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 *Slurmctl*
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 command line or SLURM_CLUSTERS environment variable. Default value is the current cluster.
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

- \textit{scontrol} option to decrease a job’s size by specifying a new node count or specific nodes to use
  - \textit{scontrol update JobId=<id> NumNodes=<count>}
  - \textit{scontrol update JobId=<id> NodeList=<names>}

- \textit{scontrol} generates a script to be executed to reset job’s environment variables

```bash
#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

<table>
<thead>
<tr>
<th>State</th>
<th>Queue new jobs</th>
<th>Run queued jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Down</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Drain (new)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Inactive (new)</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

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

- Plugin has C or LUA (script) interface
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
  - *CPUBind*: 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 `srund` `--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
Example: Allocate 10 tasks on two nodes, each with 8 CPUs. New logic leaves unused resources all on one node.

<table>
<thead>
<tr>
<th>Node 0</th>
<th>Node 1</th>
<th>Node 0</th>
<th>Node 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 0</td>
<td>Task 1</td>
<td>Task 0</td>
<td>Task 1</td>
</tr>
<tr>
<td>Task 2</td>
<td>Task 3</td>
<td>Task 2</td>
<td>Task 3</td>
</tr>
<tr>
<td>Task 4</td>
<td>Task 5</td>
<td>Task 4</td>
<td>Unused</td>
</tr>
<tr>
<td>Task 6</td>
<td>Task 7</td>
<td>Task 5</td>
<td>Unused</td>
</tr>
<tr>
<td>Task 8</td>
<td>Task 9</td>
<td>Task 6</td>
<td>Unused</td>
</tr>
<tr>
<td>Unused</td>
<td>Unused</td>
<td>Task 7</td>
<td>Unused</td>
</tr>
<tr>
<td>Unused</td>
<td>Unused</td>
<td>Task 8</td>
<td>Unused</td>
</tr>
<tr>
<td>Unused</td>
<td>Unused</td>
<td>Task 9</td>
<td>Unused</td>
</tr>
</tbody>
</table>
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

- Development stopped in early November

- Spend late October, November and December testing
  - There is a fairly stable version available now
  - http://sourceforge.net/projects/slurm/files/under_development/

- Release in December or when very stable
SLURM Job Scheduling, Typical Version 2.2 Configuration

- SLURM (Cluster 1)
- SLURM (Cluster 2)
- SLURM (Cluster #)
- SlurmDBD (SLURM Database Daemon)
- MySQL
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 CSCS)
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
Better enterprise-wide job scheduling
  • Job migration for workload changes
  • Cross-cluster file spooling
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