Perf Tools: Recent Improvements

Recent developments and discussion about TODO

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Improvements on initial set of tools

1. Tools Integration
2. Slang based Text User Interface
3. Use of build ids

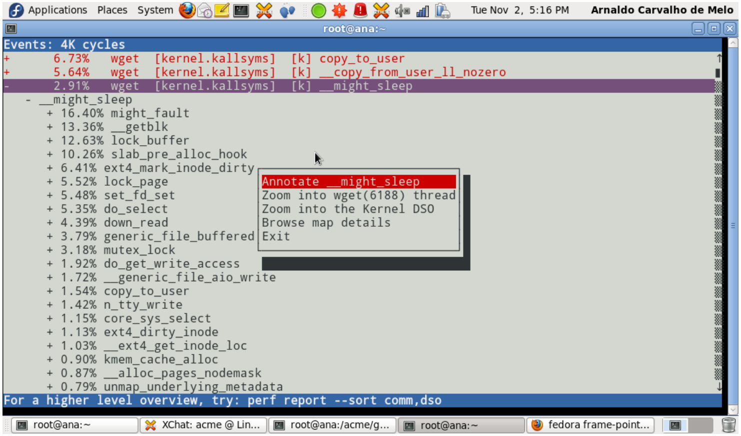
Tools Integration

1. One tool doesn't do it all
2. Combine steps to achieve multiple results
3. Allows spreading work flows over multiple machines
4. Profiling fast path
5. report to annotate
6. Reuse perf.data parsing

Slang Based TUI

1. GUIs not necessarily better
2. We still have mutt and pine users, after all
3. But the changes paves the way for GUIs
4. mutt like interface
5. report to annotate fast path
6. Zoom in/out DSOs/threads
7. Keys used: arrows + ENTER mostly, TAB sometimes
8. Still don't like it? Use –stdio

perf report TUI

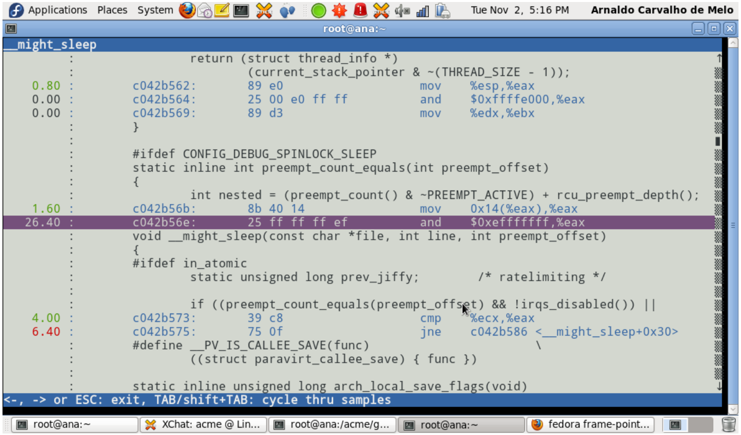


```
Events: 4K cycles
+      6.73%    wget  [kernel.kallsyms]  [k] copy_to_user
+      5.64%    wget  [kernel.kallsyms]  [k] __copy_from_user_ll_nozero
-      2.91%    wget  [kernel.kallsyms]  [k] __might_sleep
    - __might_sleep
       + 16.40% might_fault
       + 13.36% __getblk
       + 12.63% lock_buffer
       + 10.26% slab_pre_alloc_hook
       + 6.41% ext4_mark_inode_dirty
       + 5.52% lock_page               Annotate __might_sleep
       + 5.48% set_fd_set              Zoom into wget(6188) thread
       + 5.35% do_select               Zoom into the Kernel DSO
       + 4.39% down_read               Browse map details
       + 3.79% generic_file_buffered   Exit
       + 3.18% mutex_lock
       + 1.92% do_get_write_access
       + 1.72% __generic_file_aio_write
       + 1.54% copy_to_user
       + 1.42% n_tty_write
       + 1.15% core_sys_select
       + 1.13% ext4_dirty_inode
       + 1.03% __ext4_get_inode_loc
       + 0.90% kmem_cache_alloc
       + 0.87% __alloc_pages_nodemask
       + 0.79% unmap_underlying_metadata
For a higher level overview, try: perf report --sort comm,dso
```

perf annotate

1. Starts at the line with most hits
2. Tabs through ordered list of hot lines

perf annotate TUI


Applications Places System
Tue Nov 2, 5:16 PM Arnaldo Carvalho de Melo
root@ana:~
root@ana:~ XChat: acme @ Lin... root@ana:/acme/g... root@ana:~ fedora frame-point...

```
__might_sleep
       :                return (struct thread_info *)
       :                        (current_stack_pointer & ~(THREAD_SIZE - 1));
  0.80 :        c042b562:       89 e0                   mov    %esp,%eax
  0.00 :        c042b564:       25 00 e0 ff ff          and    $0xffffe000,%eax
  0.00 :        c042b569:       89 d3                   mov    %edx,%ebx
       :        }
       :
       :        #ifdef CONFIG_DEBUG_SPINLOCK_SLEEP
       :        static inline int preempt_count_equals(int preempt_offset)
       :        {
       :                int nested = (preempt_count() & ~PREEMPT_ACTIVE) + rcu_preempt_depth();
  1.60 :        c042b56b:       8b 40 14                mov    0x14(%eax),%eax
 26.40 :        c042b56e:       25 ff ff ff ef          and    $0xefffffff,%eax
       :        void __might_sleep(const char *file, int line, int preempt_offset)
       :        {
       :        #ifdef in_atomic
       :                static unsigned long prev_jiffy;        /* ratelimiting */
       :
       :                if ((preempt_count_equals(preempt_offset) && !irqs_disabled()) ||
  4.00 :        c042b573:       39 c8                   cmp    %ecx,%eax
  6.40 :        c042b575:       75 0f                   jne    c042b586 <__might_sleep+0x30>
       :        #define __PV_IS_CALLEE_SAVE(func)                               \
       :                ((struct paravirt_callee_save) { func })
       :
       :        static inline unsigned long arch_local_save_flags(void)
<-, -> or ESC: exit, TAB/shift+TAB: cycle thru samples
```

UI - TODO

1. perf top
2. Allow selecting events to record at any time
3. Start with top
4. Freeze == report
5. Save == record
6. perf probe
7. Go from annotate to probe, restart top

perf top

Considers user space symbols too:

```
 PerfTop: 155 irqs/sec kernel:83.9% [1000Hz cycles], (all, 2 CPUs)

  samples  pcnt function                             DSO
  _______ _____ _____________________________________ ___________________

   119.00 12.0% read_hpet                            [kernel]
    43.00  4.4% __strstr_ia32                        /lib/libc-2.12.1.so
    28.00  2.8% system_call                          [kernel]
    25.00  2.5% unix_poll                            [kernel]
    24.00  2.4% aes_enc_blk                          [aes_i586]
    21.00  2.1% schedule                             [kernel]
    21.00  2.1% _raw_spin_lock_irqsave               [kernel]
    19.00  1.9% _raw_spin_unlock_irqrestore          [kernel]
    19.00  1.9% aes_dec_blk                          [aes_i586]
    18.00  1.8% probe_workqueue_insertion            [kernel]
    17.00  1.7% hpet_next_event                      [kernel]
    13.00  1.3% fget_light                           [kernel]
    13.00  1.3% do_select                            [kernel]
    12.00  1.2% audit_syscall_entry                  [kernel]
    12.00  1.2% ktime_get                            [kernel]
    11.00  1.1% test_ti_thread_flag                  [kernel]
    11.00  1.1% std::_List_node_base::transfer(std::_L libstdc++.so.6.0.13
    11.00  1.1% native_sched_clock                   [kernel]
    11.00  1.1% vsnprintf                            [kernel]
    11.00  1.1% format_decode                        [kernel]
    10.00  1.0% index                                /lib/libc-2.12.1.so
```

perf stat

1. List of CPUs to monitor
2. Ask for precise events(PEBS) using suffix: "-e cycles:p"
3. Multiple 'p' characters == more precise
4. Proof of concept patch for printing counters periodically ready
5. Merge app log output sorting by timestamps

New Tools

Introduced after Plumbers'2009:

1. diff
2. archive
3. probe
4. trace
5. several trace ones (timechart, etc)

perf diff

1. Shows difference in symbol hits between two perf.data files
2. Keyed by build-ids in the cache
3. Should support more than two files
4. Generating version X samples symbol plottings
5. Read "Differential Profiling" paper by Paul McKenney on how to use it

perf archive

1. Looks at perf.data files for DSOs with hits
2. Creates tarball
3. Transfer to another machine
4. Populate the cache
5. Use report and annotate
6. Handles endianness

perf probe

1. Inserts dynamic probes
2. Doesn't necessarily requires debuginfo
3. Can collect variables
4. Struct members can be specified to any level
5. Works with callchains
6. Works on the core kernel and on modules
7. Supports wildcards in probe names
8. Together with perf trace == systemtap subset
9. Example of use together with scripting later in this presentation
10. Contributed by Masami Hiramatsu

Scripting

1. Use scripting languages to process events
2. Python and Perl
3. Allows tapping into tons of language libraries
4. Several scripts available
5. Generate scripts from perf.data
6. Contributed by Tom Zanussi

Available Scripts

```
[root@ana ~]# perf trace --list
List of available trace scripts:
  rw-by-pid                          system-wide r/w activity
  wakeup-latency                     system-wide min/max/avg wakeup latency
  workqueue-stats                    workqueue stats (ins/exe/create/destroy)
  rwtop [interval]                   system-wide r/w top
  failed-syscalls [comm]             system-wide failed syscalls
  rw-by-file <comm>                  r/w activity for a program, by file
  syscall-counts-by-pid [comm]       system-wide syscall counts, by pid
  netdev-times [tx] [rx] [dev=]      display a process of packet and processin
  sctop [comm] [interval]            syscall top
  futex-contention                   futex contention measurement
  sched-migration                    sched migration overview
  failed-syscalls-by-pid [comm]      system-wide failed syscalls, by pid
  syscall-counts [comm]              system-wide syscall counts
[root@ana ~]#
```

Generate Scripts

1. From the events found in perf.data file
2. Quickly start writing event handling
3. Creates function skeletons for each trace event
4. With a common set of parameters
5. Plus event specific parameters
6. Calls methods at init, exit and for unhandled events
7. Comes with library of tracing specific methods

Listing Possible probe points

```
[root@ana icmp]# perf probe -L icmp_rcv
<icmp_rcv:0>
      0  int icmp_rcv(struct sk_buff *skb)
      1  {

     59         if (rt->rt_flags & (RTCF_BROADCAST | RTCF_MULTICAST)) {
                        /*
                         * RFC 1122: 3.2.2.6 An ICMP_ECHO to broadcast MAY be
                         * silently ignored (we let user decide with a sysctl).
                         * RFC 1122: 3.2.2.8 An ICMP_TIMESTAMP MAY be silently
                         * discarded if to broadcast/multicast.
                         */
     66                 if ((icmph->type == ICMP_ECHO ||
                             icmph->type == ICMP_TIMESTAMP) &&
                            net->ipv4.sysctl_icmp_echo_ignore_broadcasts) {
                                goto error;
                        }
     71                 if (icmph->type != ICMP_ECHO &&
```

Listing variables that can be collected

```
[root@ana ~]# perf probe -V icmp_rcv:66
Available variables at icmp_rcv:66
        @<icmp_rcv+343>
                struct icmphdr* icmph
                struct net*     net
                struct rtable*  rt
                struct sk_buff* skb
[root@ana ~]#
```

Adding a probe

```
[root@ana icmp]# perf probe icmp_rcv:66 'type=icmph->type'
Add new event:
  probe:icmp_rcv    (on icmp_rcv:66 with type=icmph->type)

You can now use it on all perf tools, such as:

perf record -e probe:icmp_rcv -aR sleep 1

[root@ana ~]# perf probe --list
  probe:icmp_rcv (on icmp_rcv:66@net/ipv4/icmp.c with type)

[root@ana icmp]# perf record -a -g -e probe:icmp_rcv
^C[ perf record: Woken up 1 times to write data ]
[ perf record: Captured and wrote 0.324 MB perf.data ]
```

Generating a python script from perf.data

```
[root@ana icmp]# perf trace -g python
generated Python script: perf-trace.py

[root@ana icmp]# cat perf-trace.py

def trace_begin():
        print "in trace_begin"

def trace_end():
        print "in trace_end"

def probe__icmp_rcv(evname, cpu, secs, nsecs, pid, comm,
                    probe_ip, type):
        print "%s %u.%u type=%u" % (evname, secs, nsecs, type)
```

Running python script

```
[root@ana icmp]# perf trace -s perf-trace.py
in trace_begin
probe__icmp_rcv 71171.964568380 type=8
probe__icmp_rcv 71177.792382154 type=8
probe__icmp_rcv 71178.792236953 type=8
in trace_end
[root@ana icmp]#
```

Backtraces from probes

```
[root@ana ~]# perf report --stdio
# Events: 2
#
# Overhead  Command      Shared Object    Symbol
# ........  .......  .................  ........
#
   100.00%     ping  [kernel.kallsyms]  [k] icmp_rcv
               |
               --- icmp_rcv
                   ip_local_deliver_finish
                   NF_HOOK.clone.1
                   ip_local_deliver
                   ip_rcv_finish
                   NF_HOOK.clone.1
                   ip_rcv
                   __netif_receive_skb
                   process_backlog
                   net_rx_action
                   __do_softirq
                   0xb7707424

[root@ana ~]#
```

Scripting TODO List

1. Convert trace builtins to scripts (sched, kmem, etc)
2. Convert net/ipv4/tcp_probe.c
3. SCTP and DCCP variants too
4. Write more scripts for showing where IO is happening
5. Improve passing data from record to trace
6. Remove requirement on using netcat for dual machine use
7. Write more scripts (you can help here!)

KVM Support

1. Collect guest OS statistics from host side.
2. top, record, report, diff, buildid-list
3. Need to specify guest vmlinux or kallsyms, /proc/modules
4. Or –guestmount directory with sshfs mounted per pid subdirs
5. Use –pid to specify specific guest
6. Contributed by Zhang, Yanmin.

perf top kvm example

```
# perf kvm --host --guest --guestkallsyms=guest/kallsyms \
           --guestmodules=guest/modules top

 PerfTop: 16010 irqs/sec kernel:59.1% us: 1.5% guest
          kernel:31.9% guest us:7.5% [+1000Hz cycles]

  samples  pcnt function                  DSO

  ------- ----- ------------------------- --------------

 38770.00 20.4% __ticket_spin_lock        [guest.kernel]
 22560.00 11.9% ftrace_likely_update      [kernel]
  9208.00  4.8% __lock_acquire            [kernel]
  5473.00  2.9% trace_hardirqs_off_caller [kernel]
  5222.00  2.7% copy_user_generic_string  [guest.kernel]
  4450.00  2.3% validate_chain            [kernel]
  4262.00  2.2% trace_hardirqs_on_caller  [kernel]
  4239.00  2.2% do_raw_spin_lock          [kernel]
  3548.00  1.9% do_raw_spin_unlock        [kernel]
  2487.00  1.3% lock_release              [kernel]
  2165.00  1.1% __local_bh_disable        [kernel]
  1905.00  1.0% check_chain_key           [kernel]
```

Work in Progress

1. cgroups support
2. utrace to probe user space
3. PerfKit GUI
4. In addition to KernelShark and sysprof GUIs

Thanks!

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