HTCondor and Workflows: An Introduction

HTCondor Week 2015

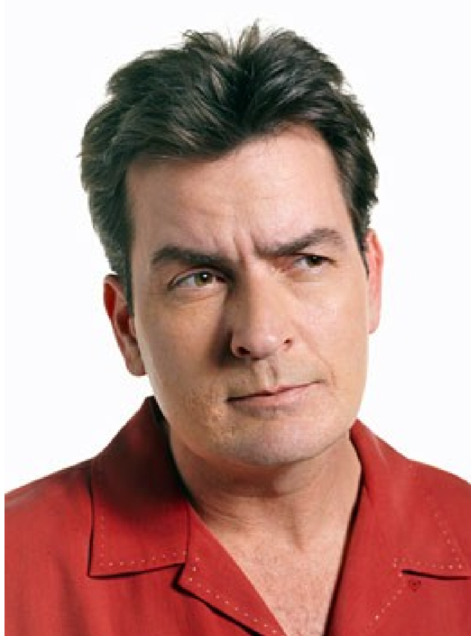
Kent Wenger

Outline

- Introduction/motivation
- Basic DAG concepts
- Pre/Post scripts
- Rescue DAGs
- Running and monitoring a DAG

Why workflows?

My jobs have dependencies…



Can HTCondor help solve my dependency problems?

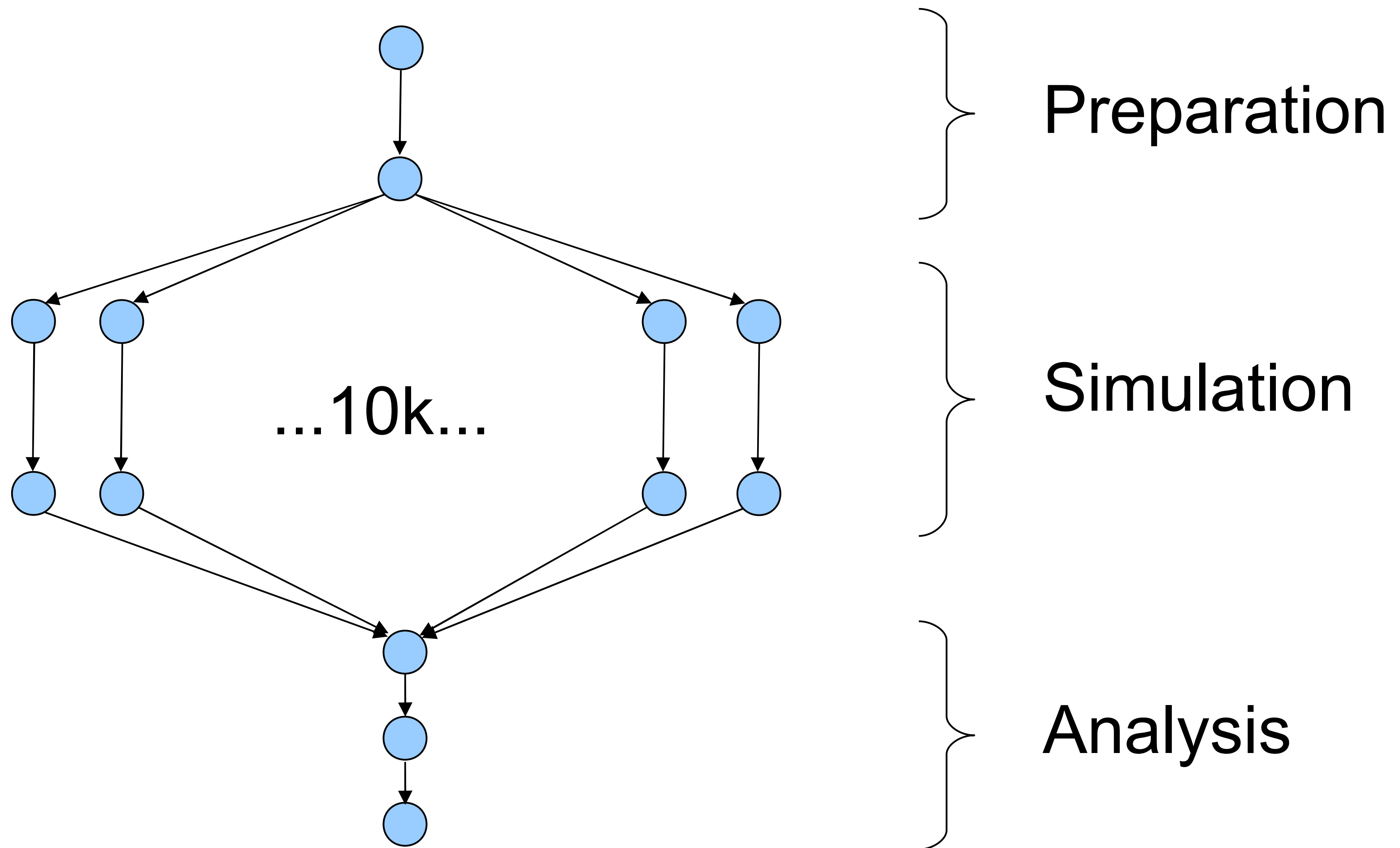
Yes!

Workflows are the answer

What are workflows?

- General: a sequence of connected steps
- Our case
  - Steps are HTCondor jobs
  - Sequence defined at higher level
  - Controlled by a Workflow Management System (WMS), *not just a script*

Example workflow



Workflows – launch and forget

- Automates tasks user *could* perform manually (for example, the previous slide)…
  - But WMS takes care of automatically
- A workflow can take days, weeks or even months
- The result: one user action can utilize many resources while maintaining complex job inter-dependencies and data flows

Workflow management systems

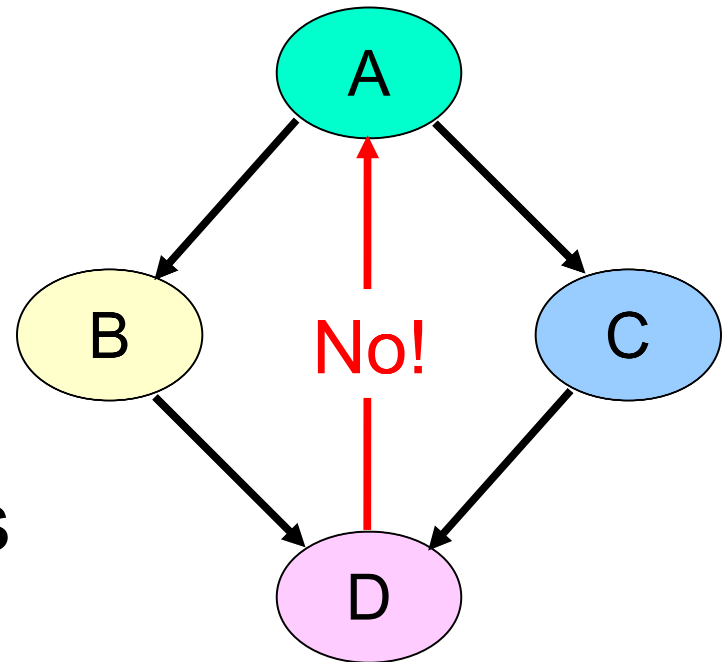
- DAGMan (Directed Acyclic Graph Manager)
  - HTCondor's WMS
  - Introduction/basic features in this talk
  - Advanced/new features in later talk
- Pegasus
  - A higher level on top of DAGMan
    - Data- and grid-aware
  - A talk tomorrow with more details

Outline

- Introduction/motivation
- Basic DAG concepts
- Pre/Post scripts
- Rescue DAGs
- Running and monitoring a DAG

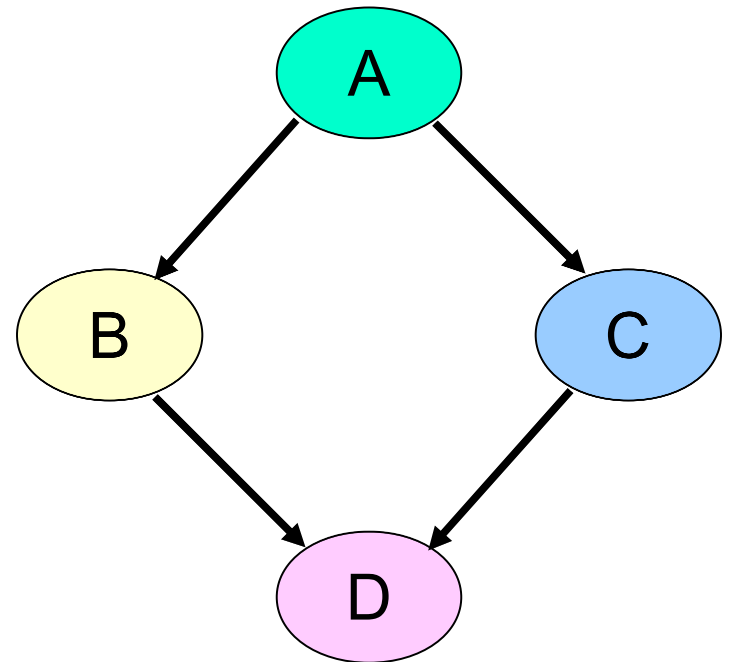
DAG (directed acyclic graph) definitions

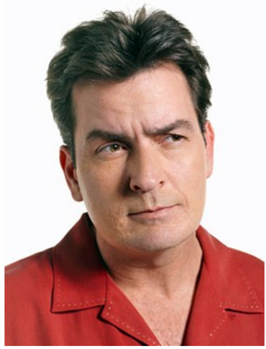
- DAGs have one or more nodes (or vertices)
- Dependencies are represented by arcs (or edges). These are arrows that go from parent to child)
- No cycles!



HTCondor and DAGs

- Each node represents an HTCondor job (or cluster)
- Dependencies define possible orders of job execution





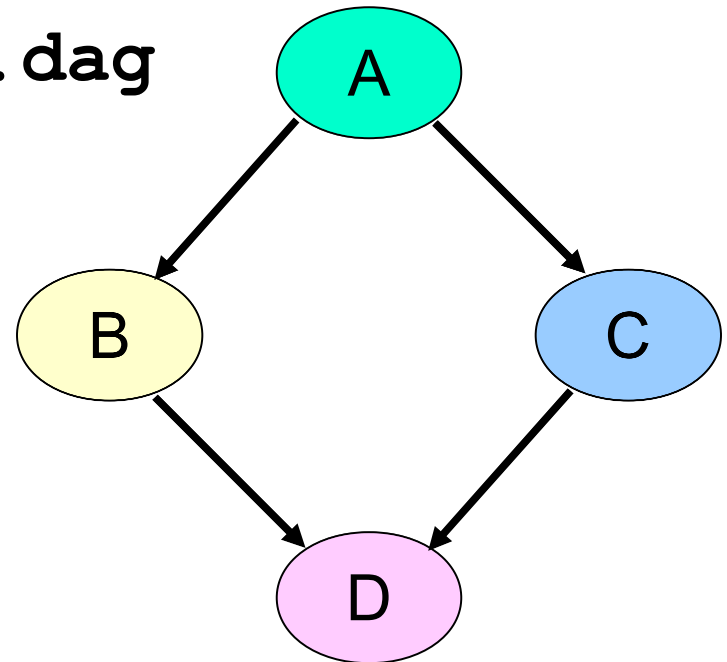
Charlie learns DAGMan

- **Directed Acyclic Graph Manager**
- DAGMan allows Charlie to specify the dependencies between his HTCondor jobs, so DAGMan manages the jobs automatically
- Dependency example: do not get married until rehab has completed successfully

Defining a DAG to DAGMan

A DAG input file defines a DAG:

```
# file name: diamond.dag
Job A a.submit
Job B b.submit
Job C c.submit
Job D d.submit
Parent A Child B C
Parent B C Child D
```



Basic DAG commands

- Job command defines a name, associates that name with an HTCondor submit file
  - The name is used in many other DAG commands
  - “Job” should really be “node”
- Parent...child command creates a dependency between nodes
  - Child cannot run until parent completes successfully

Submit description files

For node B:

```
# file name:
#    b.submit
universe   = vanilla
executable = B
input      = B.in
output     = B.out
error      = B.err
log        = B.log
queue
```

For node C:

```
# file name:
#    c.submit
universe   = standard
executable = C
input      = C.in1
output     = C.out
error      = C.err
log        = C.log
queue
Input       = C.in2
queue
```

Jobs/clusters

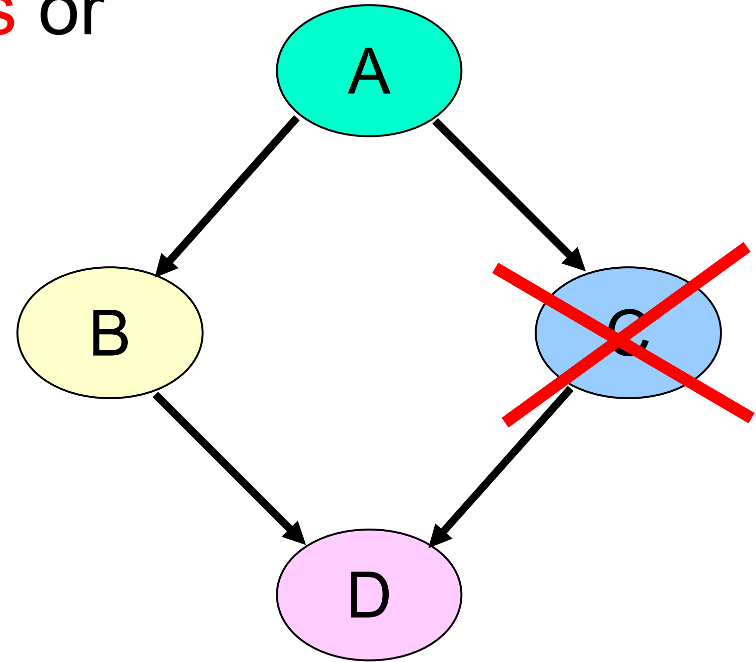
- Submit description files used in a DAG can create multiple jobs,
  but they must all be in a single cluster.
  - A submit file that creates >1 cluster causes node failure
- The failure of any job means the entire cluster fails. Other jobs in the cluster are removed.

Node success or failure

- A node either succeeds or fails
- Based on the return value of the job(s)

  0: success

  not 0: failure
- This example: C fails
- Failed nodes block execution; DAG fails

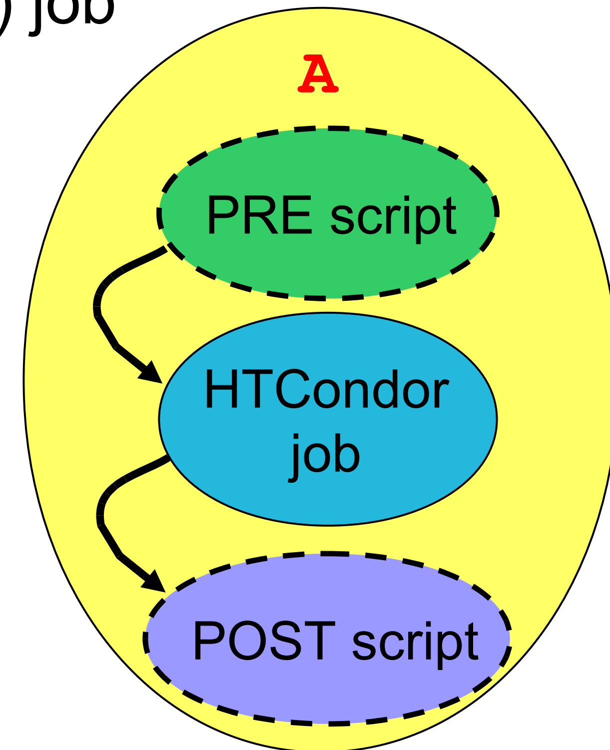


Outline

- Introduction/motivation
- Basic DAG concepts
- Pre/Post scripts
- Rescue DAGs
- Running and monitoring a DAG

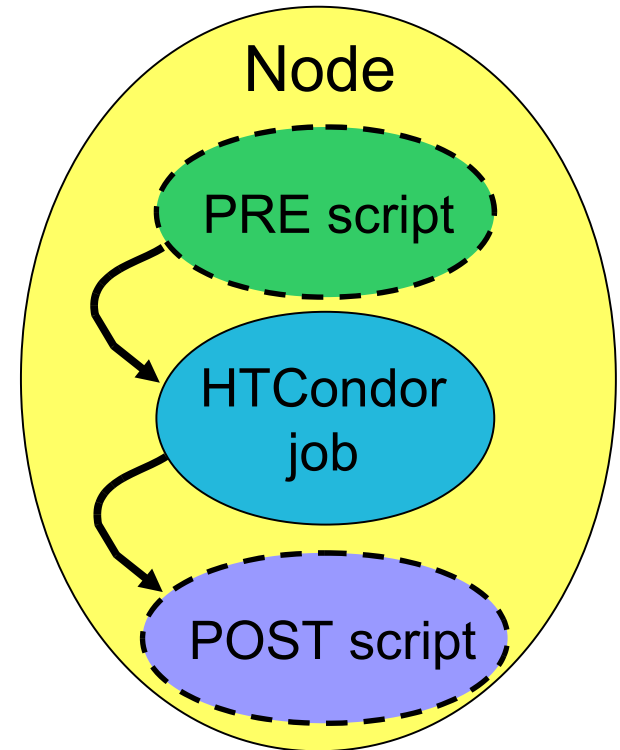
PRE and POST scripts

- DAGMan allows optional PRE and/or POST scripts for any node
  - Not necessarily a script: any executable
  - Run before (PRE) or after (POST) job
  - Scripts run on submit machine (not execute machine)
- In the DAG input file:
  - `Job A a.submit`
  - `Script PRE A before-script arguments`
  - `Script POST A after-script arguments`



DAG node with scripts

- DAGMan treats the node as a unit (e.g., dependencies are between nodes)
- PRE script, Job, or POST script determines node success or failure (table in manual gives details)
- If PRE script fails, job is not run. The POST script *is* run.



Why PRE/POST scripts?

- Set up input
- Check output
- Dynamically create submit file or sub-DAG (more later today)
- Probably lots of other reasons…

- Should be lightweight (run on submit machine)

Script argument variables

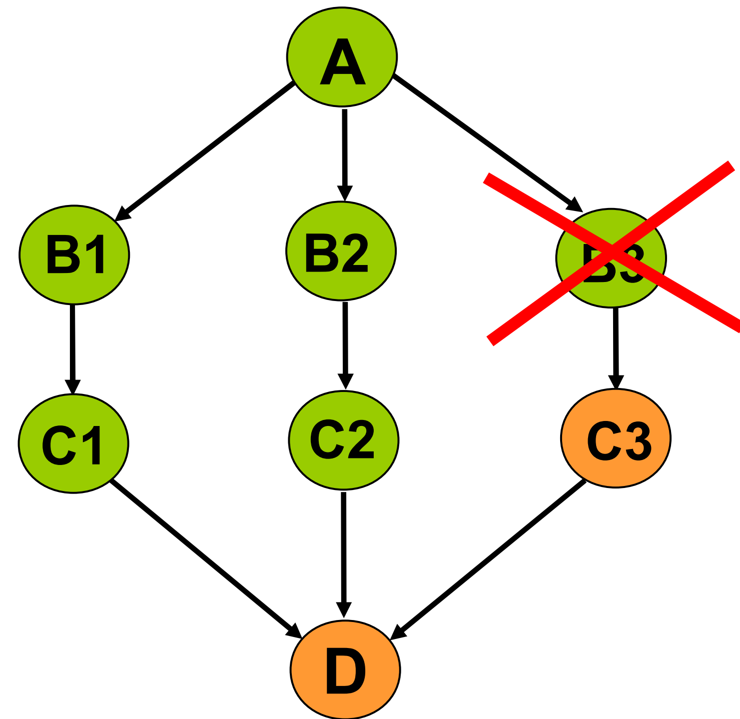
- **$JOB**: node name
- **$JOBID**: Condor ID (*cluster.proc*) (POST only)
- **$RETRY**: current retry
- **$MAX_RETRIES**: max # of retries
- **$RETURN**: exit code of HTCondor/Stork job (POST only)
- **$PRE_SCRIPT_RETURN**: PRE script return value (POST only)
- **$DAG_STATUS**: A number indicating the state of DAGMan. See the manual for details.
- **$FAILED_COUNT**: the number of nodes that have failed in the DAG

Outline

- Introduction/motivation
- Basic DAG concepts
- Pre/Post scripts
- Rescue DAGs
- Running and monitoring a DAG

Rescue DAGs

- What if things don't complete perfectly?
- We want to re-try without duplicating work
- Rescue DAGs do this – details in later talk
- Generated automatically when DAG fails
- Run automatically



Outline

- Introduction/motivation
- Basic DAG concepts
- Pre/Post scripts
- Rescue DAGs
- Running and monitoring a DAG

Submitting a DAG to HTCondor

- To submit an entire DAG, run

  condor_submit_dag *DagFile*

- **condor_submit_dag** creates a submit description file for DAGMan, and DAGMan itself is submitted as an HTCondor job (in the scheduler universe)
- **-f(orce)** option forces overwriting of existing files (to re-run a previously-run DAG)
- Don't try to run duplicate DAG instances!

Controlling running DAGs: remove

- **`condor_rm` *`dagman_id`***
  - Removes *entire* workflow
    - Removes all queued node jobs
    - Kills PRE/POST scripts
  - Creates rescue DAG (more on this on later today)
  - Work done by partially-completed node jobs is lost
    - Relatively small jobs are good

Controlling running DAGs: hold/release

- **condor_hold *dagman_id***
  - "Pauses" the DAG
    - Queued node jobs continue
    - No new node jobs submitted
    - No PRE or POST scripts are run
  - DAGMan stays in queue if not released
- **condor_release *dagman_id***
  - DAGMan "catches up", starts submitting jobs

Controlling running DAGs: the halt file

- "Pauses" the DAG (different semantics than hold)
  - Queued node jobs continue
  - POST scripts are run as jobs finish
  - No new jobs will be submitted and no PRE scripts will be run
- When all submitted jobs complete, DAGMan creates a rescue DAG and exits (if not un-halted)

The halt file (cont)

- Create a file named ***`DagFile.halt`*** in the same directory as your DAG file.
- Remove halt file to resume normal operation
- Should be noticed w/in 5 sec (**`DAGMAN_USER_LOG_SCAN_INTERVAL`**)

- Good if load on submit machine is very high
- Avoids hold/release problem of possible duplicate PRE/POST script instances

Monitoring running DAGs: condor_q -dag

- Shows current workflow state
- The **-dag** option associates DAG node jobs with the parent DAGMan job

```
> condor_q -dag
-- Submitter: nwp@llunet.cs.wisc.edu : <128.105.14.28:51264> : llunet.cs.wisc.edu
    ID      OWNER/NODENAME    SUBMITTED     RUN_TIME ST PRI SIZE CMD
    392.0   nwp              4/25 13:27   0+00:00:50 R  0   1.7  condor_dagman -f -
    393.0    |-1             4/25 13:27   0+00:00:23 R  0   0.0  1281.sh 393
    395.0    |-0             4/25 13:27   0+00:00:30 R  0   1.7  condor_dagman -f -
    399.0     |-A            4/25 13:28   0+00:00:03 R  0   0.0  1281.sh 399
4 jobs; 0 completed, 0 removed, 0 idle, 4 running, 0 held, 0 suspended
```

Monitoring a DAG: dagman.out file

- Logs detailed workflow history
- Mostly for debugging – first place to look if something goes wrong!
- ***DagFile.dagman.out***
- Verbosity controlled by the **DAGMAN_VERBOSITY** configuration macro and **-debug *n*** on the **condor_submit_dag** command line
  - 0: least verbose
  - 7: most verbose
- Don't decrease verbosity unless really needed

Dagman.out contents

```
...
04/17/11 13:11:26 Submitting Condor Node A job(s)...
04/17/11 13:11:26 submitting: condor_submit -a dag_node_name' '=' 'A -a +DAGManJobId' '='
    '180223 -a DAGManJobId' '=' '180223 -a submit_event_notes' '=' 'DAG' 'Node:' 'A -a
    +DAGParentNodeNames' '=' '"" dag_files/A2.submit
04/17/11 13:11:27 From submit: Submitting job(s).
04/17/11 13:11:27 From submit: 1 job(s) submitted to cluster 180224.
04/17/11 13:11:27       assigned Condor ID (180224.0.0)
04/17/11 13:11:27 Just submitted 1 job this cycle...
04/17/11 13:11:27 Currently monitoring 1 Condor log file(s)
04/17/11 13:11:27 Event: ULOG_SUBMIT for Condor Node A (180224.0.0)
04/17/11 13:11:27 Number of idle job procs: 1
04/17/11 13:11:27 Of 4 nodes total:
04/17/11 13:11:27  Done     Pre   Queued    Post   Ready   Un-Ready   Failed
04/17/11 13:11:27   ===     ===      ===     ===     ===        ===      ===
04/17/11 13:11:27     0       0        1       0       0          3        0
04/17/11 13:11:27 0 job proc(s) currently held
...
```

This is a small excerpt of the dagman.out file.

CENTER FOR HIGH THROUGHPUT COMPUTING

HTCondor

More information

- More in later talk!
- There's much more detail, as well as examples, in the DAGMan section of the online HTCondor manual.
- DAGMan: http://research.cs.wisc.edu/htcondor/dagman/dagman.html
- For more questions: htcondor-admin@cs.wisc.edu