Fermilab

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GlideinWMS Improvements and Challenges

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Throughput Computing Week 2026

U.S. DEPARTMENT of ENERGY

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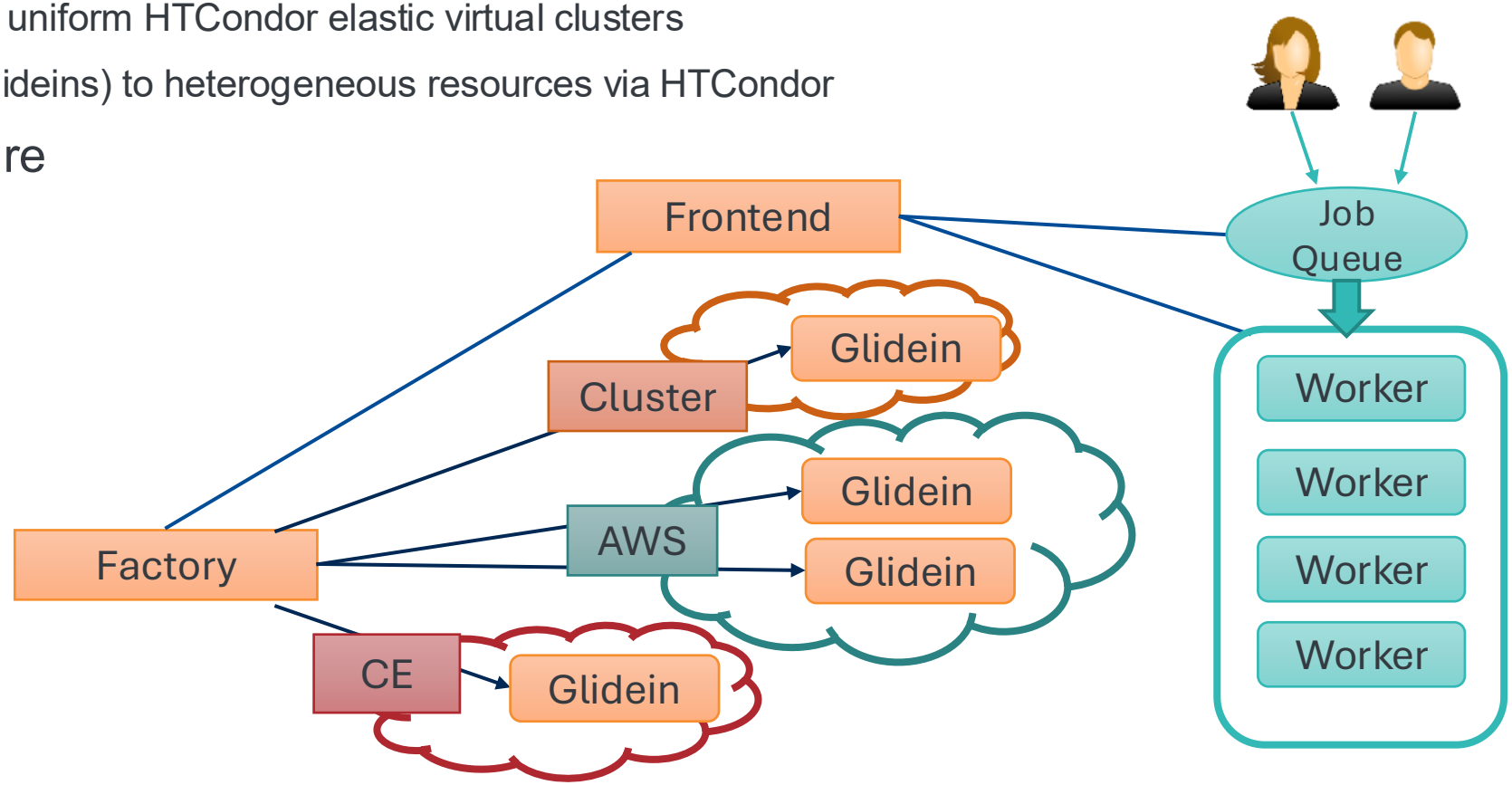
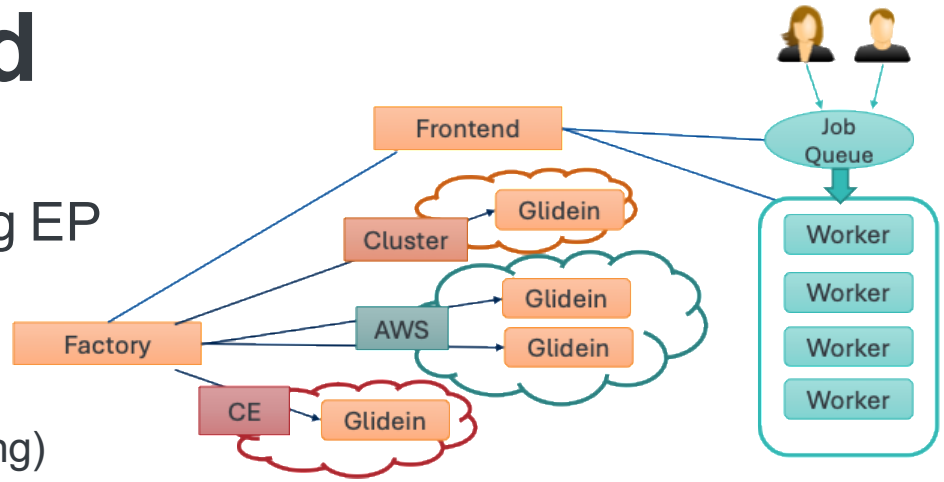
Glidein Workload Management System

- GlideinWMS is a pilot-based resource provisioning tool for distributed High Throughput Computing and leveraging heavily HTCondor:
  - Provides reliable and uniform HTCondor elastic virtual clusters
  - Submits pilot jobs (Glideins) to heterogeneous resources via HTCondor
- Distributed architecture
  - Glidein
  - Factory
  - Frontend

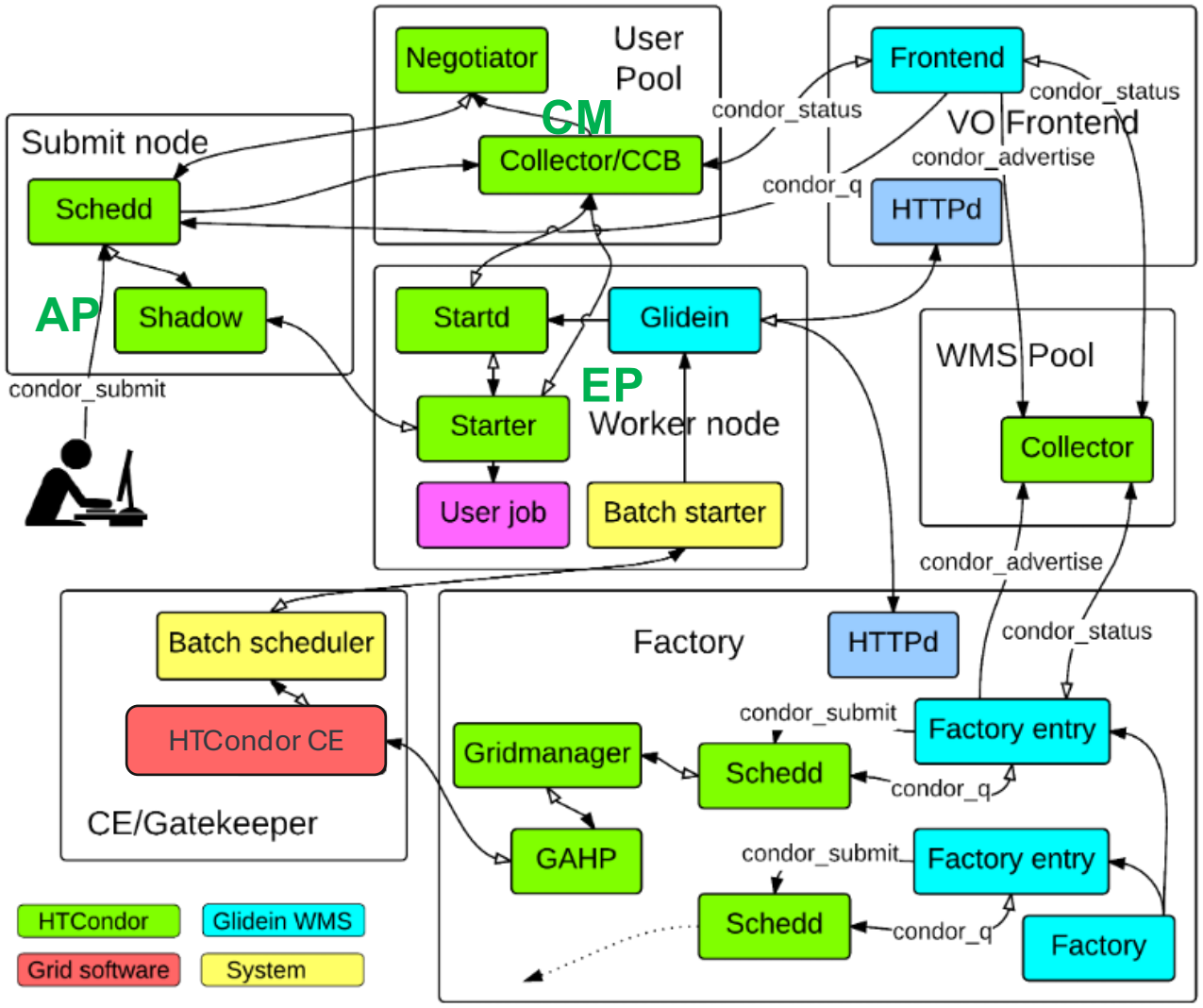


Glidein, Factory and Frontend



- Glidein (Pilot): node testing and customization, starting EP
  - Scouts for resources and validates the Worker node
  - Customizes the Worker node
  - Can manage/partition the Worker Node (space and time sharing)
  - Provides a reliable and customized Execution Point to an HTCondor Pool
- Factory: Glidein submission
  - A Glidein Factory knows how to submit to sites
  - Site entries described in the configuration (static or auto-generated)
  - HTCondor does the heavy lifting of submissions: to local and remote clusters, CEs, hosted CEs, clouds, and HPC resources
- Frontend: resource provisioning decisions
  - Monitors jobs to see how many Glideins are needed for all managed pools
  - Requests Glideins submission/removal from the Factory depending on jobs needs and available resources
  - Pressure-based system
  - Manages credentials and delegates them to the Factory and Glidein

Zoom-in on HTCondor components



Contained operation effort

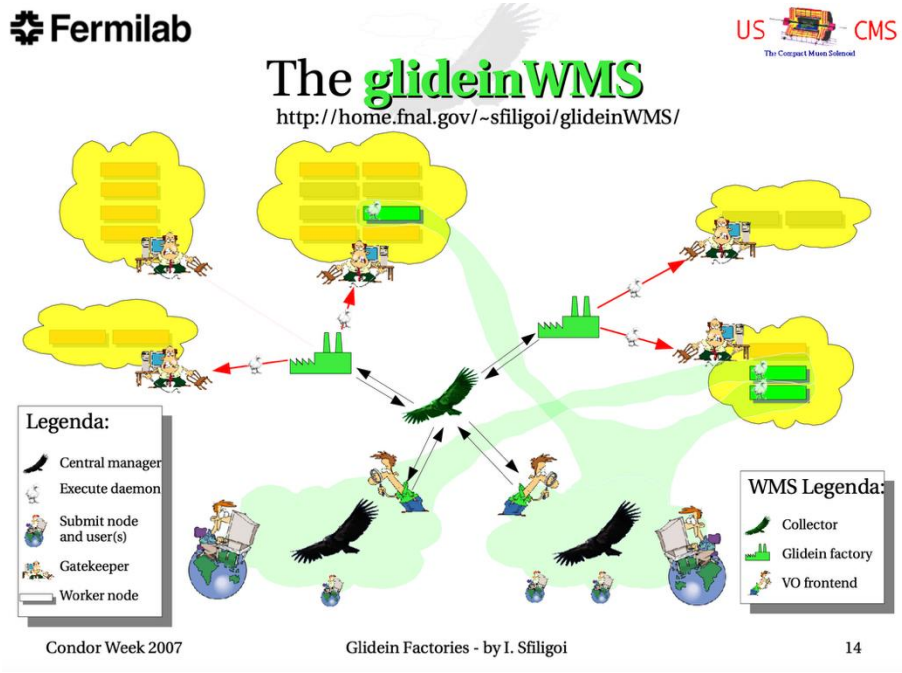
- Big VO operation (Shared Factories and CMS resources)
  - About 2.5 FTE
  - Most of it to develop monitoring and improve the system
- VO operation (Frontend and one Pool)
  - About 0.1 FTE
  - Most of that is monitoring and checking on sites

Evolved with HTCondor and Python

Thanks for the support!

- Almost 20 years old (October 2006).
  - CDF Analysis Facility using Glideins (2005)
  - Used for CMS analysis and production, later FIFE and DUNE
  - RPM package, later also container

Thanks to VDT and OSG!



- v2 and v3 (2009-12) monitoring, Python logging and new Factory API
- v3.5 (2019) Factory using a single user (no more condor switchboard)
- v3.7/v3.7.1 (2020) Token demonstrator
  - HTCondor token-auth->IDTOKENS+SciTokens
- v3.9/v3.9.3 (2020) Python 3

https://research.cs.wisc.edu/htcondor/CondorWeek2007/presentations/igor_GlideinFactories_final.pdf

Current/next steps

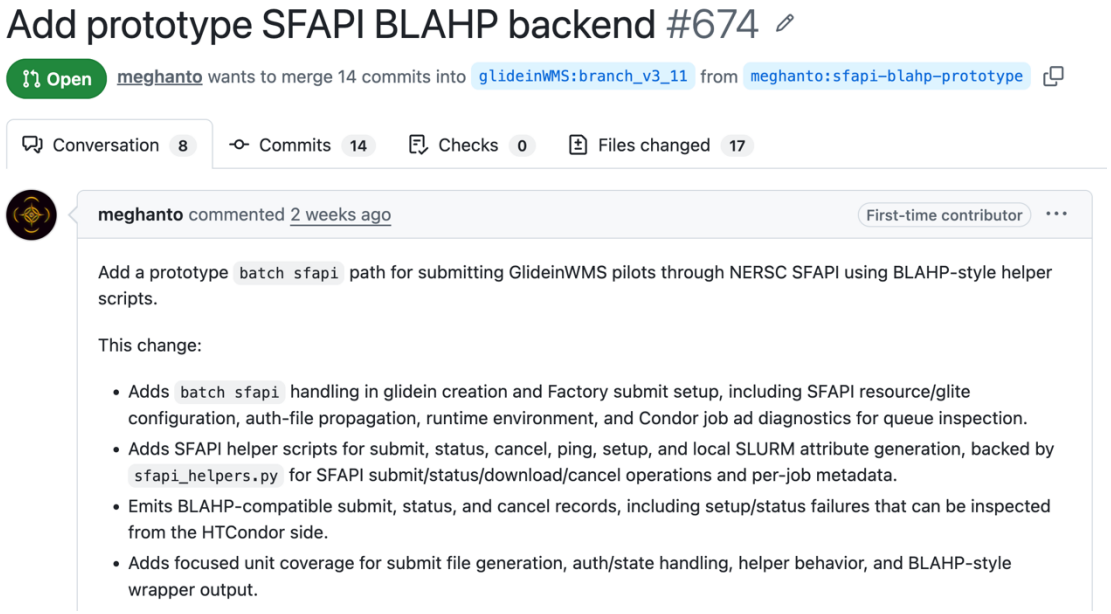
- v3.11 (2025) New credentials model and generators
- v3.11.5 (2026) On-demand CVMFS provisioning
- v3.11.6 (2026) condor_ssh_to_job in containers
- v3.11.6 (2026) Support for more HPC resources

Glidein Submission via HTCondor

- 2006 HTCondor Pool (vanilla universe)
- 2006 Grid (HTCondor-G/GRAM CE gt2, then gt5 - grid universe, gt2/gt5) up to HTC 9.x
- 2006-16 Batch systems (grid universe, batch (pbs, lsf, sge, or slurm)
- 2009-21 NorduGrid ARC CE, then v1 and finally REST (grid universe, arc)
- 2014-16 AWS, OpenStack/OpenNebula (grid universe, ec2)
- 2014 Remote cluster, aka BOSCO (ssh bridge - grid universe, batch and remote_cluster)
- 2015 HTCondor-CE/HTCondor-C (grid universe, condor)
- 2016 GCE (grid universe, gce)
- 2019 Azure (grid universe, azure)
- 2019 Split-starter and Lumberjack for no network HPC (only prototypes, no production)
- 2026? More HPC sites
  - NERSC Superfacility API
  - Integrated Research Infrastructure (IRI) API
  - Globus Compute

SuperFacility API support

- Used already for monitoring allocations, need to start using it for job management
- Code under development by Meghanto Majumder
- Thanks to the Pegasus team for sharing documentation and reference implementation
  - https://pegasus.isi.edu/docs/5.1.3-dev.0/user-guide/deployment-scenarios.html#nersc-perlmutter-via-sfapi
  - https://pegasus.isi.edu/docs/5.1.3-dev.0/reference-guide/nersc-sfapi-submission.html
- Test from development machines at Fermilab to Perlmutter at NERSC



Add prototype SFAPI BLAHP backend #674

Open meghanto wants to merge 14 commits into glideinWMS:branch_v3_11 from meghanto:sfapi-blahp-prototype

Conversation 8 Commits 14 Checks 0 Files changed 17

meghanto commented 2 weeks ago First-time contributor

Add a prototype `batch sfapi` path for submitting GlideinWMS pilots through NERSC SFAPI using BLAHP-style helper scripts.

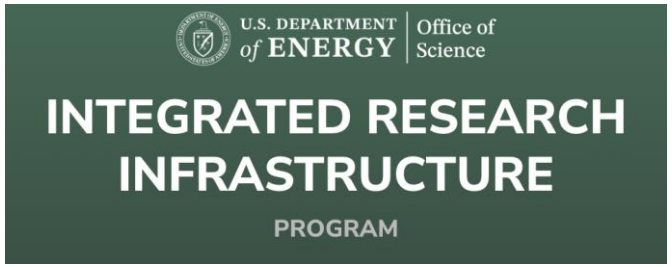
This change:

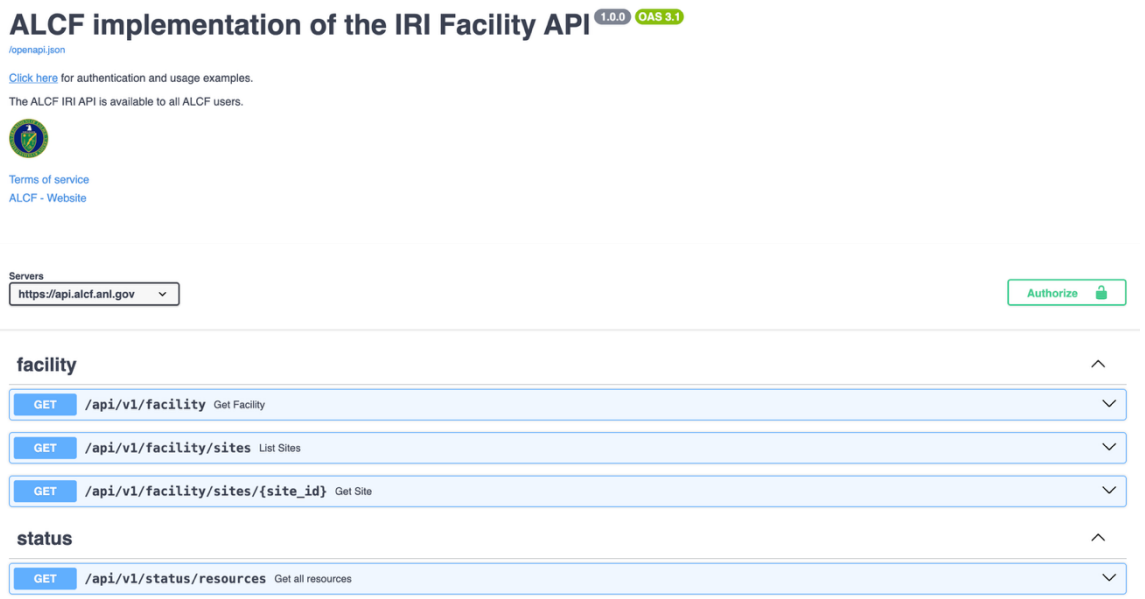
- Adds `batch sfapi` handling in glidein creation and Factory submit setup, including SFAPI resource/glite configuration, auth-file propagation, runtime environment, and Condor job ad diagnostics for queue inspection.
- Adds SFAPI helper scripts for submit, status, cancel, ping, setup, and local SLURM attribute generation, backed by `sfapi_helpers.py` for SFAPI submit/status/download/cancel operations and per-job metadata.
- Emits BLAHP-compatible submit, status, and cancel records, including setup/status failures that can be inspected from the HTCondor side.
- Adds focused unit coverage for submit file generation, auth/state handling, helper behavior, and BLAHP-style wrapper output.

```
Name                                    OpSys     Arch    State     Activity LoadAv Mem   ActivityTime

slot1@glidein_1709526_362407216@x1306c7s6b0n1h0.chn.perlmutter.nersc.gov LINUX     X86_64  Unclaimed Idle      0.000 515140  0+00:00:00

                     Total Owner Claimed Unclaimed Matched Preempting  Drain Backfill BkIdle

X86_64/LINUX     1     0     0         1       0          0     0        0      0

       Total     1     0     0         1       0          0     0        0      0
```

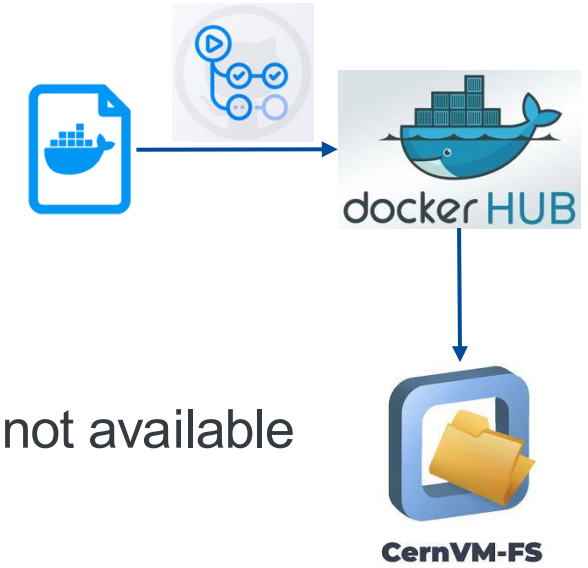
Integrated Research Infrastructure (IRI) API

- Common API to submit and monitor ASCR facilities (ALCF, OLCF, NERSC)
- https://github.com/doe-iri/iri-facility-api-python
- Planning to run some tests at least at NERSC
  - Using ALCF will add connectivity problems
- Long term ask is for HTCondor to support the IRI API





On-demand CVMFS provisioning



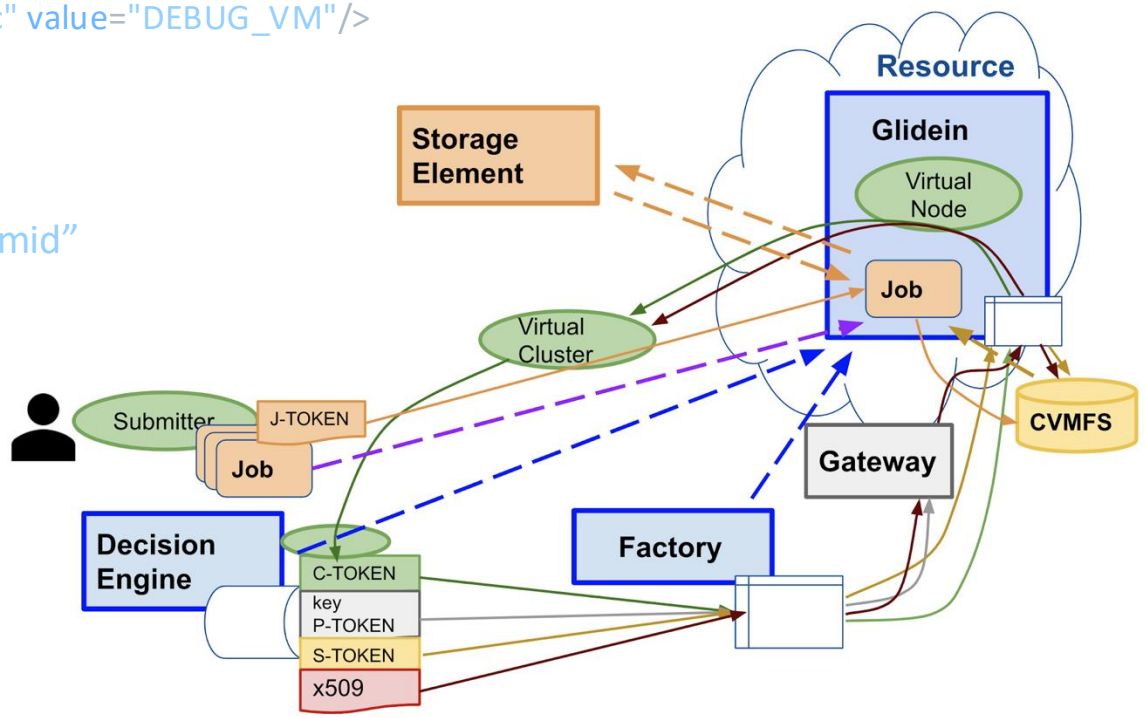
- VOs specify CVMFS requirements
- Resources may have CVMFS available
- cvmfsexec used to provision CVMFS on-demand when required and not available
  - Different cvmfsexec options used depending on OS and capabilities
    - cvmfsexec (mode 2 and 3)
    - mountrepo/umountrepo (mode 1) – nonstandard mountpoint
  - System and VO-defined list of repositories
- Apptainer allows to bind the repositories on the well-known /cvmfs mount point

New credentials and generators (v3.11)

- Multiple credentials and parameters
  - Frontend:

```
<credentials>
        <credential absfname="/opt/gwms/credentials/pilot.scitoken" purpose="request"
                    security_class="frontend" trust_domain="grid" type="scitoken"/>
        <credential absfname="dynamic_credential.py" purpose="payload"
                    security_class="frontend" trust_domain="grid" type="generator"/>
</credentials>
<parameters>
        <parameter name="ProjectId" type="generator" value="dynamic_parameter.py"/>
        <parameter name="VMId" type="static" value="DEBUG_VM"/>
</parameters>
```

  - Factory: auth_method="scitoken,grid_proxy;projectid;vmid"



Easier configuration with generators - old

Project ID is “allocation1” for SiteA, “allocation2” for SiteB, not needed otherwise

```
<security …
 <credentials />
</security>
<group name="main" enabled="True">
 <config ignore_down_entries="True" ramp_up_attenuation="3">
 …
 </config>
 <match match_expr="True" start_expr="True" policy_file="/path/to/python-policy-file">
  <factory query_expr="(GLIDEIN_Site!="SiteA) && (GLIDEIN_Site!="SiteB)” >
   <match_attrs />
   <collectors />
  </factory>
  <job query_expr="True">
   <match_attrs />
   <schedds />
  </job>
 </match>
 <security>
  <credentials>
   <credential absfname="/etc/osg/tokens/my_token.scitoken" security_class="frontend"
     trust_domain="OSG" type="scitoken"    />
  </credentials>
 </security>
 <attrs />
 <files />
</group>
```

```
<group name="group1" enabled="True"> …
<match match_expr="True" start_expr="True" policy_file="/path/to/python-policy-file">
  <factory query_expr="(GLIDEIN_Site=="SiteA)”>
   <match_attrs />
   <collectors />
  </factory>
  <job … />
</match>
 <security>
  <credentials>
   <credential absfname="/etc/osg/tokens/my_token.scitoken" security_class="frontend"
     trust_domain="OSG" type="scitoken" project_id="allocation1" />
  </credentials>
 </security> …
</group>
<group name="group2" enabled="True"> …
<match match_expr="True" start_expr="True" policy_file="/path/to/python-policy-file">
  <factory query_expr="(GLIDEIN_Site=="SiteB")">
   <match_attrs />
   <collectors />
  </factory>
  <job … />
</match>
 <security>
  <credentials>
   <credential absfname="/etc/osg/tokens/my_token.scitoken" security_class="frontend"
     trust_domain="OSG" type="scitoken" project_id="allocation2" />
  </credentials>
 </security> …
</group>
```

Easier configuration with generators - new

Project ID is “allocation1” for SiteA, “allocation2” for SiteB, not needed otherwise

```
<security …
 <credentials>
    <credential absfname="/etc/osg/tokens/my_token.scitoken" security_class="frontend" trust_domain="OSG" type="scitoken" />
 </credentials>
 <parameters>
  <parameter name="ProjectId" type="generator" value="EntryConditionGenerator”
                        context=“{‘discriminator’=‘name’, dict={‘SiteA’:’allocation1’, ‘SiteB’:’allocation2’}, default=‘’} />
 </parameters>
</security> …
<group name="main" enabled="True">
 <config ignore_down_entries="True" ramp_up_attenuation="3">
 …
 </config>
 <match match_expr="True" start_expr="True" policy_file="/path/to/python-policy-file">
  <factory query_expr=”True">
   <match_attrs />
   <collectors />
  </factory>
  <job query_expr="True">
   <match_attrs />
   <schedds />
  </job>
 </match>
 <security>
  <credentials/>
 </security>
 <attrs />
 <files />
</group>
```

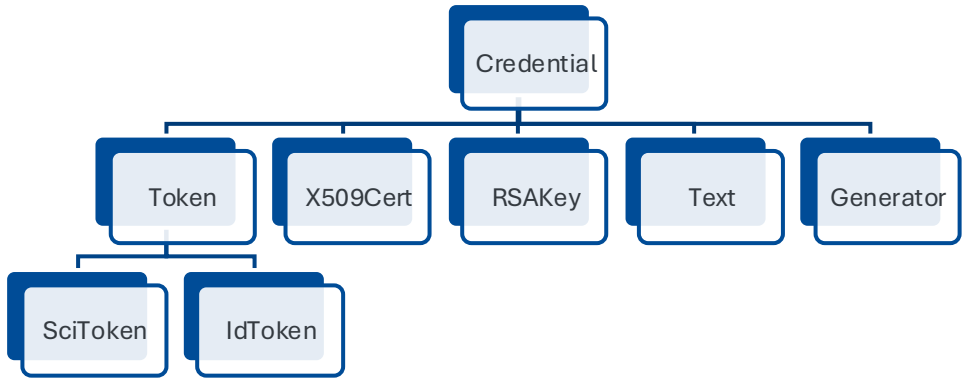
Shorter!

No duplication and consistency problems

Also with new credentials and generators

- Refactoring of the code
- Easy to define custom generators in Python
- IdTokenGenerator to customize the tokens to join the cluster
- Self-signed SciTokens for testing
  - Generates SciTokens according to the VO desires and uses its key to sign them
  - Advertises the public key with standard OAuth 2.0 authorization server metadata RFC
  - Just add a couple of lines in the CE mapfile

- Robust renewal of tokens missing
  - Problem when CM restarts – Glideins cannot rejoin the pool



GlideinWMS simplifies resource provisioning

- Glidein based Workload Management System used in production for 20 years
- Aiming to improve the provisioning and simplify operations
- Currently
  - Providing access to more HPC resources
  - Making CVMFS available on all nodes
  - Simplifying operations around credentials and submit parameters
- Thanks to the Condor team for all the support, we will keep requesting more performance and features to scale and satisfy GlideinWMS stakeholders' requests
  - Support of more HPC resources using IRI API and similar
  - Credential renewal mechanism working for all resources