Fermilab Storage Experience (and planning)

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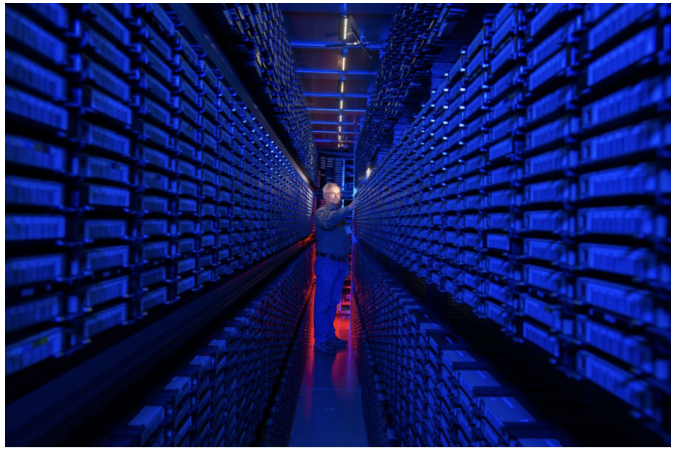
Current storage landscape at Fermilab

- Custodial and active storage for all Fermilab experiments' scientific data
  - This includes considerable storage for "external" experiments/projects (e.g. CMS and DES)

- Utilizing a tape+(spinning) disk HSM
  - Tape managed by Enstore (Fermilab)
  - Disk managed by dCache (DESY+Fermilab+NDGF)

- **264 PB** of tape in use (226 PB active)



Storage infrastructure

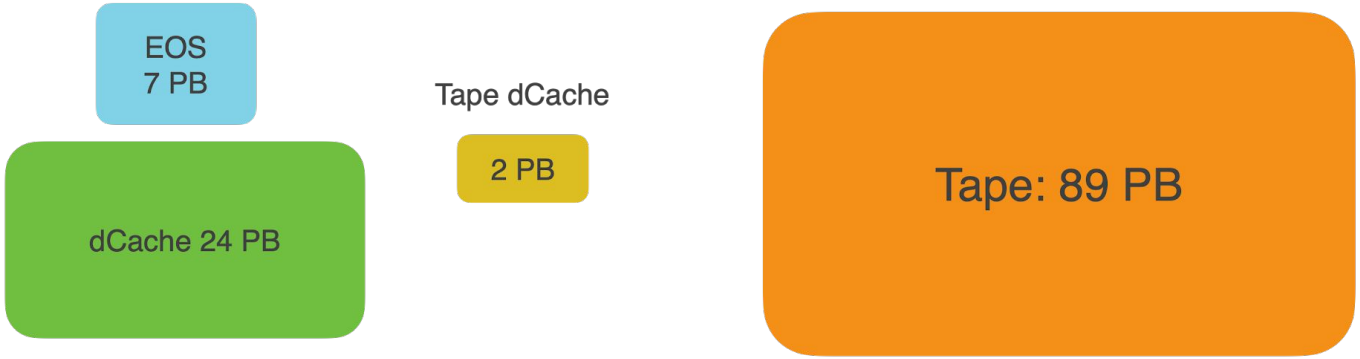
- Two major storage “instances”
  - *Public*: neutrino (DUNE, SBN, etc), muon (g-2, mu2e), DES, LQCD, etc
    - Generally all projects/experiments except CMS and Tevatron
  - *CMS*: dedicated for CMS Tier 1 storage
    - Also managed: analysis-only EOS pool

- Dedicated hardware for each instance
  - Tape library complexes
    - Multiple 10k slot libraries (details later)
  - Multiple dCache pools
    - Commodity SAN configuration (storage servers+disk arrays)

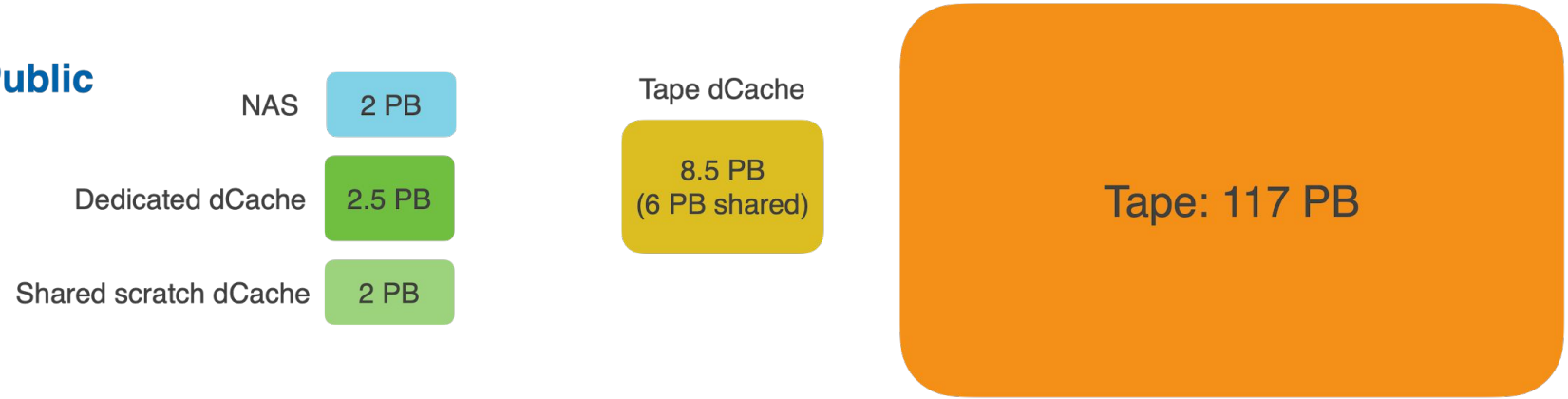
- **Resource allocation** and **use cases** differ considerably between the two

Storage infrastructure in a nutshell

CMS



Public



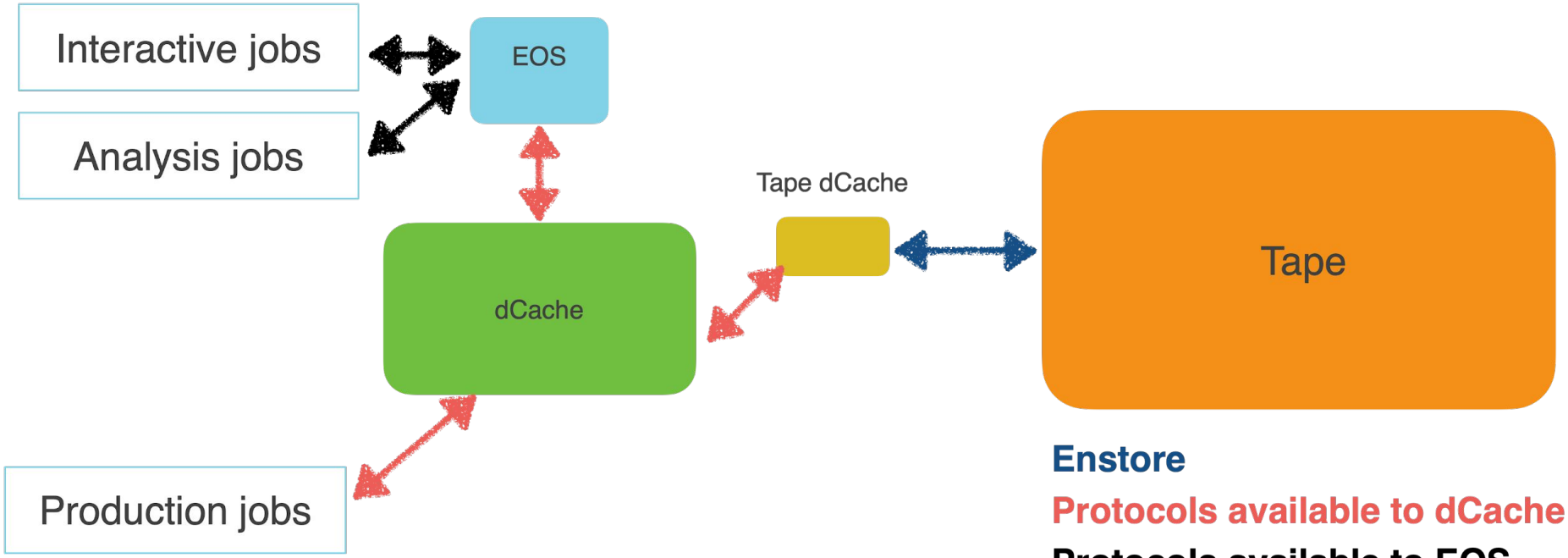
Fermilab

Archival storage at Fermilab today

- Current tape formats in use
  - **LTO-8:** 12 TB capacity, 360MB/s maximum drive speed (~4100)
  - **M8** (special LTO-7 format)**:** 9 TB capacity, 300MB/s max drive speed (~10400)
  - **T10000C/D:** 5.4/8.5 TB capacity, 250MB/s max drive speed (~18500)
    - Being **migrated** to LTO-8

- Current tape infrastructure in use
  - **3 IBM TS4500:** ~10k slots per library
    - 96 LTO-8 drives
  - **2 Oracle/Storagetek SL8500:** ~10k slots per library, 2 per library complex
    - About 90 10kC and D drives
    - To be retired
  - **Preparing for a sixth library in 2021**

CMS storage at Fermilab (today)



Fermilab

Ongoing issues/concerns/inefficiencies

- Files currently recalled and written essentially at random
  - Hundreds of datasets being transferred to write to tape simultaneously at any given time from dozens of sites across the world
    - Placed in tape families, but data arrives when it arrives.
  - Data recalled as needed by jobs
  - Data rarely streaming from tape
    - Swapping cartridges frequently, often to only read single files

- Currently in process of migrating about **50 PB** of data from SL8500 library purchased in 2010 to newer TS4500 library.
  - Process takes years.

Archival storage at Fermilab for the HL-LHC

Assumptions drawn from ESNet requirements document

- Annual data volumes for Run 4 to tape
  - 364 PB RAW, 240 PB AOD, 30(3) PB MiniAOD, 0.24(5) PB NanoAOD: **695 PB**
  - Assume 40% to Fermilab/US: **279 PB**
- Required data throughput: **400 Gbps**
  - read/write total?

Assumptions about future formats

- **LTO-9** (available now)
  - 18 TB tape capacity
  - 400MB/s max throughput
- **LTO-10** (extrapolating, ~3 years)
  - ~36 TB tape capacity
  - ~500MB/s max throughput
- Similar exercise can be done for IBM enterprise

Trying to meet HL-LHC requirements

- Data: 279PB annually
  - 23k LTO-8, 15.5k LTO-9, 7.8k LTO-10
  - **1-2 current-sized libraries per year**

- Throughput: 400Gbps (50GB/s)
  - Current Enstore efficiency achieves an average of 60% (~200MB/s) max throughput
  - LTO-8: 250 drives at avg, 140 at maximum
  - LTO-9: 208 drives at avg, 125 at maximum
  - LTO-10: 167 drives at avg, 100 at maximum

- *nb* maximum drives per library (regardless of frame count)
  - 125 for IBM TS4500, 144 for Spectra TFinity
  - Given number of drives required, min of 2 independent libraries will be required

Resources needed for Run 4 (~3 year run)

- Tape libraries (compare to current TS4500)
  - **2.5-4.5x** current slot capacity (2-3 independent libraries)
- Tape drives (compare to current LTO-8)
  - **7x** current average throughput
  - 4.5-6x current total drives
- Media (compare to current Tier-1 storage)
  - ~**10x** current storage media
- Disk buffer (for tape access only)
  - Currently a 1:50 disk:tape ratio
  - At 400Gbps 4PB fills in a day; assume a need for 4-7 days worth
  - **7.5-15x** current tape disk buffer
    - Not ready to assume a storage type for this
- Single (3 year) HL-LHC run will require **an order of magnitude more** archival storage infrastructure

Summary and Outlook

- Fermilab supplies scientific data storage for a wide range of HEP uses
  - **264 PB** of tape media, **48 PB** of disk
- Oracle exit from tape drive market dealt significant blow
  - O(100PB) of data to be migrated
- **CMS** storage needs will dominate by the end of the decade with HL-LHC
  - Storage footprint/capacity will be an order of magnitude larger than today
- Not discussed today in detail
  - Storage needs evolution of Fermilab experiments
    - See S. Timm's talk on DUNE yesterday
  - Analysis storage needs evolution
    - See analysis facility talks on Tuesday