MySQL

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MySQL Performance : Profiling Memory & CPU Usage Directly from MySQL

Frederic Descamps (LeFred)
MySQL Community Manager @Oracle

Dimitri KRAVTCHUK
MySQL Performance Architect @Oracle

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Agenda

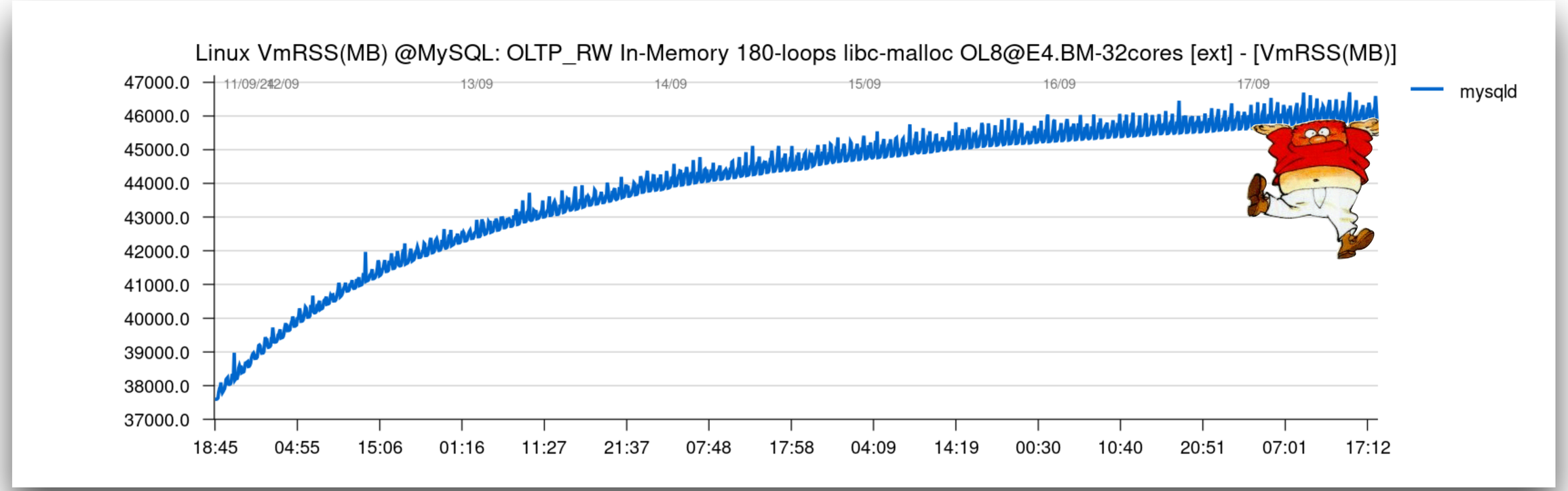
- Malloc Libs Overview
- Live Memory Profiling
- On-demand Memory Usage Profiling from MySQL
- Why not also CPU Profiler ?..
- Q & A

Malloc Libs Historically

- libc-malloc : not designed for MT-apps (not scaling)
- HOARD malloc
- mtmalloc
- umem
- jemalloc (generally preference on Linux)
- tcmalloc (my preferred ;-))
- etc..

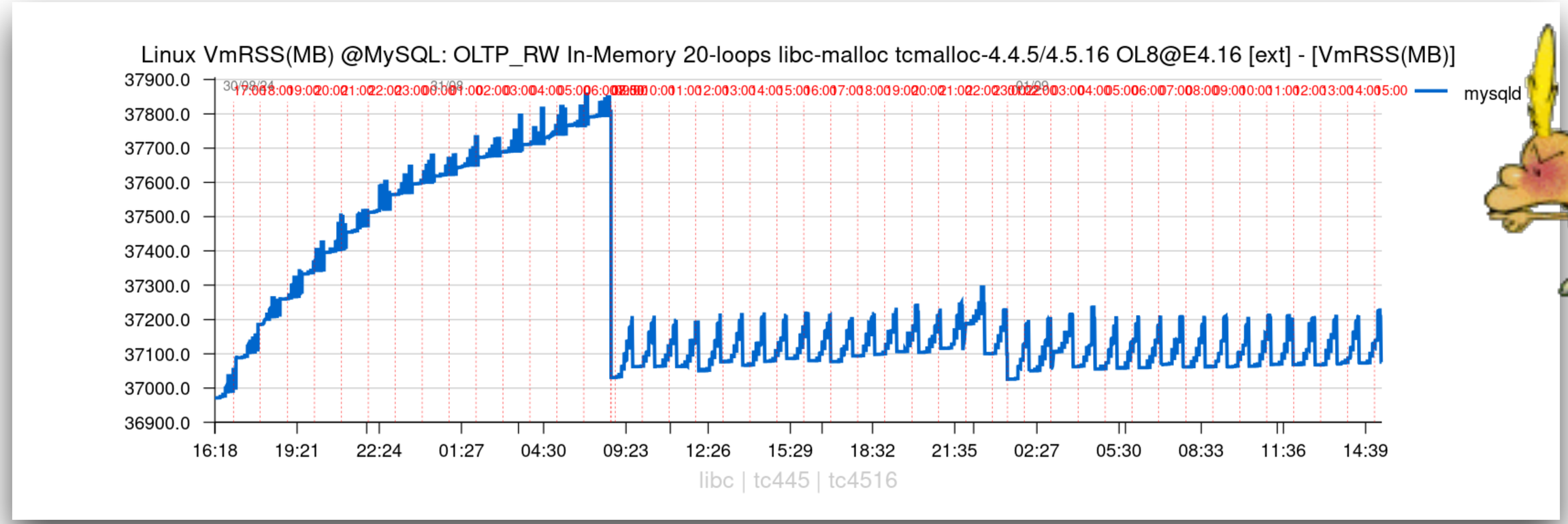
Malloc Libs Today

- glibc-malloc :
  - the latest glibc-malloc can be used with MT-apps today in most cases
  - but memory fragmentation !
- glibc-malloc : +10GB RSS usage over 1 week..



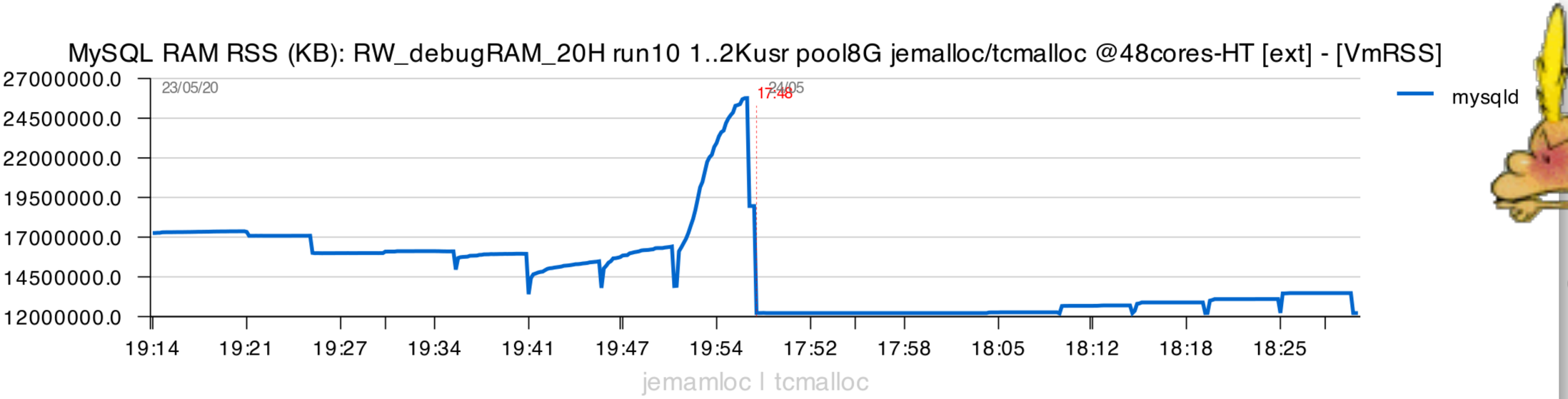
Malloc Libs Today

- glibc-malloc -vs- tcmalloc :



Malloc Libs Today

- jemalloc -vs- tcmalloc :



Memory Leaks in MySQL

- very rare today, but still possible
- cannot be ignored (often ends by OOM-killer)
- can be totally unexpected / difficult to reproduce
- MySQL PFS Memory Instrumentation : the main tool !
- tcmalloc Memory Profiler : great additional help !

tcmalloc Memory Profiler : General Use Case

- set env. variable HEAPPROFILE=/path/to/heap-dumps
- start MySQL Server with tcmalloc in LD_PRELOAD
- follow / analyze dumped heap files
- use “pprof” to print reports / call-stacks in PDF
- NOTE : limited usage possibilities
  - e.g. you need to restart MySQL
  - e.g. you need to have a reproducible test case
  - e.g. isolated debug only

tcmalloc Memory Profiler : Advanced Solution

- start MySQL Server with tcmalloc
  - use LD_PRELOAD / or compile with tcmalloc
- call tcmalloc API to provide /path/to/heap-dumps
- call tcmalloc API to start / stop profiling
- call tcmalloc API to dump collected data
- NOTE : wide flexibility in usage !
  - e.g. can be involved **on-demand** !
  - e.g. can be **auto-triggered** when a problem is detected !
  - e.g. zero overhead while disabled ! => can be deployed in Production !

- **Q** : which way to implement ?
- **A** : as MySQL Component !

tcmalloc Memory Profiler : MySQL Component

- no changes to MySQL code / no need to compile with tcmalloc
- install gperftools pkg on MySQL host system
- setup env. variables on MySQL start :
  - LD_PRELOAD=/path/to/tcmalloc.so
  - HEAP_PROFILE_ALLOCATION_INTERVAL=0 (def: 1GB)
  - HEAP_PROFILE_INUSE_INTERVAL=0 (def: 100MB)

- install / uninstall component on-demand
- start / stop / dump profiling via MySQL connection
- install "pprof" on the MySQL host to allow direct reports
- NOTE : also available for jemalloc as another Component

MySQL Profiler Component : Usage

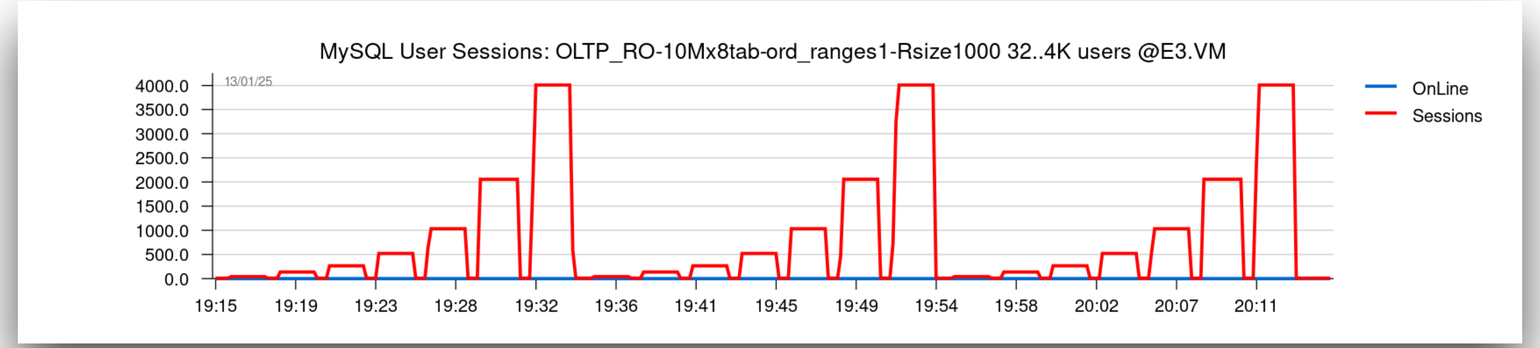
```
mysql> install component 'file://component_profiler';
mysql> install component ‘file://component_profiler_memory';

mysql> select * from mysql.component;
mysql> show global variables like 'profiler%';
mysql> show global status like 'profiler%';

mysql> select profiler_cleanup();
mysql> select memprof_start();                  – we also auto-dump on start
mysql> select memprof_dump();                   -- on-demand dump
mysql> select memprof_stop();                   -- we also auto-dump on stop

mysql> select memprof_report()\G ;              -- report from the last dump
mysql> select memprof_report( 'text', 20, 'dump-name' )\G ;
mysql> select memprof_report( 'dot' )\G ;       -- to build callgraph PDF
```

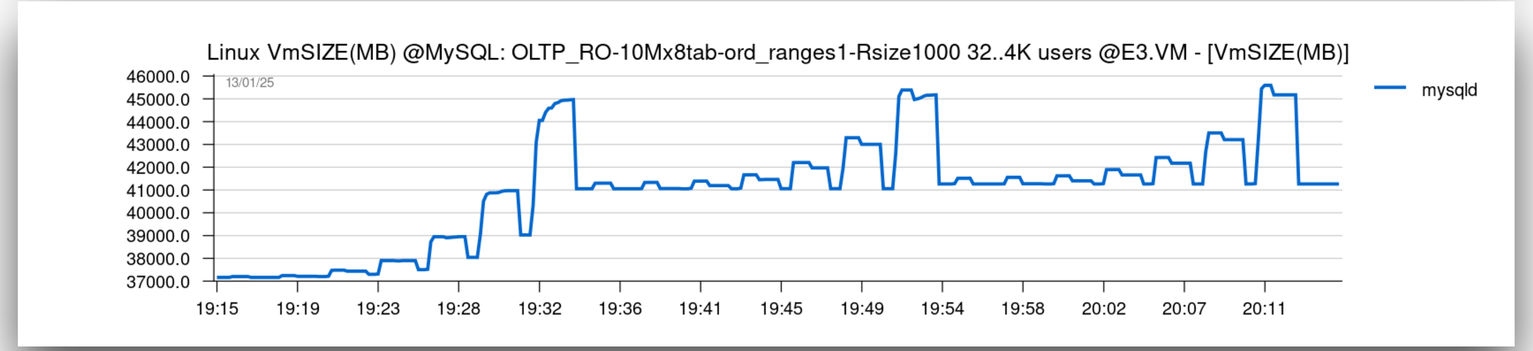
Full details ref. : https://github.com/lefred/mysql-component-profiler

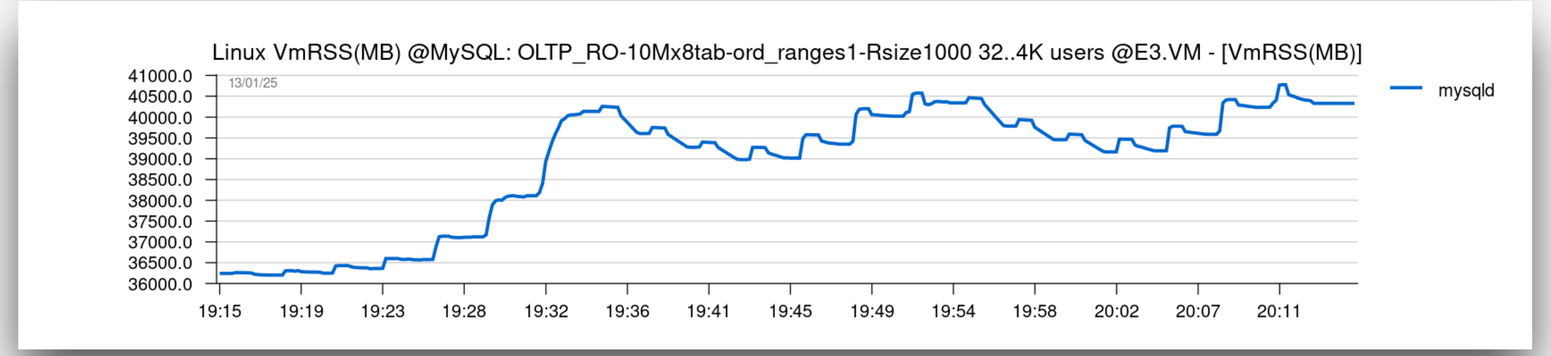
MySQL Profiler Component : Test Case (run x3 times)

```
$ export LD_PRELOAD="/apps/lib/libtcmalloc_and_profiler.so.4.6.11"
$ export HEAP_PROFILE_ALLOCATION_INTERVAL=0
$ export HEAP_PROFILE_INUSE_INTERVAL=0

$ mysql.server start                                        # BP size 32G
$ bash sb11-OLTP_RO_50M_8tab-uniform-notrx.sh 512 300       # prewarm..

for usr in 32 128 256 512 1024 2048 4000
do
  mysql> select profiler_cleanup();
  mysql> select memprof_start( 60 );
  sleep 5

  $ bash sb11-OLTP_RO_10M_8tab-uniform-ord_ranges1-Rsize1000-notrx.sh $usr 120

  mysql> select memprof_report( 'text', 100 )\G ;
  sleep 20
done
```

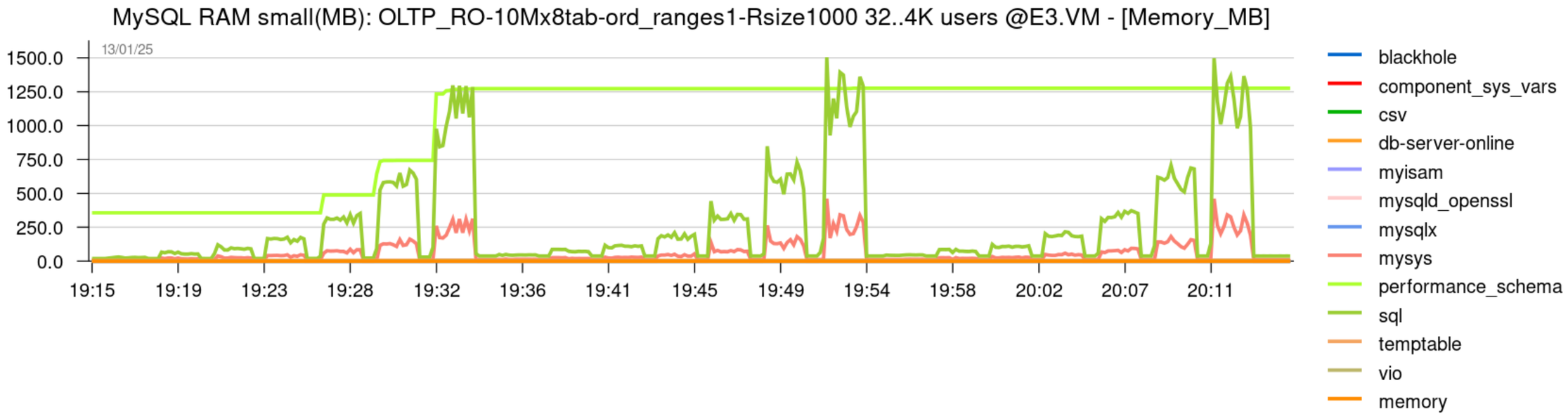
MySQL Profiler Component : Test Case, VmSIZE / RSS



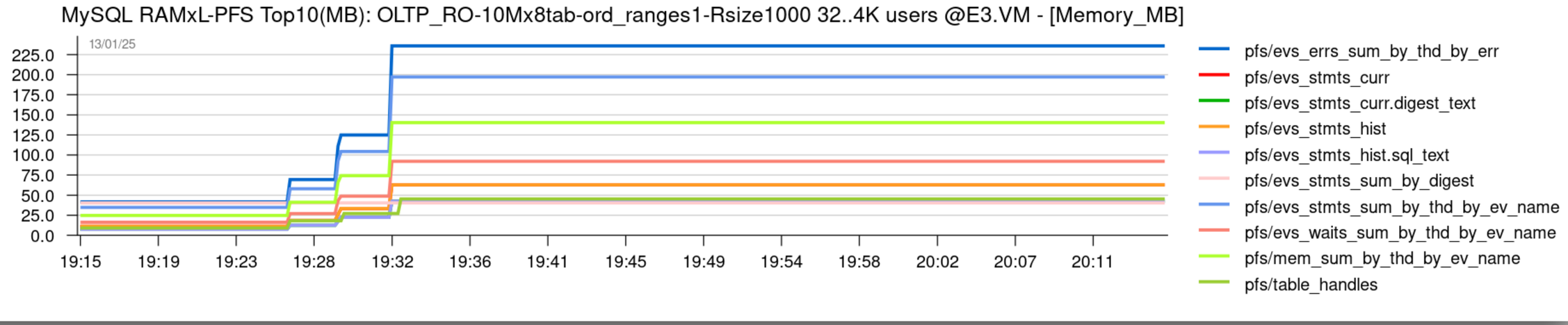


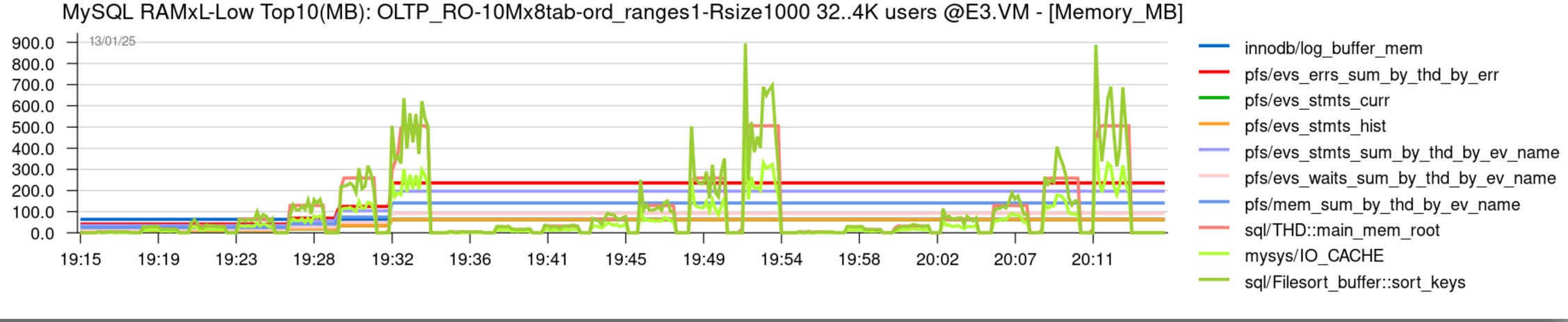


MySQL Profiler Component : Test Case, PFS Report



MySQL Profiler Component : Test Case, PFS Report (2)





MySQL Profiler Component : Test Case, PPROF Report

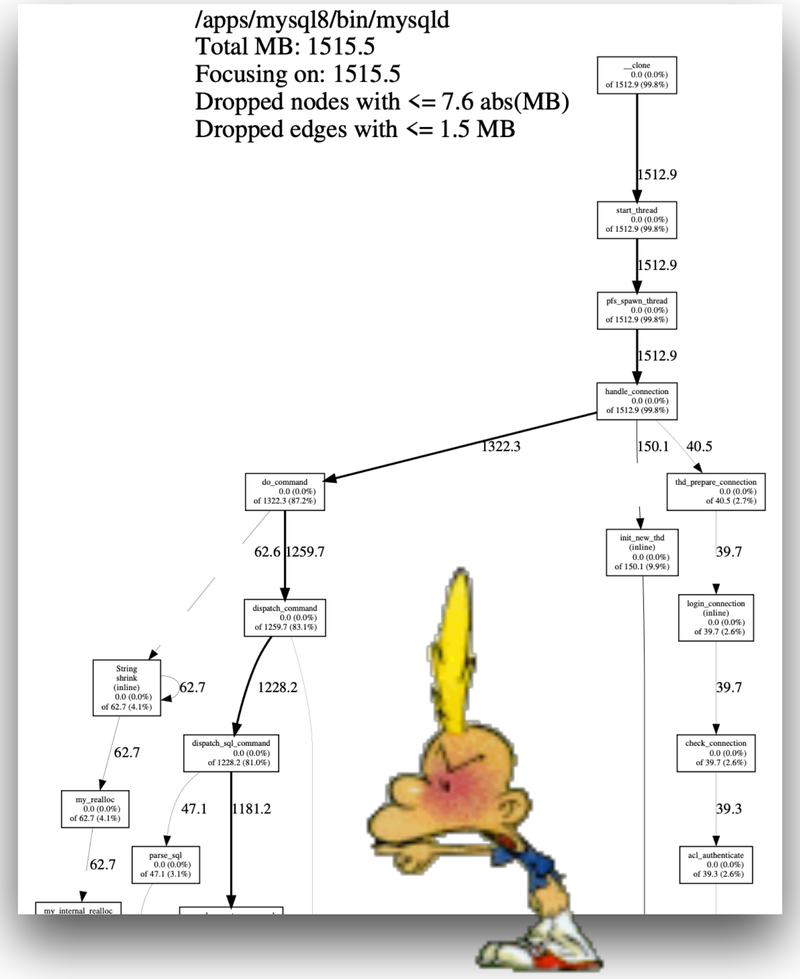
```
memprof_report( 'text', 100 ): Total: 1977.2 MB
  1336.0  67.6%  67.6%   1336.0  67.6% std_allocator (inline)
   515.9  26.1%  93.7%    515.9  26.1% pfs_malloc
    51.7   2.6%  96.3%    152.0   7.7% Channel_info::create_thd
    31.5   1.6%  97.9%     31.5   1.6% dd::cache::Element_map::Element_map (inline)
...

memprof_report( 'text', 100 ): Total: 1508.6 MB
  1391.5  92.2%  92.2%   1391.5  92.2% std_allocator (inline)
    51.7   3.4%  95.7%    150.1  10.0% Channel_info::create_thd
    30.9   2.1%  97.7%     30.9   2.1% dd::cache::Element_map::Element_map (inline)
...

memprof_report( 'text', 100 ): Total: 1515.5 MB
  1398.7  92.3%  92.3%   1398.7  92.3% std_allocator (inline)
    51.7   3.4%  95.7%    150.1   9.9% Channel_info::create_thd
    30.9   2.0%  97.7%     30.9   2.0% dd::cache::Element_map::Element_map (inline)
    12.5   0.8%  98.6%     31.6   2.1% THD::THD
...
```

MySQL Profiler Component : Test Case, PPROF Report (2)

```
  memprof_report( 'text', 100 ): Total: 1515.5 MB
    1398.7  92.3%  92.3%   1398.7  92.3% std_allocator (inline)
      51.7   3.4%  95.7%    150.1   9.9% Channel_info::create_thd
      30.9   2.0%  97.7%     30.9   2.0% dd::cache::Element_map::Element_map (inline)
      12.5   0.8%  98.6%     31.6   2.1% THD::THD
  ...

       0.0   0.0% 100.0%    481.6  31.8% Filesort_buffer::allocate_sized_block
       0.0   0.0% 100.0%      8.3   0.6% Filesort_buffer::commit_used_memory (inline)
       0.0   0.0% 100.0%    219.0  14.5% Filesort_buffer::get_contiguous_buffer
       0.0   0.0% 100.0%    262.6  17.3% Filesort_buffer::get_next_record_pointer
(inline)
  ...

       0.0   0.0% 100.0%    508.0  33.5% MEM_ROOT::Alloc (inline)
       0.0   0.0% 100.0%    508.0  33.5% MEM_ROOT::AllocBlock
       0.0   0.0% 100.0%    508.0  33.5% MEM_ROOT::AllocSlow
  ...
```

MySQL Profiler Component : Recap..

- (+) access directly from MySQL connection
- (+) on-demand install / uninstall
- (+) on-demand start / stop profiling & reports
- (+) small footprint in dumps
- (+) zero impact while profiling=OFF
- (+) cool to understand your RAM allocations
- (-) **huge overhead** when profiling=ON !!
  - rather consider to see a partial stall..
  - avoid long use in Production
  - memprof_start(Nsec) <= most safe use



- NOTE : be thankful to MySQL PFS memory instrumentation ! ;-))
  - enabled by default in MySQL Server + reasonably low overhead

MySQL Profiler Component : What about CPU ?

- gperf-tools provides tcmalloc & CPU profilers
- you can use “cpuprof” component the same way as “memprof”
- (+) similar advantages as with “memprof”
- (+) **mostly zero overhead** !!
  - comparing to “perf” overhead which can be pretty important !

MySQL Profiler Component : “perf” -vs- “cpuprof”

- probably makes sense to consider both ;-))

```
vm32_e3
Samples: 192K of event 'cycles', 99 Hz, Event count (approx.): 383999112410 lost: 0/0 drop: 0/21649 [z]
Overhead  Shared Object                      Symbol
   7.33%  libc-2.17.so                       [.] __memcpy_ssse3
   3.73%  mysqld-8403-ssl111L                [.] my_strnxfrm_uca_900_tmpl<Mb_wc_utf8mb4, 1>
   2.92%  mysqld-8403-ssl111L                [.] row_search_mvcc
   1.89%  mysqld-8403-ssl111L                [.] my_lengthsp_8bit
   1.83%  mysqld-8403-ssl111L                [.] Sort_param::make_sortkey
   1.80%  mysqld-8403-ssl111L                [.] ha_innobase::general_fetch
   1.38%  libc-2.17.so                       [.] __memcmp_sse4_1
   1.29%  mysqld-8403-ssl111L                [.] std::__introsort_loop<__gnu_cxx::__normal_iterator<u
   1.27%  mysqld-8403-ssl111L                [.] rec_init_offsets_comp_ordinary
   1.22%  mysqld-8403-ssl111L                [.] my_sql_parser_parse
   1.20%  mysqld-8403-ssl111L                [.] cmp_dtuple_rec_with_match_low
   1.12%  mysqld-8403-ssl111L                [.] page_cur_search_with_match
   1.11%  mysqld-8403-ssl111L                [.] buf_page_hash_get_low
   1.10%  [kernel]                           [k] apic_timer_interrupt
   1.09%  libc-2.17.so                       [.] __GI_memset
   0.94%  mysqld-8403-ssl111L                [.] Item_func_between::val_int
```

```
vm32_e3
cpuprof_report(): Total: 57351 samples
    4066   7.1%   7.1%     4189   7.3% __libc_send
    3684   6.4%  13.5%     3684   6.4% __memcpy_ssse3
    2371   4.1%  17.6%     2390   4.2% __libc_recv
    1331   2.3%  20.0%     2670   4.7% my_sql_parser_parse
    1278   2.2%  22.2%     2093   3.6% for_each_weight (inline)
    1178   2.1%  24.3%     1178   2.1% my_lengthsp_8bit (inline)
     892   1.6%  25.8%     8354  14.6% ha_innobase::general_fetch
     880   1.5%  27.3%      880   1.5% __memcmp_sse4_1
     878   1.5%  28.9%     8203  14.3% row_search_mvcc
     697   1.2%  30.1%      697   1.2% __memset_sse2
     667   1.2%  31.2%     1418   2.5% cmp_varlen_keys (inline)
     635   1.1%  32.4%      873   1.5% rec_init_offsets_comp_ordinary
     573   1.0%  33.4%     4299   7.5% memcpy (inline)
     521   0.9%  34.3%     5764  10.1% Sort_param::make_sortkey
     378   0.7%  34.9%      531   0.9% cmp_dtuple_rec_with_match_low
     371   0.6%  35.6%      714   1.2% Item_func_between::val_int
     370   0.6%  36.2%      954   1.7% row_sel_field_store_in_mysql_format_func
```

One more thing.. ;-))

- LeFred
  - https://github.com/lefred/mysql-component-profiler - MySQL Profiler Component repo
  - https://lefred.be - LeFred's Blog Site

- DimitriK
  - http://dimitrik.free.fr - dim_STAT (live monitoring tool, as ex.: graphs for this talk, etc.)
  - http://dimitrik.free.fr/blog - Articles about MySQL Performance, etc.
  - http://dimitrik.free.fr/blog/posts/mysql-perf-bmk-kit.html - Benchmark Kit (aka BMK-kit)

Thank You !!!

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