Submit Machine Management

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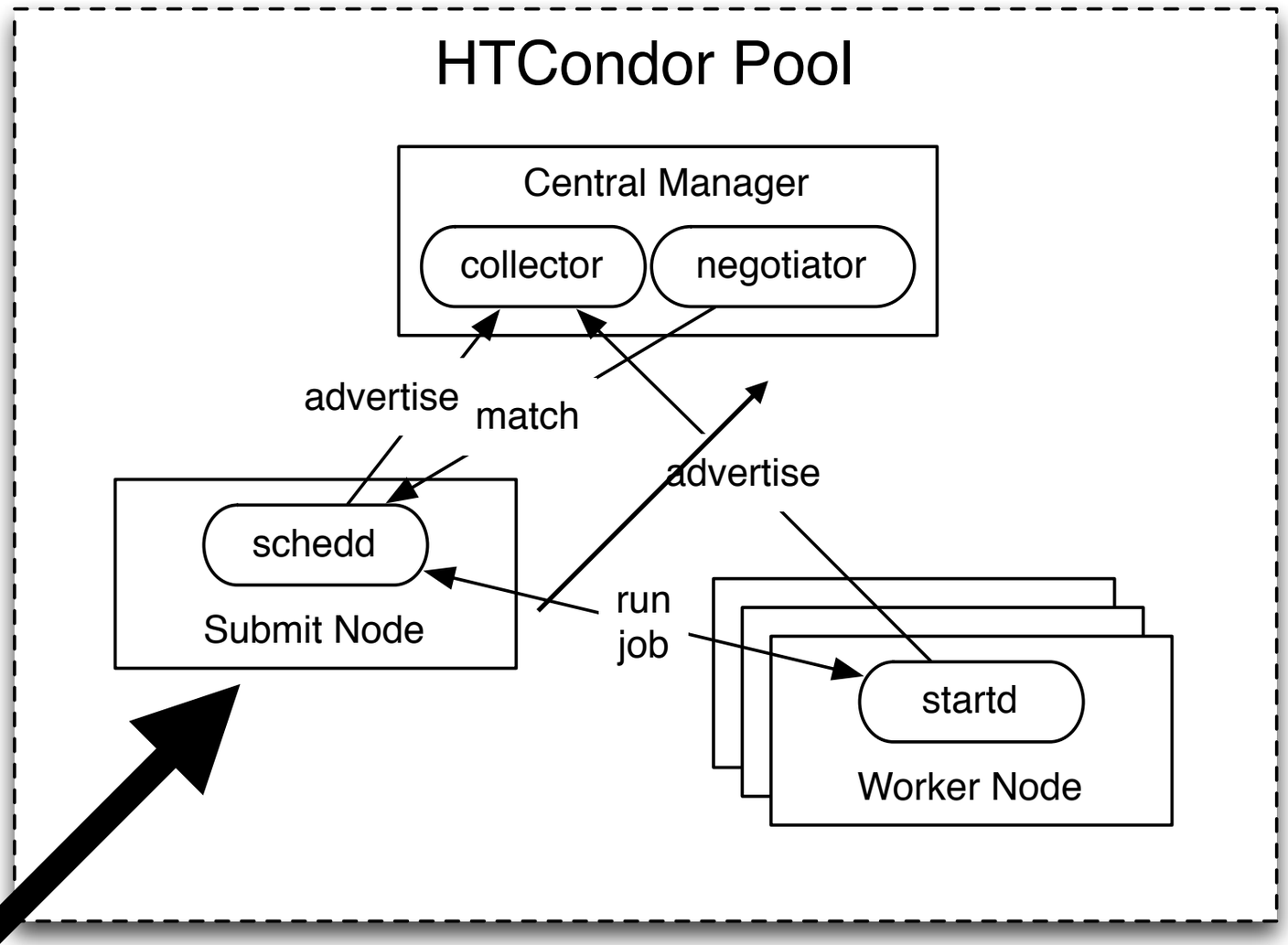
So you want to build the ultimate submit machine?

- While you can get HTCondor to run on your toaster in a weekend, providing a high-quality scalable submit service can take significant planning and effort.
    - In this talk, we'll walk through the process of putting together the service, noting special requirements for scalability and customization hooks.
        - I focus on the *non-obvious* parts of this task; this is *not* "how to build your first submit machine".
- Roughly, three portions:
    - Spec'ing out the service.
    - Installing and Configure HTCondor.
    - Customizing user environments.

Roadmap - Where Are We?



YOU ARE HERE

Spec'ing out the Service - Setting Expectations

- Before we even get to hardware, you need to work with users to understand what kind of service is needed:
  - **Job Scale**:
    - What is the maximum number of jobs this schedd will need to run? The average?
    - How many jobs are expected to be in queue?
  - **Job Rates**: What is the expected job start and stop rates? What does the distribution look like?
  - **IO requirements**: What, if anything, do you know about your per-job input and output transfer requirements?
- In general, it's really hard to determine what the distributions look like. HTCondor keeps only rough statistics itself. I prefer to do the *highly scientific* "multiply everything by two" to determine peak scale.

Spec'ing out the Service - Hardware Considerations

- Next, I outline the hardware considerations from most important to least.
- **IO**: The schedd is a single-threaded daemon which blocks on disk IO and frequently calls fsync() on its job database.
    - Therefore, your overall scalability is limited by the latency of your storage system.
- To maintain a stable service of >10k running jobs, you will want to keep the spool directory on an SSD.
- A typical setup has:
    - A dedicated, small, low-latency storage target for spool, AND
    - A large (TBs), high-throughput storage target for user home/working directories.

TL;DR:

Buy a SSD, Live Happy

Spec'ing out the Service - Hardware Considerations 2

- **Memory**: As a rule of thumb, plan on 1MB RAM per running job and 50KB per idle job.
    - In the last two years, this was reduced to 300-400KB per running job. I still prefer the above number to include a bit of a safety factor.
- **CPU**: The schedd has no CPU-bound component (the process is single-threaded anyway).
    - Base your CPU decisions on the needs of the logged-in users (i.e., compiling or running test jobs).
- **Network connectivity**: Unless you are aware of specific needs from your user base, 1Gbps is sufficient.

To shared filesystem or not?

- How do you move files between the submit and execute machines?
    - **With a shared file system**: These can be expensive and finicky, but users often love the simplicity. They don't need to know what files they use.
        - It's often difficult to carefully control usage of the shared file system - life can be chaotic!
    - **With HTCondor file transfer**: Forces users to *think* and express their file requirements inside the job.
        - Requires more work from the user - ***however***, it typically results in a more "IO friendly" job. No user hammering AFS!
        - HTCondor can throttle new transfers (future: not match machines) if the schedd is spending too much time on IO. Shared file systems typically have no concept of queueing and performance degrades massively!
        - When using file transfers, it is simpler to run jobs offsite.

DANGER! WARNING!

- While we recommend using HTCondor file transfer, we understand this is not always possible.

- **NOTE** the `condor_schedd` writes user logs in-process. If the user has this file on the shared file system and the filesystem stops responding, then **the schedd will stop responding**.

- HTCondor relies on a few obscure POSIX semantics for user logs. **No funny business** such as FUSE filesystems. Even NFS was finicky until the last 3-5 years.

OS Tweaks (for schedds with >10k jobs)

- Memory overcommit: In /etc/sysctl.conf, **sys.vm.overcommit_memory=1**
- Max socket backlog: In /etc/sysctl.conf, **net.core.somaxconn=1024**
- Max file descriptors: Set **sys.fs.file-max** to be greater than 10k (already is on most OSes!)
- Max per-process file descriptors: Set **nofile** in /etc/security/limits.d.
  - Not done commonly (see scaling talk).
- Maximum number of processes: Set **nprocs** in /etc/security/limits.d
  - Only for hosts which do lots of DAGMan / local universe.
- Beware of iptables **conntrack** module: Consider blacklisting the conntrack module if you need many TCP connections (see scaling talk).

Still relevant for some sites

OS Tweaks - 8.4.x

- Starting in the latest series, HTCondor will now perform developer-recommended reasonable kernel tunings on startup.
    - These are selected so they should be safe for “anyone,” but do touch some global settings.
- Sysadmins can turn this off (not recommended) or provide their own overrides / additions (recommended).
- This was a contentious feature internally: the need for simplicity versus reluctance to touch system settings.
    - I suspect there is tuning of the approach left to do.
    - Would love to hear feedback!

Host Firewalls and Networking

- **DNS**: DNS is a mixed bag! HTCondor can work fine with- or without DNS; in fact, DNS failures (or slow name resolution) often cause problems for submit services. Recommendations:
    - Go all-in or all-out: don't try to mix use of IP addresses in some cases and DNS in others.
    - It is the *host name*. There should be one per host; if you use DNS, the hostname should match the public DNS name for simplicity. If you need a more complex setup, the **NETWORK_HOSTNAME** config option overrides the hostname detection logic.
        - Consider your cluster's dynamics: if there's a small number (<50) of nodes and they won't come in and out of the cluster frequently, you may not need DNS.
- The worker nodes, central manager, and schedd need to be able to contact each other via the network.
- I *highly* recommend setting **USE_SHARED_PORT=true** (in fact, the plan is to make this the future default) throughout your pool. This will allow all HTCondor daemons to use the same inbound port, TCP 9618.
- HTCondor has the ability to rewrite addresses (for TCP port-forwarding setups) and intelligently manage multiple private and public networks. While this means HTCondor can work with very adverse networking conditions, *think twice before using; they can be extremely difficult to debug*.

Host Firewalls and Networking

- With shared port enabled, the firewall configuration becomes:
    - **Inbound connections**: TCP 9618 from client hosts, the central manager, and worker nodes.
    - **Outbound connections**: Outbound connections are necessary to the central manager and worker nodes.
        - HTCondor phone home: By default, the HTCondor daemons report simple usage statistics to UW via UDP. This is a requirement from the funding agencies; consider leaving this on if you wish continued support of the software. For more, see http://research.cs.wisc.edu/htcondor/privacy.html.
        - By default, UDP updates are sent to the central manager; if desired, switch them to TCP using **UPDATE_COLLECTOR_WITH_TCP=true**. All other outgoing communication uses TCP.
- The CCB allows the worker nodes to be behind a separate stateful firewall or NAT (i.e., no inbound connectivity from the schedd). This is not typically used in site setups.

Installing and Configuring

- **Basics**:
  - Always install via RPM (debs); I strongly discourage use of tarballs.
  - Always maintain your configurations with configuration management software such as Puppet or Chef.
  - *Never* edit condor_config or condor_config.local. ***Always*** use the config.d directory.

Logging Considerations

- Consider enabling the AuditLog; this contains a concise log of who used the schedd, what they did, and how they authenticated.
    - Essential for security incidents!
- Explicitly determine your log retention policy; default is 10MB x 2 files per log.
    - Most large sites will want to retain more. I use 100MB x 10 files.
- Set the logfile name to SYSLOG to forward a HTCondor log to **/dev/log**. Useful for sites that have an existing centralized log management scheme and/or strict retention policies.
    - In particular, sites should consider forwarding the AuditLog to syslog.

Monitoring - Host

- Host-level monitoring and alerting is critical, especially if users have a login to the submit host.
  - This is not HTCondor-specific; apply the security protections you believe needed for a generic login host.
  - Users are quicker than your alert system; typically, monitoring is best for post-crash telemetry.

Monitoring - HTCondor

- All HTCondor daemons export 5-20 critical metrics in their ClassAds.

- Recently, HTCondor delivered native integration with Ganglia. This allows you to turn the above metrics into time series.

  - When combined with host metrics (CPU usage, memory, network activity), these are a powerful mechanism for debugging problems.

  - If your site doesn't use Ganglia for monitoring, the daemon can integrate with your system by invoking a "gmetric" compatible command-line utility.

Accounting

- While condor_history is great, the logs *do* rotate eventually.
  - Don’t wait until your boss asks about accounting usage to discover this fact!
- If you set **PER_JOB_HISTORY_DIR**, then the schedd records the job ClassAd into a unique file when it leaves the queue.
  - Accounting can be done by reading each of these files and uploading to a DB.
  - Alternately, the **PER_JOB_HISTORY_DIR** captures the job execution *instances* on the remote startds. Further, this can be queried centrally (if you have admin privileges).

Accounting

- Recall `condor_history` can be invoked remotely.
  - Via python bindings, one can collect the poolwide history
    - Looking to make this more efficient in 8.5.x.
    - Similarly, python bindings can fetch **PER_JOB_HISTORY_DIR** from schedds and startds.
- Consider taking this centrally collected data and pushing it into ElasticSearch. Popular to do this + Kibana.

Extensive CMS-specific example:
https://github.com/bbockelm/cms-htcondor-es

Configuration Knobs to investigate

- SYSTEM_PERIODIC_REMOVE / SYSTEM_PERIODIC_HOLD: Expression to either remove or hold “malformed” jobs.
  - Check out SYSTEM_PERIODIC_XXX_REASON too!
- MAX_JOBS_RUNNING / **MAX_JOBS_SUBMITTED**: Limit the number of jobs running / submitted to prevent users from pushing the schedd into swap.
- FILE_TRANSFER_DISK_LOAD_THROTTLE: If you are using HTCondor transfer mechanisms, this limits the amount of disk load HTCondor places on the system (suggestion: set to N for a host with N spinning disks).
- MAX_TRANSFER_{INPUT,OUTPUT}_MB: Avoid transferring excessive amounts of data per job.

NEW - Managing User Job ClassAds

- Historically, the job ClassAd "belongs" to the user. All attributes *except* Owner could be modified by the user via `condor_q`. However,
  - Group accounting information is taken from ad.
  - Some attributes (X509 certificate DN) are used by admins for policy decisions.
- In 8.3.x, we introduced `SUBMIT_REQUIREMENTS`: you can force jobs to match certain constraints
- In 8.5.2, we introduced protected attributes: once set, can only be changed by the sysadmin.

Managing User ClassAds

- Finally, the big hammer: custom ClassAd functions. These can be written in python (easy) or C++ (hard).
  - Use sparingly (i.e., in SUBMIT_REQUIREMENTS but not job's REQUIREMENTS).
  - Must evaluate quickly; no side-effects, no state.
  - If it must access a remote service, cache aggressively.

SUBMIT_REQUIREMENTS Example

Config snippet:

```
SCHEDD.CLASSAD_USER_PYTHON_MODULES=my_utils
SCHEDD_ENVIRONMENT=“PYTHONPATH=/path/to/my_modules”
SUBMIT_REQUIREMENT_NAMES = CHECKTODD
SUBMIT_REQUIREMENT_CHECKTODD = isUserTodd(Owner)
SUBMIT_REQUIREMENT_CHECKTODD_REASON = \
  strcat(“This is “, Owner, “ not Todd!”)
```

Python code example:

```
import classad

def isUserTodd(user, state={}):
    return user == “todd”

classad.register(isUserTodd)
```

SUBMIT_REQUIREMENTS Example

```
$ condor_run echo "Hello world"
Submitting job(s).
ERROR: Failed to commit job submission into the queue.
ERROR: This is bbockelm not Todd!
Failed to submit Condor job.
```

Setting up the User Environment

- How does a user submit a job? It's a bit of a religious argument.
    - **School of thought #1**: Make users learn condor_submit. There's tons of documentation "on the internet", allows users to fully unlock the power of condor_submit, and is no-maintenance.
    - **School of thought #1.1**: Write a small wrapper around condor_submit to "helpfully" fix obvious errors in files or set a few site-specific defaults.
        - Alternately, can control some defaults from the user environment. I.e., add the following to **/etc/profile.d/condor.sh**:
            - export _CONDOR_AccountingGroup=\"local.`id -gn`.`id -un`\"
        - Periodically check schedd-side to see if a user is trying to game the system.
- **School of thought #2**: Any condor_* command is too damn hard to use. Replace it with a simpler site-specific interface and train them to use this.
    - *Alternately*, use **condor_qsub** because you like PBS-style scripts better!
    - *Note*: wrapper scripts require the users to play along. Do not be surprised to find they bypass your script when python bindings are used.
- **School of through #2.1**: Any command line is too hard for users; they only access the system through a webapp.

User Environments - Automating attribute settings

- **Easy**: Utilize SUBMIT_ATTRS. Add to the config file:

```
JobIsGrid = true
SUBMIT_ATTRS = $(SUBMIT_ATTRS), JobIsGrid
```

- **Medium**: Use MODIFY_REQUEST_EXPR_* to modify a user's request_* *at the startd* or JOB_DEFAULT_* to modify *at condor_submit*.

- **Medium**: Use SCHEDD_ROUND_ATTR_ to round up arbitrary attributes *at the schedd*.

- **Medium-hard**: Write a wrapper around your submit script.

- **Hard**: Use JobRouter to enforce policy schedd-side.

Upcoming Automation

- For automating attribute values, in 8.5.x, we hope to:
  - Make SUBMIT_ATTRS work schedd-side.
  - Allow attributes to be evaluated at submit time.
  - Re-introduce the "**unexpanded**" state. This causes the schedd to not consider the job until it has been transformed by the JobRouter.

Tweaks

- Ideas that make user's life better:
    - Use the custom condor_q / condor_status print formats for your site.
    - Take advantage of **~/.condor/user_config** (user-specific config file, like ~/.bashrc); for example, you can created this file on first login with a PAM module to lock the user to a specific schedd.
    - Customize MOTD to tell the user a summary of their jobs on login.

Print Formats

```
SELECT
  Name AS Name WIDTH -18
  OSG_Resource AS Resource WIDTH -18
  OSG_BatchSystems AS Batch WIDTH -8
  HTCondorCEVersion AS CEVer WIDTH -5
  split(condorversion)[1] AS CondorVer
  DaemonStartTime AS Uptime PRINTAS ACTIVITY_TIME
  grid_resource AS Resource
SUMMARY NONE
```

Print Formats

bbockelm — root@red-gw1:~ — ssh hcc-briantest — 188×35

```
[root@red-gw1 ~]# condor_ce_status -schedd -pool collector.opensciencegrid.org
Name                 Resource           Batch    CEVer CondorVer Uptime       Resource
T3SERV007.MIT.EDU    MIT_CMS_T3-CE1     Condor   2.0.0 8.4.3      18+04:36:43 condor T3SERV007.MIT.EDU T3SERV007.MIT.EDU:9619
atlt3gm.physics.arizona.edu Arizona_CE          Condor   2.0.0 8.4.4     10+19:42:52 condor atlt3gm.physics.arizona.edu atlt3gm.physics.arizona.edu:9619
bonner06.rice.edu    OSG-Rice           Condor   2.0.0 8.2.10     5+21:15:05 condor bonner06.rice.edu bonner06.rice.edu:9619
byggvir.princeton.edu UNAVAILABLE       Condor   2.0.0 8.2.10     8+20:41:16 condor byggvir.princeton.edu byggvir.princeton.edu:9619
calclab-ce.math.tamu.edu TAMU_Calclab   SLURM    2.0.0 8.2.10    10+17:56:05 condor calclab-ce.math.tamu.edu calclab-ce.math.tamu.edu:9619
carter-osg.rcac.purdue.edu Purdue-Carter PBS     1.20  8.2.10     5+15:16:53 condor carter-osg.rcac.purdue.edu carter-osg.rcac.purdue.edu:9619
ce01.brazos.tamu.edu TAMU_BRAZOS_CE     SLURM    1.20  8.2.9      5+14:39:22 condor ce01.brazos.tamu.edu ce01.brazos.tamu.edu:9619
ce01.cmsaf.mit.edu   MIT_CMS            Condor   1.16  8.4.0      3+23:23:01 condor ce01.cmsaf.mit.edu ce01.cmsaf.mit.edu:9619
ce02.cmsaf.mit.edu   MIT_CMS_2          Condor   1.16  8.4.0      2+17:10:16 condor ce02.cmsaf.mit.edu ce02.cmsaf.mit.edu:9619
ce03.cmsaf.mit.edu   MIT_CMS            Condor   2.0.0 8.4.3      3+22:50:44 condor ce03.cmsaf.mit.edu ce03.cmsaf.mit.edu:9619
cms-ce1-osg.rcac.purdue.edu Purdue-Hadoop-HTCE Condor   1.20  8.2.10     8+13:33:40 condor cms-ce1-osg.rcac.purdue.edu cms-ce1-osg.rcac.purdue.edu:9619
cms-ce2-osg.rcac.purdue.edu Purdue-Hadoop-HT-PBS-CE PBS  2.0.0 8.4.3      3+18:18:03 condor cms-ce2-osg.rcac.purdue.edu cms-ce2-osg.rcac.purdue.edu:9619
cms-grid0.hep.uprm.edu uprm-cms-ce       Condor   1.14  8.2.8     73+09:07:04 condor cms-grid0.hep.uprm.edu cms-grid0.hep.uprm.edu:9619
cms.rc.ufl.edu       UFlorida-CMS       PBS      2.0.0 8.4.3      5+10:50:58 condor cms.rc.ufl.edu cms.rc.ufl.edu:9619
cmsgrid01.hep.wisc.edu GLOW             Condor   1.20  8.4.2     13+10:01:29 condor cmsgrid01.hep.wisc.edu cmsgrid01.hep.wisc.edu:9619
cmsgrid02.hep.wisc.edu GLOW-CMS         Condor   1.20  8.4.2     14+04:00:35 condor cmsgrid02.hep.wisc.edu cmsgrid02.hep.wisc.edu:9619
cmsgrid03.hep.wisc.edu GLOW-CONDOR-CE   Condor   1.20  8.4.2     23+17:30:32 condor cmsgrid03.hep.wisc.edu cmsgrid03.hep.wisc.edu:9619
cmsosgce.fnal.gov    cmsosgce.fnal.gov  Condor   2.0.0 8.2.8      3+21:47:21 condor cmsosgce.fnal.gov cmsosgce.fnal.gov:9619
cmsosgce2.fnal.gov   cmsosgce2.fnal.gov Condor   2.0.0 8.2.8      3+21:42:39 condor cmsosgce2.fnal.gov cmsosgce2.fnal.gov:9619
cmsosgce3.fnal.gov   cmsosgce3.fnal.gov Condor   2.0.0 8.2.8      3+21:33:19 condor cmsosgce3.fnal.gov cmsosgce3.fnal.gov:9619
cmsosgce4.fnal.gov   cmsosgce4.fnal.gov Condor   2.0.0 8.2.8      3+21:32:39 condor cmsosgce4.fnal.gov cmsosgce4.fnal.gov:9619
cmstest1.rcac.purdue.edu Purdue-Hadoop-TestCE Condor 1.20  8.4.3     12+08:02:55 condor cmstest1.rcac.purdue.edu cmstest1.rcac.purdue.edu:9619
crane-gw1.unl.edu    Crane-CE1          PBS      2.0.0 8.3.5      11+15:17:02 condor crane-gw1.unl.edu crane-gw1.unl.edu:9619
gate02.grid.umich.edu AGLT2_CE_2        Condor   2.0.0 8.4.3      4+22:31:20 condor gate02.grid.umich.edu gate02.grid.umich.edu:9619
gate03.aglt2.org     AGLT2_TEST_CE      Condor   2.0.0 8.4.3      6+10:56:32 condor gate03.aglt2.org gate03.aglt2.org:9619
gate04.aglt2.org     AGLT2_SL6          Condor   2.0.0 8.4.3      4+22:14:54 condor gate04.aglt2.org gate04.aglt2.org:9619
globus1.hyak.washington.edu Hyak_CE     PBS      1.15  8.2.9     11+10:45:15 condor globus1.hyak.washington.edu globus1.hyak.washington.edu:9619
gpce01.fnal.gov      gpce01.fnal.gov    Condor   2.0.0 8.2.8      46+04:12:17 condor gpce01.fnal.gov gpce01.fnal.gov:9619
gpce02.fnal.gov      gpce02.fnal.gov    Condor   2.0.0 8.2.8      2+22:12:33 condor gpce02.fnal.gov gpce02.fnal.gov:9619
gridgk01.racf.bnl.gov BNL_ATLAS_1       Condor   1.10  8.2.7     24+01:25:15 condor gridgk01.racf.bnl.gov gridgk01.racf.bnl.gov:9619
gridgk08.racf.bnl.gov BNL_ATLAS_8       Condor   1.16  8.2.8      9+16:46:50 condor gridgk08.racf.bnl.gov gridgk08.racf.bnl.gov:9619
gridtest02.racf.bnl.gov BNL_Test_2_CE_1 Condor   2.0.0 8.2.8      8+16:49:42 condor gridtest02.racf.bnl.gov gridtest02.racf.bnl.gov:9619
hadoop-osg.rcac.purdue.edu Purdue-Hadoop-CE Condor 1.20  8.4.3      3+21:53:52 condor hadoop-osg.rcac.purdue.edu hadoop-osg.rcac.purdue.edu:9619
```

User education and training

- A little bit of user education goes a long way!
    - While we have dozens of “circuit breakers” in HTCondor to prevent more common mistakes, it helps if the user doesn’t make them in the first place.
- A handful of topics to make your life easier (beyond the “standard intro”):
    - How to avoid invoking condor_q?
    - How long to wait for a job to start / what to do when a job is idle?
    - What’s an “excessive” number of jobs in the queue?

User Education - Userlog files

- HTCondor users love to write the following code to submit or monitor jobs:

```
while true
  if [ `condor_q bbockelm -run | wc -l` -lt 100 ]; then
    condor_submit some_file
  fi
  sleep 1
done
```

- This is unnecessarily wasteful of schedd resources; if enough users do the same thing, the schedd may become unresponsive.
  - Instead, take advantage of the user logs which are typically available locally and record the job lifetime.
  - Users don't even need to parse them - utilize **condor_wait** instead!
- **condor_dagman** will do this automatically for you!

Parting Thoughts

- In the latest stable series, the best scalability tunings come out-of-the-box.

- Building a successful submit host is mostly about how users *interact* with condor - filesystems & IO, inserting appropriate default attributes.

- Make sure you have both accounting and monitoring in the planning from the beginning.

Questions?