Power Management in Linux* - State of The Art

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What Power Management Is About

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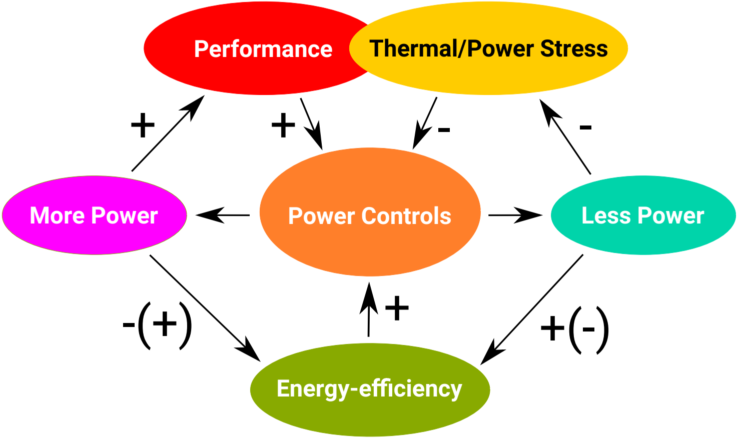
General Overview Of Power Management



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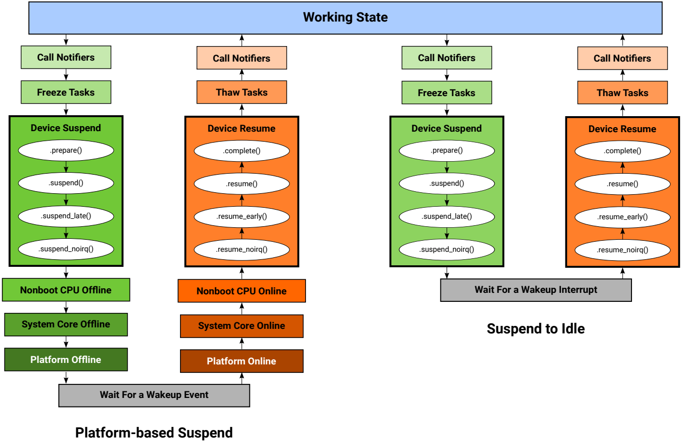
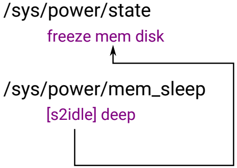
Two Different Ways To Get There

System Suspend



System Suspend/Hibernation Interface In sysfs



/sys/power/state

freeze mem disk

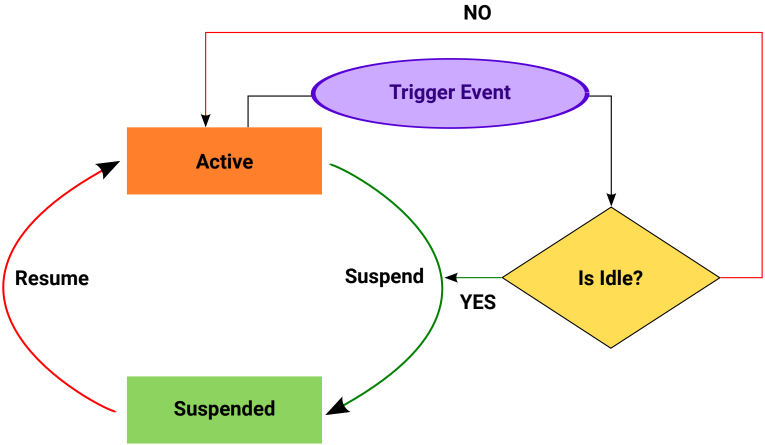
/sys/power/mem_sleep

[s2idle] deep

/sys/devices/.../power/wakeup

enabled
disabled

Overview Of PM-runtime



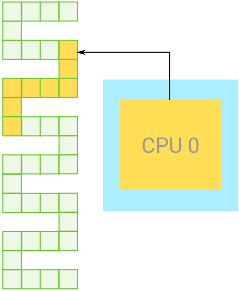
PM-runtime Control Through sysfs

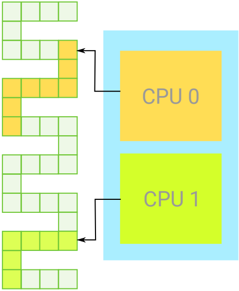
/sys/devices/.../power/control

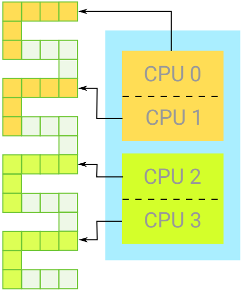
- auto
- on

/sys/devices/.../power/autosuspend_delay_ms

CPUs Are Logical Entities







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CPUs: Busy Vs Idle

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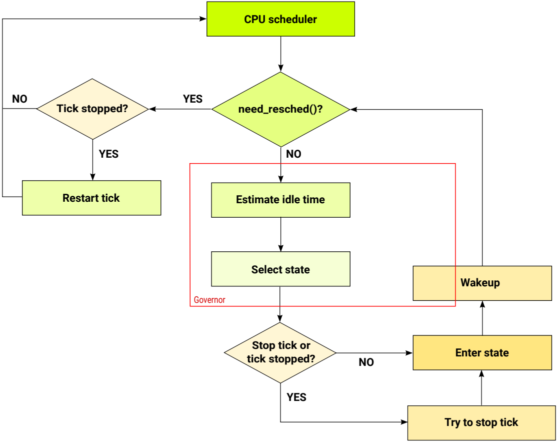
CPU Idle Loop (Linux* 4.17 And Later)



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CPU Idle Time Management Control

Kernel command line

idle=**poll**
halt
nomwait

cpuidle.off=1

intel_idle.max_cstate=0
1 ... 9

processor.max_cstate=1 ... 9
0

Special device

/dev/cpu_dma_latency

sysfs

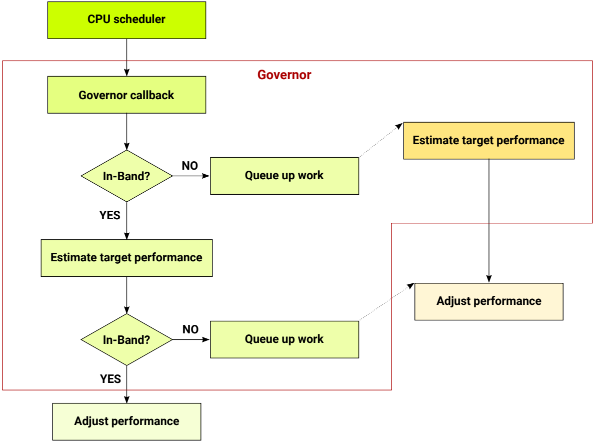
/sys/devices/system/cpu/cpuidle/
current_driver : intel_Idle
current_governor_ro : menu

/sys/devices/system/cpu/cpu<nr>/cpuidle/state<nr>/
desc : MWAIT 0x00
disable : **0**
latency : 2
name : C1
power : 0
residency : 2
time : 438396006
usage : 4637114

/sys/devices/system/cpu/cpu<nr>/power/pm_qos_resume_latency_us

CPUs: Performance And Utilization

Overview Of CPU Performance Scaling



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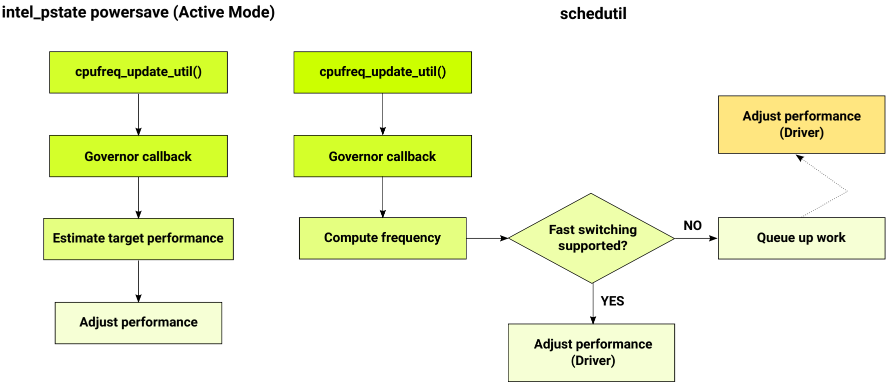
In-Band Scaling Governors


intel_pstate powersave (Active Mode)
cpufreq_update_util()
Governor callback
Estimate target performance
Adjust performance
schedutil
cpufreq_update_util()
Governor callback
Compute frequency
Fast switching supported?
NO
Queue up work
Adjust performance (Driver)
YES
Adjust performance (Driver)

CPU Performance Scaling Control

sysfs

/sys/devices/system/cpu/cpu<nr>/cpufreq/

affected_cpus : 0

cpuinfo_max_freq : 4300000

cpuinfo_min_freq : 800000

cpuinfo_transition_latency : 0

energy_performance_available_preferences : default performance balance_performance balance_power power

energy_performance_preference : **balance_performance**

related_cpus : 0

scaling_available_governors : performance powersave

scaling_cur_freq : 3039632

scaling_driver : intel_pstate

scaling_governor : **powersave**

scaling_max_freq : **4300000**

scaling_min_freq : **800000**

/sys/devices/system/cpu/intel_pstate/

max_perf_pct : **100**

min_perf_pct : **18**

no_turbo : **0**

num_pstates : 36

status: **active**

turbo_pct : 20

Kernel command line

cpufreq.off=1

intel_pstate=**active**
disable
force
hwp_only
no_hwp
passive
per_cpu_perf_limits
support_acpi_ppc

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PCI Express Active State Power Management (ASPM)

PCIe ASPM Control

Module parameter

```
pcie_aspm.policy=default
                 performance
                 powersave
                 powersupersave
```

sysfs

```
/sys/devices/pci0000:00/.../link/
    clkpm : 1
    l0s_aspm : 1
    l1_1_aspm : 1
    l1_1_pcipm : 1
    l1_2_aspm : 1
    l1_2_pcipm : 1
    l1_aspm : 1
```

Kernel command line

```
pcie_aspm= off
           force
```

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Intel Performance and Energy Bias Hint (EPB)

Intel EPB Control Through sysfs

/sys/devices/system/cpu/cpu<nr>/power/energy_perf_bias

0...15
performance
balance-performance
normal
balance-power
power

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Is Energy-efficiency Always At Odds With Performance?

Connection Between Energy-efficiency And Performance

For individual hardware components

Performance depends on the capacity and latency.

Without power budget sharing

Better energy-efficiency means more latency and/or less capacity.

However

Improving energy-efficiency of one component may change the distribution of power.

PM Features May Depend On One Another

Questions? Comments? Concerns?

References

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- Rafael J. Wysocki, *Energy-efficiency and Linux* (https://static.sched.com/hosted_files/osseu19/d1/energy-efficiency_and_Linux.pdf).
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- Rafael J. Wysocki, *Power Management Challenges in Linux* (https://www.linuxplumbersconf.org/2017/ocw//system/presentations/4652/original/linux_pm_challenges.pdf).
- Rafael J. Wysocki, *Advances in CPU Performance Scaling* (http://schd.ws/hosted_files/ossna2017/39/advances_in_cpu_perf_scaling.pdf).
- Rafael J. Wysocki, *PM Infrastructure in the Linux Kernel – Current Status and Future* (https://events.linuxfoundation.org/sites/events/files/slides/kernel_PM_infra_0.pdf).

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