INSTITUTE OF
TECHNOLOGY
DEVELOPMENT
OF CANADA

Introduction to Computers

ICR100

Fall Semester 2020

Volatile memory

- A volatile memory is a type of memory used by the **CPU** to access what it needs as fast as possible.
- **RAM** and **cache** are volatile memories: the data is temporarily stored inside them, and they are cleared every time you turn off the computer.

RAM

- **RAM** stands for **R**andom **A**ccess **M**emory.
- RAM is made to be accessed, read and written by CPU.
- Each information is stored there with a temporary **address** which allows the CPU to retrieve it.
- RAM is perfect to make everything faster, but it’s not infinite: its capacity is much smaller than a permanent storage device, such as a **hard disk**.

RAM

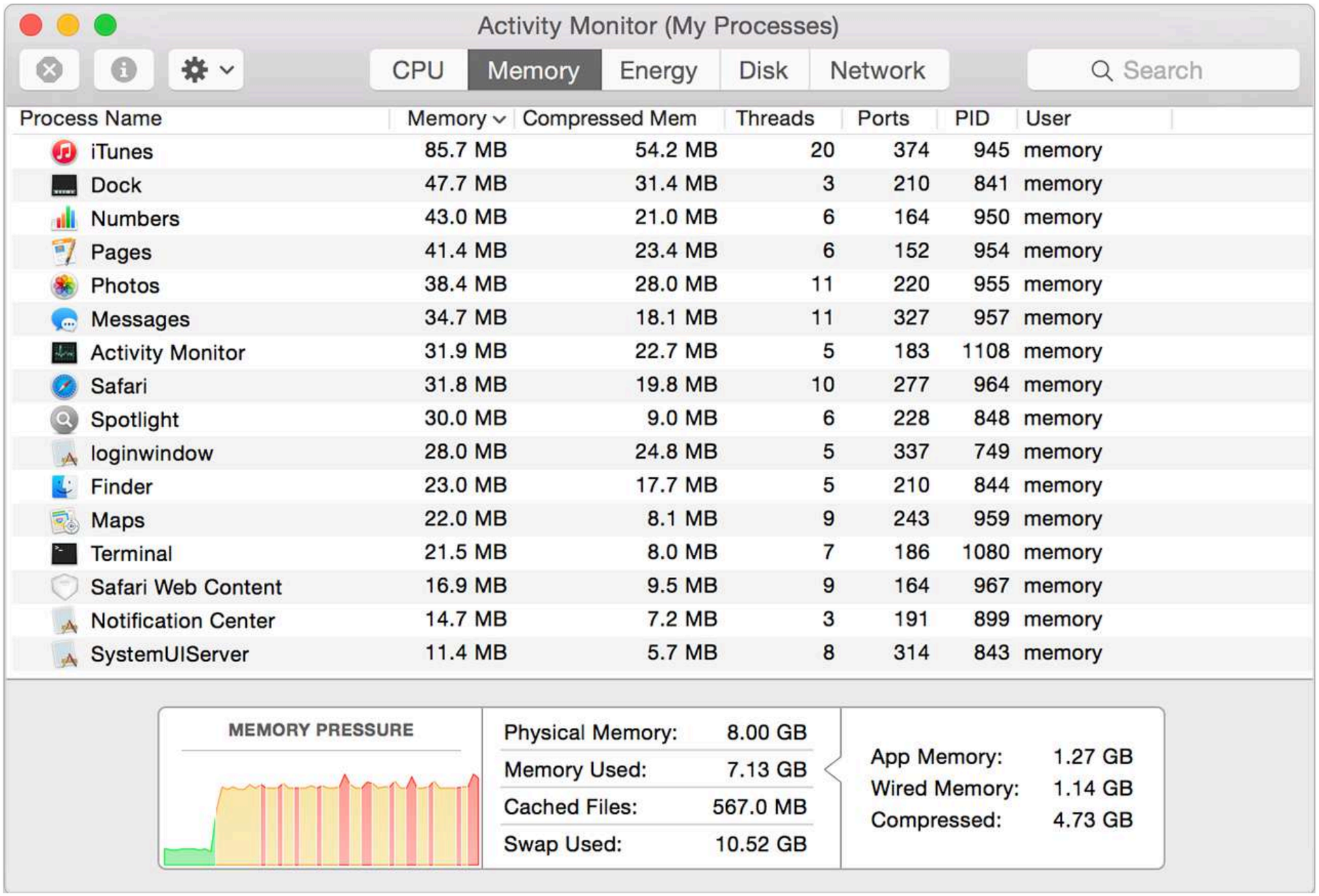
- Its space is partially taken by the **operating system**, and partially by the **running programs.**

- The amount of RAM vary a lot depending by the computer: anyway, it can be incremented in most the cases.

- Each motherboard has a certain number of **slots** where you can insert the RAM. Each slot has a maximum capacity.

- Nowadays, the highest ram capacity module is **128GB**. If your computer’s motherboard has 16 RAM slots, it means it can potentially have **1,024GB** of RAM.

RAM


Activity Monitor (My Processes)
CPU
Memory
Energy
Disk
Network
Search
Process Name
Memory
Compressed Mem
Threads
Ports
PID
User
iTunes 85.7 MB 54.2 MB 20 374 945 memory
Dock 47.7 MB 31.4 MB 3 210 841 memory
Numbers 43.0 MB 21.0 MB 6 164 950 memory
Pages 41.4 MB 23.4 MB 6 152 954 memory
Photos 38.4 MB 28.0 MB 11 220 955 memory
Messages 34.7 MB 18.1 MB 11 327 957 memory
Activity Monitor 31.9 MB 22.7 MB 5 183 1108 memory
Safari 31.8 MB 19.8 MB 10 277 964 memory
Spotlight 30.0 MB 9.0 MB 6 228 848 memory
loginwindow 28.0 MB 24.8 MB 5 337 749 memory
Finder 23.0 MB 17.7 MB 5 210 844 memory
Maps 22.0 MB 8.1 MB 9 243 959 memory
Terminal 21.5 MB 8.0 MB 7 186 1080 memory
Safari Web Content 16.9 MB 9.5 MB 9 164 967 memory
Notification Center 14.7 MB 7.2 MB 3 191 899 memory
SystemUIServer 11.4 MB 5.7 MB 8 314 843 memory
MEMORY PRESSURE
Physical Memory: 8.00 GB
Memory Used: 7.13 GB
Cached Files: 567.0 MB
Swap Used: 10.52 GB
App Memory: 1.27 GB
Wired Memory: 1.14 GB
Compressed: 4.73 GB

RAM

Two types of RAM

DRAM

- **D**ynamic **R**andom **A**ccess **M**emory
- **Dynamic**, continuously refreshed.
- Traditional RAM in computers.

SRAM

- **S**tatic **R**andom **A**ccess **M**emory
- **Static**, which means it's not continuously refreshed like the DRAM.
- Faster, but more expensive in hardware terms.
- Used **inside** the CPU.

DRAM

Going a bit deeper into DRAM…

SDRAM

- **S**ynchronous **D**ynamic **R**andom **A**ccess **M**emory.
- Much faster than DRAM, used in most computers nowadays.
- It’s synchronised with the CPU **clock** (type of signal).

DDR SDRAM

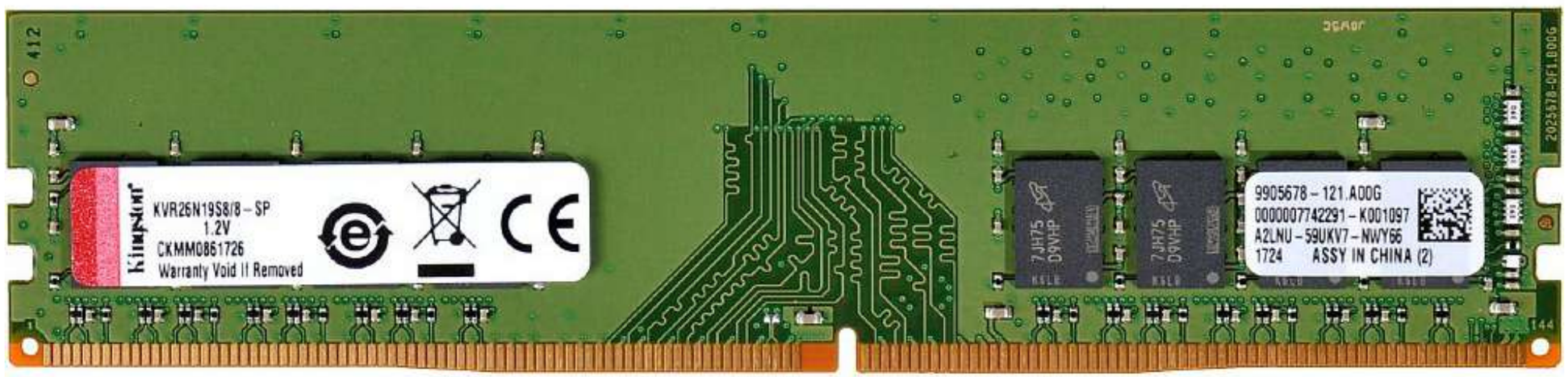
DDR 2 SDRAM

DDR 3 SDRAM

DDR 4 SDRAM

- **D**ouble **D**ata **R**ate **S**ynchronous **D**ynamic **R**andom **A**ccess **M**emory.
- Much faster than SDRAM.
- It use less electrical power.
- Released in 2012, currently the best RAM.

DRAM



The DDR 4 SDRAM is characterised by this shape.

CLOCK SPEED

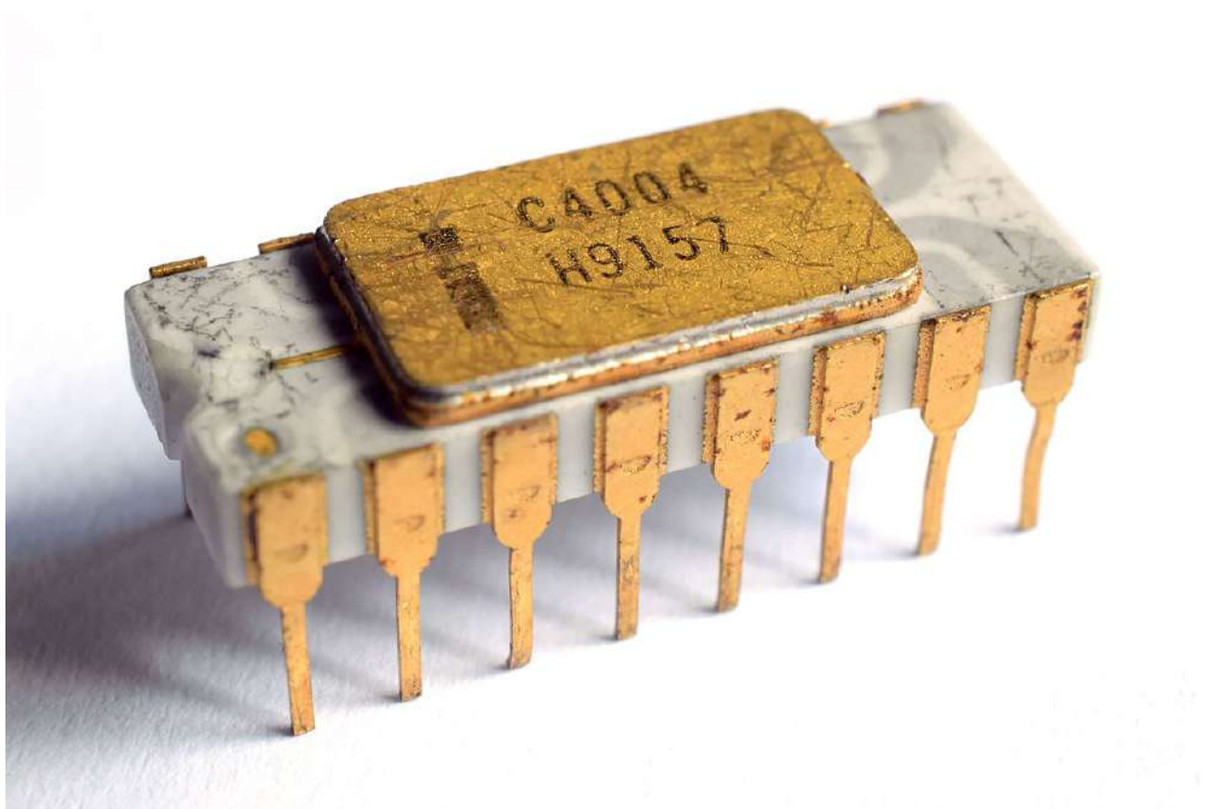
- CPU takes instructions from memory (**fetch**), read them (**decode**) and **execute** them: this process of *fetch - decode - execute* is also called **fetch-execute cycle**.

- The speed at which the CPU execute the *fetch-execute cycle* is called **clock speed**.

- The **clock speed** is measured in **hertz** (**Hz**). **1Hz** means **1 cycle per second**.

CLOCK SPEED

Intel 4004



- Do you remember the **Intel 4004**? The first microprocessor of the history (1971), made of one chip.

- It had a clock speed of **740KHz** which means 740,000 cycles per second.

- Fast, isn’t it?

CLOCK SPEED

- Today, both computers and smartphones usually have **gigahertz** of clock speed - which means **billions of CPU cycles per second**.

CLOCK SPEED

- Also, there are some procedures to manipulate the clock speed: **overclocking** and **underclocking**.

- **Overclocking** is the procedure of accelerating the CPU speed at its maximum: vendors usually leave some margin between the declared CPU speed and the actual capacity, for safety reasons. Anyway, overclocking might be really **dangerous**: due to eccessive heat the computer may even **catch fire**.

- **Underclocking** is the opposite procedure: made to reduce clock cycles, is perfect to reduce **power consumption**. For a laptop it means to gain more battery life.

CLOCK SPEED

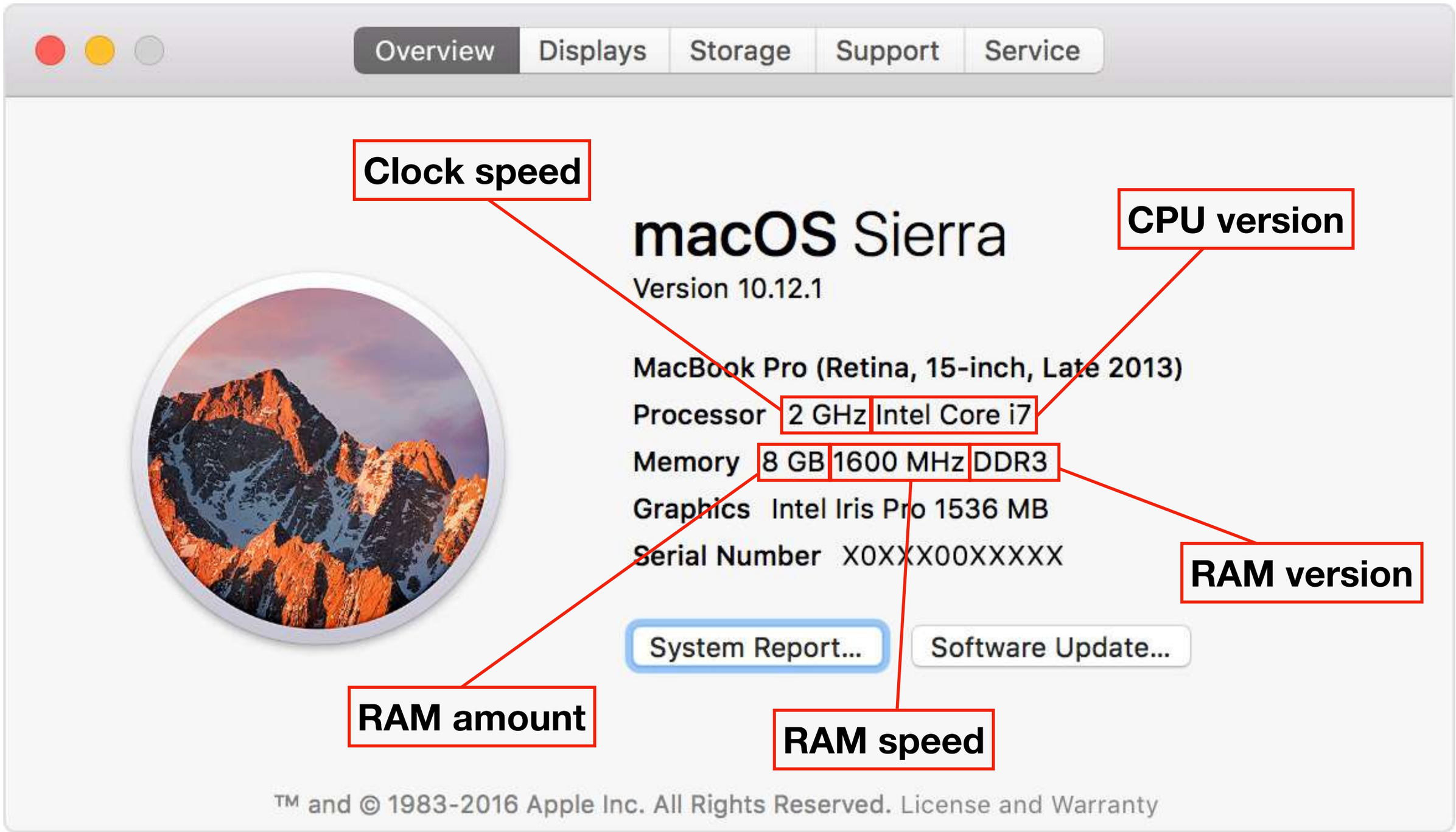
- Moreover, most computers and smartphones have a **multi core processor** nowadays.

- A **core** is a single processing unit, so a *multi core processor* has multiple processing units inside the CPU.

- For instance, a dual core 3.0GHz processor has two processing units **each with a clock speed of 3.0GHz**.

- In essence, **cores are multitasking instruments** - they allow the computer to perform multiple tasks at the same time.

CLOCK SPEED


Overview
Displays
Storage
Support
Service
Clock speed
CPU version
macOS Sierra
Version 10.12.1
MacBook Pro (Retina, 15-inch, Late 2013)
Processor 2 GHz Intel Core i7
Memory 8 GB 1600 MHz DDR3
Graphics Intel Iris Pro 1536 MB
Serial Number X0XXX00XXXXX
RAM version
System Report...
Software Update...
RAM amount
RAM speed
™ and © 1983-2016 Apple Inc. All Rights Reserved. License and Warranty

CACHE

- **Cache** is the fastest memory available for CPU, but it's smaller and more expensive compared to RAM.

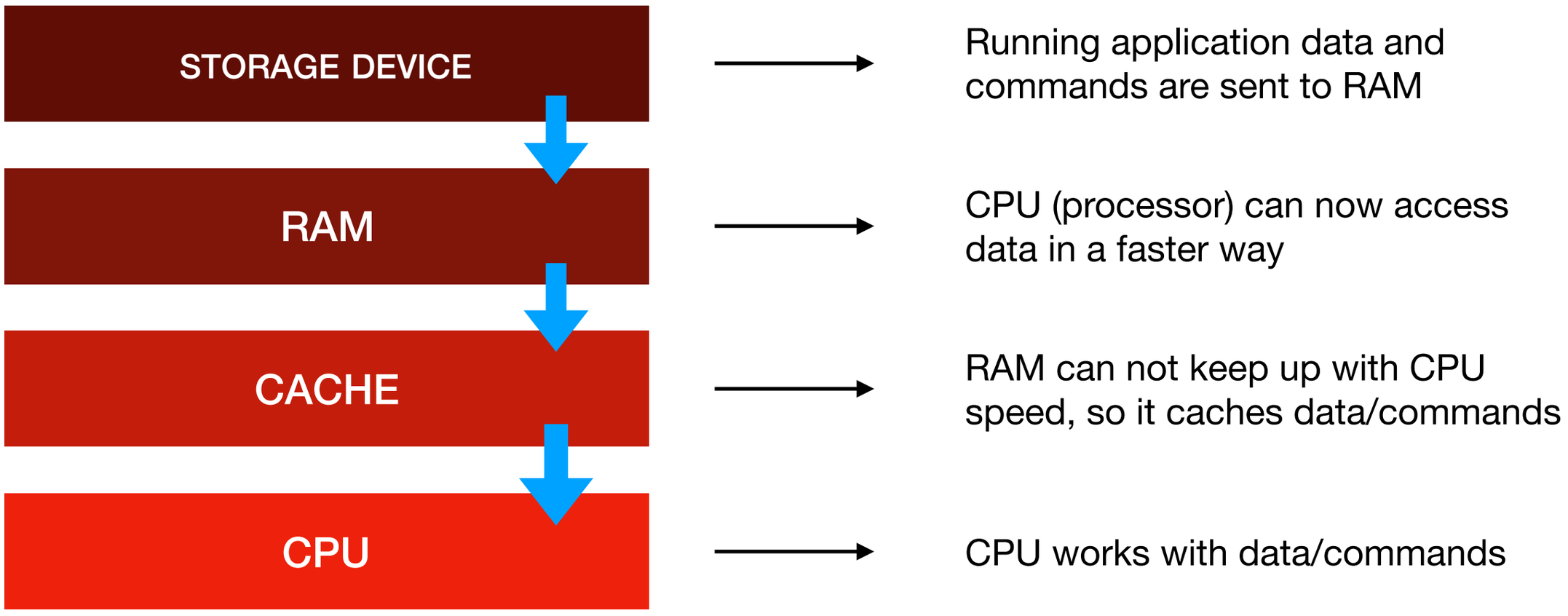
- Cache is a high-level concept: there are several types of cache (e.g. server cache), while the one related to CPU is called **memory cache**.

- The memory cache is completely managed by the **hardware**, which means it's not visibile by the **software**.

- The cache uses the **SRAM**.

CACHE

Memory structure



CACHE

Memory structure

- The cache (SRAM) is physically the **closest memory** to the CPU. The closest it is, the fastest is accessed.
- CPU first checks if the data is available in the cache:

UNAVAILABLE

Data read from RAM

AVAILABLE

Data read from cache

CACHE

- The cache itself is organised on hierarchy (**layers**).

- When we say that cache (SRAM) it’s inside the CPU, we mean the **L1** cache.

- L1 cache is extremely fast but extremely small: its capacity can be up just to **64KB**.

- The position and number of the other cache layers (L2, L3…) it may vary. Some computers have 2 layers, others have 3, others 4. Usually the other layers are stored on dedicated chips, outside the processor.

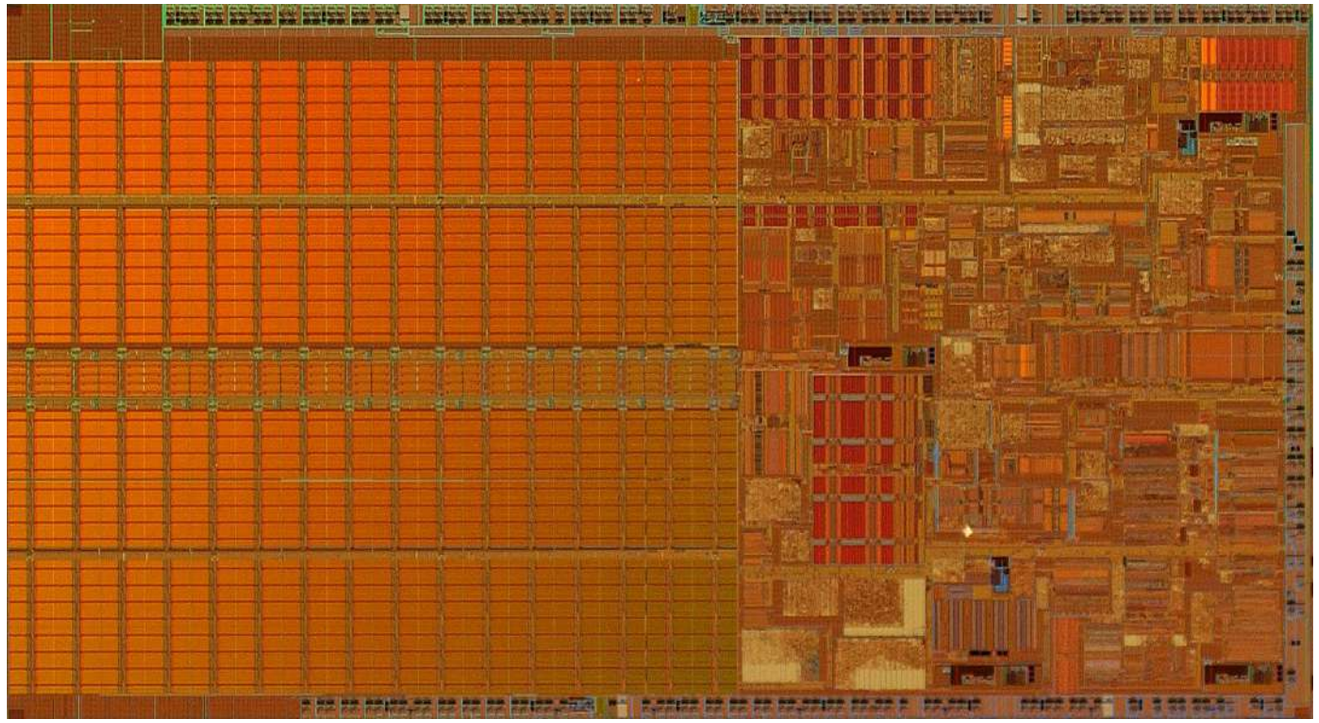
- Every layer is larger than the previous one, but slower.

CACHE

Inside of a processor

PROCESSOR

CACHE



Non-volatile memories

- A **non-volatile memory**, unlike the volatile one, it’s a memory that retains data even when the power is gone.
- **ROM** is an example of a non-volatile memory, and so are the **secondary storage devices** - such as hard disks, SSDs, etc.

ROM

- **ROM** stands for **R**ead **O**nly **M**emory.
- Data can **not** be written or modified, only read.
- The ROM contains the **BIOS**: **B**asic **I**nput **O**utput **S**ystem - what allows the correct operation of keyboard, mouse, screen, etc.
- The BIOS also carries essential information to start the processor when you turn on the computer, and crucial information for expansion cards (Sound, video, network…), and other essential instructions.
- **ROM** is the hardware where the **BIOS** (which is a software) resides.

ROM

- There’s another chip which works related with the ROM and it’s called **CMOS**.

- The CMOS (**C**omplementary **M**etal-**O**xide **S**emiconductor) is a kind of **semi-permanent memory** (it CAN be changed).

- The role of CMOS is to allow correct computer functionality of things such as computer date and time. Plus it supports custom settings for the BIOS.

- The CMOS has its own small battery on the motherboard.

ROM

COMPUTER TURNED OFF

- **ROM** retains all the static **BIOS** instructions.
- **CMOS** keeps “working” thanks to its own battery.

COMPUTER TURNED ON

ROM turned on

↓

ROM reads CMOS settings

↓

CMOS commands the CPU

↓

CPU loads the OS in the RAM

ROM

Three types of ROM

PROM

Programmable

Programmable only once.

EPROM

Erasable **P**rogrammable

It can be completely erased a certain amount of times through **UV light**.

EEPROM

Electrical **E**rasable

It can be fully erased through electrical charges. The procedure to erase it it’s called **flashing**.

SECONDARY STORAGE

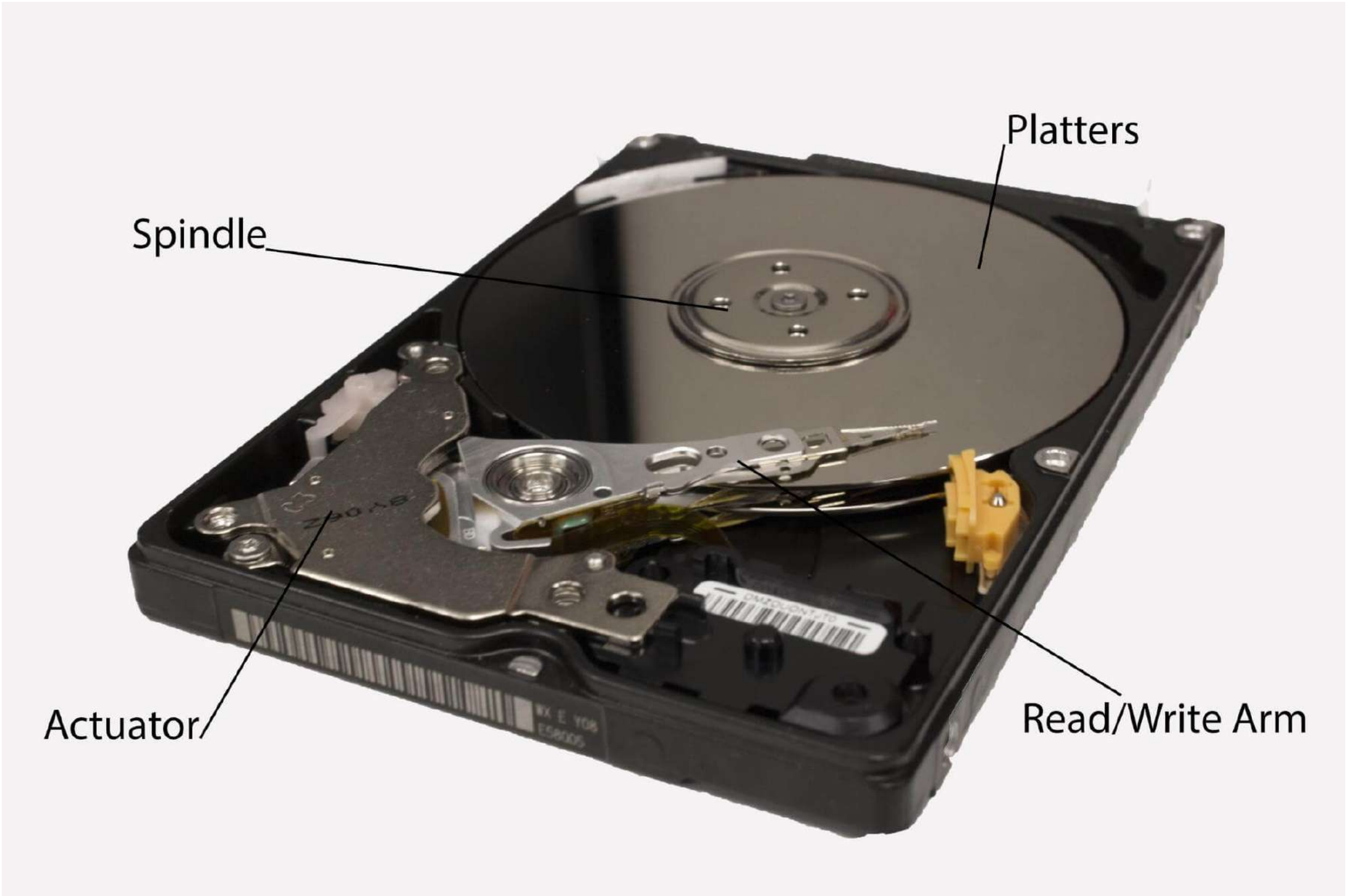
- Also known as *Non-volatile storage devices*, used to keep data and to perform **backups**.
- **Hard disks, SSDs, USB flash drives, magnetic tapes, floppy disks** are examples of secondary storage devices.

HDD vs SSD

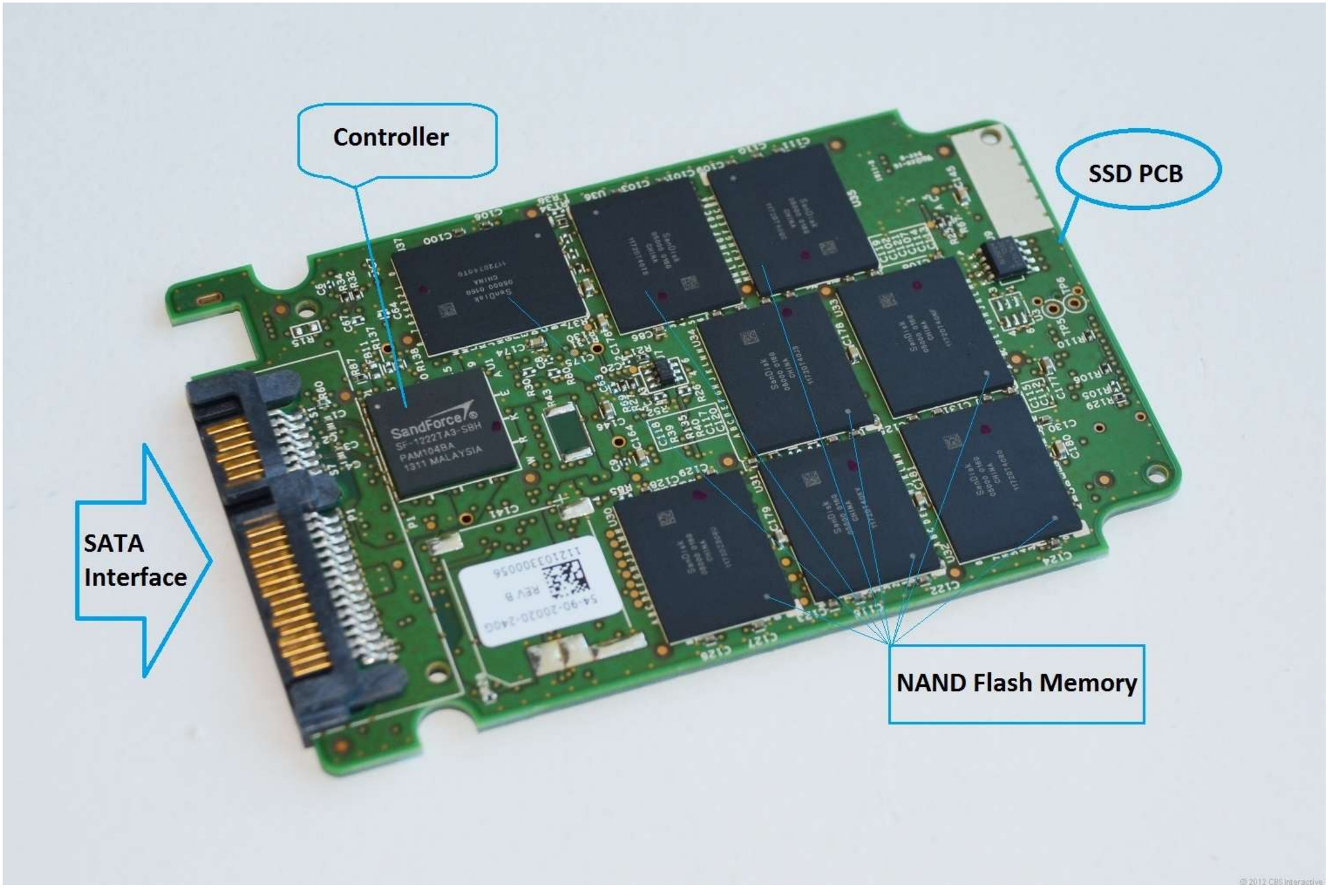
- A **Hard Disk Drive** (HDD) is made by **magnetic platters** where data can be read and written through a **head arm**. It's still a widely used technology, even though it's **electromechanical**.

- A **Solid State Drive** (SSD) uses **integrated circuits** and **flash memories** and does NOT have mechanical components.

HDD vs SSD: hard disk



HDD vs SSD: SOLID STATE DRIVE



HDD vs SSD

HDD

PROS

- For cheap price you get a huge amount of capacity.
- You may be able to rescue data easily in case of failure.
- It gives signs of failure in case it starts to fail.

CONS

- Magnets may erase data.
- Slow performance.
- Noisy.

SSD

PROS

- Incredible performance for running software and OS.
- Quiet.
- File fragmentation does not affect performance as much as HDD.

CONS

- Really expensive.
- Shorter life expectancy.

HDD vs SSD

- HDD is better for **storage**.
- SSD is better for **performance**.

HDD vs SSD

HDD vs SSD: possible solution?

- An *SSD* for the Operating System and programs.
- A *HDD* for files storage (especially large ones).

But there's a third one...

- **SSHD** (**S**olid **S**tate **H**ybrid **D**rive): it combines some aspects of the SSD and some others of the HD.

HDD vs SSD

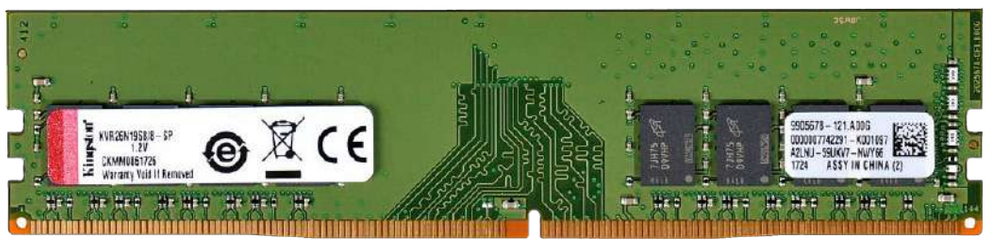
- Both of them are connected to the motherboard through a **SATA** or **PATA** cable - depending on the motherboard.
- **SATA**: **S**erial **A**dvanced **T**echnology **A**ttachment.
- **PATA**: **P**arallel **A**dvanced **T**echnology **A**ttachment.

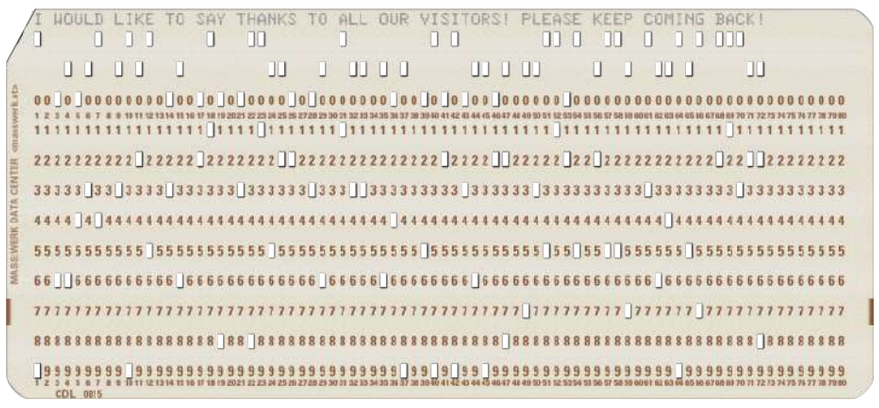
SATA III

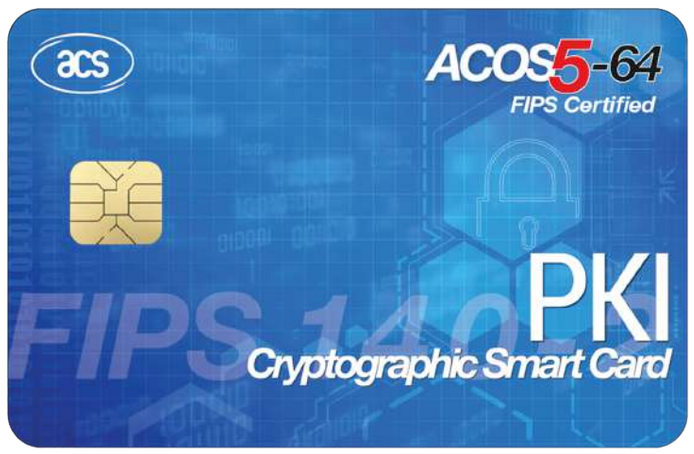
- Current standard, released in 2009.
- Latest release is SATA 3.2
- Speed up to 6GB/s (effective 4.8GB/s).

GUESS GAME

Which of these are secondary storage?







GUESS GAME

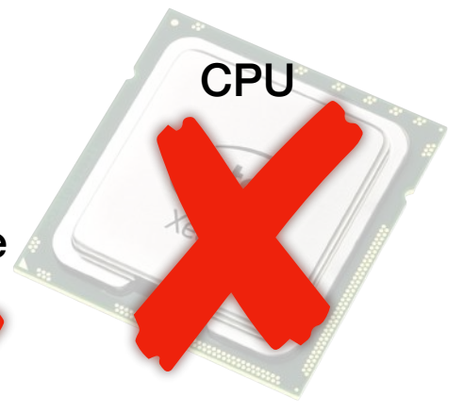
Which of these are secondary storage?

Optical Disc

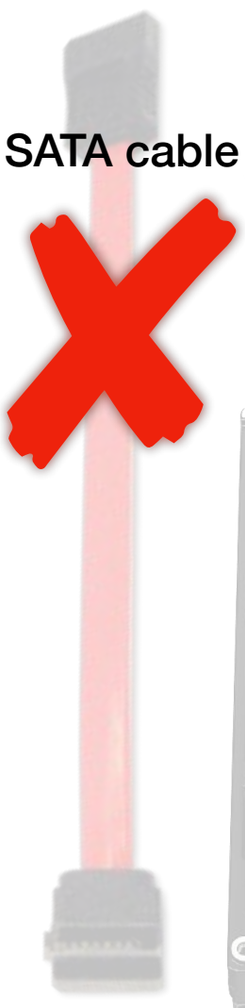
Floppy Disk

USB Key

CPU

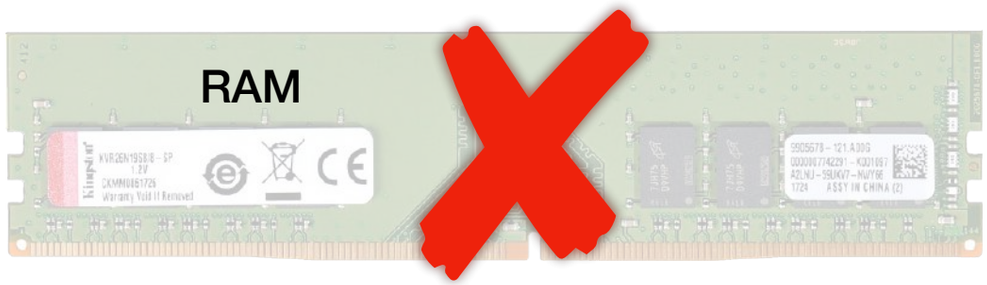


SATA cable



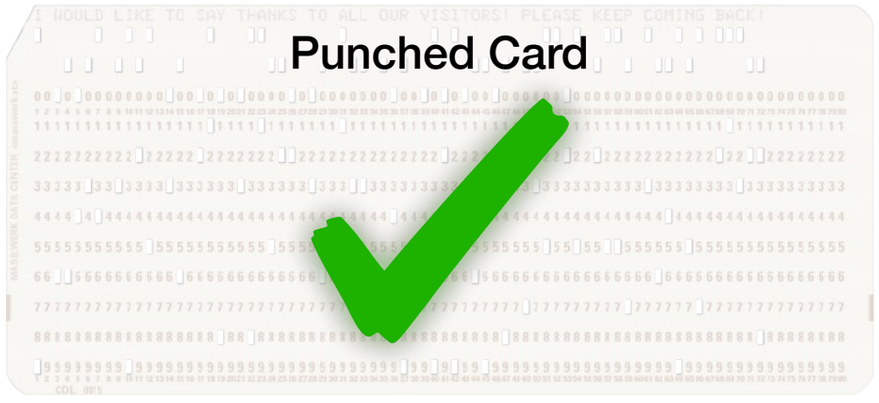
Cassette Tape

RAM



HDD

Punched Card



Smart Card

Thank You!