Dynamic Resource Provisioning for Batch Computing in the Cloud

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On behalf of the ATLAS Cloud Computing Group

Overview

- Overview of the Cloud Scheduler System
- Worker Node Virtual Machines
- Batch Configuration for Dynamic Job Requirements:
    - Single Core, Multi-Core, High Memory, etc.
- Current Deployment
- Squid Discovery with Shoal

Infrastructure-as-a-Service (IaaS) Clouds

- IaaS Cloud: A pool of virtual machine hypervisors presenting a single controller interface
  - Run many instances of one virtual machine configured for ATLAS computing
- Advantages:
  - Isolate complex application software from site administration
  - Minimize dependence on local system
  - Flexible resource allocation
- Examples:
  - OpenStack
  - Nimbus
  - Commercial clouds: Amazon, Google, etc.

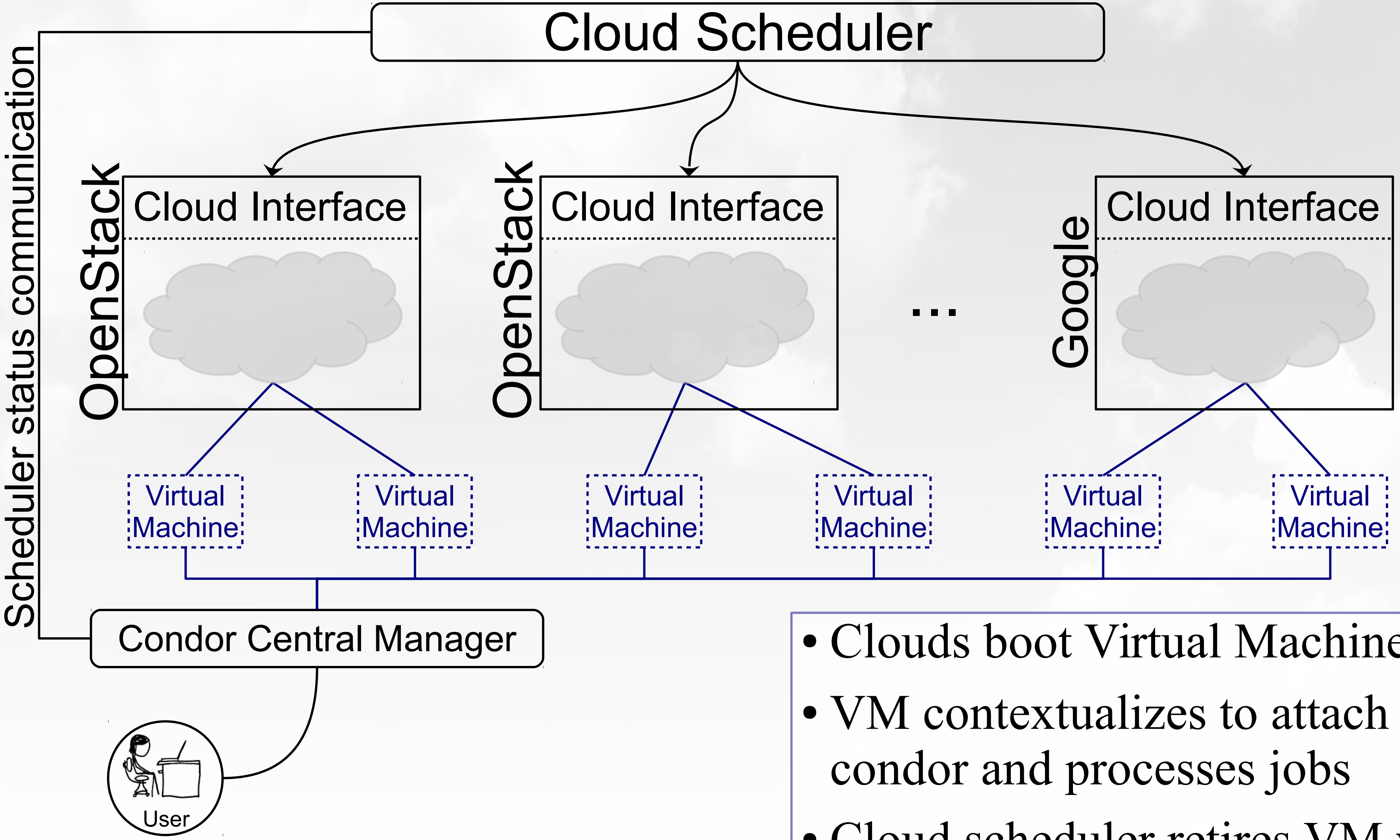
Running at labs (e.g., CERN), universities (e.g., Victoria), and research networks (e.g., GridPP)

Cloud Scheduler

- Cloud Scheduler is a python package for managing VMs on IaaS clouds
- Users submit HTCondor jobs
  - Optional attributes specify virtual machine properties
- Dynamically manages quantity and type of VMs in response to user demand
- Easily connects to many IaaS clouds, and aggregates their resources
- Provides IaaS resources in the form of an ordinary HTCondor batch system
- Used by ATLAS, Belle II, CANFAR, and BaBar

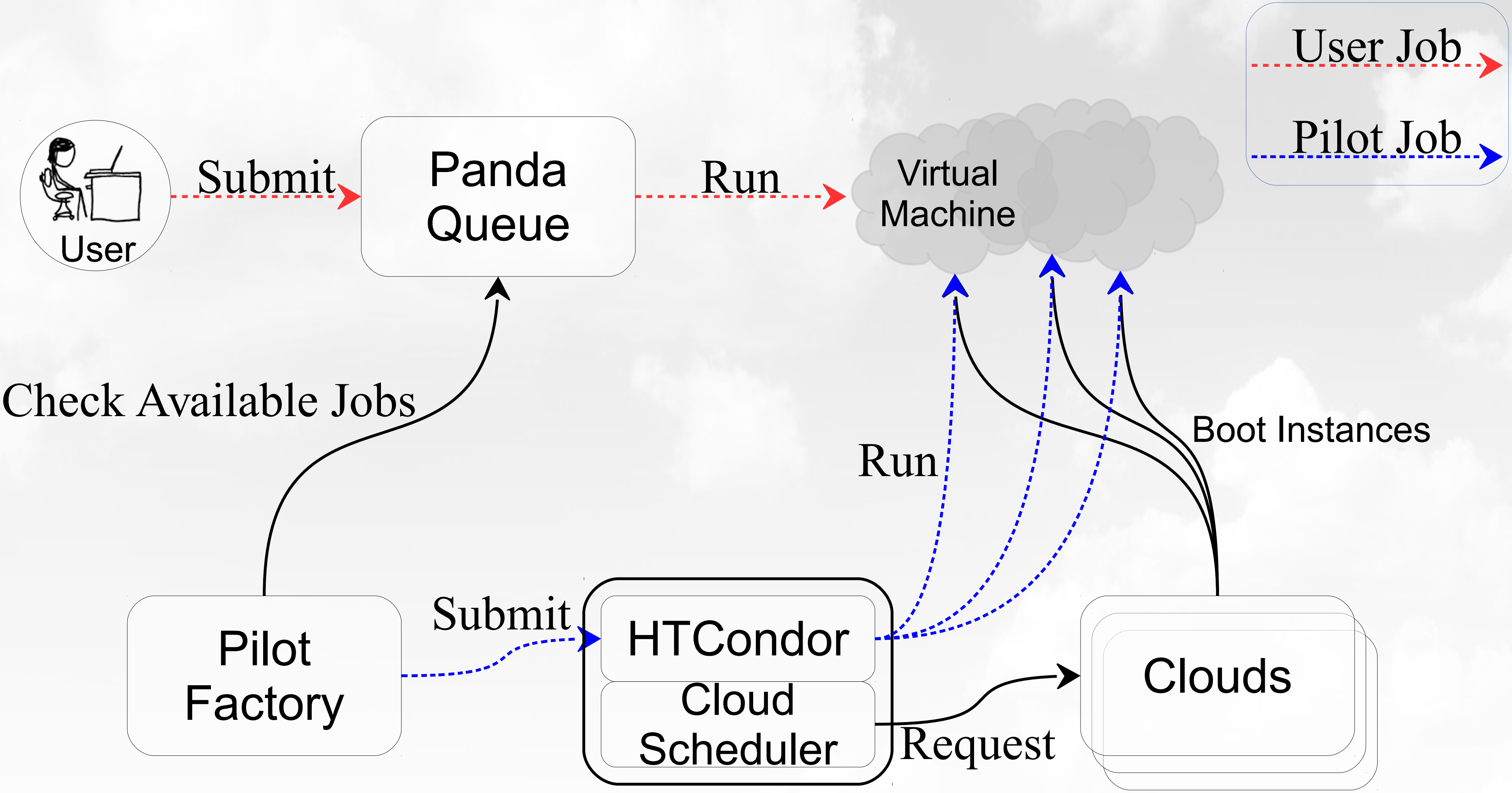
Code	https://github.com/hep-gc/cloud-scheduler
Website	http://cloudscheduler.org/
Publication	http://arxiv.org/abs/1007.0050

Cloud Scheduler



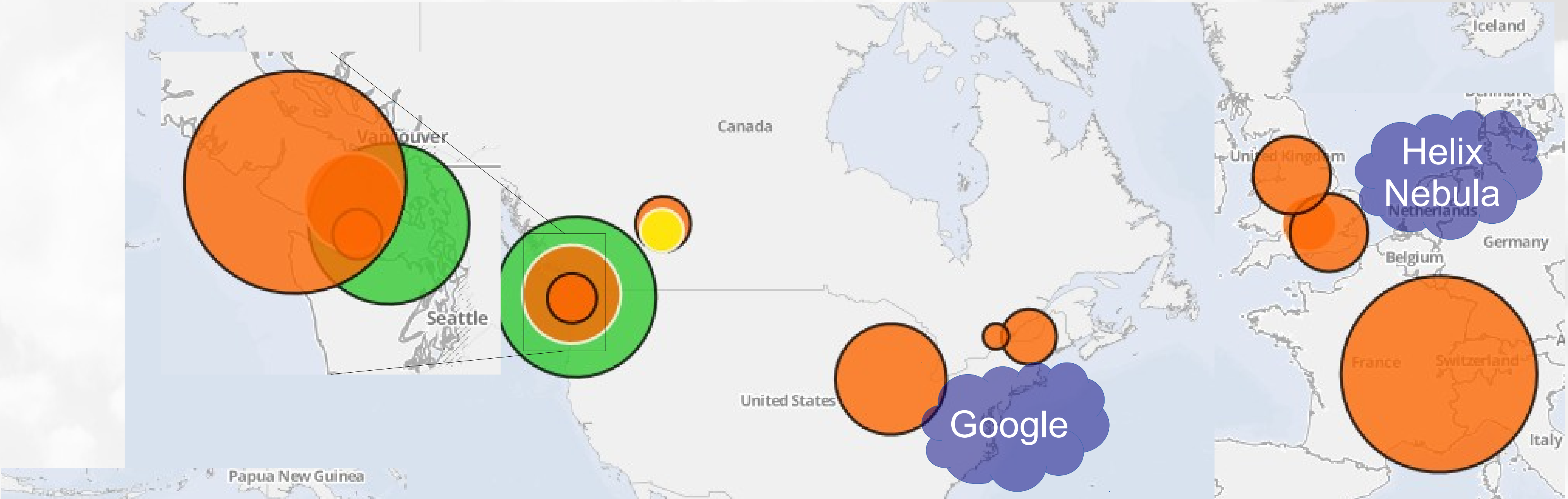
- Clouds boot Virtual Machines
- VM contextualizes to attach to the condor and processes jobs
- Cloud scheduler retires VM when no jobs require that VM

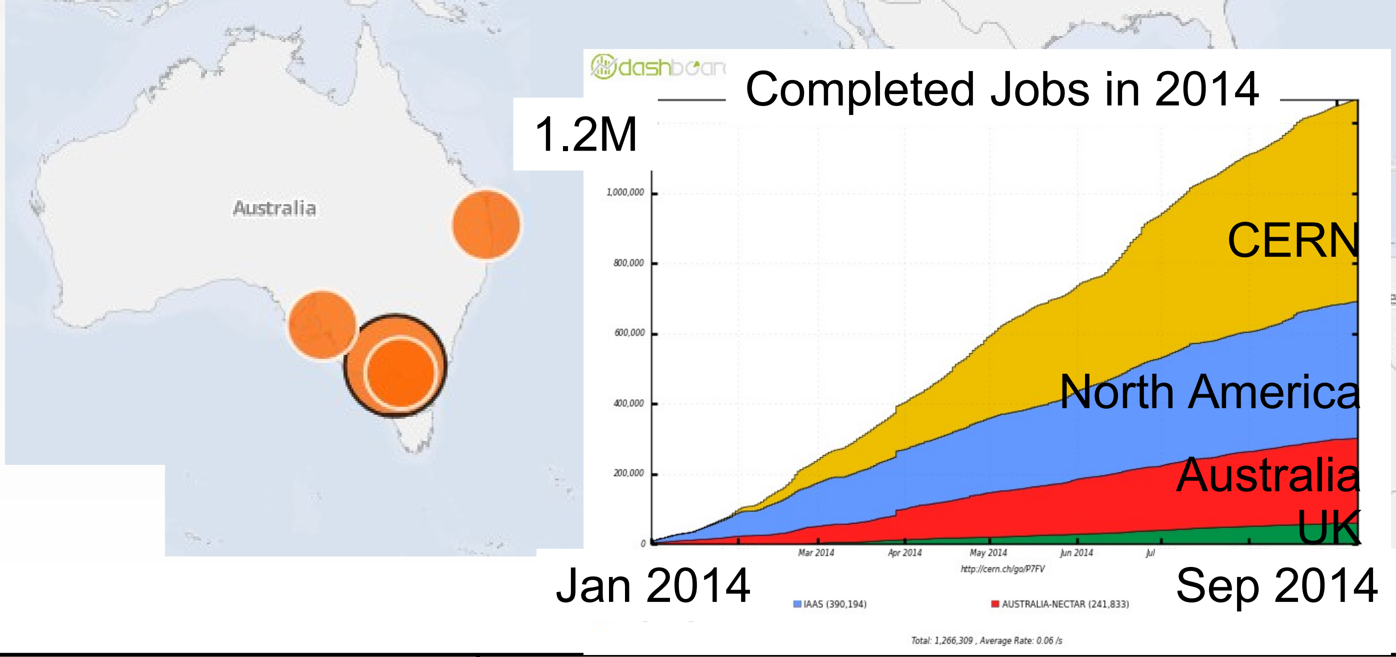
Cloud Job Flow (on the Grid)



- Easy to connect and use many clouds
- Integrated with DIRAC as well as Panda

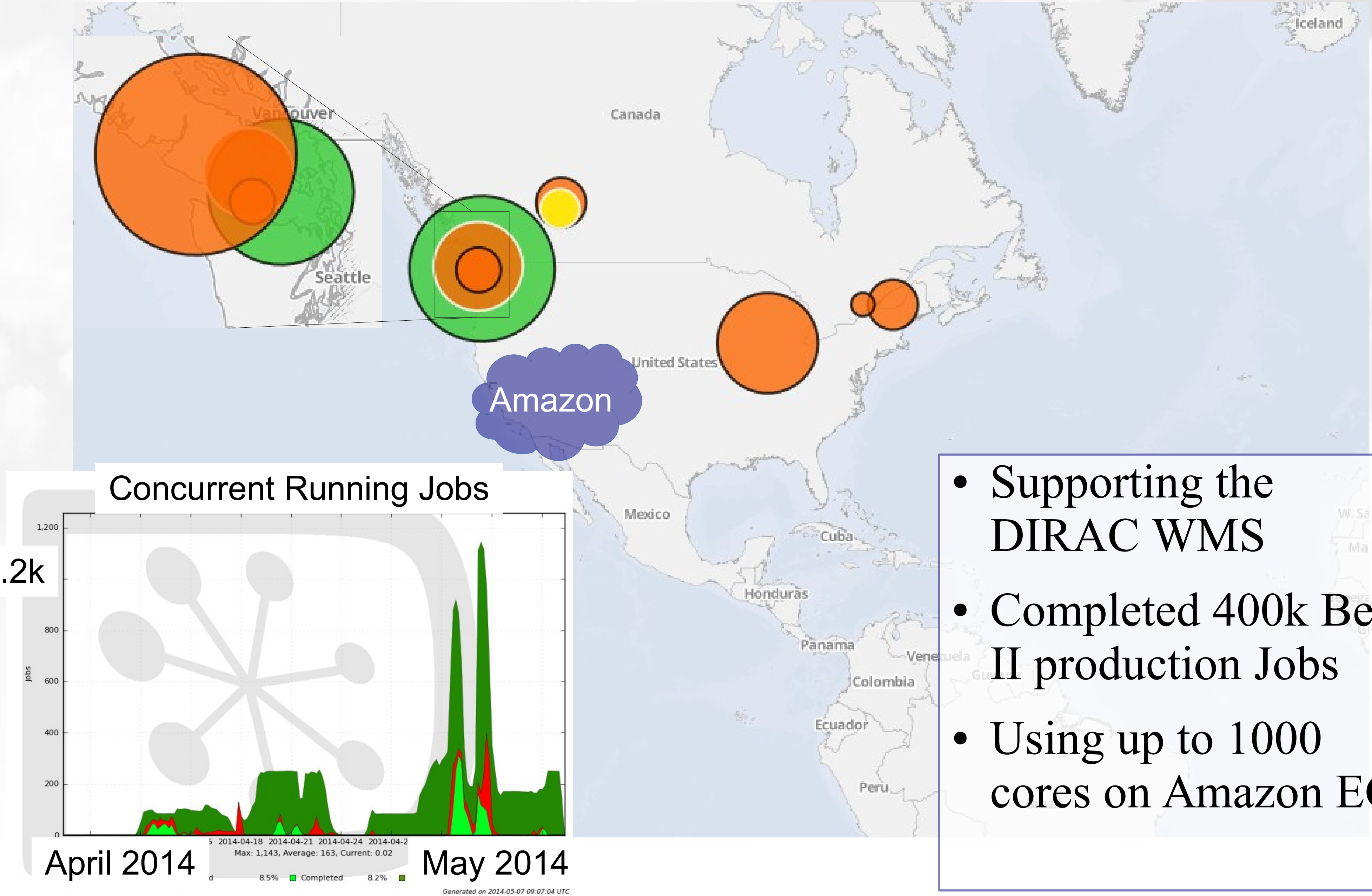
ATLAS Cloud Production in 2014





- Over 1.2M ATLAS Jobs Completed
- Mostly Single core production
- New ATLAS requirements:
  - Multi-core
  - High memory

Belle II Cloud Production in 2014



- Supporting the DIRAC WMS
- Completed 400k Belle II production Jobs
- Using up to 1000 cores on Amazon EC2

CernVM3Worker Nodes

- Features:
  - Operating system and project software is made available over cvmfs
  - Cloud-init and puppet contextualize images on boot

    https://github.com/berghaus/atlasgce-modules
    - Developed by Frank Berghaus and Henric Öhman
  - Same image works anywhere, on any Hypervisor, and on any Cloud Type
- Old static condor configuration (8-core VM):

```
NUM_SLOTS = 8
SLOT1_USER = slot01
SLOT2_USER = slot02
...
SLOT8_USER = slot08
DEDICATED_EXECUTE_ACCOUNT_REGEXP = slot[0-9]+
```

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- Dynamic Condor Slot Configuration:

```
NUM_SLOTS_TYPE_1 = 1
SLOT_TYPE_1 = cpus=100%
SLOT_TYPE_1_PARTITIONABLE = True
SLOT1_1_USER = slot01
...
SLOT1_8_USER = slot08
DEDICATED_EXECUTE_ACCOUNT_REGEXP = slot[0-9]+
```

Dynamic Batch Jobs

- **Jobs** need to specify resource requirements:

```
        request_cpus    =  2
        request_memory  =  5000     # in mbytes
        request_disk    =  10000000 # in kbytes
```

- Condor creates a dynamic slot of appropriate size on a worker node with sufficient resources

- Problem:
  - Jobs with small resource needs **fragment** worker nodes into slots with small resources
  - Jobs with large resource requirements can not run on fragmented worker nodes
- Solution: The **DEFRAG** daemon

Dynamic Batch Slots

- **Defrag** daemon cleans up unused dynamic slots (*testing*):
  - Thanks to Andrew Lahiff from RAL for their configuration details

```
DAEMON_LIST = DEFRAG

DEFRAG_INTERVAL = 600

DEFRAG_DRAINING_MACHINES_PER_HOUR = 30.0

DEFRAG_MAX_CONCURRENT_DRAINING = 60

DEFRAG_MAX_WHOLE_MACHINES = 300

DEFRAG_SCHEDULE = graceful

DEFRAG.SETTABLE_ATTRS_ADMINISTRATOR =
DEFRAG_MAX_CONCURRENT_DRAINING,DEFRAG_DRAINING_MACHINES_PER_HOUR,DEFRAG_MAX_WHOLE_MACHINES

ENABLE_RUNTIME_CONFIG = TRUE

DEFRAG_RANK = ifThenElse(Cpus >= 8, -10, (TotalCpus - Cpus)/(8.0 - Cpus))
```

Defining Target Shares

- Use condor groups to prioritize job types

```
GROUP_NAMES = group_analysis, group_production
GROUP_QUOTA_DYNAMIC_group_analysis = 0.05
GROUP_QUOTA_DYNAMIC_group_production = 0.95
GROUP_ACCEPT_SURPLUS = True
```

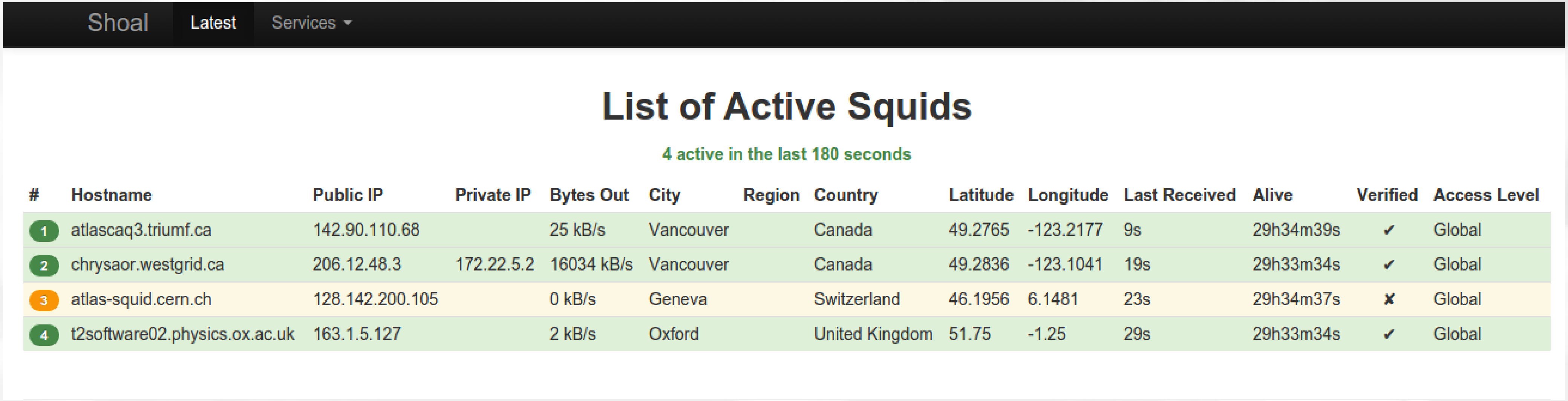
- In the job definition add:

```
AccountingGroup = "group_production" or
AccountingGroup = "group_analysis"
```

  - Thanks to Joanna Huang and Sean Crosby from the Australian ATLAS group

Relevant Tools for Distributed Computing

Shoal: Dynamic Squid Discovery



List of Active Squids

4 active in the last 180 seconds

#	Hostname	Public IP	Private IP	Bytes Out	City	Region	Country	Latitude	Longitude	Last Received	Alive	Verified	Access Level
1	atlascaq3.triumf.ca	142.90.110.68		25 kB/s	Vancouver		Canada	49.2765	-123.2177	9s	29h34m39s	✔	Global
2	chrysaor.westgrid.ca	206.12.48.3	172.22.5.2	16034 kB/s	Vancouver		Canada	49.2836	-123.1041	19s	29h33m34s	✔	Global
3	atlas-squid.cern.ch	128.142.200.105		0 kB/s	Geneva		Switzerland	46.1956	6.1481	23s	29h34m37s	✘	Global
4	t2software02.physics.ox.ac.uk	163.1.5.127		2 kB/s	Oxford		United Kingdom	51.75	-1.25	29s	29h33m34s	✔	Global

- Ready for larger scale deployment: installation instructions
- Current server: http://shoal.heprc.uvic.ca/
- Connected squids: UVic, TRIUMF, Oxford, CERN Cloud
- Included with CernVM since release 3.2
- Meets the requirements of the squid discovery task force

EMI Dynamic Federation
Thanks to Fabrizio Furano and Ryan Taylor

- High-performance
  - aggressive metadata caching in RAM
  - maximal concurrency
  - scalable
    - ~ 10^6 hit/s per core
    - 24 GB of RAM for metadata cache is enough for ~100 PB of data in end-points
- Well-designed
  - stateless, no persistency
  - standard components and protocols, not HEP-specific
  - general-purpose solution; could be adopted by multiple experiments
  - trivial to add endpoints; **no site action needed!**
- Data access
  - automatically download from nearest endpoint, or
  - download from all endpoints simultaneously (metalink + aria2)

EUROPEAN MIDDLEWARE INITIATIVE

Summary & Outlook

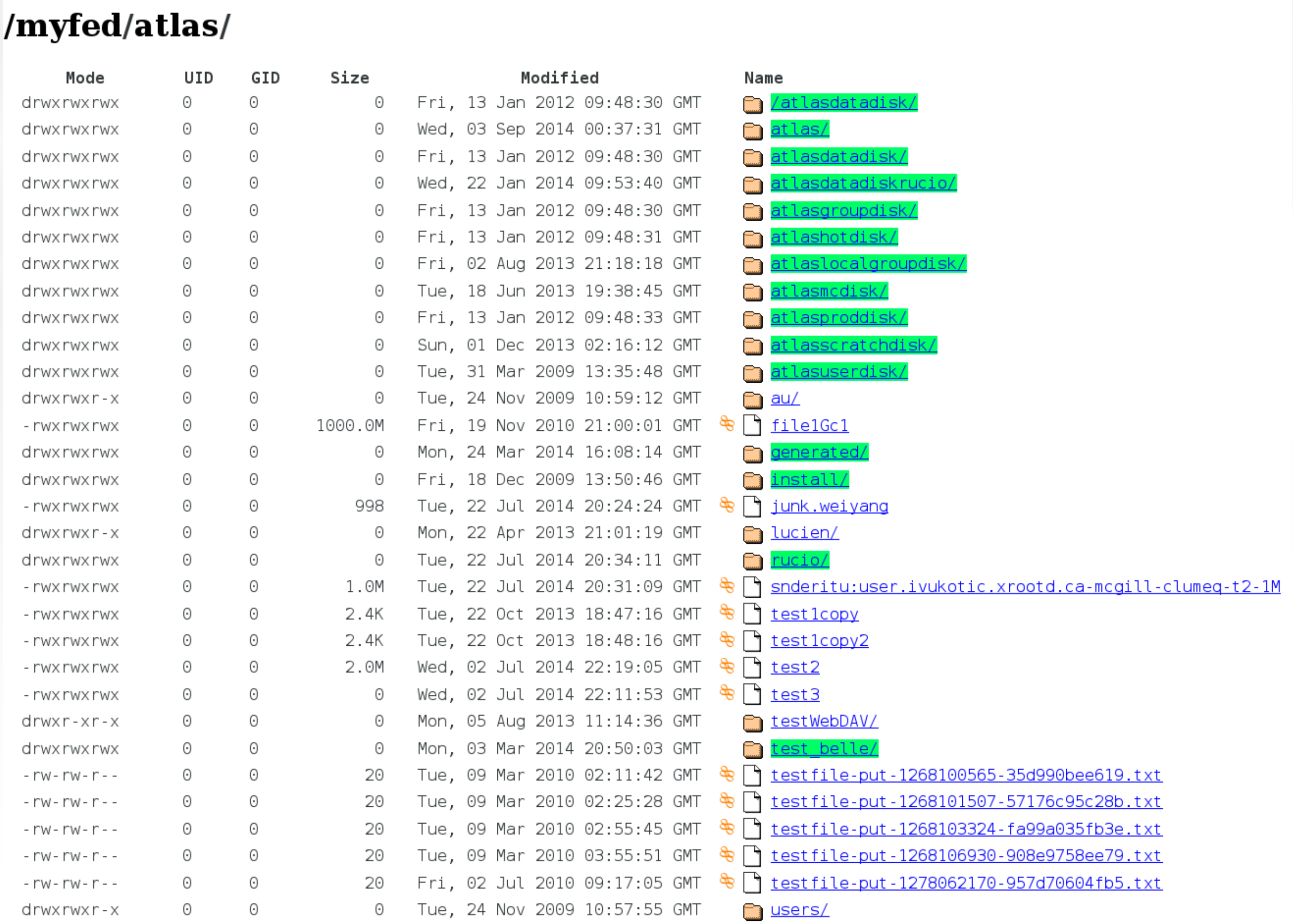
- ATLAS and Belle II Production is running on IaaS clouds
  - Over 1.2M ATLAS jobs completed in 2014
  - Dynamically allocating resources for single and multi core job requirements
  - Planning to test high memory jobs
- Dynamic resource allocation allows quick creation of necessary resources
- Aggregating many computing resources into few batch queues
- Share resources between projects
- Using micro-kernel CernVM3
- Automated squid discovery for cvmfs
- Deploying Dynamic Federation as data access solution

Backup

Federator Deployment

http://ugr.heprc.uvic.ca/myfed/atlas/

- Simple, lightweight. Easy to set up (a few person-days of effort)
- Contains all SEs in CA and AU



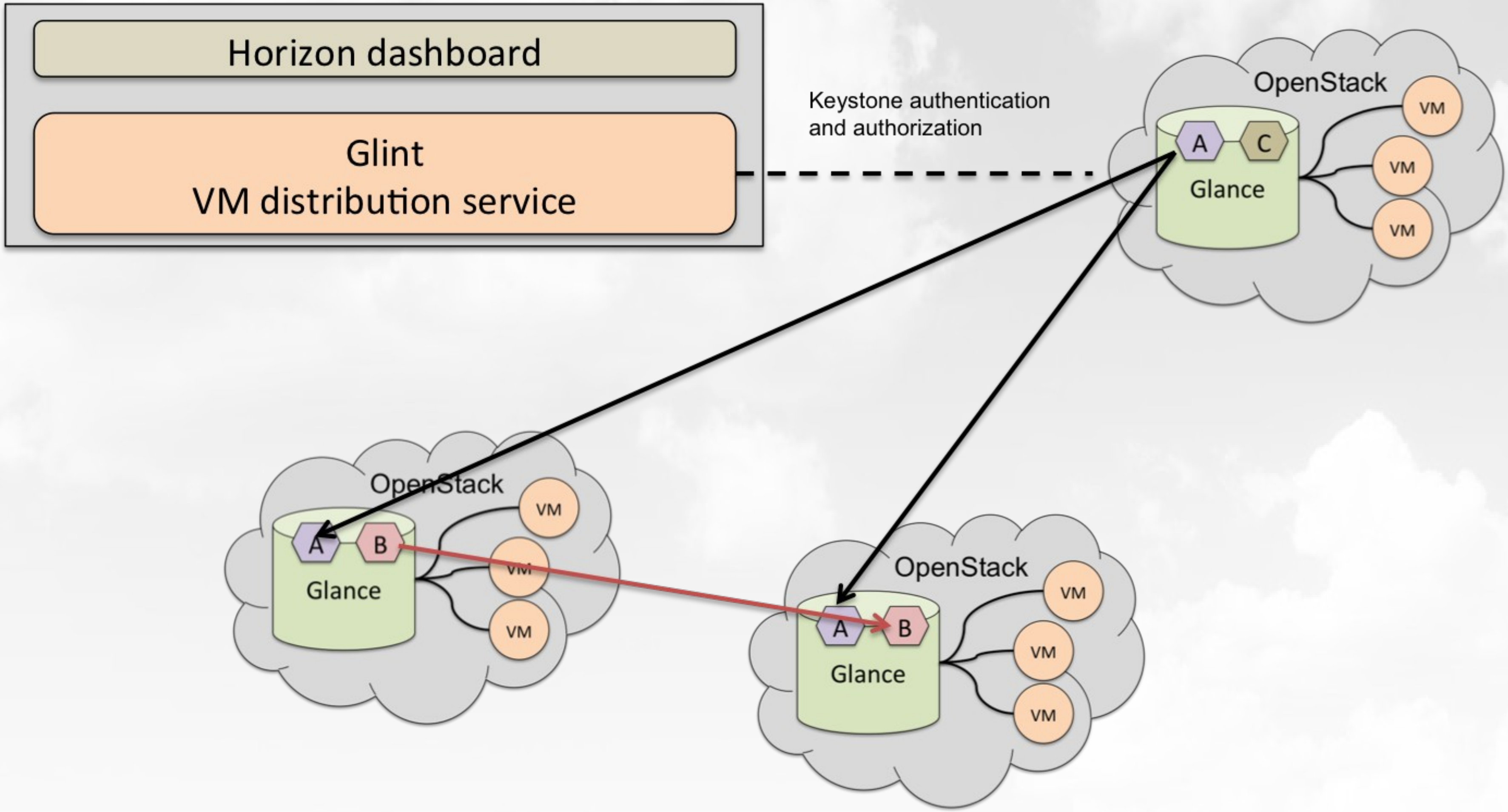
/myfed/atlas/

Mode	UID	GID	Size	Modified	Name
drwxrwxrwx	0	0	0	Fri, 13 Jan 2012 09:48:30 GMT	/atlasdatadisk/
drwxrwxrwx	0	0	0	Wed, 03 Sep 2014 00:37:31 GMT	atlas/
drwxrwxrwx	0	0	0	Fri, 13 Jan 2012 09:48:30 GMT	atlasdatadisk/
drwxrwxrwx	0	0	0	Wed, 22 Jan 2014 09:53:40 GMT	atlasdatadiskrucio/
drwxrwxrwx	0	0	0	Fri, 13 Jan 2012 09:48:30 GMT	atlasgroupdisk/
drwxrwxrwx	0	0	0	Fri, 13 Jan 2012 09:48:31 GMT	atlashotdisk/
drwxrwxrwx	0	0	0	Fri, 02 Aug 2013 21:18:18 GMT	atlaslocalgroupdisk/
drwxrwxrwx	0	0	0	Tue, 18 Jun 2013 19:38:45 GMT	atlasmcdisk/
drwxrwxrwx	0	0	0	Fri, 13 Jan 2012 09:48:33 GMT	atlasproddisk/
drwxrwxrwx	0	0	0	Sun, 01 Dec 2013 02:16:12 GMT	atlasscratchdisk/
drwxrwxrwx	0	0	0	Tue, 31 Mar 2009 13:35:48 GMT	atlasuserdisk/
drwxrwxr-x	0	0	0	Tue, 24 Nov 2009 10:59:12 GMT	au/
-rwxrwxrwx	0	0	1000.0M	Fri, 19 Nov 2010 21:00:01 GMT	file1Gc1
drwxrwxrwx	0	0	0	Mon, 24 Mar 2014 16:08:14 GMT	generated/
drwxrwxrwx	0	0	0	Fri, 18 Dec 2009 13:50:46 GMT	install/
-rwxrwxrwx	0	0	998	Tue, 22 Jul 2014 20:24:24 GMT	junk.weiyang
drwxrwxr-x	0	0	0	Mon, 22 Apr 2013 21:01:19 GMT	lucien/
drwxrwxrwx	0	0	0	Tue, 22 Jul 2014 20:34:11 GMT	rucio/
-rwxrwxrwx	0	0	1.0M	Tue, 22 Jul 2014 20:31:09 GMT	snderitu:user.ivukotic.xrootd.ca-mcgill-clumeq-t2-1M
-rwxrwxrwx	0	0	2.4K	Tue, 22 Oct 2013 18:47:16 GMT	test1copy
-rwxrwxrwx	0	0	2.4K	Tue, 22 Oct 2013 18:48:16 GMT	test1copy2
-rwxrwxrwx	0	0	2.0M	Wed, 02 Jul 2014 22:19:05 GMT	test2
-rwxrwxrwx	0	0	0	Wed, 02 Jul 2014 22:11:53 GMT	test3
drwxr-xr-x	0	0	0	Mon, 05 Aug 2013 11:14:36 GMT	testWebDAV/
drwxrwxrwx	0	0	0	Mon, 03 Mar 2014 20:50:03 GMT	test_belle/
-rw-rw-r--	0	0	20	Tue, 09 Mar 2010 02:11:42 GMT	testfile-put-1268100565-35d990bee619.txt
-rw-rw-r--	0	0	20	Tue, 09 Mar 2010 02:25:28 GMT	testfile-put-1268101507-57176c95c28b.txt
-rw-rw-r--	0	0	20	Tue, 09 Mar 2010 02:55:45 GMT	testfile-put-1268103324-fa99a035fb3e.txt
-rw-rw-r--	0	0	20	Tue, 09 Mar 2010 03:55:51 GMT	testfile-put-1268106930-908e9758ee79.txt
-rw-rw-r--	0	0	20	Fri, 02 Jul 2010 09:17:05 GMT	testfile-put-1278062170-957d70604fb5.txt
drwxrwxr-x	0	0	0	Tue, 24 Nov 2009 10:57:55 GMT	users/

Federator Software Components

- Uniform Generic Redirector (UGR)
  - Core component containing all federation logic
  - Integrated as a plugin of Apache
- Apache HTTP server
  - Frontend to clients
  - Handles client redirection
- Memcached
  - for 2nd-level shared metadata caching in RAM
- DMLite
  - Name translations for unifying grid storage endpoints

Glint: Image Distribution Service



- Addition to OpenStack (see November OS summit)
- Relies on **glance** for image management and **keystone** for authentication
- User interface in horizon dashboard
- Works on OpenStack, Amazon EC2, Google's GCE, and Nimbus