Slurm Burst Buffer Support

Tim Wickberg (SchedMD LLC)

SC15

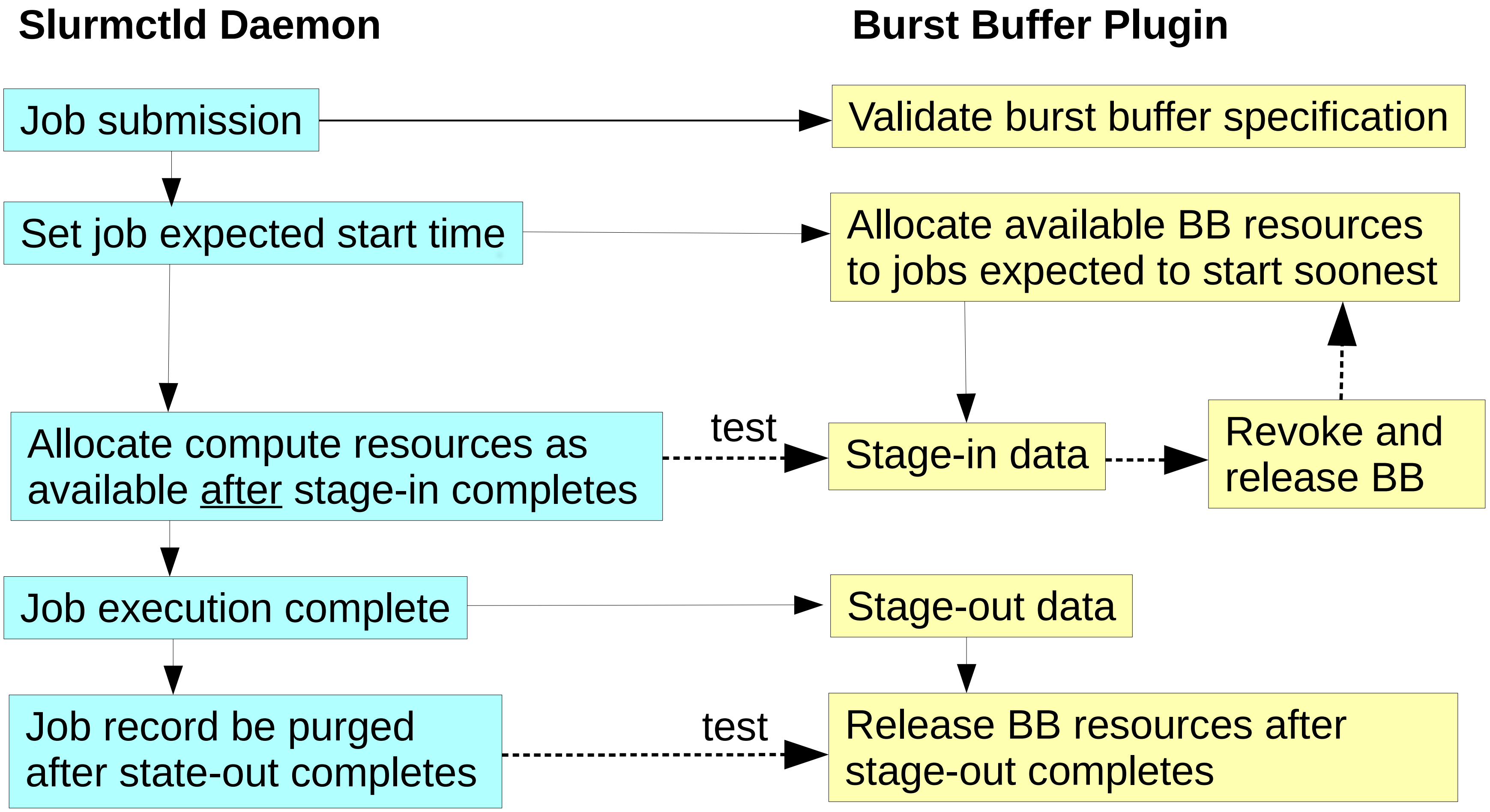
Burst Buffer Overview

- A cluster-wide high-performance storage resource
- Burst buffer (BB) support added Slurm version 15.08
- Two types of BB allocations:
  - Persistent allocations used by multiple jobs or
  - Job allocations associated with a specific job
- BB allocations can exist before, during and/or after a job allocation of compute resources
  - Used to stage-in data, scratch storage, and/or stage-out data

Workflow

- Job submission specifies burst buffer requirements, validated at submit time
- Slurm allocates available burst buffer resources to the jobs expected to start soonest (allocations may later be revoked for higher priority job)
- Stage-in of files begins
- Compute nodes may be allocated <u>after</u> stage-in of files completes
- Stage-out of files begins upon completion of computation
- Job record may be purged <u>after</u> stage-out of files completes

Workflow



Slurmctld Daemon

Burst Buffer Plugin

Job submission

Validate burst buffer specification

Set job expected start time

Allocate available BB resources to jobs expected to start soonest

Allocate compute resources as available after stage-in completes

test

Stage-in data

Revoke and release BB

Job execution complete

Stage-out data

Job record be purged after state-out completes

test

Release BB resources after stage-out completes

Workflow

- If burst buffer operation fails after job submission (e.g. file staging error) the job will be HELD and it's “Reason” field set to the error message from the API underlying the plugin
- New wait reasons
  - BurstBufferResources – Waiting for allocation of burst buffer
  - BurstBufferStageIn – Waiting for stage-in to complete
- New job error codes
  - ESLURM_BURST_BUFFER_PERMISSION - Burst Buffer permission denied
  - ESLURM_BURST_BUFFER_LIMIT - Burst Buffer resource limit exceeded
  - ESLURM_INVALID_BURST_BUFFER_REQUEST - Burst Buffer request invalid

Slurm Plugins

- Implemented using Slurm plugins to support various infrastructures
  - Cray – Uses Cray-specific APIs
    - BB is known as DataWarp on Cray systems
  - Generic – Uses generic scripts to manage burst buffers
- Slurm development stages
  - Generic plugin developed first
  - Cray plugin developed later, based upon generic plugin and required substantial changes to infrastructure
  - Generic plugin currently requires some updates

Burst Buffer Directives

- For batch jobs, specified as comments in the script
  - "#BB" prefix for generic plugin directives
  - "#DW" prefix for Cray DataWarp directives
    - Exception: Use "#BB" prefix to create/delete persistent burst buffers, operation not supported by Cray "#DW" directives
- For interactive jobs
  - Use "--bbf" option to specify path of file with same directives as batch job
  - Use "-bb" option to specify simple inline directives

Batch Job Examples

```
#!/bin/bash
# Allocate 100GB, stage-in one file, then stage-out one file
#DW jobdw capacity=100GiB type=scratch access_mode=striped,private
#DW stage_in type=file source=/home/my/input destination=/ss/input
#DW stage_out type=file source=/ss/output destination=/home/my/output
a.out
```

```
#!/bin/bash
# Allocate 2GB per compute node
#DW jobdw swap 2GiB
a.out
```

Interactive Job Examples

```
$ srun -bbf=bb.spec -N2 a.out
$ cat bb.spec
#DW jobdw capacity=100GiB type=scratch access_mode=striped,private
#DW stage_in type=file source=/home/my/input destination=/ss/input
#DW stage_out type=file source=/ss/output destination=/home/my/output
```

```
$ salloc --bb=”capacity=100g” -N2 a.out
```

```
$ salloc –bb=”swap=2g” -N2 a.out
```

NOTE: Slurm supports file staging for both batch and interactive jobs

Persistent Buffer Examples

```
#!/bin/bash
# Allocate 48GB persistent burst buffer
#BB create_persistent name=my_database capacity=48GB access=striped type=scratch
```

```
#!/bin/bash
# Use existing persistent burst buffer
#DW persistentdw name=my_database
a.out
```

```
#!/bin/bash
# Destroy the persistent burst buffer
#BB destroy_persistent name=my_database
```

Persistent Buffers

- The ability for normal user's to create persistent buffers through Slurm is configurable, disabled by default
  - See “Flags=EnablePersistent” in burst_buffer.conf
- Slurm polls system state and recognizes when persistent buffers are created or deleted
  - Changes to buffers made outside of Slurm (e.g. using DataWarp commands directly) are reflected in the accounting based upon the user's default account and QOS
  - Changes in the total burst buffer space are also accounted for (e.g. in case of failures)

Failure Management

- Persistent burst buffers will be created prior to a job beginning execution
  - Persistent burst buffers will not be destroyed even if a job is canceled prior to initiation (other jobs could have started to use them)
- Job-specific burst buffers will be staged-out only if a job starts running
  - Job-specific burst buffers will be staged-out even if the job failed, timed-out, was canceled from a running state, etc.
  - Job-specific burst buffers will be deleted without file staging if a job is canceled prior to initiation (no new data is generated if the job never starts)

Status Commands

- Current BB status visible using the sview and scontrol commands

```
$ scontrol show burst
Name=cray DefaultPool=dwcache Granularity=1GB TotalSpace=50GB UsedSpace=42GB
  StageInTimeout=60 StageOutTimeout=60 Flags=EnablePersistent
  AllowUsers=alan,brenda,charles
  GetSysState=/home/jette/Desktop/SLURM/install.linux/sbin/dw_wlm_cli
  Allocated Buffers:
    JobID=1234 CreateTime=2015-08-28T11:46:20 Size=4G State=allocated UserID=alan(1000)
    JobID=1236 CreateTime=2015-08-28T11:48:20 Size=8G State=allocated UserID=brenda(1001)
    Name=my_db CreateTime=2015-08-28T11:46:20 Size=30G State=allocated UserID=alan(1000)
  Per User Buffer Use:
    UserID=alan(1000) Used=34G
    UserID=brenda(1001) Used=8G
```

By Slurm convention: Job buffers have numeric name
Persistent buffer names start with a letter

Slurm Configuration: slurm.conf

- New *slurm.conf* options:
  - BurstBufferType – Defines the plugins to use, multiple BB plugins can be used on the same cluster
  - DebugFlags=BurstBuffer – Generates detailed logging of BB actions

Slurm Configuration: burst_buffer.conf

- New *burst_buffer.conf* file
  - May alternately be named with a specific BB plugin name (e.g. “*burst_buffer_cray.conf*”)
- In the same directory as the *slurm.conf* file
- Contains BB-specific options
  - Script/API location
  - Timeouts
  - Access controls (Allow/Deny users)
  - See “man burst_buffer.conf” for details

Advanced reservations

- Burst buffer resources can be reserved at specific times for specific users/groups
    - Ensure that burst buffers are available for critical uses
    - Optionally associated with specific compute nodes

Trackable Resource (TRes)

- Burst buffers are fully supported as a trackable resource
  - A job's burst buffer space requirements can be a factor in computing its priority
  - A job's burst buffer space consumption can be a factor in its fair-share usage calculation or changes
  - Burst buffer space consumption can be limited by association

Cray DataWarp Note

- Job requesting burst buffers will be allocated whole nodes only, not individual CPUs
  - Slurm implicitly sets job's –exclusive option
- DataWarp plugin finished
  - NERSC testing now on new Cori (XC40) system

Generic Implementation

- “Burstbuffer/Generic” plugin in progress
  - Minimal version in 15.08 now
  - Full version hopefully ready in 16.05 release
- Hooks to site-provided scripts to setup, stage-in/out data, mount filesystems, and tear-down allocated BB resources

Questions?