

# Jetstream: Building and Operating a First of Kind System (What could go wrong?)

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# NSF Funding Areas in HPC

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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<sup>nd</sup> phase)
- Chameleon (renewed for 2<sup>nd</sup> phase)

Now funding clouds to do research

- Bridges (Hybrid system)
- Jetstream

# Jetstream - Expanding NSF XD's reach and impact

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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>



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# Identifying the potential users

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“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?

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- 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?

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- 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...

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- 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...we'll get to this later)
- It isn't Amazon, Azure, or GCE (similar, but...)

# HPC vs Cloud

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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...

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- **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 is 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...

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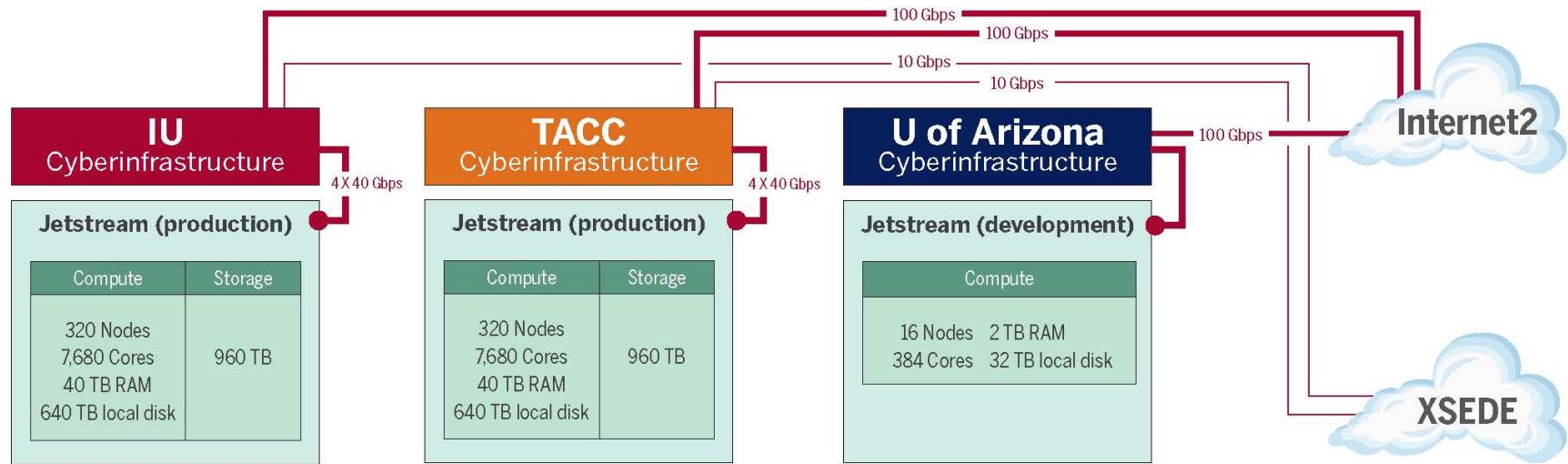


Cows, not pets: pets take great amount of care, feeding, and you name them; cows you intend to have high turnover and you give them numbers.

\*\*some caveats for gateways...

Image source unknown

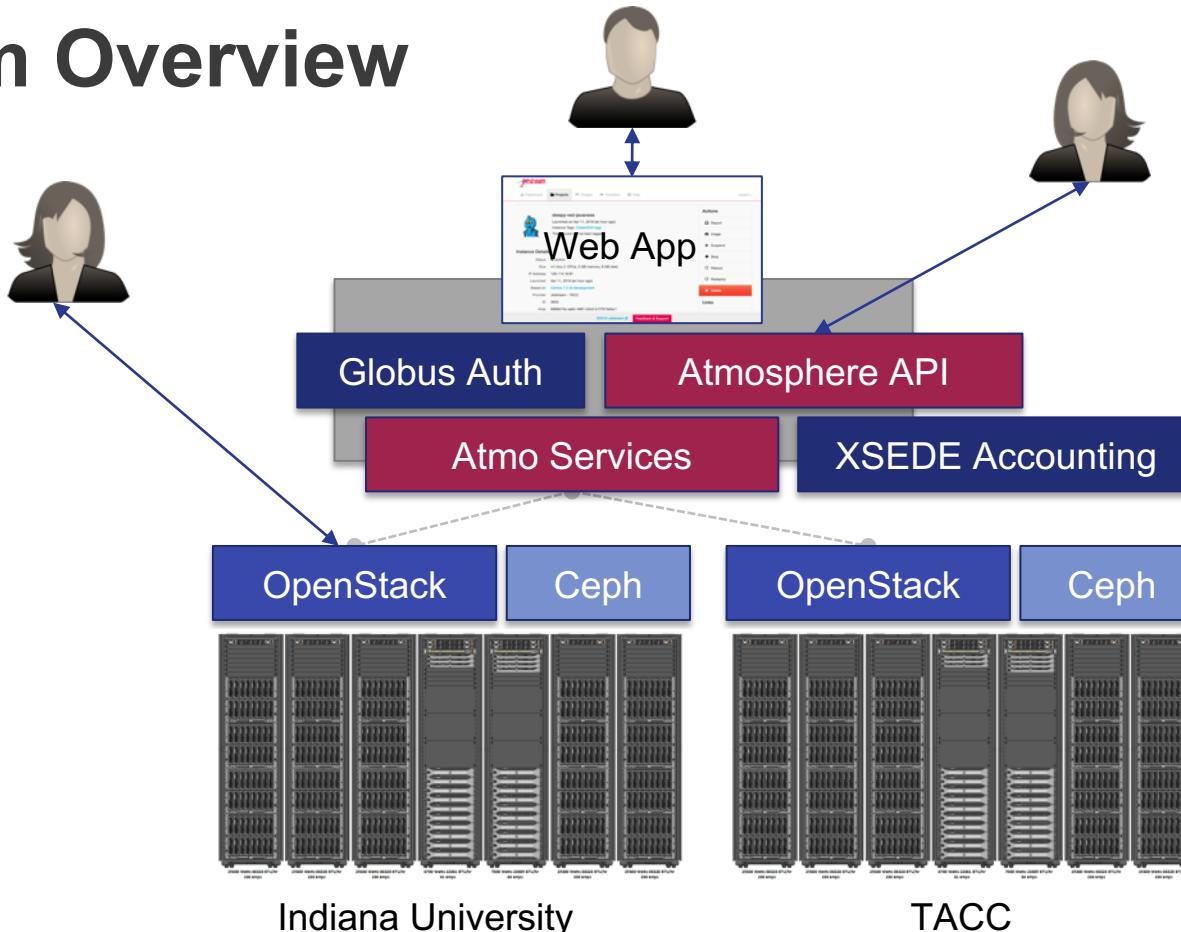
# Jetstream System Overview



# Production cloud hardware (per site)

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

# Platform Overview



# The Jetstream Atmosphere web interface

The screenshot shows the Jetstream Atmosphere web interface dashboard. At the top, there is a navigation bar with links for Dashboard, Projects, Images, Help, Admin, and a user dropdown for jfischer. Below the navigation bar, there are three main sections: "Getting Started", "Resources Used", and "Provider Resources".

**Getting Started**

- Launch New Instance**: An icon of a rocket ship. Description: Browse Atmosphere's list of available images and select one to launch a new instance.
- Browse Help Resources**: An icon of a cloud with a question mark. Description: View a video tutorial, read the how-to guides, or email the Atmosphere support team.
- Change Your Settings**: An icon of a gear. Description: Modify your account settings, view your resource quota, or request more resources.

**Resources Used** Need more?

**Allocation Source**

Allocation	Source	Percentage
0%	TG-STA1100245	5.06%
23.15%	TG-ASC160018	32.23%
17.61%	TG-CDA160007	0%
0%	TG-TRA160003	0%
0%	TG-TRA160027	0%

**10 Instances**

Status	Count
active	8
shutoff	2

**4 Volumes**

Status	Count
available	4

**Provider Resources**

Provider	Resource Type	Usage (%)
Jetstream - Indiana University	CPU	9.09%
Jetstream - TACC	CPU	0%

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# Hardware and Instance "Flavors"

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

\*\* 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

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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

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

# Not just the usual suspects...

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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

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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!

# *Another Use Case: Galaxy riding Jetstream*

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

- The main project instance ([usegalaxy.org](http://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

# Jetstream Gateway Highlights

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- 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 April 2019

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- 414 active XSEDE projects covering 73 fields of science and **2300 active users** representing **207 institutions**
- **80%** of Jetstream users have **not used any other XSEDE system**
- >190M CPU hours allocated to XSEDE projects since June 2016
- 24 active science gateways
- 54 education/teaching allocations serving over 904 students
- 1458 (avg concurrent) active VMs in current qtr, 1590 peak active VM count
- **Highest user satisfaction** in most recent XSEDE survey

# Requesting access to Jetstream

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- 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!

# Where can I get help?

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Wiki / Documentation: <http://wiki.jetstream-cloud.org>

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

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

Email: [help@xsede.org](mailto:help@xsede.org)

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

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

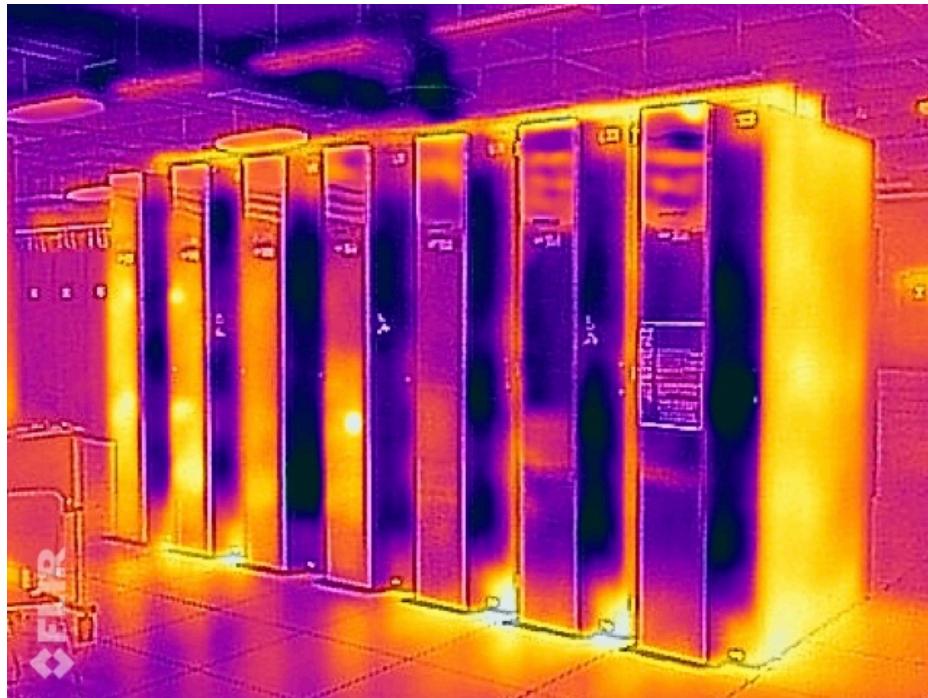
Jetstream Allocations Virtual Workshop: <https://cvw.cac.cornell.edu/JetstreamReq/>

# Jetstream Fun: Happy cluster / Angry Cluster

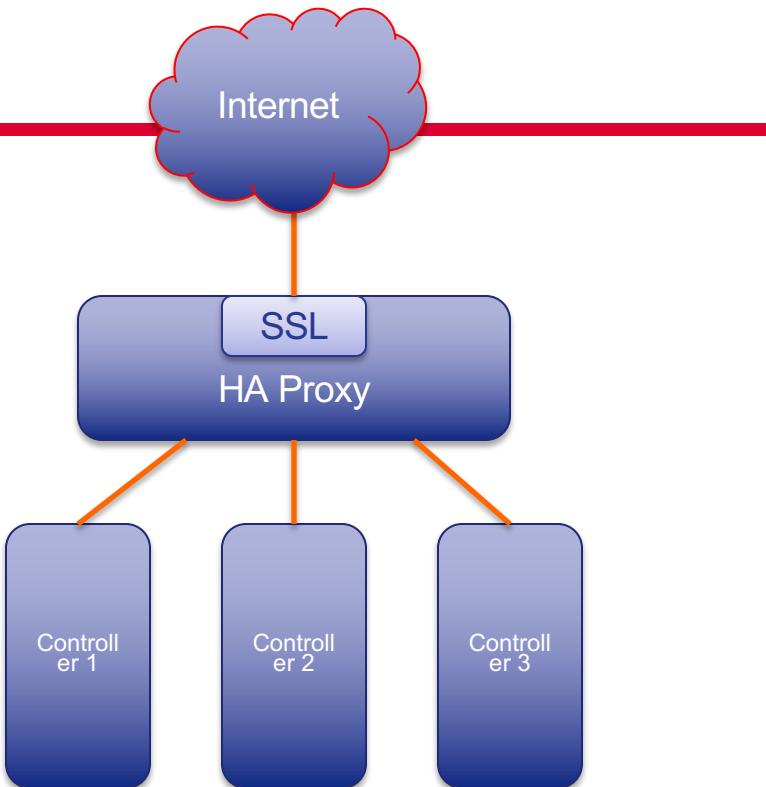
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# Infrared image of Jetstream



**ChilledDoor®**  
Rack Cooling System  
*motivair*®



Load  
Balancer 1



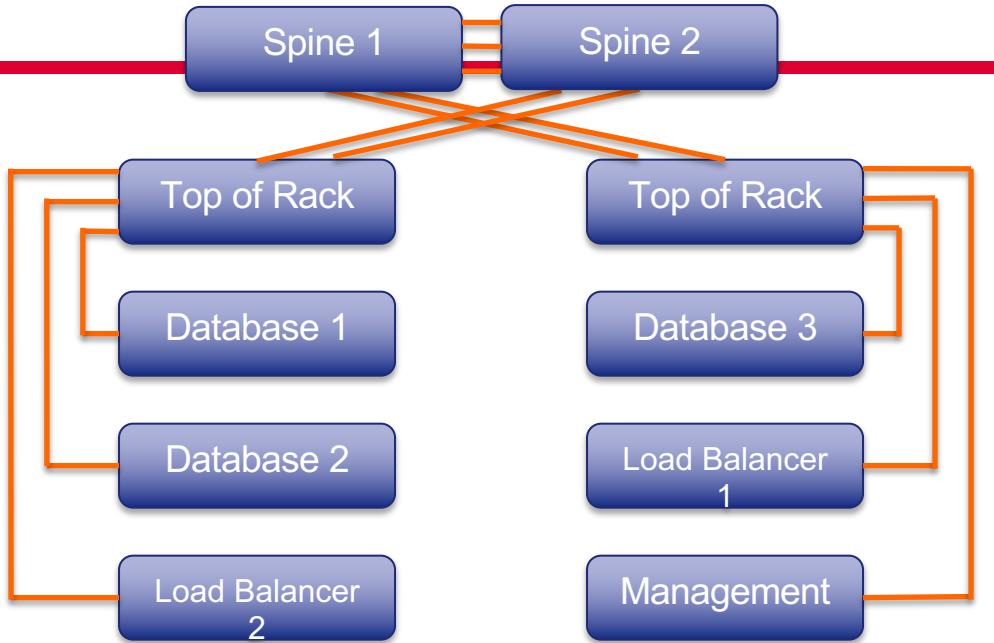
Load  
Balancer 2

Keep Alive

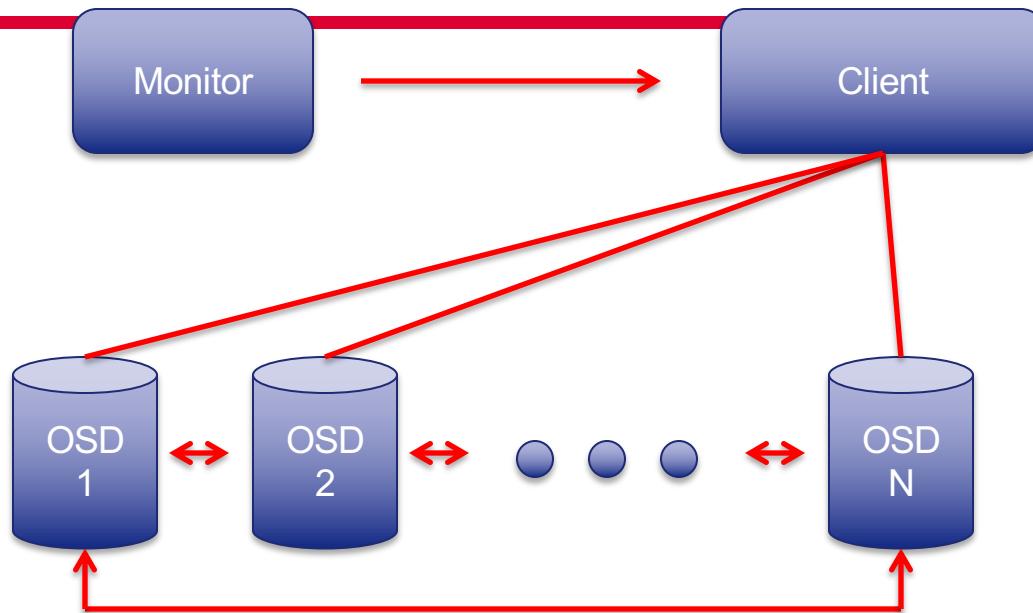
DNS Round Robin  
IP1 – IP2

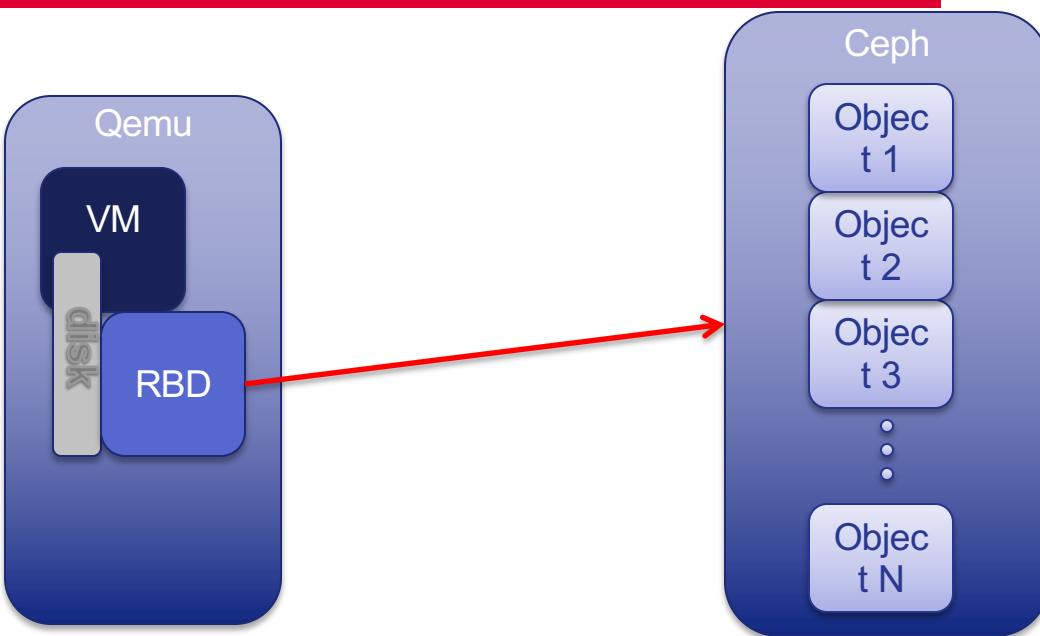


## High Availability layout for the databases

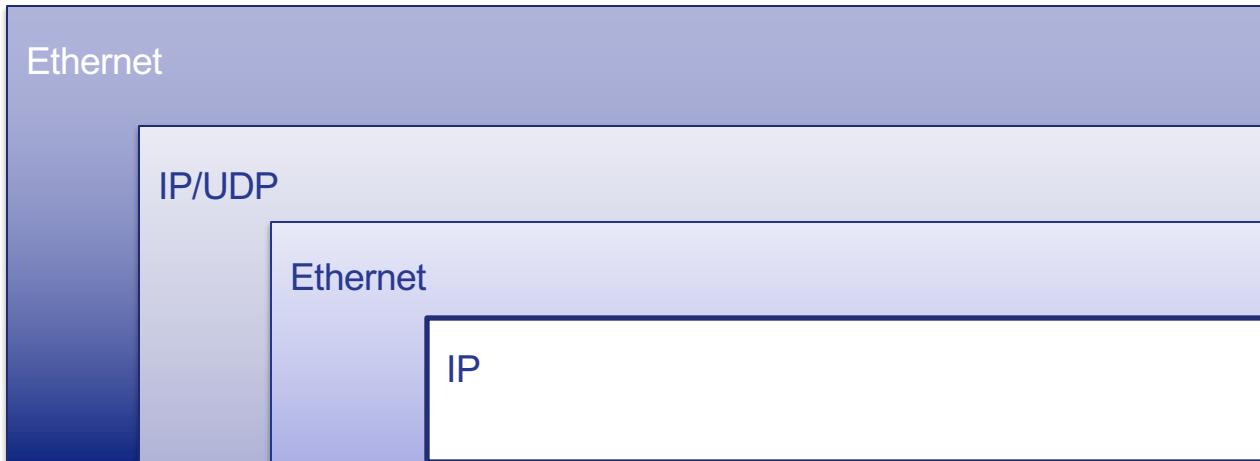


# Glance - Cinder - Ceph

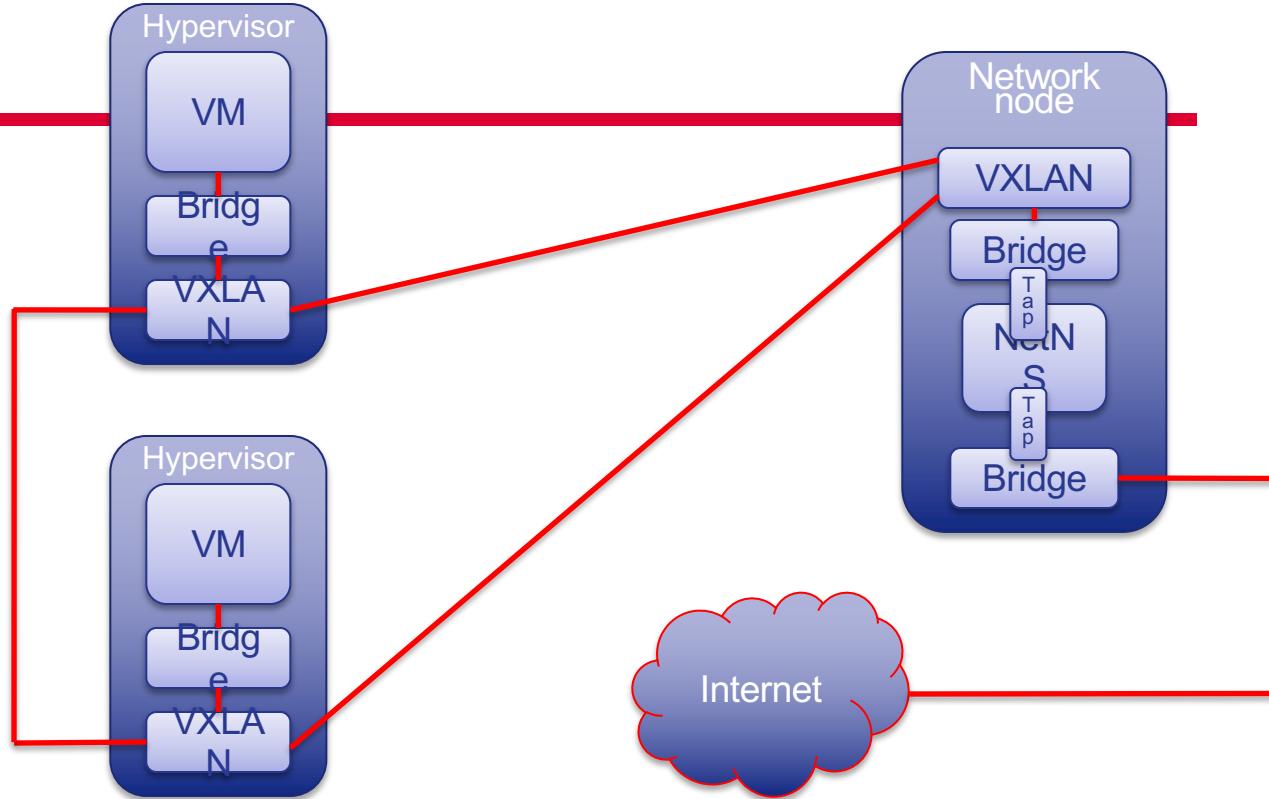




# VXLAN Packet



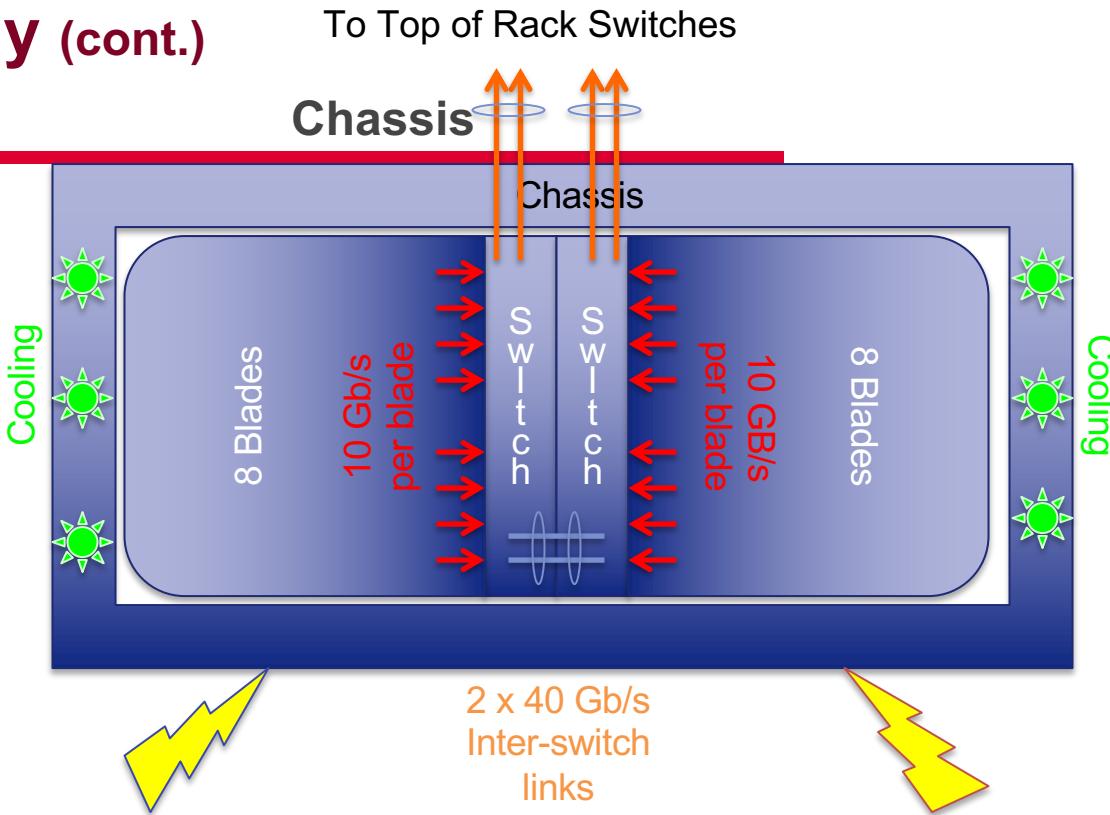
# Neutron Networking



# Network Topology (cont.)

Sixteen blades per chassis  
Two switches per chassis

- 10 Gb/s
- 40 Gb/s
- LAG

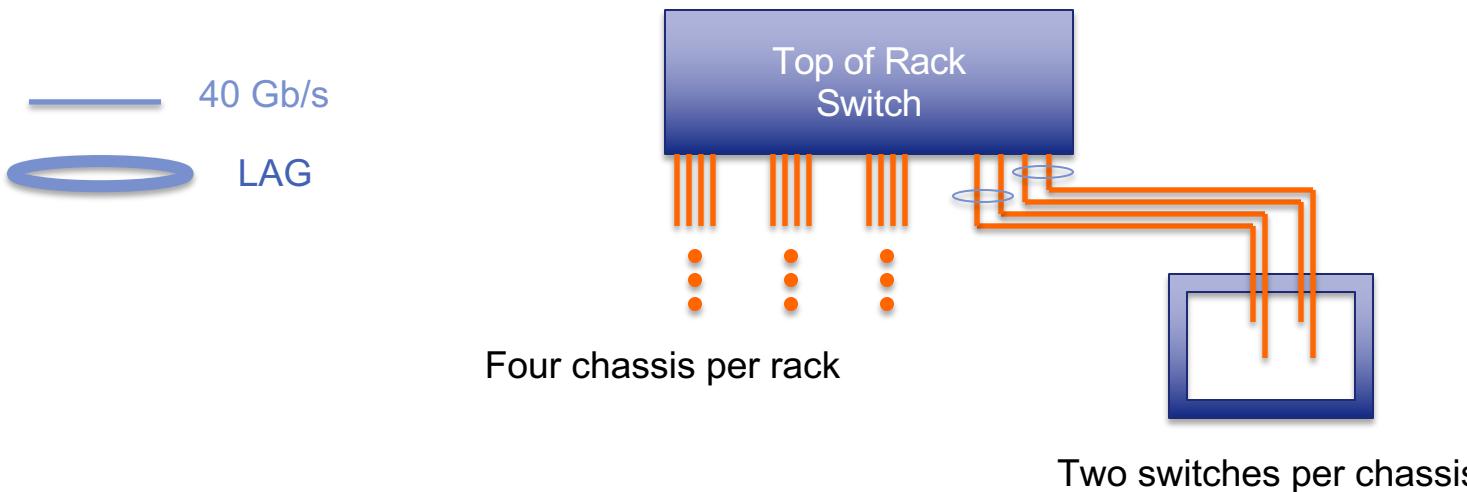


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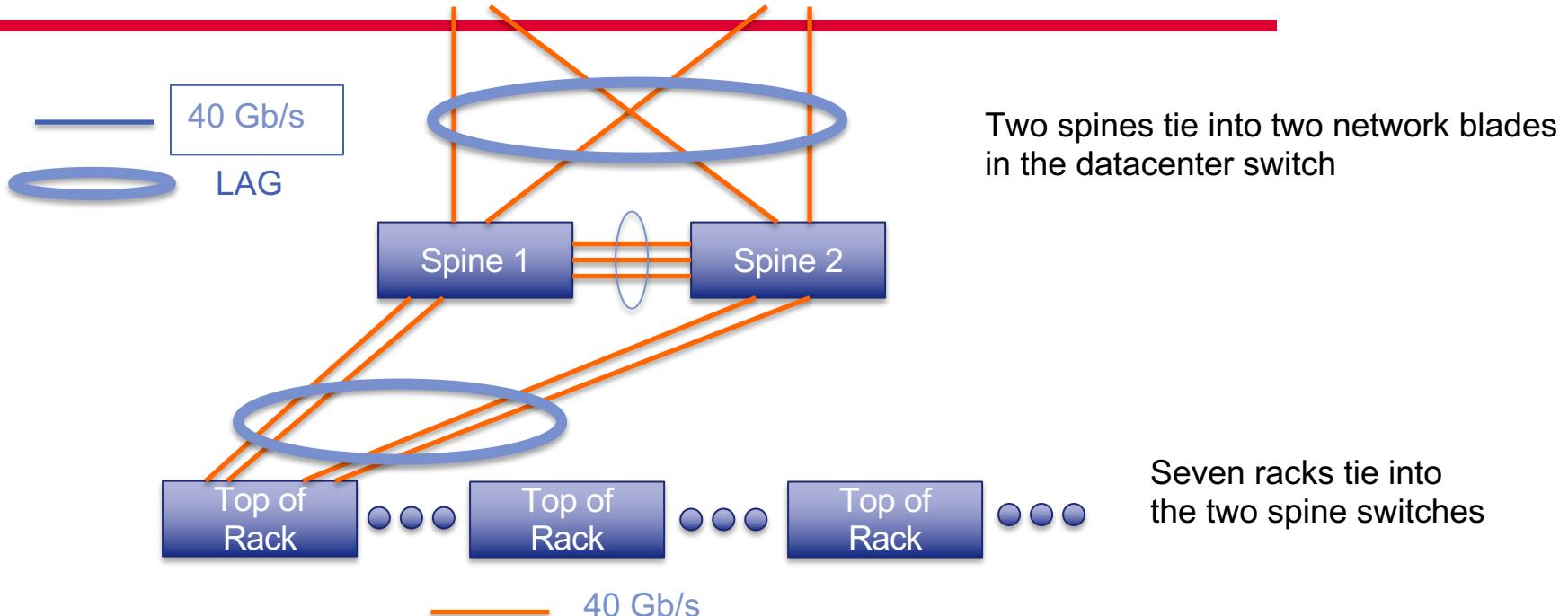


# Network Topology (cont.)

## Chassis to Top of Rack



# Network Topology (cont.)



# Jetstream Partners



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PERVASIVE TECHNOLOGY INSTITUTE



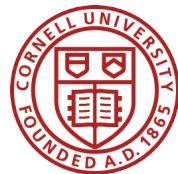
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# Questions?

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Project website: <http://jetstream-cloud.org/>

Project email: [help@jetstream-cloud.org](mailto:help@jetstream-cloud.org) Direct email: [jomlowe@iu.edu](mailto:jomlowe@iu.edu)

## License Terms

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