

Ohio Supercomputer Center

An **OH·TECH** Consortium Member

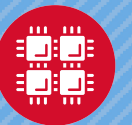
JESSE OWENS
OLYMPIC CHAMPION, BEACON FOR EQUALITY, YOUTH ADVOCATE



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An introduction to OSC services, hardware, and environment

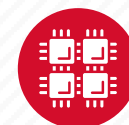
May 20, 2021





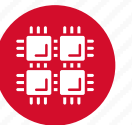
Kate Cahill
Education & Training Specialist

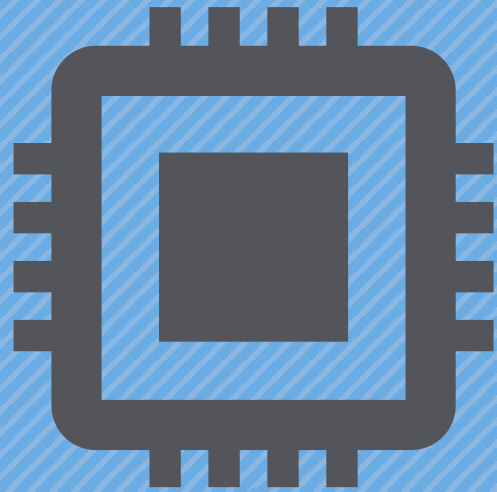
“OSC is here to empower your research.”



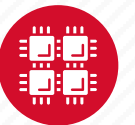
Outline

- What is OSC?
- High-Performance Computing (HPC) Concepts
- Hardware Overview
- Getting a New Project/Account
- User Environment
- Using Software on OSC systems
- Batch Processing
- OnDemand demo



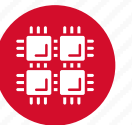


What is the Ohio Supercomputer Center?



About OSC

- Founded in 1987, through the Ohio Department of Higher Education
- Statewide resource for all universities in Ohio
 - high performance computing services
 - computational science expertise



Service Catalog



Cluster Computing

A fully scalable center with mid-range machines to match those found at National Science Foundation centers and other national labs.



Research Data Storage

High-performance, large capacity data storage spaces along with others that are perfect for a wide variety of research data.



Education

High performance computing and networking resources come together to create an exciting and innovative teaching and research environment.



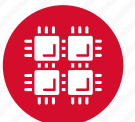
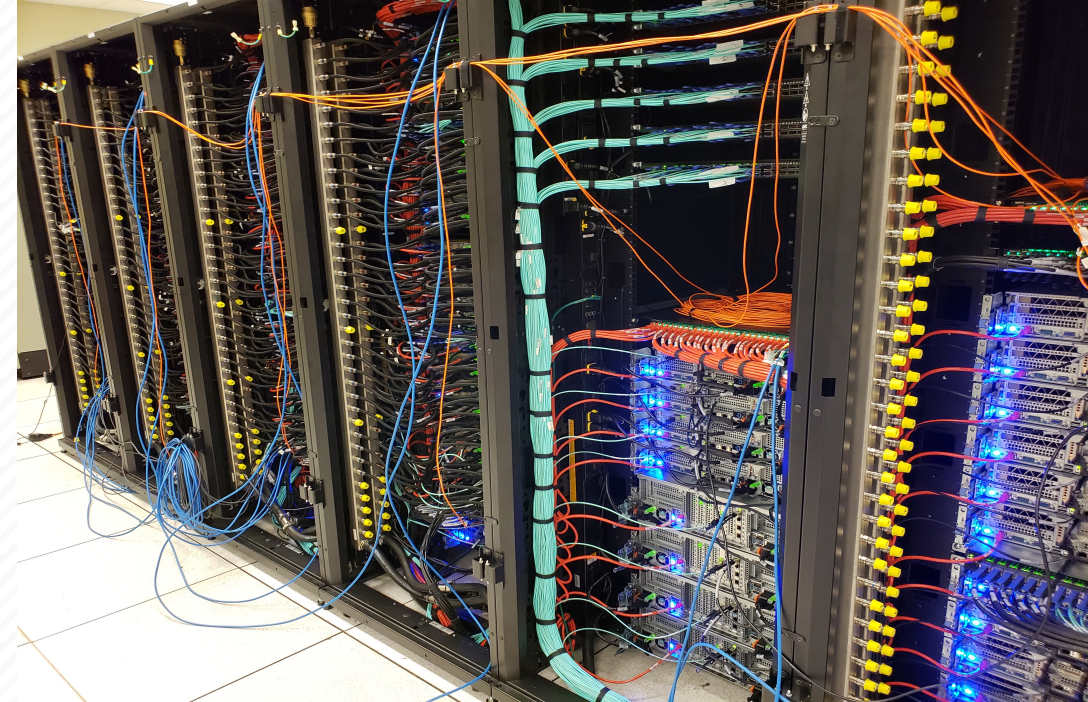
Web Software Development

Our expert web development team helps you create custom web interfaces to simplify the use of powerful HPC resources.



Scientific Software Development

Deep expertise in developing and deploying software that runs efficiently and correctly on large scale cluster computing platforms.



Client Services

CY2020



34 Ohio
Universities



59 Companies



33 Non-Profits
and Government
Agencies



124 Other
Educational
Institutions



5,256 Clients



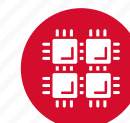
209 Ohio
Higher-Ed
Courses



17 Training
Opportunities

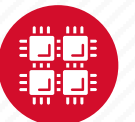


374 Trainees



Ohio Higher-Ed using OSC

CY2020



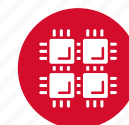
Ohio Higher-Ed Courses using OSC

CY2020

4,732 students, 209 courses, 78 departments, 21 universities

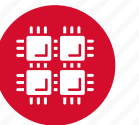
Institution	Students	Courses	Dept.'s
Air Force Inst. of Tech.	1	1	1
Bluffton University	10	1	1
Bowling Green State U.	35	5	3
Cedarville University	14	1	1
Cleveland State U.	27	3	3
Denison University	3	1	1
Kent State University	48	9	3
Kenyon College	41	4	1
Miami University	56	4	4
Ohio State University	3,538	129	33
Ohio University	31	6	4

Institution	Students	Courses	Dept.'s
Stark State College	26	2	1
University of Akron	9	1	1
University of Cincinnati	747	27	10
University of Dayton	18	3	2
University of Mount Union	11	2	1
University of Toledo	4	1	1
Urbana University	2	1	1
Wittenberg University	7	1	1
Wright State University	59	3	2
Xavier University	45	4	3

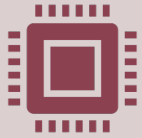




HPC Concepts



Why Use HPC?



Your simulations or analyses take too long on your personal computer

More (faster) cores
Multithreading
Multi-node parallelization (openmpi & Rmpi)
GPU acceleration (NVIDIA's CUDA)
Distributed computing (Apache Spark with Python and R)

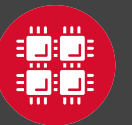


The size of your data is too large to be contained (storage) or accessed (memory) on your computer

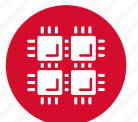
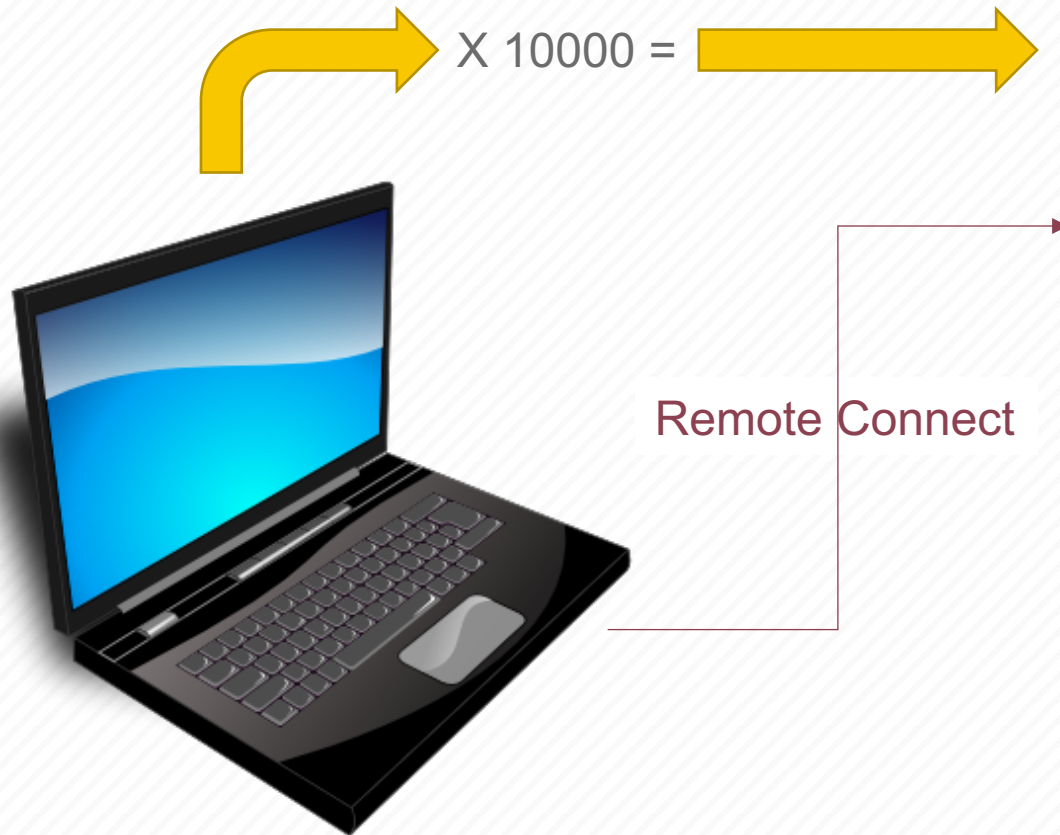
Large memory nodes: 768GB; 1.5TB, 3TB
Distributed computing (Apache Spark with R)
Compute node disk space: 1TB, 4TB, & 24TB
Project storage: TBs range



You need a particular software or package for your work



What is the difference between your laptop and a supercomputer?



HPC Terminology

Compute Node

- Equivalent to a high-end workstation, part of a cluster

Compute Cluster

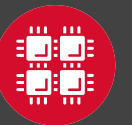
- A group of computers (nodes) connected by a high-speed network, forming a supercomputer

Core

- A processor (CPU), multiple cores per processor chip

Graphical Processing Unit (GPU)

- A separate multi-core processor that can handle many small calculations



Memory



Holds data that is being calculated on, as well as computational instructions



Memory types

Shared memory is local to one node and several process

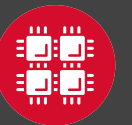
Distributed memory is on multiple nodes



Each core has an associated amount of memory

Standard nodes: ~4 GB/core

Huge memory nodes: ~75 GB/core



Storage



Storage: different types of “disk” for different needs



Local disk in the compute node



Project storage

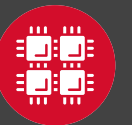


Shared scratch

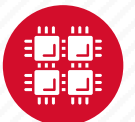
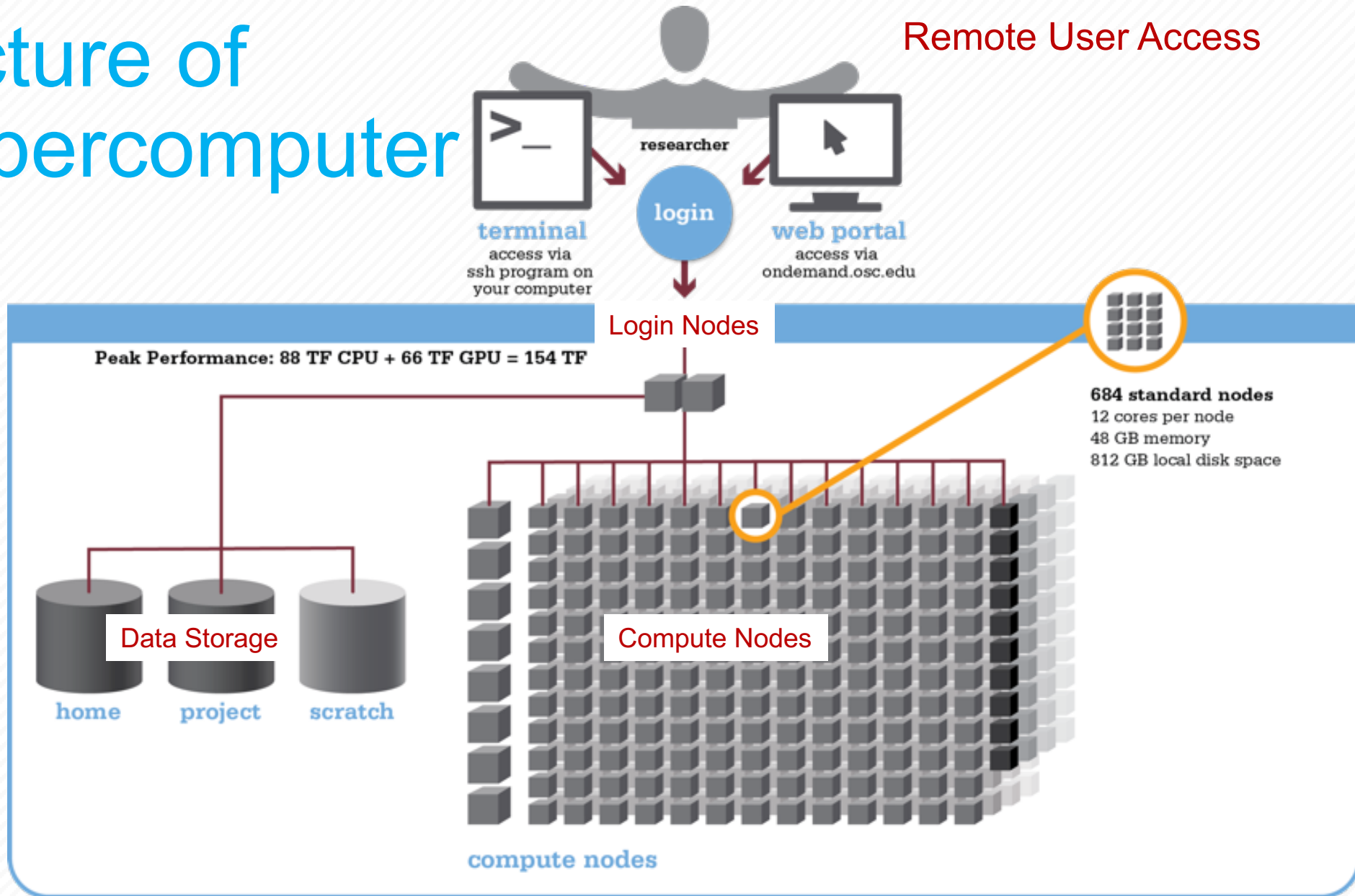
Short-term storage only



Longer-term or archive

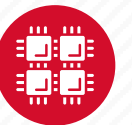


Structure of a Supercomputer

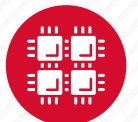
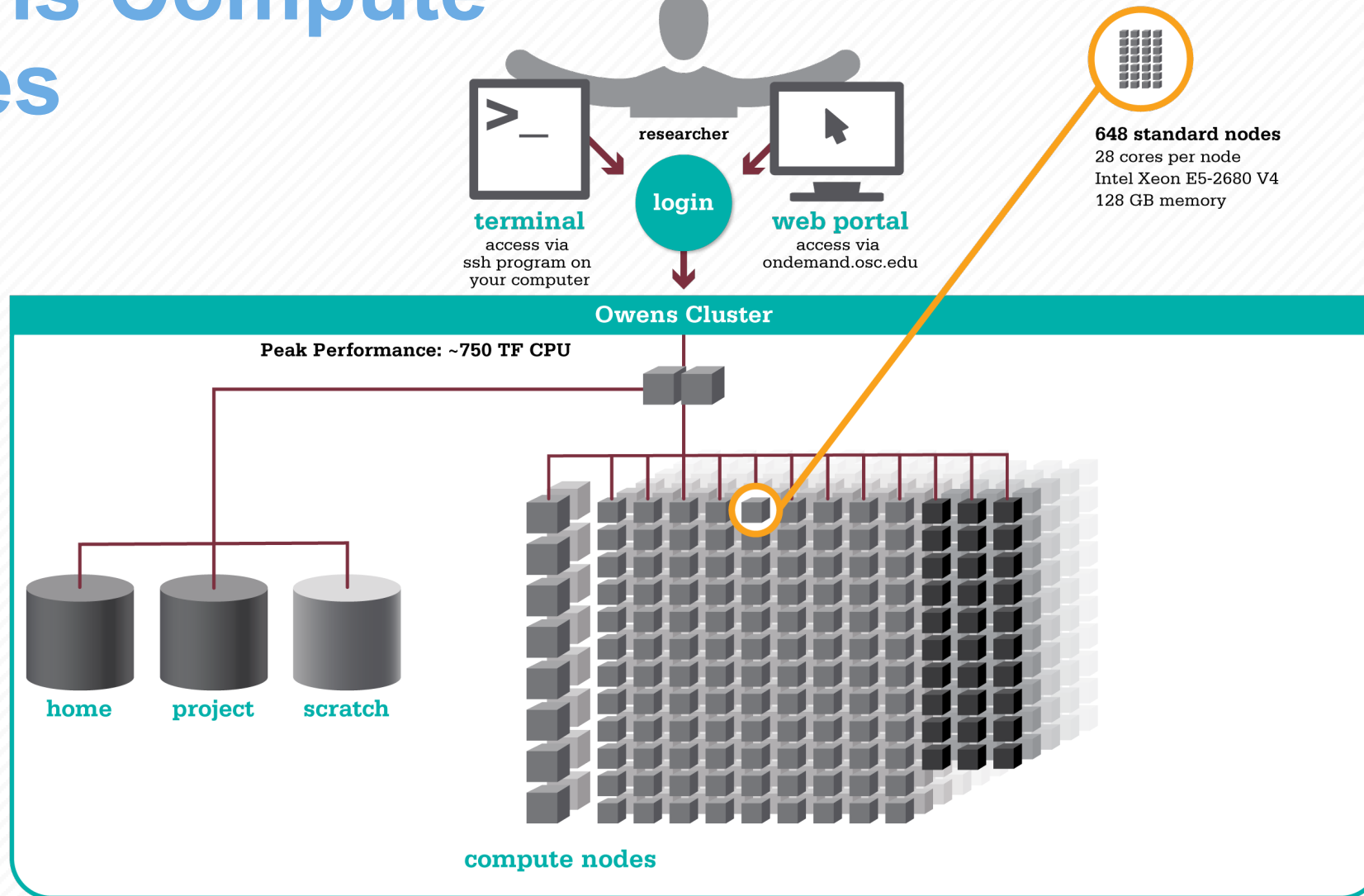




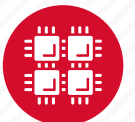
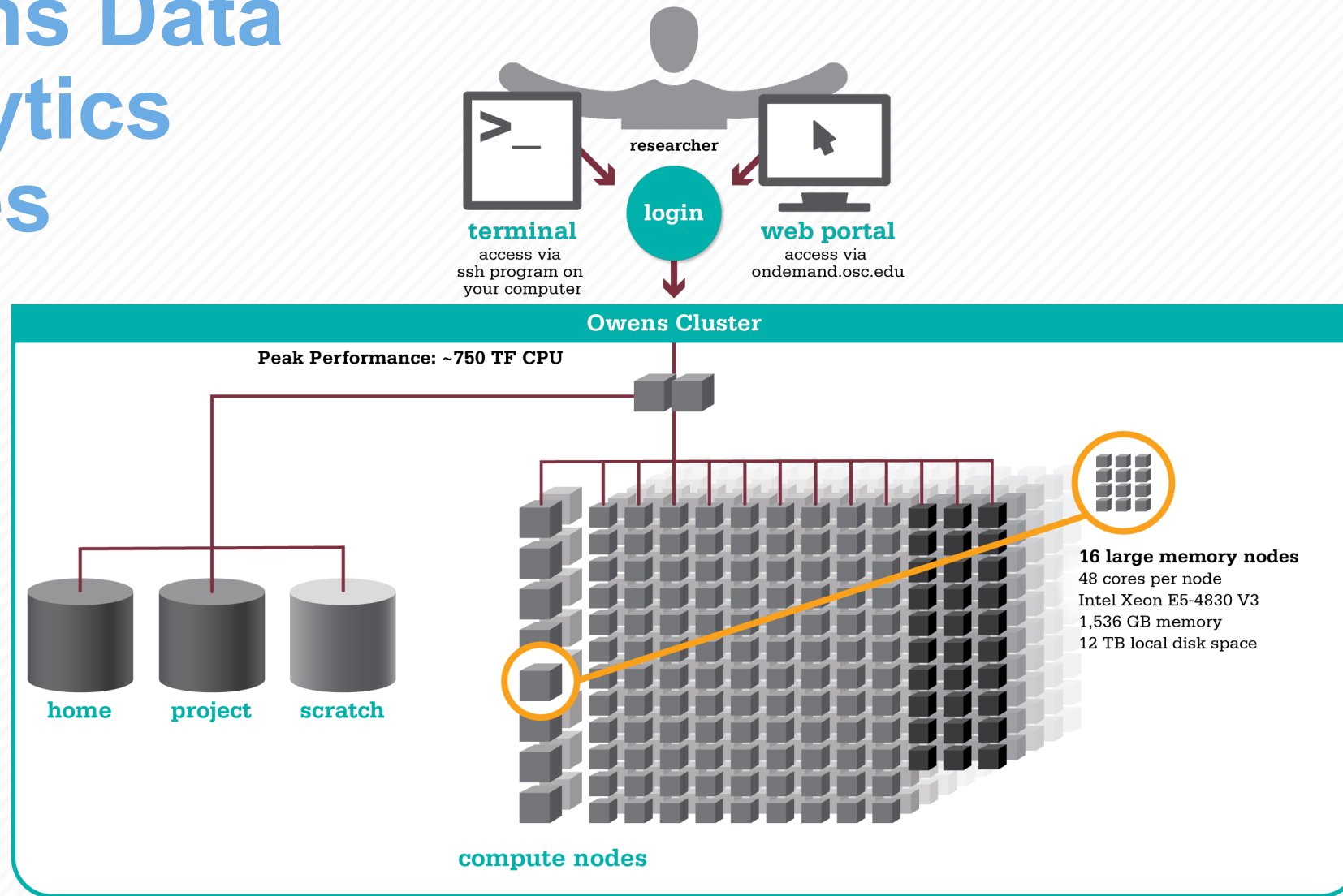
Hardware Overview



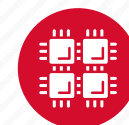
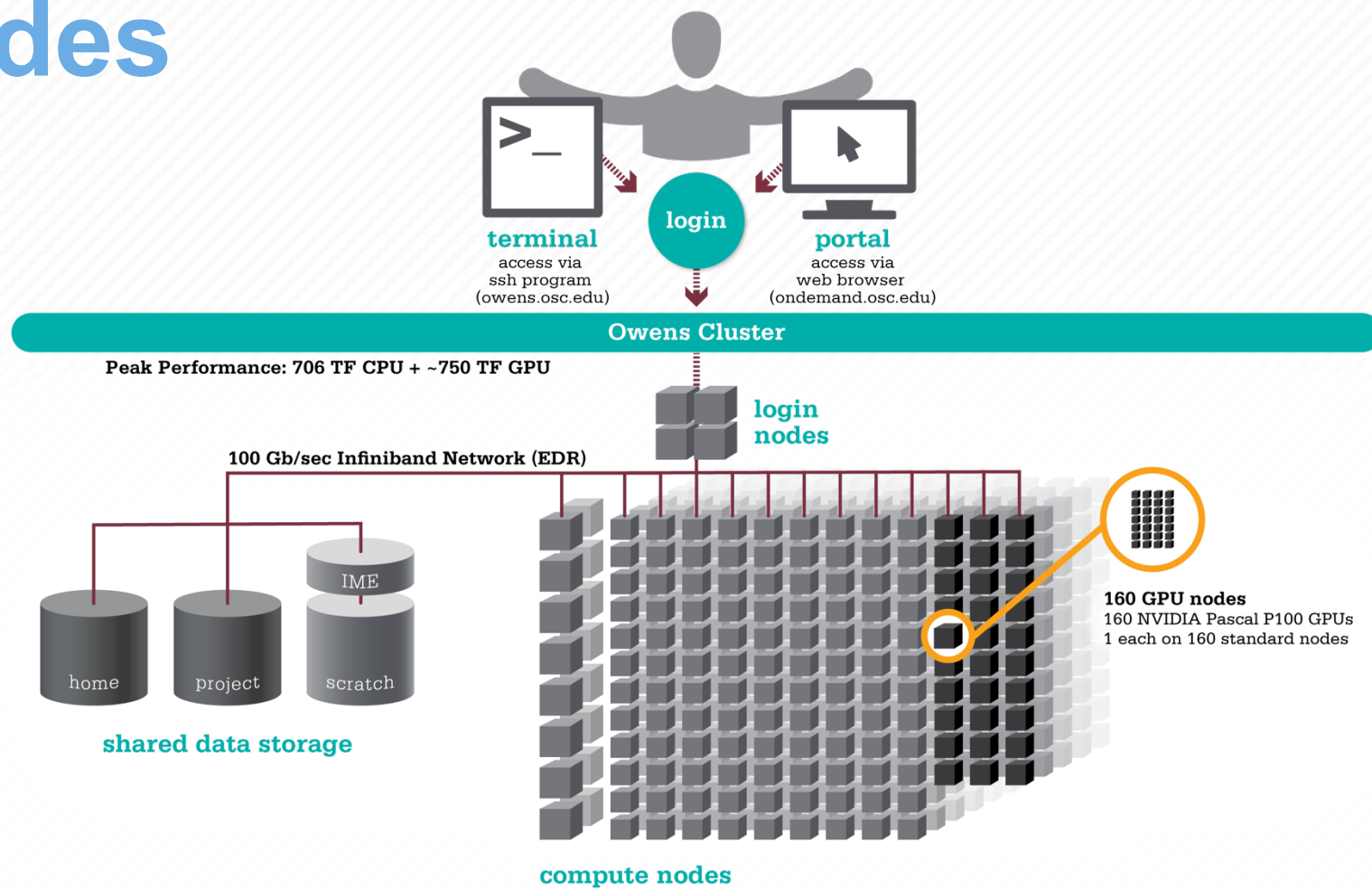
Owens Compute Nodes



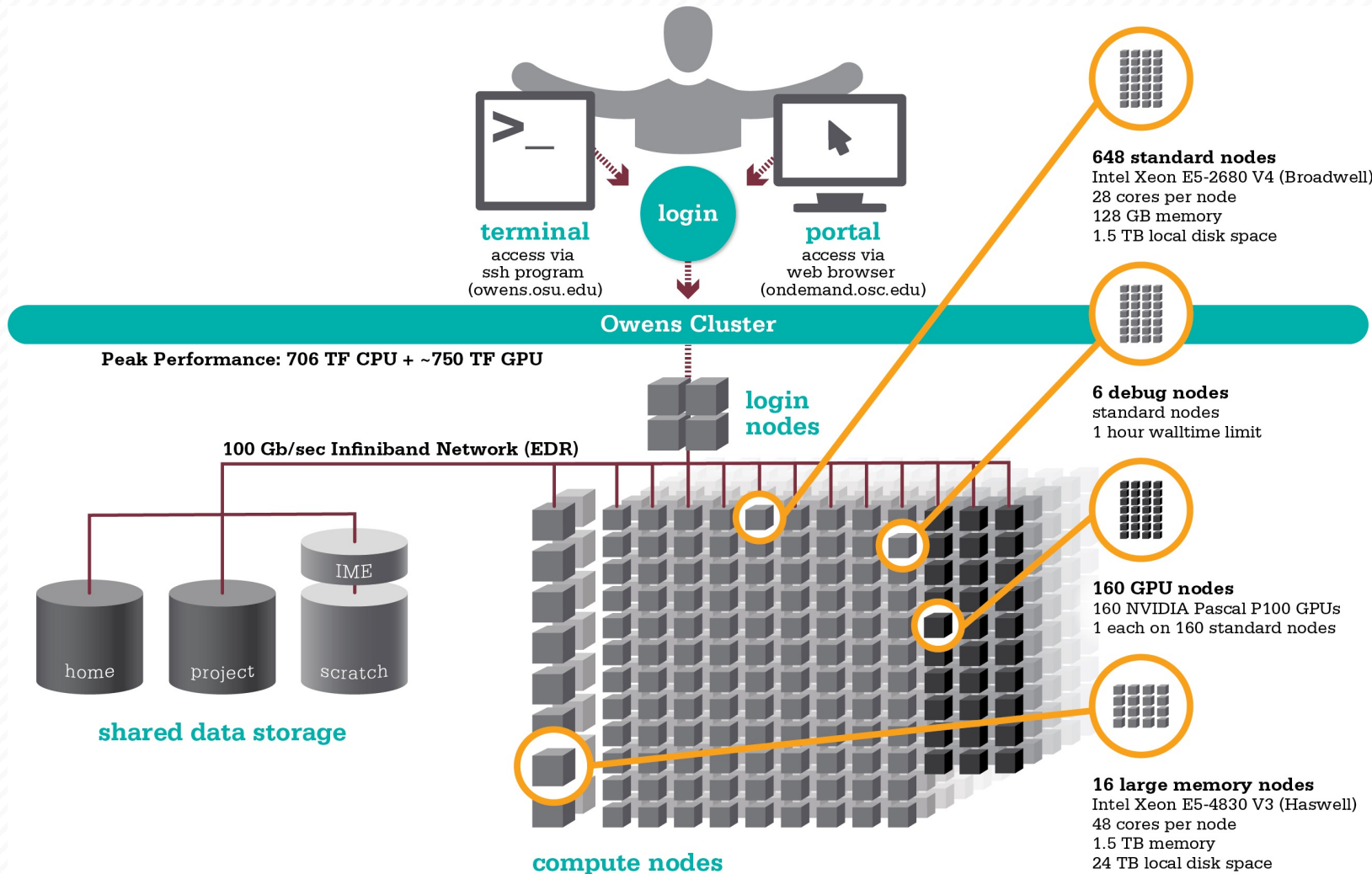
Owens Data Analytics Nodes



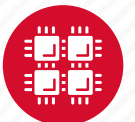
Owens GPU Nodes



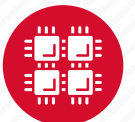
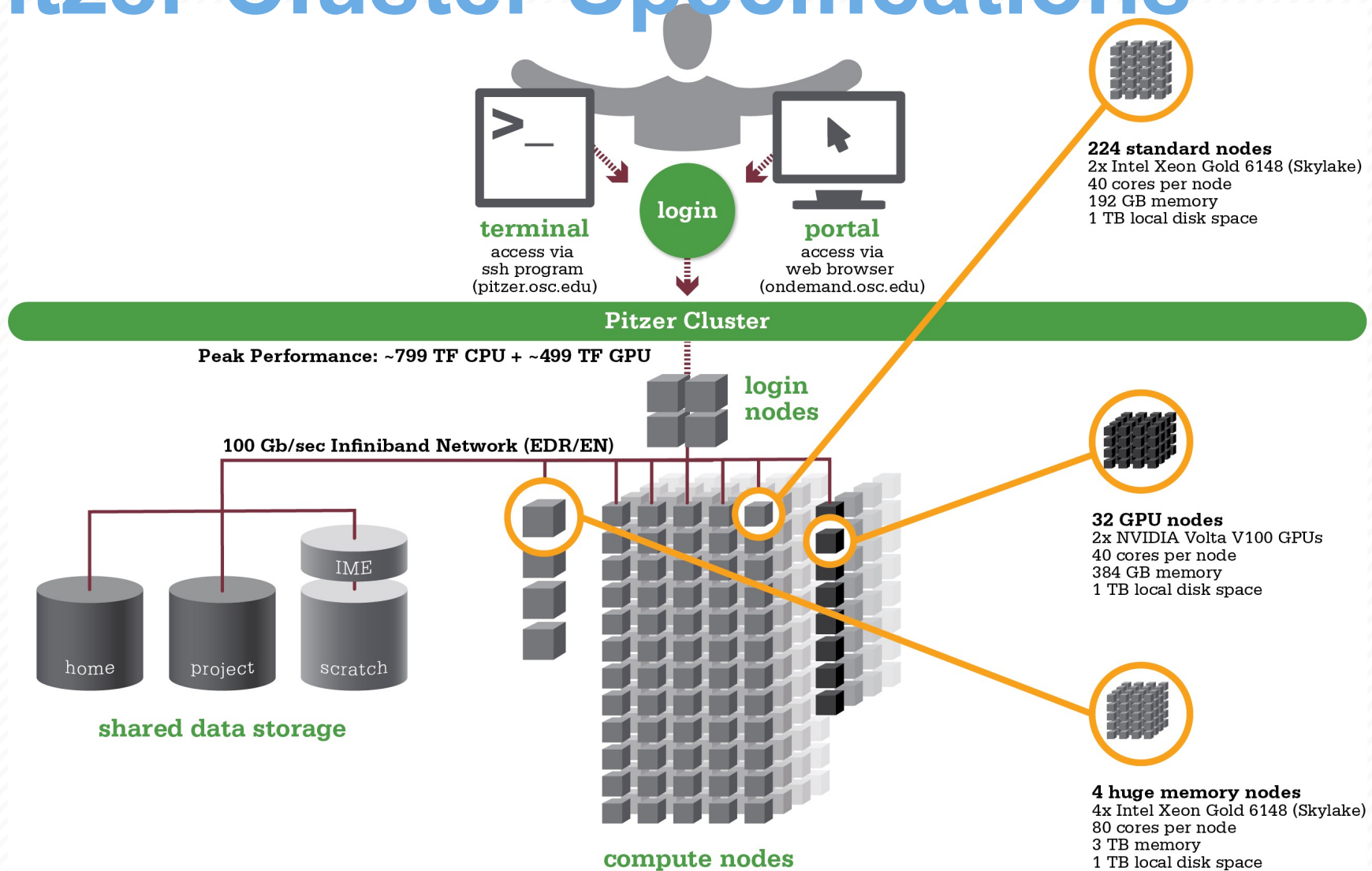
Owens Cluster Specifications



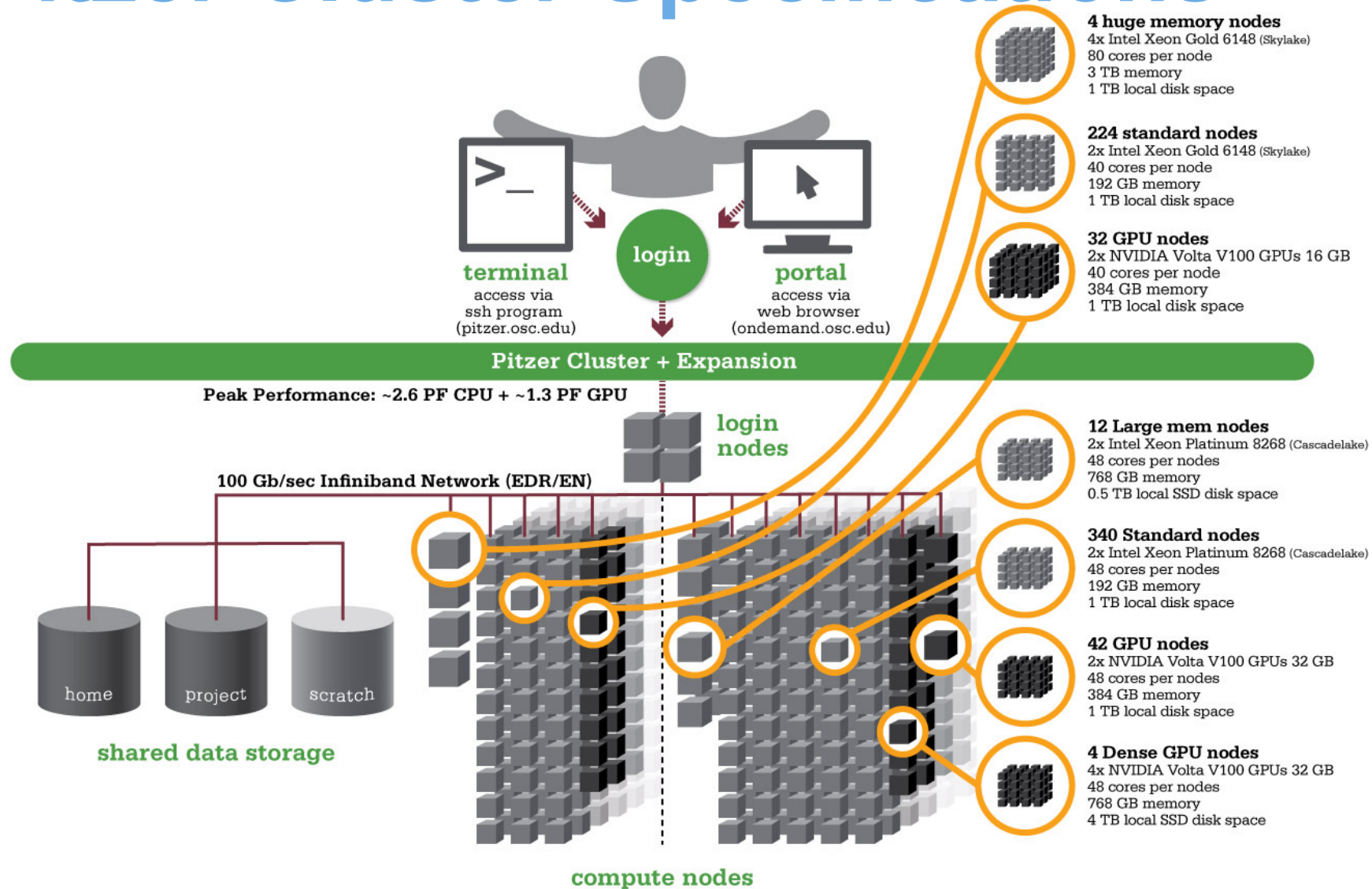
https://www.osc.edu/resources/technical_support/supercomputers/owens



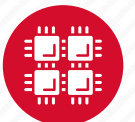
Pitzer Cluster Specifications



Pitzer Cluster Specifications

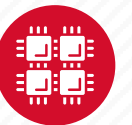


https://www.osc.edu/resources/technical_support/supercomputers/pitzer



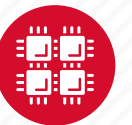
Login Nodes – Usage

- Purpose
 - Submit jobs to batch system
 - Edit files
 - Manage your files
 - Interactive work – small scale
- Limits
 - 20 minutes CPU time
 - 1GB memory
- **Use the batch system for serious computing**

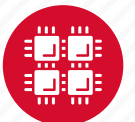
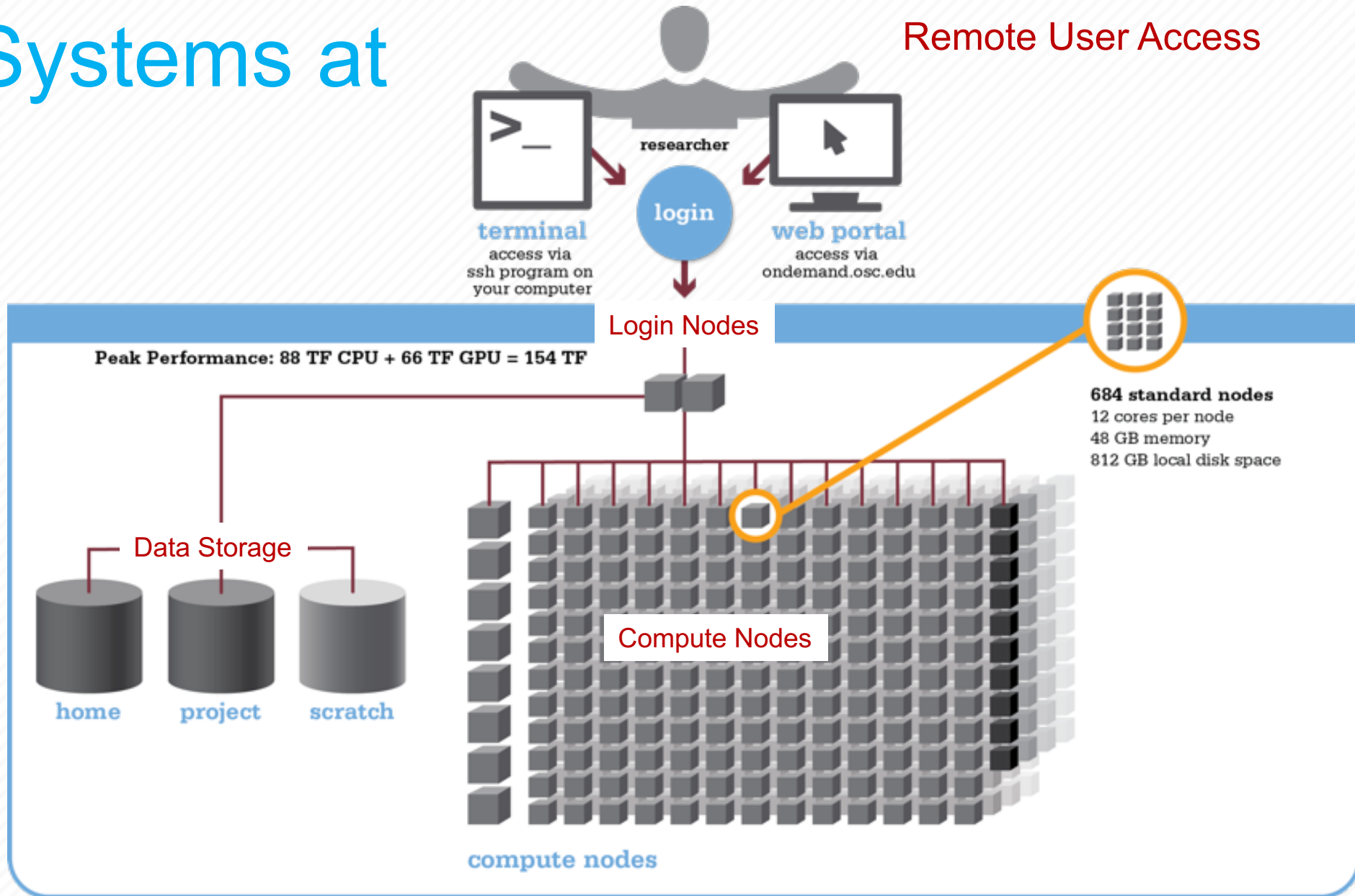




Data Storage Systems



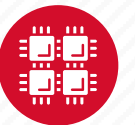
File Systems at OSC



Research Data Storage

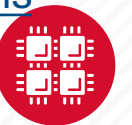
- Home
 - Store your files here, backed up daily
 - 500GB per user
- Project/ESS
 - Available to Project PIs by request; shared by all users on a project, backed up daily
 - 1-5TB standard request
- Scratch
 - Faster I/O than Home or Project
 - Temporary storage, not backed up
- Compute Nodes
 - Storage on compute nodes, for use during your batch job
 - All data purged when job quits
- Archive
 - Long term storage, by request

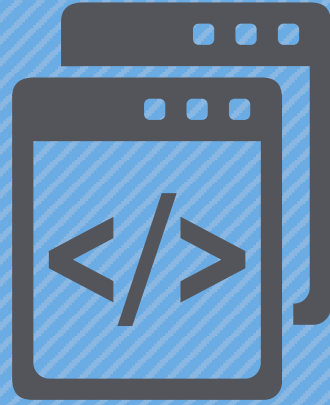
<https://www.osc.edu/supercomputing/storage-environment-at-osc/available-file-systems>



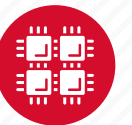
Filesystem <small>(Reference)</small>	Quota	Network	Backed-Up?	Purged?
Home (\$HOME)	500GB	10 GB/s	Yes	No
Project (/fs/project or /fs/ess)	By request (Typically 1-5 TB)	50 GB/s	Yes	No
Scratch (/fs/scratch)	100TB	100 GB/s	No	Yes – 90 days
Compute (\$TMPDIR)	Varies (~1 TB)	Varies	No	Yes – when job completes

<https://www.osc.edu/supercomputing/storage-environment-at-osc/storage-hardware/overview> of file systems



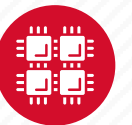


Getting Started at OSC



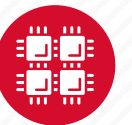
Who can get an OSC project?

- Academic project
 - Principal investigator (PI) must be a full-time faculty member or research scientist at an Ohio academic institution
 - PI may authorize accounts for students, post-docs, collaborators, etc.
 - Classroom projects are also available
- Commercial projects
 - Commercial organizations may purchase time on OSC systems



Accounts and Projects at OSC

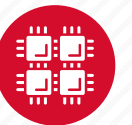
- Project
 - Headed by a PI
 - May include other users
 - Oversees computing resources for a project
- Account
 - Username and password to access HPC systems
 - Each account used by one person
 - If you work on multiple projects, you will have one account that can access all of them



Usage Charges

- Charges are in terms of core hours, GPU hours, TB months
- Project has a dollar balance
- Services, e.g. compute and storage, are charged to a project
- General Compute, GPU, Huge Memory, Storage costs are still partially subsidized and highly competitive

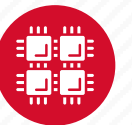
https://www.osc.edu/content/academic_fee_model_faq



Ohio Academic Projects

- Standard Projects
 - Each PI can receive \$1,000 grant annually to cover OSC services
 - PI can set a budget so no unexpected charges
 - No more proposal submissions
- Classroom projects are fully subsidized
- Request at my.osc.edu

<https://www.osc.edu/supercomputing/support/account>



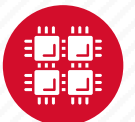
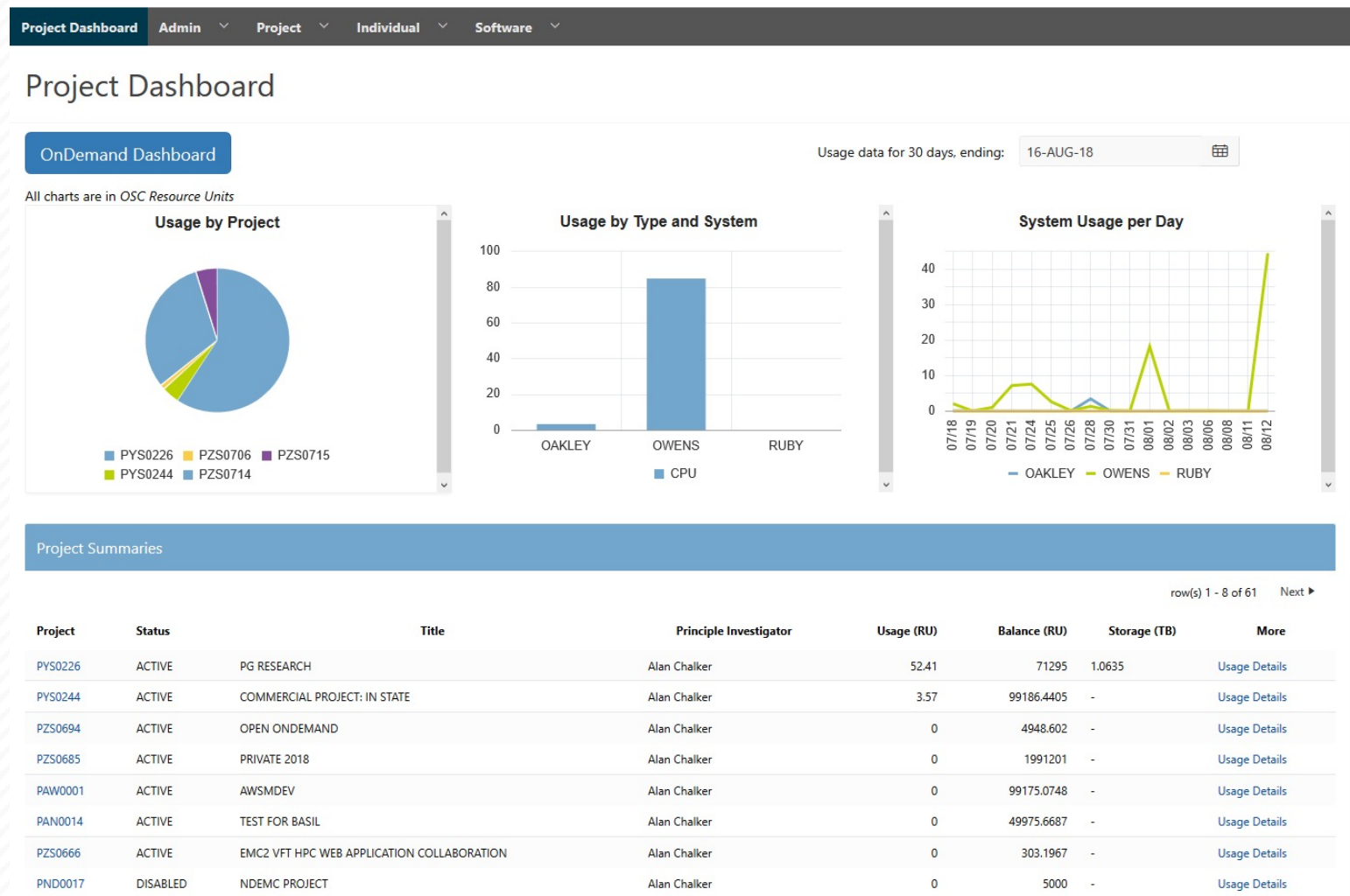
Client Portal– my.osc.edu

Features

- Create your account
- Update your email
- Change your password
- Recover access to your account
- Change your shell

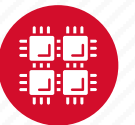
PI resources

- Project reporting
- Authorized user management
- Requesting services (e.g. software access)



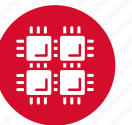
Statewide Users Group (SUG)

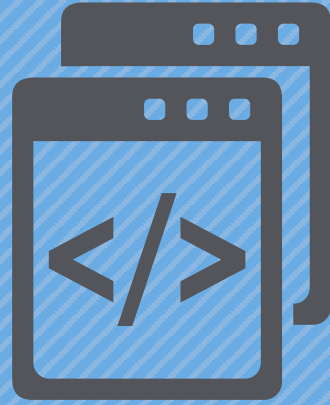
- The Statewide Users Group (SUG) is made up of OSC users
 - Provides program and policy advice to OSC
 - Meets twice a year
 - Headed by a chairperson elected yearly
- Standing committees
 - Software and Activities
 - Hardware and Operations
- Get involved!
 - Twice a year- April and October



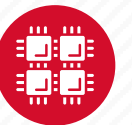
Citing OSC

- Please cite OSC in your publications:
 - Details at www.osc.edu/citation
- These publications should be reported to OSC



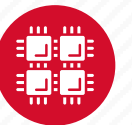


User Environment



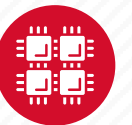
Linux Operating System

- “UNIX-like”
- Widely used in HPC
- Mostly command-line
- Choice of shells (bash is default)
- Freely distributable, open-source software
- Tutorials available
- www.linux.org



Connecting to an OSC Cluster

- Connect to OSC machines using **ssh** (secure shell)
 - From a Linux/UNIX (and Mac) terminal: At prompt, enter
ssh *userid*@owens.osc.edu
 - From Windows: **ssh** client software needed
 - Both commercial and free versions are available
- Connect using OSC OnDemand portal (web-based)
- Connect with graphics. Programs can have an X-based GUI
 - Linux/UNIX and Mac: Use **-x** flag
ssh -X *userid*@owens.osc.edu
 - Windows: extra software needed for X11 forwarding
 - Programs run primarily on log in nodes. Can also submit batch job



OSC OnDemand

ondemand.osc.edu

- 1: User Interface

- Web based
 - Usable from computers, tablets, smartphones
 - Zero installation
- Single point of entry
 - User needs three things
 - ondemand.osc.edu
 - OSC Username
 - OSC Password

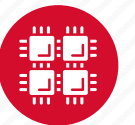
Connected to all resources
at OSC



- 2: Interactive Services

- File Access
- Job Management & Monitoring
- Visualization Apps
 - Desktop access
 - Single-click apps (Abaqus, Ansys, Comsol, Paraview)
- Terminal Access

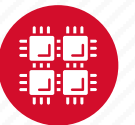
Tutorial available at
osc.edu/ondemand



Transferring Files to and from the Cluster

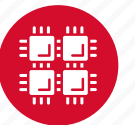
- Most file transfers to and from OSC machines use **sftp** or **scp**
 - Linux and Mac have them built in
 - Windows needs extra software - FileZilla
- For small files, connect to a login node
owens.osc.edu
- For large files, transfer may fail due to shell limits
 - Connect to **sftp.osc.edu** (file transfer only)
- OnDemand drag and drop file transfer up to 5GB files
- GLOBUS-- a large file transfer system

https://www.osc.edu/resources/getting_started/howto/howto_use_globus_overview



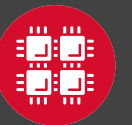


Using and Running Software at OSC



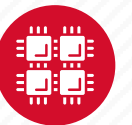
Software Maintained by OSC

- 145+ software packages maintained for users
- **Always** first check software page on https://www.osc.edu/resources/available_software/browse_software
 - Version information for all clusters
 - License information – some software you must request access
 - Usage examples



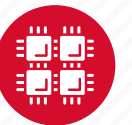
Third party applications

- **General programming software** (⌘ statewide licensed)
 - gnu compilers and debugger
 - ⌘ Intel compilers
 - ⌘ Arm DDT debugger
 - ⌘ Arm MAP profiler
 - ⌘ ANSYS
 - MPI library
 - HDF5
 - NetCDF
 - Java, Java Virtual Machine
 - Python
 - R Statistical & Programming environment



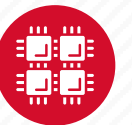
Third party applications

- **Parallel programming software** (⌘ statewide licensed)
 - MPI library (mvapich, mvapich2)
 - OpenMP
 - CUDA
 - OpenCL
 - OpenACC



Access to Licensed Software

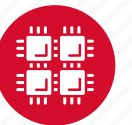
- Most software licenses for academic use only
- Some software requires signed license agreement
 - Check website
 - Contact OSC Help
- List of applications can be found at Software page:
<http://www.osc.edu/supercomputing/software/>



OSC doesn't have the software you need?

- Commercial software
 - Fill out a request form (see our FAQ)
 - SUG will consider it
- Open-source software
 - You can install it yourself in your home directory*
 - If there's enough demand, we can install it for shared use
- Have your own license?
 - Contact OSC Help

*https://www.osc.edu/resources/getting_started/howto/howto_locally_installing_software



Loading Software Environment



What modules do you have loaded?

`module list`



What modules are available?

`module spider` or `module avail`



Multiple versions of the same software

`module avail intel`



Add a software module to your environment

`module load cuda`



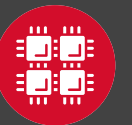
Remove a software package from your environment

`module unload intel`



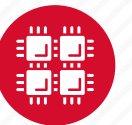
Load a different software version

`module swap intel intel/13.1.3.192`

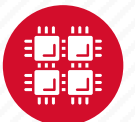
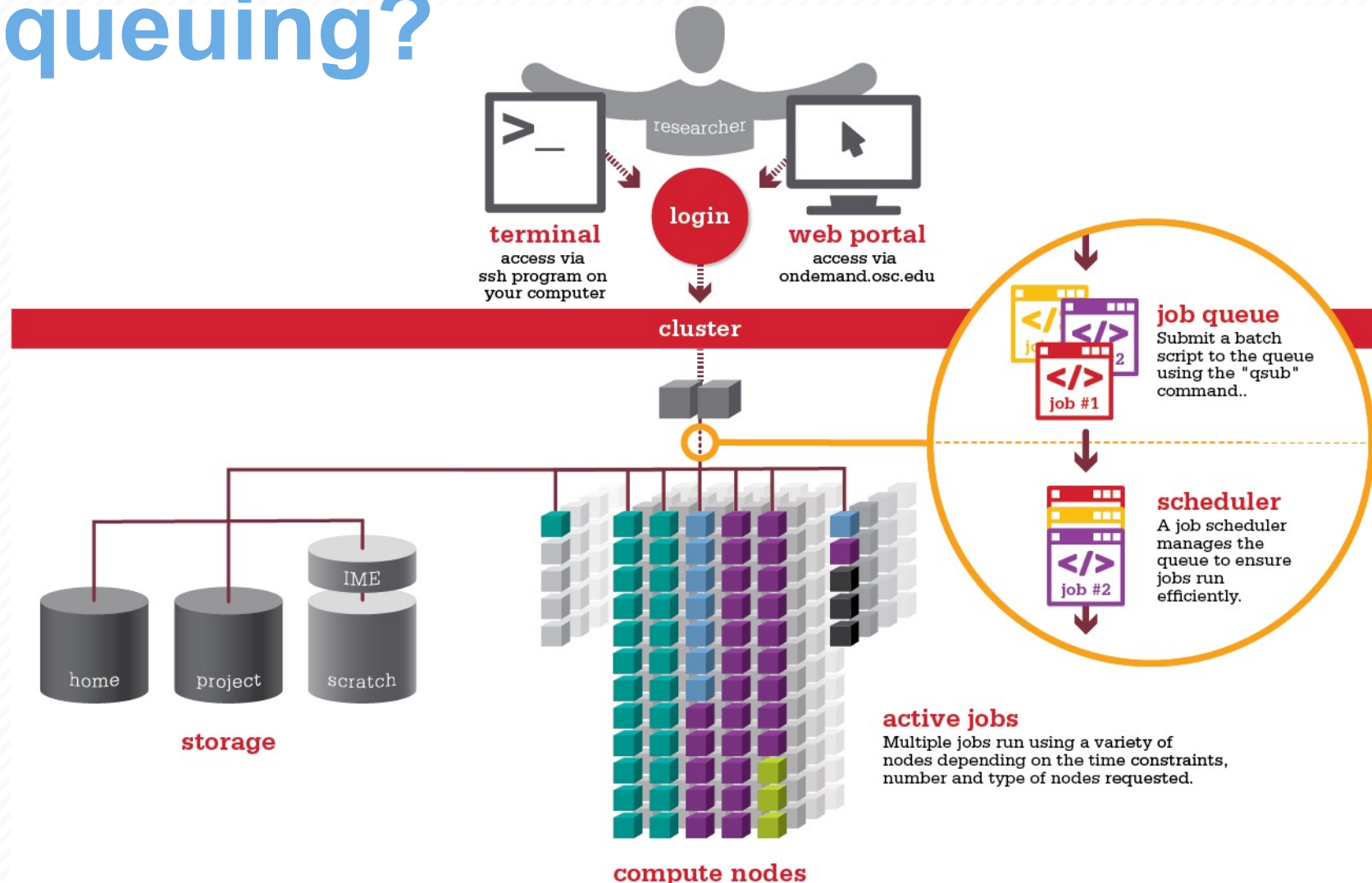




Batch Processing

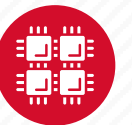


Why do supercomputers use queuing?



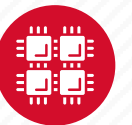
Steps for Running a Job on the Compute Nodes

1. Create a batch script for a job
2. Submit the job
3. Job gets queued
4. Job runs when resources become available
5. Get your results when the job finishes



Specifying Resources in a Job Script

- Nodes and cores (processors) per node, GPUs
- Memory (optional)
- Walltime
 - Overestimate slightly – job will be deleted if it hits limit
 - Shorter job may start sooner due to backfill
- Project #
- Software licenses
 - See specific software page on OSC website



Sample SLURM Batch Script

```
#!/bin/bash
#SBATCH --time=1:00:00
#SBATCH --nodes=2 --ntasks-per-node=40
#SBATCH --job-name=hello
#SBATCH --account=PZSXXXX
#SLURM already starts job in working directory
cd $SLURM_SUBMIT_DIR
```

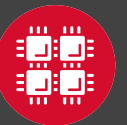
Job setup information
for SLURM

```
#Set up software environment
module load intel
#Move input files to compute node
cp hello.c $TMPDIR
```

Commands
to be run

```
mpicc -O2 hello.c -o hello
srun ./hello > hello_results
#Copy results back to working directory
cp hello_results $SLURM_SUBMIT_DIR
```

Put all this into a text file!

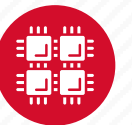


Submit & Manage Batch Jobs

SLURM Directive	Description
<code>sbatch <jobscript></code>	Submit job script
<code>scancel <jobid></code>	Cancel a job
<code>scontrol hold <jobid></code>	Put job on hold
<code>scontrol release <jobid></code>	Release job from hold
<code>squeue -u <user></code>	View information about job(s) of a user

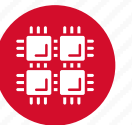
Submitted job SLURM response:

Submitted batch job 35484



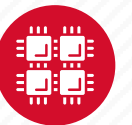
Scheduling Policies and Limits

- Walltime limit
 - 168 hours for serial jobs (single node)
 - 96 hours for parallel jobs (multiple nodes)
- Per-user limits
 - 128 concurrently running jobs
 - 2040 processor cores in use
 - 1000 jobs in the batch system, running or queued
- Per-group limits
 - 192 concurrently running jobs
 - 2040 processor cores in use



Waiting for Your Job To Run

- Queue wait time depends on many factors
 - System load
 - Resources requested
 - nodes, cores, large memory, gpus, software licenses
 - Fair share limits (if load is high)
 - reduced priority for users or groups using a lot of resources



Interactive Batch Jobs



Interactive, but handled through batch system

Resource limits same as standard batch limits



Useful for tasks forbidden on login nodes

Debug parallel programs

Run a GUI program that's too large for login node



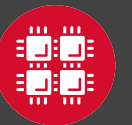
May not be practical when system load is high

Long wait, same as standard batch job



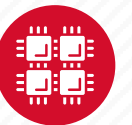
To submit an interactive batch job (example)

sinteractive -N 1 -n 4 -t 00:10:00 -J test

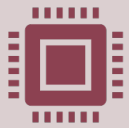


Batch Queues

- The two clusters have separate batch systems
 - Submit job and check status on the same cluster
- Debug reservation
 - A few nodes on each system are reserved for short jobs (≤ 1 hour)



Parallel Computing



Each processor is fast, but real speed comes from using multiple processors



Multithreading

Use multiple cores on a single node

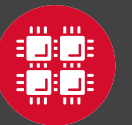
Shared memory



Message passing interface (MPI)

Use one or multiple nodes

Distributed memory



To Take Advantage of Parallel Computing



Program must be written to take advantage of multiple cores and/or multiple nodes



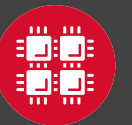
Many commercial applications have multithreaded or parallel versions



Use *mpiexec* for multiple nodes



Can't just request more nodes or cores and expect your job to run faster



Resources to get your questions answered

FAQs: https://www.osc.edu/resources/getting_started/supercomputing_faq

HOW TOs: https://www.osc.edu/resources/getting_started/howto

Installing Software

Installing R packages

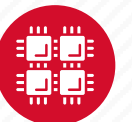
Tutorial materials: https://khill42.github.io/OSC_IntroHPC/

Office Hours: Virtual, every other Tuesday, 1:00pm – 4:00pm

Ask.ci: <https://ask.cyberinfrastructure.org/c/ohio-supercomputing/54>

System updates

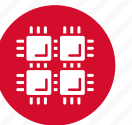
- Read Message of the Day on login
- Follow @HPCNotices on Twitter



A group of people are gathered around a large poster at a conference. A man in a red and blue plaid shirt is pointing at the poster, while a woman in a white shirt points to a specific section. Other people are looking on, some holding folders. In the background, a digital screen displays a car. A semi-transparent dark grey bar is at the bottom, containing the text "Questions?".

Questions?

<https://ondemand.osc.edu/>





OH·TECH

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A Division of the Ohio Department of Higher Education

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Ohio Academic Price Sheet

High Performance Computing Services	Standard Nodes		Big Memory Nodes		Add-on GPU
	per node hr	per core hr	per node hr	per core hr	per GPU hr
Owens Cluster	\$0.08	\$0.003*	\$0.19	\$0.004*	+ \$0.045
Pitzer Cluster	\$0.12		\$0.32		
Pitzer Expansion	\$0.14		\$0.19		
 *Current subsidies allow for reduced costs. Original per core hour cost is \$0.014. Costs subject to change.					

Monthly billing is based on usage of nodes/cores to the nearest minute.

Data Storage & Transfer Services	Price per TB per month
Home directories, parallel scratch and network transfer	\$0
Project storage (high performance, high availability file system, includes backup)	\$1.60

Monthly billing is based on the allocated storage quota to the nearest half TB.

