System Sleep vs Runtime Power Management

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2. System Sleep
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Hibernation is not covered by what follows, so “system sleep” means “the state entered by suspending to RAM”.

“Remote wakeup” is a mechanism by which suspended devices signal that they should be resumed because of an external event possibly requiring attention.

Two Flavours of Power Management

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Claim

These two concepts are substantially different and generally cannot be used to implement each other.

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Rules

1. System suspend can happen at any time.
2. It should put the system into the deepest (lowest-power) state possible
   - in which the contents of RAM is preserved and
   - from which the system can be woken up in (a) specific way(s).
3. System suspend and resume should be as fast as reasonably possible.

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However, since the freezer makes user space do nothing

User space is not available during system suspend and resume (e.g. do not request firmware or probe devices at those times).

Suspend Sequence

1. Call notifiers (while user space is still there).
2. Freeze tasks.
3. 1st phase of suspending devices (`.suspend() callbacks`).
4. Disable device interrupts.
5. 2nd phase of suspending devices (`.suspend_noirq() callbacks`).
6. Disable non-boot CPUs (using CPU hot-plug).
7. Turn interrupts off.
8. Execute system core callbacks.
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Disabling non-boot CPUs after suspending I/O devices is an ACPI requirement.

Resume Sequence

1. (Wakeup signal.)
2. Run boot CPU's wakeup code.
3. Execute system core callbacks.
4. Turn interrupts on.
5. Enable non-boot CPUs (using CPU hot-plug).
6. 1st phase of resuming devices (`.resume_noirq() callbacks`).
7. Enable device interrupts.
8. 2nd phase of suspending devices (`.resume() callbacks`).
9. Thaw tasks.
10. Call notifiers (when user space is back).

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“Hmm, perhaps I don’t need to freeze tasks ...”

No, there are too many ways in which user space may interact with drivers for the drivers to intercept all of them without concurrency issues (e.g. deadlocks).

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Power break even for the whole system is difficult to estimate.

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User space decides which of them will wake up from system sleep.

Difference between “opportunistic” and user-initiated suspend is hard to tell.

CPUidle

Put idle CPUs into low-power states (no code execution)

- CPU scheduler knows when a CPU is idle.
- Next usage information from clock events.
- Maximum acceptable latency from PM QoS.
- CPU low-power states (C-states) characteristics are known.
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CPU scheduler may take the “power topology” information into account (work in progress).

I/O Runtime PM

Framework for device runtime PM

1. Subsystems and drivers provide callbacks
   - `.runtime_suspend(dev)`
   - `.runtime_resume(dev)`
   - `.runtime_idle(dev)`
2. Subsystems and drivers handle remote wakeup.
3. The core handles concurrency (locking etc.).
4. The core takes care of device dependencies (parents vs children).
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Initial idea was that subsystems (bus type, device type, device class) and drivers will choose the (low-power) states to put devices into, but that doesn't work well with power domains.

What A Power Domain Is

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Representation via `struct dev_power_domain` and derived structures.

If a power domain object exists for a device, its PM callbacks take precedence over bus type (or device class, or type) callbacks (new in the 3.0-rc1 kernel).

Runtime PM Of Power Domains

Observations

1. All devices in a power domain have to be idle so that a shared power resource can be turned off (e.g. clock stopped or power removed).
2. Power is necessary for remote wakeup to work.
3. Latency to turn a power domain on generally depends on all devices in it.

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Thus the PM core should provide means by which:

1. The status of devices in a power domain may be monitored.
2. Decisions to turn power domains off may be made on the basis of (known) device latencies and predicted next usage time (and PM QoS).

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Nevertheless, it generally is possible to use the same PM callback routines for both runtime PM and system suspend/resume at the driver level (not necessarily at the subsystem level).

It is, in fact, recommended that drivers do that if they can.

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This applies to power domain PM callbacks too.

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System sleep means "stay in the low power state indefinitely", so the lowest-power state available can always be used.

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It generally is not a good idea to replace one with the other (that will lead to problems in the long run).

References

- P. Bellasi, *Linux Power Management Architecture* (http://www.google.pl/url?sa=t&source=web&cd=8&ved=0CFYQFjAH&url=http%3A%2F%2Fhome.dei.polimi.it%2Fbellasi%2Flib%2Fexe%2Ffetch.php%3Fmedia%3Dteaching%3A2010%3Alinuxpowermanagement.pdf&rct=j&q=Linux%20Power%20Management%20Architecture&ei=g2niTdC0ConEvQ07r-zxBg&usg=AFQjCNFa5Ed-f0TDaXGcBX766oB0KuouYw&sig2=60e3dkZrUQRscdV6suNBVA&cad=rja).

- R. J. Wysocki, *Runtime Power Management in the PCI Subsystem* (http://www.linuxplumbersconf.org/2010/ocw/system/presentations/279/original/PCI_runtime_PM.pdf).

Documentation And Source Code

- `Documentation/power/devices.txt`
- `Documentation/power/runtime_pm.txt`
- `Documentation/power/pci.txt`
- `include/linux/cpuidle.h`
- `include/linux/device.h`
- `include/linux/pm.h`
- `include/linux/pm_runtime.h`
- `include/linux/pm_wakeup.h`
- `include/linux/suspend.h`
- `drivers/base/power/`
- `drivers/cpuidle/`
- `kernel/power/`