

Lecture 3

”The PC Boot Process
and
Troubleshooting”

Administration of computer systems, 2009

Lecture goals

- Understand the PC boot process
 - Useful for debugging/troubleshooting
- Learn about basic PC configuration
 - BIOS
- You should be able to analyze and solve PC-related problems in a structured way
 - Methodology
 - Tools
- Preparation for exercise 2
 - Analyzing and repairing a malfunctioning PC

“Booting”

- From the word “bootstrapping” as in “Pull yourself up by your bootstraps”
 - Start from very basic state and end up with a fully running system



Power on

- Turning the system on
 - “On” switch
 - Wake-on-lan network card
 - Wake-on-power
- The PSU signals the chipset when it is ready to supply power to the motherboard and other devices. “Power Good”
- Chipsets resets CPU



Cold and warm boot

- If the PC has been powered off it performs a *cold boot* when you start it.
- If it is restarting a *warm boot* is performed
- Hard/soft reset
- POST is not run during a warm boot
- Typically power button is *soft*, i.e. it sends a message to the OS to power off, hold down for *hard* reset or pull power cable.
- What are the risks of using *hard* resets/poweroff?

CPU accesses BIOS memory

- The CPU starts by reading an instruction at a fixed location in the BIOS memory on the motherboard. “Jump address”
- The instruction tells the CPU where to continue reading BIOS code
- BIOS Shadowing ROM->RAM



Basic Input/Output System

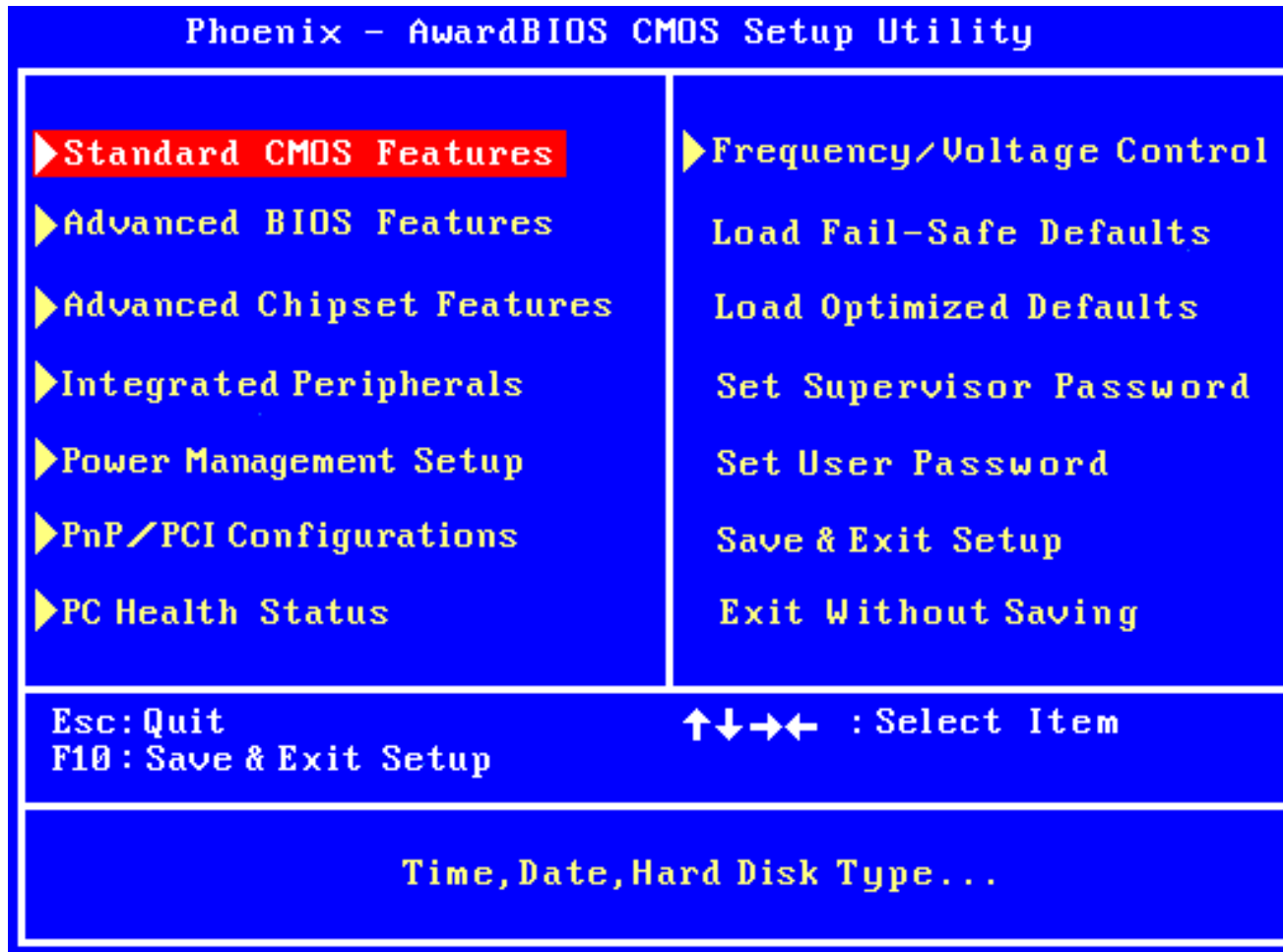
- Minimal software to initialize other components in the PC
- Performs the Power-On Self-Test (POST)
- Resides in separate flash memory on the motherboard
- Configuration changes in BIOS are stored in a non-volatile memory (historically CMOS)

BIOS memory history

- Initially stored in Read-only memory (ROM) or Programmable ROM (PROM)
 - Write once
- Improved using Erasable PROM (EPROM)
 - Expose to UV-light to erase contents
- Now usually Electrically Erasable PROM (EEPROM)
 - Use higher voltage to reprogram

BIOS Configuration

- Enter into BIOS setup during bootup (F2, F12 etc.)



BIOS upgrade

- Load a new version of the BIOS software into the flash (EEPROM) memory, “flashing”
- System vendors supply updates to fix bugs and add functionality
- Sensitive to errors, always verify the BIOS image before writing to flash

Power-On Self-Test

- Checks that the basic components are functioning correctly
 - Motherboard
 - Power supply
 - Memory
 - Video
 - Keyboard



POST “beep codes”

- Problems are indicated through the system speaker
- Consult BIOS/system manual for the meaning of the beep sequences
- Example, repeated long beeps indicate memory problems.

Device BIOS

- Attached devices may have their own BIOS chips
 - Video cards
 - RAID cards
 - Disk controllers
- Device BIOS may display their own info
 - Video card logo
 - RAID card setup menu

Non-POST tests

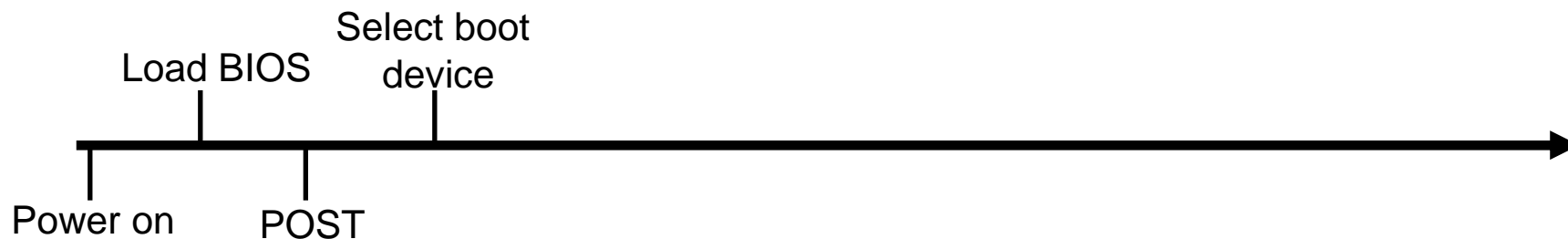
- Video is now available so any error messages go to the screen
 - Memory count-up test
 - Drive failures
- Tip: Use the “Pause” button on the keyboard to read messages

BIOS info screens

- BIOS manufacturer
- BIOS Version number
- Setup access keys (e.g. F2, F12, Del)
- Device information, CPU, HD, etc.

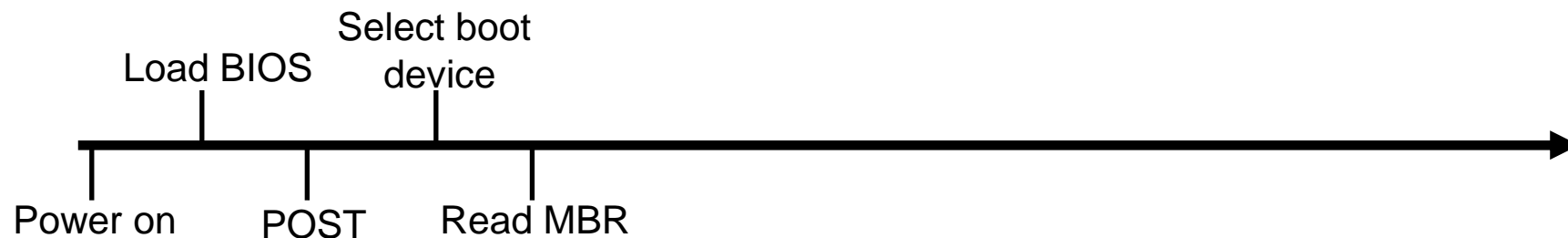
Boot device selection

- BIOS selects one of the attached devices as the boot device, for example:
 - Hard drive
 - CD-ROM
 - Floppy
 - USB



Boot record

- The BIOS searches for startup information in the boot sector of the device
- Master Boot Record (MBR) for devices with partitions
- Volume Boot Record for non-partitioned devices

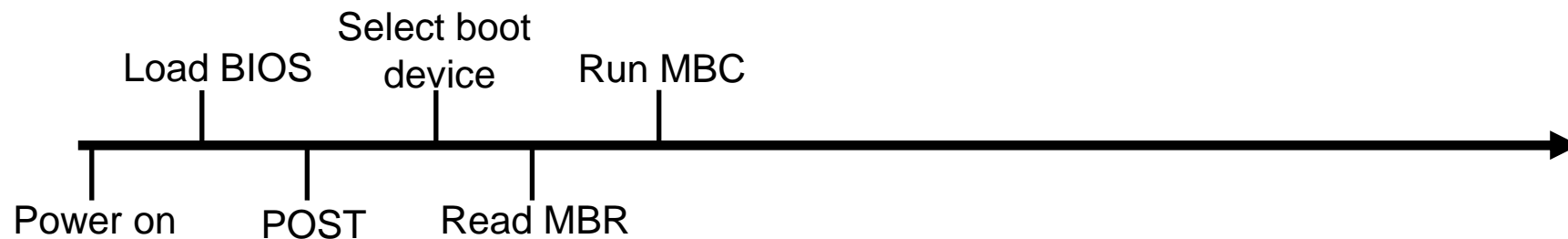


Master Boot Record

- Partition table
 - Allows four entries (*primary/physical* partitions)
 - One primary partition is marked as *active*
- Master Boot Code (MBC)
 - Looks for the active partition and loads the boot sector of that partition into memory
 - This code can be altered depending on what OS(s) are installed

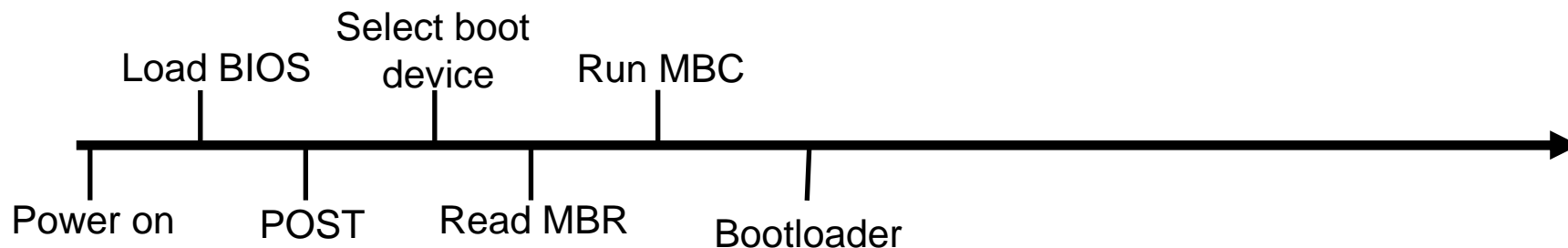
Master Boot Code (MBC)

- The MBC usually does one of two things
 1. Transfers control directly to an OS
 2. Transfers control to a *bootloader*



Bootloaders

- Program that allows the user to select which OS to boot, called from MBR
 - NTLDR (NT-Loader) comes with Windows
 - LILO, GRUB, LOADLIN from the Linux world
 - BootX from Apple



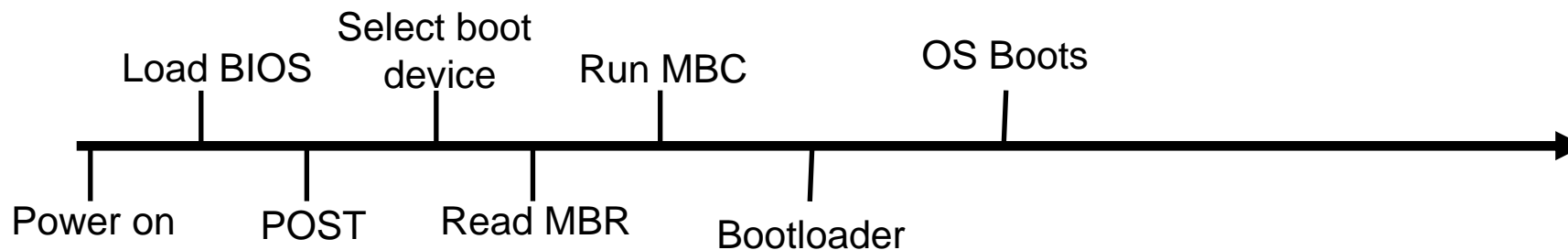
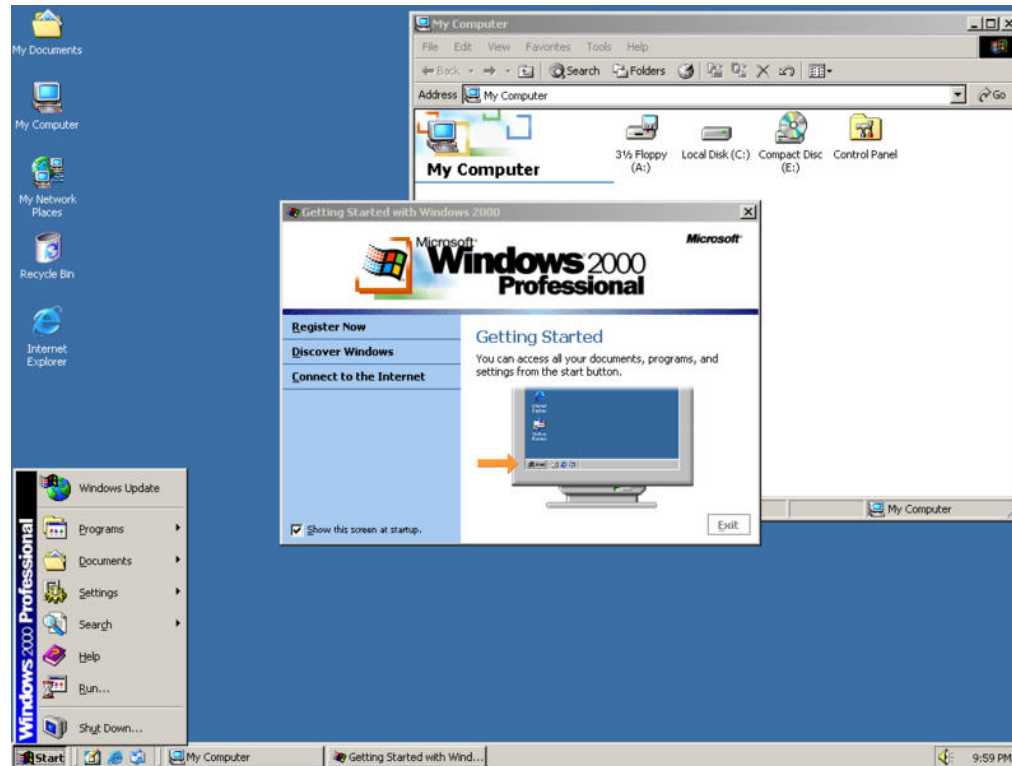
Bootloaders

```
Ubuntu 8.04, kernel 2.6.24-16-generic  
Ubuntu 8.04, kernel 2.6.24-16-generic (recovery mode)  
Ubuntu 8.04, memtest86+
```

Use the ↑ and ↓ keys to select which entry is highlighted.
Press enter to boot the selected OS, 'e' to edit the
commands before booting, or 'c' for a command-line.

GRUB bootloader, selection menu

Operating system boots



Common BIOS settings

Boot order

- Change the order of which devices BIOS tries to boot from, e.g.
 - 1) CD
 - 2) HD
 - 3) Floppy
 - 4) USB
- This boot order may be problematic if you want to boot from a floppy, why?

AC Power Recovery

- On – When power returns the PC starts
- Off – When power returns the PC does not start
- Last – When power returns the PC goes to the state it was in when before was lost
- What are sensible values to choose here?

Fan control

- Speed-controlled fans
 - Set desired temperature
 - Set temperature alarms/shutdown
- Check voltages
- Check fan speeds (RPM)

Clock speed settings

- Clock multiplier
 - Defines CPU speed as a multiple of Front Side Bus (FSB) speed. Changing multiplier affects only the CPU speed

Ex: 133Mhz FSB+10x multiplier = 1330Mhz CPU clock speed

- FSB speed
 - Changing FSB speed affects CPU speed as well (assuming same multiplier)

Troubleshooting

9/9

0800 Antcom started
 1000 " stopped - antcom ✓
 1300 (032) MP-MC $\left\{ \begin{array}{l} 1.2700 \quad 9.037847025 \\ 9.037846995 \text{ correct} \\ 4.615925059(-2) \end{array} \right.$
 (033) PRO 2 2.130476415
 correct 2.130676415

Relays 6-2 in 033 failed special speed test
 in relay " 11,000 test.

Relay 3145
 Relay 3370

1100 Started Cosine Tapc (Sine check)
 1525 Started Multy Adder Test.

1545



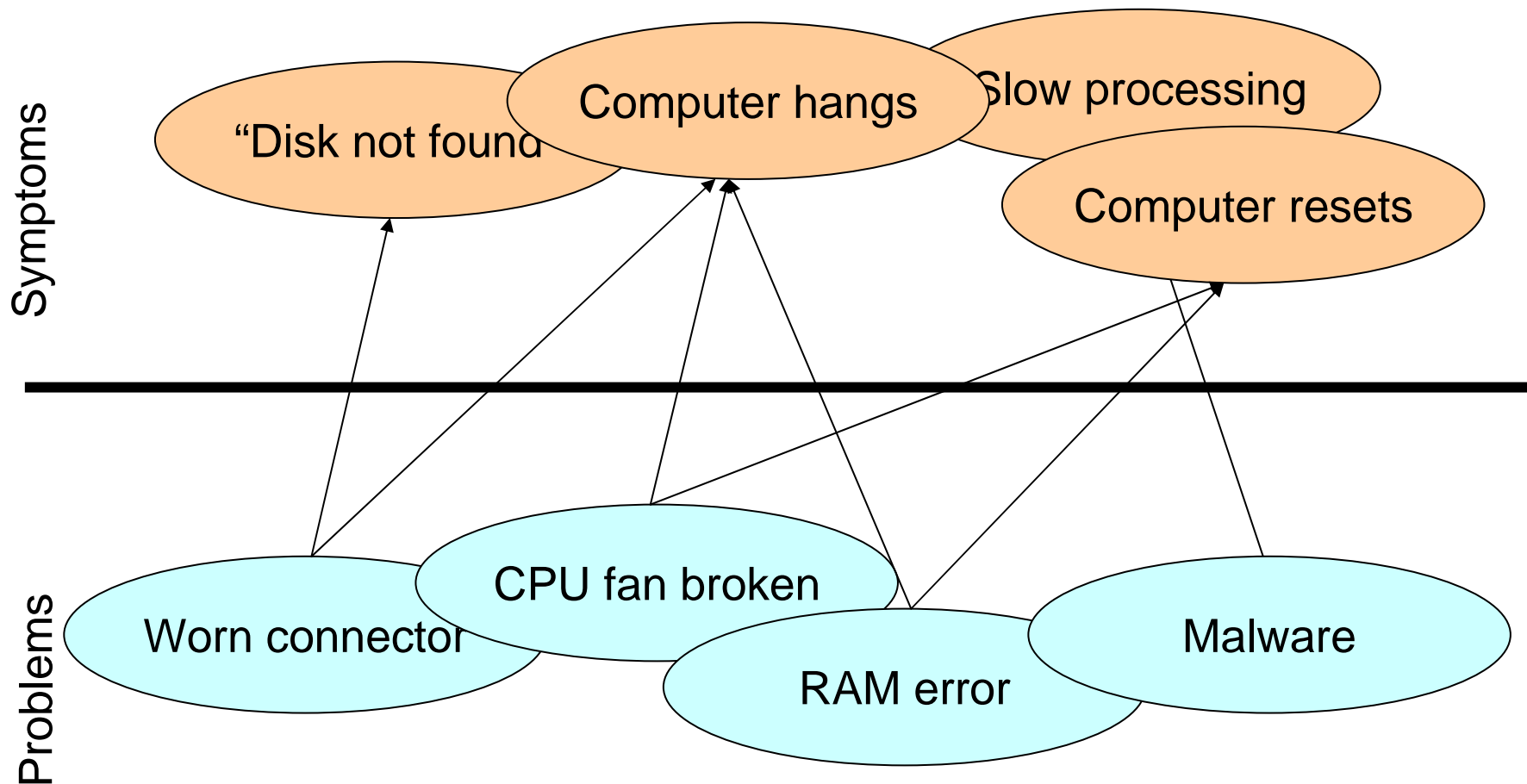
Relay #70 Panel F
 (moth) in relay.

First actual case of bug being found.
~~1630~~ Antcom started.
 1700 closed down.

Examples of problems

- Hardware
 - Malfunctioning memory modules
 - Worn connectors
 - Cooling/ventilation issues
- Software
 - Driver incompatibilities
 - Viruses/Malware
 - Construction problems, *bugs*

Problems have symptoms



Have a plan

- Keeps you from “panic mode”
- Rank problems by their likelihood
 - Avoid unnecessary work
 - Avoid fixes that cause more problems
 - Avoid cost of unnecessary fixes
 - Avoid only treating the symptom, “false fix”

General “soft” tips

- Have enough time
- If you get stuck, do something else for a while
- Get help from others
 - Online and in person

Lots of good advice from PC techs online, e.g.
pcguide.com

Troubleshooting elements

- Maintenance journal
- Diagnostic checklist and questions
- Identification of possible causes
- Identification of possible solutions
- Application and testing of solutions
- Follow-up/validation



Troubleshooting tools

- Hardware
 - “Known-good” replacement parts/identical systems
 - Voltmeter, mechanical tools
- Software
 - Bootable diagnostic software
- Documentation
 - System manuals
 - Diagnostic flowcharts
 - Journals
- Experience

Maintenance journal

- Keep a log for each machine
 - Hardware and software specification
 - Maintenance record
 - Rescue disks etc.
 - Warranty/manufacturer information

Component	Configuration	Date in service	Notes
CPU	Intel Celeron 1.6GHz	2008-01-01	Upgraded cooling 2008-02-02
RAM	256MB, 1 DIMM DRAM	2008-01-01	

Identify the problem

- User-description/Observation
 - What are the symptoms of the problem?
 - Error messages
 - Beep codes
 - Has it occurred before?
 - Have changes been made recently?
- Check the maintenance journal
- Retrieve system logs
- Try to reproduce the error

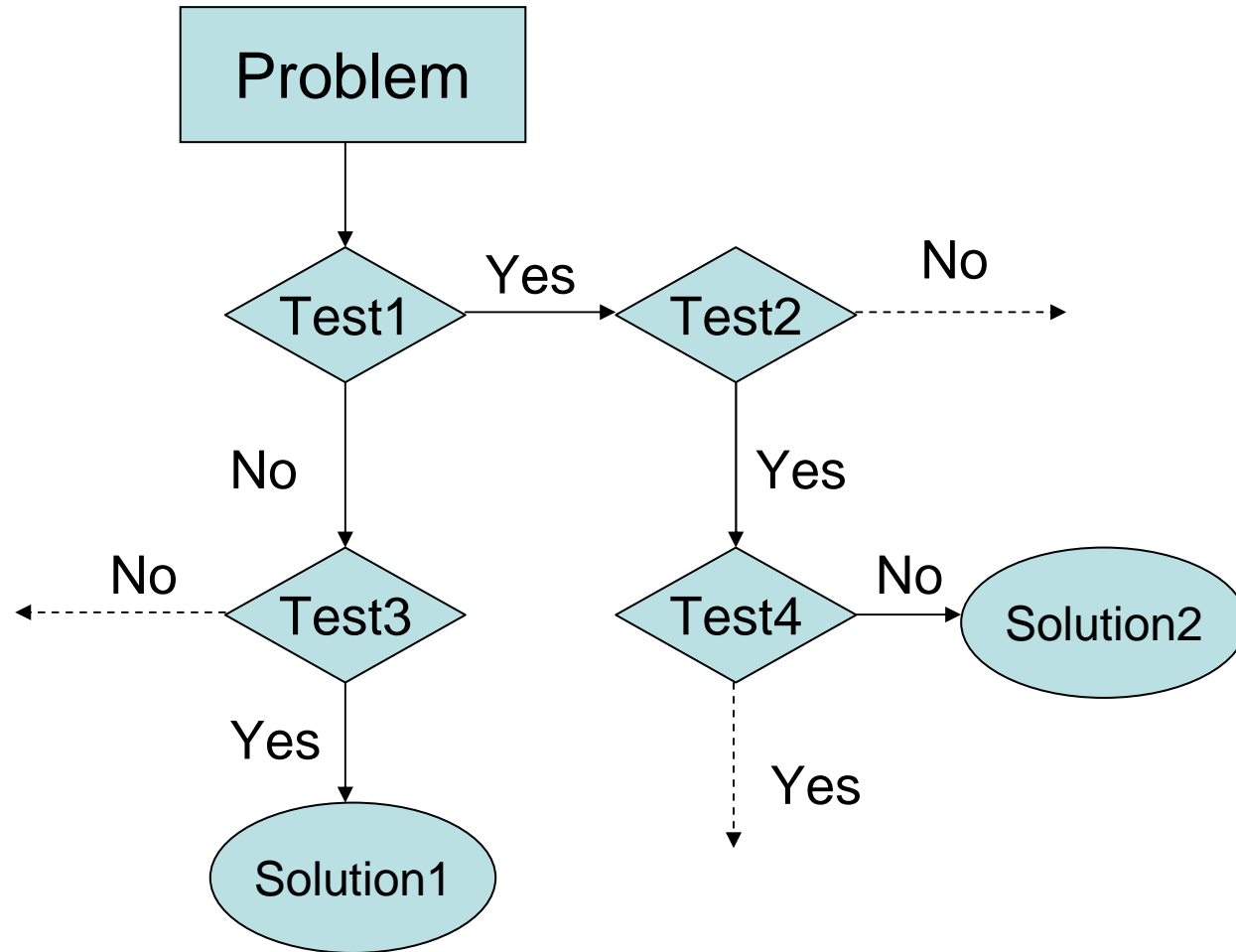
Identify possible causes

- Create a list of possible causes ordered by likelihood
- Create test cases for each possible cause
- Stepwise elimination
 - Only make one change per step
- “Known-good” method
 - Switch identical components
 - Minimal working configuration

Plan your work

- Rank causes
 - Likelihood
 - Ease of testing
- Create a diagnostic checklist or flowchart
- Gather more information
- Repeat as many times as necessary

Diagnostic flowchart



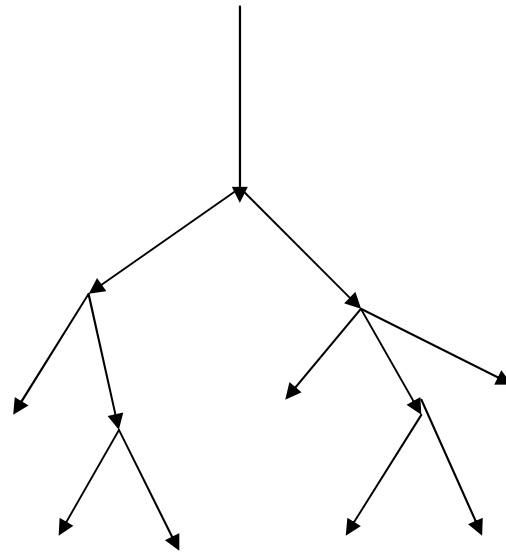
Example

- Bob is contacted by a user whose computer doesn't start. He troubleshoots and finds that the PSU is broken and replaces it. A week later the same problem occurs, and he applies the same fix. A week later...
- What would you do?

Root cause analysis (RCA)



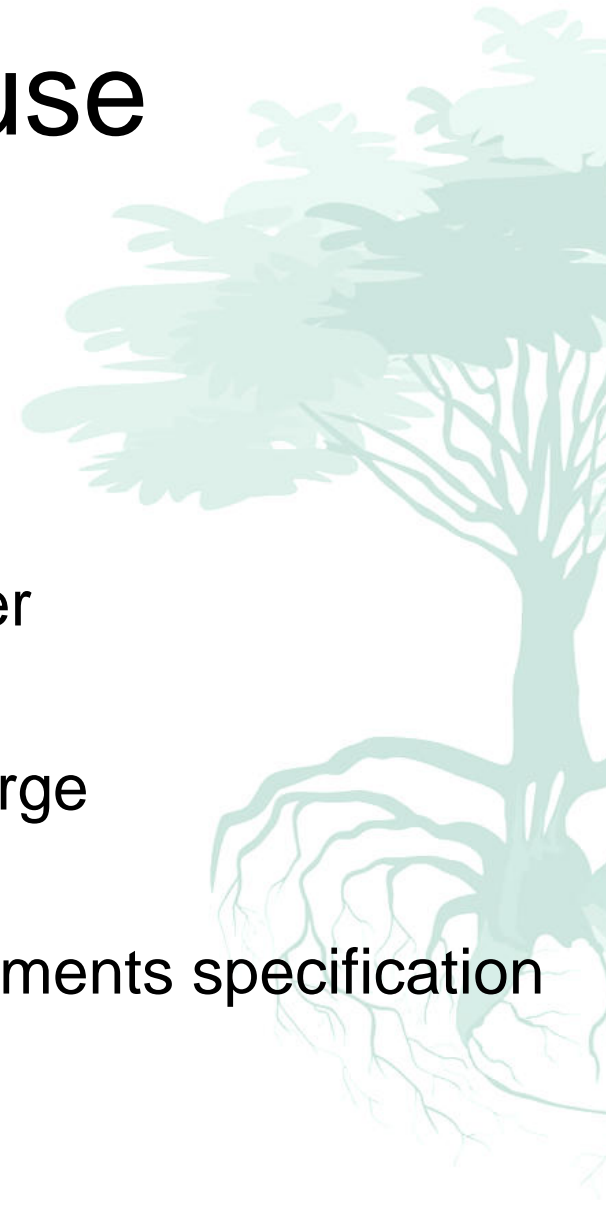
Root cause(s)



PSU Broken

Find the root cause

- “The five why’s”
- Example
 - The PC does not start
 - Why? The motherboard has no power
 - Why? The PSU is broken
 - Why? PSU damaged by electrical surge
 - Why? Insufficient surge protection
 - Why? Surge protection not in requirements specification
 - Why? ...

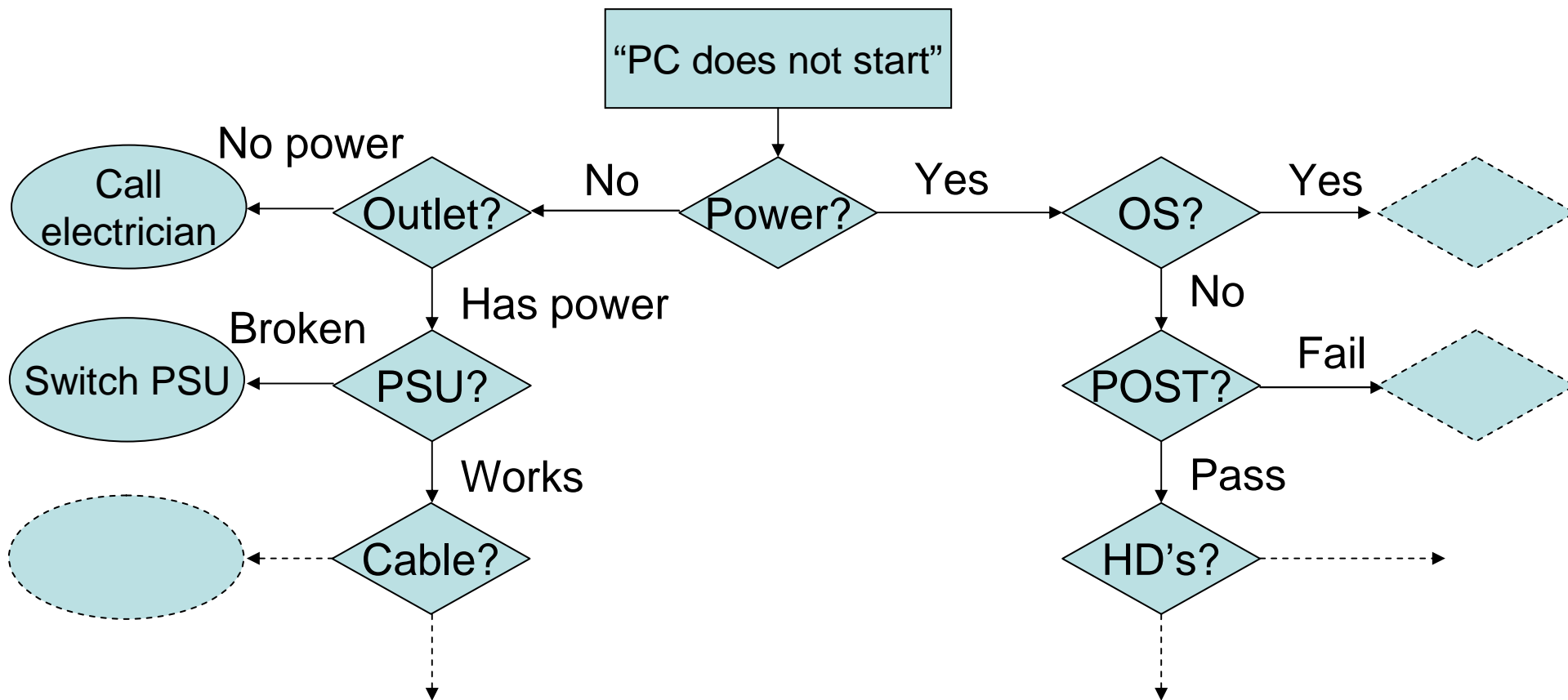


A troubleshooting example

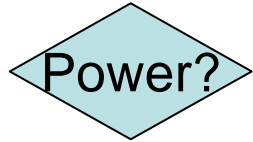
“I arrived this morning and my computer doesn’t work!”

- Identify the problem
 - “It worked yesterday”
 - “The lights flash and I can hear the hard drive”
 - “At first I see a lot of text that appears and disappears quickly”
 - “Then the screen is black except for a blinking underscore”

Identify possible causes and test cases



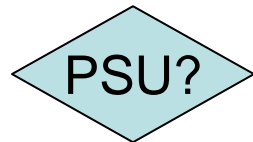
Test cases



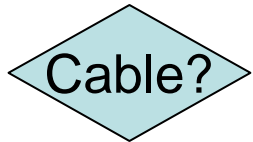
Does the computer power on? HD spins up, lights flash, etc.



Is there power in wall outlet? Test using voltmeter/desk lamp



Switch PSU from broken machine with known-good PSU



Use voltmeter to check continuity of power cable



Does operating system boot? OS logos, messages, etc.



Do any beep-codes occur?

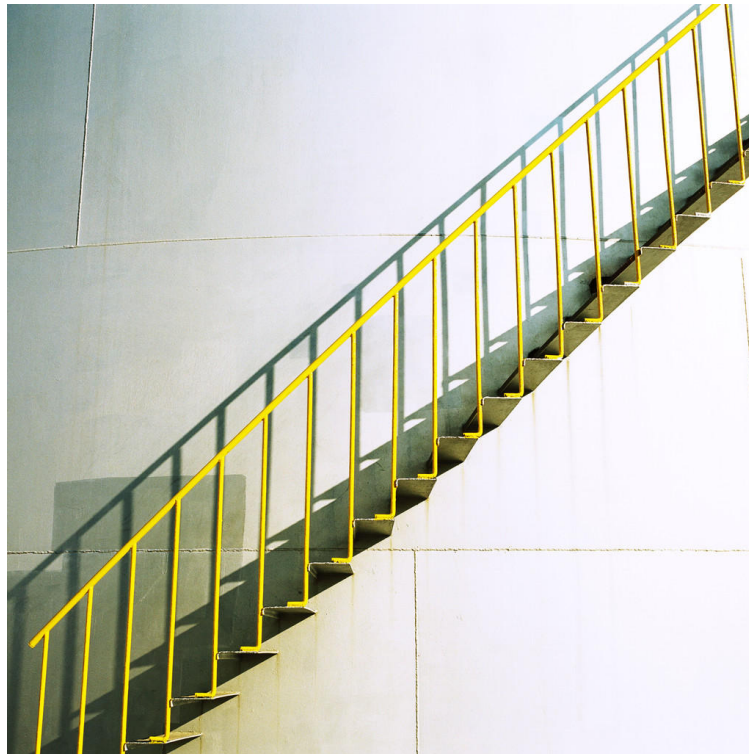


Jumpers, cables, switch with known-good HD's

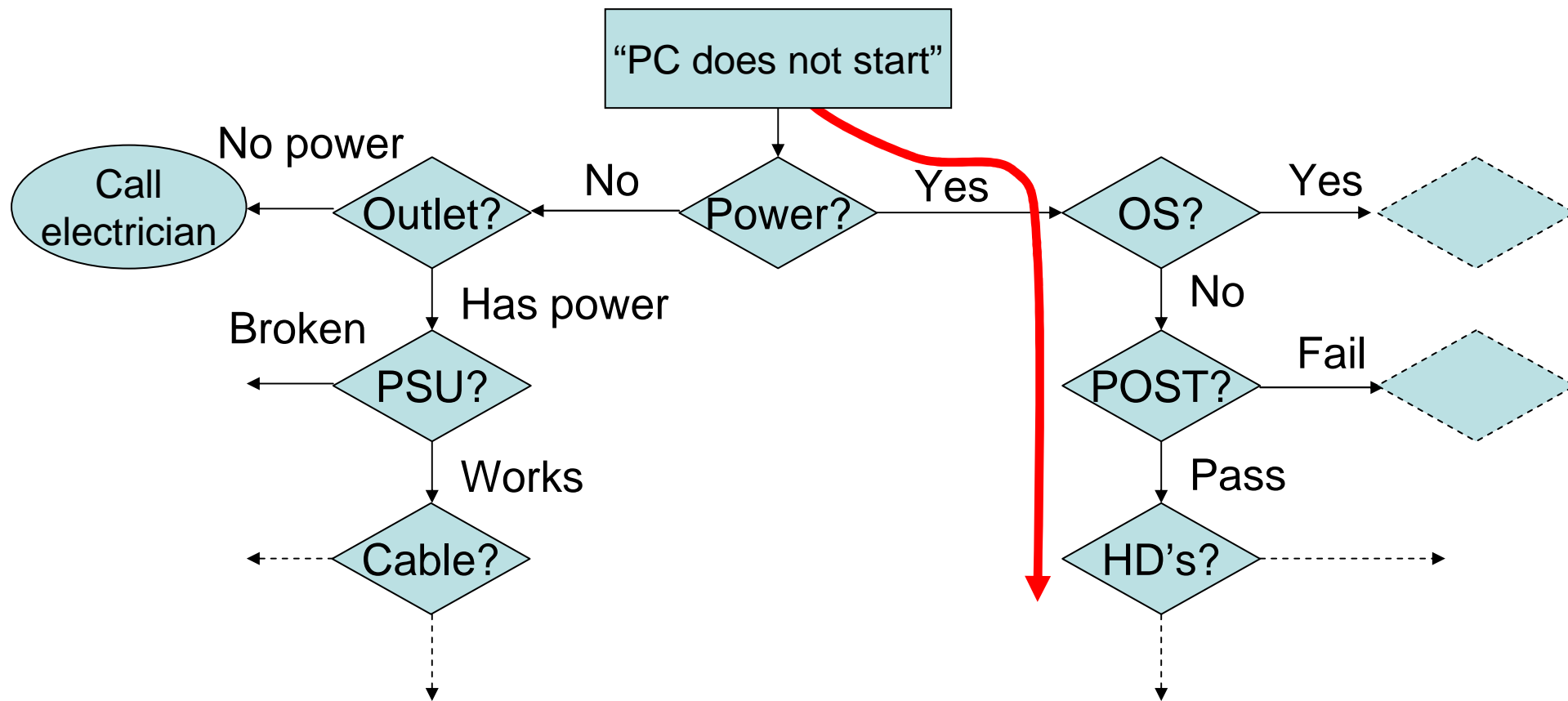
Stepwise elimination

One change per step

- Make sure you know what changes solved the problem or did not help



Perform stepwise elimination



Solution and verification

- Apply solution and record it in the maintenance log
- Verify that the solution solves the problem and that no new problems have been introduced.
- Comparing to previously made benchmarks is useful

Root cause analysis

- The computer was not booting the OS
- Why? The primary HD had wrong jumper settings
- Why? The service log says it was switched overnight but jumper settings were not changed from default.
- Why? Poor instructions to install personnel, no verification step after installing new HD. (Possible root cause)

Getting help

- Chances are that others have had the same problem
- Use detailed search terms
 - “boot” “blinking underscore” “windows 2000”
- Include detailed error messages
 - “Error performing inpage operation”

Getting help

- Manufacturer support
 - Helpline
 - Online, e.g. MS Knowledgebase, Dell tag
- User-based support
 - Forums
 - OS communities, e.g. Ubuntu Linux
- All are indexed by search engines

Ask correct questions

- Include as much information as possible about your system and problems symptoms
 - HW configuration
 - SW configuration
 - Steps to reproduce the error
 - Logs
 - Any troubleshooting steps you have taken
- First try to find the answer on your own
 - RTFM “Read The Fine Manual”

Examples of problems and symptoms

Power supply

- Under-dimensioned PSU
- Fan failures
 - Check for exhaust obstructions, e.g. dust
- Voltage selector set wrong (230V in EU)
- Grounding failure/short circuit
 - Blown fuses, ground-fault protector tripped
- Do not service, replace

Motherboard

- Loose connectors to PSU
- Cracked/broken connectors
 - Too much force used when inserting memory, expansion cards, CPU etc.
- Short-circuits
 - Metal objects, typically screws that fall onto the MB
- Bad jumper settings

RAM modules

- Module not correctly installed in socket
- Module incompatibilities
 - Different types/manufacturers
- RAM speed/bus frequency mismatch
- ESD damage
 - Often causes random bluescreens
 - Run e.g. memtest86

Hard drives

- Jumper settings wrong
 - Verify that drives are correctly identified in BIOS
- Listen for atypical HD noise
 - “Click of death”, try to salvage data as soon as possible
- Insufficient cooling
 - Drives get hot, make sure there is sufficient airflow

HMI devices

- Depleted batteries in wireless devices
 - Dust and dirt in mechanical mice
 - Too reflective surface for optical mouse
 - Cabling
-
- Easy to test with “known good” components

Networking

- Network Interface Card (NIC) drivers
- Static/dynamic IP assignment
 - Is the closest hub/switch reachable?
- Correct type of cabling, crossover/straight

Review

- From power on to OS load
 - POST
- Boot devices and boot records
- BIOS
 - Purpose
 - Common settings
- Troubleshooting framework
 - Analyzing
 - Planning
 - Solving
 - Recording
- Root cause analysis
- Common problems and symptoms

Visit the course page!

- Exercise 2 is on the web page
- Sign up for a session for exercise 2 through the signup system

<http://www.hh.se/te2003>