



Low power systems architecture for ICT4D

Stephen Okay

Abdus Salam International Center for Theoretical Physics,
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Power consumption in a desktop PC

- Mainboard 20–30 W
- 2 Ghz CPU 50 W
- RAM 10 W per 128MB
- IDE Disk 5–15 W per disk
- IDE CDROM 5–15 W
- PCI 5 W per slot
- Network 5 W
- Video 5–25 W



160-185 W

(Without Monitor)

190-255 W

(With 17" Monitor)

260W or >

(17" Monitor w/ High-performance graphics card)

Low-power("embedded") systems

- Consume 1–15W power from a 3–12 V, 0.5–5A input
- low-power, or older-generation CPU
- Single-board computer(SBC)
 - limited / no expansion capability
 - use flash memory for storage instead of hard disk
 - limited or no video output
 - I/O ports may use custom connectors, cables
 - Can use multiple power sources

Characteristics of low-power systems

- Designed for low-power/low-load usage
- Tolerant of unreliable/inconsistent power
- Access points, routers, etc. use POE
- Servers/end-user stations assume battery, but can work just as well off solar, bicycle power, etc.

Types of low-power systems



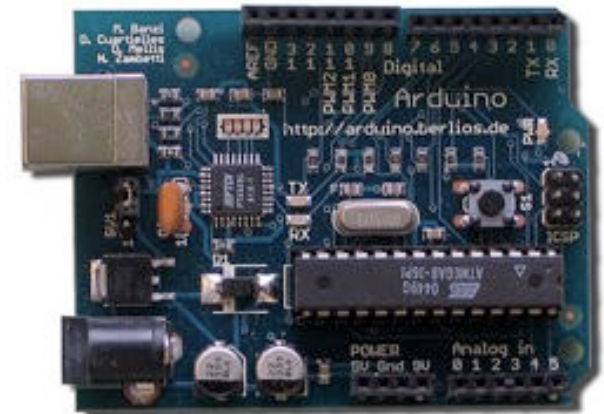
LinkSys WRT-54G



Inveneo Comm. Station

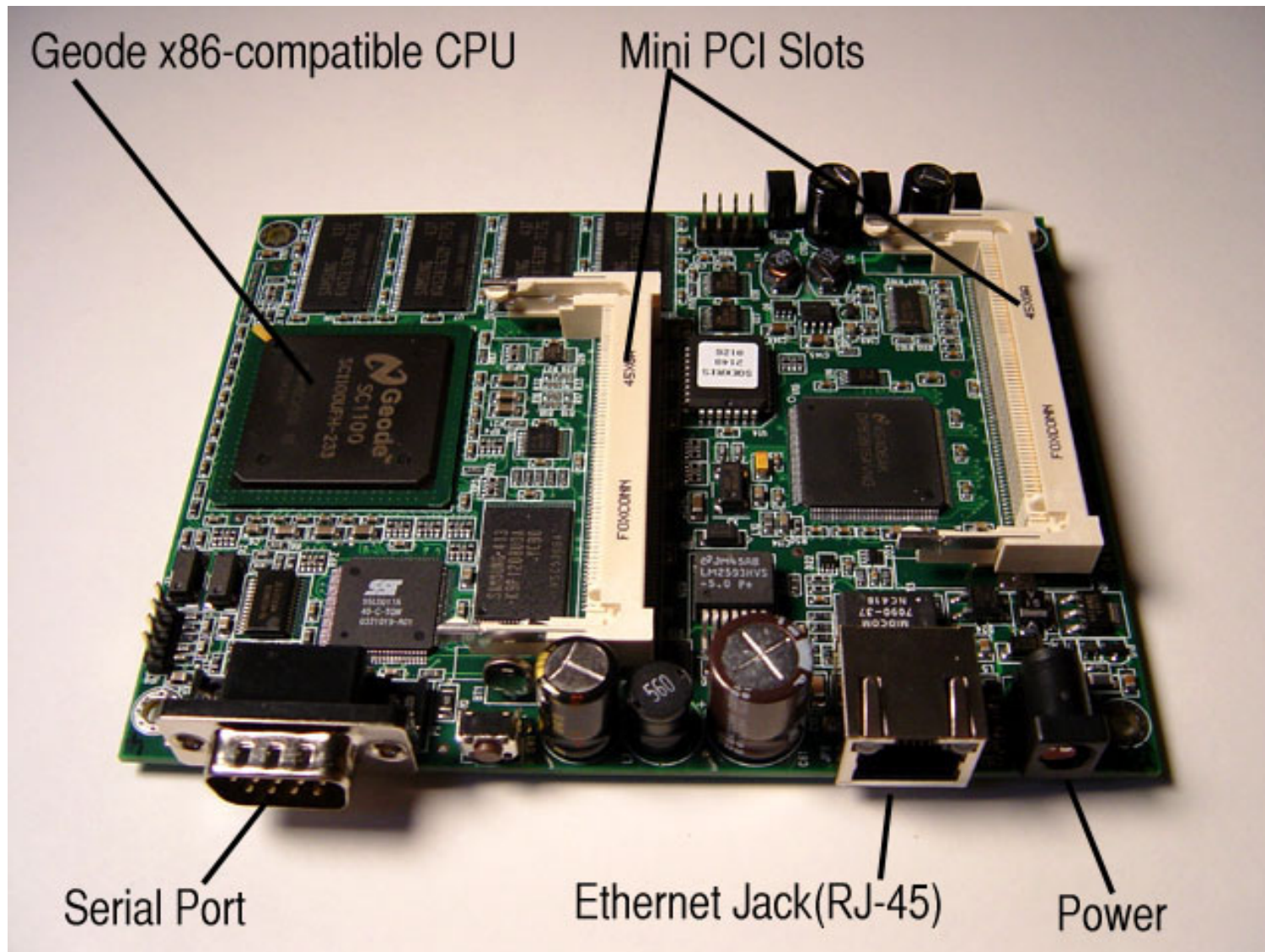


WRAP SBC in outdoor housing

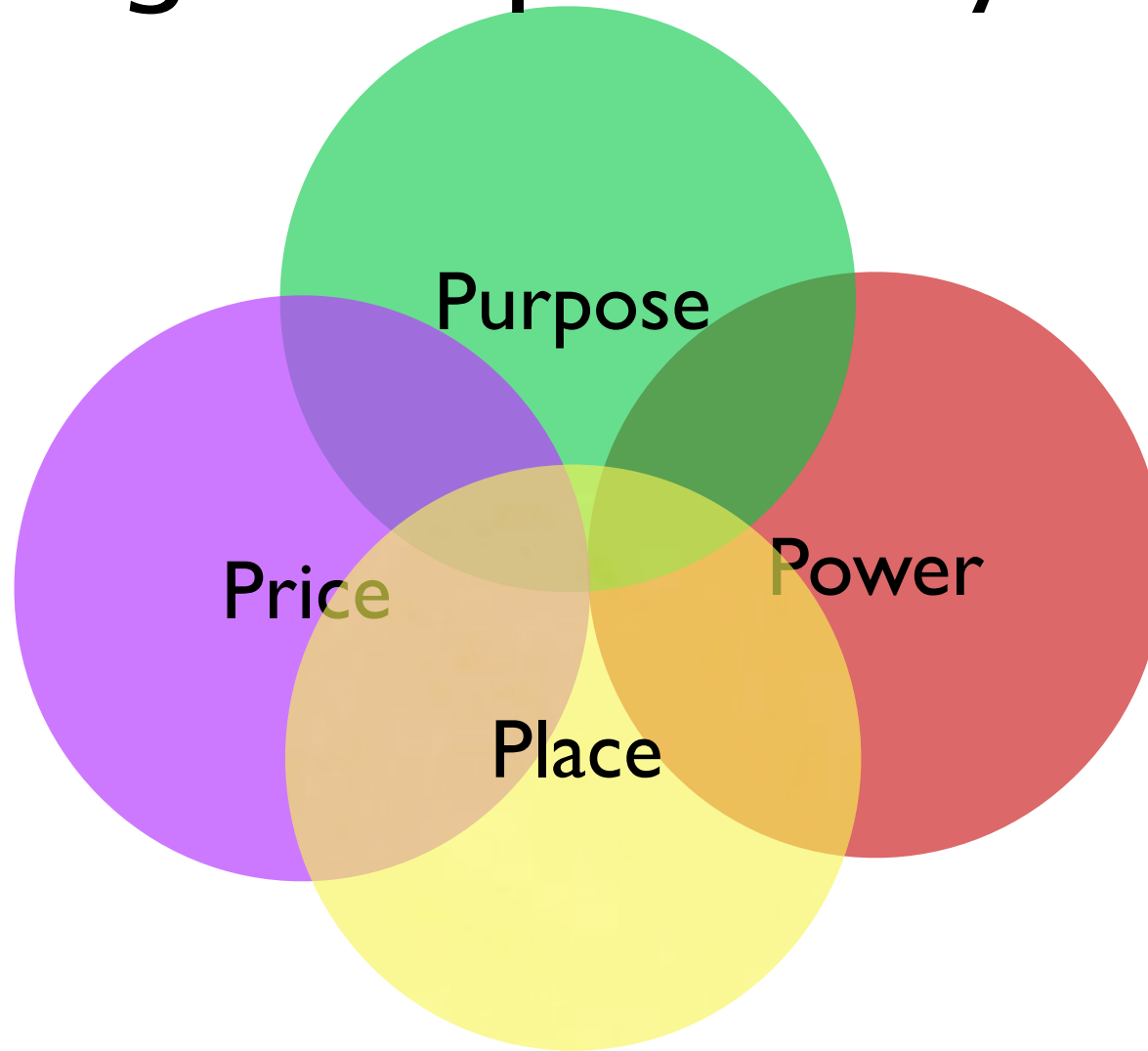


Arduino Prototyping board

Soekris Single-Board System



Designing low-power systems



Low-power design

- Question the obvious
- Build for purpose
- Take out what you don't need
 - What can be moved into another device?
 - Do all functions have to be available at all times?
- Allow for servicing/repair
 - You will need to get back inside someday

Systems Software guidelines

- Choose an embedded-friendly OS (such as Linux)
- Run in RAM as much as possible
 - Saves wear on flash media
 - Lower power consumption
 - Faster than disk
- Disable or remove unnecessary programs from install image
- Schedule and batch communications sessions via cron ("Space Probe" model)
- Display
 - LED, serial(RS-232) or LCD
 - Web GUI or shell access.

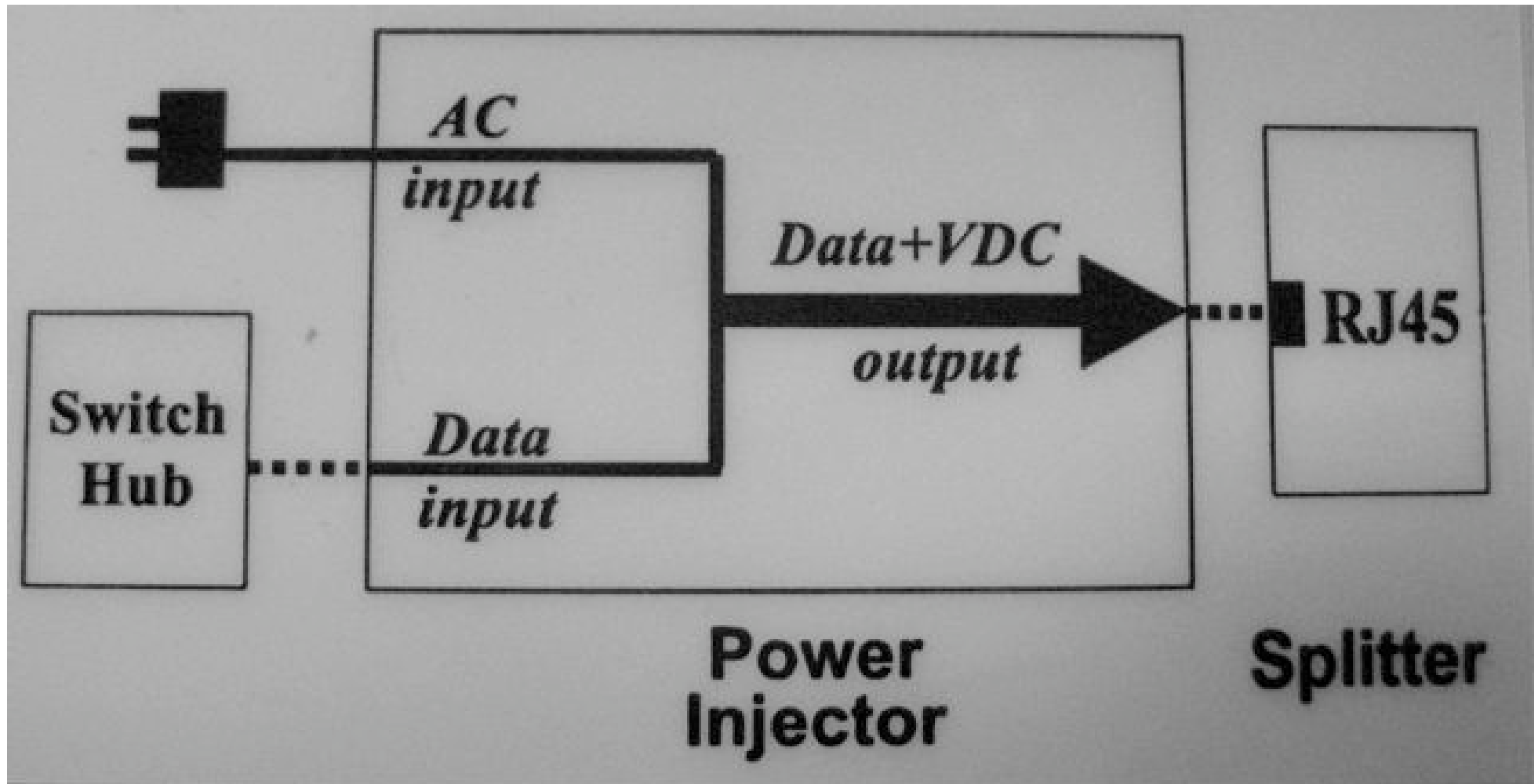
Power Inputs

- Power “Brick” / “Injector”
- Battery pack
- Power over Ethernet(POE)
- Solar (To charge battery)
- “Anderson” connectors on power leads for ease of connection/ replacement

Power-Over-Ethernet

- Power Over Ethernet (POE)
- Defined by IEEE standard 802.3af
- Provides 48V @ 350 mA, supplying 15W
- Uses non-data pairs in RJ-45 cable
- Can damage equipment if not implemented carefully

POE "Injector"



CPUs

- Common low-power CPUs
 - 486
 - ARM
 - AMD Geode
 - Pentium Mobile and Crusoe available, but expensive

Storage for low-power systems



Compact Flash

- Most common form factor, 256MB-4GB capacity
- Limited lifespan (approx 100K write ops)
- 5V 40mA Power draw
- \$20-90 US



Microdrive

- Hard disk in CF form factor, 1-8GB
- Same power profile as CF card
- \$50-\$200 US
- Does not have CF write problems



NAND Flash Drive

- Chip-sized form factor, 16MB-1GB
- IDE/SCSI emulation
- Wear-leveling to extend lifespan
- Hard disk-like read/write times
- Very low physical profile
- \$20-\$500 US

System provisioning

- Provisioning
 - How the system gets software loaded onto it
 - Host/Target
 - Read-only Flash
 - Removable CF media
 - Network
 - OS/Software load and booting is done all over the network

Host / Target Method

```
Filesystem 1K-blocks  Used Avail Capacity  Mounted on
/dev/disk0s3 97554672 90220592 7078080   93%  /
fdesc       1           1     0 100%  /dev
fdesc       1           1     0 100%  /dev
<volfs>     512        512     0 100%  /,vol
/dev/disk2s1 519096     25384 493712    5%   /Volumes/Target_CF
notebook-33-146:~ armadilo#
```

Host system
Contains OS Image



1. OS Image
configured on
host system

2. Write image to removable media



Target System Runs
Host-generated image

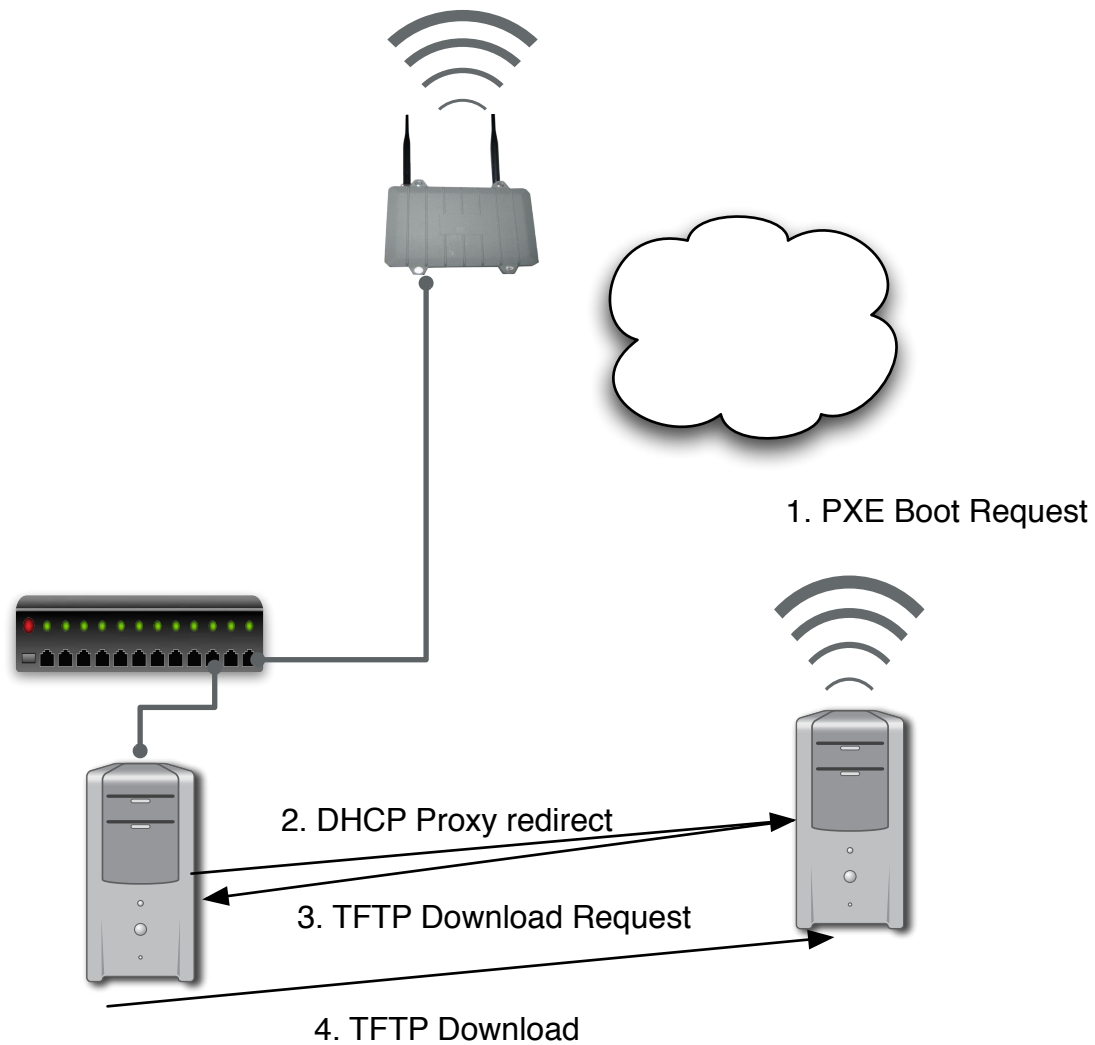


3. Install media in Target system

Host/Target method

- Pro:
 - Ensures functionality and integrity
- Con:
 - Even minor changes can mean a re-install
 - Need more attention to prep & planning

Networking Provisioning



Network Provisioning

- Pro:
 - Can dynamically reconfigure target systems simply by rebooting
 - Requires NO permanent storage, just RAM
 - Lower cost
- Con:
 - Systems will fail to boot if connectivity is disrupted
 - Needs server system for booting and storing user data

Maintenance/Control

- Web GUI
- Shell (avoid telnet, turn on ssh)
- Serial

Common network chipsets & their Linux Drivers

- Wireless
 - 802.11G: Broadcom, Atheros, Prism
 - 802.11B: Hermes, Orinoco, Cisco
- Ethernet
 - Intel EtherExpress, RealTek81xx series, National Semiconductor DP8381x series

How do I know what I have?

- Under Linux
 - Check logs like `/var/log/messages`, `dmesg`, etc.
 - `cat /proc/pci/devices` or `/proc/usb/devices`
 - list kernel modules installed w/ `lsmod`
 - examine hardware itself: model numbers, manufacturer, part numbers
 - don't take "unknown device" for an answer!

Some Linux distributions for low-power systems

- Pebble
- DD-WRT
- OpenWRT
- Pyramid
- OLSR
- TIER

Environmental Issues

- Weather Damage
- Temperature vs Power
- Pests
- Theft and Vandalism

Links for low-power systems

- Soekris Engineering www.soekris.com
- Metrix Systems www.metrix.net
- Earth LCD www.earthlcd.com
- “Linux Devices”
www.linuxdevices.com
- Arduino Project www.arduino.cc