Load Sharing Facility (LSF)

Minerva Scientific Computing Environment

https://labs.icahn.mssm.edu/minervalab

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Outline

- LSF introduction and basic/helpful LSF commands
- Dependent job
- Self-scheduler
- Parallel jobs: job arrays, parallel processing and GPUs
- Job checkpoint/restart
- Tips for efficient usage of the queuing system

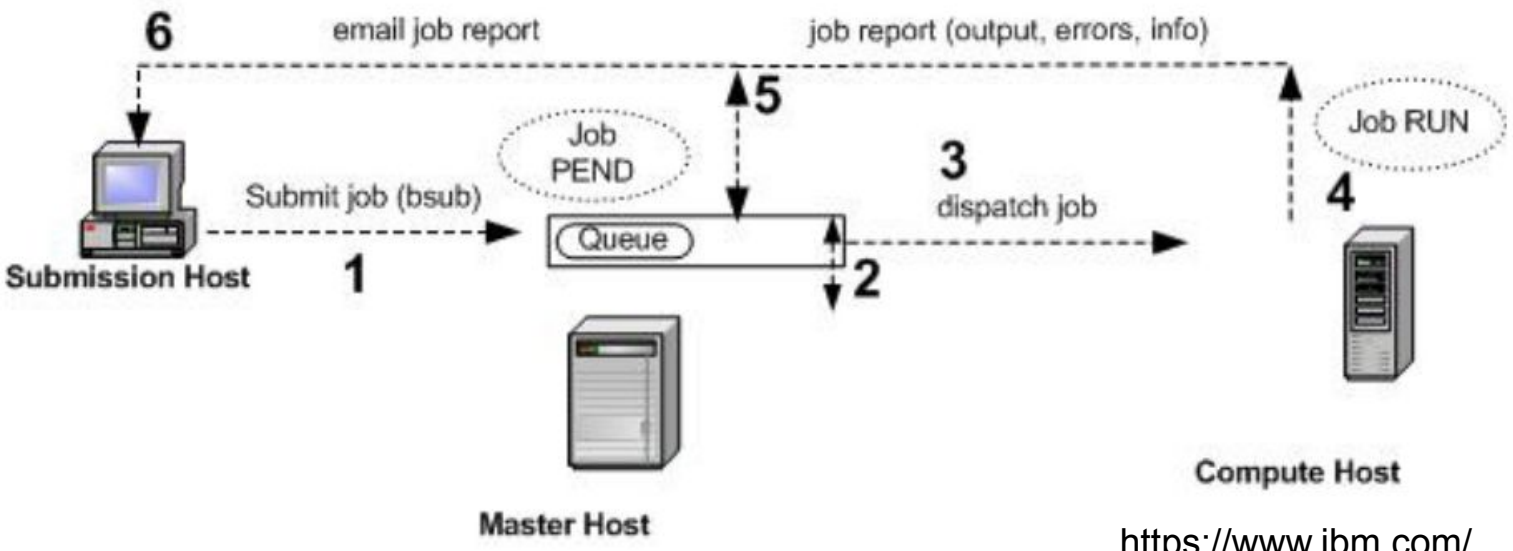
Distributed Resource Management System (DRMS)

- Used to optimize utilization of resources and maximize throughput for high-performance cluster computing systems

- Controls
  - CPU cycles;
  - Memory;
  - Specialty resources

- Widely deployed DRMSs
  - **Platform Load Sharing Facility (LSF)**
  - Portable Batch Systems (PBS)
  - **Simple Linux Utility for Resource Management (Slurm)**
  - others such as IBM Load Leveler and Condor

LSF Job Lifecycle



https://www.ibm.com/

1. submit a job
2. schedule the job
3. dispatch the job
4. run the job
5. return output/record stats
6. send Email to client (disabled on Minerva)

LSF: batch job submission: bsub

Batch jobs submission:

 # simple standard job submission

bsub [options] command

$ bsub -P acc_hpcstaff -q premium-n 1 -W 00:10 echo "Hello World"

 # simple LSF script submission

bsub [options] < *pathToScript*

$ bsub -q premium-n 1 -W 00:10 < helloWorld.lsf

where helloWorld.lsf is:

```
#bsub -P acc_hpcstaff
#bsub -q express
echo "salve mundi"
```

Execution environment:

Shell is your current shell (can change with -L)

Working directory on execution host is same as on submission host

Environment variables are copied over (aliases are not)

...

LSF: batch job submission: bsub

Major options:

- -P accountName - Of the form: acc_projectName

To see the list of accessible project accounts:

```
$ mybalance
User_ID      Project_name      BODE
-------      ---------------   -------
choh07       acc_hpcstaff      Yes
choh07       acc_DGXTrial      No
```

- -q queuename - submission queue
- -W wallClockTime - in form of HH:MM
- -n ncpu - number of cpu's requested (default: 1)
- -R rusage[mem=#MB] - amount of real memory per "-n" in MB
  - max memory per node:160GiB (compute), 326GB (GPU), 1.4TiB (himem)
- -R span[#-n's per physical node]
  - span[ptile=4] - 4 cores per node/host
  - span[hosts=1] - all cores on same node/host
- -R himem - Request high memory node

LSF: bsub major options

- -o Name of output file (concatenated)
- -oo Name of output file (overwrite)
- -e Name of error file (concatenated)
- -eo Name of error file (overwrite)

NOTE: Default output is mailed to the user BUT since we have disabled mail response, it goes into the bit bucket.

If -o(o) is specified but not -e, error is appended to output file

bsub - submit a job to LSF (interactive and batch)

Interactive jobs:

- Set up an interactive environment on compute nodes with **internet access**
- Useful for testing and debugging jobs
- **Interactive GPU** is available for job testing

bsub -XF -P acc_hpcstaff -q interactive -n 1 -W 2:00 -R rusage[mem=3000] -Is /bin/bash

- -q : to specify the queue-name from where to get the nodes
- -Is: Interactive terminal/shell
- -n : to specify the total number of compute cores (job slot) needed
- -R : Resource request specifying in a compute node
- -XF: X11 forwarding
- /bin/bash : the shell to use

```
gail01@li03c03: ~ $ bsub -XF -P acc_hpcstaff -q interactive -n 1 -W 2:00 -R rusage[mem=3000]
-Is /bin/bash
Job <2916837> is submitted to queue <interactive>.
<<ssh X11 forwarding job>>
<<Waiting for dispatch ...>>
<<Starting on lc02a29>>
```

bjobs - status of jobs

- Check your own jobs: **$bjobs**

```
gail01@li03c03: ~ $ bjobs
     JOBID      USER    JOB_NAME   STAT     QUEUE  FROM_HOST   EXEC_HOST   SUBMIT_TIME    START_TIME
TIME_LEFT
    2937044    gail01   myfirstjob  PEND    premium   li03c03     -       Sep 10 14:38      -         -
```

- Check all jobs: **$bjobs -u all**

```
JOBID      USER    JOB_NAME   STAT     QUEUE  FROM_HOST   EXEC_HOST   SUBMIT_TIME    START_TIME
TIME_LEFT
    2845103   beckmn01 *>junkK.432    RUN    premium    regen2    lc02e24  Sep  9 21:19  Sep 10 14:25    23:57 L
    2845113   beckmn01 *>junkK.442    RUN    premium    regen2    lc02e24  Sep  9 21:19  Sep 10 14:26    23:58 L
    2845088   beckmn01 *>junkK.417    RUN    premium    regen2    lc04a10  Sep  9 21:18  Sep 10 14:23    23:55 L
    2845089   beckmn01 *>junkK.418    RUN    premium    regen2    lc04a10  Sep  9 21:18  Sep 10 14:23    23:55 L
    2845090   beckmn01 *>junkK.419    RUN    premium    regen2    lc04a10  Sep  9 21:18  Sep 10 14:23    23:55 L
    2845091   beckmn01 *>junkK.420    RUN    premium    regen2    lc04a10  Sep  9 21:18  Sep 10 14:23    23:55 L
    2845092   beckmn01 *>junkK.421    RUN    premium    regen2    lc04a10  Sep  9 21:18  Sep 10 14:23    23:55 L
    2845093   beckmn01 *>junkK.422    RUN    premium    regen2    lc04a10  Sep  9 21:18  Sep 10 14:23    23:55 L
 ……...
```

- Long format with option -l

LSF Useful Commands

bhosts: Displays hosts and their static and dynamic resources

- List all the compute nodes on Minerva

HOST_NAME	STATUS	JL/U	MAX	NJOBS	RUN	SSUSP	USUSP	RSV
filizm02-3	ok	-	24	1	1	0	0	0
lc01a05	closed	-	48	48	48	0	0	0
lc01a07	closed	-	48	48	16	0	0	32
lc04a19	unavail	-	48	0	0	0	0	0
lg03a01	ok	-	32	0	0	0	0	0
lg03a02	ok	-	32	17	17	0	0	0
lh03c03	closed	-	48	48	48	0	0	0

bhosts: himem, gpu, bode, nonbode (major nodes), interactive

```
gail01@li03c03: ~ $ bhosts himem
HOST_NAME          STATUS       JL/U    MAX  NJOBS    RUN  SSUSP  USUSP    RSV
lh03c01            closed          -     48     48     48      0      0      0
lh03c02            closed          -     48     48     29      0      0     19
lh03c03            closed          -     48     48     26      0      0     22
lh03c04            closed          -     48     48     48      0      0      0
gail01@li03c03: ~ $ bhosts gpu
HOST_NAME          STATUS       JL/U    MAX  NJOBS    RUN  SSUSP  USUSP    RSV
lg03a02            ok              -     32      0      0      0      0      0
lg03a03            closed          -     32     32     32      0      0      0
lg03a04            ok              -     32      1      1      0      0      0
lg03a05            ok              -     32      0      0      0      0      0
lg03a06            ok              -     32      0      0      0      0      0
lg03a07            closed          -     32     32     32      0      0      0
lg03a08            ok              -     32      0      0      0      0      0
lg03a09            ok              -     32     12     12      0      0      0
lg03a10            ok              -     32      0      0      0      0      0
lg03a11            ok              -     32      0      0      0      0      0
lg03a12            unavail         -     32      0      0      0      0      0
gail01@li03c03: ~ $ bhosts bode |head
HOST_NAME          STATUS       JL/U    MAX  NJOBS    RUN  SSUSP  USUSP    RSV
lc01g17            ok              -     48     37     37      0      0      0
lc01g18            closed          -     48     48     48      0      0      0
lc01g19            ok              -     48     37     37      0      0      0
lc01g20            ok              -     48     37     37      0      0      0
lc01g21            ok              -     48     37     37      0      0      0
lc01g22            ok              -     48     17     17      0      0      0
lc01g23            ok              -     48     17     17      0      0      0
```

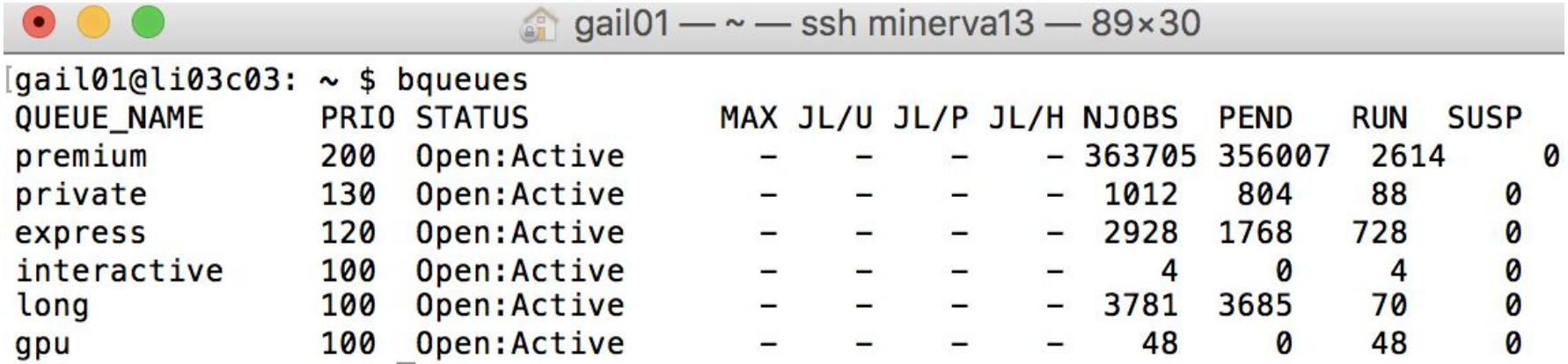
bhosts: himem, gpu, bode, nonbode (major nodes), interactive

```
gail01@li03c03: ~ $ bhosts nonbode | head
HOST_NAME          STATUS       JL/U    MAX  NJOBS    RUN  SSUSP  USUSP    RSV
lc01a05            closed          -     48     48     16      0      0     32
lc01a06            closed          -     48     48     18      0      0     30
lc01a07            closed          -     48     48     16      0      0     32
lc01a08            closed          -     48     48     16      0      0     32
lc01a09            closed          -     48     48     30      0      0     18
lc01a10            closed          -     48     48     12      0      0     36
lc01a11            closed          -     48     48     12      0      0     36
lc01a12            closed          -     48     48     14      0      0     34
lc01a13            closed          -     48     45     13      0      0     32
```

```
gail01@li03c03: ~ $ bhosts interactive
HOST_NAME          STATUS       JL/U    MAX  NJOBS    RUN  SSUSP  USUSP    RSV
lc02a27            ok              -     48      1      1      0      0      0
lc02a28            ok              -     48      0      0      0      0      0
lc02a29            ok              -     48      9      9      0      0      0
lc02a30            ok              -     48     10     10      0      0      0
lg03a01            ok              -     32      0      0      0      0      0
gail01@li03c03: ~ $
```

nonbode and himem are usually quite busy, while bode and interactive are usually open to jobs in minutes; Availability of gpu queue varies from time to time

bqueues: displays information about all the available queues



bqueues -l interactive

QUEUE: interactive
-- For interactive jobs
PARAMETERS/STATISTICS
PRIO NICE STATUS MAX JL/U JL/P JL/H NJOBS PEND RUN SSUSP USUSP RSV
100 0 Open:Active - - - - 4 0 4 0 0 0
Interval for a host to accept two jobs is 0 seconds
DEFAULT LIMITS:
RUNLIMIT
120.0 min
MAXIMUM LIMITS:
RUNLIMIT
720.0 min
…….
USERS: all
HOSTS: interactive/

LSF: Queue structure (bqueues)

Queue structure in Minerva		
Queue	**Wall time limit**	**available resources**
interactive (Dedicated to interactive jobs)	12 hours	4 nodes+1 GPU node
premium	6 days	270 nodes + 4 himem nodes
express	12 hours	270 nodes+ 4 dedicated nodes (may change)
long	2 weeks	4 dedicated (192 cores)
gpu	6 days	44 V100
private	unlimited	private nodes

***default memory : 3000MB / per core**

bmod - modify submission options of pending jobs

bmod takes similar options to bsub

- bmod -R rusage[mem=20000] <jobID>
  - -R replaces **ALL** R fields not just the one you specify
- bmod -q express <jobID>

```
gail01@li03c03: ~ $ bmod -q express 2937044
Parameters of job <2937044> are being changed
```

bpeek - display output of the job produced so far

bpeek <jobID>

```
gail01@li03c03: ~ $ bpeek 2937044
<< output from stdout >>
“Hello Chimera”

<< output from stderr >>
```

bkill - kill jobs in the queue

Lots of ways to get away with murder

bkill <job ID>

Kill by job id
bkill 765814

Kill by job name
bkill -J myjob_1

Kill a bunch of jobs
bkill -J myjob_*

Kill all your jobs
bkill 0

bhist - historical information

```
gail01@li03c03: ~ $ bhist -n 1 -l 2937044

Job <2937044>, Job Name <myfirstjob>, User <gail01>, Project <acc_hpcstaff>, Ap
                     plication <default>, Command <#!/bin/bash;#BSUB -J myfirst
                     job;#BSUB -P acc_hpcstaff  ;#BSUB -q premium;#BSUB -n 1;#B
                     SUB -W  6:00 ;#BSUB -R rusage[mem=4000];#BSUB -o %J.stdout
                     ;#BSUB -eo %J.stderr;#BSUB -L /bin/bash ; module load gcc
                     ;which gcc;echo "Hello Chimera">
Tue Sep 10 14:38:25: Submitted from host <li03c03>, to Queue <premium>, CWD <$H
                     OME>, Output File <%J.stdout>, Error File (overwrite) <%J.
                     stderr>, Re-runnable, Requested Resources <rusage[mem=4000
                     ]>, Login Shell </bin/bash>;

 RUNLIMIT
 360.0 min of li03c03

 MEMLIMIT
    3.9 G
Tue Sep 10 14:38:40: Parameters of Job are changed:
                         Job queue changes to : express;
Tue Sep 10 14:39:36: Dispatched 1 Task(s) on Host(s) <lc02a13>, Allocated 1 Slo
                     t(s) on Host(s) <lc02a13>, Effective RES_REQ <select[((hea
                     lthy=1)) && (type == local)] order[!-slots:-maxslots] rusa
                     ge[mem=4000.00] same[model] affinity[core(1)*1] >;
Tue Sep 10 14:39:37: Starting (Pid 399431);
Tue Sep 10 14:39:39: Running with execution home </hpc/users/gail01>, Execution
                      CWD </hpc/users/gail01>, Execution Pid <399431>;
Tue Sep 10 14:39:41: Done successfully. The CPU time used is 1.5 seconds;
Tue Sep 10 14:39:41: Post job process done successfully;

MEMORY USAGE:
MAX MEM: 9 Mbytes;  AVG MEM: 2 Mbytes

Summary of time in seconds spent in various states by  Tue Sep 10 14:39:41
  PEND     PSUSP    RUN      USUSP    SSUSP    UNKWN    TOTAL
  71       0        5        0        0        0        76
```

Common errors of batch jobs

1. Valid allocation account needed in the submission script

```
-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-
   Project acc_project is not valid for user gail01
-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-
Request aborted by esub. Job not submitted.
```

- $mybalance (note BODE eligible)

```
gail01@li03c03: ~ $ mybalance
User_ID       Project_name       BODE
-------       ---------------    ------------
gail01        acc_hpcstaff          Yes
gail01        acc_DGXTrial           No
```

2. Reach memory limit

bhist -n 10 -l 107992756

```
Fri Jul 27 11:07:33: Completed <exit>; TERM_MEMLIMIT: job killed after
reaching LSF memory usage limit;
```

- memory based on one core, with 3000MB as default
- multithreaded applications need to be on the same node, such as STAR, BWA

Wrapper script: LSFqueue module

- We have installed a wrapper script authored by Harm van Bakel, which will make it easier to interact with the LSF job scheduler on Minerva, per user request

  To load them up, $ml LSFqueue

  To get more info on the module, $module help LSFqueue; And a detailed readme file at

  /hpc/packages/minerva-centos7/LSFqueue/1.0/README.txt

Dependent Job

Any job can be dependent on other LSF jobs.
Syntax
bsub -w 'dependency_expression'
usually based on the job states of preceding jobs.

bsub -J myJ < myjob.lsf

bsub -w 'done(myJ)' < dependent.lsf

Self-scheduler

- Submit large numbers of independent serial jobs as a single batch
  - It is mandatory for short batch jobs less than ca. 10 minutes
  - These jobs put heavy load on the LSF server and will be killed

```
#!/bin/bash
#BSUB -q express
#BSUB -W 00:20
#BSUB -n 12
#BSUB -J selfsched
#BSUB -o test01
module load selfsched                    # load the selfsched module
mpirun -np 12 selfsched < test.inp       # 12 cores, with one master process
```

$PrepINP < templ.txt > test.inp (InputForSelfScheduler)

$cat templ.txt

```
1 10000 2  F        ← start,  end,  stride,  fixed field length?
/my/bin/path/Exec_# < my_input_parameters_# > output_#.log
```

$cat test.inp (a series of job command)

```
/my/bin/path/executable < my_input_parameters_1 > output_1.log
/my/bin/path/executable < my_input_parameters_3 > output_3.log
.
/my/bin/path/executable < my_input_parameters_9999 > output_9999.log
```

Job submission script example: selfsched.lsf

```
#!/bin/bash
#BSUB -J myMPIjob                    # Job name
#BSUB -P acc_bsr3101                 # allocation account
#BSUB -q express                     # queue
#BSUB -n 64                          # number of compute cores
#BSUB -R span[ptile=4]               # 4 cores per node
#BSUB -R rusage[mem=4000]            # 256 GB of memory (4 GB per core)
#BSUB -W 00:20                       # walltime (30 min.)
#BSUB -o %J.stdout                   # output log (%J : JobID)
#BSUB -eo %J.stderr                  # error log
#BSUB -L /bin/bash                   # Initialize the execution environment

echo "Job ID                 : $LSB_JOBID"
echo "Job Execution Host     : $LSB_HOSTS"
echo "Job Sub. Directory     : $LS_SUBCWD"

module load python
module load selfsched
mpirun -np 64 selfsched  <  JobMixPrep.inp  > JonMixPrep.out
```

Parallel Job

- **Array job**: Parallel analysis for multiple instances of the same program
  - Execute on multiple data files simultaneously
  - Each instance running independently

- **Distributed memory program**: Message passing between processes (e.g. MPI)
  - Processes execute across multiple CPU cores or nodes

- **Shared memory program** (SMP): multi-threaded execution (e.g. OpenMP)
  - Running across multiple CPU cores on same node

- **GPU programs**: offloading to the device via CUDA

Array Job

- Groups of jobs with the same executable and resource requirements, but different input files.
  - -J “Jobname[index | start-end:increment]”
  - Range of job index is 1~ 10,000
  - LSB_JOBINDEX is set to array index

```
#!/bin/bash
#BSUB -P acc_hpcstaff
#BSUB -n 1
#BSUB -W 02:00
#BSUB -q express
#BSUB -J "jobarraytest[1-10]"
#BSUB -o logs/out.%J.%I
#BSUB -e logs/err.%J.%I
echo “Working on file.$LSB_JOBINDEX”
```

```
gail01@li03c03 $ bsub < myarrayjob.sh
Job <2946012> is submitted to queue <express>.
gail01@li03c03: ~ $ bjobs
     JOBID      USER    JOB_NAME   STAT     QUEUE  FROM_HOST    EXEC_HOST
SUBMIT_TIME    START_TIME  TIME_LEFT
    2946012     gail01 *rraytest[1]   PEND    express    li03c03      -       Sep 10 14:50      -         -
    2946012     gail01 *rraytest[2]   PEND    express    li03c03      -       Sep 10 14:50      -         -
    2946012     gail01 *rraytest[3]   PEND    express    li03c03      -       Sep 10 14:50      -         -
    2946012     gail01 *rraytest[4]   PEND    express    li03c03      -       Sep 10 14:50      -         -
    2946012     gail01 *rraytest[5]   PEND    express    li03c03      -       Sep 10 14:50      -         -
    2946012     gail01 *rraytest[6]   PEND    express    li03c03      -       Sep 10 14:50      -         -
    2946012     gail01 *rraytest[7]   PEND    express    li03c03      -       Sep 10 14:50      -         -
    2946012     gail01 *rraytest[8]   PEND    express    li03c03      -       Sep 10 14:50      -         -
    2946012     gail01 *rraytest[9]   PEND    express    li03c03      -       Sep 10 14:50      -         -
    2946012     gail01 *raytest[10]   PEND    express    li03c03      -       Sep 10 14:50      -         -
```

Message Passing Interface (MPI) Jobs

- This example requests 48 cores and 2 hours in the "express" queue.
  - Those 48 cores can be dispatched across multiple nodes

```
#!/bin/bash
#BSUB -J myjobMPI
#BSUB -P acc_hpcstaff
#BSUB -q express
#BSUB -n 48

#BSUB -W 02:00
#BSUB -o %J.stdout
#BSUB -eo %J.stderr
#BSUB -L /bin/bash

cd $LS_SUBCWD

module load openmpi

mpirun -np 48 /my/bin/executable < my_data.in
```

Multithreaded Jobs - OpenMP

- Multiple CPU cores within one node using shared memory
  - In general, a multithreaded application uses a single process which then spawns multiple threads of execution
  - It's highly recommended the number of threads is set to the number of compute cores
- Your program needs to be written to use multi-threading

```
#!/bin/bash
#BSUB -J myjob
#BSUB -P YourAllocationAccount
#BSUB -q express
#BSUB -n 4
#BSUB -R "span[hosts=1]"
#BSUB -R rusage[mem=12000]
#BSUB -W 01:00
#BSUB -o %J.stdout
#BSUB -eo %J.stderr
#BSUB -L /bin/bash

cd $LS_SUBCWD
export OMP_NUM_THREADS=4          #sets the number of threads
/my/bin/executable < my_data.in
```

Job submission script example: star.lsf

```
#!/bin/bash
#BSUB -J mySTARjob                  # Job name
#BSUB -P acc_PLK2                   # allocation account
#BSUB -q premium                    # queue
#BSUB -n 8                          # number of compute cores
#BSUB -W 12:00                      # walltime in HH:MM
#BSUB -R rusage[mem=4000]           # 32 GB of memory (4 GB per core)
#BSUB -R span[hosts=1]              # all cores from one node
#BSUB -o %J.stdout                  # output log (%J : JobID)
#BSUB -eo %J.stderr                 # error log
#BSUB -L /bin/bash                  # Initialize the execution environment

module load star
WRKDIR=/sc/orga/projects/hpcstaff/benchmark_star
STAR --genomeDir $WRKDIR/star-genome --readFilesIn Experiment1.fastq --runThreadN 8
--outFileNamePrefix Experiment1Star
```

Submit the script with the **bsub** command:

```
bsub < star.lsf
```

Specifying a resource - OpenMP job

Span: define the shape of the slots you ask for:

-n 12 -R span[hosts=1] - allocate all 12 cores to one host

-n 12 -R span[ptile=12] - all 12 slots/cores must be on 1 node

-n 24 -R span[ptile=12] - allocate 12 cores per node = 2 nodes

OMP_NUM_THREADS must be set in script:

- **bsub -n 12 -R span[hosts=1] < my_parallel_job**

  export OMP_NUM_THREADS=12
- **bsub -n 12 -R span[ptile=12] -a openmp < my_parallel_job**

  LSF sets it for you as number of procs per node
- **bsub -n 1 -R "affinity[core(12)]" -R "rusage[mem=12000]" -a openmp < my_parallel_job**
  - 1 job slot with 12 cores, 12000MB merory to that job slot...not per core
  - Advantage: Can vary number of cores and/or memory without making any other changes or calculations

A Bravura Submission - Mixing it all together

Suppose you want to run a combined MPI-openMP job. One mpi process per node, openMP in each MPI Rank:

bsub -n 20 -R span[ptile=1] -R affinity[core(8)] -a openmp < my_awsome_job

ptile=1 - one slot on each node

core(8) - 8 cores per job slot

openmp - will set OMP_NUM_THREADS on each node to 8

GPGPU (General Purpose Graphics Processor Unit)

- GPGPU resources on Minerva
  - Interactive queue (1 GPU node)
  - gpu queue for batch (11 GPU nodes)
    - Can be quite busy sometimes

number of nodes	12
GPU card	4 v100
CPU cores	32
host memory	384GB
GPU memory	16 GB

```
#BSUB -q gpu                                  # submit to gpu queue
#BSUB -n Ncpu                                 # Ncpu is 1~32 on v100

#BSUB -R v100                                 # request specified gpu node v100
#BSUB -R "gpu rusage[ngpus_excl_p=2]"         # The number of GPUs requested per node ( 1 by
                                              default)
module purge
module load anaconda3 ( or 2)                 # to access tensorflow
module load cuda                              # to access the drivers and supporting
source activate tfGPU                         subroutines

python -c "import tensorflow as tf"
```

GPGPU (continue)

- Request multiple GPU cards across different GPU nodes

```
#BSUB -q gpu                                          # submit to gpu queue
#BSUB -n 8                                            # 8 compute cores  requested
#BSUB -R span[ptile=2]                                # 2 cores per node, so 4 nodes in total requested
#BSUB -R v100                                         # request specified gpu node v100
#BSUB -R "gpu rusage[ngpus_excl_p=2]"                 # 2 GPUs requested per node
```

Checkpoint/Restart

https://hpc.mssm.com->Minerva Documentation->Checkpoint-Restart

- Checkpoint: Save the state of a process at a particular point in the computation
- Restart: Restore the state of a process and continue the computation from the saved state.

Checkpoint/Restart

https://hpc.mssm.com->Minerva Documentation->Checkpoint-Restart

- The long-time standard BLCR method is no longer supported
- It has been replaced by the more modern method: Checkpoint/Restart In User space (CRIU)

bsub -k "checkpoint_dir [init=initial_checkpoint_period] [check-point_period] [method=method_name]"

E.g.,

bsub -k "chkpntDir init=10 90 method=criu"

Checkpoint/Restart

https://hpc.mssm.com->Minerva Documentation->Checkpoint-Restart

- To restart, use brestart command
- Must restart on same type of machine.
- Can increase memory, change queue, add dependency, etc (see man page)

brestart [options] checkpointFolder jobid

brestart -W 4:00 -R rusage[mem=26000] chkpnt 193876

BONUS: You may be able to checkpoint a process even if you didn't set it up via LSF.

See HPC web site for details.

More bsub [options]

https://www.ibm.com/support/knowledgecenter/SSETD4_9.1.3/lsf_command_ref/bsub.heading_options.1.html

Tips for efficient usage of the queuing system

- User limitation
  - Max pending job per user: 20,000
  - Heavy users: depending on the resource requested
- Find appropriate queue and nodes
  - use -q interactive: for debug (both CPU and GPU with internet access)
  - use -q express if walltime < 12h
  - use himem node for memory intensive job
- Request reasonable resource
  - Prior knowledge needed (run test program and use top or others to monitor)
  - Keep it simple
- Job not start after a long pending time
  - Whether the resource requested is non-exist: -R rusage[mem = 10000] -n 20
  - Run into PM:

```
NOTE: Because of PM reservations, job may not run
      until after Sat 21 Mar at  8:00PM
-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-
Job <6628109> is submitted to queue <premium>.
```

- If you see memory not enough
  - Think about shared memory vs distributed memory job……
  - Use -R span[hosts=1] where needed

Final Friendly Reminder

- Never run jobs on login nodes
  - For file management, coding, compilation, etc., purposes only
- Never run jobs outside LSF
  - Fair sharing
  - Scratch disk not backed up, efficient use of limited resources
  - Job temporary dir configured to /local/JOBS instead of /tmp.
- Logging onto compute nodes is no longer allowed

- Follow us by visiting https://labs.icahn.mssm.edu/minervalab , weekly update and twitter
- Acknowledge Scientific Computing at Mount Sinai should appear in your publications
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Last but not Least

- Got a problem? Need a program installed? Send an email to:

hpchelp@hpc.mssm.edu