Managing a Dynamic Sharded Pool

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HTCondor Week 2019
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Introduction

- Some archaeology from my time at Fermilab
  - Earliest archived Fermilab talks at HTCondor Week – 15 years ago!
  - My earliest HTCondor Week talk in 2012
- Describe the current state of the cluster(s)
- Along the way, I hope to:
  - Show some (maybe) unique uses of HTCondor
  - Explain why we did what we did
  - Give a peek into some future activities
In the Beginning… (At least for me)

- There was HTCondor! And it was Good.
  - When I started, the silent “HT” hadn’t been added to the name yet

- Single VO
- Grid-enabled
- Priorities
- CMS + OSG

- Multi-VO Pool
- Grid-enabled
- Quotas
- Many experiments + OSG

- CMS Tier-1
- CMS LPC
- Single VO Pool
- Local Analysis only
- Priority based scheduling

- GPGPgrid
### Net Batch Slot Utilization – 2013 Scientific Computing Portfolio Review

**Last 3 months**

![Graph showing Net Batch Slot Utilization](image)

**FermiGrid - Overall Total/Busy/Free Slots - Last Quarter**

- **Queued**: 24000
- **Idle**: (Graph shows idle slots)
- **Busy**: (Graph shows busy slots)
- **| - Holidays - |**: (Indicates period of holidays in the graph)

#### Table: Net Batch Slot Utilization

<table>
<thead>
<tr>
<th>Category</th>
<th>Maximum</th>
<th>Average</th>
<th>Minimum</th>
<th>Last Val</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>23924</td>
<td>22984.54</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Busy</td>
<td>23196</td>
<td>17769.44</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Idle</td>
<td>15118</td>
<td>5108.52</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unavailable</td>
<td>3948</td>
<td>103.59</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Waiting</td>
<td>39978</td>
<td>4328.35</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Held</td>
<td>2062</td>
<td>553.22</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Running</td>
<td>23196</td>
<td>17751.27</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Effective</td>
<td>22757</td>
<td>14975.48</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Raw Occupancy</td>
<td>99.37</td>
<td>77.46</td>
<td>35.12</td>
<td>65.81</td>
</tr>
<tr>
<td>Eff Utilization</td>
<td>98.76</td>
<td>65.25</td>
<td>21.56</td>
<td>59.31</td>
</tr>
<tr>
<td>Eff/Raw Ratio</td>
<td>1.0088</td>
<td>0.8357</td>
<td>0.2850</td>
<td>8.8851</td>
</tr>
</tbody>
</table>

Merged data from all FermiGrid clusters between 13-Oct-2012 and 16-Jan-2013

Plot generated at 16-Jan-2013 18:28:08 on fermigrid0.fnal.gov
FIFE Batch

- FifeBatch was created using GlideinWMS
  - Main motivation was the desire to use OSG resources seamlessly.
FIFEBatch

- FIFEBatch was a GlideinWMS pool
  - All slots are similar – controlled by pilot (glidein)
  - Used the glideinWMS Frontend to implement policies
  - Used the OSG Factory for pilot submission
  - Pilot “shape” defined by Factory
  - All of the benefits of glideinWMS and OSG

- All FNAL experiment jobs ran within the FifeBatch pool
- FIFEBatch managed by experimental support team
- GPGGrid Managed by Grid Computing team
SC-PMT - GP Grid Processing requests:
Large memory or multi-core as single slot

- We began to see increased demand for large memory or multi-core slots
- For context:
  - A “standard” slot was defined as 1 core, 2GB RAM
- Partitionable slots limited by the pilot size
- Unable to use extra worker resources beyond what is claimed by the pilot

Last year’s SC-PMT

History and Requested GP Grid Processing

- Old FY15 req
- Old FY16 req
- 2015 actual
- New FY16 req
- New FY17 req
- New FY18 req

- Other
- LArIAT
- b-2
- DES
- SBN
- Seaquest
- MicroBoone
- MARS
- CDF
- DUNE
- Minerva
- Mu2e
- Minos
- Nova

Fermilab
Combined: GPGrid + FifeBatch = FermiGrid

- FermiGrid
  - Worker Nodes
  - OSG Pilots

- GlideinWMS Services
  - Quota based scheduling
  - Priority based scheduling

- OSG
CMS Tier-1 + LPC

• New requirements:
  – Make LPC available to CMS Connect
  – Make CRAB3 jobs run on LPC resources

• LPC workers reconfigured to remove all extra storage mounts
  – Now LPC workers look identical to the Tier-1 workers

• LPC needed Grid interface for CMS Connect and CRAB3
  – The Tier-1 was already Grid-enabled

• However, 2 competing usage models:
  – Tier-1 wants to be fully utilized
  – LPC wants resources at the time of need
CMS - Docker

HTCondor-CE

Job Router

Sets WantDocker = MachineAttrFERMIHTC_DOCKER_CAPABLE0
Sets DockerImage = image expression

HTCondor Worker

Advertises:
FERMIHTC_DOCKER_CAPABLE=True
FERMIHTC_DOCKER_TRUSTED.Images= <comma separated list>

LPC Schedd

Job Transform

Sets WantDocker = MachineAttrFERMIHTC_DOCKER_CAPABLE0
Sets DockerImage = image expression

GlideinWMS Pilot

Advertises:
FERMIHTC_DOCKER_CAPABLE=False
HEPCloud - Drivers for Evolving the Facility

- HEP computing needs will be 10-100x current capacity
  Two new programs coming online (DUNE, High-Luminosity LHC), while new physics search programs (Mu2e) will be operating

- Scale of industry at or above R&D
  - Commercial clouds offering increased value for decreased cost compared to the past

Price of one core-year on Commercial Cloud

$2,000
$1,500
$1,000
$500
$0


0 500 1000 1500 2000 2500 3000 3500

integrated luminosity [fb^-1]

10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38

Year

Run 1 Run 2 Run 3 Run 4 Run 5 Run 6

trigger rate: 
- Run 1: 500 kHz
- Run 2: 1 kHz
- Run 3: 1 kHz
- Run 4: 7.5 kHz
- Run 5: 7.5 kHz
- Run 6: 7.5 kHz

LS 1 LS 2 LS 3 LS 4 LS 5 LS 6
HEPCloud - Drivers for Evolving the Facility: Elasticity

- Usage is not steady-state
- Computing schedules driven by real-world considerations (detector, accelerator, …) but also ingenuity – this is research and development of cutting-edge science
HEPCloud - Classes of Resource Providers

**Grid**
- Virtual Organizations (VOs) of users trusted by Grid sites
- VO allocations
  - Pledges
    - Unused allocations: opportunistic resources

“Things you borrow”

Trust Federation

**Cloud**
- Community Clouds - Similar trust federation to Grids
- Commercial Clouds - Pay-As-You-Go model
  - Strongly accounted
  - Near-infinite capacity → Elasticity
  - Spot price market

“Things you rent”

Economic Model

**HPC**
- Researchers granted access to HPC installations
- Peer review committees award Allocations
  - Awards model designed for individual PIs rather than large collaborations

“Things you are given”

Grant Allocation
HEPCloud

• New DOE requirements: Use LCF Facilities
• HEPCloud adds Cloud and HPC resources to the pool
• Cloud and HPC resource requests are carefully curated for specific classes of jobs
  – Only want appropriate jobs to land on Cloud and HPC resources
  – Additional negotiator also gives more flexibility in handling new resource types
HEPCloud Era

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Monitoring – Negotiation Cycles

**Negotiation Cycle Time**

**Successful Matches**

**Idle Jobs**

**Considered Jobs**

**Rejected Jobs**
Monitoring – Central Manager

Average match rates

Recent Updates

0.86 s/job (avg) match rate

0.20 s/job (avg) match rate

214675 recent updates

201471 recent updates

2 recent updates

2 recent updates
Next Steps

• CI/CD pipelines for Docker containers
• Containerizing workers? (Kubernetes, DC/OS, etc.)
• HTCondor on HPC facilities with no outbound networking
• Better handling of MPI jobs
  – No dedicated FIFO scheduler
  – No preemption
Questions, Comments?