HTCondor-CE: Basics and Architecture

HTCondor Workshop 2019 - EU Joint Research Centre

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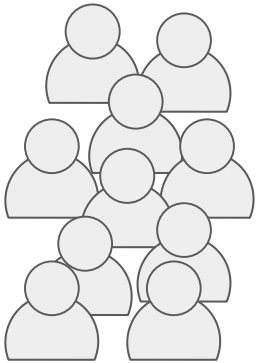
The Pilot Overlay Model

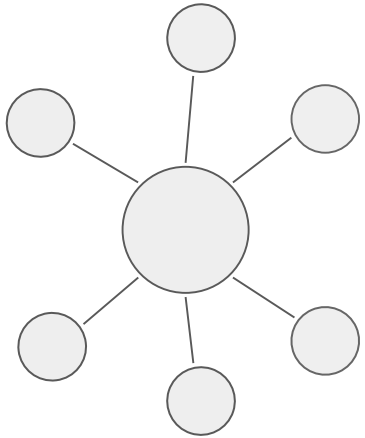


User Submit

Pilot Factory

Compute Element

Local Batch System



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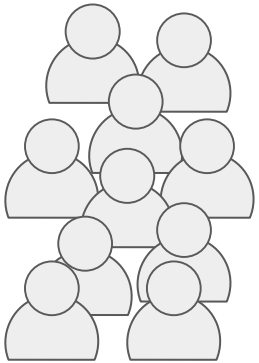

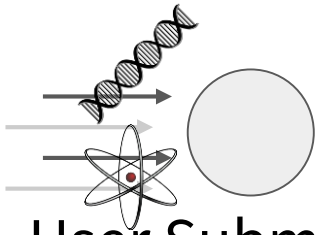

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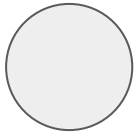
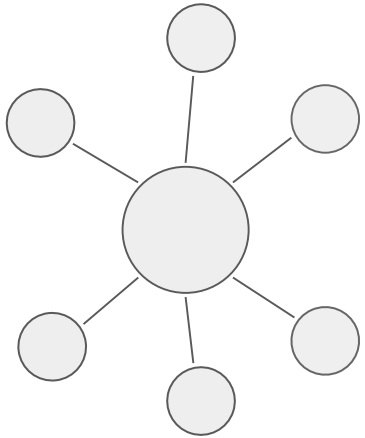
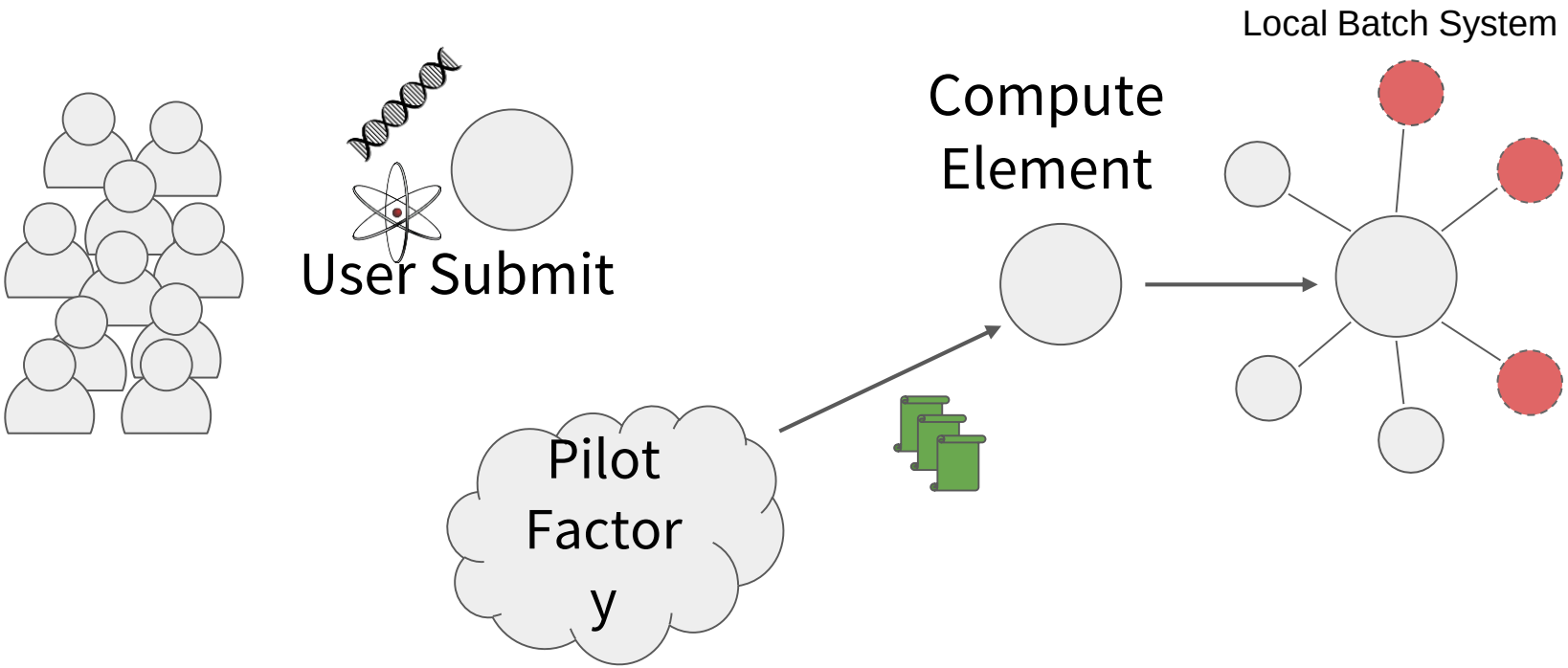


Local Batch System



Pilot Factory

The Pilot Overlay Model



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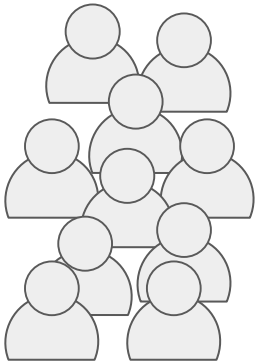

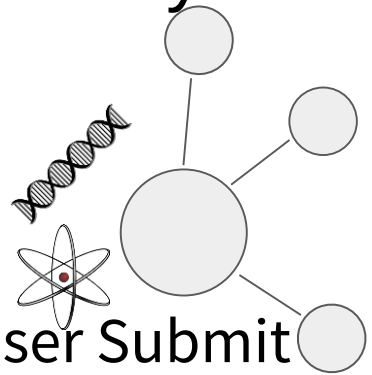

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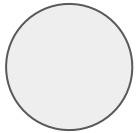
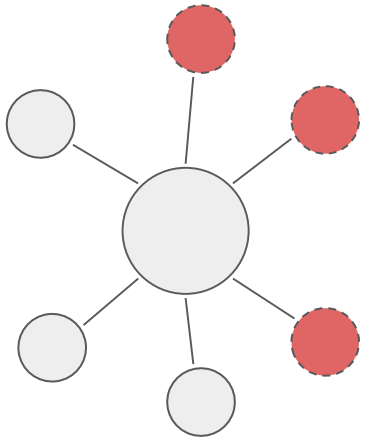


Local Batch System

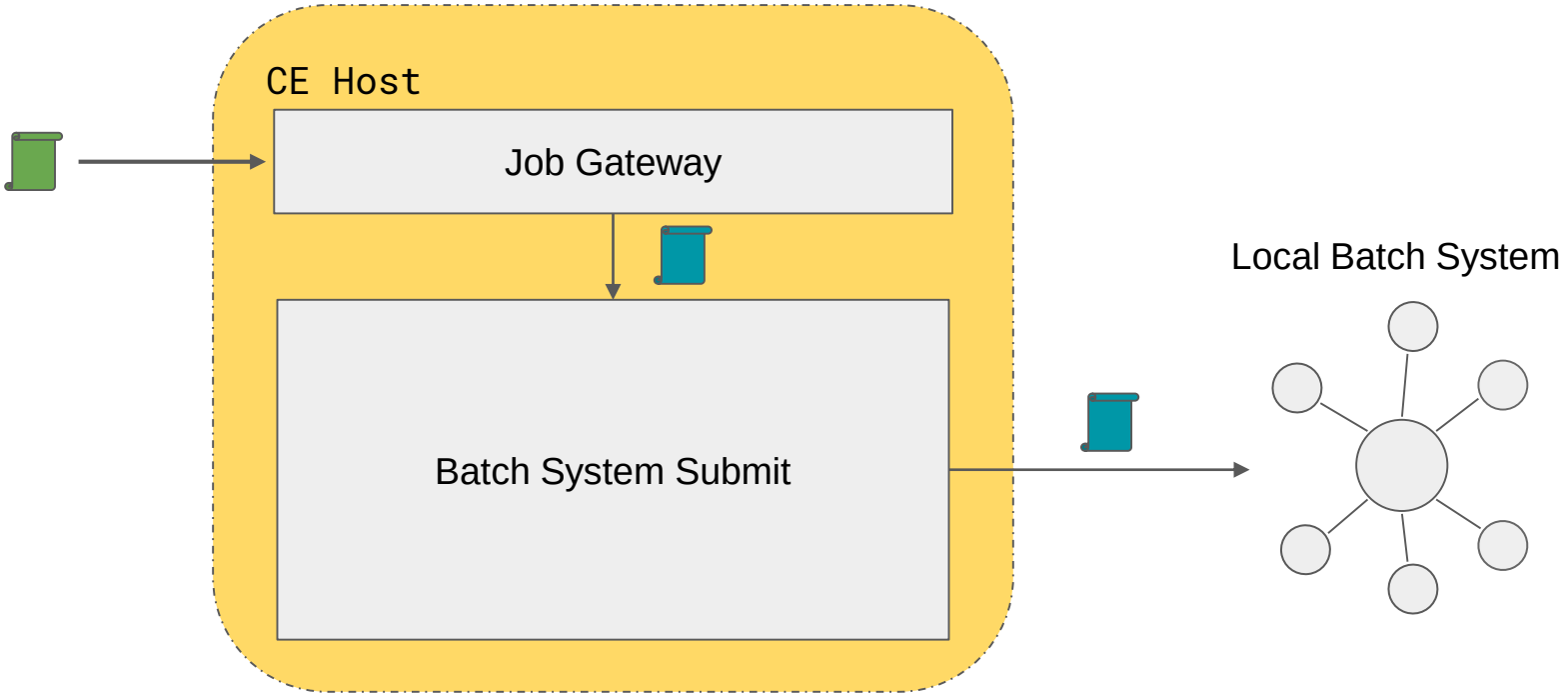


Pilot Factory

What is a CE?

- A compute element (CE) serves as the entry point to your local compute resources
  - Exposes a **remote API** for resource acquisition
  - Provides authentication and **authorization** of remote clients
  - Interacts with the **resource layer** (i.e. batch system)
- A CE is made up of a thin layer of **job gateway** software installed on a host that can submit to and manage jobs on your local batch system
- Designed to support the pilot job overlay model (i.e. resource provisioning requests) and is generally not intended for direct user submission

Compute Element Architecture



HTCondor as a Job Gateway

HTCondor-CE is HTCondor configured as a job gateway

- Same HTCondor binaries, ClassAds, and configuration language to provide the **remote API**
- Relevant tools wrapped to use the HTCondor-CE configuration (e.g., `condor_ce_q`, `condor_ce_status`, etc.)
- Separate `condor-ce` service

HTCondor-CE + HTCondor Batch System

- Two sets of HTCondor daemons
  - Two sets of configuration: `/etc/condor-ce/config.d/` and `/etc/condor/config.d/`
  - Two sets of logs: `/var/log/condor-ce/` and `/var/log/condor/`
- Note the lack of the `condor_negotiator` for the CE set of daemons. HTCondor-CE doesn't manage any worker nodes so it doesn't need to do matchmaking!

```
# pstree
[...]
  ├─condor_master─┬─condor_collector
  │               ├─condor_negotiator
  │               ├─condor_procd
  │               ├─condor_schedd
  │               ├─condor_shared_port
  │               └─condor_startd
  ├─condor_master─┬─condor_collector
  │               ├─condor_job_router
  │               ├─condor_procd
  │               ├─condor_schedd
  │               └─condor_shared_port
  │
[...]
```

HTCondor as a Job Gateway

- By default, provides GSI authentication (authN) and uses HTCondor security for **authorization**
- HTCondor-CE 4 iterates on the default authentication model:
  - GSI authN is still supported but SciTokens is preferred if presented by a client (and you're using a SciTokens-enabled HTCondor binaries)
  - HTCondor-CE daemons authenticate with each other using filesystem (i.e. Unix user) authN instead of GSI!
- Schedd AuditLog is used to record modifications to the job queue
- Payload jobs are also audited if incoming pilots report back to the HTCondor-CE's collector daemon (e.g. GlideinWMS)

HTCondor as a Job Gateway

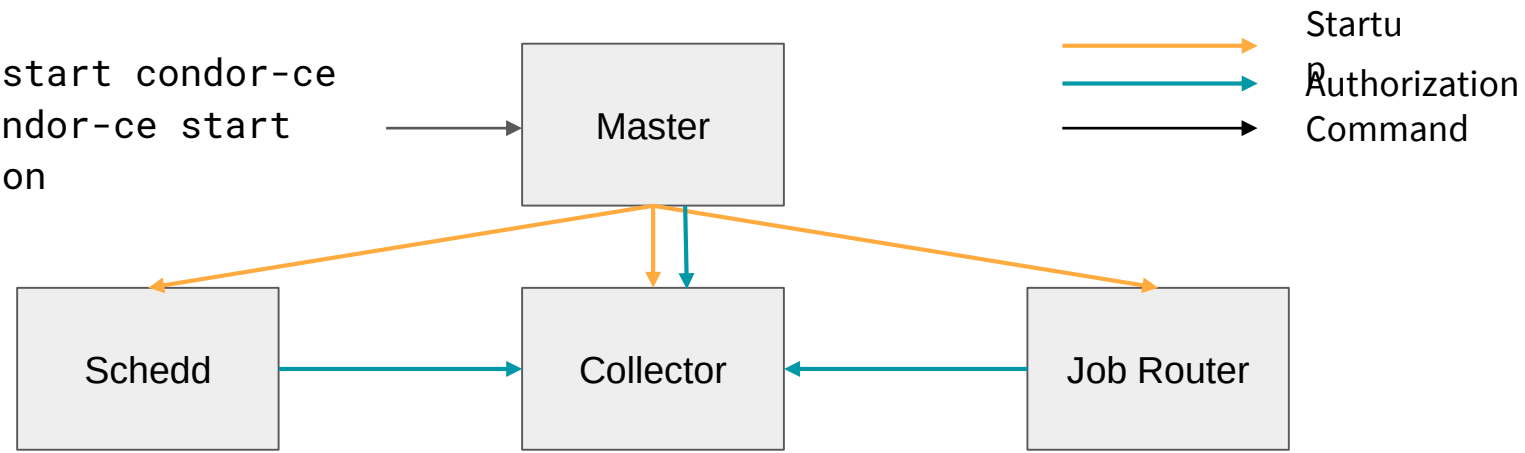
- Supports interaction with the following **resource layers**...
  - HTCondor batch systems directly
  - Slurm, PBS Pro/Torque, SGE, and LSF batch systems
  - Also with all of the above via SSH
- Non-HTCondor batch systems and SSH submission are supported via the HTCondor GridManager daemon and the Batch ASCII Language Helper Protocol (BLAHP)
  - Takes the routed job and further transforms it into your local batch's JDL
  - Specific Job ClassAd attributes result in batch system specific directives, e.g. the `Queue` attribute results in `#SBATCH --partition ...` for Slurm
  - Queries the local batch job to pass along state updates back along the job chain

Job Router Daemon

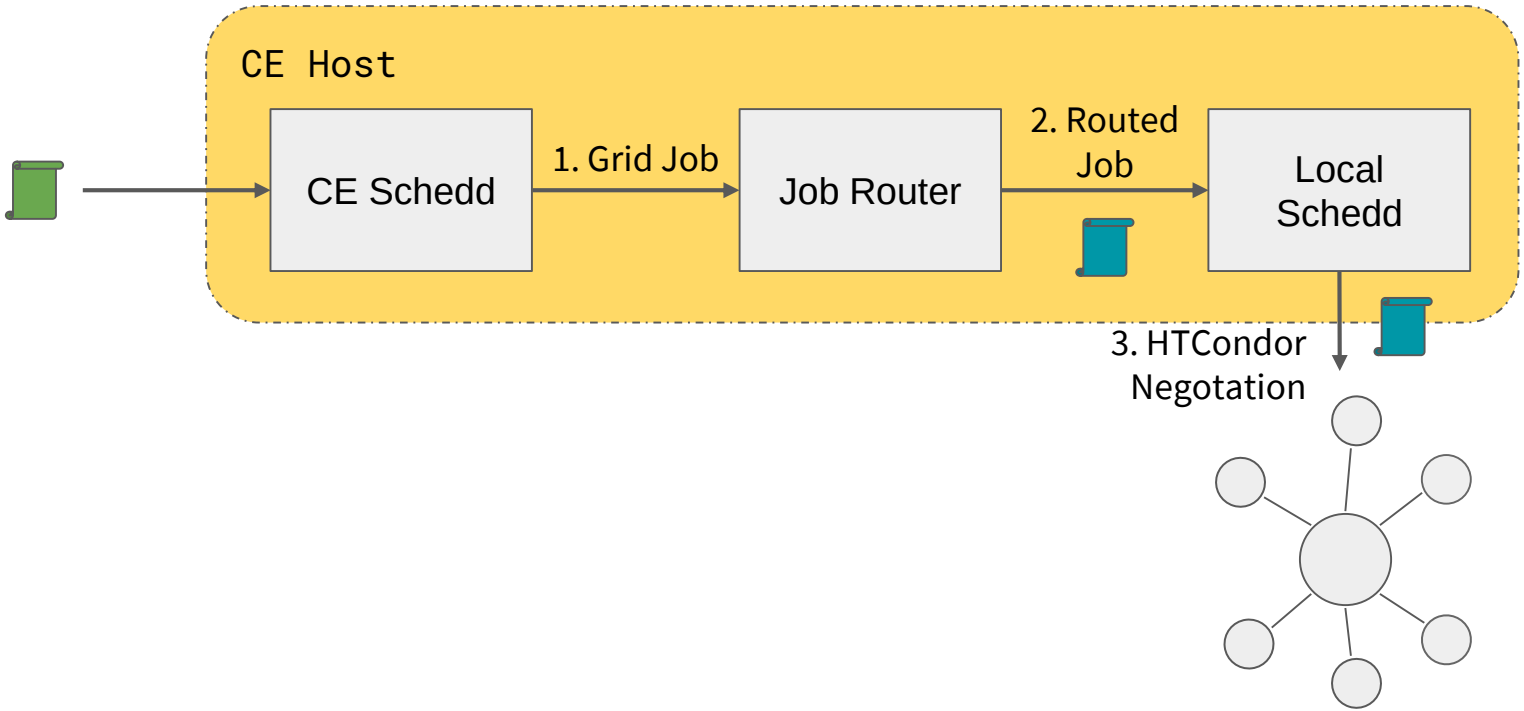
- The Job Router is responsible for taking a job, creating a copy, and changing the copy according to a set of rules
  - When running an HTCondor batch system, the copy is inserted directly into the site batch schedd. Otherwise, the copy is inserted back into the CE schedd
  - Each chain of rules is called a “job route” and is defined by a ClassAd
  - Job routes reflect a site’s policy
- Once the copy has been created, attribute changes and state changes are propagated between the source and destination jobs
- Can be configured to match jobs to routes using round-robin or first-match (the default) strategies

HTCondor-CE Daemons

```
systemctl start condor-ce
service condor-ce start
condor_ce_on
```



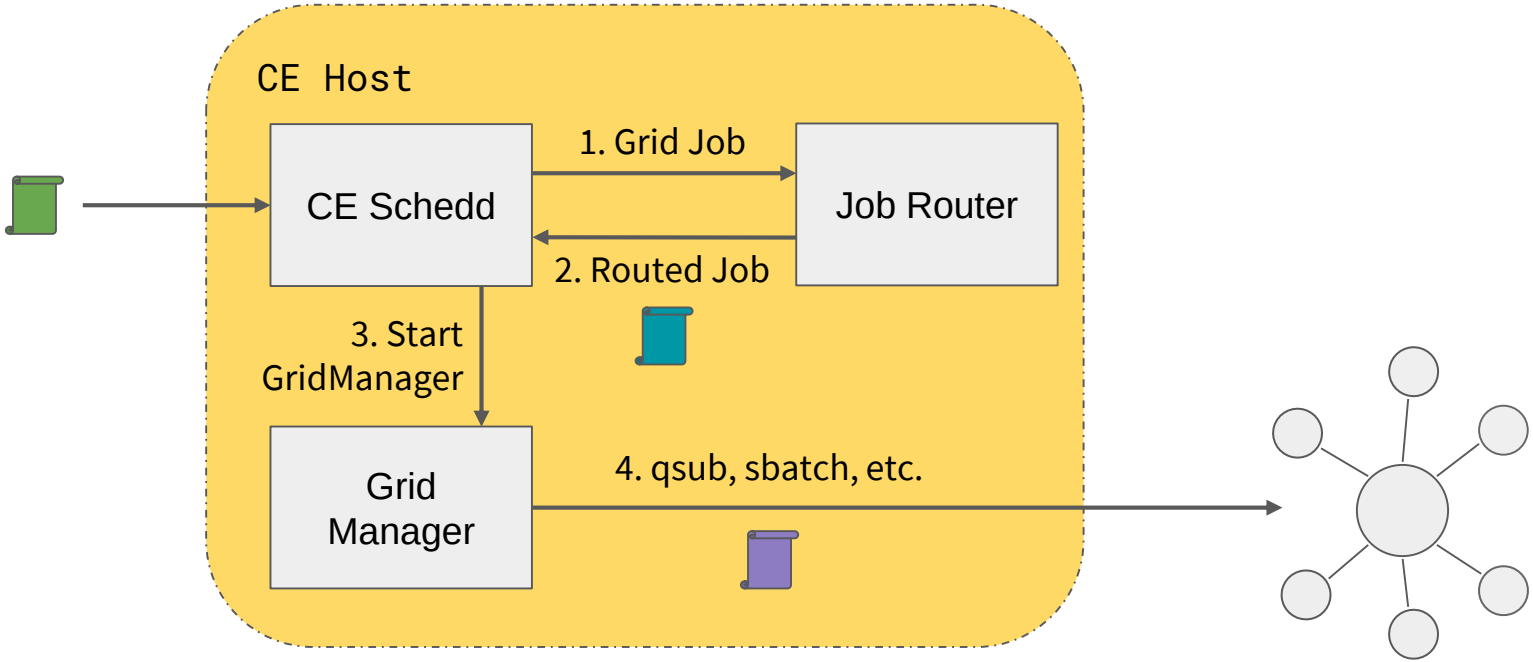
HTCondor-CE + HTCondor Batch System



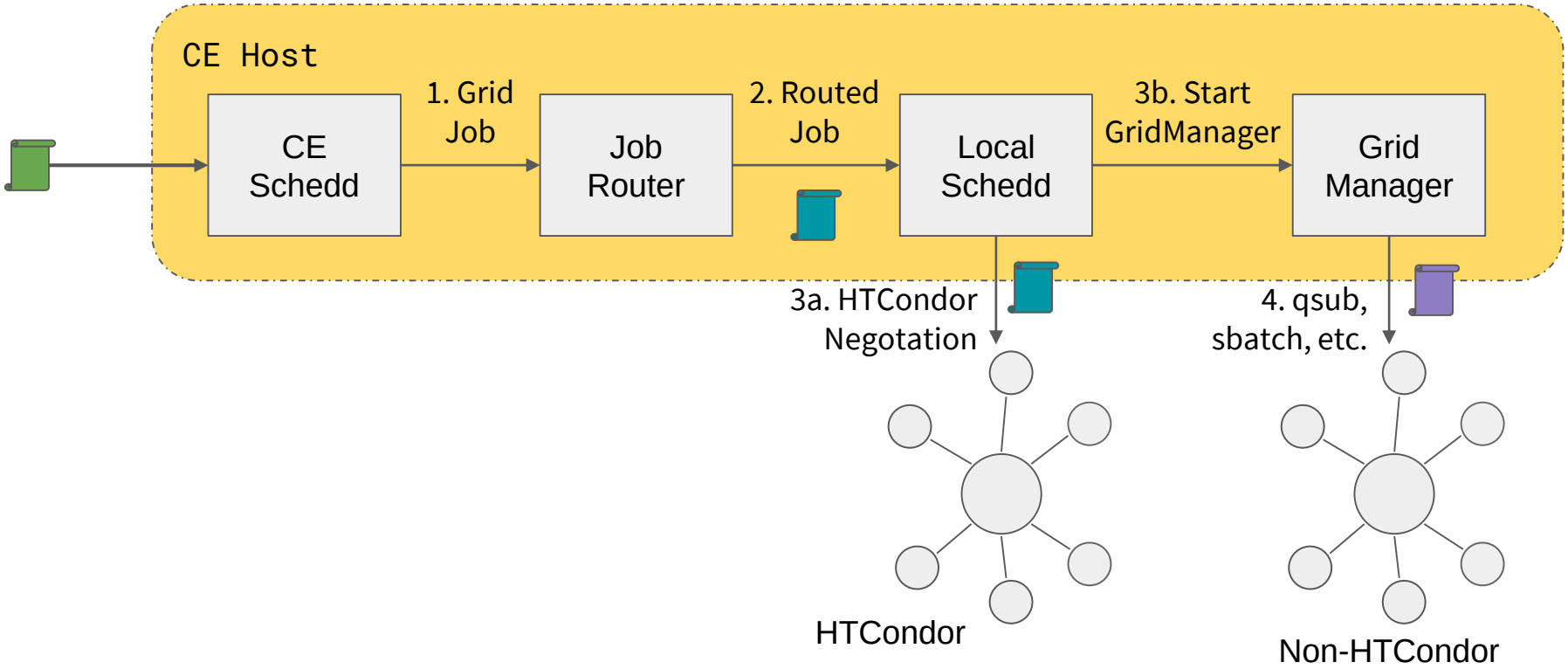
HTCondor-CE + Non-HTCondor Batch System

- Since there is no local batch system schedd, jobs are routed back into the CE schedd as “Grid Universe” jobs
- Grid universe jobs spawn a Gridmanager daemon per user with log files: `/var/log/condor-ce/GridmanagerLog.<user>`
- Requires a shared filesystem across the cluster for pilot job file transfers

HTCondor-CE + Non-HTCondor Batch System



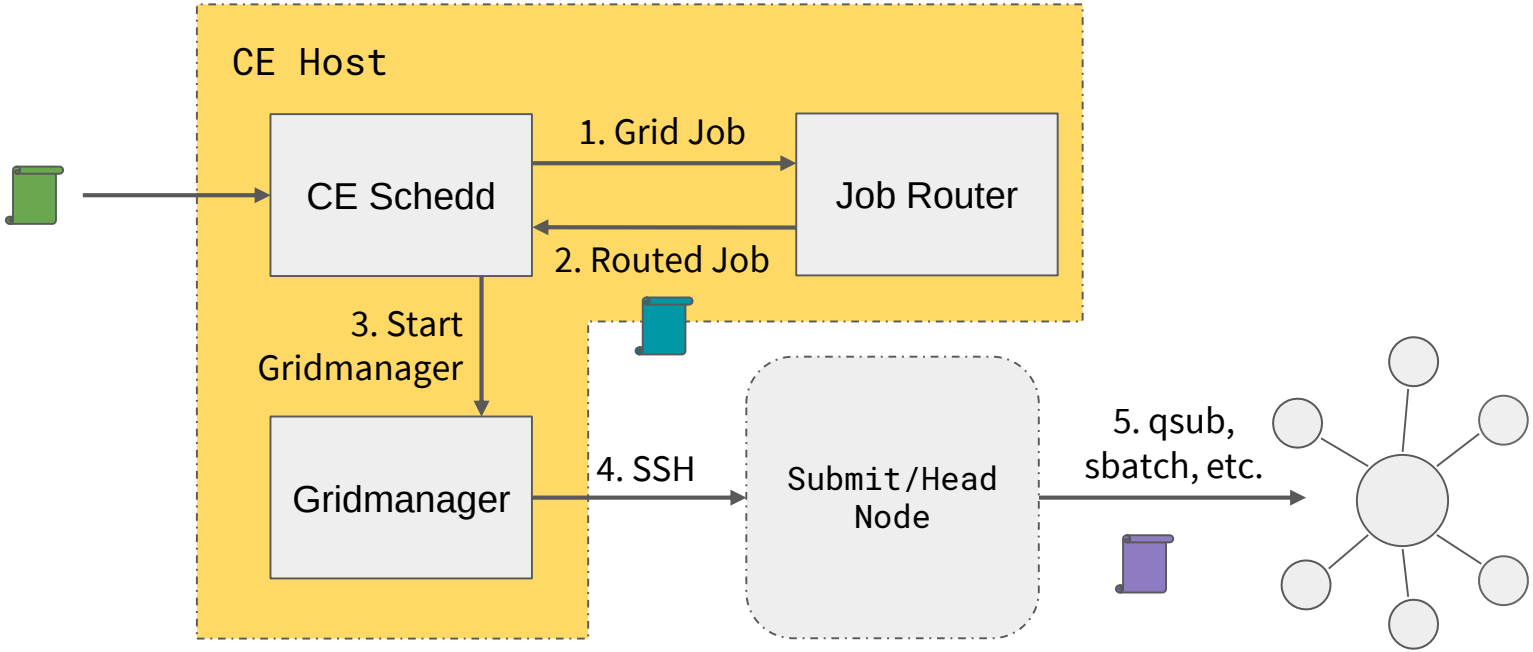
HTCondor-CE + HTCondor + Non-HTCondor



HTCondor-CE + SSH

- Using BOSCO (https://osg-bosco.github.io/docs/), HTCondor-CE can be configured to submit jobs over SSH
  - Requires SSH key-based access to an account on a node that can submit and manage jobs on the local batch system
  - Requires shared home directories across the cluster for pilot job file transfer
- The Open Science Grid (OSG) uses HTCondor-CE over SSH to offer HTCondor-CE as a Service (a.k.a. Hosted CE) for small sites
- Can support up to ~10k jobs concurrently

HTCondor-CE + SSH



HTCondor-CE Requirements

- Open port (TCP) 9619
- Shared filesystem for non-HTCondor batch systems for pilot job file transfer
- CA certificates and CRLs installed in `/etc/grid-security/certificates/`
  VO information installed in `/etc/grid-security/vomsdir/`
- Ensure mapped users exist on the CE (and across the cluster)
- Minimal hardware requirements
  - Handful of cores
  - HTCondor backends should plan on ~½ MB RAM per job
  - Expecting high rates of jobs? HTCondor-CE SPOOL dir should live on an SSD
    Default: `/var/lib/condor-ce/spool` (`condor_ce_config_val -v SPOOL`)
- For example, our Hosted CEs run on 2 vCPUs and 2GB RAM

HTCondor-CE Information Systems

- HTCondor-CE offers a simple information service using the built-in HTCondor View feature to report useful grid information
  - Contact information (hostname/port)
  - Access policy (authorized virtual organizations)
  - What resources can be accessed?
  - Debugging info (site batch system, site name, versions) for humans
- Each HTCondor-CE in a grid can be configured to report information to one or more HTCondor-CE Central Collectors
  - Under the hood, CE Schedd attributes are published to the Central Collector(s)
  - There are still some OSG smells here: tooling and default status output keys off of `OSG_*` attributes

HTCondor-CE Information Systems

```
$ condor_ce_info_status
Name                        CPUs    Memory  MaxWallTime AllowedVOs

OU_OSCER_ATLAS_2650         20       32768           4320 atlas, dosar
OU_OSCER_ATLAS_2670         24       65536           4320 atlas, dosar
R510                        8        24576           1440 osg, cms
R730xd                      12       32768           1440 osg, cms
OUHEP_ITB_1                 4        6144            1440 atlas, dosar
CancerComputer_MinneUE      12       24576           1440 osg, sbgrid, mis
USCMS-FNAL-WC1              8        16384           2850 "cms"
AGLT2-Dell1                 8        16000           4300 atlas
AGLT2-Dell2                 8        16000           4300 atlas
[...]
```

HTCondor-CE Information Systems

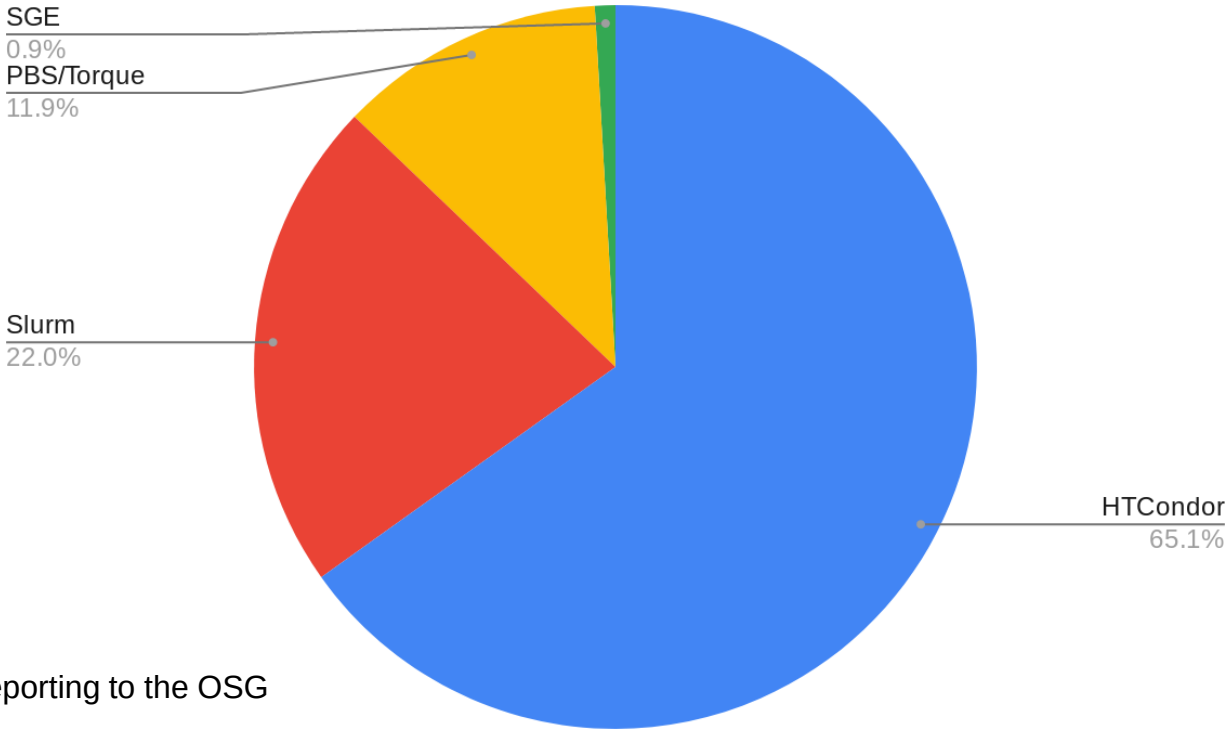
```
$ condor_status -schedd -pool collector.opensciencegrid.org:9619
Name                                    Machine                                 RunningJobs   IdleJobs   HeldJobs

CE01.CMSAF.MIT.EDU                      CE01.CMSAF.MIT.EDU                            412          7          6
CE02.CMSAF.MIT.EDU                      CE02.CMSAF.MIT.EDU                            669          1          0
CE03.CMSAF.MIT.EDU                      CE03.CMSAF.MIT.EDU                           1532          7          0
atlas-ce.bu.edu                         atlas-ce.bu.edu                              2568       1627
            27
bgk01.sdcc.bnl.gov                      bgk01.sdcc.bnl.gov                              5          2          0
bonner06.rice.edu                       bonner06.rice.edu                               7          1          8
brown-osg.rcac.purdue.edu               brown-osg.rcac.purdue.edu                       2          8          0
ce01.brazos.tamu.edu                    ce01.brazos.tamu.edu                            2          1          4
ce01.ific.uv.es                         ce01.ific.uv.es                              1012        265          0
ce1-vanderbilt.sites.opensciencegrid.org ce1-vanderbilt.sites.opensciencegrid.org      310        194          4
ce2-vanderbilt.sites.opensciencegrid.org ce2-vanderbilt.sites.opensciencegrid.org     1162        357          0
cit-gatekeeper.ultralight.org           cit-gatekeeper.ultralight.org                  76         33          2
cit-gatekeeper2.ultralight.org          cit-gatekeeper2.ultralight.org                 96         32          8
cit-gatekeeper3.ultralight.org          cit-gatekeeper3.ultralight.org                 98         34          3
[...]
```

HTCondor-CE Information Systems

```
$ condor_status -schedd -pool collector.opensciencegrid.org:9619 -json
[
{
  "AddressV1": "{[ p=\"primary\"; a=\"18.12.1.31\"; port=9619; n=\"Internet\"; spid=\"323298_41ac_3\"; noUDP=true; ], [
p=\"IPv4\"; a=\"18.12.1.31\"; port=9619; n=\"Internet\"; spid=\"323298_41ac_3\"; noUDP=true; ]}",
  "AuthenticatedIdentity": "ce01.cmsaf.mit.edu@daemon.opensciencegrid.org",
  "AuthenticationMethod": "GSI",
  "Autoclusters": 0,
  "CollectorHost": "CE01.CMSAF.MIT.EDU:9619",
  "CondorPlatform": "$CondorPlatform: X86_64-CentOS_7.5 $",
  "CondorVersion": "$CondorVersion: 8.6.13 Oct 30 2018 $",
  "CurbMatchmaking": false,
  "DaemonCoreDutyCycle": 0.04549036158372677,
  "DaemonStartTime": 1569321031,
  "DetectedCpus": 16,
  "DetectedMemory": 24094,
  "FileTransferDownloadBytes": 0.0,
[...]
```

HTCondor-CE Information Systems



Data from 109 CEs reporting to the OSG Central Collector

Why Use HTCondor-CE

- If you are using HTCondor for batch:
  - One less software provider - same thing all the way down the stack.
  - HTCondor has an extensive feature set - easy to take advantage of it (i.e., Docker universe).
- Regardless, a few advantages:
  - Can scale well (up to at least 16k jobs; maybe higher).
  - Declarative ClassAd-based language.
- But disadvantages exist:
  - Non-HTCondor backends are finicky outside PBS and Slurm.
  - Declarative ClassAd-based language.

Getting Started with HTCondor-CE

- Available as RPMs via HTCondor (and OSG) Yum repositories
- Start installation with documentation available via htcondor-ce.org