LTTng: The Challenges of User-Space Tracing

Tracing Summit 2023

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Summary

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- Lots of feedback from users
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- Challenges of integrating a user-space tracer in Linux ecosystem
- Apply to other tools and applications

User-space Tracer Properties Trifecta

1. **Integrity** [I] of application
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2. **Reliability** [R] of results
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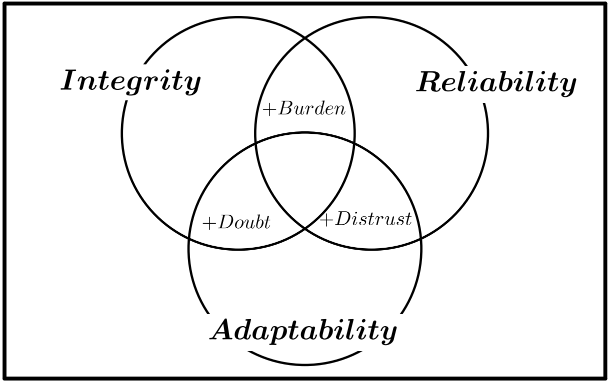
   - Report tracing setup complete or partial failures
3. **Adaptability** [A] of tracer
   - Automatically adapt to the software and hardware environments
   - Minimize the amount of user intervention and configuration required for tracing

User-space Tracer Properties Trifecta (continuation)

- R + A = user **distrusts** the tracer; won't deploy it
- I + A = results are **doubted** by the user
- I + R = increased of **burden** put on the user



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- Current solution [I]
  - **LD_PRELOAD** `lttng-ust-fork.so` [2]
- Future solution [A]
  - Implement own memory allocator within `LTTng-UST`

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- Future solution [A]
  - `LTTng-UST` listener threads with different file descriptor table

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  - LTTng-UST does not rely on signals for IPC (Inter Process Communication)
  - LTTng-UST listener threads block all signals

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- Possible solution
  - Protect dynamic loader structures with RCU (Read Copy Update) or reference counters

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- Future solution [A]
  - Use `pthread_atfork(3)`
    - Require own memory allocator

Transparent Multi-Threading

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  - Single-threaded application are not expecting other threads
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- Solution [I]
  - `LTTng-UST` forks a worker process

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    - Allocation and publication overheads
- Current solution [R]
  - Recommend to use **per-pid** ring buffers
- Future solution [R, A]
  - Introduce the notion of sub-buffer producer ownership
    - Only a single owner by sub-buffer (between step 1 and 3) by tagging it
    - Can detect stalled vs terminated owner

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    - Not NUMA (Non-Uniform Memory Access) aware
- Future solution [A]
  - Adaptative per-cpu allocation (shared memory)
    - NUMA aware (RSEQ `numa_mm_cid`)
    - RSEQ concurrency IDs for IPC namespace

Limited I/O, CPU Time and Persistent Storage

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  - Dynamic filtering
  - Snapshots (flight recorder tracing)
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- Future solution
  - Trace hit counters [8]

Structured Instrumentation in Runtimes Other than C

- Problems
  - Structural tracing in runtimes other than C/C++
    - Python
    - Golang
    - Java
    - Javascript

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    - Python
    - Golang
    - Java
    - Javascript
- Future solution [A]
  - Use ABI proposed by `libside` [9]

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References I

[1] EfficiOS, "Lttng-ust listener threads quiescent state," 2020, https://github.com/lttng/lttng-ust/blob/master/src/lib/lttng-ust-common/lttng-ust-urcu.c#L661.

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Questions

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