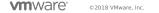
# Swimming with the New KernelShark

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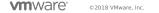


# What is KernelShark?



\* Front end reader of Linux kernel tracing data (Ftrace)





# What is KernelShark?



### \* Front end reader of Linux kernel tracing data (Ftrace)

- \* The original version started in 2009.
- \* Written in *Gtk+-2.0*
- \* Main goal: analyse and fully understood the performance of the Real-time scheduler.

# What is KernelShark?



# \* Front end reader of Linux kernel tracing data (Ftrace)

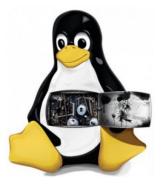
- \* **New KernelShark**: use all lessons learned from the old version.
- \* Completely rewritten to use Qt.
- \* But not only this ...

# The New KernelShark is

- a. Optimized for processing significantly larger amounts of data.
- b. New scalable data model log(n) time complexity.
- c. OpenGL-based visualization.
- d. Preconfigurable Json config I/O.
- e. User modifiable plugins.

# Why do we need KernelShark?

- a. Ftrace the official tracing infrastructure of the Linux kernel.
- b. Extremely powerful instrument.
- c. Allows to see what is happening in the kernel.
- d. But you must know what you are looking for





Compositor-1124 Compositor-1124	[001]	236364.639086:	_cond_resched <-futex_wait_queue_me rcu_all_qs <cond_resched< th=""></cond_resched<>
chromium-browse-1117			<pre>do_syscall_64 &lt;-entry_SYSCALL_64_after_hwframe</pre>
Compositor-1124			drop_futex_key_refs.isra.14 <-futex_wait
chromium-browse-1117			<pre>syscall_trace_enter &lt;-do_syscall_64</pre>
Compositor-1124			hrtimer_cancel <-futex_wait
chromium-browse-1117			secure computing <-syscall_trace_enter
Compositor-1124			<pre>hrtimer_try_to_cancel &lt;-hrtimer_cancel</pre>
chromium-browse-1117		236364.639087:	seccomp_filter <secure_computing< td=""></secure_computing<>
Compositor-1124			hrtimer_active <-hrtimer_try_to_cancel
chromium-browse-1117			<pre>seccomp_run_filters <seccomp_filter 20="" a="" batimer="" concel<="" in="" lack="" pre="" tags="" to=""></seccomp_filter></pre>
Compositor-1124			<pre>lock_hrtimer_base.isra.20 &lt;-hrtimer_try_to_cancel</pre>
Compositor-1124		236364.639088:	
chromium-browse-1117			SyS_futex <- do_syscall_64
Compositor-1124			remove_hrtimer <-hrtimer_try_to_cancel
Compositor-1124			_raw_spin_unlock_irqrestore <-hrtimer_try_to_cancel
chromium-browse-1117 chromium-browse-1117			<pre>ktime_get &lt;-SyS_futex ktime_get &lt;-SyS_futex</pre>
			<pre>ktime_add_safe &lt;-SyS_futex</pre>
chromium-browse-1117			<pre>do_futex &lt;-SyS_futex</pre>
chromium-browse-1117			futex_wait <-do_futex
chromium-browse-1117			hrtimer_init <-futex_wait
chromium-browse-1117			hrtimer_init <-hrtimer_init
chromium-browse-1117			hrtimer_init_sleeper <-futex_wait
chromium-browse-1117			<pre>ktime_add_safe &lt;- futex_wait</pre>
chromium-browse-1117			<pre>futex_wait_setup &lt;-futex_wait</pre>
chromium-browse-1117			<pre>get_futex_key &lt;-futex_wait_setup </pre>
chromium-browse-1117			<pre>get_futex_key_refs.isra.13 &lt;-get_futex_key</pre>
chromium-browse-1117			hash_futex <- futex_wait_setup
chromium-browse-1117			_raw_spin_lock <-futex_wait_setup
chromium-browse-1117			<pre>get_futex_value_locked &lt;-futex_wait_setup</pre>
chromium-browse-1117			<pre>futex_wait_queue_me &lt;-futex_wait</pre>
chromium-browse-1117			hrtimer_start_range_ns <-futex_wait_queue_me
Compositor-1124 chromium-browse-1117			do_syscall_64 <- entry_SYSCALL_64_after_hwframe
citromitum-prowse-1117	[000]	230304.03909/:	<pre>lock_hrtimer_base.isra.20 &lt;-hrtimer_start_range_ns</pre>

#### **vm**ware<sup>®</sup>

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c. Compositor-1124 chromium-browse-1117 Compositor-1124 chromium-browse-1117 Compositor-1124 chromium-browse-1117		9: ktime_get <-SyS_futex 0: ktime_add_safe <-SyS_futex 0: do_futex <-SyS_futex 1: futex_wait <-do_futex 1: hrtimer_init <-futex_wait

#### **vm**ware<sup>•</sup>

Compositor-1124 Compositor-1124 chromium-browse-1117	[001] 236364.639085: _cond_resched <-futex_wait_queue_me [001] 236364.639086: rcu_all_qs <cond_resched [000] d 236364.639086: do_syscall_64 &lt;-entry_SYSCALL_64_after_hwframe</cond_resched 
	n be hard to find what you need. You must be <b>kernel) detective</b> .
Compositor-1124 chromium-browse-1117 Compositor-1124 chromium-browse-1117 Compositor-1124	<pre>[001] 236364.639088: nrtimer_active &lt;-nrtimer_try_to_cancet [000] 236364.639088: seccomp run filters &lt; seccomp filter [001] 236364.639088: lock_hrtimer_base.isra.20 &lt;-hrtimer_try_to_cancet [001] 236364.639088: raw spin lock irgsave &lt;-lock_hrtimer_base.isra.20 [000] 236364.639088: SyS_futex &lt;-do_syscall_64 [001] d 236364.639088: _remove hrtimer &lt;-hrtimer_try_to_cancet [001] d 236364.639088: _remove hrtimer &lt;-hrtimer_try_to_cancet</pre>
In	teractive visualization can be very useful.
chromium-browse-1117 chromium-browse-1117 chromium-browse-1117 chromium-browse-1117 chromium-browse-1117 chromium-browse-1117 chromium-browse-1117 chromium-browse-1117 chromium-browse-1117 chromium-browse-1117	<pre>[000] 236364.639092: ktime_add_safe &lt;-futex_wait [000] 236364.639093: futex_wait setup &lt;-futex_wait [000] 236364.639093: get_futex_key &lt;-futex_wait_setup [000] 236364.639093: get_futex_key_refs.isra.13 &lt;-get_futex_key [000] 236364.639094: hash_futex &lt;-futex_wait_setup [000] 236364.639095: _raw_spin_lock &lt;-futex_wait_setup [000] 236364.639095: get_futex_value_locked &lt;-futex_wait_setup [000] 236364.639095: futex_wait_queue_me &lt;-futex_wait_setup [000] 236364.639095: futex_wait_queue_me &lt;-futex_wait_setup [000] 236364.639095: httimer_start_range_ns &lt;-futex_wait_queue_me [001] d 236364.639097: lock_hrtimer_base.isra.20 &lt;-hrtimer_start_range_ns</pre>

#### **vm**ware<sup>•</sup>

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Hmm, why do you think that this complete mess of colors can be of any help?



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3129018	7	167.215952	<idle></idle>	0	d.h3	bprint		update_curr: GOOD: [7] rq->clock_update_flags (4) >= 2)
3129019	7	167.215952	<idle></idle>	0	d.h3	bprint		update_load_avg: GOOD: [7] rq->clock_update_flags (4) >= 2)
3129020	0	167.215952	<idle></idle>	0	d2	bprint		rq_clock: GOOD: [0] rq->clock_update_flags (2) >= 2)
3129021	4	167.215953	trace-cmd	1386	d.h1	bprint		sched_avg_update: GOOD: [4] rq->clock_update_flags (4) >= 2)
3129022	7	167.215953	<idle></idle>	0	d.h3	bprint		cpufreq_update_util: calling intel_pstate_update_util 0xfffffff816cfde0
3129023	4	167.215953	trace-cmd	1386	d.h1	bprint		scheduler_tick: [4] clock 4 update rf 0 to 4
3129024	7	167.215953	<idle></idle>	0	d.h3	bprint		cpufreq_update_util: GOOD: [7] rq->clock_update_flags (4) >= 2)
3129025	7	167.215954	<idle></idle>	0	d.h3	bprint		intel_pstate_update_util: enter 7 vs 7
3129026	0	167.215954	<idle></idle>	0	d2	bprint		schedule: [0] clock was 2 now 0
3129027	7	167.215954	<idle></idle>	0	d.h3	bprint		intel_pstate_update_util: delta2=4852339
3129028	7	167.215955	<idle></idle>	0	dNh3	bprint		check_preempt_curr: [7] clock was 4 now 5
3129029	7	167.215956	<idle></idle>	0	dNh3	sched_wakeup		commetrace-cmd pid=1384 prio=120 target_cpu=007
3129030	7	167.215956	<idle></idle>	0	dNh3	bprint		ttwu_do_wakeup: GOOD: [7] rq->clock_update_flags (5) >= 2)
3129031	7	167.215956	<idle></idle>	0	dNh3	bprint		try_to_wake_up: [7] clock 5 update rf 0 to 4
3129032	7	167.215961	<idle></idle>	0	dN.2	bprint		cpu_load_update_nohz_stop: [7] clock was 5 now 1 (cleark rf 0)
3129033	7	167.215961	<idle></idle>	0	dN.2	bprint		update_rq_clock: [7] clock was 1 now 5
3129034	7	167.215962	<idle></idle>	0	dN.2	bprint		sched_avg_update: GOOD: [7] rq->clock_update_flags (5) >= 2)
3129035	7	167.215962	<idle></idle>	0	dN.2	bprint		sched_avg_update: GOOD: [7] rq->clock_update_flags (5) >= 2)
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If we **Zoom in** a bit, we will start seeing the time structure of the trace.

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		ime Stamp		PID	Latency		Info
234107 4		67.392744		0		bprint	cpufreq_update_util: GOOD: [4] rq->clock_update_flags (4) >= 2)
34108 4		67.392745		0		bprint	intel_pstate_update_util: enter 4 vs 4
34109 4		67.392745		0	d.h3	bprint	intel_pstate_update_util: delta2=1139005
34110 4		67.392747		0	dNh3	bprint	check_preempt_curr: [4] clock was 4 now 5
34111 4		67.392748		0		sched_wakeup	comm=trace-cmd pid=1387 prio=120 target_cpu=004
234112 4		67.392749		0	dNh3	bprint	ttwu_do_wakeup: GOOD: [4] rq->clock_update_flags (5) >= 2)
34113 4		67.392750		0		bprint	try_to_wake_up: [4] clock 5 update rf 0 to 4
34114 4		67.392761		0	dN.2	bprint	schedule: [4] clock was 5 now 1 (cleark rf 0)
234115 4		67.392762		0	dN.2	bprint	schedule: [4] clock was 1 now 2
234116 4		67.392763		0	dN.2	bprint	update_load_avg: GOOD: [4] rq->clock_update_flags (2) >= 2)
34117 4		67.392764		0	dN.2	bprint	set_next_entity: GOOD: [4] rq->clock_update_flags (2) >= 2)
234118 4		67.392764		0	dN.2	bprint	update_load_avg: GOOD: [4] rq->clock_update_flags (2) >= 2)
34119 4		67.392765		0	dN.2	bprint	set_next_entity: GOOD: [4] rq->clock_update_flags (2) >= 2)
34120 4		67.392766		0	dN.2	bprint	update_load_avg: GOOD: [4] rq->clock_update_flags (2) >= 2)
234121 4		67.392767		0		bprint	set_next_entity: GOOD: [4] rq->clock_update_flags (2) >= 2)
34122 4		67.392767		0	dN.2	bprint	update_load_avg: GOOD: [4] rq->clock_update_flags (2) >= 2)
34123 4		67.392768		0		bprint	set_next_entity: GOOD: [4] rq->clock_update_flags (2) >= 2)
234124 4	1	67.392770	<idle></idle>	0	d2	sched_switch	prev_comm=swapper/4 prev_pid=0 prev_prio=120 prev_state=S ==> next_comm=trace-cmd next_pid=1387 next_prio=120
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This is a deep zoom. Let's try to understand what is visualized here.

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- a. Double click on the graph selects a trace record.
- b. The same can be done by clicking on the table row which shows the record as text.

**vm**ware<sup>\*</sup>

CPU 5							
CPU 6							
Search:	(	Info 👻	contains	≁ clo		te_flags (0) Next Prev	8% 326 SGraph follows
#	CPU	Time Stamp		PID	Latency		Info
# 56625	2 2		Task deadline_test		Latency d3	Event bprint	Info intel_pstate_update_util: delta2=3091632
	2 2 2	162.127129		1393			
56625	2 2 2 2	162.127129 162.127129	deadline_test	1393 1393	d3	bprint	intel_pstate_update_util: delta2=3091632 push_dl_task.part.40: push_dl_task 2097
56625 56626	2 2 2 2 2 2	162.127129 162.127129 162.127130	deadline_test deadline_test	1393 1393 1393	d3 d3	bprint bprint	intel_pstate_update_util: delta2=3091632

# Search panel

a. Provides interactive searching.

b. Very useful in combination with the Dual marker.

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PU3	🖬				CF	PU 6		<u> </u>					
					CE	PU 7							
PU 4				_									
earch: Column	n# ~	contains +		_									
			Latenc	v Event									
CPU	Time Stamp		Latend	ty Event				: [3] clock was	4 now 4	_			
CPU 234257 3	Time Stamp 167.392882	Task PID						: [3] clock was DOD: [3] rq->c		lags (4) >	= 2)		
CPU 234257 3 234258 3 234259 3	Time Stamp 167.392882 167.392883 167.392883	Task PID deadline_test 1399 deadline_test 1399 deadline_test 1399	dN.2 dN.2 dN.2	bprint bprint bprint				DOD: [3] rq->c d call to cpufr	lock_update_f eq_update_uti	L:4			
CPU 234257 3 234258 3 234259 3 234260 3	Time Stamp 167.392882 167.392883 167.392883 167.392884	Task PID deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399	dN.2 dN.2 dN.2 dN.2	bprint bprint bprint bprint				DOD: [3] rq->c d call to cpufr : GOOD: [3] rc	lock_update_f eq_update_uti ->clock_updat	l: 4 :e_flags (4	1) >= 2)		
CPU 234257 3 234258 3 234259 3 234260 3 234261 3	Time Stamp 167.392882 167.392883 167.392883 167.392884 167.392884	Task PID deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399	dN.2 dN.2 dN.2 dN.2 dN.2 dN.2	bprint bprint bprint bprint bprint	Apply	Cancel		DOD: [3] rq->c d call to cpufre s: GOOD: [3] rq DOD: [3] rq->c	lock_update_f eq_update_uti i->clock_updat lock_update_f	l: 4 :e_flags (4 lags (4) >	1) >= 2) = 2)		
CPU 234257 3 234258 3 234259 3 234260 3 234260 3 234261 3 234262 3	Time Stamp 167.392882 167.392883 167.392883 167.392884 167.392884 167.392885 167.392885	Task PID deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399	dN.2 dN.2 dN.2 dN.2 dN.2 dN.2 dN.2	bprint bprint bprint bprint bprint bprint		Cancel		DOD: [3] rq->c d call to cpufre : GOOD: [3] rq->c DOD: [3] rq->c : GOOD: [3] rq->c	lock_update_f eq_update_uti i->clock_updat lock_update_f ->clock_update	l: 4 xe_flags (4 lags (4) > e_flags (4	1) >= 2) = 2) ) >= 2)		
CPU 234257 3 234258 3 234259 3 234260 3 234260 3 234261 3 234262 3 234263 3	Time Stamp 167.392882 167.392883 167.392883 167.392884 167.392885 167.392886 167.392886 167.392888	Task PID deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399	dN.2 dN.2 dN.2 dN.2 dN.2 dN.2 dN.2 dN.2	bprint bprint bprint bprint bprint sched s				DOD: [3] rq->c d call to cpufn :: GOOD: [3] rq DOD: [3] rq->c : GOOD: [3] rq- c	lock_update_f eq_update_uti ->clock_updat lock_update_f ->clock_update pid=1399 pre	l: 4 :e_flags (4 lags (4) > e_flags (4 v_prio=-1	1) >= 2) = 2) ) >= 2)	_comm=deadline_test	next_pid≈1397 next, prío≈-1
CPU 234257 3 234258 3 234259 3 234260 3 234260 3 234262 3 234262 3 234263 3	Time Stamp 167.392882 167.392883 167.392883 167.392884 167.392885 167.392886 167.392888 167.392888 167.392888	Task PID deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399	dN.2 dN.2 dN.2 dN.2 dN.2 dN.2 dN.2 dN.2	bprint bprint bprint bprint bprint sched s bprint			rq_clock: GOOD	DOD: [3] rq->c d call to cpufri :: GOOD: [3] rq DOD: [3] rq->c : GOOD: [3] rq :: GOOD: [3] rq :: GOOD: [3] rq :: GOOD: [3] rq :: GOOD: [3] rq->c	lock_update_f eq_update_uti ->clock_update_f lock_update_f ->clock_update pid=1399 pre odate_flags (4)	l: 4 :e_flags (4) > e_flags (4) > (4) = flags (4) (5) = 1 (5) = 2)	1) >= 2) = 2) ) >= 2)	_comm=deadline_test	pid=1397 next_prio=-1
CPU 234257 3 234258 3 234259 3 234260 3 234260 3 234260 3 234260 3 234264 3 234265 3	Time Stamp 167.392882 167.392883 167.392883 167.392884 167.392886 167.392886 167.392888 167.392888 167.392888 167.392888	Task PID deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399	dN.2 dN.2 dN.2 dN.2 dN.2 dN.2 dN.2 dN.2	bprint bprint bprint bprint bprint bprint sched s bprint bprint			rq_clock: GOOD rq_clock: GOOD	DOD: [3] rq->c d call to cpufn : GOOD: [3] rq->c : GOOD: [3] rq->c : GOOD: [3] rq->c : GOOD: [3] rq->c : [3] rq->clock_uj : [3] rq->clock_uj	lock_update_f eq_update_uti ->clock_update_f ->clock_update_f pid=1399 pre odate_flags (4) odate_flags (4)	L: 4 te_flags (4) > e_flags (4) > e_flags (4) > v_prio=-1   >= 2)   >= 2)	1) >= 2) = 2) ) >= 2)	comm=deadline_test	next_pid=1397 next, price=1
CPU 34257 3 34258 3 34259 3 34260 3 34260 3 34262 3 34263 3 34263 3 34266 3	Time Stamp 167.392882 167.392883 167.392883 167.392883 167.392885 167.392886 167.392888 167.392889 167.392889	Task PID deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399	dN.2 dN.2 dN.2 dN.2 dN.2 dN.2 dN.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2	bprint bprint bprint bprint bprint bprint sched s bprint bprint			rq_clock: GOOD rq_clock: GOOD rq_clock: GOOD	DOD: [3] rq->c d call to cpufr : GOOD: [3] rq->c : GOOD: [3] rq->c : GOOD: [3] rq->c : [3] rq->clock_uy : [3] rq->clock_uy : [3] rq->clock_uy	lock_update_f eq_update_uti i->clock_update_f >clock_update_f >clock_update_f pdd=1399 pre odate_flags (4) odate_flags (4)	L: 4 te_flags (4) > e_flags (4) > e_flags (4) > v_prio=-1   >= 2)   >= 2)	1) >= 2) = 2) ) >= 2)	comm=deadline_test	next_pid=1397 next_prio=-1
CPU 34257 3 34258 3 34258 3 34260 3 34260 3 34262 3 34263 3 34265 3 34265 3 34266 3	Time Stamp 167.392882 167.392883 167.392883 167.392884 167.392886 167.392886 167.392888 167.392889 167.392889 167.392889 167.392899	Task PID deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399	dN.2 dN.2 dN.2 dN.2 dN.2 dN.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d	bprint bprint bprint bprint bprint bprint bprint bprint bprint			rq_clock: GOOD rq_clock: GOOD rq_clock: GOOD _schedule: [3]	DOD: [3] rq->c d call to cpufr : GOOD: [3] rq ODD: [3] rq->c : GOOD: [3] rq : [3] rq->clock_uy : [3] rq->clock_uy : [3] rq->clock_uy : [3] rq->clock_uy : [3] rq->clock_uy	lock_update_f eq_update_uti ->clock_update_f lock_update_f ->clock_update pdd=1399 pre vdate_flags (4) vdate_flags (4) vdate_flags (4) 4	L: 4 te_flags (4) > e_flags (4) > e_flags (4) > v_prio=-1   >= 2)   >= 2)	1) >= 2) = 2) ) >= 2)	_comm=deadline_test	next pid=1397 next price=1
CPU 34257 3 34258 3 34259 3 34260 3 34260 3 34262 3 34263 3 34265 3 34266 3 34267 3 34268 3	Time Stamp 167.392882 167.392883 167.392883 167.392884 167.392885 167.392886 167.392886 167.392888 167.392889 167.392889 167.392889 167.392890 167.392890	Task         PID           deadline_test         1399	dN.2 dN.2 dN.2 dN.2 dN.2 dN.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d	bprint bprint bprint bprint bprint bprint bprint bprint bprint bprint			rq_clock: GOOD rq_clock: GOOD rq_clock: GOOD schedule: [3] schedule: [3]	DOD: [3] rq >c d call to cpufri :: GOOD: [3] rq -c GOOD: [3] rq -c : GOOD: [3] rq :: GOOD: [3] rq :: GOOD: [3] rq :: [3] rq ->clock_uy : [3] rq ->clock_uy : [3] rq ->clock_uy : [3] rq ->clock uy : [clock was 4 now : clock 4 update rf	lock_update_f eq_update_uti r>clock_update_f lock_update_f pdd=1399 pre odate_flags (4) odate_flags (4) odate_flags (4) date_flags (4) 4	L: 4 te_flags (4) > e_flags (4) > e_flags (4) > v_prio=-1   >= 2)   >= 2)	1) >= 2) = 2) ) >= 2)	.comm=deadline_test	nest_pid=1397 nest_pilo=1
CPU 34257 3 34258 3 34259 3 34260 3 34260 3 34262 3 34263 3 34266 3 34266 3 34266 3 34269 3	Time Stamp 167.392882 167.392883 167.392883 167.392885 167.392885 167.392886 167.392888 167.392889 167.392889 167.392889 167.392890 167.392890	Task PID deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399 deadline_test 1399	dN.2 dN.2 dN.2 dN.2 dN.2 dN.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d	bprint bprint bprint bprint bprint bprint bprint bprint bprint			rq_clock: GOOD rq_clock: GOOD rq_clock: GOOD schedule: [3] schedule: [3] push_dl_task.pa	DDD: [3] rq>c d call to cpufn : GOOD: [3] rq GOOD: [3] rq-c c GOOD: [3] rq-c c (3] rq-clock_up : [3] rq-sclock_up : [3] rq-sclo	lock_update_f eq_update_uti i>>clock_update_f >clock_update_f etal=ses (4) date_flags (4) date_flags (4) date_flags (4) 4 4 4 to 4 ask 2033	L: 4 te_flags (4) > e_flags (4) > e_flags (4) > v_prio=-1   >= 2)   >= 2)	1) >= 2) = 2) ) >= 2)	comm=deadline_test	next_pid=1397 next_prio=1
CPU 34257 3 34258 3 34259 3 34260 3 34261 3 34261 3 34262 3 34265 3 34265 3 34265 3 34266 3 34266 3 34266 3 34266 3 34269 3 34269 3	Time Stamp 167.392882 167.392883 167.392884 167.392884 167.392884 167.392884 167.392888 167.392888 167.392889 167.392899 167.392890 167.392892 167.392892 167.392892	Task         PID           deadline_text         1399           deadline_text         1397           deadline_text         1397           deadline_text         1397           deadline_text         1397	dN.2 dN.2 dN.2 dN.2 dN.2 dN.2 dN.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d	bprint bprint bprint bprint bprint sched s bprint bprint bprint bprint bprint bprint			rq_clock: GOOD rq_clock: GOOD rq_clock: GOOD schedule: [3] o schedule: [3] o push_dl_task.pa push_dl_task.pa	DOD: [3] rq >c d call to cpufri :: GOOD: [3] rq -c GOOD: [3] rq -c : GOOD: [3] rq :: GOOD: [3] rq :: GOOD: [3] rq :: [3] rq ->clock_uy : [3] rq ->clock_uy : [3] rq ->clock_uy : [3] rq ->clock uy : [clock was 4 now : clock 4 update rf	lock_update_f eq_update_uti ->clock_update_f ->clock_update_f pide1199 prei date_flags (4) date_flags (4) date_flags (4) date_flags (4) 4 4 to 4 ask 2033 ask 2039	L: 4 te_flags (4) > e_flags (4) > e_flags (4) > v_prio=-1   >= 2)   >= 2)	1) >= 2) = 2) ) >= 2)	.comm=deadline_test	nest, pid=1397 nest, prio=-1
CPU 234257 3 234258 3 234259 3 234260 3 234261 3 234262 3 234264 3 234266 3 234266 3 234266 3 234267 3 234269 3 234269 3 234269 3 234271 3	Time Stamp 167.392882 167.392883 167.392883 167.392883 167.392884 167.392886 167.392889 167.392889 167.392889 167.392899 167.392890 167.392890 167.392892 167.392892	Task         PID           deadline_test         1399	dN.2 dN.2 dN.2 dN.2 dN.2 dN.2 dN.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d	bprint bprint bprint bprint bprint bprint bprint bprint bprint bprint bprint bprint			rq_clock: GOOD rq_clock: GOOD schedule: [3] o schedule: [3] o schedule: [3] o push_dl_task.pa push_dl_task.pa push_dl_task.pa	DDD: [3] rq>c d call to cpufr s: GODD: [3] rq DDD: [3] rq CODD: [3] rq cufine. test prev (3] rq>clock_uy (3] rq>clock_uy (3] rq>clock_uy (3] rq>clock_uy (3] rq>clock_uy (1) rq clock was 4 now (1:40: push_dl_t rt.40: push_dl_t	lock_update_f eq_update_uti i>>clock_update_f >clock_update_f >clock_update_f id=1399 presidate_flags (4) odate_flags (4) odate_flags (4) date_flags (4) 4 4 to 4 ask 2033 ask 2030	L: 4 te_flags (4) > e_flags (4) > e_flags (4) > v_prio=-1   >= 2)   >= 2)	1) >= 2) = 2) ) >= 2)	.comm=deadline_test	nest, gid+1397 nest, grio+-1
earch: Column CPU 234257 3 234258 3 234268 3 234260 3 234260 3 234262 3 234266 3 234266 3 234266 3 234266 3 234266 3 234269 3 234269 3 234269 3 234269 3 234271 3 234271 3	Time Stamp 167.392882 167.392883 167.392883 167.392883 167.392884 167.392886 167.392889 167.392889 167.392889 167.392890 167.392892 167.392892 167.392892	Task         PID           deadine text         1399           deadine text         1397           deadine text <t>1397           deadine text         1397           deadine text         1397           deadine text         1397           deadine text         1397</t>	dN.2 dN.2 dN.2 dN.2 dN.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d.2 d	bprint bprint bprint bprint bprint bprint bprint bprint bprint bprint bprint bprint bprint bprint			rq_clock: GOOD rq_clock: GOOD schedule: [3] o schedule: [3] o schedule: [3] push_dl_task.pa push_dl_task.pa push_dl_task.pa	DDD: [3] rq>c d call to cuff : CODD: [3] rq DDD: [3] rq-c ; COOD: [3] rq DDD: [3] rq-c ; COOD: [3] rq calline test prev [3] rq-sclock.up ; [3] rq-	lock_update_f eq_update_uti took_update_f >clock_update_f >clock_update_f date_flags (4) date_flags (4) date_fl	L: 4 te_flags (4) > e_flags (4) > e_flags (4) > v_prio=-1   >= 2)   >= 2)	1) >= 2) = 2) ) >= 2)	comm=deadline_test	nest, pid=1397 nest, prios=1

# Selecting which CPU to visualize.

#### **vm**ware<sup>\*</sup>

ointer: 167.39								
< + •	> ++ •	Marker A	167.39288	8	Ma	arker B	167.392890	A,B Delta: 0.000002
167.3928	38							167.392878 167.39291
					)		Tasks	
PU 0				-	Tasks:	all		
PU1				-		Pid	Task	A
						1390	trace-cmd	
PU 2						1391	trace-cmd	
						1392	deadline test	
>U3						1393	deadline test	
14						1394	deadline_test	
						1395	deadline_test	
						1396	deadline test	
arch: Column	# ~ c	ontains +			<b>V</b>	1397	deadline test	s
CPU	Time Stamp Ta	k PID	Latenc	V E			deadline_test	
34257 3		adline_test 1399	dN.2	ь		1398		t_dl: [3] clock was 4 now 4
34258 3		adline_test 1399	dN.2	ь	V	1399	deadline_test	I: GOOD: [3] rq->clock_update_flags (4) >= 2)
34259 3		adline_test 1399	dN.2	b		1400	deadline_test	I: old call to cpufreq_update_util: 4
34260 3 34261 3		adline_test 1399 adline_test 1399	dN.2 dN.2	b		1401	deadline test	date: GOOD: [3] rq->clock_update_flags (4) >= 2) I: GOOD: [3] rq->clock_update_flags (4) >= 2)
34201 3		adline_test 1399	dN.2	b			-	c dl: GOOD: [3] rq->clock_update_rlags (4) >= 2) c dl: GOOD: [3] rq->clock_update_flags (4) >= 2)
34263 3		adline test 1399	d2			1402	cat	eadline test prev pid=1399 prev prio=-1 prev state=S ==> next comm=deadline test next pid=1397 next prio=-1
34264 3		adline_test 1399		ь	Apply	Can	cel	D: [3] rg->clock update flags (4) >= 2)
34265 3	167.392889 de	adline_test 1399	d2	bpr	inc	_		א: wwwD: [3] rq->clock_update_flags (4) >= 2)
34266 3		adline_test 1399		bpr				k: GOOD: [3] rq->clock_update_flags (4) >= 2)
34267 3		adline_test 1399		bpr				dule: [3] clock was 4 now 4
34268 3		adline_test 1399		bpr				dule: [3] clock 4 update rf 4 to 4
34269 3 34270 3		adline_test 1397 adline test 1397	d2 d2	bpr				L_task.part.40: push_dl_task 2033 L_task.part.40: push_dl_task 2039
34270 3 34271 3		adline test 1397	d2	bpr				Ltask.part.40: push_dLtask.2039
4272 3		adline test 1397	d2	bpr				Ltask.part.40: push_dLtask.2050
34273 3		adline test 1397	d2	bpr				l task.part.40: push dl task 2061
34274 3		adline test 1397	d2	bor				l task.part.40: push dl task 2068

## Selecting which Task to visualize.

#### **vm**ware<sup>®</sup>



# Filter menu

- a. Filter out tasks
- b. Filter in tasks
- c. Filter events
- d. Advanced (content-based) filtering

# Event filters

Pointer: 167.39286	5 deadline_test-1394 CPI	U2 d 2 horint workto cure dis CONTRE Recorder Events	<ul> <li>update, flags (4) &gt;= 2)</li> </ul>
< + · ·	> ++ Marker A 1		: 0.000002
167.392838		Events: 🖌 all	57.392878 167.392918
107.392838			0132210 10132210
		✓ borint	
:PU 0		<ul> <li>✓ bputs</li> </ul>	
		✓ branch	
2PU 1 🚽 🗌		✓ context_switch ✓ funcoraph entry	
		✓ funcgraph exit	
		✓ function	
CPU 2		🖌 hwlat	
		✓ kernel_stack ✓ mmiotrace map	
PU3		✓ mmiotrace_map ✓ mmiotrace rw	
		✓ print	
		✓ raw_data	
PU 4		✓ user_stack ✓ wakeup	
		✓ wakeup ▼ ✓ sched	
		sched kthread stop	
earch: Column #	<ul> <li>contains</li> </ul>	✓ sched kthread stop ret	
		✓ sched_migrate_task ✓ sched_move_numa	
	me Stamp Task PID	✓ sched_move_numa ✓ sched_pi_setorio	
	67.392882 deadline_test 1399	✓ sched process exec	3] clock was 4 now 4
	57.392883 deadline_test 1399	✓ sched_process_exit	OD: [3] rq->clock_update_flags (4) >= 2)
	67.392883 deadline_test 1399	✓ sched_process_fork	call to cpufreq_update_util: 4
	57.392884 deadline_test 1399	✓ sched process free ✓ sched process hang	GOOD: [3] rq->clock_update_flags (4) >= 2)
	67.392885 deadline_test 1399	✓ sched_process_hang ✓ sched process wait	OD: [3] rq->clock_update_flags (4) >= 2)
	67.392886 deadline_test 1399	✓ sched stat blocked	5OOD: [3] rq->clock_update_flags (4) >= 2)
	67.392888 deadline_test 1399	✓ sched_stat_iowait	he_test prev_pid=1399 prev_prio=-1 prev_state=S ==> next_comm=deadline_test next_pid=1397 next_prio=-1
	57.392888 deadline_test 1399	✓ sched stat runtime ✓ sched stat sleep	rq->clock_update_flags (4) >= 2)
	57.392889 deadline_test 1399	✓ sched_stat_sleep ✓ sched_stat_wait	rq->clock_update_flags (4) >= 2)
	57.392889 deadline_test 1399	✓ sched stick numa	rq->clock_update_flags (4) >= 2)
	57.392890 deadline_test 1399	sched_swap_numa	k was 4 now 4
	67.392890 deadline_test 1399		k 4 update rf 4 to 4
	57.392892 deadline_test 1397	✓ sched_wait_task ✓ sched_wake_idle_without_ipi	0: push_dl_task 2033
	57.392892 deadline_test 1397	✓ sched_wake_idie_without_ipi ✓ sched_wakeup	0: push_dl_task 2039
	57.392892 deadline_test 1397	✓ sched_wakeup new	0: push_dl_task 2050
			0: push dl task 2058
234272 3 1	57.392893 deadline_test 1397	✓ sched_waking	
234272 3 1	67.392893 deadline_test 1397 67.392893 deadline_test 1397	Apply Cancel	0: push_dl_task 2061

# Kernel Shark - Sessions

		Help								
Pointer:	Open	Ctrl+O			_					
< Ø S	Sessions	Þ	📀 Restor Last S	ession	Marker B		A.B Delta:			
× × <	Quit	Ctrl+Q	Import Session	on n	MININE D		A, D Deita.			
			🚵 Export Sassio	n						
Search: Colum	mn #	* contain	5 ¥		Next Pre	v <b>√</b> Graph f	ollows			
Search: Colun	mn # CPU	▼ contain Time Stam		PID	Next Pro		'ollows Info			
				PID						

- a. Import/Export session
- b. Restor last session.

# Kernel Shark - Recording

File Filter Plots Tools Help	
Pointer:	
< + - > ++ Marker A Marker B	A,B Delta:
Search: Column #	
# CPU Time Stamp Task PID Latency	Event Info
	Authentication Required
C	
	Authentication is required to run KernelShark Record
	Yordan
	Password:
	Cancel Authenticate

- a. Trace data can be recorded directly from Kernel Shark.
- b. Root password is required.

**vm**ware<sup>\*</sup>

# Kernel Shark - Recording

File Filter Plots Tools Help		
Pointer:		
<++> ++ ·· N	arker A Marker B A,B De	(ta:
CPU Time Stamp		tar
	Plugin: nop •	
	Output file: /home/yordan/trace.dat Browse	
	Command: sleep 0.1 Display output	
	Capture Apply Close	

Compositor-1124 Compositor-1124	[001]	236364.639086:	_cond_resched <-futex_wait_queue_me rcu_all_qs <cond_resched< th=""></cond_resched<>
chromium-browse-1117			<pre>do_syscall_64 &lt;-entry_SYSCALL_64_after_hwframe</pre>
Compositor-1124			drop_futex_key_refs.isra.14 <-futex_wait
chromium-browse-1117			<pre>syscall_trace_enter &lt;-do_syscall_64</pre>
Compositor-1124			hrtimer_cancel <-futex_wait
chromium-browse-1117			secure computing <-syscall_trace_enter
Compositor-1124			<pre>hrtimer_try_to_cancel &lt;-hrtimer_cancel</pre>
chromium-browse-1117		236364.639087:	seccomp_filter <secure_computing< td=""></secure_computing<>
Compositor-1124			hrtimer_active <-hrtimer_try_to_cancel
chromium-browse-1117			<pre>seccomp_run_filters <seccomp_filter 20="" a="" batimer="" concel<="" in="" lack="" pre="" tags="" to=""></seccomp_filter></pre>
Compositor-1124			<pre>lock_hrtimer_base.isra.20 &lt;-hrtimer_try_to_cancel</pre>
Compositor-1124 chromium-browse-1117		236364.639088:	
			SyS_futex <- do_syscall_64
Compositor-1124			remove_hrtimer <-hrtimer_try_to_cancel
Compositor-1124			_raw_spin_unlock_irqrestore <-hrtimer_try_to_cancel
chromium-browse-1117 chromium-browse-1117			<pre>ktime_get &lt;-SyS_futex ktime_get &lt;-SyS_futex</pre>
			<pre>ktime_add_safe &lt;-SyS_futex</pre>
chromium-browse-1117			<pre>do_futex &lt;-SyS_futex</pre>
chromium-browse-1117			futex_wait <-do_futex
chromium-browse-1117			hrtimer_init <-futex_wait
chromium-browse-1117			hrtimer_init <-hrtimer_init
chromium-browse-1117			hrtimer_init_sleeper <-futex_wait
chromium-browse-1117			<pre>ktime_add_safe &lt;-futex_wait</pre>
chromium-browse-1117			<pre>futex_wait_setup &lt;-futex_wait</pre>
chromium-browse-1117			<pre>get_futex_key &lt;-futex_wait_setup </pre>
chromium-browse-1117			<pre>get_futex_key_refs.isra.13 &lt;-get_futex_key</pre>
chromium-browse-1117			hash_futex <- futex_wait_setup
chromium-browse-1117			_raw_spin_lock <-futex_wait_setup
chromium-browse-1117			<pre>get_futex_value_locked &lt;-futex_wait_setup</pre>
chromium-browse-1117			<pre>futex_wait_queue_me &lt;-futex_wait</pre>
chromium-browse-1117			hrtimer_start_range_ns <-futex_wait_queue_me
Compositor-1124			do_syscall_64 <- entry_SYSCALL_64_after_hwframe
chromium-browse-1117	[000]	230304.039097:	<pre>lock_hrtimer_base.isra.20 &lt;-hrtimer_start_range_ns</pre>

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			cond resched <-futex wait queue me
Compositor-1124	[001]	236364.639086:	rcu all qs <- cond resched
chromium-browse-1117	[000] d	236364.639086:	do syscall 64 <-entry SYSCALL 64 after hwframe
			drop futex key refs.isra.14 <-futex wait
chromium-browse-1117	[000]	236364.639087:	syscall trace enter <-do syscall 64
Compositor-1124	[001]	236364.639087:	hrtimer cancel <-futex wait

### What do we do if:

- a. We have a very large data-set of trace records.
- b. We are limited by the number of screen pixels available.

[001] d... 236364.639089: raw spin unlock irgrestore <-hrtimer try to cancel Compositor-1124 chromium-browse-1117 .... 236364.639089: ktime get <- SvS futex [000] chromium-browse-1117 [000] .... 236364.639090: ktime add safe <-SyS futex .... 236364.639090: do futex <-SyS futex chromium-browse-1117 [000] .... 236364.639091: futex wait <-do futex chromium-browse-1117 [000] .... 236364.639091: hrtimer init <- futex wait chromium-browse-1117 [000] chromium-browse-1117 [000] .... 236364.639092: hrtimer init <-hrtimer init 10001 betimen init cleaner - futer unit chromium brouco 1117

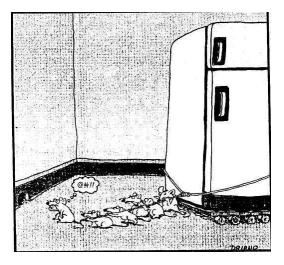
### And we have to process all this in a reasonable amount of time.

chromium-browse-111/	[000] 236364.63909:	3: get_tutex_key_rets.isra.13 <-get_tutex_key
chromium-browse-1117	[000] 236364.639094	4: hash futex <-futex wait setup
chromium-browse-1117	[000] 236364.639095	5: raw spin lock <-futex wait setup
chromium-browse-1117	[000] 236364.639095	5: get futex value locked < futex wait setup
chromium-browse-1117	[000] 236364.639095	5: futex wait queue me <-futex wait
chromium-browse-1117	[000] 236364.639096	5: hrtimer start range ns <-futex wait queue me
Compositor-1124	[001] d 236364.639097	7: do syscall 64 <- entry SYSCALL 64 after hwframe
chromium-browse-1117	[000] 236364.639097	7: lock_hrtimer_base.isra.20 <-hrtimer_start_range

#### **vm**ware

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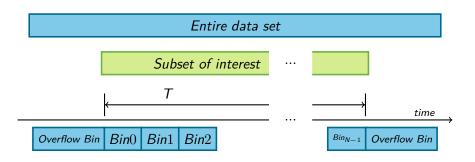
# Fitting something large inside something small ...



# ... and we have to do this quickly!

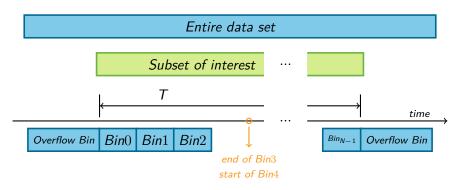


Visualization model - How does it work?



- a. Break the data-set into *time-bins*  $\mapsto$  like a histogram.
- b. Check only the records at the beginning and at the end of each bin.  $\mapsto$  constant time.

# Visualization model - How does it work?

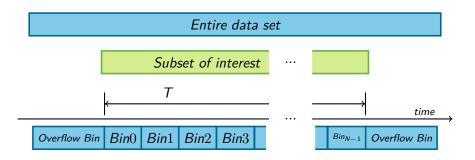


- c. Have the trace records, sorted in time.
- d. Knowing the index of the first record in each *Bin* determines the state of the model.
- e. But the first element can be found with a binary search  $\mapsto \mathsf{log}(\mathsf{n})$  complexity.

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Visualization model - How does it work?

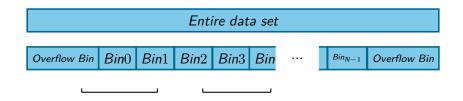


# **Data Binning** provides $O(\log_2(n))$ average time complexity of all operations of the model.

Visualization model & tracing data formats

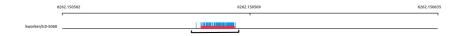
- The KernelShark Visualization model is not coupled to a particular data format.
- Uses KernelShark-specific data structure.
- Contains only the absolute minimum of information need by the model.
- The rest of the information available on demand (can be slow)

# Visualization model & tracing data



- Only one model (data structure) for all graphs.
- Worst-case complexity becomes linear.
- Solution Data collections.

# Visualization model & Data collections.



- Only one model (data structure) for all graphs.
- Worst-case complexity becomes linear.
- Solution Data collections.

# DEMO



# KernelShark: current version 0.9

https://git.kernel.org/pub/scm/utils/trace-cmd/trace-cmd.git/

To build the code follow the instructions in

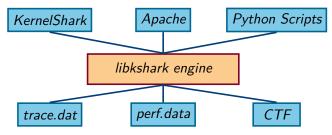
 $/ {\tt trace-cmd}/{\tt kernel-shark-qt}/{\tt README}$ 

and

/trace-cmd/README



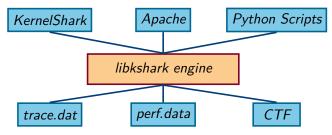
KernelShark is not a GUI. KernelShark is a toolkit.



# What's next after KernelShark 1.0?

- a. KernelShark engine (libkshark.so)
- b. Available under GNU LGPL v2.1
- c. Highly customizable (via plugins)
- d. Will read multiple data formats

KernelShark is not a GUI. KernelShark is a toolkit.



# What's next after KernelShark 1.0?

- a. Any tool will be able to use the library
- b. Available for Python applications (libkshark.py)
- c. The KernelShark application is just a "shell".