ilifu Online Training – Advanced `slurm`

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IDIA Inter-University Institute for Data Intensive Astronomy

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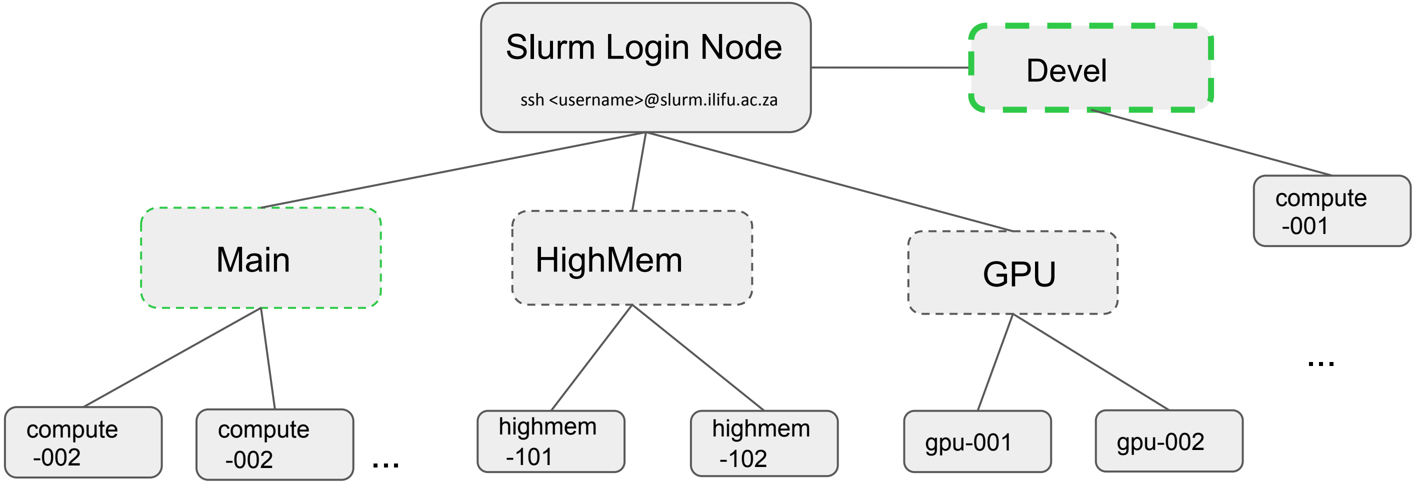
Overview

- Interactive Jobs
    - Persistent Terminals `(tmux)`
- Advanced Slurm monitoring:
    - How busy is the cluster? `(sinfo)`
    - Where are my jobs in the queue? `(squeue)`
    - Which jobs have I submitted in the past and what happened? `(sacct)`
- Advanced Slurm job submission:
    - Slurm Arrays
    - Slurm Job Dependencies

SLURM

http://docs.ilifu.ac.za/#/tech_docs/running_jobs?id=specifying-resources-when-running-jobs-on-slurm

Main	HighMem	GPU	Devel
~85 nodes	3 nodes	8 nodes	1 node
32 CPUs / 232 GB RAM	32 CPUs / 480 GB RAM	2 GPUs / 232 GB RAM	32 CPUs / 237 GB RAM



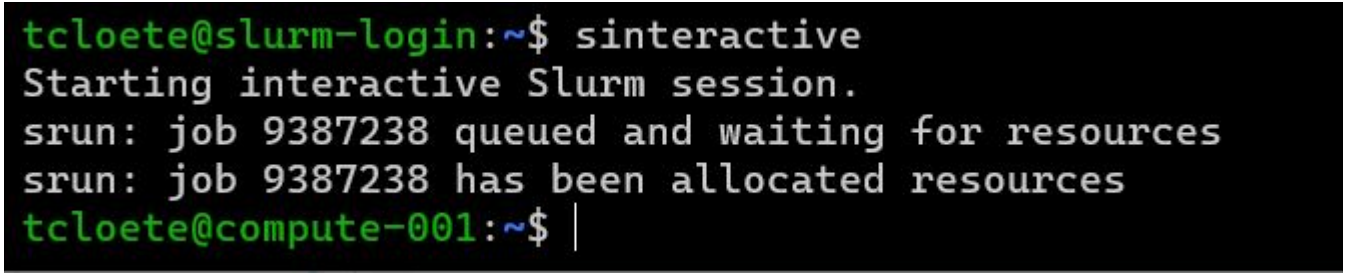
SLURM - running an interactive job

Login to Slurm Login Node

```
$ ssh <username>@slurm.ilifu.ac.za
```

```
$ sinteractive
```

- Devel partition



```
tcloete@slurm-login:~$ sinteractive
Starting interactive Slurm session.
srun: job 9387238 queued and waiting for resources
srun: job 9387238 has been allocated resources
tcloete@compute-001:~$ |
```

```
$ srun --pty bash
```

- Main partition

SLURM - running an interactive job

Login to Slurm Login Node

```
$ ssh <username>@slurm.ilifu.ac.za
```

Defaults: 1 CPU for 3 hours:

```
$ sinteractive -c 1 –time 03:00
```

Example: 5 CPU for 5 days (maximum):

```
$ sinteractive -c 5 –time 5-00:00
```

Note: All resources on the Devel partition are shared. Including CPU and memory.

For interactive jobs requiring dedicated resources, please use: `srun` on the Main partition

SLURM - running an interactive job (x11 support)

Login to Slurm Login Node

```
$ ssh -Y <username>@slurm.ilifu.ac.za
```

```
$ sinteractive --x11
```

Testing X11 Support:

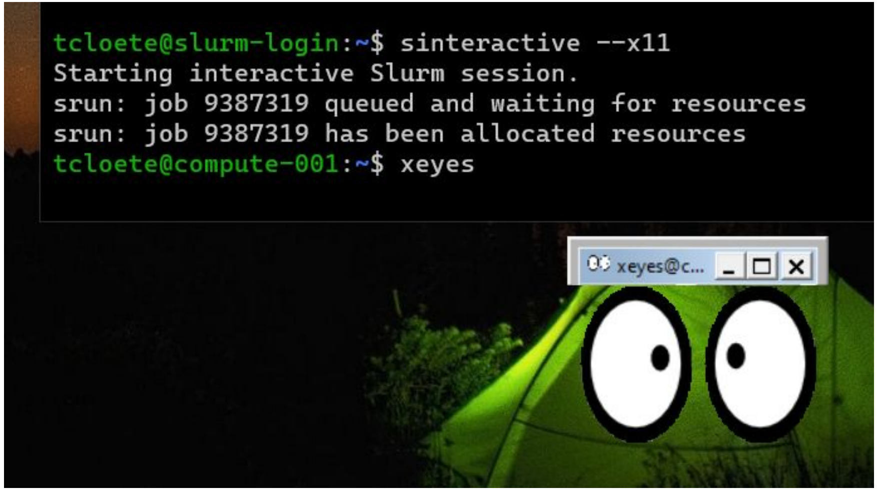
```
$ xeyes
```

OR

```
$ xmessage 'hello'
```

Windows users:

Install X11 server:
e.g. XMing or Vcxsrv



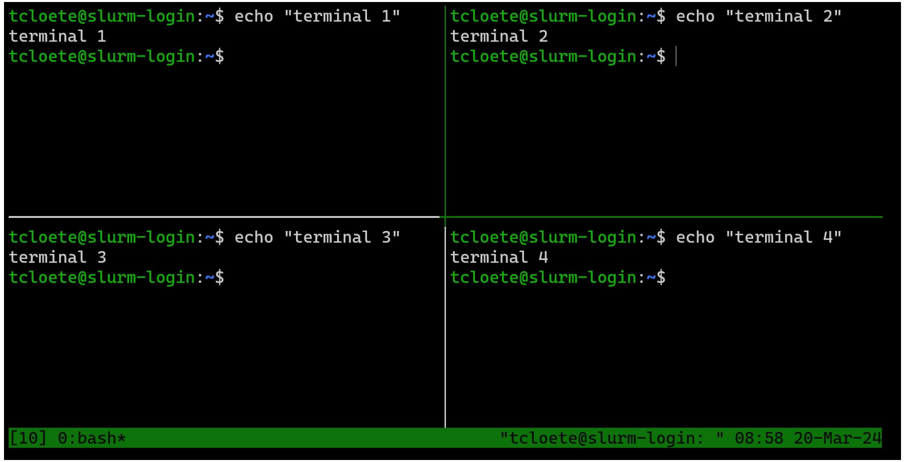
```
tcloete@slurm-login:~$ sinteractive --x11
Starting interactive Slurm session.
srun: job 9387319 queued and waiting for resources
srun: job 9387319 has been allocated resources
tcloete@compute-001:~$ xeyes
```

Persistent Terminals

tmux — terminal multiplexer

- Runs Multiple Terminals
- Persistent Connections

Note: Persistent terminals can be lost if the Slurm-login node had to be restarted



```
tcloete@slurm-login:~$ echo "terminal 1"      tcloete@slurm-login:~$ echo "terminal 2"
terminal 1                                    terminal 2
tcloete@slurm-login:~$                        tcloete@slurm-login:~$

tcloete@slurm-login:~$ echo "terminal 3"      tcloete@slurm-login:~$ echo "terminal 4"
terminal 3                                    terminal 4
tcloete@slurm-login:~$                        tcloete@slurm-login:~$

[10] 0:bash*                           "tcloete@slurm-login: " 08:58 20-Mar-24
```

Commands

```
$ tmux              # start a new tmux session
$ tmux attach       # Attach to running session

$ tmux ls           # List active sessions
$ tmux --help       # show help
```

Persistent Terminals (2)

Keyboard shortcuts

```
Ctrl+b %   # split the screen horizontally
Ctrl+b "   # split the screen vertically

Ctrl+b <arrow key> # switch to the pane in arrow direction

Ctrl+b x   # kill terminal pane
Ctrl+b d  # detach session (can reconnect)
```

Ilifu docs Reference:
https://docs.ilifu.ac.za/#/tech_docs/running_jobs?id=persistent-terminals

Video Tutorial (Jeremy Howard): https://youtu.be/0pWjZByJ3Lk?t=2474

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Overview

- Interactive Jobs
- Persistent Terminals `(tmux)`
- Advanced Slurm monitoring:
  - How busy is the cluster? `(sinfo)`
  - Where are my jobs in the queue? `(squeue)`
  - Which jobs have I submitted in the past and what happened? `(sacct)`
- Advanced Slurm job submission:
  - Slurm Arrays
  - Slurm Job Dependencies

SLURM monitoring commands: usage

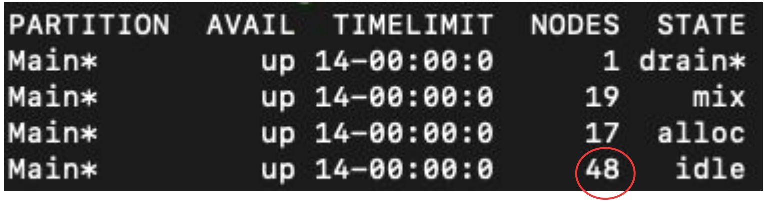
Slurm Commands	Before Running a Job	Starting a New Job	Monitoring a Running Job	After Jobs have Completed
`sinfo`	X			
`squeue`	X		X	
`sbatch`		X		
`srun`		X		
`scontrol*`			X	
`sacct`				X

* Shows all information about a pending/running job:

```
$ scontrol show job <jobID>
```

sinfo: How busy is the cluster?

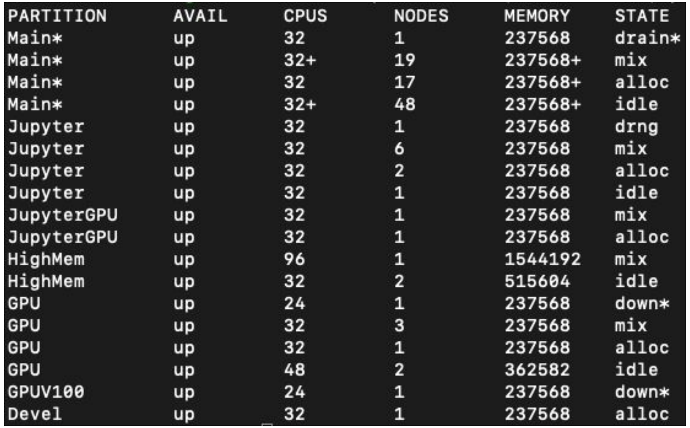
```
$ sinfo
```



```
PARTITION  AVAIL  TIMELIMIT  NODES  STATE
Main*         up 14-00:00:0      1 drain*
Main*         up 14-00:00:0     19    mix
Main*         up 14-00:00:0     17  alloc
Main*         up 14-00:00:0     48   idle
```

List partitions and their specs

```
$ sinfo -O "partition,available,cpus,nodes,memory,statecompact"
```



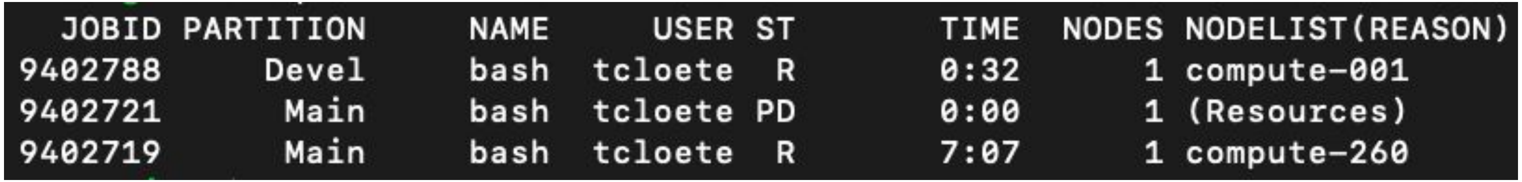
```
PARTITION      AVAIL     CPUS      NODES     MEMORY    STATE
Main*          up        32        1         237568    drain*
Main*          up        32+       19        237568+   mix
Main*          up        32        17        237568+   alloc
Main*          up        32+       48        237568+   idle
Jupyter        up        32        1         237568    drng
Jupyter        up        32        6         237568    mix
Jupyter        up        32        2         237568    alloc
Jupyter        up        32        1         237568    idle
JupyterGPU     up        32        1         237568    mix
JupyterGPU     up        32        1         237568    alloc
HighMem        up        96        1         1544192   mix
HighMem        up        32        2         515604    idle
GPU            up        24        1         237568    down*
GPU            up        32        3         237568    mix
GPU            up        32        1         237568    alloc
GPU            up        48        2         362582    idle
GPUV100        up        24        1         237568    down*
Devel          up        32        1         237568    alloc
```

For a list of sinfo columns:

```
$ man sinfo
```

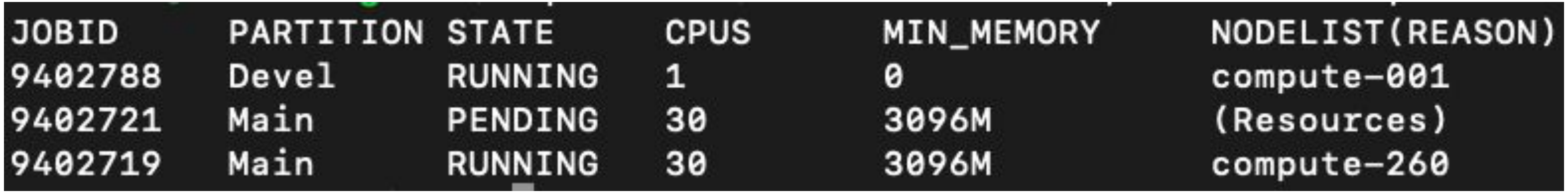
squeue: Where is my job in the queue?

```
$ squeue -u $USER
```



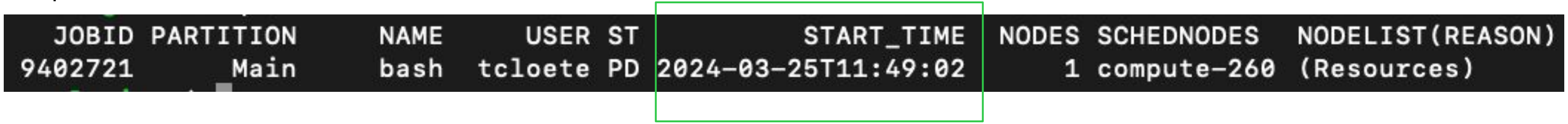
```
  JOBID PARTITION     NAME     USER ST       TIME  NODES NODELIST(REASON)
9402788     Devel     bash  tcloete  R       0:32      1 compute-001
9402721      Main     bash  tcloete PD       0:00      1 (Resources)
9402719      Main     bash  tcloete  R       7:07      1 compute-260
```

```
$ squeue -u $USER -O JobID,Partition,State,NumCPUs,MinMemory,NodeList,ReasonList
```



```
JOBID         PARTITION STATE      CPUS         MIN_MEMORY      NODELIST(REASON)
9402788       Devel     RUNNING    1            0               compute-001
9402721       Main      PENDING    30           3096M           (Resources)
9402719       Main      RUNNING    30           3096M           compute-260
```

```
$ squeue -u $USER --start
```



```
  JOBID PARTITION     NAME     USER ST          START_TIME  NODES SCHEDNODES           NODELIST(REASON)
9402721      Main     bash  tcloete PD 2024-03-25T11:49:02      1 compute-260          (Resources)
```

sacct: Which jobs have been submitted in the past?

Show jobs submitted by the user in the past 1 day:

```
$ sacct -u $USER
```

Show one line per job (combines job steps):

```
$ sacct -u $USER -X
```

Filter on jobs submitted between a start date and an end date

```
$ sacct -u $USER -X -S 2024-03-25 -E 2025-03-26
```

Show specific columns:

```
$ sacct -u $USER -X -S 2024-03-25 -E 2025-03-26
-o Jobid,JobName,NCPU,NNodes,Start,End,Elapsed,TimeLimit,State
```

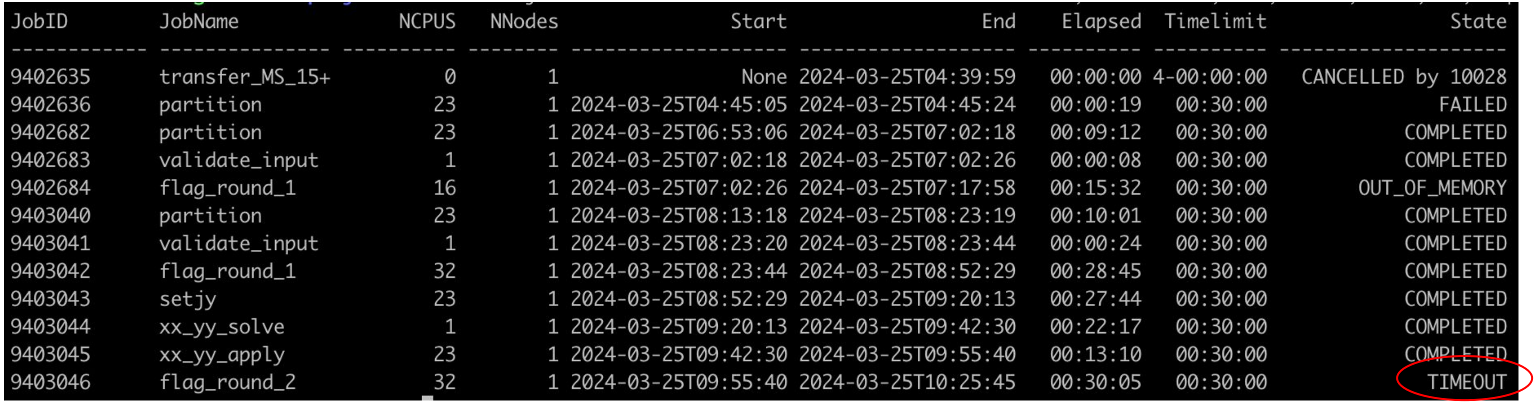
Add Formatting e.g. %-15 is a column with width of 15 and a left justification

```
$ sacct -u $USER -X
-o Jobid,JobName%-15,NCPU,NNodes,Start,End,Elapsed,TimeLimit,State%20
```

sacct: Which jobs have been submitted in the past?

Example for showing how long jobs ran to help set the Wall time (TimeLimit)

```
$ sacct -u $USER -X
-o Jobid,JobName%-15,NCPU,NNodes,Start,End,Elapsed,TimeLimit,State%20
```

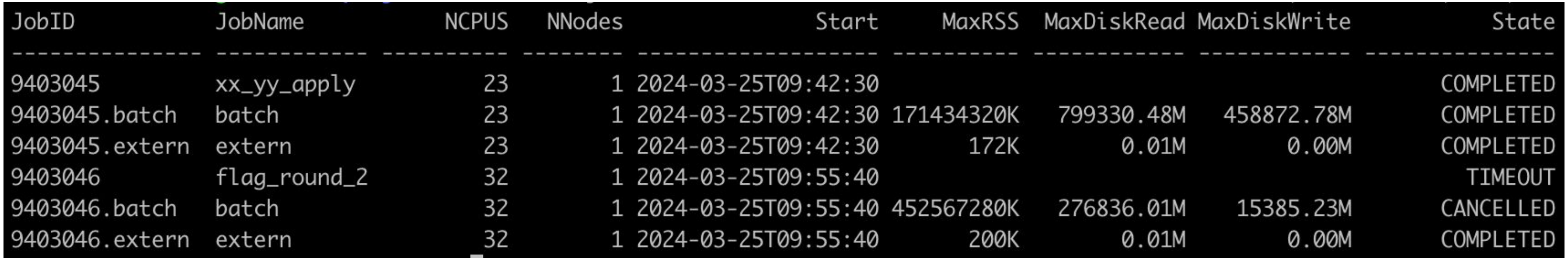


```
JobID        JobName              NCPUS   NNodes               Start                 End    Elapsed  Timelimit                State
------------ --------------- ---------- -------- ------------------- ------------------- ---------- ---------- --------------------
9402635      transfer_MS_15+          0        1                None 2024-03-25T04:39:59   00:00:00 4-00:00:00   CANCELLED by 10028
9402636      partition               23        1 2024-03-25T04:45:05 2024-03-25T04:45:24   00:00:19   00:30:00               FAILED
9402682      partition               23        1 2024-03-25T06:53:06 2024-03-25T07:02:18   00:09:12   00:30:00            COMPLETED
9402683      validate_input           1        1 2024-03-25T07:02:18 2024-03-25T07:02:26   00:00:08   00:30:00            COMPLETED
9402684      flag_round_1            16        1 2024-03-25T07:02:26 2024-03-25T07:17:58   00:15:32   00:30:00        OUT_OF_MEMORY
9403040      partition               23        1 2024-03-25T08:13:18 2024-03-25T08:23:19   00:10:01   00:30:00            COMPLETED
9403041      validate_input           1        1 2024-03-25T08:23:20 2024-03-25T08:23:44   00:00:24   00:30:00            COMPLETED
9403042      flag_round_1            32        1 2024-03-25T08:23:44 2024-03-25T08:52:29   00:28:45   00:30:00            COMPLETED
9403043      setjy                   23        1 2024-03-25T08:52:29 2024-03-25T09:20:13   00:27:44   00:30:00            COMPLETED
9403044      xx_yy_solve              1        1 2024-03-25T09:20:13 2024-03-25T09:42:30   00:22:17   00:30:00            COMPLETED
9403045      xx_yy_apply             23        1 2024-03-25T09:42:30 2024-03-25T09:55:40   00:13:10   00:30:00            COMPLETED
9403046      flag_round_2            32        1 2024-03-25T09:55:40 2024-03-25T10:25:45   00:30:05   00:30:00              TIMEOUT
```

sacct: Which jobs have been submitted in the past?

Example for showing how much resources jobs used
e.g. MaxRSS = Maximum RAM usage in bytes
Note: Only on job-step level

```
$ sacct -u $USER -S 2024-03-25 -E 2025-03-25 -o
Jobid%-15,JobName%-15,NCPU,NNodes,Start,MaxRSS,MaxDiskRead,MaxDiskWrite,State%20
```



```
JobID           JobName           NCPUS   NNodes               Start     MaxRSS  MaxDiskRead MaxDiskWrite           State
--------------- ------------ ---------- -------- ------------------- ---------- ------------ ------------ ---------------
9403045         xx_yy_apply          23        1 2024-03-25T09:42:30                                            COMPLETED
9403045.batch   batch                23        1 2024-03-25T09:42:30 171434320K   799330.48M   458872.78M       COMPLETED
9403045.extern  extern               23        1 2024-03-25T09:42:30       172K        0.01M        0.00M       COMPLETED
9403046         flag_round_2         32        1 2024-03-25T09:55:40                                              TIMEOUT
9403046.batch   batch                32        1 2024-03-25T09:55:40 452567280K   276836.01M    15385.23M       CANCELLED
9403046.extern  extern               32        1 2024-03-25T09:55:40       200K        0.01M        0.00M       COMPLETED
```

SLURM - advanced user commands

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- After / during running jobs :
- `jobId` is given from sbatch output / squeue

Shows info about job running including working directory

```
$ scontrol show job <jobID>
```

Shows squeue with start time (%S)

```
$ squeue --start -u $USER
```

Shows info for multi-CPU jobs

```
$ sacct -o JoBID%-15,JobName%-15,Partition,Account,
  Elapsed,NNodes%6,NTASK%6,NCPUS%5,MaxDiskRead,MaxDiskWrite,
 NodeList%20,MaxRSS,CPUTime,State,ExitCode
```

Shows jobs started and completed between these dates

```
$ sacct -S 2021-09-01-09:00 -E 2021-09-14-10:00 -X -o
  Jobid,JobName,Start,End,State
```

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SLURM - advanced user commands

- Email parameters

```
$ srun --mail-user=<address> --mail-type=<event_types>
```

- ***Events : BEGIN,END,FAIL,TIME_LIMIT_80***

- Exclude nodes
- e.g. problematic nodes (report to ilifu support)

```
$ srun --exclude=compute-[101,101-105]
```

SLURM - running an interactive job

- Specify lower wall-time (default 3 hours) and less memory (default ~7GB) increases chance of job launching immediately

- In steps:

```
$ srun --pty --time=10 --mem=1GB bash
$ singularity shell /idia/software/containers/python-3.6.img
$ python3 job_script.py
```

- In single call:

```
$ srun --pty --time=10 --mem=1GB singularity exec
/idia/software/containers/python-3.6.img python3 job_script.py
```

- Must manually process after this

Topics

- Interactive Jobs
- Persistent Terminals `(tmux)`
- Advanced Slurm monitoring:
    - How busy is the cluster? `(sinfo)`
    - Where are my jobs in the queue? `(squeue)`
    - Which jobs have I submitted in the past and what happened? `(sacct)`
- Advanced Slurm job submission:
    - Slurm Arrays
    - Slurm Job Dependencies

SLURM - array jobs

- Array jobs allow quick submission of many similar jobs, each the with same resources, without any manual launch

  - Passes array task ID into script, which changes behavior of each job each time i.e different inputs
  - Can be used to run many related steps in a serial process

- Example job array Running, 20 jobs, with 5 run concurrently.

```
#!/bin/bash
#SBATCH --array=1-20%5
#SBATCH --job-name=myarrayjob
#SBATCH --output=logs/%x-%A_%a.out
#SBATCH --error=logs/%x-%A_%a.err

module load python/3.11.0

python myscript.py --input $SLURM_ARRAY_TASK_ID
```

SLURM - substitutions and environment variables

Parameter	Substitution / filename pattern	Environment Variables
jobID of running job	`%j`	`SLURM_JOB_ID`
Job name	`%x`	`SLURM_JOB_NAME`
Job array's master job allocation number	`%A`	`SLURM_ARRAY_JOB_ID`
Job array task ID (index) number	`%a`	`SLURM_ARRAY_TASK_ID`

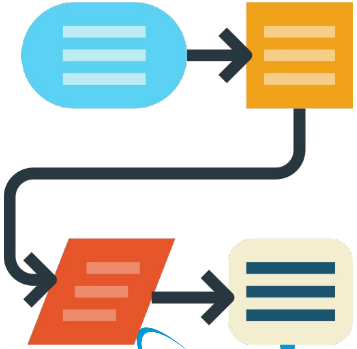
```
For example:
#SBATCH --array=1-20%5
#SBATCH --job-name=myarrayjob
#SBATCH --output=logs/%x-%A_%a.out

With submitted first job id: 1000
```

%j = 1000,1001…,1019
%x = myarrayjob
%A = 1000
%a = 1,2,3,...,19,20 (order not guaranteed)

SLURM Job dependencies

- Allow jobs to be scheduled for running, based on the status of a previous job

- e.g only begin a particular job once previous one successfully completes



```
Submit another_job.sh to SLURM queue, to begin after jobID 1234 successfully
completes , or cancel the job if jobID 1234 fails
$ sbatch -d afterok:1234 --kill-on-invalid-dep=yes another_job.sh

Submit another_job.sh to SLURM queue, to begin after jobID 1234 & 5678 completes
$ sbatch -d afterany:1234:5678 another_job.sh
```

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SLURM - Best practice

Do's :

- Run jobs using sbatch rather than interactive jobs
- Identify job resources requirements:
  - No. of nodes and CPUs, amount of RAM and wall-time.
- Remove files that aren't needed
  - `/scratch3` folder after data processing is complete
  - Old raw data, temporary products , etc.
- Use Singularity (cannot install software on nodes)
- Use **`username@transfer.ilifu.ac.za`** for data transfers

Don't:

- Don't run software/heavy processes on login node
- Don't place large files in your home directory (`/users`)
- Don't transfer using scp/rsync on the login node

Thank you!

Remember our support channels!

support@ilifu.ac.za
https://docs.ilifu.ac.za