Using Comet File Systems

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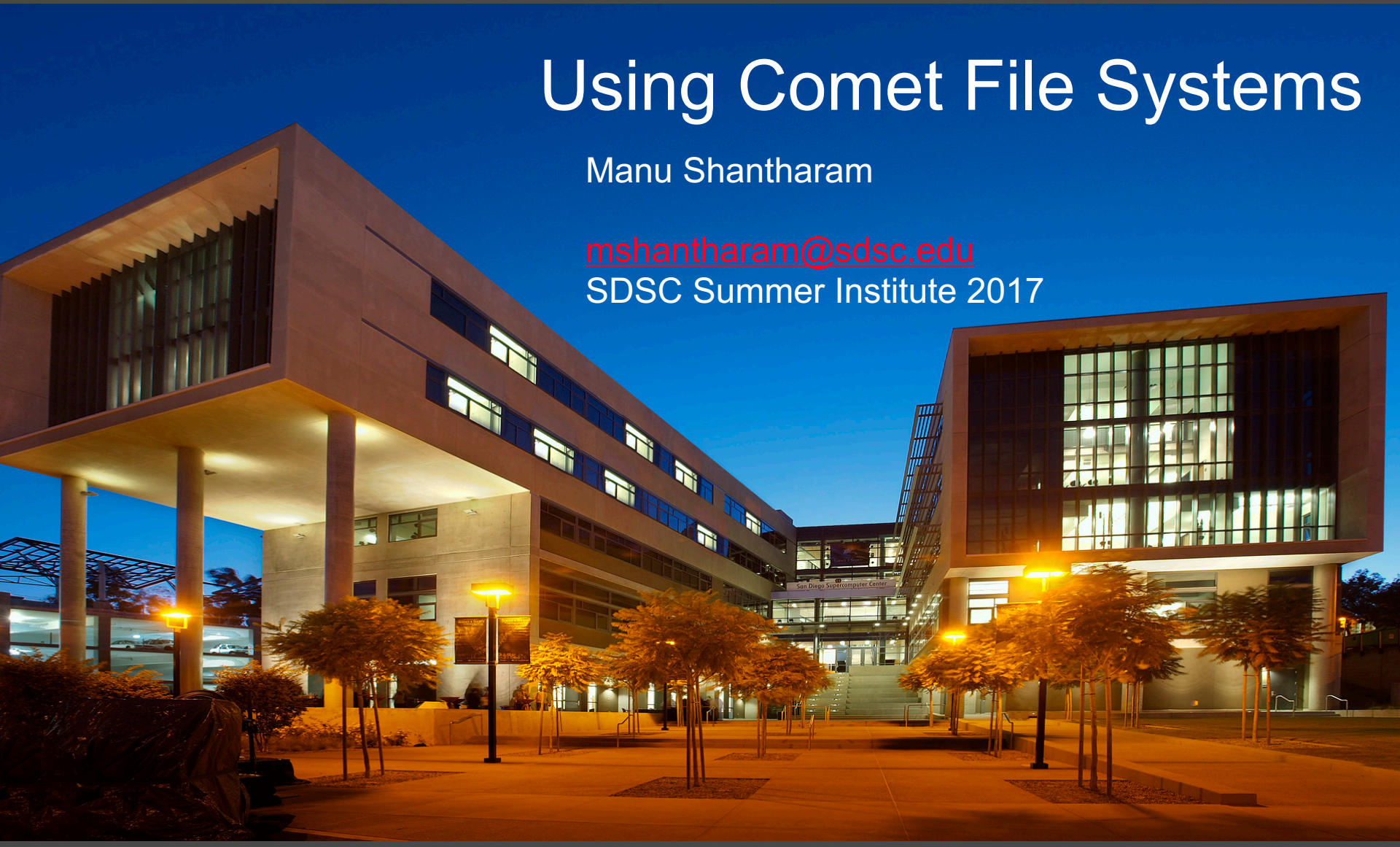


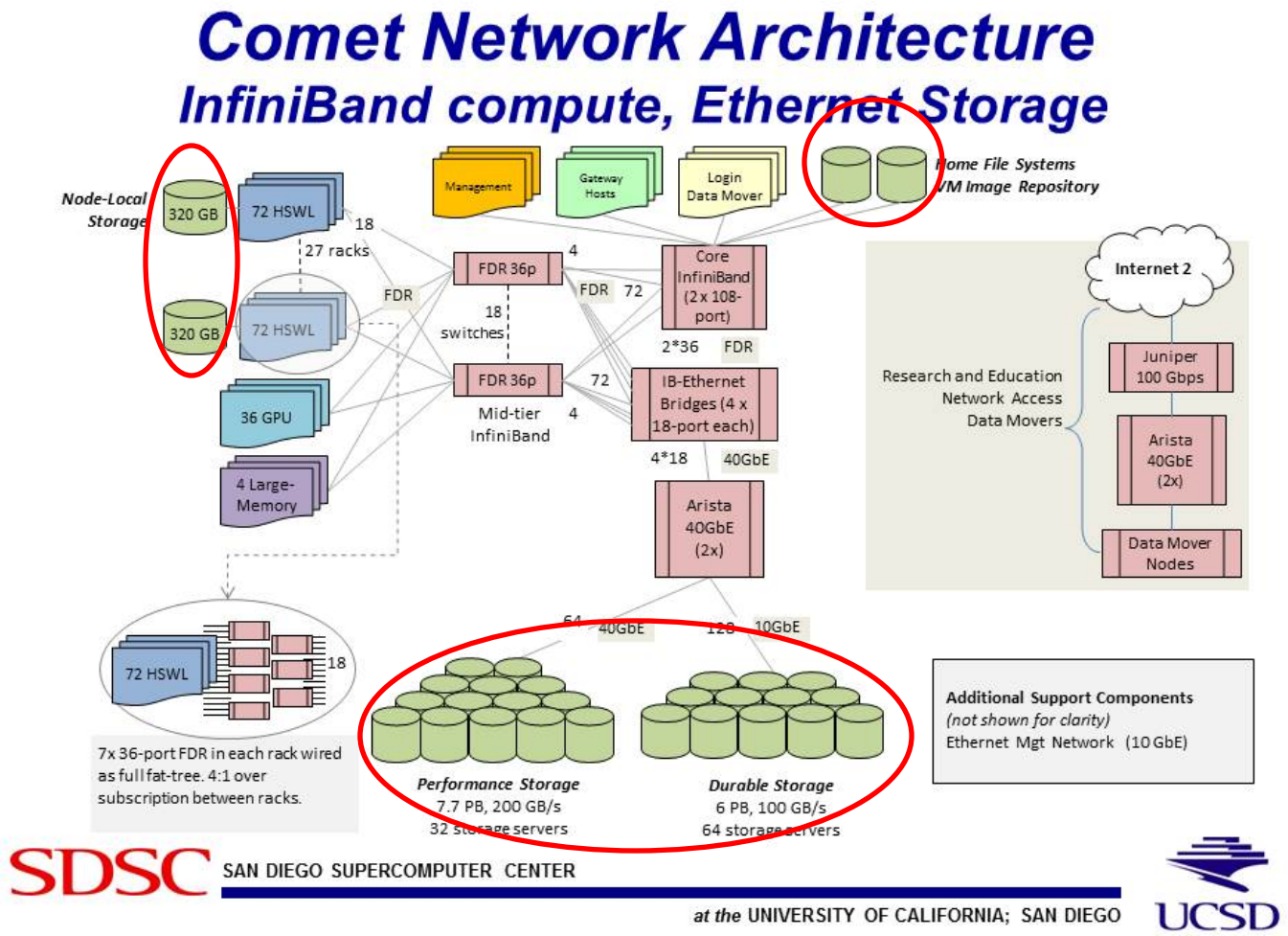
Why File Systems

- Out-of-core calculations generating 1000s of temporary files – genome sequencing
- Large shared file dumps due to checkpointing – weather forecasting codes
- Large number of files per process

A Cautionary Tale

http://www.youtube.com/watch?v=gDfLXAtRJfY&feature=youtu.be

Comet File System Overview



Why Various Filesystems

- Performance
- Shared access across nodes
- Backup / long-term
- Quota

Comet File Systems

Path	Purpose	User Access Limits	Lifetime
$HOME	NFS storage; Source code, important files	100 GB	Backed-up
/oasis/scratch/comet/$USER/temp_project	Global/Parallel Lustre FS; temp storage for distributed access	500 GB	No backup
/oasis/projects/nsf	Global/Parallel Lustre FS; project storage	~2.5 PB total	Backed-up
/scratch/$USER/$SLURM_JOB_ID	Local SSD on batch job node fast per-node access	210 GB per compute node, 286GB on GPU, Large memory nodes	Purged after job ends

Order of Magnitude Guide

Storage	file/directory	file sizes	BW
Local HDD	1000s	GB	100 MB/s
Local SSD	1000s	GB	500 MB/s
RAM FS	10000s	GB	GB/s
NFS	100s	GB	100 MB/s
Lustre/GPFS	100s	TB	100 GB/s

Local file systems are good for small and temporary files
(low latency, modest bandwidth)

Network file systems very convenient for sharing data between systems
(high latency, high bandwidth)

Application Focus

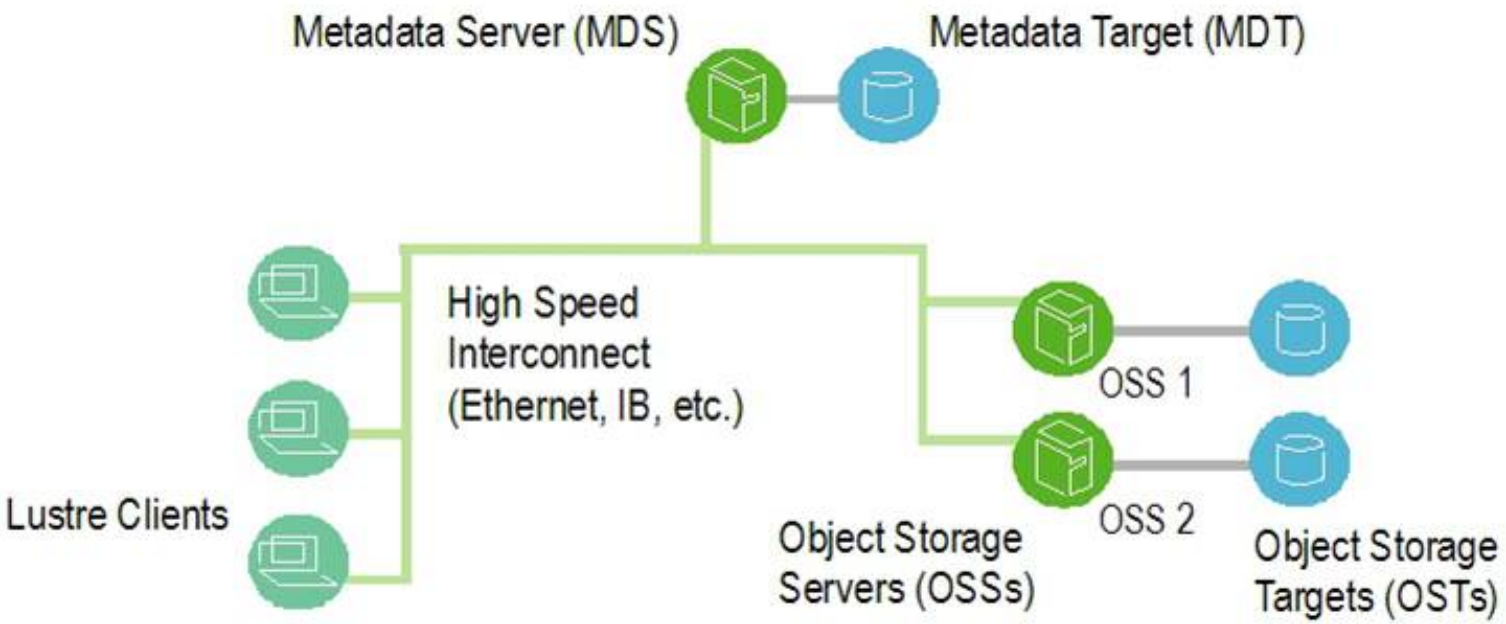
Storage choices should be driven by application need, not just what's available.

But, applications need to adapt as they scale.

Writing a few small files to an NFS server is fine…
writing 1000's simultaneously will wipe out the server.

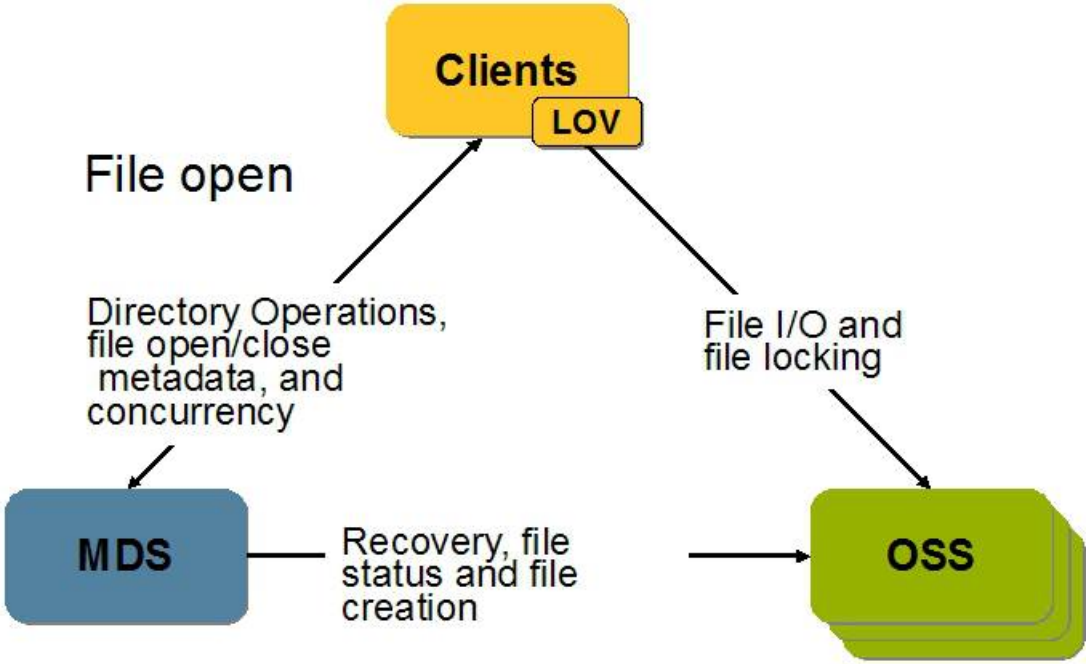
If you use binary files, don't invent your own format. Consider HDF5.

Lustre File System



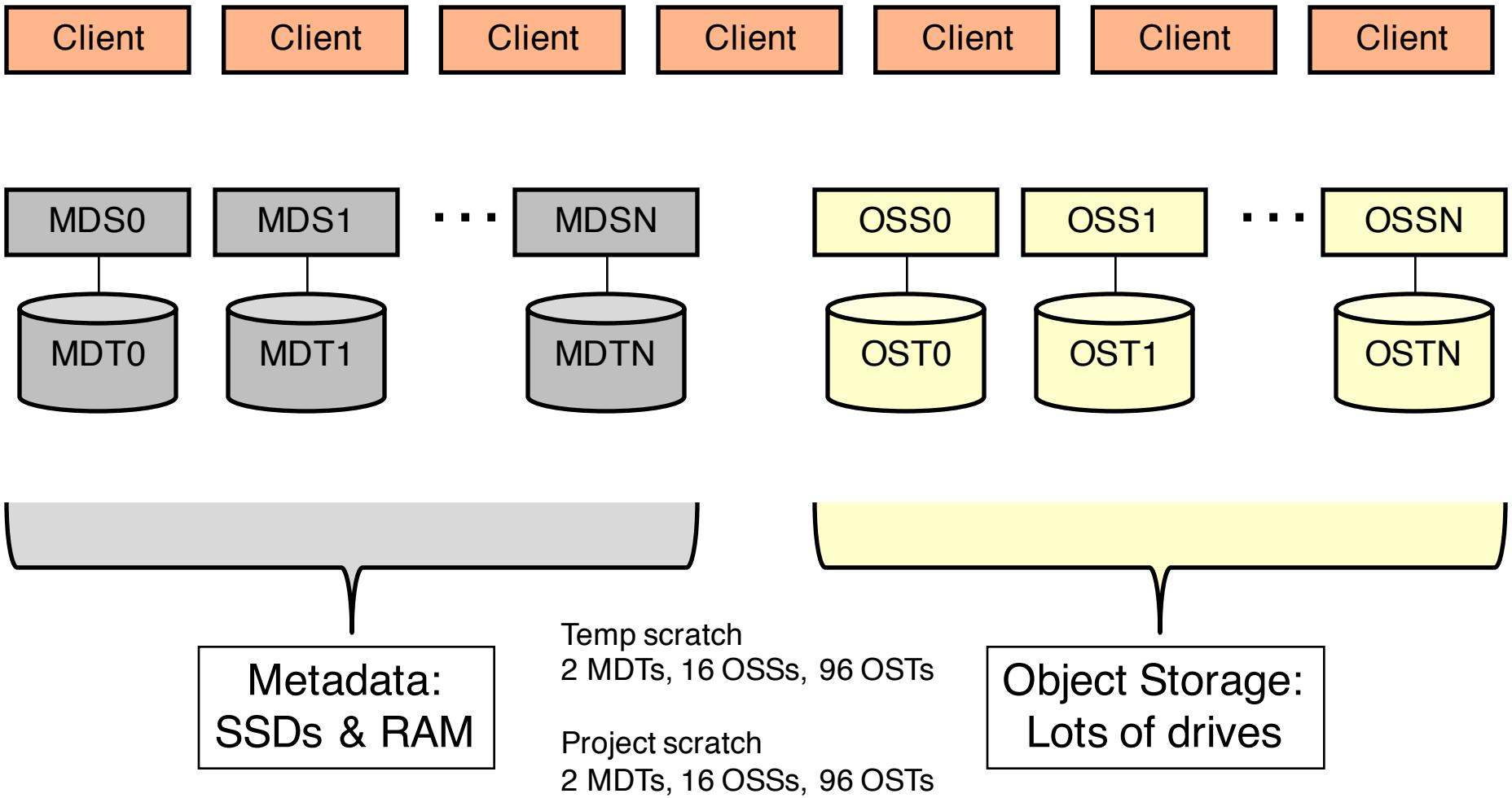
Ref: Cornell Virtual Workshop

LFS Interactions



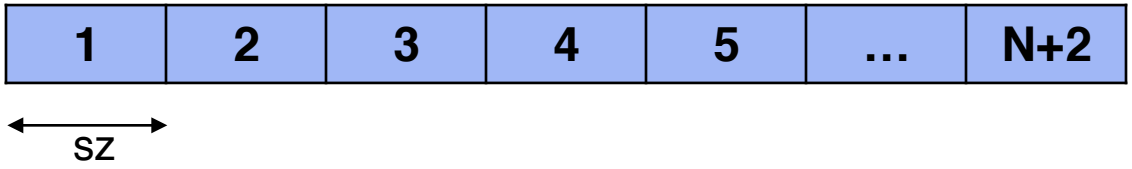
Ref: Cornell Virtual Workshop

A Typical LFS



File View

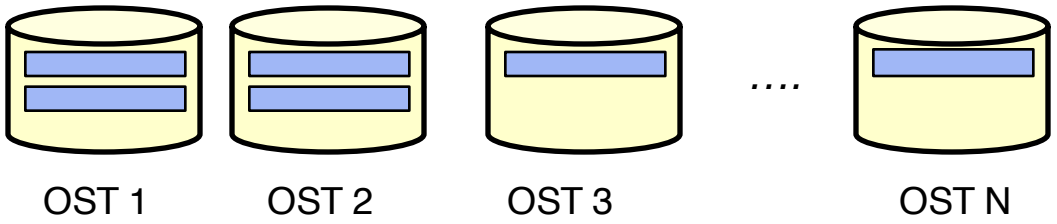
Logical view of a file with N+2 segments



Stripe count = N

Stripe size = sz

Physical view of the file across OSTs



Why is striping useful?

- a way to store a large file
- file can be accessed in parallel, increasing the bandwidth

LFS Commands

lfs help – lists all options

lfs osts – lists all the OSTs

lfs mdts – lists all the MDTs

lfs getstripe – retrieves the striping information of a file / directory

lfs setstripe – sets striping information of a file / directory

LFS Commands: getstripe

```
-bash-4.1$ lfs getstripe testout
testout
lmm_stripe_count:   1
lmm_stripe_size:    1048576
lmm_pattern:        1
lmm_layout_gen:     0
lmm_stripe_offset:  43
              obdidx                 objid                 objid                 group
                  43               8979631               0x8904af                     0

-bash-4.1$ lfs getstripe --stripe-count testout
1
-bash-4.1$ lfs getstripe --stripe-size testout
1048576
```

LFS Commands: setstripe

lfs setstripe -c 16 testout

-bash-4.1$ lfs getstripe testout
testout
lmm_stripe_count: 16
lmm_stripe_size: 1048576
lmm_pattern: 1
lmm_layout_gen: 0
lmm_stripe_offset: 89

obdidx	objid	objid	group
89	9202813	0x8c6c7d	0
45	9819070	0x95d3be	0

.....

LFS Commands: setstripe

```
bash-4.1$ lfs setstripe -c -1 test1
bash-4.1$ lfs getstripe test1
test1
lmm_stripe_count:   96
lmm_stripe_size:    1048576
lmm_pattern:        1
lmm_layout_gen:     0
lmm_stripe_offset:  65
              obdidx                objid                objid                group
                  65              9738084           0x949764                    0
                  41              9153699           0x8baca3                    0
                                  ..............................
```

LFS Commands: setstripe

```
-bash-4.1$ mkdir dir
-bash-4.1$ lfs setstripe -c 4 dir
-bash-4.1$ vi dir/test
-bash-4.1$ lfs getstripe dir/test
dir/test
lmm_stripe_count:   4
lmm_stripe_size:    1048576
lmm_pattern:        1
lmm_layout_gen:     0
lmm_stripe_offset:  43
              obdidx                objid                objid                group
                  43              8979901           0x8905bd                    0
                  25             10609192           0xa1e228                    0
```

LFS Usage Guidelines

- Avoid certain operations
  - ls –l, ls with color, frequent file opens/closes
  - find, du, wildcards (ls *.out)
  - Why??
  - Try /bin/ls -U instead of ls -l
- Select appropriate stripe count / size
  - Best case selection is complicated
- Do not store too many files in one directory

LFS Performance Using IOR Benchmark

- IOR (Interleaved Or Random) developed at LLNL to benchmark/test parallel filesystems.
- Current version is very versatile (beyond what the name suggests).
- Test aggregate I/O rates using several I/O options including **POSIX, MPIIO, HDF5, and NCMPI.**
- Control several aspects of I/O to help mimic real applications:
  - Overall I/O Size
  - Transfer size
  - File access mode – single or file/task ….

IOR Options

IOR -h gives you all the options. Some important ones are:

-F : *write one file per task*

(without -F a single file is written)

-b : *blockSize – contiguous bytes to write per task*

-t : *size of transfer in bytes (e.g. 8, 4k, 2m, 1g)*

-w : *Only write a file (default is to write and read)*

-r : *Only read an existing file*

-i : *number of iterations*

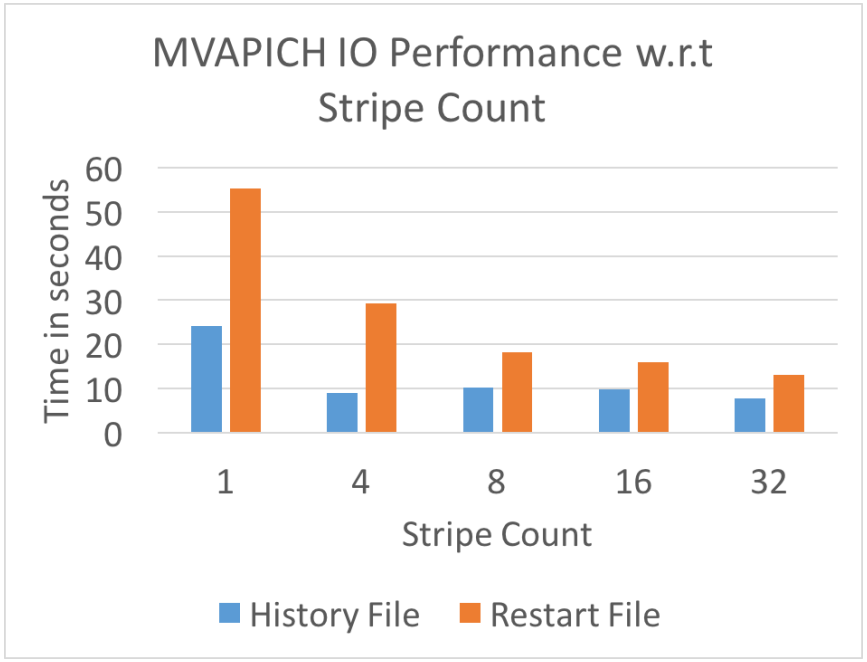
-B : *uses O_DIRECT for POSIX, bypassing I/O buffers*

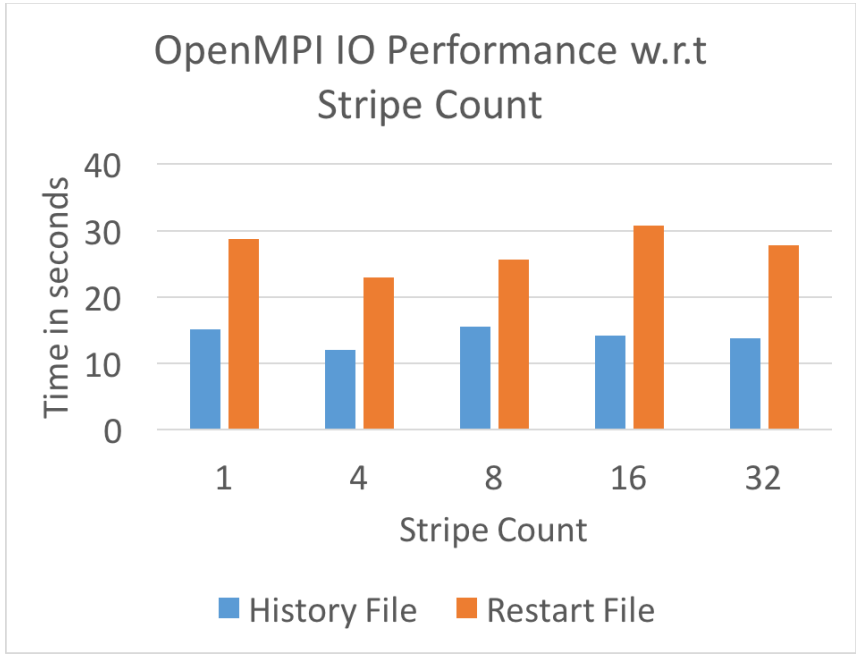
Command: mpirun -n 16 ./IOR.mpiio -a MPIIO -b 1g -w -k -t 1m -i 1 –o testfile

Case Study: WRF

- Weather Research & Forecasting (WRF) Model: collaboration between NCAR, NCEP, NRL and many other institutions
- Used for atmospheric research
- Different types of I/O within WRF
  - Reading from a large input file, writing forecast history files periodically, writing restart files periodically
- Various ways to perform I/O:
  - NetCDF file from task 0, PNetCDF, I/O Quilting – processors dedicated for output

I/O Performance vs Lustre Stripe Count
(240 cores)





Stripe count matters, need to carefully tune the libraries

Choosing

My application needs to:

Write a checkpoint dump from memory from a large parallel simulation.

I should consider:

A parallel file system and a binary file format like HDF5.

Choosing

My application needs to:

write and read 1000s of small files local to each process, store all the files across all the processes

I should consider:

a combination of local SSDs and Lustre!

Choosing

My application needs to:

Randomly access many small files, or read and write small blocks from large files.

I should consider:

RAM FS, or local scratch space.