APPS ON SPEED

IMPROVING THE PERFORMANCE OF C++ APPLICATIONS

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OUTLINE

- Motivation
- Preparations
- Tooling
  - Linux Perf
  - Intel® VTune™ Amplifier
  - Valgrind: Callgrind & Massif
  - `pmap`
  - `mallocinfo`

MOTIVATION

- Faster is (perceived) better
- Run Everywhere
- Do More

PREPARATIONS

LET OTHERS WORK FOR YOUR

Enable optimizations **and** debug symbols.

```
cmake -DCMAKE_BUILD_TYPE=RelWithDebInfo
# i.e. let it generate Makefiles containing:
g++ -O2 -g ...
```

TESTING TESTING TESTING

- Prevent regressions, keep functionality - don't overoptimize.
- Don't be afraid of (extensive?) refactoring.
- Write standalone benchmarks.

THE ROOT OF ALL EVIL

- Don't microoptimize, know the 90/10 rule.
- Beware of premature optimizations!
- Yet also keep premature pessimizations in mind.

KNOWLEDGE IS KING

- Knowing the ins and outs of your codebase and libraries allows for true optimizations.
- A better algorithm often yields more performance, than optimizing a bad alternative.
- Be aware: *"Faster"* code might be slower for smaller datasets.

TOOLING

LINUX PERF

- Fast, sampling based `-Wall` time profiling.
- Versatile: hardware & software counters, tracepoints
- Cross platform: works wherever Linux runs

LINUX PERF

Find system-wide hotspots.

Profile across process boundaries.

```
$ sudo perf top

Samples: 10K of event 'cycles', Event count (approx.): 2036162123
 10.67%  libQtGui.so.4.8.5                [.] 0x0000000000230f07
 10.25%  libc-2.17.so                     [.] __memcpy_ssse3_back
  2.63%  libQtCore.so.4.8.5               [.] 0x00000000001a7d17
  2.42%  Xorg                             [.] 0x000000000003ff6f
  2.05%  perf                             [.] symbol_filter
  1.87%  libc-2.17.so                     [.] _int_malloc
  1.72%  perf                             [.] d_print_comp.part.8
  1.66%  libc-2.17.so                     [.] __strcmp_sse42
  1.57%  perf                             [.] symbols__insert
  1.38%  [kernel]                         [k] unix_poll
  1.37%  [kernel]                         [k] fget_light
  1.18%  libc-2.17.so                     [.] __strstr_sse42
  1.13%  libglib-2.0.so.0.3600.3          [.] 0x0000000000086e9d
  ...
```

LINUX PERF

Profile individual processes, see callgraphs.

```
$ perf record -g dwarf <yourapp>
# or attach to a running app:
# perf record -g dwarf -p $(pidof <yourapp>)
$ perf report
```

```
+   7.00%    kdevelop  libQtCore.so.4.8.4          [.] 0x00000000000b71e5
+   4.52%    kdevelop  libsqlite3.so.0.8.6         [.] 0x00000000000279f4
+   2.45%    kdevelop  libkdecore.so.5.10.3        [.] 0x00000000000ad310
-   2.27%    kdevelop  libc-2.17.so                [.] _int_malloc
- _int_malloc
  - 94.29% malloc
    - 30.10% operator new(unsigned long)
    - 8.50% KDevelop::DUContext::findDeclarations(KDevelop::Identifier...
      - 72.20% CMakeProjectVisitor::createUses(CMakeFunctionDesc const&)
        - CMakeProjectVisitor::walk(QList<CMakeFunctionDesc> const&,...
          - 70.44% CMakeProjectVisitor::visit(IfAst const*)
            IfAst::accept(CMakeAstVisitor*) const
...
```

LINUX PERF

Gather performance counter statistics.

```
$ perf stat <yourapp>
Performance counter stats for '<yourapp>':

  5606.202068 task-clock                #    0.473 CPUs utilized
      604,632 context-switches          #    0.108 M/sec
          146 cpu-migrations            #    0.026 K/sec
        1,740 page-faults               #    0.310 K/sec
5,983,888,876 cycles                    #    1.067 GHz                      [82.94%]
3,373,405,595 stalled-cycles-frontend   #   56.37% frontend cycles idle     [82.82%]
2,305,588,563 stalled-cycles-backend    #   38.53% backend  cycles idle     [67.53%]
5,558,174,058 instructions              #    0.93  insns per cycle
                                        #    0.61  stalled cycles per insn [83.62%]
1,224,492,195 branches                  #  218.417 M/sec                    [82.90%]
  22,178,629 branch-misses              #    1.81% of all branches          [83.81%]

11.845618581 seconds time elapsed
```

LINUX PERF

- Great potential to become *the* profiling tool on Linux.
- Custom trace points enable custom tools to be build.
- **Proper UI *desperately* needed!**

INTEL® VTUNE™ AMPLIFIER

- Fast, sampling based `-Wall` time profiling.
- Excellent visualizations, good workflow.
- Proprietary, but available **free of charge** for non-commercial Linux work.
- **Most features require Intel CPUs!**

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Profile Overview

Top Waiting Objects

This section lists the objects that spent the most time waiting in your application. Objects can wa
synchronizations. A significant amount of Wait time associated with a synchronization object refl
parallelism.

Sync Object	Wait Time	Wait Count
Sleep	13.190s	15,072
Futex 0xe9ec8d73	0.009s	2,426
poll	0.091s	260
Futex 0x6e1f8871	0.002s	257
Mutex 0xbf7f3edc	1.267s	175
[Others]	9.761s	729

Thread Concurrency Histogram

This histogram represents a breakdown of the Elapsed Time. It visualizes the percentage of the
simultaneously. Threads are considered running if they are either actually running on a CPU or a
Thread Concurrency is a measurement of the number of threads that were not waiting. Thread C
in the runnable state and not consuming CPU time.

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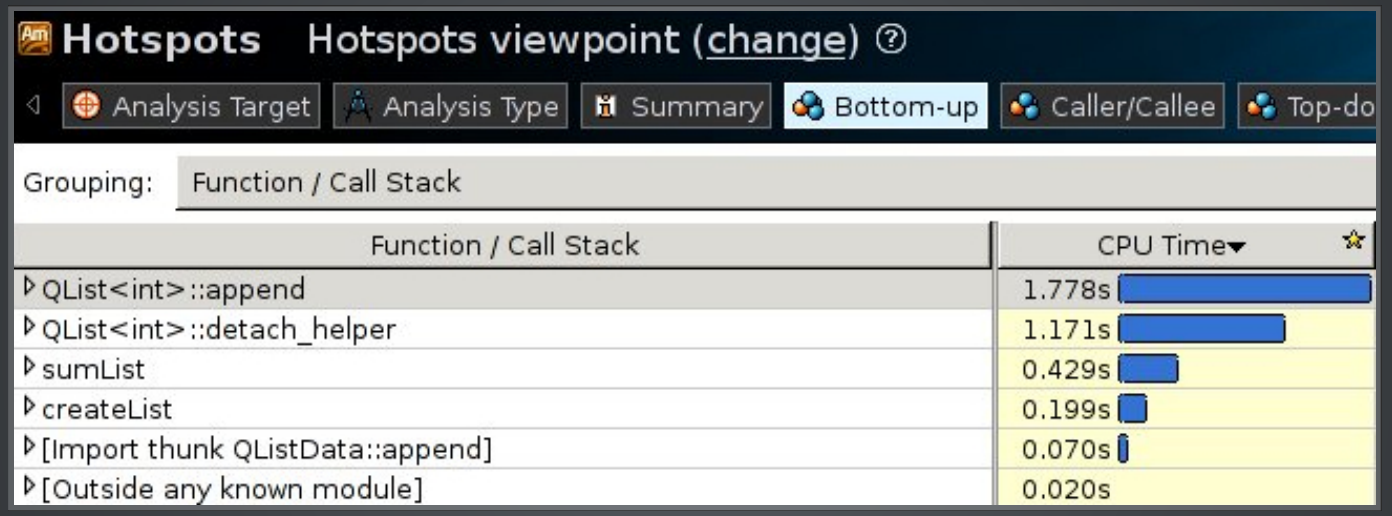
Detecting CPU hotspots



Hint: **Don't use `QList`** by default, prefer `QVector` with proper `Q_DECLARE_METATYPE` hints.

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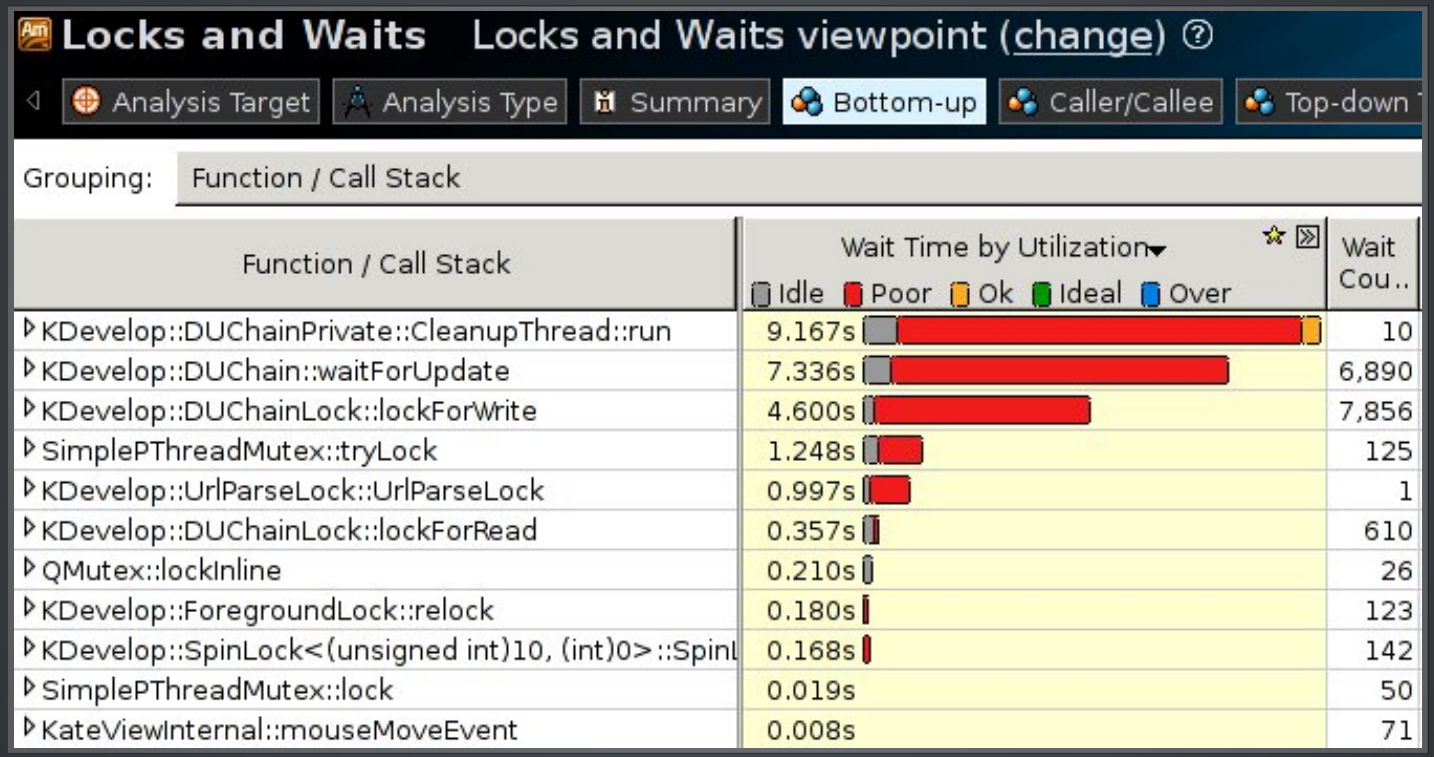
Finding Locks and Waits



Note: Not all waits are bad - an idle `QThread` will wait in the eventloop e.g.

Hint: Avoid synchronous API; prefer **message passing** over locking

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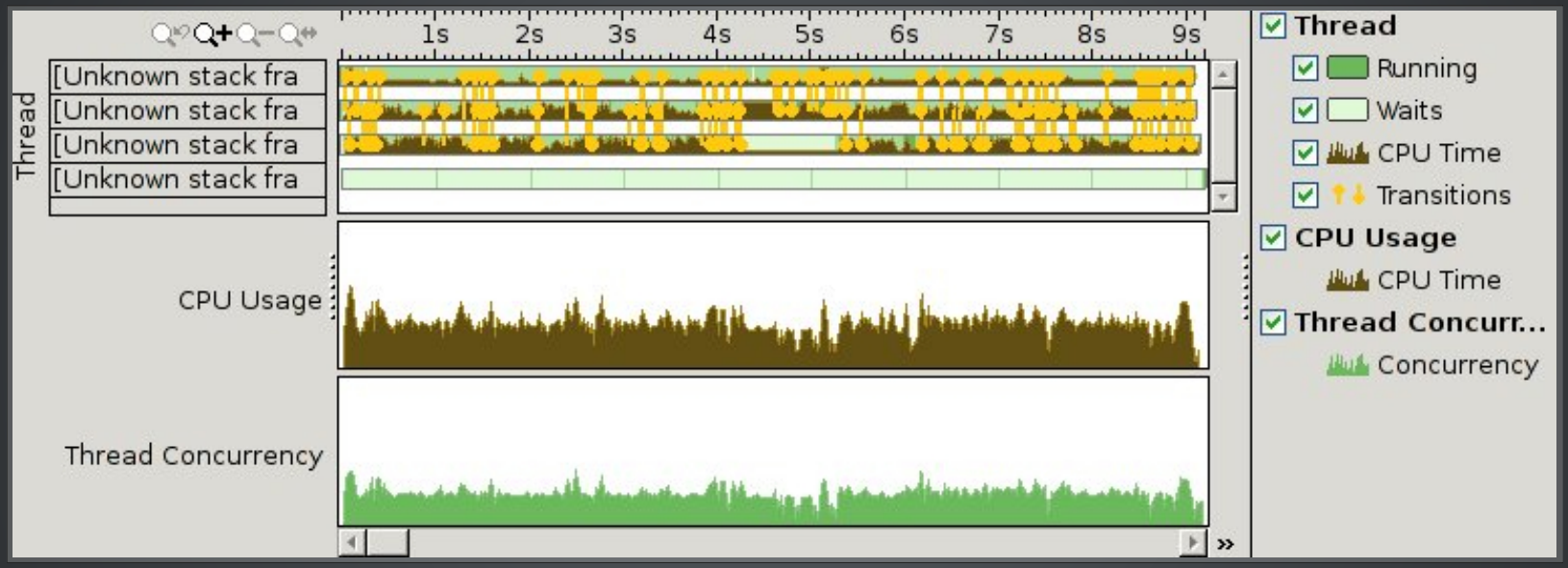
Per-Thread CPU Usage, Context Switches, Waits



Note: Fixing KDevelop requires extensive refactoring, proper API design with threading in mind.

VALGRIND

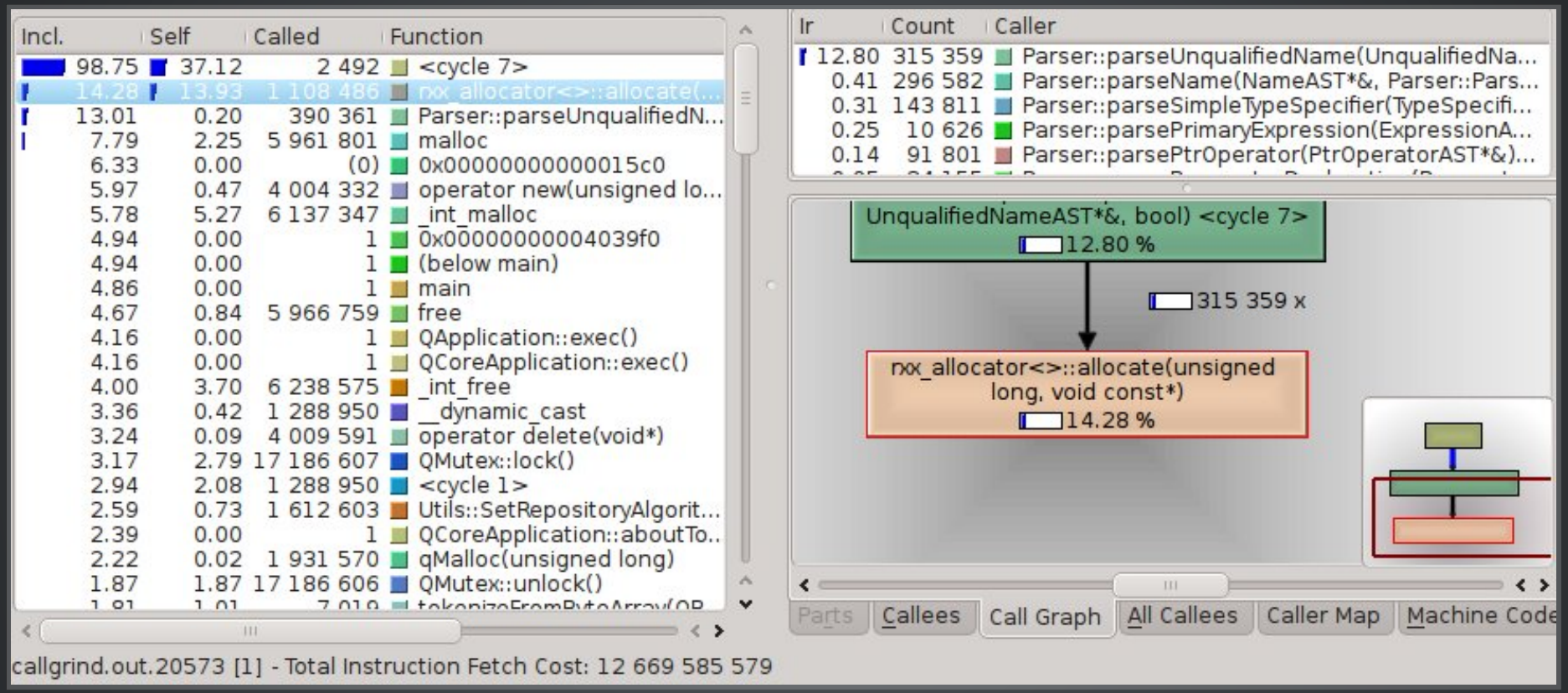
- **Callgrind:** deterministic instruction profiler
- **Massif:** heap profiler

```
$ valgrind --tool={massif,callgrind} <yourapp>
```

Sadly large overhead, very slow

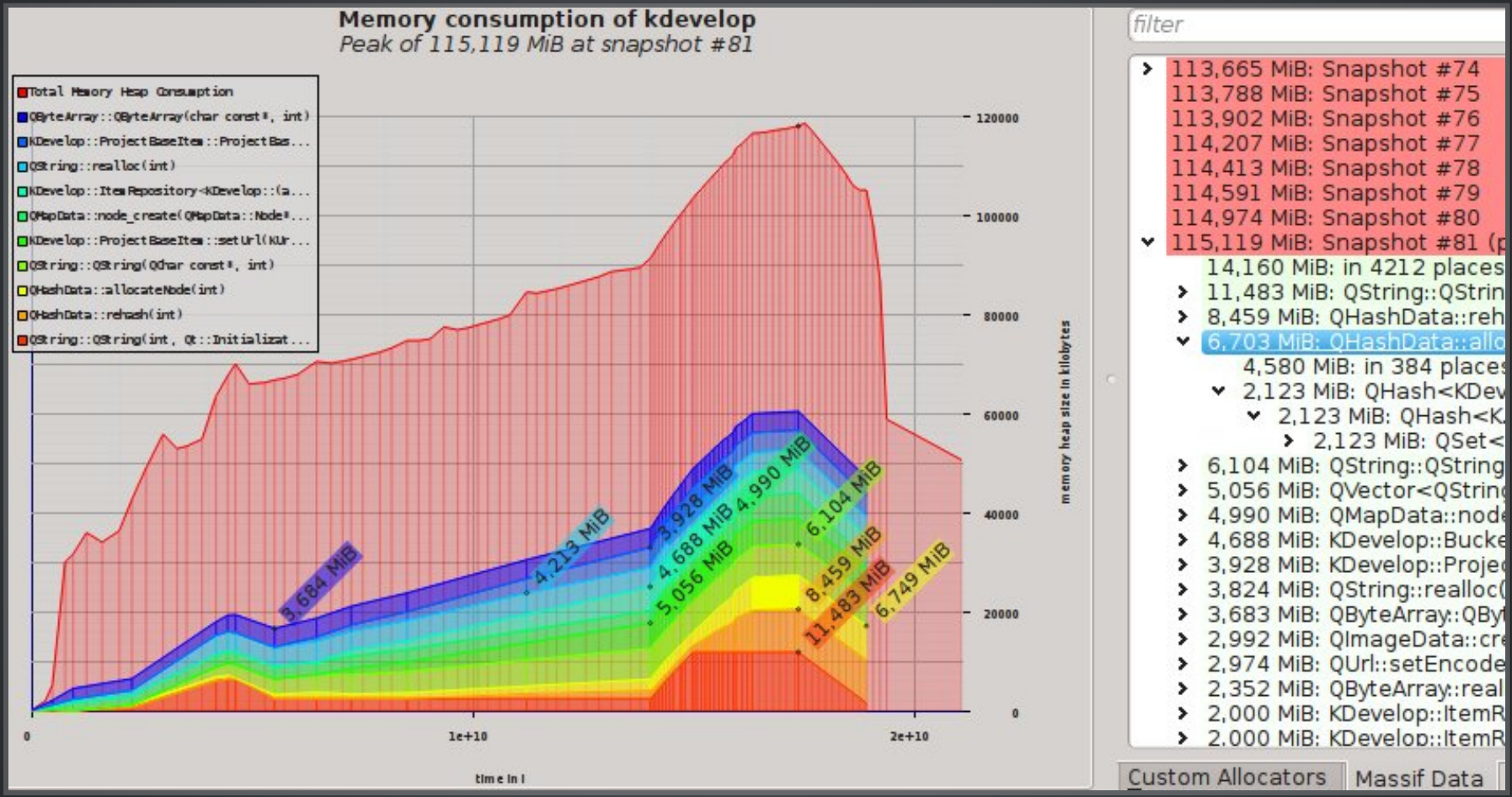
Hint: For apps using a JIT compiler (i.e. via `QtScript`, `QtWebKit`, `QML`, `QRegularExpression`), add the following argument to valgrind: `--smc-check=all-non-file`.

KCACHEGRIND



Todo: support for `perf.data` files.

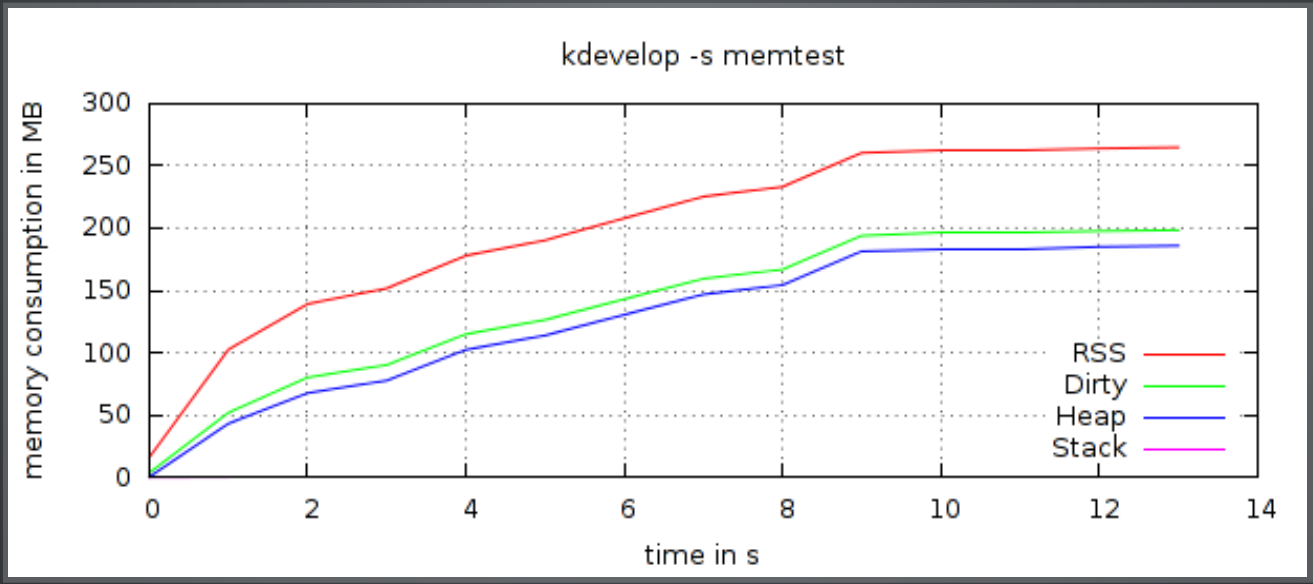
MASSIF VISUALIZER



PMAP

Lightweight memory tracking

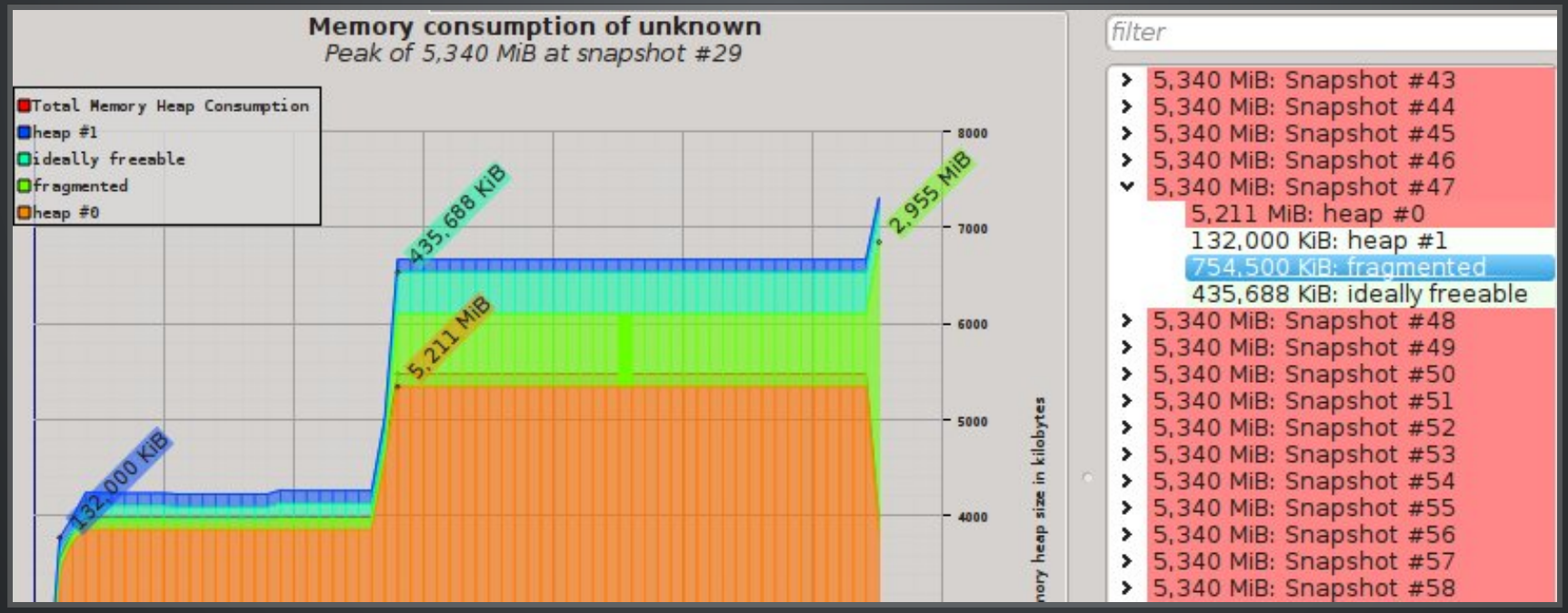
```
$ track_memory.sh <yourapp>
$ show_memory.sh mem.log.PID
```



MALLOCINFO

Track `malloc` statistics, memory fragmentation

```
$ run_mallocinfo <yourapp>
# requires mallocinfo branch in massif-visualizer
$ massif-visualizer mem.log.PID
```



THE END

QUESTIONS? FEEDBACK?

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