Low Power Linux

SCALEX 2009

Agenda

- Why?
- General Concepts
- Software Approaches
- Hardware Assistance
- PM for other components
- Current Examples
- Compromises
- Measurements
- Cases
- Questions
Why?

- Lower power, less heat!
- Longer run time
- Lower power bill
- Green

General Concepts

- Turn things off!
- Switch slowly
- CMOS power is proportional to speed
- \( P \sim V^2 \times f \)
Software Approaches

- APM/ACPI (x86)
- BIOS to abstract hardware
- x86 hlt instruction
- Tickless support (NO_HZ)
- Sleep while idle
- Suspend/hibernate

Software Approaches

- Userland
  - sleep instead of spinning
    for(i=0xfff; i;i--); vs
    sleep(20);
  - Use a kernel driver
  - Avoid hard real time
Hardware assistance

- Design for low power
- Intel Atom
- ARM core
- Transmeta
- Advance instructions
  - MMX/SSE/FPU (x86)
  - Neon/VFP (ARM)
- Less memory

Hardware assistance

- Variable frequency
  - CPUFREQ
- Variable voltage
- Wake up trigger
- Accelerators
  - Graphics
  - DSP
  - Jazelle
PM on other parts

- SDRAM self refresh
- LCD backlight
- DPMS
  Display Power Management System
- USB as part of spec.
- PCI as part of spec.
- Power supply controller shutdown

PM on other parts

- Bluetooth sniff/park modes
- Network Wake on LAN
- WiFi power save mode
- Shutdown input on serial driver
- Solid state storage in place of rotating media
- Hard drive PM modes
Current design: x86
Intel Atom

- Derived from Pentium
- Lot of press coverage
- Makes chipset main power draw
- Not an SoC
- Significant improvement in power usage
- 2.5W/11.8W
- Used in MID/UMPC

Current design: ARM
TI OMAP3

- ARM Cortex A8
- Dual core: Includes a DSP
- Variable voltage
- A SoC
  - Subsystems can be clock gated and powered off
- Less then 2W
Trade offs

- Latency
- Tricky coding to maintain state
- Side effects
  - hlt on x86 impacted sound
- Documentation may be harder to find.
- Can be system specific

Measurements

- Basic DMM to measure current
  - Connected in series
  - Measure at battery
  - Measure at CPU
  - Error from I*R losses and power supply losses
Measurements

- Some boards may have measurement points designed in
- i.MX31 PDK has a header
- Beagle has a jumper and on board sensor
- Can provide more details to identify hot spots

Measurements

- New design provisions:
  - 0 ohm jumpers on power lines
  - Accessible trace
  - On board sensors
  - PowerTop
  - Id power consuming processes
**Cases - 1**

- 40MHz 386 acting as a home router
- 100W measured
- "WRT54" router for $100
- 10W power supply
- Assume $0.15/KWh
  \[(100W - 10W) \times 24h \times 30\text{day} = 64.8\text{KWh}\]
  \[\$0.15 \times 64.8\text{KWh} = \$9.72/\text{month}\]
  Payback <1 year!

**Cases - 2**

TI OMAP3 based Beagle Board
Bootloader: 333mA

<table>
<thead>
<tr>
<th></th>
<th>Idle</th>
<th>Busy</th>
</tr>
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<tbody>
<tr>
<td>No PM</td>
<td>132mA</td>
<td>223mA</td>
</tr>
<tr>
<td>PM - Performance (550MHz)</td>
<td>154mA</td>
<td>248mA</td>
</tr>
<tr>
<td>PM - Power save (125MHz)</td>
<td>127mA</td>
<td>145mA</td>
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</table>
Cases - 2 (con't)

- Numbers are extremes
- Actual application would be a mix
- Governors can help
- NOHZ may help if there is IO

Questions?