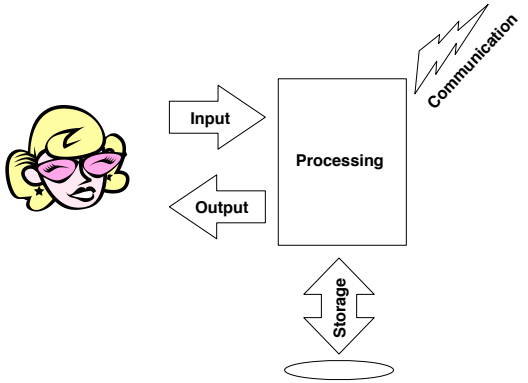
Hardware

Design of a Computer



Introduction to Hardware

Computer Hardware

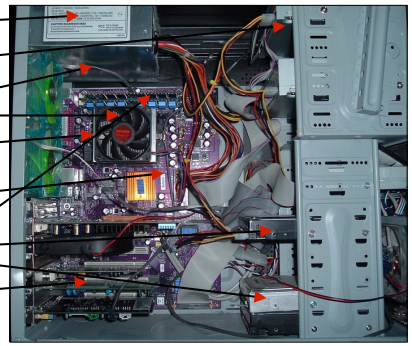
- "Those parts of the system that you can hit with a hammer (not advised) are called hardware"
- Modular

http://en.wikipedia.org/wiki/Computer_hardware

Inside the System Unit

Modular Components

- Power Supply
- Optical Drives
- Cooling Fans
- CPU
- Motherboard
- Hard Drives
- Expansion Cards
- RAM



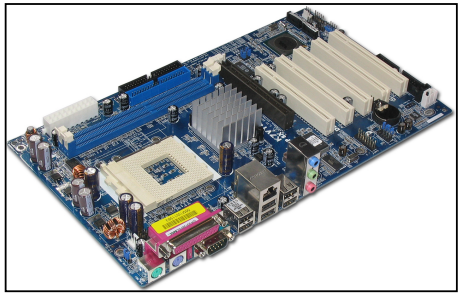
Power Supply

Converts AC to lower DC voltage

Motherboard

Main circuit board for the computer

- Everything else connects to the motherboard



Processor

CPU (Central Processing Unit)

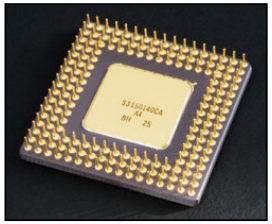
- "Brain"
- Follows instructions

Speed

- Computation speed often measured in operations per second (OPS)
- Clock speed (Hz) is the speed with which electrical signals pass through the CPU
- The faster the better, except ...

Cooling

- ... heat is one of the major limitations
- The faster the CPU the hotter it gets
- CPU must be kept cool
- Cooling fan, Heat sink, Water cooled



Clock Speed of a CPU

Speed	CPU
1 MHz	6502 (Apple II 1977)
4 MHz	8088 (IBM XT 1981)
16 MHz	80286 (IBM AT)
24 MHz	80386
66-100 MHz	80486 (1989)
75 - 166 MHz	Intel Pentium / AMD K5 (1993)
166 - 233 MHz	Intel Pentium MMX
200 - 450 MHz	Intel Pentium II / AMD K6
400MHz - 1 GHz	Intel Pentium III / AMD Athlon
1 – 3.4 GHz	Intel Pentium 4 / AMD Athlon XP (2000)
1.6 - 3.4 GHz	Intel Core i7 (2010)

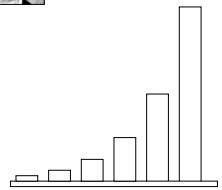
Things are more complicated now (the GHz hasn't changed in 10 years).

- Power efficiency and heat are just as important as processor speed.
  - Many netbooks or mobile devices have a 1GHz speed.
- CPUs have improved performance with lower clock speeds.
- Processors have several *cores* now. Commonly from 2 to 8.

Moore's Law

The number of transistors on a single chip doubles approximately every 2 years, while the price remains the same. (It turned out that performance doubled in closer to 18 months.)

Gordon E. Moore
(co-founder of Intel)



In 3 Years
- Potentially 4 times the work in the same time

In 15 years
- Potentially 1,000 times the work in the same time

In 30 years
- Potentially 1,000,000 times the work in the same time

http://en.wikipedia.org/wiki/Moore%27s_law

Wirth's Law

"Software gets slower faster than hardware gets faster."

http://en.wikipedia.org/wiki/Wirth%27s_law

Memory

Random Access Memory (RAM)

- Primary memory, main memory
- Data is lost when electricity switched off
- Size of the RAM is most important
- Speed also important (dependent on motherboard)
- To access memory can take anywhere from 1 to 20 nano seconds (billionth's of a second)

http://en.wikipedia.org/wiki/Random_access_memory

Memory Capacity

Measured in bytes

Plain Text (approx.)
- 1 byte — 1 character - using the old standard for encoding
- 1 KB — 200 words / 10 lines
- 1 MB — 300 pages
- 1 GB — 175 phone books

Music (approx.)
- 1 GB — 2 hours

DVD (approx.)
- 1 GB — 20 minutes

"640K ought to be enough for anybody."
Bill Gates in 1981

Expansion Cards

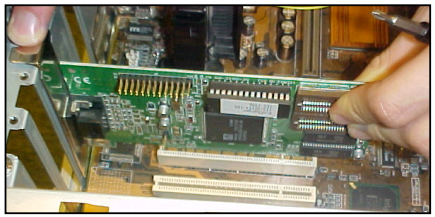
Circuit board that provides additional functionality

- Sound Card
- Graphics Card
- Network Card
- RAID controller

Depending on the Motherboard - these may be included on the board itself.

Plugs into the Motherboard using standard slots

- ISA
- PCI
- AGP
- PCI-Express



http://en.wikipedia.org/wiki/Expansion_card

Graphics Card

Converts the internal representation of an image into something that can be displayed using a computer monitor

- 2D Graphics Card
- 3D Graphics Card
  - NVidia
  - ATI now part of AMD

Secondary Storage

Mass Storage

- Long-term storage
- Persistent
- Much slower to access than RAM
- Much cheaper than RAM

Devices

- Hard Disk (HDD)
- Flash Memory
- Magnetic Tape

Optical Devices

- CD
- DVD
- Blu-ray Drive

http://en.wikipedia.org/wiki/Hard_disk

Shrinking

According to Wikipedia all of the data stored here, from 1959, in punch cards can fit in a 4GB USB stick.

http://en.wikipedia.org/wiki/USB_flash_drive

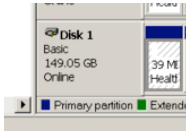
Size ambiguity

160 GB (decimal - last lecture)

OS reports GB with binary meaning.

To avoid ambiguity use GB for decimal and GiB for binary.

160 GB = 149.05 GiB



Optical Media

- CD-ROM: read-only, 700 MB, manufactured by a press
- CD-R: recordable once, 700 MB
- CD-RW: rewritable, 700 MB
- DVD-ROM: read only, 4.7 GB, manufactured by a press
- DVD-R: recordable once, 4.7 GB
- DVD+R: recordable once, 4.7 GB
- DVD-RW: rewritable, 4.7 GB
- DVD+RW: rewritable, 4.7 GB
- DVD-RAM: rewritable, 4.7 GB
- DVD-R DL: dual layer record once, 8.5 GB
- DVD+R DL: dual layer record once, 8.5 GB
- DVD-RW DL: dual layer rewritable, 8.5 GB
- DVD+RW DL: dual layer rewritable, 8.5 GB
- Blu-ray, 25 GB
- Blu-ray DL, 50 GB
- Blu-ray 16 layer, 400GB

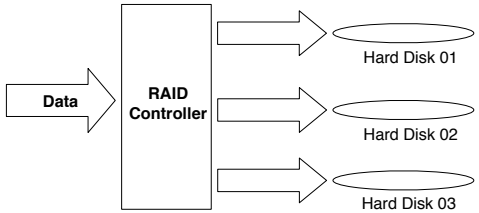
http://en.wikipedia.org/wiki/CD
http://en.wikipedia.org/wiki/DVD
http://en.wikipedia.org/wiki/Blu-ray_Disc

RAID

Bottleneck of performance on many systems is the secondary storage

Redundant Array of Independent Disks

- Read and write in parallel
- Write additional information to prevent lost data
- Fast, cheap and reliable



Solid State Drives

Another approach to speed up access to data on storage devices is to remove the moving parts.

- Solid State devices are purely electronic with no moving parts.
- They are still more expensive per GB stored than magnetic disk drives.
- USB sticks/Flash drives are small solid state drives.
- They interface to the computer in the same way as magnetic drives (but there are some differences in the way the operating system handles them).

http://en.wikipedia.org/wiki/Solid-state_drive

Input Devices

A machine that feeds data from a user into a computer

- Keyboard
  - Typewriter (QWERTY / DVORAK)
  - Keypad
- Pointing Device
  - Mouse, Trackball, Touch Screen (now multitouch)
  - Digitizing Tablet, Digital Pen
- Direct Entry
  - Scanner
  - Webcam, Microphone
  - Bar code reader

More Human Computer Interfaces

Voice recognition
- Automated Telephone Systems
- Voice tags for phone numbers, and other commands
- Siri

Biometric scanners (fingerprint, retina, iris, face, body)
- US border control
- Some laptops have them
- Biometric passports (contactless RFID)

Radio-frequency identification (RFID) tags
- Small chips that respond to a signal, and send back ID data
- Used in university swipe cards
- In the USA:
  - Scheme to voluntarily implant RFID with medical info
  - School uses RFID to track students' attendance
- Soon also in products, grocery shopping bags?
- Problem: we do not want everybody to read our RFID chips
- Suggested solution: RFID chips are shielded or destroyed after use

Output Devices

A machine that takes information processed by a computer and presents it in a form that a human can understand

Screen
- Cathode-Ray Tube (rare now)
- Flat-Panel display (LCD, Plasma)
- Projector
- Head-mounted

Printer
- Inkjet, Laser

Speakers

Touch based

"A printer consists of three main parts:
the case, the jammed paper tray and the blinking red light"

Connectors and Buses

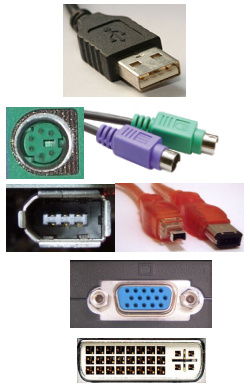
Universal Serial Bus (USB)
- Used for almost everything except monitors
  - Version 1 is slow (~1.5MB/s)
  - Version 2 is fast (~60 MB/s)
  - Version 3 is very fast (~570 MB/s)
- Many devices can be connected with hubs

PS/2 connector
- Used for mouse & keyboard

Firewire
- Used for video cameras, HDs
- High-speed (~60-100MB/s)

Video Graphics Array (VGA) connector
- Used only for monitors

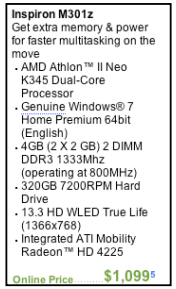
Digital Visual Interface (DVI)
- Used for LCD monitors or projectors
- Transmits video data digitally (better quality)



Understanding Advertisements

Specifications

- CPU type
- CPU number of cores
- Size of RAM
- Size of HDD
- Size/Type of Monitor
- Other drives (DVD, Blu-ray)



Buying a Computer

What do you want it for?

- Games - 3D Graphics Card, CPU, RAM
- Internet - Modem / Network Card
- Home / Office Applications

Desktop or Laptop

- Price
- Portability
- Ease of use

Laptop

- Battery capacity!!! How long can you use it without external power?
- Weight: how much do you want to carry around?
- Screen size: want to watch movies on your laptop?
- Internal speakers: usually very bad, sometimes surprisingly good

Some Advice

Spend a bit extra on the screen

- Interface between you and the machine
- Glare /non-glare

Buy more RAM

- More applications open at once
- Better performance
- 2GB - 8GB (I would start at 4GB if possible)

Hard Drive Capacity

- Depends on use
- Digital Photos
- Music Storage

Processor

- Almost anything will be adequate (except possibly on netbooks)