Informatics 1.
Lecture 1: Hardware

using Ferenc Wettl's
and Kristóf Kovács's material

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2019-09-09

Curriculum

1. **Hardware**
2. Operating system, programs, file structure
3. Representing data in a computer
4. Internet, network

5. HTML, CSS
6. TEX, LATEX
7. Making presentations, beamer
8. Graphics, TikZ

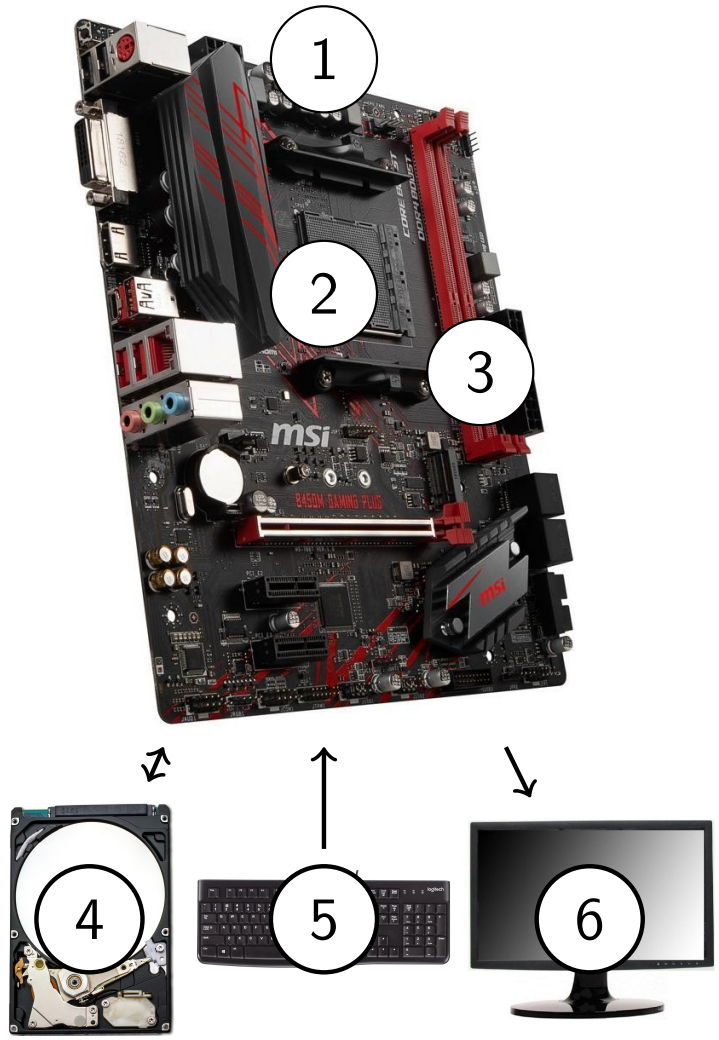
9. Numerical mathematics and computer algebra systems
10. Variable, if branching, function call, recursion
11. Octave
12. Sage

Basic concepts

- Hardware
  - Any physical components in a computer
  - A computer can execute programs written in a binary language.
- Software
  - Programs written in a language understood by the computer
  - Data required for the execution of the programs

Hardware

- Main components of a computer:
  1. Motherboard
  2. Processor: Central Processing Unit (CPU)
  3. Memory: Random-Access Memory (RAM)
  4. Mass storage (HDD, SSD)
  5. Input
  6. Output
- Main types of computers:
  - Server,
  - Personal computer (PC),
  - Laptop, Notebook,
  - Tablet,
  - Smart phone, etc.



Processor

- Function
  - Executes basic operations (addition, subtraction, storage, etc.)
  - During the execution of a program the CPU (Central Processing Unit) executes these bacis operations in the order given by the program with the values given by the program
- Interesting facts
  - Building a CPU factory is one of the most expensive things in the world
  - More and more features are crammed into a CPU, for example modern processors have integrated graphics processors (APU)

Processor specifics

- Clock speed
  - Number of (basic) operations per second
  - Example: 4GHz
- Number of cores (parallel computations)
  - Modern CPUs have multiple cores
  - A well written program can make use of more than just one core
  - Intel has a technology called virtual core: the CPUs that feature this technology (example: i3, i7) double their number of parallel operations by making use of a virtual core inside every core
- Heat generation
  - The main thing holding back the smartphone CPUs is their heat generation
  - Bigger computers can have better cooling, hence stronger CPUs

Operation costs

Lets say that addition has a computation cost of 1. Then the cost of other operations is shown in the table (these are just estimates).

	operation	cost
cheap	integer addition, subtraction, multiplication	1-5
medium	integer division, modulo (except with power of 2)	~10
expensive	division, sqrt, sin, cos, tan, asin, acos, atan	~100

- FLOPS
  - **fl**oating-point **o**perations **p**er **s**econd
  - real arithmetic operations per second
  - Theoretically

$$\text{number of cores} \times \text{clock speed} \times \frac{\text{FLO}}{\text{cycle}}$$

  - Desktop CPUs: 10-100 Giga FLOPS

Memory (RAM)

- Function
  - Temporary data storage
  - The processor reads data and programs from the memory
  - random access, as opposed to sequential
- Interesting facts
  - A computer with 2 sticks of 2GB of RAM is faster than the one with 1 stick of 4GB of RAM.
  - It is a misbelief that the speed of a computer is proportional to the size of its memory.

DDR

DDR2

DDR3

DDR4

SO-DIMM

Units of measurement

SI prefix		Old usage	Binary prefix	
Notation	Value	Value	Notation	Value
kB KB (kilobyte)	$1000^1 = 10^3$	$1024^1 = 2^{10}$	KiB (kibibyte)	2^{10}
MB (megabyte)	$1000^2 = 10^6$	$1024^2 = 2^{20}$	MiB (mebibyte)	2^{20}
GB (gigabyte)	$1000^3 = 10^9$	$1024^3 = 2^{30}$	GiB (gibibyte)	2^{30}
TB (terabyte)	$1000^4 = 10^{12}$	$1024^4 = 2^{40}$	TiB (tebibyte)	2^{40}
PB (petabyte)	$1000^5 = 10^{15}$	$1024^5 = 2^{50}$	PiB (pebibyte)	2^{50}
EB (exabyte)	$1000^6 = 10^{18}$	$1024^6 = 2^{60}$	EiB (exbibyte)	2^{60}
ZB (zettabyte)	$1000^7 = 10^{21}$	$1024^7 = 2^{70}$	ZiB (zebibyte)	2^{70}
YB (yottabyte)	$1000^8 = 10^{24}$	$1024^8 = 2^{80}$	YiB (yobibyte)	2^{80}

$2^{10} = 1024$

$2^{20} = 1048576$

$2^{30} = 1073741824$

$2^{40} = 1099511627776$

$2^{50} = 1125899906842624$

$2^{60} = 1152921504606846976$

$2^{70} = 1180591620717411303424$

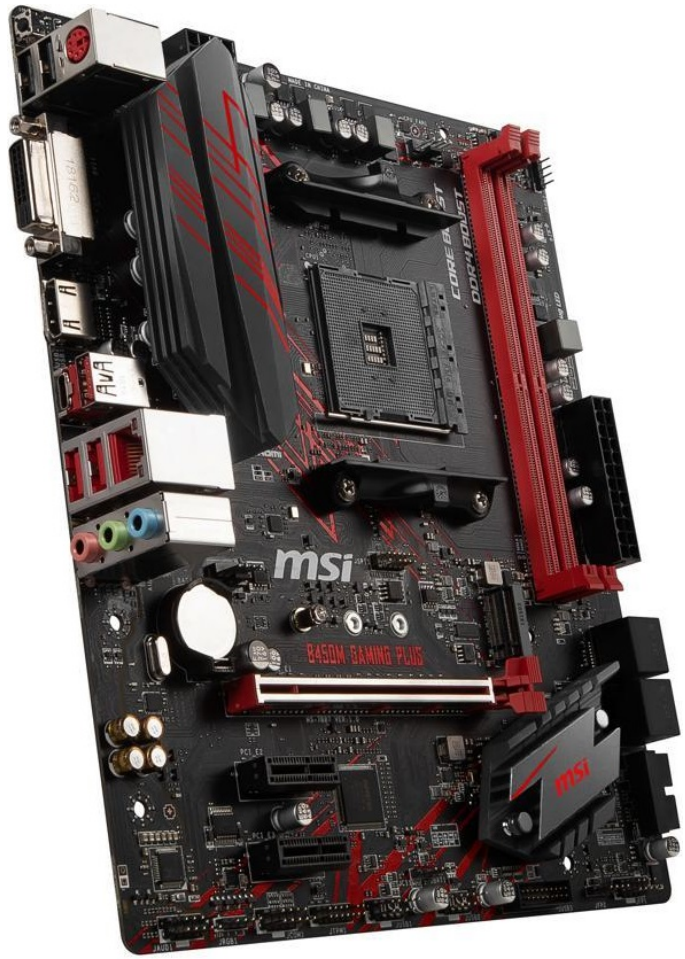
$2^{80} = 1208925819614629174706176$

Memory specifics

- Clock speed
  - The performance of the memory is mainly influenced by the speed of reading and writing data from and to the memory.
  - The clock speed represents this read/write speed
- Capacity (storage space)
  - The amount of data the memory can store
  - Most operating systems use *virtual memory*, this feature uses a part of the mass storage as memory in case the real memory fills up. This is significantly slower, even for an SSD.
  - When the memory fills up the operating system tries to swap the least frequently used parts of the memory to the *virtual memory* (swap).
  - This is the reason why a computer with a really strong CPU can still slow down if it runs out of memory.
- Type (socket)
  - Motherboards have a specific RAM socket, not all types of memories can be placed into a specific motherboard.

Motherboard

- Function
  - Acts as a link between the other components
  - May contain an integrated graphics, network and/or sound card
- Specifics
  - Processor socket
  - Memory socket
  - Mass storage plug type
  - Number of other plugs (like USB)
- Interesting facts
  - In theory, it is possible that a low quality motherboard slows down a computer, if the data transfer rate between the components is slow.

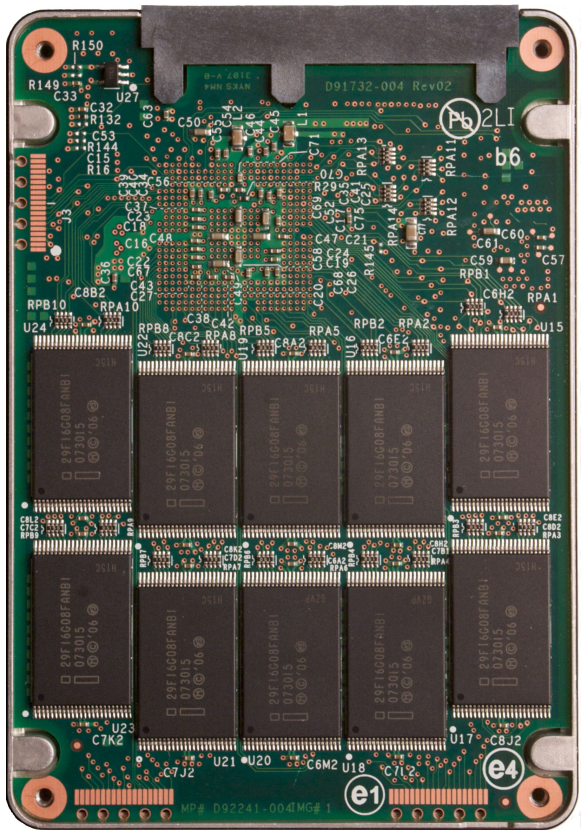


Mass storage

- Function
  - Long term data storage (files)
- Specifics
  - Storage size
  - Type (SSD, HDD)
  - Speed of read/write
- Interesting facts
  - In 1956 16GB (which can be store in a microSD nowadays) could only fit in mass storage structure the size of a 10 story building.
  - In hungarian some people still call mass storage devices *winchesters*, in 1973 this was the codename of a widely used mass storage device.

SSD/HDD

- HDD (Hard Disk Drive)
  - A spinning, magnetized disk stores the data
  - Fragile, ages
  - Speed (example: 7200rpm – revolutions per minute)
  - Best for sequantial data access
- SSD (Solid-State Drive)
  - Works in a similar manner as RAM
  - Significantly faster than HDD
  - ages with usage
  - Still a lot more expensive than HDD
  - If our computer has some SSD storage it is worth to store the operating system there.



Peripheries

- Examples of input devices
  - Mouse
  - Keyboard
  - Touchpad
  - Motion capture
  - Microphone
- Examples of output devices
  - Monitor
  - Printer
  - Speakers
- Interesting facts
  - The introduction of USB (Universal Serial Bus) simplified the usage and manufacturing of the different peripheries. For example before the USB, mouses and keyboards had different plugs.

Questions

- What is the difference between the CPU, RAM and mass storage?
- What does it mean that a processor has more than one core, and that operations can ran in parallel.
- How much data does these represent: kB, MB, GB, TB, KiB, MiB, GiB, TiB?
- What is virtual memory and what is the swap operation?
- What is the difference between an HDD and an SSD?