

Slurm: A quick start tutorial

Slurm is a resource manager and job scheduler. Users can submit jobs (i.e. scripts containing execution instructions) to slurm so that it can schedule their execution and allocate the appropriate resources (CPU, RAM, etc..) on the basis of a user's preferences or the limits imposed by the system administrators. The advantages of using slurm on a computational cluster are multiple. For an overview of them please read [these pages](#).

Slurm is **free** software distributed under the [GNU General Public License](#).

What is a parallel job?

A parallel job consists of tasks that run simultaneously. Parallelization can be achieved in different ways, among which:

- by running a multi-process program, for example using [OpenMPI](#).
- by running a multi-threaded program, for example see [pthreads](#).

A multi-process program consists of multiple tasks orchestrated by MPI and possibly executed by different nodes. On the other hand, a multi-threaded program consists of multiple task using several CPUs on the same node.

Slurm's command ``srun'` (see below) allows users to create tasks and/or request CPUs for a particular task such that both types of parallelizations mentioned above can be achieved easily. For instance, the `-ntasks n (-N)` option will create **n processes**, while the `-cpus-per-task n (-c)` option will create a single **n-threaded process**. Tasks cannot be split across several compute nodes. See the examples below.

Slurm's architecture

Slurm is made of a `slurmd` daemon running on each compute node and a central `slurmctld` daemon running on a management node (with the possibility of setting up a fail-over twin). If ``accounting'` is enabled, then there is a third daemon called `slurmdbd` managing the communications between an accounting database and the management node.

Common slurm user commands include `sacct`, `salloc`, `sattach`, `sbatch`, `sbcast`, `scancel`, `scontrol`, `sinfo`, `smap`, `squeue`, `srun`, `strigger` and `sview` and they are available on each compute node. Manual pages for each of these commands are accessible in the usual manner, that is `man sbatch` for example (see below).

Node

A node in slurm is a compute resource. This is usually defined by particular consumable resources, i.e. memory, CPU, etc...

Partitions

A partition (or queue) is a set of nodes with usually common characteristics and/or limits.

Partitions group nodes into logical (even overlapping if necessary) sets.

Jobs

Jobs are allocations of consumable resources assigned to a user under specified conditions.

Job Steps

A job step is a single task within a job. Each job can have multiple tasks (steps) even parallel ones.

Common user commands

- **sacct**: used to report job or job step accounting information about active or completed jobs.
- **salloc**: used to allocate resources for a job in real time. Typically this is used to allocate resources and spawn a shell. The shell is then used to execute srun commands to launch parallel tasks.
- **sbatch**: used to submit a job script for later execution. The script typically contains an srun command to launch parallel tasks plus any other environment definitions needed.
- **scancel**: used to cancel a pending or running job or job step.
- **sinfo**: used to report the state of partitions and nodes managed by Slurm.
- **squeue**: used to report the state of running and pending jobs or job steps.
- **srun**: used to submit a job for execution or initiate job steps in real time. srun allows users to requests arbitrary consumable resources.

Examples

Determine what partitions exist on the system, what nodes they include, and the general system state.

```
$ sinfo
PARTITION      AVAIL  TIMELIMIT  NODES  STATE NODELIST
playground*    up     infinite    2      mix  maris[029,031]
playground*    up     infinite   34      idle
maris[004-022,030,032-033,035-046]
computation    up     infinite   14      mix
maris[052,057-061,064-068,071-073]
computation    up     infinite    5      alloc maris[062-063,069-070,074]
computation    up     infinite    9      idle  maris[047-051,053-056]
emergency      up     infinite    3      mix  maris[071-073]
emergency      up     infinite    3      alloc maris[069-070,074]
notebook       up     infinite    2      mix  maris[024,027]
```

```

notebook          up    infinite    3  alloc maris[023,025-026]
notebook          up    infinite    1  idle  maris028
gpu               up    infinite    1  idle  maris075
computation-intel up  3-00:00:00    1  mix   maris076
computation-intel up  3-00:00:00    1  alloc maris077

```

A * near a partition name indicates the default partition. See `man sinfo`

Display all active jobs by user bongo?

```

$ squeue -u bongo
          JOBID PARTITION     NAME     USER ST       TIME  NODES
NODELIST(REASON)
          324936 computati VVV2_VV    bongo  R 1-02:11:54      1 maris068

```

See `man squeue`.

Report more detailed information about partitions, nodes, jobs, job steps, and configuration

```

$ scontrol show partition notebook
PartitionName=notebook
  AllowGroups=ALL AllowAccounts=ALL AllowQos=ALL
  AllocNodes=ALL Default=NO QoS=notebook
  DefaultTime=NONE DisableRootJobs=NO ExclusiveUser=NO GraceTime=0
Hidden=NO
  MaxNodes=UNLIMITED MaxTime=UNLIMITED MinNodes=1 LLN=NO
MaxCPUsPerNode=UNLIMITED
  Nodes=maris0[23-28]
  PriorityJobFactor=1 PriorityTier=1 RootOnly=NO ReqResv=NO
OverSubscribe=NO
  OverTimeLimit=NONE PreemptMode=OFF
  State=UP TotalCPUs=48 TotalNodes=6 SelectTypeParameters=NONE
  DefMemPerNode=UNLIMITED MaxMemPerCPU=4096

```

```

$scontrol show node maris004
NodeName=maris004 Arch=x86_64 CoresPerSocket=4
  CPUAlloc=8 CPUErr=0 CPUTot=8 CPULoad=0.01
  AvailableFeatures=(null)
  ActiveFeatures=(null)
  Gres=(null)
  NodeAddr=maris004 NodeHostName=maris004 Version=16.05
  OS=Linux RealMemory=16046 AllocMem=16000 FreeMem=2082 Sockets=2 Boards=1
  State=ALLOCATED ThreadsPerCore=1 TmpDisk=9951 Weight=1 Owner=N/A
MCS_label=N/A
  BootTime=2016-12-22T12:08:05 SlurmdStartTime=2017-02-17T09:19:46
  CapWatts=n/a
  CurrentWatts=0 LowestJoules=0 ConsumedJoules=0
  ExtSensorsJoules=n/s ExtSensorsWatts=0 ExtSensorsTemp=n/s

```

```
novamaris [1087] $ scontrol show jobs 1052
```

```

JobId=1052 JobName=slurm_engine.sbatch
  UserId=xxxxxxx(1261909) GroupId=lorentz(9999) MCS_label=N/A
  Priority=1 Nice=0 Account=zzzzzz QOS=normal
  JobState=RUNNING Reason=None Dependency=(null)
  Requeue=1 Restarts=0 BatchFlag=1 Reboot=0 ExitCode=0:0
  RunTime=00:49:06 TimeLimit=UNLIMITED TimeMin=N/A
  SubmitTime=2017-02-23T12:17:34 EligibleTime=2017-02-23T12:17:34
  StartTime=2017-02-23T12:17:36 EndTime=Unknown Deadline=N/A
  PreemptTime=None SuspendTime=None SecsPreSuspend=0
  Partition=average-computation AllocNode:Sid=maris004:20658
  ReqNodeList=(null) ExcNodeList=(null)
  NodeList=maris[024-033,035-040]
  BatchHost=maris024
  NumNodes=16 NumCPUs=128 NumTasks=128 CPUs/Task=1 ReqB:S:C:T=0:0:*:*
  TRES=cpu=128,mem=514784M,node=16
  Socks/Node=* NtasksPerN:B:S:C=0:0:*:* CoreSpec=*
  MinCPUsNode=1 MinMemoryNode=32174M MinTmpDiskNode=0
  Features=(null) Gres=(null) Reservation=(null)
  OverSubscribe=OK Contiguous=0 Licenses=(null) Network=(null)
  Command=./slurm_engine.sbatch
  WorkDir=/marisdata/%u/
  StdErr=/marisdata/xxxxxxx/.log/abcd.err
  StdIn=/dev/null
  StdOut=/marisdata/xxxxxxx/.log/abcd.out
  Power=

```

See man `scontrol`.

Create three tasks running on different nodes

```

novamaris [1088] $ srun -N3 -l /bin/hostname
2: maris007
0: maris005
1: maris006

```

Create three tasks running on the same node

```

novamaris [1090] $ srun -n3 -l /bin/hostname
2: maris005
1: maris005
0: maris005

```

Create three tasks running on different nodes specifying which nodes should at least be used

```

srun -N3 -w "maris00[5-6]" -l /bin/hostname
1: maris006
0: maris005
2: maris007

```

Allocate resources and spawn job steps within that allocation

```
novamaris [1094] $ salloc -n2
salloc: Granted job allocation 1061
novamaris [997] $ srun /bin/hostname
maris005
maris005
novamaris [998] $ exit
exit
salloc: Relinquishing job allocation 1061
novamaris [1095] $
```

Create a job script and submit it to slurm for execution

Suppose `batch.sh` has the following contents

```
#!/bin/env bash
#SBATCH -n 2
#SBATCH -w maris00[5-6]
srun hostname
```

then submit it using `sbatch script.sh`.

See `man sbatch`.

Less-common user commands

- **sacctmgr**
- **sstat**
- **sshare**
- **sprio**
- **sacct**

sacctmgr

Display info on configured qos

```
$ sacctmgr show qos format=Name,MaxCpusPerUser,MaxJobsPerUser,Flags
      Name MaxCPUsPU MaxJobsPU          Flags
-----
   normal
playground      32          1      DenyOnLimit
  notebook      4           1      DenyOnLimit
```

sstat

Displays information pertaining to CPU, Task, Node, Resident Set Size (RSS) and Virtual Memory (VM) of a running job

```
$sstat -o JobID,MaxRSS,AveRSS,MaxPages,AvePages,AveCPU,MaxDiskRead
8749.batch
```

JobID	MaxRSS	AveRSS	MaxPages	AvePages	AveCPU	MaxDiskRead
8749.batch	196448K	196448K	0	0	01:00.000	7.03M



Note that in the example above the job is identified by id 8749.batch in which the word 'batch' is appended to the id displayed using the squeue command. This is a necessary addition whenever a running program is not parallel i.e. not using 'srun'.

sshare

Display the shares associated to a particular user

```
$ sshare -U -u xxxxx
```

Account	User	RawShares	NormShares	RawUsage
xxxxx	yyyyyy	1	0.024390	37733389

sprio

Display priority information of a pending job id xxx

```
sprio -l -j xxx
```

To find what priority a running job was given type

```
squeue -o %Q -j <jobid>
```

sacct

It displays accounting data for all jobs and job steps in the Slurm job accounting log or Slurm database. For instance

```
sacct -o JobID,JobName,User,AllocNodes,AllocTRES,AveCPUFreq,AveRSS,Start,End
-j 13180,13183
```

JobID	JobName	User	AllocNodes	AllocTRES	AveCPUFreq	AveRSS	Start	End
13180	13183							

```

-----
13180          test2      xxxxxxxx          1 cpu=8,mem+
2017-04-10T13:34:33 2017-04-10T14:08:24
13180.batch      batch          1 cpu=8,mem+      116.13M
354140K 2017-04-10T13:34:33 2017-04-10T14:08:24
13183          test3      xxxxxxxx          1 cpu=8,mem+
2017-04-10T13:54:52 2017-04-10T14:26:34
13183.batch      batch          1 cpu=8,mem+          2G
10652K 2017-04-10T13:54:52 2017-04-10T14:26:34
13183.0          xpyxmci          1 cpu=8,mem+      1.96G
30892K 2017-04-10T13:54:53 2017-04-10T14:26:34

```

Tips

To minimize the time your job spends in the queue you could specify multiple partitions so that the job can start as soon as possible. Use `--partition=notebook,playground,lowmem`

To have a rough estimate of when your queued job will start type `squeue --start`

To translate a job script written for a scheduler different than slurm to slurm's own syntax consider using <http://www.schedmd.com/slurmdocs/rosetta.pdf>

top-like node usage

Should you want to monitor the usage of the cluster nodes in a top-like fashion type

```
watch -n 1 -x sinfo -S"-0" -o "%.9n %.6t %.10e/%m %.100 %.15C"
```

top-like job stats

To monitor the resources consumed by your running job type

```
watch -n1 sstat --format
JobID,NTasks,nodelist,MaxRSS,MaxVMSize,AveRSS,AveVMSize,AveCpuFreq
<jobid>[.batch]
```

Make local file available to all nodes allocated to a slurm job

To transmit a file to all nodes allocated to the currently active Slurm job use `sbcst`. For instance

```
> cat my.job
#!/bin/env bash
sbcst my.prog /tmp/my.prog
srun /tmp/my.prog
```

```
> sbatch --nodes=8 my.job  
srun: jobid 145 submitted
```

Specify nodes for a job

For instance #SBATCH --nodelist=maris0xx

Environment variables available to any slurm job

You can use any of the following variables in your jobs

```
$ salloc -p playground -N 10  
salloc: Granted job allocation 13709  
$ printenv | grep -i slurm_  
SLURM_NODELIST=maris[031-033,035-041]  
SLURM_JOB_NAME=bash  
SLURM_NODE_ALIASES=(null)  
SLURM_JOB_QOS=normal  
SLURM_NNODES=10  
SLURM_JOBID=13709  
SLURM_TASKS_PER_NODE=1(x10)  
SLURM_JOB_ID=13709  
SLURM_SUBMIT_DIR=/tmp/bla-bla  
SLURM_JOB_NODELIST=maris[031-033,035-041]  
SLURM_CLUSTER_NAME=maris  
SLURM_JOB_CPUS_PER_NODE=1(x10)  
SLURM_SUBMIT_HOST=novamaris.lorentz.leidenuniv.nl  
SLURM_JOB_PARTITION=playground  
SLURM_JOB_ACCOUNT=yuyuysu  
SLURM_JOB_NUM_NODES=10  
SLURM_MEM_PER_NODE=32174
```

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