# OSG Technologies for sharing Compute Resources

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This project is supported by National Science Foundation under Cooperative Agreement OAC-2030508. Any opinions, findings, conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.


# Resource Sharing on OSG

OSG is a consortium dedicated to the advancement of all of open science via the practice of distributed High Throughput Computing (dHTC), and the advancement of its state of the art.

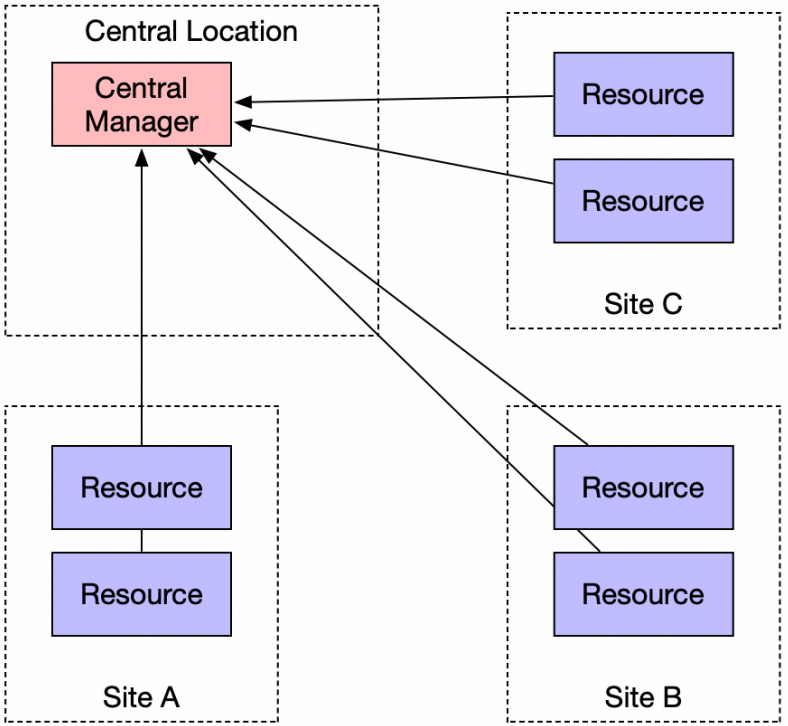
dHTC enables us to effectively enable resource sharing across more than a hundred sites in the US!

# Sites and OSG

- A site on the OSG is a collection of resources – clusters – that are run by a specific administrative domain.
  - **Example**: the Holland Computing Center at Nebraska is an OSG site that makes several clusters available as OSG resources.
  - **Example**: A new CC* award recipient would like to make their new compute cluster available to LIGO and backfilled by other scientific work on the OSG.
- *Goal for today*: explain how PATh runs a fabric of capacity services allowing sites to share resources with external communities.
  - Ideally, for new CC* awardees, this helps you meet your goal of 20% of resources available.
  - Meant to be high-level – not exhaustive technical details!
  - **Site-centric**: we are not going to cover how this looks for OSG Users!

# Resource Sharing

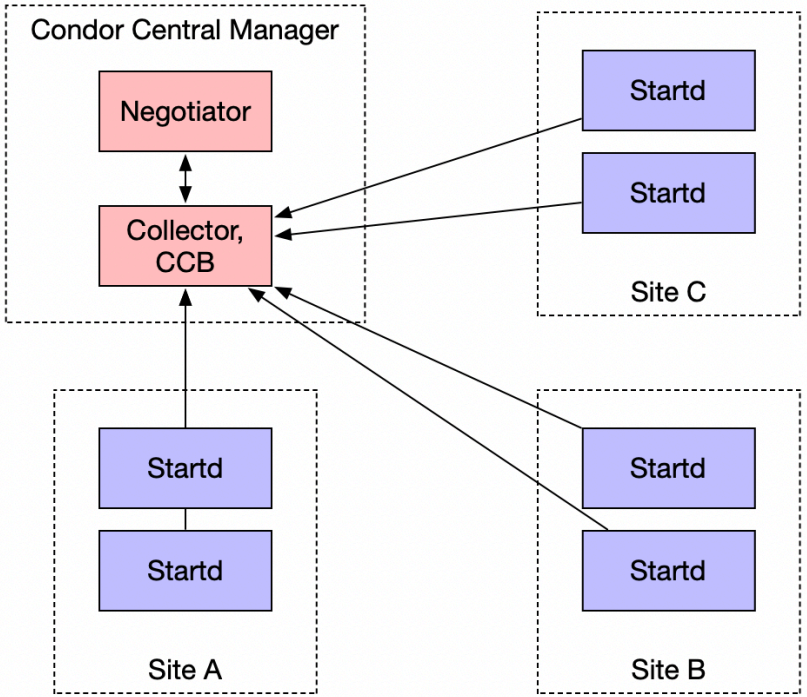
- OSG shares resources via the concept of an “overlay pool”.
  - Disparate worker node resources are allocated (think: starting a VM).
  - Some piece of software (“pilot”) starts on the worker node which subsequently connects to a central pool.
  - Work – batch jobs! - from the outside is pulled down to the worker node and executed. These are “payload” jobs.
- Technologies we’ll see today:
  - HTCondor manages the jobs and central pool.
  - glideinWMS helps decide where and when to allocate resources.



# Now with Jargon!

In HTCondor Jargon:

- The software the pilot deploys on the site's worker node is called the **startd**.
- The central manager has three primary components:
  - **Collector**: daemon where all the resource descriptions are uploaded from the worker node.
  - **Condor Connection Broker (CCB)**: Used to manage network connections, allowing **startd** to be behind a NAT.
  - **Negotiator**: Implements policy and allocates the share of resources to different users.



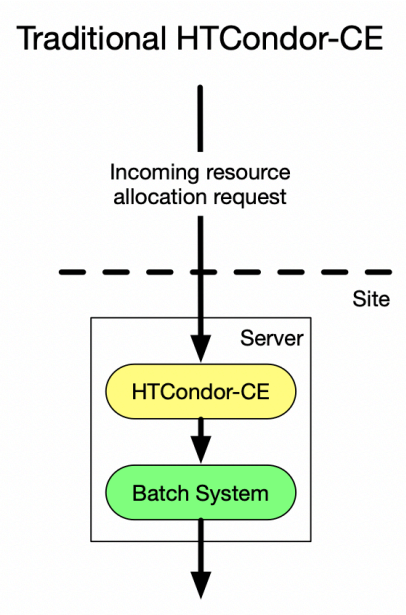
# Processes on the worker

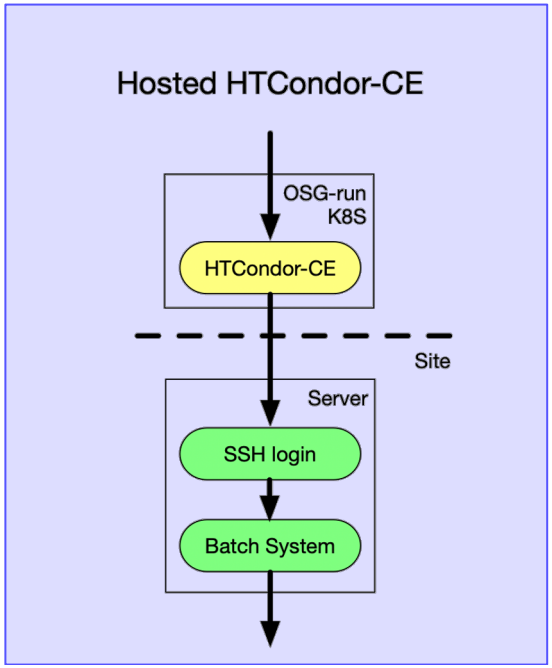
```
condor_startd -f
  └─condor_starter -f -a slot1 test-006.t2.ucsd.edu
      └─condor_exec.exe /var/lib/condor/execute/dir_146125/condor_exec.exe -v std -name gfactory_instance -entry OSG_US_UCSD_TEST_CE_004 -clientname test.test -schedd...
          └─condor_startup. /var/lib/condor/execute/dir_146125/glide_q5Xf8G/main/condor_startup.sh glidein_config
              └─condor_master -f -pidfile /var/lib/condor/execute/dir_146125/glide_q5Xf8G/condor_master2.pid
                  ├─condor_procd -A /var/lib/condor/execute/dir_146125/glide_q5Xf8G/log/procd_address -L /var/lib/condor/execute/dir_146125/glide_q5Xf8G/log/ProcLog -R ...
                  └─condor_startd -f
```

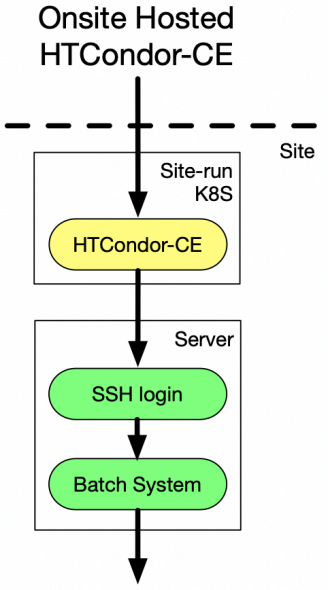
- Beyond the batch system processes, the running pilot has a few components:
  - A shell wrapper to startup the pilot,
  - Condor helper daemons,
  - The condor worker node processes and the process representing the running job
  - And finally, any processes that are part of the payload job!
- **Warning: more processes than you typically see on the worker node.**

# Resource Requests

- To start a pilot at the site, some service is needed to connect the site's batch system to the external world.
  - This is a "Compute Entrypoint", or "CE".
  - We use the "HTCondor-CE" implementation.
  - Three supported models: traditional onsite deploy (by site), Hosted CE (run by OSG), or an onsite hosted CE (run by OSG).

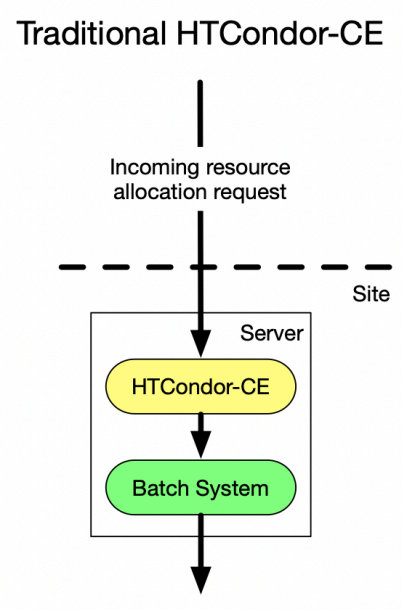


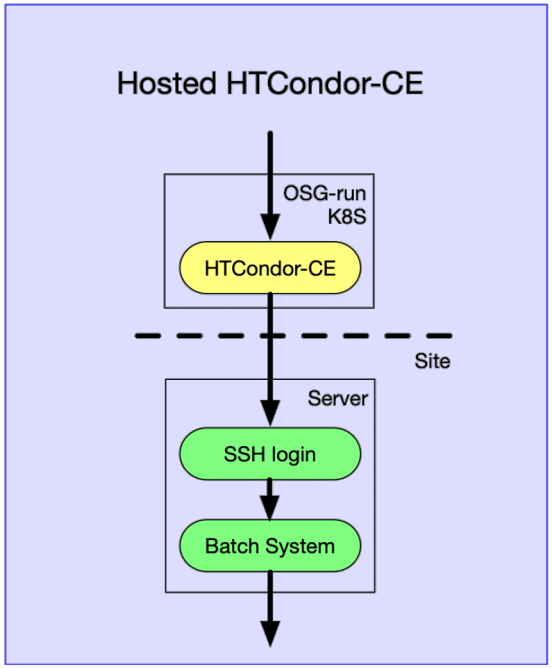



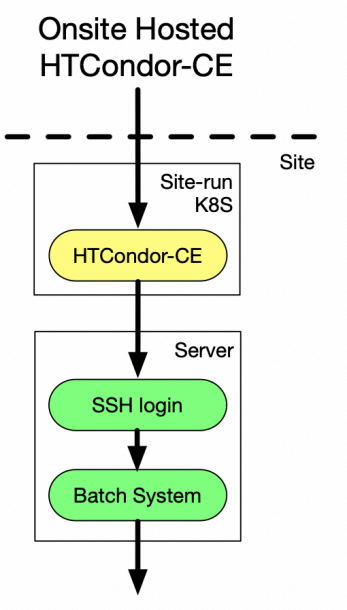



# Resource Requests

- Today we'll cover the Hosted CE. The different deployment types:
  - Determine how much **configuration the site controls** (traditional deploy offers most control).
  - Determines the **total site admin time invested** (hosted option is the minimal option).



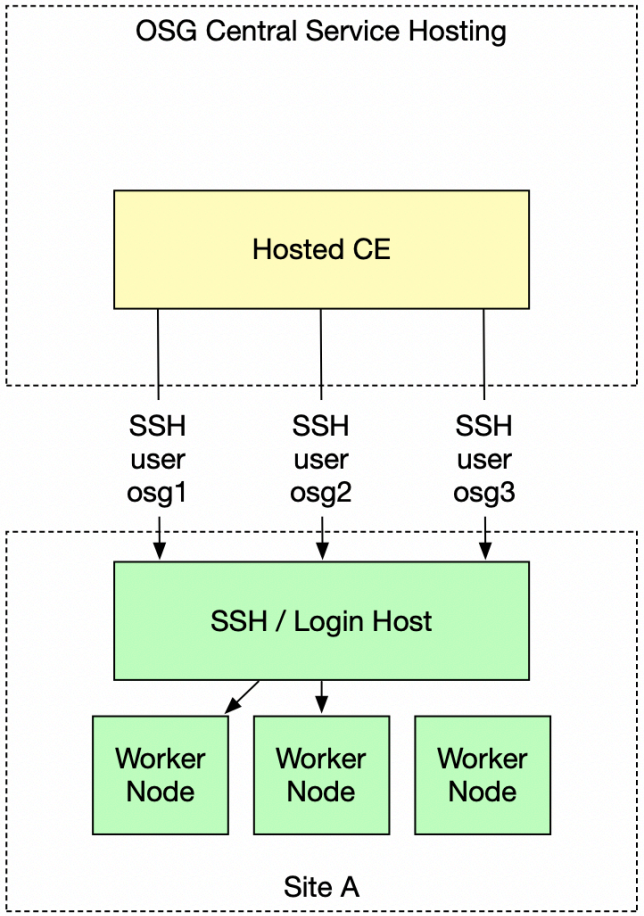



# Allocating Resources

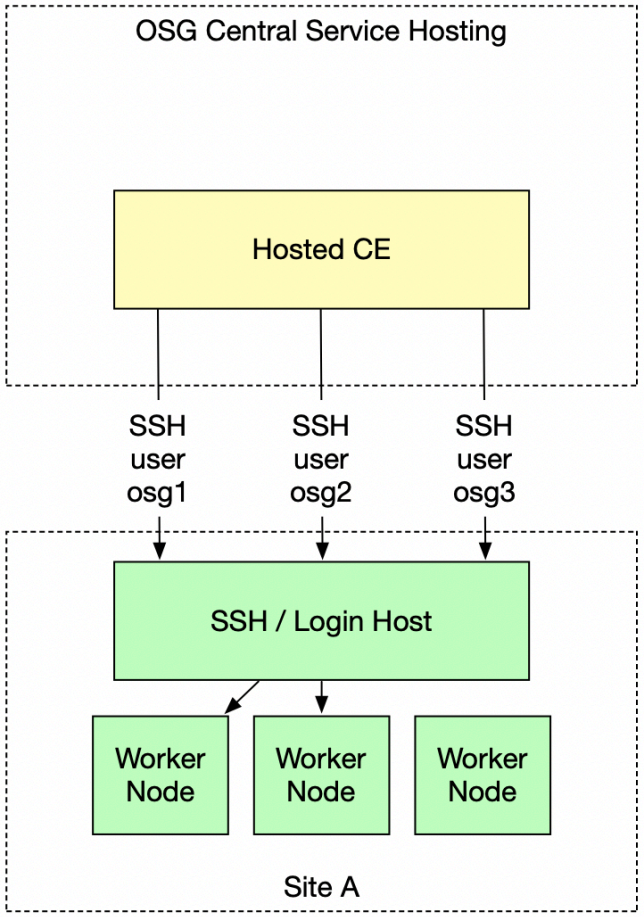
"Resources Allocations" are really batch jobs.

- These batch jobs arrive from the hosted CE to the site login host via SSH.
  - One CE per SSH host.
  - **Each supported community is a separate Unix account**.
- You can ban or prioritize individual communities without involving OSG as each community is a distinct batch user.



# Allocating Resources

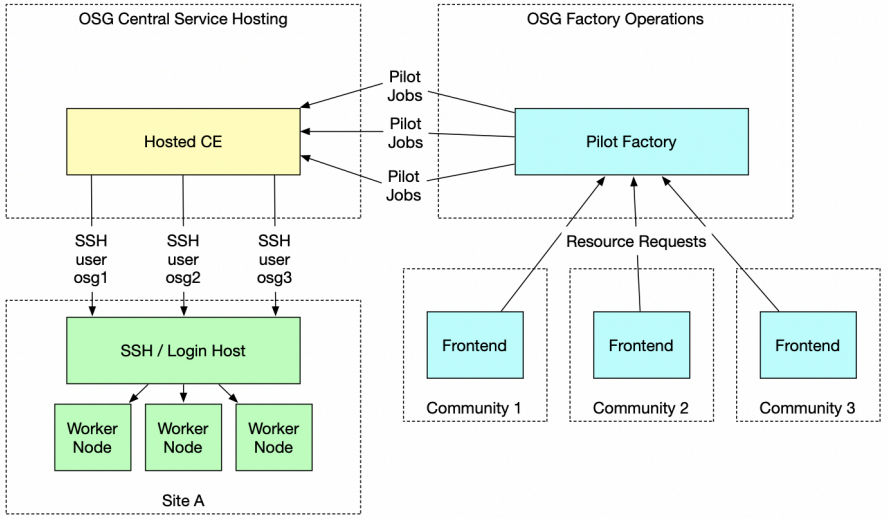
- OSG is here to facilitate resource sharing, not demand specific resource allocations.
  - There is a “special community” (“OSG”), run by OSG, which redistributes resources with an emphasis on single PIs.
  - The “OSG Community” also include XSEDE allocations, scientific collaborations -- all under the umbrella of ‘open science’ and research.
    - We have simple demographics and accounting for this community available to you.
- We have expertise with a variety of batch systems and can help you implement your desired policy!



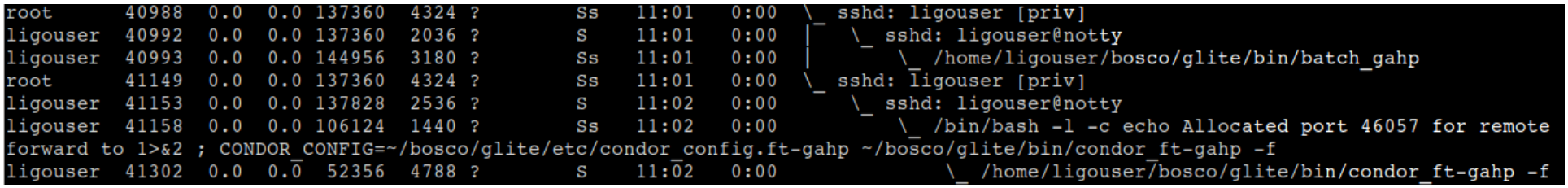
# Allocating Resources

The OSG "factory" creates pilot jobs for each CE to submit to the local batch system.

- Most, but not all, communities use the OSG-run factory. Some run their own.
- Each community has a "frontend," which determines the resource requests per site based on their current job load and profile.
- The factory translates those resource requests to pilot jobs to various CEs.
  - The hosted OSG-CE will transform these to jobs appropriate for your site's batch system and submit over SSH.



# Example – Processes on the SSH host




- On the SSH login host, the site will see two persistent SSH connections:
  - One for the processes that interacts with the batch system (`batch_gahp`).
  - One for file movement (`condor_ft-gahp`).
- These will occasionally launch other processes (e.q. `qsub`).

# Other activities at the site

- What else occurs at the site?
  - You'll see one set of processes on the submit host for each user account setup for OSG.
  - Worker nodes need outgoing network connectivity to the central pool and submit hosts.  NAT is fine!
    - The outgoing IP addresses will vary from community to community.
  - Only inbound connections go to SSH host.
  - For non-HTCondor sites, a shared filesystem is needed to move startup scripts and logs.
- Individual science communities (such as LHC) may require additional services; let us know who you want to support, and we can provide more details.

# Getting Started

- To get started with the hosted CE:
  - Contact support@opensciencegrid.org to schedule a discussion with the OSG team.
    - This helps us set our goals for integrating the site and determine what services we should target.
  - For hosted CEs, we'll ask you to fill in the cluster integration questionnaire.
    - This simply gets us some basic technical facts.
- Feel free to contact us early in the design process – you don't need to have a batch system or hardware to start planning!

Online Documentation

# SECURITY ON OSG

# Security on OSG

- Security is an important process required to establish mutual trust between parties!
  - OSG acts as a trusted middleman.
  - OSG establishes identity and relationships with both sites and communities.
- Sites must know their computing resources are used for the advancement of science and engineering.
  - For example, The facilitation team meets with each OSG User over video to help establish identity.
- Communities must know their computing is performed on valid resources.

# Security on OSG

- A few examples of technical mechanisms in place to protect your site:
  - TrustedCI, NSF's Cybersecurity Center of Excellence, has performed an assessment of the security of the HTCondor-CE itself.
    - All of our containers are periodically rebuilt to pick up the latest RedHat security patches.
  - The SSH private key is accessible only to the OSG Operations team and will only be used from specific, narrow IP ranges.
    - OSG components use mutual X.509-based authentication to establish identities; all communication is encrypted.
  - All OSG services are periodically scanned for vulnerabilities.

# Security – Everyone's Responsibility

- Sites, too, have responsibilities:
  - As necessary, participate in and be responsive during a security incident response.
  - Notify OSG in the case of a site-level incident affecting grid components.
  - Maintain a secure local environment; perform best-practice techniques such as:
    - Keep hosts patched and up-to-date.
    - Maintain traceability – keep logs of activity at the site.
    - Monitor network activity for suspicious traffic.
- Remember, OSG users are trusting the site with their data, credentials, and scientific work!


# RESOURCE ACCOUNTING

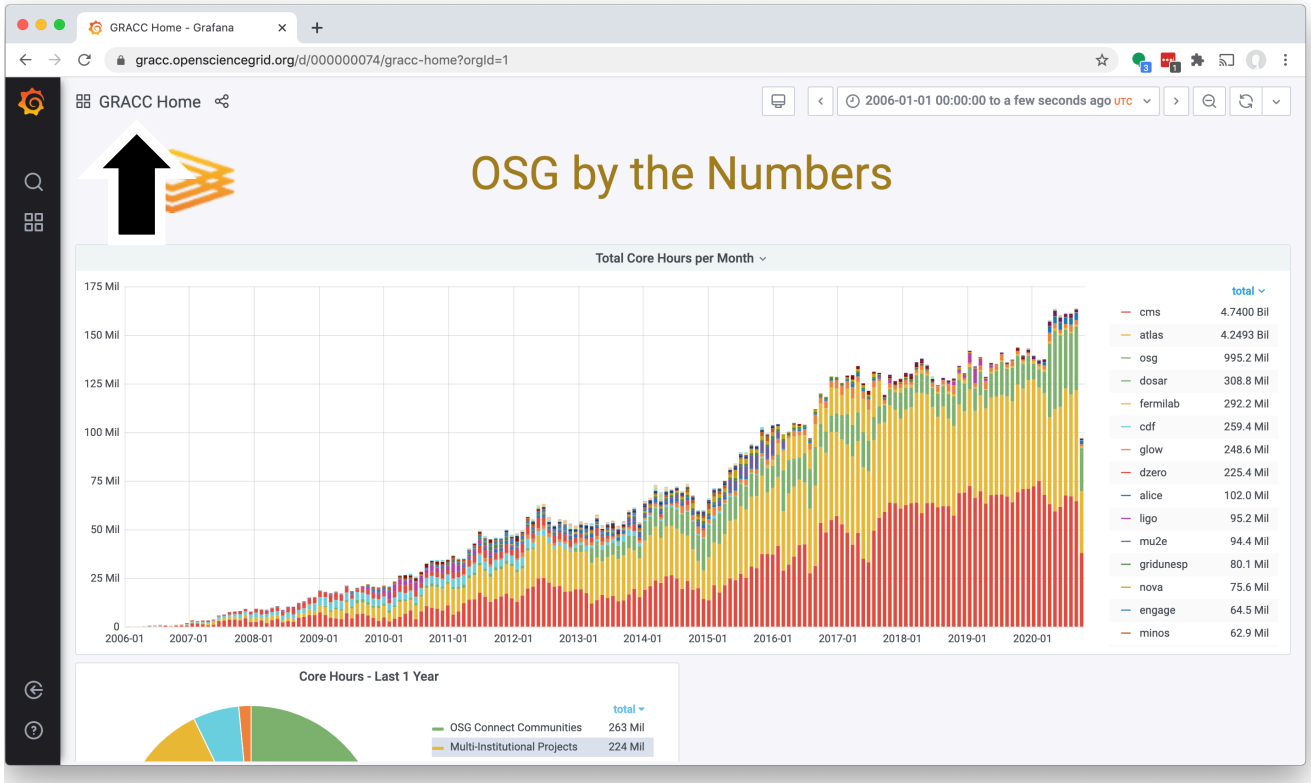
# Resource Accounting for CC*

- CC* program aims to make available 20% of the resources to external communities.
  - Both “make available” and “20%” are surprisingly hard to define. How you interpret this is between you and NSF – not OSG’s business!
  - OSG helps provide input to this process by making some simple accounting numbers available.
- Unfortunately, accounting is surprisingly subtle on OSG:
  - **Pilot** accounting tells us what compute resources were made available via the batch system.
  - **Payload** accounting tells us how the communities use the allocated resources.
- Ideally, these are identical: **in practice, they are not**!
  - Example: a pilot may start up but find that all payload jobs are already gone.
  - In most cases, these numbers are within 10% of each other.

# Other Accounting Gotchas

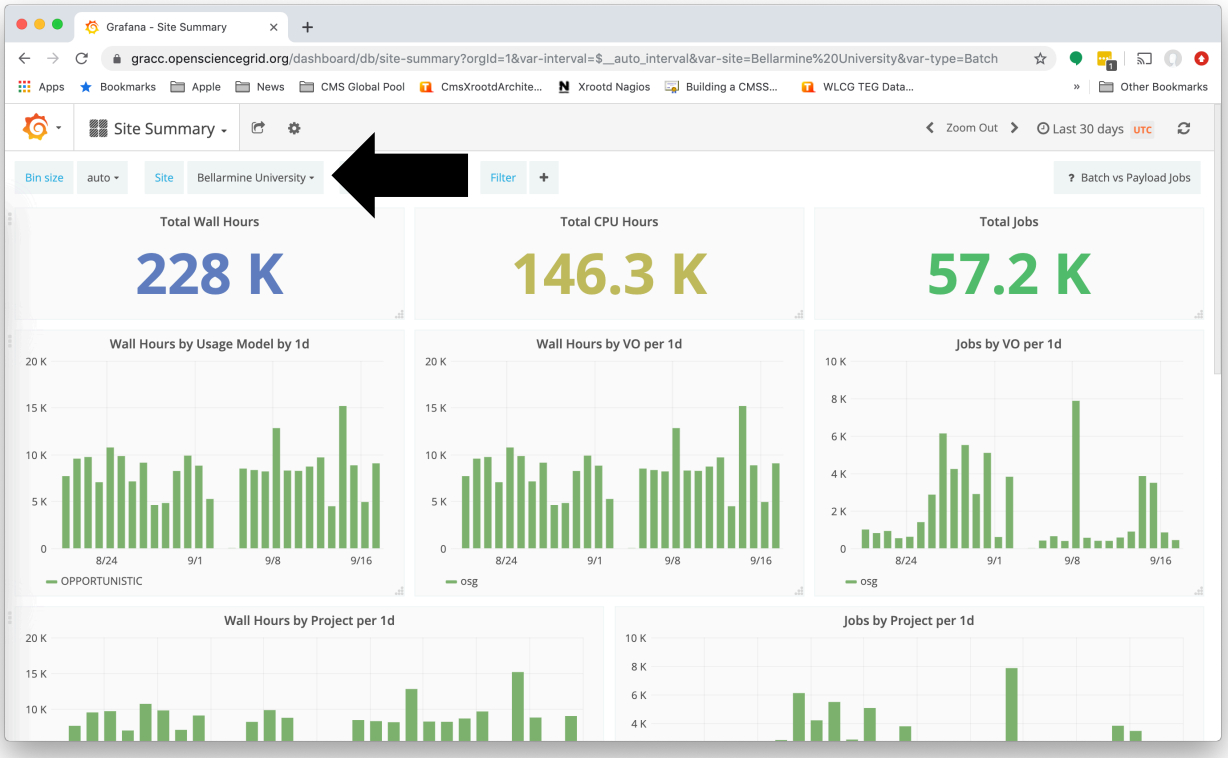
- A few other notable “gotchas”
  - Not all communities report the same details to OSG on how they use the resources.
    - **Example**: LHC community does not provide payload details.
  - Some communities utilize the OSG services to reach non-US sites.
    - **Example**: we only get payload information from European sites running IceCube, not pilot.
- Because this is complex, it’s useful to think carefully about what question you want to ask the system.
  - I’ll walk through a few screenshots on what I think is most important.

# Grid Resource ACCounting (GRACC) portal




Accessible at https://gracc.opensciencegrid.org or by clicking on "explore our accounting portal" on the homepage.

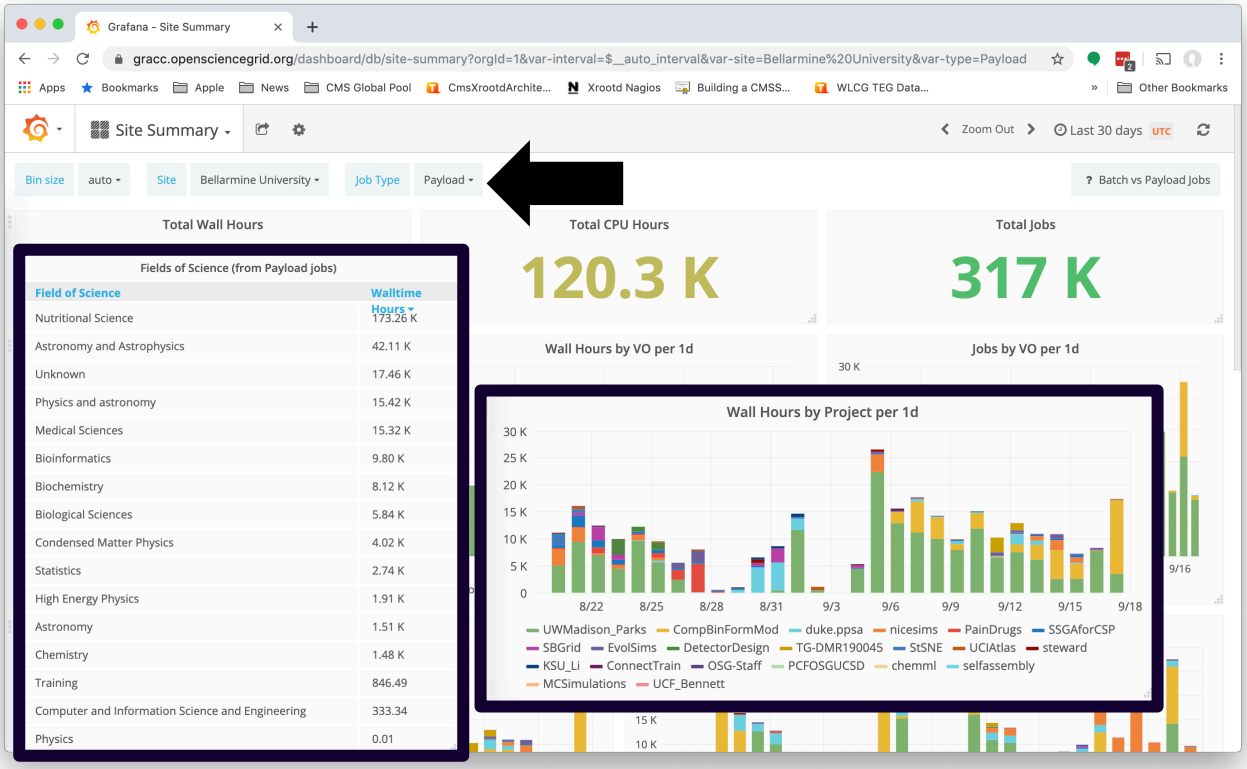
# Grid Resource ACCounting (GRACC) portal




The "Site Summary" page defaults to all sites; use the drop-down to select your site name.

- You get to pick your site name. Names like "Bellarmine University" tend to be more descriptive than "KR-KISTI-GSDC-02".
- This shows the view by community; in this case, only the special "osg" community was run.

# Grid Resource ACCounting (GRACC) portal




- Switch to the “payload” job type to get information about the resource usage, including
- The projects names inside the community.
- The corresponding fields of science.

# OTHER OSG SERVICES

# Sharing Resources More Effectively

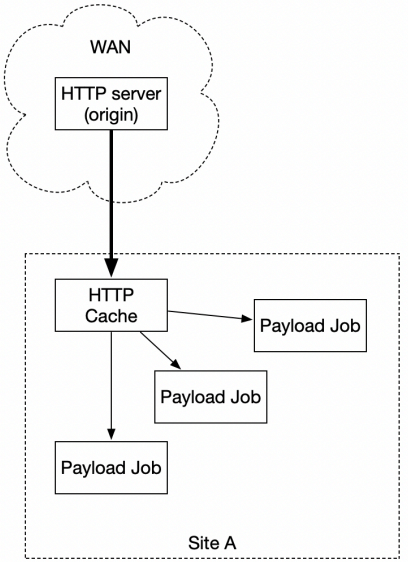
- Integrating a Hosted CE is the simplest way to share resources.
  - Requires no site-run services and aims to minimize required site effort.
- By running additional services, your site will run more efficiently or be able to support a broader range of jobs
  - Example: effectively all our GPU jobs require container support at the site.
- Your site does more science – but more effort is involved!
  - Your local researchers may be the ones benefitting from these services.


# Sharing Resources More Effectively

- Example site services:
  - **HTTP Cache**: helps avoid frequent retransfer of many (small) resources over HTTP.
  - **Worker-node Container Distribution**: Global, read-only, caching filesystem for distributing containers and software (data is moved via the HTTP cache).
  - **Singularity**: Allows us to launch jobs inside containers. Relies on the container distribution mechanism.
  - **Data Caches**: Helps jobs avoid moving large data repeatedly.
- I'll include links to documentation; tackle these if desired (and after the basics are working).

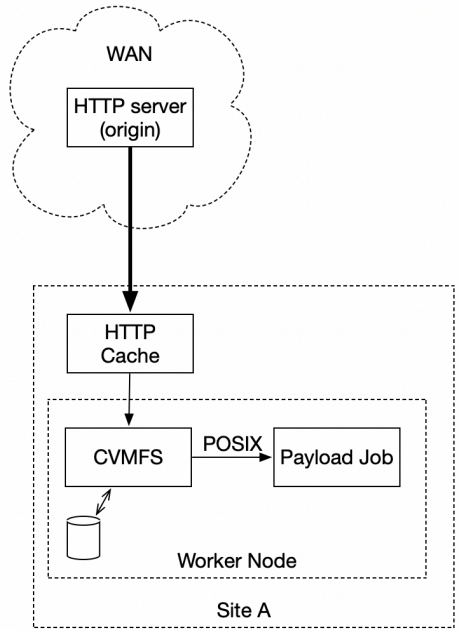
# Sharing Resources More Effectively - HTTP Cache

- A broad set of data – software, configurations, job inputs – can be moved to the worker node via HTTP. A significant amount is very frequently reused.
  - By placing a HTTP cache on-site, repeated data use only goes over the LAN instead of the WAN.
  - Any caching HTTP proxy can work for OSG. However:
    - Not all scale well in terms of concurrency.
    - Most are tuned for HTML files, not objects in the >1MB range.
  - We work with the Frontier project to support a special configuration of the venerable Squid software, frontier-squid. Monitoring, logging, and configuration are tuned specifically for OSG usage.
- Sysadmin Documentation. Complexity level: **Easy**. Standalone service on dedicated host.
  - Can be run on local Kubernetes by OSG staff.



# Sharing Resources More Effectively – Container Distribution (CVMFS)

- CVMFS is a global, integrity-checked, read-only POSIX filesystem. This achieves scale by distributing data through HTTP caches and a CDN.
  - Everything is cached – filesystem metadata and data – all the way to the local worker node. Data is moved to the worker node only on access.
  - In OSG, we use this as a mechanism to distribute science community containers and software. Given the popularity of containers, many jobs require this.
  - **Downside**: This is software that is run on the worker node, which adds complexity.
  - **Downside**: Implemented using FUSE and autofs, two tricky technologies.
  - **Good news on the horizon**: In newest CentOS 7, this can be done by the batch job completely unprivileged. Nothing to install or monitor on the worker node.
    - Integration is ongoing in OSG – expected later this year.
- Sysadmin Documentation. Complexity level: **Moderate**. Software that is installed on worker node & filesystem mounted.



# Sharing Resources More Effectively – Containers (Singularity)


- Singularity is a container runtime that aims to fit the needs of running containers inside a batch system. No running daemon like Docker – just a process inside the batch job.
  - For full functionality, a `setuid` (extra privileges) binary is needed.
  - For OSG use cases – and on RHEL7 – we recommend using unprivileged (no `setuid`).
- The pilot will invoke Singularity prior to starting the payload; this way, the pilot sees the host operating system and the payload sees the container of its choice.
  - The containers are typically distributed via CVMFS.
- OSG provides targeted support for the "community edition" of Singularity.
- Sysadmin Documentation. Complexity level: **Easy**. Single configuration file on worker node.

# Sharing Resources More Effectively – Data Caches

- The Frontier-Squid software targets the distribution of “small-ish” objects – less then 1GB:
  - Is inefficient to use for files over 1GB.
  - Does not provide a mechanism to securely cache proprietary scientific data. (Note: OSG does not provide mechanisms suitable for HIPAA data.)
- We have a separate software (XCache, a special configuration of the XRootD software) to fill this role.
  - Designed for delivering 1-10GB of data to jobs where there is cache-friendly access and the total working set size of a workflow is <10TB.
  - Provides mechanisms to authenticate and authorize
  - In the end, still transfers data via HTTP / HTTPS.
- Sysadmin Documentation. Complexity Level: **Moderate / Hard**.
  - Can be run on local Kubernetes by OSG staff.

# Putting it all Together

- Some important take-homes for today:
  - OSG can enable effective resource sharing through the use of an overlay pool.
  - Resources can be added to the pool by submitting resource allocation requests, or pilots, through a compute entrypoint.
    - OSG can host the CE so the site only needs a SSH login host, a batch system, and network.
  - The success of the ecosystem requires effective security processes, involving participation from the users, sites, and OSG.
  - There are a number of additional services around improving the support of data on OSG.


# Questions?

support@opensciencegrid.org

This material is based upon work supported by the National Science Foundation under Grant No. 2030508. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.