

Informatics 1.

Lecture 1: Hardware

Kristóf Kovács, Ferenc Wettl

Budapest University of Technology and Economics

2017-09-04

Requirements to pass

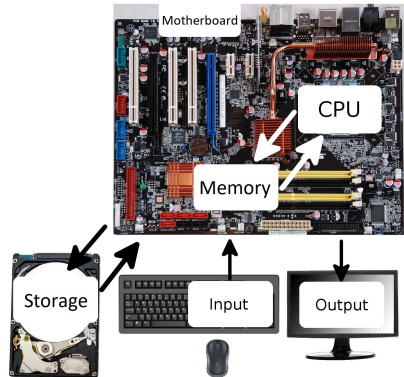
- 3 written exams
 - week 5, 9, 14
 - each examination is worth 20%
 - individually need 50% on each examination
 - 2 exams can be repeated
- weekly homework, 30%, min 50%
- 10 "pop quizzes"
 - at the start of each practical class, 1-2 minutes
 - each of them is worth 1%
 - 50% required to pass (not individually)

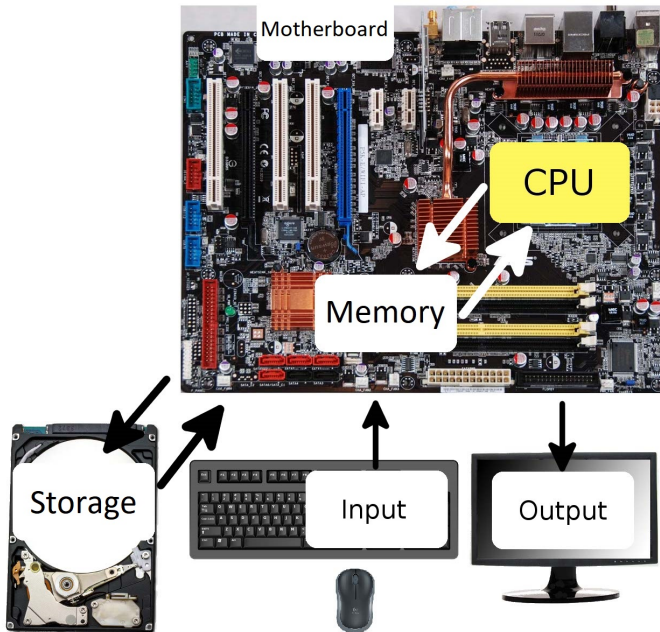
- 1 **Hardware**
- 2 Operating system, programs, file structure
- 3 Representing data in a computer
- 4 Internet, network
- 5 HTML, CSS
- 6 T_EX, L^AT_EX
- 7 Making presentations, beamer
- 8 Graphics, TikZ
- 9 Numerical mathematics and computer algebra systems
- 10 Variable, if branching, function call, recursion
- 11 Octave
- 12 Sage
- 13 Mathematica

- Hardware
 - A computer is a sum of its components.
 - A computer can execute programs written in a language that it can understand.
- Software
 - Programs written in a language understood by the computer
 - Data required for the execution of the program

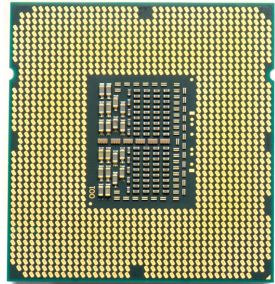
Hardware

- Main components of a computer:
 - Motherboard
 - Processor (CPU)
 - Memory (RAM)
 - Mass storage (HDD, SSD)
 - Periphery (Input, Output)
- Main types of computers:
 - Server,
 - Personal computer (PC),
 - Laptop, Notebook,
 - Tablet,
 - Smart phone, etc.





- Function
 - Executes basic operations (addition, subtraction, storage, etc.)
 - During the execution of a program the CPU (Central Processing Unit) executes these basic 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 as well

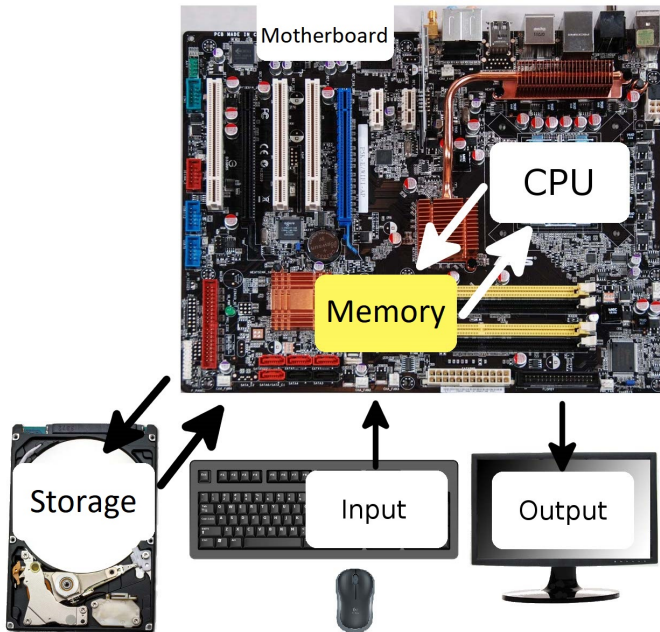


- Clock speed
 - Number of (basic) operations per second
 - Example: 2.5GHz
- Number of cores (parallel computations)
 - Modern CPUs have multiple cores
 - A well written program can make use of more than just one core
 - Intel has a technology called virtual core: the CPUs that feature this technology (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 development of CPUs is their heat generation
 - There are processors that are designed to be used without cooling (example: CPUs in mobile phones)
 - Other ones require significant cooling to function

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, they vary based on processor, manufacturer, etc.).

	operation	cost
cheap	addition, subtraction, comparison	1
	absolute value	2
	multiplication	4
medium	division (except with power of 2)	10
	remainder (modulo)	10
expensive	power of e	50
	sin, cos, tan	60
	asin, acos, atan	80
	power	100
	root	varies



Memory (RAM)

- Function
 - Temporary data storage
 - The processor reads data and programs from the memory
- 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.



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}

$$2^{10} = 1024$$

$$2^{50} = 1125899906842624$$

$$2^{20} = 1048576$$

$$2^{60} = 1152921504606846976$$

$$2^{30} = 1073741824$$

$$2^{70} = 1180591620717411303424$$

$$2^{40} = 1099511627776$$

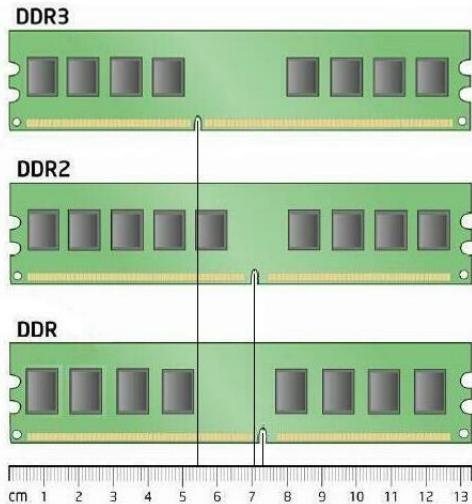
$$2^{80} = 1208925819614629174706176$$

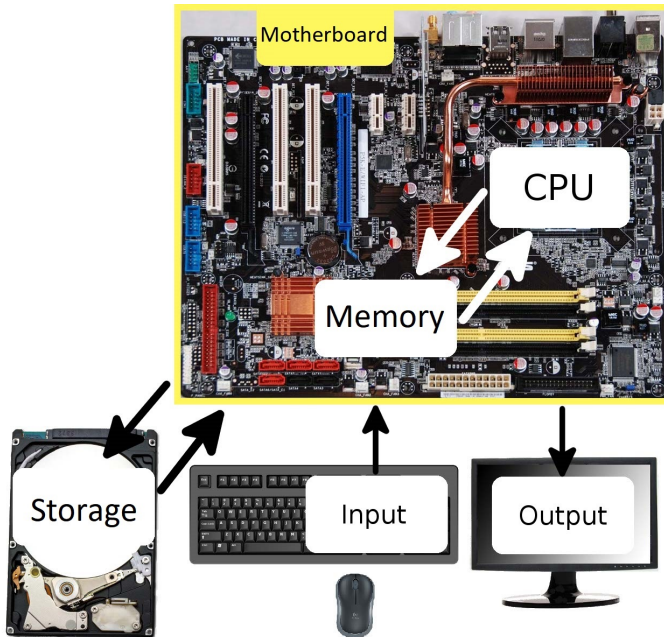
Memory specifics

- 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.

Memory sockets

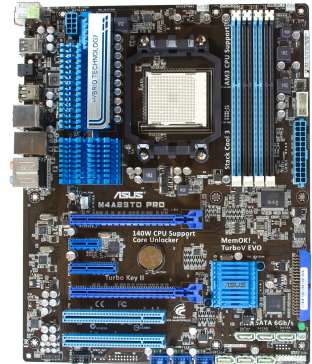
Nowadays every type of motherboard uses the DDR3 socket.

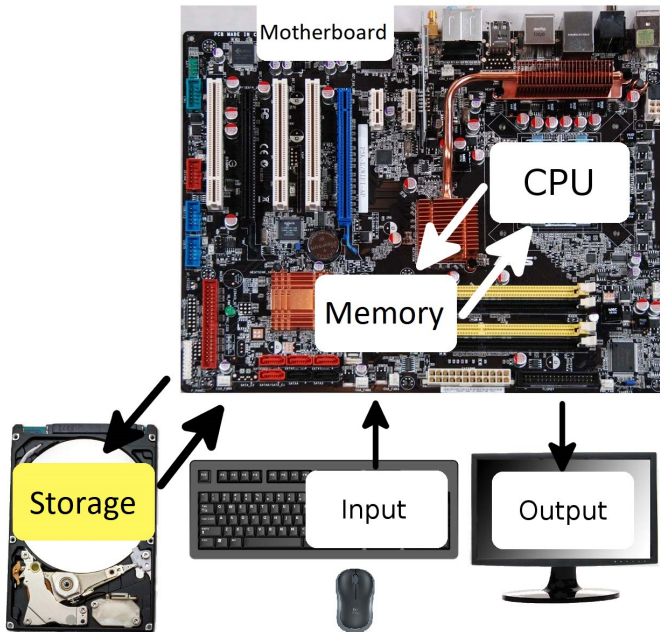




Motherboard

- 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, for example if the data transfer rate between the processor and the memory is slow, then even a high end CPU and memory could feel slow.



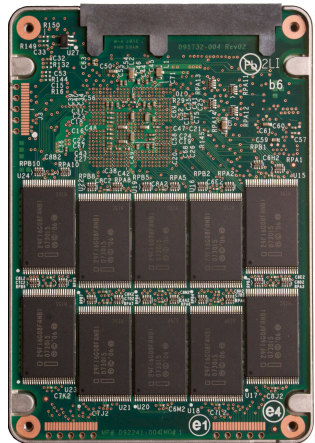


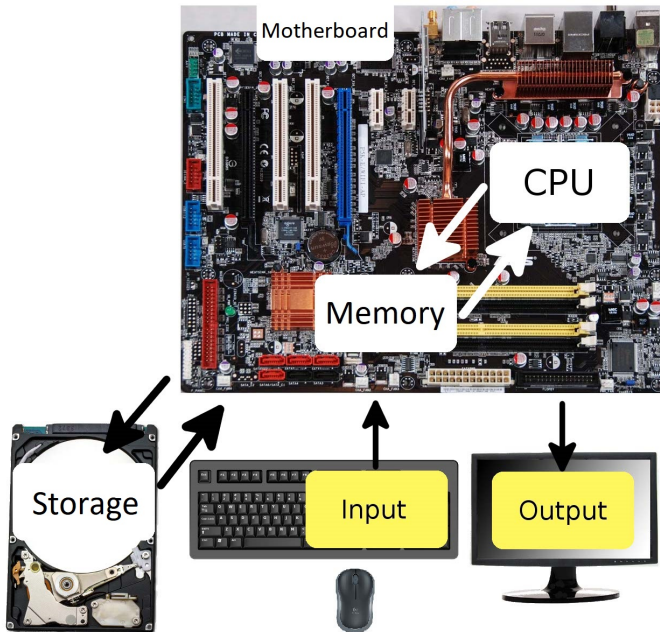
Mass storage

- Function
 - Long term data storage
- Specifics
 - Storage size
 - Type (SSD, HDD)
 - Speed of read/write operations
- 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.



- HDD (Hard Disk Drive)
 - A spinning disk stores the data
 - Fragile, ages
 - Speed (example: 7200rpm – revolutions per minute)
- SSD (Solid-State Drive)
 - Works in a similar manner as RAM
 - Significantly faster than HDD
 - Does not age, instead it wears down due to usage
 - Still a lot more expensive than HDD
 - If our computer has some SSD storage it is worth to store the operating system there.





- 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 peripherals. For example before the USB, mouses and keyboards had different plugs.



- 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 run 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?