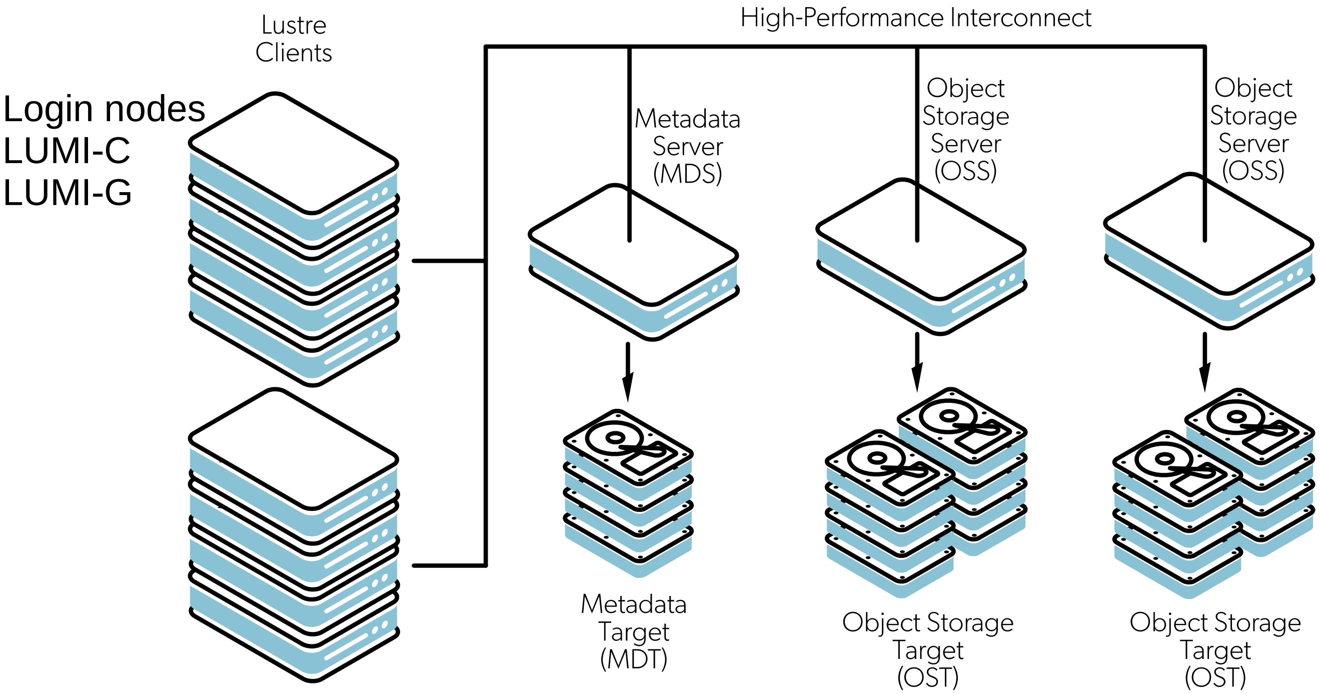
Lustre

LUMI has a highly parallel load

- Large amounts of data
- Compute and login nodes need access to storage
- Often multiple nodes require simultaneous read or write access to same data
- Danger of data corruption

Parallel file system to handle load

Lustre consists of 3 major functional units

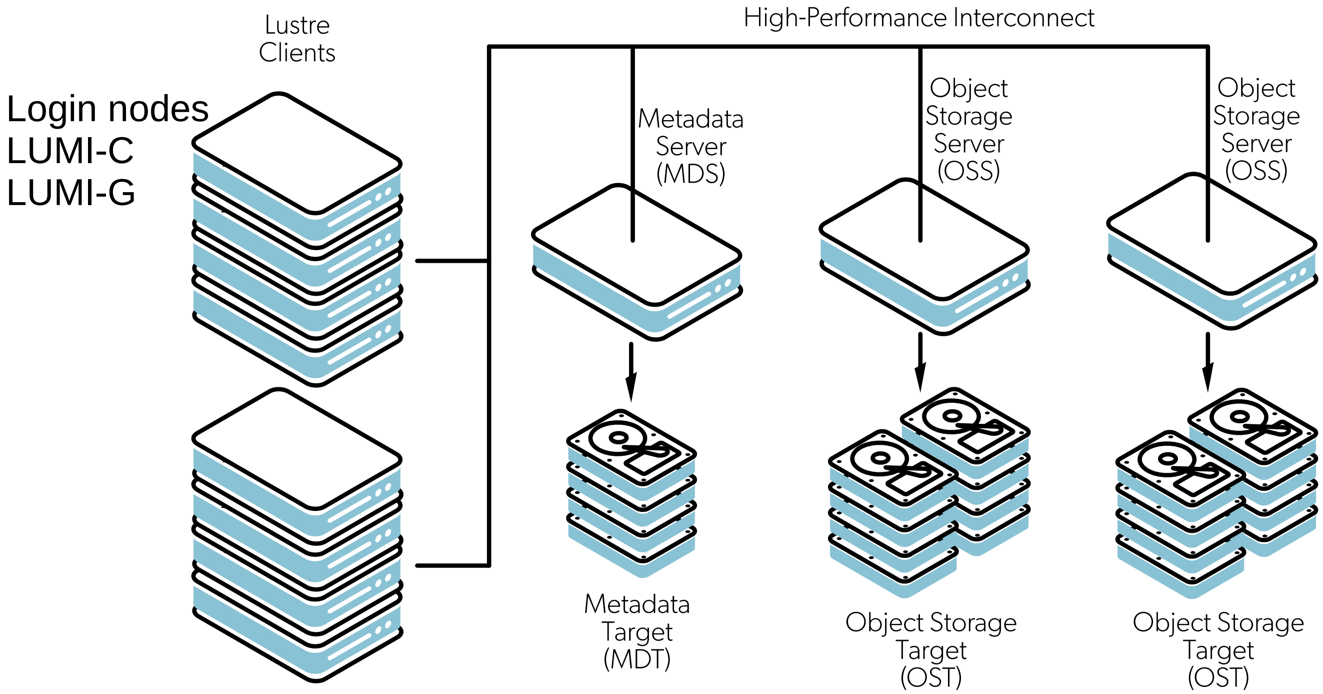


What steps happen when a file is accessed?

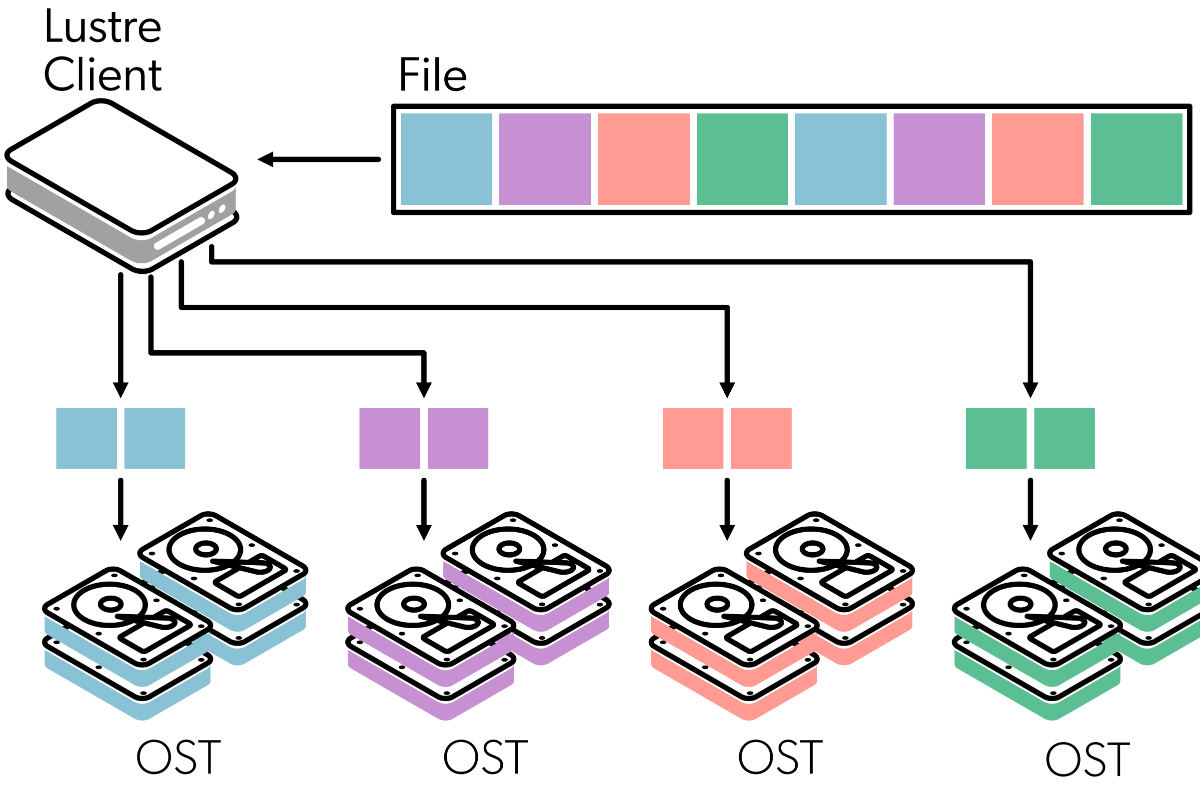
Client e.g. compute node wants read file

1. Client queries **Metadata Server** (MDS) for file
2. MDS returns location and layout
3. Client uses striping information to determine which **Object Storage Target** (OST) has which part of the file
4. Client requests file content from OSTs via **Object Storage Server** (OSS)
5. Data integrity it checked by client with checksums from OST

Lustre consists of 3 major functional units



Files are spread across multiple OSTs



Striping behavior can be adapted

Different tools to setting and displaying stripe properties

- `lfs setstripe` Set striping properties of a directory or new file
- `lfs getstripe` Return information on current striping settings
- `lfs df -h` Show disk usage of file system

Striping count and size are most important

Count: Number of OSTs to stripe over (0 default, -1 all)

- # files > # OSTs —> Set stripe_count = 1
  Reduce lustre contention and OST file locking and gain performance
- # files == 1 —> Set stripe_count = #OSTs or a number where your performance plateaus
  - Assuming you have more than 1 I/O client
- # files < # OSTs —> Select stripe_count so that you use all OSTs
  For example you write 8 files at the same time and have 32 OSTs, then select stripe_count=4

➡ Try to use all OSTs

Striping count and size are most important

Size: Bytes on each OST (0 filesystem default)

- No effect if stripe count is 1
- For large files
  - smallest recommended stripe size is 512 KB.
  - good stripe size is between 1 MB and 4 MB in most situations.
  - maximum stripe size is 4 GB but you should only use this value for very large files

Striping has to be set before file is created

```
jodietze@uan01:~> ls lfs.test
ls: cannot access 'lfs.test': No such file or
directory
jodietze@uan01:~> lfs setstripe -c 4 -S 2m lfs.test
jodietze@uan01:~> lfs getstripe lfs.test
lfs.test
lmm_stripe_count:  4
lmm_stripe_size:   2097152
lmm_pattern:       raid0
lmm_layout_gen:    0
lmm_stripe_offset: 10
obdidx    objid    objid    group
    10        110905348       0x69c4804             0
    12        110883990       0x69bf496             0
    14        110883882       0x69bf42a             0
    16        110888976       0x69c0810             0
```

Striping has to be set before file is created

```
jodietze@uan01:~> lfs setstripe -c 1 -S 1m lfs.test

lfs setstripe: setstripe error for 'lfs.test': stripe already set
```

Lustre is shared and finite

Metadata Storage Servers and Targets

- Are involved in many filesystem operations like creating, open, closing files
- Also queried everytime file attributes are looked up (e.g. with `stat` or `ls -l`)
- Are limited and can become bottleneck

For reading and writing OST are directly contacted

Some lustre **performance** tips

- Avoid stat() calls
- Open files read-only if that is the intention
- Read on rank-0 and broadcast instead of reading small files from every task
- Avoid very large directories
- Avoid appending to a file from many nodes (clients)

Many small files can be problem

- Slowdowns can occur when many (small) files are being opened
- Usually not restricted by bandwidth or actual file access latency
- But MDS is being flooded with request for files
- Especially installations and compilations can create hundreds of thousands of files
- Use archives or containers which are unpacked on compute node
- Special `lumi-container-wrapper` or `cotainr` for pip or conda environments

Storage on LUMI

LUMI has two storage systems

LUMI-P

- Disk based
- 4 independ Lustre file systems with each 20 PB
- Aggregated 240 Gb/s bandwidth

LUMI-F

- Solid-state (flash) based
- 8.5 PB
- 1740 GB/s bandwidth

LUMI has **four** storage areas

Area	Path	Quota	Files	Rention time
User home	`/users/<username>`	20 GB	100k	User lifetime
Project persistent	`/project/<project>`	50 GB	100k	Proj lifetime
Project scratch	`/scratch/<project>`	50 TB	2000k	90 days
Project flash	`/flash/<project>`	2 TB	100k	30 days

+ LUMI-O (object storage)

Weird errors → check your quota

Use `lumi-workspaces` to

- check for quota (file and size)
- see on which file system your home and project is located

Weird errors → check your quota

```
jodietze@uan02:~> lumi-workspaces
Quota for your projects:
Disk area                              Capacity(used/max)  Files(used/max)
----------------------------------------------------------------------
Personal home folder
Home folder is hosted on lustrep2
/users/jodietze                                  1,7G/22G         43K/100K
----------------------------------------------------------------------
Project: project_465000005
Project is hosted on lustrep2
/projappl/project_465000005                      4,1K/54G           1/100K
/scratch/project_465000005                       3,8G/55T          72/2,0M
/flash/project_465000005                         4,1K/2,2T          1/1,0M
----------------------------------------------------------------------
```

Temporary storage /tmp

- Compute nodes don’t have local disks/flash
- `/tmp` resides in memory
- Consumes space of your memory allocation
- Remember to allocate enough memory if you want to use `/tmp`

Conclusion

- Lustre achieves high performance through parallelism
  - Lots of bandwidth if used correctly
  - Metadata server can be a bottleneck
  - Striping options to optimize performance
  - Avoid large number of files
- LUMI has 4 storage areas with different quotas and lifetimes
- Check your quota with `lumi-workspaces`

LUMI

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