Open Science Grid

Job Matching, Handling, and Other HTCondor Features

Monday, Lecture 3

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Questions so far?

Goals for this Session

- Understand HTCondor mechanisms more deeply
- Automation, additional use cases and features

How is HTC Optimized?

- System must track jobs, machines, policy, …
- System must recover gracefully from failures
- Try to use all available resources, all the time
- Lots of variety in users, machines, networks, ...
- Sharing is hard (e.g. policy, security)

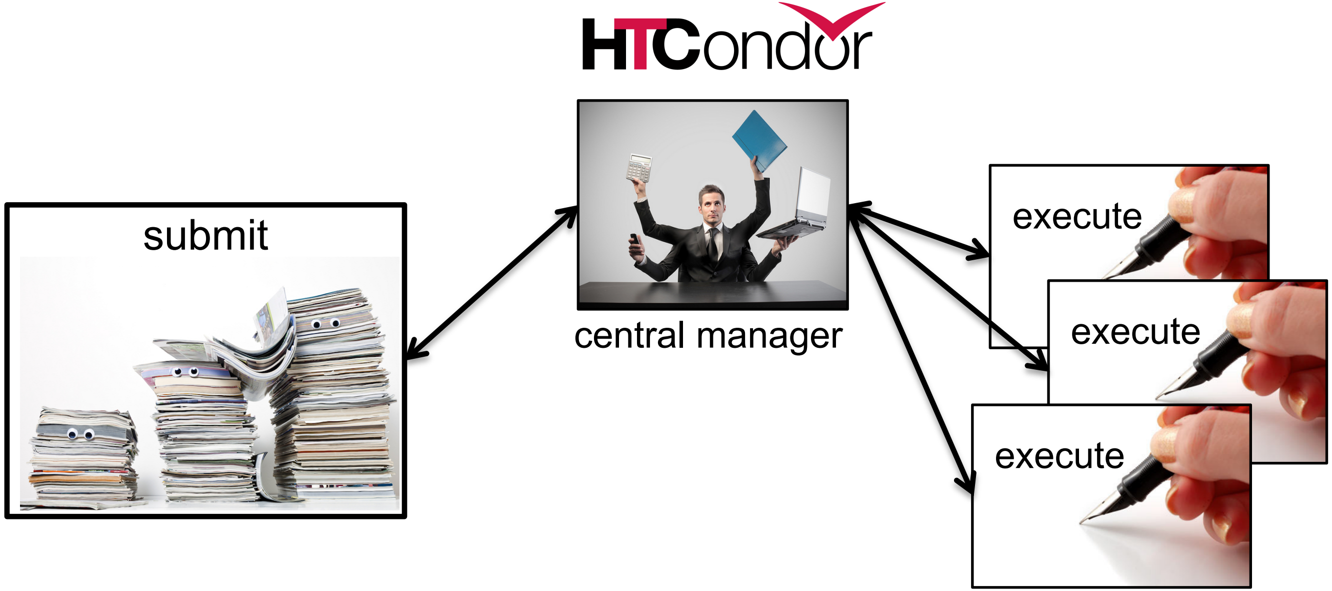
HTCONDOR MATCHMAKING

Roles in an HTCondor System

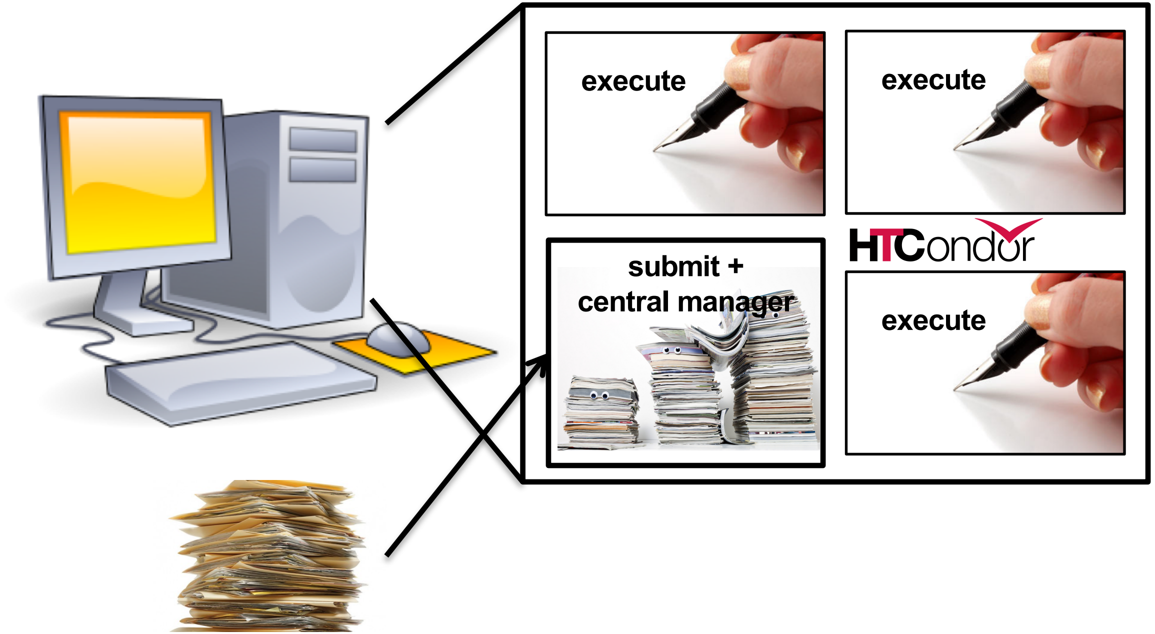
- **Users**
  - Define jobs, their requirements, and preferences
  - Submit and cancel jobs
  - Check on the status of jobs
- **Administrators**
  - Configure and control the HTCondor system
  - Implement policies
  - Check on the status of machines
- **HTCondor Software**
  - Track and manage machines
  - Track and run jobs
  - Match jobs to machines (enforcing all policies)

Job Matching

- On a regular basis, the **central manager** reviews **Job** and **Machine** attributes, and pool policies, and matches jobs to **slots**.



Single Computer



Terminology: Matchmaking

two-way process of finding a slot for a job

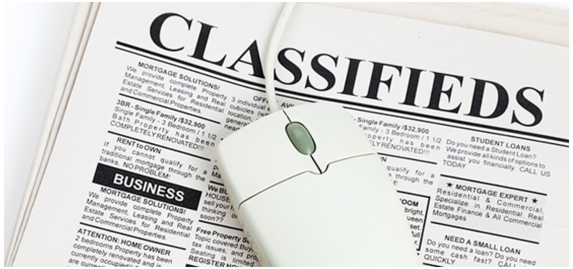
- ***Jobs* have requirements and preferences**
  - e.g.: I need one CPU core, 100 GB of disk space, and 10 GB of memory
- ***Machines* have requirements and preferences**
  - E.g.: I run jobs only from users in the Comp. Sci. dept., and prefer to run ones that ask for a lot of memory
- *Important jobs may run first or replace less important ones*

HTCondor Priorities

- **User priority**
  - Computed based on past usage
  - Determines user’s “fair share” percentage of slots
  - Lower number means run sooner (0.5 is minimum)
- **Job priority**
  - Set per job by the user (owner)
  - Relative to that user’s other jobs
  - Set in submit file or changed later with `condor_prio`
  - Higher number means run sooner
- **Preemption**
  - Low priority jobs stopped for high priority ones (stopped jobs go back into the regular queue)
  - Governed by fair-share algorithm and pool policy
  - Not enabled on all pools

Class Ads

- HTCondor stores a list of information about **each job** and **each machine** of potential slots.
- This information is stored for each job and each machine as its “**Class Ad**”



- Class Ads have the format:

```
AttributeName = value
```

can be a boolean (T/F), number, or string

HTCondor Manual: Appendix A: Class Ad Attributes

Job ClassAd

Submit file

```
executable = compare_states
arguments = wi.dat us.dat wi.dat.out

should_transfer_files = YES
transfer_input_files = us.dat, wi.dat
when_to_transfer_output = ON_EXIT

log = job.log
output = job.out
error = job.err

request_cpus = 1
request_disk = 20MB
request_memory = 20MB

queue 1
```

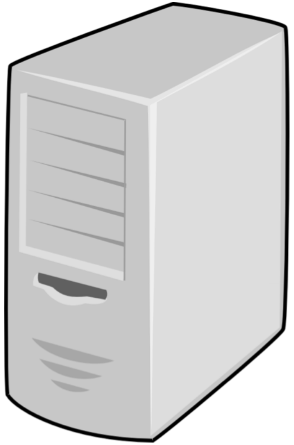
+

Default HTCondor configuration

=

```
RequestCpus = 1
Err = "job.err"
WhenToTransferOutput = "ON_EXIT"
TargetType = "Machine"
Cmd =
"/home/alice/tests/htcondor_week/compare_states"
JobUniverse = 5
Iwd = "/home/alice/tests/htcondor_week”
NumJobStarts = 0
WantRemoteIO = true
OnExitRemove = true
TransferInput = "us.dat,wi.dat"
MyType = "Job"
Out = "job.out"
UserLog =
"/home/alice/tests/htcondor_week/job.log"
RequestMemory = 20
...
```

Machine ClassAd



+

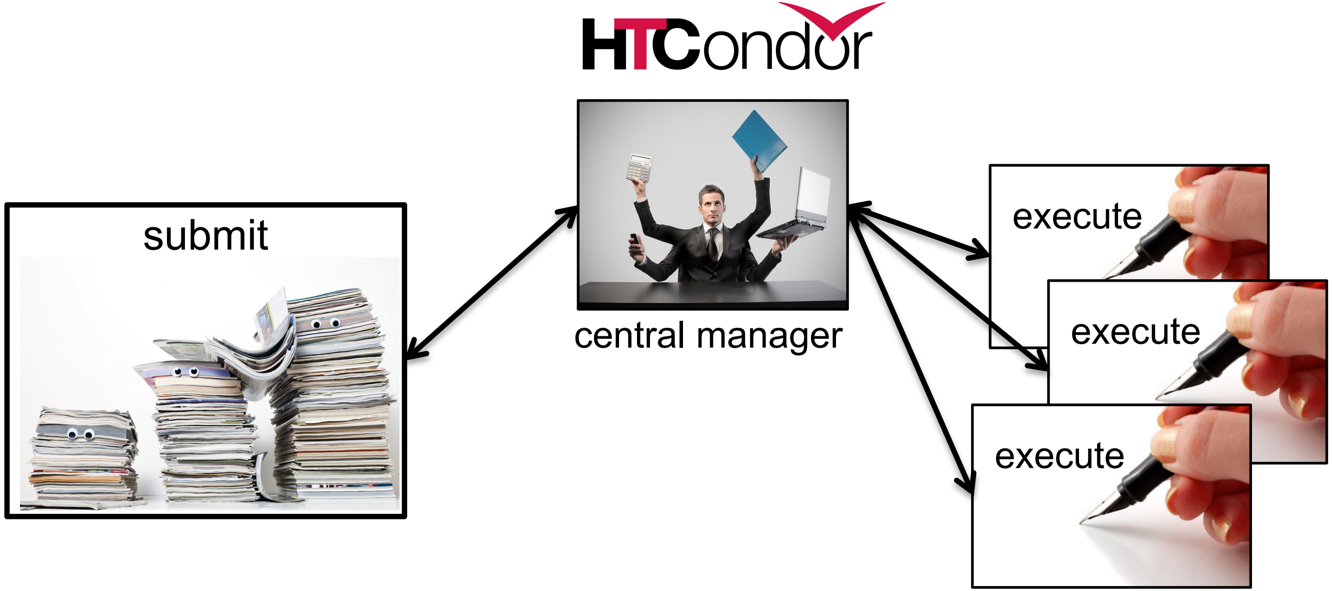
Default HTCondor configuration

=

```
HasFileTransfer = true
DynamicSlot = true
TotalSlotDisk = 4300218.0
TargetType = "Job"
TotalSlotMemory = 2048
Mips = 17902
Memory = 2048
UtsnameSysname = "Linux"
MAX_PREEMPT = ( 3600 * ( 72 - 68 *
( WantGlidein =?= true ) ) )
Requirements = ( START ) && (
IsValidCheckpointPlatform ) && (
WithinResourceLimits )
OpSysMajorVer = 6
TotalMemory = 9889
HasGluster = true
OpSysName = "SL"
HasDocker = true
...
```

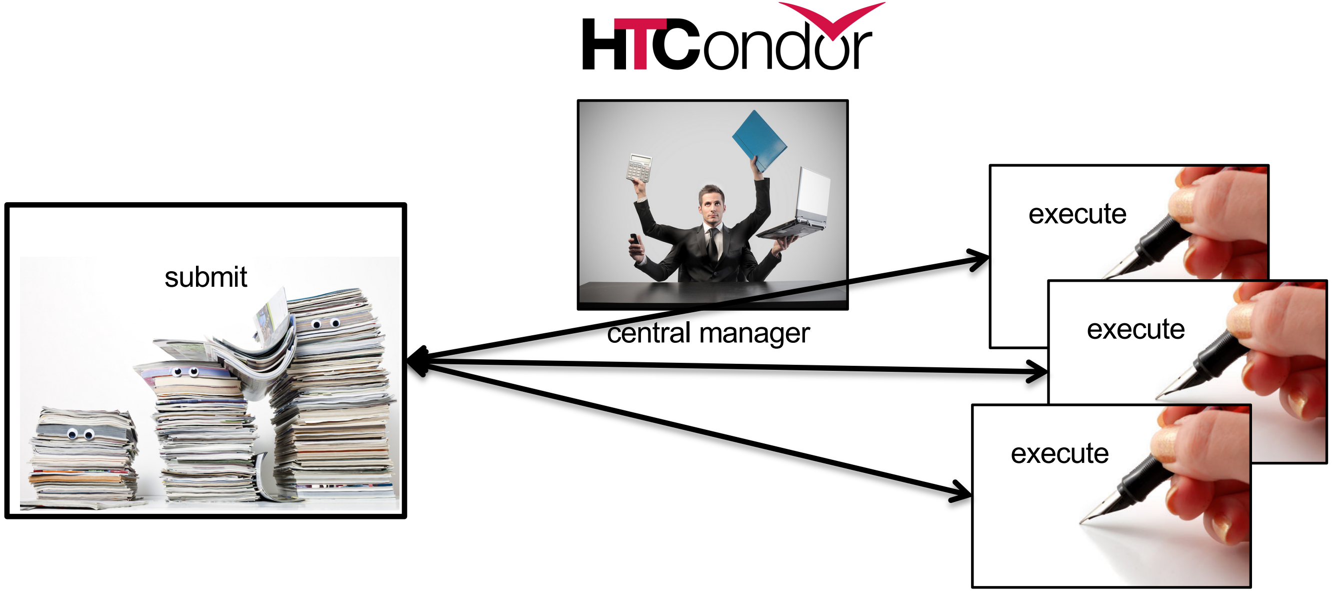
Job Matching

- On a regular basis, the central manager reviews **Job** and **Machine** *ClassAds* and matches jobs to **slots**.



Job Execution

- (Then the submit and execute points communicate directly.)



USING CLASSADS

Class Ads for People

- Class Ads also provide lots of useful information about jobs and computers to HTCondor users and administrators

Finding Job Attributes

- Use the “long” option for condor_q

  condor_q -l *JobId*

```
$ condor_q -l 12008.0
WhenToTransferOutput = "ON_EXIT"
TargetType = "Machine"
Cmd = "/home/alice/tests/htcondor_week/compare_states"
JobUniverse = 5
Iwd = "/home/alice/tests/htcondor_week"
RequestDisk = 20480
NumJobStarts = 0
WantRemoteIO = true
OnExitRemove = true
TransferInput = "us.dat,wi.dat"
MyType = "Job”
UserLog = "/home/alice/tests/htcondor_week/job.log"
RequestMemory = 20
...
```

Useful Job Attributes

- **`UserLog`**: location of job log
- **`Iwd`**: Initial Working Directory (i.e. submission directory) on submit node
- **`MemoryUsage`**: maximum memory the job has used
- **`RemoteHost`**: where the job is running
- **`JobBatchName`**: user-labeled job batches
- ...and more

Displaying Job Attributes

- View only specific attributes (**-af** for 'autoformat')

  condor_q [U/C/J] -af *Attribute1* *Attribute2* ...

```
$ condor_q -af ClusterId ProcId RemoteHost MemoryUsage

17315225 116 slot1_1@e092.chtc.wisc.edu 1709
17315225 118 slot1_2@e093.chtc.wisc.edu 1709
17315225 137 slot1_8@e125.chtc.wisc.edu 1709
17315225 139 slot1_7@e121.chtc.wisc.edu 1709
18050961 0 slot1_5@c025.chtc.wisc.edu 196
18050963 0 slot1_3@atlas10.chtc.wisc.edu 269
18050964 0 slot1_25@e348.chtc.wisc.edu 245
```

condor_q Reminder

- Default output is batched jobs
  - Batches can be grouped by the user with the **JobBatchName** attribute in a submit file:

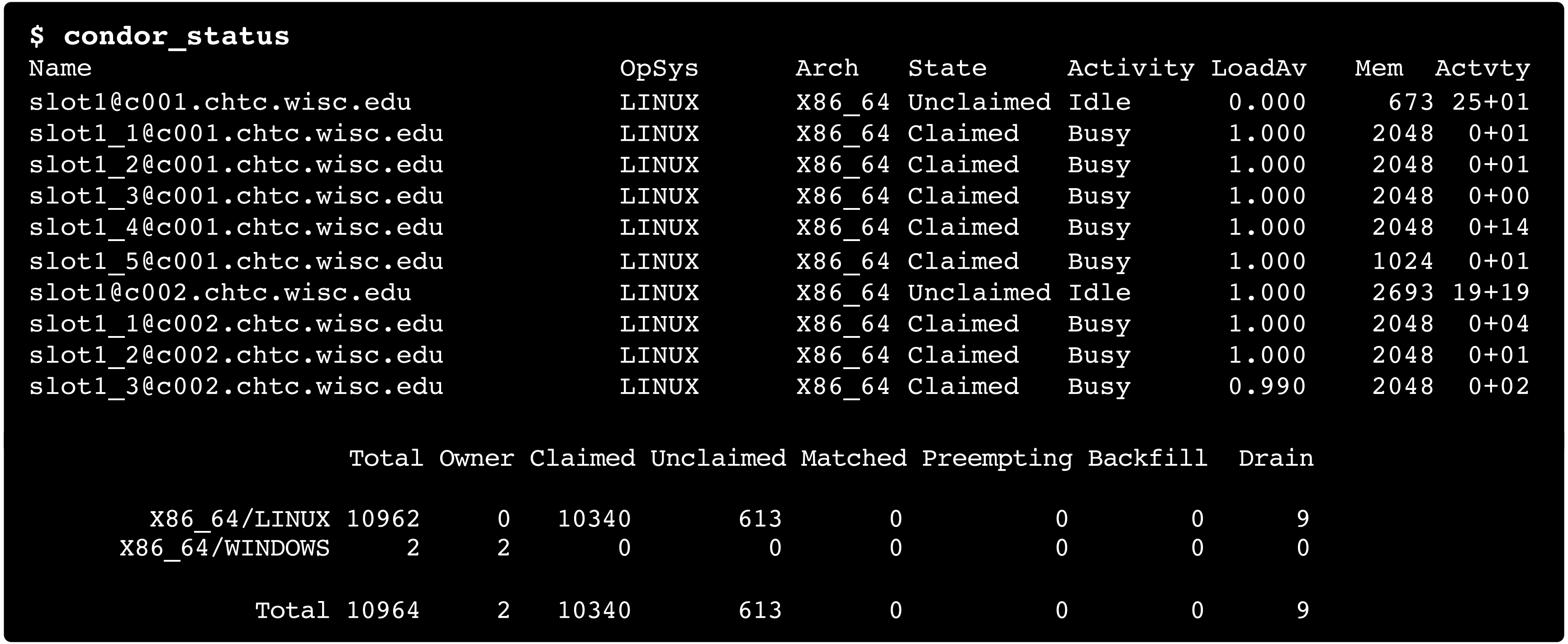
```
JobBatchName = CoolJobs
```

  - Otherwise HTCondor groups jobs, automatically, by same executable
- To see individual jobs, use:

```
condor_q -nobatch
```

ClassAds for Machines & Slots

as **condor_q** is to jobs, **condor_status** is to computers (or "machines")



```
$ condor_status
Name                                 OpSys       Arch   State     Activity LoadAv   Mem  Actvty
slot1@c001.chtc.wisc.edu             LINUX       X86_64 Unclaimed Idle       0.000   673 25+01
slot1_1@c001.chtc.wisc.edu           LINUX       X86_64 Claimed   Busy       1.000  2048  0+01
slot1_2@c001.chtc.wisc.edu           LINUX       X86_64 Claimed   Busy       1.000  2048  0+01
slot1_3@c001.chtc.wisc.edu           LINUX       X86_64 Claimed   Busy       1.000  2048  0+00
slot1_4@c001.chtc.wisc.edu           LINUX       X86_64 Claimed   Busy       1.000  2048  0+14
slot1_5@c001.chtc.wisc.edu           LINUX       X86_64 Claimed   Busy       1.000  1024  0+01
slot1@c002.chtc.wisc.edu             LINUX       X86_64 Unclaimed Idle       1.000  2693 19+19
slot1_1@c002.chtc.wisc.edu           LINUX       X86_64 Claimed   Busy       1.000  2048  0+04
slot1_2@c002.chtc.wisc.edu           LINUX       X86_64 Claimed   Busy       1.000  2048  0+01
slot1_3@c002.chtc.wisc.edu           LINUX       X86_64 Claimed   Busy       0.990  2048  0+02


                    Total Owner Claimed Unclaimed Matched Preempting Backfill  Drain

       X86_64/LINUX 10962     0   10340       613       0          0        0      9
     X86_64/WINDOWS     2     2       0         0       0          0        0      0

              Total 10964     2   10340       613       0          0        0      9
```

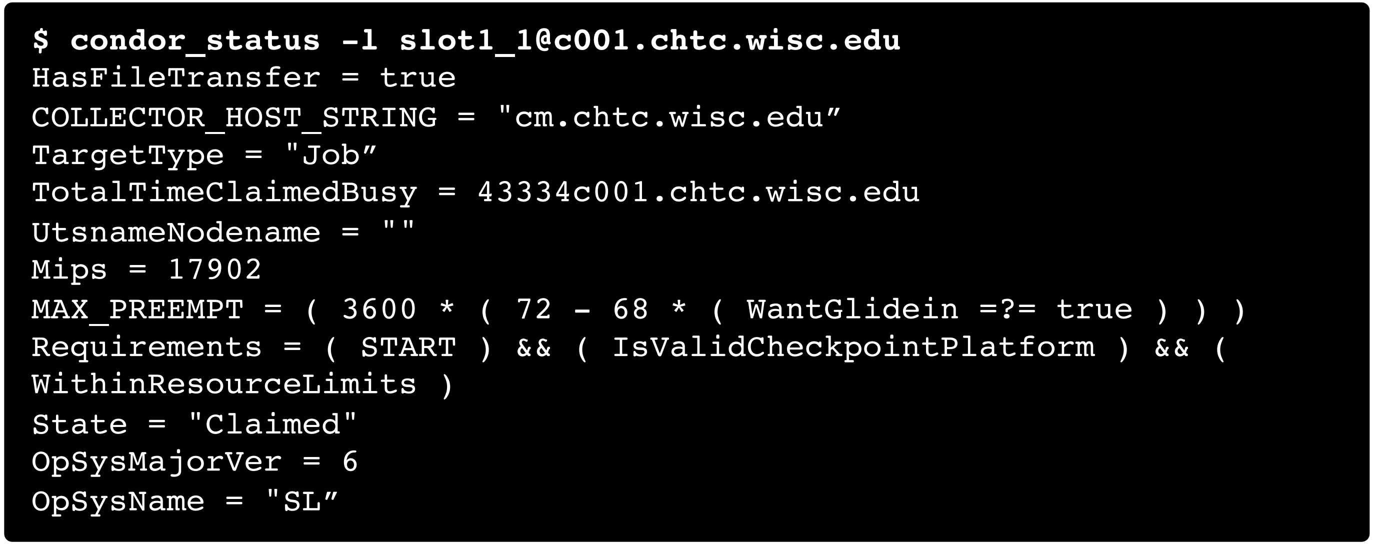
HTCondor Manual: condor_status

Machine Attributes

- Use same ClassAd options as **condor_q**:

condor_status ***-l Slot/Machine***

condor_status ***[Machine] -af Attribute1 Attribute2 ...***

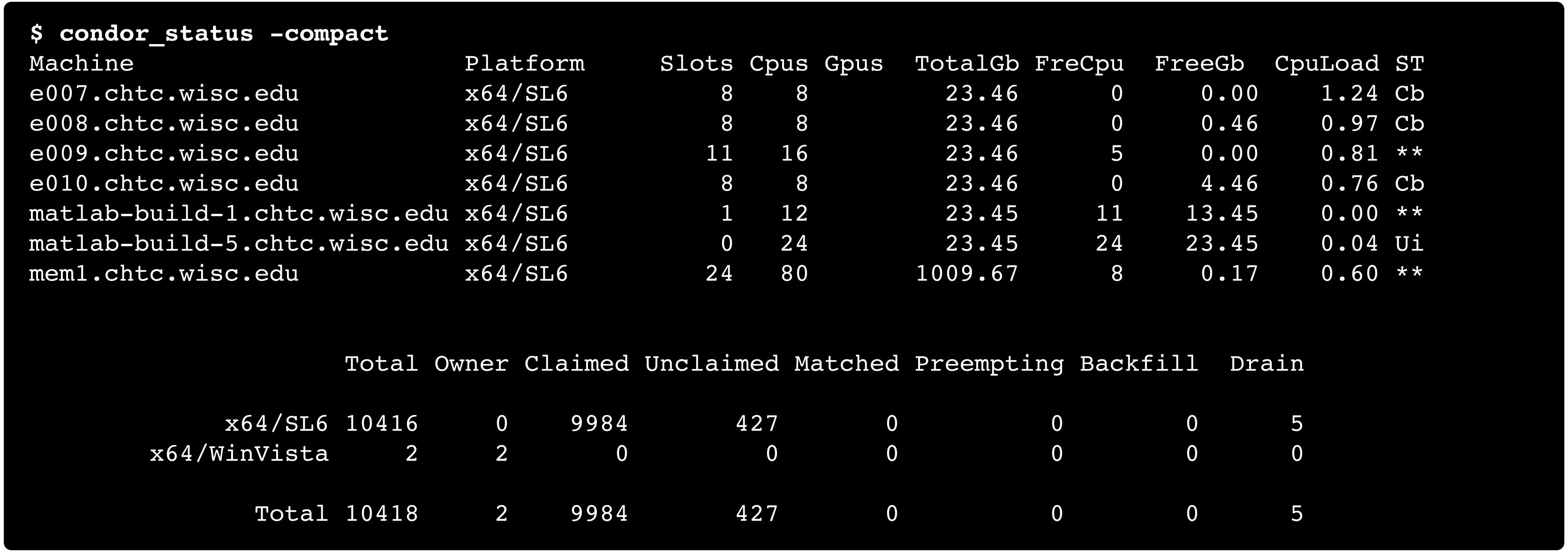


```
$ condor_status -l slot1_1@c001.chtc.wisc.edu
HasFileTransfer = true
COLLECTOR_HOST_STRING = "cm.chtc.wisc.edu”
TargetType = "Job”
TotalTimeClaimedBusy = 43334c001.chtc.wisc.edu
UtsnameNodename = ""
Mips = 17902
MAX_PREEMPT = ( 3600 * ( 72 - 68 * ( WantGlidein =?= true ) ) )
Requirements = ( START ) && ( IsValidCheckpointPlatform ) && (
WithinResourceLimits )
State = "Claimed"
OpSysMajorVer = 6
OpSysName = "SL”
```

Machine Attributes

- To summarize, use the "-compact" option:

  condor_status -compact



```
$ condor_status -compact
Machine                      Platform     Slots Cpus Gpus  TotalGb FreCpu  FreeGb  CpuLoad ST
e007.chtc.wisc.edu           x64/SL6          8    8         23.46      0    0.00     1.24 Cb
e008.chtc.wisc.edu           x64/SL6          8    8         23.46      0    0.46     0.97 Cb
e009.chtc.wisc.edu           x64/SL6         11   16         23.46      5    0.00     0.81 **
e010.chtc.wisc.edu           x64/SL6          8    8         23.46      0    4.46     0.76 Cb
matlab-build-1.chtc.wisc.edu x64/SL6          1   12         23.45     11   13.45     0.00 **
matlab-build-5.chtc.wisc.edu x64/SL6          0   24         23.45     24   23.45     0.04 Ui
mem1.chtc.wisc.edu           x64/SL6         24   80       1009.67      8    0.17     0.60 **


                     Total Owner Claimed Unclaimed Matched Preempting Backfill  Drain

             x64/SL6 10416     0    9984       427       0          0        0      5
        x64/WinVista     2     2       0         0       0          0        0      0

               Total 10418     2    9984       427       0          0        0      5
```

AUTOMATION AND OTHER FEATURES

Retries

- Problem: a small number of jobs fail with a known error code; if they run again, they complete successfully.
- Solution: If the job exits with an error code, leave it in the queue to run again. This is done via the automatic option `max_retries`.

```
max_retries = 5
```

More automation

- Check out the Intro to HTCondor talk from HTCondor Week 2019 for more on:
  - self-checkpointing
  - automatic hold/release (e.g. if job running too long)
  - auto-increasing memory request (e.g. if memory usage varies a lot across jobs)

“Live” Troubleshooting

- To log in to a job where it is running, use:

condor_ssh_to_job *JobId*

```
$ condor_ssh_to_job 128.0
Welcome to slot1_31@e395.chtc.wisc.edu!
Your condor job is running with pid(s) 3954839.
```

HTCondor Manual: condor_ssh_to_job

Interactive Jobs

- An interactive job proceeds like a normal batch job, but opens a bash session into the job’s execution directory instead of running an executable.

```
condor_submit -i submit_file
```

```
$ condor_submit -i interactive.submit
Submitting job(s).
1 job(s) submitted to cluster 18980881.
Waiting for job to start...
Welcome to slot1_9@e184.chtc.wisc.edu!
```

- Useful for testing and troubleshooting

Job Universes

- HTCondor has different “universes” for running specialized job types

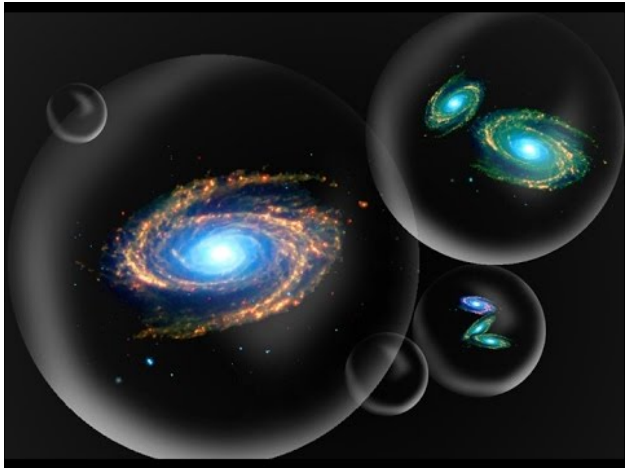
  HTCondor Manual: Choosing an HTCondor Universe

- Vanilla (default)
  - good for most software

  HTCondor Manual: Vanilla Universe

- Set in the submit file using:

```
universe = vanilla
```



Other Universes

- Standard
  - Built for code (C, fortran) that can be statically compiled with `condor_compile`

  HTCondor Manual: Standard Universe
- Java
  - Built-in Java support

  HTCondor Manual: Java Applications
- Local
  - Run jobs on the submit node

  HTCondor Manual: Local Universe

Other Universes (cont.)

- Docker
  - Run jobs inside a Docker container

  HTCondor Manual: Docker Universe Applications
- VM
  - Run jobs inside a virtual machine

  HTCondor Manual: Virtual Machine Applications
- Scheduler
  - Runs DAG workflows (Thursday)

  HTCondor Manual: Parallel Applications

Multi-CPU and GPU Computing

- Jobs that use multiple cores on a single computer can use the vanilla universe (parallel universe for multi-server MPI, where supported):

```
request_cpus = 16
```

- If there are computers with GPUs, request them with:

```
request_gpus = 1
```

Want More HTCondor Features?

- See the “Introduction to Using HTCondor” talk from HTCondor Week 2019!!

  http://research.cs.wisc.edu/htcondor/HTCondorWeek2017/tuesday.html

YOUR TURN!

Exercises!

- Ask questions!
- Lots of instructors around

- Coming up:
  - Now-3:00 Hands-on Exercises
  - 3:00 – 3:15 Break
  - 3:15 – 5:00 Intro to DHTC, OSG