Pooling the Resources of the CMS Tier-1 Sites

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Distributed Computing Infrastructure

More than 50 CMS centers, in more than 20 countries

Tier 0
- Main task in Run1:
  - Prompt reconstruction
  - Store RAW data and export to T1s
- Disk and tape storage

Tier 1
- Main tasks in Run1:
  - Re-reconstruction & MC production
  - Long term storage of RAW and MC files
- Disk and tape storage

Tier 2
- Main tasks in Run1:
  - MC production
  - User analysis
- Only disk storage

Flags taken from Wikipedia:
http://de.wikipedia.org/wiki/Liste_der_Nationalflaggen

During Run1:
Rather strict coupling of workflow types to tiers
Tape Configuration and Operations in Run1

- Disk and tape space coupled through HSM
  - Files written to tape automatically (immediately or as soon as possible)
  - Files (usually) get flushed from disk when space is needed on buffer disks

- Staging form tape: 3 cases
  - On demand: when file gets requested
  - Through SRM request
  - In practice often by ticket to site

- Pinning on disk: 2 cases
  - Through SRM commands
  - Again using tickets
Implications of Run1 Setup

- Strict coupling of processing and tape archival of output
  - Processing always had to happen at the archiving location
  - Limiting flexibility where to run

- Limited Tier-1 access for analysis users
  - No easy way to figure out what files are on disk
  - Uncontrolled tape staging needs to be avoided
  - CMS allowed only “expert users” to run at Tier-1 using VOMS role `t1access`

- Difficult to include Tier-1 sites into AAA data federation
  - Files need to be on disk for remote access
  - Requires an easy way to determine what is on disk

Solution: Separation of disk and tape archiving at Tier-1s
Disk Tape Separation

Basic concept

- Separation into two logical parts
  - **Disk endpoint**: no automated tape migration, all access from CPU and AAA data federation to this endpoint
  - **Archive**: automatic tape migration, only data management system can access data for reading and writing

- Transition from disk to tape becomes a **Subscription** in the data management system

Implementation at the sites

- Two independent storage systems
- Split namespace
Technical Implementation

- Sites free to choose the most suitable solution for their storage systems

- Different storage instances
  - CERN: CASTOR for tape and EOS for disk
  - FNAL: Two dCache instances (+ EOS for user data)
  - JINR: Only dCache disk atm, plans another dCache instance for tape

- Two independent namespace trees on the same storage
  - RAL: CASTOR
  - KIT, CCIN2P3, PIC: dCache
  - CNAF: GPFS with StoRM

- Transfers between the two areas managed with the standard WLCG service: FTS
Population of new Disk Endpoints

- Pioneered by RAL in April 2013, completed at FNAL in March 2014
- New disk endpoints populated with over 10 PB of data during the migration

![CMS PhEDEx - Cumulative Transfer Volume Graph]

- Total: 11,257 TB, Average Rate: 0.00 TB/s
Commissioning of Sites and Transfer System

- Change site configuration to interact with Disk endpoint only
  - Mapping of Logical File Name (LFN) to URL via Trivial File Catalog (TFC)
    - Jobs read from/write to disk endpoint only
- Introduce additional transfer links in the transfer system
  - Connect new Tier-1 disk endpoints to other disk endpoints and tape endpoints
- Verification of functionality by test workflows

Some recent tape staging tests:

<table>
<thead>
<tr>
<th>Site</th>
<th>Expected Rate (MB/s)</th>
<th>Achieved Rate (MB/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FNAL</td>
<td>650</td>
<td>~900</td>
</tr>
<tr>
<td>CNAF</td>
<td>210</td>
<td>~630</td>
</tr>
<tr>
<td>JINR*</td>
<td>150</td>
<td>*</td>
</tr>
<tr>
<td>KIT</td>
<td>150</td>
<td>~200</td>
</tr>
<tr>
<td>RAL</td>
<td>135</td>
<td>~700</td>
</tr>
<tr>
<td>IN2P3</td>
<td>135</td>
<td>~650</td>
</tr>
<tr>
<td>PIC</td>
<td>75</td>
<td>~500</td>
</tr>
</tbody>
</table>

All tape rates well above needs

* Tape at JINR to be commissioned
Big Gain in Flexibility

➢ Processing can start immediately
  ▪ No need to wait for creation of tape families at archival site

➢ Workload can run at any Tier-1 site
  ▪ No restriction to run at archiving Tier-1 location

➢ Subscription to tape can be delayed
  ▪ Allows for check of results
  ▪ Cleaning garbage from disk much easier than from tape

➢ All files on disk endpoint get published through AAA data federation
  ▪ Allows for remote access
  ▪ Fraction of data processing can run without local subscription

➢ Tier-1 sites can be opened for analysis jobs
  ▪ Jobs can only access files on disk endpoint
Example: Flexibility in DIGI-RECO Workflow Assignment

50% or more get assigned to other site than archiving (=custodial) site after separation of disk and tape resources at Tier-1 sites.
Summary

➢ In Run1 tape resources strictly coupled to local Tier-1 disk resources
  ▪ Restricted assignment of Tier-1 workflows to archiving site
  ▪ Prevented analysis jobs from being run at Tier-1 sites
  ▪ Enforced tape family creation before start of actual processing

➢ Effort to separate disk and tape resources
  ▪ Run separate storage instances for disk and tape
  ▪ Separation through different trees in the namespace
  ▪ Tape reading/writing becomes a subscription in the data management system

➢ Big gain in flexibility
  ▪ Restriction from Run1 resolved