Jetstream Overview:
A national research and education cloud

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UIT Research Technologies

NSF Funding Areas in HPC

Traditionally concentrated on enabling petascale capability
- Blue Waters – 13.3 petaflops, 2012 (under re-compete)
- Stampede – 9.6 petaflops, 2013 (extended to Stampede2 in 2017 – 18 petaflops)
- Comet – ~2.0 petaflops, 2014

Has funded research into building clouds and computer science
- CloudLab (renewed for 2\textsuperscript{nd} phase)
- Chameleon (renewed for 2\textsuperscript{nd} phase)

Now funding clouds to do research
- Bridges (Hybrid system)
- Jetstream
Lots of stats below –

tl;dr summary: no one has enough computing resources…but most aren’t using XSEDE in any capacity at all.

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

http://jetstream-cloud.org/
Identifying the potential users

“But I really don’t have research needs… I don’t need the national research cyberinfrastructure.”

--- multiple researchers at a number of small colleges and universities
What is Jetstream and why does it exist?

- NSF’s first production cloud facility
- Part of the NSF eXtreme Digital (XD) program
- Focus on ease-of-use, broad accessibility
- Provides on-demand *interactive* computing and analysis or persistent gateways
- Enables *configurable* environments and *programmable* cyberinfrastructure
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…)

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HPC vs Cloud

Adapting to a different environment:

• No reservations, no queueing – more interactive usage
• Being your own admin – hey, we have root!**
• You really can have almost any (linux) software you want**
• Constantly getting new features (https://www.openstack.org/software/project-navigator/)

** Here there be dragons…
Jetstream and way of the cloud…

• **Cloudy Technologies**: clouds are more than 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…

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

-- Mike Lowe (Jetstream architect)

**some caveats for gateways…
Jetstream System Overview

Jetstream (production)
- IU Cyberinfrastructure
  - Compute: 320 Nodes, 7,680 Cores, 40 TB RAM, 640 TB local disk
  - Storage: 960 TB

Jetstream (production)
- TACC Cyberinfrastructure
  - Compute: 320 Nodes, 7,680 Cores, 40 TB RAM, 640 TB local disk
  - Storage: 960 TB

Jetstream (development)
- U of Arizona Cyberinfrastructure
  - Compute: 16 Nodes, 2 TB RAM, 384 Cores, 32 TB local disk

Internet2

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http://jetstream-cloud.org/
## 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</td>
<td>Compute hosts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>128 GB RAM</td>
<td>OpenStack services</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 TB local disk</td>
<td></td>
</tr>
<tr>
<td>Dell PowerEdge R630 1U server</td>
<td>7</td>
<td>2x Intel E5-2680v3 “Haswell” 24 cores @ 2.5 GHz</td>
<td>Cluster management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>128 GB RAM</td>
<td>High Availability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 TB local disk</td>
<td>Databases</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RabbitMQ</td>
</tr>
<tr>
<td>Dell PowerEdge R730xd 2U servers</td>
<td>20</td>
<td>2x Intel E5-2680v3 “Haswell” 24 cores @ 2.5 GHz</td>
<td>~1 PB Ceph storage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>64 GB RAM</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>48 TB storage for 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</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Spine</td>
</tr>
</tbody>
</table>
Platform Overview

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

Indiana University

TACC
The Jetstream Atmosphere web interface
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>

** s1.* storage-rich instances are not eligible to be saved into a customized image

- Short-term *ephemeral* storage comes as part of launched instance
- Long-term storage is XSEDE-allocated
- Implemented as OpenStack Volumes and object storage
- Default storage is modest, but more is available via allocation
Using Jetstream VMs

Manipulating Jetstream VMs:
- Jetstream Atmosphere web interface
- Direct API access via OpenStack command line or Horizon access
  - API access enables Science Gateways and other always on services or on demand use cases; e.g. elastic compute techniques

Primary methods of logging into Jetstream VMs to work:
- Interactive user access via web interface with VNC/SSH
- Direct VNC/SSH to individual instances
<table>
<thead>
<tr>
<th>Discipline or area of interest</th>
<th># of Jetstream allocations</th>
<th>SU's allocated on Jetstream</th>
<th>% of SU's allocated on Jetstream</th>
<th>% of all SU's 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>
Jetstream for engineering researchers (and others)

Matlab and SimuLink and additional toolkits are installed on Jetstream

You do NOT need to have a local license to use MATLAB on Jetstream

If you are a researcher, and MATLAB or SimuLink… you’re ready to go!

If you are an engineering researcher, and you need other tools... Let us know – we are happy to consider other requests

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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
Jetstream for Education

Jetstream has been used in multiple graduate and undergraduate courses

- Management, Access, and Use of Big and Complex Data
- Multiple informatics and general bioinformatics courses
- Business Intelligence (big data and analysis)
- Research Topics in Music
- Multiple genetics and sequencing courses
- Multiple information security and assurance courses
- …and others…

Multiple Research Data Alliance Workshops, multiple workshops/classes on Galaxy, data analysis in finance using R, security and intrusion detection, and principles in cloud computing and more!

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Another Use Case: 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

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Jetstream Gateway Highlights

- **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
- **ChemCompute Gateway**
  - Providing a computational chemistry gateway for educational use

- Coming gateways: The Neuroscience Gateway, UltraScan III, and others
Jetstream usage highlights – 1 October 2018

- 413 active XSEDE projects covering 75 fields of science and 2558 active users representing 190 institutions
- 80% of Jetstream users have not used any other XSEDE system
- >143M CPU hours allocated to XSEDE projects since June 2016
- 15 active science gateways
- 47 education/teaching allocations serving over 904 students
- 1151 (avg concurrent) active VMs in previous qtr, 955 in PY2*
- Highest user satisfaction in most recent XSEDE survey

*M&O PY2 to date 11/12 months
Jetstream Timeline…what comes next?

- Completed our second year of operations on September 1, 2018
- Soliciting Research allocation requests plus Startup and Education allocations – including Science Gateways!
- Adding services as deemed useful/mature (Heat, Magnum, Trove, Manila, etc)
- Atmosphere enhancements on a regular cycle
- Working on partnerships with groups like HubZero and others to extend the value of Jetstream
Requesting access to Jetstream

- Trial allocations available TODAY
  http://wiki.jetstream-cloud.org/Jetstream+Trial+Access+Allocation
- You can request startup allocations anytime. (Startups are simple!)
  http://wiki.jetstream-cloud.org/Jetstream+Allocations
- You can request allocations for educational use anytime.
- Next submission period for large allocations is 15 Sept - 15 Oct 2018.
- Research allocation: Main project description (up to 10 pages) and Scaling doc (up to 5 pages) – We can help!
Expanding the reach: Jetstream REU Program

- NSF Supplement for undergraduates
- 4 students participated in 2017
- 6 students participated in 2018

- REU student videos on YouTube
  https://www.youtube.com/user/IUPTI
Where can I get help?


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

Introduction to Jetstream Virtual Workshop: https://cvw.cac.cornell.edu/jetstream/

Jetstream Allocations Virtual Workshop: https://cvw.cac.cornell.edu/JetstreamReq/
Jetstream Fun: Happy cluster / Angry Cluster

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Infrared image of Jetstream
Jetstream Partners

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Questions?

Project website: http://jetstream-cloud.org/
Project email: help@jetstream-cloud.org Direct email: jeremy@iu.edu

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• XSEDE is supported by NSF award 1053575 (John Towns, UIUC, PI)
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And onward…
Cloud Computing Terms...simplified

**Image**: a file on a disk. It will be booted to create an...

**Instance**: a running virtual server; i.e. something you can log into.

**Running**: the *instance* is up & available for use

**Suspended**: the *instance* is memory resident but not running

**Stopped**: the *instance* is shutdown akin to powering down

**Shelved**: the *instance* is shutdown, written to disk, and stored
Cloud Computing Terms…simplified

**Flavor**: the size of a running instance; i.e. #core, RAM, disk

**Hypervisor**: the thing the instance runs on; something akin to a software defined hardware compute server.

**Snapshot**: the process of taking an instance and turning it to an image.

**State**: something worth remembering; i.e. the state of the system
**Object store**: a blob of bits; it has a starting address & a size. There may be metadata associated with the object. The data is consumed in a streaming manner.

**Block store**: a software defined entity akin to an unformatted hardware disk drive.

**Filesystem**: hierarchical in nature, directories & files, ability to open, seek, read, write.

**Persistent storage**: If you pull the plug, it will still exist when power is restored. Safe to store data or state here.

**Ephemeral storage**: If you pull the plug, it no longer exists. (Don’t put your data here!!!)