Jetstream Overview:  
A national research and education cloud

ESIP Summer Meeting 2019  
July 16, 2019 – Tacoma, WA.

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Manager, Jetstream Cloud, UITS Research Technologies

NSF Funding Areas in HPC

Traditionally concentrated on enabling petascale capability
- Blue Waters – 13.3 petaflops, 2012 (Frontera awarded late 2018, coming in 2019)
- 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 2nd phase)
- Chameleon (renewed for 2nd phase)

Now funding clouds to do research
- Bridges (Hybrid system)
- 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*
“But I really don’t have research needs... I don’t need the national research cyberinfrastructure.”

– multiple researchers at small colleges and universities
What is Jetstream and why does it exist?

• NSF’s first production cloud facility

• Focus on ease-of-use, broad accessibility

• User-selectable library of preconfigured virtual machines

• Provides on-demand interactive computing and analysis or persistent services such as gateways

• Enables configurable environments; 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 VMs 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...they’re coming!)
• It isn’t Amazon, Azure, or GCE (similar, but...)
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**

** 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

- **TACC Cyberinfrastructure**
  - Compute:
    - 320 Nodes
    - 7,680 Cores
    - 40 TB RAM
    - 640 TB local disk
  - Storage: 960 TB

- **U of Arizona Cyberinfrastructure**
  - Compute:
    - 16 Nodes
    - 2 TB RAM
    - 384 Cores
    - 32 TB local disk

**Connections**

- 4x40 Gbps
- 100 Gbps
- 10 Gbps
- 10 Gbps

**Networks**

- Internet2
- XSEDE
Platform Overview

Globus Auth  Atmosphere API

Atmo Services  XSEDE Accounting

OpenStack  Ceph

OpenStack  Ceph

Indiana University  TACC
The Jetstream Atmosphere web interface
The Jetstream Atmosphere web interface
<table>
<thead>
<tr>
<th>Discipline or area of interest</th>
<th># of Jetstream allocations</th>
<th>SUs allocated on Jetstream</th>
<th>SU Increase/Decrease on Jetstream over previous year</th>
<th>% of SUs allocated on Jetstream</th>
<th>% of all SUs allocated on other XSEDE-supported systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral Sciences</td>
<td>6</td>
<td>3,465,516</td>
<td>100% Increase</td>
<td>4.24%</td>
<td>0.61%</td>
</tr>
<tr>
<td>Biological Sciences</td>
<td>89</td>
<td>15,041,928</td>
<td>72.18% Increase</td>
<td>18.40%</td>
<td>3.59%</td>
</tr>
<tr>
<td>Biophysics</td>
<td>86</td>
<td>3,627,026</td>
<td>44.15% Decrease</td>
<td>4.44%</td>
<td>13.56%</td>
</tr>
<tr>
<td>Computer Science</td>
<td>72</td>
<td>6,883,269</td>
<td>33.28% Increase</td>
<td>8.42%</td>
<td>2.98%</td>
</tr>
<tr>
<td>Earth Sciences</td>
<td>37</td>
<td>5,476,250</td>
<td>37.06% Increase</td>
<td>6.70%</td>
<td>4.60%</td>
</tr>
<tr>
<td>Education and Training</td>
<td>128</td>
<td>16,599,512</td>
<td>2.62% Increase</td>
<td>20.31%</td>
<td>4.66%</td>
</tr>
<tr>
<td>Engineering</td>
<td>13</td>
<td>520,690</td>
<td>71.21% Increase</td>
<td>0.64%</td>
<td>1.75%</td>
</tr>
<tr>
<td>Materials Science</td>
<td>6</td>
<td>1,035,508</td>
<td>100% Increase</td>
<td>1.27%</td>
<td>13.89%</td>
</tr>
<tr>
<td>Mathematics</td>
<td>13</td>
<td>688,505</td>
<td>150.37% Increase</td>
<td>0.84%</td>
<td>0.90%</td>
</tr>
<tr>
<td>Molecular Science/Biochemistry</td>
<td>21</td>
<td>4,254,643</td>
<td>10.15% Decrease</td>
<td>5.20%</td>
<td>5.83%</td>
</tr>
<tr>
<td>Neuroscience</td>
<td>19</td>
<td>4,708,180</td>
<td>327.87% Increase</td>
<td>5.76%</td>
<td>1.98%</td>
</tr>
<tr>
<td>Physics</td>
<td>10</td>
<td>2,440,581</td>
<td>15.58% Decrease</td>
<td>2.99%</td>
<td>8.65%</td>
</tr>
<tr>
<td>Social Sciences and Humanities</td>
<td>28</td>
<td>2,409,633</td>
<td>192.27% Increase</td>
<td>2.95%</td>
<td>0.81%</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!
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

Research Data Alliance workshops, Galaxy workshops, data analysis in finance using R, security and intrusion detection, and principles in cloud computing...
Another Use Case: Galaxy riding Jetstream

Galaxy, a platform for biomedical research, focused on accessibility, transparency and reproducibility

- 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

Use Jetstream as a bursting platform

- From Galaxy Main, send jobs to a Slurm cluster running on Jetstream
- Run Galaxy Interactive Environments (Jupyter/RStudio containers) via 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
Jetstream Gateway Highlights

- **Simulations of Nanoscale Biomolecular Systems** - Aleksei Aksimentiev, University of Illinois Champaign-Urbana
- **The Neuroscience Gateway** - Amitava Majumdar, University of California, San Diego
- **Parallelizing Development of Immunomics and Genomics Tools** - Ramy Arnaout, Beth Israel Deaconess Medical Center
- **Atmospheric Science in the Cloud: Enabling Data-Proximate Science** – Mohan Ramamurthy, UNIDATA (University Corporation for Atmospheric Research)
- **Science and Engineering Applications Grid (SEAGrid): A Gateway for Simulation of Molecular and Material Structures and Dynamics** – Sudhakar Pamidighantam, Indiana University
- **GIS Gateway** (Coming Soon!) – Eric Shook, University of Minnesota

And others!
Expanding the reach: Jetstream REU Program

- NSF Supplement for undergraduates
  - 4 students participated in 2017
  - 6 students participated in 2018
  - 7 students participating presently
- REU student videos on YouTube
  https://www.youtube.com/user/IUPTI
Jetstream usage highlights – 1 May 2019

- 418 XSEDE projects covering 71 fields of science and over 2375 **active users** representing **208 institutions**
- 80% of Jetstream users have **not used** any other XSEDE system
- >200M CPU hours allocated to XSEDE projects since June 2016
- 25 active science gateways
- 58 education/teaching allocations serving over 1000 students
- 1438 mean active VMs in previous qtr, 1614 peak active VM count
- **Highest** user satisfaction in most recent XSEDE survey
Jetstream Timeline...what comes next?

- Completed our second year of operations with extension to November 2020
- 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 Sep 2019 – 15 Oct 2019
• Research allocation: Project desc (<10 pages) and Scaling doc (<5 pages)
  • We can help!
Where can I get help?

- User guides: [https://portal.xsede.org/user-guides](https://portal.xsede.org/user-guides)
- XSEDE KB: [https://portal.xsede.org/knowledge-base](https://portal.xsede.org/knowledge-base)
- Email: [help@xsede.org](mailto:help@xsede.org)
- Campus Champions: [https://www.xsede.org/campus-champions](https://www.xsede.org/campus-champions)
- Introduction to Jetstream Virtual Workshop: [https://cvw.cac.cornell.edu/jetstream/](https://cvw.cac.cornell.edu/jetstream/)
- Jetstream Allocations Virtual Workshop: [https://cvw.cac.cornell.edu/JetstreamReq/](https://cvw.cac.cornell.edu/JetstreamReq/)
Questions?

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

License Terms

- Jetstream is supported by NSF award 1445604 (David Y. Hancock, IU, PI)
- XSEDE is supported by NSF award 1053575 (John Towns, UIUC, PI)
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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.

**State:** something worth remembering; i.e. the state of the system
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.
Cloud Computing Terms...simplified

**States:**

**Running:** the *instance* is up & running

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

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

**Shelved:** the *instance* is shutdown, written to disk, and stored
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, data is stored in blocks and has no metadata associated at the lowest levels

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 leave your data here!!!)
OpenStack Overview

Client ➔ Keystone ➔ Nova ➔ Glance ➔ Ceph ➔ Cinder ➔ Compute

Token ➔ Keystone ➔ Nova ➔ Cinder ➔ Ceph ➔ Glance ➔ Compute
Getting into the hands on part -

Open https://use.jetstream-cloud.org in your browser

Login slips will be distributed momentarily!