ilifu Online Training – Advanced `slurm`

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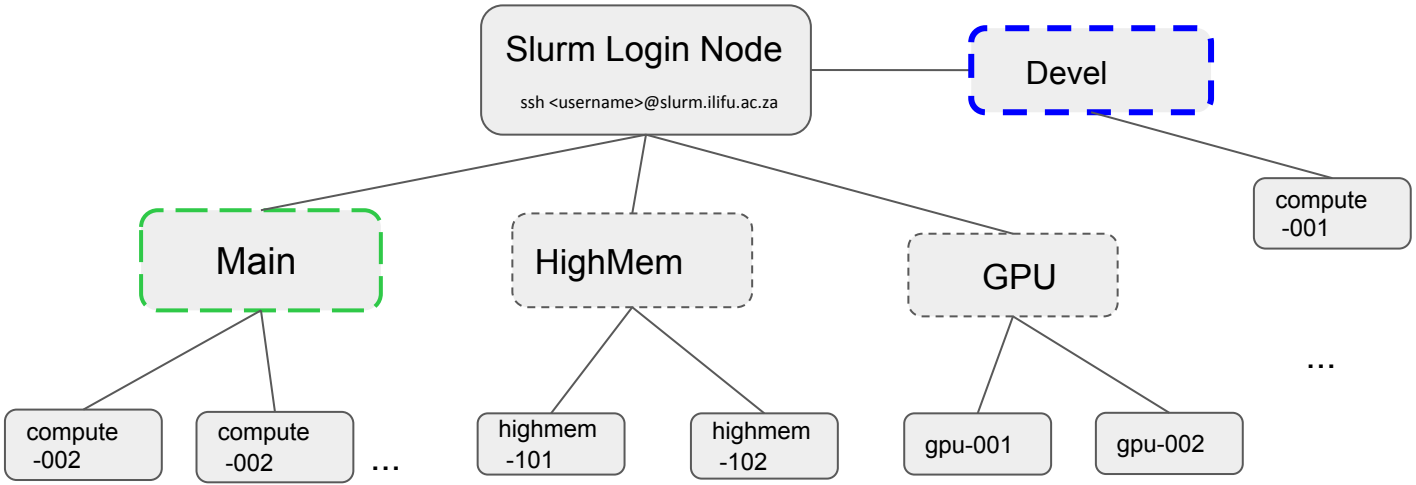
Overview

- 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	8 nodes	7 nodes	1 node
32 CPUs / 232 GB RAM	32 CPUs / 480 GB RAM	2 GPUs / 232 GB RAM	32 CPUs / 237 GB RAM



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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:~$
```

The sinteractive script is a wrapper script we created for calling Slurm's *srun* command with useful default parameters.

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

- Main partition

```
srun -p Main --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:

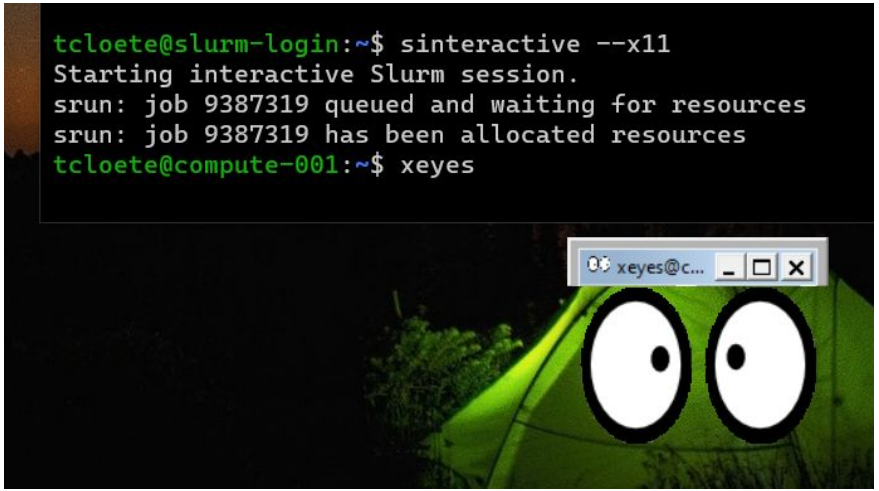
```
$ xeyes
```

OR

```
$ xmessage 'hello'
```

Windows users:

Install X11 server:
e.g. XMing or Vcxsrv

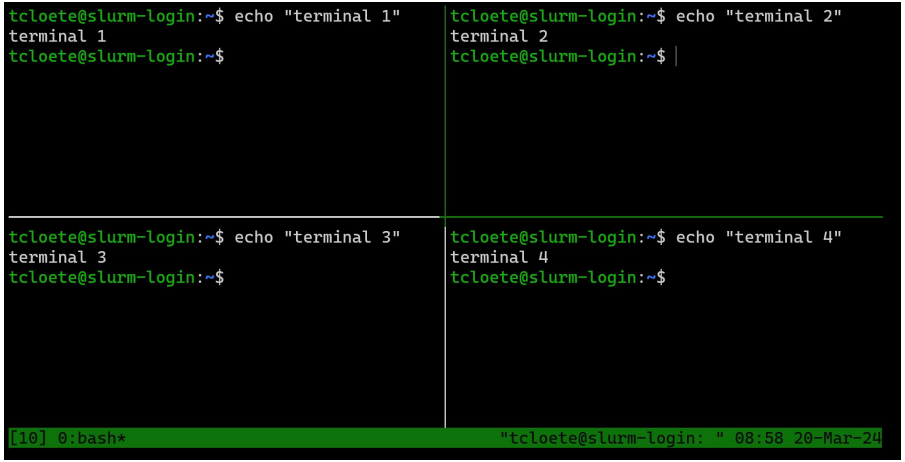


Persistent Terminals

tmux — terminal multiplexer

- Persistent Connections
- Runs Multiple Terminals

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



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

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

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

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
```

```
tcloete@compute-001:~/demo/interactive_script$ sacct -u $USER
JobID           JobName  Partition    Account  AllocCPUS      State ExitCode
------------ ---------- ---------- ---------- ---------- ---------- --------
10042739           bash      Devel b05-pipel+          1    RUNNING      0:0
10042739.ex+     extern            b05-pipel+          1    RUNNING      0:0
10042739.0         bash            b05-pipel+          1    RUNNING      0:0
10043369           bash      Devel b05-pipel+          1  COMPLETED      0:0
10043369.ex+     extern            b05-pipel+          1  COMPLETED      0:0
10043369.0         bash            b05-pipel+          1  COMPLETED      0:0
```

Show one line per job (combines job steps):

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

Outputs a list of available column names:

```
$ sacct -e
$ sacct --helpformat
```

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
```

Nicer formatting of columns 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?

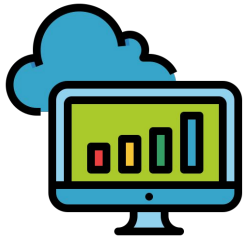
Example for showing how much resources jobs used
e.g. MaxRSS = Maximum RAM usage in bytes
Note: Only on job-step level

```
$ 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

- 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
```

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

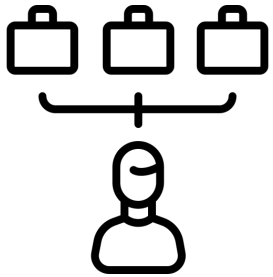
- Interactive Jobs
- Persistent Terminals `(tmux)`
- Advanced Slurm monitoring:
  - How busy is the cluster? `(sinfo)`
  - Where are my jobs in the queue? `(squeue)`
  - Which jobs have I submitted in the past and what happened? `(sacct)`
- Advanced Slurm job submission:
  - Slurm Arrays
  - Slurm Job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

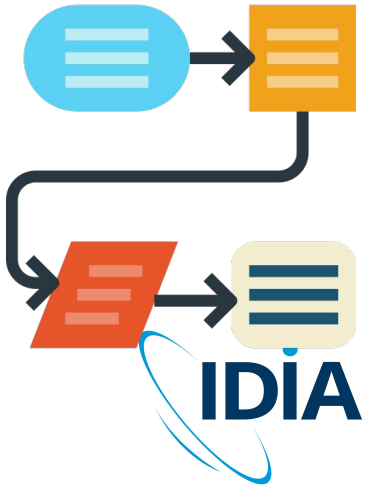
SLURM Job dependencies

- 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