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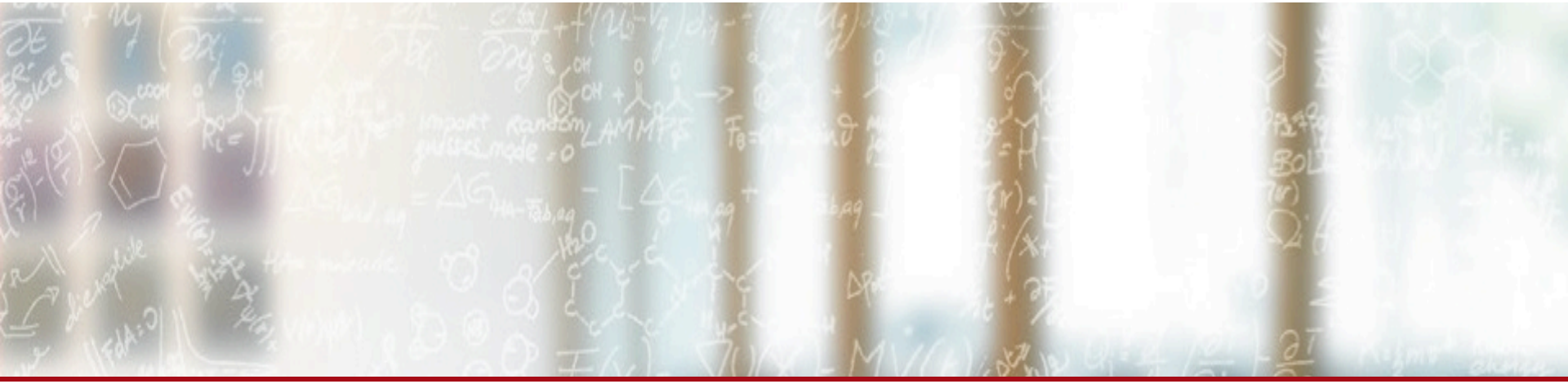

# Tuning Slurm the CSCS way

Slurm User Group 2018

Miguel Gila, CSCS

September 26, 2018

# Three things we do a bit differently

1. RM-Replay
2. GPU Reporting with Slurm
3. Slurm command logging

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To be published during SC18

# RM-Replay: A High-Fidelity Tuning, Optimization and Exploration Tool for Resource Management

Maxime Martinasso, CSCS

https://github.com/eth-cscs/slurm-replay

# RM-Replay

- Like probably every other HPC center out there, we **always** have (recurrent) users complaining about this:
  - “Why are there available nodes and my jobs are not running??”

- Well, you can’t satisfy everyone, but you sure can tune the configuration to be more *effective* in keeping users happier

- Of course, this also depends on users doing something on their side. But that’s a different story...

# RM-Replay

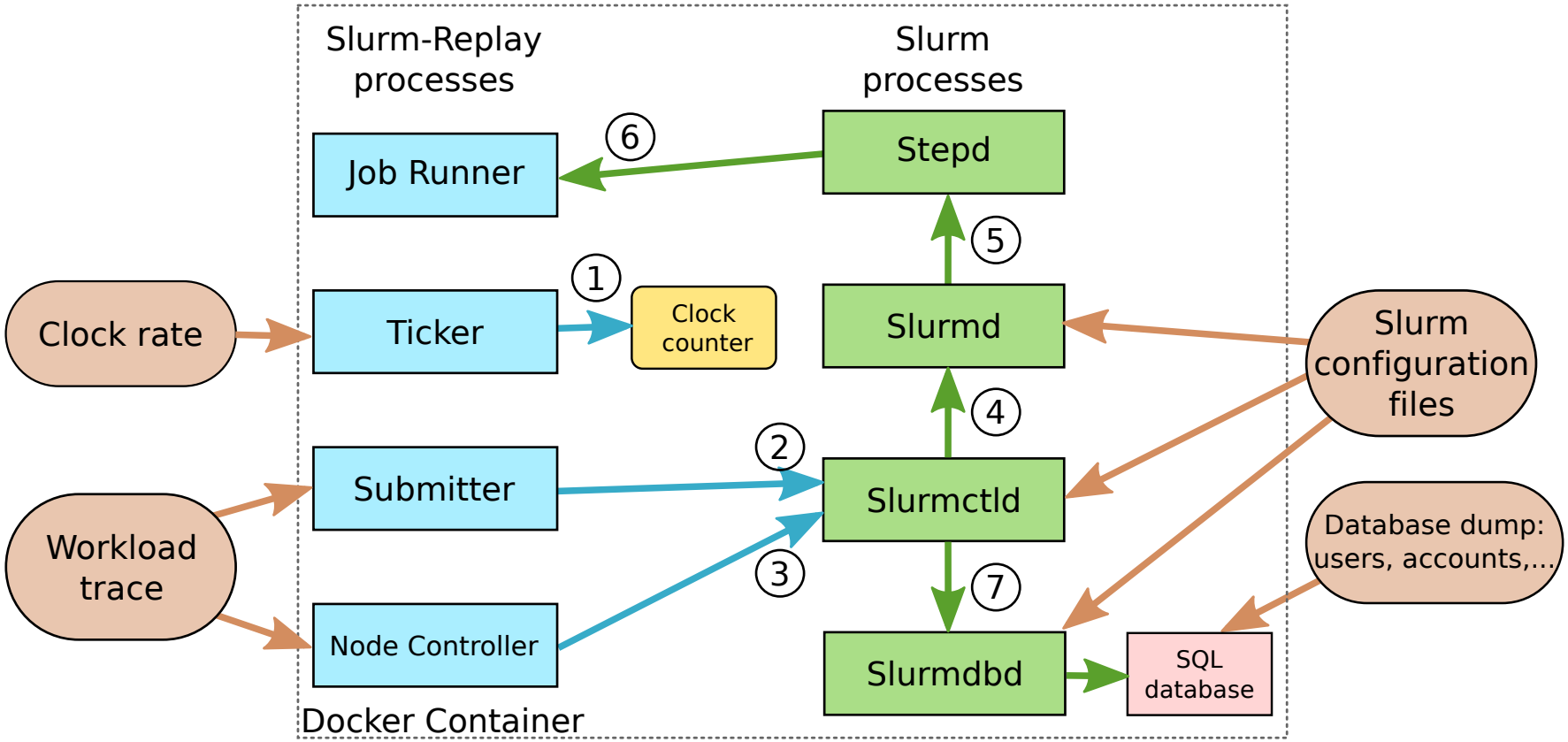
- How can you evaluate changes in the Slurm configuration and how they affect scheduling and the usage of the machine?

- RM-Replay can replay the submissions done in a period of time and give you an estimation of how busy the machine would have been with the new settings, compared to the original configuration

- Built as a Docker container. Can naturally be executed in Shifter

- With a clever approach it uses unmodified Slurm source code with a few additions to re-play scheduling much faster than real time

# How does it work?



# How do you use it?

**Generate job dependencies**

```
$ python ./extractlog.py > daint_jobdependency.txt
```

**Create workload off slurmDBD**

```
$ submitter/./trace_builder_mysql -p XXX -u YYY -s '2018-01-01 01:00:00' \
-e '2018-01-01 01:30:00' -d slurmZZZ  -h AAA.BBB.com -P 1234 -c daint \
-x daint_jobdependency.txt -f daint.20180101T010000_20180101T013000.trace
```

**Get a unmodified SlurmDBD dump**

```
$ mysqldump -u XXX -p -P 1234 -h AAA.BBB.com slurmZZZ acct_table acct_coord_table \
qos_table tres_table user_table daint_assoc_table > slurmdb_tbl_slurm-17.02.9.sql
```

**Run the replay within the container**

```
$ docker run --rm -it --volume /mydir/data:/replayuser/data \
mmxcscs/slurm-replay:replayuser_slurm-17.02.9
$ ./start_slurm.sh -w ..data/daint.20180101T010000_20180101T013000.trace \
-r 0.05 -n SR1
```

**Analyz**

```
./trace_metrics -w replay.daint.20180101T010000_20180101T013000.trace -r 1
Range: min_start=1514761200 [0,1] start_range=1514761200 end_range=1514764800 all=583 preset=529 (otherp=1)

[ALL=583] Makespan=3600 Util=0.83171724 Avg_Wait=(568.30769231,3754.01788857,13,207,1467,6.6056)
Dispersion=0.13148193 Slowdown=0.00188138 Throughtput=271

[MC=176] Makespan=3600 Util=0.50134048 Avg_Wait=(135.09523810,405.52628944,21,207,669,3.0018)
Dispersion=0.24988875 Slowdown=0.00772033 Throughtput=26

[GPU=406] Makespan=3600 Util=0.94495123 Avg_Wait=(175.03846154,760.43499697,26,635,1467,4.3444)
Dispersion=0.18711216 Slowdown=0.00270158 Throughtput=245
```

# How do we want to use it?

- During development, we've used the tool to identify two important points:
  - Using the **switch** options increases the fragmentation of the schedule reducing by 10% the job throughput
  - When users provide a better **runtime** accuracy of their jobs, this decreases the likelihood that their jobs will have a long waiting time in the queue
- Ideally, an auto-tuning framework could potentially make use of this tool in order to automatically configure Slurm and react to change in the job mix
- But for now the plan is to put this on a dedicated system and use it analyze major changes to our configuration and what-if scenarios

# GPU Reporting[*]

[*] Also presented by Nick Cardo at the Cray User Group 2018

# Describing the problem

- A batch job is submitted to a compute node containing a GPU
  - Did they utilize the GPU or just the node's processor?
- Easy to tell if a GPU was requested
  - Can check GRES
  - Can check node name
- Hard to tell if a GPU was used from existing accounting
- How to report GPU usage in a meaningful way?

# Available tools

- **nvidia-smi**

```
Nid00032: > nvidia-smi -q -d accounting

==============NVSMI LOG==============

Timestamp                           : Thu May 17 11:52:07
2018
Driver Version                      : 384.111

Attached GPUs                       : 1
GPU 00000000:02:00.0
    Accounting Mode                 : Enabled
    Accounting Mode Buffer Size     : 1920
    Accounted Processes
        Process ID                  : 10757
            GPU Utilization         : 0 %
            Memory Utilization      : 0 %
            Max memory usage        : 291 MiB
            Time                    : 272 ms
            Is Running              : 0
        Process ID                  : 15098
            GPU Utilization         : 71 %
            Memory Utilization      : 5 %
            Max memory usage        : 289 MiB
            Time                    : 25194 ms
            Is Running              : 0
        Process ID                  : 15125
            GPU Utilization         : 93 %
            Memory Utilization      : 6 %
            Max memory usage        : 289 MiB
            Time                    : 91777 ms
            Is Running              : 0
        Process ID                  : 4448
            GPU Utilization         : 93 %
            Memory Utilization      : 6 %
            Max memory usage        : 0 MiB
            Time                    : 91899 ms
```

- **RUR**
  - Tool present only on Cray systems
  - Can be used to aggregate data coming from different plugins, including GPU counters
  - Needs modifications to be used with native Slurm and not ALPS

- **Slurm prolog/epilog**
  - Used to call Cray RUR to start/stop counter collection

# How to store data in a meaningful way?

- Store data in Slurm job accounting record
  - Keeps all job data together, no separate database or utilities
  - Reuse an existing text field – *AdminComment*
  - Use JSON format to store multiple pieces of data

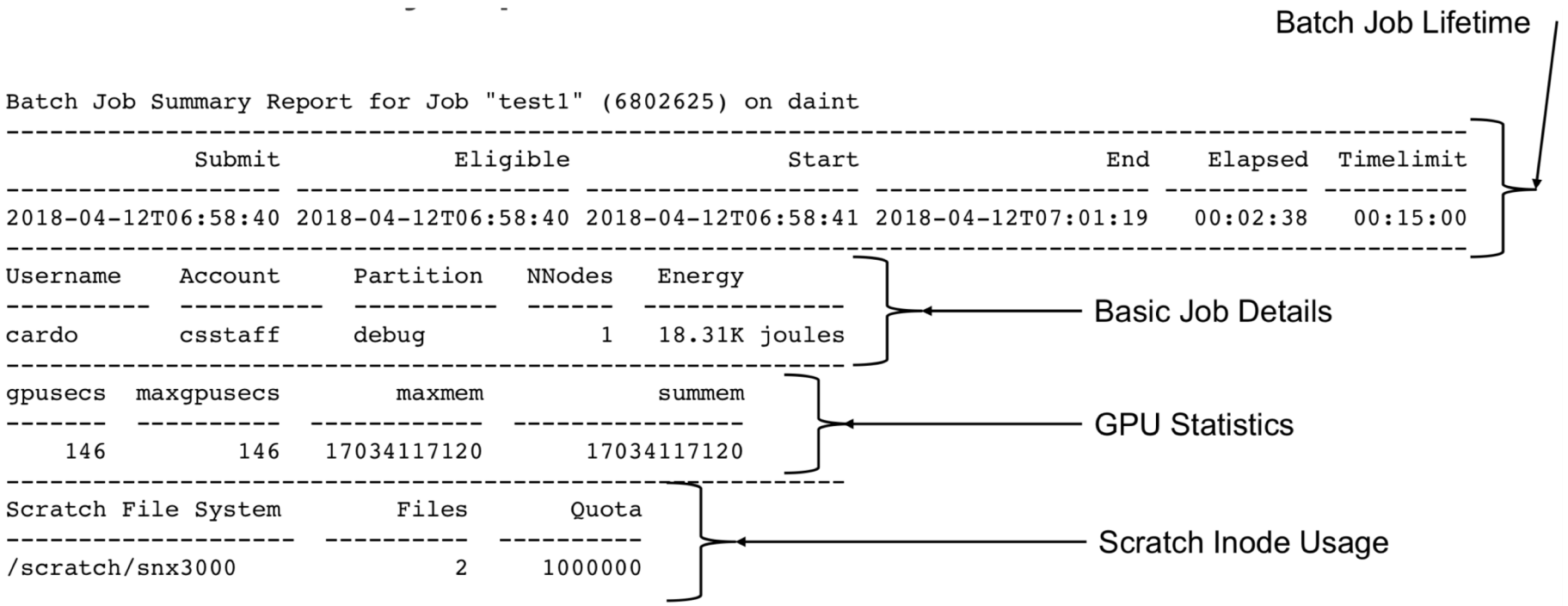
- Data is sent to SlurmDBD with a modified RUR plugin that runs at job end

```
/usr/bin/mysql -h HOST -u DBUSER -pDBPASS DATABASE -e 'update %s_job_table set admin_comment=\"%s\" where
id_job=%s and id_user=%s'" % (cluster,jout.replace("\"",'\\"'),jobid,uid)
```

- Extractable with sacct
  - `sacct -o AdminComment`

# Batch Job Summary Report

- How to report GPU usage in a meaningful way?



# Open questions

- RUR is nice... But perhaps there could be a way to have similar functionality embedded in Slurm itself?
- Would slurmd/slurmctld be able to do such aggregation?
- What about database fields for additional accounting data?
- Jobcomp/ElasticSearch plugin?

# Slurm command logging

# Describing the problem

Jobs with *bajillions* of tasks

```
# sacct -j XXXXXX |wc -l
25337
```

- **Services** have access to dedicated nodes that query Slurm and/or submit jobs
  - Continuous Integration Systems (Jenkins, etc.)
  - Special frontends (UNICORE, ARC)

Loops with failing tasks...

```
#!/bin/bash
#SBATCH -N 512
#SBATCH --time=05:05:05
while true; do
  srun /usr/bin/false
done
```

- **Users** have access to login nodes to submit jobs
  - Daint has a few login nodes
  - Intended to allow users to submit jobs and build apps
  - But users can basically do whatever they want

Some loops are evil!

```
#!/bin/bash
while :
do
clear
squeue | grep JOBID
squeue | grep ${USER}
sleep 1
done
```

- So, what do you do when
  - User commands start timing out everywhere without any apparent reason?
  - Slurmctld logs show it being busy putting tasks on CNs for hours?
    - This somehow tends to happen during weekends or at night...

```
[2018-09-25T14:41:07.832] debug:  _slurm_rpc_job_pack_alloc_info: JobId=840324 NodeList=nid00007 usec=2
[2018-09-25T14:41:07.841] debug:  laying out the 1 tasks on 1 hosts nid00007 dist 1
[2018-09-25T14:41:07.841] debug:  reserved ports 24790 for step 840324.6
[2018-09-25T14:41:08.592] debug:  freed ports 24790 for step 840324.6
[2018-09-25T14:41:08.662] debug:  _slurm_rpc_job_pack_alloc_info: JobId=840324 NodeList=nid00007 usec=2
[2018-09-25T14:41:08.671] debug:  laying out the 1 tasks on 1 hosts nid00007 dist 1
[2018-09-25T14:41:08.671] debug:  reserved ports 24791 for step 840324.7
```

# How do we know what users do?

- Ideally, we would love Slurm to be able to rate-limit the amount of RPCs per user/host/account

- But first, how can we identify precisely what users are doing?
  - Yes, *auditd* is an option...
  - But what's the performance impact of enabling this on Cray's version of the OS?

- What else is out there?

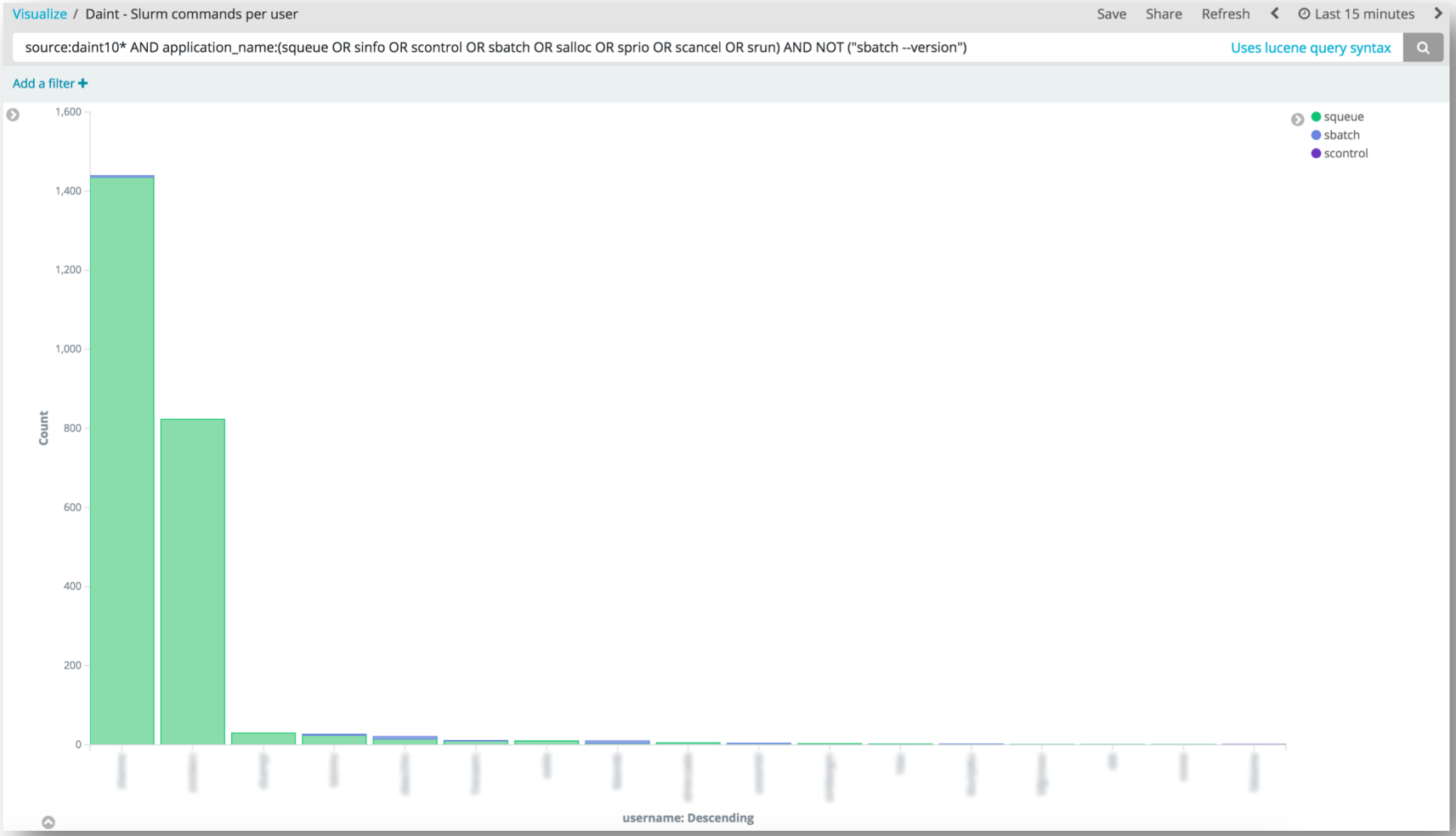
# Slurm patch to log user calls

```
diff --git a/src/sacctmgr/sacctmgr.c b/src/sacctmgr/sacctmgr.c
index ed4ae35c79..1c354dd51a 100644
--- a/src/sacctmgr/sacctmgr.c
+++ b/src/sacctmgr/sacctmgr.c
@@ -108,6 +108,7 @@ int main(int argc, char **argv)
  quiet_flag        = 0;
  readonly_flag     = 0;
  verbosity         = 0;
+  log_command_execution_syslog(argc, argv);
  slurm_conf_init(NULL);
  log_init("sacctmgr", opts, SYSLOG_FACILITY_DAEMON, NULL);
```

```
diff --git a/src/salloc/salloc.c b/src/salloc/salloc.c
index 876c0a8ee5..1303a5f597 100644
--- a/src/salloc/salloc.c
+++ b/src/salloc/salloc.c
@@ -195,6 +195,7 @@ int main(int argc, char **argv)
  slurm_allocation_callbacks_t callbacks;
  ListIterator iter_req, iter_resp;

+  log_command_execution_syslog(argc, argv);
  slurm_conf_init(NULL);
  debug_flags = slurm_get_debug_flags();
  log_init(xbasename(argv[0]), logopt, 0, NULL);
```

```
diff --git a/src/common/log.c b/src/common/log.c
index 28ace318c4..a755979ec2 100644
--- a/src/common/log.c
+++ b/src/common/log.c
@@ -79,6 +79,11 @@
 #include "src/common/xmalloc.h"
 #include "src/common/xstring.h"

+#include <syslog.h>
+#include <stdlib.h>
+#include <pwd.h>
+#include <libgen.h>
+
 #ifndef LINEBUFSIZE
 #  define LINEBUFSIZE 256
 #endif
@@ -1244,3 +1249,26 @@ extern int get_log_level(void)
   level = MAX(level, log->opt.stderr_level);
   return level;
 }
+
+/* Undocumented, CSCS only: logs to syslog the execution of a command */
+void log_command_execution_syslog(int argc, char ** argv){
+  int i = 1;
+  uid_t uid = geteuid();
+  struct passwd *pw = getpwuid(uid);
+  static const int BUFFER_SIZE = 256;
+  char * buffer = malloc(sizeof(char) * (BUFFER_SIZE + 1));
+
+  // if we cannot allocate memory, skip and ignore
+  if (getenv("SLURM_LOG_ACTIONS") && (buffer != NULL)) {
+    for (i=1; i<argc; i++) {
+      if ( strlen(buffer) < BUFFER_SIZE )
+        strncat(buffer, argv[i], BUFFER_SIZE-strlen(buffer));
+      else
+        break;
+    }
+    setlogmask (LOG_UPTO (LOG_NOTICE));
+    openlog (basename(argv[0]), LOG_CONS | LOG_PID | LOG_NDELAY, LOG_LOCAL1);
+    syslog (LOG_NOTICE, "User: %s, command: %s %s", pw->pw_name, basename(argv[0]), buffer);
+    closelog ();
+  }
+}
diff --git a/src/common/log.h b/src/common/log.h
index bf55fe10b7..fd429f5761 100644
--- a/src/common/log.h
+++ b/src/common/log.h
@@ -268,4 +268,6 @@ void  debug3(const char *, ...) __attribute__ ((format (printf, 1, 2)));
 void debug4(const char *, ...) __attribute__ ((format (printf, 1, 2)));
 void debug5(const char *, ...) __attribute__ ((format (printf, 1, 2)));

+void log_command_execution_syslog(int argc, char ** argv);
+
 #endif /* !_LOG_H */
```

# What are our users doing?



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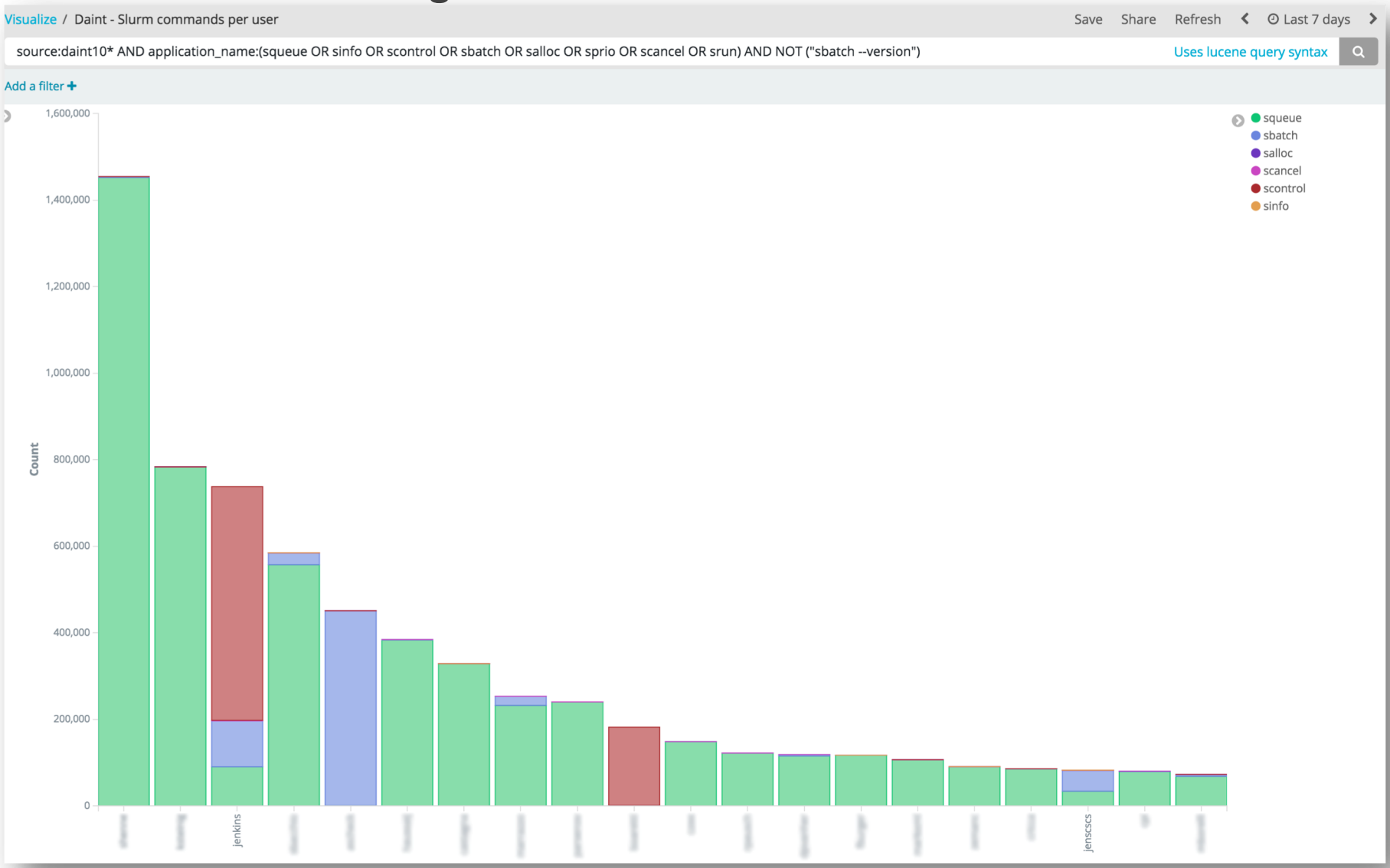

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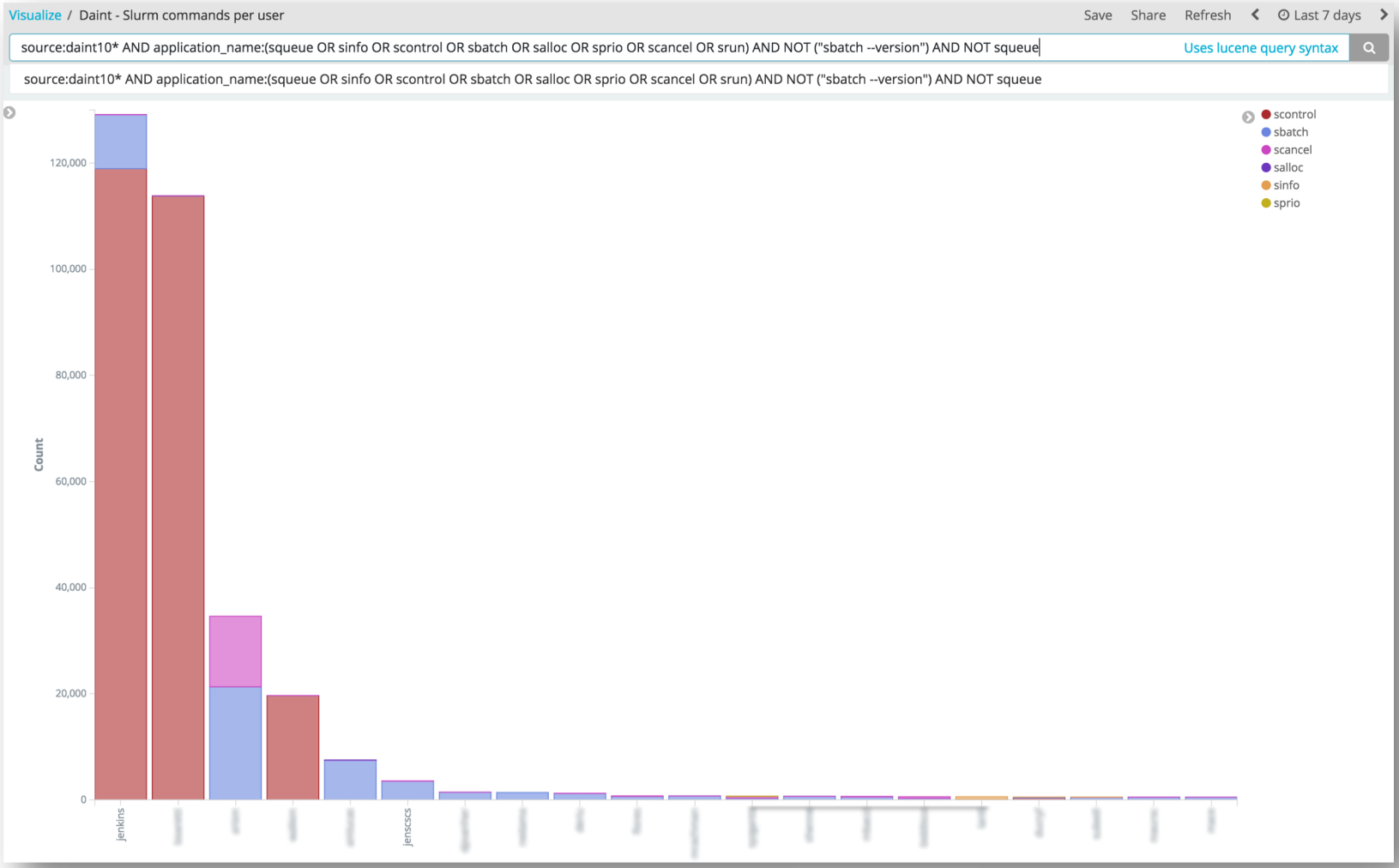

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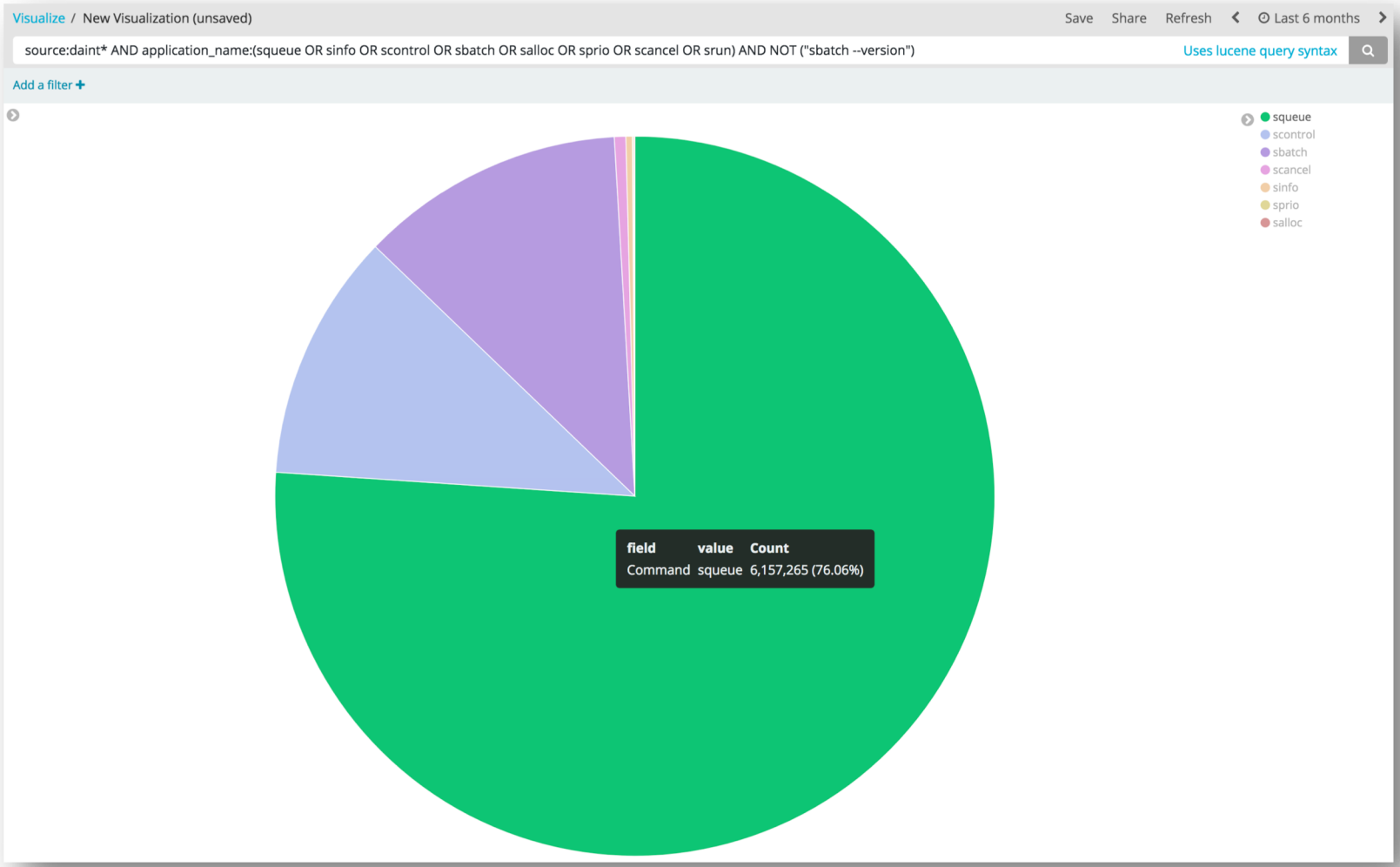


# This new information is very useful

- We've detected a few good use cases where we have been able to help users improve their usage of available tools
  - Corner cases where a service needs to query a few hundreds of jobs every few minutes
  - Users that abuse Shell loops or *watch* because they don't know how things work below
  - Usage of *scontrol* + awesome *grep+awk* combinations instead of *sinfo*
  - Insane amounts of parallel *sruns,* which lead us to adapt GREASY[*]

- Now we can identify, quickly, when a submission script or a job goes rogue

- Believe it or not, there is so much to learn from users!

[*] https://user.cscs.ch/tools/high_throughput/

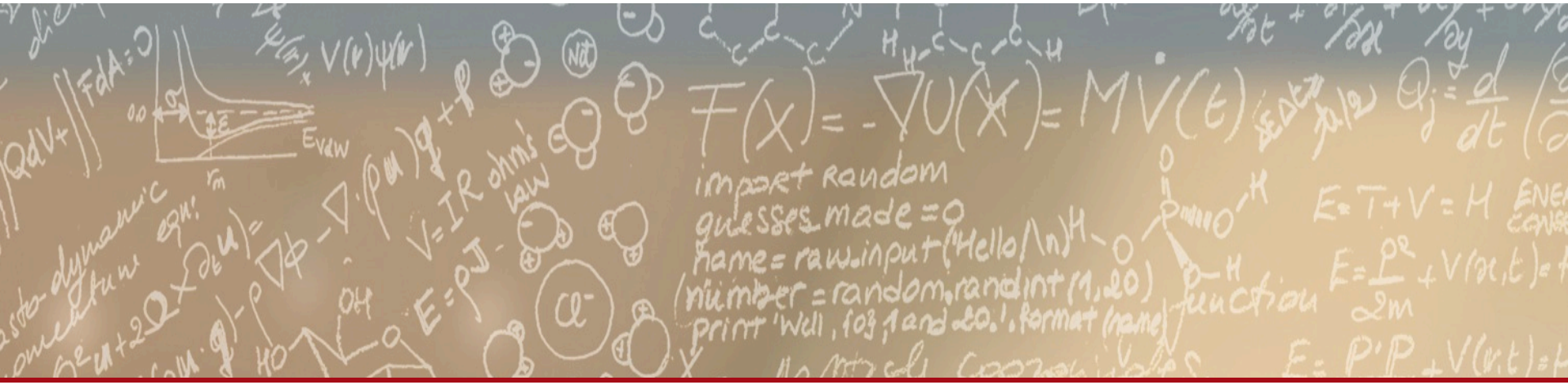
# What now?

- Does anybody **really** need to have *squeue* open, refreshed every second, 24/7 (even at night) to see if his/her jobs are running??

- Is there any way to rate-limit what users do?
  - We love memcached [*], can it be used here somehow?

- However, this partially highlights that there are valid use cases for alternative ways to access Slurm:
  - **RESTful API**
  - Fully supported Python/Go bindings
    - PySlurm is really cool, give it a try!

[*] See Nick Cardo's presentation at SLUG17 (https://slurm.schedmd.com/SLUG17/Cardo-SLUG2017.pdf)




# Thank you for your attention.