INF9380

Cloud computing intro

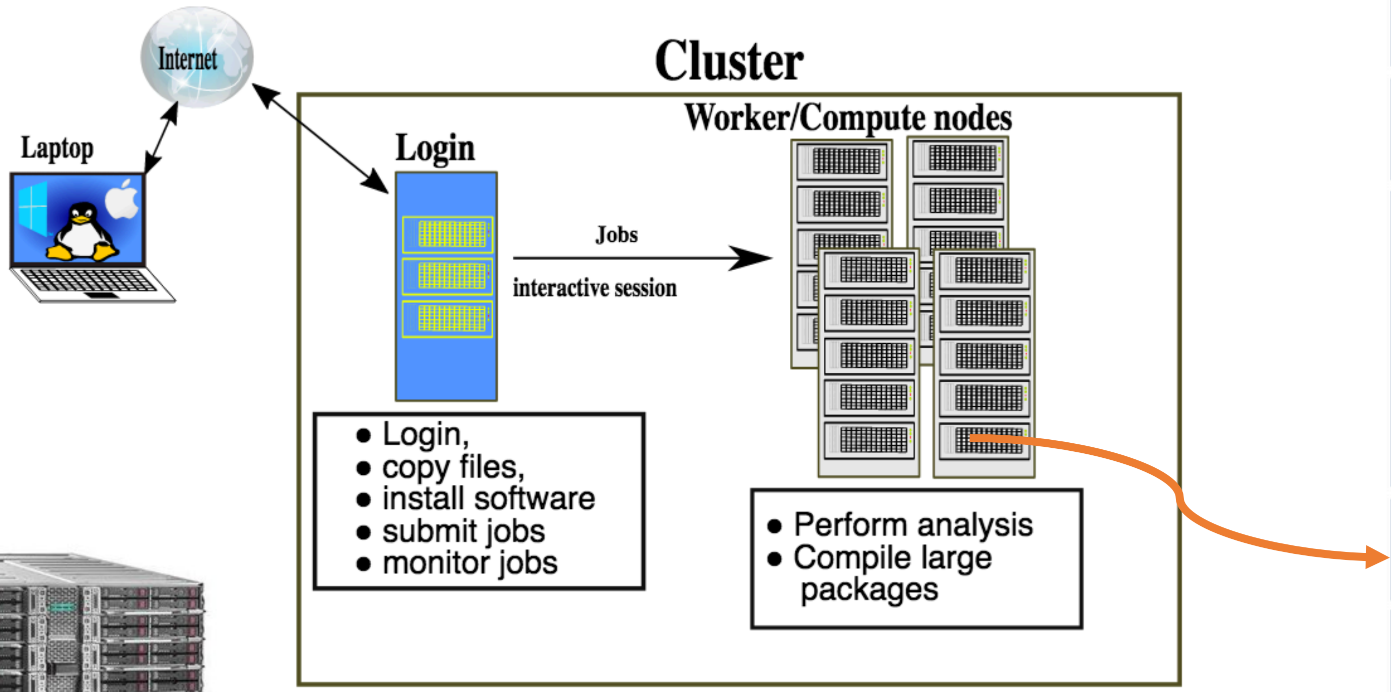
Outline of cloud session

1. Cloud, HPC, Scheduling systems - rough overview
2. Create a cluster on the cloud – Elasticluster tutorial
    - Intro to Elasticluster
    - Set up and submit a job to your own cluster - tutorial
3. Distributed computing – computing grids – example with Worldwide LHC computing grid (WLCG)
    - Introduction to the WLCG
    - Send a job to the grid

Part 1.
Cloud, HPC, Scheduling systems rough overview

“Traditional” computing cluster resource versus cloud resource

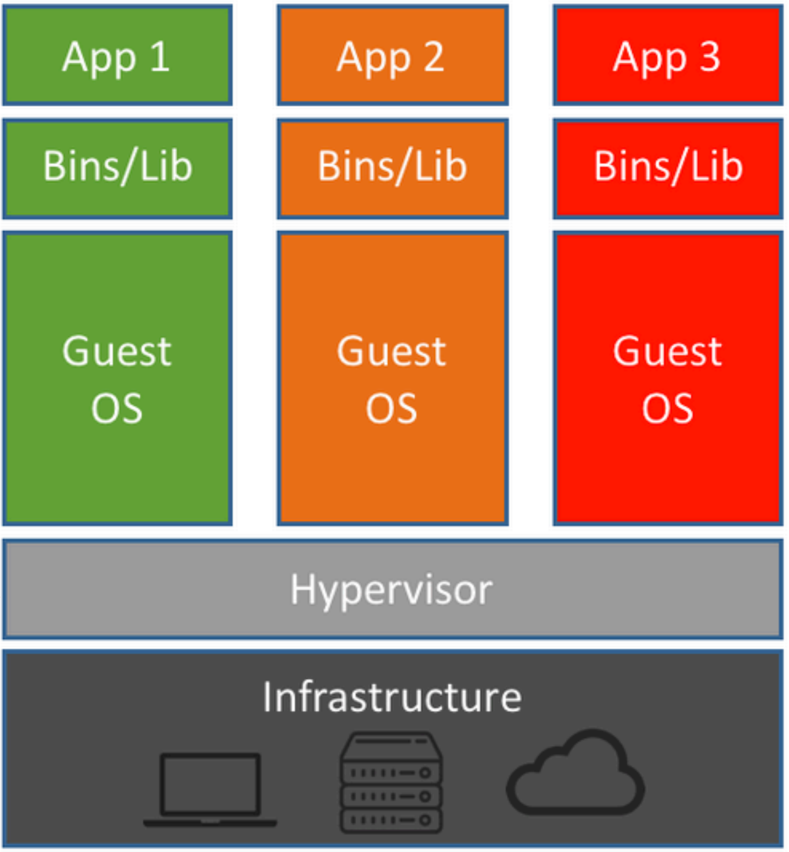
Traditional cluster



- Login,
- copy files,
- install software
- submit jobs
- monitor jobs

- Perform analysis
- Compile large packages

Cloud Virtualisation



Machine Virtualization

Node: One computer with X number of processors, each with Y number of cores

Example: 1 node with 2 processors, each with 20 cores per processor. Total cores: 40

“Traditional” computing cluster resource

Good, but non-flexible

- All machines have the same CPU chip architecture, let’s say Intel or AMD processors
- High performance processors, not the regular standard processors (usually)
- All machines have the same OS, e.g. Red Hat 8
- Some speciality nodes: big-mem, GPU’s
- Fast interconnect between nodes
- Access to common shared file system
- Queue system, some times with a long waiting time

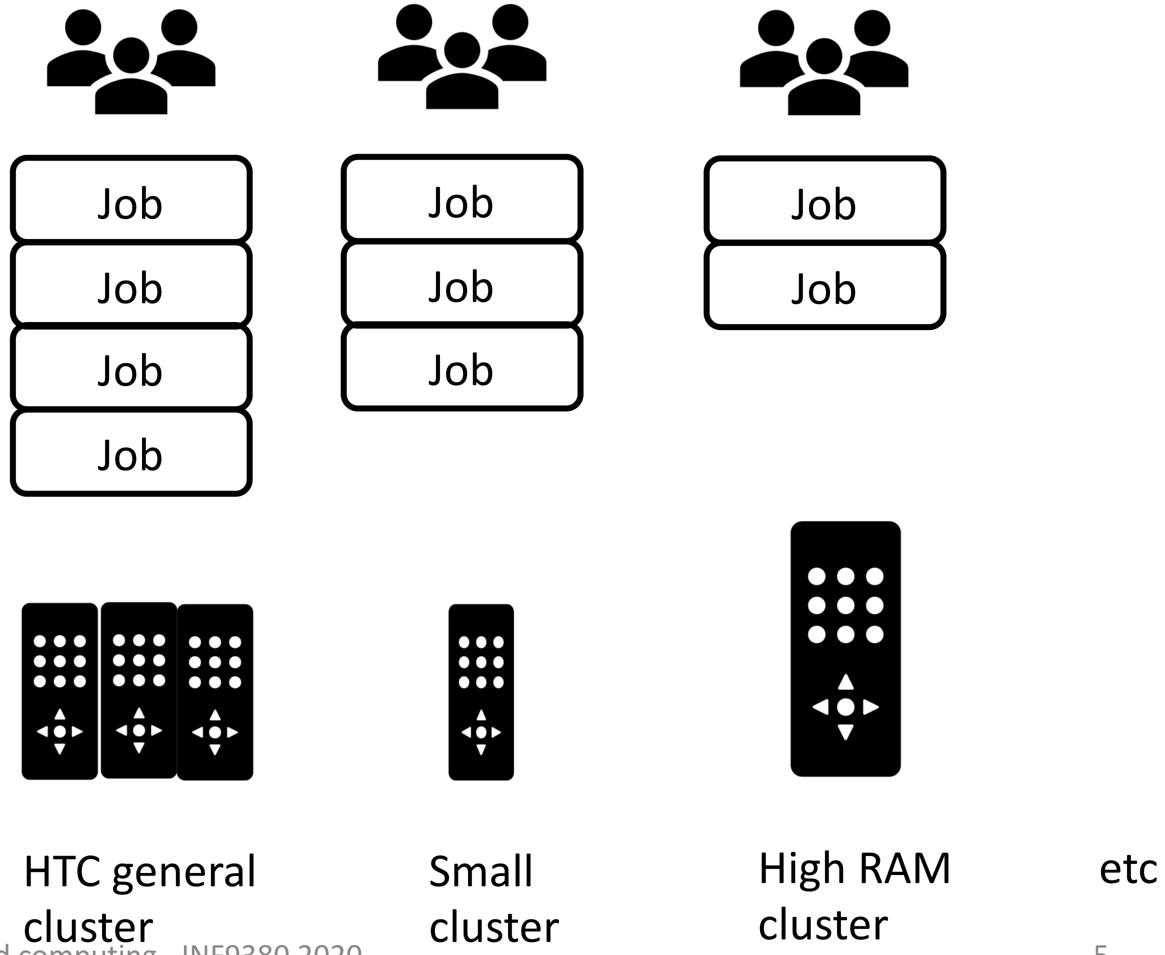
Queueing system (SLURM):
“Please wait in line.
The big-mem nodes you are requesting
are busy, and will be so for another 2 weeks.
If you hold the line you will move forward
In the queue. “

User:
☹ ☹ ☹

Fast and powerful system,
but waiting time can be long

HPC on cloud

- Virtualisation is used to provision servers
- Dynamic set of servers – i.e. virtual servers are fired up as needed, and destroyed when not needed anymore
- You can pick and choose the type of (virtual) server you want: size (number of virtual cpu’s, size of RAM, size of disk etc etc)
- Can set up as many queues as you want or as many clusters as you want – you create the cluster that suits your needs
- You do not have to wait in line!
- Flexible!!
- Not necessarily high performance hardware – can be “off-the-shelf” processors
- Not necessarily very good interconnect between nodes (no infiniband)



Job
Job
Job
Job

Job
Job
Job

Job
Job

HTC general cluster

Small cluster

High RAM cluster

etc

When would you use HPC on cloud?

- Example use-case:
  - You would like to run some application that requires more cores than you have available (general use-case for cluster computing) and that can benefit from more cores i.e. be parallelized
  - You have access to a cloud resource
  - You do not have access to an HPC resource, or you do not want to use your quota there, or don’t want to wait in line
  - …

Some cloud platforms/providers

- Google Cloud Platform
- Amazon Web Services (AWS)
- Microsoft Azure
- Oracle Cloud
- ...https://www.guru99.com/cloud-computing-service-provider.html

Public - commercial

- Openstack - free open standard
  - NREC: *Norwegian* Research and Education Cloud
  - This is what we will be working in

Terminology and workflow - clouds

- Region
  - When you create virtual machines you do that in a geographical region – e.g. North Europe, Oslo, Bergen etc
  - Your virtual machines will then be created on host machines in a data center belonging to that region
  - Can be performance issues and/or political reasons for choosing a certain region
- Instance
  - A virtual machine
- Images
  - What OS image to install on your instance
- Flavor
  - The specifications of the virtual machine:
    - Number of virtual CPU's (vCPU)
    - Amount of RAM
    - Amount of disk
    - Processor type (AMD/Intel/ARM)
- Key pairs
  - To connect to your instances you use an ssh private-public key pair
- Network security group
  - Set of network rules

Workflow - clouds

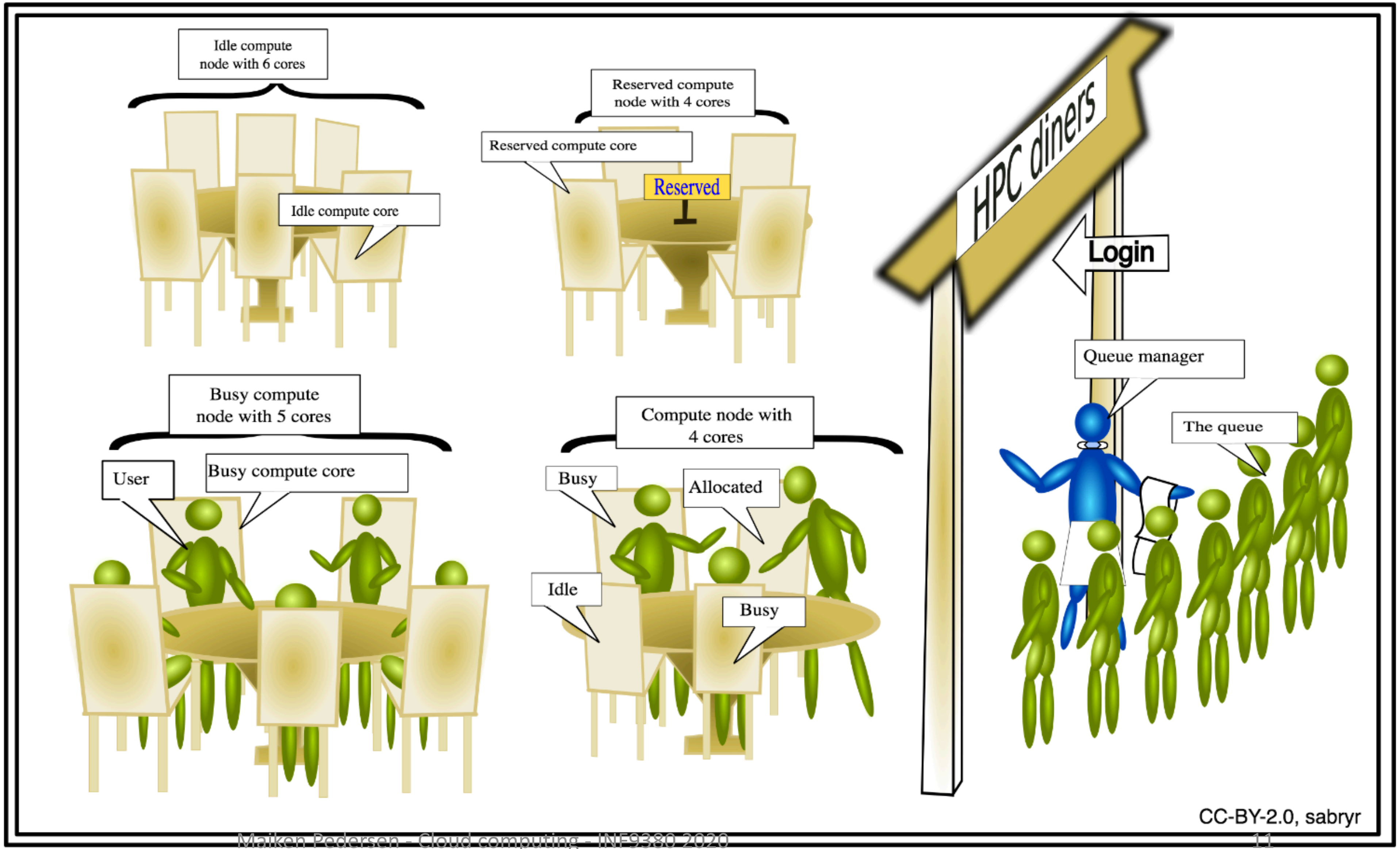
- Launch
  - Create the virtual machine with a base OS
- Configure
  - Install necessary software like e.g. database software, web application software, scientific software etc etc
- Connect
  - Remotely connect to your instance via ssh

Automation tools

Working with HPCs or other clusters with a scheduling system

Computing on a cluster – scheduling systems

- To handle the compute jobs that are submitted by the users, the cluster has a queuing system installed
- Examples: SLURM, HTCondor, PBS, Torque…
- Job is scheduled based on: Priorities, special requests (node with large RAM), cpu-hours left in project, etc etc



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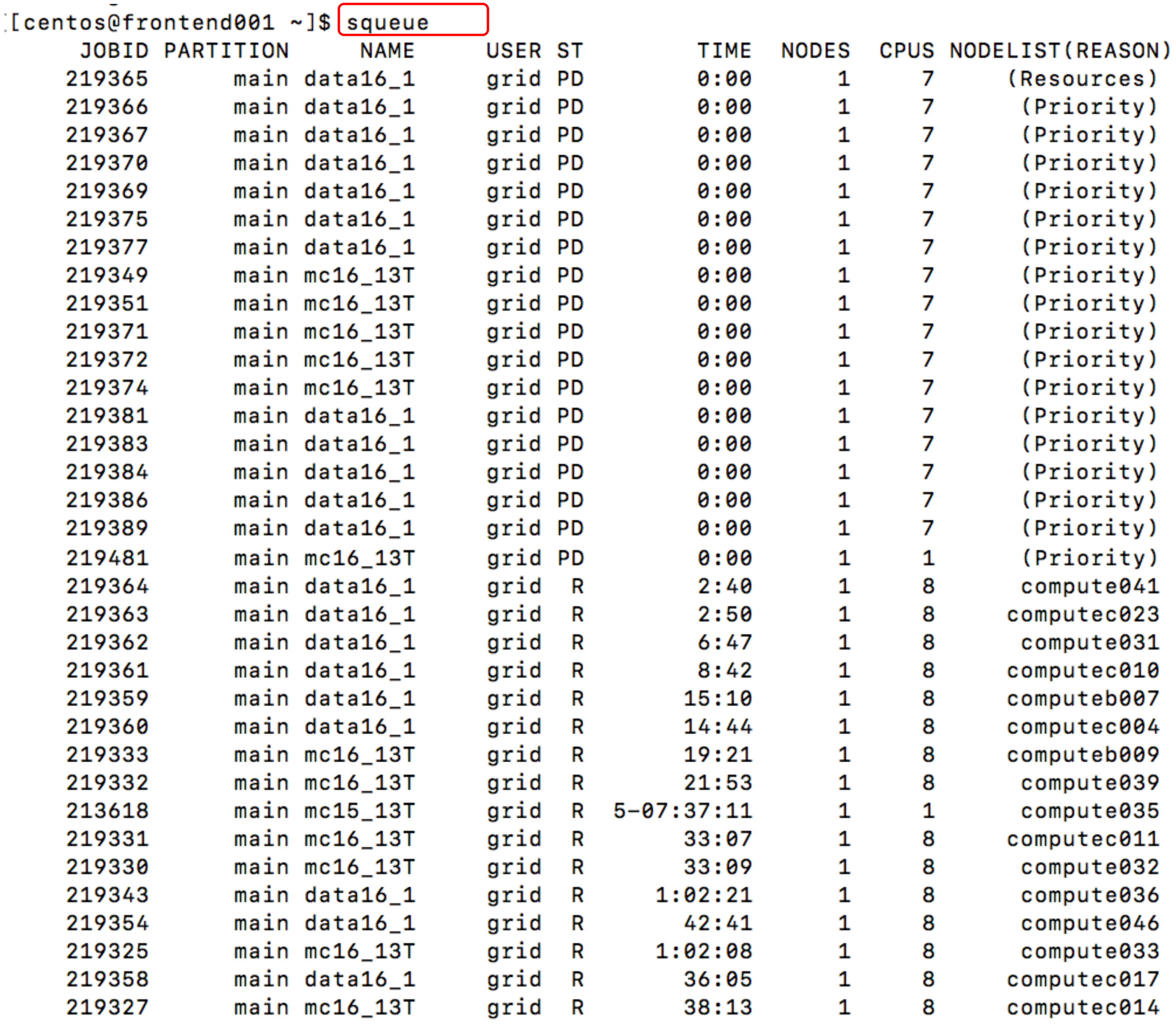
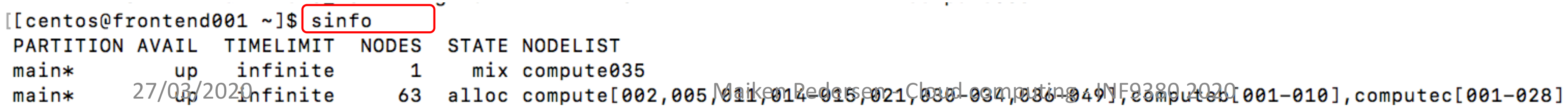
https://hpc-carpentry.github.io/hpc-intro/13-scheduler/index.html

Slurm command examples:

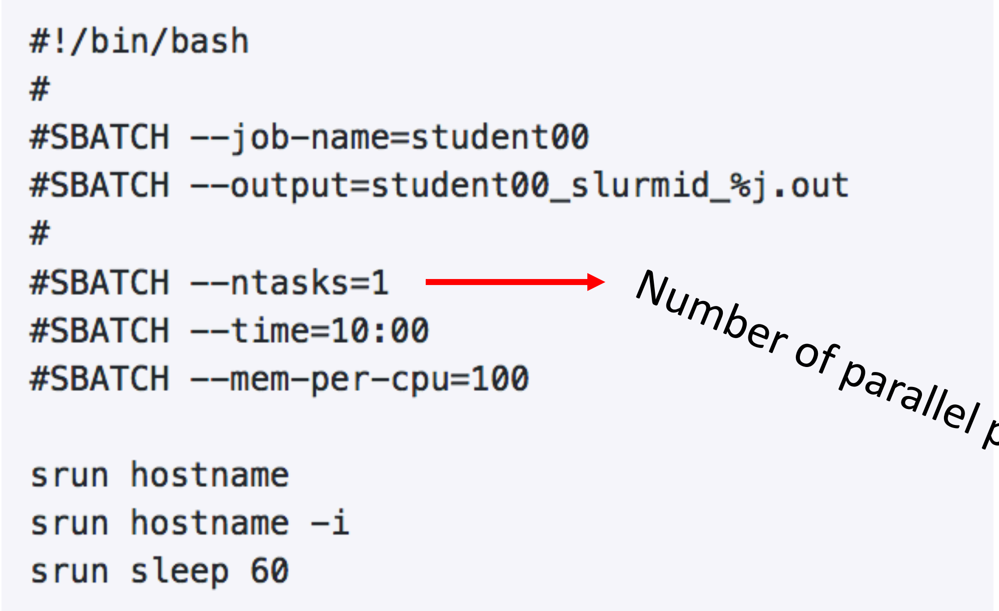
- squeue
- sinfo
- sbatch
- srun



```
[centos@frontend001 ~]$ squeue
     JOBID PARTITION     NAME     USER ST       TIME  NODES   CPUS NODELIST(REASON)
    219365      main data16_1     grid PD       0:00      1      7      (Resources)
    219366      main data16_1     grid PD       0:00      1      7       (Priority)
    219367      main data16_1     grid PD       0:00      1      7       (Priority)
    219370      main data16_1     grid PD       0:00      1      7       (Priority)
    219369      main data16_1     grid PD       0:00      1      7       (Priority)
    219375      main data16_1     grid PD       0:00      1      7       (Priority)
    219377      main data16_1     grid PD       0:00      1      7       (Priority)
    219349      main mc16_13T     grid PD       0:00      1      7       (Priority)
    219351      main mc16_13T     grid PD       0:00      1      7       (Priority)
    219371      main mc16_13T     grid PD       0:00      1      7       (Priority)
    219372      main mc16_13T     grid PD       0:00      1      7       (Priority)
    219374      main mc16_13T     grid PD       0:00      1      7       (Priority)
    219381      main data16_1     grid PD       0:00      1      7       (Priority)
    219383      main data16_1     grid PD       0:00      1      7       (Priority)
    219384      main data16_1     grid PD       0:00      1      7       (Priority)
    219386      main data16_1     grid PD       0:00      1      7       (Priority)
    219389      main data16_1     grid PD       0:00      1      7       (Priority)
    219481      main mc16_13T     grid PD       0:00      1      1       (Priority)
    219364      main data16_1     grid  R       2:40      1      8       compute041
    219363      main data16_1     grid  R       2:50      1      8      computec023
    219362      main data16_1     grid  R       6:47      1      8       compute031
    219361      main data16_1     grid  R       8:42      1      8      computec010
    219359      main data16_1     grid  R      15:10      1      8      computeb007
    219360      main data16_1     grid  R      14:44      1      8      computec004
    219333      main mc16_13T     grid  R      19:21      1      8      computeb009
    219332      main mc16_13T     grid  R      21:53      1      8       compute039
    213618      main mc15_13T     grid  R 5-07:37:11      1      1       compute035
    219331      main mc16_13T     grid  R      33:07      1      8      computec011
    219330      main mc16_13T     grid  R      33:09      1      8       compute032
    219343      main data16_1     grid  R    1:02:21      1      8       compute036
    219354      main data16_1     grid  R      42:41      1      8       compute046
    219325      main mc16_13T     grid  R    1:02:08      1      8       compute033
    219358      main data16_1     grid  R      36:05      1      8      computec017
    219327      main mc16_13T     grid  R      38:13      1      8      computec014
```



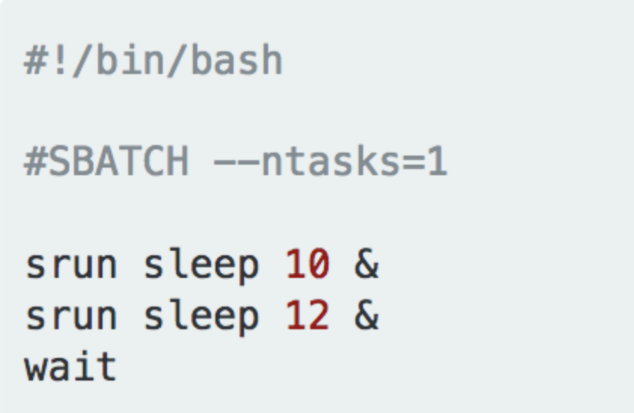
```
[centos@frontend001 ~]$ sinfo
PARTITION AVAIL  TIMELIMIT  NODES  STATE NODELIST
main*        up   infinite      1    mix compute035
main*        up   infinite     63  alloc compute[002,005,011,014-015,021,030-034,036-049],computeb[001-010],computec[001-028]
```



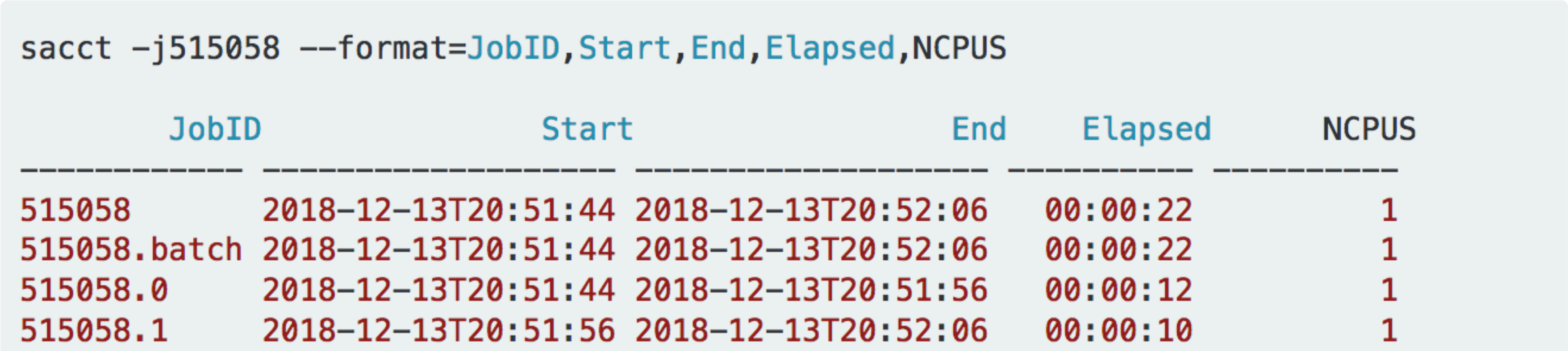
```
#!/bin/bash
#
#SBATCH --job-name=student00
#SBATCH --output=student00_slurmid_%j.out
#
#SBATCH --ntasks=1
#SBATCH --time=10:00
#SBATCH --mem-per-cpu=100

srun hostname
srun hostname -i
srun sleep 60
```

Number of parallel processes

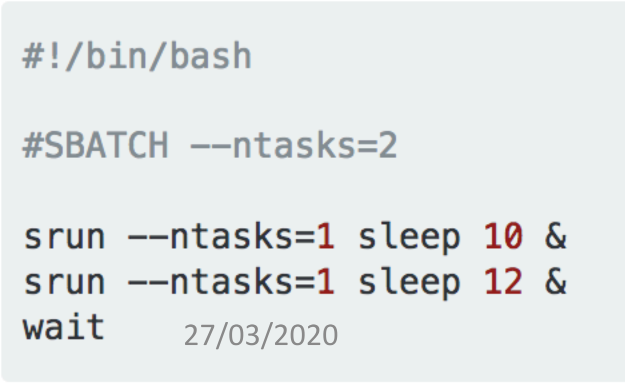
- Submit job with sbatch <jobscript-name>
- https://slurm.schedmd.com/sbatch.html



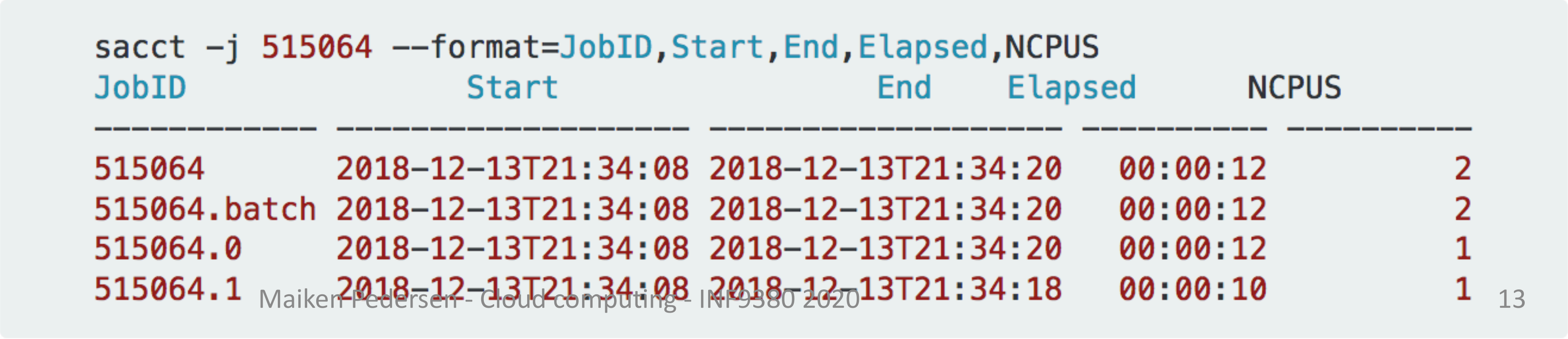
```
#!/bin/bash

#SBATCH --ntasks=1

srun sleep 10 &
srun sleep 12 &
wait
```



```
sacct -j515058 --format=JobID,Start,End,Elapsed,NCPUS

       JobID               Start                 End    Elapsed      NCPUS
------------ ------------------- ------------------- ---------- ----------
515058       2018-12-13T20:51:44 2018-12-13T20:52:06   00:00:22          1
515058.batch 2018-12-13T20:51:44 2018-12-13T20:52:06   00:00:22          1
515058.0     2018-12-13T20:51:44 2018-12-13T20:51:56   00:00:12          1
515058.1     2018-12-13T20:51:56 2018-12-13T20:52:06   00:00:10          1
```



```
#!/bin/bash

#SBATCH --ntasks=2

srun --ntasks=1 sleep 10 &
srun --ntasks=1 sleep 12 &
wait
```



```
sacct -j 515064 --format=JobID,Start,End,Elapsed,NCPUS
JobID                  Start                 End    Elapsed      NCPUS
------------ ------------------- ------------------- ---------- ----------
515064       2018-12-13T21:34:08 2018-12-13T21:34:20   00:00:12          2
515064.batch 2018-12-13T21:34:08 2018-12-13T21:34:20   00:00:12          2
515064.0     2018-12-13T21:34:08 2018-12-13T21:34:20   00:00:12          1
515064.1     2018-12-13T21:34:08 2018-12-13T21:34:18   00:00:10          1
```