Hardware Debugging

How to troubleshoot a hardware failure

- Later lectures will deal with software
- Problems:
  - Machine won't power on
  - No display once powered on
  - Random OS crashes
  - Disk sector failures
  - Heat issues
  - Other misc issues
  - Network cable testing and construction
- Tools you need in an admin's physical toolbox

My "Doctor Bag"

Disclaimer

- A lot of this is based on my own anecdotal experience with fixing failed computers
  - Not any comprehensive study
- But I think there are some good rules of thumb here
- Your mileage may vary

Machine won't turn on?

Machine won't power on?

- Power supply tester

Power supply testing

- Power off the machine!
- Move plugs from motherboard to tester
  - Start with motherboard, then try disk power
- Power on the machine, read voltage
  - Check that it matches the specification
- Many have a simple design, that just lights all green lights if ok:

What I would buy

- A cheap tester is usually sufficient (<$20)
- Be sure it tests at least connectors for:
  - ATX motherboard
  - IDE disk
  - SATA disk
- The digital display is nice, but the green lights are sufficient

No voltage at all?

- Double check the switch on the back of the power supply
  - Really do this first
- Test the outlet too

Burning smell, no power?

- On a really old system, check the voltage selector
- Most modern power supplies are rated for both 120V (US) and 240V (Europe + some US data centers)
  - Your laptop probably is, but check the fine print on the power cord
  - Older ones had to manually select the voltage
    - Get it wrong, cook the hardware
    - Release the “new computer smell”

Power supply = weak link

- Anecdotally, power supply failures are a substantial cause of systems I've had to replace
  - Failures tend to cook the motherboard + disks
  - RAID? A bad power supply cooks all the disks
    - Make sure you have a backup disk on a different power supply!
- Sadly, not a lot of warning before one fails

The importance of good power

- In some areas, power is “dirty”
  - Including Long Island
- Clean power has a regular wave pattern
  - Dirty pattern is irregular
- Dirty power stresses equipment, shortens lifespan
- What to do?
  - Buy a decent Uninterrupted Power Supply (UPS)

What is a UPS?

- Basically, a big battery backup for the computer
  - Come in lots of sizes
  - One sufficient for a beefy computer is ~$150
- Main purpose is to keep the machine up if the power goes out (e.g., in a storm)
  - Or at least allow the computer time to shutdown cleanly
  - Most newer ones include a USB cable and monitoring software
- Bonus: they tend to also be good at power conditioning (smooth out power waves)

No power recap

- Is the outlet hot?
- Is the power supply on?
- Is the power supply emitting correct voltage?
- If the power supply is good, you should at least hear/see case fans spin up
- UPSes are nice, and important if you have dirty power

No display?

Digression: The BIOS

- The Basic Input/Output System (BIOS) is the first thing a computer runs
  - Initializes the hardware, including video card
  - Usually shows a boot screen, some output messages
    - Press F2 (or Del) to configure
  - Passes control to the bootloader, which then load the OS

- Note: newer systems replace a PC BIOS with UEFI
  - A more principled, but similar idea

Power-On Self Test (POST)

- One of the first things the BIOS usually does
- As the name implies, makes sure all sub-components turn on and appear to be working
- If not, may stop booting
  - Sometimes before turning on video
  - If you are lucky, it prints an error message on monitor
- How to debug this?

POST Code Reader

- Plugs into PCI slot
- Displays a hex code indicating error or success of POST

Alternatives

- Some motherboards have a “bell” and send morse-code like messages
- Dell includes 4 lights (usually marked ABCD) that encode an error message based on which ones are amber and which are green
- In all cases, need a manual to decode these values and figure out what is wrong

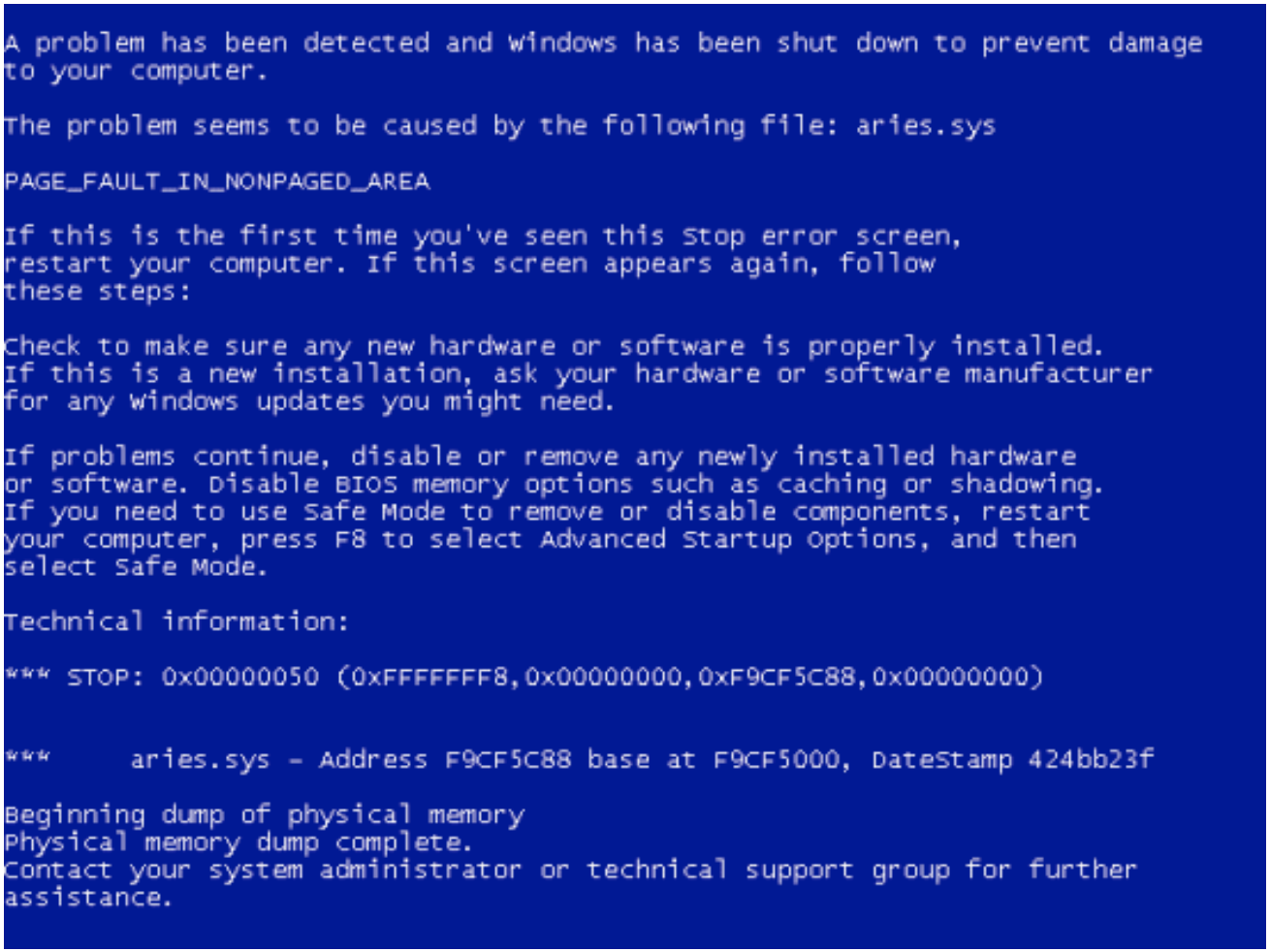
Now what?

- Sometimes you can use a message to identify a bad component that is replaceable
  - E.g., CPU, RAM
- In most cases, the component is on the motherboard and you are hosed

POST Summary

- POST readers are also handy
  - At least for systems that can't display an error on the case
- Diagnose some errant hardware installations or failed components
- Often, one chip on the motherboard is bad
  - But you have to replace the whole thing

Random system crashes



Random crashes

- I mean crashes that happen after the machine has been on for a while
- Can't be reproduced with a specific task
- But seem to happen a lot

- What are the most likely culprits?

2 Usual Suspects

1. Bad RAM
2. Binary corruption on disk

Bad RAM

- Sometimes part of a RAM chip goes bad and sporadically flips bits
  - Tends to be somewhat heat sensitive
  - Some evidence this could be a latent manufacturing flaw
- There is a pretty good test for this: memtest86
  - Installed as an option in bootloader
  - Runs for a while (hours) stress testing memory
  - Reports errors if any found
  - If errors, buy new RAM

OS Corruption

- In my experience, much more likely that bits get flipped on disk
- What to do?
  - Reinstall everything
  - Try updates (e.g., Service Packs)
    - Hidden blessing when users don't keep up with service packs

Unfortunately

- At least in Windows, most problems are hard to solve except by reinstalling everything
- Some even consider this good hygiene

Random crashes

- Test the memory
- Try applying OS updates
- Reinstall
  - If a fresh install also crashes randomly, buy a new computer

Disk sector failures

- Disks store data at the granularity of a sector
  - Usually 512 or 4096 bytes
- Individual sectors can fail
- Disks have a small number of "spare" sectors
  - Can remap a failed sector to a spare
  - At least until the spares run out
- As spares get low, probably time to replace the disk
  - Disks generally wear out after 3—5 years of use

SMART monitoring

- Most disks include a certain amount of built-in health monitoring
  - Including remapped sector count
  - Can signal approaching doom
  - Called SMART
- BIOS can often report SMART errors, as can utility programs
  - Probably a good idea to install a SMART monitoring application to notify you of a pending disk failure

Ubuntu disk health tool

160 GB Hard Disk (ATA Hitachi HDS721616PLA380) – SMART Data

Updated:	6 minutes ago	Self-tests:	Completed OK
Powered On:	1,6 years	Power Cycles:	3507
Temperature:	38° C / 100° F	Bad Sectors:	1 bad sector
Self Assessment:	Passed	Overall Assessment:	Disk has a few bad sectors

Refresh
Reads SMART Data, waking up the disk

Run Self-test
Test the disk surface for errors

Attributes

ID	Attribute	Assessment	Value
			Value: 160 msec
4	**Start/Stop Count** Number of spindle start/stop cycles	N/A	Normalized: 100 Worst: 100 Threshold: 0 Value: 3514
5	**Reallocated Sector Count** Count of remapped sectors. When the hard drive finds a read/write/verification error, it marks the sector as "reallocated" and transfers data to a special reserved area (spare area)	Warning	Normalized: 100 Worst: 100 Threshold: 5 Value: 1 sector
7	**Seek Error Rate** Frequency of errors while positioning	Good	Normalized: 100 Worst: 100 Threshold: 67 Value: 0

Don't warn if the disk is failing

Disk summary

- Install a smart monitoring tool
- Replace the disk when remapped sector count gets too high, or other SMART errors reported

Heat

- A lot of computer components are sensitive to heat
- Disks are the worst---cuts their lives shorter
- CPU and RAM can get bit flips when operating outside of their expected temperature range
  - Although should work correctly when cooled back down

Heat Sources

- Hot room (obviously)
- Poorly ventilated rack
- Failed fan inside the case
- Obstructed airflow through the case
- Dust – like putting a sweater on the components

What to do?

- Your CPU reports its temperature, as do disks and other components
- Lots of tools to read this:
  - Mac: istat nano
  - Linux: /proc/cpuinfo, etc.
- If too high, and room isn't hot:
  - Check airflow
  - Dust
  - Pause CPU-intensive programs

Remote Access

- Lights-out manager (aka IPMI, other names)
- A small system that runs on the motherboard
  - *Even when the power (switch) is off*
  - Listens for network connections
    - (shared or dedicated network plug)
- Key features:
  - Turn power on/off/reboot over the network
  - Remote video/serial console
- Extremely useful for managing server rooms

Network Cables (CAT 5/6)

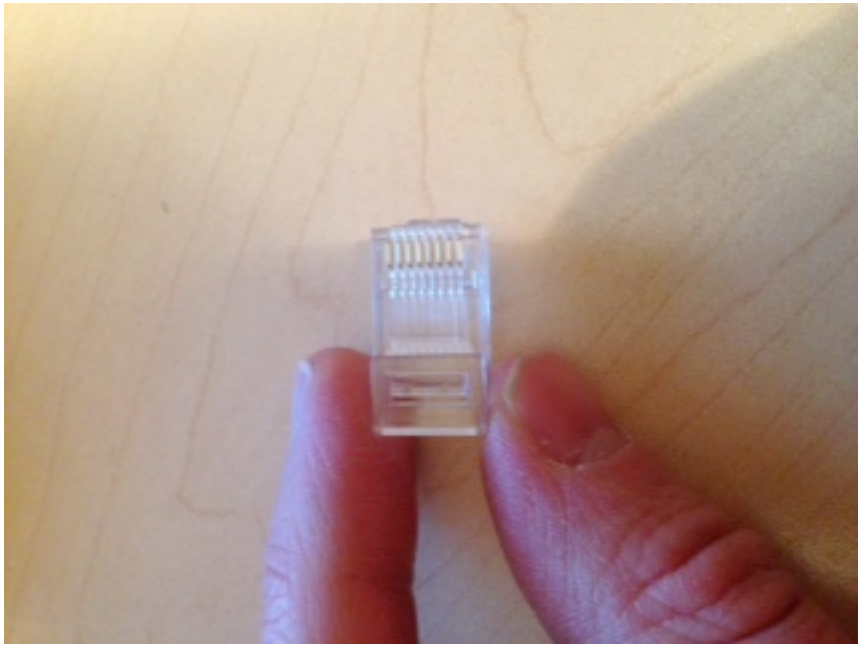
- Easy to make, and cheap!
  - Get the cable by the foot at Lowes/Home Depot
  - Ends come in a package as well
- Just need to know the pinout for the ends
- And need a crimping tool

Cat 5 Basics

- 4 twisted pairs of wires inside a cable
- Each pair is a color + white with color stripe
  - Green, Orange, Blue, Brown
- To terminate a cable:
  - Carefully remove sheath of cable
  - Untwist pairs, trim to same length
  - Follow pinout of ends
  - Crimp
  - Test

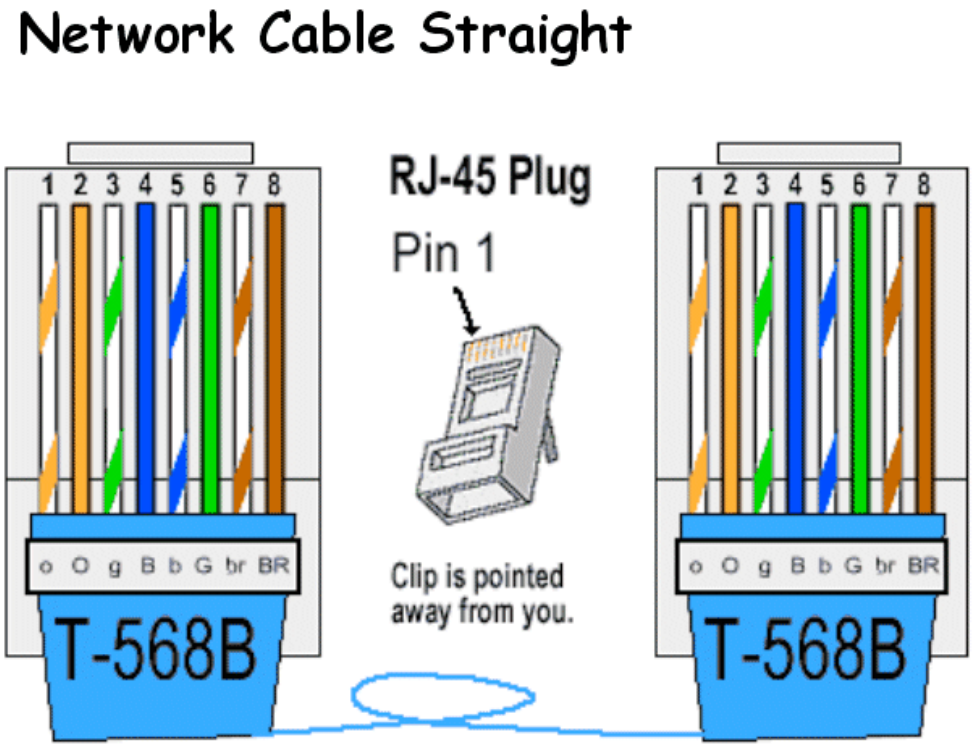
Finished cable

Ends



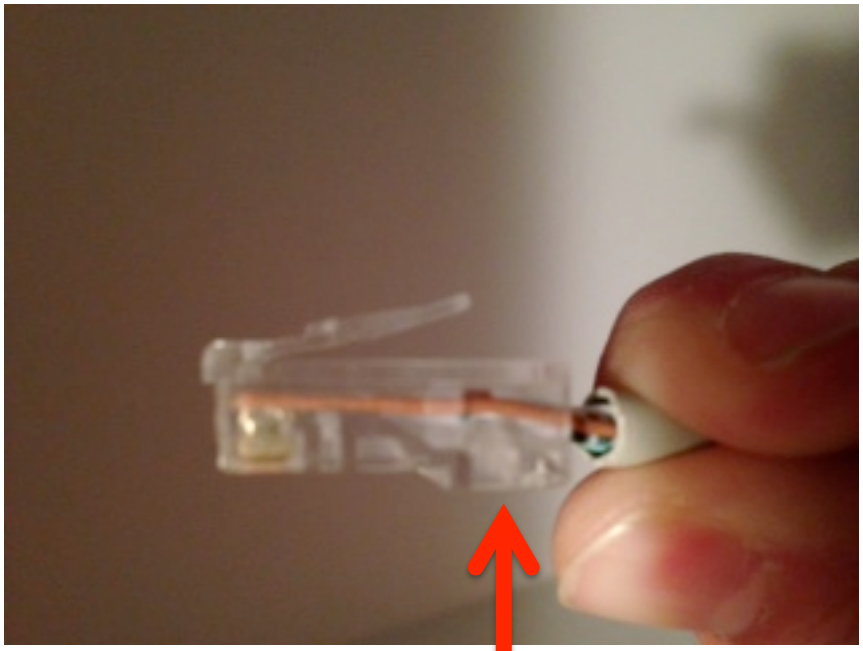
Pinouts

- More than one that work
  - What actually matters is where the pairs of wires go

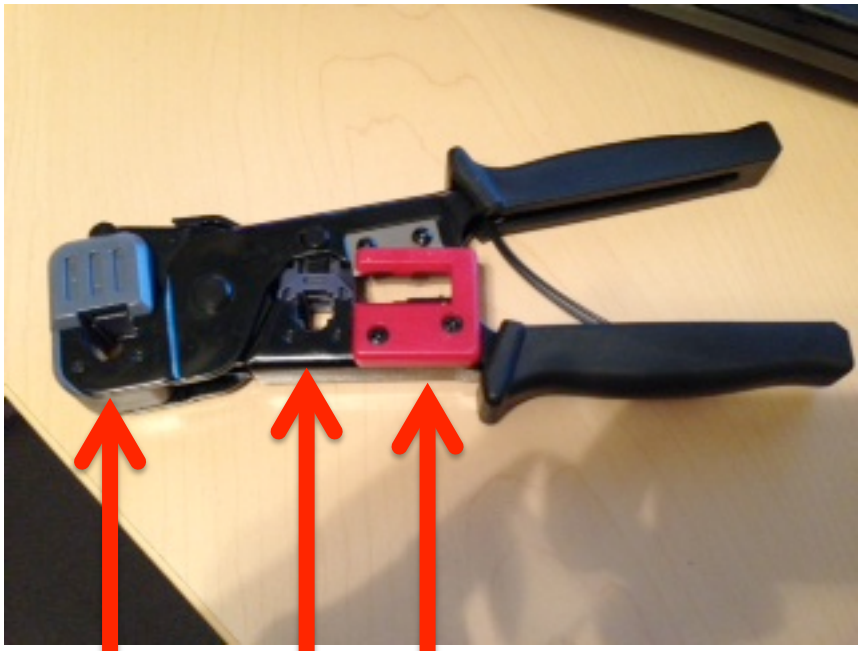


From: http://www.siongboon.com/projects/2006-03-06_serial_communication/

Crimping tool



End has a spikey-thing that presses into the wires, holding end on and wires in place



RJ 45 (Cat 5)

RJ 11 (phone)

Wire cutter

Crimping Tool

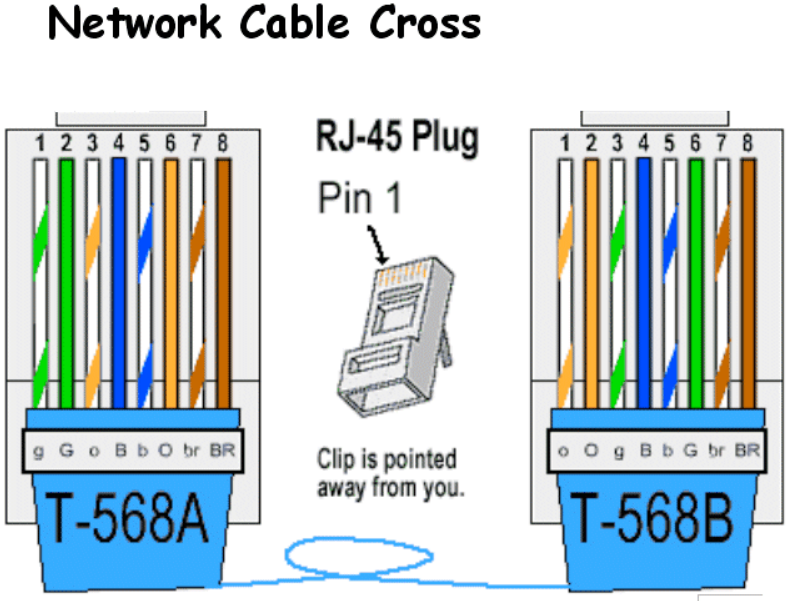
Open

Closed

A little tab comes down when closed pushes the spikey thing down

Straight vs. Crossover

- Straight wiring is for a computer to a switch
- You can also go computer-to-computer if you change the pinout
  - Usually indicated with a red cable
  - Some NICs can cross using a straight cable, and vice versa



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Testing a cable

From: http://hiwtc.com

- Tester can tell if some wires aren't making good connection
- Good ones have a remote so you can test one in a wall
- Tone generators can also be helpful for finding a wire

Network cabling crash course

- Not hard to make custom cables
  - Just follow the pinout and crimp
  - Female ends (wall plugs) work similarly
- You may need to troubleshoot a network cable/plug that doesn't work

Summary

- Crash course in hardware troubleshooting
- A few inexpensive tools can be very useful
- A big part of any IT/IS job is tech support
  - Even my CS PhD students troubleshoot hardware