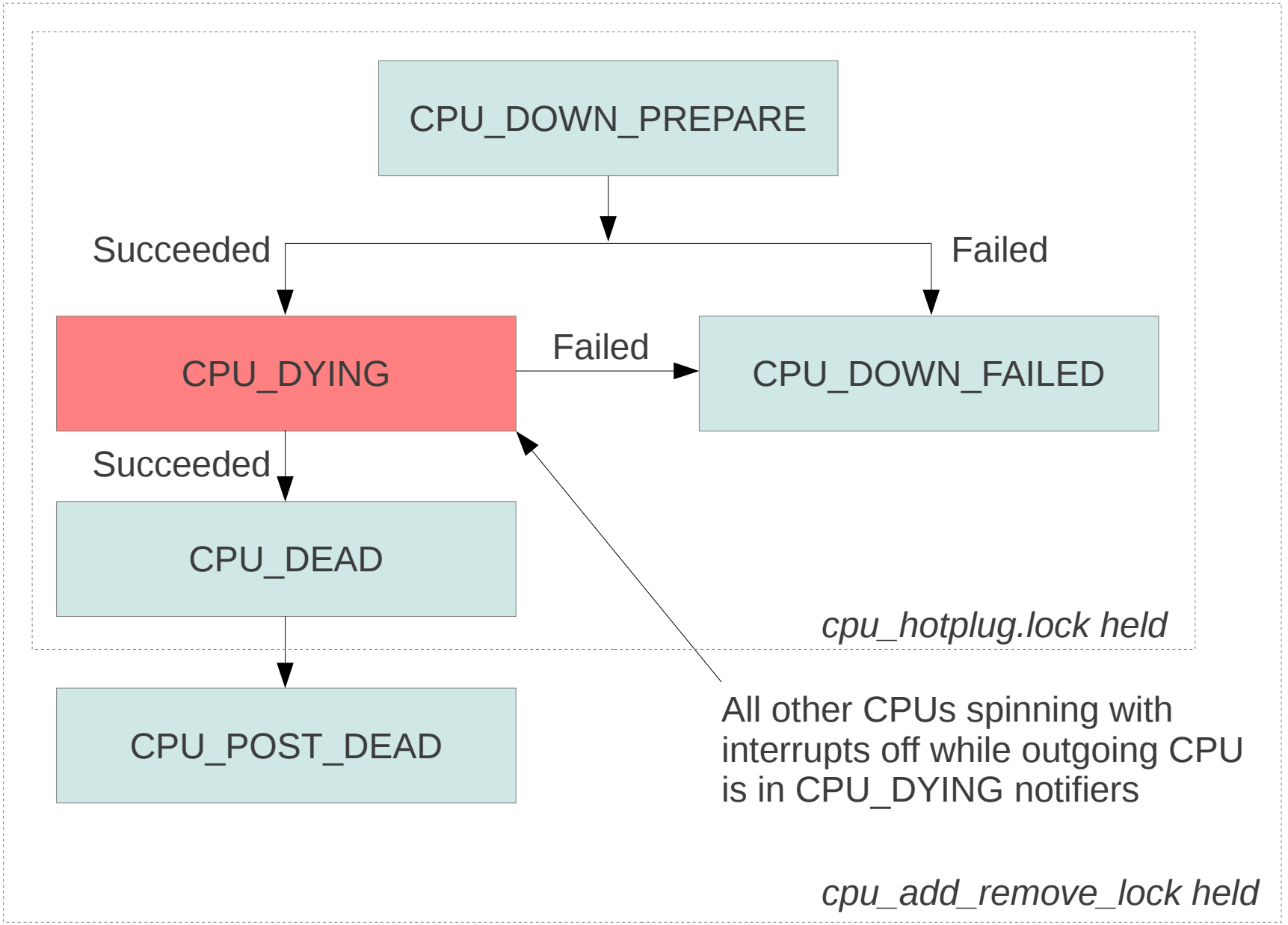
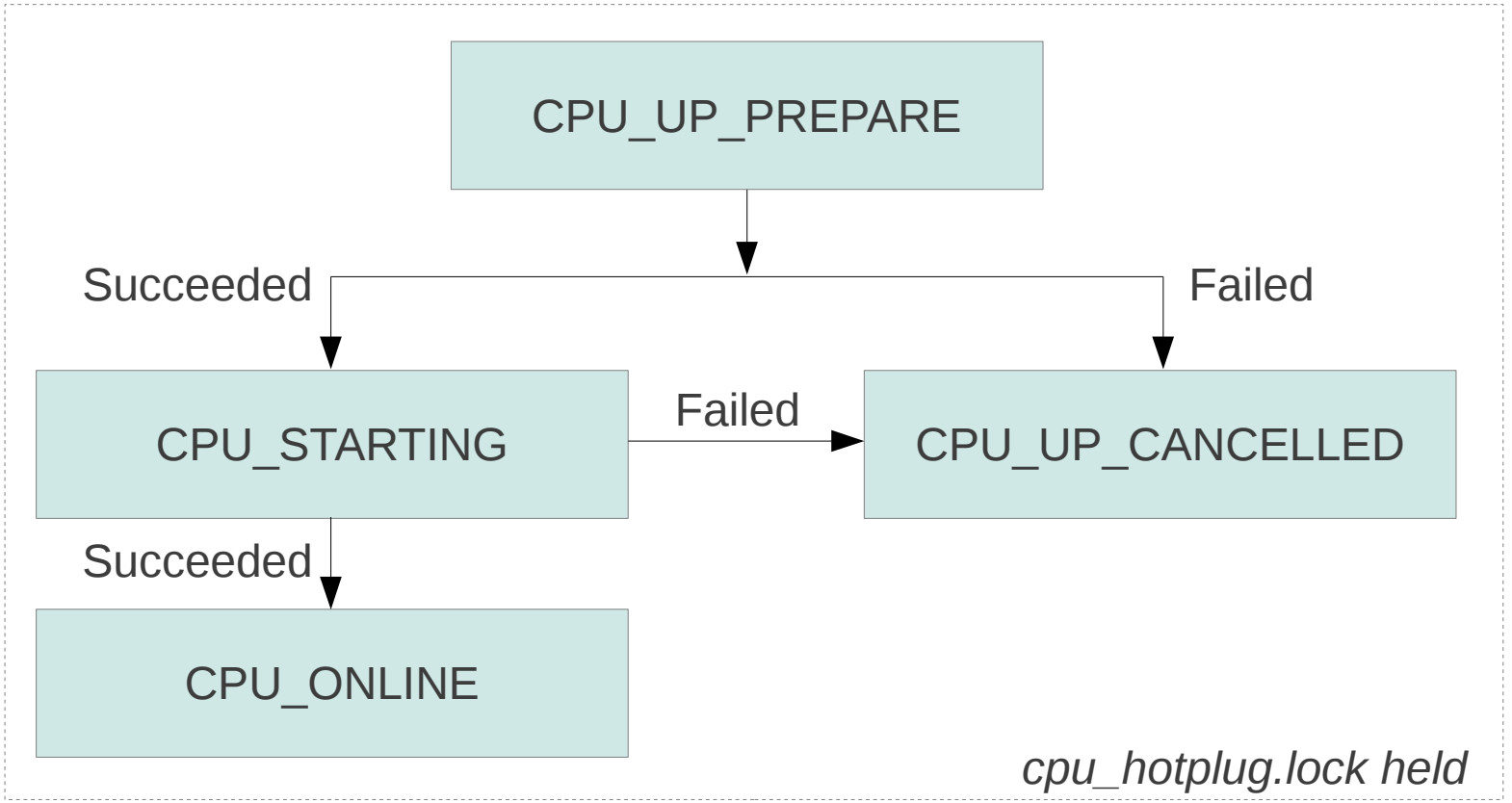
Cleaning Up Linux's CPU Hotplug For Real Time and Energy Management

Thomas Gleixner (Linutronix)
Paul E. McKenney (IBM Linux Technology Center assigned to Linaro)
Vincent Guittot (ST-Ericsson assigned to Linaro)

CPU Hotplug Offline Process

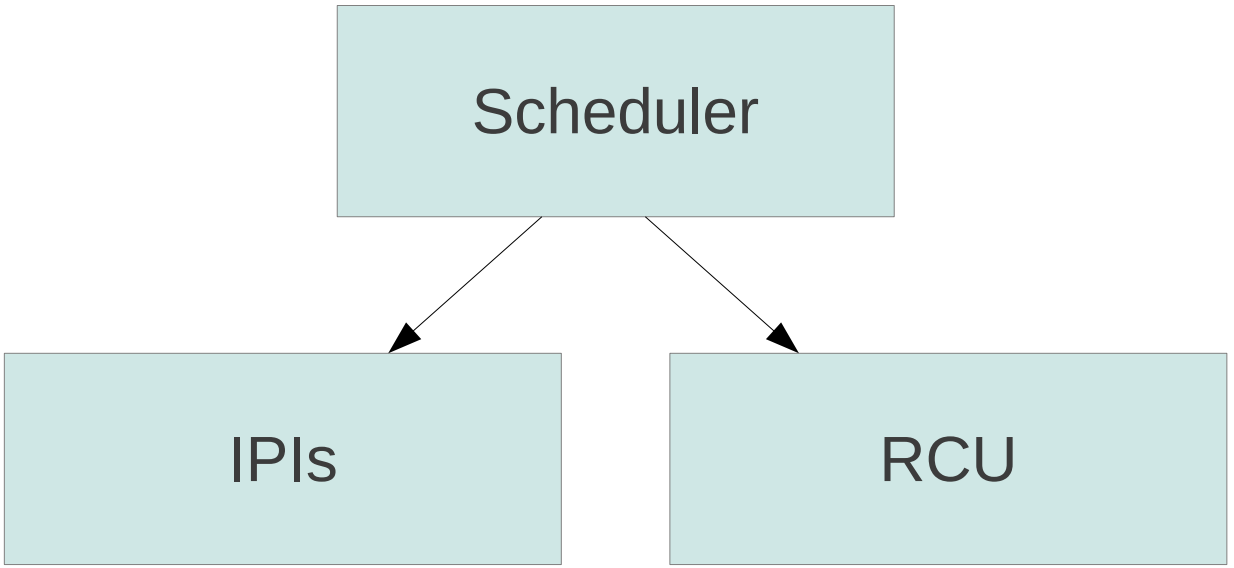


CPU Hotplug Online Process



cpu_add_remove_lock held

CPU Hotplug Is Not Atomic



Valid notifier order for online:

- IPIs
- RCU
- Scheduler

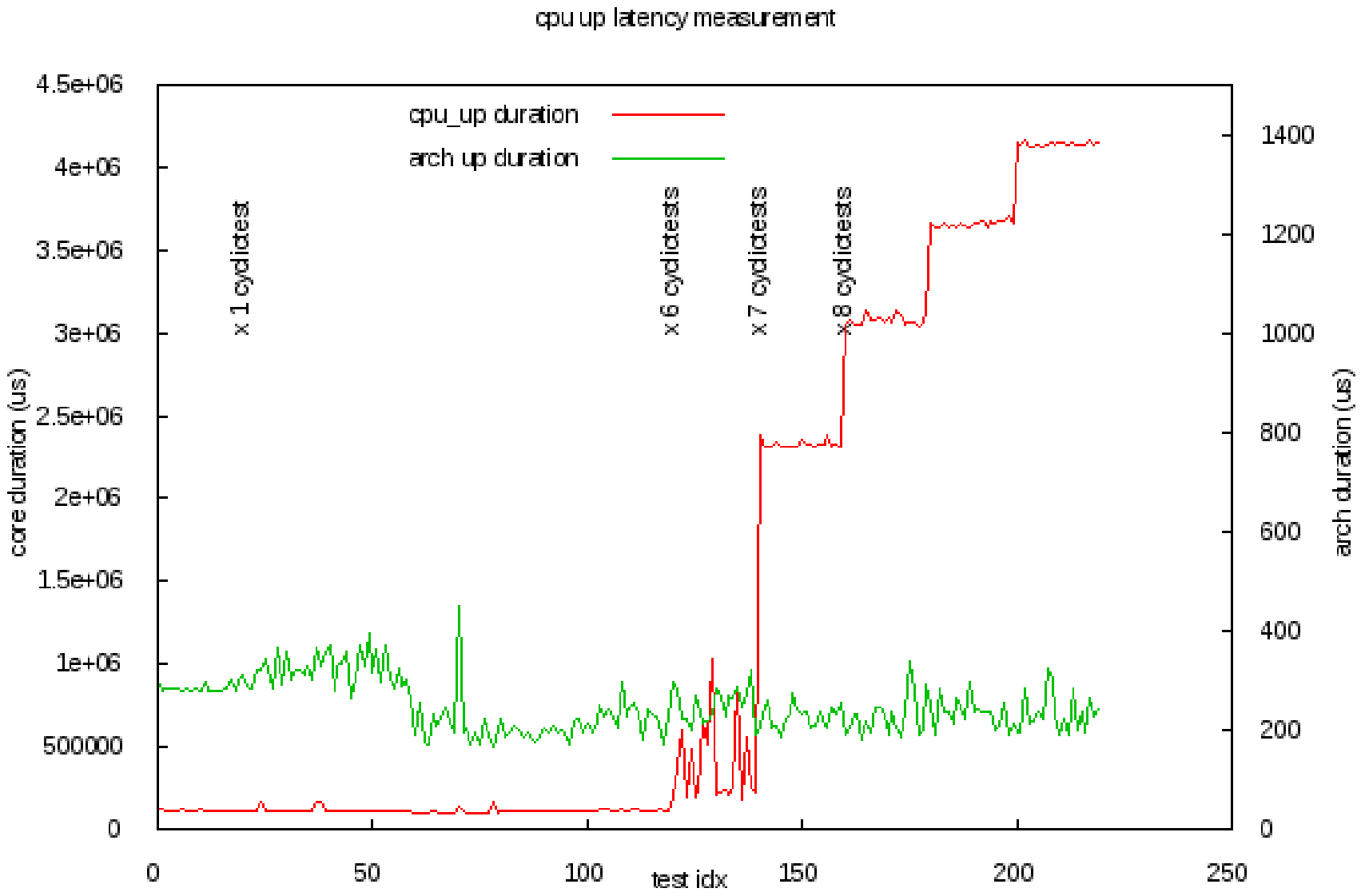
Must reverse order for offline

Reality will intrude...

- RCU depends on scheduler
- Circular dependency!

Must further decompose RCU and scheduler interaction

Source of CPU-Hotplug Latency



Source: Vincent Guittot (https://wiki.linaro.org/WorkingGroups/PowerManagement/Doc/Hotplug), reproduced by Silas Boyd-Wickizer

Parking Per-CPU kthreads

- Thomas Gleixner patchset:
  - kthread_create_on_cpu(...)
  - kthread_should_park(void)
  - kthread_park(struct task_struct *k)
  - kthread_unpark(struct task_struct *k)
  - kthread_parkme(void)
  - smpboot_register_percpu_thread(struct smp_hotplug_thread *plug_thread);
  - smpboot_unregister_percpu_thread(struct smp_hotplug_thread *plug_thread);
  - smpboot_thread_check_parking(struct smpboot_thread_data *td);
- This approach should remove per-CPU kthread creation overhead
  - Also move notification to kthreads, offline in kthread

for_each_online_cpu()

- More than 300 uses of this primitive
  - To many to reliably classify by hand
- Silas Boyd-Wickizer automating classification
  - Uses “sparse” static-analysis tool for Linux kernel
  - Leverage sparse “address spaces”
    - Identify usage contexts
    - For example, uses protected by get_online_cpus() need not change when CPU offline moves away from stop_machine()

Alternative Approaches Considered

- Continue using existing CPU hotplug
  - Not feasible: slow, unreliable, disruptive to real time
- Modify CPU hotplug to reverse offline notifier order
  - Doesn't help with kthread creation overhead
- Dump CPU hotplug in favor of something new
  - Still need to clear all current and future work from each CPU, so similar complexity required
  - Plus still need CPU hotplug for failing hardware

Possible Issues With Approach

- Old-style interrupt controllers
- Scheduler-RCU circular dependency
- Early-boot initialization (before kthreads can be created)
- X86 MTRRs on hyperthreaded systems still require quiesce (but faster than CPU_DYING)
- Scanning online CPUs and changing for_each_online_cpu() semantics