HTCondor Architecture
HTCondor European Workshop 2020

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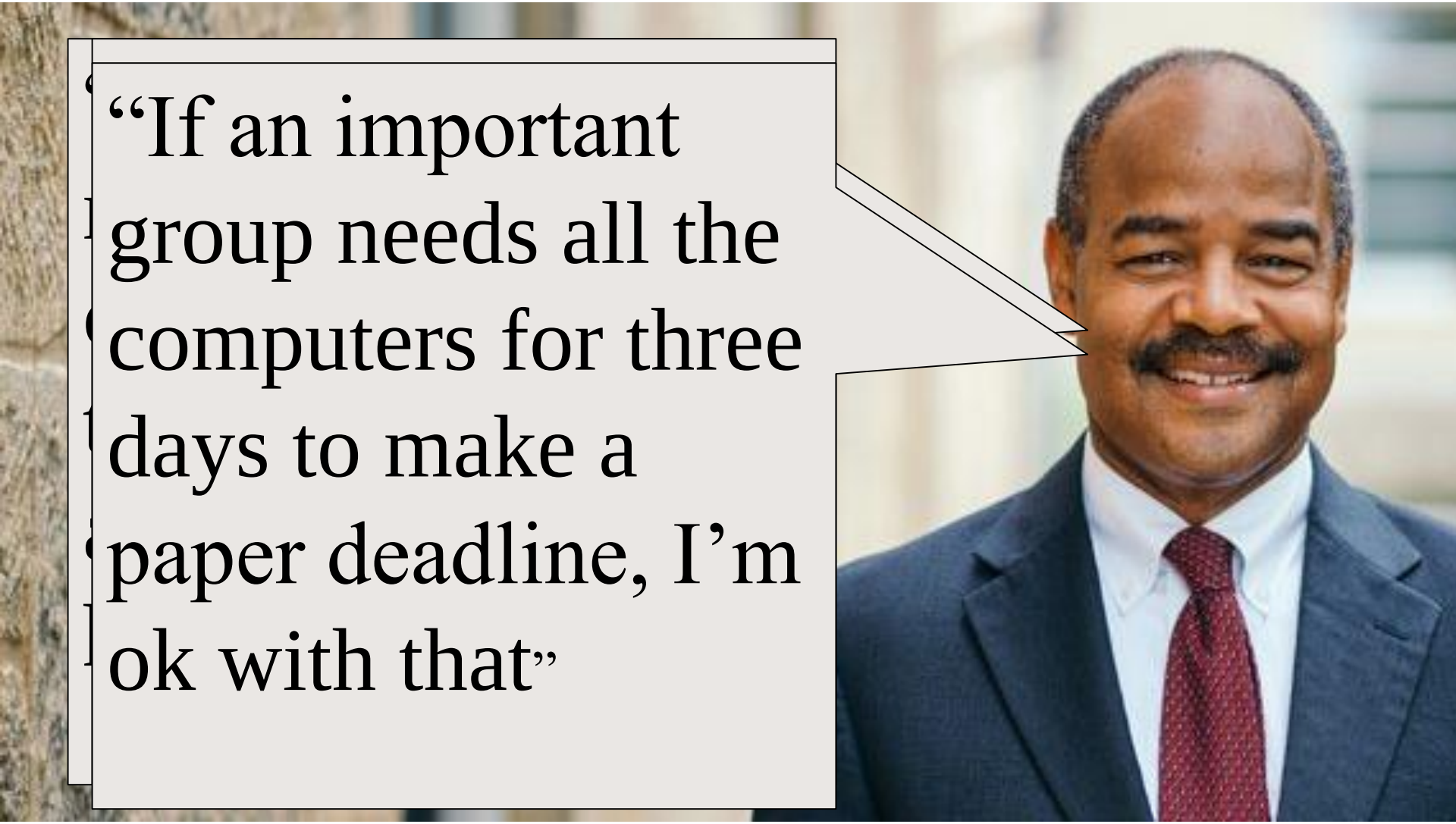
Start with People


People have Problems


“Some of my jobs need a lot of memory, others a lot of cores”


“If an important group needs all the computers for three days to make a paper deadline, I’m ok with that”


HTCondor
Manages
These
constraints

Not even that easy
In the real world, many users,
Many resource providers

This is a distributed problem.

Distributed because of *people*

Not because of machines.

Our goal is to satisfy all these constraints.

The Philosophy on 1 slide

To ***reliably*** run ***as much work*** as possible

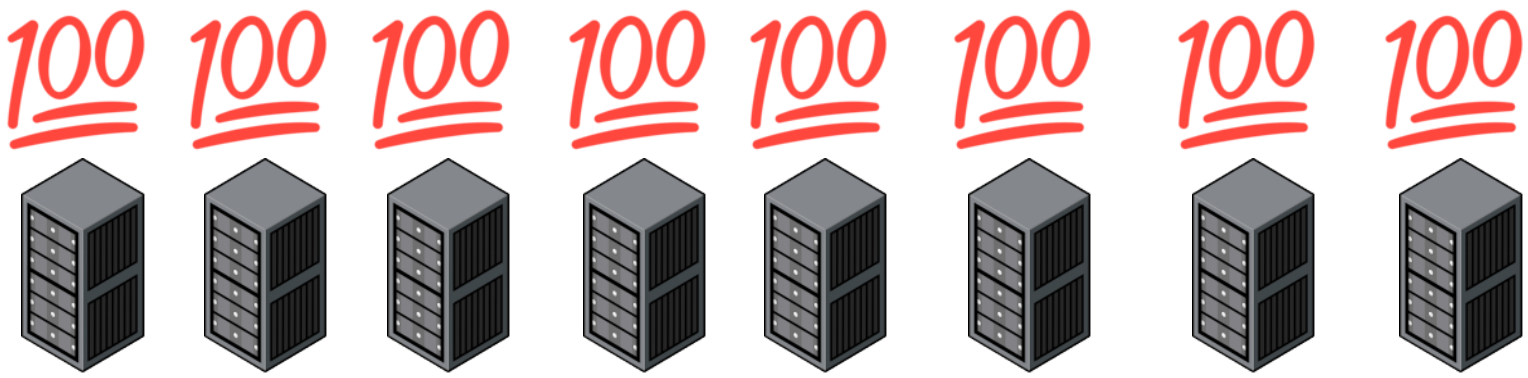
on ***as many machines*** as possible

Subject to all ***constraints***

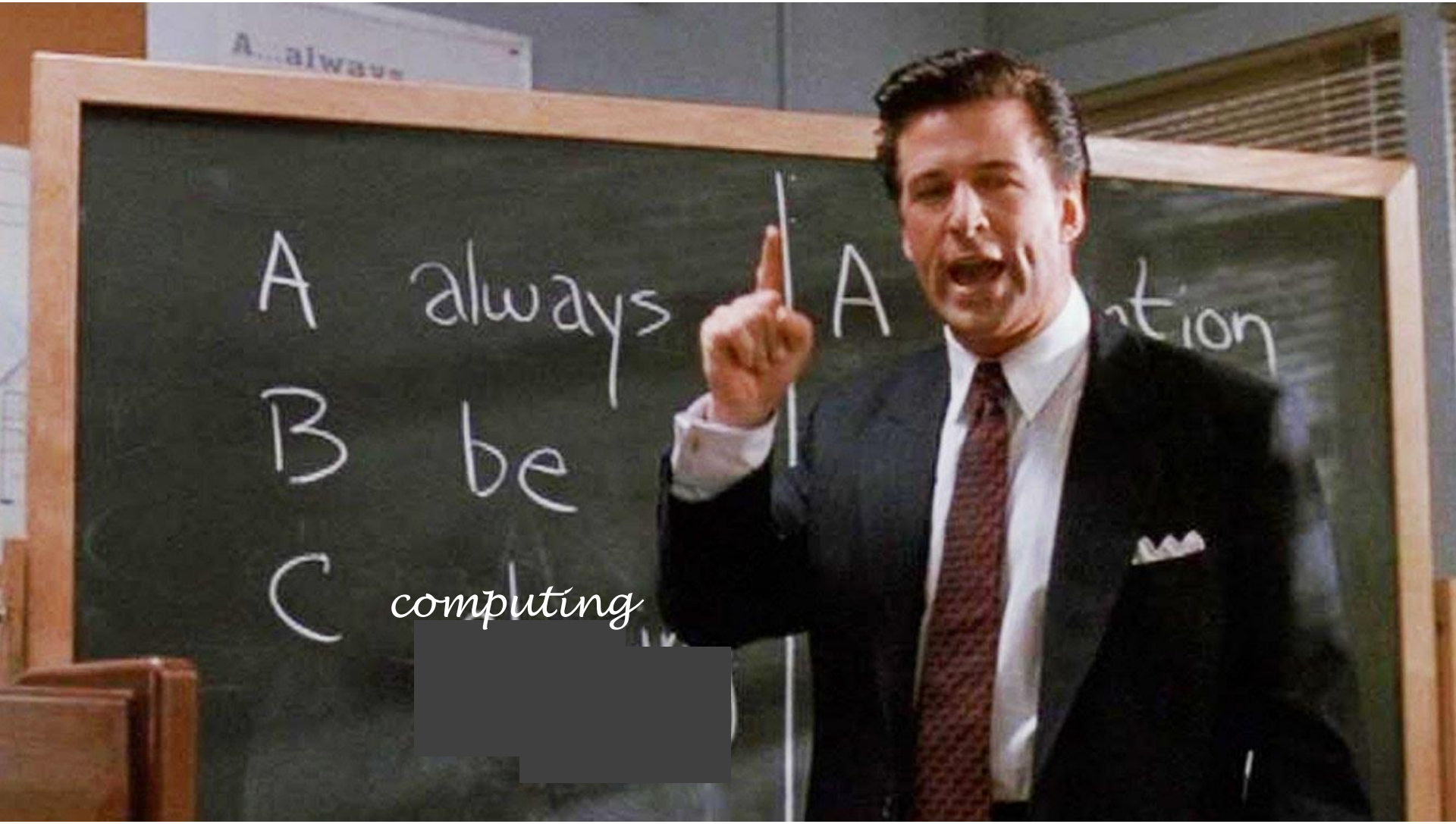
The other side: administrator's

To ***maximize*** machine ***utilization***

****subject to constraints****



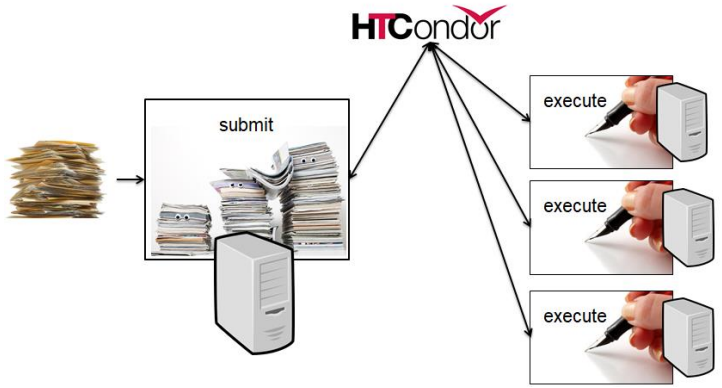
High Throughput is also High Utilization Computing!


A always A
B be
C computing

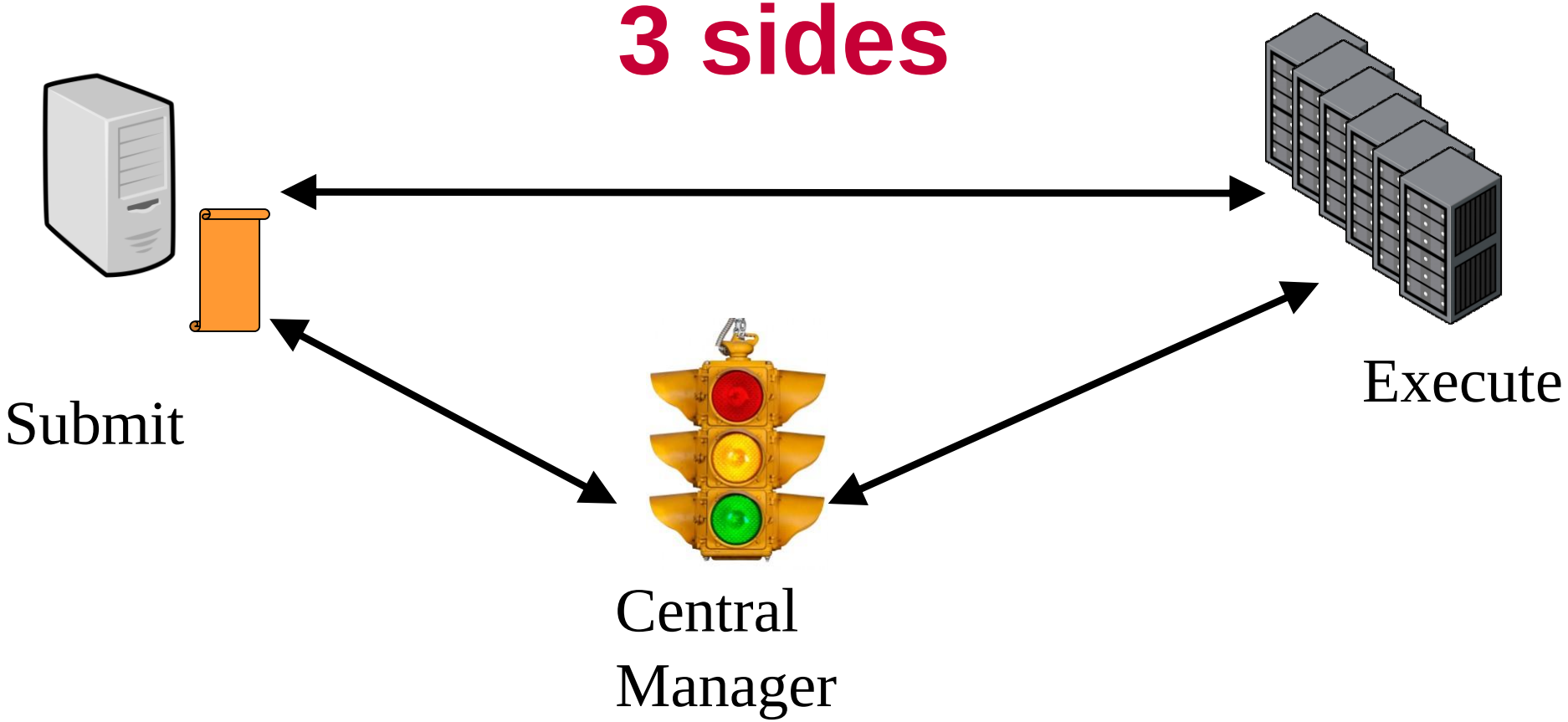
The Unstated Assumption

"Work" can be broken up into smaller jobs

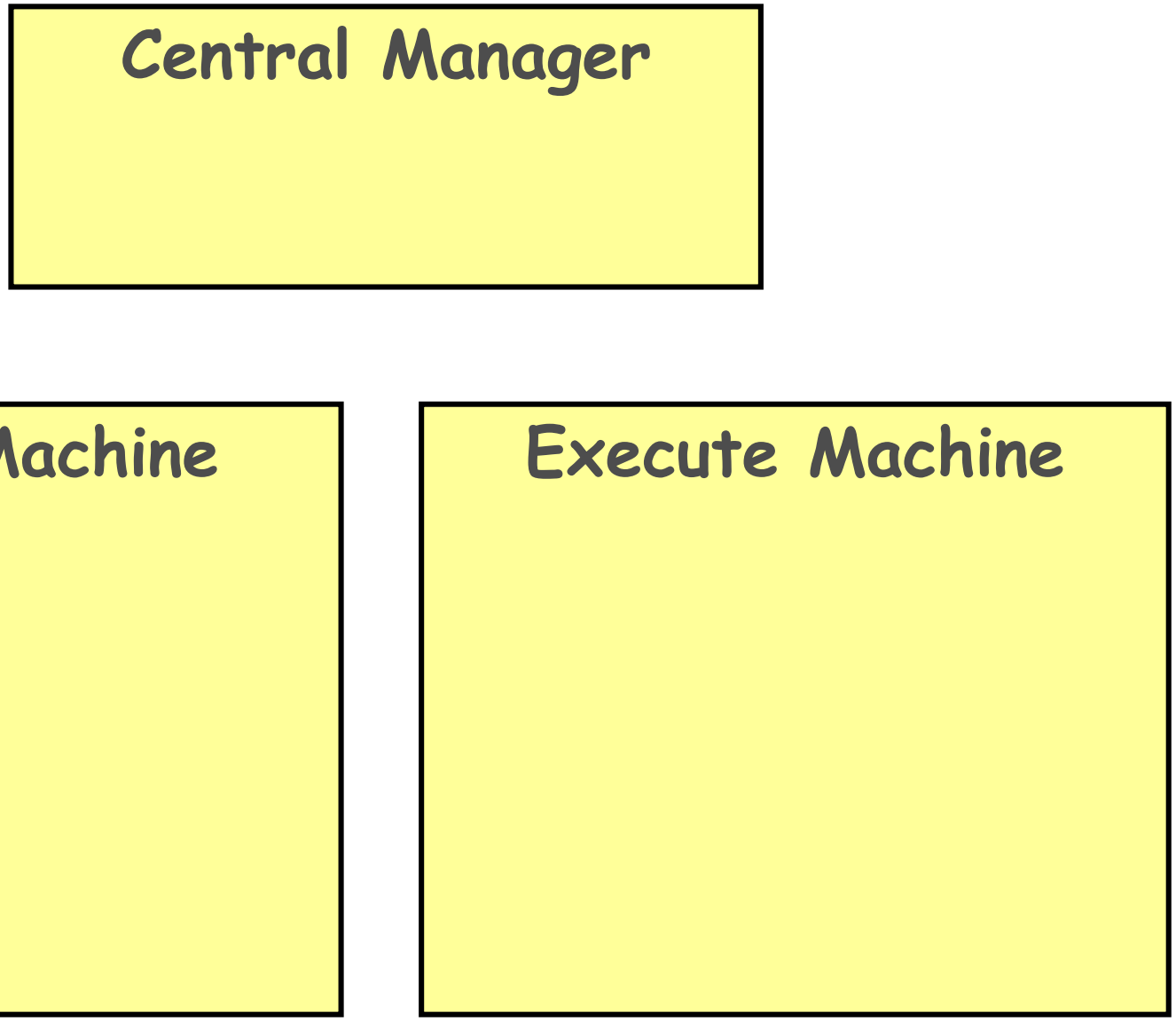
- Smaller the better (up to a point)
- files as ipc
- any interdependencies via DAGs
- Optimize time-to-finish
  - not time-to-run



Overview of HTCondor: 3 sides



We are going to fill in the boxes!



ClassAds: The *lingua franca* of HTCondor

What are ClassAds?

ClassAds is a language for objects (jobs and machines) to

- Express attributes about themselves
- Express what they require/desire in a “match” (similar to personal classified ads)

Structure : Set of attribute name/value pairs, where the value can be a literal or an expression. Semi-structured, no fixed schema.

ClassAd Values

- Literals
  - Strings (“RedHat6”), integers, floats, boolean (true/false), …
- Expressions
  - Similar look to C/C++ or Java : operators, references, functions
  - References: to other attributes in the same ad, or attributes in an ad that is a candidate for a match
  - Operators: +, -, *, /, <, <=,>, >=, ==, !=, &&, and || all work as expected
  - Built-in Functions: if/then/else, string manipulation, regular expression pattern matching, list operations, dates, randomization, math (ceil, floor, quantize,…), time functions, eval, …

Simple Example

Job Ad

```
Type   = "Job"
Requirements =
    HasMatlabLicense
      == True &&
    Memory >= 1024
Rank = kflops + 1000000
  * Memory
Cmd= "/bin/sleep"
Args = "3600"
Owner = "gthain"
NumJobStarts = 8
KindOfJob = "simulation"
Department = "Math"
```

Machine Slot Ad

```
Type = "Machine"
Cpus   = 40
Memory = 2048
Requirements =
  (Owner == "gthain")   ||
  (KindOfJob ==
  "simulation")
Rank = Department == "Math"
HasMatlabLicense = true
MaxTries = 4
kflops = 41403
```

The Magic of Matchmaking

- Two ClassAds can be matched via special attributes: Requirements and Rank
- Two ads match if both their Requirements expressions evaluate to True
- Rank evaluates to a float where higher is preferred; specifies the which match is desired if several ads meet the Requirements.
- Scoping of attribute references when matching
  - MY.name – Value for attribute “name” in local ClassAd
  - TARGET.name – Value for attribute “name” in match candidate ClassAd
  - Name – Looks for “name” in the local ClassAd, then the candidate ClassAd

ClassAd Types

- HTCondor has many types of ClassAds
  - A "Job Ad" represents a job to Condor
  - A "Machine (Slot) Ad" represents a computing resource
  - Others types of ads represent other instances of other services (daemons), users, accounting records.

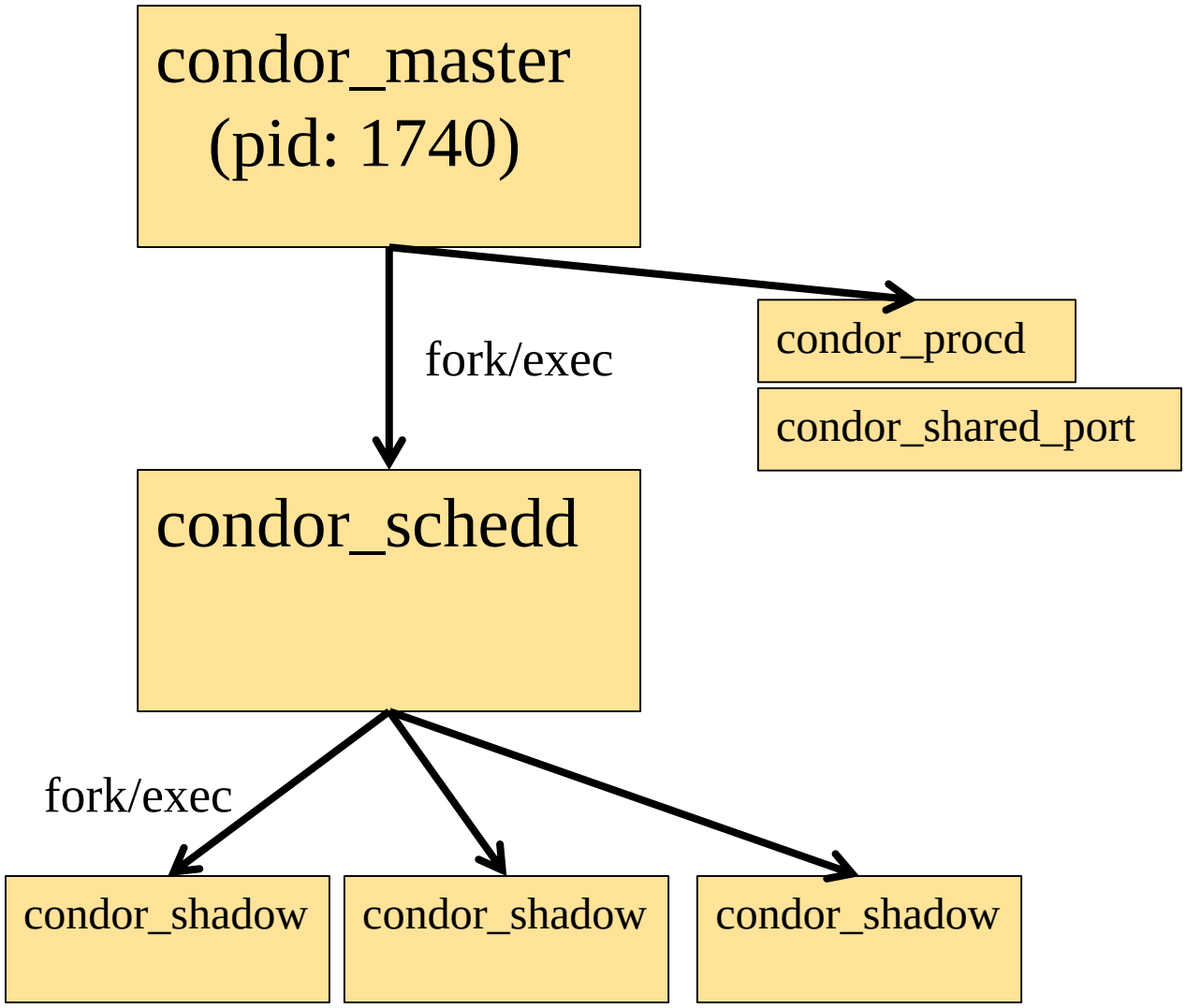
Architecture & Job Startup

HTCondor

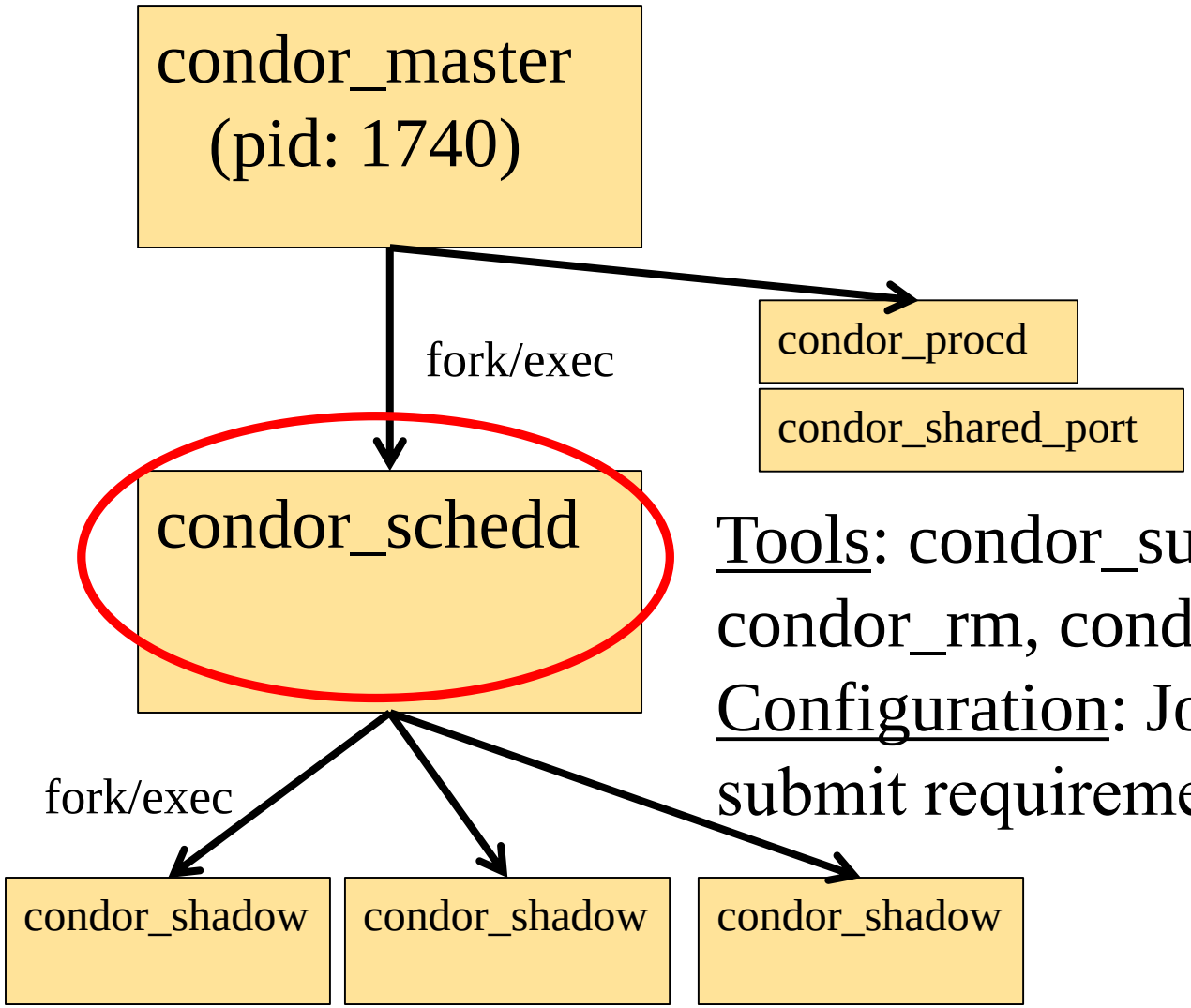
Quick Review of HTCondor components (daemons)

- Every running daemon has a *specific area of responsibility* (reflected in the Manual).
  - condor_master: runs on all machines, plus a condor_procd, condor_shared_port
  - condor_schedd: manages a submit machine
  - condor_startd: manages an execute machine
  - condor_negotiator, condor_collector: runs on the central manager

Submit Machine Process View



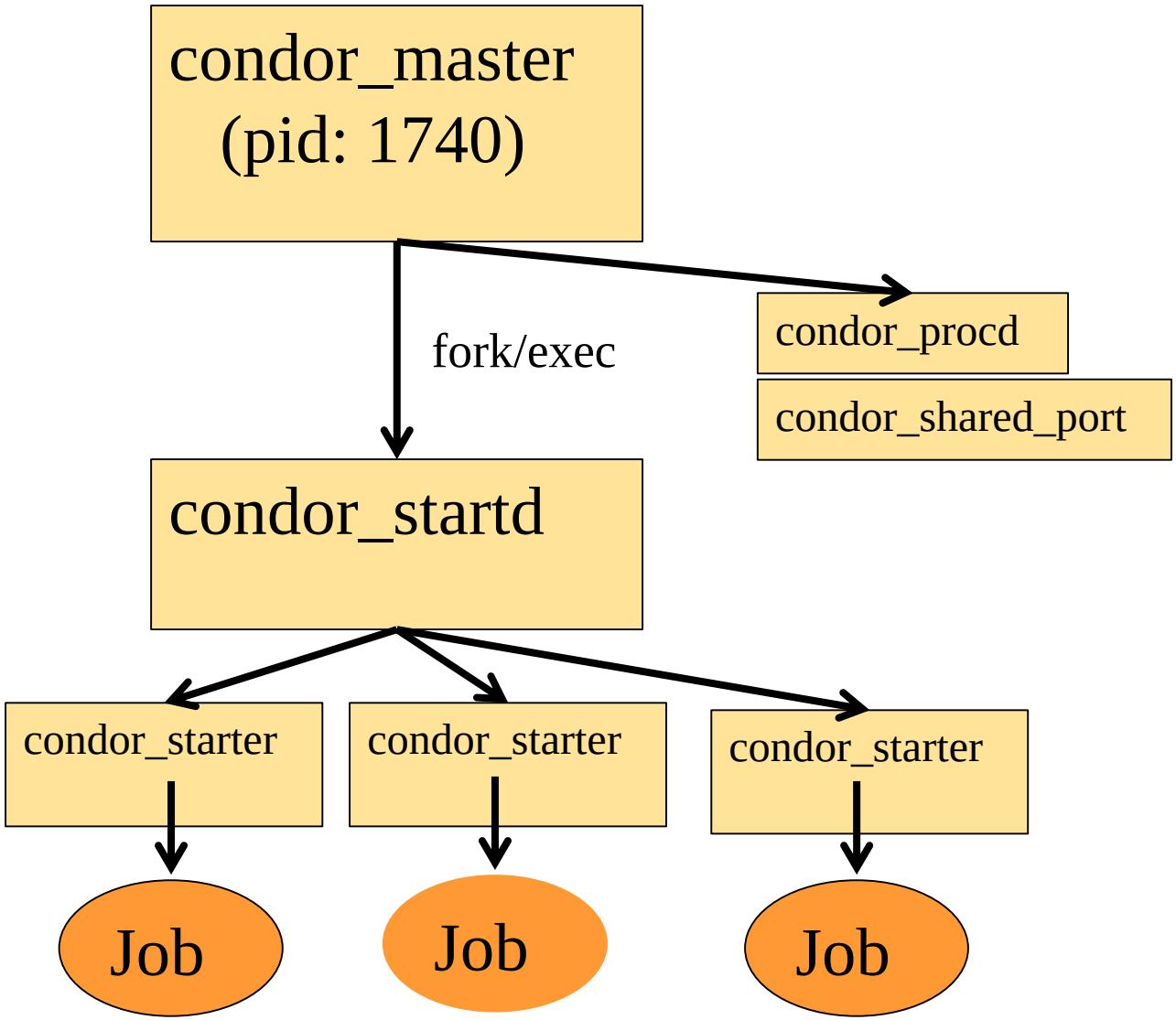
Submit Machine Process View



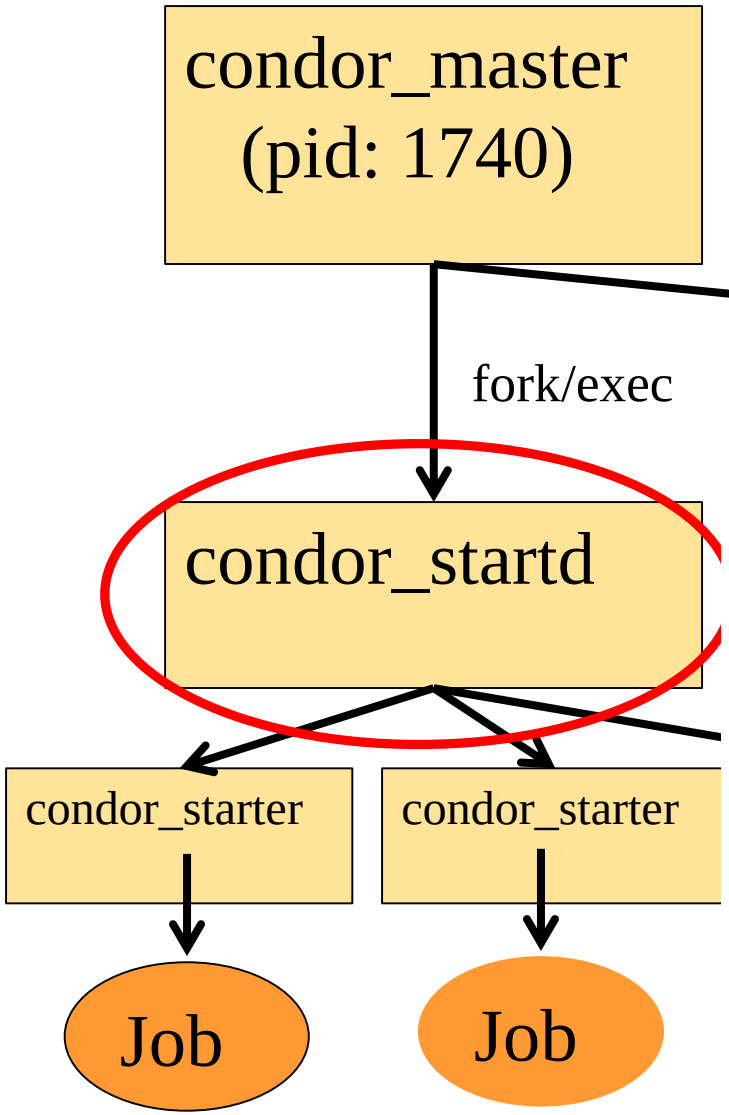
Tools: condor_submit, condor_q, condor_rm, condor_hold, …

Configuration: Job limits / defaults, submit requirements, transforms, …

Execute Machine Process View

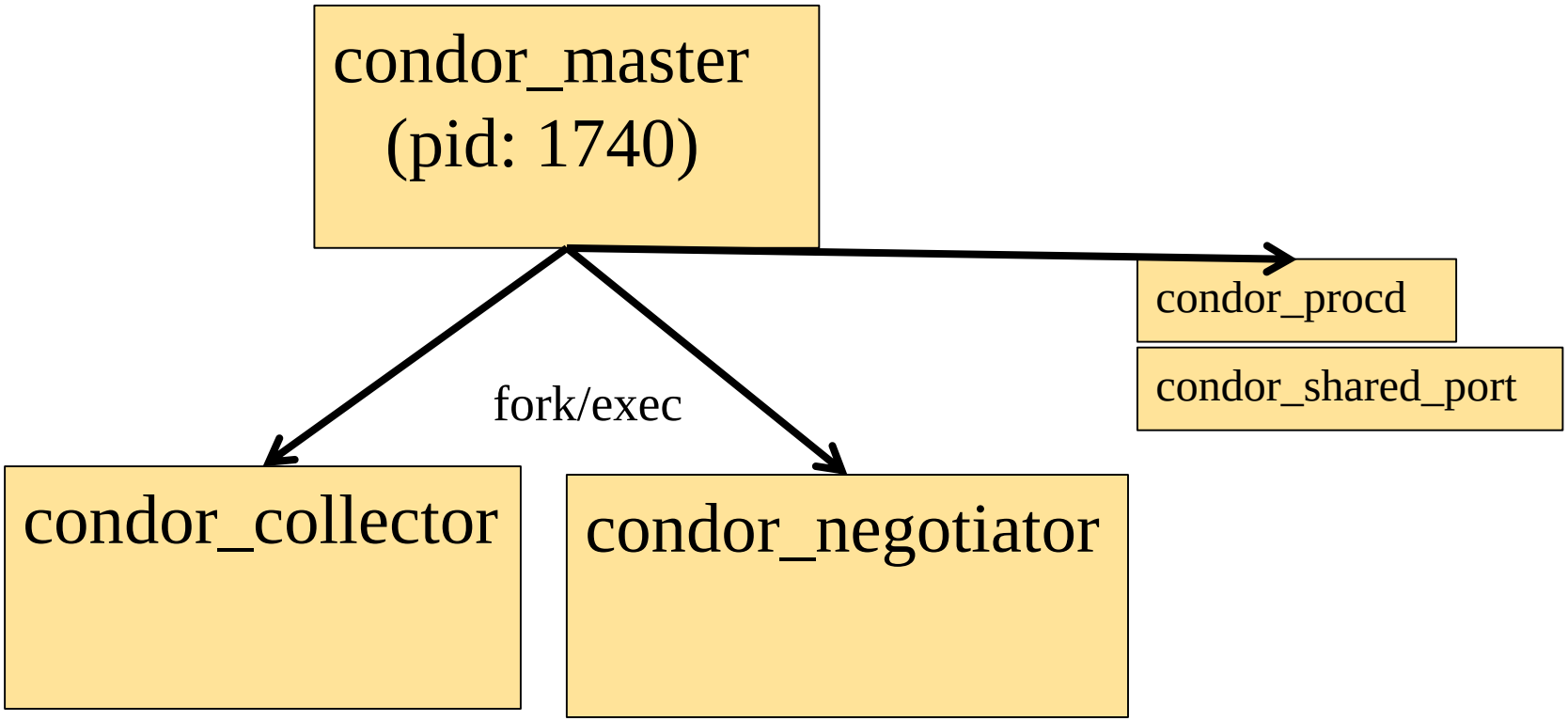


Execute Machine Process View

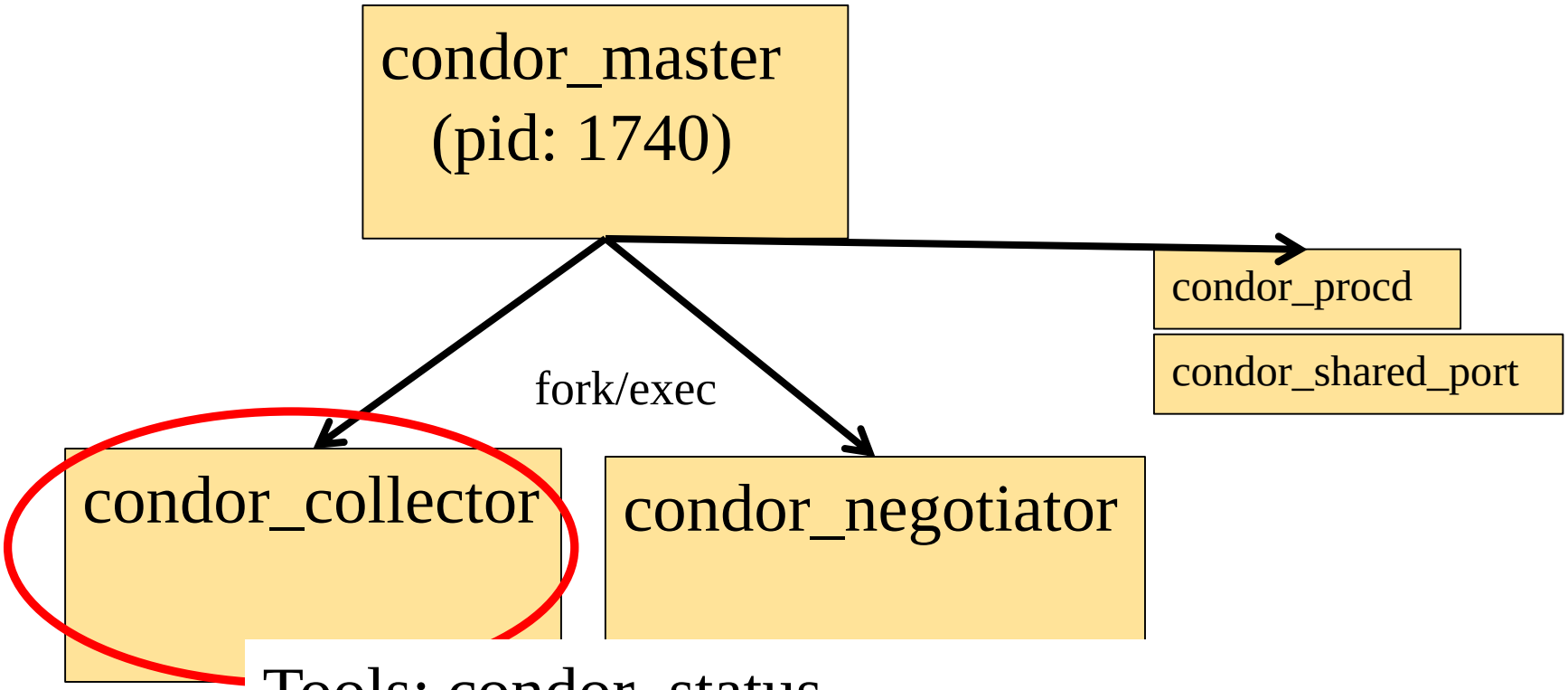


Tools: condor_drain, condor_vacate…
Configuration: Divide machine resources into slots, when can a job run here, requirements and rank on which jobs run, how long a user can claim a slot, …

Central Manager Process View



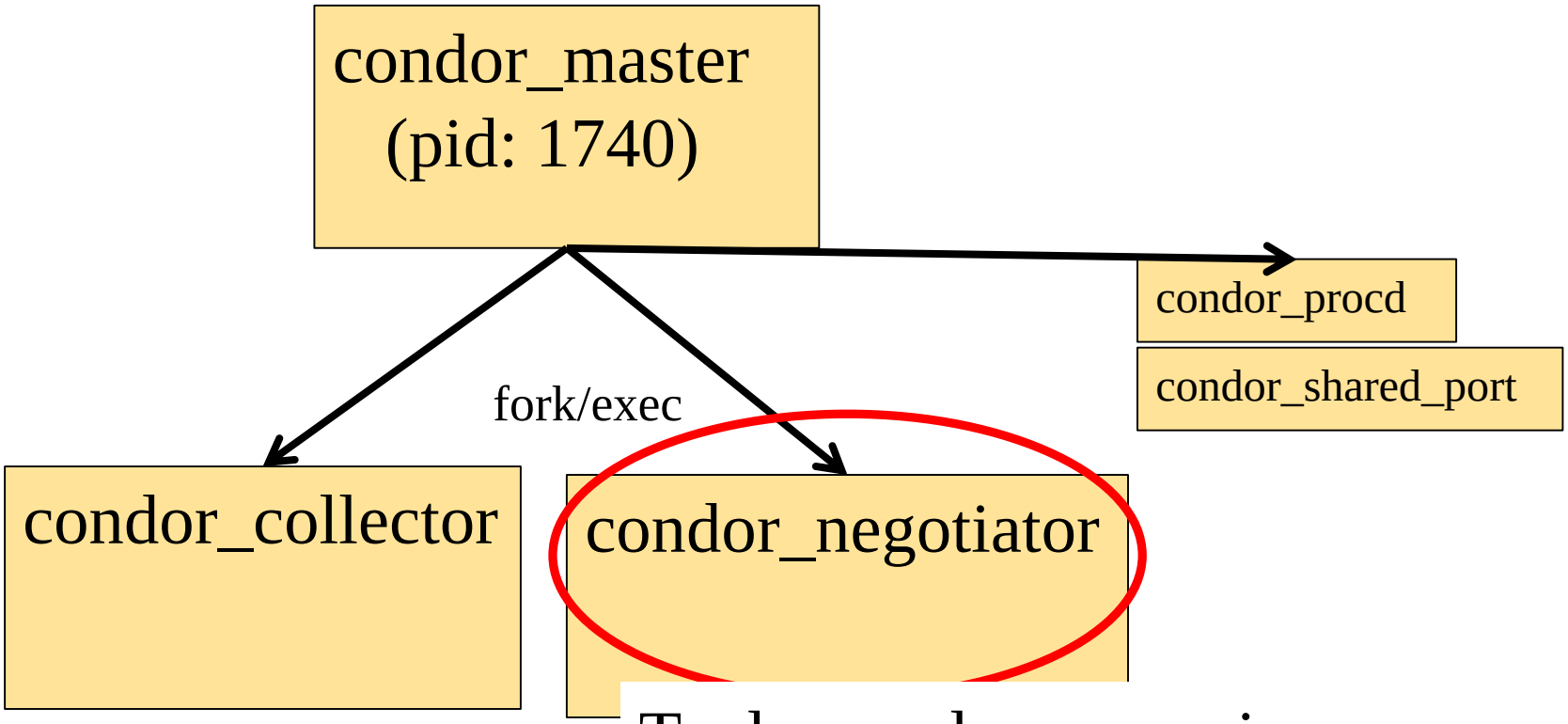
Central Manager Process View



Tools: condor_status

Configuration: Which daemons (machines) can "join" the pool, absent machines, …

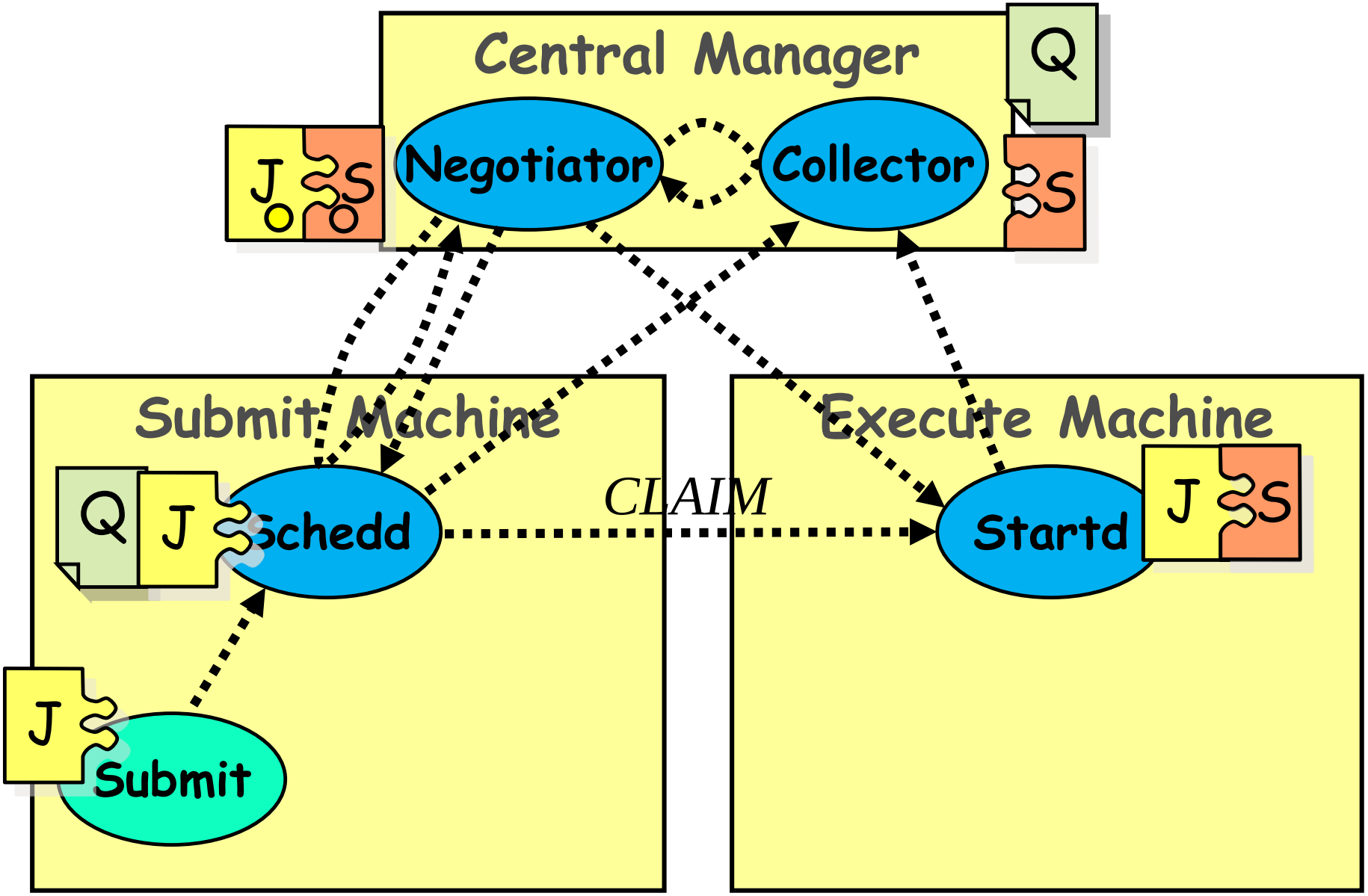
Central Manager Process View



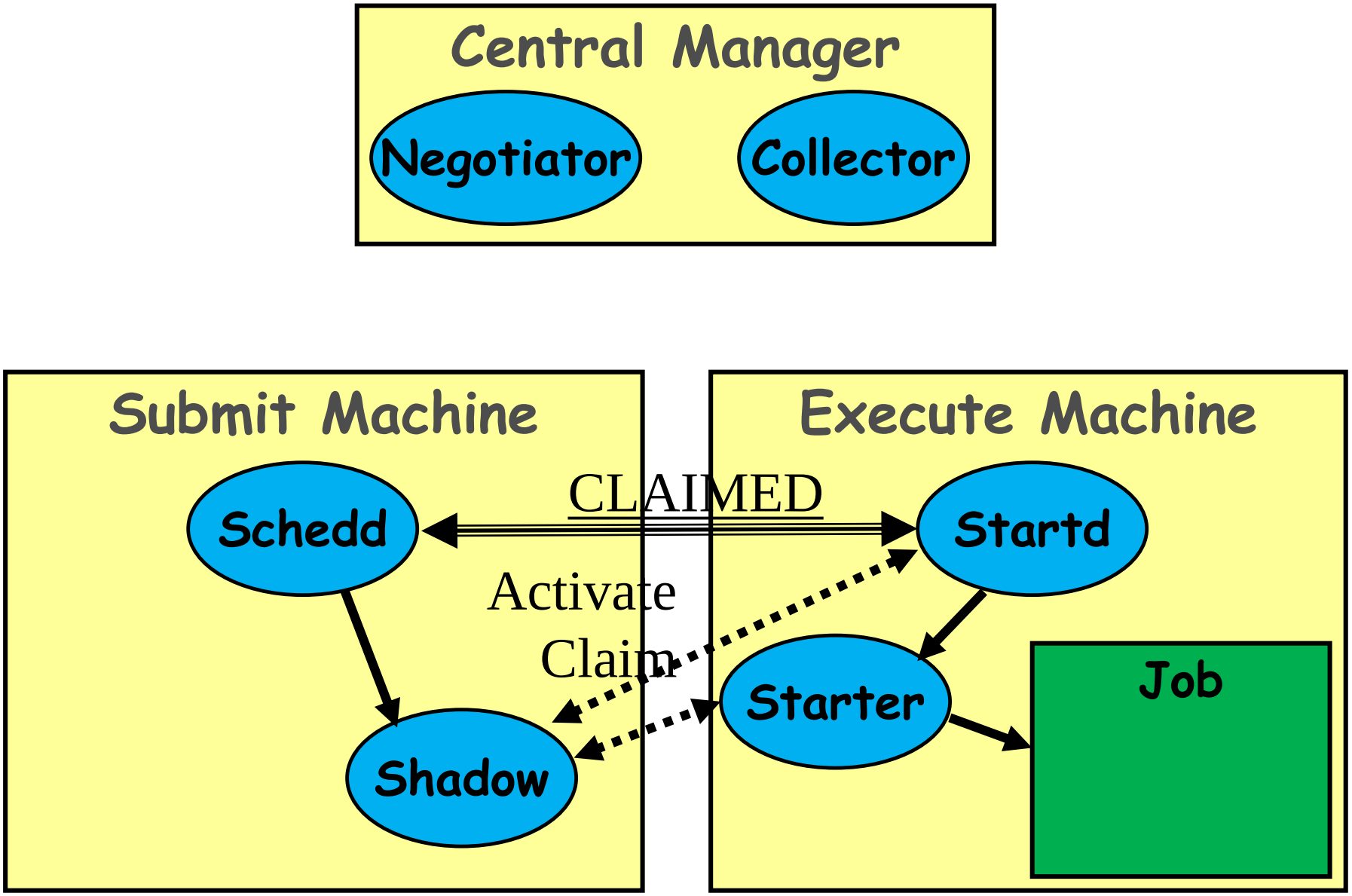
Tools: condor_userprio

Configuration: Accounting groups, concurrency limits (licenses), preemption rules due to priority,…

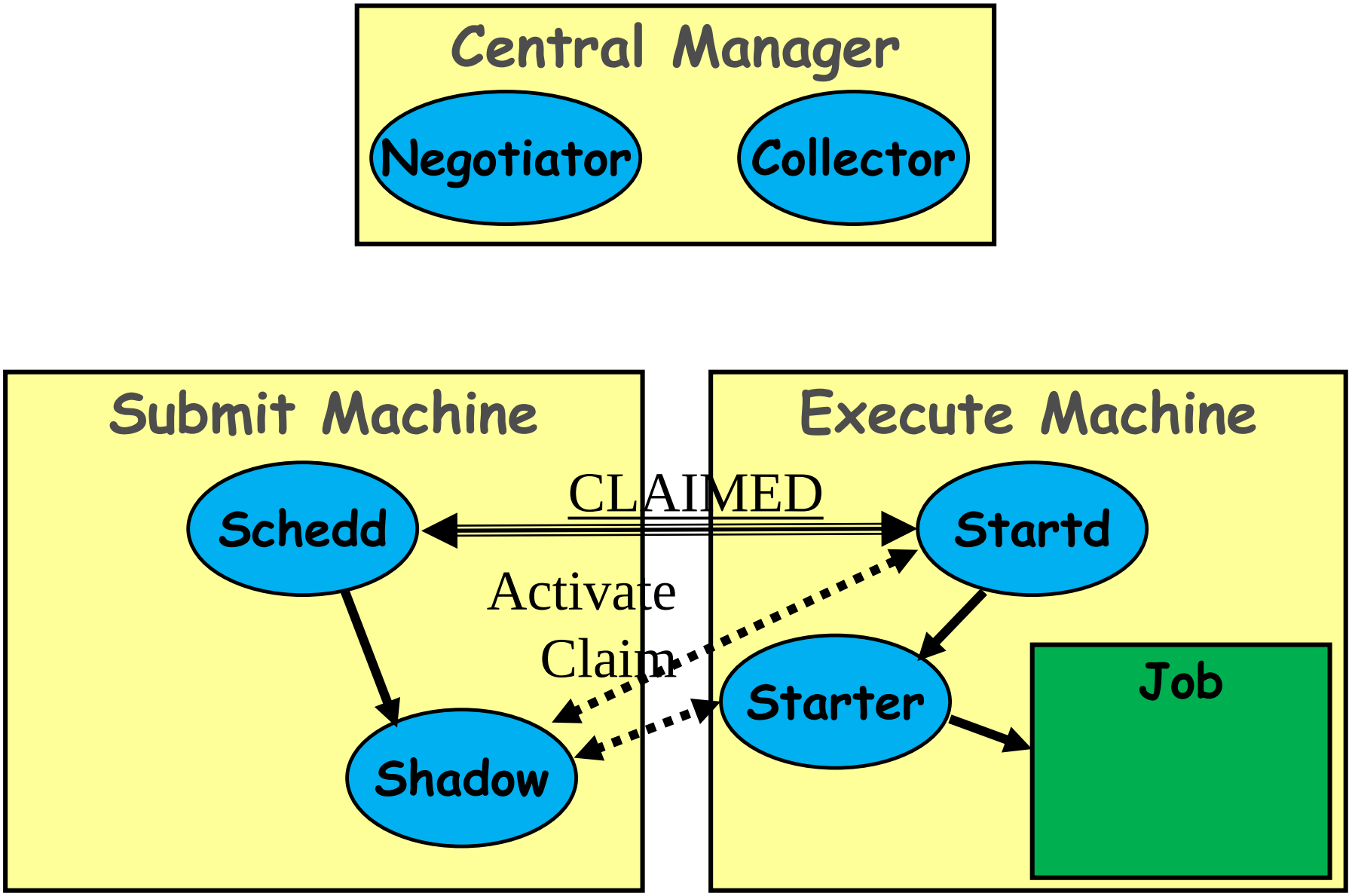
Claiming Protocol



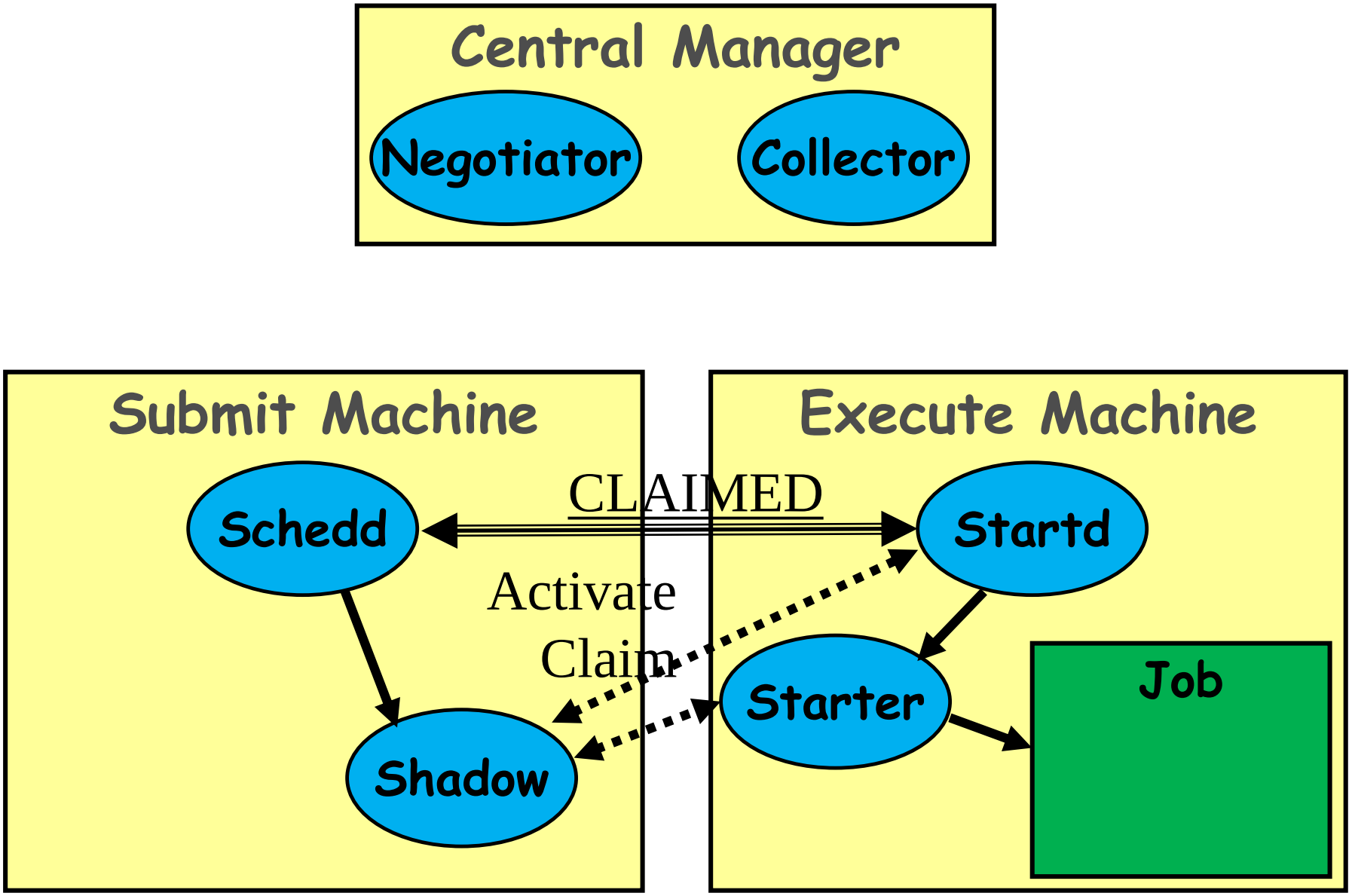
Claim Activation



Repeat until Claim released



Repeat until Claim released



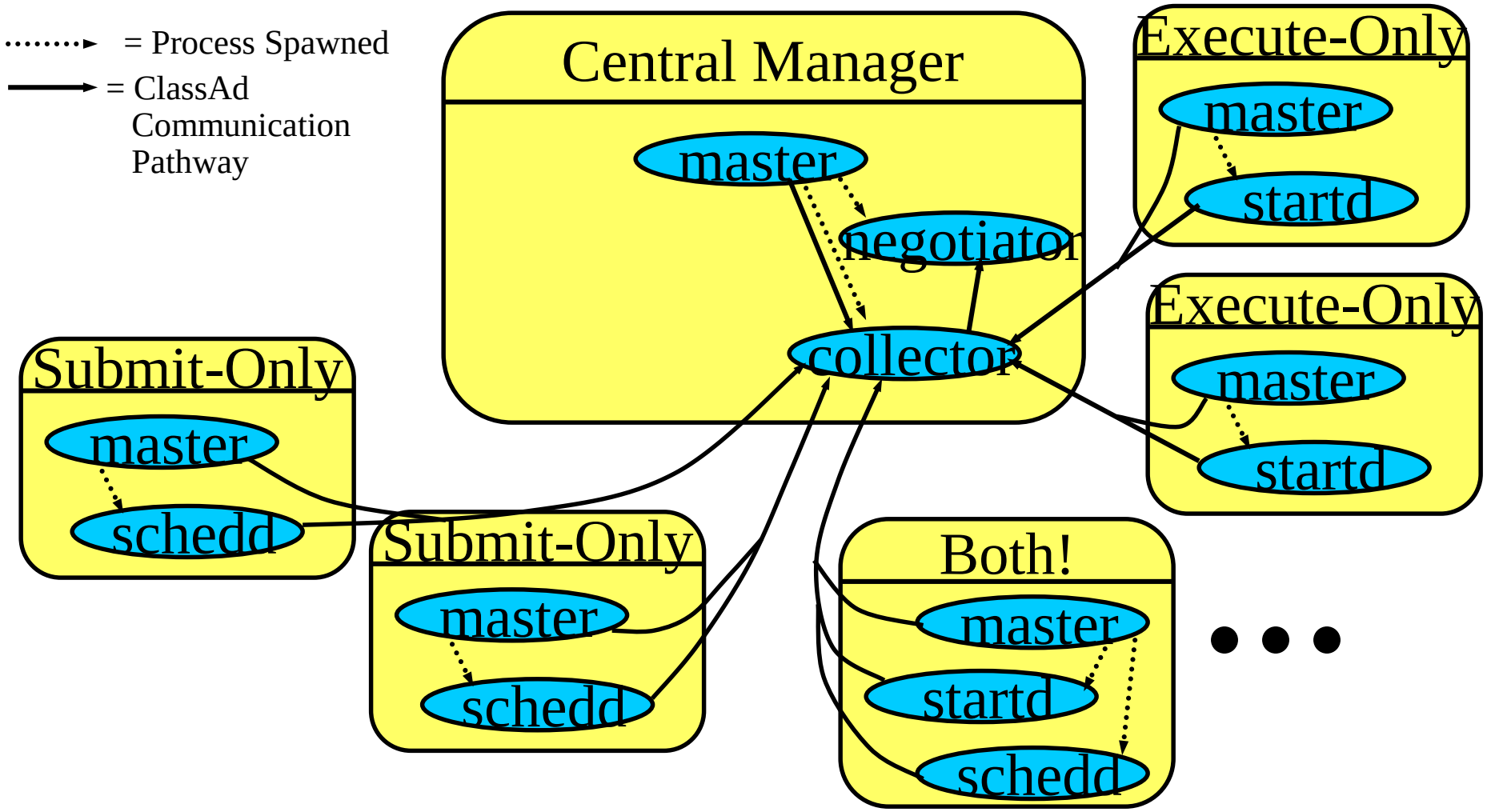
When is claim released?

- When relinquished by one of the following
  - lease on the claim is not renewed
    - Why? Machine powered off, disappeared, etc
  - schedd
    - Why? Out of jobs, shutting down, schedd didn't "like" the machine, etc
  - startd
    - Why? Policy re CLAIM_WORKLIFE, prefers a different match (via Rank), non-dedicated desktop, etc
  - negotiator
    - Why? User priority inversion policy
  - explicitly via a command-line tool
    - E.g. condor_vacate

Architecture items to note

- Machines (startds) or submitters (schedds) can dynamically appear and disappear
  - Key for expanding a pool into clouds or grids
  - Key for backfilling HPC resources
- Scheduling policy can be very flexible (custom attributes) and very distributed
- Central manager just makes a match, then gets out of the way
- Distributed policy enables federation of resources across different organizations (administrative domains)
  - Lots of network arrows on previous slides
  - Reflects the P2P nature of HTCondor

Layout of a General Condor Pool



Thank You!