

# SLURM Version 2.2: Features and Release Plans

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## Agenda

- Major enhancements currently in version 2.2
- Additional features planned for version 2.2
- Release schedule for version 2.2
- SLURM plans for 2011 and beyond

## Major Enhancements to SLURM Version 2.2

- State preserved when upgrading from version 2.1 (including running jobs)
- Commands can operate between clusters
- Management added for generic resources
- Jobs can specify a time limit range
- Running jobs can decrease in size
- Major improvements for high throughput computing
- Additional partition states
- Added job submit plugin
- Job preemption more configurable
- Limit and QOS (Quality of Service) enhancements

## Major Enhancements to SLURM Version 2.2 (continued)

- Added *TotalView* support to attach to subset of tasks
- Many *sview* enhancements
- Many *DebugFlags* configuration parameters added
- Added support for user hold of jobs
- Consumable resources plugin modified to reduce fragmentation
- Queue or run time added to email notifications
- Jobs can specify multiple partitions (queues) and use the first available
- Test added for circular job dependencies
- Perl APIs available for SlurmDBD communications

## Major Enhancements to SLURM Version 2.2 (continued)

- Additional event triggers (by Bull)
  - Triggers for state changes in database, *SlurmDBD*, and *Slurmctld*

## Commands can Operate Between Clusters

- The client and server do not need to be running the same version of SLURM
- *SlurmDBD* required and must have the latest minor version (*slurmctld* v2.2.# requires *SlurmDBD* v2.2.#)
- The client and server do not need to be running on the same architecture (e.g. BlueGene and Cray or traditional Linux cluster)
- Use the `–clusters=<name>` or `–M <name>` option on SLURM commands. Default value is the current cluster.

## Commands can Operate Between Clusters (continued)

- Batch job will be sent to the one cluster with the earliest expected start time from the list of clusters specified. It will not migrate after job submission
- New *sbatch* option *-export* or *SBATCH\_EXPORT* environment variables control what environment variables get propagated
- There is currently NO spooling of files between clusters. Global file systems required for input files

## Management of Generic Resources (GRES)

- Generic resources can be defined on a per-node basis and consumed by jobs and job steps
- Generic resources can be associated with specific device files and (later) access controlled using *cgroups*
- The *gres/gpu* plugin currently controls access using an environment variable *CUDA\_VISIBLE\_DEVICES*



## Generic Resource Configuration and Use (example)

```
# slurm.conf (excerpt)
GresTypes=gpu
NodeName=linux[0-15] Sockets=4 CoresPerSocket=2 Gres=gpu:4
```

```
# gres.conf (from compute node)
Name=gpu File=/dev/nvidia[0-3]
```

```
# Launch batch job on one node with 4 CPUs and 2 GPUs
$ sbatch -N1 -n4 --gres=gpu:2 my.script
```

```
# Environment variable set for the batch job
CUDA_VISIBLE_DEVICES=0,1
```

## Jobs can Specify a Time Limit Range

- The *-time* or *-t* option specifies the maximum time limit
- A new option *-time-min* specifies the minimum acceptable job run time, default is same as *-time*
- Job will receive its maximum time limit unless reducing the time permits backfill scheduling to start it earlier
- The job's time limit does not change after starting execution (needed for jobs to calculate remaining time consistently)

## Running Jobs can Decrease in Size

- *scontrol* option to decrease a job's size by specifying a new node count or specific nodes to use
  - *scontrol update JobId=<id> NumNodes=<count>*
  - *scontrol update JobId=<id> NodeList=<names>*
- *scontrol* generates a script to be executed to reset job's environment variables

```
#bin/sh
# Do parallel work
srun my.work
# Release all but one node
scontrol update jobid=$SLURM_JOBID NumNodes=1
. slurm_job_${SLURM_JOBID}_resize.sh
srun my.post.processing
```

## Major Improvements for High Throughput Computing

- MySQL database restructured for 50 to 75% speedup
- Multiple job record send to *SlurmDBD* in single RPC
- General improvements in scheduling algorithms
- Additional *SchedulerParameters* for tuning
  - *Default\_queue\_depth* (default job count for scheduling, default is 100, previously no limit)
  - *Interval* (for *sched/backfill*, in seconds)
  - *Max\_job\_bf* (for *sched/backfill*, job count)
- *MinJobAge* parameter can now purge jobs more quickly

## Additional Partition States

State	Queue new jobs	Run queued jobs
Up	Yes	Yes
Down	Yes	No
Drain (new)	No	Yes
Inactive (new)	No	No

An *Alternate* partition parameter has also been added. Jobs submitted to a partition in *Drain* or *Inactive* state will automatically be transferred to the *Alternate* partition (if any).

## Added Job Submit Plugin

- Called by *slurmctld* daemon for each job submit or job modification call
- Can be used to customize environment by site or user
- Sample use:
  - Set default job partition (queue) based upon job characteristics

## Job Preemption More Configurable

- The mechanism used to preempt jobs can be configured on a per partition or per QOS (Quality Of Service)
- Sample configuration:
  - Jobs in standby QOS get requeued
  - Jobs in normal QOS get suspended and resumed

## Limit and QOS (Quality of Service) Enhancements

- *MaxCPUs*: Maximum number of CPUs any one job in this association can use
- *GrpCPUs*: Maximum number of CPUs all jobs in this association can use
- Default QOS per association
- Default account by cluster



## TotalView support to attach to subset of tasks

- Better scalability than attaching to all tasks
- Disable with *–disable-partial-attach* option to *configure* (build) script

## Many *sview* Enhancements

- Default configuration (preferences) saved in ~/.slurm/sviewrc file
- Switch between clusters viewed
- Select multiple jobs, partitions, etc.
- View database configuration
- Add and remove visible tabs
- Better highlighting of selected rows

## Many *DebugFlags* Added

- Generates detailed logging for specific sub-systems
  - *Backfill*: Backfill scheduling
  - *CPU\_Bind*: CPU binding details for job and steps
  - *Gang*: Gang scheduling
  - *GRES*: Generic Resources
  - *Priority*: Job priority calculation
  - *Reservation*: Advanced reservations
  - *Steps*: Resource allocation for job steps
  - *Triggers*: Event triggers
  - And many more

## Added Support for User Hold of Jobs

- Submit job using *sbatch* or *srun -hold* or *-H* option
- Hold and release using *scontrol* command
  - *scontrol hold <jobid>*
  - *scontrol release <jobid>*
- User can not release jobs held by system administrator
- Job *Reason* reported by *squeue* and *scontrol*
  - *JobHeldUser* if held by user
  - *JobHeldAdmin* if held by system administrator

## Reduced Fragmentation with Consumable Resources Plugin



- Old logic would identify nodes to use then evenly distribute tasks
- New logic packs allocation onto nodes (subject to job specifications). Idle resources normally located on one node



## Reduced Fragmentation with Consumable Resources Plugin

Example: Allocate 10 tasks on two node, each with 8 CPUS  
 New logic leaves unused resources all on one node

Node 0	Node 1
Task 0	Task 1
Task 2	Task 3
Task 4	Task 5
Task 6	Task 7
Task 8	Task 9
Unused	Unused
Unused	Unused
Unused	Unused

Node 0	Node 1
Task 0	Task 1
Task 2	Task 3
Task 4	Unused
Task 5	Unused
Task 6	Unused
Task 7	Unused
Task 8	Unused
Task 9	Unused

## Queue or Run Time Added to E-Mail Notifications

SLURM Job\_id=123 Name=my\_job Began, Queued time 01:23:45

SLURM Job\_id=123 Name=my\_job Ended, Run time 1-00:15:20

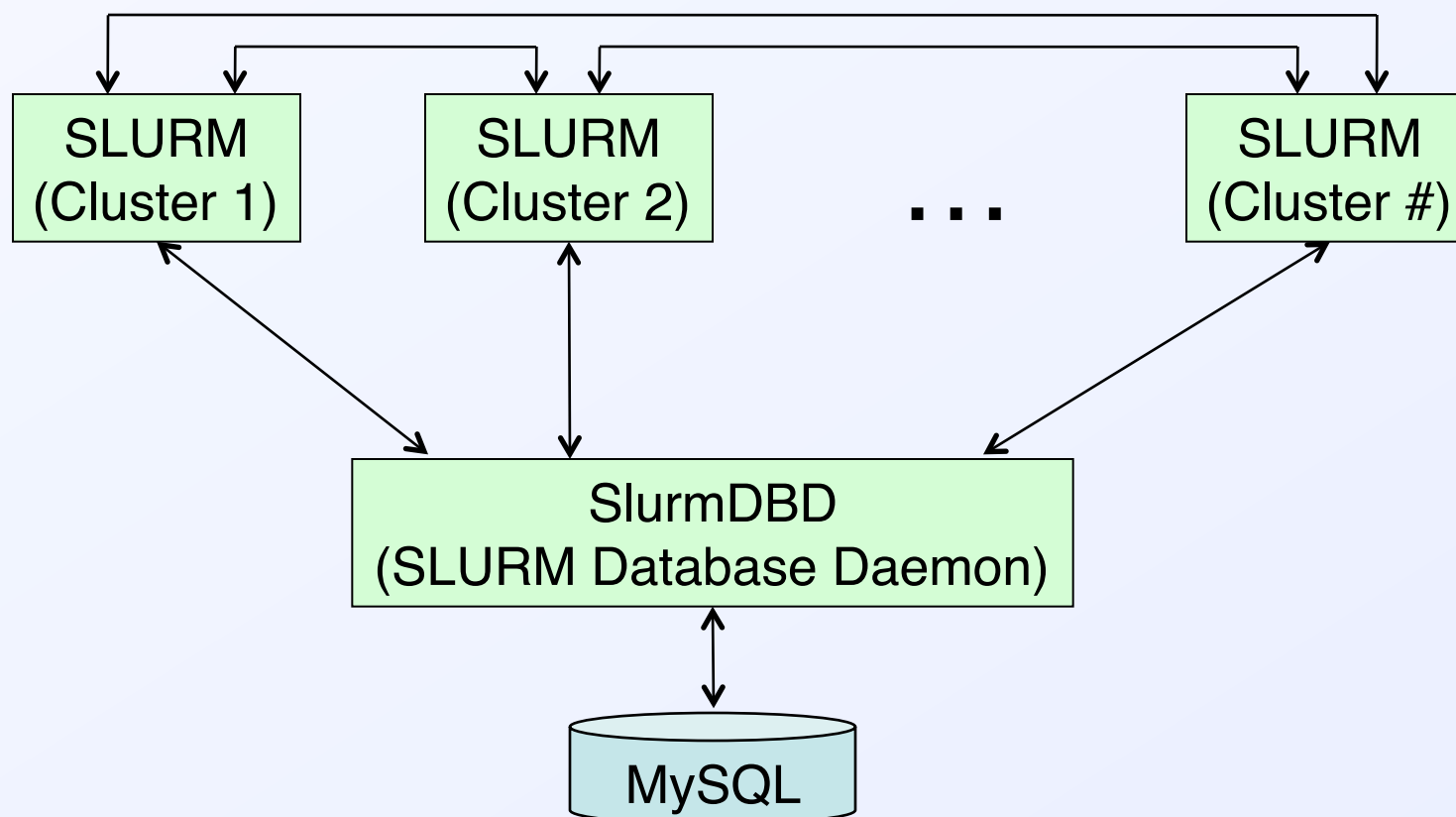
Time format:  
[days-]hours:minutes:seconds

## Release Schedule for Version 2.2

- Stop development in mid-October
- Spend late October, November and December testing
  - There should be a fairly stable version for SC10
- Release in December or when very stable



# SLURM Job Scheduling, Typical Version 2.2 Configuration



## Plans for 2011

- Release SLURM version 2.3 soon, about May 2011
- Support for Linux *cgroups* (job containers, by Bull)
  - Integrate with *PAM*
  - Integrate with generic resources (manage access to device files)
- Support for Cray XE and XT systems (by SCSC)

## Plans for 2011 at LLNL

- Focus at LLNL in 2011 on port to BlueGene/Q
  - 20 Pflops, 5-D torus interconnect
  - Completely new interface for managing network, booting nodes, etc.
- Enhanced permissions for operators and administrators (as configured in the database) not running as root
  - Cancel or requeue any user's job
  - Create, delete, or modify partitions
  - Create, delete, or modify reservation

## Areas of Interest, 2011 and Beyond

- Better fault tolerance for user applications (e.g. hot-spare nodes)
- Replace *mpirun* with *srun* on BlueGene systems
  - Uniform interface across architectures
- Faster task launch
  - In user space, without *slurmctld* daemon
- Support for running jobs to grow in size

## Areas of Interest, 2011 and Beyond (continued)

- Advanced resource reservation enhancements
  - Topology aware resource reservation
  - Better integration with gang scheduling
  - Query to identify where and when reservations can be created
  - Floating reservations (start early if possible)
- Integrate license management with FlexLM
- Better checkpoint/restart integration for fault tolerance

## Areas of Interest, 2011 and Beyond (continued)

- Better enterprise-wide job scheduling
  - Job migration for workload changes
  - Cross-cluster file spooling

## Questions and Comments?

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