Intermediate Condor: DAGMan
Monday, 1:15pm

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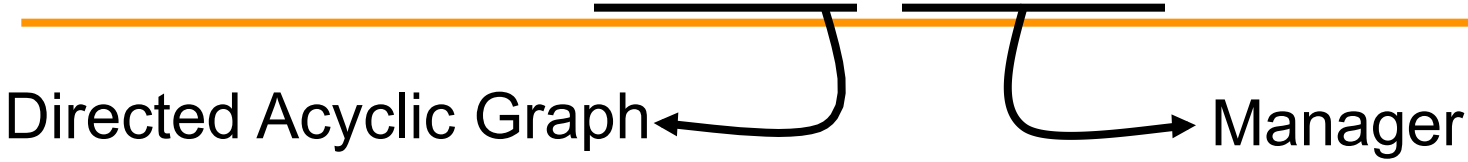
Before we begin…

- Any questions on the lectures or exercises up to this point?

Open Science Grid

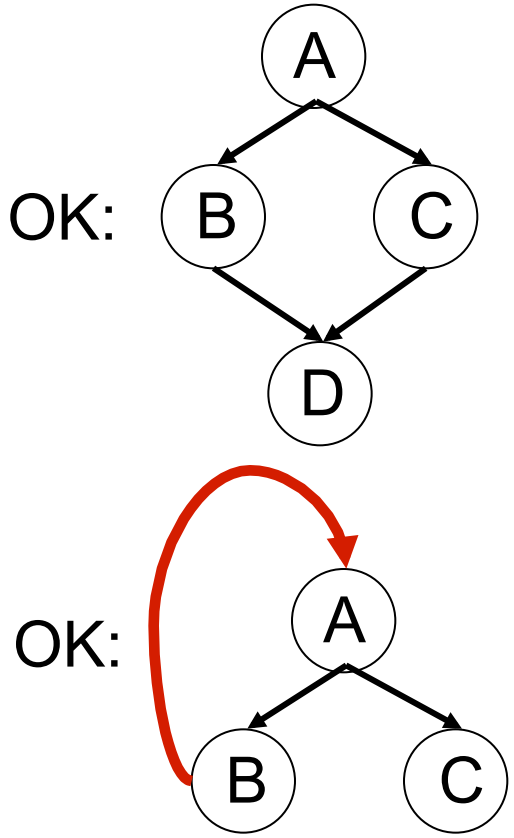
DAGMan



- DAGMan allows you to specify the dependencies between your Condor jobs, so it can manage them automatically for you.
- Example: “Don’t run job B until job A has completed successfully.”

What is a DAG?

- A DAG is the data structure used by DAGMan to represent these dependencies.
- Each job is a node in the DAG.
- Each node can have any number of "parent" or "children" nodes – as long as there are no loops!

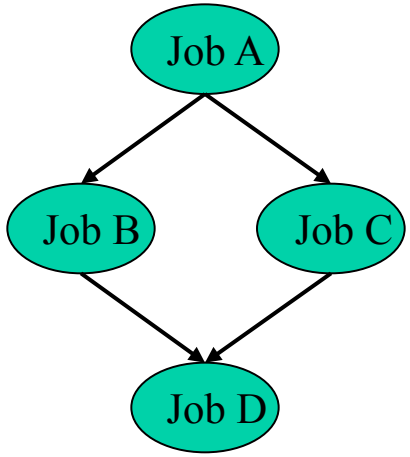


Defining a DAG

- A DAG is defined by a *.dag file*, listing each of its nodes and their dependencies. For example:

```
Job A a.sub
Job B b.sub
Job C c.sub
Job D d.sub

Parent A Child B C
Parent B C Child D
```



DAG Files….

- This complete DAG has five files

One DAG File:

```
Job A a.sub
Job B b.sub
Job C c.sub
Job D d.sub

Parent A Child B C
Parent B C Child D
```

Four Submit Files:

```
Universe = Vanilla
Executable = analysis…
```

```
Universe = …
```

Submitting a DAG

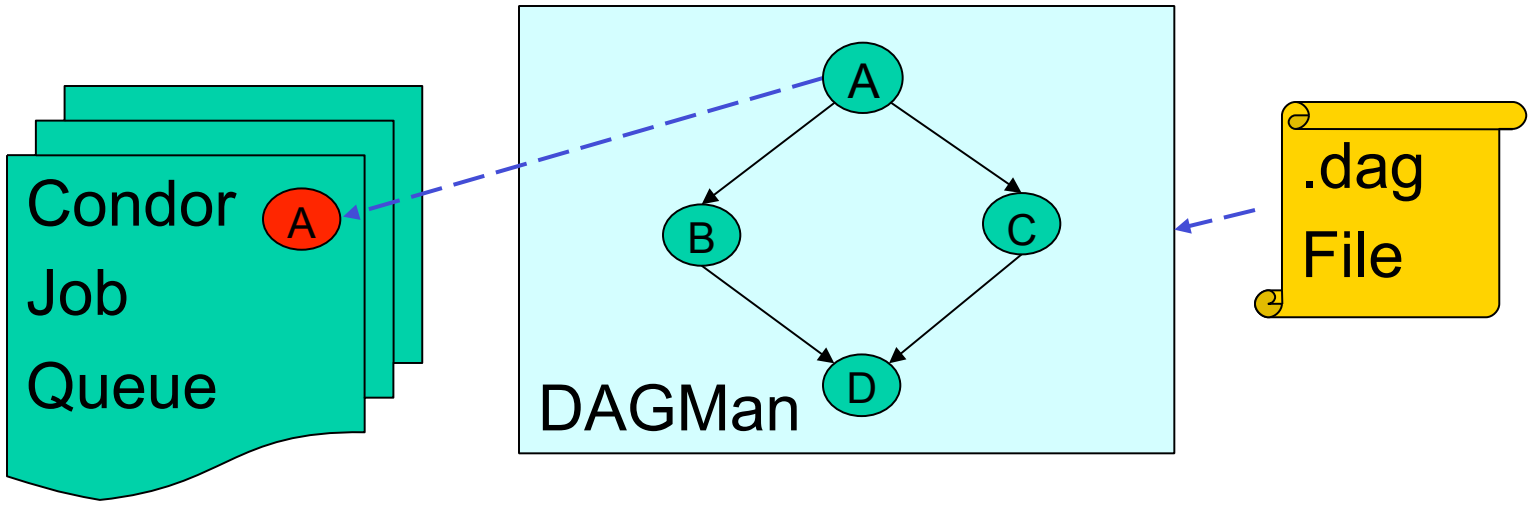
- To start your DAG, just run **`condor_submit_dag`** with your .dag file, and Condor will start a personal DAGMan process which to begin running your jobs:

```
% condor_submit_dag diamond.dag
```

- condor_submit_dag submits a Scheduler Universe job with DAGMan as the executable.
- Thus the DAGMan daemon itself runs as a Condor job, so you don't have to baby-sit it.

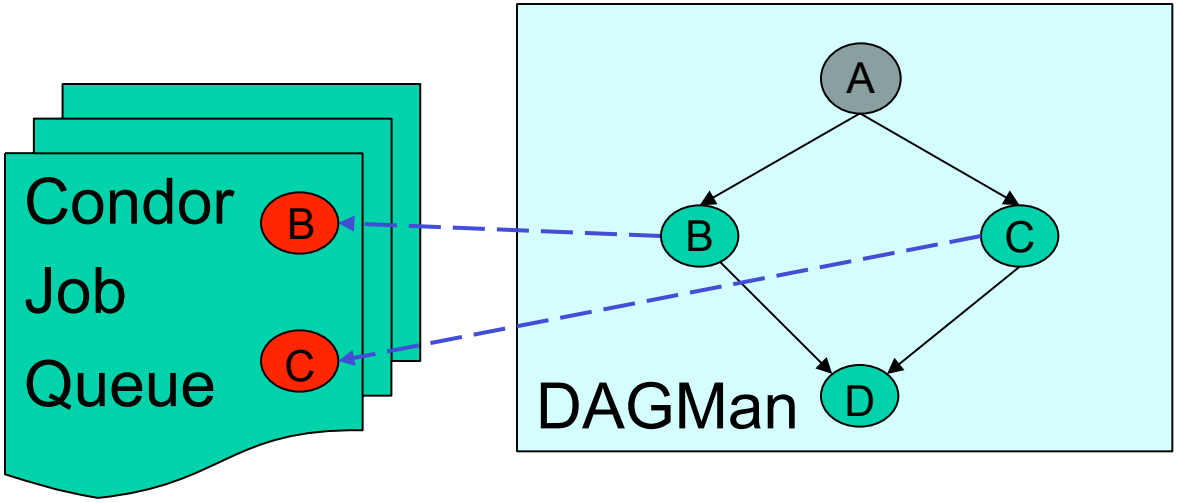
Running a DAG

- DAGMan acts as a scheduler, managing the submission of your jobs to Condor based on the DAG dependencies.



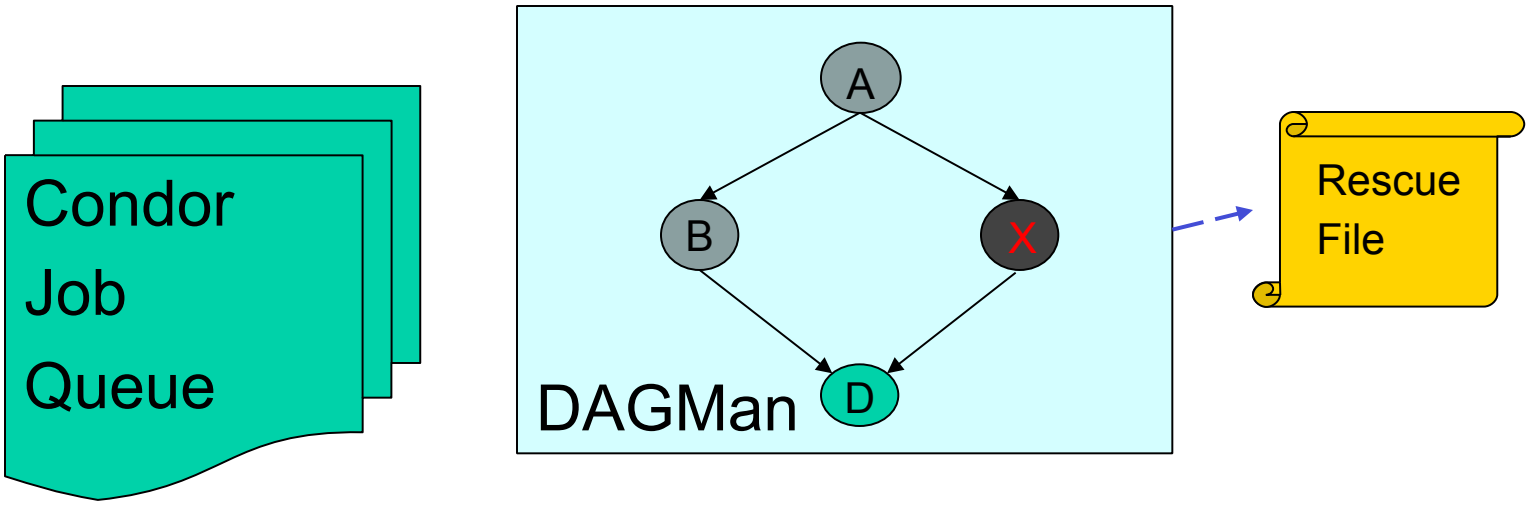
Running a DAG (cont'd)

- DAGMan holds & submits jobs to the Condor queue at the appropriate times. For example, after A finishes, it submits B & C.



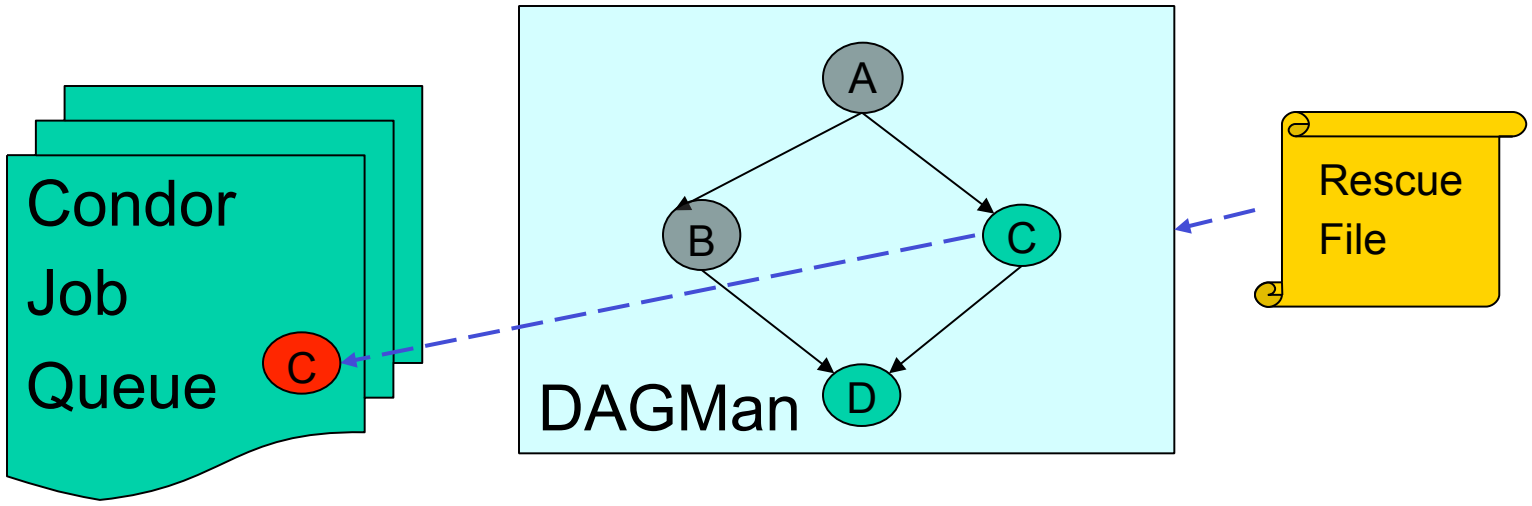
Running a DAG (cont'd)

- In case of a job failure, DAGMan continues until it can no longer make progress, and then creates a *"rescue" file* with the current state of the DAG.



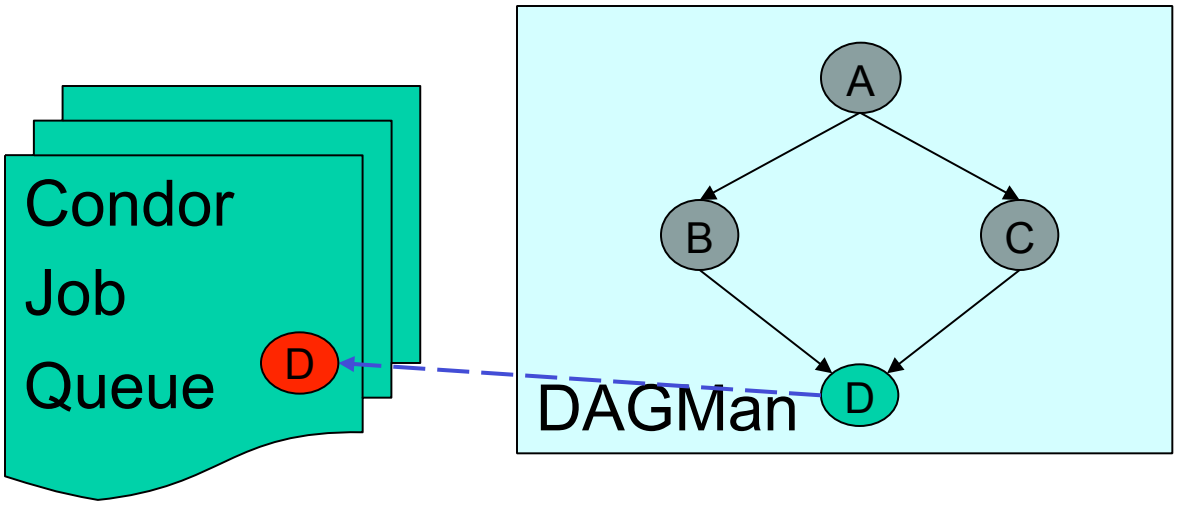
Recovering a DAG

- Once the failed job is ready to be re-run, the rescue file can be used to restore the prior state of the DAG.



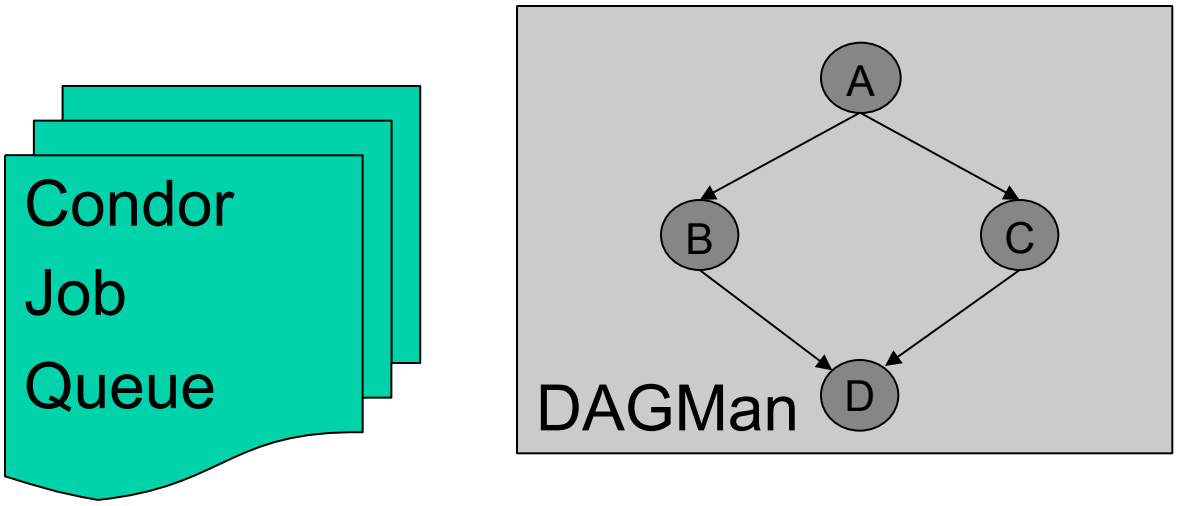
Recovering a DAG (cont'd)

- Once that job completes, DAGMan will continue the DAG as if the failure never happened.

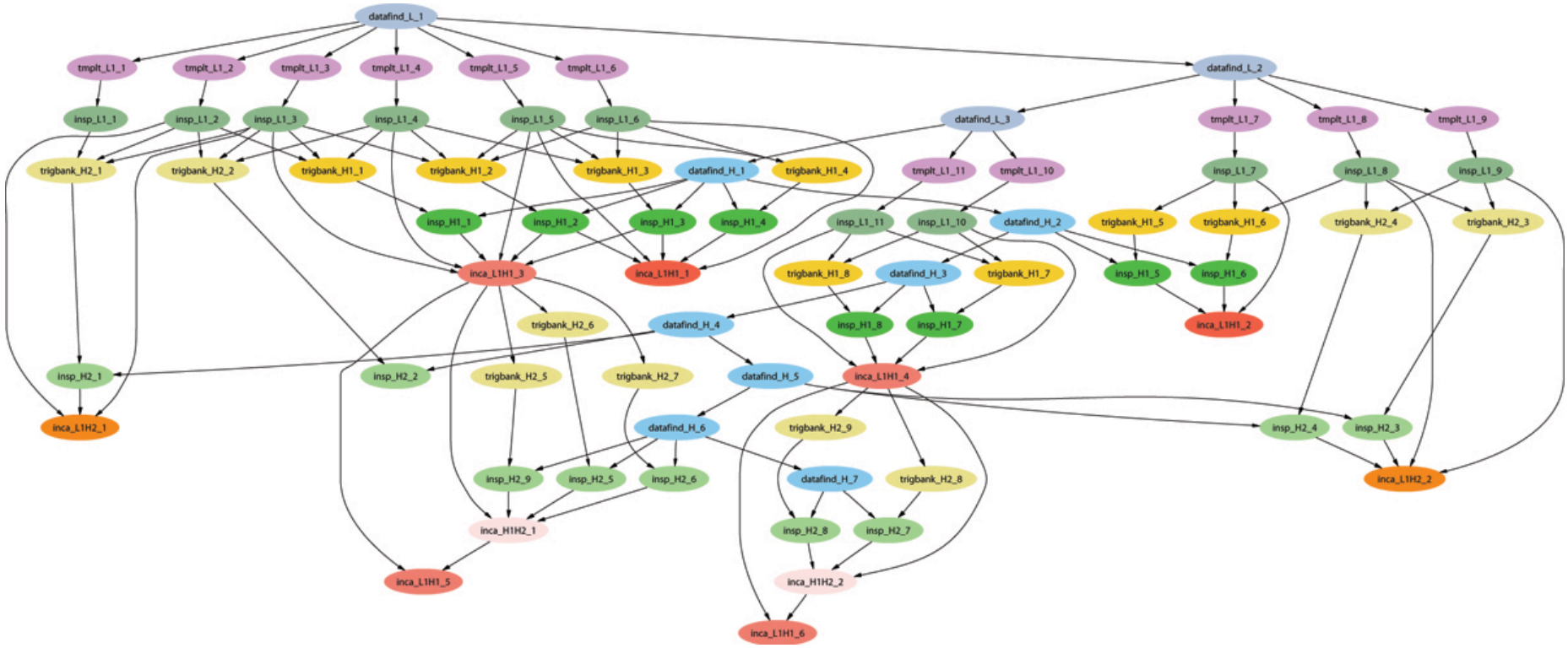


Finishing a DAG

- Once the DAG is complete, the DAGMan job itself is finished, and exits.

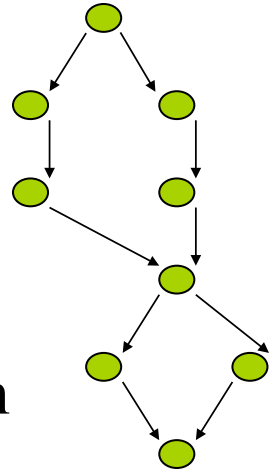


Example of a LIGO Inspiral DAG



Use of Condor by the LIGO Scientific Collaboration

- Condor handles 10's of millions of jobs per year running on the LDG, and up to 500k jobs per DAG.
- Condor standard universe check pointing widely used, saving us from having to manage this.
- At Caltech, 30 million jobs processed using 22.8 million CPU hrs. on 1324 CPUs in last 30 months.
- For example, to search 1 yr. of data for GWs from the inspiral of binary neutron star and black hole systems takes ~2 million jobs, and months to run on several thousand ~2.6 GHz nodes.



(Statement from 2010—"last 30 months" isn't from now. Also, I think they do up to 1 million jobs per DAG now.)

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DAGMan & Fancy Features

- DAGMan doesn't have a lot of "fancy features"
  - No loops
  - Not much assistance in writing very large DAGs (script it yourself)
- Focus is on solid core
  - Add the features people need in order to run large DAGs well.
  - People build systems on top of DAGMan (c.f. Pegasus on your own time)

DAGMan & Log Files

- For each job, Condor generates a log file
- DAGMan reads this log to see what has happened
- If DAGMan dies (crash, power failure, etc…)
  - Condor will restart DAGMan
  - DAGMan re-reads log file
  - DAGMan knows everything it needs to know
  - Principle: DAGMan can recover state from files and without relying on a service (Condor queue, database…)

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Advanced DAGMan Tricks

- Throttles and degenerative DAGs
- Sub-DAGs
- Pre and Post scripts: editing your DAG

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Throttles

- Failed nodes can be automatically retried a configurable number of times
  - Can retry N times
  - Can retry N times, unless a node returns specific exit code
- Throttles to control job submissions
  - Max jobs submitted
  - Max scripts running
  - These are important when working with large DAGs

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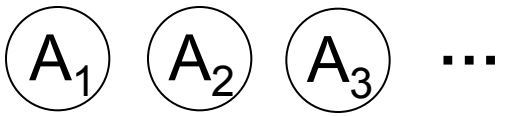
Degenerative DAG

- Submit DAG with:
  - 200,000 nodes
  - No dependencies



- Use DAGMan to throttle the jobs
  - Condor is scalable, but it will have problems if you submit 200,000 jobs simultaneously
  - DAGMan can help you get scalability even if you don't have dependencies

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Sub-DAG

- Idea: any given DAG node can be another DAG
  - SUBDAG External Name DAG-file
- DAG node will not complete until recursive DAG finishes,
- Interesting idea: A previous node could *generate* this DAG node
- Why?
  - Simpler DAG structure
  - Implement a fixed-length loop
  - Modify behavior on the fly

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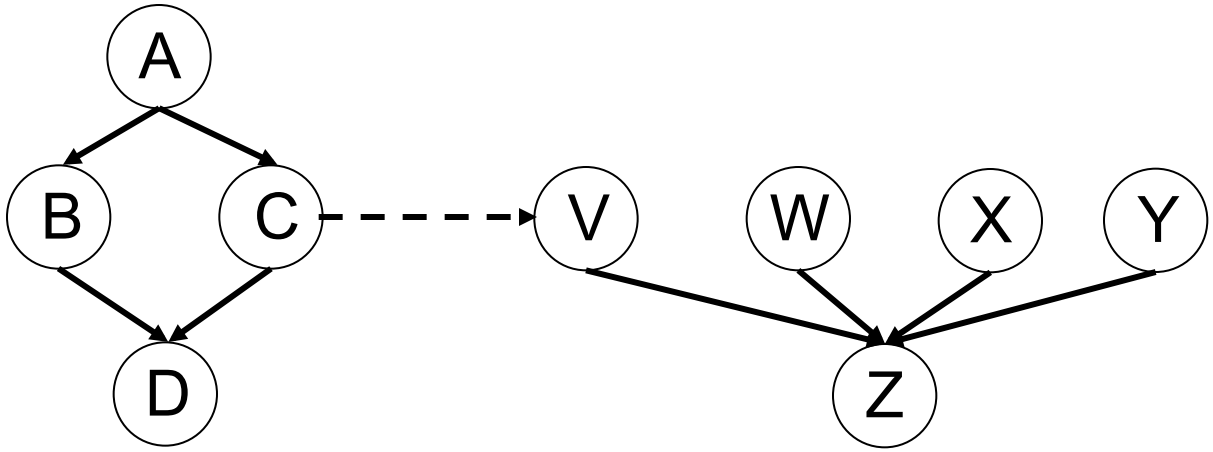
Sub-DAG



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DAGMan scripts

- DAGMan allows pre & post scripts
  - Don't have to be scripts: any executable
  - Run before (pre) or after (post) job
  - Run on the same computer you submitted from
- Syntax:

```
JOB A a.sub
SCRIPT PRE A before-script $JOB
SCRIPT POST A after-script $JOB $RETURN
```

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So What?

- Pre script can make decisions
  - Where should my job run? (Particularly useful to make job run in same place as last job.)
  - What should my job do (e.g. cmd-line arguments)
  - Generate Sub-DAG
  - Lazy decision making
    - Noop jobs
- Post script can change return value
  - DAGMan decides job failed in non-zero return value
  - Post-script can look at {error code, output files, etc} and return zero or non-zero based on deeper knowledge.

Let's try it out!

- Exercises with DAGMan.

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Questions?

- Questions? Comments?
- Feel free to ask me questions later:

  Alain Roy <roy@cs.wisc.edu>
- Upcoming sessions
  - Now – 3:15pm
    - Hands-on exercises
  - 3:15pm – 3:30pm
    - Break
  - 3:30pm – 4:55pm
    - Final Condor session