Embedded Linux Conference 2010

Using the LTTng Tracer for System-Wide Performance Analysis and Debugging (Hands-on Tutorial)

Presentation and files at:
http://www.efficios.com/elc2010

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> Presenter

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  - LTTng, LTTV, Userspace RCU
- Ph.D. in computer engineering
  - Low-Impact Operating System Tracing

> Plan

- LTTng Installation
- Tracing Strategy
- Trace Analysis (Hands-on Example)
- Questions

> LTTng installation

- http://lttng.org
  - LTTng
  - LTT control
  - LTTV
- Documentation
  - LTTng Kernel Tracer Manual
  - LTTng Compatibility List

> Lockless Trace Clock

- dmesg, check for LTT warnings
- Cycle counter is used
- For architectures with non-synchronized cycle counters (e.g. some x86):
  - cpufreq-set -g performance
  - idle=poll (kernel parameter)
- LTTng fully supports power management and frequency scaling on ARM OMAP3
  - funded by Nokia

> Tracing Strategy

- Problem Identification
- Trace Session Setup
- Anchor / Trigger

> Problem identification

- Bug report summary
  - What is going wrong with the system ?
  - What is the system configuration affected ?
    - Hardware
    - Software
  - Optionally: known good / known bad configurations

> Tracing strategy (decision factors)

- Tracing strategy decision factors
  - Reproducible on development setup or only in production ?
  - Tracing overhead the system can tolerate
  - Frequency of problem occurrence
  - Availability of the system
    - Remote/local
    - Controlled by third-party
  - Number of tracing iterations available

> Trace Session Setup

- Identify the tracer setup best suited to solve the problem
  - Producer-consumer tracing
  - Flight recorder tracing
  - Per-channel buffer size
  - Activated instrumentation

> Anchor / Trigger

- Traces are hard to analyze
  - Large volume of information collected
  - Hard to identify relevant information
- Add anchor instrumentation to the system
- Use triggers to stop flight recorder tracing

> Anchor

- Starting point for trace analysis
- Identify surrounding of problem occurrence
- Different types
  - Instrumentation anchors
  - Analysis-generated anchors

> Anchor

- Instrumentation anchors
  - Userland or kernel instrumentation
    - UST (Userspace Tracer)
    - Write to /debugfs/ltt/write_event
    - Add kernel TRACE_EVENT/markers
  - Events generated from user interaction
    - Input subsystem
  - Instrumentation of program error-handling
- Analysis-generated anchors
  - e.g. longest timer interrupt jitter

> Producer-consumer tracing

- Writes trace data to the file system
- Whole trace session duration
- Initial state dump : complete state collected
  - (+) Very accurate state representation
  - (-) Consumes disk or network I/O bandwidth

```
(as root)
ltt-armall
lttctl -C -w /tmp/trace-prod1 trace-prod1
...
lttctl -D trace-prod1
```

> Flight recorder tracing

- Gather trace data in circular ring buffers
- Kept in memory, oldest data overwritten
- Last events available when tracing is stopped
- Per-channel size is configurable
  - (+) Very low system throughput overhead
  - (-) Shorter available backlog
  - (-) System state is less accurate
    - Partially unknown

> Triggers

- Instrumentation with side-effect
  - Start/stop tracing when executed
- Particularly useful for flight recorder mode
  - Produces event backlog that lead to execution of “trigger”
- Kernel API
  - ltt_trace_start(“name”), ltt_trace_stop(“name”)
- From user-space
  - lttctl -s name ; lttctl -p name

> Userland trigger example

Userland trigger for flight recorder trace

(as root)
ltt-armall
lttctl -c -o channel.all.overwrite=1 -w /tmp/trace-utrigger1 trace-utrigger1
lttctl -s trace-utrigger1
...
(trigger) → lttctl -p trace-utrigger1
lttctl -d -w /tmp/trace-utrigger1 trace-utrigger1

> Kernel trigger example

Kernel trigger

(as root)
ltt-armall
lttctl -c -o channel.all.overwrite=1 -w /tmp/trace-ktrigger1 trace-ktrigger1
lttctl -s trace-ltrigger1
...
(trigger in kernel) → ltt_trace_stop("trace-ktrigger1");

lttctl -d -w /tmp/trace-ktrigger1 trace-ktrigger1

> Trace Analysis (Hands-on Example)

- Identify sources of audio latency
- Scheduler latency
  - wakeup-latency.c
    - write_event anchor
- With 2.6.33.2 kernel

maximum latency: 44614.1 µs
average latency: 3851.4 µs
missed timer events: 0

> Find anchors

Filter expression:
  <field> <comparator> <value>
  <field> <comparator> <value> <logical> <expression>
    (comparators: =, !=, <, <=, >, >=)
    (logical: &, |, !, ^)
(see lttv-gui "filter" plugin for expression examples)

Find all events in channel "userspace"
(written through write_event):

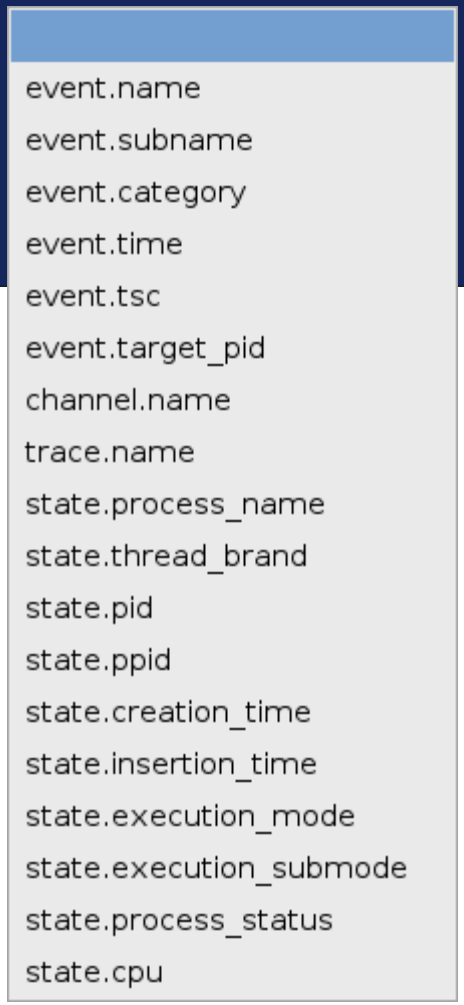
```
% lttv -m textDump -e "channel.name=userspace" \
        -t /tmp/trace-prod1
```

Filter by channel.event (list with "find /debugfs/ltt/markers") :

```
% lttv -m textDump -e "event.name=kernel.sched_schedule" \
      -t /tmp/trace-prod1
```

Filter by PID :

```
% lttv -m textDump -e "state.pid=1" -t /tmp/trace-prod1
```



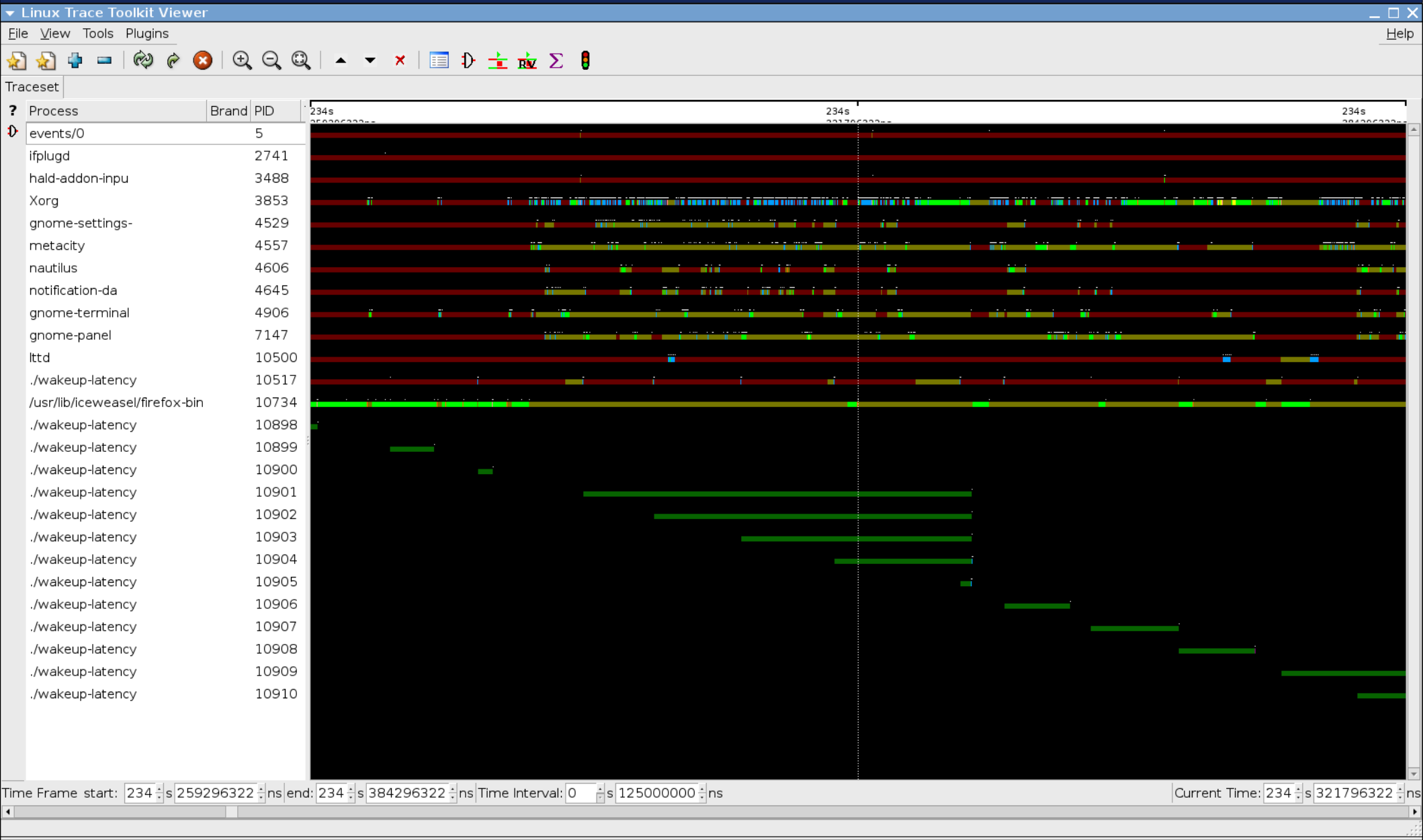
Filter fields

> Finding "wakeup-latency" Anchor

```
% lttv -m textDump -e "channel.name=userspace" -t /tmp/trace-cfs-2/

...
userspace.event: 234.334734395 (/tmp/trace-cfs-2/userspace_0),
      10905, 10516, ./wakeup-latency, , 10517, 0x0,
      SYSCALL { string = "late by: 44614.1 µs" }
...
```

> Viewing execution patterns



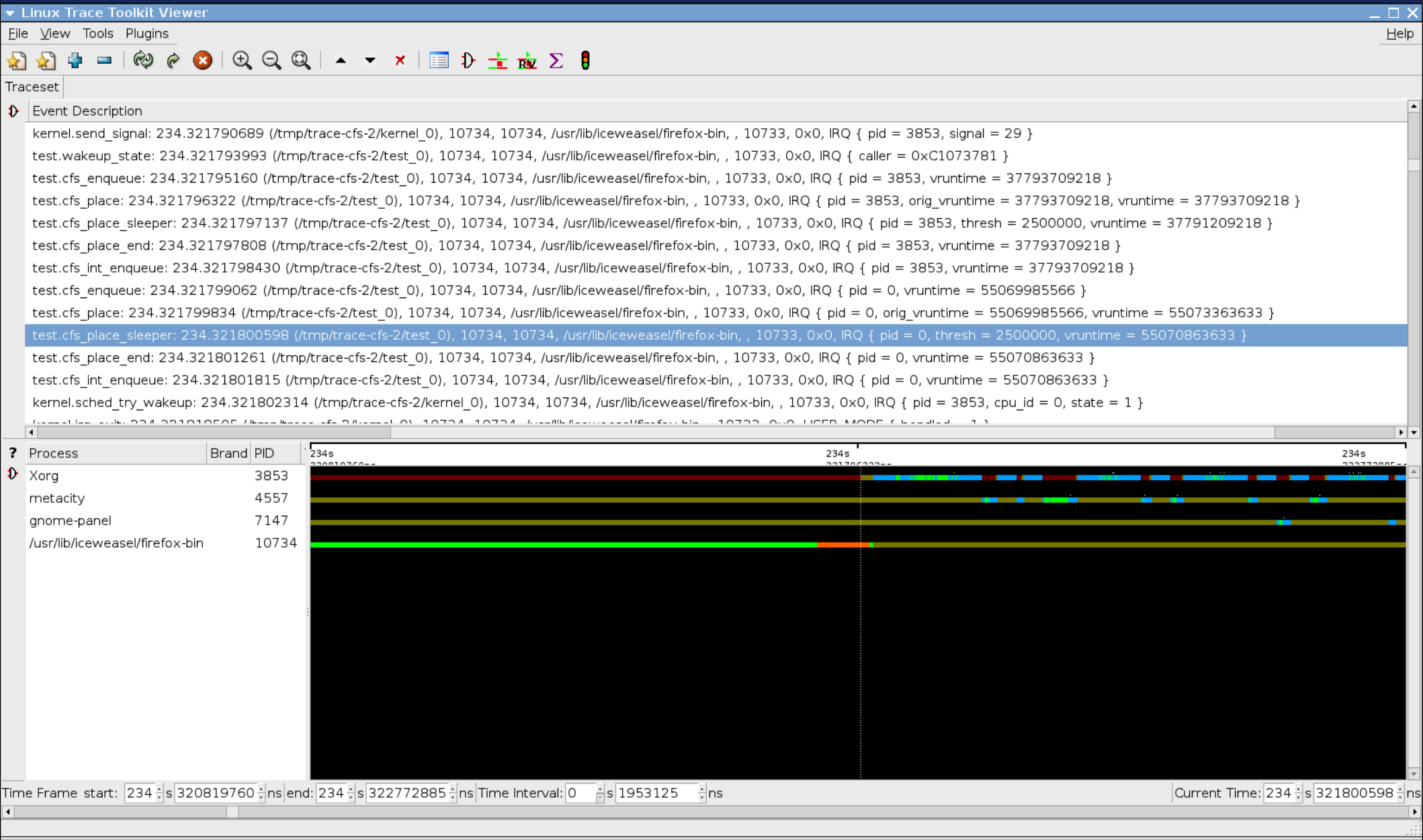
> Instrumentation addition iterations

Instrumentation example (with markers) :

```
Index: linux-2.6-lttng.git/kernel/sched_fair.c
===================================================================
--- linux-2.6-lttng.git.orig/kernel/sched_fair.c        2010-04-10
11:47:04.000000000 -0400
+++ linux-2.6-lttng.git/kernel/sched_fair.c     2010-04-10
11:50:59.000000000 -0400
....
@@ -764,12 +768,18 @@
                        thresh >>= 1;

                vruntime -= thresh;
+               trace_mark(test, cfs_place_sleeper,
+                          "pid %d thresh %lu vruntime %llu",
+                          task_of(se)->pid, thresh, vruntime);
        }
....
```

> Digging into Xorg scheduling



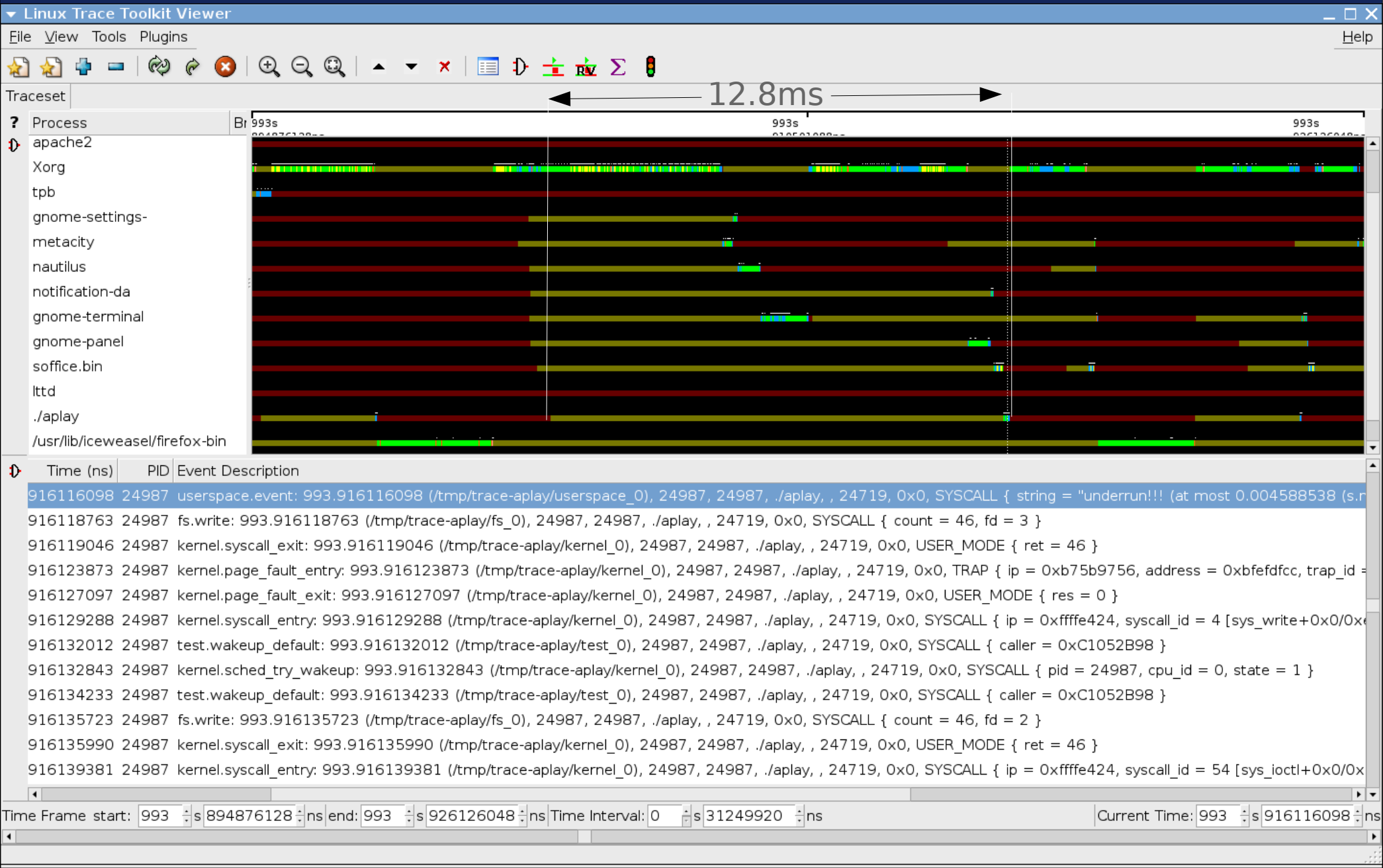
> Looking at alsa

- Adding instrumentation of buffer underrun into aplay as anchor
  - write_event

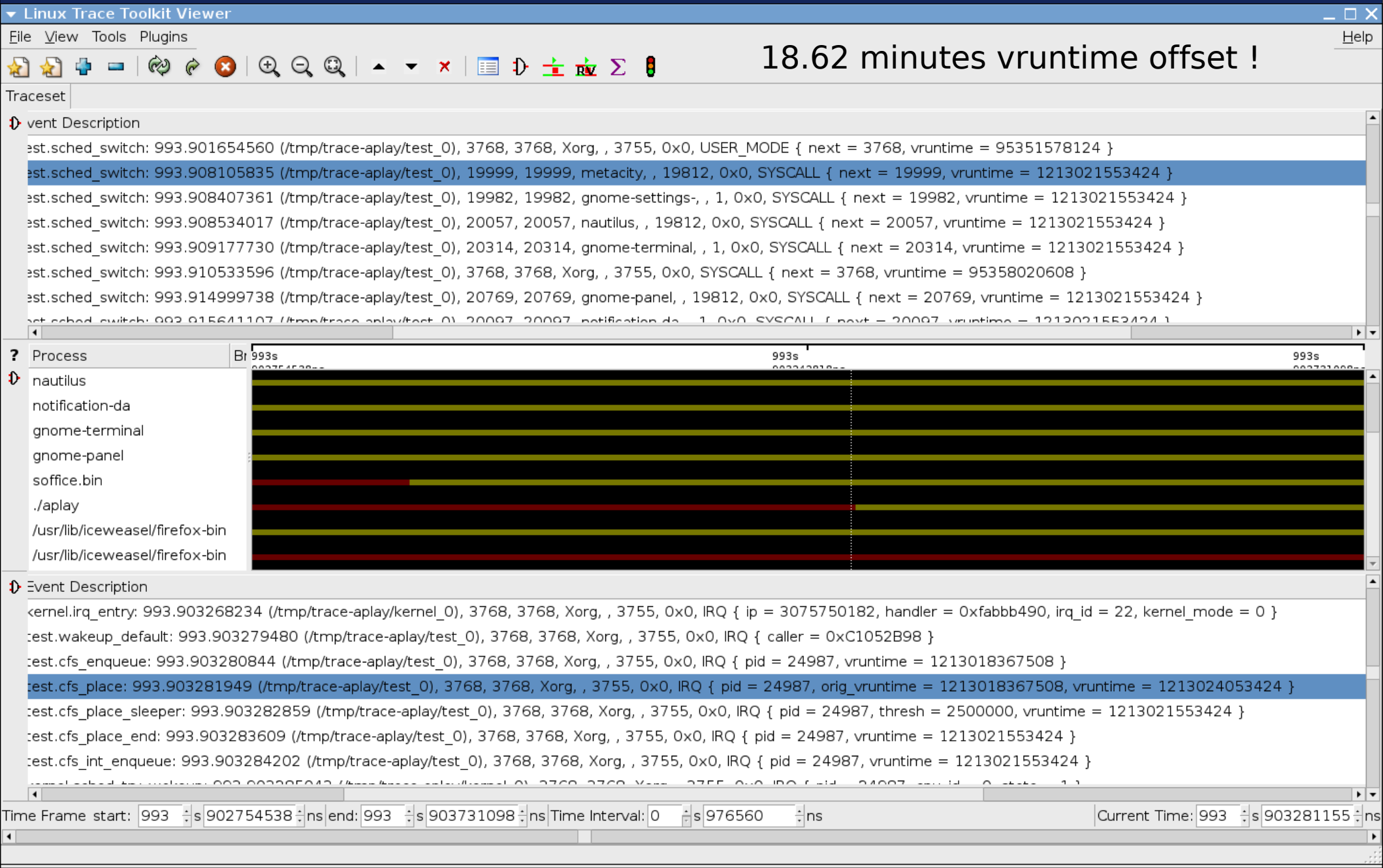
./aplay --period-size=128 --buffer-size=512 -D hw:0 test.wav

Buffer:
512 samples / 48000 samples/s = 10.6ms
Period:
128 samples / 48000 samples/s = 2.6ms

> View of a buffer underrun



> sched_fair vruntime analysis



> Questions ?

EfficiOS

- http://www.efficios.com

- LTTng Information

  - http://lttng.org
  - ltt-dev@lists.casi.polymtl.ca