Back to the Basics of DAGMan

Automating Workflows via DAGMan

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Why use DAGMan?

AUTOMATION

- DAGMan provides a way for the researcher to organize HTCondor jobs into workflows to be automatically submitted.
- DAGMan guarantees jobs run in a particular order as described by the researcher.
- This is useful for jobs that require the output of another job as input.

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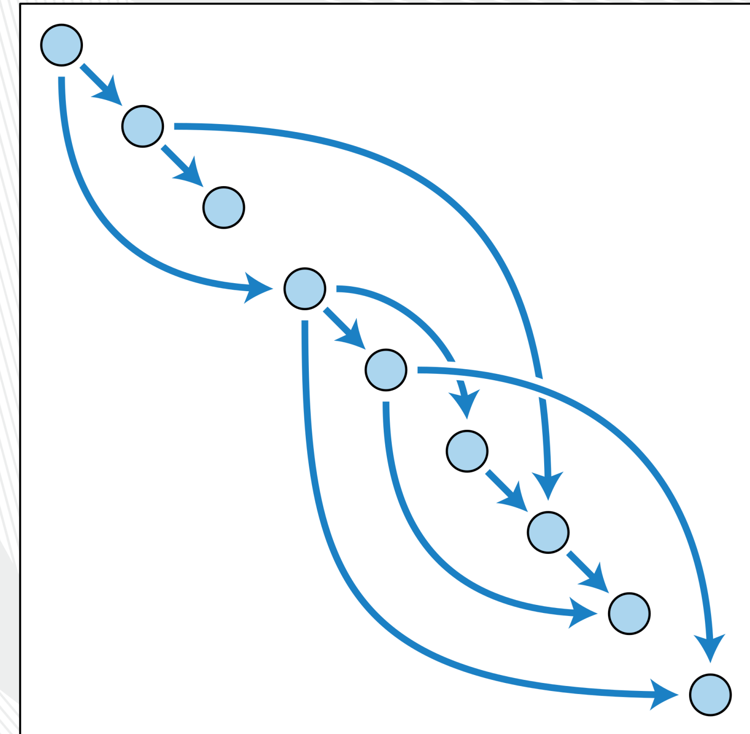
What is DAGMan?

DAGMan stands for Directed Acyclic Graph (DAG) Manager

Directed Acyclic Graph (DAG):

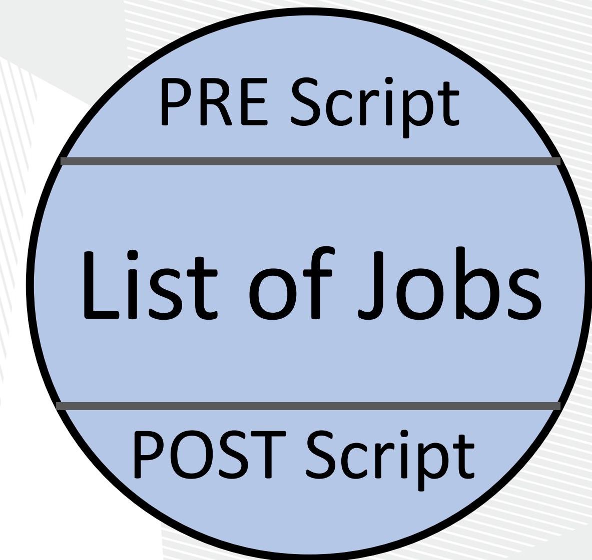
- A topological ordering of vertices ("**nodes**") established by directional connections ("**edges**")
- The **acyclic** aspect requires a start and end with no looped repetition.



Directed Acyclic Graph - Wikipedia

What is a DAGMan Node?

- A node is a unit of work comprising of up to three parts:
  2. (Required) A list of one or more jobs. The core of a node!



Awesome-Science.sub

```
executable = ./find_waldo.py
arguments = ”--scan --retry 3”
input        = “book.png”
output       = “found.png”
request_disk = 3GB
request_cpus = 4

queue 100
```

Note: DAGMan views a list of jobs as a single entity. Meaning all must succeed to be considered successful.

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Simple Example

diamond.dag

Creates Nodes (A,B,C,D)

Creates Edges

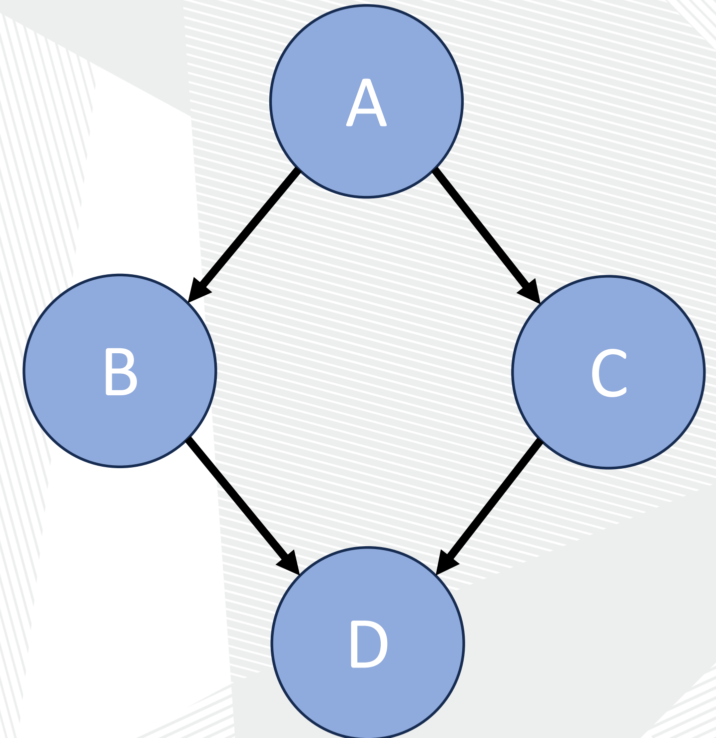
```
JOB A A.sub
JOB B B.sub
JOB C C.sub
JOB D D.sub

PARENT A CHILD B C
PARENT B C CHILD D
```

(dag_dir) /

A.sub B.sub
C.sub D.sub
diamond.dag
(other job files)

Diamond DAG visualized



Note: All parts of the DAG (nodes, edges, modifications) must be declared in the DAG description file prior to submission.

Running a DAG

Submitting a DAG

DAG Submission commands:

condor_submit_dag dag_file

htcondor dag submit dag_file

```
$ htcondor dag submit diamond.dag
DAG 6 was submitted.
```

```
$ condor_submit_dag diamond.dag
-----------------------------------------------------------------------
File for submitting this DAG to HTCondor    : diamond.dag.condor.sub
Log of DAGMan debugging messages             : diamond.dag.dagman.out
Log of HTCondor library output               : diamond.dag.lib.out
Log of HTCondor library error messages       : diamond.dag.lib.err
Log of the life of condor_dagman itself      : diamond.dag.dagman.log

Submitting job(s).
1 job(s) submitted to cluster 6.
-----------------------------------------------------------------------
```

[condor_submit_dag Man Pages]

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What happens?

- Submitting a DAG to HTCondor produces an HTCondor scheduler universe job for the DAGMan process (DAGMan job proper).

Lots of files produced:

- Informational DAG files
  - *.dagman.out = DAG progress/error output
  - *.nodes.log = Collective job event log (Heart of DAGMan)
  - *.metrics = JSON formatted DAG information
- DAGMan job proper files
  - *.condor.sub = Submit File
  - *.dagman.log = Job Log
  - *.lib.err = Job Error
  - *.lib.out = Job Output

Monitoring a DAG

- Simply use **condor_q** to view the DAG in queue
  - Use **–nobatch –dag** to see a broken-out view of the DAG and running jobs (with associated node names).
- Can even use **condor_watch_q**

```
$ condor_q
-- Schedd: COLES_AP@ : <127.0.0.1:49473?... @ 07/06/23 10:14:23
OWNER      BATCH_NAME         SUBMITTED   DONE   RUN    IDLE  TOTAL JOB_IDS
cole       diamond.dag+6     7/6  10:14      _      _      1      4 7.0

$ condor_q -nobatch -dag
-- Schedd: COLES_AP@ : <127.0.0.1:49473?... @ 07/06/23 10:14:25
 ID       OWNER             SUBMITTED     RUN_TIME ST PRI SIZE CMD
   6.0    cole             7/6  09:18   0+00:00:11 R  0    0.5 condor_dagman ...
   7.0      |-A            7/6  09:18   0+00:00:00 I  0    0.1 /bin/sleep 15
```

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Checking a DAGs status

htcondor dag status <Job-Id>

```
[cabollig@ap2002 ~]$ htcondor dag status 1746219
DAG 1746219 [science.dag] has been running for 09:33:35
DAG has submitted 184 job(s), of which:
         41 are held.
        138 have completed.
          5 have failed.
DAG contains 328 node(s) total, of which:
    [#] 138 have completed.
    [=]  41 are running: 41 jobs.
    [-] 121 are waiting on other nodes to finish.
    [!]  23 will never run.
    [!]   5 have failed.
DAG had at least one node fail. Only 91.46% of the DAG can complete.
[#####################################===========--------------------------------!!!!!!!!!]
DAG is 42.07% complete.
```

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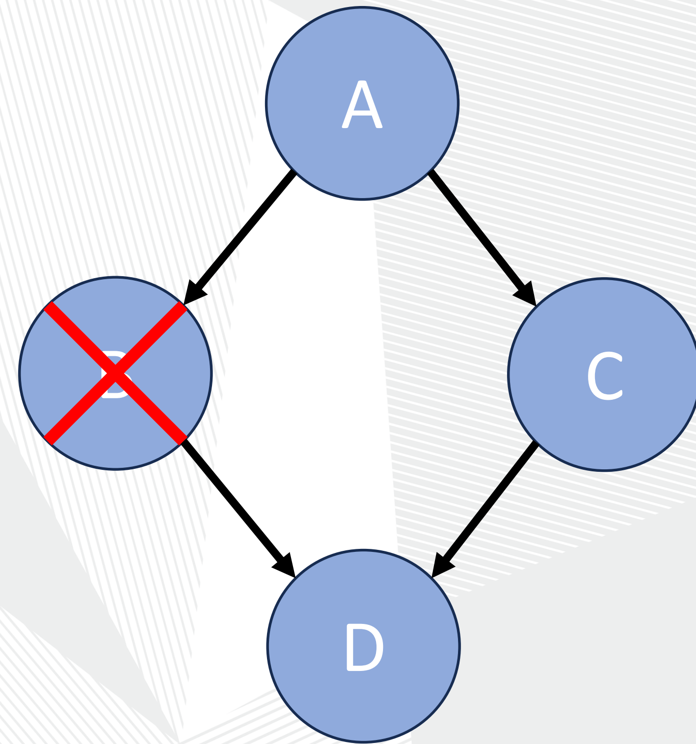
All Things Come to an End

Ideally everything runs smoothly, and the DAG completes successfully.
But just in case…

Node Failure = DAG failure

- DAGMan will try to make as much forward progress until no more nodes can be executed due to dependencies.
- If any of a nodes associated jobs fail (non-zero exit code) then the node is failed.



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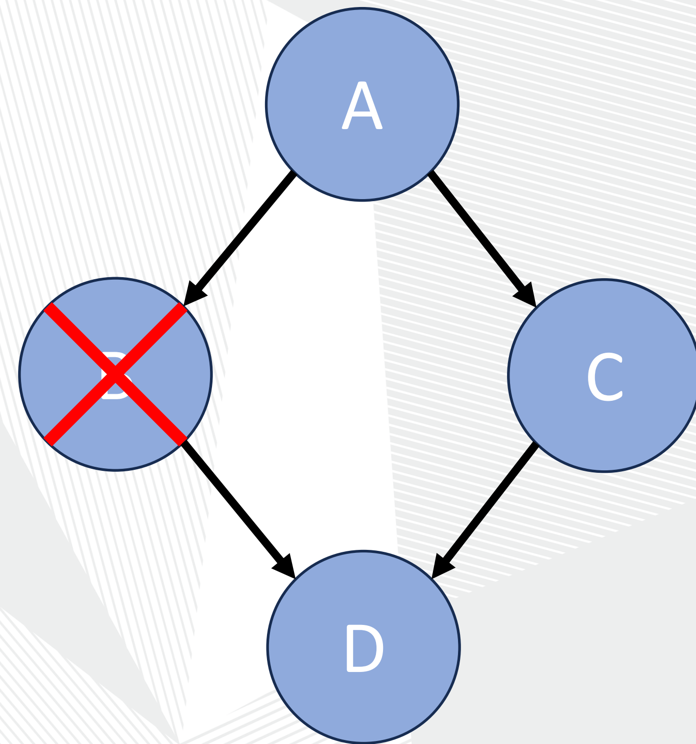
All Things Come to an End

Ideally everything runs smoothly, and the DAG completes successfully.

But just in case…

What happens when a DAG fails?

- DAGMan produces a rescue file ***.rescue001**
- Simply fix any issues and resubmit the DAG. DAGMan will read the most recent rescue file to skip rerunning already successfully completed nodes.



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Other DAGMan Features

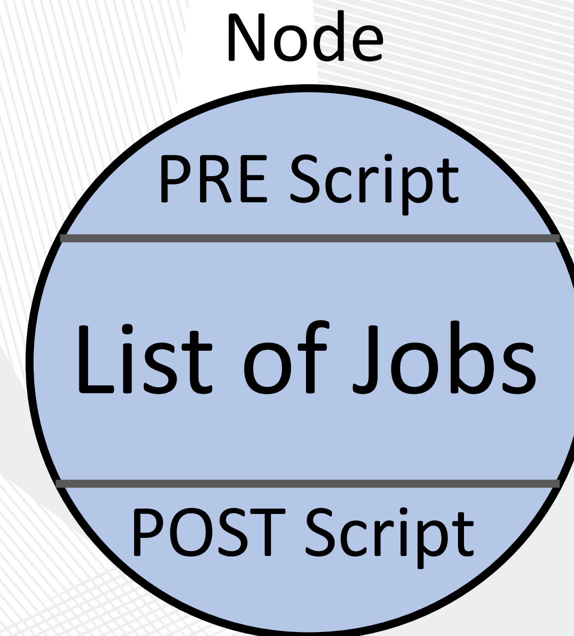
DAGMan Node Scripts

- Scripts provide a way to preform tasks at key points in a node's lifetime. Each script type has different execution time.
  - Pre Scripts run before a Node's jobs are submitted to the Schedd.
  - Post Scripts run after a node jobs have exited the Schedd queue.
- All DAGMan scripts run on the Access Point (AP) and not the Execution Point (EP).

example.dag

```
JOB A job1.sub

SCRIPT PRE A verify.sh
SCRIPT POST A check.sh $RETURN
```



DAGMan Scripts Documentation

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Automatically Retry a Failed Node

- Retry a node up to N times when said node has failed for any reason (PRE Script Failed, an associated job failed, POST Script failed)
- When retired all parts of the node are re-run. PRE Script, POST Script and the entire list of jobs (even those previously successful).
- Use **UNLESS-EXIT** to short circuit retry

RETRY NodeName N

```
JOB A job1.sub
JOB B same.sub
JOB C same.sub
JOB D job4.sub

RETRY D 5 UNLESS-EXIT 3

PARENT A CHILD B C
PARENT B C CHILD D
```

diamond.dag

DAGMan Retry Documentation

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Reusing Components with VARS

- Using the VARS command in the DAG description file creates macros to be used by the job submit description.
- Allows one job submit description to be used for many DAG nodes.
  - Can pass custom Job Ad attributes to the node's jobs using My. syntax.
  - Also has special macros
    - $(JOB) becomes node name
    - $(RETRY) becomes current retry attempt

diamond.dag

```
JOB A job1.sub
JOB B same.sub
JOB C same.sub
JOB D job4.sub

VARS B country="USA"
VARS C country="Canada"

PARENT A CHILD B C
PARENT B C CHILD D
```

same.sub

```
executable = my_script.sh
arguments = $(country)
log         = $(country)-$(cluster).log
error       = $(country)-$(cluster).err
output      = $(country)-$(cluster).out

queue
```

DAGMan VARS Documenation

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SUBDAG EXTERNAL

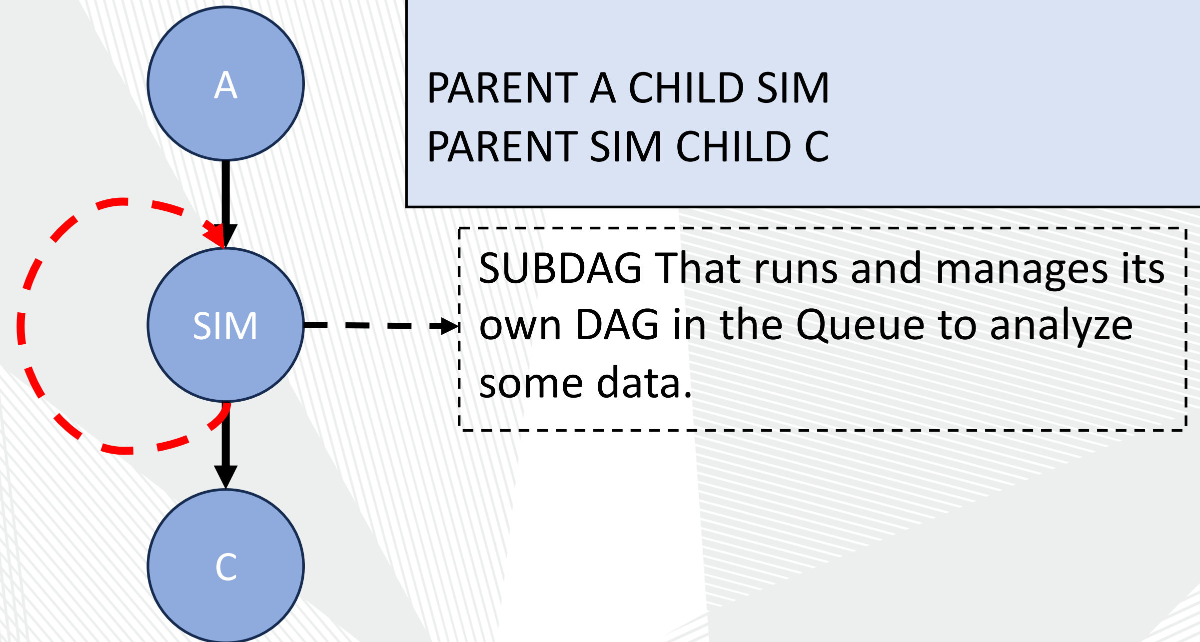
- To the parent DAG it is just a single node
  - Can use RETRY
  - Can have Pre and POST Script
- Submits as another DAG to the Schedd that has its own DAGMan job process and output files.
- DAG file and nodes don't need to exist at submission time of parent DAG
- Good for running sub-workflows where the number of jobs is not predefined

sample.dag

```
JOB A job.sub
SUBDAG EXTERNAL SIM simulation.dag
JOB C job.sub

SCRIPT POST SIM …
RETRY 10 SIM

PARENT A CHILD SIM
PARENT SIM CHILD C
```



DAGMan Sub-DAGs Documentation

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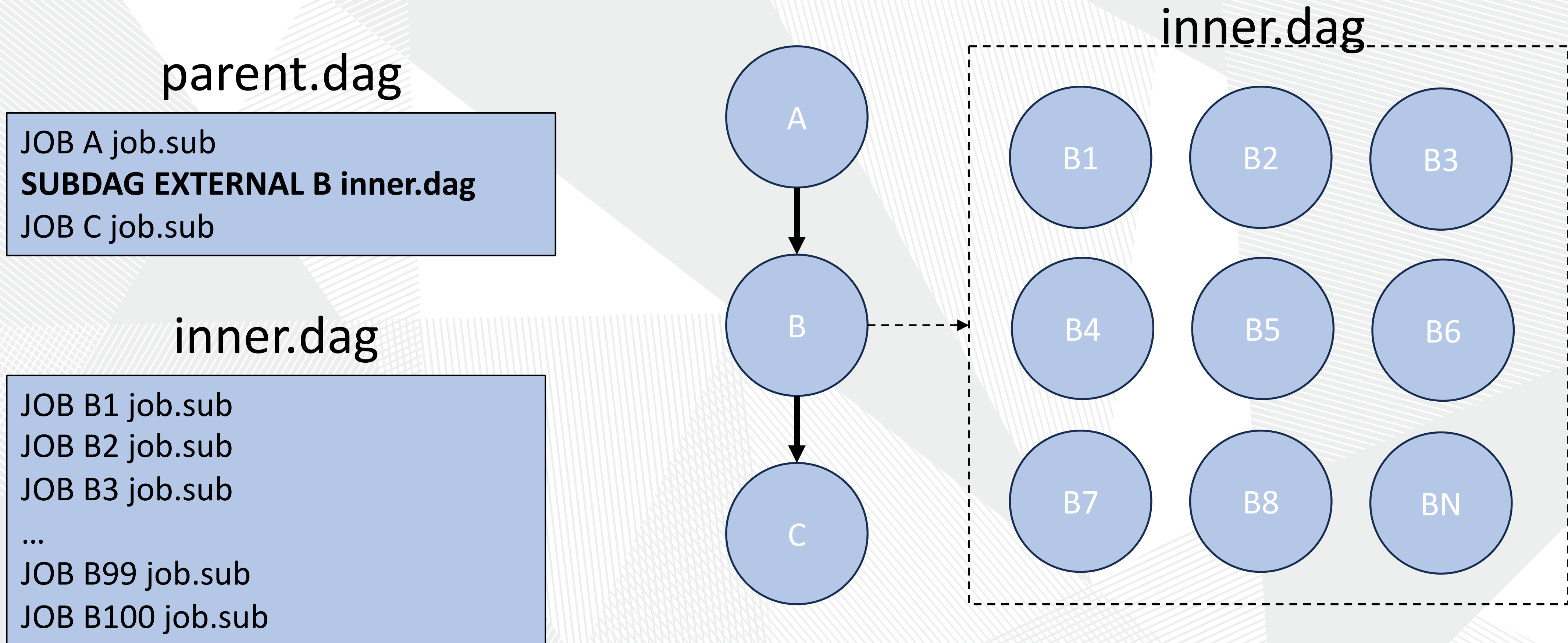
Dynamically Run N Nodes

- Useful for when the number of nodes is not known at submission time.



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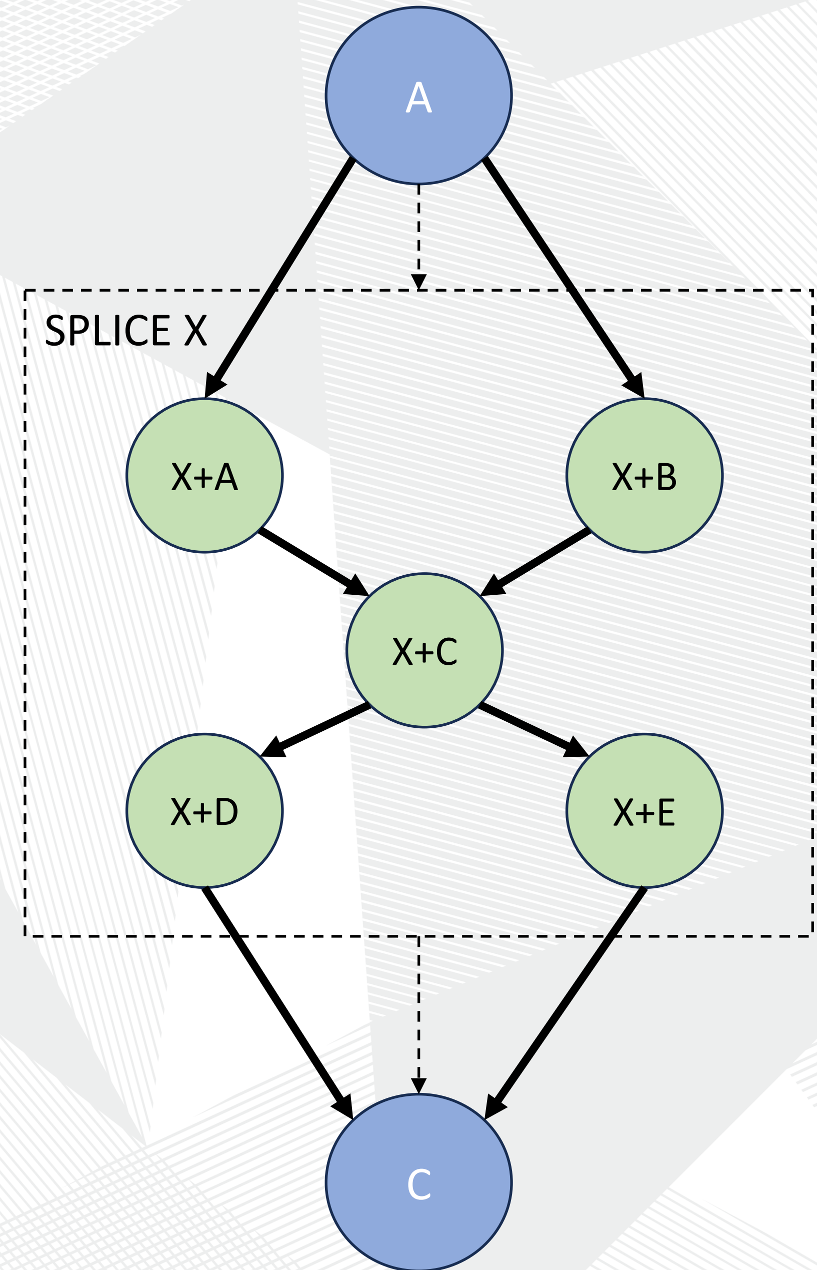
SPLICE

- Splices have their nodes merged into the parent DAG
- Allows easy reusability
- Low strain on the Access Point (AP)
- All splice files must exist at submit time
- Pre and Post scripts cannot run on splices as a whole
- Splices can not use the RETRY capability

sample.dag

```
JOB A job.sub
SPLICE X cross.dag
JOB C job.sub

PARENT A CHILD X
PARENT X CHILD C
```



DAGMan Splicing Documentation

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Questions?