Introduction to DHTC

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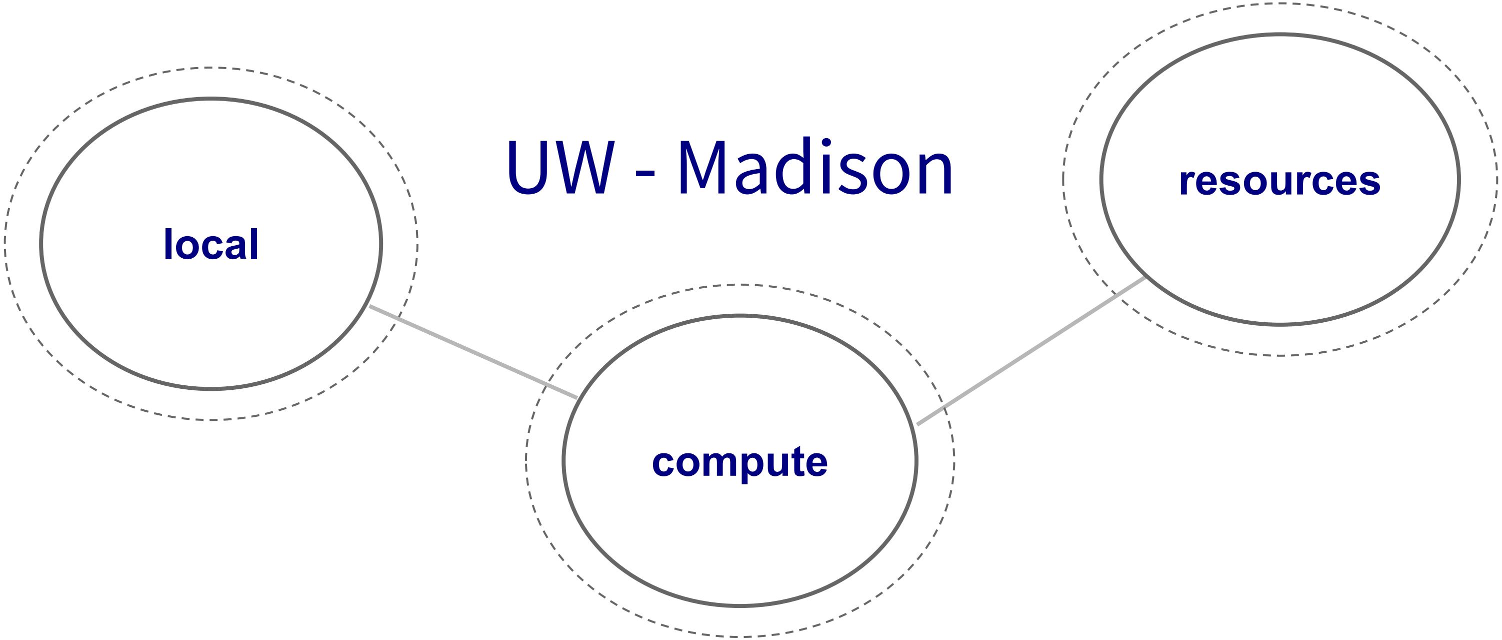
Local High Throughput Computing



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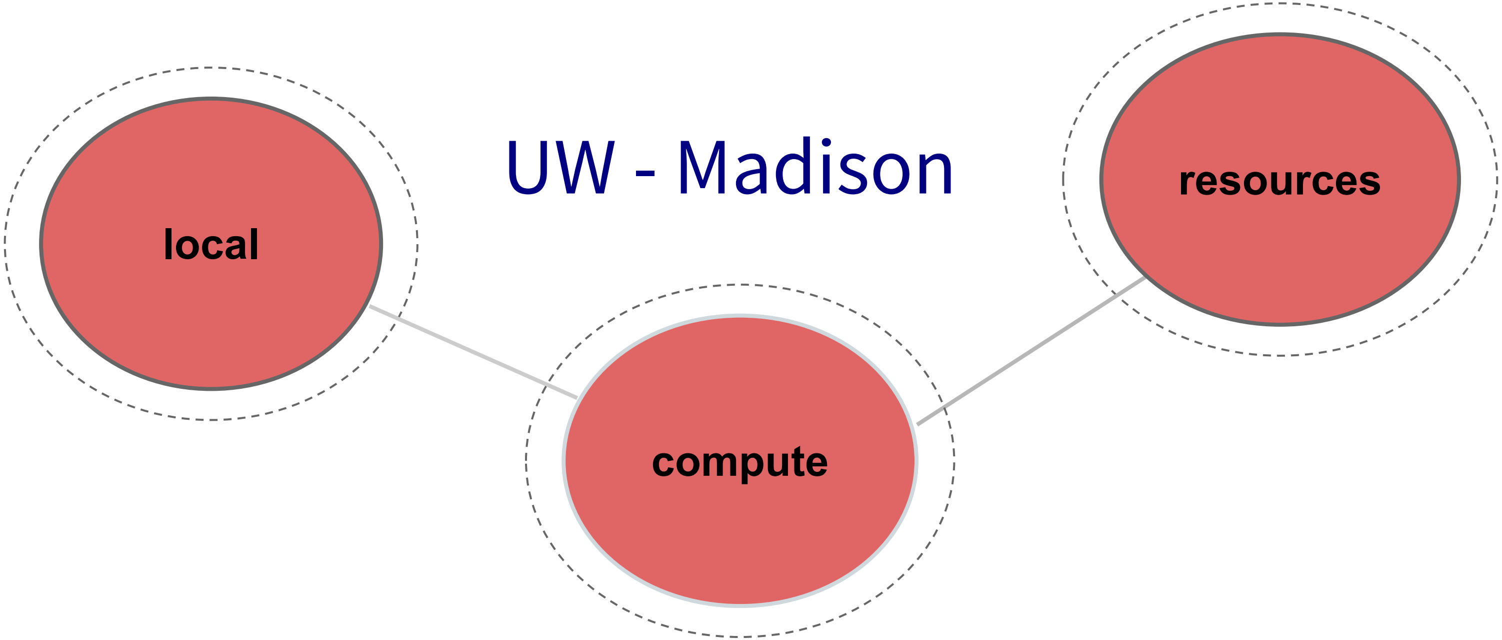

How do you get more computing resources?

#1: Buy Hardware

#1: Buy Hardware

- Great for specific hardware/privacy requirements
- Costs $$$
  - Initial cost
  - Maintenance
  - Management
  - Power and cooling
- Delivery and installation takes time
- Rack/floor space
- Obsolescence
- Plan for peak usage, pay for all usage

#2: Use the Cloud

#2: Use the Cloud - Pay per cycle

- e.g. Amazon Web Services, Google Compute Engine, Microsoft Azure, Rackspace
- Fast spin-up
- Costs $$$
- Still needs expertise + management
  - Easier than in the past with the `condor_annex` tool
- Does payment fit with your institutional or grant policies?

#2: Use the Cloud - ‘Managed’ clouds

- e.g. Cycle Computing, Globus Genomics
- Pay someone to manage your cloud resources — still costs $$$
- Researchers and industry have used this to great success
  - Using Docker, HTCondor, and AWS for EDA Model Development
  - Optimizations in running large-scale Genomics workloads in Globus Genomics using HTCondor
  - HTCondor in the enterprise
  - HTCondor at Cycle Computing: Better Answers. Faster.

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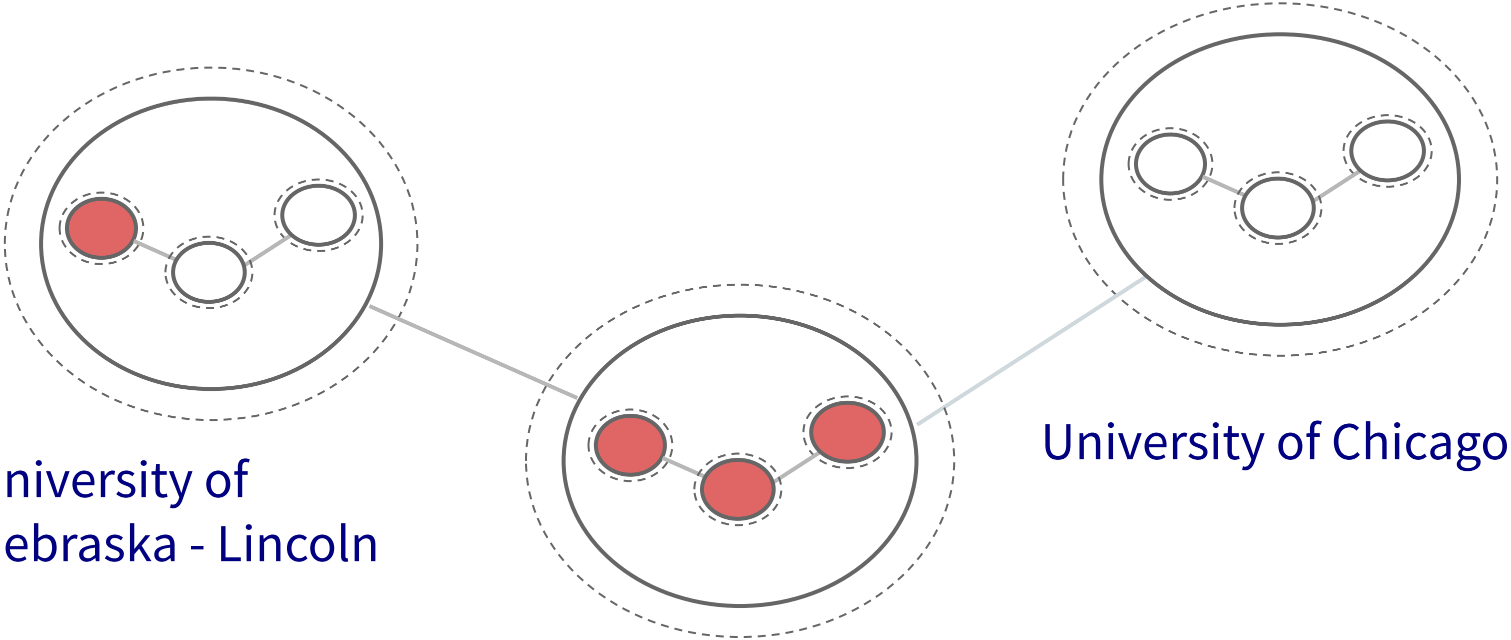
#3: Share Resources

#3: Share Resources - Distributed HTC



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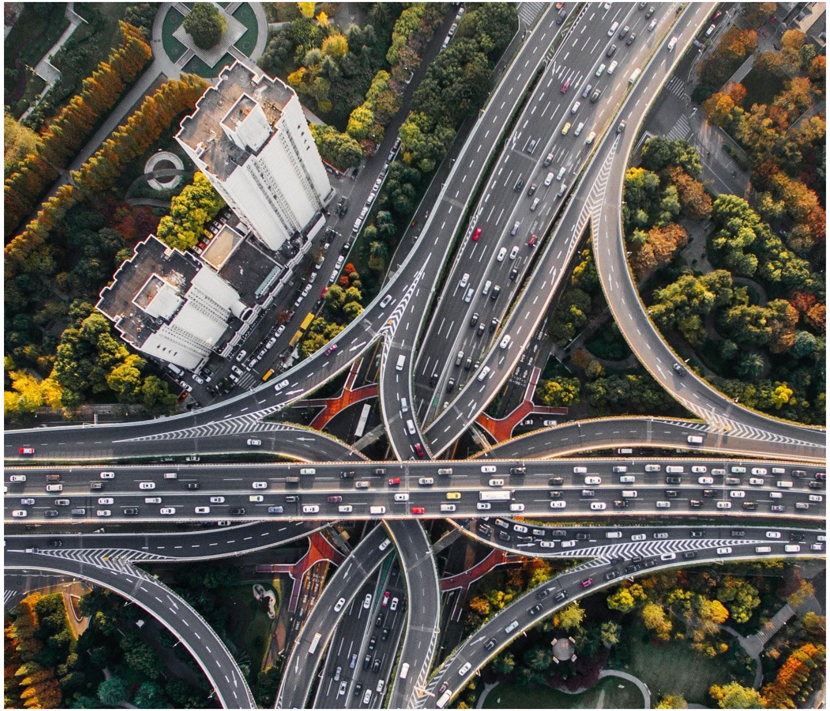
i.

Split Up Your Jobs Manually

Let’s start sharing!

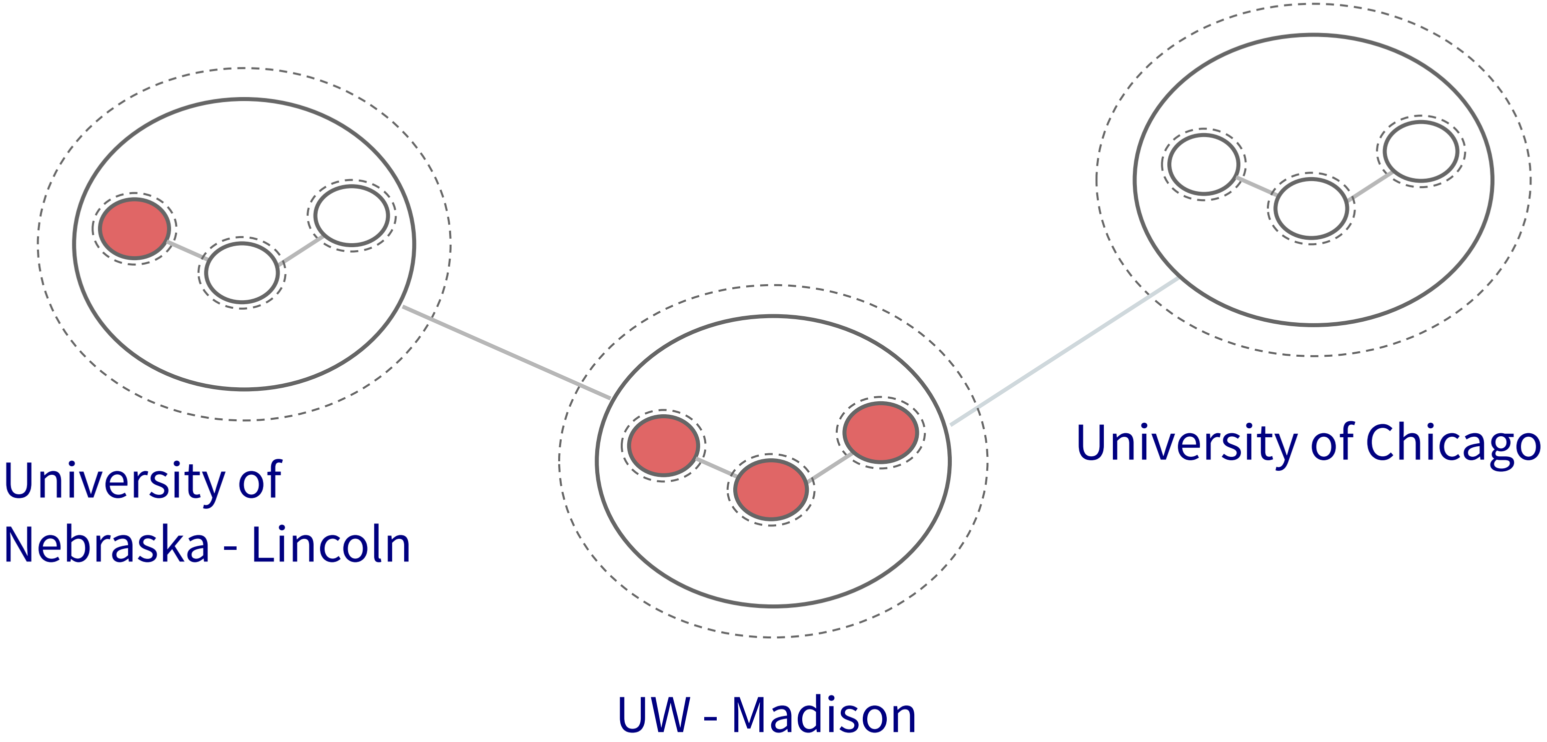
Manual Job Split



- Obtain login access
- Query each cluster for idle resources
- Split and submit jobs based on resource availability

Photo by Denys Nevozhai on Unsplash

#3: Share Resources - Distributed HTC



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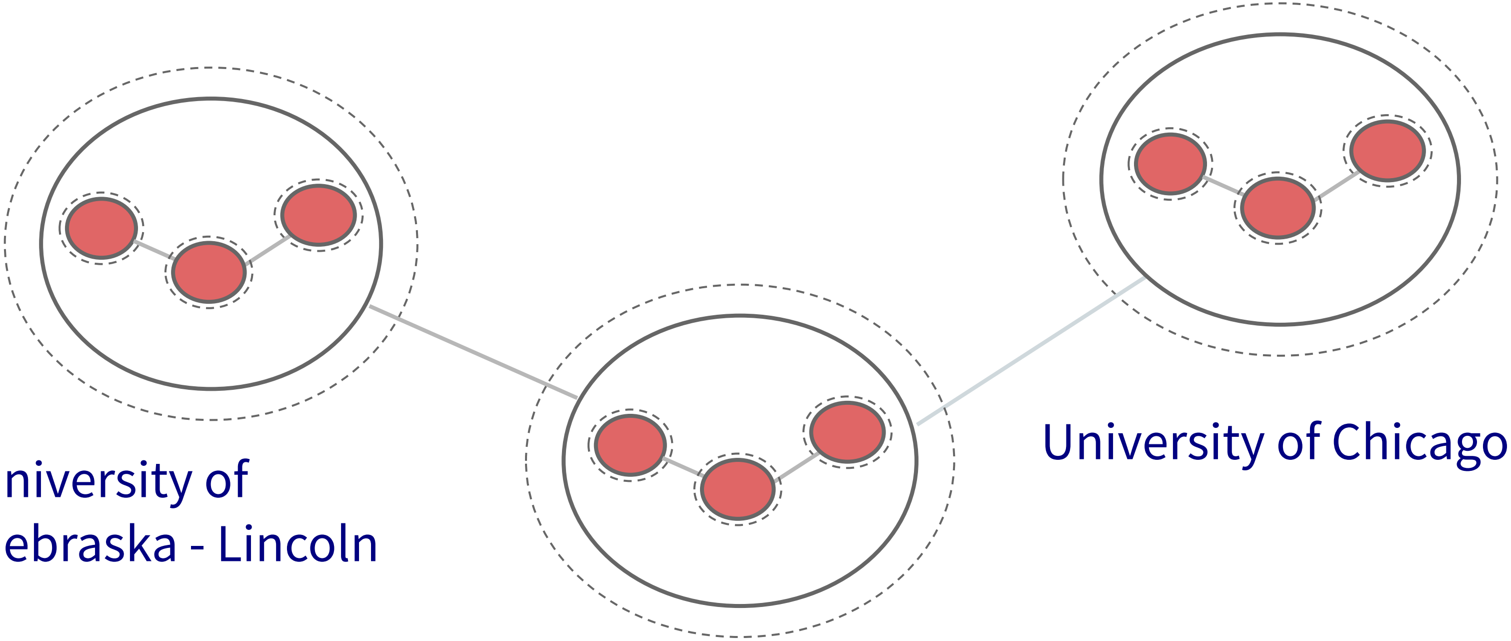

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Manual Job Split - Shortcomings

- Fewer logins = fewer potential resources
- More logins = more account management
- Why would they give you accounts? Are your friends going to want CHTC accounts?
- Querying and splitting jobs is tedious and inaccurate
- Not all clusters use HTCondor — other job schedulers e.g., SLURM, PBS, etc.
- Pools are independent — workflows must be confined to a single pool

ii.

Split Up Your Jobs Automatically

Let the computers do the work

Automatic Job Split - Shortcomings

Homer: Kids: there's three ways to do things; the right way, the wrong way and the Max Power way!

Bart: Isn't that the wrong way?

Homer: Yeah, but faster!

Groening, M (Writer), Michels, P. (Director) . (1999). Homer to the Max [Television Series Episode]. In Scully, M. (Executive Producer), *The Simpsons.* Los Angeles, CA: Gracie Films

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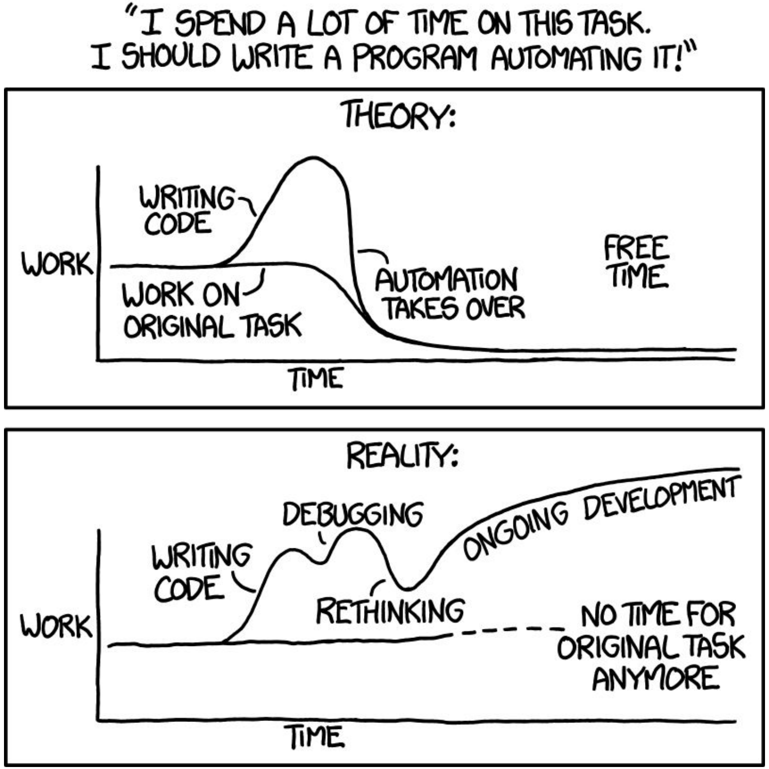
Automatic Partitions - Shortcomings



Source: https://xkcd.com/1319/

#3: Share Resources - Requirements

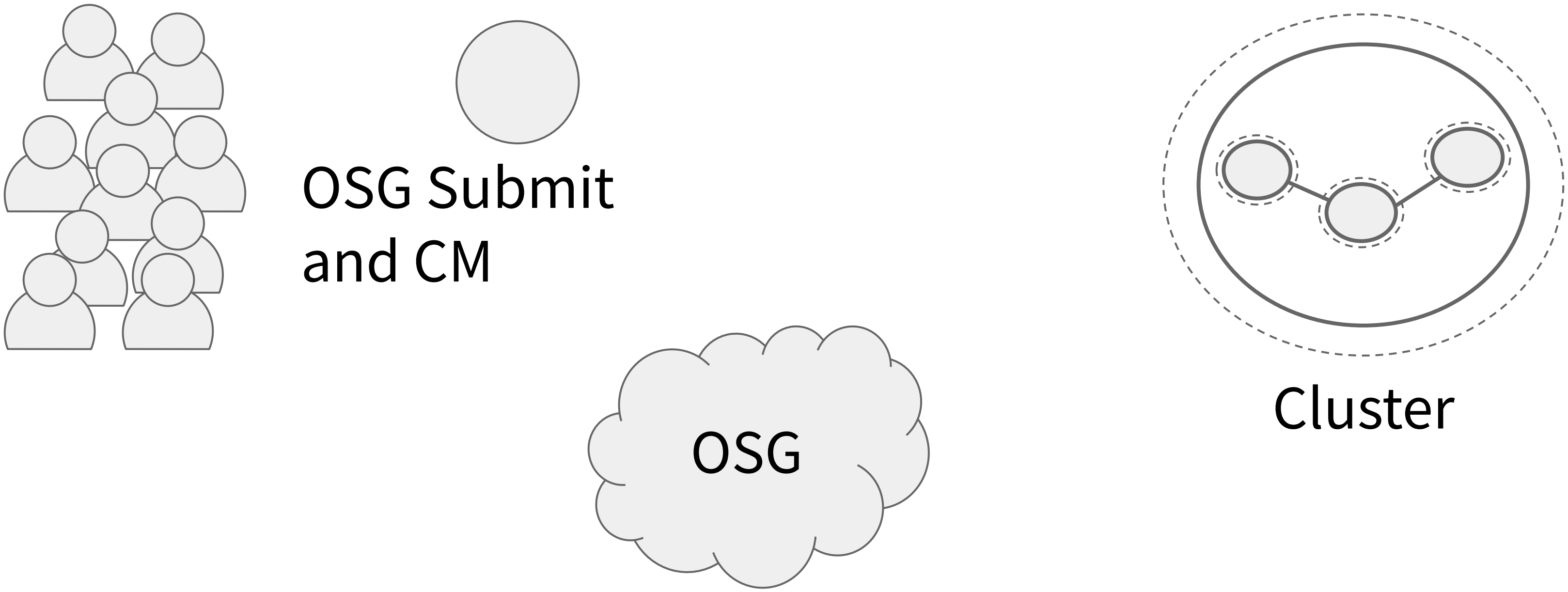
- Minimal account management
- No job splitting
- DAG workflow functionality
- HTCondor only!
- No resource sharing requirements

iii.

Overlay Systems

Let the OSG do the heavy lifting

The OSG Model

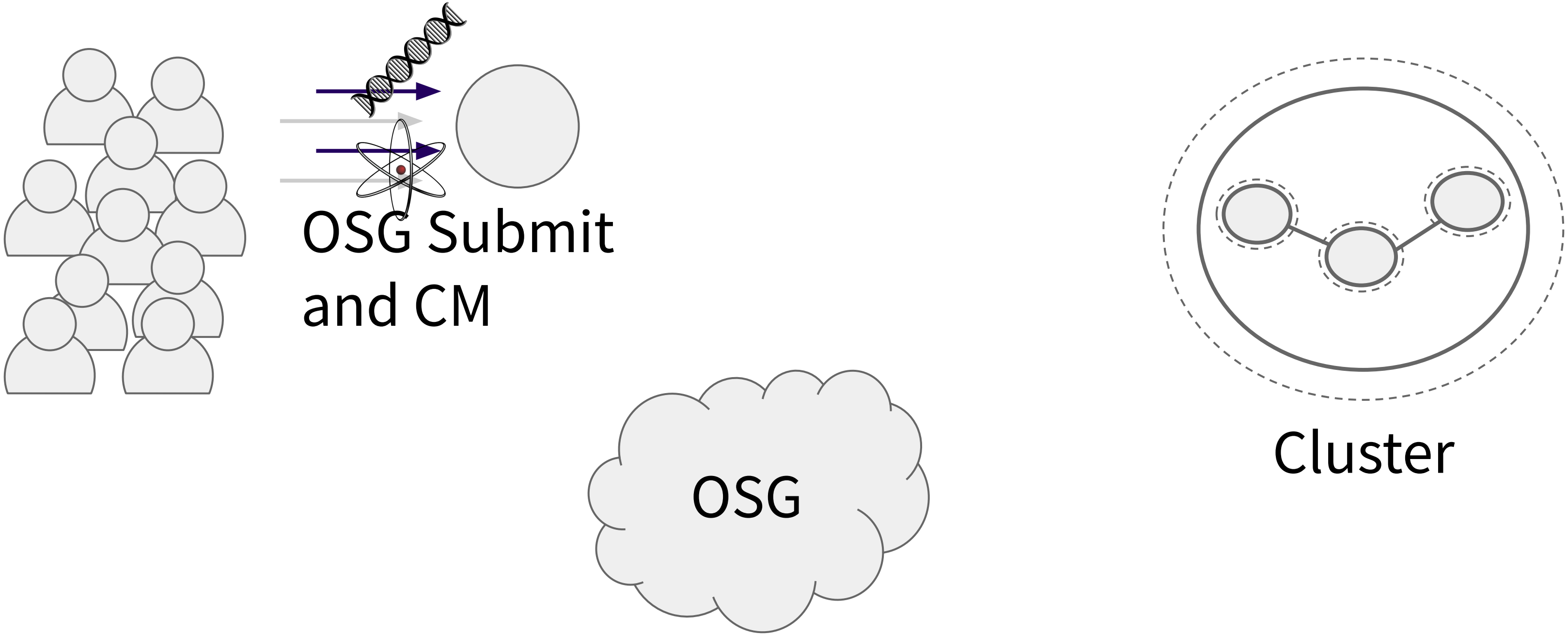


OSG Submit and CM

OSG

Cluster

The OSG Model



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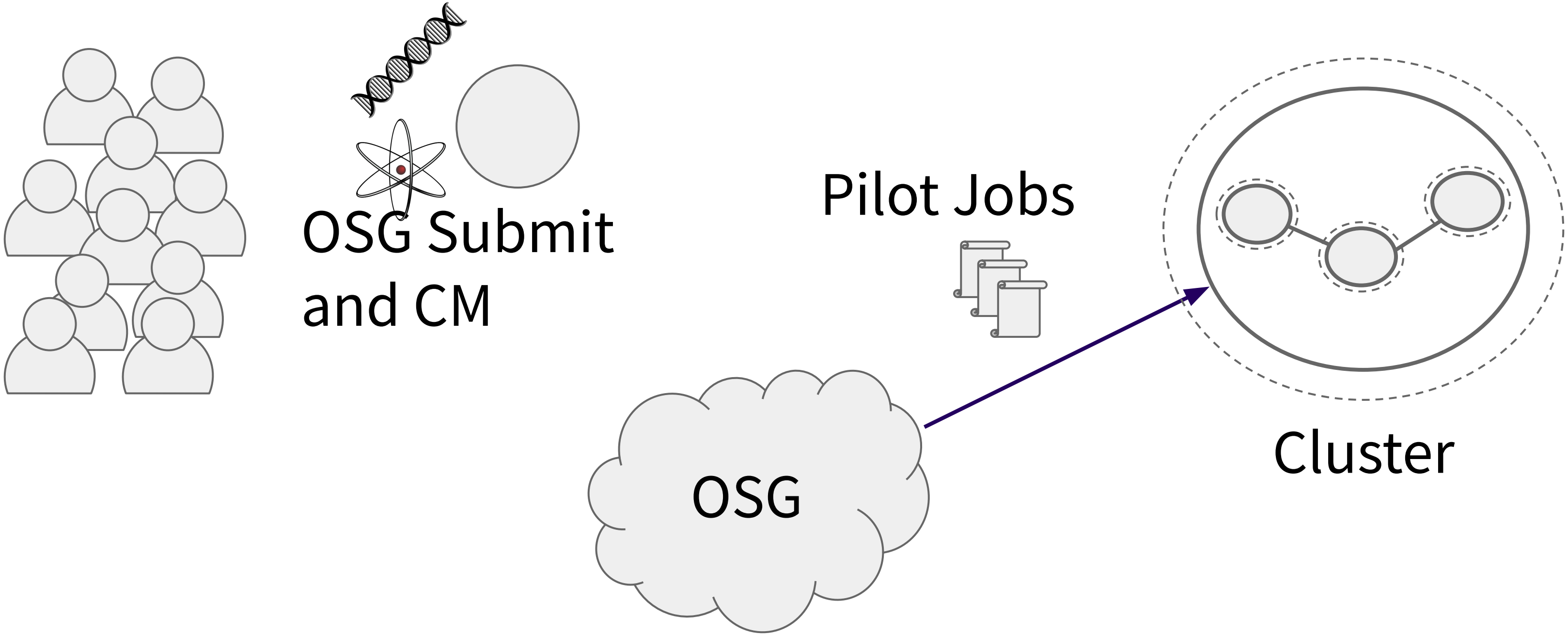


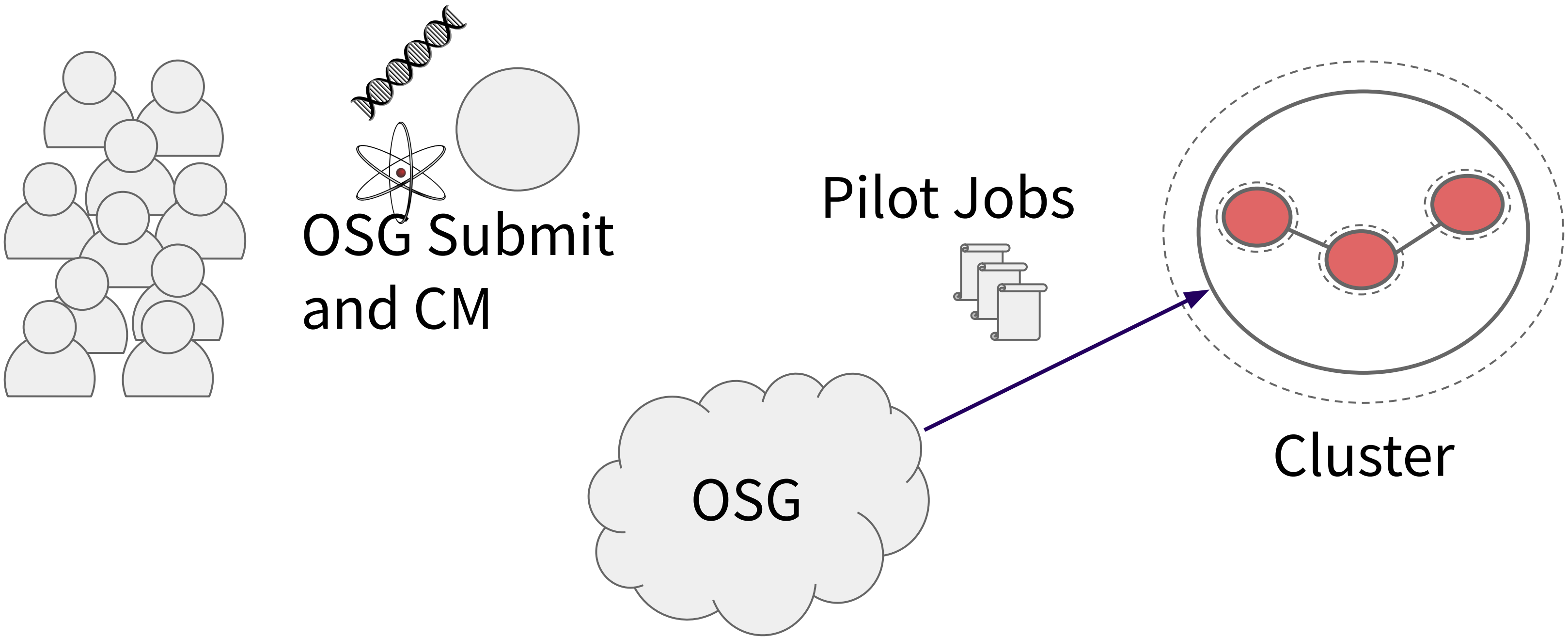
OSG Submit and CM

Pilot Jobs

OSG

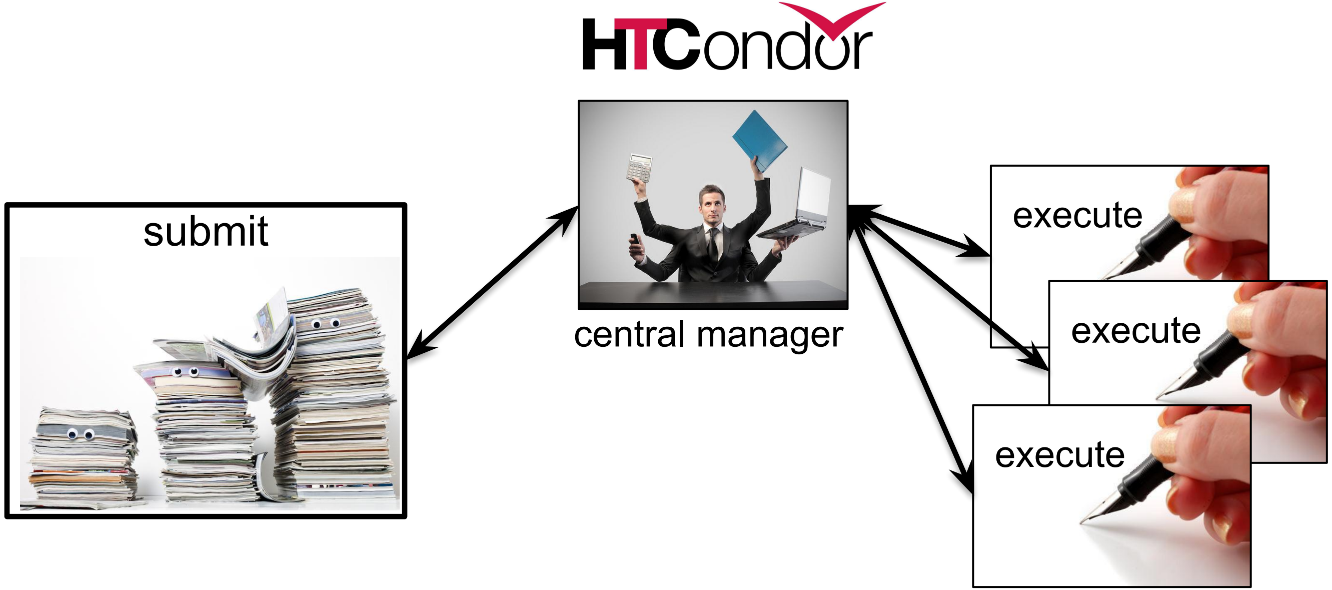
Cluster

The OSG Model

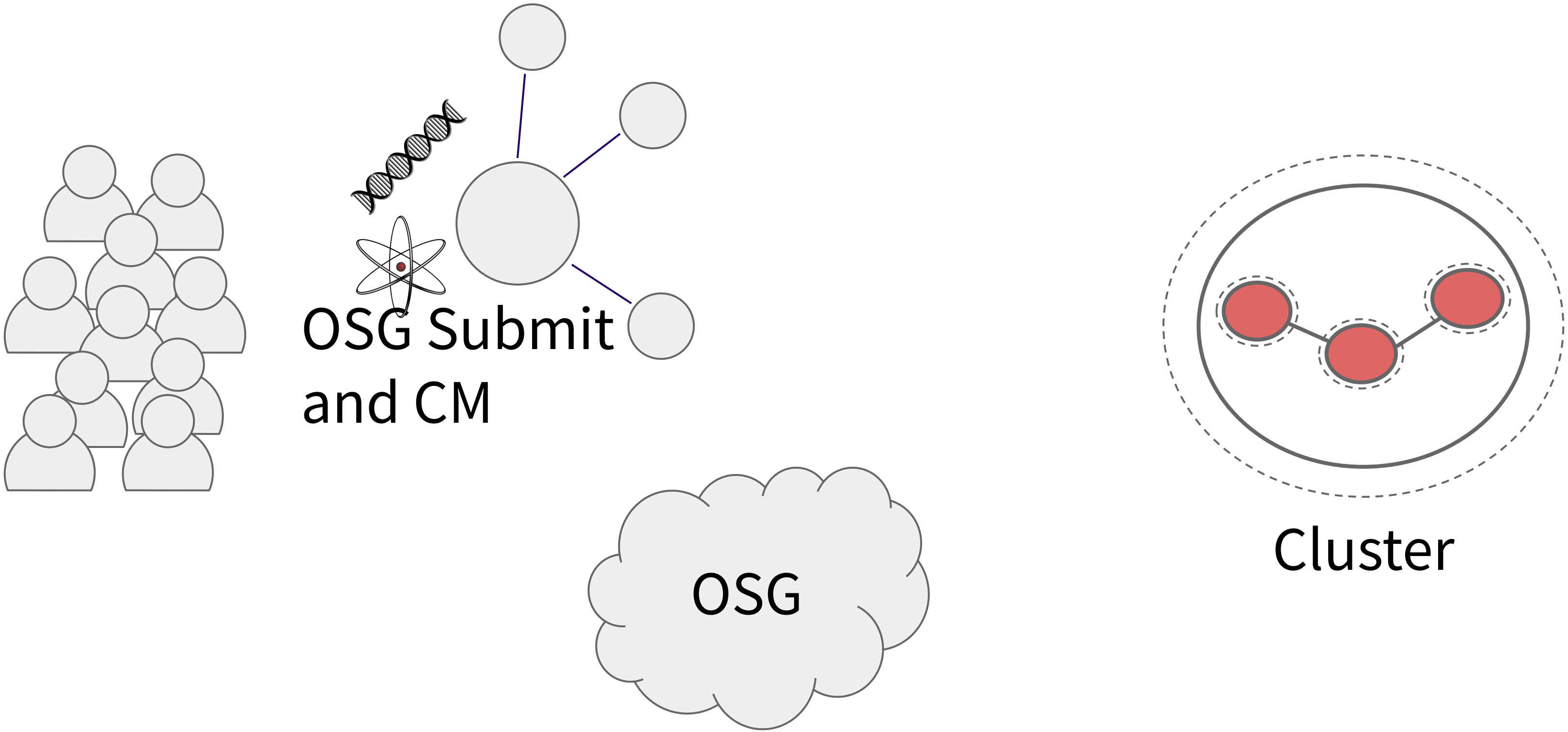


Job Matching

- On a regular basis, the central manager reviews Job and Machine attributes and matches jobs to slots.



The OSG Model



OSG Submit and CM

OSG

Cluster

The OSG Model - Jobs in Jobs

Photo Credit: Shereen M, Untitled, Flickr https://www.flickr.com/photos/shereen84/2511071028/ (CC BY-NC-ND 2.0)

#3: Share Resources - Requirements

- Minimal account management: only one submit server
- No job splitting: only one HTCondor pool
- DAG workflow functionality: Only one HTCondor pool
- HTCondor only: Only one HTCondor pool
- No resource sharing requirements: the OSG doesn’t require that users “pay into” the OSG

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The OSG Model - Recap

- Pilot jobs (or pilots) are special jobs
- Pilots are sent to sites with idle resources
- Pilot payload = HTCondor execute node software
- Pilot execute node reports to your OSG pool
- Pilots lease resources:
  - Lease expires after a set amount of time or lack of demand
  - Leases can be revoked!

The OSG Model - Leasing the Cloud

- What if there aren’t enough idle resources?
- Combine overlay system with cloud technology
- Some of your OSG jobs may run in the cloud in the next few years
- … but this should be completely transparent to you

The OSG Model - Collection of Pools

- Your OSG pool is just one of many
- Separate pools for each Virtual Organization (VO)
- Your jobs will run on the OSG VO pool

Photo by Martin Sanchez on Unsplash

The OSG Model - Getting Access

- During the school:
  - OSG submit node at UW (exercises)
  - OSG submit node via OSG Connect (exercises)
- After the school:
  - Both of the above
  - Institution-hosted submit node
  - VO-hosted submit nodes

Questions?

Overlay Systems are Awesome!

Photo by Zachary Nelson on Unsplash

What’s the Catch?

Requires more infrastructure, software, set-up, management, troubleshooting...

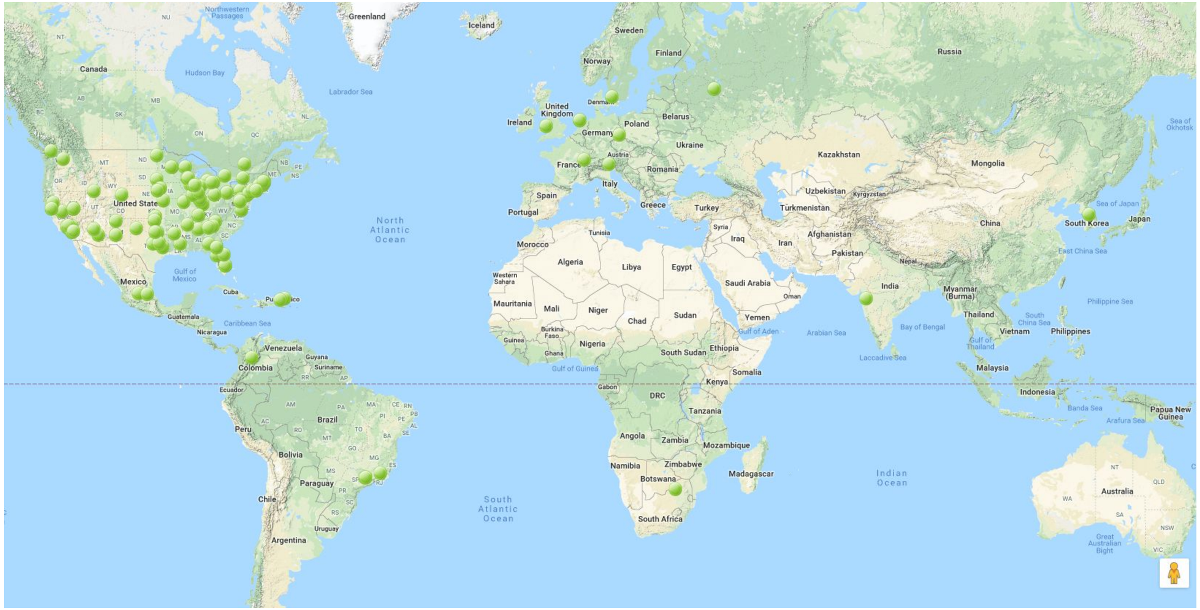
“You know you have a ***distributed system*** *when the crash of a computer you’ve never heard of stops you from getting any work done.”*

- Leslie Lamport

#1: Heterogenous Resources

Accounting for differences between the OSG and your local cluster

Sites of the OSG



Source: http://display.opensciencegrid.org/

Heterogeneous Resources - Software

- Different operating systems (Red Hat, CentOS, Scientific Linux; versions 6 and 7)
- Varying software versions (e.g., at least Python 2.6)
- Varying software availability (e.g., no BLAST*)

Solution: Make your jobs more portable: OASIS, containers, etc (more in Wednesday’s talks)

Hetero. Resources - Hardware

- CPU: Mostly single core
- RAM: Mostly < 8GB
- GPU: Limited #s but more being added
- Disk: No shared file system (more in Thursday’s talks)

Solution: Split up your workflow to make your jobs more high throughput

#2: With Great Power Comes Great Responsibility

How to be a good netizen

Resources You Don't Own

- Primary resource owners can kick you off for any reason
- No local system administrator relationships
- No sensitive data (again)!

Photo by Nathan Dumlao on Unsplash

Be a Good Netizen!

- Use of shared resources is a privilege
- Only use the resources that you request
- Be nice to your submit nodes

Solution: Test jobs on local resources with

```
condor_submit -i
```

#3: Slower Ramp Up

Leasing resources takes time!

Slower Ramp Up

- Adding slots: pilot process in the OSG vs slots already in your local pool
- Not a lot of time (~minutes) compared to most job runtimes (~hours)
  - Small trade-off for increased availability
  - Tip: If your jobs only run for < 10min each, consider combining them so each job runs for at least 30min

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Robustify Your Jobs

Succeeding in the face of failure

Job Robustification

- Test small, test often
- Specify output, error, and log files at least while you develop your workflow
- Use on_exit_hold to catch different failure modes
  - `on_exit_hold = (ExitCode =?= 3)`
  - `on_exit_hold = (time() - JobCurrentStartDate < 1 * $(HOUR))`
- For jobs that run too long:

```
periodic_hold      = (time() - JobCurrentStartDate > 4 * $(HOUR))
periodic_release       = (HoldReasonCode == 3) && (NumJobStarts < 3)
```

`HoldReasonCode` is 3 for any jobs where `on_exit_hold` or `periodic_hold` evaluate to True

Job Robustification

- In your own code:
  - Self checkpointing
  - Different exit codes for use with `on_exit_hold`
  - Defensive troubleshooting (`hostname`, `ls -l`, `pwd`, `condor_version` in your wrapper script)
  - Add simple logging (e.g. print, echo, etc)

Questions?