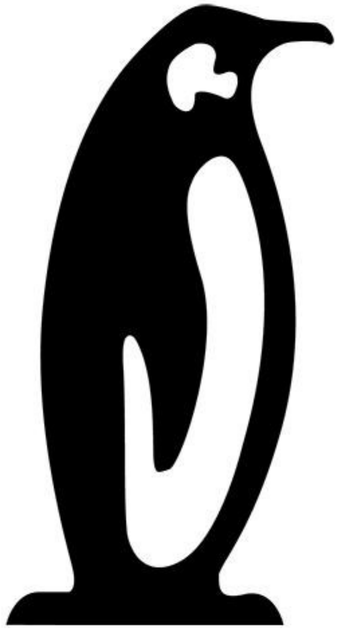
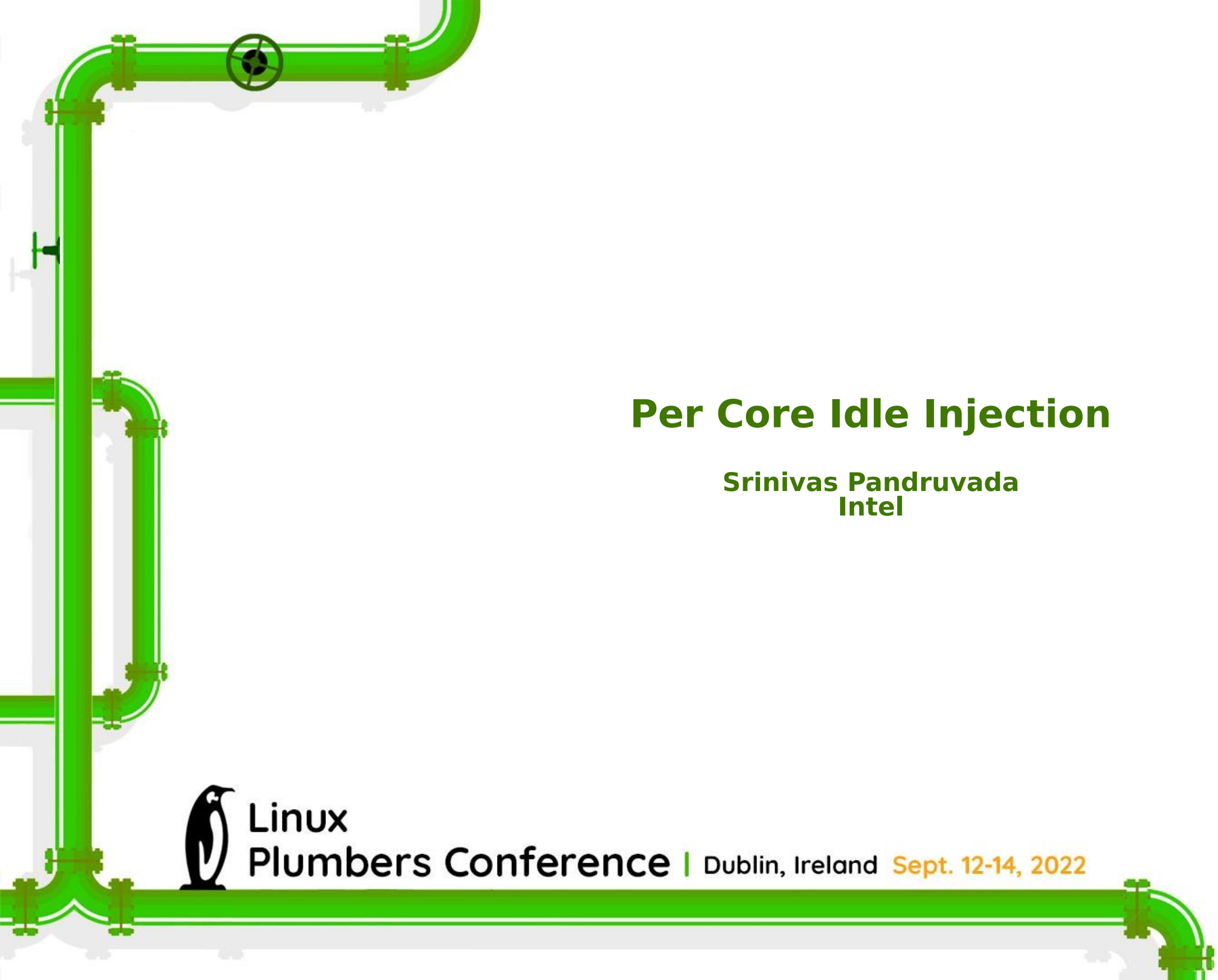


Linux Plumbers Conference

Dublin, Ireland September 12-14, 2022



Per Core Idle Injection

Srinivas Pandruvada
Intel

Linux
Plumbers Conference | Dublin, Ireland Sept. 12-14, 2022

Use Case

- Clients
  - Thermal Control
  - Low power mode “Power saver” mode
- Server
  - Provide higher frequencies in fewer cores

Requirements

- Should be able to run on a Linux distro
- Per CPU Thermal control
- Allow to keep fewer CPUs active
  - Don’t break affinity by using online/offline
  - Fast transition in and out of mode

Idle Injection in Linux

- Intel Power Clamp driver
  - Used for System wide Injection for a while
- Per CPU Idle injection
  - Used in ARM based systems for a while
  - Not used on Intel x86

Solution

- Implement per CPU idle injection for x86
  Should coexist with system wide idle injection via powerclamp
- Enhance idle-inject for to support powerclamp
  For package idle % compensation

Power Clamp and Per Core Idle injection

- Both can call play_idle* at the same time
  Powerclamp driver should use powercap/idle-inject also to avoid this issue

Issues

- Soft IRQ issues
  - Warnings
  - Dependency on kernel version
  - In general IRQs should be migrated before idle injection
    - When possible (from user space)
- High timer jitter for pinned timers
- High wake because of interrupts reduces the effect
- To do: NO_HZ_FULL impact

Warnings

- Warning for Tick Stop when Soft IRQs is pending [appendix 1]

[147777.095484] NOHZ tick-stop error: Non-RCU local softirq work is pending, handler #08!!!
[147777.099719] NOHZ tick-stop error: Non-RCU local softirq work is pending, handler #288!!!
[147777.103725] NOHZ tick-stop error: Non-RCU local softirq work is pending, handler #288!!!

- Caused by race condition with Idle inject FIFO task and ksoftirqd scheduling
- An IRQ can happen, not finish the softirq in its tail
  schedule ksoftirqd
    But not get scheduled because idle (injection) wins on priority.
- Either don’t print warning in this path or fix

5.18+

- Dependency on kernel version
  Bug in kernel which prevents warning
  https://elixir.bootlin.com/linux/latest/source/kernel/time/tick-sched.c#L1013
  Tick may stop except when CONFIG_PREEMPT_RT and no_hz_full CPU
  https://elixir.bootlin.com/linux/latest/source/include/linux/bottom_half.h#L36

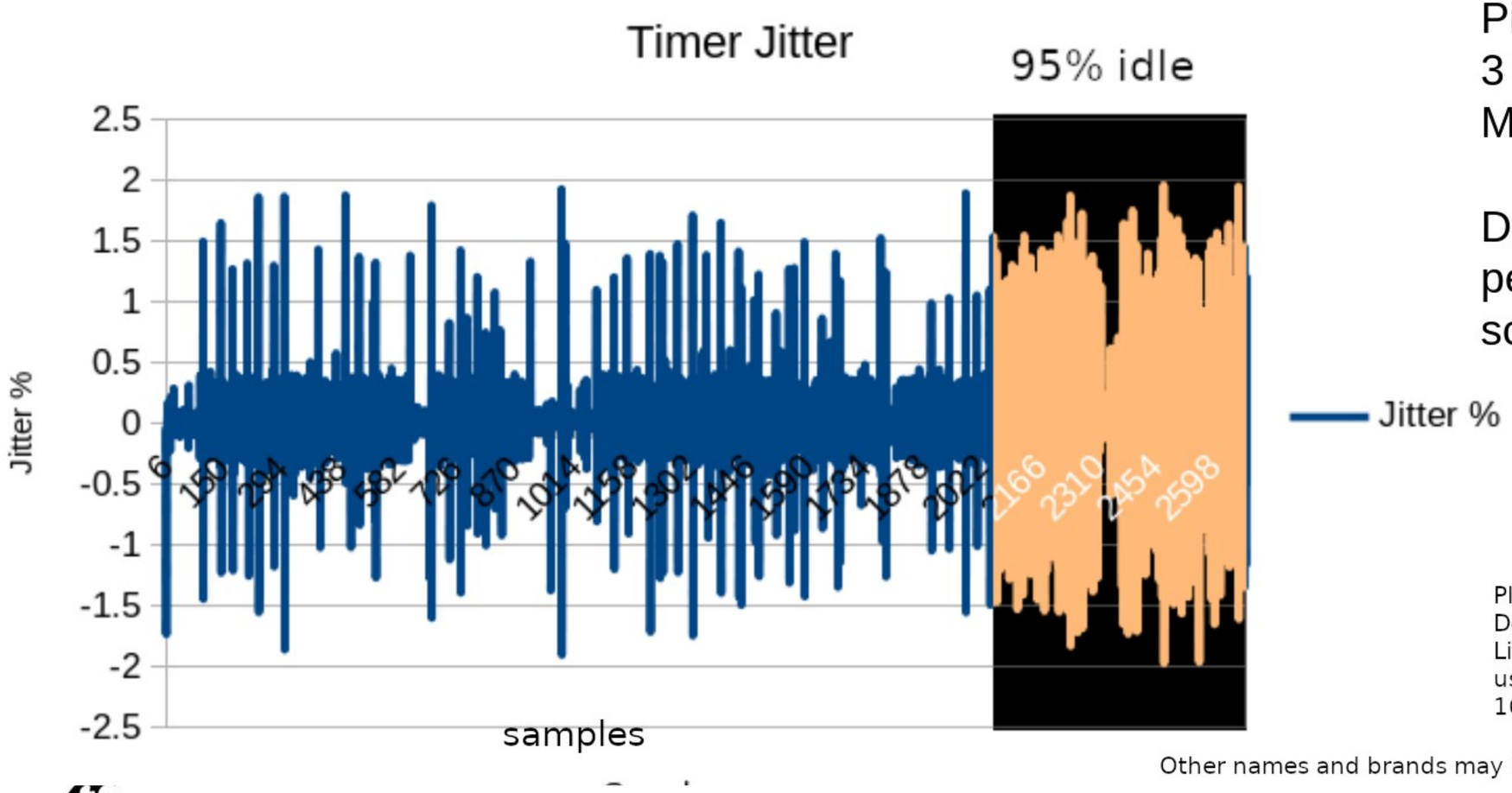
Solution for warnings/delays

- Give chance to ksoftirqd to run if it is in runnable state
  - *Yield for 1 jiffee (test patch from Frederic Weisbecker)*
- Sleep timer adjustment because of yield for lost time in soft irqs
- Prevent Soft IRQ storm in idle injection loop

Give chance to run Soft IRQ

- Add additional check in while loop in do_idle()
  need_resched() || **task_is_running(__this_cpu_read(ksoftirqd)**);

- In play_idle_precise(), if idle duration timer is not expired and do_idle() loop break
  Call **schedule_timeout(1) and return to call do_idle again()**
  for the remaining idle duration
  - To prevent storm of IRQs
    Introduce a max idle_duration(like usleep_range)
    This way loop will break and return -EAGAIN



Pinned Timers:
3 users in kernel
Mce, ipv4 (2 instances)

Do we care as we are in performance limited scenario?

Platform:
Dell XPS 9310
Linux 5.19 with a sample program using pinned timers with duration 16ms.

Appendix [1]

Soft IRQ errors

```
<idle>-0     [003]   231.067277: softirq_raise:       vec=1 [action=TIMER]
<idle>-0     [003]   231.067282: softirq_raise:       vec=7 [action=SCHED]
<idle>-0     [003]   231.067282: hrtimer_expire_exit:  hrtimer=0xffff94beddcdc160
<idle>-0     [003]   231.067283: hrtimer_start:       hrtimer=0xffff94beddcdc160 function=tick_sched_timer/0x0 expires=229191521504 softexpires=229191521504
<idle>-0     [003]   231.067288: irq_handler_entry:    irq=129 name=xhci_hcd
<idle>-0     [003]   231.067305: softirq_raise:       vec=6 [action=TASKLET]
<idle>-0     [003]   231.067309: irq_handler_exit:     irq=129 ret=handled
<idle>-0     [003]   231.067312: softirq_entry:       vec=1 [action=TIMER]
<idle>-0     [003]   231.067313: timer_cancel:        timer=0xffffd8063fcccc58
<idle>-0     [003]   231.067314: timer_expire_entry:   timer=0xffffd8063fcccc58 function=kthread_delayed_work_timer_fn now=4294949557 baseclk=4294949557
<idle>-0     [003]   231.067315: sched_kthread_work_queue_work: work struct=0xffffd8063fcccc30 function=clamp_idle_injection_func worker=0xffff94bb66a26880
<idle>-0     [003]   231.067316: sched_waking:         comm=ksoftirqd/3 pid=1941 prio=49 target_cpu=003
<idle>-0     [003]   231.067319: sched_wakeup:         ksoftirqd/3:1941 [49]<CANT FIND FIELD success> CPU:003
<idle>-0     [003]   231.067320: timer_expire_exit:    timer=0xffffd8063fcccc58
<idle>-0     [003]   231.067321: softirq_exit:        vec=1 [action=TIMER]
<idle>-0     [003]   231.067321: softirq_entry:       vec=7 [action=SCHED]
<idle>-0     [003]   231.067326: softirq_exit:        vec=7 [action=SCHED]
<idle>-0     [003]   231.067327: sched_waking:        comm=ksoftirqd/3 pid=33 prio=120 target_cpu=003
<idle>-0     [003]   231.067330: sched_wakeup:        ksoftirqd/3:33 [120]<CANT FIND FIELD success> CPU:003
<idle>-0     [003]   231.067339: sched_switch:        swapper/3:0 [120] R ==> ksoftirqd/3:1941 [49]
ksoftirqd/3-1941  [003]   231.067341: sched_kthread_work_execute_start: work struct 0xffffd8063fcccc30: function clamp_idle_injection_func
ksoftirqd/3-1941  [003]   231.067342: play_idle_enter:      state=24000000 cpu_id=3
ksoftirqd/3-1941  [003]   231.067342: hrtimer_init:        hrtimer=0xffffb8064221be40 clockid=CLOCK_MONOTONIC mode=0x9
ksoftirqd/3-1941  [003]   231.067345: hrtimer_start:       hrtimer=0xffffb8064221be40 function=idle_inject_timer_fn/0x0 expires=229211664941 softexpires=229211664941
ksoftirqd/3-1941  [003]   231.067358: bprint:            can_stop_idle_tick.isra.16: NOHZ tick-stop error:3
(Tick will not be stopped because of pending softirq)

ksoftirqd/3-1941  [003]   231.067358: cpu_idle:          state=3 cpu_id=3
ksoftirqd/3-1941  [003]   231.071528: cpu_idle:          state=4294967295 cpu_id=3
```

<ksoft irq processing is delayed

Appending [2] 5.19 Soft IRQ

<idle>-0 [007] 2736.421871: softirq_exit: vec=7 [action=SCHED]
<idle>-0 [007] 2736.421871: sched_waking: comm=ksoftirqd/7 pid=58 prio=120 target_cpu=007
<idle>-0 [007] 2736.421872: sched_wakeup: ksoftirqd/7:58 [120]<CANT FIND FIELD success> CPU:007
<idle>-0 [007] 2736.421873: bprint: do_idle: need_resched loop end:7
<idle>-0 [007] 2736.421875: sched_switch: swapper/7:0 [120] R ==> idle_inject/7:1856 [49]
idle_inject/7-1856 [007] 2736.421876: sched_kthread_work_execute_start: work struct 0xffffda70ffdeb830: function clamp_idle_injection_func
...
idle_inject/7-1856 [007] 2736.421878: bprint: can_stop_idle_tick.isra.0: report_idle_softirq pending bh
...
idle_inject/7-1856 [007] 2736.421878: tick_stop: success=1 dependency=NONE
...
idle_inject/7-1856 [007] 2736.446231: sched_stat_runtime: comm=idle_inject/7 pid=1856 runtime=16135 [ns] vruntime=0 [ns]
idle_inject/7-1856 [007] 2736.446241: sched_switch: idle_inject/7:1856 [49] S ==> ksoftirqd/7:58 [120]
ksoftirqd/7-58 [007] 2736.446246: softirq_entry: vec=3 [action=NET_RX]

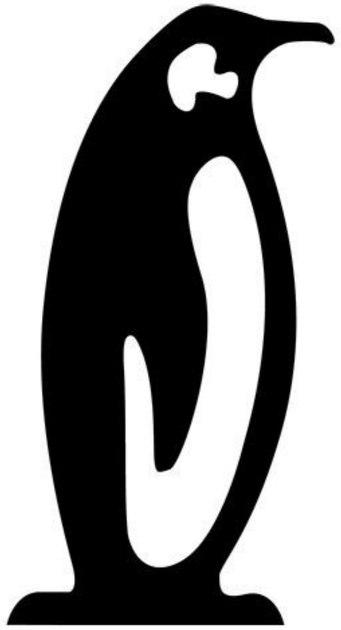
Appending [3] Timer Delay

```
idle_inject/7-56    [007]  6230.039784: sched_waking:         comm=ksoftirqd/7 pid=58 prio=120 target_cpu=007
   idle_inject/7-56    [007]  6230.039785: sched_wakeup:         ksoftirqd/7:58 [120]<CANT FIND FIELD success>
CPU:007
   idle_inject/7-56    [007]  6230.039786: cpu_idle:             state=3 cpu_id=7
   idle_inject/7-56    [007]  6230.039787: cpu_idle:             state=4294967295 cpu_id=7
   idle_inject/7-56    [007]  6230.039788: softirq_raise:        vec=1 [action=TIMER]
 ...
 ...
   idle_inject/7-56    [007]  6230.043765: softirq_raise:        vec=1 [action=TIMER]
...
   idle_inject/7-56    [007]  6230.047806: softirq_raise:        vec=1 [action=TIMER]
...
   idle_inject/7-56    [007]  6230.051822: softirq_raise:        vec=1 [action=TIMER]
...
   idle_inject/7-56    [007]  6230.056044: softirq_raise:        vec=1 [action=TIMER]
....
   idle_inject/7-56    [007]  6230.058575: play_idle_exit:       state=24000000 cpu_id=7
   idle_inject/7-56    [007]  6230.058577: sched_stat_runtime:   comm=idle_inject/7 pid=56  runtime=7119 [ns]
vruntime=0 [ns]
   idle_inject/7-56    [007]  6230.058584: sched_switch:         idle_inject/7:56 [49] S ==> ksoftirqd/7:58 [120]
     ksoftirqd/7-58    [007]  6230.058587: softirq_entry:        vec=1 [action=TIMER]
```

6230.058587 - 6230.039788 = 18ms later

Patch Link

https://github.com/spandruvada/linux-kernel/tree/idle-inject



Linux Plumbers Conference

Dublin, Ireland September 12-14, 2022