LinuxCon Europe 2011

LTTng 2.0 : Application, Library and Kernel tracing within your Linux distribution.

E-mail:
mathieu.desnoyers@efficios.com

> Buzzword compliant !

- LTT: Linux Trace Toolkit
- “ng” : Next Generation
- 2.0 !

LTTng 2.0 !

- All we miss is a recursive acronym. ;)

> Presenter

- Mathieu Desnoyers
- EfficiOS Inc.
  - http://www.efficios.com
- Author/Maintainer of
  - LTTng, LTTng-UST, Babeltrace, LTTV, Userspace RCU

> Benefits of low-impact tracing in a multi-core world

- Understanding interaction between
  - Kernel
  - Libraries
  - Applications
  - Virtual Machines
- Debugging
- Performance tuning
- Monitoring

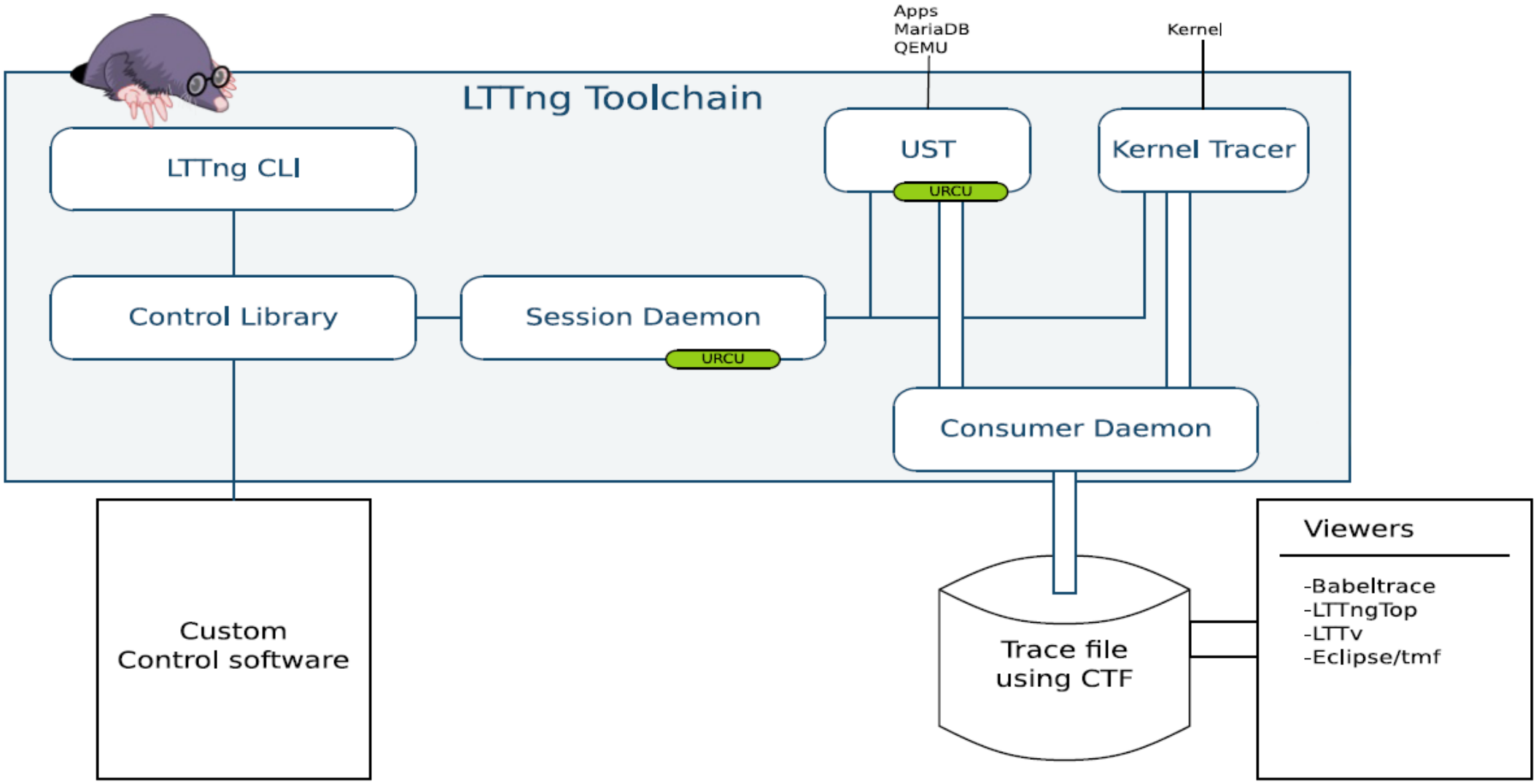
> Tracing use-cases

- Telecom
  - Operator, engineer tracing systems concurrently with different instrumentation sets.
  - In development and maintenance phases.
- Embedded
  - System development, maintenance of deployed systems.
- Server/Desktop software
  - Qemu/KVM, MariaDB.

> Why do we need a LTTng 2.0 ?

- Need more flexible trace data layout format
  - Introduce Common Trace Format (CTF)
- Introduction of user-space tracing (UST)
  - Leverage common control infrastructure for kernel and user-space tracing
  - Simplification of the kernel-level infrastructure
- Need more flexible ring buffer
  - Snapshot, mmap and splice, global and per-cpu, kernel and user-space, configurable crash dump support.

> LTTng 2.0 Toolchain Overview



> LTTng 2.0 Tracing Session

- Multiple domains:
  - Kernel, User-space
  - Eventually: Hypervisor, multiple hosts
- Controlled through same UI/API:
  - lttng -k ...
  - lttng -u …
- Correlation across domains (common time-line)
- Viewed by pointing trace viewer to the top-level trace collection directory

> LTTng 2.0 Kernel Tracer

- Build against a vanilla or distribution kernel, without need for additional patches,
- Tracepoints, Function tracer, Perf CPU Performance Monitoring Unit (PMU) counters, kprobes, and kretprobes support,
- Supports multiple tracing sessions, flight recorder mode, snapshots, ...

> LTTng 2.0 Kernel Tracer

- ABI based on ioctl() returning anonymous file descriptors
  - implemented a top-level DebugFS “lttng” file.
- Lib Ring Buffer, initially developed generically for mainline Linux kernel (as a cleanup of the LTTng 0.x ring buffer) has been merged into LTTng 2.0.
- Exports trace data through the Common Trace Format (CTF).

> LTTng 2.0 Kernel Tracer

- Supports dynamically selectable “context” information to augment event payload
  - Any Perf Performance Monitoring Unit counter
  - PID, PPID, TID, process name, VPID, VTID, …
  - Dynamic Priority, nice value

> LTTng-UST 2.0 User-space Tracer Features

- TRACEPOINT_EVENT() API for application/library static instrumentation (planned sdt.h gdb/systemtap integration).
- Per-user tracing.
- System-wide tracing.
  - "tracing" group: no need to be root to perform system-wide tracing.

> LTTng-UST 2.0 User-space Tracer Infrastructure

- libust in-process library.
- libust constructor registers to session daemon upon application startup, waits for commands.
- This rendez-vous point allows
  - Tracing across all system's applications/libraries
  - Tracing on per-application executable name basis
- Fast: trace applications without per-event system call overhead into per-cpu/process buffers.

> TRACEPOINT_EVENT

In header:

```
TRACEPOINT_EVENT(ust_tests_hello_tptest,
        TP_PROTO(int anint, long *values,
                 char *text, size_t textlen,
                 double doublearg, float floatarg),
        TP_ARGS(anint, values, text, textlen,
                doublearg, floatarg),
        TP_FIELDS(
                ctf_integer(int, intfield, anint)
                ctf_integer_hex(int, intfield2, anint)
                ctf_array(long, arrfield1, values, 3)
                ctf_sequence(char, seqfield1, text,
                             size_t, textlen)
                ctf_string(stringfield, text)
                ctf_float(float, floatfield, floatarg)
                ctf_float(double, doublefield, doublearg)
        )
)
```

Tracepoint name convention

> User-level Tracepoint

Name convention

< [com_company_]project_[component_]event >

Where "company" is the name of the company,
"project" is the name of the project,
"component" is the name of the project component (which may include several levels of sub-components, e.g. ...component_subcomponent_...) where the tracepoint is located (optional),
"event" is the name of the tracepoint event.

Tracepoint invocation within the code:

```
void fct(void)
{
    tracepoint(ust_tests_hello_tptest, i, values,
                text, strlen(text), dbl, flt);
}
```

> tracepoint_printf()

- Feature planned.
- Debug-style tracing.
- tracepoint_printf(name, “fmt”, …);
- Augment Common Trace Format to store format strings.
- Export only binary data through buffers.
- Pretty-printing performed at post-processing.

> LTTng-UST 2.0 Buffering

- Port of the lib ring buffer to user-space.
- Supports buffering between processes through POSIX shared memory maps.
- Fast-paths stay in user-space (no system call).
- Wake-up though pipes.
- Buffers per process (for security), shared with consumer. Faster/lower memory consumption insecure global buffers feature planned too.

> LTTng Tracing Session Daemon

- Central (system-wide) and per-user instances.
- Controls
  - LTTng kernel tracer
  - LTTng-UST application/library tracer
  - Right management by UNIX socket file access rights.
  - System-wide tracing controlled by tracing group.
  - File descriptors passed through UNIX sockets
- Presents a unified notion of system-wide tracing session, with multiple “domains”.

> LTTng Consumers

- Spawned by the tracing sessions daemon
- Design guide-lines:
  - Minimal access, aiming at a design where sessiond opens all files, consumers just copy data between memory maps and file descriptors (received though UNIX socket credentials).
- Disk output (splice, mmap).
- In-place mmap buffer consumption (lttngtop).
- Planned network transport.

> LTTng CLI / liblttngctl

- Unified control interface for kernel and user-space tracing
  - “lttng” git-alike command line interface
  - All tracing control commands available through an API: liblttngctl and lttng.h

> LTTng UI examples

```
lttng list -k                          # list available kernel tracepoints
lttng create mysession                 # create session “mysession”
lttng enable-event -k -a               # enable all syscalls/tracepoints
lttng enable-event -k --syscall -a # trace system calls
lttng enable-event sched_switch,sched_wakeup -k
lttng enable-event aname -k --probe symbol+0x3
lttng enable-event aname -k --function <symbol_name>
lttng add-context -k -e sched_switch -t pid        # add PID
context
lttng add-context -k -e sched_switch -t perf:cpu-cycles
lttng start                            # start tracing
...
lttng stop                             # stop tracing
lttng destroy                          # teardown session
# text output
babeltrace -n $HOME/lttng-traces/mysession-<date>-<time>
```

> LTTng 2.0 high-speed “strace”

lttng enable-event --syscall -a

compudj@squeeze-amd64: ~

```
lp
name = sys_brk, stream.packet.context = { cpu_id = 1 }, event.fields = { brk = 28622848 }
name = exit_syscall, stream.packet.context = { cpu_id = 1 }, event.fields = { ret = 28622848 }
name = sys_read, stream.packet.context = { cpu_id = 1 }, event.fields = { fd = 3, buf = 0x1B48008, count = 9645 }
name = exit_syscall, stream.packet.context = { cpu_id = 1 }, event.fields = { ret = 9645 }
name = sys_close, stream.packet.context = { cpu_id = 1 }, event.fields = { fd = 3 }
name = exit_syscall, stream.packet.context = { cpu_id = 1 }, event.fields = { ret = 0 }
name = sys_open, stream.packet.context = { cpu_id = 1 }, event.fields = { filename = "/root/.bash_history", flags = 513, mode
name = exit_syscall, stream.packet.context = { cpu_id = 1 }, event.fields = { ret = 3 }
name = sys_write, stream.packet.context = { cpu_id = 1 }, event.fields = { fd = 3, buf = 0x1B48081, count = 9524 }
name = exit_syscall, stream.packet.context = { cpu_id = 1 }, event.fields = { ret = 9524 }
name = sys_close, stream.packet.context = { cpu_id = 1 }, event.fields = { fd = 3 }
name = exit_syscall, stream.packet.context = { cpu_id = 1 }, event.fields = { ret = 0 }
name = sys_rt_sigprocmask, stream.packet.context = { cpu_id = 1 }, event.fields = { how = 0, nset = 0x7FFF28A2A040, oset = 0x
name = exit_syscall, stream.packet.context = { cpu_id = 1 }, event.fields = { ret = 0 }
name = sys_ioctl, stream.packet.context = { cpu_id = 1 }, event.fields = { fd = 255, cmd = 21520, arg = 140733875134380 }
name = exit_syscall, stream.packet.context = { cpu_id = 1 }, event.fields = { ret = 0 }
name = sys_rt_sigprocmask, stream.packet.context = { cpu_id = 1 }, event.fields = { how = 2, nset = 0x7FFF28A29FC0, oset = 0x
name = exit_syscall, stream.packet.context = { cpu_id = 1 }, event.fields = { ret = 0 }
name = sys_setpgid, stream.packet.context = { cpu_id = 1 }, event.fields = { pid = 0, pgid = 4235 }
name = exit_syscall, stream.packet.context = { cpu_id = 1 }, event.fields = { ret = 0 }
name = sys_exit_group, stream.packet.context = { cpu_id = 1 }, event.fields = { error_code = 0 }
name = exit_syscall, stream.packet.context = { cpu_id = 1 }, event.fields = { ret = 1 }
name = sys_gettimeofday, stream.packet.context = { cpu_id = 1 }, event.fields = { tv = 0x7FFF0E61DC10, tz = 0x0 }
name = exit_syscall, stream.packet.context = { cpu_id = 1 }, event.fields = { ret = 0 }
```

> Common Trace Format

- Trace format specification
  - Funded by
    - Linux Foundation CE Linux Forum and Ericsson
  - In collaboration with Multi-Core Association Tool Infrastructure Workgroup
    - Freescale, Mentor Graphics, IBM, IMEC, National Instruments, Nokia Siemens Networks, Samsung, Texas Instruments, Tilera, Wind River, University of Houston, Polytechnique Montréal, University of Utah.
  - Gathered feedback from Linux kernel developers and SystemTAP communities.

> Common Trace Format

- Targets system-wide and multi-system trace representation in a common format, for integrated analysis:
  - Software traces
    - Across multiple CPUs
    - Across the software stack (Hypervisor, kernel, library, applications)
  - Hardware traces
    - DSPs, device-specific tracing components.
    - GPUs.

> Common Trace Format

- Babeltrace
  - Reference implementation trace conversion tool and read/seek API for trace collections.
  - Initially converts
    - From CTF to text
    - From dmesg text log to CTF
- LTTng kernel 2.0 and LTTng-UST 2.0
  - Native CTF producer reference implementation.
- Available at: http://www.efficios.com/ctf

> Distributions

- Distributions shipping LTTng 0.x
  - Wind River Linux, Montavista, STlinux, Linaro, Yocto, Mentor Embedded Linux, ELinOS, Novell SuSE Enterprise RT Linux.
- Packages
  - Debian and Ubuntu
    - UST, Userspace RCU, LTTV
- Working closely with Ubuntu and Debian to have LTTng 2.0 toolchain ready for the next Ubuntu LTS.

> Distributions

- Fedora
  - Fedora packages available for LTTng 0.x user-space tracing and trace analysis, LTTng 2.0 packages soon to be integrated,
- RHEL 6
  - In discussion with Redhat developers to backport tracepoint patches needed for LTTng 2.0 kernel tracer support. Else will target RHEL 7.

> Conditional tracing for UST 2.0

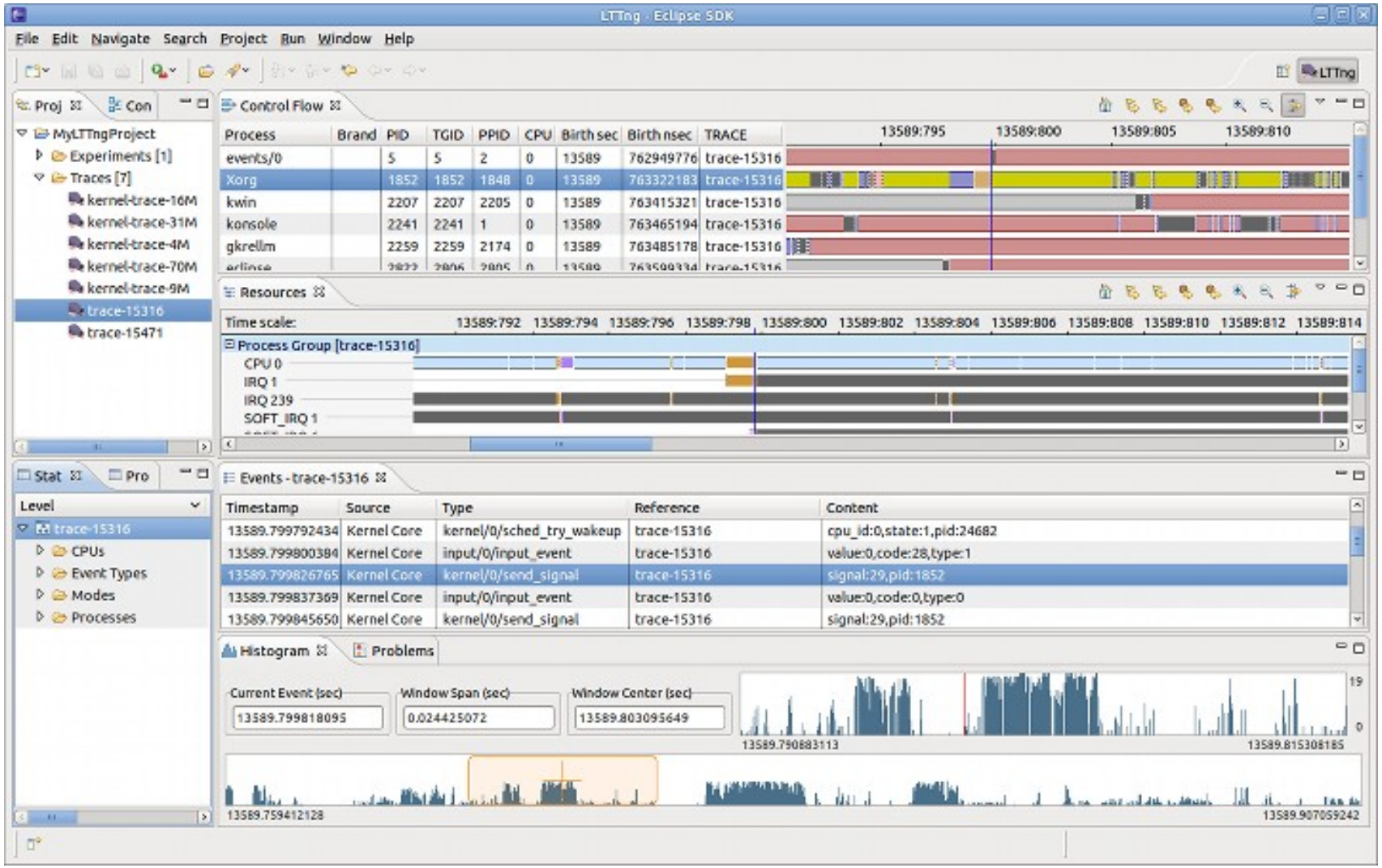
- Work planned for 2012
- Dynamic filtering of event payloads
- Very fast: zero-copy, filtering before any interaction with the ring buffer.

> Trace analysis tools

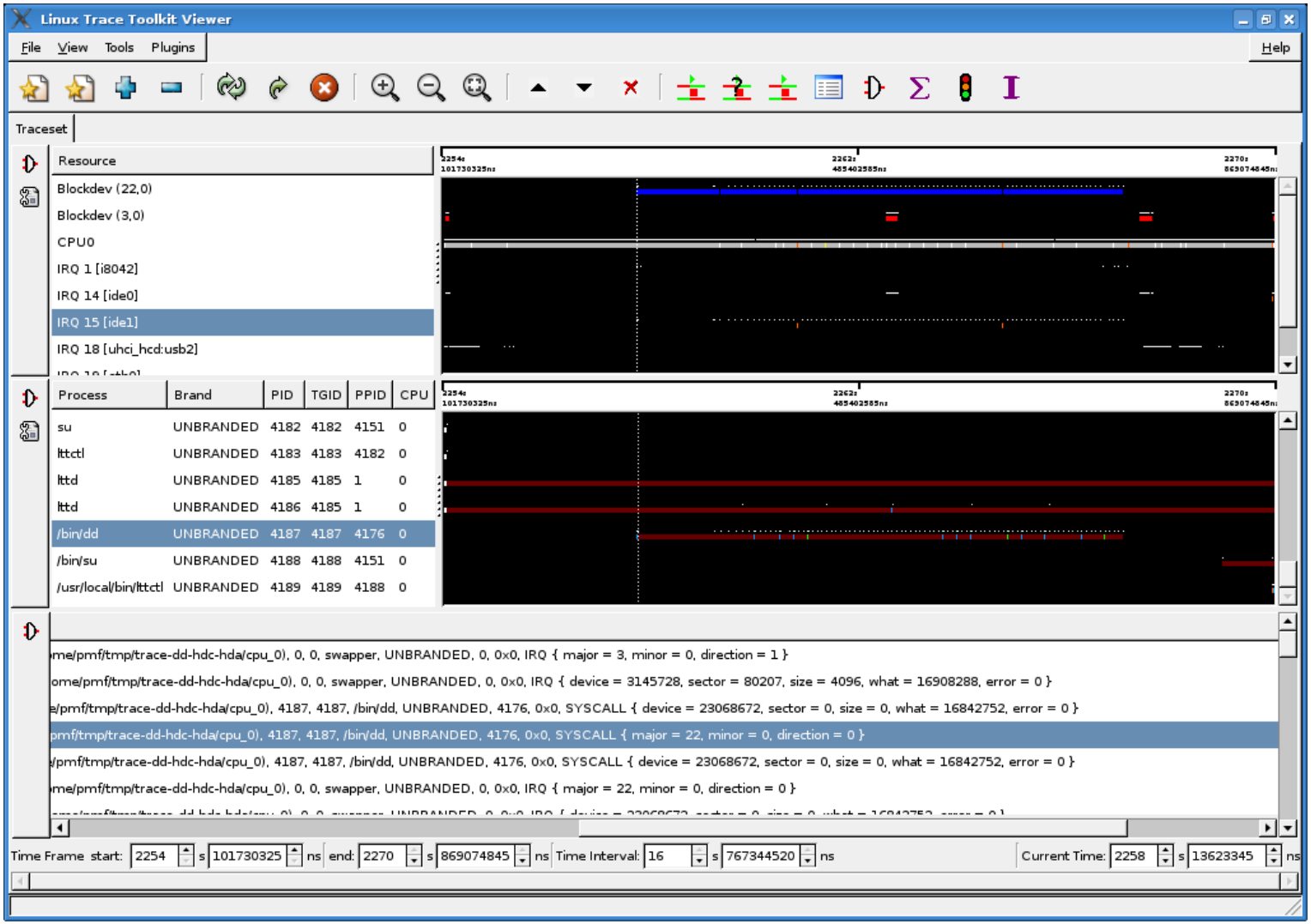
- Graphical
  - Eclipse Linux Tools Project: LTTng support.
  - LTTV
- Text-based
  - LTTngtop
  - LTTV
  - Babeltrace

> Eclipse Linux Tools Project: LTTng support

- http://wiki.eclipse.org/Linux_Tools_Project/LTTng



> LTTV



- Will be ported to LTTng 2.0 soon.

> Questions ?

LTTng 2.0 pre-releases available at http://lttng.org/lttng2.0

EfficiOS

- http://www.efficios.com

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