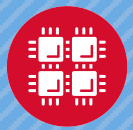
Ohio Supercomputer Center

An OH·TECH Consortium Member

An introduction to OSC services, hardware, and environment

January 13, 2022



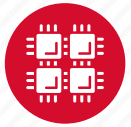
Kate Cahill

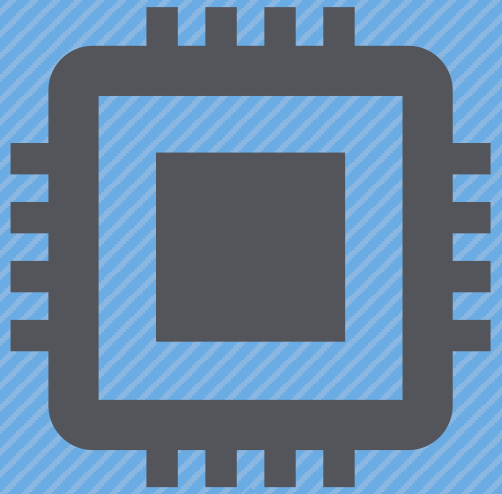
Education & Training Specialist

“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



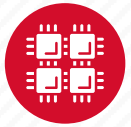


What is the Ohio Supercomputer Center?

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

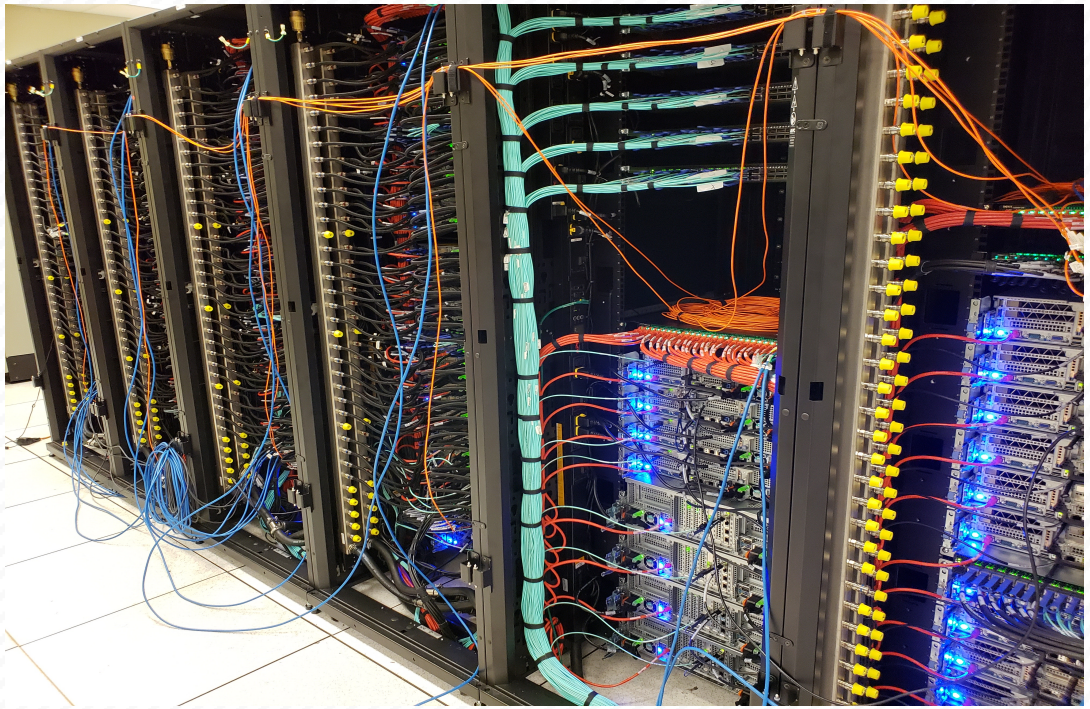
A fully scalable center with mid-range machines to match those found at National Science Foundation centers and other national labs.

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

FY2021

32 Ohio Universities

39 Companies

25 Non-Profits and Government Agencies

97 Other Educational Institutions

5,756 Clients

967 PIs

13% faculty/staff
77% students
10% other

249 college courses used OSC

22 Training Opportunities

419 Trainees

Ohio Higher-Ed using OSC

FY2021

Ohio Higher-Ed Courses using OSC

FY2021

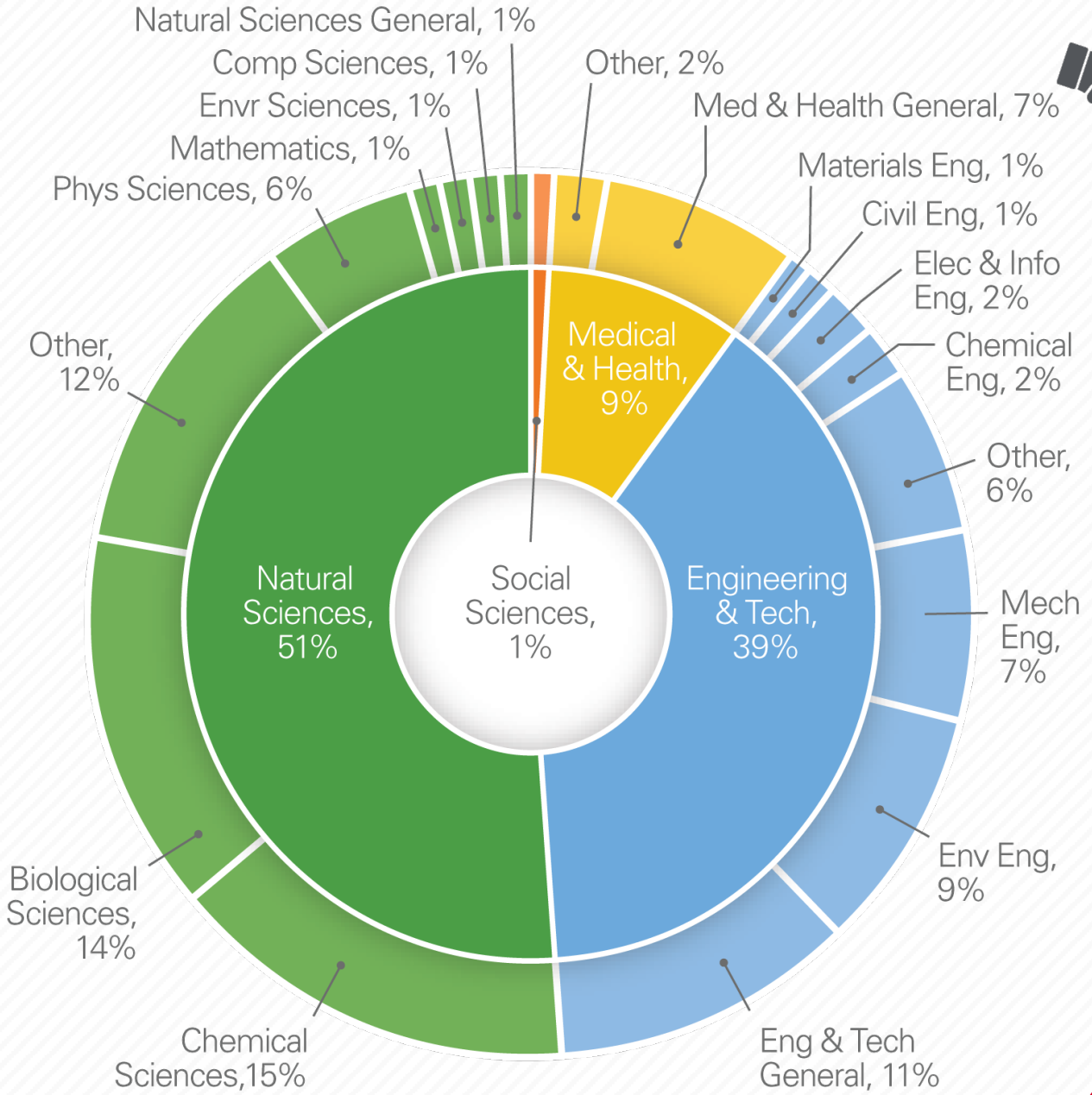
5,565 enrollees, 249 courses, 77 departments, 20 universities

Institution	Students	Courses	Dept.'s
Air Force Institute of Tech.	1	1	1
Bluffton University	10	1	1
Bowling Green State U.	69	6	3
Cedarville University	14	1	1
Cleveland State University	57	5	3
Kent State University	74	14	3
Kenyon College	55	4	1
Miami University	53	4	3
Ohio State University	4140	154	35
Ohio University	54	7	3

Institution	Students	Courses	Dept.'s
Stark State College	36	3	1
University of Akron	15	2	2
University of Cincinnati	760	28	7
University of Dayton	18	3	2
U. of Mount Union	7	1	1
University of Toledo	50	3	3
Urbana University	2	1	1
Wittenberg University	16	2	2
Wright State University	98	4	2
Xavier University	36	5	2

Usage by Field of Study*

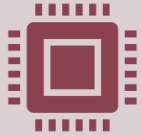
FY2021



*Fields of study are self-reported and classified based on "Revised Field of Science and Technology (FOS) Classification in The Frascati Manual" found here https://www.oecd.org/science/inno/38235147.pdf

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?

X 10000 =

Remote Connect

HPC Terminology

Compute Node

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

Compute Cluster

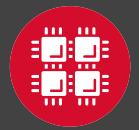
- A group of computers (nodes) connected by a high-speed network, forming a supercomputer

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

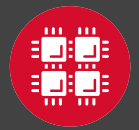
Shared memory is local to one node and several process

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

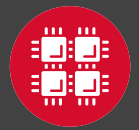
Local disk in the compute node

Project storage

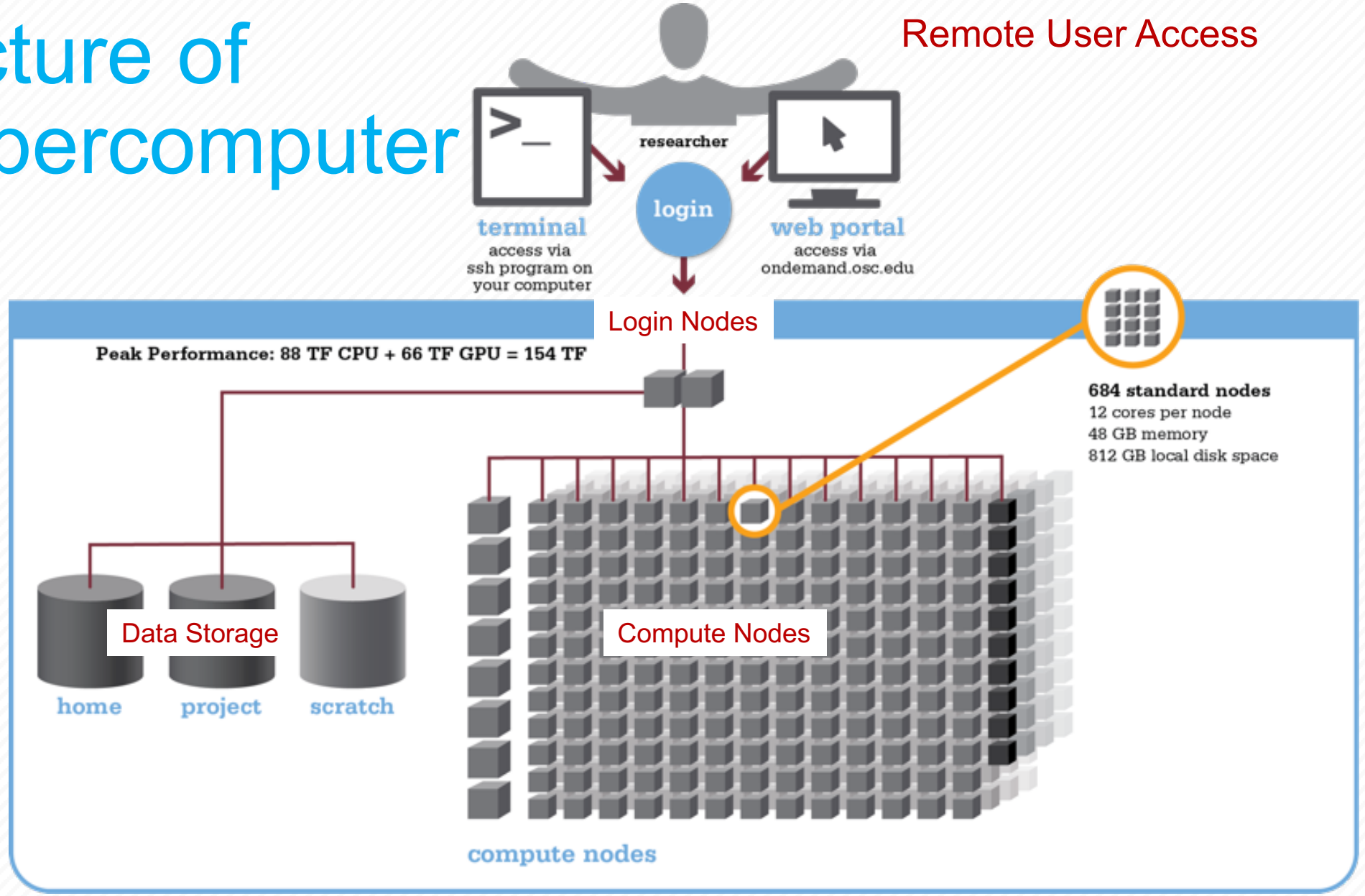
Shared scratch

Short-term storage only

Longer-term or archive



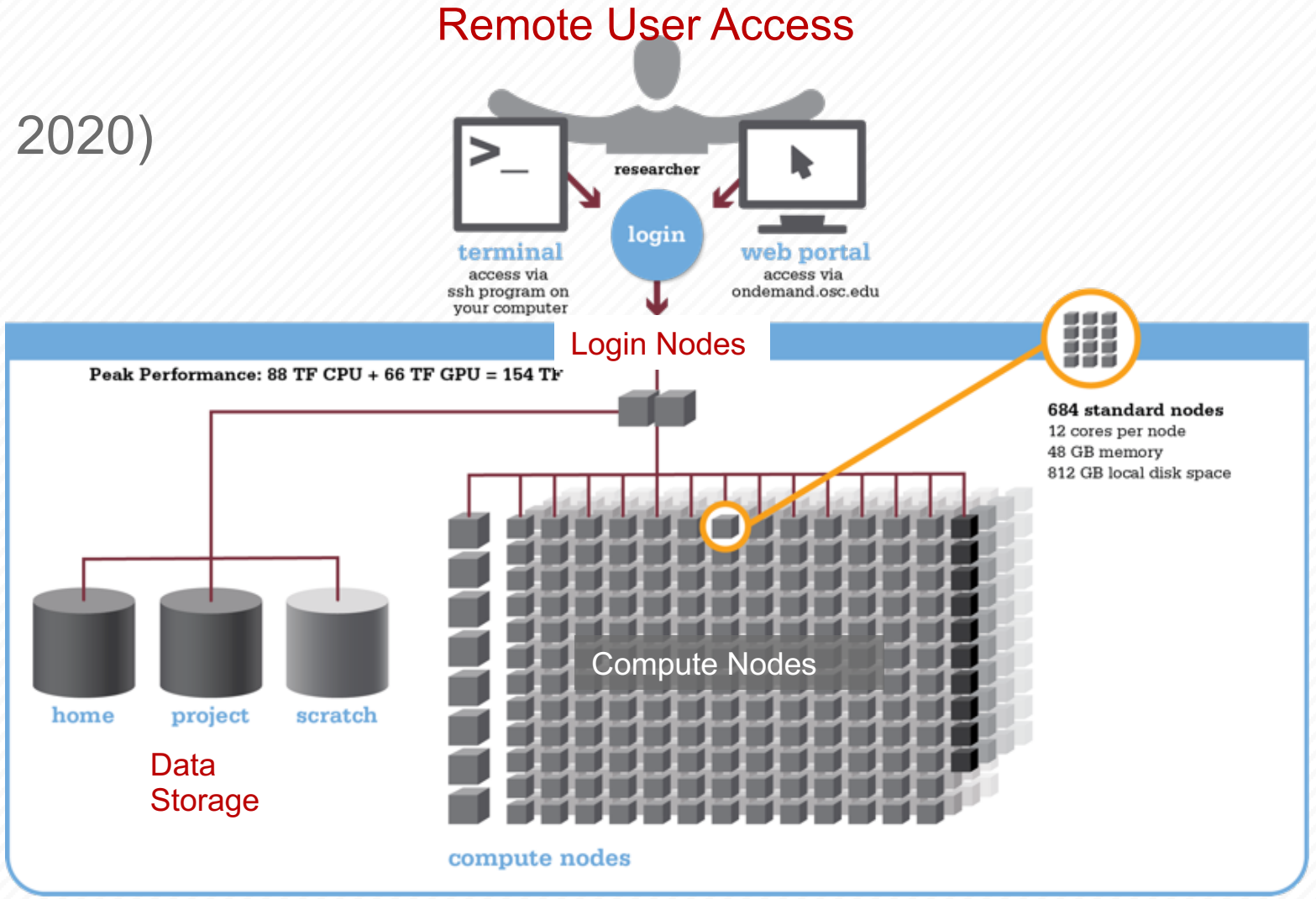
Structure of a Supercomputer



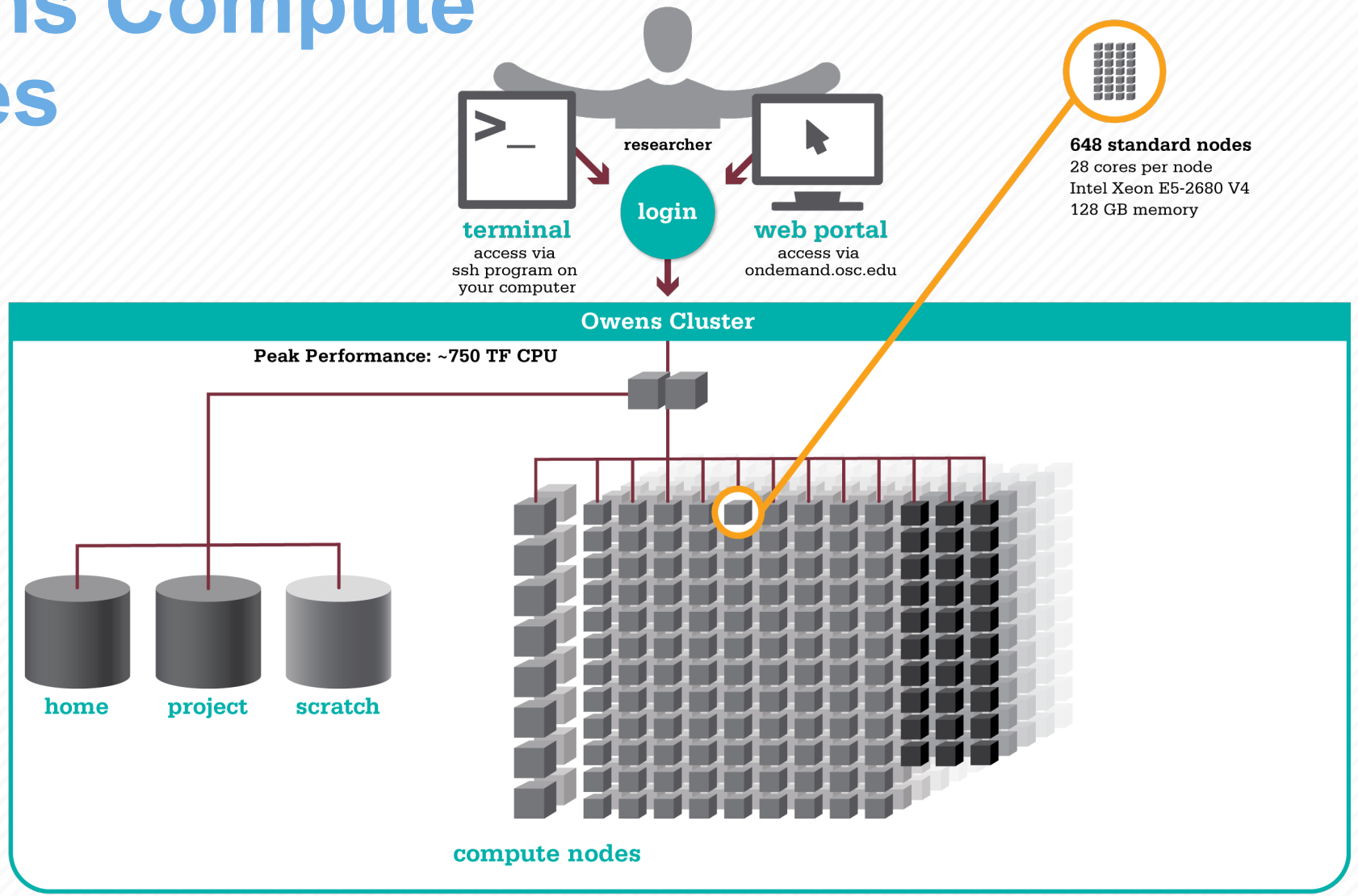
Hardware Overview

Current OSC Clusters

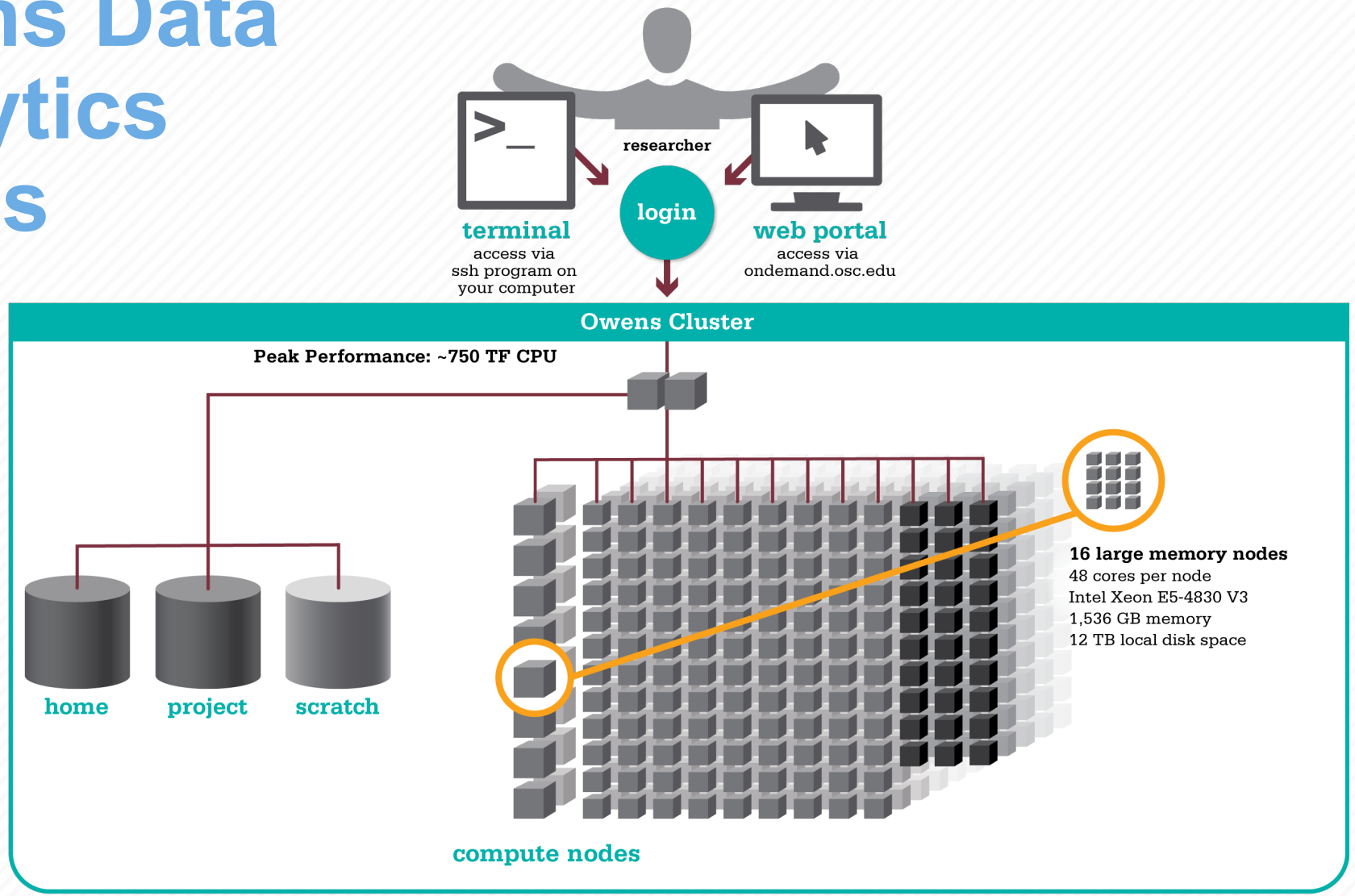
- Owens (2016)
- Pitzer (2018 & 2020)



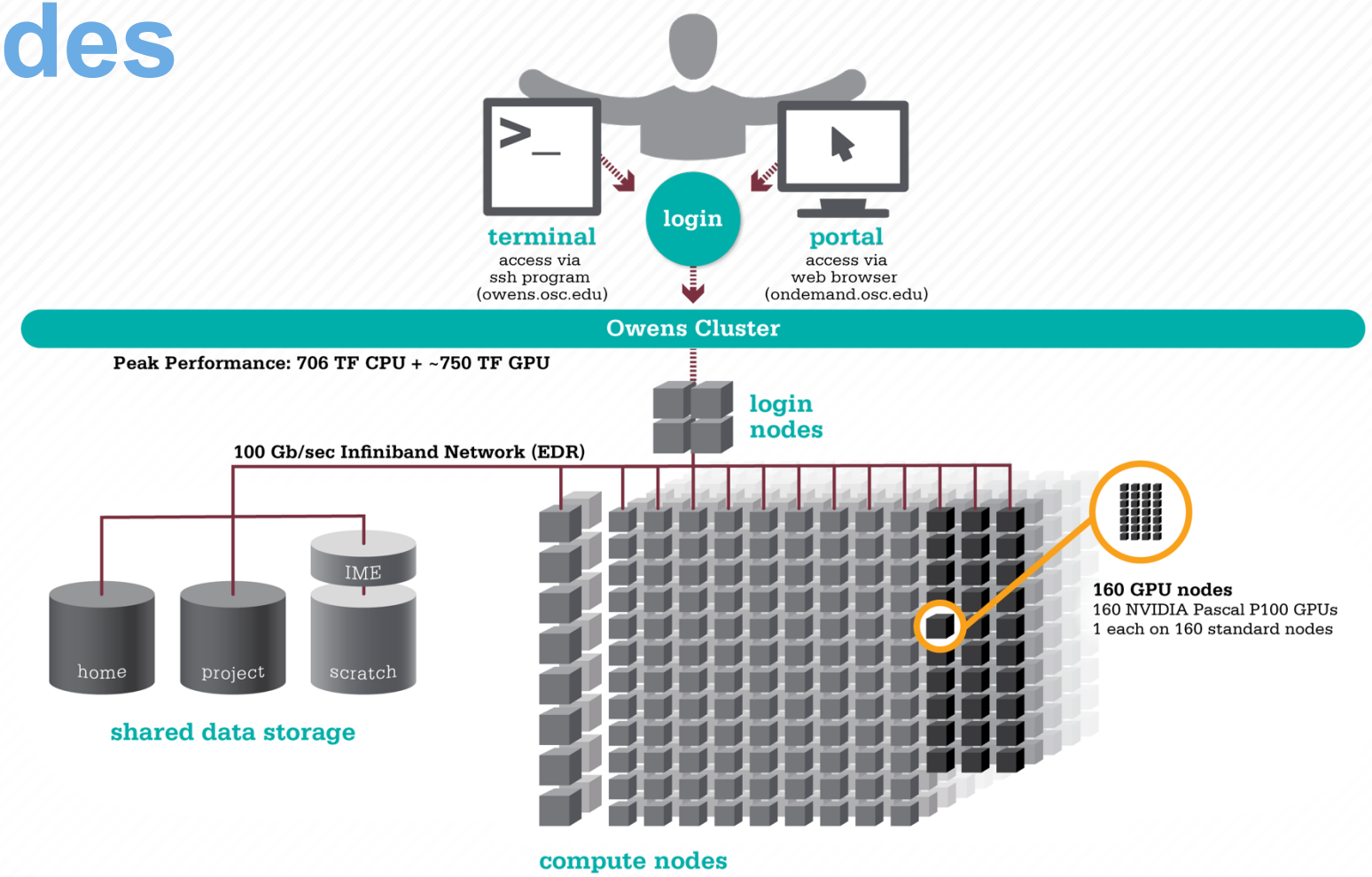
Owens Compute Nodes



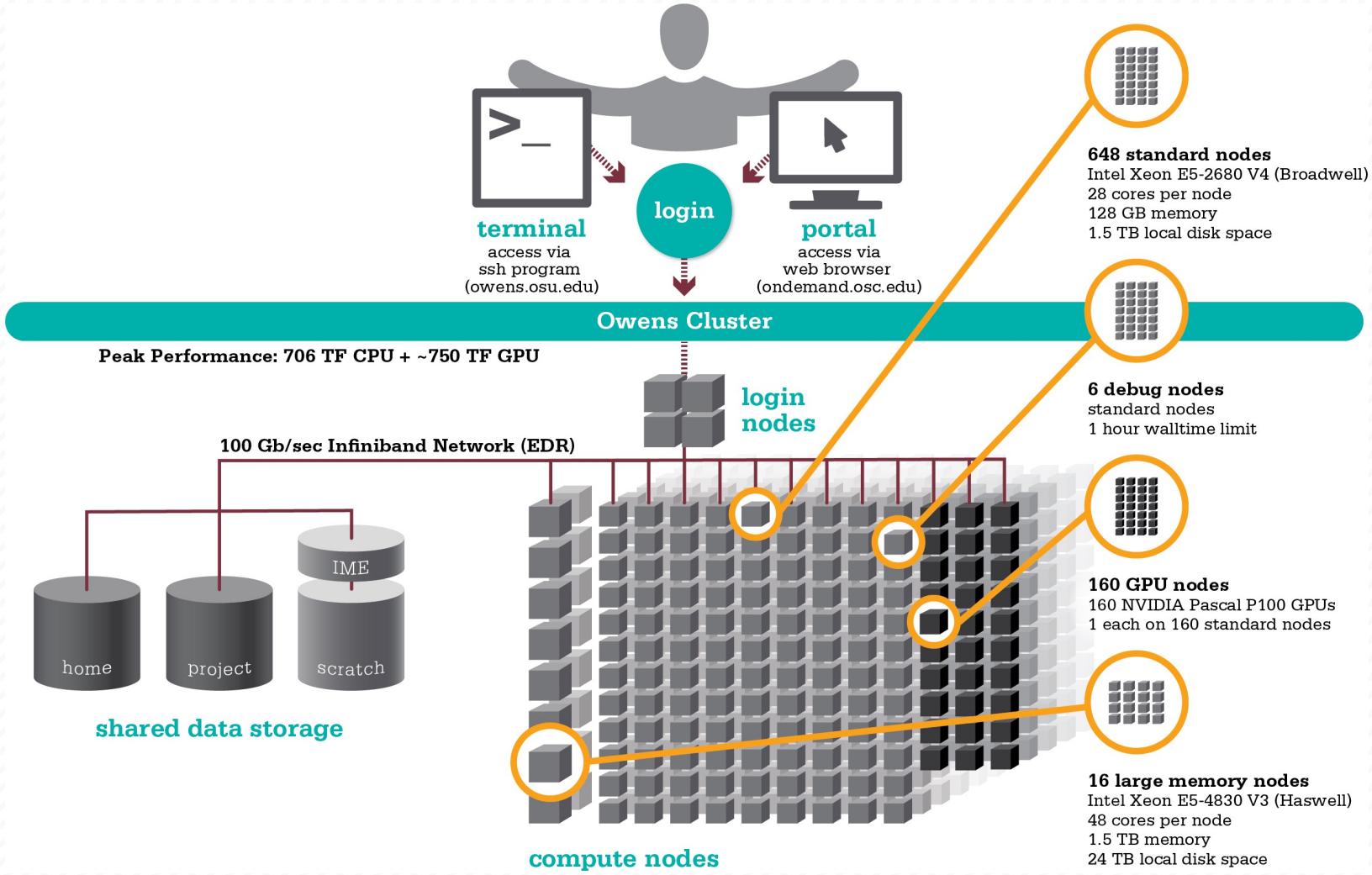
Owens Data Analytics Nodes



Owens GPU Nodes



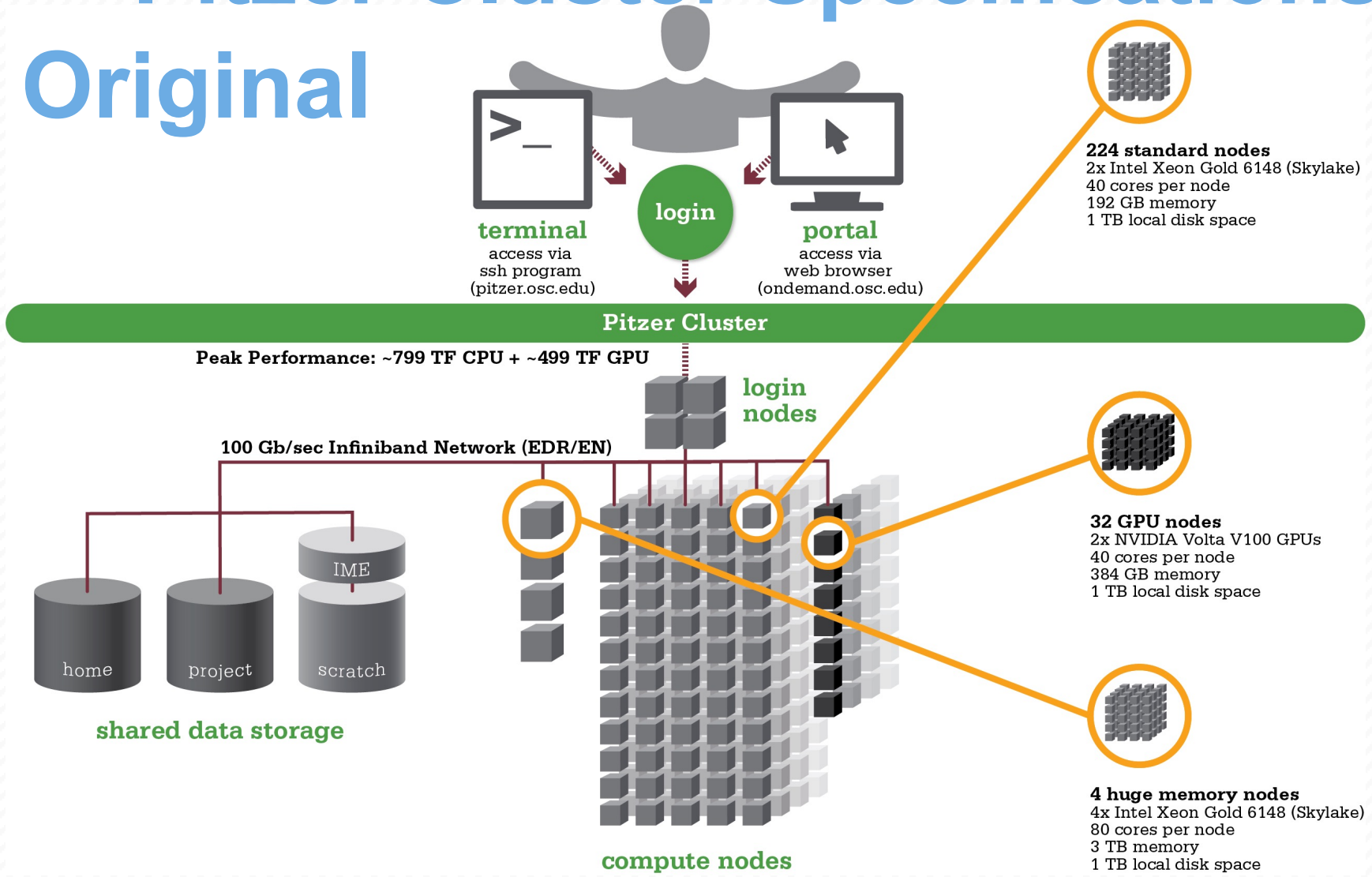
Owens Cluster Specifications



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

Pitzer Cluster Specifications

Original



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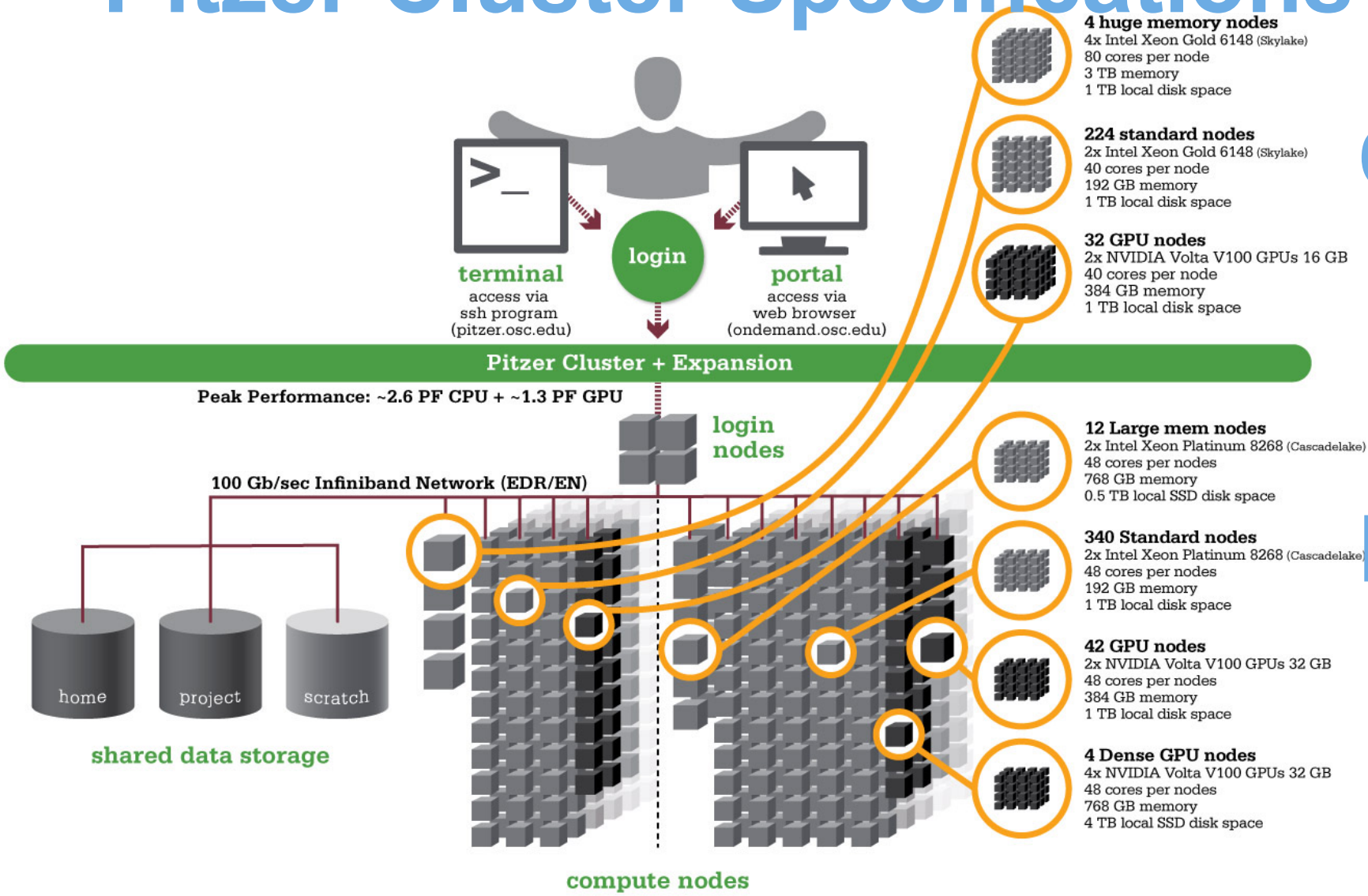
Pitzer Cluster Specifications



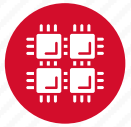
Original

Expansion

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

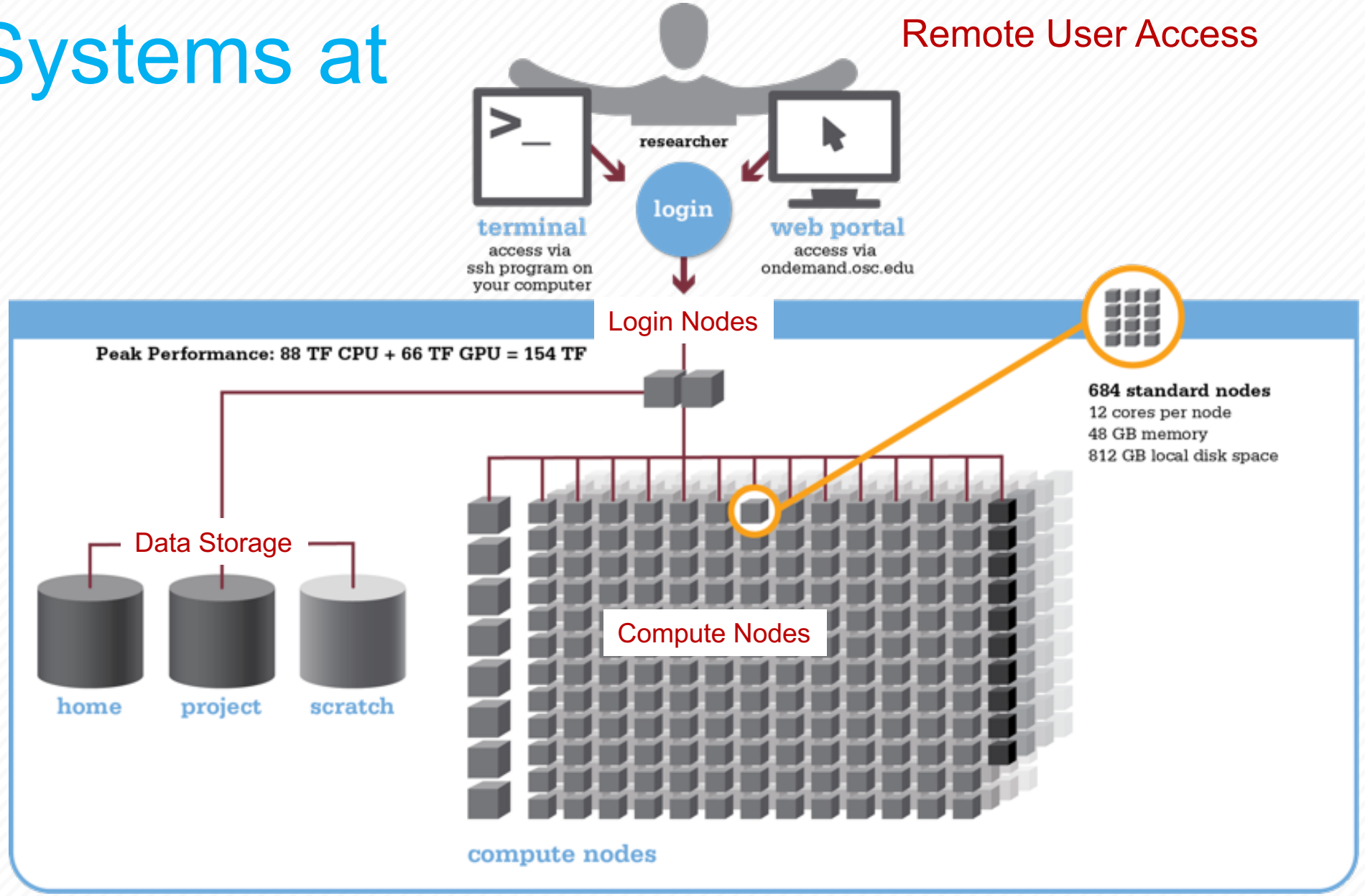
Login Nodes – Usage

- 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

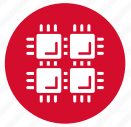
File Systems at OSC



Research Data Storage

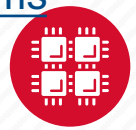
- Home
  - Store your files here, backed up daily
  - 500GB per user
- Project/ESS
  - Available to Project PIs by request; shared by all users on a project, backed up daily
  - 1-5TB standard request
- Scratch
  - Faster I/O than Home or Project
  - Temporary storage, not backed up
- Compute Nodes
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

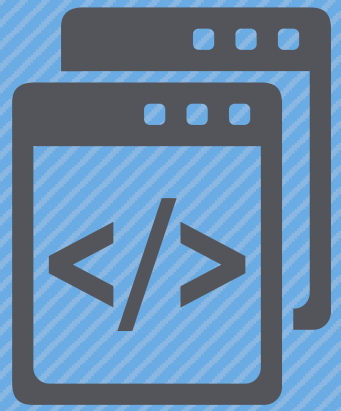
https://www.osc.edu/supercomputing/storage-environment-at-osc/available-file-systems



Filesystem (Reference)	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

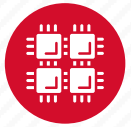




Getting Started at OSC

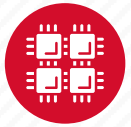
Who can get an OSC project?

- 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

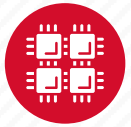
- Project
  - Headed by a PI
  - May include other users
  - Oversees computing resources for a project
- Account
  - Username and password to access HPC systems
  - Each account used by one person
  - If you work on multiple projects, you will have one account that can access all of them



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

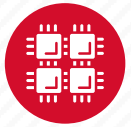
https://www.osc.edu/content/academic_fee_model_faq



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



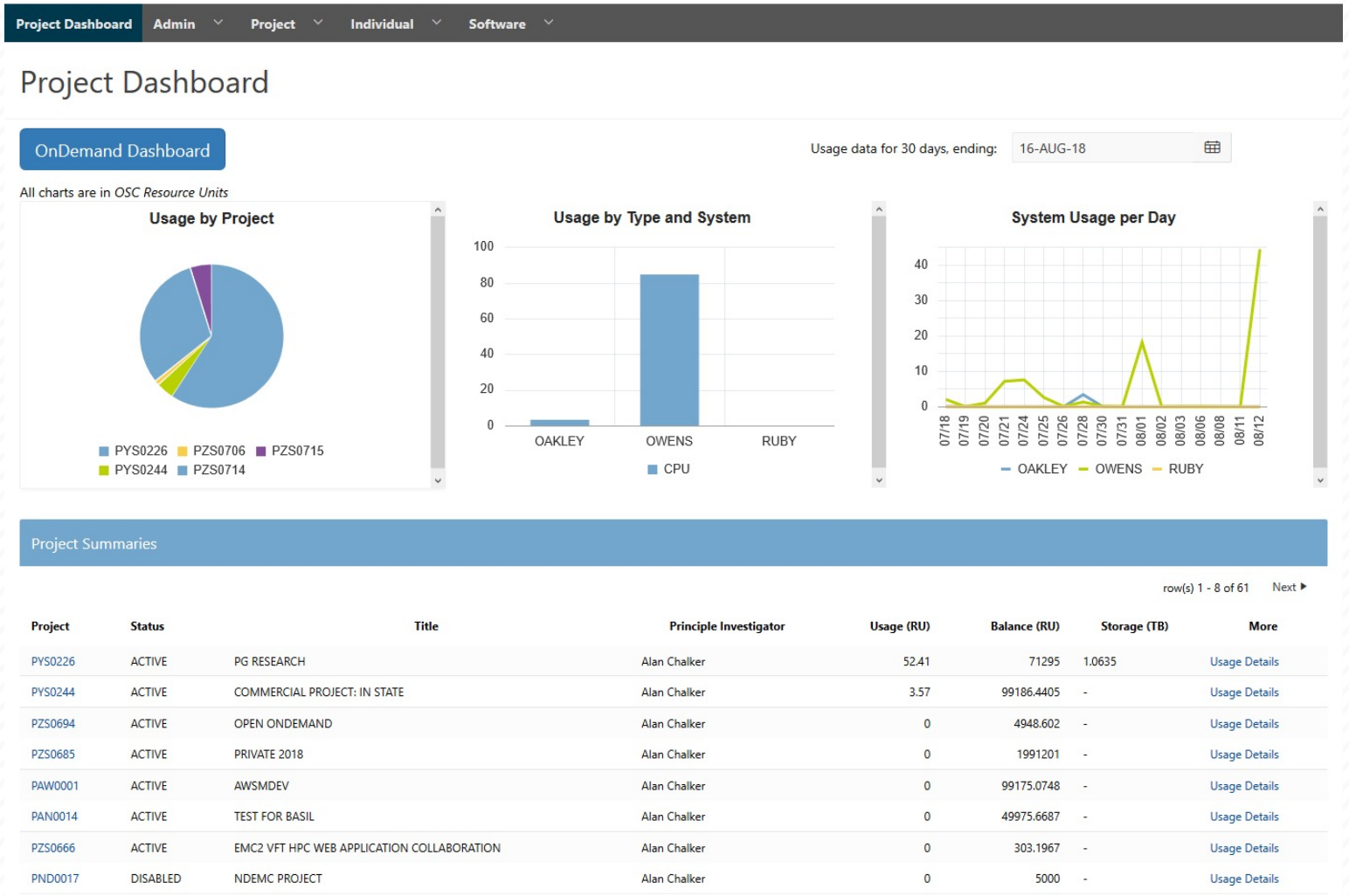
Client Portal– my.osc.edu

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)

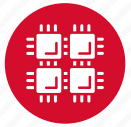


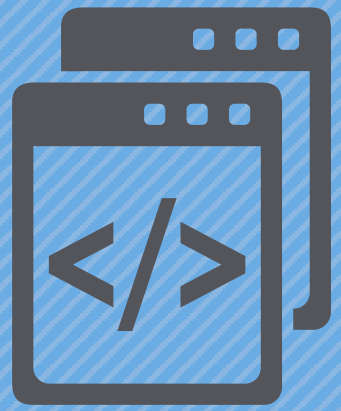
Statewide Users Group (SUG)

- 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: OSC calendar

Communications & Citing OSC

- Keep your email updated
  - We send regular user emails
  - notifications of regular and unplanned maintenance
    - quarterly downtimes
- Please cite OSC in your publications:
  - Details at www.osc.edu/citation
- These publications should be reported to OSC





User Environment

Linux Operating System

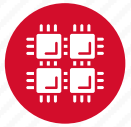
- “UNIX-like”
- Widely used in HPC
- Mostly command-line
- Choice of shells (bash is default)
- Freely distributable, open-source software
- Tutorials available: https://www.osc.edu/content/linux-command-line-fundamentals
- www.linux.org

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

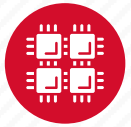
osc.edu/ondemand

Transferring Files to and from the Cluster

- Most file transfers to and from OSC machines use **`sftp`** or **`scp`** from a terminal window
- 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 life transfer system

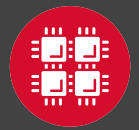
https://www.osc.edu/resources/getting_started/howto/howto_use_globus_overview



Using and Running Software at OSC

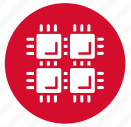
Software Maintained by OSC

- 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



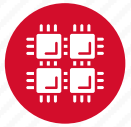
Third party applications

- **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 & Programing environment



Third party applications

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

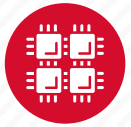


Access to Licensed Software

- 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:

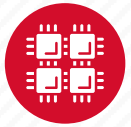
  http://www.osc.edu/supercomputing/software/



OSC doesn't have the software you need?

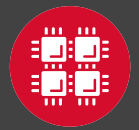
- Commercial software
  - Fill out a request form (see our FAQ)
  - SUG will consider it
- Open-source software
  - You can install it yourself in your home directory*
  - If there's enough demand, we can install it for shared use
- Have your own license?
  - Contact OSC Help

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



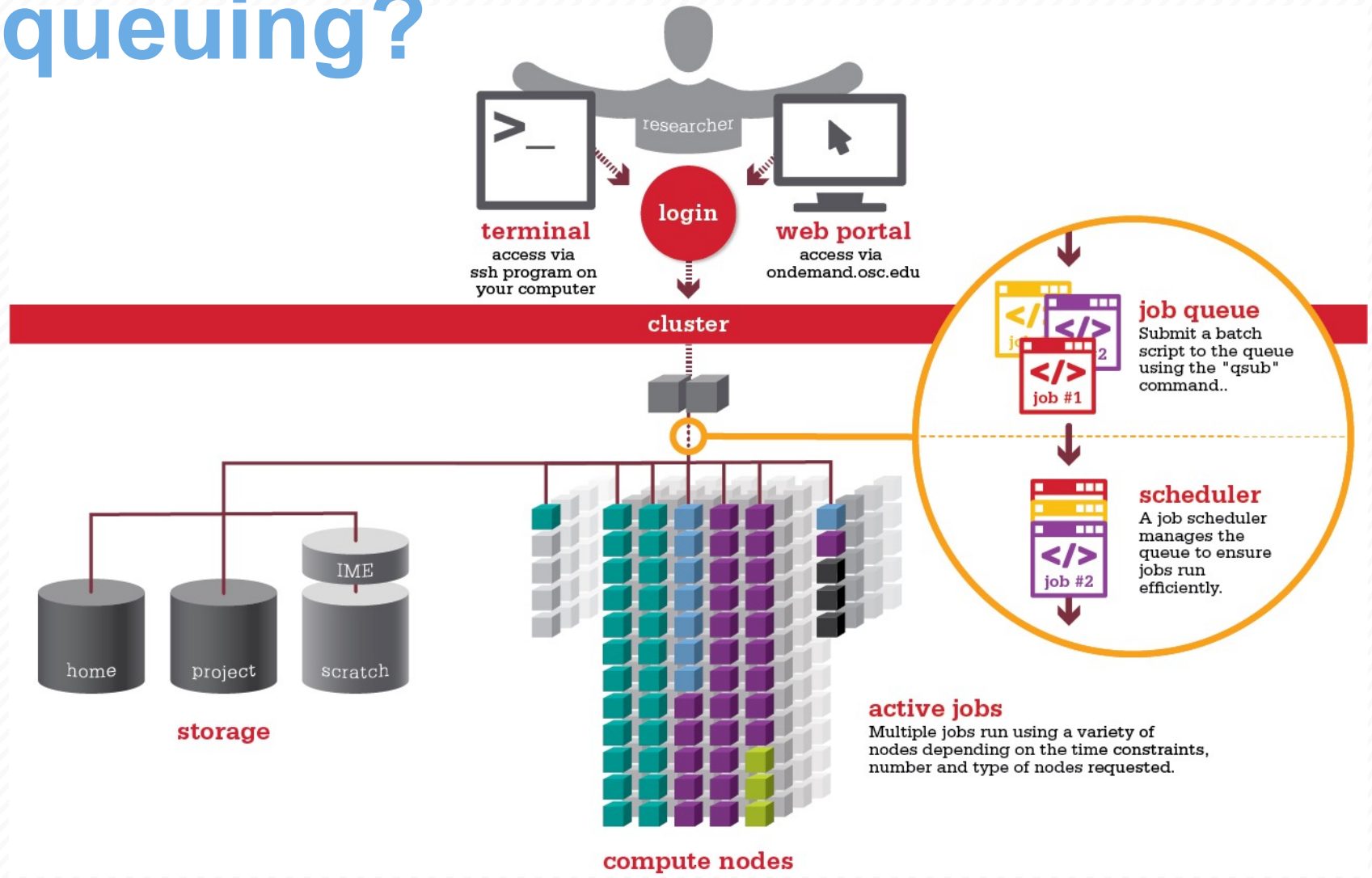
Loading Software Environment

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?

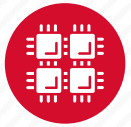


Steps for Running a Job on the Compute Nodes

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



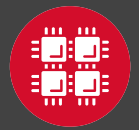
Sample Slurm Batch Script

```
#!/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

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

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

Job setup information for SLURM

Commands to be run

Put all this into a text file!



Submit & Manage Batch Jobs

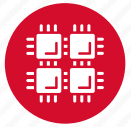
Slurm Directive	Description
sbatch <jobscript>	Submit job script
scancel <jobid>	Cancel a job
scontrol hold <jobid>	Put job on hold
scontrol release <jobid>	Release job from hold
squeue -u <user>	View information about job(s) of a user

Submitted job Slurm response:

Submitted batch job 35484

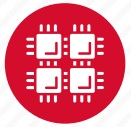
Learn more at Batch System training – check OSC calendar

https://www.osc.edu/supercomputing/batch-processing-at-osc



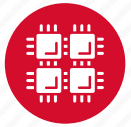
Scheduling Policies and Limits

- 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



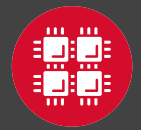
Waiting for Your Job To Run

- 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



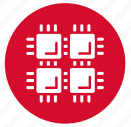
Interactive Batch Jobs

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***

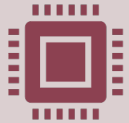


Batch Queues

- 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

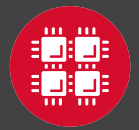
Use multiple cores on a single node

Shared memory

Message passing interface (MPI)

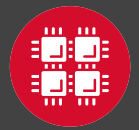
Use one or multiple nodes

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

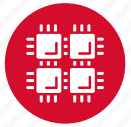
Tutorial materials: https://khill42.github.io/OSC_IntroHPC/

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

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

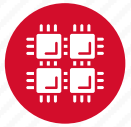
System updates

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




Questions?

https://ondemand.osc.edu/



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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	$.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.