SHARCNET General Interest Webinar Series

Understand (and potentially reduce) job wait times by examining scheduler configuration, load in the queue and account usage

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October 10th, 2018

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Overview

Factors that affect wait times in the queue of the general purpose clusters (Graham and Cedar).

Usage decisions that can lead to unnecessarily long wait times in the queue.

Querying the properties of the systems, scheduler and job queue

Factors that affect wait times

Resources (cluster) and resource requests (jobs)

- cores, gpus, memory..

Ordering of jobs in the scheduling queue (priority)

- target share, usage, core equivalent

Scheduler configuration (partitions)

- Specific resource requests are isolated to subsets of nodes

Usage decisions that can lead to unnecessarily long wait times

Node memory limits

Partition constraints

Heterogeneous job submission from a single account

Core equivalent usage charge

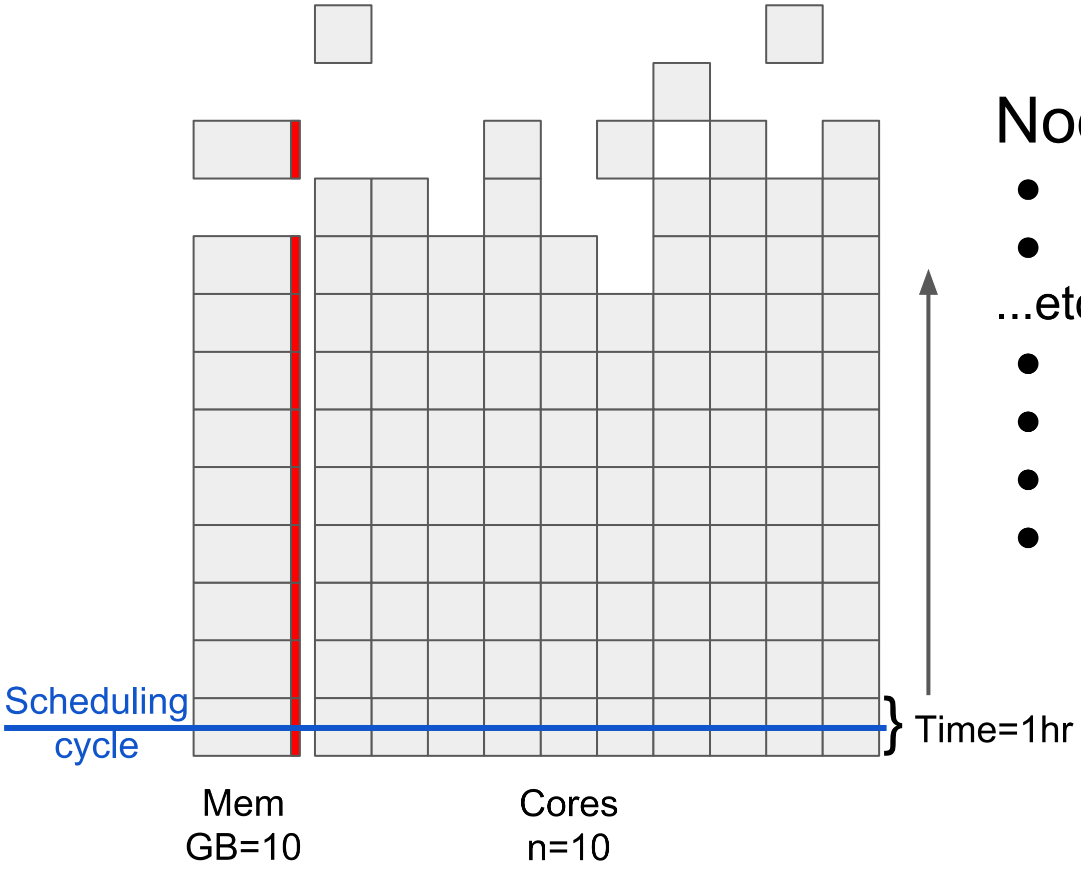
Querying properties of the system, scheduler and job queue

What resources are available? sinfo, partition-stats,

How are the nodes organized into partitions? scontrol show partitions

What is the job load in the queue and running on the nodes? squeue, sacct

Node resources and resource requests (jobs)



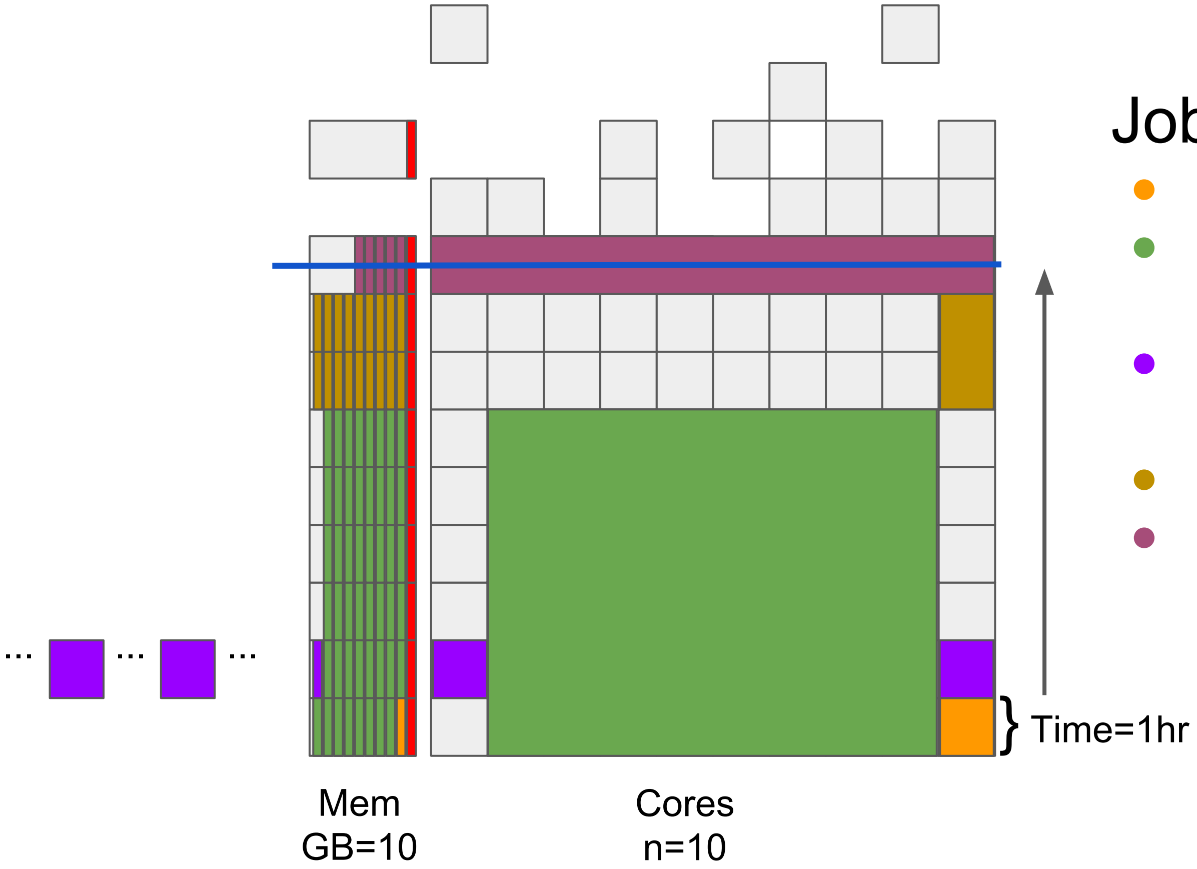
Node resources

- Cores
- Memory

...etc

- GPUs
- Software licenses
- …
- Time

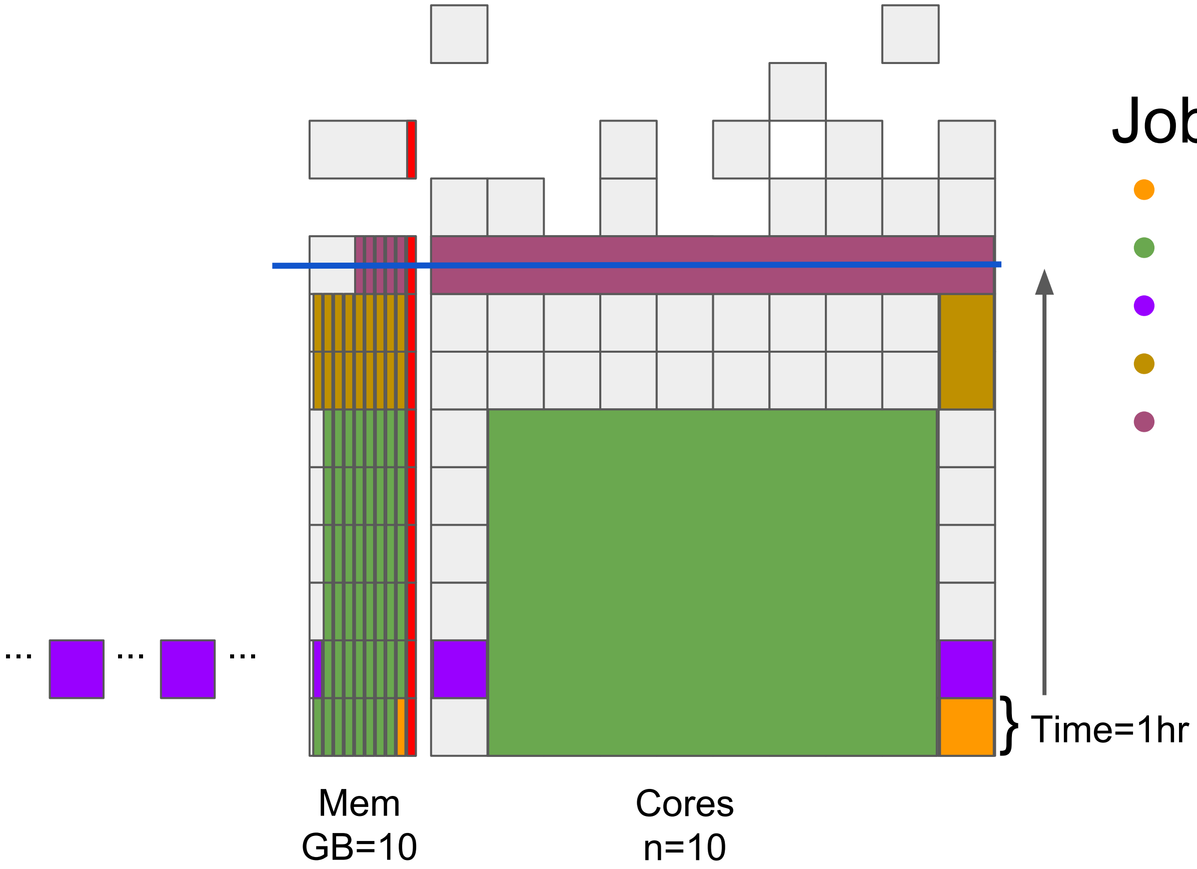
Node resources and resource requests (jobs)



Job size

- ● --time=1:00 --mem=1G
- ● --time=6:00 --mem=8G --cpu-per-task=8
- ● --time=1:00 --ntasks=10 --mem-per-cpu=400
- ● --time=2:00 --mem=9G
- ● --time=1:00 --nodes=1 --ntasks-per-node=10 --mem-per-cpu=400

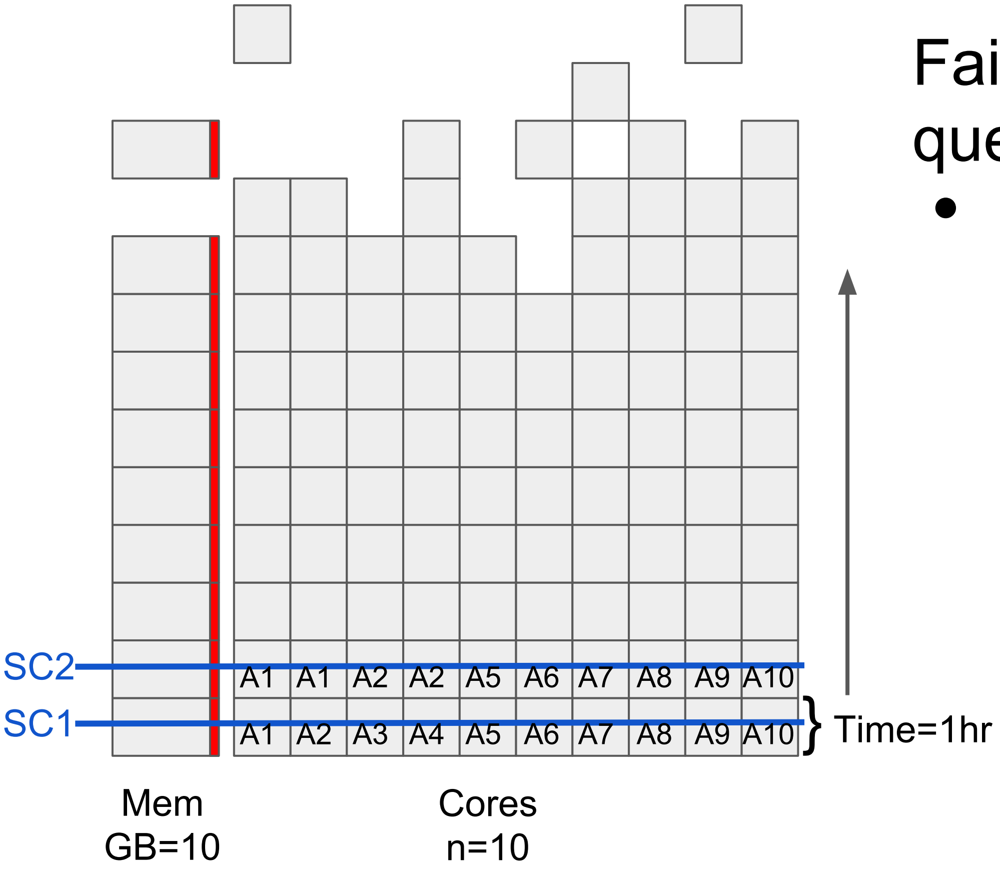
Node resources and resource requests (jobs)



Job billing (by core & mem)

- ● 1 core equivalent
- ● 8 core equivalent
- ● 10 core equivalent
- ● 9 core equivalent
- ● 10 core equivalent

Ordering of jobs in the scheduling queue (priority)

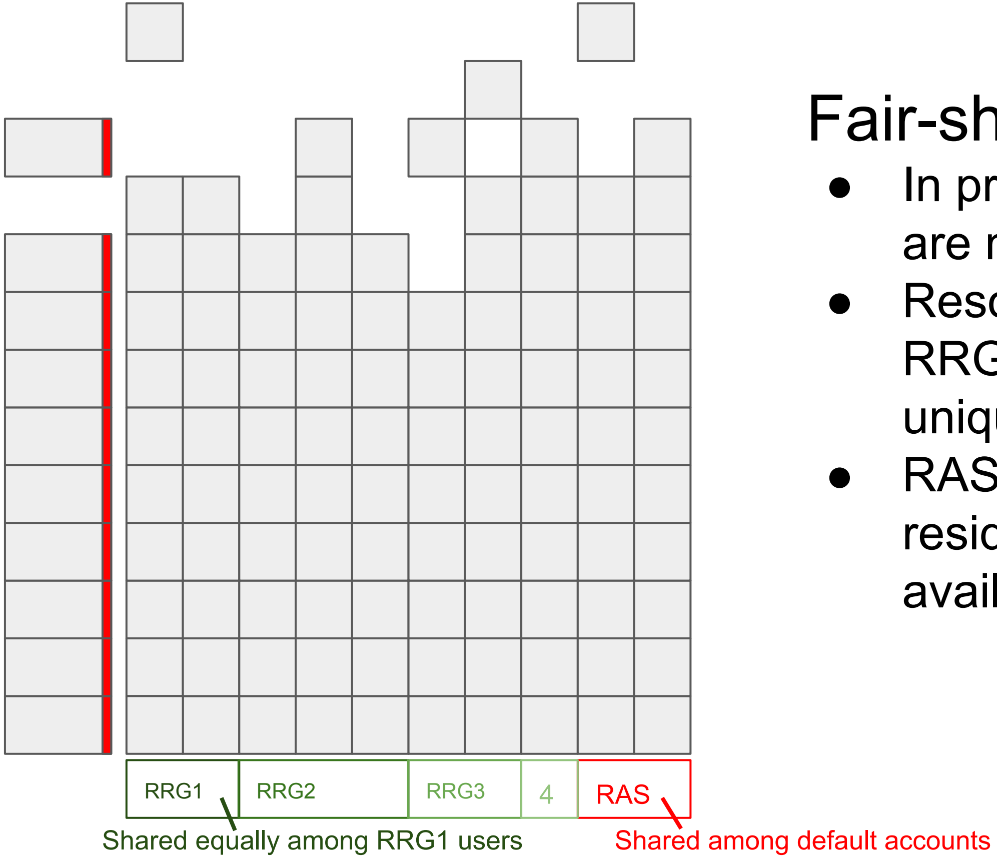

SC2
SC1
A1 A1 A2 A2 A5 A6 A7 A8 A9 A10
A1 A2 A3 A4 A5 A6 A7 A8 A9 A10
Time=1hr
Mem
GB=10
Cores
n=10

Fair-share priority queue sorting

- Example: 10 accounts with equal shares of 1.

SC1	SC2	SC3
A1, .5	A1, .5	A3, .75
A2, .5	A1, .5	A4, .75
A3, .5	A2, .5	A5, .5
A4, .5	A2, .5	A6, .5
A5, .5	A5, .5	A7, .5
A6, .5	A6, .5	A8, .5
A7, .5	A7, .5	A9, .5
A8, .5	A8, .5	A10, .5
A9, .5	A9, .5	A1, .25
A10, .5	A10, .5	A2, .25
(FIFO)	(FIFO)	(FS priority)

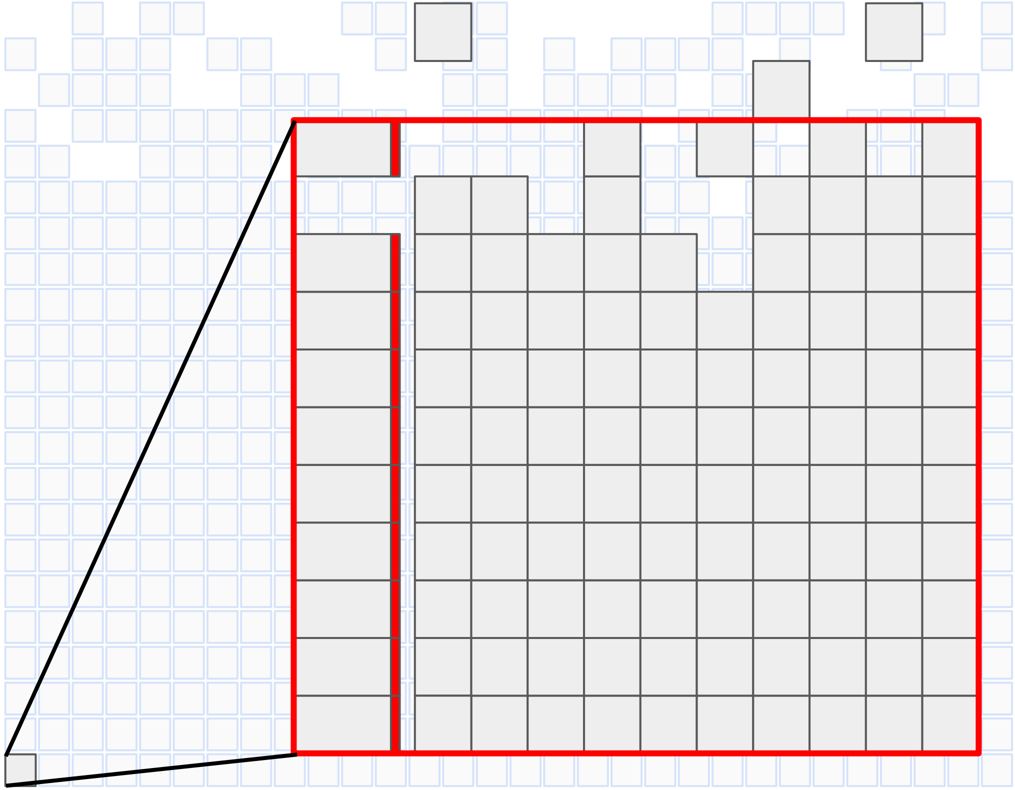
Ordering of jobs in the scheduling queue (priority)


RRG1
RRG2
RRG3
4
RAS
Shared equally among RRG1 users
Shared among default accounts

Fair-share targets

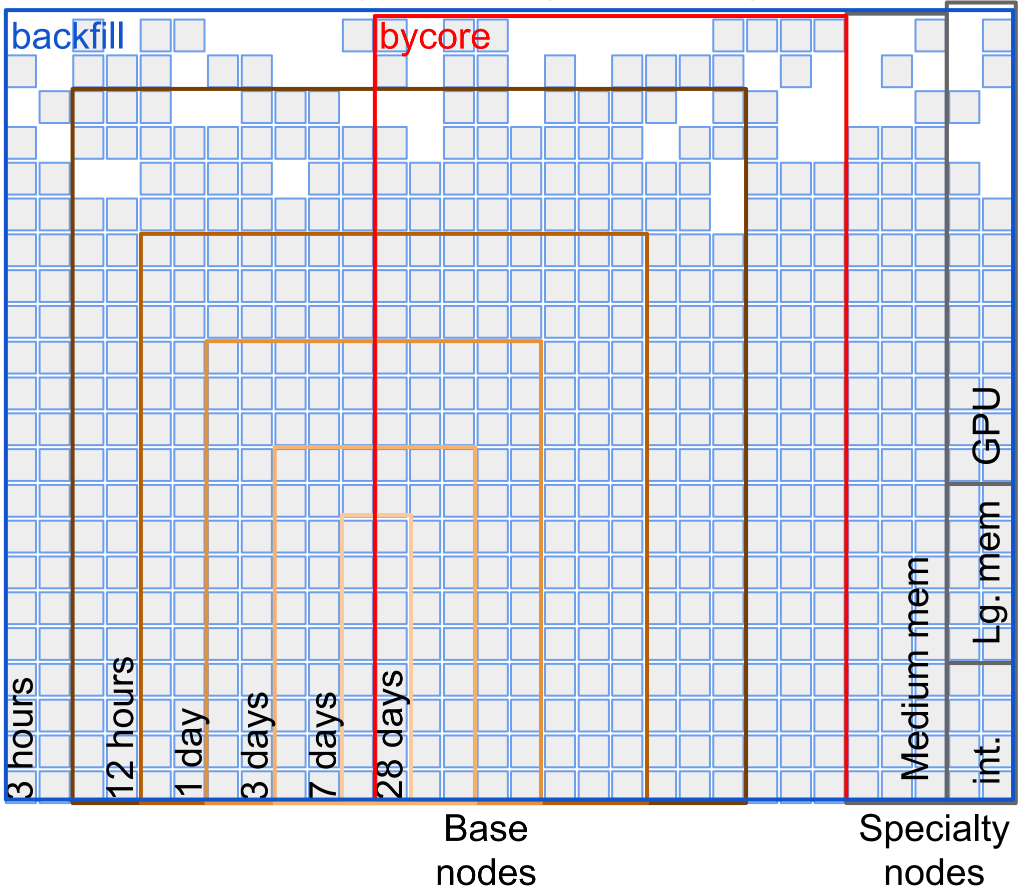
- In production target shares are not equal
- Resource allocations (e.g. RRG, RPP) are defined by unique share targets.
- RAS is the equally shared residual system resources available beyond allocations

Scheduler configuration (partitions)



Partitions

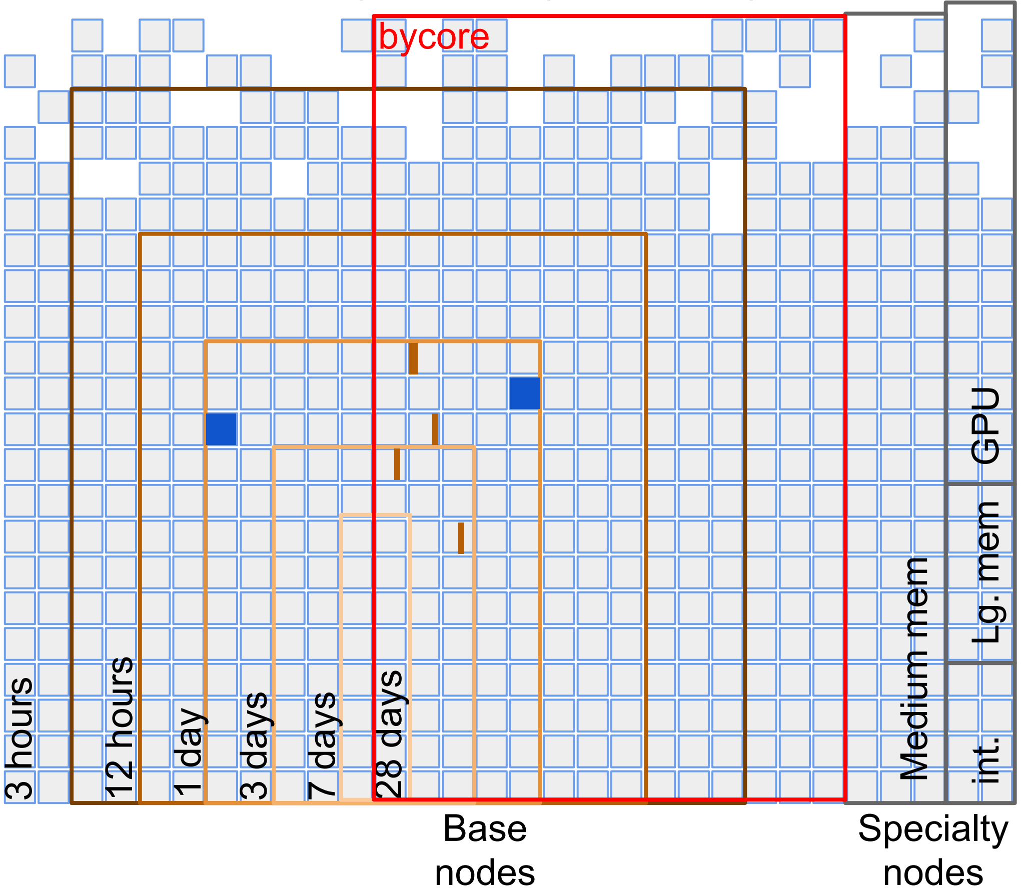
Scheduler configuration (partitions)



Partitions

- Restrict jobs of specific shapes to node sets
- Full node jobs can run on most any node (bynode)
- Jobs 24 hours and shorter can run on most any node
- Longer run time jobs have access to fewer nodes
- Partial node jobs (bycore) have access to fewer nodes
- Backfill jobs can run on most any node

Scheduler configuration (partitions)



Partitions

- By node vs by core
  - By node jobs can perform better
  - By core jobs have more opportunity to run
- --time=3-00:00 --nodes=1
- --ntasks-per-node=32
- --time=3-00:00 --ntasks=32

Monitoring jobs, the queue and the cluster

Show all of the jobs in the queue sorted by their current priority:

```
squeue -P --sort=-p,i --states=PD -o "%.4a %P %.8C %m %V %l %t %p" | less
```

Show properties of all jobs on the system since a stated date:

```
sacct -aX -S 2018-10-08 -o account%4,partition%24,submit,start,timelimit,reqmem,ncpus,nnodes,state | less
```

Show node properties:

```
sinfo --Node --long
```

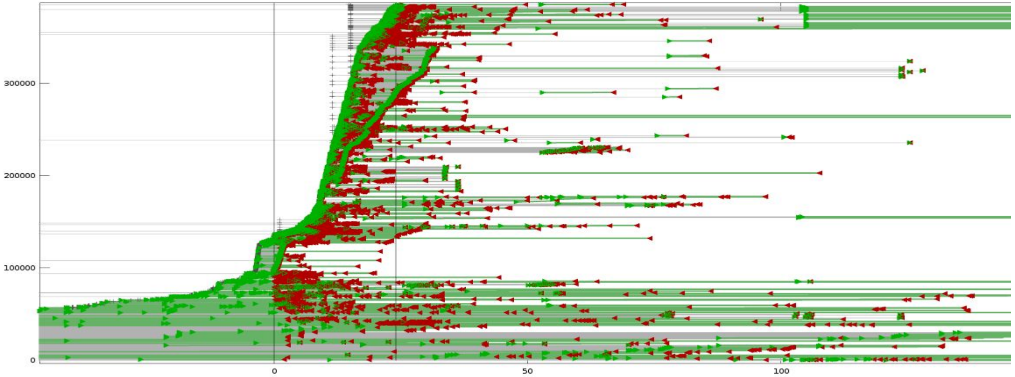
Show partition properties:

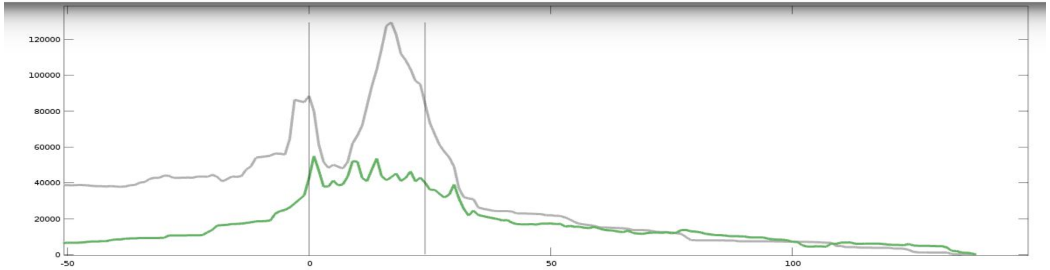
```
partition-stats
```

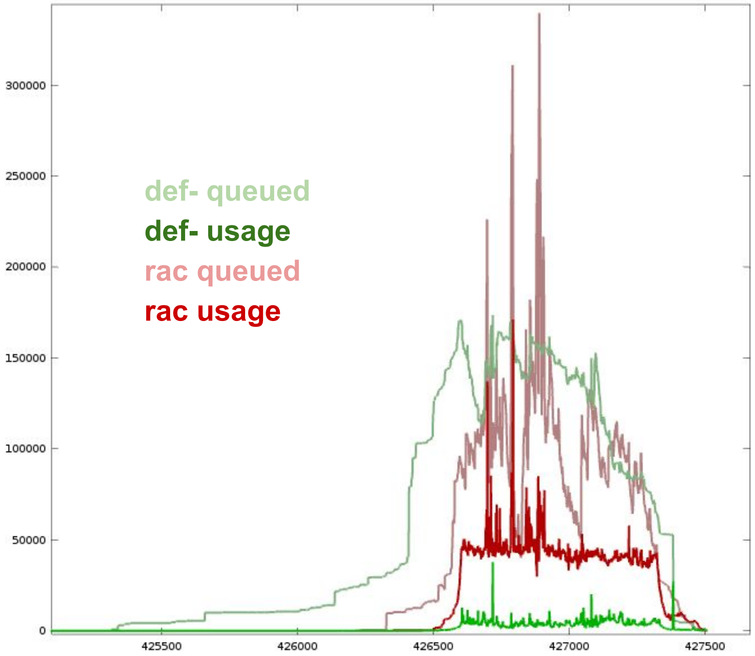
```
scontrol show partition
```

Redirecting sacct output to csv for local interactive work and visualization

```
sacct -aX -S 2018-10-04 -E 2018-10-05 -p --delimiter "|" -n --units=M -o
jobid,user,account,ncpus,nnodes,reqmem,timelimit,submit,start,end,elapse,state,priority,partition%36 | grep "cpubase_"
| grep -E 'rrg-|rpp-' > cdr_cpubase_rac_2018_10_04_10_05.csv
```







Redirecting sacct output to csv for local interactive work and visualization

Sacctplot gitlab repo: https://git.sharcnet.ca/jdesjard/sacctplot

REMOTE:

```
sacct -aX -S 2018-10-09 -E 2018-10-10 -p --delimiter "|" -n --units=M -o jobid,user,account,ncpus,nnodes,reqmem,timelimit,submit,start,end,elapse,state,priority,partition%36 | grep "cpubase_" | grep -E 'rrg-|rpp-' > cdr_cpubase_rac_2018_10_09_10_10.csv
```

LOCAL:

```
sshfs jdesjard@cedar.computecanada.ca:/home/jdesjard/queueplot tmpmnt
```

OCTAVE:

```
[cr_tal,cq_tal,ts]=jobstack('tmpmnt/cdr_cpubase_rac_2018_10_09_10_10.csv',8,9,10,11,4,5,6,7,12,'2018-10-09','2018-10-10');
```

Documentation and getting help

Slurm Documentation

- https://slurm.schedmd.com/

Compute Canada wikis

- https://docs.computecanada.ca/wiki/Graham https://docs.computecanada.ca/wiki/Cedar
- https://docs.computecanada.ca/wiki/Running_jobs
- https://docs.computecanada.ca/wiki/Job_scheduling_policies

Related videos at the SHARCNET YouTube channel

- All about job wait times in the graham queue
- Serial farming on Graham
- The benefits of GLOST for many jobs

support@computecanada.ca

What can be done about wait times?

Node memory limits

Consider node and partition memory constraints as they relate to the resources that are available for a job. (memory requests in M instead of G)

Partition constraints

Consider how the shape of the resource request may isolate the job to a subset of resources.

Heterogeneous job submission from a single account

Consider how jobs from an account affect each other (run specific job types on different systems)

Core equivalent usage charge

Consider the effect that job requests have on your account billing and priority of subsequent jobs

What can be done about wait times?

Job resource footprint (shape of the job on the cluster)

- Decrease job footprint: minimize accurate requests, checkpointing, dependent queuing
- Consider the compressed vs distributed footprint of MPI jobs.

Load on the system (relative to resources available)

- Users have no control over the load on the system (by others) but there are methods to view the state
- The contribution model gives users the ability to influence the resource pool

Account target share (fair-share priority)

- Be efficient about usage (both in terms of job numbers and footprint)
- Apply for a resource target allocation

Conclusions

The scheduling policy is prioritizing account target consumption and system utilization.

Job submission should prioritize the optimal running of the procedure (profiling, scaling tests, etc) and feasibility within the scheduling policy.

The configuration of the cluster (partitions, etc) will be adjusted to best suit the system workloads defined by user job shapes.

Do not hesitate to open support tickets regarding job shape and queue properties by email us at:

support@computecanada.ca

Thank you for your attention!

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Monitoring jobs, the queue and the cluster

```
[jdesjard@gra-login4 ~]$ sacct -aX -S 2018-04-20 -o account%4,partition%32,submit,start,end,timelimit,reqmem,ncpus,nnodes,state

…
rrg+                cpubase_bycore_b2 2018-04-24T13:11:21 2018-04-24T21:56:56             Unknown   12:00:00            256Mc               1         1         RUNNING
rrg+                cpubase_bycore_b2 2018-04-24T13:11:21 2018-04-24T21:56:56             Unknown   12:00:00            256Mc               1         1         RUNNING
rpp+                cpubase_bycore_b2 2018-04-24T21:57:02 2018-04-24T21:57:09 2018-04-24T21:59:52   06:00:00            4Gn       1         1         FAILED
def+      cpubase_bycore_b2,cpubackfill 2018-04-24T21:57:03           Unknown             Unknown   05:00:00            4Gn       1         1         PENDING
def+                cpubase_bycore_b6 2018-04-24T21:57:09             Unknown             Unknown 10-00:00:+            32Gn      16        1         PENDING
def+      cpubase_bycore_b1,cpubackfill 2018-04-24T21:57:09           Unknown             Unknown   03:00:00            4Gn       1         1         PENDING
def+                cpubase_bycore_b1 2018-04-24T19:56:06 2018-04-24T21:57:09 2018-04-24T21:59:42   03:00:00            4Gn       1         1  COMPLETED
def+                cpubase_bycore_b1 2018-04-24T19:56:06 2018-04-24T21:57:09 2018-04-24T21:59:42   03:00:00            4Gn       1         1  COMPLETED
def+                cpubase_bycore_b1 2018-04-24T19:56:06 2018-04-24T21:57:09 2018-04-24T21:59:46   03:00:00            4Gn       1         1  COMPLETED
def+                cpubase_bycore_b1 2018-04-24T19:56:06 2018-04-24T21:57:09 2018-04-24T21:59:46   03:00:00            4Gn       1         1  COMPLETED
def+                cpubase_bycore_b1 2018-04-24T19:56:06 2018-04-24T21:57:09 2018-04-24T21:59:50   03:00:00            4Gn       1         1  COMPLETED
rpp+                cpubase_bycore_b2 2018-04-24T21:57:11 2018-04-24T21:57:11             Unknown   06:00:00            4Gn       1         1         RUNNING
rpp+                cpubase_bycore_b2 2018-04-24T21:57:15 2018-04-24T21:57:22             Unknown   06:00:00            4Gn       1         1         RUNNING
def+      cpubase_bycore_b1,cpubackfill 2018-04-24T21:57:18           Unknown             Unknown   00:05:00            256Mc               1         1         PENDING
rpp+                cpubase_bycore_b2 2018-04-24T21:57:20 2018-04-24T21:57:22             Unknown   06:00:00            4Gn       1         1         RUNNING
...
```

Monitoring jobs, the queue and the cluster

```
squeue -P --sort=-p,i --states=PD -o "%.4a %P %.8C %m %V %e %l %r %t %S" | less

ACCO PARTITION        CPUS MIN_MEMORY SUBMIT_TIME END_TIME TIME_LIMIT REASON ST START_TIME
...
def- cpubackfill      256 125G 2018-03-16T15:58:38 N/A 2:30:00 Resources PD N/A
def- cpularge_bynode_b1       256 1T 2018-02-07T17:23:29 N/A 2:30:00 Resources PD N/A
def- cpubackfill      256 1T 2018-02-07T17:23:29 N/A 2:30:00 Resources PD N/A
def- cpubase_bycore_b1        3600 2G 2018-03-16T15:13:26 N/A 10:00 Resources PD N/A
def- cpubackfill      3600 2G 2018-03-16T15:13:26 N/A 10:00 Resources PD N/A
def- cpubase_bycore_b1        1728 2G 2018-03-16T16:16:45 N/A 5:00 Resources PD N/A
def- cpubackfill      1728 2G 2018-03-16T16:16:45 N/A 5:00 Resources PD N/A
def- cpubase_bynode_b2        256 256M 2018-01-19T07:33:47 N/A 3:30:00 Resources PD N/A
def- cpubackfill      256 256M 2018-01-19T07:33:47 N/A 3:30:00 Resources PD N/A
def- cpubase_bycore_b2        3840 30G 2018-04-13T11:15:31 N/A 12:00:00 Resources PD N/A
def- cpubackfill      3840 30G 2018-04-13T11:15:31 N/A 12:00:00 Resources PD N/A
def- cpubase_bycore_b2        3840 30G 2018-04-13T11:26:57 N/A 12:00:00 Resources PD N/A
def- cpubackfill      3840 30G 2018-04-13T11:26:57 N/A 12:00:00 Resources PD N/A
def- cpubase_bynode_b1        32 125G 2018-02-09T18:05:06 N/A 2:20:00 Resources PD N/A
def- cpubackfill      32 125G 2018-02-09T18:05:06 N/A 2:20:00 Resources PD N/A
rpp- cpubase_bycore_b6        2 100G 2018-04-23T18:02:27 2018-05-04T20:37:01 7-12:00:00 Resources PD 2018-04-27T08:37:01
rrg- cpubase_bycore_b5        60 8000M 2018-04-23T23:10:30 2018-05-02T19:03:14 7-00:00:00 Resources PD 2018-04-25T19:03:14
rrg- cpubase_bycore_b5        60 8000M 2018-04-23T23:11:12 2018-05-05T00:13:54 7-00:00:00 Priority PD 2018-04-28T00:13:54
...
rrg- cpubase_bycore_b5        60 8000M 2018-04-24T14:07:54 2018-05-05T00:13:54 7-00:00:00 Priority PD 2018-04-28T00:13:54
def- cpubase_bycore_b1        4 2024M 2018-04-18T18:09:47 N/A 3:00:00 Dependency PD N/A
def- cpubackfill      4 2024M 2018-04-18T18:09:47 N/A 3:00:00 Dependency PD N/A
def- cpubase_bycore_b1        4 2024M 2018-04-20T15:53:57 N/A 3:00:00 Dependency PD N/A
…
```

Monitoring jobs, the queue and the cluster

```
[jdesjard@gra-login4 ~]$ sinfo
PARTITION             AVAIL  TIMELIMIT  NODES  STATE NODELIST
cpubase_interac       up      3:00:00       1      mix gra800
cpubase_interac       up      3:00:00       1  alloc gra796
cpubase_interac       up      3:00:00       3   idle gra[797-799]
cpubase_bynode_b1     up      3:00:00       15 drain* gra[222,732,988-997,1020,1030,1040]
cpubase_bynode_b1     up      3:00:00       16   drng gra[13,33,37,39,46,60,67-68,71,79,87,115,120,130,135,343]
cpubase_bynode_b1     up      3:00:00 144     mix
gra[44,47,91,100-101,116,118,124,138-139,225,236,263,284-286,291,293,295,299-300,309,314,321-323,325-331,333-340,342,344-352,354-
355,357,360-368,370,372-375,377-379,381,384,387-389,391,393-396,401,428,433,447,506,509,542,547,550,568,584-585,608,616,622,625-6
26,634-635,640,643-644,647,650-651,668-669,701-702,720,724,727,738-739,741-745,998-1002,1005-1011,1013-1014,1016,1018,1026,1031-1
036,1042]
cpubase_bynode_b1     up      3:00:00 687  alloc
gra[1-12,14-32,34-36,38,40-43,45,48-59,61-66,69-70,72-78,80-86,88-90,92-99,102-114,117,119,121-123,125-129,131-134,136-137,140-22
1,223-224,226-235,237-262,264-283,287-290,292,294,296-298,301-308,310-313,315-320,324,332,341,353,356,358-359,369,371,376,380,382
-383,385-386,390,392,397-400,402-427,429-432,434-446,448-505,507-508,510-541,543-546,548-549,551-567,569-583,586-607,609-615,617-
621,623-624,627-633,636-639,641-642,645-646,648-649,652-667,670-700,703-719,721-723,725-726,728-731,733-737,740,746-795,1003-1004
,1012,1015,1017,1019,1027,1037-1038,1041,1108-1127]
cpubase_bynode_b1     up      3:00:00       9   idle gra[1021-1025,1028-1029,1039,1043]
cpubase_bynode_b2     up    12:00:00  15 drain* gra[222,732,988-997,1020,1030,1040]
cpubase_bynode_b2     up    12:00:00  16   drng gra[13,33,37,39,46,60,67-68,71,79,87,115,120,130,135,343]
cpubase_bynode_b2     up    12:00:00  144    mix
gra[44,47,91,100-101,116,118,124,138-139,225,236,263,284-286,291,293,295,299-300,309,314,321-323,325-331,333-340,342,344-352,354-
355,357,360-368,370,372-375,377-379,381,384,387-389,391,393-396,401,428,433,447,506,509,542,547,550,568,584-585,608,616,622,625-6
26,634-635,640,643-644,647,650-651,668-669,701-702,720,724,727,738-739,741-745,998-1002,1005-1011,1013-1014,1016,1018,1026,1031-1
036,1042]
cpubase_bynode_b2     up    12:00:00  667  alloc
gra[1-12,14-32,34-36,38,40-43,45,48-59,61-66,69-70,72-78,80-86,88-90,92-99,102-114,117,119,121-123,125-129,131-134,136-137,140-22
1,223-224,226-235,237-262,264-283,287-290,292,294,296-298,301-308,310-313,315-320,324,332,341,353,356,358-359,369,371,376,380,382
-383,385-386,390,392,397-400,402-427,429-432,434-446,448-505,507-508,510-541,543-546,548-549,551-567,569-583,586-607,609-615,617-
621,623-624,627-633,636-639,641-642,645-646,648-649,652-667,670-700,703-719,721-723,725-726,728-731,733-737,740,746-795,1003-1004
```

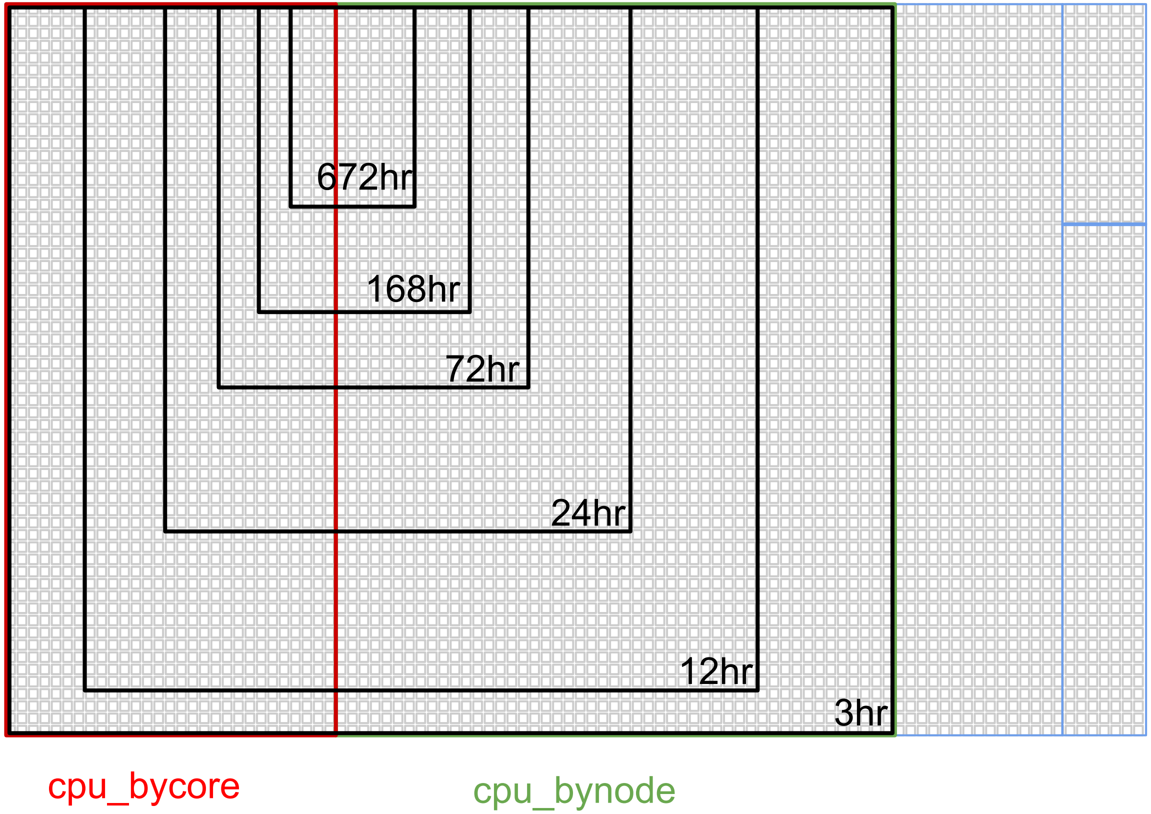
Monitoring jobs, the queue and the cluster

```
[jdesjard@gra-login4 ~]$ partition-stats

Node type |                   Max walltime
        |   3 hr   |  12 hr   |  24 hr   |  72 hr   |  168 hr |  672 hr |
----------|-------------------------------------------------------------
        Number of Queued Jobs by partition Type (by node:by core)
----------|-------------------------------------------------------------
Regular   |   29:179 |   7:5492|  69:293 | 238:724 |   1:945 |   3:118 |
Large Mem |    1:0   |   0:0   |   0:0   |   0:9   |   0:6   |   2:2   |
GPU     |      0:101 |   0:10  |   0:44  | 181:23  | 412:35  |   1:0   |
----------|-------------------------------------------------------------
        Number of Running Jobs by partition Type (by node:by core)
----------|-------------------------------------------------------------
Regular   |   43:76  |  14:1437|  73:204 | 106:250 |   7:960 |  24:110 |
Large Mem |    0:0   |   0:0   |   0:0   |   0:1   |   0:1   |   0:2   |
GPU     |      0:18  |   1:36  |  15:53  |  49:39  |   0:7   |   0:2   |
----------|-------------------------------------------------------------
        Number of Idle nodes by partition Type (by node:by core)
----------|-------------------------------------------------------------
Regular   |    1:0   |   1:0   |   1:0   |   1:0   |   0:0   |   0:0   |
Large Mem |    3:1   |   3:1   |   0:0   |   0:0   |   0:0   |   0:0   |
GPU     |   13:0   |  13:0   |   7:0   |   0:0   |   0:0   |   0:0   |
----------|-------------------------------------------------------------
        Total Number of nodes by partition Type (by node:by core)
----------|-------------------------------------------------------------
Regular   |  871:431 | 851:411 | 821:391 | 636:276 | 281:164 |  90:50  |
Large Mem |   27:12  |  27:12  |  24:11  |  20:3   |   4:3   |   3:2   |
GPU     |  156:78  | 156:78  | 144:72  | 104:52  |  13:12  |  13:12  |
----------|-------------------------------------------------------------
```

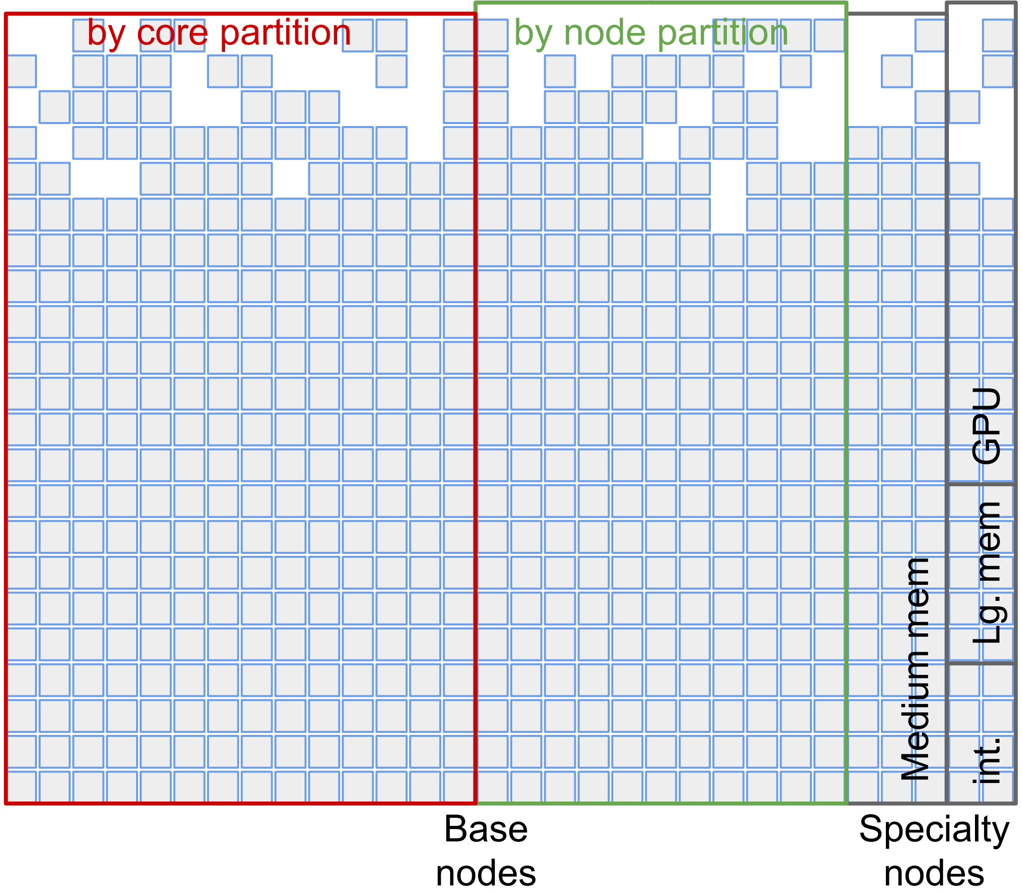
Monitoring jobs, the queue and the cluster

```
[jdesjard@gra-login4 ~]$ scontrol show partition
PartitionName=cpubase_interac
   AllowGroups=ALL AllowAccounts=ALL AllowQos=ALL
   AllocNodes=ALL Default=NO QoS=N/A
   DefaultTime=01:00:00 DisableRootJobs=NO ExclusiveUser=NO GraceTime=0 Hidden=NO
   MaxNodes=UNLIMITED MaxTime=03:00:00 MinNodes=1 LLN=NO MaxCPUsPerNode=UNLIMITED
   Nodes=gra[796-800]
   PriorityJobFactor=1 PriorityTier=1 RootOnly=NO ReqResv=NO OverSubscribe=NO
   OverTimeLimit=NONE PreemptMode=OFF
   State=UP TotalCPUs=160 TotalNodes=5 SelectTypeParameters=NONE
   DefMemPerCPU=256 MaxMemPerNode=UNLIMITED
   TRESBillingWeights=CPU=1.0,Mem=0.25G

PartitionName=cpubase_bynode_b1
   AllowGroups=ALL AllowAccounts=ALL AllowQos=ALL
   AllocNodes=ALL Default=NO QoS=N/A
   DefaultTime=01:00:00 DisableRootJobs=NO ExclusiveUser=NO GraceTime=0 Hidden=NO
   MaxNodes=UNLIMITED MaxTime=03:00:00 MinNodes=1 LLN=NO MaxCPUsPerNode=UNLIMITED
   Nodes=gra[1-795,988-1043,1108-1127]
   PriorityJobFactor=12 PriorityTier=1 RootOnly=NO ReqResv=NO OverSubscribe=NO
   OverTimeLimit=NONE PreemptMode=OFF
   State=UP TotalCPUs=27872 TotalNodes=871 SelectTypeParameters=NONE
   DefMemPerCPU=256 MaxMemPerNode=UNLIMITED
   TRESBillingWeights=CPU=1.0,Mem=0.25G

PartitionName=cpubase_bynode_b2
   AllowGroups=ALL AllowAccounts=ALL AllowQos=ALL
   AllocNodes=ALL Default=NO QoS=N/A
...
```

Cluster resource basics: categorization of resources that affect priority (partitions)



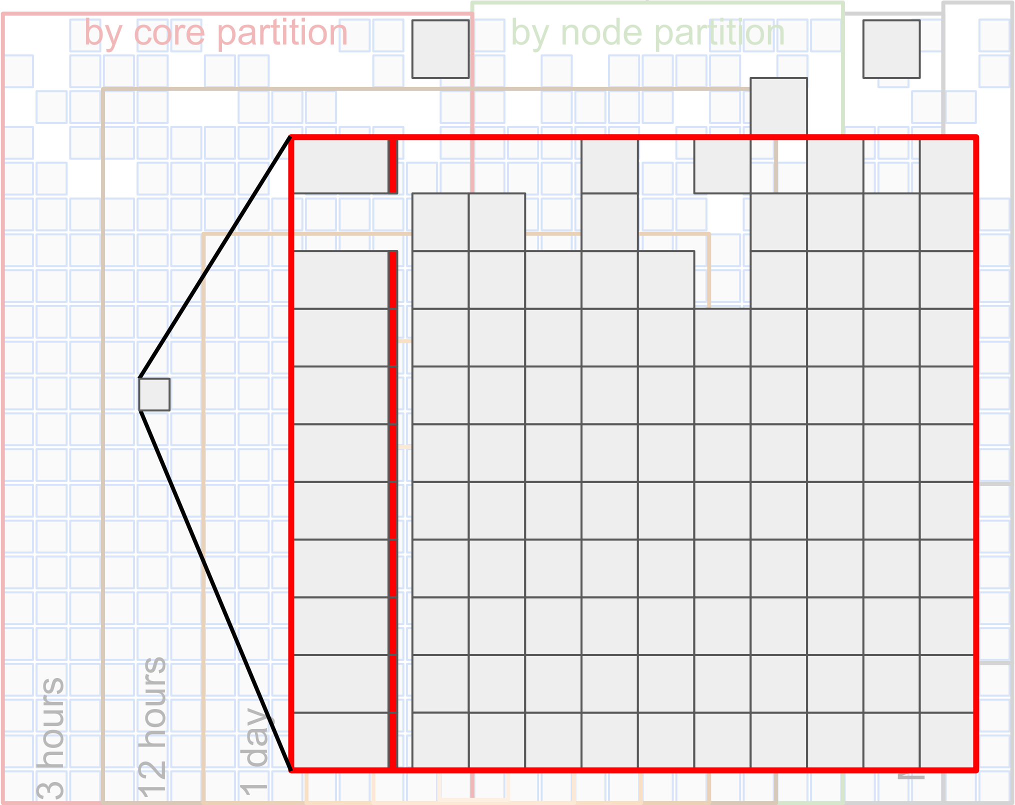
Cluster resource basics: categorization of resources that affect priority (partitions)



Partitions

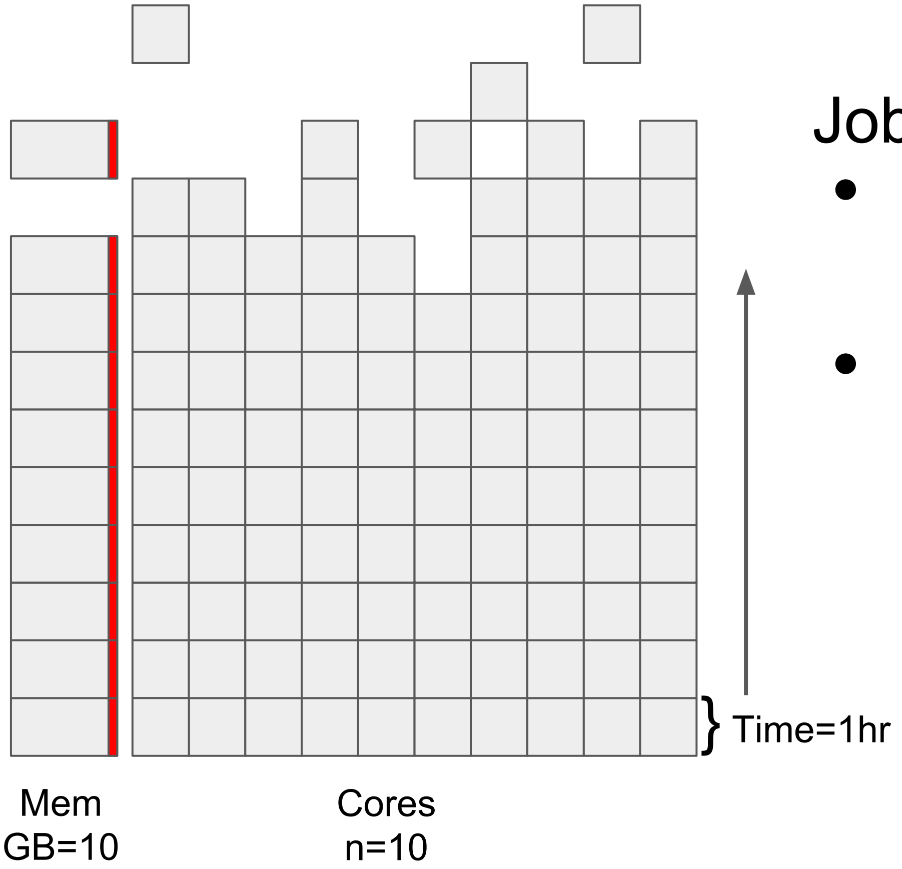
- By node
  - ○ ntasks=32
nodes=1
- By core
  - ○ ntasks=32

Cluster resource basics: categorization of resources that affect priority (partitions)



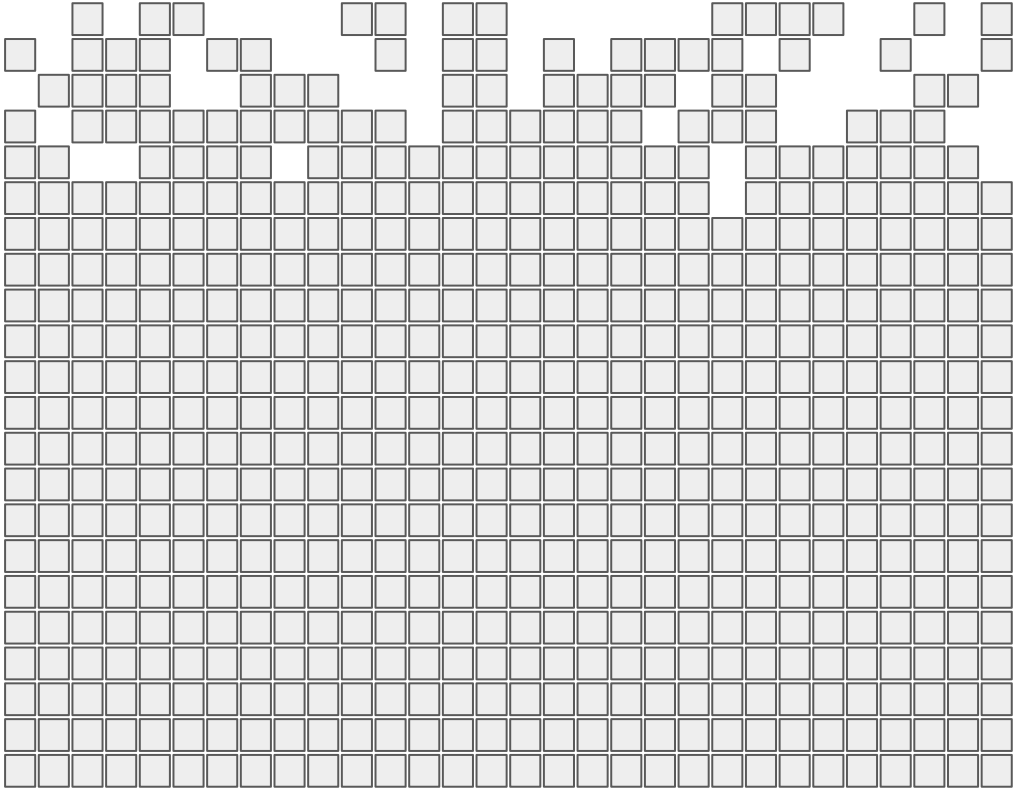
Backfill

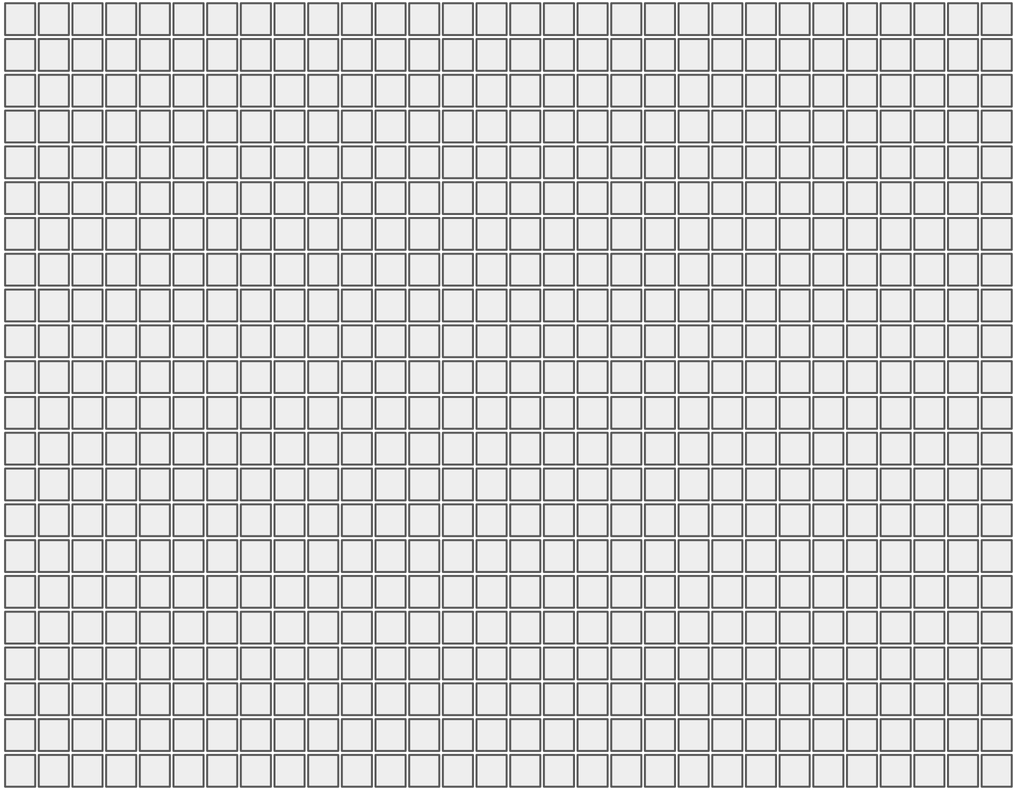
Scheduling basics: node resources and resource requests (job queue)



Job size

- Full node
  - MPI
  - Threaded
- By core
  - MPI
  - Threaded
  - serial





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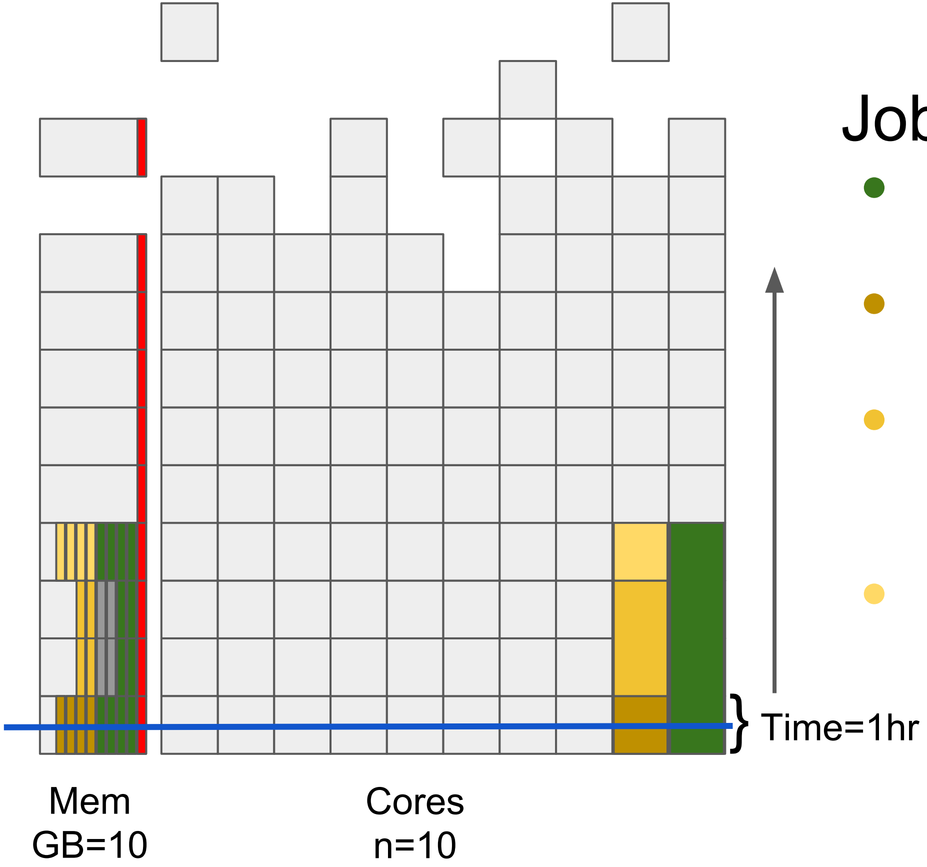
Scheduling basics: node resources and resource requests (job queue)



Job dependencies

- jobid 1
  - --time=4:00 --mem=4G
- jobid 2
  - --time=1:00 --mem=4G
- jobid 3
  - --time=2:00 --mem=2G --dependency=afterok:2
- jobid 4
  - --time=1:00 --mem=4G --dependency=afterok:3

Factors contributing to job queue time

Job resource footprint (shape of the job on the cluster)

Load on the system (relative to resources available)

Account target share (fairshare priority)

Monitoring jobs, the queue and the cluster

cluster

- sinfo
- scontrol show

Job queue basics: factors that affect the order of jobs in queue (priority)

Job size

- The shape of requested resources affects a job’s priority

Age

- A jobs duration in the queue affects its priority (for FIFO this is the only factor)

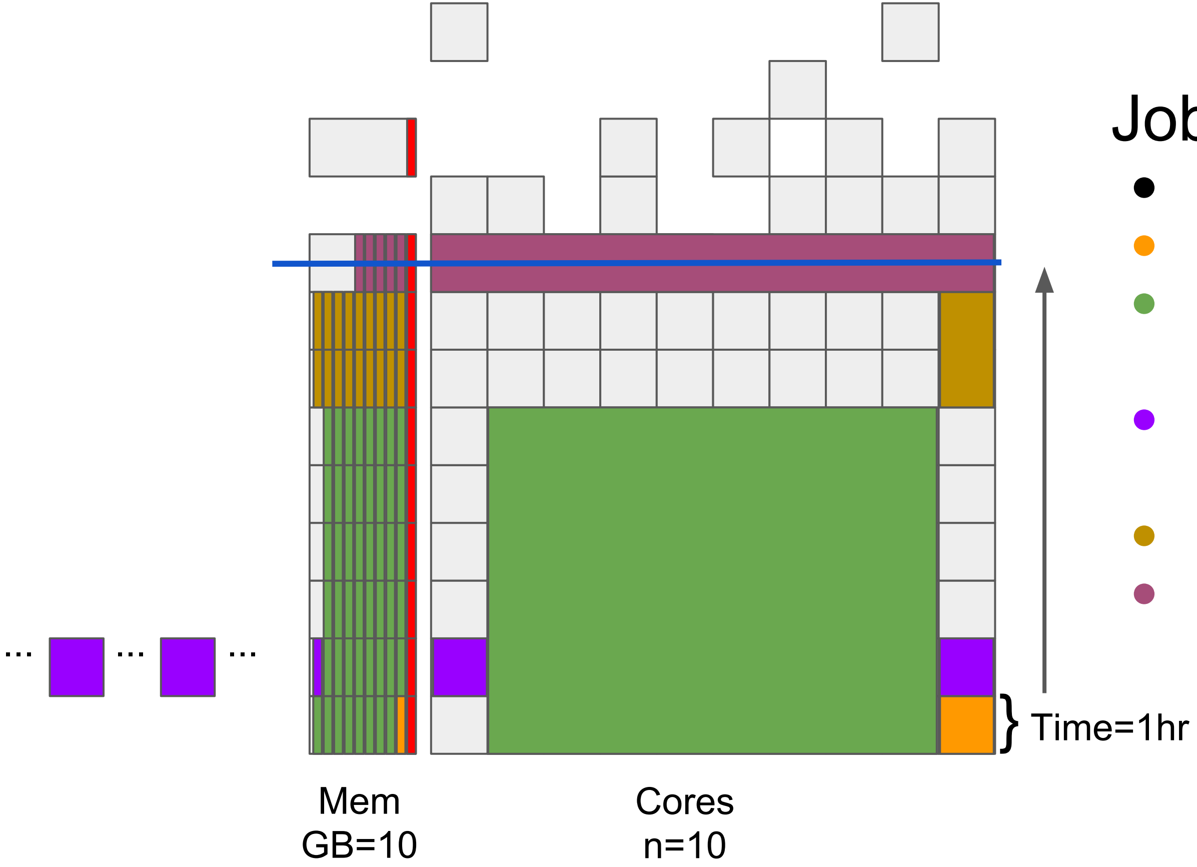
Fair-share

- An account’s past usage affects the priority of queued jobs

Partition

- The classification of node sets interacts with job size in determining priority

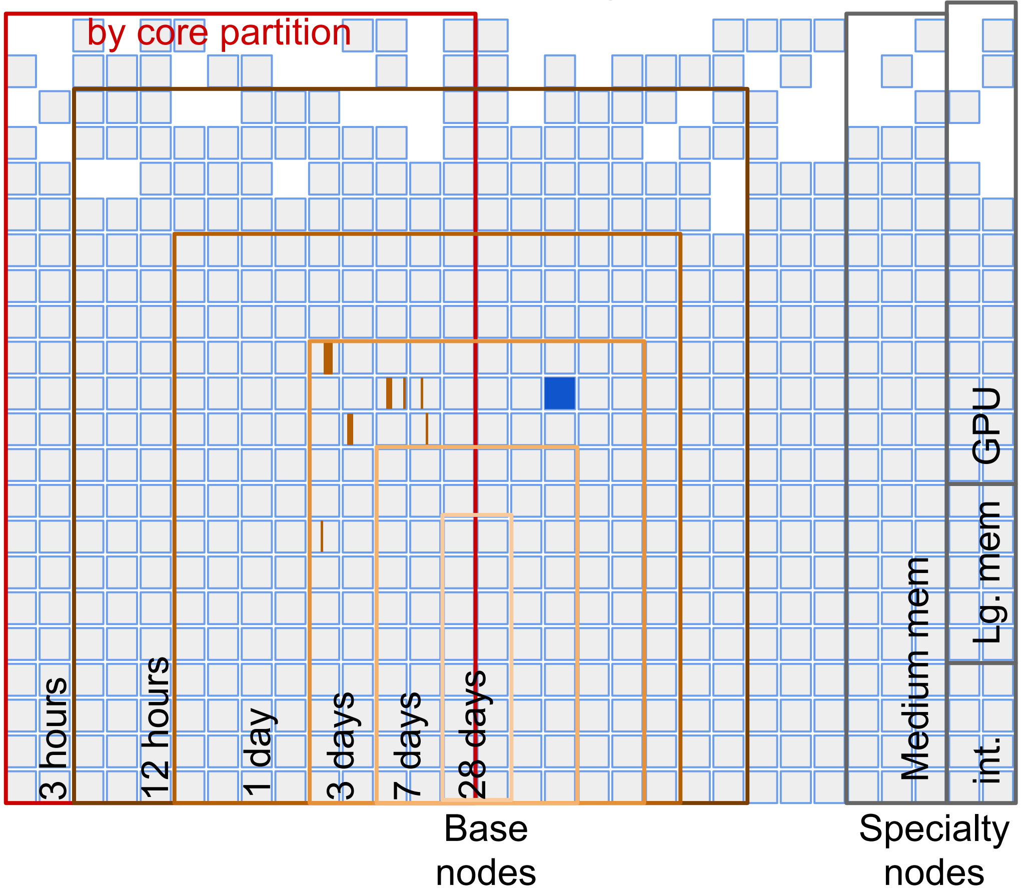
Job queue basics: factors that affect the order of jobs in queue (priority)



Job age

- FIFO (First In First Out)
- --time=1:00 --mem=1G
- --time=6:00 --mem=8G --cpu-per-task=8
- --time=1:00 --ntasks=8 --mem-per-cpu=400
- --time=2:00 --mem=9G
- --time=1:00 --ntasks=10 --nodes=1 --mem-per-cpu=400

Cluster resource basics: segmentation of nodes in the cluster (partitions)



Partitions

- By node vs by core
  - By node jobs can perform better
  - By core jobs have more opportunity to run
- --time=3-00:00 --ntasks=32 --nodes=1
- --time=3-00:00 --ntasks=32 --nodes=1

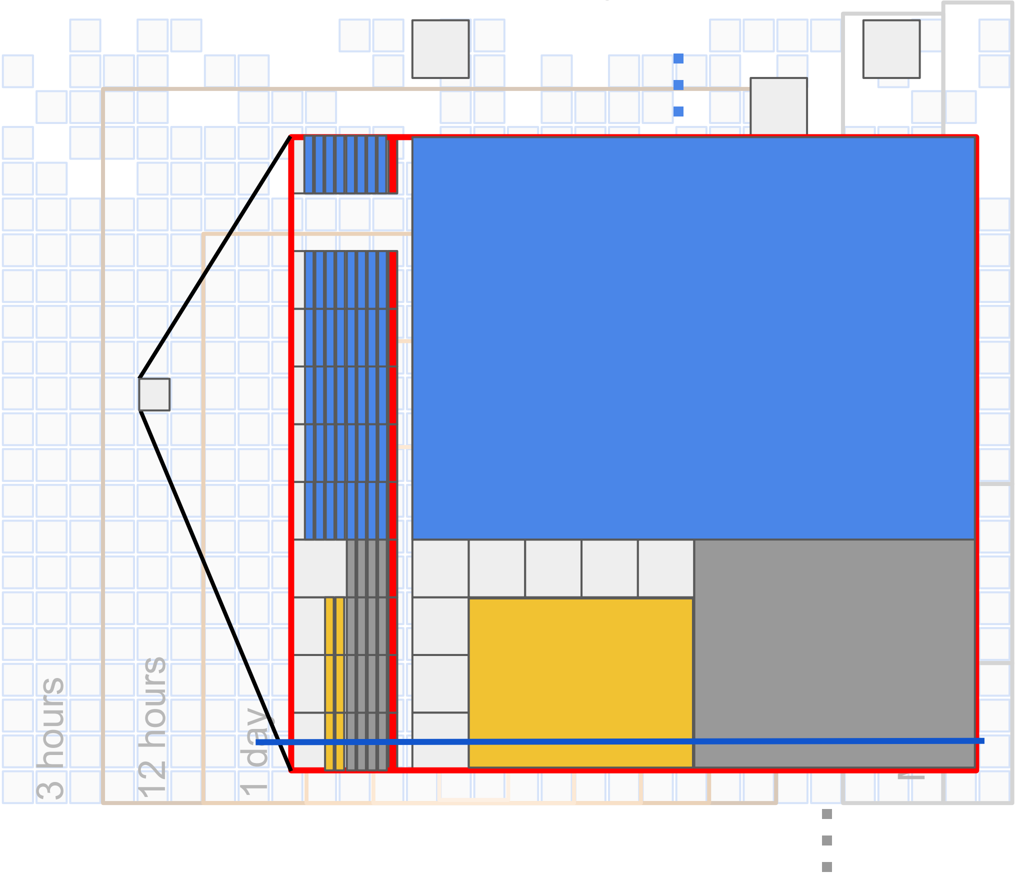
General purpose clusters

Traditionally SHARCNET systems were relatively homogeneous

The researcher chose a system based on fitting job resources to system specs

On Graham and Cedar the scheduler makes decisions about where a job runs on a heterogeneous system.

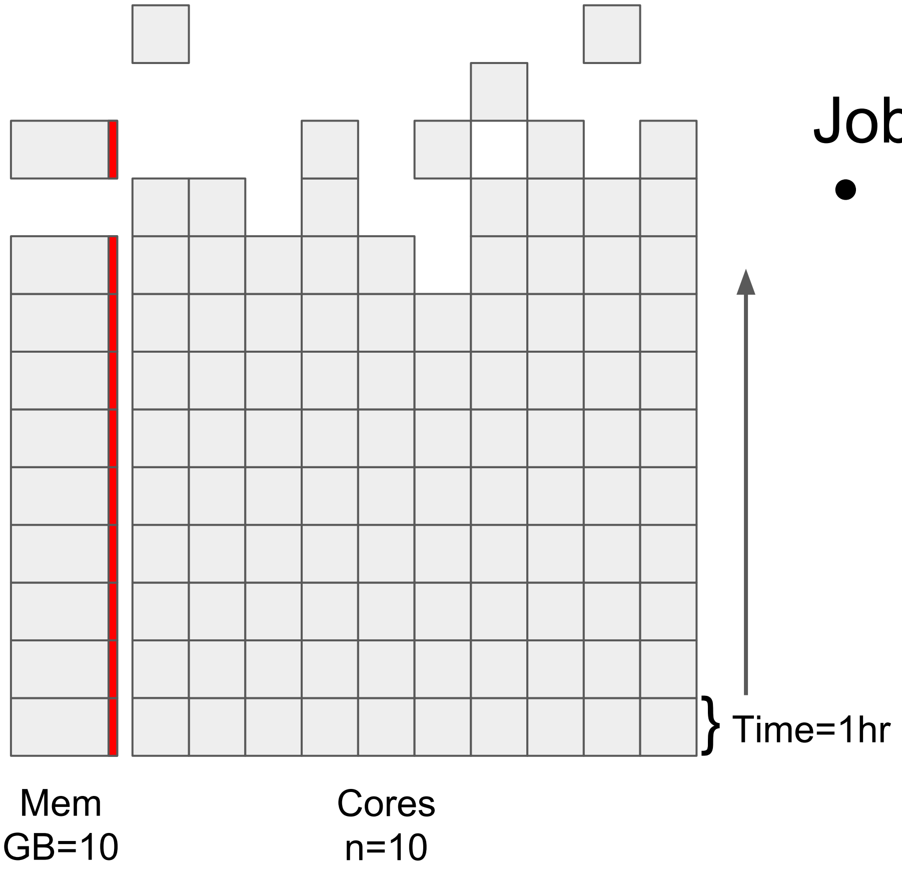
Cluster resource basics: segmentation of nodes in the cluster (partitions)



Backfill

- Running of lower priority jobs that can finish before any higher priority job can begin
- --time=12:00 --ntasks=1 --cpus-per-task=10 --mem=8G
- --time=12:00 --ntasks=1 --cpus-per-task=4 --mem=2G
- --time=3:00 --ntasks=1 --cpus-per-task=4 --mem=2G

Job queue basics: factors that affect the order of jobs in queue (priority)



Job age

- FIFO (First In First Out)