Seminar: Leistungsanalyse unter Linux

Performance analysis using GPerfTools and LTTng

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Profiling and Tracing

- What?
  - Collecting information during execution
- Why?
  - Understanding software for debugging / tuning (esp. on multicore systems)
- How?
  - “Great Performance Tools” and “Linux Trace Toolkit next generation”

Great Performance Tools

- Distributed under BSD license
- Community run
- Libraries are available for Windows, Linux, Solaris, and Mac
- Supports C/C++ and all languages that can call C code

GPerfTools – History

- Originally called “Google Performance Tools”
- Started in March 2005
- Version 1.0 early 2009
- Version 2.0 since February 2012

GPerfTools – History

- Main contributor “csilvers" stepped down since v. 2.0
- Google withdrew ownership → now completely community run
- Renaming to “gperftools”, where “g” stands for “great”
- Main developer from now on is David Chappelle

GPerfTools – Overview

- CPU Profiler – performance of functions
- TCMalloc – fast, thread aware malloc
- Heap Leak Checker – memory leak detector
- Heap Profiler – record program stack

GPerfTools – CPU Profiler

- To use the CPU Profiler you have to
  - Link the library with `-lprofiler`
  - Set `$CPUPROFILE` to the path where to save the profile
  - Surround the code to be profiled with
    - `ProfilerStart(“profile name”)`
    - `ProfilerStop()`
- Output can be analyzed with `pprof` (we'll get back to `pprof` later)

GPerfTools – TCMalloc

- To use TCMalloc simply link the library with `-ltcmalloc`
- Faster than clib malloc
- Low overhead on small objects
- Reduces thread lock contention in multithreaded environments
- The Heap Leak Checker and Heap Profiler work with TCMalloc

GPerfTools – Heap Leak Checker

- To use the Heap Leak Checker you have to
  - Link the library with `-ltcmalloc`
  - Set `$HEAPCHECK` to the desired mode
    - minimal, normal, strict, draconian, as-is, local
- Output can be analyzed with `pprof` (we'll get back to `pprof` later)

GPerfTools – Heap Profiler

- To use the Heap Profiler you have to
  - Link the library with `-ltcmalloc`
  - Set `$HEAPPROFILE` to the path where to save the profile
  - Surround the code to be profiled with
    - `HeapProfilerStart(“prefix name”)`
    - `HeapProfilerStop()`
- Output can be analyzed with `pprof` (we'll get back to `pprof` later)

GPerfTools – Profiler Insights

- Function of `GetStackFrames()`:

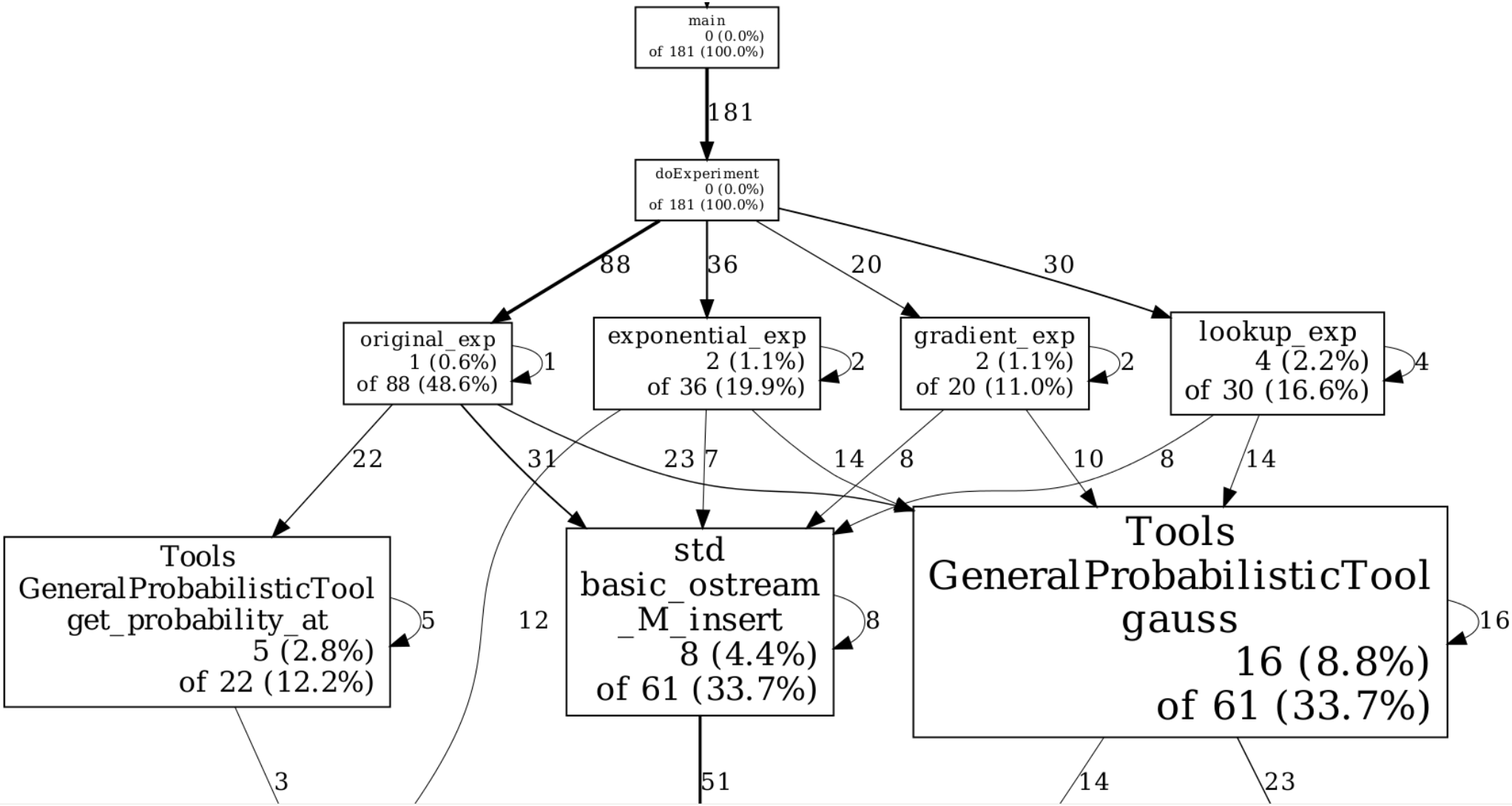
```
main() { foo(); }
foo()  { bar(); }
bar()  {
   void* result[10];
   int sizes[10];
   int depth = GetStackFrames(result,sizes,10,1); }
```

- Result:
  - `depth = 2`
  - `result[0] = foo, sizes[0] = 16`
  - `result[1] = bar, sizes[1] = 16`

GPerfTools – pprof

- Analyzes profiles generated by
  - CPU Profiler – Weighted call graph with timing information
  - Heap Leak Checker – call graph of reported leaks
  - Heap Profiler – weighed directed graph of memory allocations
- Text, postscript (gv), dot, pdf, gif, source-code listings, & disassembly

GPerfTools – pprof



Generated with pprof

Linux Trace Toolkit next generation

- Distributed under GPLv2
- Community run
- Offers Kernel and User Space Tracing
- Only available for Linux (32 & 64 bit)
- Supports C/C++ and all languages that can call C code

LTTng – History

- Successor of Linux Trace Toolkit
- Launched in 2005
- Version 2.0 since March 2012
- Written and maintained by Mathieu Desnoyers

LTTng – Overview

- Consists of 3 parts:
  - Kernel part → Kernel tracing
  - User space command-line application (lttcl)
  - User space daemon (lttd)
- Modular: 5 modules
  - ltt-core, generates events, controls:
    - ltt-heartbeat, ltt-facilities, ltt-statedump
  - ltt-base, built in kernel object, keeps symbols & data structures

LTTng – Tracing

- Observes operating system kernel events such as:
  - system calls, interrupt requests, scheduling & network activities
- Multiple traces can be recorded simultaneously (on mult. CPUs)
- Events are recorded by so called “Tracepoints”

LTTng – Tracepoints

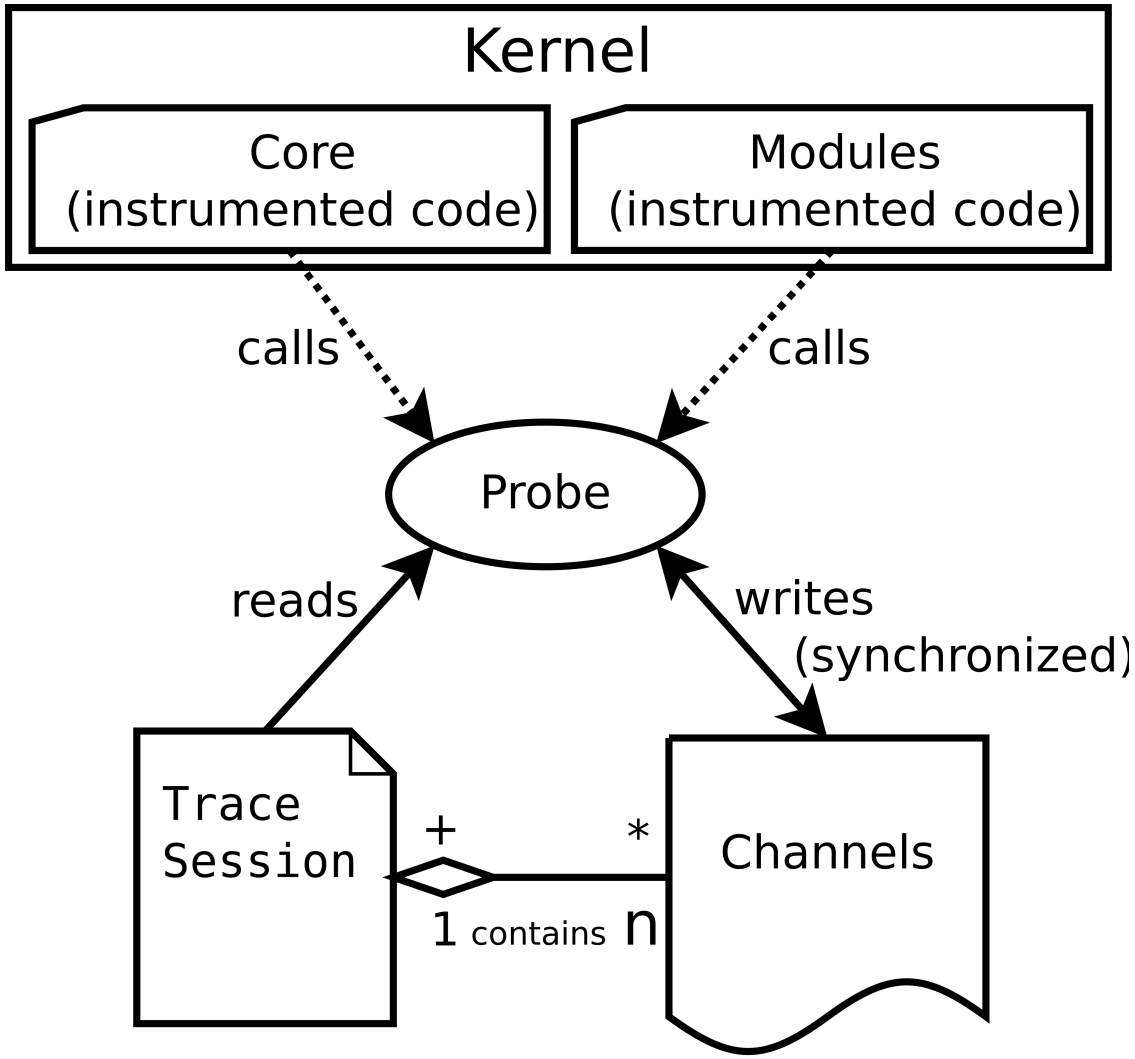
- Tracepoints are small pieces of code, like this:

```
if (tracepoint_1_active)
    (*tracepoint_1_probe)(arg1, arg2);
```

- Almost no overhead when inactive

- Overhead when active comparable to a C function call

LTTng – Tracepoints



* one trace sessoin contains multiple channels

LTTng – Storage & Tracemodes

- Data can be written to disk or sent to a network stream
- Available tracemodes are:
  - Write-to-disk, flight recorder
  - Still under development: stream to remote disk & live monitoring

LTTng – Overhead

Load size	Test Series	CPU time (%)			Data rate (MiB/s)	Events/s
		load	probes	lttd		
Small	mozilla (browsing)	1.15	0.053	0.27	0.19	5,476
Medium	find	15.38	1.150	0.39	2.28	120,282
High	find + gcc	63.79	1.720	0.56	3.24	179,255
Very high	find + gcc + ping flood	98.60	8.500	0.96	16.17	884,545

Source: Desnoyers: *A low impact performance and behavior monitor for GNU/Linux.*

LTTng – Post-Processing

- Babeltrace
  - Text based, LTTng 2.0 traces in CTF (Common Trace Format)
- LTT Viewer
  - Visual analyzer, written in C, extendable with plug-ins
- Eclipse
  - TMF (Trace Monitoring Framework) plug-in, displays:
    - Control Flow, Resources, and Statistics

Areas of application

- GPerfTools
  - Google, …
- LTTng
  - IBM, Siemens, Autodesk, Ericsson, …
  - Included in packages of Montavista, Wind River, STLinux, & Suse

Summary

- GPerfTools:
  - CPU Profiler, TCMalloc, Heap Leak Checker, Heap Profiler
  - Pprof for analysis
- LTTng:
  - Kernel & user space tracer → tracepoint → probe → channel → I/O
  - Babeltrace, LTT Viewer, and eclipse for analysis

Sources

- **GperfTools**: http://gperftools.googlecode.com
- **Desnoyers**:
  - *Low-Impact Operating System Tracing*
  - *A low impact performance and behavior monitor for GNU/Linux*
- **LTTng**: http://www.lttng.org
- **Chakraborty, Anjoy**: *Efficiency of LTTng as a Kernel and Userspace Tracer on Multicore Environment*