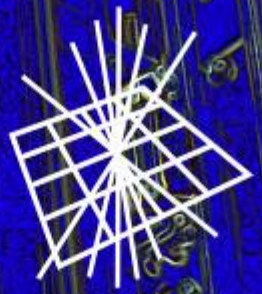


GridPP

UK Computing for Particle Physics

HTCondor at the RAL Tier-1

Andrew Lahiff,

Alastair Dewhurst, John Kelly, Ian Collier, James Adams

STFC Rutherford Appleton Laboratory

HTCondor Week 2014

Science & Technology Facilities Council

GridPP
UK Computing for Particle Physics

Outline

- Overview of HTCondor at RAL
- Monitoring
- Multi-core jobs
- Dynamically-provisioned worker nodes

Introduction

- RAL is a Tier-1 for all 4 LHC experiments
  - Provide computing & disk resources, and tape for custodial storage of data
  - In terms of Tier-1 computing requirements, RAL provides
    - 2% ALICE
    - 13% ATLAS
    - 8% CMS
    - 32% LHCb
  - Also support ~12 non-LHC experiments, including non-HEP
- Computing resources
  - 784 worker nodes, over 14K cores
  - Generally have 40-60K jobs submitted per day

Migration to HTCondor

- Torque/Maui had been used for many years
  - Many issues
  - Severity & number of problems increased as size of farm increased
- Migration

2012 Aug	Started evaluating alternatives to Torque/Maui
	(LSF, Grid Engine, Torque 4, HTCondor, SLURM)
2013 Jun	Began testing HTCondor with ATLAS & CMS
2013 Aug	Choice of HTCondor approved by management
2013 Sep	HTCondor declared production service
	Moved 50% of pledged CPU resources to HTCondor
2013 Nov	Migrated remaining resources to HTCondor

Experience so far

- Experience
  - Very stable operation
    - Staff don't need to spend all their time fire-fighting problems
  - Job start rate much higher than Torque/Maui, even when throttled
    - Farm utilization much better
  - Very good support

Status

- Version
  - Currently 8.0.6
  - Trying to stay up to date with the latest stable release
- Features
  - Partitionable slots
  - Hierarchical accounting groups
  - HA central managers
  - PID namespaces
  - Python API
  - condor_gangliad
- In progress
  - CPU affinity being phased in
  - cgroups has been tested, probably will be phased-in next

Computing elements

- All job submission to RAL is via the Grid
  - No local users
- Currently have 5 CEs, schedd on each:
  - 2 CREAM CEs
  - 3 ARC CEs
- CREAM doesn't currently support HTCondor
  - We developed the missing functionality ourselves
  - Will feed this back so that it can be included in an official release
- ARC better
  - But didn't originally handle partitionable slots, passing CPU/memory requirements to HTCondor, …
  - We wrote lots of patches, all included in upcoming 4.1.0 release
- Will make it easier for more European sites to move to HTCondor

HTCondor in the UK

- Increasing usage of HTCondor in WLCG sites in the UK
  - 2013-04-01: None
  - 2014-04-01: RAL Tier-1, RAL Tier-2, Bristol, Oxford (in progress)
- The future
  - 7 sites currently running Torque/Maui
  - Considering moving to HTCondor or will move if others do

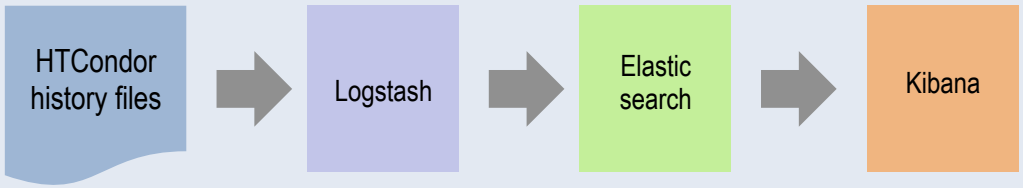
Monitoring

Jobs monitoring

- Useful to store details about completed jobs in a database
- What we currently do
  - Nightly cron reads HTCondor history files, inserts data into MySQL
- Problems
  - Currently only use subset of content of job ClassAds
    - Could try to put in everything
    - What happens then if jobs have new attributes? Modify DB table?
  - Experience with similar database for Torque
    - As database grew in size, queries took longer & longer
    - Database tuning important
- Is there a better alternative?

Jobs monitoring

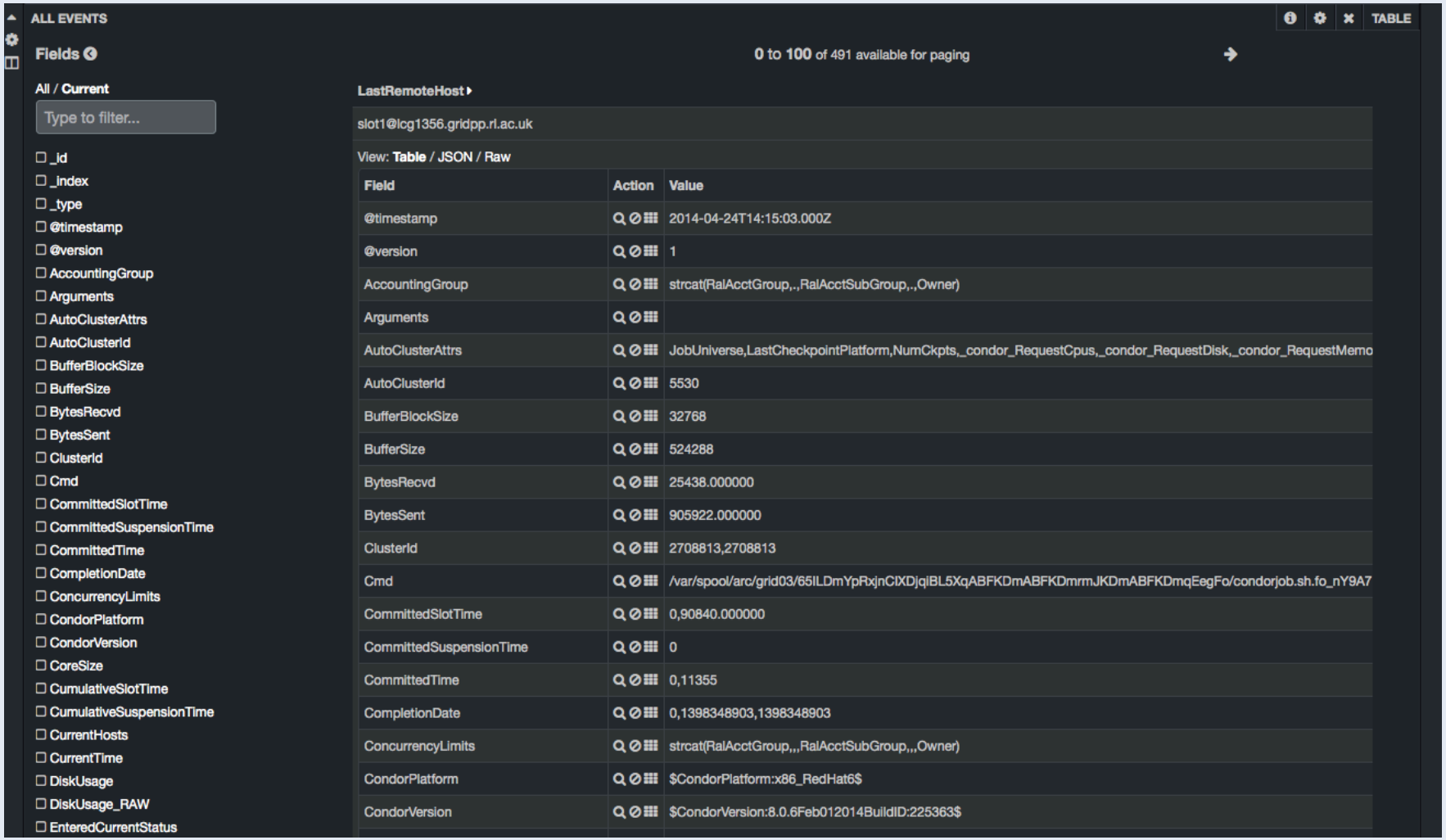
- CASTOR team at RAL have been testing Elasticsearch
  - Why not try using it with HTCondor?
- Elasticsearch ELK stack
  - Logstash: parses log files
  - Elasticsearch: search & analyze data in real-time
  - Kibana: data visualization



- Hardware setup
  - Test cluster of 13 servers (old diskservers & worker nodes)
    - But 3 servers could handle 16 GB of CASTOR logs per day
- Adding HTCondor
  - Wrote config file for Logstash to enable history files to be parsed
  - Add Logstash to machines running schedds

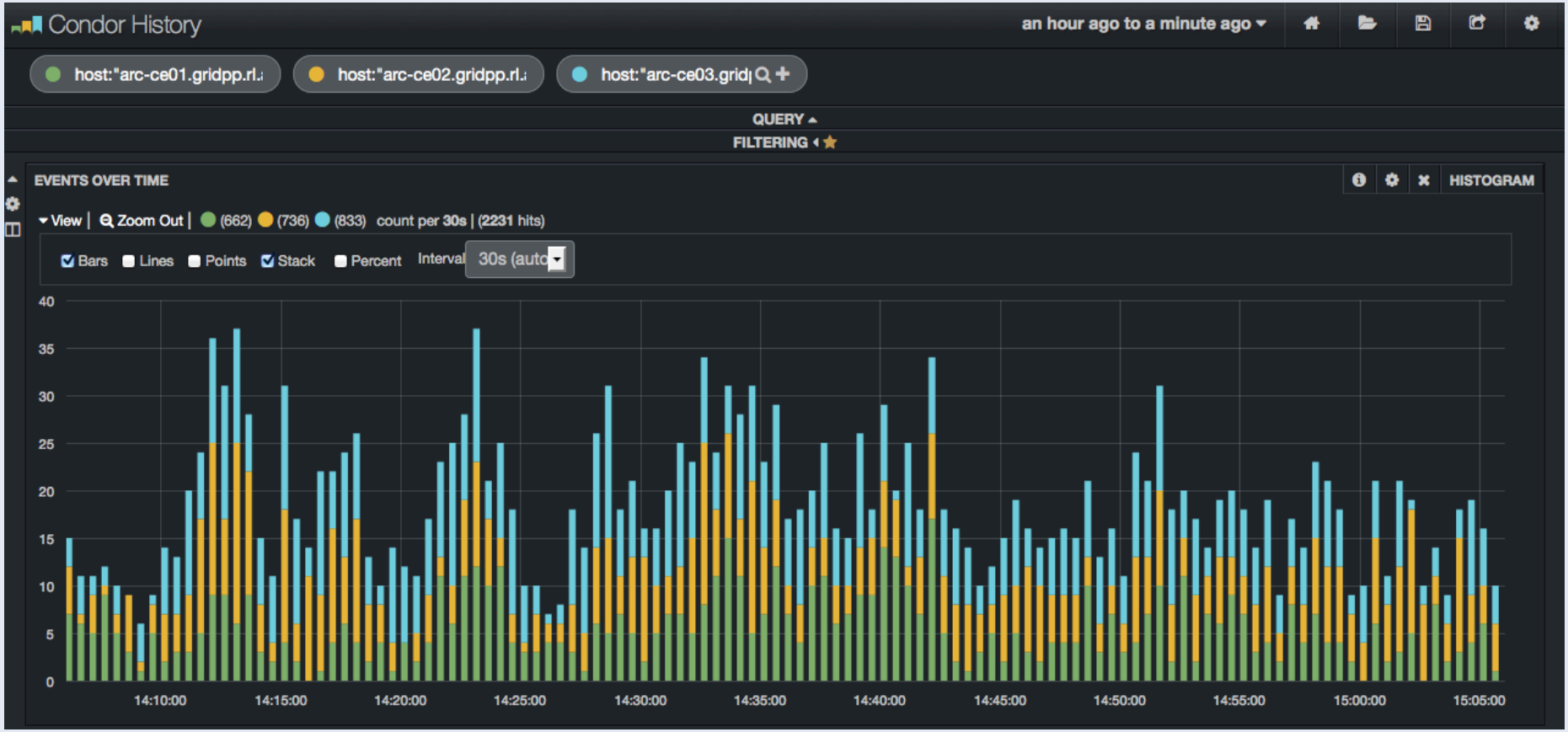
Jobs monitoring

- Can see full job ClassAds



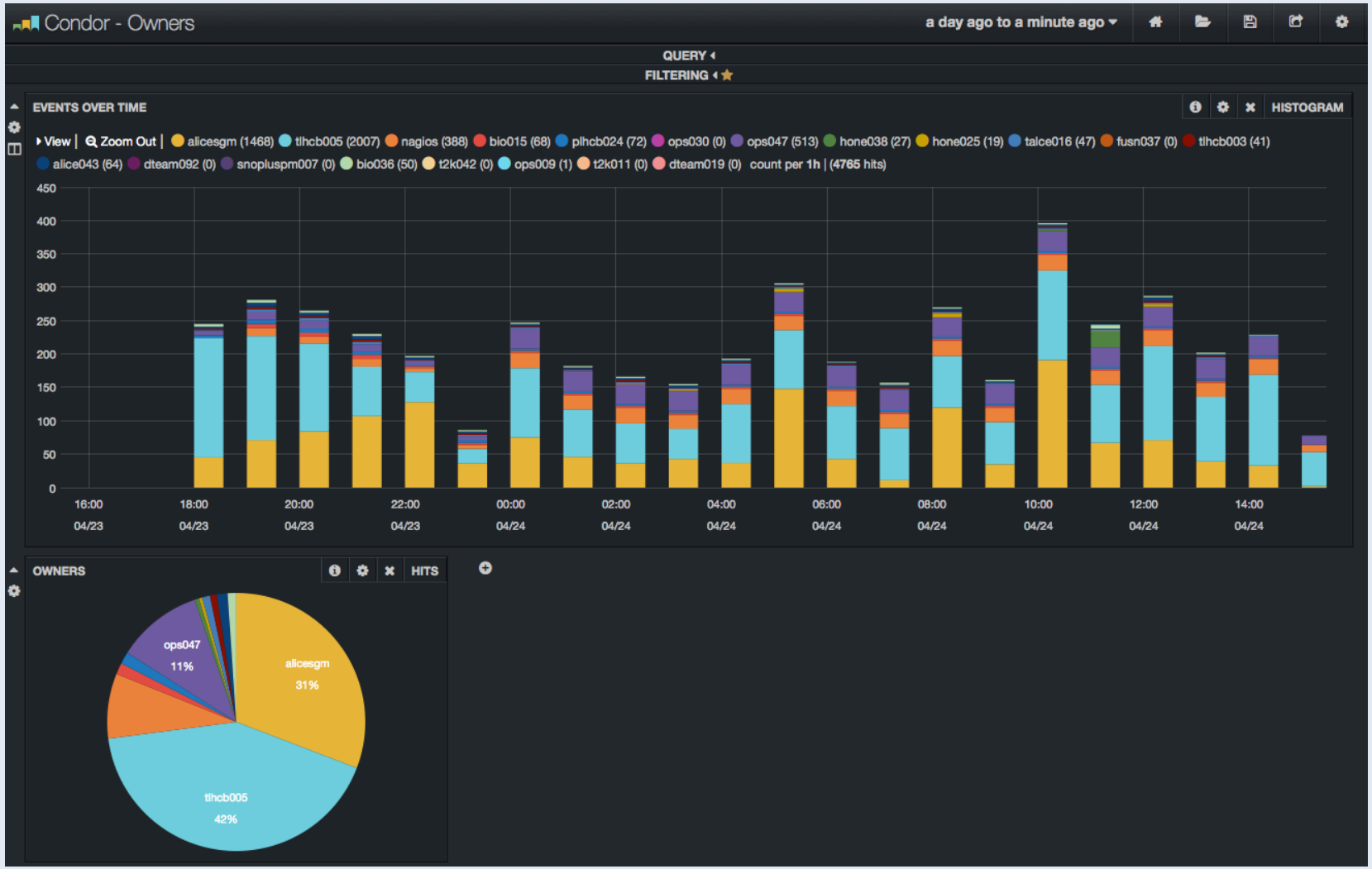
Jobs monitoring

- Custom plots
  - E.g. completed jobs by schedd



Jobs monitoring

- Custom dashboards



Jobs monitoring

- Benefits
  - Easy to setup
    - Took less than a day to setup the initial cluster
  - Seems to be able to handle the load from HTCondor
    - For us (so far): < 1 GB, < 100K documents per day
  - Arbitrary queries
  - Queries are faster than using condor_history
  - Horizontal construction
    - Need more capacity? Just add more nodes

Multi-core jobs

Multi-core jobs

- Situation so far
  - ATLAS have been running multi-core jobs at RAL since November
  - CMS submitted a few test jobs, will submit more eventually
  - Interest so far only for multi-core jobs, not whole-node jobs
    - Only 8-core jobs
- Our aims
  - Fully dynamic
    - No manual partitioning of resources
  - Number of running multi-core jobs determined by group quotas

Multi-core jobs

- Defrag daemon
  - Essential to allow multi-core jobs to run
  - Want to drain 8 cores only. Changed:

```
DEFRAG_WHOLE_MACHINE_EXPR = Cpus == TotalCpus && Offline=!=True
```

    to

```
DEFRAG_WHOLE_MACHINE_EXPR = (Cpus >= 8) && Offline=!=True
```

  - Which machines more desirable to drain? Changed

```
DEFRAG_RANK = -ExpectedMachineGracefulDrainingBadput
```

    to

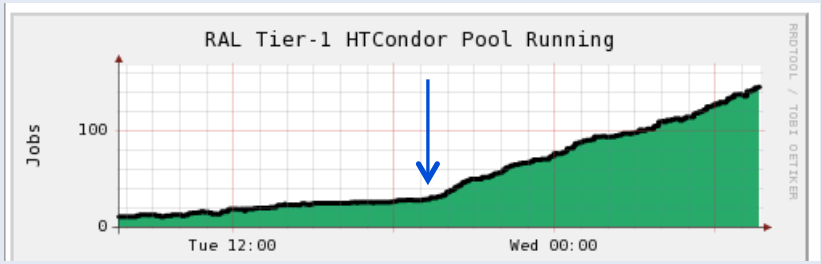
```
DEFRAG_RANK = ifThenElse(Cpus >= 8, -10, (TotalCpus - Cpus)/(8.0 - Cpus))
```

  - Why make this change?
    - With default DEFRAG_RANK, only older full 8-core WNs were being selected for draining
    - Now: (Number of slots that can be freed up)/(Number of needed cores)
      - For us this does a better job of finding the “best” worker nodes to drain

Multi-core jobs

- Effect of changing DEFRAG_RANK

Running multi-core jobs



  - No change in the number of concurrent draining machines
  - Rate in increase in number of running multi-core jobs much higher

Multi-core jobs

- Group quotas
  - Added accounting groups for ATLAS and CMS multi-core jobs
  - Force accounting groups to be specified for jobs using SUBMIT_EXPRS
    - Easy to include groups for multi-core jobs

```
AccountingGroup =
…
    ifThenElse(regexp("patl",Owner) && RequestCpus > 1, “group_ATLAS.prodatls_multicore", \
    ifThenElse(regexp("patl",Owner),                    “group_ATLAS.prodatls", \
…
SUBMIT_EXPRS = $(SUBMIT_EXPRS) AccountingGroup
```

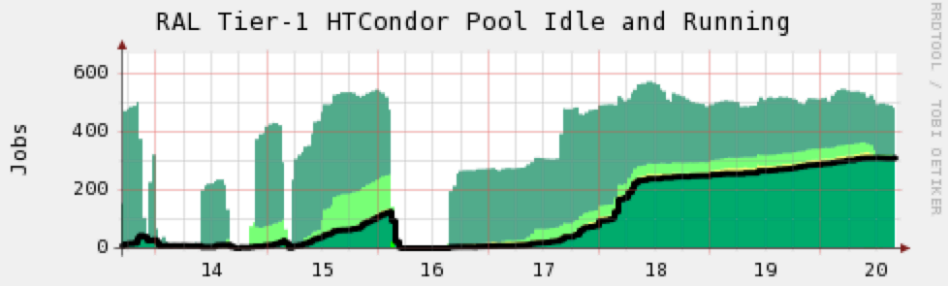
- Negotiator
  - Modified GROUP_SORT_EXPR so that the order is:
    - High priority groups (Site Usability Monitor tests)
    - Multi-core groups
    - Remaining groups
  - Helps to ensure multi-core slots not lost too quickly

Multi-core jobs

- Defrag daemon issues
  - No knowledge of demand for multi-core jobs
    - Always drains the same number of nodes, irrespective of demand
    - Can result in large amount of wasted resources
  - Wrote simple cron script which adjusts defrag daemon config based on demand
  - Currently very simple, considers 3 cases:
    - Many idle multi-core jobs, few running multi-core jobs
      - Need aggressive draining
    - Many idle multi-core jobs, many running multi-core jobs
      - Less agressive draining
    - Otherwise
      - Very little draining
  - May need to make changes when other VOs start submitting multi-core jobs in bulk

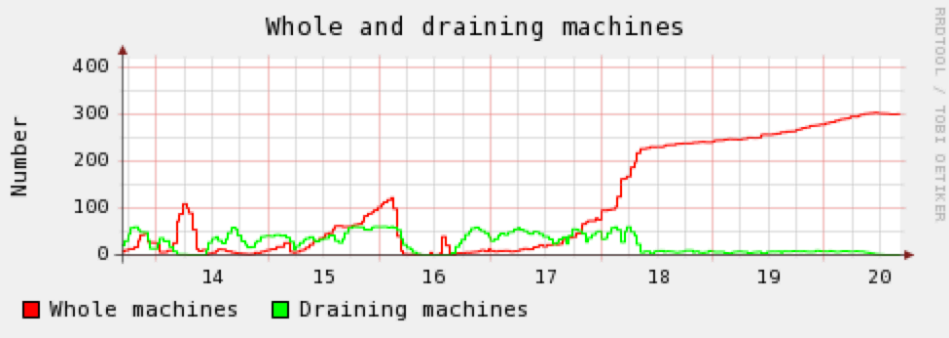
Multi-core jobs

- Recent ATLAS activity



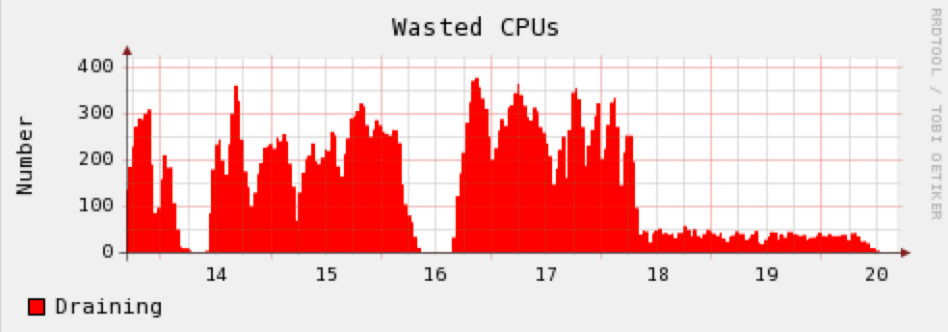
Running & idle multi-core jobs

Gaps in submission by ATLAS results in loss of multi-core slots.



Number of “whole” machines & draining machines

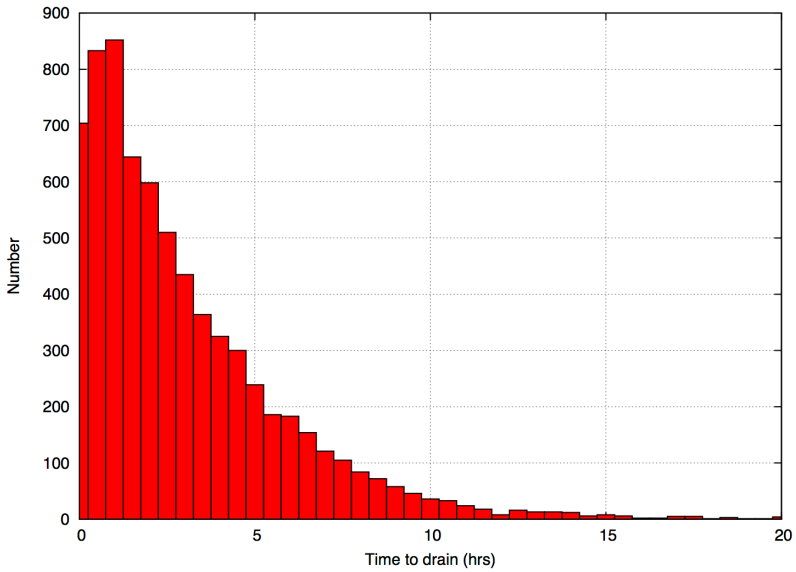
Data from condor_gangliad



Significantly reduced CPU wastage due to the cron

Multi-core jobs

- Other issues
  - Defrag daemon designed for whole-node, not multi-core
    - Won't drain nodes already running multi-core jobs
    - Ideally may want to run multiple multi-core jobs per worker node
  - Would be good to be able to run "short" jobs while waiting for slots to become available for multi-core jobs
    - On other batch systems, backfill can do this



Time taken for 8 jobs to drain
- lots of opportunity to run short jobs

Multi-core jobs

- Next step: enabling “backfill”
  - ARC CE adds custom attribute to jobs: JobTimeLimit
    - Can have knowledge of job run times
  - Defrag daemon drains worker nodes
    - Problem: machine can’t run any jobs at this time, including short jobs
  - Alternative idea:
    - Python script (run as a cron) which plays the same role as defrag daemon
      - But doesn’t actually drain machines
    - Have a custom attribute on all startds, e.g. NodeDrain
      - Change this instead
    - START expression set so that:
      - If NodeDrain false: allow any jobs to start
      - If NodeDrain true: allow only short jobs under certain conditions, e.g. for a limited time after “draining” started
  - Provided (some) VOs submit short jobs, should be able to reduce wasted resources due to draining

Dynamically-provisioned worker nodes

Private clouds at RAL

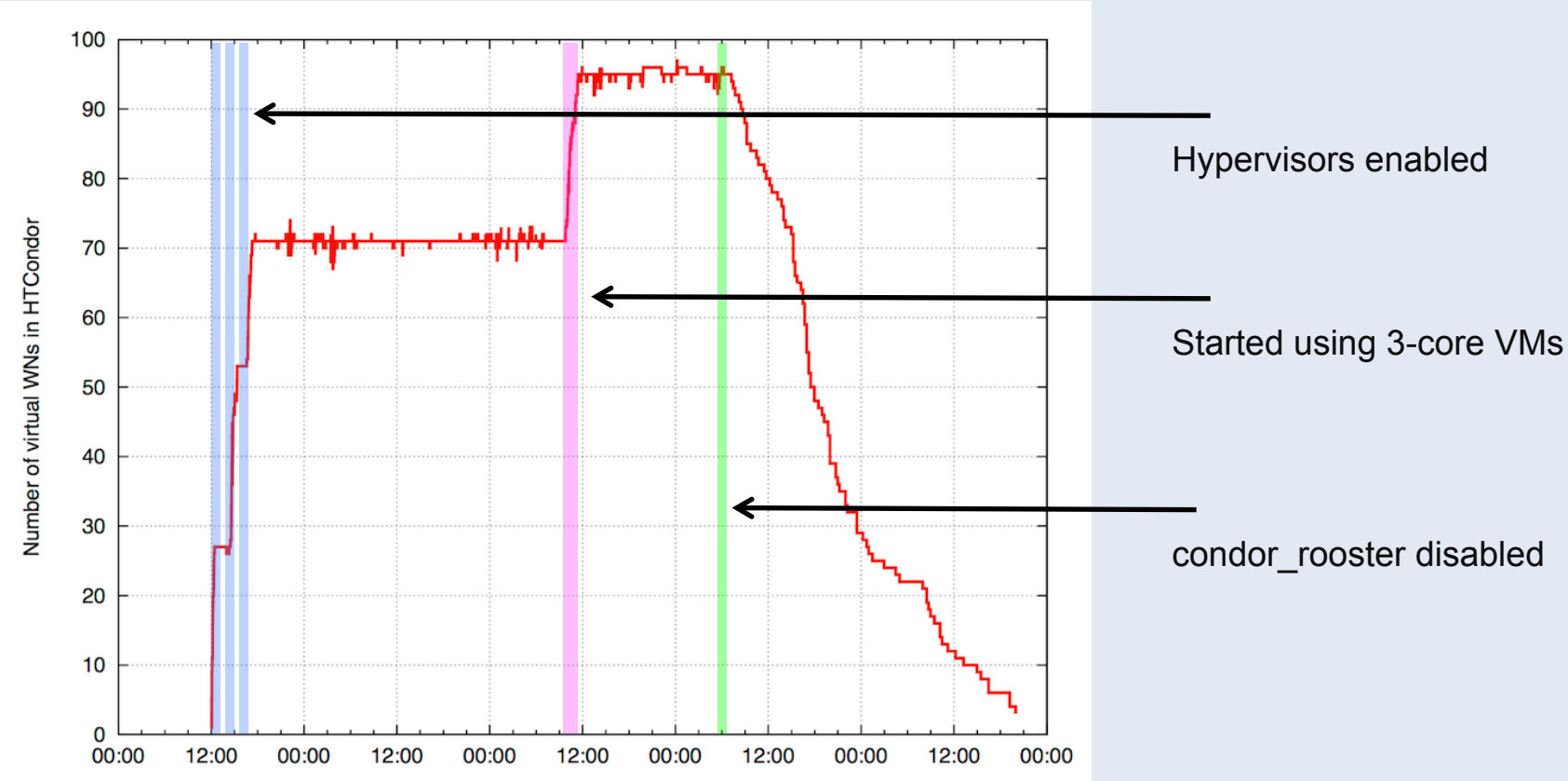
- Prototype cloud
  - StratusLab (based on OpenNebula)
  - iSCSi & LVM based persistent disk storage (18 TB)
  - 800 cores
  - No EC2 interface
- Production cloud
  - (Very) early stage of deployment
  - OpenNebula
  - 900 cores, 3.5 TB RAM, ~1 PB raw storage for Ceph
- Aims
  - Integrate with batch system, eventually without partitioned resources
  - First step: allow the batch system to expand into the cloud
    - Avoid running additional third-party and/or complex services
    - Use existing functionality in HTCondor as much as possible
    - Should be as simple as possible

Provisioning worker nodes

- Use HTCondor's existing power management features
  - Send appropriate offline ClassAd(s) to the collector
    - Hostname used is a random string
    - Represents a type of VM, rather than specific machines
  - condor_rooster
    - Provisions resources
    - Configured to run appropriate command to instantiate a VM
  - When there are idle jobs
    - Negotiator can match jobs to the offline ClassAds
    - condor_rooster daemon notices this match
      - Instantiates a VM
      - Image has HTCondor pre-installed & configured, can join the pool
  - HTCondor on the VM controls the VM's lifetime
    - START expression
      - New jobs allowed to start only for a limited time after VM instantiated
    - HIBERNATE expression
      - VM is shutdown after machine has been idle for too long

Testing

- Testing in production
  - Initial test with production HTCondor pool
  - Ran around 11,000 real jobs, including jobs from all LHC VOs
  - Started with 4-core 12GB VMs, then changed to 3-core 9GB VMs



Summary

- Due to scalability problems with Torque/Maui, migrated to HTCondor last year
- We are happy with the choice we made based on our requirements
  - Confident that the functionality & scalability of HTCondor will meet our needs for the foreseeable future
- Multi-core jobs working well
  - Looking forward to more VOs submitting multi-core jobs
- Dynamically-provisioned worker nodes
  - Expect to have in production later this year

Thank you!