Tracing Summit 2019

Integration of the LTTng user-space tracer with the RSEQ system call

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- How is RSEQ useful for LTTng-UST ?
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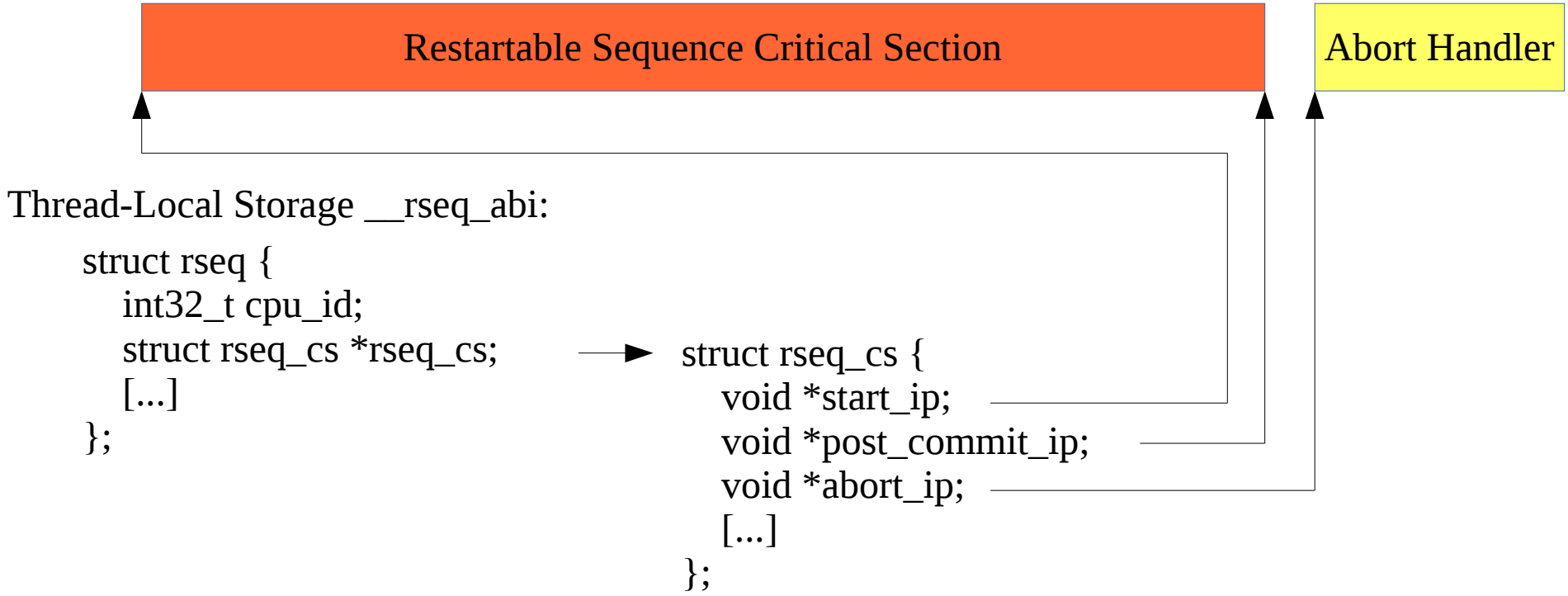
What are Restartable Sequences (RSEQ) ?

- Linux kernel system call registering a Thread-Local Storage area allowing user-space to perform updates on per-cpu data efficiently,
- Achieve critical section atomicity with respect to scheduler by aborting critical sections on preemption and signal delivery rather than disabling preemption.

RSEQ Structure Members



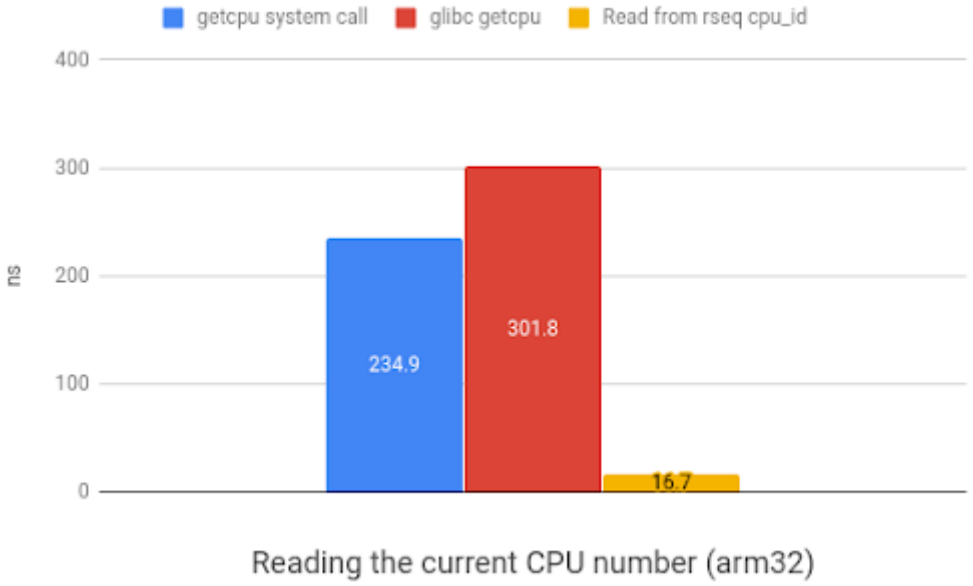
How is RSEQ useful for LTTng-UST ?

- LTTng-UST implements per-CPU ring buffers:
  - Eliminate false-sharing,
  - Reserve and commit counters scheme,
- RSEQ accelerates reading the current cpu number,
- RSEQ replaces atomic operations for reserve and commit on per-CPU data by faster non-atomic loads and stores.

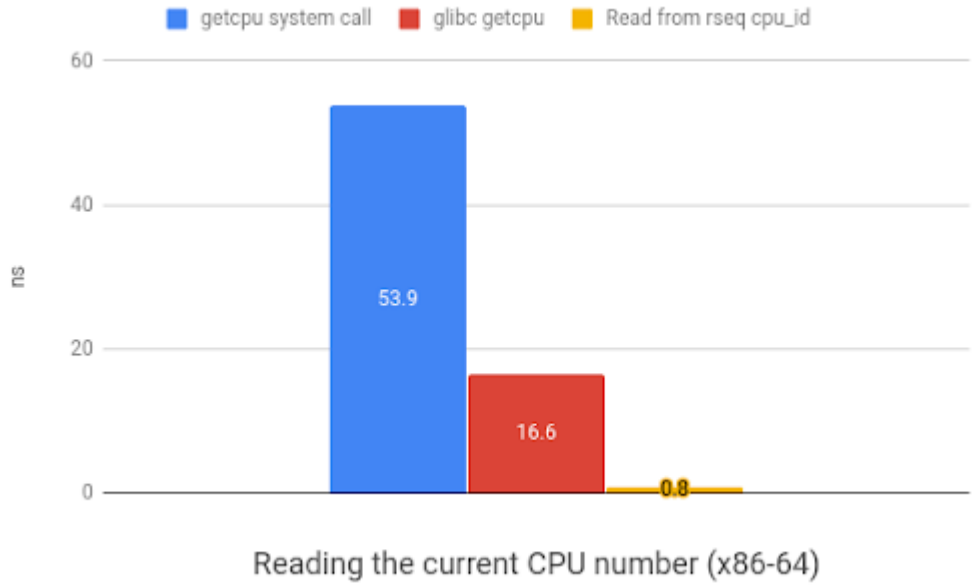
Other uses of RSEQ

- Per-CPU pool memory allocation,
- Per-CPU ring buffer,
- Per-CPU statistics accounting,
- Per-CPU RCU grace period tracking,
- User-space PMU counters read from user-space on big/LITTLE ARM64.

RSEQ Benchmarks: Get Current CPU Number



Reading the current CPU number (arm32)



Reading the current CPU number (x86-64)

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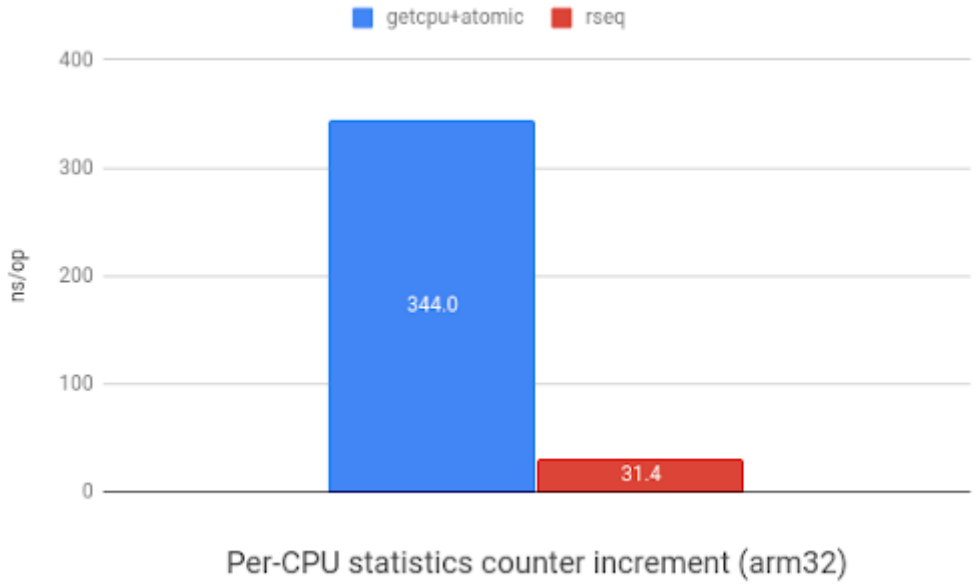
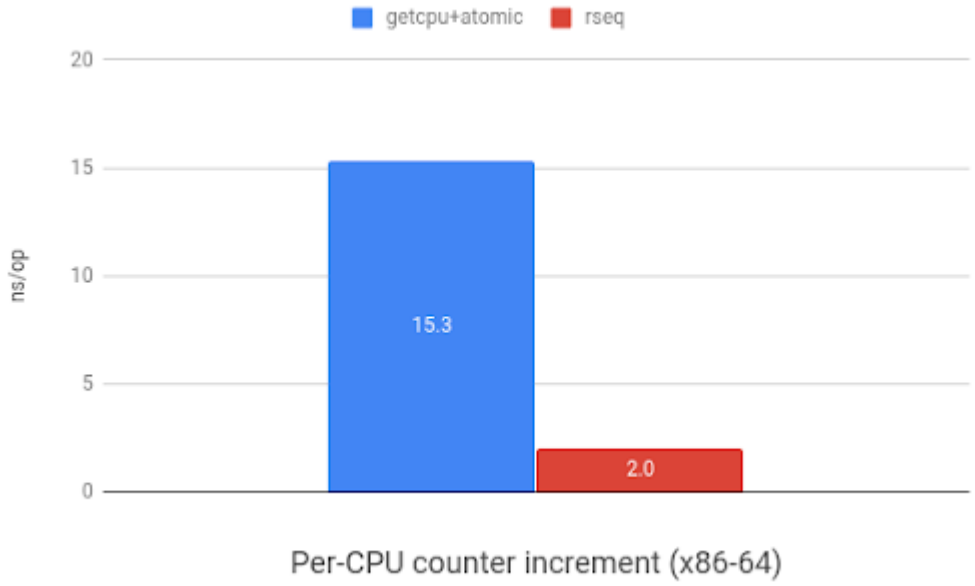
RSEQ Benchmarks: Statistics Counter



Per-CPU statistics counter increment (arm32)



Per-CPU counter increment (x86-64)

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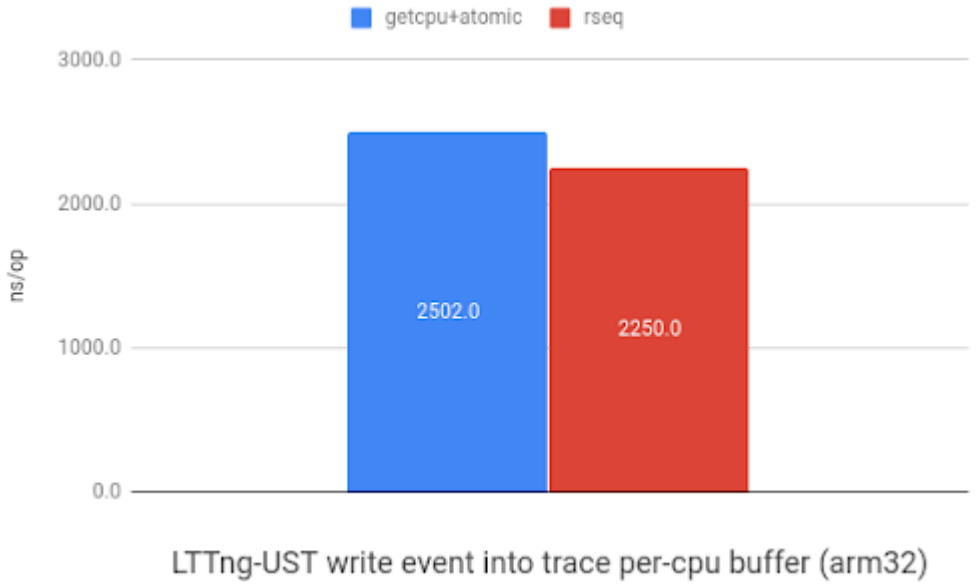
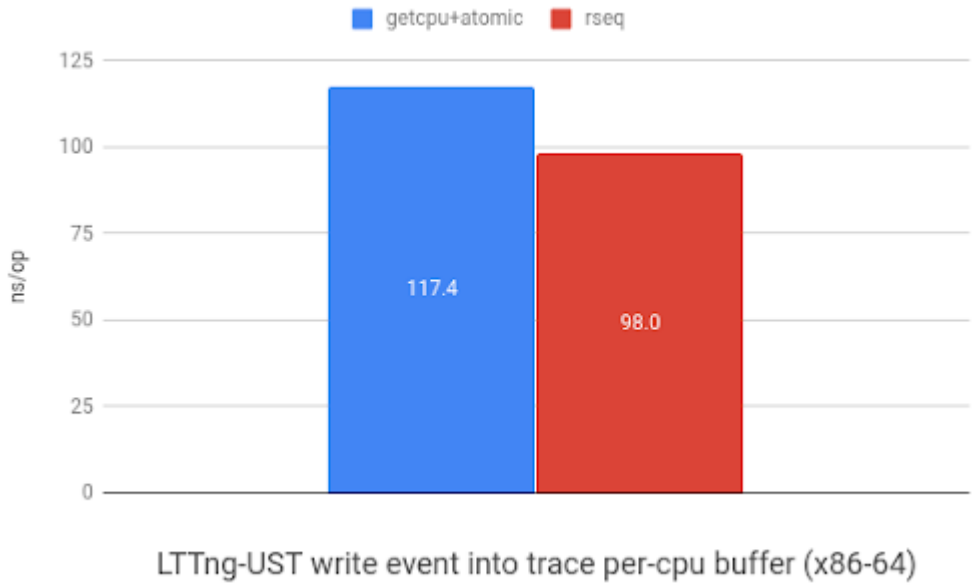
RSEQ Benchmarks: LTTng-UST Ring Buffer



LTTng-UST write event into trace per-cpu buffer (arm32)



LTTng-UST write event into trace per-cpu buffer (x86-64)

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Restartable Sequences Linux Integration

- Linux 4.18:
  - RSEQ system call merged,
  - RSEQ wired up for x86 32/64, powerpc 32/64, arm 32, mips 32/64,
- Linux 4.19:
  - RSEQ wired up for arm 64, s390 32/64,

Restartable Sequences glibc Integration

- Submitted for glibc 2.31,
- Includes:
  - RSEQ TLS registration,
  - Use of RSEQ to accelerate sched_getcpu(3).

Missing Pieces

- Perform update of per-CPU data from ***other cpus***:
  - The case of lttng-consumerd live and switch timers.
  - Cannot be done reliably with CPU affinity due to CPU hotplug.

Missing Pieces

- ***Early/late use*** in libc initialization and thread lifetime, where the RSEQ TLS is not yet registered:
  - Within libc and dynamic linker initialization,
  - Preloaded libraries constructors,
  - Audit libraries,
  - IFUNC resolvers,
  - Signal handlers,
- Guarantee ***progress*** under debugger single-stepping for current debuggers.

Solutions

- New system call: ***do_on_cpu()*** (previously submitted as cpu_opv())
- eBPF bytecode interpreter within the kernel,
  - Running either in IPI handler or thread context with preemption disabled on the target CPU,
  - Specialized to load and store exclusively from/to user-space memory.
- Use this system call as fallback when RSEQ is not registered for the current thread or aborts due to preemption.

Ongoing Effort

1) Upstreaming RSEQ TLS registration within glibc,
   - Submitted, being reviewed by maintainers,
2) Justify further RSEQ-related kernel code by showing RSEQ adoption by the community,
3) Consider upstreaming do_on_cpu() eBPF bytecode interpreter system call into Linux,
4) Complete integration of RSEQ+do_on_cpu() within LTTng-UST.