# Introduction to SLURM & SLURM batch scripts

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# Overview of Talk

- Basic SLURM commands
- SLURM batch directives
- Accounts and Partitions
- SLURM Environment Variables
- SLURM Batch scripts
- Running an Interactive Batch job
- Monitoring Jobs
- Where to get more Information

# Basic SLURM commands

- **sinfo** - shows partition/node state
- **sbatch <scriptname>** - launches a batch script
- **squeue** - shows all jobs in the queue
  - **squeue -u <username>** - shows only your jobs
- **scancel <jobid>** - cancels a job

Notes:

For **sinfo, squeue** – can add **–M all** to see all clusters using given slurm installation (notchpeak, kingspeak, lonepeak, ember, ash)

Can also add **–M cluster** OR use full path /uufs/<cluster>.peaks/sys/pkg/slurm/std/bin/<command> to look at the queue, or submit or cancel jobs for a different cluster (ember is .arches)

# Some Useful Aliases

- Bash to add to .aliases file:

```
alias si="sinfo -o \"%20P %5D %14F %8z %10m %10d %11l %16f %N\""
alias si2="sinfo -o \"%20P %5D %6t %8z %10m %10d %11l %16f %N\""
alias sq="squeue -o \"%8i %12j %4t %10u %20q %20a %10g %20P %10Q %5D %11l %11L %R\""
```

- Tcsh to add to .aliases file:

```
alias si 'sinfo -o "%20P %5D %14F %8z %10m %11l %16f %N"'
alias si2 'sinfo -o "%20P %5D %6t %8z %10m %10d %11l %N"'
alias sq 'squeue -o "%8i %12j %4t %10u %20q %20a %10g %20P %10Q %5D %11l %11L %R"‘
```

Can add **–M** to **si** and **sq** also

You can find these on the CHPC Slurm page
https://www.chpc.utah.edu/documentation/software/slurm.php#aliases

# SLURM Batch Directives

#SBATCH --time 1:00:00 ← wall time of a job (or -t)

#SBATCH --partition=name ← partition to use (or -p)

#SBATCH --account=name ← account to use (or -A)

#SBATCH --nodes=2 ← number of nodes (or -N)

#SBATCH --ntasks 12 ← total number of tasks (or -n)

#SBATCH --mail-type=FAIL,BEGIN,END ← events on which to send email

#SBATCH --mail-user=name@example.com ← email address to use

#SBATCH -o slurm-%j.out-%N ← name for stdout; %j is job#, %N node

#SBATCH -e slurm-%j.err-%N ← name for stderr; %j is job#, %N node

#SBATCH --constraint “C20” ← can use features given for nodes (or -C)

# Accounts and Partitions

- You need to specify an **account** and a **partition** to run jobs
- You can see a list of partitions using the sinfo command
- For general allocation usage the partition is the cluster name
- If no allocation (or out of allocation) use *clustername*-freecycle for partition
- Your account is typically your PI's name (e.g., if your PI is Baggins, use the "baggins" account) – there are a few exceptions!
- Private node accounts and partition have the same name – PI last name with cluster abbreviation, e.g., baggins-kp, baggins-em, etc
- Private nodes can be used as a guest using the "owner-guest" account and the *cluster*-guest partition
- Remember general nodes on notchpeak and kingspeak need allocation; general nodes on ember, lonepeak and tangent are open to all users without allocation

# More on Accounts

| Allocations and node ownership status | What resource(s) are available |
|---|---|
| No general allocation, no owner nodes | Unallocated general nodes<br>Allocated general nodes in freecycle mode - not recommended<br>Guest access on owner nodes |
| General allocation, no owner nodes | Unallocated general nodes<br>Allocated general nodes<br>Guest access on owner nodes |
| Group owner nodes, no general allocation | Unallocated general nodes<br>Allocated general nodes in freecycle mode - not recommended<br>Group owned nodes<br>Guest access on owner nodes of other groups |
| Group owner node, general allocation | Unallocated general nodes<br>Allocated general nodes<br>Group owned nodes<br>Guest access on owner nodes of other groups |

See https://www.chpc.utah.edu/documentation/guides/index.php#parts

# Query your accounts/partitions

~]$ **sacctmgr -p show assoc user=u0028729 format=cluster,account,partition,qos**

**Cluster|Account|Partition|QOS|**

notchpeak|chpc||notchpeak|
kingspeak|kingspeak-gpu||kingspeak-gpu|
ember|ember-gpu||ember-gpu|
ash|smithp-guest||ash-guest,ash-guest-res|
lonepeak|chpc||lonepeak|
kingspeak|chpc||kingspeak|
lonepeak|owner-guest||lonepeak-guest|
ember|owner-guest||ember-guest|
kingspeak|owner-guest||kingspeak-guest|
kingspeak|owner-gpu-guest||kingspeak-gpu-guest|
ember|chpc||ember|

***Note that partition field is empty – for the most part partition and qos are paired***

# Query your allocation

~]$ myallocation

You have a general allocation on kingspeak. Account: chpc, Partition: kingspeak
You can use preemptable mode on kingspeak. Account: owner-guest, Partition: kingspeak-guest
You can use preemptable GPU mode on kingspeak. Account: owner-gpu-guest, Partition: kingspeak-gpu-guest
You have a GPU allocation on kingspeak. Account: kingspeak-gpu, Partition: kingspeak-gpu
You have a general allocation on notchpeak. Account: chpc, Partition: notchpeak
You can use preemptable GPU mode on notchpeak. Account: owner-gpu-guest, Partition: notchpeak-gpu-guest
You can use preemptable mode on notchpeak. Account: owner-guest, Partition: notchpeak-guest
You have a GPU allocation on notchpeak. Account: notchpeak-gpu, Partition: notchpeak-gpu
You have a general allocation on ember. Account: chpc, Partition: ember
You can use preemptable mode on ember. Account: owner-guest, Partition: ember-guest
You have a GPU allocation on ember. Account: ember-gpu, Partition: ember-gpu
You have a general allocation on lonepeak. Account: chpc, Partition: lonepeak
You can use preemptable mode on lonepeak. Account: owner-guest, Partition: lonepeak-guest

# Checking job efficiency

~]$ pestat -u $USER

| Hostname | Partition | Node State | Num_CPU Use/Tot | | CPUload | Memsize (MB) | Freemem (MB) | Joblist JobId User ... |
|---|---|---|---|---|---|---|---|---|
| kp016 | kingspeak* | alloc | 16 | 16 | 1.00* | 64000 | 55494 | 7430561 u0123456 |
| kp378 | schmidt-kp | alloc | 28 | 28 | .00* | 256000 | 250656 | 7430496 u0123456 |

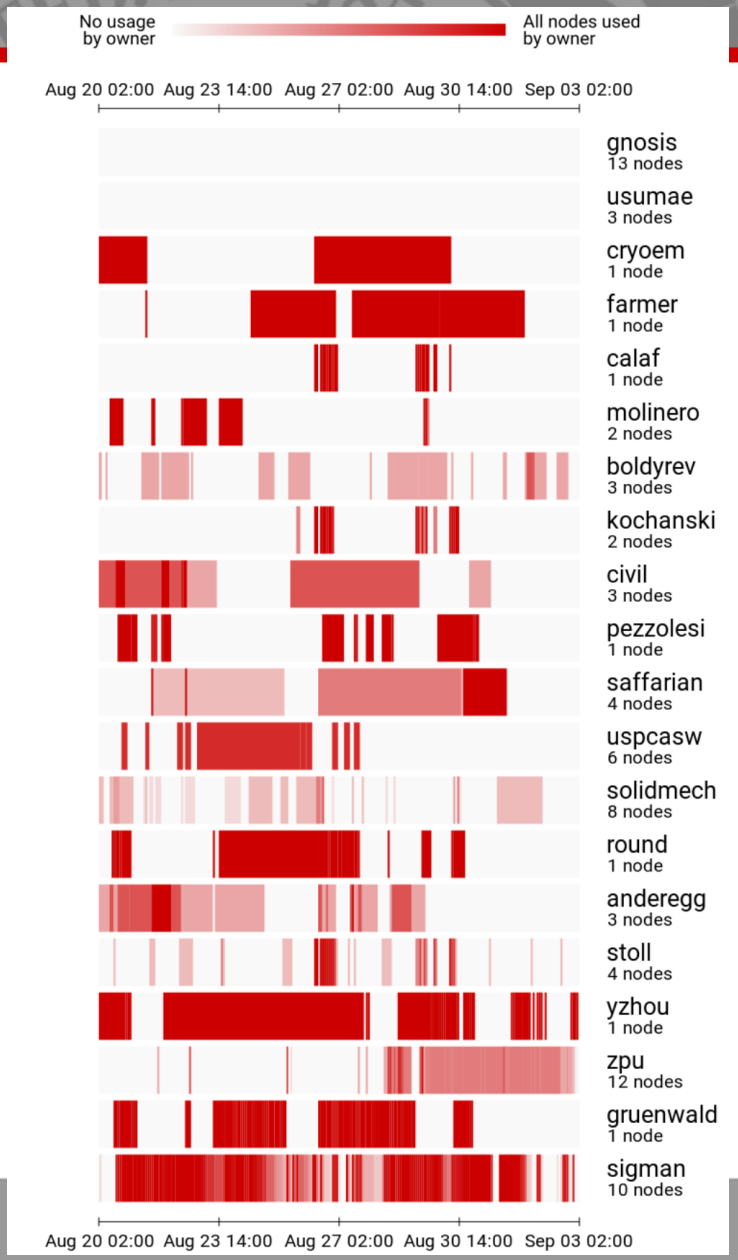
# Node Sharing

- Use the shared partition for a given set of nodes (using normal account for that partition)
  - notchpeak* 4 4/0/0/4 2:16:2 95000 1800000 3-00:00:00 chpc,c32,m96 notch[005-008]
  - notchpeak-shared 4 4/0/0/4 2:16:2 95000 1800000 3-00:00:00 chpc,c32,m96 notch[005-008]
  - molinero-np 2 2/0/0/2 2:16:2 95000 1800000 3-00:00:00 molinero,c32,m96 notch[024-025]
  - molinero-shared-np 2 2/0/0/2 2:16:2 95000 1800000 3-00:00:00 molinero,c32,m96 notch[024-025]
- In script:
  - #SBATCH --partition=cluster-shared
  - #SBATCH --ntasks=2
  - #SBATCH --mem=32G
- If there is no memory directive used the default is that 2G/core will be allocated to the job.
- Allocation usage of a shared job is based on the percentage of the cores and the memory used, whichever is higher

https://www.chpc.utah.edu/documentation/software/node-sharing.php

# Owner/Owner-guest

- CHPC provides heat maps of usage of owner nodes by the owner over last two weeks
- https://www.chpc.utah.edu/usage/constraints/
- Use information provided to target specific owner partitions with use of constraints (more later)



# SLURM Environment Variables

- Depends on SLURM Batch Directives used
- Can get them for a given set of directives by using the env command inside a script (or in a srun session).
- Some useful environment variables:
  - $SLURM_JOBID
  - $SLURM_SUBMIT_DIR
  - $SLURM_NNODES
  - $SLURM_NTASKS

# Basic SLURM script flow

1. Set up the #SBATCH directives for the scheduler to request resources for job
2. Set up the working environment, by loading appropriate modules
3. If necessary, add any additional libraries or programs to $PATH and $LD_LIBRARY_PATH, or set other environment needs
4. Set up temporary/scratch directories if needed
5. Switch to the working directory (often group/scratch)
6. Run the program
7. Copy over any results files needed
8. Clean up any temporary files or directories

# Basic SLURM script - bash

```
#!/bin/bash
#SBATCH --time=02:00:00
#SBATCH --nodes=1
#SBATCH -o slurmjob-%j.out-%N
#SBATCH -e slurmjob-%j.err-%N
#SBATCH --account=owner-guest
#SBATCH --partition=kingspeak-guest
#Set up whatever package we need to run with
module load somemodule
#set up the temporary directory
SCRDIR=/scratch/general/lustre/$USER/$SLURM_JOBID
mkdir -p $SCRDIR
#copy over input files
cp file.input $SCRDIR/.
cd $SCRDIR
#Run the program with our input
myprogram < file.input > file.output
#Move files out of working directory and clean up
cp file.output $HOME/.
cd $HOME
rm -rf $SCRDIR
```

# Basic SLURM script - tcsh

```
#!/bin/tcsh
#SBATCH --time=02:00:00
#SBATCH --nodes=1
#SBATCH -o slurmjob-%j.out-%N
#SBATCH -e slurmjob-%j.err-%N
#SBATCH --account=owner-guest
#SBATCH --partition=kingspeak-guest
#Set up whatever package we need to run with
module load somemodule
#set up the scratch directory
set SCRDIR /scratch/local/$USER/$SLURM_JOBID
mkdir -p $SCRDIR
#move input files into scratch directory
cp file.input $SCRDIR/.
cd $SCRDIR
#Run the program with our input
myprogram < file.input > file.output
#Move files out of working directory and clean up
cp file.output $HOME/.
cd $HOME
rm -rf $SCRDIR
```

# Parallel Execution

- MPI installations at CHPC are SLURM aware, so mpirun will usually work without a machinefile (unless you are manipulating the machinefile in your scripts)
- If machinefile or host list needed, create the node list:
  - `srun hostname | sort -u > nodefile.$SLURM_JOBID`
  - `srun hostname | sort > nodefile.$SLURM_JOBID`
- Alternatively, you can use the srun command instead, but you need to compile with a more recently compiled MPI
- Mileage may vary, and for different MPI distributions, srun or mpirun may be preferred (check our slurm page on the CHPC website for more info or email us)

# Running interactive batch jobs

- An interactive command is launched through the srun command

```
srun --time=1:00:00 --nodes=1 --account=chpc
        --partition=ember --pty /bin/tcsh -l
```

- Launching an interactive job automatically forwards environment information, including X11 forwarding
- "`--pty`" must be set to shell preferred for the session (either /bin/tcsh or /bin/bash
- `-l` (lower case “L”) at the end required

# Slurm for use of GPU Nodes

- Ember – 8 GPU nodes
  - All are general nodes, each with M2090 cards
- Kingspeak – 8 GPU nodes
  - 4 general nodes, two with 4 Tesla K80 cards (8 GPUs) each, two with 8 GeForce TitanX cards each
  - 4 owner nodes each with 2 Tesla P100 cards (owned by School of Computing)
- Notchpeak – 13 GPU nodes
  - 3 general nodes each with 3 Tesla V100 cards; 3 general nodes each with 4 RTX2080Ti cards; 1 general node with 2 RTX2080Ti plus 1 P40 card
  - 1 owner node with 4 TitanV cards
  - 1 owner node with 8 GTX1080Ti cards
  - 4 owner nodes each with 4 RTX2080Ti cards
- Use partition and account set to ***cluster***-gpu (for general) or ***cluster***-gpu-guest for guest jobs on owner
- Must get added to the gpu accounts – request via helpdesk@chpc.utah.edu
- Use only if you are making use of the GPU for the calculation
- Most codes do not yet make efficient use of multiple GPUs so we have enabled node sharing
- See https://www.chpc.utah.edu/documentation/guides/gpus-accelerators.php

# Node Sharing on GPU nodes

- Need to specify number of CPU cores, amount of memory, and number of GPU
- Core hours used based on highest % requested among cores, memory and GPUs

| Option | Explanation |
|---|---|
| #SBATCH --gres=gpu:k80:1 | request one K80 GPU (others types names are titanx, m2090, p100, v100, titanv, 1080ti, 2080ti, p40) |
| #SBATCH --mem=4G | request 4 GB of RAM (default is 2GB/core if not specified) |
| #SBATCH --mem=0 | request all memory of the node; use this if you do not want to share the node as this will give you all the memory |
| #SBATCH --tasks=1 | requests 1 core |

# Strategies for Serial Applications

- https://www.chpc.utah.edu/documentation/software/serial-jobs.php
- When running serial applications (no MPI, no threads) unless memory constraint, you should look to options to bundle jobs together so using all cores on nodes
- There are multiple ways to do so
  - srun --multi-prog
  - submit script
- Also consider OpenScienceGrid as an option (especially if you have a large number of single core, short jobs)

# Strategies for Job Arrays

- https://www.chpc.utah.edu/documentation/software/slurm.php#jobarr
- Useful if you have many similar jobs when each use all cores on a node or multiple nodes to run where only difference is input file
- sbatch --array=1-30%n myscript.sh – where n is maximum number of jobs to run at same time
- In script: use $SLURM_ARRAY_TASK_ID to specify input file:
  - ./myprogram input$SLURM_ARRAY_TASK_ID.dat

# Job Priorities

- https://www.chpc.utah.edu/documentation/software/slurm.php#priority
- **sprio** give job priority for all jobs
  - sprio –j JOBID for a given job
  - sprio –u UNID for all a given user's jobs
- Combination of three factors added to base priority
  - Time in queue
  - Fairshare
  - Job size

# Checking Job Performance

- With an active job – can ssh to node
  - Useful commands, top, ps, sar
- Also from interactive node can query job
  - /uufs/chpc.utah.edu/sys/installdir/pestat/pestat
  - Working on adding documenation
- Can query node status
  - scontrol show node notch024

# Slurm Documentation at CHPC

https://www.chpc.utah.edu/documentation/software/slurm.php

https://www.chpc.utah.edu/documentation/software/serial-jobs.php

https://www.chpc.utah.edu/documentation/software/node-sharing.php

https://www.chpc.utah.edu/usage/constraints/

https://www.chpc.utah.edu/documentation/guides/index.php#GenSlurm

# Other good documentation sources

http://slurm.schedmd.com/documentation.html

http://slurm.schedmd.com/pdfs/summary.pdf

http://www.schedmd.com/slurmdocs/rosetta.pdf

# Getting Help

- CHPC website
  - www.chpc.utah.edu
    - Getting started guide, cluster usage guides, software manual pages, CHPC policies
- Service Now Issue/Incident Tracking System
  - Email: helpdesk@chpc.utah.edu
- Help Desk: 405 INSCC, 581-6440 (9-5 M-F)
- We use chpc-hpc-users@lists.utah.edu for sending messages to users