Step Management Enhancements

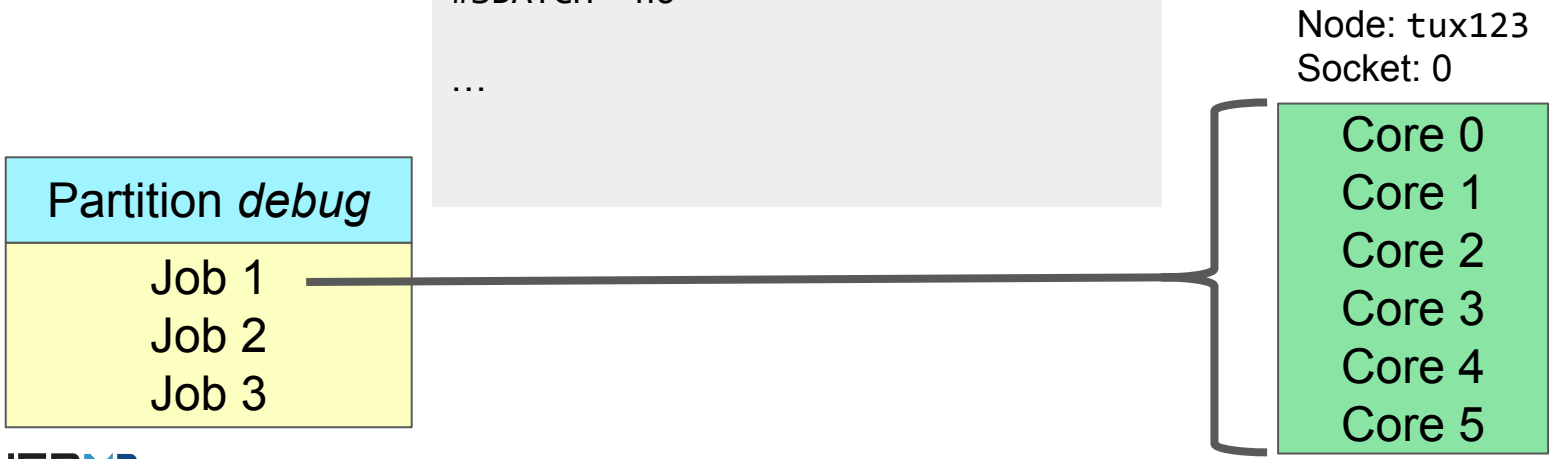
Brian Christiansen

Slurm User Group 2023

What is a job and a step?

- Job
  - An allocation of resources (nodes, cpus, memory, gpus, licenses, etc.)

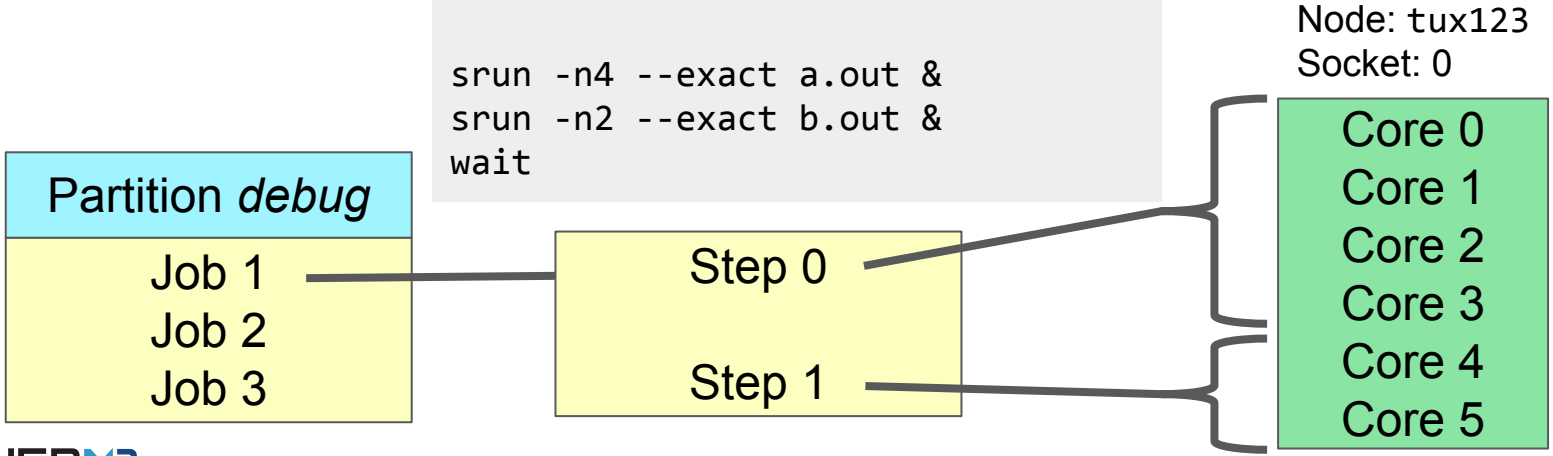
```
#!/bin/bash
#SBATCH -n6

…
```



What is a job and a step?

- Step
  - Allocated resources of the job that run processes/tasks
  - Can carve up allocated resources into multiple steps
  - Steps typically run parallel programs (e.g. MPI)
  - Steps can run serially or concurrently

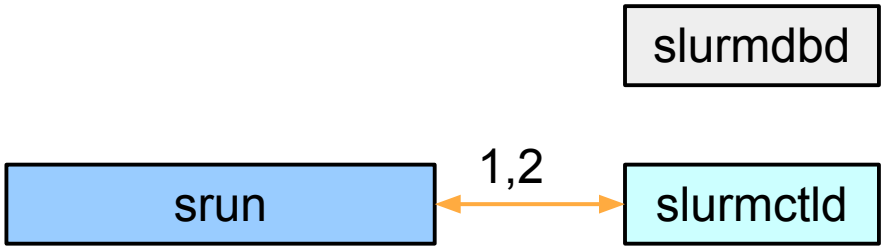
```
#!/bin/bash
#SBATCH -n6

srun -n4 --exact a.out &
srun -n2 --exact b.out &
wait
```



What is a job and a step?

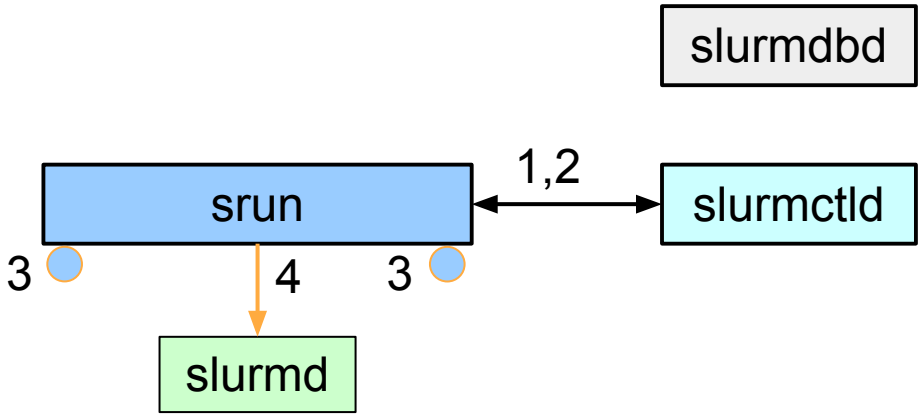
- batch step
  - Runs the batch script
- interactive step
  - Step created on compute node with a PTY for interactive work inside allocation
- extern step
  - Enabled through PrologFlags=contain
  - Runs on all slurmds
  - Used to:
    - Launch prologs before allocation
    - Setup X11 forwarding, containers
    - Track processes started outside of allocation (e.g. pam_slurm_adopt, ssh, mpi)
    - Did you know? mpirun typically uses srun to launch the task
- job step
  - execs and shepherds processes

Step Launch Sequence



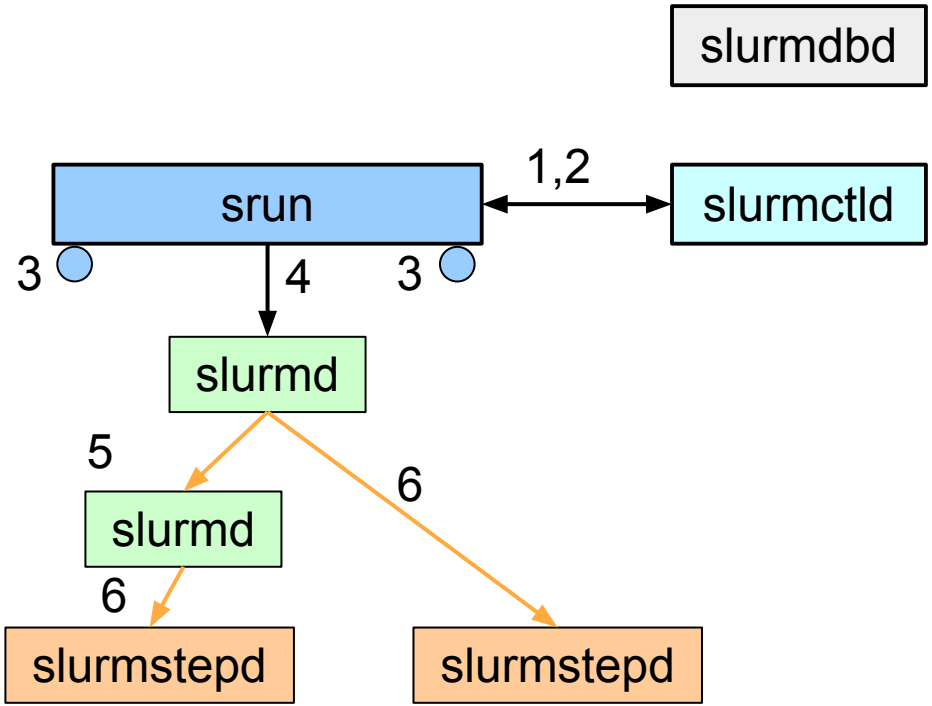
1. **srun** sends step create request to **slurmctld**
2. **slurmctld** responds with step credential

Step Launch Sequence



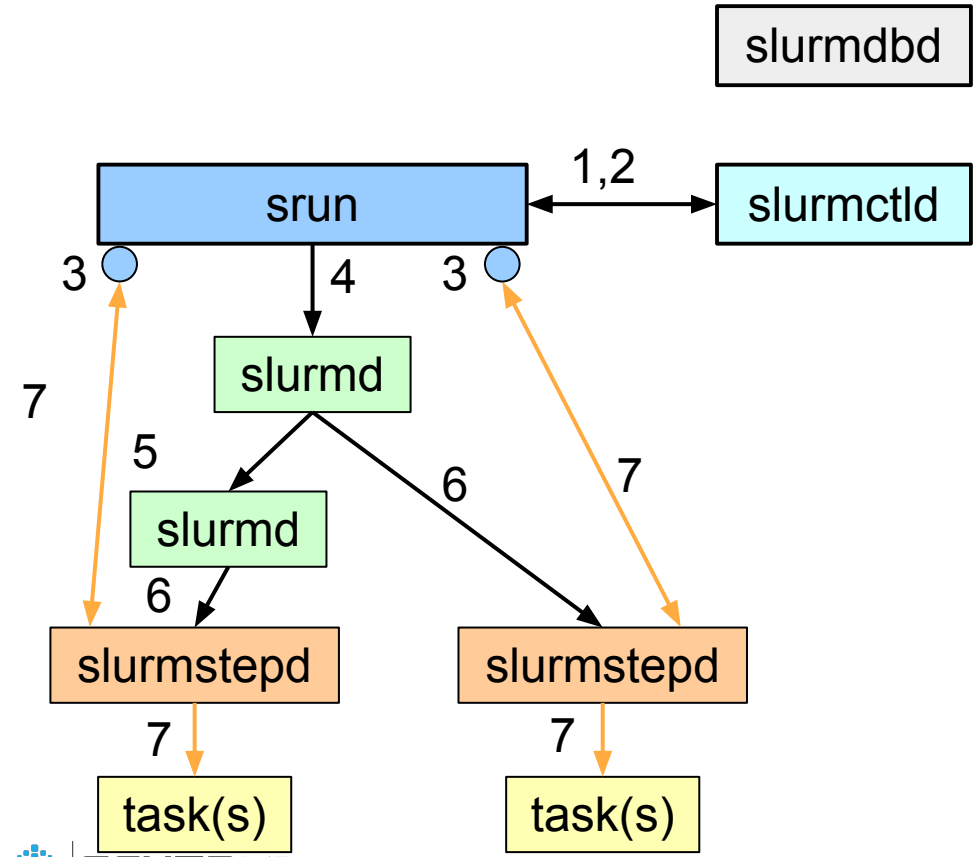
1. **srun** sends step create request to **slurmctld**
2. **slurmctld** responds with step credential
3. **srun** opens sockets for I/O
4. **srun** forwards credential with task info to **slurmd**

Step Launch Sequence



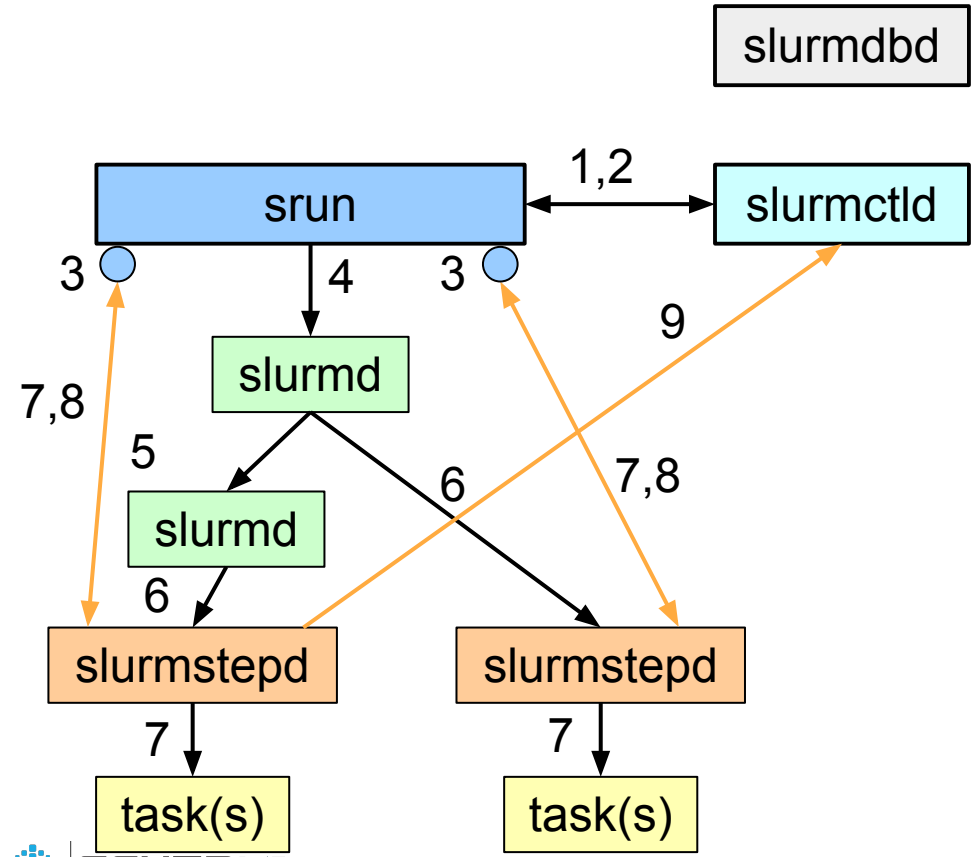
1. **srun** sends step create request to **slurmctld**
2. **slurmctld** responds with step credential
3. **srun** opens sockets for I/O
4. **srun** forwards credential with task info to **slurmd**
5. **slurmd** forwards request as needed (per fanout)
6. **slurmd** forks/execs **slurmstepd**

Step Launch Sequence



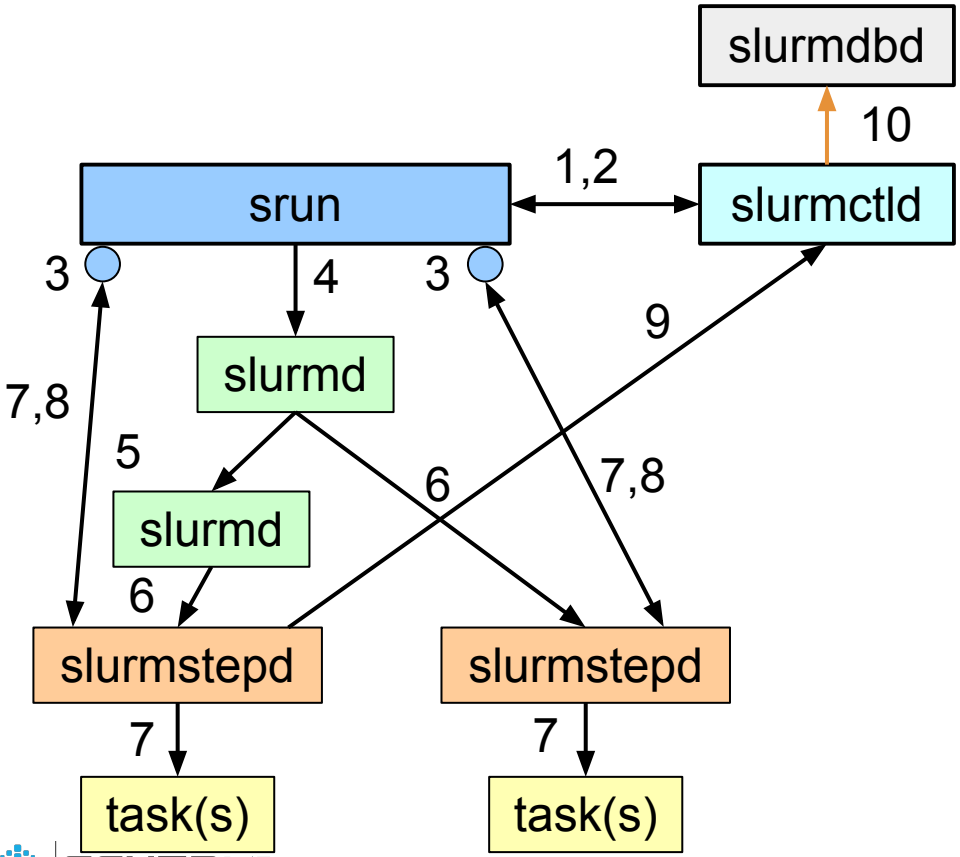
1. **srun** sends step create request to **slurmctld**
2. **slurmctld** responds with step credential
3. **srun** opens sockets for I/O
4. **srun** forwards credential with task info to **slurmd**
5. **slurmd** forwards request as needed (per fanout)
6. **slurmd** forks/execs **slurmstepd**
7. **slurmstepd** connects I/O and launches **tasks**

Step Launch Sequence



1. **srun** sends step create request to **slurmctld**
2. **slurmctld** responds with step credential
3. **srun** opens sockets for I/O
4. **srun** forwards credential with task info to **slurmd**
5. **slurmd** forwards request as needed (per fanout)
6. **slurmd** forks/execs **slurmstepd**
7. **slurmstepd** connects I/O and launches **tasks**
8. On task termination, **slurmstepd** notifies **srun**
9. **slurmstepd** sends step completions to **slurmctld** (per reverse fanout (7))

Step Launch Sequence



1. **srun** sends step create request to **slurmctld**
2. **slurmctld** responds with step credential
3. **srun** opens sockets for I/O
4. **srun** forwards credential with task info to **slurmd**
5. **slurmd** forwards request as needed (per fanout)
6. **slurmd** forks/execs **slurmstepd**
7. **slurmstepd** connects I/O and launches **tasks**
8. On task termination, **slurmstepd** notifies **srun**
9. **slurmstepd** sends step completions to **slurmctld** (per reverse fanout (7))
10. **slurmctld** sends step completion to **slurmdbd**

Step congestion

- Step management is done by the controller
  - Can be a source of congestion
- Step management requires controller job write lock
  - locks up the system
  - Slurm is highly threaded but not highly concurrent
- Bigger issue when creating many steps
  - Doing own resource management within allocation
  - e.g. 1 allocation with 1000's of steps

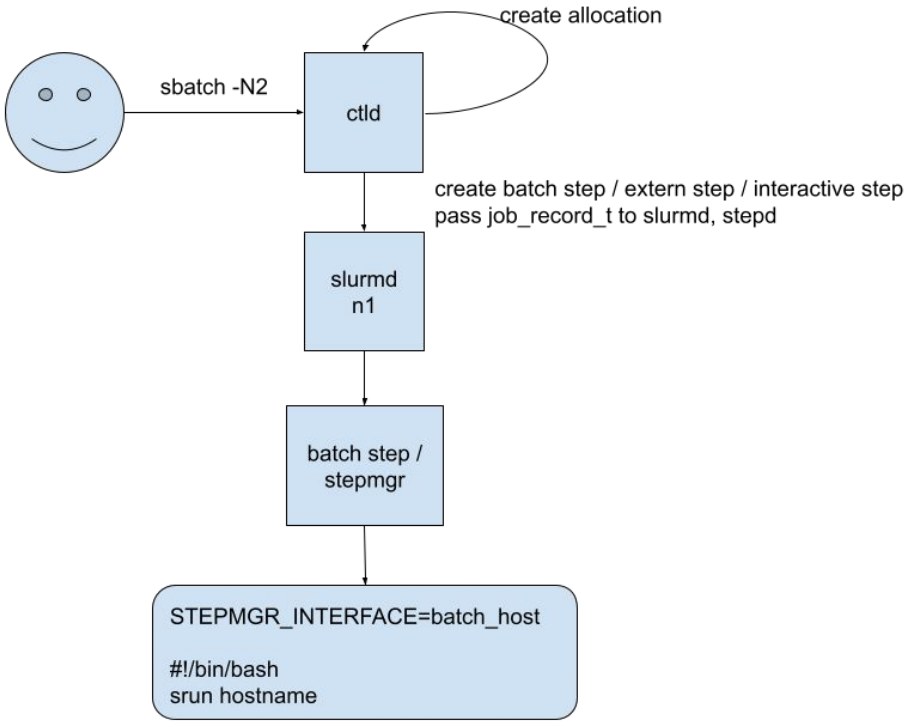
Step relief

- Move step management out of the controller
- step management done by stepd (stepmgr)
- Reduce rpc congestion and locking on the controller

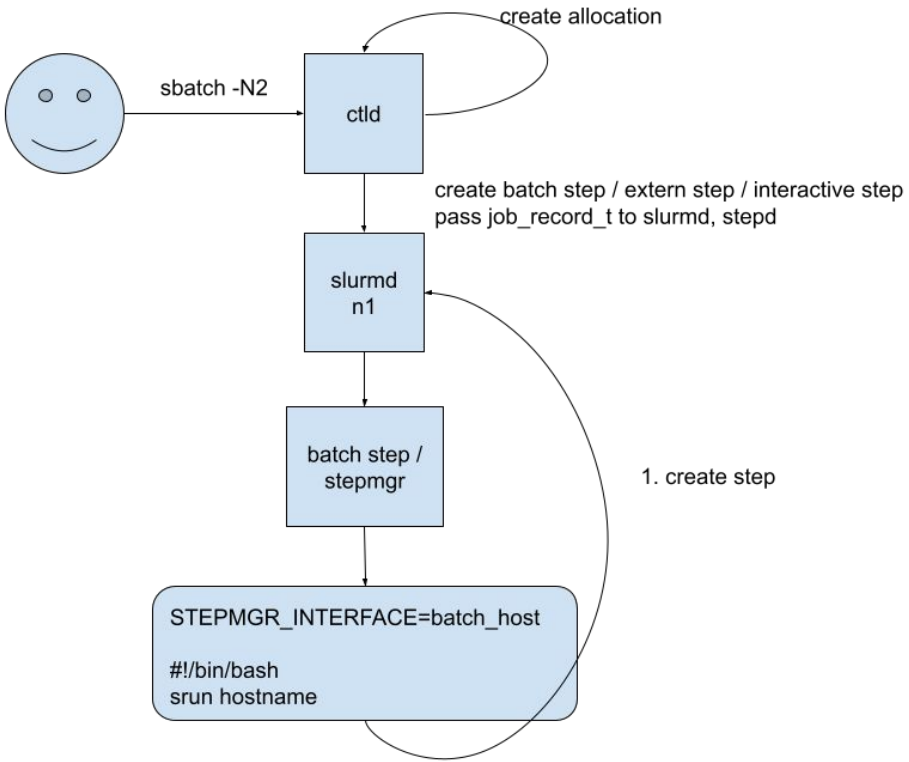
Stepmgr

- Designate a stepd as the stepmgr for the job
  - batch step / extern step / interactive step
- Job allocation/environment tells which slurmd has the stepmgr
  - STEPMGR_INTERFACE=<host>
- Stepmgr creates and manages steps for the job

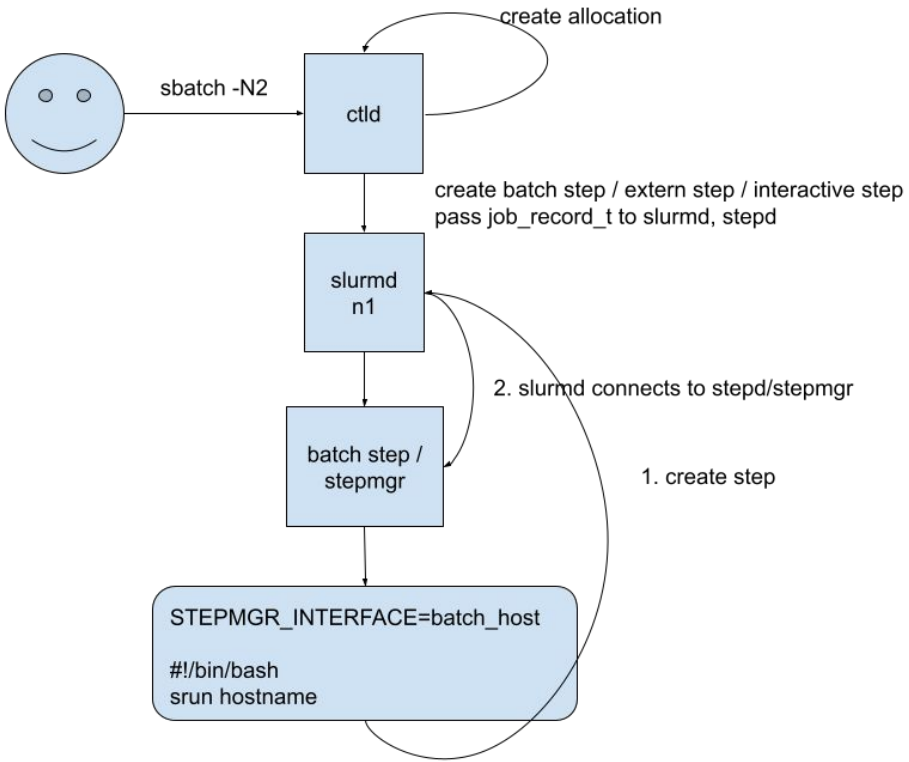
Stepmgr


create allocation
sbatch -N2
ctld
create batch step / extern step / interactive step
pass job_record_t to slurmd, stepd
slurmd
n1
batch step /
stepmgr
STEPMGR_INTERFACE=batch_host
#!/bin/bash
srun hostname

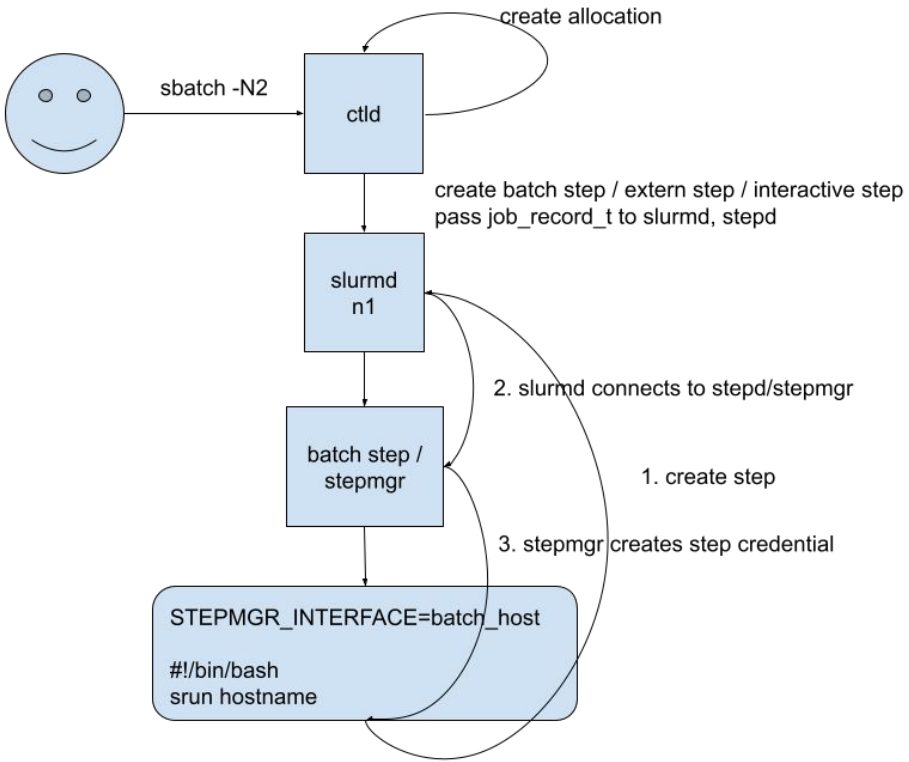
Stepmgr


create allocation
sbatch -N2
ctld
create batch step / extern step / interactive step
pass job_record_t to slurmd, stepd
slurmd
n1
batch step /
stepmgr
1. create step
STEPMGR_INTERFACE=batch_host
#!/bin/bash
srun hostname

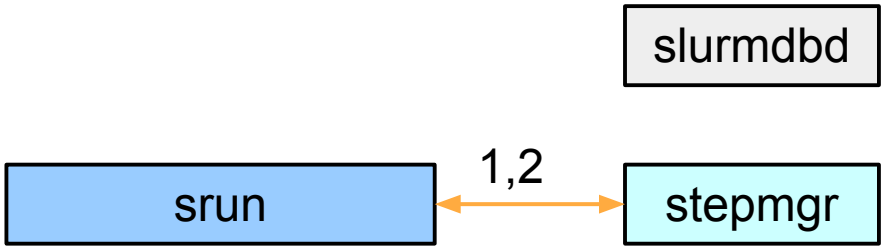
Stepmgr


create allocation
sbatch -N2
ctld
create batch step / extern step / interactive step
pass job_record_t to slurmd, stepd
slurmd
n1
2. slurmd connects to stepd/stepmgr
batch step /
stepmgr
1. create step
STEPMGR_INTERFACE=batch_host
#!/bin/bash
srun hostname

Stepmgr

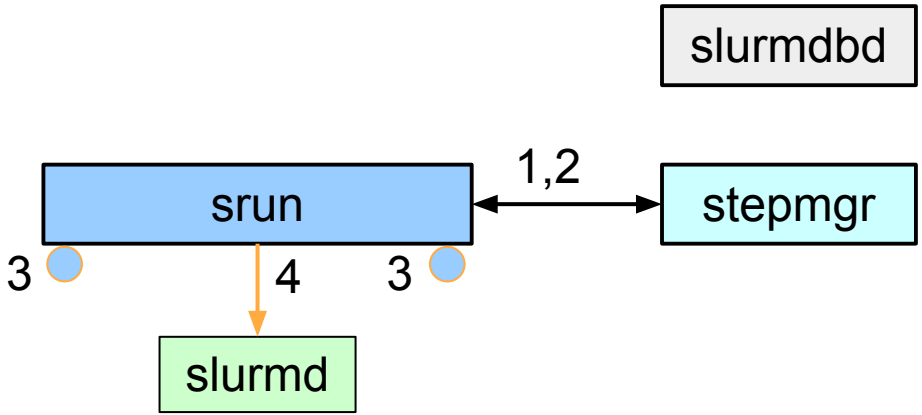

create allocation
sbatch -N2
ctld
create batch step / extern step / interactive step
pass job_record_t to slurmd, stepd
slurmd
n1
2. slurmd connects to stepd/stepmgr
batch step /
stepmgr
1. create step
3. stepmgr creates step credential
STEPMGR_INTERFACE=batch_host
#!/bin/bash
srun hostname

Step Launch Sequence



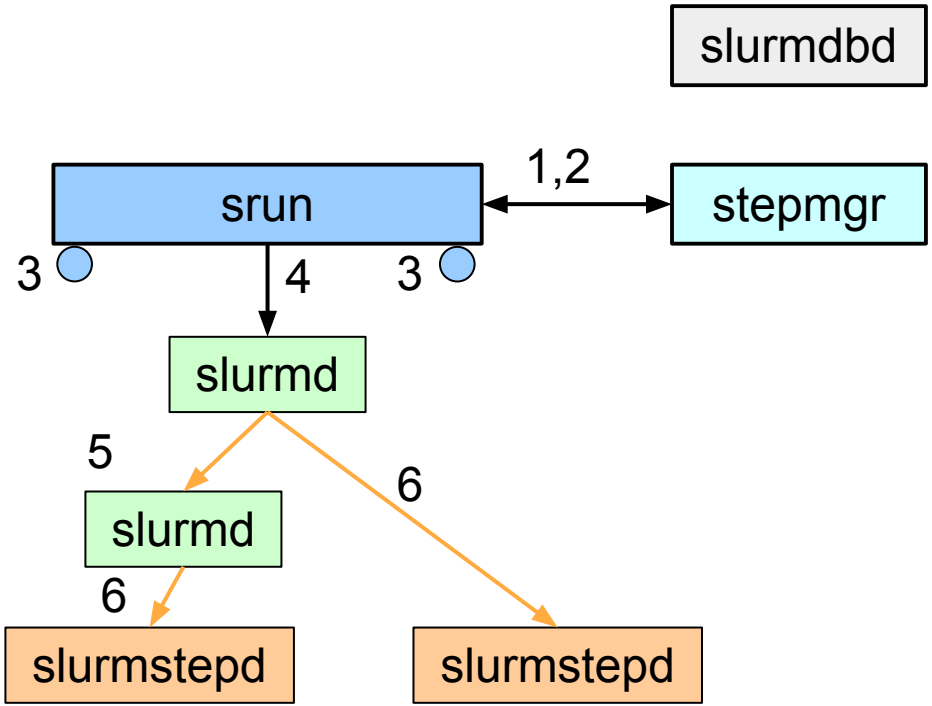
1. **srun** sends step create request to **stepmgr**
2. **stepmgr** responds with step credential

Step Launch Sequence



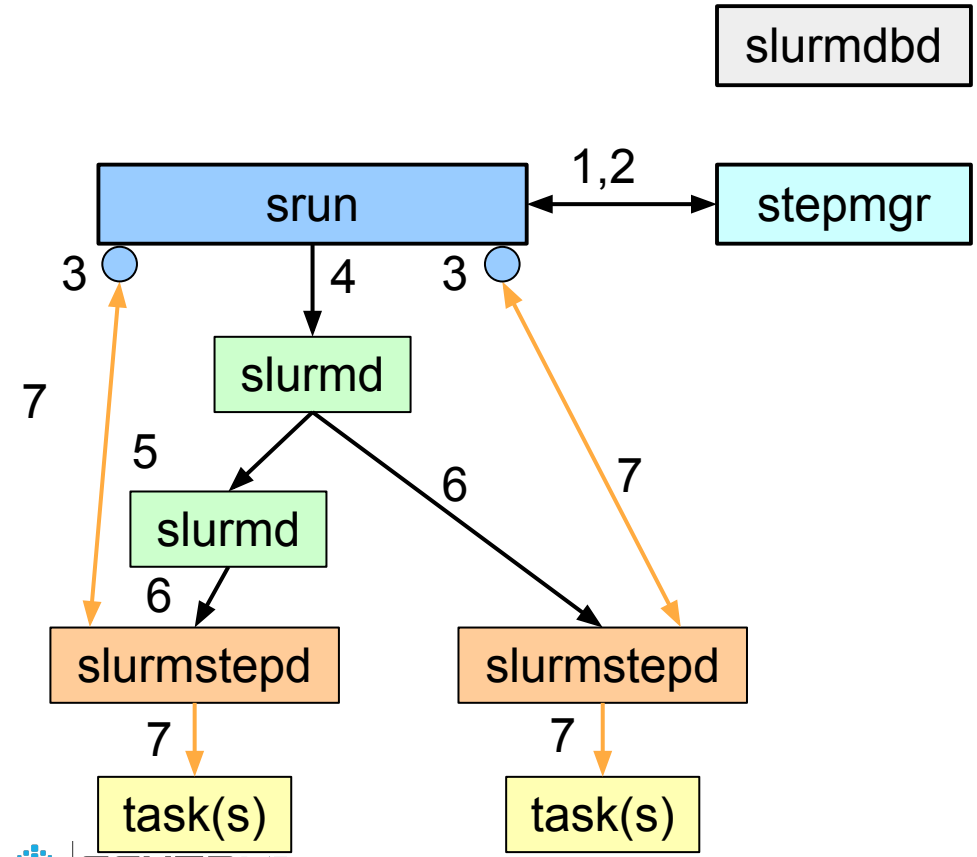
1. **srun** sends step create request to **stepmgr**
2. **stepmgr** responds with step credential
3. **srun** opens sockets for I/O
4. **srun** forwards credential with task info to **slurmd**

Step Launch Sequence



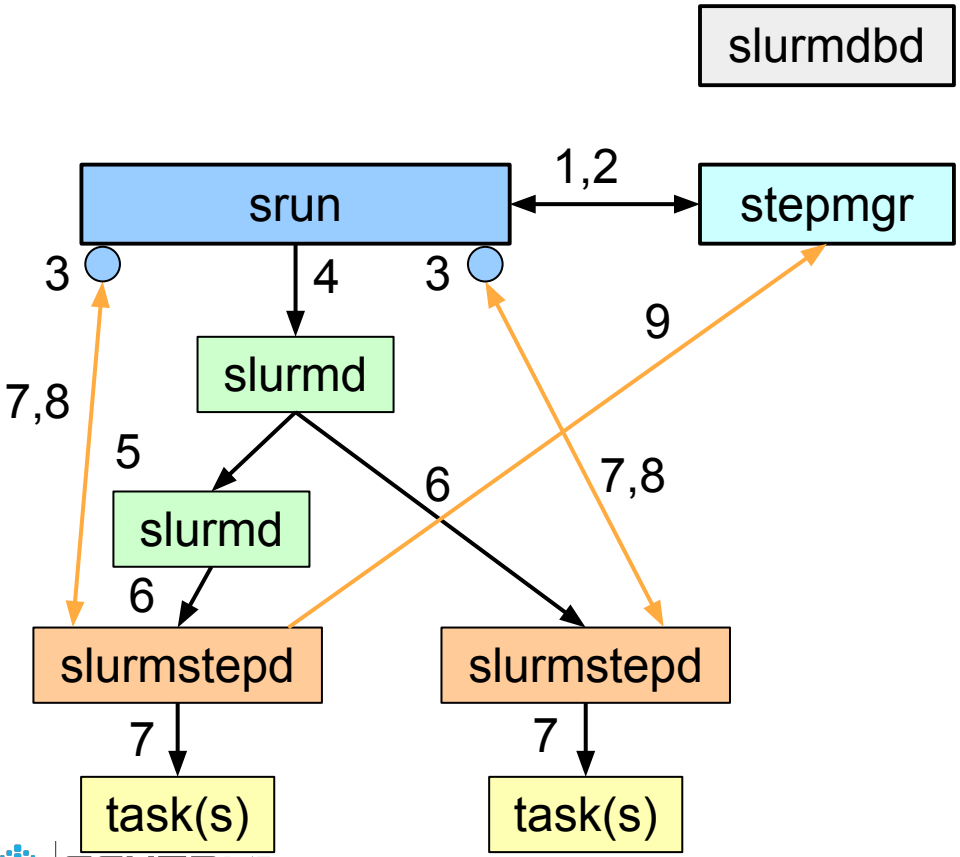
1. **srun** sends step create request to **stepmgr**
2. **stepmgr** responds with step credential
3. **srun** opens sockets for I/O
4. **srun** forwards credential with task info to **slurmd**
5. **slurmd** forwards request as needed (per fanout)
6. **slurmd** forks/execs **slurmstepd**

Step Launch Sequence



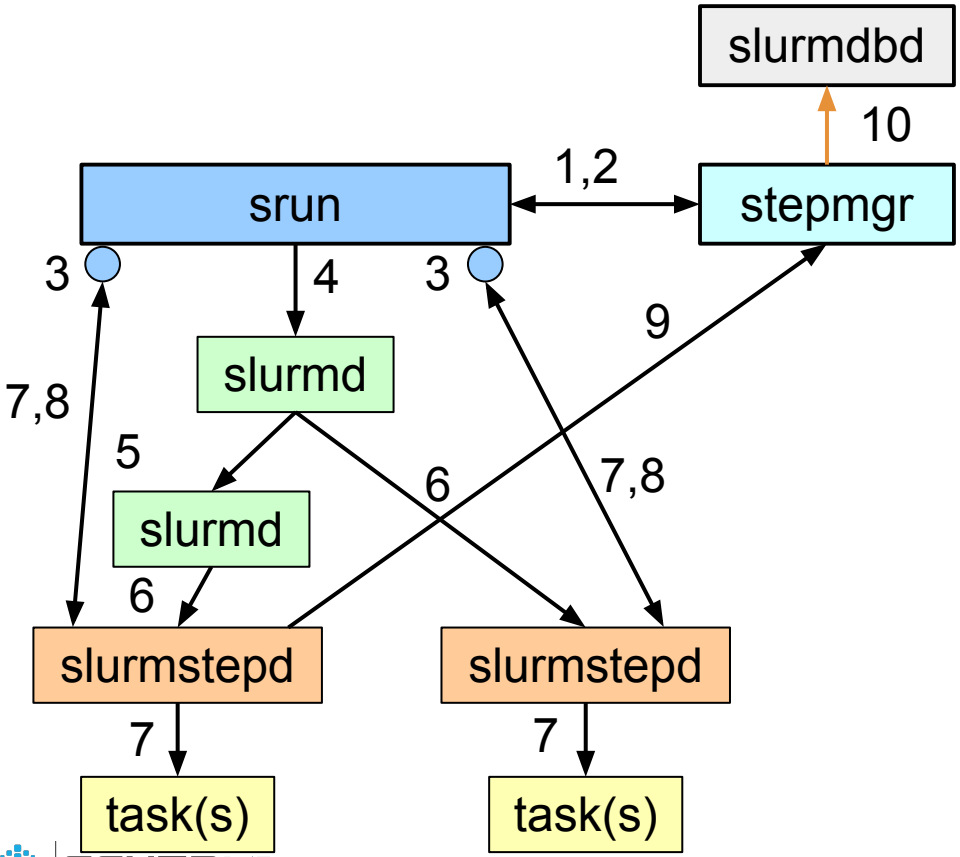
1. **srun** sends step create request to **stepmgr**
2. **stepmgr** responds with step credential
3. **srun** opens sockets for I/O
4. **srun** forwards credential with task info to **slurmd**
5. **slurmd** forwards request as needed (per fanout)
6. **slurmd** forks/execs **slurmstepd**
7. **slurmstepd** connects I/O and launches **tasks**

Step Launch Sequence



1. **srun** sends step create request to **stepmgr**
2. **stepmgr** responds with step credential
3. **srun** opens sockets for I/O
4. **srun** forwards credential with task info to **slurmd**
5. **slurmd** forwards request as needed (per fanout)
6. **slurmd** forks/execs **slurmstepd**
7. **slurmstepd** connects I/O and launches **tasks**
8. On task termination, **slurmstepd** notifies **srun**
9. **slurmstepd** sends step completions to **stepmgr** (per reverse fanout (7))

Step Launch Sequence



1. **srun** sends step create request to **stepmgr**
2. **stepmgr** responds with step credential
3. **srun** opens sockets for I/O
4. **srun** forwards credential with task info to **slurmd**
5. **slurmd** forwards request as needed (per fanout)
6. **slurmd** forks/execs **slurmstepd**
7. **slurmstepd** connects I/O and launches **tasks**
8. On task termination, **slurmstepd** notifies **srun**
9. **slurmstepd** sends step completions to **stepmgr** (per reverse fanout (7))
10. a. no step accounting
    b. **stepmgr** sends step completion to **slurmdbd**
    c. **stepmgr** sends to slurmctld, slurmctld sends to **slurmdbd**

Things to tackle / figure out

Accounting

- Currently, the stepds reverse fanout (7) to stepd 0
  - stepds send to the controller if can't reverse
- Controller sends info to dbd
- But controller doesn't have record of steps
- Options
  - No step accounting
  - Accounting through slurmstepd
  - Accounting through slurmctld

Heterogenous jobs

- The controller keeps track of the different jobs in a het job
  - thus the het step id.
- Controller to do step management for het jobs

Clients

- squeue -s
- scontrol show steps
  - query all slurmds and stepds to get list of steps?

Questions or Thoughts?


SCHEDMD
The Slurm Company