Priority and Provisioning
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HTCondorWeek 2015
Overview

Important HTCondor architecture bits
Detour to items that doesn’t fit elsewhere
Groups and why you should care
User priorities and preemption
Draining
Provisioning vs. Scheduling

› HTCondor separates the two
  • Very important
› Central Manager (negotiator) provisions
› Schedd schedules
Provisioning

- Negotiator selects a slot for a **USER**
- Based on USER attributes (and machine)
  - With some small thought to the users’s job
- At slower frequency: the negotiation cycle
  - Don’t obsess about negotiation cycle time
Scheduling

› Schedd takes that slot for the user
  • And runs one or more jobs on it
  • For how long?
    • CLAIM_WORKLIFE = some_seconds
Consequences

- May take much longer to start 1\textsuperscript{st} job
- The central manager responsible for users
- The central manager responsible for groups
- Accounting happens in the CM
THE SCHEDD, DUDE

DOESN'T SCHEDULE!
Now, for the detour…
Schedd Policy: Job Priority

- Set in submit file with: `JobPriority = 7`
- … or dynamically with `condor_prio` cmd
- Integers, larger numbers are better priority
- Only impacts order between jobs for a single user on a single schedd
- A tool for users to sort their own jobs
Schedd Policy: Job Rank

› Set with

› RANK = Memory

› In condor_submit file

› Not as powerful as you may think:
  • Negotiator gets first cut at sorting
  • Remember steady state condition
Concurrenty Limits

› Useful for globally (pool-wide):
  • License limits,
  • NFS server overload prevention
  • Limiting database access

› Limits total number jobs across all schedds
Concurrencey Limits (2)

› In central manager config
  › MATLAB_LICENSE_LIMIT = 10

› In submit file
  › concurrency_limits = matlab
Rest of this talk: Provisioning, not Scheduling

- schedd sends idle users to the negotiator
- Negotiator picks machines (idle or busy) to send to the schedd for those users
- How does it pick?
What’s a user?

- Bob in schedd1 same as Bob in schedd2?
- If have same UID_DOMAIN, they are.
  - Default UID_DOMAIN is FULL_HOSTNAME
- Prevents cheating by adding schedds
- Map files can redefine the local user name
Or, a User could be a “group”
Accounting Groups (2 kinds)

- Manage priorities across groups of users
  Can guarantee maximum numbers of computers for groups (quotas)
- Supports hierarchies
- Anyone can join any group
Accounting Groups as Alias

» In submit file
  • Accounting_Group = group1

» Treats all users as the same for priority

» Accounting groups not pre-defined

» No verification – condor trusts the job

» condor_userprio replaces user with group
Accounting Groups w/ Quota
aka: “Hierarchical Group Quota”
quota, n.

Pronunciation: Brit. /ˈkwɔːtə/, U.S. /ˈkwɑːdə/
Forms:
- quota
- quoto (chiefly U.S. regional)
- cotta
- gotta

1. Originally: the part or share which an individual is obliged to contribute to a total amount (in early use chiefly with reference to contributions of men, money, or supplies from a particular town, district, or country; cf. CONTINGENT n. 5). Later more widely: an amount contributed to a larger quantity.

1618–1668

b. Econ. A maximum quantity of a particular product which under official controls can be produced, exported, imported, or caught. Also: a target setting a minimum production for a particular factory, employee, etc.
2. A share of a larger number or quantity; a portion, an allocation.

b. Polit. In a system of proportional representation: the minimum number of votes required to elect a candidate.

3. Chiefly U.S.

a. A maximum number of immigrants allowed to enter a country within a set period. Also: a maximum number of students (as of a particular racial or ethnic group) allowed to enrol for a course at a college, etc., in a particular year.

   The Emergency Quota Act was passed by the U.S. Congress in 1921.

b. A minimum number or proportion (of racial or ethnic minorities, or women) sought in order to ensure a desired balance in a workforce, student body, etc.
HGQ: Strict quotas

- “a” limited to 10
- “b” to 20,
- Even if idle machines
- What is the unit?
  - Slot weight.
- With fair share of users within group

Must be predefined in cm’s config file:
- GROUP_NAMES = a, b, c
- GROUP_QUOTA_a = 10
- GROUP_QUOTA_b = 20

And in submit file:
- Accounting_Group = a
- Accounting_User = gthain
Group_accept_surplus

- Group_accept_surplus = true

- Group_accept_surplus_a = true

- This is what creates hierarchy
  - But only for quotas
GROUP_AUTOREGROUP

› Allows groups to go over quota if idle machines

› “Last chance” wild-west round, with every submitter for themselves.
Hierarchical Group Quotas

- **physics**
  - string theory
    - CMS
    - ATLAS
    - CDF
  - particle physics
  - 700

- **CompSci**
  - architecture
    - 100
  - 200
  - DB
  - 100

- Physics: 700
- CompSci: 200
Hierarchical Group Quotas

GROUP_QUOTA_physics = 700
GROUP_QUOTA_physics.string_theory = 100
GROUP_QUOTA_physics.particle_physics = 600
  GROUP_QUOTA_physics.particle_physics.CMS = 200
  GROUP_QUOTA_physics.particle_physics.ATLAS = 200
  GROUP_QUOTA_physics.particle_physics.CDF = 100

...
Groups configured to accept surplus will share it in proportion to their quota.

Here, unused particle physics surplus is shared by ATLAS and CDF.

GROUP_ACCEPT_SURPLUS_physics.particle_physics.ATLAS = true
GROUP_ACCEPT_SURPLUS_physics.particle_physics.CDF = true
Gotchas with quotas

- Quotas don’t know about matching
- Assuming everything matches everything
- Surprises with partitionable slots
- Managing groups not easy

- May want to think about draining instead.
Enough about Groups

› Remember: group quota comes first!
› Groups only way to limit total running jobs per user/group
› Haven’t gotten to matchmaking yet
Negotiation Cycle

› Gets all the slot ads from collector
› Based on new user prio, computes submitter limit for each user
› Foreach user, finds the schedd, gets a job
  • Finds all matching machines for job
  • Sorts the machines
  • Gives the job the best machine (may preempt)
Negotiator metric: User Priority

- Negotiator computes, stores the user priority
- View with `condor_userprio tool`
- Inversely related to machines allocated (lower number is better priority)
  - A user with priority of 10 will be able to claim twice as many machines as a user with priority 20
(Effective) User Priority is determined by multiplying two components

- Real Priority * Priority Factor
Real Priority

- Based on actual usage, starts at .5
- Approaches actual number of machines used over time
  - Configuration setting `PRIORITY_HALFLIFE`
  - If `PRIORITY_HALFLIFE = +Inf`, no history
  - Default one day (in seconds)
- Asymptotically grows/shrinks to current usage
Priority Factor

- Assigned by administrator
  - Set/viewed with `condor_userprio`
  - Persistently stored in CM
- Defaults to 1000 (DEFAULT_PRIO_FACTOR)
- Allows admins to give prio to sets of users, while still having fair share within a group
- “Nice user”s have Prio Factors of 1,000,000
## Command usage:

```bash
condor_userprio -most
```

<table>
<thead>
<tr>
<th>User Name</th>
<th>Effective Priority</th>
<th>Priority Factor</th>
<th>In Use (wghted-hrs)</th>
<th>Last Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="mailto:lmichael@submit-3.chtc.wisc.edu">lmichael@submit-3.chtc.wisc.edu</a></td>
<td>5.00</td>
<td>10.00</td>
<td>0</td>
<td>0+23:46</td>
</tr>
<tr>
<td><a href="mailto:blin@osghost.chtc.wisc.edu">blin@osghost.chtc.wisc.edu</a></td>
<td>7.71</td>
<td>10.00</td>
<td>0</td>
<td>0+01:05</td>
</tr>
<tr>
<td><a href="mailto:osgtest@osghost.chtc.wisc.edu">osgtest@osghost.chtc.wisc.edu</a></td>
<td>90.57</td>
<td>10.00</td>
<td>47</td>
<td>&lt;now&gt;</td>
</tr>
<tr>
<td><a href="mailto:cxiong36@submit-3.chtc.wisc.edu">cxiong36@submit-3.chtc.wisc.edu</a></td>
<td>500.00</td>
<td>1000.00</td>
<td>0</td>
<td>0+00:09</td>
</tr>
<tr>
<td><a href="mailto:ojalvo@hep.wisc.edu">ojalvo@hep.wisc.edu</a></td>
<td>500.00</td>
<td>1000.00</td>
<td>0</td>
<td>0+05:37</td>
</tr>
<tr>
<td><a href="mailto:wjiang4@submit-3.chtc.wisc.edu">wjiang4@submit-3.chtc.wisc.edu</a></td>
<td>500.00</td>
<td>1000.00</td>
<td>0</td>
<td>0+21:25</td>
</tr>
<tr>
<td><a href="mailto:cxiong36@submit.chtc.wisc.edu">cxiong36@submit.chtc.wisc.edu</a></td>
<td>500.00</td>
<td>1000.00</td>
<td>0</td>
<td>0+21:42</td>
</tr>
</tbody>
</table>
Prio factors with groups

condor_userprio -setfactor 10 group1.wisc.edu
condor_userprio -setfactor 20 group2.wisc.edu

Note that you must get UID_DOMAIN correct

Gives group1 members 2x resources as group2
NEGOTIATOR_PRE_JOB_RANK = RemoteOwner =?= UNDEFINED

JOB_RANK = mips

NEGOTIATOR_POST_JOB_RANK =

(RemoteOwner =?= UNDEFINED) *

(KFlops)
Power of \texttt{NEGOTIATOR\_PRE\_JOB\_RANK}

- Very powerful
- Used to pack machines
- \texttt{NEGOTIATOR\_PRE\_JOB\_RANK} = \texttt{isUndefined(RemoteOwner)} \times (- \texttt{SlotId})
- Sort multicore vs. serial jobs
More Power of NEGOTIATOR_PRE_JOB_RANK

Best fit of multicore jobs:

\[
\text{NEGOTIATOR\_PRE\_JOB\_RANK} = (1000000 \times (\text{RemoteOwner} \neq \text{UNDEFINED})) - (100000 \times \text{Cpus}) - \text{Memory}
\]
If Matched machine claimed, extra checks required

- `PREEMPTION_REQUIREMENTS` and `PREEMPTION_RANK`
- Evaluated when `condor_negotiator` considers replacing a lower priority job with a higher priority job
- Completely unrelated to the `PREEMPT` expression (which should be called `evict`)
A note about Preemption

› Fundamental tension between
  • Throughput vs. Fairness
› Preemption is required to have fairness
› Need to think hard about runtimes, fairness and preemption
› Negotiator implementation preemption
› (Workers implement eviction: different)
PREEMPTION_REQUIREMENTS

› MY = busy machine  //  TARGET = job
› If false will not preempt machine
  • Typically used to avoid pool thrashing
  • Typically use:
    • RemoteUserPrio – Priority of user of currently running job (higher is worse)
    • SubmittorPrio – Priority of user of higher priority idle job (higher is worse)
 Replace jobs running > 1 hour and 20% lower priority

\[ \text{StateTimer} = \left( \text{CurrentTime} - \text{EnteredCurrentState} \right) \]

\[ \text{HOUR} = (60*60) \]

\[ \text{PREEMPTION\_REQUIREMENTS} = \left( \text{$(\text{StateTimer}) > (1 * \text{$(\text{HOUR})}) \ \&\& \ \text{RemoteUserPrio} > \text{SubmittorPrio} * 1.2} \right) \]
By default, won’t preempt to make quota
But, “there’s a knob for that”

PREEMPTION_REQUIREMENTS =
(SubmitterGroupResourcesInUse < SubmitterGroupQuota) &&
(RemoteGroupResourcesInUse > RemoteGroupQuota) && (RemoteGroup != SubmitterGroup)
PREEMPTION_REQUIREMENTS is an expression

```
› ( MY.TotalJobRunTime > 
ifThenElse((is Undefined (MAX_PREEMPT) ||
(MAX_PREEMPT =?= 0)), (72 * (60 * 60)), MAX_PREEMPT) )

› && RemoteUserPrio > SubmittorPrio * 1.2
```
Of all claimed machines where PREEMPTION_REQUIREMENTS is true, picks which one machine to reclaim

Strongly prefer preempting jobs with a large (bad) priority and a small image size

\[
\text{PREEMPTION\_RANK} = (\text{RemoteUserPrio} \times 1000000) - \text{ImageSize}
\]
Based on …

Runtime?
Cpus?
SlotWeight?
MaxJobRetirementTime

- Can be used to guarantee minimum time
- E.g. if claimed, give an hour runtime, no matter what:
  - MaxJobRetirementTime = 3600
- Can also be an expression
Partitionable slots

› What is the “cost” of a match?
  • SLOT_WEIGHT (cpus)

› What is the cost of an unclaimed pslot?
  • The whole rest of the machine
  • Leads to quantization problems

› By default, schedd splits slots

› “Consumption Policies”: some rough edges
Draining and defrag

› Instead of preemping, we can drain
› Condor\_drain command initiates draining

› Defrag daemon periodically calls drain
Defrag knobs

DEFRAG_MAX_WHOLE_MACHINES = 12
DEFRAG_DRAINING_MACHINES_PER_HOUR = 1
DEFRAG_REQUIREMENTS = PartitionableSlot &&
    TotalCpus > 4 && …
DEFRAG_WHOLE_MACHINE_EXPR=
    PartitionableSlot && cpus > 4
Summary

› Many ways to schedule

› Knobs: We got ‘em!