Computers

Hardware
Acknowledgments

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- Wikipedia
- Prof. Patrice Koehl
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- http://microsoft.toddverbeek.com
- http://www.webopedia.com
- http://www.engin.umd.umich.edu/
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Computer Layers

Hardware

BIOS

Operating System

Applications
Computer Layers

Hardware

BIOS

Operating System

Applications
Computers

- What different types of computers are there?
Computers

- Laptop, desktop, workstation,
- Tablet, chromebook, smartphones.
- Mainframe
- Supercomputer
- Server farm and data center (cloud computing)
Tech cycles

Next wave: wearable?
The world is evolving and fast.
Computers come in different shapes and sizes, from small laptops (notebooks), desktops to mainframe computers. They all share however the same internal architecture!
IBM Blue Gene Supercomputer
Data Center

https://www.youtube.com/watch?v=avP5d16wEp0
Computer: basic scheme

Input devices
- input (keyboard)
- CD-ROM

CPU

Output devices
- output (monitor)

Storage
- hard drive
- floppy drive
The motherboard: 
backbone of the computer

Power supply connector

Slot for memory: 
RAM

Slot for CPU

Input/Output: 
Keyboard, Mouse, ...

Extension cards: 
Video, sound, internet...
Hardware communication: buses

The memory bus:

- a 16 bit bus
- Communication between the CPU and the RAM is defined by:
  - the CPU speed
  - The RAM speed
  - The number of bits transferred per cycle

Other buses:

- USB, Firewire, PCI Express,…
The Central Process Unit (CPU):
The “brain” of the computer

CPUs are getting smaller, and can include more than one “core” (or processors).

CPUs get hot, as their internal components dissipate heat: it is important to add a heat sink and fans to keep them cool.
CPU

- Transistors

- The integrated circuit (IC) allowed a large number of transistors to be manufactured on a single semiconductor-based die, or "chip."

- VLSI (very large scale IC)

- Also known as microprocessor, microcontroller, etc.

- It starts from the beach....
800x magnification of an early chip
Moore’s Law

The empirical observation that the transistor density of integrated circuits, with respect to minimum component cost, doubles every 24 months.

- attributed to Gordon E. Moore, a co-founder of Intel.

- Doubling is very powerful.
## A few numbers

<table>
<thead>
<tr>
<th>Name</th>
<th>Date</th>
<th>Transistors</th>
<th>Microns</th>
<th>Clock speed</th>
<th>Data width</th>
<th>MIPS</th>
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</thead>
<tbody>
<tr>
<td>8080</td>
<td>1974</td>
<td>6,000</td>
<td>6</td>
<td>2 MHz</td>
<td>8 bits</td>
<td>0.64</td>
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<tr>
<td>8088</td>
<td>1979</td>
<td>29,000</td>
<td>3</td>
<td>5 MHz</td>
<td>16 bits</td>
<td>0.33</td>
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<tr>
<td>80286</td>
<td>1982</td>
<td>134,000</td>
<td>1.5</td>
<td>6 MHz</td>
<td>16 bits</td>
<td>1</td>
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<tr>
<td>80386</td>
<td>1985</td>
<td>275,000</td>
<td>1.5</td>
<td>16 MHz</td>
<td>32 bits</td>
<td>5</td>
</tr>
<tr>
<td>80486</td>
<td>1989</td>
<td>1,200,000</td>
<td>1</td>
<td>25 MHz</td>
<td>32 bits</td>
<td>20</td>
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<tr>
<td>Pentium</td>
<td>1993</td>
<td>3,100,000</td>
<td>0.8</td>
<td>60 MHz</td>
<td>32 bits 64-bit bus</td>
<td>100</td>
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<tr>
<td>Pentium II</td>
<td>1997</td>
<td>7,500,000</td>
<td>0.35</td>
<td>233 MHz</td>
<td>32 bits 64-bit bus</td>
<td>~300</td>
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<tr>
<td>Pentium III</td>
<td>1999</td>
<td>9,500,000</td>
<td>0.25</td>
<td>450 MHz</td>
<td>32 bits 64-bit bus</td>
<td>~510</td>
</tr>
<tr>
<td>Pentium 4</td>
<td>2000</td>
<td>42,000,000</td>
<td>0.18</td>
<td>1.5 GHz</td>
<td>32 bits 64-bit bus</td>
<td>~1,700</td>
</tr>
<tr>
<td>Pentium 4 &quot;Prescott&quot;</td>
<td>2004</td>
<td>125,000,000</td>
<td>0.09</td>
<td>3.6 GHz</td>
<td>32 bits 64-bit bus</td>
<td>~7,000</td>
</tr>
</tbody>
</table>
CPU speed

- 1 hertz = 1 "cycle" per second
- A typical watch operates at 1 Hertz (one "clock tick" per second)
- Intel Pentium D: 3.20 GigaHertz (GHZ)
- 3.2 billion cycles per second
CPU

- ALU (Arithmetic logic unit)
- Control Unit
- Register
- Cache

- Connected to memory
- Instructions are stored in machine language as binary number.
The Fetch/Execute Cycle

A machine cycles through a series of operations, performing an instruction on each round

- Fetch/execute cycle is a five-step cycle:
  1. Instruction Fetch (IF)
  2. Instruction Decode (ID)
  3. Data Fetch (DF)
  4. Instruction Execution (EX)
  5. Result Return (RR)

Acknowledgement: Lawrence Snyder, “fluency with information technology”, for following slides
Control Unit

- Hardware implementation of the Fetch/Execute Cycle
- Its circuitry fetches an instruction from memory and performs other operations of the cycle on it
  - A typical instruction might have the form ADD 2000, 2080, 4000
  - This instruction asks that the numbers stored in locations 2000 and 2080 be added together, and the result stored in location 4000
  - Data Fetch step must get these two values and after they are added, Result Return step will store the answer in location 4000
Instruction Interpretation

- Process of executing a program
  - Computer is interpreting our commands, but in its own language

- Before the F/E Cycle begins, some of the memory locations and the PC are visible in the control unit
Instruction Interpretation (cont'd)

- Execution begins by moving instruction at the address given by the PC from memory to control unit.

*Figure 9.6. Instruction Fetch: Move instruction from memory to the control unit.*
Instruction Interpretation (cont'd)

- Bits of instruction are placed into the decoder circuit of the CU
- Once instruction is fetched, the PC can be readyed for fetching the next instruction
Figure 9.6. Instruction Fetch: Move instruction from memory to the control unit.
Instruction Interpretation (cont'd)

- In Instruction Decode step, ALU is set up for the operation.
- Decoder will find the memory address of the instruction's data (source operands):
  - Most instructions operate on two data values stored in memory (like ADD), so most instructions have addresses for two source operands.
  - These addresses are passed to the circuit that fetches them from memory during the next step, Data Fetch.
- Decoder finds destination address for the Result Return step, and places it in RR circuit.
- Decoder determines what operation the ALU will perform, and sets it up appropriately.
**Figure 9.7.** Instruction Decode: Pull apart the instruction, set up the operation in the ALU, and compute the source and destination operand addresses.

**Figure 9.8.** Data Fetch: Move the operands from memory to the ALU.
Instruction Execution

Instruction Execution: The actual computation is performed. For ADD instruction, the addition circuit adds the two source operands together to produce their sum.
Figure 9.9. Instruction Execute: Compute the result of the operation in the ALU.
Instruction

- **Result Return**: result of execution is returned to the memory location specified by the destination address.

- Once the result is returned, the cycle begins again.
Figure 9.10. Result Return: Store the result from the ALU into the memory at the destination address.
Many, Many Simple Operations

- Computers can only perform about 100 different instructions
  - About 20 different kinds of operations (different instructions are needed for adding bytes, words, decimal numbers, etc.)

- Everything computers do must be reduced to some combination of these primitive, hardwired instructions
Examples of Other Instructions

Besides ADD, MULT (multiply) and DIV (divide), other instructions include:

- Shift the bits of a word to the left or right, filling the emptied places with zeros and throwing away bits that fall off the end
- Compute logical AND (test if pairs of bits are both true, and logical OR, which tests if at least one of two bits is true
- Test if a bit is zero or non-zero, and jump to new set of instructions based on outcome
- Move data around in memory
- Sense signals from input/output devices
Cycling the F/E Cycle

- Computers get their impressive capabilities by executing many of these simple instructions per second

- The Computer Clock: Determines rate of F/E Cycle
  - Measured in megahertz, or millions of cycles per second
CPU: Instruction Execution Engines

- What computers can do
  - Deterministically perform or execute instructions to process information
  - The computer must have instructions to follow

- What computers can't do
  - Have no imagination or creativity
  - Have no intuition
  - Have no sense of irony, subtlety, proportion, decorum, or humor
  - Are not vindictive or cruel
  - Are not purposeful
  - Have no free will
  - Do not get mad even if one asks the same thing over and over,

Acknowledgement: Lawrence Snyder, “fluency with information technology”
How Important is Clock Speed?

- Modern computers try to start an instruction on each clock tick
- Pass off finishing instruction to other circuitry
  - Five instructions can be in process at the same time
- Does a 1 GHz clock really execute a billion instructions per second?
  - Not a precise measurement. Computer may not be able to start an instruction on each tick, but may sometimes be able to start more than one instruction at a time
Multi-core

- The use of multiple CPUs in the same computer
  - Dual-core, Quad-core, multi-core

- Benefits:

- Challenges:
Memory & Storage
Memory and Storage
Memory

- Hierarchical structure

- CPU <-> Cache <-> Ram <-> virtual memory/hard-disk
RAM

- RAM: Random access memory (RAM) is the best known form of computer memory. RAM is considered "random access" because you can access any memory cell directly if you know the row and column that intersect at that cell.
- Capacitors
- Word: cells of memory (one byte or multiple bytes)
- Address (grid structure)
Types

- SRAM: Static random access memory
- DRAM: Dynamic random access memory
Storage

Hard drive

Floppy disk

USB key

CD or DVD

Tape
Hard Drive (Magnetic disk)

- Capacity
- Speed, RPM (revolutions per minute)
- Format a disk
- Defragmentation
- Disk partition

- Hard disk failure?
RAID

- Redundant Array of Inexpensive (Independent) Disks
- A technology that simultaneous uses two or hard disks for better performance, reliability, and/or volume
- Seen as one disk
- Popular options:
  - RAID 0, RAID 1, RAID 5
Acknowledgement: pictures taken from wikipedia
RAID5

Acknowledgement: picture taken from wikepedia
Solid State Drive

- Data storage device

Pros:
- No moving part
- Faster access time

Cons:
- Currently more expensive
Optical disks

- CD-ROM (Compact disc)
- CD-W
- CD-RW
- DVD (digital video/versatile disk)
  - Double layer, double sided
- DVD-RW
- BluRay and HD-DVD
Q: is permanent storage “permanent”? 
Other Components
Source: Morgan Stanley
Communicating with a computer

Screen

Keyboard

Mouse
Input Devices

- Keyboard
- Mouse
- Scanner
- Camera
- Gamepad
- Haptic device
- Gesture
Keyboard

- Press a key
- Detect
- Interrupt
- Read
Optical Mouse

- LED lights up
- Camera
- DSP
- Pass the information
- Position mouse on the screen
Touch Screen

http://electronics.howstuffworks.com/iphone1.htm
http://electronics.howstuffworks.com/iphone3.htm
Output components

- Monitor
- Printer
  - Dot-matrix
  - Ink-jet
  - Laser
  - Dye sublimation
- Speaker
- Haptic device
Interfaces

- USB (Universal Serial Bus)
  - USB 1.0 (12Mbps), 2.0 (480Mbps), 3.0 (4.8Gb/s)
  - Good interface, hot-swapping
- Firewire (IEEE 1394)
- SCSI (small computer system interface)
- IDE (Integrated Device Electronics) and EIDE (Enhanced IDE)
## USB 1.x/2.0 standard pinning

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Cable color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VBUS</td>
<td>Red</td>
<td>+5 V</td>
</tr>
<tr>
<td>2</td>
<td>D−</td>
<td>White</td>
<td>Data −</td>
</tr>
<tr>
<td>3</td>
<td>D+</td>
<td>Green</td>
<td>Data +</td>
</tr>
<tr>
<td>4</td>
<td>GND</td>
<td>Black</td>
<td>Ground</td>
</tr>
</tbody>
</table>

[Image of USB connector types]
USB 3.0

Standard-A USB 3.0

USB 3.0 Standard-B

USB 3.0 Micro-B plug
Computer Layers

Hardware

BIOS

Operating System

Applications
BIOS refers to the firmware code usually stored on a flash memory chip on the motherboard that is run by a computer when first powered on.

The chip holds a few small programs and some settings.

**BIOS performs two major tasks:**

- The **Power On Self Tests (POST)** are conducted. These tests verify that the hardware system is operating correctly.

- The BIOS initiate the **boot process**. The BIOS looks for boot information that is contained in file called the master boot record (MBR) at the first sector on the disk (boot sector). Once an acceptable boot record is found the **operating system** is loaded which takes over control of the computer.
UEFI

- UEFI (unified extensible firmware interface): defines a software interface between an operating system and platform firmware. Meant to replace BIOS. Currently co-exist.

- Advantages:
  - 32-bit, 64-bit processor mode
  - Boot from a large disk
  - Flexible pre-OS environment, including network capability
  - Secure booting

Picking the right hardware

- Desktop, laptop, phone, tablet
- What do you need it for?
- Your budget (shall one go for the newest model?)
- Your style
- Life expectancy

- If a device breaks, what should you do?
- Data?
A few practical tips

- The computer fails the POST tests
- Likely cause: One of the essential devices is either failing or is missing
- Try:
  - Check for any loose connections (keyboard, mouse,
  - Check that the fans are working
  - Swap memory
The computer is thrashing.

The computer all used all its RAM resources and starts using the hard drive as alternative memory, slowing down significantly.

Try:

- Close all applications you are not using anymore …
- Get more memory for the computer
The computer becomes very hot.

Most probably one of the fans is not working anymore.

Detect fans that are not working and replace them.
The computer “freezes” (i.e. becomes non-responsive)

There are many possible reasons:

- it looks as if it is frozen The computer may be thrashing …
- one application has crashed …
- the Window manager is down …

Unfortunately, often the only solution is to restart the computer (either by turning it off first or in the worst case by unplugging it, or by pressing continuously on the on/off button.)
Devices not working together

- Ex: laptop and projector
- Ex: computer and printer
Blue Screen

- Last known good configuration.
- Enough free space
- Viruses
- Service packs and updates
- Update drivers
- Etc.

Windows 8 blue screen

http://pcsupport.about.com/od/fixtheproblem/ht/stoperrors.htm
Again

- Your best friend is ...

- Be aware of con artists