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 1st job
- The central manager responsible for users
- The central manager responsible for groups
- Accounting happens in the CM


THE SCHEDD, DUDE
DOESN'T SCHEDULE!
memegenerator.net

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

Concurrency Limits

- Useful for globally (pool-wide):
  - License limits,
  - NFS server overload prevention
  - Limiting database access
- Limits total number jobs across all schedds

Concurrency 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”

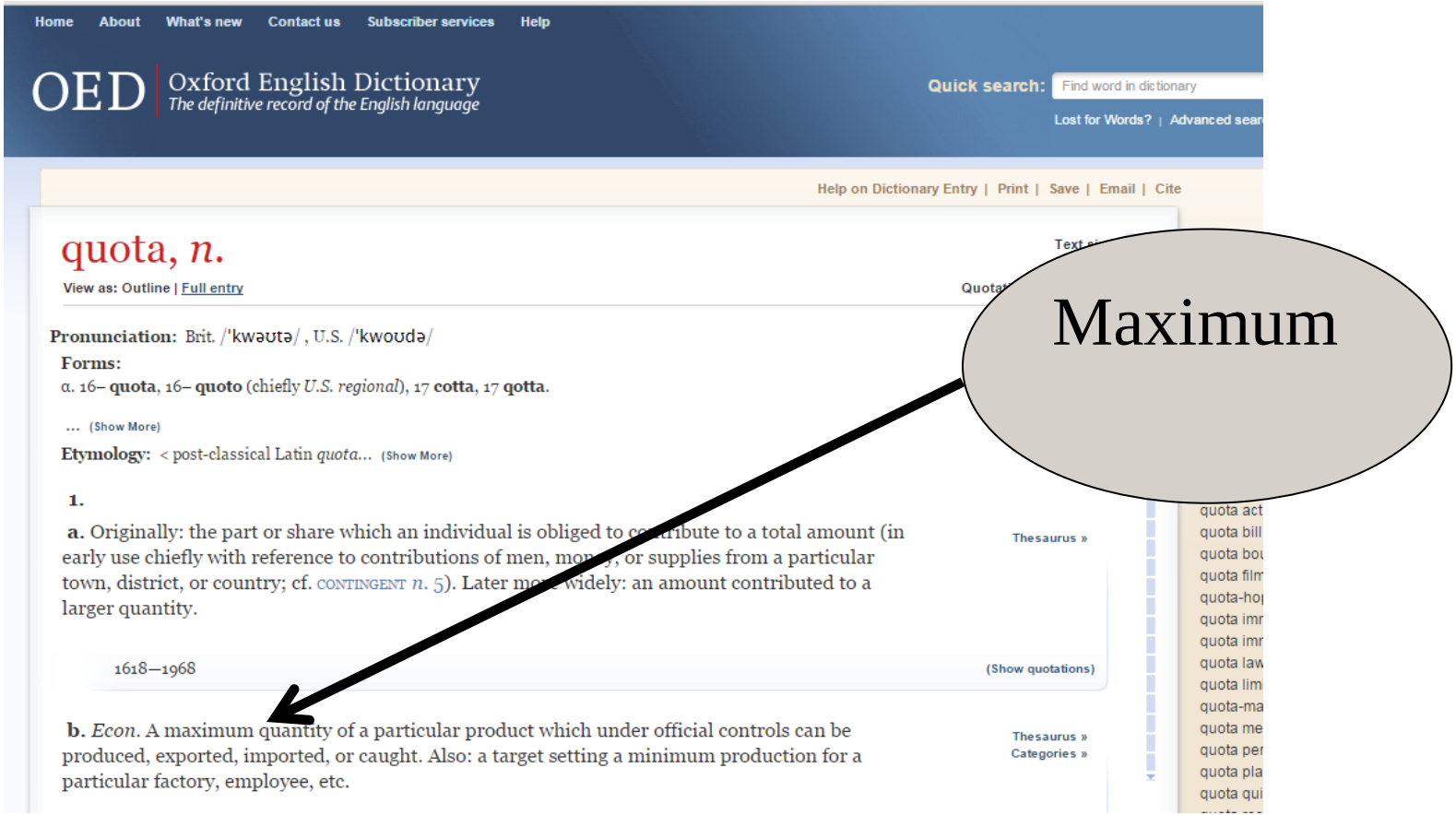
Accounting Groups (2 kinds)

- 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”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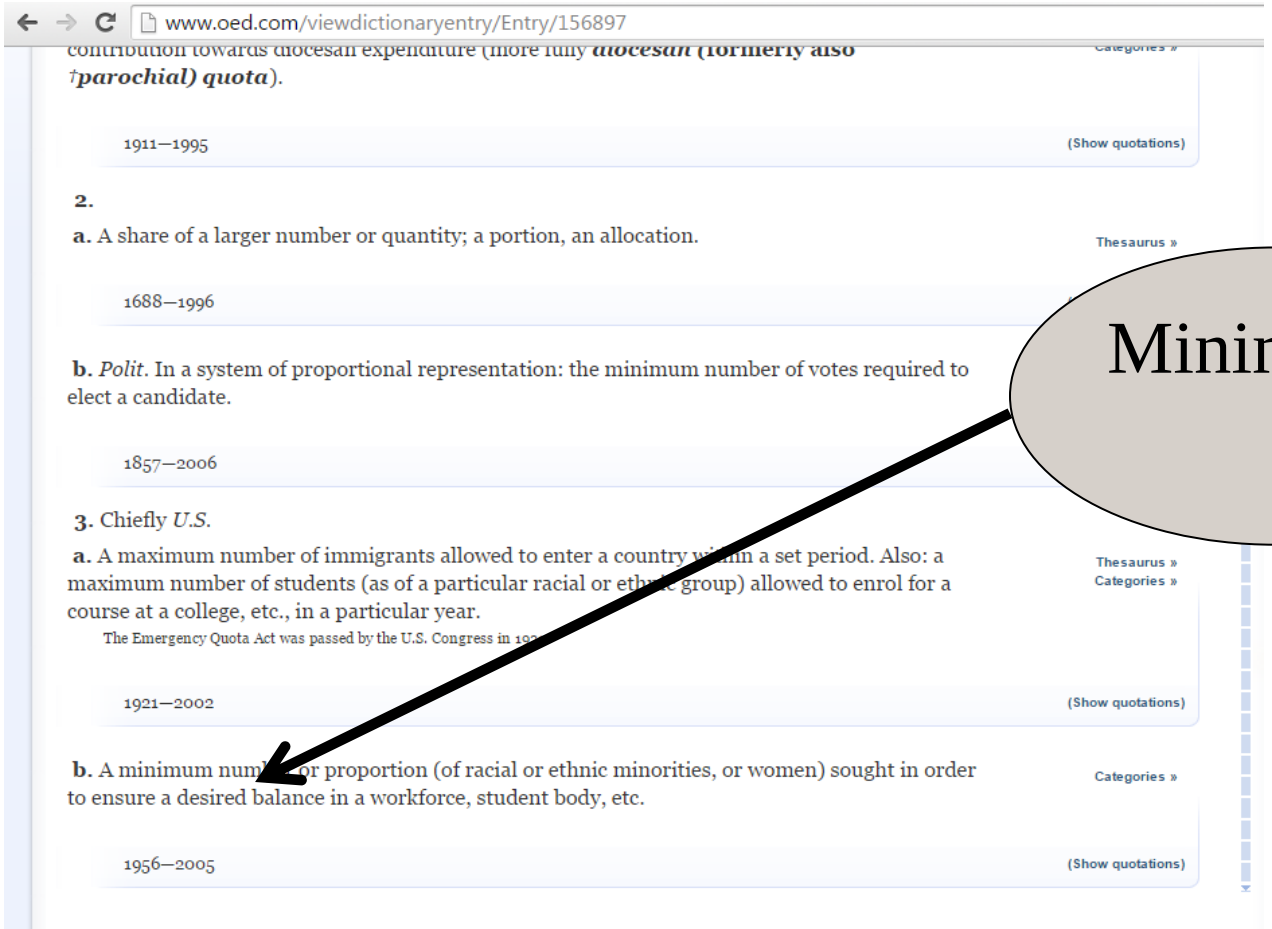
quota, n.
View as: Outline | Full entry
Pronunciation: Brit. /ˈkwəʊtə/ , U.S. /ˈkwoʊdə/
Forms:
α. 16– quota, 16– quoto (chiefly U.S. regional), 17 cotta, 17 qotta.
... (Show More)
Etymology: < post-classical Latin quota... (Show More)
1.
a. Originally: the part or share which an individual is obliged 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.
Thesaurus »
1618—1968
(Show quotations)
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.
Thesaurus »
Categories »
Maximum


www.oed.com/viewdictionaryentry/Entry/156897
†parochial) quota).
1911–1995
(Show quotations)
2.
a. A share of a larger number or quantity; a portion, an allocation.
Thesaurus »
1688–1996
b. Polit. In a system of proportional representation: the minimum number of votes required to elect a candidate.
1857–2006
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.
Thesaurus »
Categories »
1921–2002
(Show quotations)
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.
Categories »
1956–2005
(Show quotations)
Minimum

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

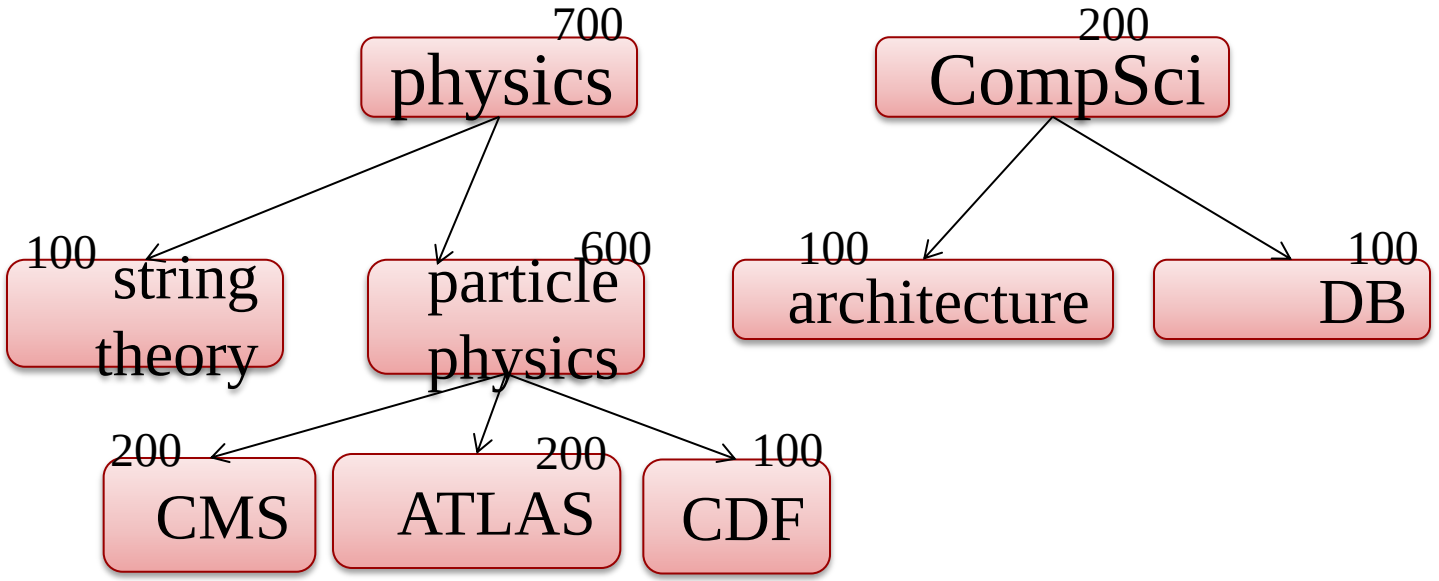
- Group_accept_surplus = true
- Group_accept_surplus_a = true
- This is what creates hierarchy
  - But only for quotas

GROUP_AUTOREGROUP

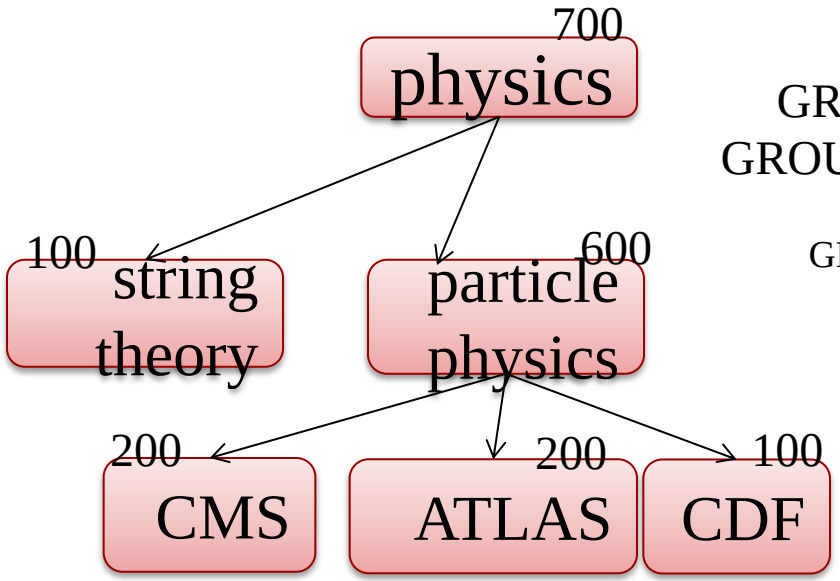
- Allows groups to go over quota if idle machines

- “Last chance” wild-west round, with every submitter for themselves.

Hierarchical Group Quotas



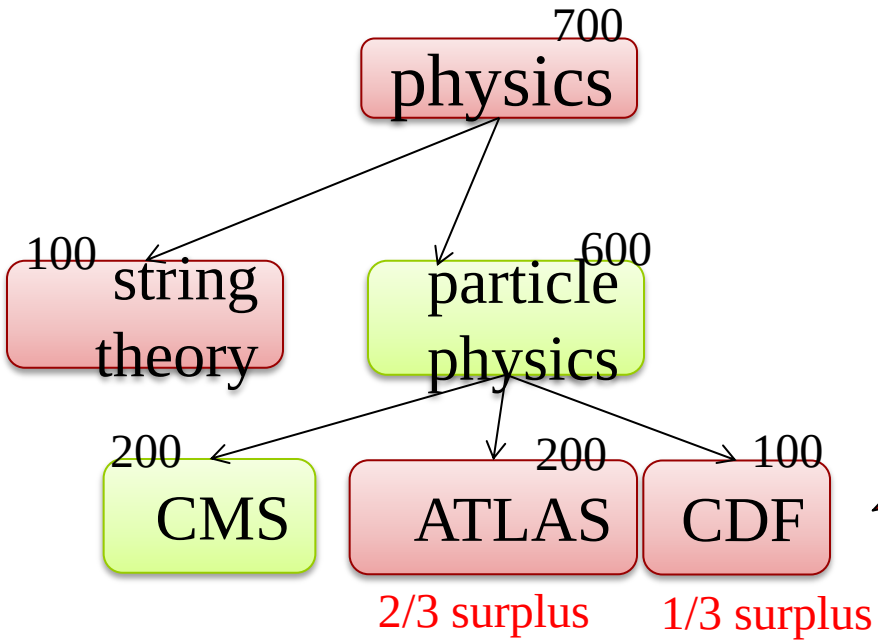
Hierarchical Group Quotas



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

group.sub-group.sub-sub-group…

Hierarchical Group Quotas



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 prio
- 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

User Priority

- (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

condor_userprio

- Command usage:

```
condor_userprio -most
```

```
                                     Effective   Priority
User Name                            Priority     Factor   In Use (wghted-hrs) Last Usage
------------------------------------ --------- ---------- ------ ------------ ----------
lmichael@submit-3.chtc.wisc.edu           5.00      10.00      0        16.37    0+23:46
blin@osghost.chtc.wisc.edu                7.71      10.00      0      5412.38    0+01:05
osgtest@osghost.chtc.wisc.edu            90.57      10.00     47     45505.99      <now>
cxiong36@submit-3.chtc.wisc.edu         500.00    1000.00      0         0.29    0+00:09
ojalvo@hep.wisc.edu                     500.00    1000.00      0    398148.56    0+05:37
wjiang4@submit-3.chtc.wisc.edu          500.00    1000.00      0         0.22    0+21:25
cxiong36@submit.chtc.wisc.edu           500.00    1000.00      0        63.38    0+21:42
```

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

Sorting slots: sort levels

```
NEGOTIATOR_PRE_JOB_RANK =
    RemoteOwner =?= UNDEFINED
JOB_RANK = mips
NEGOTIATOR_POST_JOB_RANK =
    (RemoteOwner =?= UNDEFINED) *
(KFlops)
```

Power of NEGOTIATOR_PRE_JOB_RANK

- Very powerful
- Used to pack machines
  - `NEGOTIATOR_PRE_JOB_RANK = isUndefined(RemoteOwner) * (- SlotId)`
- Sort multicore vs. serial jobs

More Power of NEGOTIATOR_PRE_JOB_RANK

Best fit of multicore jobs:

```
NEGOTIATOR_PRE_JOB_RANK =
(1000000 * (RemoteOwner =?= UNDEFINED))
    - (100000 * Cpus) - 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)

PREEMPTION_REQUIREMENTS

- Replace jobs running > 1 hour and 20% lower priority

```
StateTimer = \
  (CurrentTime - EnteredCurrentState)
HOUR = (60*60)
PREEMPTION_REQUIREMENTS = \
  $(StateTimer) > (1 * $(HOUR)) \
  && RemoteUserPrio > SubmittorPrio * 1.2
```

Preemption with HQG

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((isUndefined(MAX_PREEMPT) ||
    (MAX_PREEMPT =?= 0)),(72*(60 *
  60)),MAX_PREEMPT) )
  ```

- ```
  && RemoteUserPrio > SubmittorPrio * 1.2
  ```

PREEMPTION_RANK

- 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

```
PREEMPTION_RANK = \
  (RemoteUserPrio * 1000000)- ImageSize
```

Better PREEMPTION_RANK

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!