



Job and Machine Policy
HTCondor Week UK 2018
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Policy Expressions

- › Policy Expressions allow jobs and machines to
 - perform job steering
 - handle errors and retries
 - limit when/where jobs can start
 - restrict access

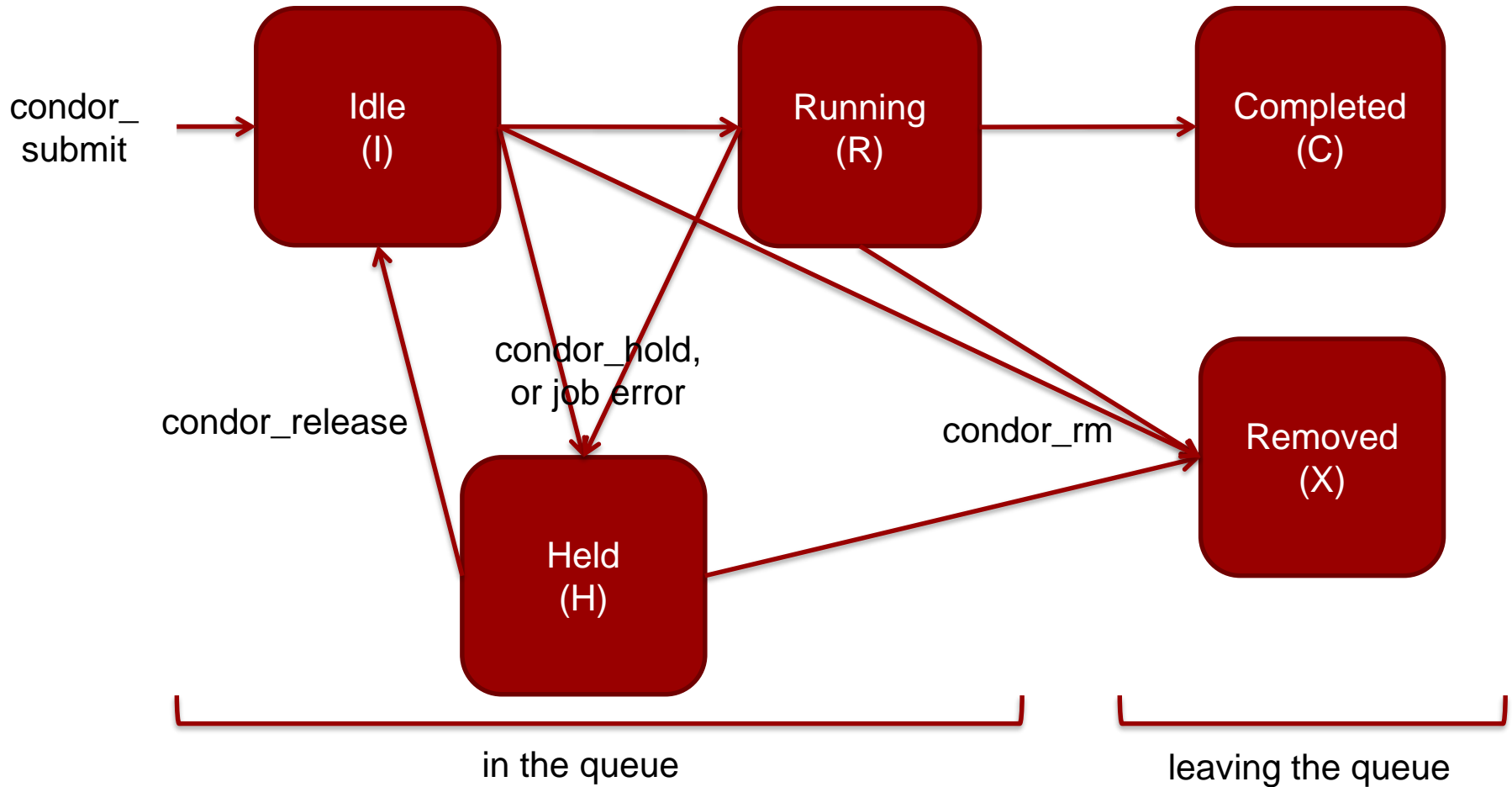
We learned earlier...

- › Job submit file can specify Requirements and Rank expressions to express constraints and preferences on a match

```
Requirements = OpSysAndVer=="RedHat6"  
Rank = kflops
```

- › Another set of policy expressions control job status

Job States Diagram



Job Status Policy Expressions

- › User specifies in the job submit file
- › Can reference any job attribute
- › Evaluated periodically

`periodic_remove = <expression>`

`periodic_hold = <expression>`

`periodic_release = <expression>`

- › Evaluated when the job exits

`on_exit_remove = <expression>`

`on_exit_hold = <expression>`

Example: on_exit policies

- › Do not remove if exits with a signal:

```
on_exit_remove = ExitBySignal == False
```

- › Place on hold if exits with nonzero status or ran for less than an hour:

```
on_exit_hold = (ExitCode != 0) \  
  || ((time() - JobStartDate) < 3600)
```

Example: a periodic policy

› The following lines will:

- request a default amount of memory (2GB)
- put the job on hold if it is exceeded
- release the the job with an increased memory request

```
periodic_hold = (JobStatus == 2) \  
  && (MemoryUsage >= (RequestMemory * 5/4))  
  
periodic_release = (JobStatus == 5) \  
  && ((time() - EnteredCurrentStatus) > 180) \  
  && (NumJobStarts < 5) \  
  && (HoldReasonCode != 13) && (HoldReasonCode != 34)  
  
request_memory = ifThenElse(MemoryUsage is undefined, \  
  2048, (MemoryUsage * 3/2))
```

Job Policies by the Admin

- › Configure in the Schedds config

```
system_periodic_remove = <expression>
system_periodic_hold = <expression>
system_periodic_release = <expression>
```
- › For all jobs managed by the Schedd
- › Period is max percentage of Schedd's time, with minimum and maximum
 - Default 1%, min=60sec, max=1200sec

Startd Policy Expressions

- › How do you specify Requirements and Rank for machine slots?
- › Specified in condor_config
- › Machine slot policy (or 'startd policy') expressions can reference items in either the machine or candidate job ClassAd (See manual appendix for list)

Administrator Policy Expressions

- › Some Startd Expressions (when to start/stop jobs)
 - START = <expr>
 - RANK = <expr>
 - SUSPEND = <expr>
 - CONTINUE = <expr>
 - PREEMPT = <expr> (*really means evict*)
 - And the related WANT_VACATE = <expr>

Startd's START

- › START is the primary policy
- › When FALSE the machine enters the Owner state and will not run jobs
- › Acts as the Requirements expression for the machine, the job must satisfy START
 - Can reference job ClassAd values including Owner and ImageSize

Startd's RANK

- › Indicates which jobs a machine prefers
- › Floating point number, just like job rank
 - Larger numbers are higher ranked
 - Typically evaluate attributes in the Job ClassAd
 - Typically use + instead of &&
- › Often used to give priority to owner of a particular group of machines
- › Claimed machines still advertise looking for higher ranked job to preempt the current job
 - LESSON: Startd Rank creates job preemption

Startd's PREEMPT

- › Really means vacate (I prefer nothing vs this job!)
- › When PREEMPT becomes true, the job will be killed and go from Running to Idle
- › Can “kill nicely”
 - WANT_VACATE = <expr>; if true then send a SIGTERM and follow-up with SIGKILL after **MachineMaxVacateTime** seconds.

Startd's Suspend and Continue

- › When True, send SIGSTOP or SIGCONT to all processes in the job

Default Startd Settings

- › Always run jobs to completion

START = True

RANK = 0

PREEMPT = False

SUSPEND = False

CONTINUE = True

this is

Use **POLICY: always_run_jobs**

Policy Configuration



- › I am adding special new nodes, only for simulation jobs from Math. If none, simulations from Chemistry. If none, simulations from anyone.

Prefer Chemistry Jobs

START = KindOfJob == "Simulation"

RANK =

10 * Department == "Math" +

Department == "Chemistry"

SUSPEND = False

PREEMPT = False



Policy Configuration

- › *Don't let any job run longer than 24 hrs, except Chemistry jobs can run for 48 hrs.*

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<http://www.flickr.com/photos/vmos/2078227291/> <http://www.webcitation.org/5XIff1deZ>

Settings for showing runtime limits

```
START = True
```

```
RANK = 0
```

```
PREEMPT = TotalJobRunTime >  
  ifThenElse (Department=?="Chemistry",  
              48 * (60 * 60),  
              24 * (60 * 60) )
```

Note: this will result in the job going back to Idle in the queue to be rescheduled.

Runtime limits with a chance to checkpoint

```
START = True
```

```
RANK = 0
```

```
PREEMPT = TotalJobRunTime >  
  ifThenElse (Department=?="Chemistry",  
              48 * (60 * 60),  
              24 * (60 * 60) )
```

```
WANT_VACATE = True
```

```
MachineMaxVacateTime = 300
```

Wonder if the user will have any idea why their jobs was evicted....

Runtime limits with job hold

```
START = True
```

```
RANK = 0
```

```
TIME_EXCEEDED = TotalJobRunTime >  
    ifThenElse (Department=?="Chemistry",  
                48 * (60 * 60),  
                24 * (60 * 60) )
```

```
PREEMPT = $(TIME_EXCEEDED)
```

```
WANT_HOLD = $(TIME_EXCEEDED)
```

```
WANT_HOLD_REASON =
```

```
    ifThenElse ( Department=?="Chemistry",  
                "Chem job failed to complete in 48 hrs",  
                "Job failed to complete in 24 hrs" )
```

```
C:\temp>condor_q
```

```
-- Submitter: ToddsThinkpad : <127.0.0.1:49748> : ToddsThinkpad
```

ID	OWNER	SUBMITTED	RUN_TIME	ST	PRI	SIZE	CMD
1.0	tannenba	12/5 17:29	0+24:00:03	H	0	0.0	myjob.exe

```
1 jobs; 0 completed, 0 removed, 0 idle, 0 running, 1 held, 0 suspended
```

```
C:\temp>condor_q -hold
```

```
-- Submitter: ToddsThinkpad : <127.0.0.1:49748> : ToddsThinkpad
```

ID	OWNER	HELD_SINCE	HOLD_REASON
1.0	tannenba	12/6 17:29	Job failed to complete in 24 hrs

```
1 jobs; 0 completed, 0 removed, 0 idle, 0 running, 1 held, 0 suspended
```

Could we implement via job policy instead of startd policy?

› Yes. Put in condor_config on submit host:

```
SYSTEM_PERIODIC_HOLD =
```

```
(time()-JobStartTime) > (24*60*60)
```

```
SYSTEM_PERIODIC_HOLD_REASON =
```

```
"Job failed to complete in 24 hrs"
```

› Which to use?

- You may only have control of one or the other
- Startd policy evaluated more often (every 5 secs)
- Consider if policy is associated with the job or with the machine – keep responsibilities of both in mind

STARTD SLOT CONFIGURATION

Custom Attributes in Slot Ads

- › Several ways to add custom attributes into your slot ads
 - From the config file(s) (for static attributes)
 - From a script (for dynamic attributes)
 - From the job ad of the job running on that slot
 - From other slots on the machine
- › Can add a custom attribute to all slots on a machine, or only specific slots

Custom Attributes

from config file (static attributes)

- › Define your own slot attributes that jobs can match against.
- › If you want the slot to have
`HasMatlab=true`
- › Define value in config, and then add name to `STARTD_ATTRS` list, like this

```
STARTD_ATTRS = $(STARTD_ATTRS) HasMatlab
```

```
HasMatlab = true
```

```
Or SLOT_TYPE_<N>_HasMatlab = true
```

- › Note: Also `SUBMIT_ATTRS`, `SCHEDD_ATTRS`, `MASTER_ATTRS`, ...

Custom Attributes from a script (for dynamic attrs)

- › Run a script/program to define attributes
 - Script returns a ClassAd
 - Attributes are merged into Slot ClassAds

```
STARTD_CRON_JOB_LIST = tag  
STARTD_CRON_tag_EXECUTABLE = detect.sh
```

- › Run once or periodically
- › Control which slots get the attributes with SlotMergeConstraint or SlotId

Custom attributes from job classad running on the slot

- › Can take attribute X from job ad and publish it into slot ad when job is running on this slot.

- › `condor_config` :

```
STARTD_JOB_EXPRS = $(STARTD_JOB_EXPRS) CanCheckpoint
```

- › Example submit file:

```
executable = foo  
+CanCheckpoint = True  
queue
```

- › Now can reference attributes of the job in machine policy and `PREEMPTION_REQUIREMENTS`, e.g.

```
PREEMPT = CanCheckpoint =?= True
```

Cross publishing Slot Attributes

› Policy expressions sometimes need to refer to attributes from other slots

› Cross-publish with `STARTD_SLOT_ATTRS`

```
STARTD_SLOT_ATTRS = State, Activity
```

Now all slots can see `Slot1_State`, `Slot2_state`,...

› Each slot's attrs published in ALL slot ads with `SlotN_X`, so you can do this:

```
START = $(START) && (SlotId==2 && \
Slot1_State != "Claimed") && ...
```

Default Behavior:

One static slot per core

- › One static execution slot per CPU core, such that each slot is single core slot
- › Other resources (Disk, Memory, etc) are divided evenly among the slots

- › How can I customize this?

It is easy to Lie!

- › Set Arbitrary values for CPUs, Memory
- › HTCondor will allocate resources to slots *as if the values are correct*

```
NUM_CPUS = 99
```

```
MEMORY = \
```

```
$(DETECTED_MEMORY) * 99
```

- › Default values:

```
NUM_CPUS = $(DETECTED_CPUS)
```

```
MEMORY = $(DETECTED_MEMORY)
```



Control how resources are allocated to slots

- › Define up to 10 slot ‘types’
- › For each slot type you can define
 - A name prefix for the slot (defaults to “slot”)
 - The number of slots of that type to create
 - How many machine resources each slot should contain
 - Policy knobs (START, PREEMPT, etc) per slot type

Why?

› Perhaps to match your job load

› Examples

- Each slot has two cores

```
NUM_SLOTS_TYPE_1 = $(DETECTED_CPUS) / 2
```

```
SLOT_TYPE_1 = Cpus=2
```

- Non-uniform static slots: Make one “big” slot, the rest in single core slots

```
NUM_SLOTS_TYPE_1 = 1
```

```
SLOT_TYPE_1 = Cpus=4, Memory=50%
```

```
NUM_SLOTS_TYPE_2 = $(DETECTED_CPUS) - 4
```

```
SLOT_TYPE_2 = Cpus=1
```


[Aside: Big slot plus small slots]

› How to steer single core jobs away from the big multi-core slots

- Via job ad (if you control submit machine...)

`DEFAULT_RANK = RequestCPUs - CPUs`

- Via condor_negotiator on central manager

`NEGOTIATOR_PRE_JOB_RANK = \`
`RequestCPUs - CPUs`

Another why – Special Purpose Slots

Slot for a special purpose, e.g data movement, maintenance, interactive jobs, etc...

```
# Lie about the number of CPUs
NUM_CPUS = $(DETECTED_CPUS)+1
# Define standard static slots
NUM_SLOTS_TYPE_1 = $(DETECTED_CPUS)
# Define a maintenance slot
NUM_SLOTS_TYPE_2 = 1
SLOT_TYPE_2 = cpus=1, memory=1000
SLOT_TYPE_2_NAME_PREFIX = maint
SLOT_TYPE_2_START = owner=="tannenba"
SLOT_TYPE_2_PREEMPT = false
```

```
C:\home\tannenba>condor_status
```

Name	OpSys	Arch	State	Activity	LoadAv	Mem	ActvtyTime
maint5@ToddsThinkpa	WINDOWS	X86_64	Unclaimed	Idle	0.000	1000	0+00:00:08
slot1@ToddsThinkpa	WINDOWS	X86_64	Unclaimed	Idle	0.000	1256	0+00:00:04
slot2@ToddsThinkpa	WINDOWS	X86_64	Unclaimed	Idle	0.110	1256	0+00:00:05
slot3@ToddsThinkpa	WINDOWS	X86_64	Unclaimed	Idle	0.000	1256	0+00:00:06
slot4@ToddsThinkpa	WINDOWS	X86_64	Unclaimed	Idle	0.000	1256	0+00:00:07
	Total	Owner	Claimed	Unclaimed	Matched	Preempting	Backfill
X86_64/WINDOWS	5	0	0	5	0	0	0
Total	5	0	0	5	0	0	0

Advanced Slot Specialization

> `SLOT_TYPE_N_attr` where *attr* is

START

SUSPEND

CONTINUE

PREEMPT

KILL

CLAIM_WORKLIFE

MaxJobRetirementTime

MachineMaxVacateTime

Rank

SlotWeight

WANT_SUSPEND

WANT_VACATE

WANT_HOLD

WANT_HOLD_REASON

PERIODIC_CHECKPOINT

START_BACKFILL

EVICT_BACKFILL

FetchWorkDelay

...MORE...

Defining a custom resource

- › Define a custom STARTD resource
 - **MACHINE_RESOURCE_<tag>**
- › Can come from a script (if you want dynamic discovery)
 - **MACHINE_RESOURCE_INVENTORY_<tag>**

Fungible resources or "Unnamed" resources

- › For OS resources you don't need to know a name to use
 - Cpu cores, Memory, Disk
- › For intangible resources
 - Bandwidth
 - Licenses?
- › Works with Static and Partitionable slots



Unnamed custom resource example : bandwidth (1)

```
> condor_config_val -dump Bandwidth  
MACHINE_RESOURCE_Bandwidth = 1000
```

```
> grep -i bandwidth userjob.submit  
REQUEST_Bandwidth = 200
```

Unnamed custom resource example : bandwidth (2)

› Assuming 4 static slots

```
> condor_status -long | grep -i bandwidth
```

```
Bandwidth = 250
```

```
DetectedBandwidth = 1000
```

```
TotalBandwidth = 1000
```

```
TotalSlotBandwidth = 250
```


Non-fungible resources or Named resources

- › For resources not assigned by OS, and thus need to be assigned via name
 - GPUs, Instruments, Directories
- › Configure by listing resource ids
 - Ids must be unique
 - Quantity is inferred
- › Specific id(s) are assigned to slots
 - Passed to job using environment variables



Named custom resource example : GPUs (1)

```
> condor_config_val -dump gpus
MACHINE_RESOURCE_GPUs = CUDA0, CUDA1
ENVIRONMENT_FOR_AssignedGPUs = \
    CUDA_VISIBLE_DEVICES=/CUDA// GPU_NAME
ENVIRONMENT_VALUE_FOR_UnAssignedGPUs = 10000

> grep -i gpus userjob.submit
REQUEST_GPUs = 1
```

Or

use feature: GPUs

Named custom resource example : GPUs (2)

```
> condor_status -long slot1 | grep -i gpus
```

```
AssignedGpus = "CUDA0"
```

```
DetectedGPUs = 2
```

```
GPUs = 1
```

```
TotalSlotGPUs = 1
```

```
TotalGPUs = 2
```

Named custom resource example : GPUs (3)

- › Environment of a job running on that slot

```
> env | grep -I CUDA
_CONDOR_AssignedGPUs = CUDA0
CUDA_VISIBLE_DEVICES = 0
GPU_NAME = CUDA0
```

Partitionable Slots:

The big idea

- › One parent “partitionable” slot
 - A holder for resources
- › From which child “dynamic” slots are made at claim time
 - Resources carved off of the parent slot
- › When dynamic slots are unclaimed, their resources are merged back into the partitionable parent slot

(cont)

- › Partitionable slots split on
 - Cpu
 - Disk
 - Memory
 - (plus any custom startd resources you defined)
- › When you are out of CPU or Memory, you're out of slots

3 types of slots

- › Static (e.g. the usual kind)
- › Partitionable (e.g. unclaimed resources)
- › Dynamic (claimed slots carved off a partitionable slot parent)
 - Dynamically created at claim time
 - But once created, act as static
 - When unclaimed, resources go back to partitionable parent

8 Gb Partitionable slot

7 Gb Partitionable slot

1Gb

6 Gb Partitionable slot

1Gb

1Gb

5 Gb Partitionable slot

1Gb

1Gb

1Gb

0 Gb Partitionable slot

1Gb

1Gb

1Gb

1Gb

1Gb

1Gb

1Gb

1Gb

4 Gb Partitionable slot

1Gb

1Gb

1Gb

1Gb

1 Gb Partitionable slot

1Gb

1Gb

1Gb

4Gb

How to configure

```
NUM_SLOTS = 1
```

```
NUM_SLOTS_TYPE_1 = 1
```

```
SLOT_TYPE_1 = cpus=100%
```

```
SLOT_TYPE_1_PARTITIONABLE = true
```

or

```
use feature:PartitionableSlot
```

Looks like

```
$ condor_status
```

Name	OpSys	Arch	State	Activity	LoadAv	Mem
slot1@c	LINUX	X86_64	Unclaimed	Idle	0.110	8192

	Total	Owner	Claimed	Unclaimed	Matched
X86_64/LINUX	1	0	0	1	0
Total	1	0	0	1	0

When running

```
$ condor_status
```

Name	OpSys	Arch	State	Activity	LoadAv	Mem
slot1@c	LINUX	X86_64	Unclaimed	Idle	0.110	4096
slot1_1@c	LINUX	X86_64	Claimed	Busy	0.000	1024
slot1_2@c	LINUX	X86_64	Claimed	Busy	0.000	2048
slot1_3@c	LINUX	X86_64	Claimed	Busy	0.000	1024

Can specify default Request values

JOB_DEFAULT_REQUEST_CPUS

JOB_DEFAULT_REQUEST_MEMORY

JOB_DEFAULT_REQUEST_DISK

Fragmentation

Name	OpSys	Arch	State	Activity	LoadAv	Mem
slot1@c	LINUX	X86_64	Unclaimed	Idle	0.110	4096
slot1_1@c	LINUX	X86_64	Claimed	Busy	0.000	2048
slot1_2@c	LINUX	X86_64	Claimed	Busy	0.000	1024
slot1_3@c	LINUX	X86_64	Claimed	Busy	0.000	1024

Now I submit a job that needs 8G – what happens?

Solution: Draining

- › condor_drain
- › condor_defrag
 - One daemon defrags whole pool
 - Central manager good place to run
 - Scan pool, try to fully defrag some startds by invoking condor_drain to drain machine
 - Only looks at partitionable machines
 - Admin picks some % of pool that can be “whole”
- › Note: some heuristics can reduce need to defrag, such as packing large jobs on high number nodes and low jobs on low number

Oh, we got knobs...

DEFRAG_DRAINING_MACHINES_PER_HOUR

DEFRAG_MAX_WHOLE_MACHINES

DEFRAG_SCHEDULE

- graceful (obey MaxJobRetirementTime, default)
- quick (obey MachineMaxVacateTime)
- fast (hard-killed immediately)

Match Only Multicore Jobs to recently drained machines

- › Since the purpose of the defrag daemon is to drain jobs on a p-slot so multi-core jobs can begin to match, it would be best to implement a policy where recently drained p-slots can **insist** on matching only multicore jobs for a period of time.
- › See <https://htcondor-wiki.cs.wisc.edu/index.cgi/wiki?p=HowToMatchMulticoreAfterDrain>
- › Many other good HOWTO recipes on homepage

Further Information

- › For further information, see section 3.5 “Policy Configuration for the condor_startd” in the Condor manual
- › HTCondor HOWTOs recipes at <http://htcondor.org>.
- › htcondor-users mailing list
 - <http://htcondor.org/mail-lists/>