

Stony Brook University CSE/ISE 311: Systems Administration

Hardware Debugging


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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

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My "Doctor Bag"



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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


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Machine won't turn on?

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Machine won't power on?


- Power supply tester



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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:



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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

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No voltage at all?

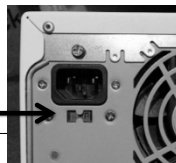
- Double check the switch on the back of the power supply
 - Really do this first
- Test the outlet too



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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”



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Power supply = weak link

- Anecdotal, 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

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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)

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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)

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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

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No display?

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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

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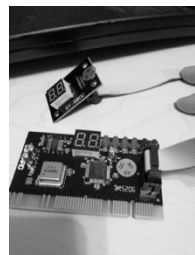
Power-On Self Test (POST)

- 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?

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POST Code Reader

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



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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

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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


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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

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Random system crashes



```

A problem has been detected and windows has been shut down to prevent damage
to your computer.

The problem seems to be caused by the following file: arles.sys

PAGE_FAULT_IN_NONPAGED_AREA

If this is the first time you've seen this Stop error screen,
restart your computer. If this screen appears again, follow
these steps:

Check to make sure any new hardware or software is properly installed.
If this is a new installation, ask your hardware or software manufacturer
for any windows updates you might need.

If problems continue, disable or remove any newly installed hardware
or software. Disable BIOS memory options such as caching or shadowing.
If you need to use safe mode to remove or disable components, restart
your computer, press F8 to select Advanced startup options, and then
select Safe Mode.

Technical information:
*** STOP: 0x00000050 (0xffffffff,0x00000000,0xf9cfc3b8,0x00000000)

*** arles.sys - Address f9cfc3b8 base at f9cfc300, DateStamp 424b23f
Engineering dump of physical memory
Physical memory dump complete.
Contact your system administrator or technical support group for further
assistance.
  
```

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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?

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2 Usual Suspects

1. Bad RAM
2. Binary corruption on disk

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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

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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

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Unfortunately

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

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Random crashes

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

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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

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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

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Ubuntu disk health tool

100 GB HDD (ATA HIC80 HUS720T0PLASH0) - SMART: USB3

Updated: 6 minutes ago
 Powered On: 1.6 years
 Temperature: 38° C / 100° F
 Self Assessment: Passed

Self-tests: Completed OK
 Power Cycles: 3507
 Bad Sectors: 1 bad sector
 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

ID	Attribute	Assessment	Value
4	Start/Stop Count Number of spindle start/stop cycles	N/A	Value: 160 msec 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 yawn if the disk is failing

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Disk summary

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

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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

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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

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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

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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

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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


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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

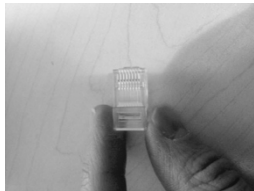
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Finished cable



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Ends



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Pinouts

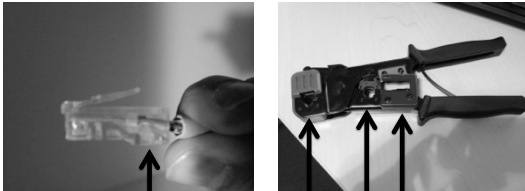
- More than one that work
 - What actually matters is where the pairs of wires go

Network Cable Straight

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

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Crimping tool



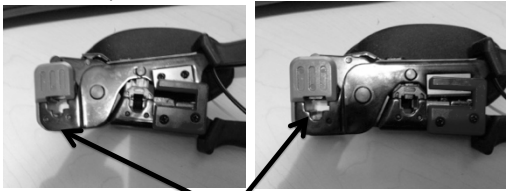
End has a spikey-thing that presses into the wires, holding end on and wires in place

RJ 45 (Cat 5) RJ 11 (phone) Wire cutter

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Crimping Tool

Open Closed



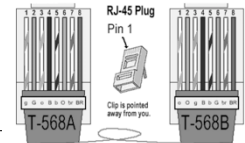
A little tab comes down when closed pushes the spikey thing down

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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


Network Cable Cross



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

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Testing a cable



- 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

From: <http://hiwtc.com>

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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

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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