

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 parallel computing?

A parallel job consists of tasks that run simultaneously. Parallelization can be achieved in different ways. Please read the relevant wiki page [here](#).

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 *svview* 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
EffectvUsage	FairShare			
-----	-----	-----	-----	-----
xxxxxx	yyyyyy	1	0.024390	37733389
0.076901	0.112428			

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	test2	xxxxxxx	1	cpu=8,mem+			2017-04-10T13:34:33	2017-04-10T14:08:24
13180.batch	batch		1	cpu=8,mem+	116.13M		2017-04-10T13:34:33	2017-04-10T14:08:24
13183	test3	xxxxxxx	1	cpu=8,mem+			2017-04-10T13:54:52	2017-04-10T14:26:34
13183.batch	batch		1	cpu=8,mem+	2G		2017-04-10T13:54:52	2017-04-10T14:26:34
13183.0	xpyxnci		1	cpu=8,mem+	1.96G		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 could start as soon as possible. Use `–partition=notebook,playground,computation` for instance.

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

```
sinfo -i 5 -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 `sbcast`. For instance

```
> cat my.job  
#!/bin/env bash  
sbcast 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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