Job and Machine Policy Configuration HTCondor / ARC CE Workshop Barcelona 2016

Todd Tannenbaum

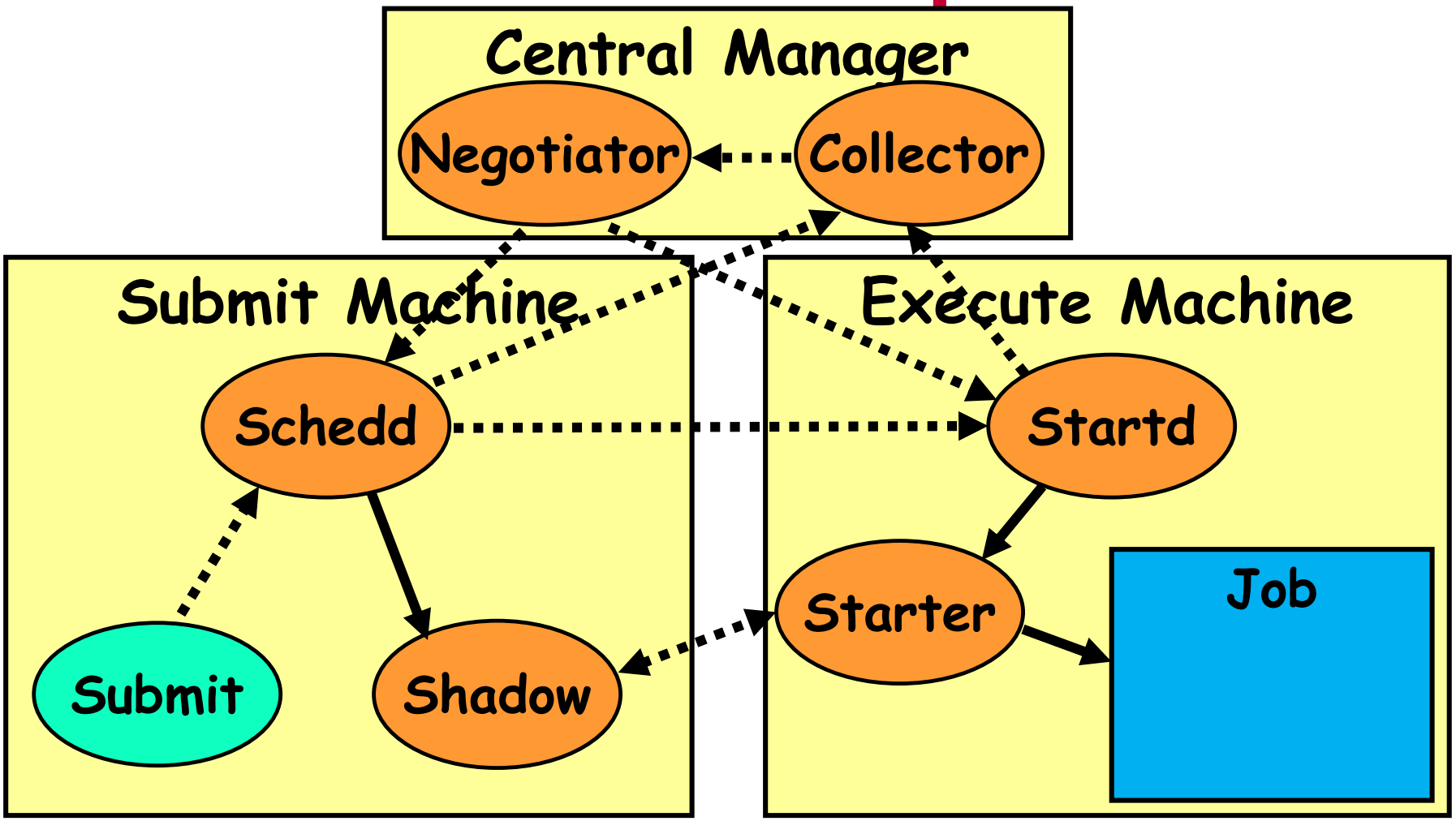
Quick Review

ClassAds: Example

```
[
Type = "Apartment";
SquareArea = 3500;
RentOffer = 1000;
HeatIncluded = False;
OnBusLine = True;
Rank = other.RentOffer
  + other.UnderGrad?0:10;
Requirements =
  TARGET.RentOffer >
  (MY.RentOffer - 150);
]
```

```
[
Type = "Renter";
UnderGrad = False;
RentOffer = 900;
Rank = 1/(other.RentOffer
   + 100.0);
Requirements =
  OnBusLine &&
  SquareArea > 1500;
]
```

Job Startup


Central Manager
Negotiator
Collector
Submit Machine
Execute Machine
Schedd
Startd
Starter
Job
Submit
Shadow

Policy Expressions

- Policy Expressions allow jobs and machines to restrict access, handle errors and retries, perform job steering, set limits, when/where jobs can start, etc.

Assume a simple setup

- Lets assume a pool with only one single user (me!).
  - no user/group scheduling concerns, we'll get to that later…

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
Executable = matlab
queue
```

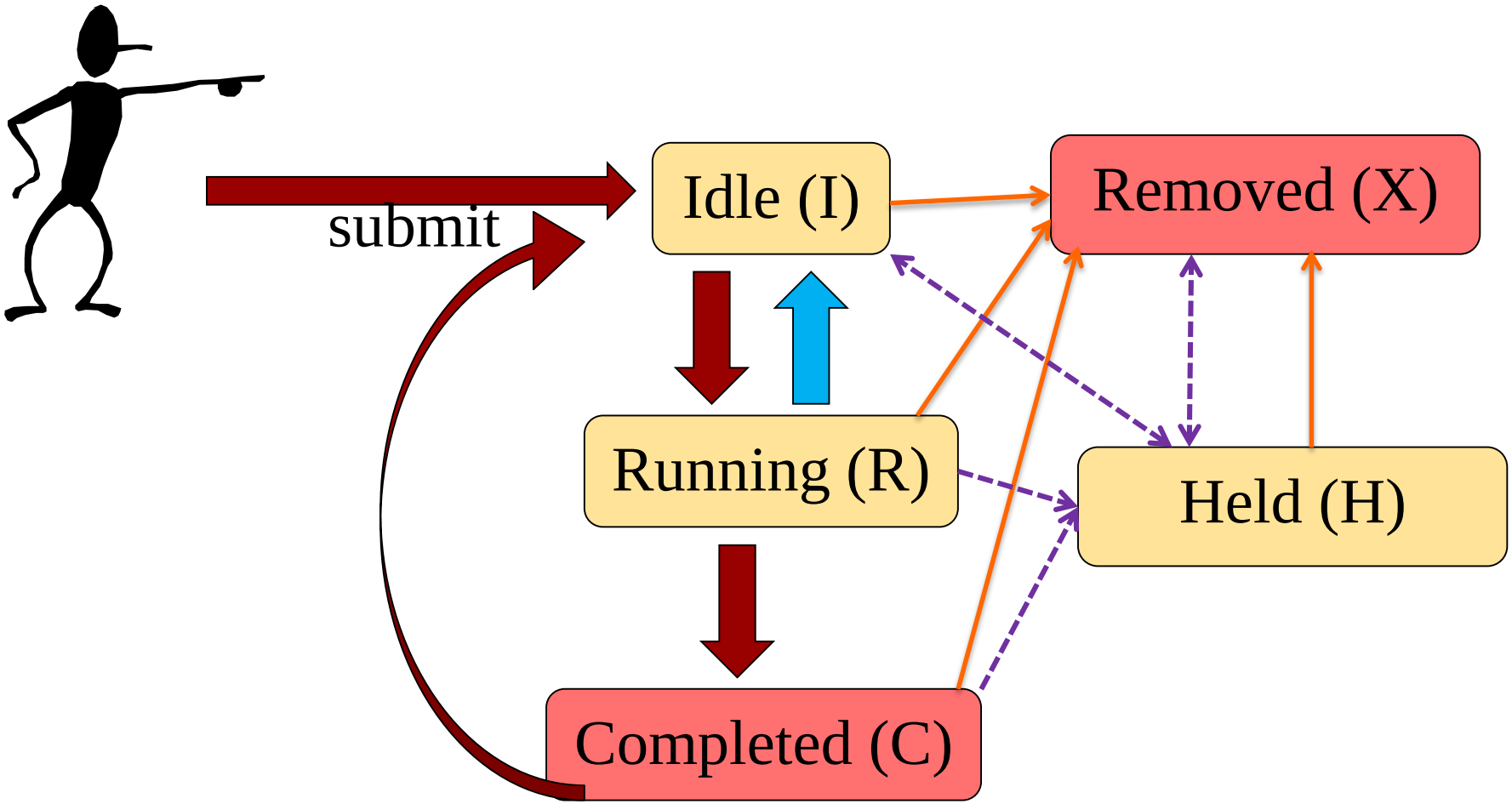
- Another set of policy expressions control job status

Job Status Policy Expressions

- User can supply job policy expressions in the job submit file. See condor_submit man page.
- These expressions can reference any job ad attribute.

```
on_exit_remove = <expression>
on_exit_hold = <expression>
periodic_remove = <expression>
periodic_hold = <expression>
periodic_release = <expression>
```

Job Status State Diagram



Job Policy Expressions

- 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)
```

- Place on hold if job has spent more than 50% of its time suspended:

```
periodic_hold =
  ( CumulativeSuspensionTime >
    (RemoteWallClockTime / 2.0) )
```

Job Policies by the Admin

- Admins can also provide supply periodic job policy expressions in the condor_config file.
- These expressions impact all jobs submitted to a specific schedd.

```
system_periodic_remove = <expression>
system_periodic_hold = <expression>
system_periodic_release = <expression>
```

- **What is the period? Frequency of evaluation is configurable via a floor (1 minute), max (20 minutes), and schedd timeslice (1%).**

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

OR

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.*

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_EXPRS (or _ATTRS), like this

```
STARTD_EXPRS = $(STARTD_EXPRS) HasMatlab
HasMatlab = true
Or SLOTX_HasMatlab = true
```

- Note: Also SUBMIT_EXPRS, SCHEDD_EXPRS, MASTER_EXPRS, …

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@ToddsThinkp 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
```

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
```

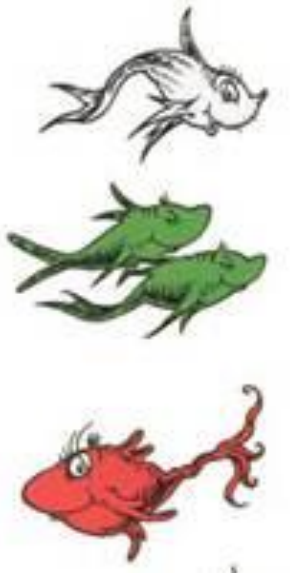
Unnamed custom resource example : bandwidth (2)

- 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
  - Quantity is inferred
- Specific id(s) are assigned to slots
- Works with Static and Partitionable slots



Named custom resource example : GPUs (1)

```
> condor_config_val -dump gpus
MACHINE_RESOURCE_GPUs = CUDA0, CUDA1
ENVIRONMENT_FOR_AssignedGPUs = GPU_NAME GPU_ID=/CUDA//
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
```

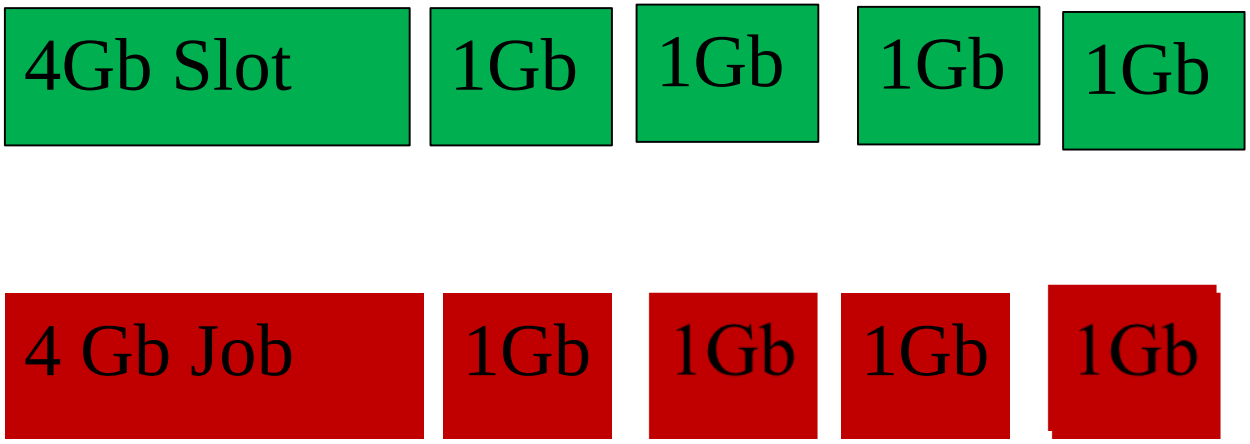
Named custom resource example : GPUs (3)

- Environment of a job running on that slot

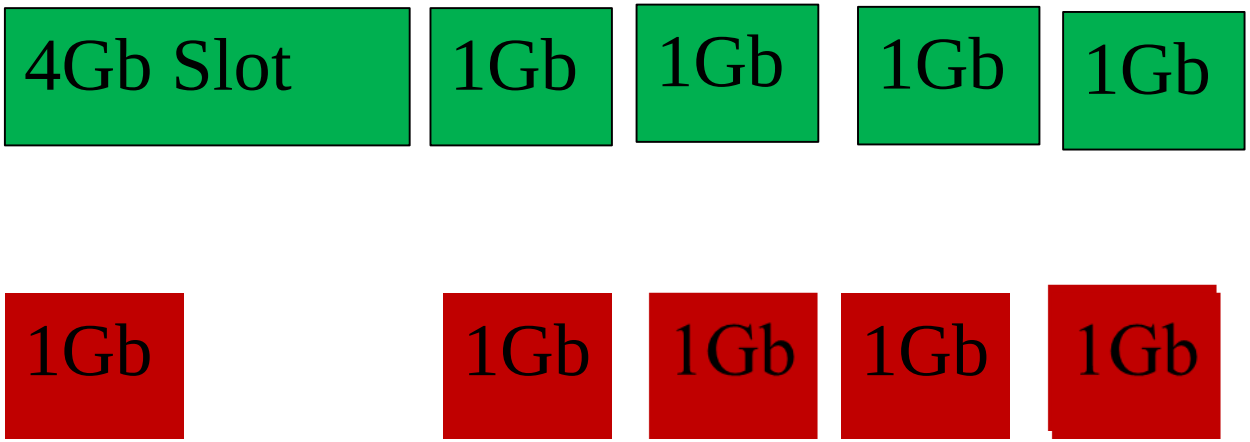
```
> env | grep -I CUDA
_CONDOR_AssignedGPUs = CUDA0
GPU_NAME = CUDA0
GPU_ID = 0
```

Non-uniform static slots help, but not perfect…

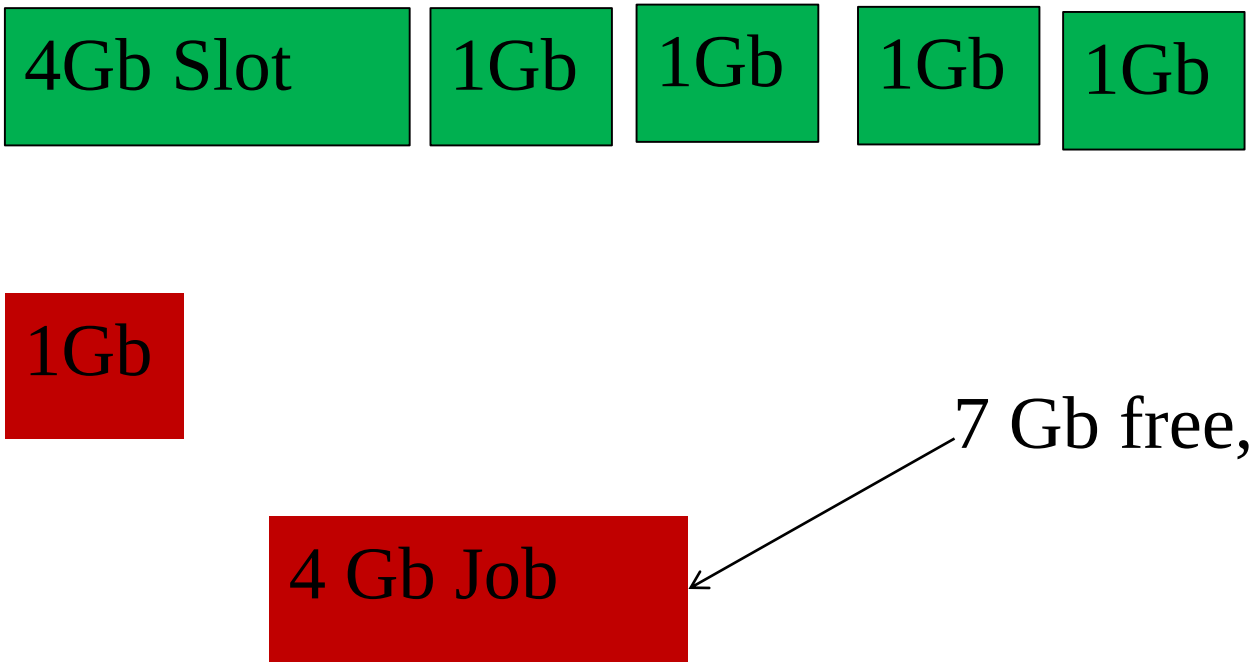
8 Gb machine partitioned into 5 static slots



8 Gb machine partitioned into 5 static slots



8 Gb machine partitioned into 5 static slots



Partitionable Slots: The big idea

- One parent “partionable” slot
- From which child “dynamic” slots are made at claim time
- When dynamic slots are released, their resources are merged back into the partionable parent slot

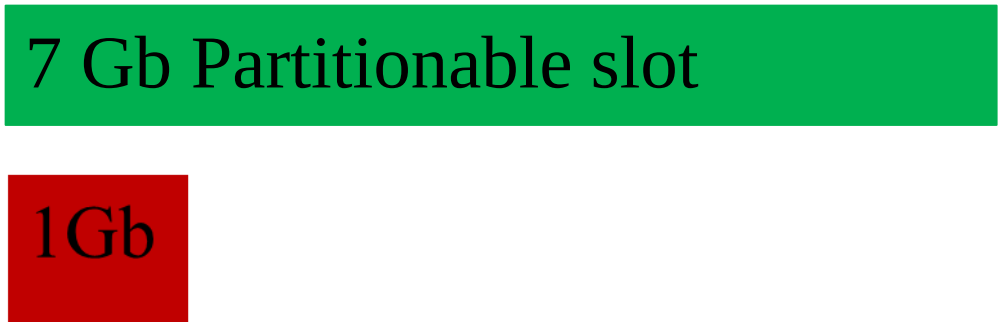
(cont)

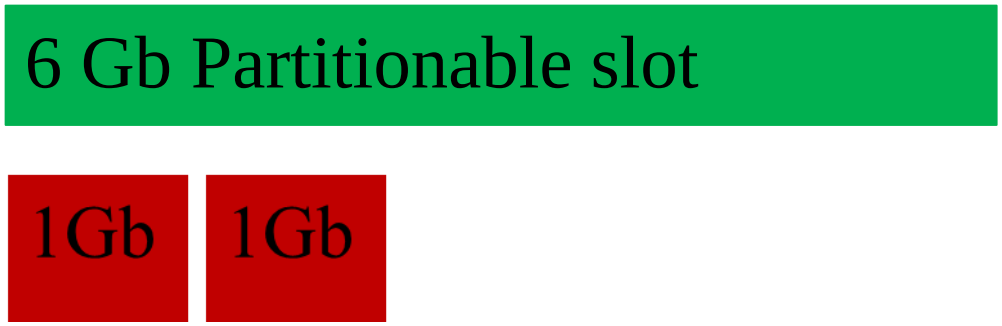
- Partionable slots split on
  - Cpu
  - Disk
  - Memory
  - (plus any custom startd resources you defined)
- When you are out of CPU or Memory, you're out of slots

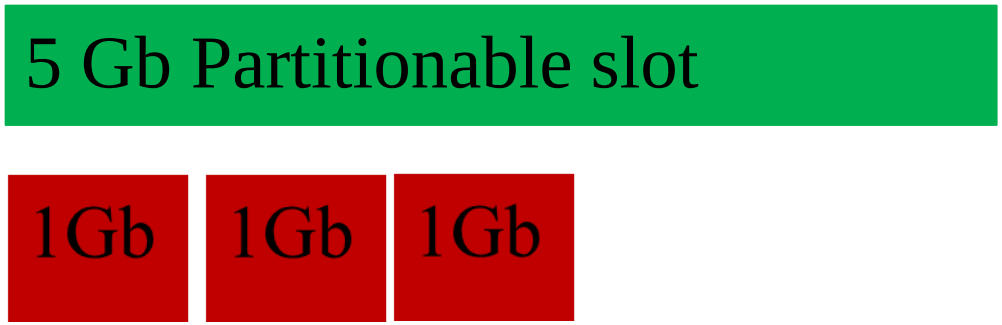
3 types of slots

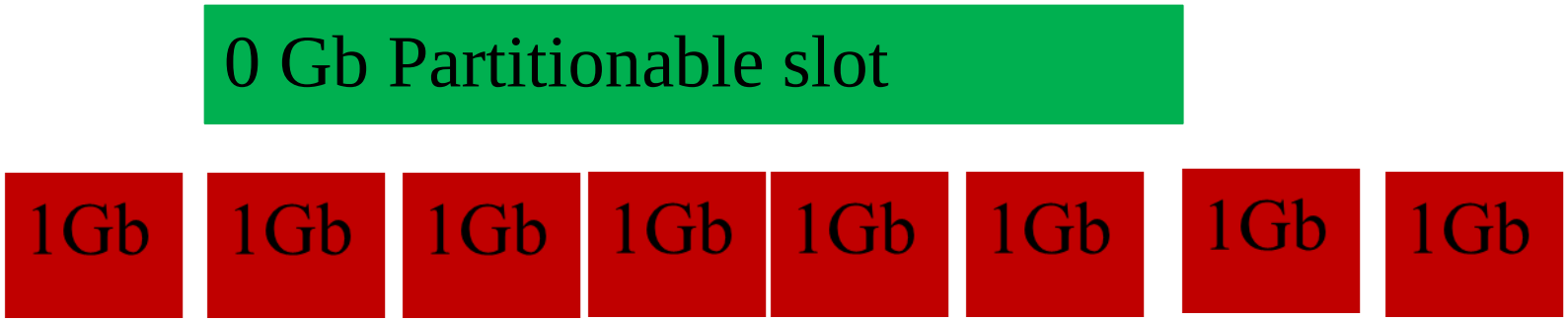
- Static (e.g. the usual kind)
- Partitionable (e.g. unclaimed resources)
- Dynamic (claimed slots carved off a partitionable slot parent)
  - Dynamically created at claim time
  - But once created, act as static
  - When unclaimed, resources go back to partitionable parent

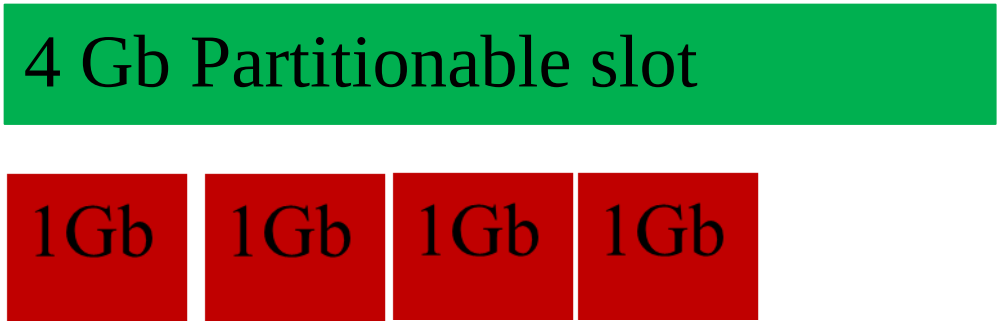
8 Gb Partitionable slot

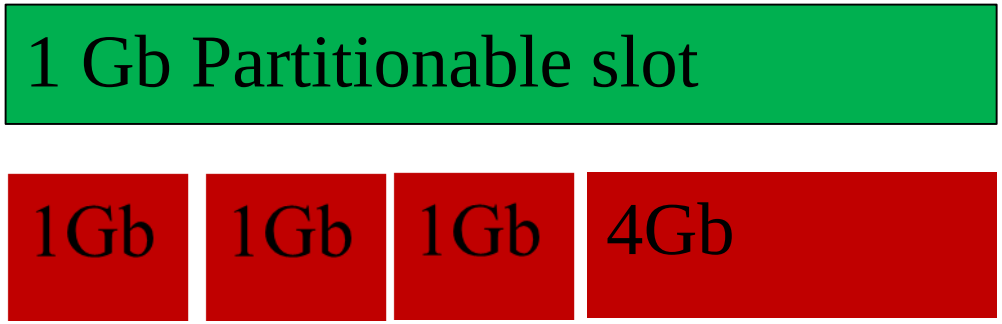

7 Gb Partitionable slot
1Gb


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
```

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

Future work on Partitionable Slots

- See my talk Wednesday!

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/