# Using Comet Filesystems

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SDSC Summer Institute 2017

# Why Filesystems

# Basics

# Example I: an IOP

How long does it take to get or put a small amount of data?

- **What is "small"?**
  ~4k
- **From where?**
  - Case I: Network storage
  - Case II: Local SSD
  - Case III: RAM

**Dominant term:**
*Latency (Δt)*

**Case I:**
Δt = 5 ms

**Case II:**
Δt = 100 us

**Case III:**
Δt = 50 ns

# Example II: Moving a GB

**How fast can I move a GB?**

- **From where?**
  - Case I: Network storage
  - Case II: Local SSD
  - Case III: RAM
- **Dominant term:**
  Bandwidth
  Δd/s or GB/Δt

**Case I:**

Δd = 1-5 GB

Δt = 200 ms - 1 s

**Case II:**

Δd = 500 MB

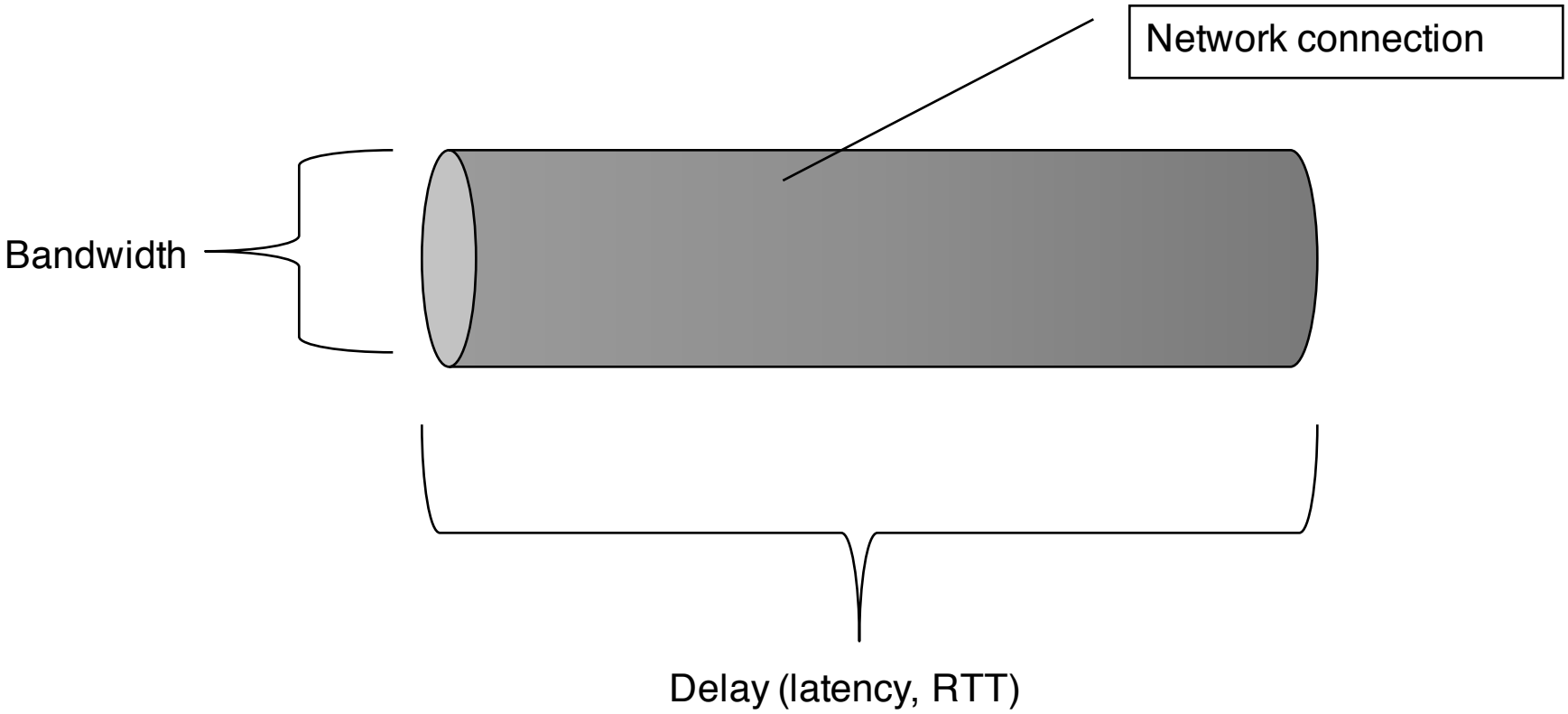
Δt = 2 s

**Case III:**

Δd = 50 GB

Δt = 20 ms

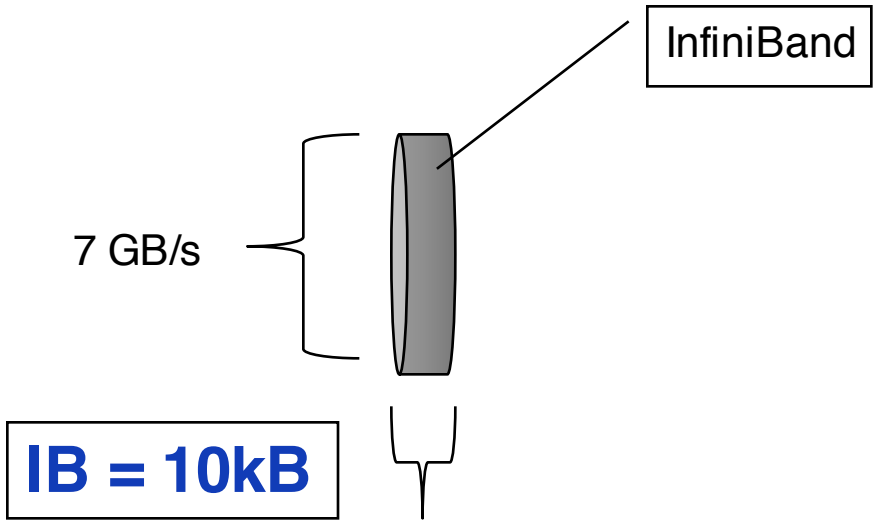
# Fancy Term: Bandwidth Delay Product

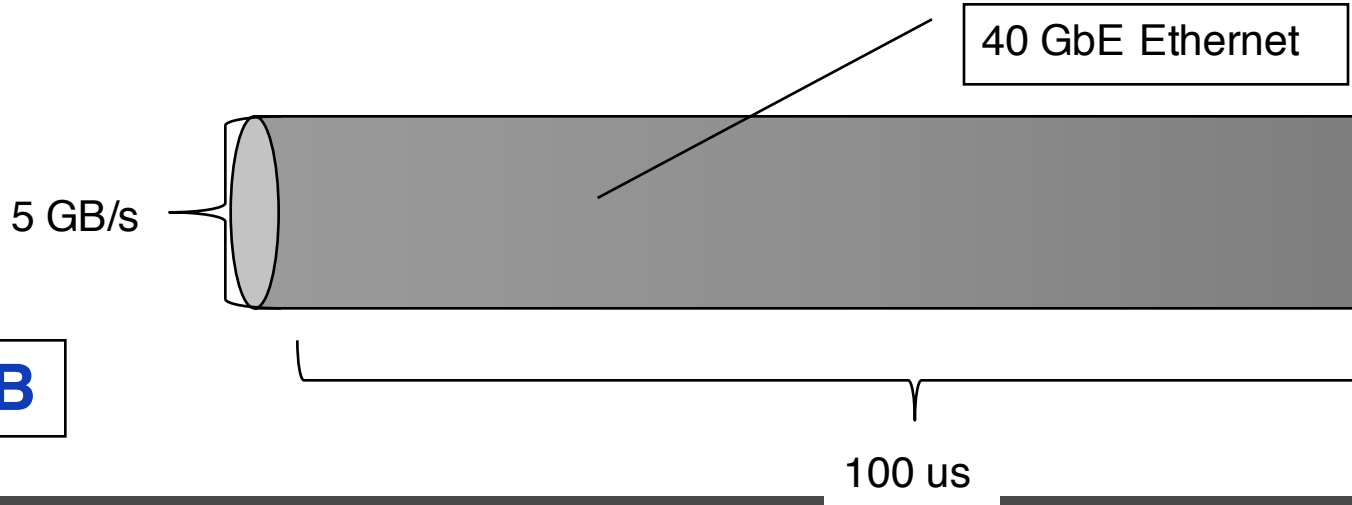



**BDP = Bandwidth x RTT**

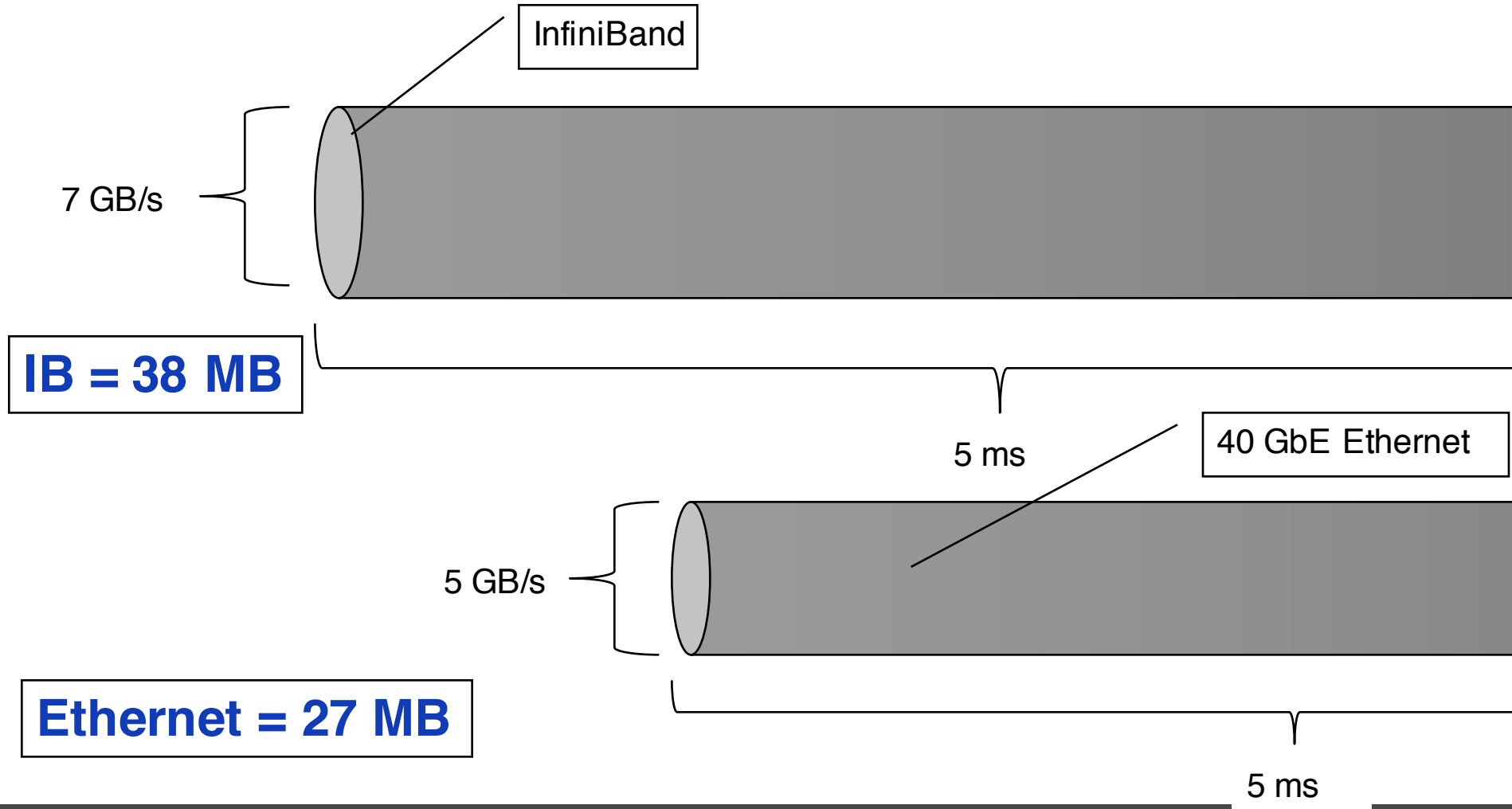
**How much data fits in the pipe.**

# Fancy Term: Bandwidth Delay Product



# BDP w/Drive Access



# The Lesson

If you ask for data over the network, ask for a lot!

# Corollary

If you don't need a lot of data, don't use the network!


# Dealing with Data: Choosing a Good Storage Technology for Your Application


# 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.

# Storage Technologies

## File Systems

- ext4
- ext4
- NFS
- Lustre
- GPFS
- FUSE

## Devices

- memory
- block

## Services

- HTTP(S)
- MySQL
- CouchDB
- memcached

# Storage Technologies

## File Systems

- ext4
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- NFS
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## Devices

- memory
- block

**Each has its own performance characteristics**

**Not all are available everywhere**

## Services

- HTTP(S)
- MySQL
- CouchDB
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# File Systems

**Classic access, POSIX, Windows**

**Most relevant:**

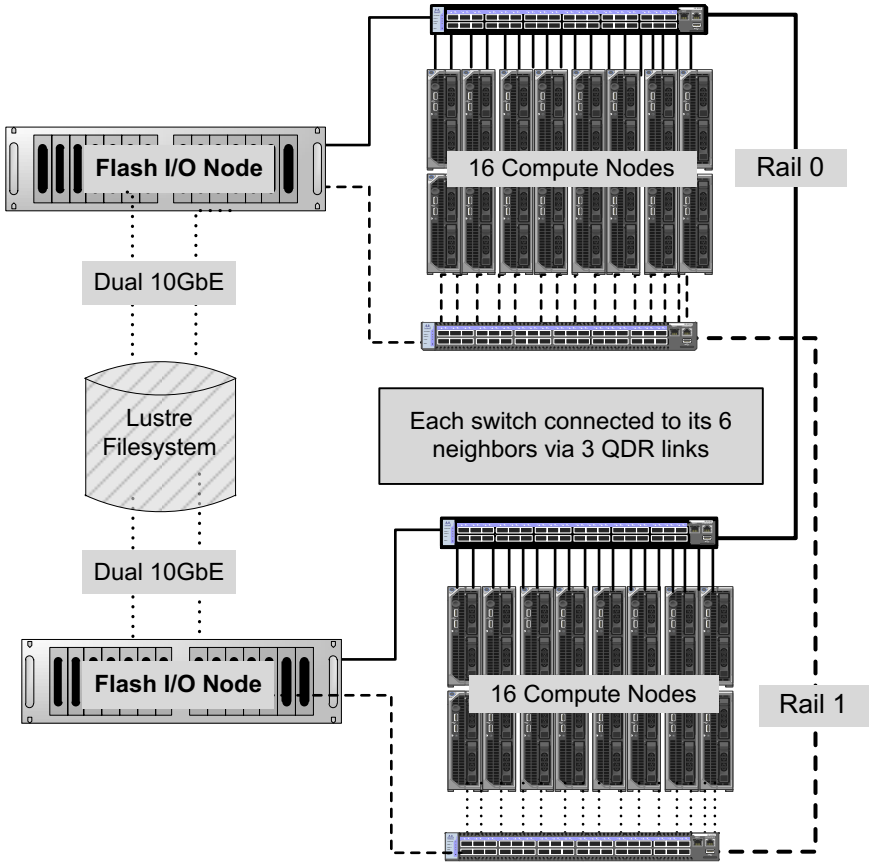
- Local
- Remote
  - NFS, CIFS
  - Parallel (Lustre, GPFS)

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

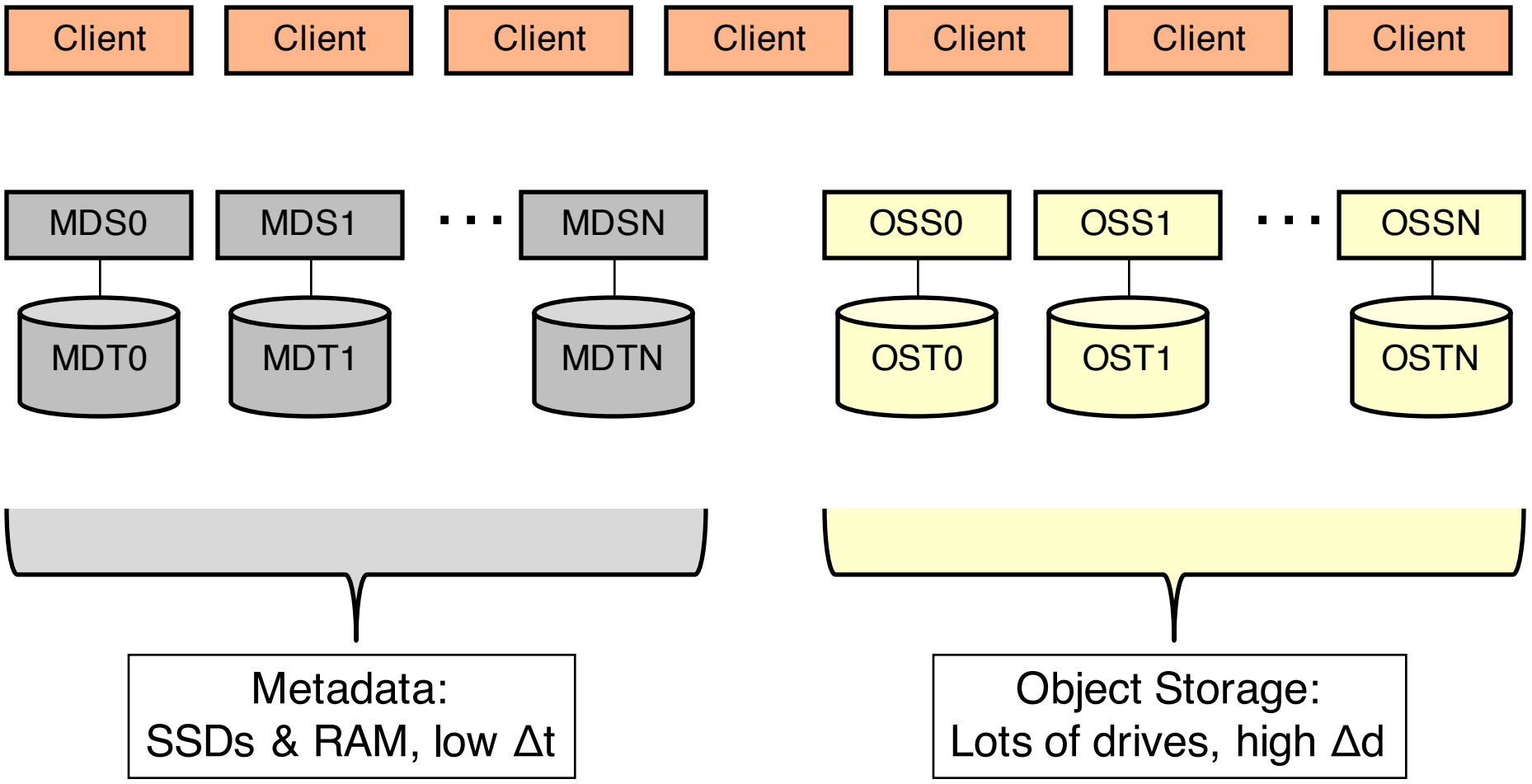
Network file systems very convenient for sharing data between systems
(high latency, high bandwidth)

# Comet Filesystem Overview

# Parallel File Systems



# Parallel File Systems



# A Cautionary Tale

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

# Devices

Raw block device (/dev/sdb) or RAM FS (/dev/shm)

Useful in specific cases, like fast scratch

Can be very good for small I/O

# Services



Things accessed programmatically

Frequents the last thought for HPC applications: A MISTAKE


Databases
Cloud storage (Amazon S3)
Document storage (MongoDB, CouchDB)

# Know What You Need

http://www.youtube.com/watch?v=F4OlDszDA9E

# Order of Magnitude Guide

| Storage | file/directory | file sizes | BW | IOPs |
|---|---|---|---|---|
| Local HDD | 1000s | GB | 100 MB/s | 100 |
| Local SSD | 1000s | GB | 500 MB/s | 10000 |
| RAM FS | 10000s | GB | GB/s | 10000 |
| NFS | 100s | GB | 100 MB/s | 100 |
| Lustre/GPFS | 100s | TB | 100 GB/s | 1000 |
| Cloud | Infinite | TB | 10 GB/s | 0 |
| DB | N/A | N/A | N/A | 10000 |

# 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:**

Run analysis on remote systems and return the results to a web portal for users.

**I should consider:**

Cloud storage for results and input, and local scratch space for the job.

# Choosing

**My application needs to:**

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

**I should consider:**

A database, RAM FS, or local scratch space.

# Step #3: Loading Data

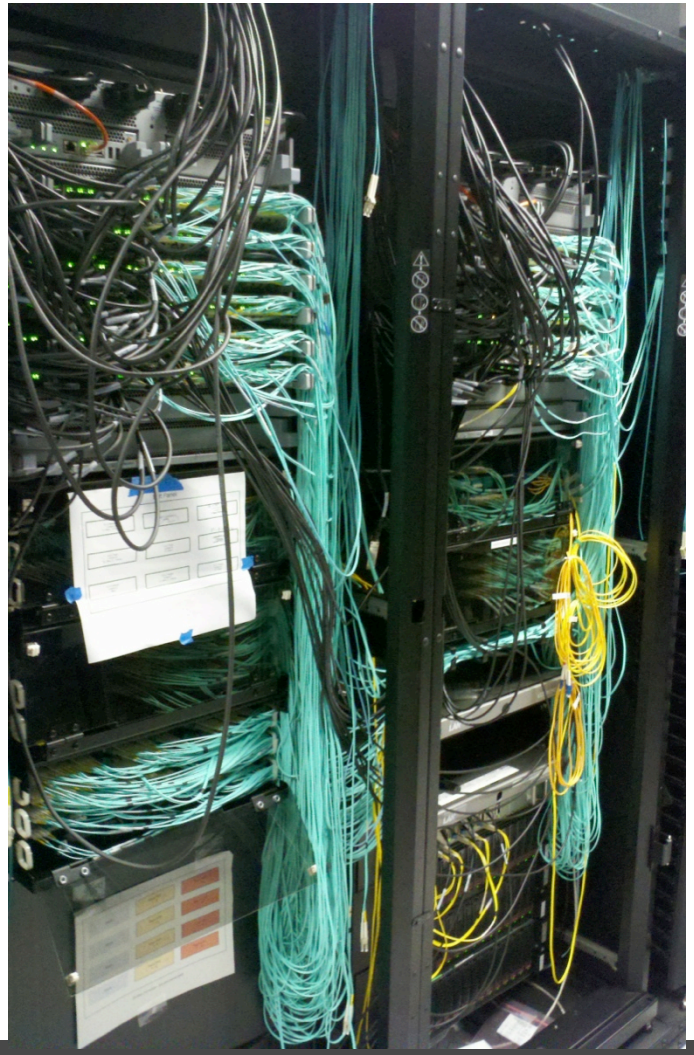
- **Input: raw reads from 438 full human genomes**
  - 50 TB of compressed, encrypted data from Janssen
  - 4,230 files (paired-end .fastq.gz)

***How do you get this data into a supercomputer?***

***They don't exactly have USB ports***

***Pictured: 2 of 12 Data Oasis racks; each blue light is 2x4 TB disks***

# Loading Data via Network



## External

- 60 Gbit/s connectivity to outside world
- 100 Gbit/s connection installed and being tested

## Internal

- 60 Tbit/s switching capacity
- 100 Gbit/s from Data Oasis to edge coming in summer

## Gordon

- 20 Gbit/s from IO nodes to Data Oasis
- 40 Gbit/s dedicated storage fabric (IB)

**Pictured: 2x Arista 7508 switches, core of the HPC network**

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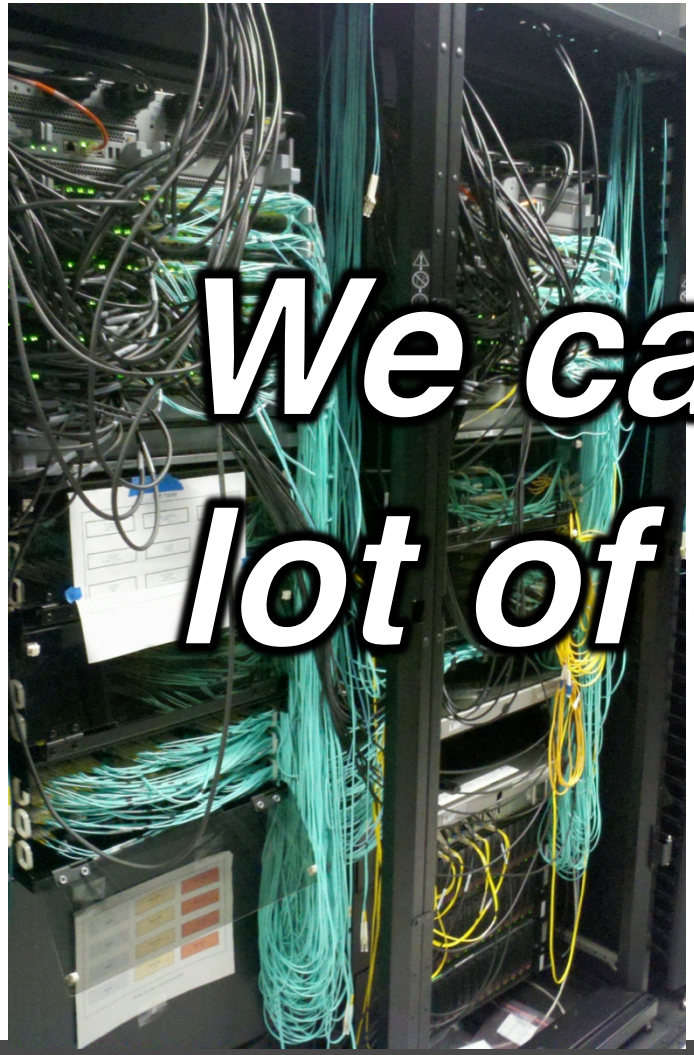

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**We can move a lot of data**

# “Hands-on”