Computing Services to Accelerate Research and Innovation

Dr. Judy Gardiner
Autumn 2015

Outline

• Overview
  – What is OSC?
  – HPC Concepts
  – Hardware Overview
  – Resource Grants and Accounts at OSC

• How to use our systems
  – User Environment
  – Batch Processing
  – Storage
  – Third-Party Software Applications
  – Policies
What is the Ohio Supercomputer Center?

www.osc.edu

The OH-TECH Consortium

<table>
<thead>
<tr>
<th><strong>Ohio Supercomputer Center</strong></th>
<th>provides high performance computing, software, storage and support services for Ohio’s scientists, faculty, students, businesses and their research partners.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OARnet</strong></td>
<td>connects Ohio’s universities, colleges, K-12, health care and state and local governments to its high-speed fiber optic network backbone. OARnet services include co-location, support desk, federated identity and virtualization.</td>
</tr>
<tr>
<td><strong>OhioLINK</strong></td>
<td>serves nearly 600,000 higher education students and faculty by providing a statewide system for sharing 50 million books and library materials, while aggregating costs among its 90 member institutions.</td>
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<tr>
<td><strong>eStudent Services</strong></td>
<td>provides students increased access to higher education through e-learning and technology-enhanced educational opportunities, including virtual tutoring.</td>
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<tr>
<td><strong>Research &amp; Innovation Center</strong></td>
<td>will operate, when opened, as the proving grounds for next-generation technology infrastructure innovations and a catalyst for cutting-edge research and collaboration.</td>
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</table>

www.osc.edu
About OSC

- Founded in 1987
- Statewide resource for all universities in Ohio
  - high performance computing services
  - computational science expertise
  - “… propel Ohio’s research universities and private industry to the forefront of computational based research.”
- Funded through the Ohio Department of Higher Education
- Reports to the Chancellor
- Located on OSU’s west campus
- Fiscal agent is OSU
Research Impact FY2014

• Production Capacity
  – **82+ million CPU core-hours** delivered
  – Over **3.3 million jobs**
  – **835 TB data storage** space in use
  – **98% uptime** (target: 96% cumulative uptime)

• Client Service Facts
  – **24 universities** served around the state
  – **194 projects** received allocations
  – **948 individuals** ran a computing simulation or analysis
  – **330+ individuals** attended **18 training opportunities**

Active Projects

- 1 – 5
- 6 – 10
- 10 – 20
- 21+ (UC 35 & OSU 246)
Computing Resource Usage by Field of Science (FoS)

Aggregate Hours

- Mathematical and Physical Sciences: 50%
- Computer and Information Science and Engineering: 13%
- Biological, Behavioral, and Social Sciences: 10%
- Geosciences: 9%
- Engineering: 15%
- Other: 2%
- None: 1%

HPC Client Services

- Technical Assistance
  - Help desk and basic consulting
  - Contact by phone or email (oschelp@osc.edu)
- Facilitation
  - Meet with OSC staff to discuss your research needs
  - Get recommendations on services, connections to subject matter experts, and specialized projects initiated
- Project Administration
  - Manage allocations
  - Add/Remove authorized users
  - Utilization reports
- Training
  - Usually three workshops per semester on a variety of topics
- Advanced consulting
  - Code parallelization & optimization
  - Software development, algorithm research
- Website
  - www.osc.edu/supercomputing
What can OSC provide you?

• You can complete your research for less cost.
• You can do more science for the same cost.
• You can get to solution faster.

What can OSC provide you?

• “Capability computing” (High Performance Computing)
  – Computation too large to run on laptop/desktop
• “Capacity computing” (High Throughput Computing)
  – Takes too long on laptop, need to make many runs
• Data Analytics
  – Massive memory requirements
• Access to licensed software
  – Have academic licenses for many commercial packages
• Expertise, collaboration
  – Parallel computing, algorithms, web portals, etc.
Statewide Licensed Software

• Use the software in your lab or office
  – Connect to license server at OSC
• Software available
  – Altair Hyperworks
  – Totalview Debugger
  – Intel Compilers, Tools, Libraries
  – Portland Group Compilers
• Contact OSC Help
  – Provide your IP address

HPC Concepts

www.osc.edu
Big Numbers

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Example: bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>K – kilo, $10^3$, thousand</td>
<td>• 1KB – very small</td>
</tr>
<tr>
<td>M – mega, $10^6$, million</td>
<td>• 12MB L2 cache per core</td>
</tr>
<tr>
<td>G – giga, $10^9$, million</td>
<td>• 48GB memory per node</td>
</tr>
<tr>
<td>T – tera, $10^{12}$, trillion</td>
<td>• .5 TB disk space per user</td>
</tr>
<tr>
<td>P – peta, $10^{15}$, quadrillion</td>
<td>• 4 PB aggregate storage</td>
</tr>
<tr>
<td>E – exa, $10^{18}$, quintillion</td>
<td>• Exascale systems – current research area</td>
</tr>
</tbody>
</table>

HPC Terminology

• Cluster
  – A group of computers (nodes) connected by a high-speed network, forming a supercomputer
• Node
  – Equivalent to a high-end workstation, part of a cluster
• Core
  – A processor (CPU), multiple cores per processor chip
• FLOPS
  – “FLoating-point Operations (calculations) Per Second”
Supercomputers at OSC

- Ruby cluster (small cluster, limited access)
  - Online March 2015
  - Named for Ruby Dee, actress, poet, playwright, screenwriter, journalist and activist. She was born in Cleveland.
  - HP system, Intel Xeon processors, 4800 cores
- Oakley cluster
  - Online March 2012
  - Named for Annie Oakley, famous Ohio sharpshooter
  - HP system, Intel Xeon processors, 8280 cores
- Glenn cluster
  - “Glenn phase II” online July 2009
  - Named for John Glenn, Ohio astronaut and senator
  - IBM 1350, AMD Opteron processors, 3500 cores
Run jobs by submitting your batch script to the compute nodes using the "qsub" command. Your job is submitted to a queue and will wait in line until nodes are available. Queues are managed by a job scheduler that allows jobs to run efficiently.
Login Nodes – Configuration

- Oakley
  - 2 general-purpose login nodes
  - 12 cores, 124 GB memory each
  - Connect to oakley.osc.edu
- Ruby
  - 2 general-purpose login nodes
  - 20 cores, 132 GB memory each
  - Connect to ruby.osc.edu
- Glenn
  - 2 general-purpose login nodes
  - 16 cores, 64 GB memory each
  - Connect to glenn.osc.edu

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!
Compute Nodes – Oakley

- 684 standard nodes
  - 12 cores per node
  - 48 GB memory (4GB/core)
  - 812 GB local disk space
- 8 large memory nodes
  - 12 cores per node
  - 192 GB memory (16GB/core)
  - 812 GB local disk space
- Network
  - Nodes connected by 40Gbit/sec Infiniband network (QDR)

Special Resources – Oakley

- GPU computing
  - 128 NVIDIA Tesla M2070 GPUs
  - 64 of the standard nodes have 2 GPUs each
- 1 huge memory node
  - 32 cores
  - 1 TB memory
Compute Nodes – Ruby

• 240 standard nodes
  – 20 cores per node
  – 64 GB memory (3.2GB/core)
  – 1 TB local disk space
• Network
  – FDR Infiniband interconnect

Special Resources – Ruby

• GPU computing
  – 20 NVIDIA Tesla K40 GPUs
• Intel Xeon Phi accelerators
  – 20 Intel Xeon Phi 5110p coprocessors
• 1 huge memory node
  – 32 cores
  – 1 TB memory
Compute Nodes – Glenn

- 436 compute nodes
  - 8 cores per node
  - 24 GB memory (3GB/core)
  - 393 GB local disk space

Network
- Nodes connected by 20Gbit/sec Infiniband network (DDR)

Special Resources – Glenn

- GPU computing
  - 18 NVIDIA Quadro Plex S4 systems
  - Each Quadro Plex S4 has 4 Quadro FX GPUs
  - 36 of the standard nodes have 2 GPUs each
Hardware Performance – Oakley

- CPU performance
  - 88 trillion floating point operations per second (TFLOPS) peak performance
  - 79 TFLOPS sustained performance
- GPU acceleration
  - 66 TFLOPS peak performance
- Total peak performance
  - 154 TFLOPS

Specs: Oakley Cluster vs. Top 500 Systems in the World

<table>
<thead>
<tr>
<th>Metric</th>
<th>June 2012</th>
<th>June 2012</th>
<th>November 2012</th>
<th>November 2012</th>
<th>June 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Ranking in the World</td>
<td>180th</td>
<td>37th</td>
<td>460th</td>
<td>30th</td>
<td>Not Listed</td>
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<tr>
<td>Overall Ranking in US</td>
<td>89th</td>
<td>8th</td>
<td>235th</td>
<td>8th</td>
<td>Not Listed</td>
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<tr>
<td>Overall Academic Ranking in the World</td>
<td>40th</td>
<td>9th</td>
<td>91st</td>
<td>13th</td>
<td>Not Listed</td>
</tr>
<tr>
<td>Overall Academic Ranking in US</td>
<td>11th</td>
<td>2nd</td>
<td>23rd</td>
<td>2nd</td>
<td>Not Listed</td>
</tr>
</tbody>
</table>
OSC File Space Information

- Lustre – Parallel File System (Temporary Space)
  - ~570 TBs (all disk)
- GPFS
  - ~1.1PB total usable (Disk)
  - Hierarchical storage capable to tape subsystem
  - Allocated to projects in TBs, for limited time periods
- Home Directory Space / NFS
  - ~295 TBs usable (Disk)
  - Allocated to each user, 500 GB quota limit

Mass Storage Overview

- 2 Petabytes (PBs) of usable disk
- 1100 TBs GPFS storage
- 570 TBs Lustre storage
- 1.8 PBs tape

Resource Grants and Accounts at OSC

www.osc.edu
Who can get an account?

- Academic accounts
  - 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 accounts are also available
  - No cost to Ohio academic users
- Commercial accounts
  - Commercial organizations may purchase time on OSC systems

Accounts and Projects at OSC

- Project
  - Headed by a PI
  - May include other users
  - Basis for accounting at OSC
  - Submit proposal for computing resources for a project
- Account
  - Username and password to access HPC systems
  - Each account associated with one project
  - Each account used by one person (please!)
  - If you work on multiple projects, you will have multiple accounts.
Allocations and Charges

- Charges are in terms of resource units
- Resource units
  - 1 resource unit (RU) = 10 CPU hours
  - CPU hour = walltime x (total # of cores requested)
- Project receives an allocation of RUs
- Jobs are charged to a project

Getting an Account

- Startup grant
  - One per PI per lifetime
  - Provide contact info, institution, department
  - 5000 RUs
- Additional allocations for a project
  - Submit a proposal for more RUs
    - Standard: 10,000
    - Major: 30,000
    - Discovery: >30,000
  - Peer-reviewed
  - Grants awarded by Statewide Users Group (SUG)
Citing OSC

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

ARMSTRONG Researcher Portal

• [https://armstrong.osc.edu](https://armstrong.osc.edu)
• Manage your project and accounts
  – Monitor resource utilization on all your projects
  – Add authorized users (request accounts) – PIs only
• View current information
  – OSC system notices
  – Research opportunities
• Post publications
ARMSTRONG Researcher Portal
https://armstrong.osc.edu

MyOSC

- Site for managing your identity at OSC
- Update your email
- Change your password
- Recover access to your account
- Change your shell
- And a lot more in the future
  - Project reporting
  - Authorized user management
  - Requesting services (e.g. software access)
Your Contact Info

- Keep your contact information current
  - Use my.osc.edu to manage your account details.
- If your student continues to use OSC after graduation, make sure email address is updated
  - Acceptable if still collaborating with you
- May need to contact you about problems
- Will need to contact you about regular password changes
- You can opt out of routine notifications

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
  - Allocations
  - Software and Activities
  - Hardware and Operations
- Get involved!
  - Next meeting is December 3rd in Columbus
System Status

- Check system status on:
  - [https://www.osc.edu/supercomputing](https://www.osc.edu/supercomputing) (bottom of page)
  - [https://armstrong.osc.edu/systemnotices/index.php](https://armstrong.osc.edu/systemnotices/index.php)
  - Message of the day (/etc/motd) – displayed at login
  - Twitter: @HPCnotices
  - Email for major outages or problems

- Scheduled downtimes
  - Quarterly maintenance – one day outage
  - Jobs held for up to two weeks prior

Demo

- Website tour: [www.osc.edu](http://www.osc.edu)
- ARMSTRONG: [https://armstrong.osc.edu](https://armstrong.osc.edu)
- MyOSC: [https://my.osc.edu](https://my.osc.edu)
Demo

- Website tour:  www.osc.edu
- MyOSC: https://my.osc.edu/
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 the Oakley, Ruby, or Glenn Cluster

- Connect to OSC machines using ssh (secure shell)
  - From a Linux/UNIX machine: At prompt, enter
    ssh userid@oakley.osc.edu
    ssh userid@ruby.osc.edu
    ssh userid@glenn.osc.edu
  - From a Mac: Enter ssh command in TERMINAL window
  - From Windows: ssh client software needed
    - Both commercial and free versions are available
- New: Connect using OnDemand portal (web-based)
OSC OnDemand

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
   - Visualization Apps
     • Desktop access
     • Single-click apps (Abaqus, Ansys, Comsol, Paraview)
   - Terminal Access

Connecting to an OSC Cluster with Graphics

- Programs on the cluster can have an X-based GUI
  - Display graphics on your computer
- Linux/UNIX and Mac: Use -X flag
  ```bash
  ssh -X userid@oakley.osc.edu
  ```
- Windows: Need extra software
  - Both commercial and free versions are available
  - Configure your ssh client to tunnel or forward X11
- Primarily used with programs on login node
  - Can also use with interactive batch jobs
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
- For small files, connect to login node
  [oakley.osc.edu](mailto:oakley.osc.edu)
  [glenn.osc.edu](mailto:glenn.osc.edu)
- For large files, transfer may fail due to shell limits
  - Connect to [gridftp01.osc.edu](http://gridftp01.osc.edu) (file transfer only)
Text editing

- Traditional Unix editors
  - vi
  - emacs
  - Many books and web pages about vi and emacs
- GUI editor
  - gedit
- Simple editor
  - nano
- Can also edit on your computer and transfer files back and forth
  - dos2unix, unix2dox, mac2unix

Demo

- OSC OnDemand
- ssh
- sftp
- Linux
- Home directory tree
- Text editor: nano
Modules

- Add or remove software from your environment, e.g.,
  - `module load comsol`
- Allow multiple versions of software to coexist on our system
- Allow us to make changes without affecting you
  - PLEASE DON’T HARDCODE PATHS!
- Can load modules at command prompt or in your `.bash_profile` or `.bashrc` file
- Also load modules in your job (batch) scripts

Modules and your shell environment

- How modules work
  - Modify environment variables like `$PATH` and `$MANPATH` within your shell
- Default set of modules loaded at login
  - module system, batch system (do not unload)
  - default compiler and MPI modules
- Do NOT completely replace `$PATH` in your `.bash_profile` or `.bashrc`
- DO prepend directories to the existing `$PATH`
  - Type: `export PATH=$HOME/bin:$PATH`
Module Commands (Oak/Glenn not the same!)

- 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
Run jobs by submitting your batch script to the compute nodes using the "qsub" command. Your job is submitted to a queue and will wait in line until slots are available. Queues are managed by a job scheduler that allows jobs to run efficiently.

Batch System at OSC

- Compute nodes are allocated through the batch system
  - PBS – Portable Batch System
  - Torque – resource manager
  - Moab – scheduler
- Documentation at [www.osc.edu/supercomputing/batch-processing-at-osc](http://www.osc.edu/supercomputing/batch-processing-at-osc)
Run jobs by submitting your batch script to the compute nodes using the "qsub" command. Your job is submitted to a queue and scheduled to run until slots are available. Queues are managed by a job scheduler that allows jobs to run efficiently.

Idea Behind Batch Processing

- Whatever you would normally type at the command prompt goes into your batch script
- Output that would normally go to the screen goes into a log file (or files)
- The system runs your job when resources become available
- Very efficient in terms of resource utilization
Running a Job on the Compute Nodes

- Create a batch script for a job
- Submit the job
- Job gets queued
- Job runs when resources become available
- Get your results when the job finishes

Sample Batch Script

```bash
#PBS -N serial_fluent
#PBS -l walltime=1:00:00
#PBS -l nodes=1:ppn=1
#PBS -j oe
#PBS -l software=fluent+1

# Set up the FLUENT environment
module load fluent

# Move to directory job was submitted from
cd $PBS_O_WORKDIR

# Run fluent
fluent 3d -g < run.input
```

Job setup information for PBS

# This is a comment

Commands to be run

Put all this into a text file!
Submitting a Job and Checking Status

- Command to submit a job
  - `qsub script_file`
- Response from PBS (example)
  - `123456.oak-batch.osc.edu`
- Show status of batch jobs
  - `qstat -a jobid`
  - `qstat -u username`
  - `qstat -f jobid`

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
• To see estimated start time for job
  – showstart jobid
  – Very unreliable
Job Output

- Screen output ends up in file `job_name.ojobid`
  - Copied to your working directory when job ends
  - Example: `testjob.o1234567`
- To see screen output while job is running
  - `qpeek jobid`
  - Example: `qpeek 1234567`

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)
  - `qsub -I -X -l nodes=2:ppn=12 -l walltime=1:00:00`
Batch Queues

- Oakley, Ruby, and Glenn 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)
  - Special flag required on Ruby: -q debug

Glenn or Oakley – Which should I choose?

- Some software installed only on one system
  - See software page for your application
- Oakley is newer and faster, with more memory
- Glenn often has shorter queue waits
- Can switch between them
  - Most sequential code will run on either system
  - Performance may be better on system code was built on
  - Keep separate executables in different subdirectories
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 (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
• Must use mpiexec for multiple nodes
• Can’t just request more nodes or cores and expect your job to run faster
Specifying Resources in a Job Script

• Nodes and cores (processors) per node
• Memory
• GPUs
  – See “Batch Processing at OSC” on OSC website
• Walltime
  – Overestimate slightly – job will be deleted if it hits limit
  – Shorter job may start sooner due to backfill
• Software licenses
  – See specific software page on OSC website

Storage

www.osc.edu
Home Directories

- Each user has a home directory
- Visible from all OSC systems
- Backed up daily – “permanent storage”
- Quotas
  - 500GB of storage per user account
  - 1,000,000 files maximum
  - Cannot create new files if over quota
  - Quota and usage info displayed at login

Project Directories

- PI may request project directory if more space needed
  - Send request to OSC Help
  - Large requests are reviewed by SUG Allocations Committee
  - Shared by all users in the project
- Backed up daily
- Visible from all OSC systems
- Project quota is separate from the home directory quota
Sample Quota Display

Quota display at login (information collected nightly):

As of 2010 Jul 15 04:02 userid usr1234 on /nfs/06 used 28GB of quota 500GB and 41374 files of quota 1000000 files
As of 2010 Jul 16 04:02 project/group PRJ0321 on /nfs/proj01 used 27GB of quota 5000GB and 573105 files of quota 1000000 files

Output from `quota` command (run manually):

```
Disk quotas for user usr1234 (uid 11059):
Filesystem    blocks  quota  limit  grace  files  quota  limit  grace
fs06-oak.ten.osc.edu:/nfs/06/osc  201698292  450000000 524288000          631137  950000 1000000
```

File Management

- Compress large, rarely used files
  - Use `gzip` or `bzip2` commands
- Combine large numbers of small files into an archive
  - Use `tar` command
Parallel File System – Lustre

• Designed to handle heavy parallel I/O load
• Faster access than home and project directories
• NOT good for small files
• Visible from all cluster nodes (shared)
• Suitable for short-term storage (up to 6 months) of large amounts of data
• Also useful as batch-managed temporary storage
• **Scratch storage – NOT backed up!**

Local Disk – $TMPDIR

• Local file system on each compute node
  – 812 GB on each Oakley node
  – 1000 GB on each Ruby node
  – 393 GB on each Glenn node
• Fast – use for intermediate or scratch files
• Not shared between nodes
• Not backed up
• Managed by the batch system
• Data removed when job exits
Overloading the File Servers

• “A supercomputer is a device for turning compute-bound problems into I/O-bound problems.” --Ken Batcher (parallel computing pioneer)
• One user’s heavy I/O load can affect responsiveness for all users on that file system
• **Never** do heavy I/O in your home or project directory!
• Use $TMPDIR, copying files in and out as necessary
• Don’t let large numbers of jobs run in lockstep.
Access to Licensed Software

- Most software licenses for academic use only
- Some software requires signed license agreement
  - Check website
  - Contact OSC Help

Third party applications

- **Chemistry** (*license agreement required)
  - *AMBER
  - ChemTools
  - COLUMBUS
  - *CSD (Cambridge Structural Database)
  - ESPRESSO
  - GAMESS
  - *Gaussian
  - GROMACS
  - LAMMPS
  - MacroModel®
  - MEAD
  - NAMD
  - NWChem
  - Open Babel
  - *Turbomole
Third party applications

• Bioinformatics
  – BioPerl
  – BLAST
  – BLAT
  – Bowtie
  – Clustal W
  – EMBoss
  – FilmModel
  – HMMER
  – MrBayes
  – NAMD
  – PAML
  – PAUP
  – RAxML
  – RepeatMasker
  – TreeBeST

Third party applications

• Structural Mechanics (*license agreement required; ﬁstatewide licensed)
  – ABAQUS
  – Altair HyperWorks
  – ANSYS
  – COMSOL Multiphysics
  – LSDYNA
  – LS-PREPOST
Third party applications

- Fluid Dynamics (*license agreement required)
  - *Fluent
  - OpenFOAM

- Mathematics/Statistics (¶ statewide licensed)
  - MATLAB (special licensing restrictions)
  - Octave
  - R
  - Stata
  - FFTW
  - ScaLAPACK
  - MINPACK
  - sprng2
  - ¶ Intel MKL
  - ACML (Glenn only)
Third party applications

• **General programming software** (statewide licensed)
  – gnu compilers and debugger
  – Intel compilers
  – Totalview debugger
  – PGI compilers
  – MPI library
  – HDF5
  – NetCDF
  – Java, Java Virtual Machine
  – Python

• **Parallel programming software** (statewide licensed)
  – MPI library (mvapich, mvapich2)
  – OpenMP
  – CUDA
  – OpenCL
  – OpenACC
Third party applications

• Visualization software
  – GNUplot
  – Jmol
  – VTK

• More 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
OSC Policies

- OSC-1, OSC Data Lifecycle Management Policy
  - Use of home directory, project directory and $TMPDIR
  - Storage and file quotas
  - Backup and recovery

- OSC-11, OSC User Management Policy
  - Who can get an account
  - Charges for accounts
  - Types of accounts
  - Account restrictions
  - Account resource units
  - Inappropriate system use
For More Information

- Visit our documentation website
  www.osc.edu/supercomputing

- Contact the help desk (OSC Help) 24/7
  oschelp@osc.edu
  614-292-1800
  1-800-686-6472

Questions
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Questions

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