HTCondor at the RACF

SEAMLESSLY INTEGRATING MULTICORE JOBS AND OTHER DEVELOPMENTS

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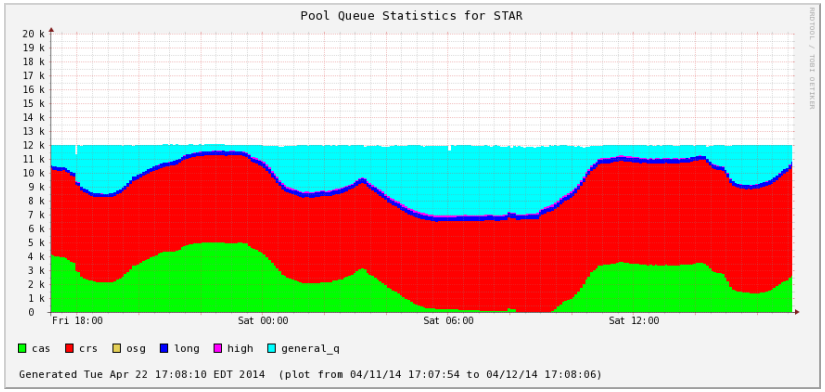
RACF Overview

Main HTCondor pools

- PHENIX—12.2kCPU
- STAR—12.0kCPU
- ATLAS—13.1kCPU



STAR/PHENIX are RHIC detectors

- Loose federation of individual users

ATLAS—tightly controlled, subordinate to PANDA workflow management, strict structure

Smaller Experiments

- LBNE
- Dayabay
- LSST

Supporting Multicore

Priorities and Requirements

- Keep management workload at a minimum
  - No manual re-partitioning
    - Needs to be dynamic and/or partitionable
  - Support automatic demand-spillover
    - Need to retain group-quota system with accept-surplus feature
- Maximize throughput—minimize latency
  - Same goals as above
- Attempt to support future developments in same framework
  - More than just multicore
    - High-Memory already used in this context (with caveat)
- Principle of proportional pain
  - Okay to make multicore wait longer—but *no* starvation is allowed

Supporting Multicore

STEP 1: PARTITIONABLE SLOTS EVERYWHERE

Required change to monitoring

- Job-count no longer correct metric for measuring occupancy

Minor script change with SlotID

- Slot<n> → Slot<m>_<n>

Works with no side effects

STEP 2: POLICY CHANGES

Preemption is no longer possible

- OK for now since not needed

Slot-Weight can only be CPUs

- Needs to change in the future

Defragmentation is necessary

- Detail next slide

Dedicated queues for now

Defragmentation Policy

DEFRAGMENTATION DAEMON

Start Defragmentation

- (PartitionableSlot && !Offline && TotalCpus > 12)

End Defragmentation

- (Cpus >= 10)

Rate: max 4/hr

KEY CHANGE: NEGOTIATOR POLICY

Default policy is breadth-first filling of equivalent machines

- (Kflops – SlotId)

Depth-first filling preserves continuous blocks longer

- (-Cpus)

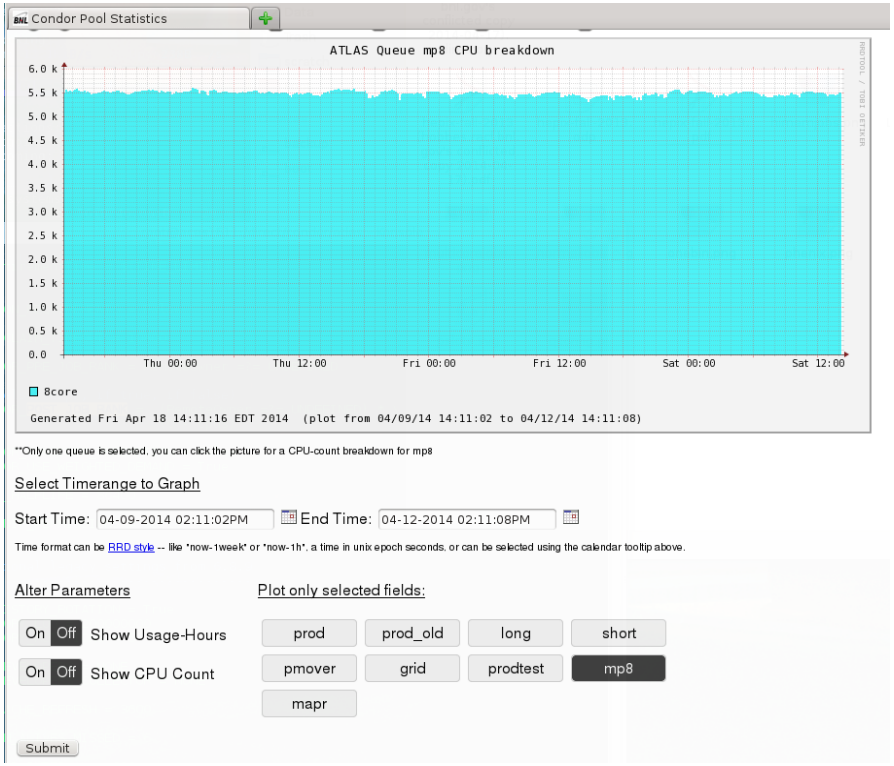
Multicore in Dedicated Queues

Works well now, issues were resolved

- Allocation is handled by group quota and surplus-share

Dedicated queue per species of job

- Currently two—high-memory (6Gb) and 8-core
- Changing requirements require manual action



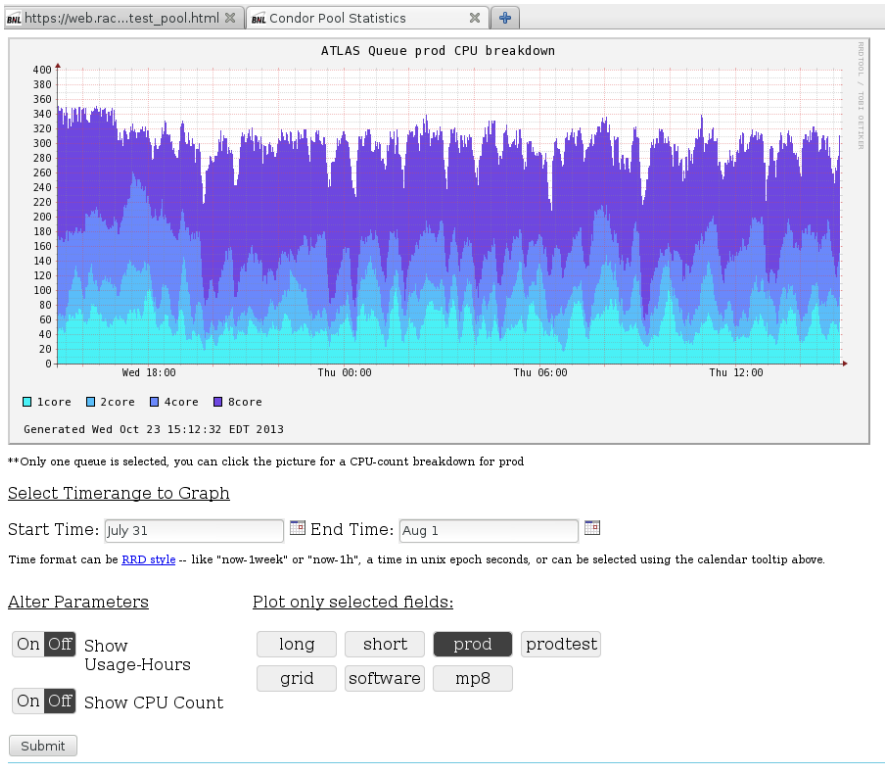
Multicore in common Queue

Works well, no starvation

- Lack of control over strict allocation of m. vs. n core jobs within queue

Not currently done in ATLAS

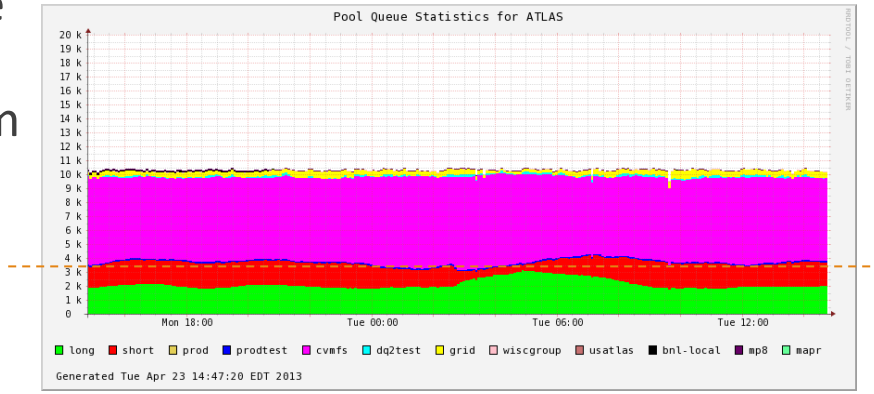
- Issue of allocation control is just part of reason why
- Structural and not likely to change soon



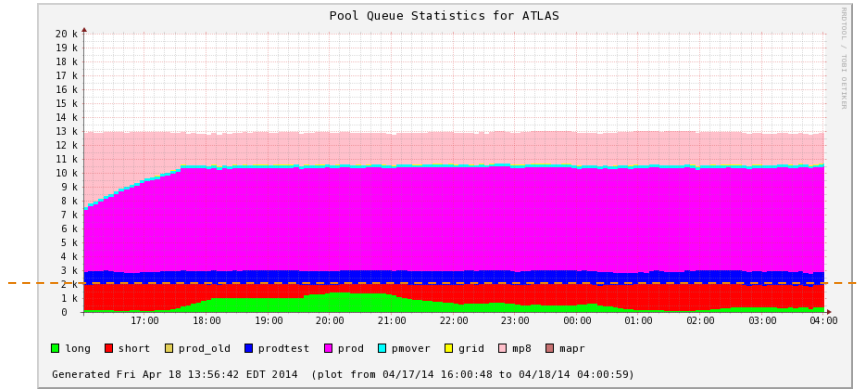
Fixing bugs in HTCondor

Last summer a period of intensive development/testing in collaboration with HTCondor team

- Built a VM testbed, rapid build & test of patches from HTCondor team
- Built new monitoring interface
- After many iterations had working config with Partitionable slots and Hierarchical Group Quotas with accept_surplus



Should Stay Here



Now it does!

Bugfix Testbed Details

Rapid build, test, deploy cycle from git patches

- Email patch
- Rebuild condor
- Run test-feeder

Job Feeder

- Defines groups in config-file with different random length-ranges and requirements
- Variable workload—keep N jobs idle in each queue

README | report.txt | feeder.py | queues.cfg

```
1  # Queue                    num_idle   avg_runtime   splay   racf      weight_string
2  group_atlas.analysis.long  10         1200          300     long      1,1,8,2,4
3  group_atlas.analysis.short 18         300           100     short     1,1,1,2
4  group_atlas.prod.production 49        900           300     prod      1,1,1,2,4,8
5  group_atlas.prod.test      2          200           160     prodtest  1
6  group_atlas.prod.mp        7          300           100     mp8       16
7  group_atlas.software       2          120           20      sw        1,2
8  group_grid                 6          300           120     grid      1,1,2
9
```

Current Multicore Status

Fully utilize PSlots

- All traditional nodes (x86_64) can have same config

```
SLOT_TYPE_1 = 100%
NUM_SLOTS = 1
NUM_SLOTS_TYPE_1 = 1
SLOT_TYPE_1_PARTITIONABLE = True
SlotWeight=Cpus
```

Fix works perfectly when accept_surplus is on for any combination of groups

Major Limitation: SlotWeight=Cpus

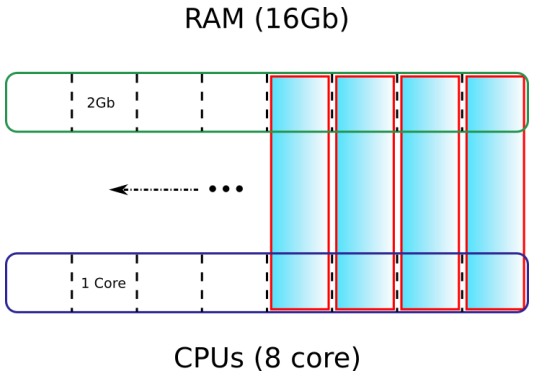
- High-memory jobs can be accommodated by asking for more CPUs.
- Need ability to partition better and interact with global resource limits
- SlotWeight should be a configurable function of all consumable resources

Other Limitation: No Preemption

- Required to support opportunistic usage

Issue With High Memory Jobs

1



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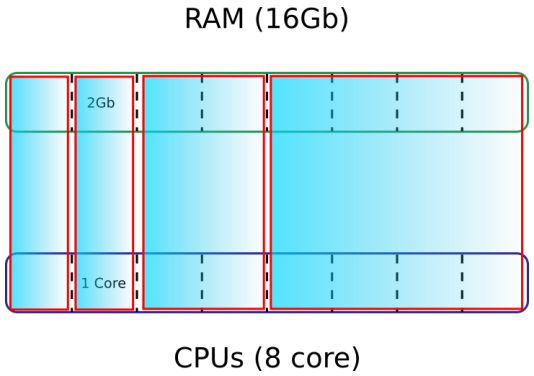

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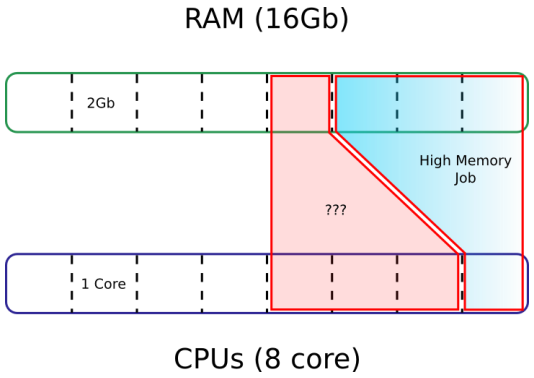


1…ok, 2…ok, 3…**not** ok!

General problem:

- Inefficiencies in heterogeneous jobs scheduling to granular resources
- Worse as you add dimensions: imagine GPSs, Disks, CoProcessors, etc…

Goals

Need all the same behavior as we have now regarding groups and accept_surplus

Want to be able to slice by any resource

Sane and configurable defaults/quantization of requests

Defragmentation inefficiencies should be kept to a minimum—we are mostly there already!

Overall we are something like ¾ of the way to our ideal configuration.

Problem of Weights and Costs

What does SlotWeight mean with heterogeneous resources?

- Job of administrator to determine how much to “charge” for each requested resources
  - E.g. (cpus + 1.5(ram exceeding cpus * ram/core))
- Are these weights normalized to what CPU counting would give?
  - If not then what does the sum of SlotWeights represent?

Quotas related to sum of SlotWeights, needs to be constant pool-wide and independent of current job allocation—if specifying static number!

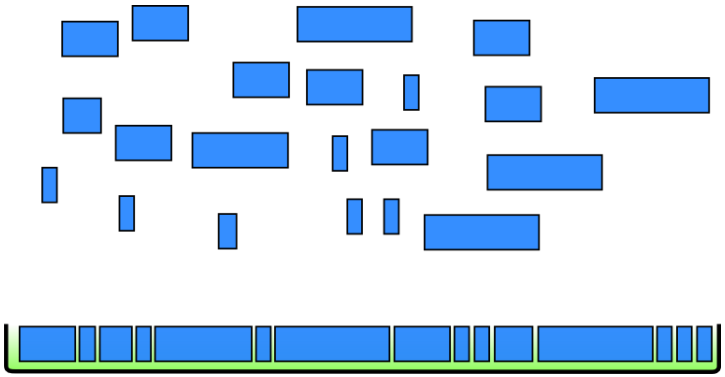
- Cost functions need to be linear?
- Only dynamic quota instead (e.g. 80%X + 20%Y)…

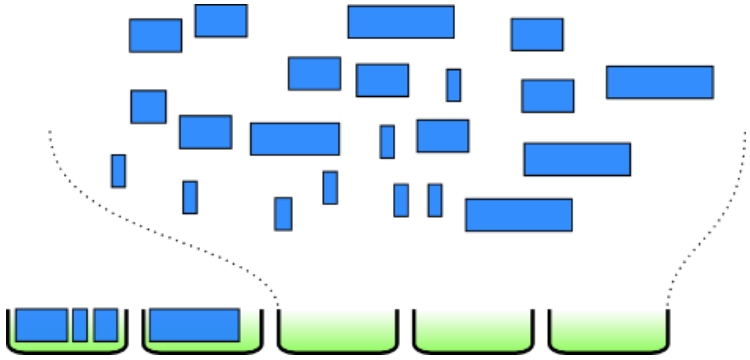
Implications

A picture is worth 1000 words…

The more barriers between nodes that can be broken down the better

- MPI-like batch software with NUMA-aware scheduling making other machines like further away NUMA nodes?





ATLAS Load Balancing

PANDA contains knowledge of upcoming work

Wouldn't it be nice to adapt the group allocation accordingly

- A few knobs can be tuned—surplus and quota
- Dynamic adjustment based on current pending-work
- Gather heuristics on past behavior to help

Timeframe: Fall 2014—project will be picked up by a summer student this year

PHENIX Job Placement

Data stored on PHENIX nodes (dCache)

- New this year is RAW data is placed hot off the DAQ
- Reprocessing no longer requires second read from tape
  - Less tape wear, faster—no stage latency
- Analysis continues to read input from dCache

No intelligent placement of jobs

- HDFS-like job placement would be great—but without sacrificing throughput
- Approach:
  - Need to know where files are first!
  - Need to suggest placement without waiting for the perfect slot
- Started as proof-of-concept for efficacy of non-flat network
  - Testing Infiniband fabrics with tree-based topology

PHENIX Job Placement

File placement harvested from nodes and placed in database

- Database contains map of file->machine
- Also contains machines->rack and rack->rack-group mapping

Machines run a STARTD_CRON to query & advertise their location

Job-RANK statement used to steer jobs towards machines where their files are

- E.g: `(3*(Machine==“a” || Machine==“c”)) + 2*(Rack==“21-6”) + (RackGroup == “10”)`
- Slight increase in negotiation time, upgraded hardware to compensate
- Several thousand matches/hr with possibly unique RANK statements

Working on modified dCache client to directly read file if on local node

PHENIX Job Placement Results

We achieved expected results with machine-local jobs

- >80% on an empty farm
- ~10% on a full farm

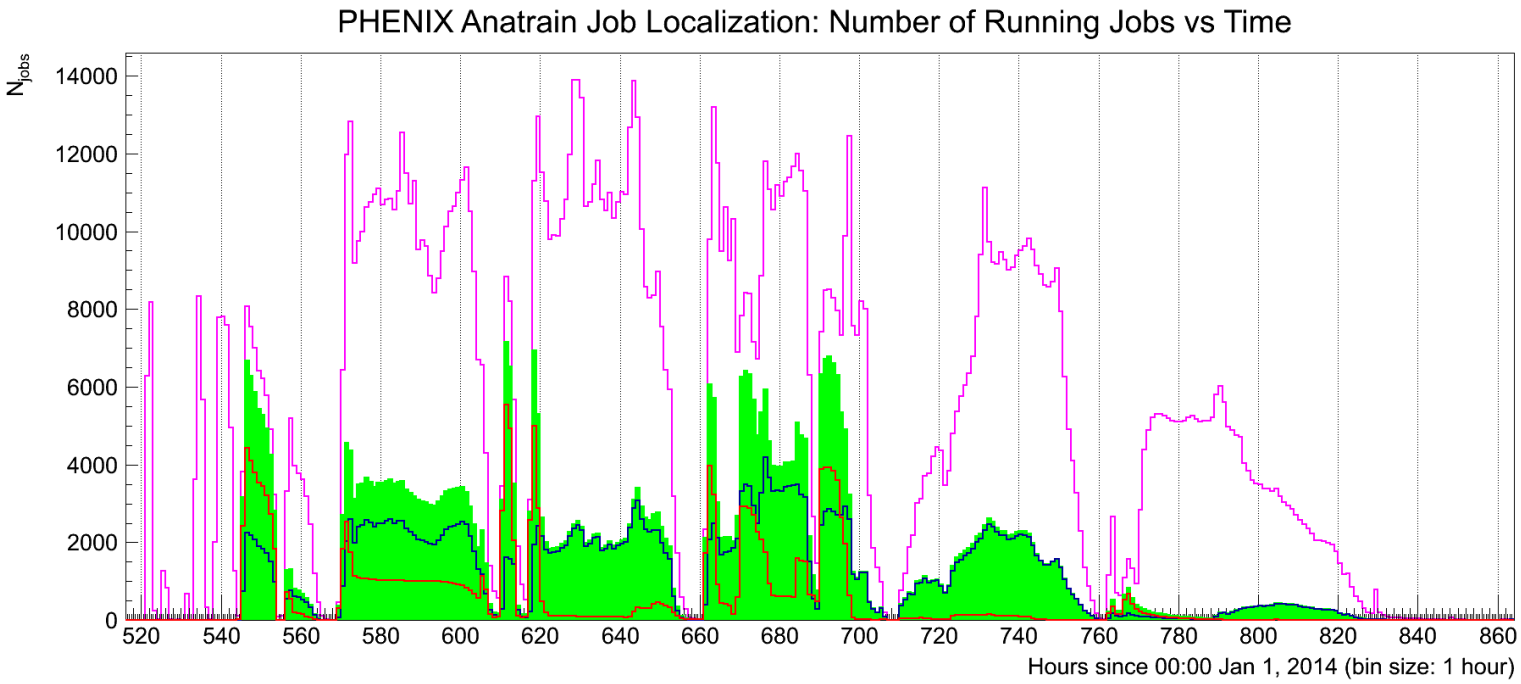
All localization in rack-group

- >90% empty farm
- ~15% full farm

Argues that great benefit could be gained from utilizing multi-tier networking

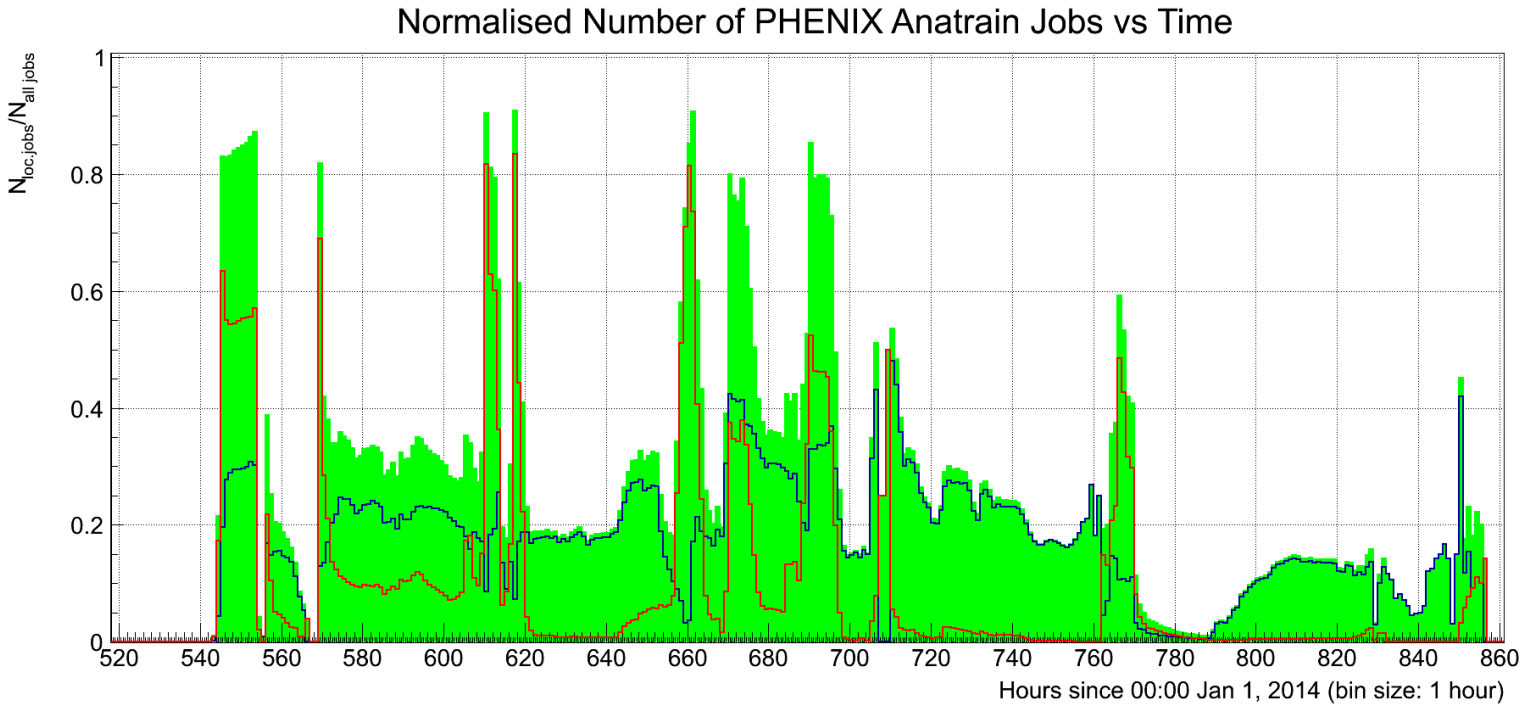
- Without it, only machine-local jobs benefit

PHENIX Job Placement Results



1. Machine-Local
2. Rack-Local (exclusive of Machine-Local)
3. All Localized (Sum 1. + 2.)
4. All Jobs

PHENIX Job Placement Results



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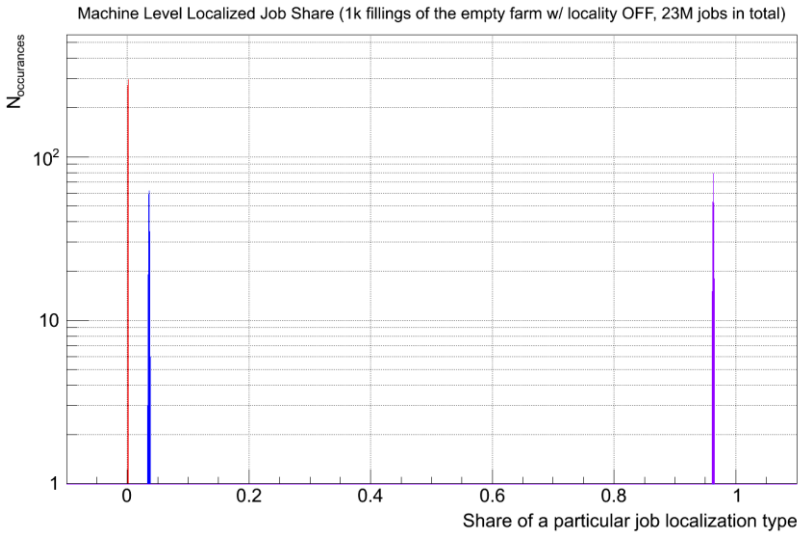
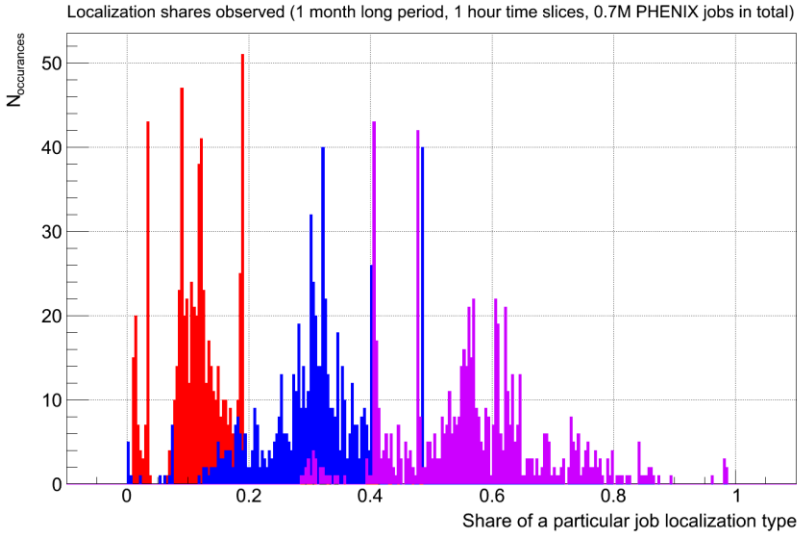
PHENIX Job Placement Results

SIMULATED NO LOCALIZATION



RESULTS FROM LOCALIZATION



1. Machine-Local
2. Rack-Local (exclusive of Machine-Local)
3. Non-Local

Histogram of portion of jobs in each state taken in 1 hour intervals

*Plots generated by Alexandr Zaytsev

THANK YOU

Questions? Comments?
Stock Photo?

Configuration Changes

TAKING ADVANTAGE OF CONFIG-DIR

Since 7.8 Condor supports a config.d/ directory to read configuration from

More easily allows programmatic/automated management of configuration

Refactored configuration files at RACF to take advantage

Old Way

```
Main Config:

LOCAL_CONFIG_FILES = /dir/a, /dir/b

Order:

1. /etc/condor/condor_config (or $CONDOR_CONFIG)
2. /dir/a
3. /dir/b
```

New Way

```
Main Config:

LOCAL_CONFIG_DIR = /etc/condor/config.d

LOCAL_CONFIG_FILES = /dir/a, /dir/b

Order:

1. /etc/condor/condor_config (or $CONDOR_CONFIG)
2. /etc/condor/config.d/* (in alphanumeric order)
3. /dir/a
4. /dir/b
```