Jetstream – Early Operations
Performance, Adoption, and Impacts

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What is “the” Jetstream?

- Fast moving air currents
- Hot/Cold air boundaries
- An NSF-funded cloud environment

NASA’s Suomi NPP satellite collected this natural-color image using the VIIRS (Visible Infrared Imaging Radiometer Suite) instrument on Sept. 4, 2017. Actively burning areas are outlined in red. NASA image courtesy Jeff Schmaltz LANCE/EOSDIS MODIS Rapid Response Team, GSFC
National Science Foundation – Funding in HPC

- Traditionally concentrated on enabling peta-scale capability via track I/II programs
  - Blue Waters – 13.3 petaflops, 2012 (under re-compete)
  - Stampede – 9.6 petaflops, 2013 (extended to Stampede 2)
  - Comet – ~2.0 petaflops, 2014
- Have funded research into building clouds and computer science testbeds
  - CloudLab
  - Chameleon (renewed for second phase)
- Now funding clouds to do research
  - Bridges (Hybrid system)
  - Jetstream

http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604
What is Jetstream and why does it exist?

• NSF’s first production cloud facility
• Focus on ease-of-use, broad accessibility
• Encourage collaboration and community development
• User-selectable library of preconfigured virtual machines
• Provides on-demand interactive computing and analysis or persistent services such as gateways (e.g. SEAGrid, Galaxy, GenApp, and others)
• Enables configurable environments and programmable cyberinfrastructure
• Reproducibility: Share VMs and then store, publish via IU Scholarworks (DOI)
Jetstream – Expanding NSF XD’s reach and impact

Around 350,000 researchers, educators, & learners received NSF support in 2015

- **Less than 2%** completed a computation, data analysis, or visualization task on XD/XSEDE program resources
- Less than 4% had an XSEDE Portal account
- **70%** of researchers surveyed* claimed to be resource constrained

Why are the people not using XD/XSEDE systems not using them?

- Perceived **ease of access** and use
- HPC resources – the traditional view of what XSEDE offers - are often **not well-matched** to their needs
- They just don’t need **that much** capability

*XSEDE Cloud Survey Report - http://hdl.handle.net/2142/45766
Who uses Jetstream?

- The researcher needing a handful of cores (1 to 44/vCPU)
- Software creators and researchers needing to create their own customized virtual machines and workflows
- Science gateway creators using Jetstream as either the frontend or processor for scientific jobs
- STEM Educators teaching on a variety of subjects
What Jetstream isn’t…

- It’s not traditional HPC
- There’s no shared filesystem (think cloudy!)
- There’s no high-end interconnect fabric (keep thinking cloudy!)
- There aren’t GPUs (yet…stay tuned)
- It isn’t Amazon, Azure, or GCE (similar, but…)
Jetstream and way of the cloud...

• **Cloudy Technologies**: clouds are more the just virtual machines (VM)
  • **Old way**: robust (expensive) infrastructure, weak (cheap) software
    • You expect the hardware to not fail
    • State in maintained in volatile data structures
  • **Cloudy way**: commodity infrastructure, robust software
    • Expect & plan for infrastructure to fail
    • Put intelligence into the software to handle infrastructure failure
• **And my favorite**...
Thinking about VMs…

• Cattle, not pets: pets take great amount of care, feeding, and you name them; cattle you intend to have high turnover and you give them numbers.

-- Mike Lowe (Jetstream architect)

** Some caveats for gateways, but…
# Production cloud hardware (per site)

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Number</th>
<th>Specifications</th>
<th>Function (IU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dell PowerEdge M630 blades</td>
<td>320</td>
<td>2x Intel E5-2680v3 “Haswell” 24 cores @ 2.5 GHz 128 GB RAM 2 TB local disk</td>
<td>Compute hosts OpenStack services</td>
</tr>
<tr>
<td>Dell PowerEdge R630 1U server</td>
<td>7</td>
<td>2x Intel E5-2680v3 “Haswell” 24 cores @ 2.5 GHz 128 GB RAM 2 TB local disk</td>
<td>Cluster management High Availability</td>
</tr>
<tr>
<td>Dell PowerEdge R730xd 2U servers</td>
<td>20</td>
<td>2x Intel E5-2680v3 “Haswell” 24 cores @ 2.5 GHz 64 GB RAM 48 TB storage for</td>
<td>~1 PB Ceph storage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ceph pool</td>
<td></td>
</tr>
<tr>
<td>Dell S6000-ON network switches</td>
<td>9</td>
<td>32+2 40 Gb/s ports</td>
<td>Top of Rack Spine</td>
</tr>
</tbody>
</table>
Platform Overview

Atmosphere	API
Globus	Auth
Atmo Services
XSEDE	Accounting
OpenStack
Ceph
Web App

Indiana University
TACC
What is Jetstream, continued...

• Software layers
  • **Atmosphere** web interface
    • library of images, generic, domain specific
    • simplify VM administration
  • **OpenStack**: software tools for building and managing cloud computing platforms for public and private clouds.
  • **KVM** hypervisor: what the VMs run on
  • **Ceph**: storage platform that stores data on a single distributed computer cluster, and provides interfaces for object-, block- and file-level storage.
  • **Operating systems**: CentOS, Ubuntu, Windows?
  • **Applications**: e.g. software developed by the domain specialist, gateways, etc.
Jetstream’s Atmosphere interface

https://use.jetstream-cloud.org/
(no login required to this point)
Jetstream’s Atmosphere interface

(Select identity provider)
Jetstream’s Atmosphere interface

Welcome to the XSEDE’s Client Authorization Page

Science Gateway Access

The XSEDE Science Gateway or Service below is requesting access to your XSEDE account. If you approve, please sign in.

Name: Globus
URL: http://www.globus.org/

Please send any questions or comments about this site to help@cecc.gwu.edu
Jetstream’s Atmosphere interface (user’s home space)
Hardware and instance "flavors"

<table>
<thead>
<tr>
<th>Flavor</th>
<th>vCPUs</th>
<th>RAM</th>
<th>Storage</th>
<th>Per Node</th>
</tr>
</thead>
<tbody>
<tr>
<td>tiny</td>
<td>1</td>
<td>2</td>
<td>8</td>
<td>46</td>
</tr>
<tr>
<td>small</td>
<td>2</td>
<td>4</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>medium</td>
<td>6</td>
<td>16</td>
<td>60</td>
<td>7</td>
</tr>
<tr>
<td>large</td>
<td>10</td>
<td>30</td>
<td>120/60*</td>
<td>4</td>
</tr>
<tr>
<td>xlarge</td>
<td>24</td>
<td>60</td>
<td>240/60*</td>
<td>2</td>
</tr>
<tr>
<td>xxlarge</td>
<td>44</td>
<td>120</td>
<td>480/60*</td>
<td>1</td>
</tr>
</tbody>
</table>

- Short-term storage comes as part of launched instance
- Long-term storage is XSEDE-allocated
- *Flavors updated March 2017, storage-rich flavors are not imaged
Jetstream usage highlights

As of October 2017:
• 360 active XSEDE projects covering 66 fields of science and **2180 active users** representing **191 institutions**
• **86%** of Jetstream users new to XSEDE (at end of PY1)
• >76 million CPU hours allocated to XSEDE projects since June 2016
• **9** science gateways
• **42** education/teaching allocations serving almost 800 students
• Averaging **816 concurrent VMs**
• **100%** system availability, **99.4%** cap availability
• **97.7%** “job” completion (at end PY1)
Not just the usual suspects...

Physics, chemistry, and other “usual” HPC suspects are represented, but Jetstream also is home to projects on:

- Financial analysis / Economics
- Political science
- Humanities / Text analysis
- Network analysis
- Computer Science / Machine learning
- Satellite data analysis
<table>
<thead>
<tr>
<th>Discipline or area of interest</th>
<th># of Jetstream allocations</th>
<th>SUs allocated on Jetstream</th>
<th>% of SUs allocated on Jetstream</th>
<th>% of all SUs allocated on other XSEDE-supported systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astronomy</td>
<td>2</td>
<td>1,108,096</td>
<td>3.04%</td>
<td>8.61%</td>
</tr>
<tr>
<td>Atmospheric Sciences</td>
<td>4</td>
<td>2,752,400</td>
<td>7.55%</td>
<td>3.73%</td>
</tr>
<tr>
<td>Biological Sciences</td>
<td>57</td>
<td>5,199,000</td>
<td>14.27%</td>
<td>4.95%</td>
</tr>
<tr>
<td>Campus/Domain Champions</td>
<td>123</td>
<td>6,105,500</td>
<td>16.76%</td>
<td>0.09%</td>
</tr>
<tr>
<td>Computational Science</td>
<td>11</td>
<td>1,150,000</td>
<td>3.16%</td>
<td>0.92%</td>
</tr>
<tr>
<td>Computer Science</td>
<td>15</td>
<td>4,944,302</td>
<td>13.57%</td>
<td>1.8%</td>
</tr>
<tr>
<td>Education Allocations</td>
<td>24</td>
<td>2,847,600</td>
<td>7.82%</td>
<td>0.01%</td>
</tr>
<tr>
<td>Engineering</td>
<td>1</td>
<td>100,000</td>
<td>0.27%</td>
<td>3.81%</td>
</tr>
<tr>
<td>Geosciences</td>
<td>10</td>
<td>1,978,400</td>
<td>5.43%</td>
<td>2.87%</td>
</tr>
<tr>
<td>Humanities/Social Sciences</td>
<td>10</td>
<td>560,000</td>
<td>1.54%</td>
<td>0.45%</td>
</tr>
<tr>
<td>Molecular Biosciences</td>
<td>8</td>
<td>4,647,520</td>
<td>12.75%</td>
<td>17.65%</td>
</tr>
<tr>
<td>Network Science</td>
<td>3</td>
<td>200,000</td>
<td>0.55%</td>
<td>0.06%</td>
</tr>
<tr>
<td>Ocean Science</td>
<td>3</td>
<td>230,000</td>
<td>0.63%</td>
<td>1.30%</td>
</tr>
<tr>
<td>Physics</td>
<td>4</td>
<td>2,252,400</td>
<td>6.18%</td>
<td>16.43%</td>
</tr>
<tr>
<td>Training &amp; Development</td>
<td>11</td>
<td>2,362,000</td>
<td>6.48%</td>
<td>0.16%</td>
</tr>
</tbody>
</table>
About those gateways...

- **IRIS**
  - Serving large scale earthquake and geographical data for analysis
- **Unidata**
  - Providing distribution and analysis of meteorological data
- **OpenMRS**
  - Providing medical records systems for the resource-constrained
- **SEAGrid**
  - Computational chemistry, molecular and fluid dynamics, and structural mechanics gateway
- **NAMDRunner**
  - Based on the GenApp gateway – over 1 million computing hours used to date for MD
- **Coming gateways:** CIPRES Gateway, The Neuroscience Gateway, ChemCompute gateway, UltraScan III
Galaxy riding Jetstream

- Galaxy is a platform for biomedical research, focused on accessibility, transparency and reproducibility
  - The main project instance (usegalaxy.org) has more than 100,000 registered users executing 300,000+ jobs each month
  - Many users need more capacity than the public quota, or other customizations (e.g., new tools)

Use Jetstream as a **bursting** platform
- From Galaxy Main, offload jobs onto a remote Slurm cluster running on Jetstream instances
- Run Galaxy Interactive Environments (i.e., Dockerized iPython/RStudio containers) in an isolated environment on a Swarm cluster running on Jetstream

Use Jetstream as a **self-service** platform
- Pre-built Galaxy image configured with hundreds of tools and access to TBs of genomic reference data, available via the self-launch model within minutes
- Allows users to acquire (free) resources, and gives them complete control

funded by the National Science Foundation
Award #ACI-1445604
Jetstream Galaxy bursting: ~10K unique users, 115K jobs

< 5% of the Jobs

15–20% of the CPU time

Disk throughput is important

Now leveraging containers and Jupyter Notebooks
HPC vs Cloud

• Adapting to a different environment:
• No reservations, no queueing
• More interactive use and less/no batch queuing
• What? No parallel filesystem?!?
• Being your own admin – hey, we have root!
• You really can have almost any (Linux) software you want**
• Constantly getting new features
  – ** Here there be dragons…

http://jetstream-cloud.org/ funded by the National Science Foundation Award #ACI-1445604
PY1 Challenges

• Outreach efforts largely funded by IU and partners
• Barriers to XSEDE adoption in general
• XRAC process cumbersome to intended audience
• User support needs are significant
• Can be intimidating to port traditional HPC workflows
Jetstream REU Program 2017

- NSF Supplement for 4 undergraduates
- Looking to recruit 4-6 students for 2018

- REU student videos on YouTube
  https://www.youtube.com/user/IUPTI

- News release describing their experiences
  https://itconnections.iu.edu/2017-august/jetstream.php
Requesting access to Jetstream

- Trial allocations available **TODAY**
- You can request startup allocations anytime.
- You can request allocations for educational use anytime.
- Next submission period for large allocations is 15 December 2017 – 15 January 2018.
- We are happy to help you prepare a request and create a successful proposal.
- You do not have to have prior use of Jetstream to be successful.
- You do need a US-based collaborator
PY2 Plans

- Enabling better Jupyter deployments for training and research
- Continue improving trial allocations
- More videos/training
- Encouraging orchestration for more communities
- Image build repository (proposed to XSEDE for funding)
PY2 plans continued...

• Partner with XSEDE Campus Champions and ACI-REF Facilitators to do tutorials for interested under-served researchers

• Explore better ways to communicate with the user community and to allow them to communicate with each other

• Develop additional domain science images with input from the Jetstream and XSEDE community

• Begin work on Windows VM adaptation for Jetstream API if licensing can be resolved
Jetstream partners
Help / References


User guides: https://portal.xsede.org/user-guides

XSEDE KB: https://portal.xsede.org/knowledge-base

Email: help@xsede.org

Campus Champions: https://www.xsede.org/campus-champions

Paper describing Jetstream: Jetstream: A self-provisioned, scalable science and engineering cloud environment

Configuration management: https://github.com/jetstream-cloud/Jetstream-Salt-States
Questions?

Project email: help@jetstream-cloud.org Direct email: dyh@iu.edu

License Terms

- Jetstream is supported by NSF award 1445604 (Craig Stewart, IU, PI)
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Things left behind…

Flickr user Oiluj Samall Zeid - Lejos de Yulín
Just for fun: Happy Cluster – Mad Cluster