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Selecting the Right Tools for Performance Analysis

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To measure is to know.
-Lord Kelvin

If you can not measure it,
you can not improve it.
-Lord Kelvin

The Importance of Correct Metrics

- Have standard econbox car
- Want it “faster”

The Ugly Result of Using the Wrong Metric

http://commons.wikimedia.org/wiki/File:Poser.JPG

What are your important metrics?

- Response time for a query
- Maximum number of simultaneous requests
- Memory required per query
- Time spent in key sections of code

Acceptable measurement cost?

- Zero cost
- Low cost
- Cost is no object

When is it “Good Enough”?

- Fine as is
- Nice if a bit better
- Need to meet some specific performance metric
- Never “good enough”

Want data that guide actions

- Some metrics show there is a problem
- Want metrics to show how or where to fix the problem

Map your metrics to tool metrics

- Your metrics probably not the same as the tool's metrics
- Need to translate into available tool measurements
- Typical tool metrics:
  - Software events (for example page faults)
  - Latency
  - Code hotspots
  - Processor microarchitecture performance

What region metrics measured?

- Single process
- User-space
- Kernel-space
- System-wide

Many Linux Performance Tools

- Tools developed to address specific issues
- Provide different:
  - Measurements
  - Performance impact
  - Filtering
  - Data analysis

Instrumentation Techniques

Statistical Sampling

- Every Nth (+/-) sample record details
- Number of samples should be proportional to events at that location
- Reduces overhead
- Often used with hardware performance counters

Probing

- Predefined points in software:
  - kernel tracepoints
  - user-space markers
- Use breakpoints instructions:
  - Kprobes
  - Uprobes
- Only encounter cost when hit
- Can be used on already running code

Binary Rewrite

- Examine the code as it is loaded
- Take machine code apart
- Add instrumentation and generate new code
- Allow instrumentation of code without recompilation of source
- Cannot attach to already running apps
- Can significantly slow the startup and execution of code

Shared Library Wrapper

- Inserts a wrapper function between caller and callee in shared library
- Lower overhead than binary rewrite
- Limit to function call boundaries
- Cannot attach to already running apps
- Implemented with LD_PRELOAD=libwrapper.so

Mapping Data Back to Source Code

- Most performance tools collect instruction addresses
- Want to map instruction address to source code
- Debuginfo (-g) provides mapping
- Debuginfo does not affect runtime performance
- Can strip out debuginfo to make executables smaller

Mapping Data Back for Interpreters

- Instruction address maps to runtime
- Just-In-Time translation no debug info for address
- Some interpreters provide profilers:
  - Python (python -m cProfile.py ..)
  - Perl (perl -d:DProf ...)
  - Ruby (ruby-prof ...)
- Some interpreters have hooks for other tools:
  - Java jvmti and jvmpi interfaces

Where are the processors spending time?

Why?

OProfile

- Useful for finding code hotspots
- Not useful for I/O or latency problems
- Uses performance monitoring hardware
- Performs sampling
- Collects system-wide data
- Requires root privileges
- Can record data for Java applications
- Supports a wide range of processors
- Available on most distributions

Perf

- Provides access to:
  - performance monitoring hardware
  - Kernel software events
- Data metrics:
  - Count events (stats)
  - Trace of samples (record)
- Available to normal user
- Requires newer Linux kernels (>= 2.6.32)

What about watching events across processes?

What about watching events in both user- and kernel-space?

SystemTap

- Can instrument already running apps
- Probes system-wide (both user- and kernel-space)
- Very flexible filtering
- Requires special privileges

Why is so much memory being used?

Valgrind

- Originally a tool to look at memory issues:
  - Allocation, initialization, and freeing
- Actually a very flexible binary rewrite framework:
  - Memory diagnostics, memory allocation, cache simulator, threading
- Instruments shared libraries, but not kernel code
- Slows application (4x-100x slower)
- Run as normal user
- Cannot attach to already running code

Valgrind (cachegrind) Example

valgrind --tool=cachegrind stap -p4 disktop.stp

...

==10672==

==10672== I   refs: 4,556,135,689

==10672== I1 misses: 2,192,463

==10672== LLi misses: 30,208

==10672== I1 miss rate: 0.04%

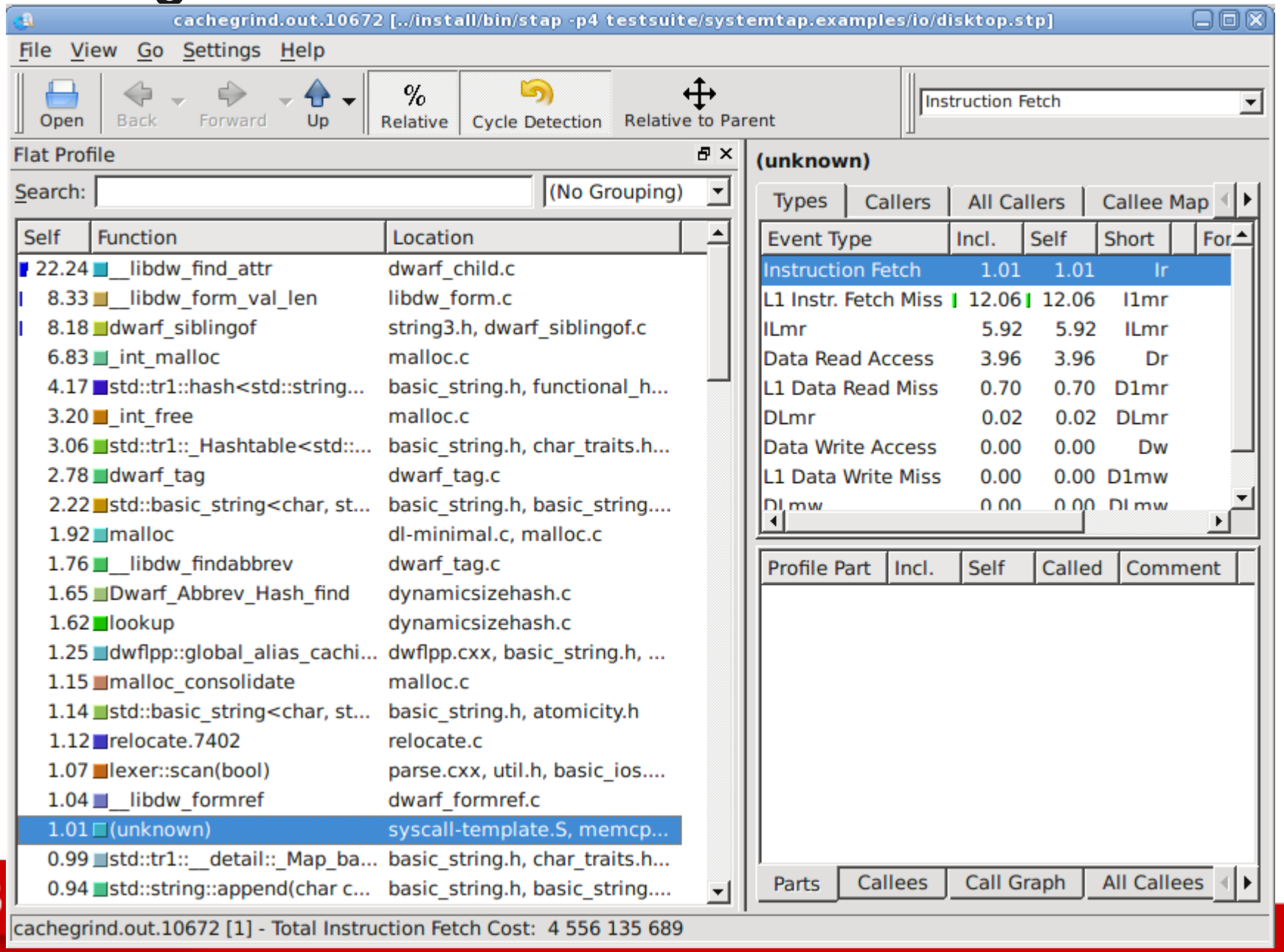
==10672== LLi miss rate: 0.00%

...

Valgrind (cachegrind) Example (cont.)

```
==10672==
==10672== D   refs:      1,846,734,454  (1,161,695,711 rd   + 685,038,743 wr)
==10672== D1  misses:       15,404,912  (   13,300,378 rd   +   2,104,534 wr)
==10672== LLd misses:        8,070,771  (    6,160,076 rd   +   1,910,695 wr)
==10672== D1  miss rate:           0.8% (          1.1%     +         0.3%  )
==10672== LLd miss rate:           0.4% (          0.5%     +         0.2%  )
==10672==
==10672== LL refs:          17,597,375  (   15,492,841 rd   +   2,104,534 wr)
==10672== LL misses:         8,100,979  (    6,190,284 rd   +   1,910,695 wr)
==10672== LL miss rate:            0.1% (          0.1%     +         0.2%  )
```


Kcachegrind GUI

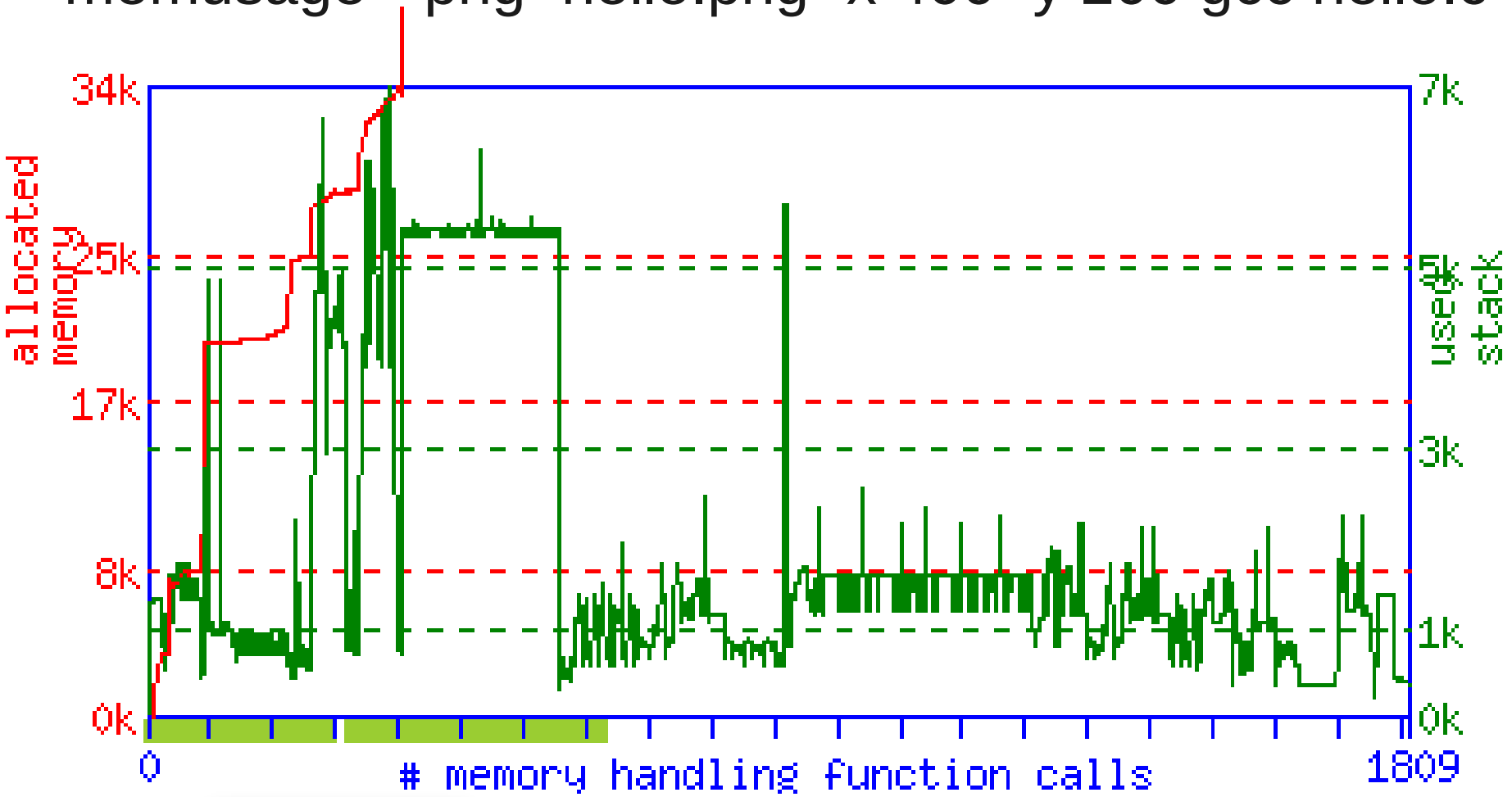


Glibc-utils

- Analysis more limited than Valgrind:
  - Only analyzes memory allocation/free operations
  - No checks for use of uninitialized memory
- Faster than valgrind:
  - Intercepting calls for memory allocation/free
  - Not rewriting and instrumenting the binary code
- Tools in the glibc-utils rpm

Glibc memusage demonstration

memusage --png=hello.png -x 400 -y 200 gcc hello.c



Graphical User Interface?

- Eclipse IDE
- Plug-ins:
  - Systemtap
  - Oprofile
  - Valgrind
- Navigate data by point and click

Further Information

- Developer Guide on http://docs.redhat.com/docs/en-US/index.html
- Oprofile - http://oprofile.sourceforge.net/news/
- Perf – perf help
- SystemTap - http://sourceware.org/systemtap/
- Valgrind - http://valgrind.org/
- glibc utils – memusage –help

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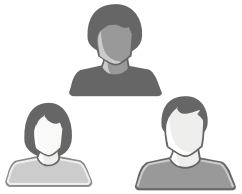
Instrumenting the Linux Kernel with SystemTap

Review Tech brief

Performance Issues in Red Hat Enterprise Linux (Part 1)

Review Tech brief



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