Instrumenting Slurm User Commands to Gain Workload Insight

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Motivation

• Need to understand factors influencing job execution and success/failure
• Multiple ways users can specify job requirements
• Many different workloads of varying complexity
• Automated analysis to root cause job failures

• Challenges
  – Instrumenting data sources of user activities
  – Automated collection and processing of user data from compute nodes
**Slurm Batch Jobs**

- **User submits job on external login nodes with `sbatch`**
- **Batch script is executed on a compute node in the job allocation**
- **`srun` launches the parallel application**
  - `srun` itself only executes on the job head node
Slurm Interactive Jobs

- "salloc" on elogin proxies user to internal mom node
- `salloc` on mom node obtains compute allocation and launches one node `srun` to launch interactive shell
- `srun` launches the parallel application
  - `srun` itself only executes on the job head node
Example script

- **test.sh:**

```bash
#!/bin/bash
#SBATCH -p regular
#SBATCH -t 5:00:00
#SBATCH --constraint=haswell

srun ./my_openmp_app "$@
```

- **Execution:**

```
sbatch -N 5 --reservation=dmj test.sh input.
```
Analysis of the example

• **Script makes it clear that the user requested**
  – the **regular** partition
  – a **5 hour** time limit
  – **haswell** nodes.

• **Issues**
  – The number of nodes, reservation, and script arguments are not recorded in the script.
  – It appears to be an openmp application, was `$OMP_NUM_THREADS` set? `cpu_binding` style?
  – Debugging this user’s experience will rely somewhat on their memory of the job submission.
Monitoring Slurm Data

• **Needed Data beyond the Slurm Database**
  
  – slurmcld data structure representations of job/step data
    
    • jobcomp/nersc
  
  – capturing and logging all job and step submissions options, including aspects of the environment
    
    • cli_filter *(this topic)*
  
  – jobacctgather profiling data *(site enforced)*
    
    • need more scalable backends, hdf5 file per node per job doesn’t scale well
    
    • 2018 NERSC priority
Instrumenting Slurm Commands

cli_filter

- new stackable plugin infrastructure
- adds hooks to allow site-definable, configurable behavior for
  - `salloc`
  - `sbatch`
  - `srun`
  - `sbcast` (limited support)
cli_filter setup_defaults()

• setup_defaults
  – Runs once per cli_filter plugin per CLI execution
  – Non-zero exit will terminate the CLI execution
  – Runs after opt data structure allocation and initialization, before environment or option processing
  – Run long-running checks exactly once

• Implementations
  – cli_filter/user_defaults reads ~/.slurm_defaults to set options
  – cli_filter.lua to set site default options
cli_filter/user Defaults

- Set defaults command line options in $HOME/.slurm_defaults. Accepts (?:)(?:) = syntax.
- $HOME/.slurm_defaults example:

```plaintext
partition = regular
cori:constraints = knl,quad,cache
edison:constraints = ivybridge
salloc::*:gos = premium
```
• **pre_submit**
  – Runs once per job-pack per cli_filter plugin per CLI execution
  – Non-zero exit will terminate CLI execution
  – Runs after all option processing but before slurmctld message preparation (can change options here)

• **Implementations**
  – cli_filter/lua plugin can be used to read options, implement policy, change options or terminate job submission
function slurm_cli_pre_submit(cli_type, options)
  -- dangerous to run on controller node, may get stuck if PFS misbehaving
  local fs_quota_auth = os.execute("/usr/bin/myquota -c")
  if fs_quota_auth ~= 0 then
    slurm.log_error("ERROR: in violation of quota limits. " ..
      "Job submission disabled."")
    return slurm.ERROR
  end
  -- TODO: check options['workdir'] to check aux filesystem quotas

  if cli_type == CLI_ALLOC and options['qos'] ~= nil
    and options['qos'] == "interactive" then
    options['immediate'] = 30
  end

  local balance = io.popen("/something/to/get/external/accounting")
  local time_requested = calculate_time(options)
  if balance > time_requested and not options['parsable'] then
    slurm.log_info("WARNING: Low on allocation, your job moving to scavenger")
  end
  return slurm.SUCCESS
end
**cli_filter post_submit()**

- **post_submit**
  - Runs once per job-pack per cli_filter plugin per CLI execution
  - Non-zero exit will attempt to terminate job (invalid for `sbatch`)
  - Runs after all option processing but before `slurmctld` message preparation (can change options here)

- **Implementations**
  - cli_filter/lua plugin can get data and log it cli_filter/syslog dumps json record of submission to syslog
cli_filter/syslog Example output

Sep 22 22:08:49 slurmd ev srun/syslog[24345]: post_submit: 
{"job_id":182,"accel_bind":
"alloc_nodelist":"slurmd","allocate":"false",
"argc":"1","argv":"hostname",
"bcast_flag":"false","begin":"0","ckpt_dir":"/var/slurm/checkpoint",
"ckpt_interval":"0","cmd_name":"hostname","compress":"0",
"contiguous":"false","core_spec":65534,
"core_spec_set":"false","cores_per_socket":-2,
"cpu_bind_type":0,"cpu_bind_type_set":"false",
"cpu_freq_gov":4294967294,"cpu_freq_max":4294967294,
"cpu_freq_min":4294967294,"cpus_per_task":0,"cpus_set":false,"cwd":"/home/
"cwd_set":"false","deadline":"0","debugger_test":"false",
"delay_boot":4294967294,"disable_status":"false",
"distribution":1,"egid":-1,"euid":-1,
"exclusive":false,"extra_set":false,"gid":100,
"hint_set":false,"hold":false,"immediate":0,
"job_flags":0,"job_name":bash,"job_name_set_cmd":false,
"job_name_set_env":true,"jobid":182,"jobid_set":false,
"join":false,"kill_bad_exit":-2,"labelio":false,
"launch_cmd":false,"mail_type":0,"max_exit_timeout":60,
"max_launch_time":0,"max_nodes":1,"max_threads":60,
"max_wait":0,"mem_bind_type":0,"mem_per_cpu":-2,
"min_nodes":1,"msg_timeout":10,"multi_prog":false,
"multi_prog_cmds":0,"network_set_env":false,"nice":-2,
"no_alloc":false,"no_kill":false,"no_rotate":false,
"nodes set":true."nodes_set_env":true"}
Use Case 1: ALTD runtime library tracking

- **cli_filter/lua allows the runtime library tracking**
  - Automatic Library Tracking Database (ALTD) is used to track the library usage at NERSC by wrapping the ld (linker) and srun (job launcher) commands at compile and runtime. However, wrappers are often not desirable, especially at runtime.

```shell
a.zz217@cori11:~/tests> objdump -s -j .altd a.out

Contents of section .altd:

0000 414c5444 5f4c696e 6b5f496e 666f0000  ALTD_Link_Info..
0010 00000000 00005665 7273696f 6e3a322e  ......Version:2.
0020 303a004d 61636869 6e653a63 6f72693a 0:.Machine:cori:
0030 00546167 5f69643a 39653131 35313965 .Tag_id:9e11519e
0040 2d303165 2d343337 392d6137 652d301e -301e-4379-a76e-30
0050 66346265 3636144a 12a005965 .Ye
0060 61723a32 30318a00 00000000 00000000 ar:2018:........
0070 414c5444 5f4c696e 6b5f496e 666f5f45 ALTD_Link_Info_E
0080 6e6400  nd.
```

Just need to collect the **Tag_id**.
Use case 2: Application workload analysis

• **cli_filter/syslog** used to get the detailed workload analysis for all `srun/sbatch/salloc` executions
  – Slurm can track the application names that are run with the `srun`, however, it is often desirable to know more details about how the applications are used, e.g., what are the most commonly used code paths, which provides developers with a more targeted code optimizations

• **cli_filter/lua** used to collect workload-specific data
  – e.g., VASP, we can collect its input control files (not atomic positions), to find out the commonly used job types (code paths) to guide the application readiness effort for the developers.
Gathering Data via LLM

- elogin nodes
- service/mom nodes
- tier2 nodes
- tier1 nodes
- SMW
- Log
- External RabbitMQ
Service Node add /var/spool/rsyslog/local-rules/ruleset.conf

### Direct SlurmCli Syslog
$RuleSet rule.slurmcli.syslog
$MainMsgQueueFileName slurmcli_syslog
$MainMsgQueueDiscardMark 880000
$MainMsgQueueHighWatermark 660000
$RulesetCreateMainQueue on
$IncludeConfig /var/spool/rsyslog/local-rules/always.conf
$IncludeConfig /var/spool/rsyslog/local-rules/rule.slurmcli.syslog.conf
$IncludeConfig /var/spool/rsyslog/rsyslog-forward.conf
$IncludeConfig /var/spool/rsyslog/rsyslog-options.conf
*.* -?file-userslurm;format-rfc5424
$InputPTCPServerBindRuleset rule.slurmcli.syslog
$InputPTCPServerRun 5187
$InputUDPServerBindRuleset rule.slurmcli.syslog
$UDPServerRun 5187
Setting up LLM Rules

SMW add `/var/spool/rsyslog/local-rules/main.conf`

```
$template file-slurmcli, "/var/opt/cray/log/%MSGID%/slurmcli/%APP-NAME%-%$YEAR%$MONTH%$DAY%"

if $structured-data == '[slurmcli@34]' then
  -?file-slurmcli;format-message

& stop
```
Using LLM

Have cli_filter plugins use script to:

- On elogin, use syslog
- On service node, use syslog
- On compute, send UDP message to randomly selected tier2 node on configured LLM port

RFC 5424 formatted message like:

<34>1 2018-05-24T00:51:15.003Z c0-0c0s1n1 altd 42 bootsession [slurmcli@34] test userslurm message
Future Work

- **Upcoming**
  - Working with SchedMD to explore cli_filter merge options
  - Finish modeling work on test system
  - Export via rsyslog to site data collect (RabbitMQ)