

8 hours of battery life on your lap(top)

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Dream of 8 hours

- Arimasa Naitoh, VP at development at Lenovo:
 - Battery life will also be of supreme importance as we move closer towards laptops that can run for a full working day on a single battery. Naitoh promised that, within the next two years, Lenovo will have a notebook that runs for eight hours using Lithium Ion technology.
 - easily possible with non-i386 machines
 - zaurus sl-5500 has 10 hours of battery life without backlight... on 3.6Wh battery
 - ...but Arimasa failed to mention that we can do 8 hours today, on Lenovo notebook

Gentle introduction to Li-ion



- likes to explode
- limited by internal resistancy „more energy available, but not for you“
- internal resistancy goes up with temperature going down
- internal resistancy goes up with battery getting older
- fancy charging characteristics:
 - battery is charged very slowly if it was completely dead – charger needs to make sure that it is really li-ion and that it basically works
 - current-limited phase
 - voltage-limited phase (4.2V / cell. 0.1V more, and see picture above)

Li-ion care and feeding

- they day at age of 3 no matter what you do
 - always check manufacture date
- deep discharges are harmful
 - full charge/discharge cycle is only needed for calibration of electronics
- high temperatures (>40C) are harmful
- very low temperatures are very harmful (<0C)
- when unused, charge to 60% and store at 15Celsius
- charging when battery is 99% full is harmful

Quick quiz #1

- When battery was new, it lasted 4 hours while working, or 40 hours suspend-to-RAM. It is 3 years old now, and it only lasts 30 minutes while working. How long will it last when suspended-to-RAM?
 - a) around 4 hours
 - b) around 2 hours
 - c) around 35 hours

Quick quiz #2

- Full charge of cellphone battery takes 1 hour. You need your battery at least 50% charged. You need to charge it for about:
 - a) 15 minutes
 - b) 45 minutes
 - c) 30 minutes

Easy way for 8 hours

- Just use machine designed for low power consumption:
- Sharp Zaurus sl-5500 can last for 10 hours at 3.6Wh battery
- (that is 208 hours on battery from thinkpad X60!)

ThinkPad X60

- Small machine with big battery...
- 74.8 Wh battery, <2kg
- core duo cpu, e1000 ethernet card, ipw3945 wifi, small 1024x768 screen, SATA
- Numbers on next slides are for thinkpad X60, and I'll assume we can actually do 8 hours for illustration (~9W).
- Baseline linux takes ~16W, ~4hours 40minutes
- Quiz #3: what component eats most power (at idle)?
- ...and the worst offender is:

Backlight

- (I had to cheat a bit to get it here). On zaurus, backlight eats 2x as much power as rest of system, combined
- +3W, -1 hour 55 minutes (min to max, no backlight is -0.9W)
- but we can't do anything about it, can we?
- ...that's why ambient light sensor is important
- ...userspace can help here by making backlight adjustment very easy
- ...some kind of time-of-day based auto adjustment?
- ...automatically turn the backlight down when not typing?
- please convert drivers to common backlight interface

USB

- +3.3W, -2 hours 5 minutes
- UHCI is misdesigned, and keeps busmastering even when idle, preventing deep sleep of CPU
- software workarounds are possible when no devices are active (in -mm)

Harddisk (+SATA)

- harddisk spinning is +0.5W, -24 minutes
- SATA controller active is +1W, -46 minutes
- harddisk + SATA active is +1.5W, -66 minutes
- minimum powersaving is stopping unused links. Tejun has a patch, but for the old kernel
- turning it off during runtime would be possible, but currently wake up takes way too long; can be fixed

Wifi

- +1.3W, -58 minutes
- it is important to keep wireless off when not needed
 - userspace should make that simple
 - good for security, too
- implement wifi power saving

Video card

- baseline is vga=1 – 80x25 text mode
- -0.2W, +11 minutes for SVGA TextMode 40x12x8 text mode.
 - 80x25 text mode is bad enough, this is just not realistic
- +0.6W, -28 minutes for X windows running
- +0.15W, -7 minutes for X at 640x480, 8-bit depth
 - heh, turning down color depth and resolution when user is not looking would be nicely evil.
- +0.35W, -16 minutes for X at 8-bit depth
 - could we turn down color depth when user is not looking?
- +0.5W, -24 minutes for truecolor framebuffer at 60Hz
- +0.45W, -22 minutes for truecolor at 43Hz

Ethernet

- Maybe it was mistake to use 1Gbps card in notebook this small?
- when cable is connected, +0.5W, -24 minutes
- is some kind of power saving possible on wired ethernet? Only listen once per second if there's new data?

HZ

- +0.5W, -24 minutes for HZ=1000
- +0.3W, -14 minutes for HZ=250
- greater savings possible with dynticks patch...
 - ...but that needs fixed userspace, first.

Sound

- +0.3W, -14 minutes when driver loaded
- ...drivers should power down the hardware when 'their' device is not used

Can someone call the GhostBusters?

- ...please?
- suspend to RAM saves 0.3W, +14 minutes
- ...not sure why, probably bug somewhere

Thermal management

- +0.3W, -14 minutes when the fan kicks in
 - ...and fan kicks in mostly randomly, to make measurements more difficult
 - ...and when you forcibly disable it, machine overheats, which leads to raised power consumption, too. (Throttling? Silicon less effective at higher temperatures?)

Save energy: drive a smaller shell

- Baseline is idle cpu
- same-gnome running is +0.5W, -24 minutes
- galeon downloading pages is +0.8W, -37 minutes
- single-CPU kernel compilation is +19W, -5 hours 23 minutes
- dual-CPU kernel compilation is +28W, -6 hours
 - so it is just a bad idea to compile kernels while on battery power
 - for the same reason, composite X desktop with nice effects may be very bad idea
 - I was not able to measure how much 3D subsystem eats, but it is probably non-trivial, too

Crazy ideas

- Turn fans off when battery very low („we'll not have time to overheat, anyway“)
 - preferring passive cooling at that point would not be so crazy
- Would be nice to turn backlight even lower than vendor wanted
- How much does memory eat? Can we turn it off?

UI changes

- Ask wisely for options that eat a lot of power
 - Ex.: Infrared?
 - off
 - on for 3 minutes
 - Crazy? No, if you realize that infrared port eats as much power as rest of your cellphone. (Bluetooth is slightly better than that, only eats 50% of power of rest of cellphone)
- Synchronize animation accross applications, so CPU is only woken up once
 - or disable eye-candy altogether when on battery power?
 - or just rule that application may not animate when it is not foreground?

Summary

- Stripped down system can be in ~9.3W range, giving 8 hours
- Unoptimized Linux is in ~16W range, giving 4hours 40minutes
- Kernel compilation on both cpus is in ~42W range, 1hour 47min

Questions?

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