CSCI 210: Computer Organization
Lecture 3: Inside Your Computer

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Oberlin College
Feb. 23, 2022
Slides from Cynthia Taylor

Announcements

- Problem Set 0 due Friday, 11:59 pm!
  - Submit via Gradescope
- Clickers required Friday!
- Office Hours Friday 13:30 – 14:30

What’s Inside a Computer?

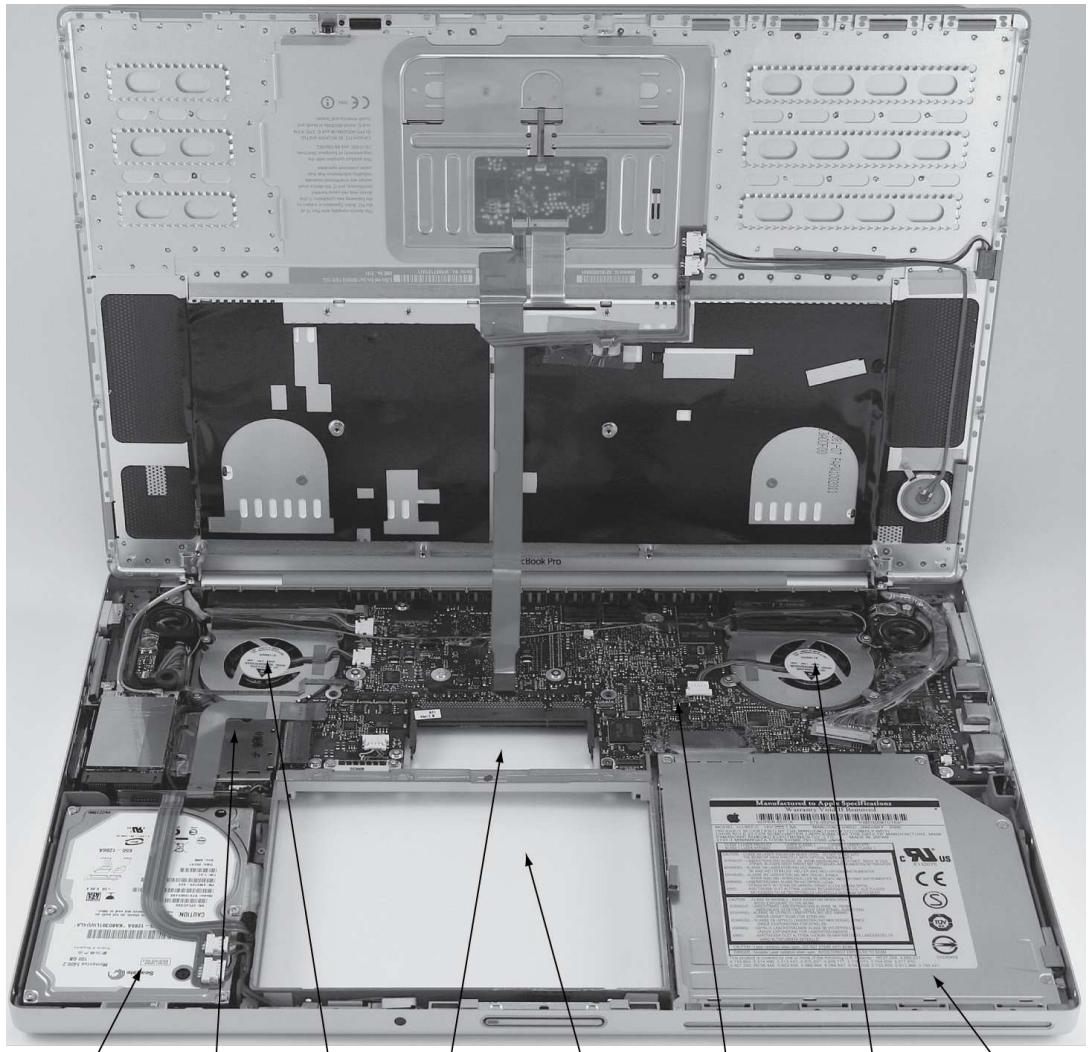
What’s Inside a Computer

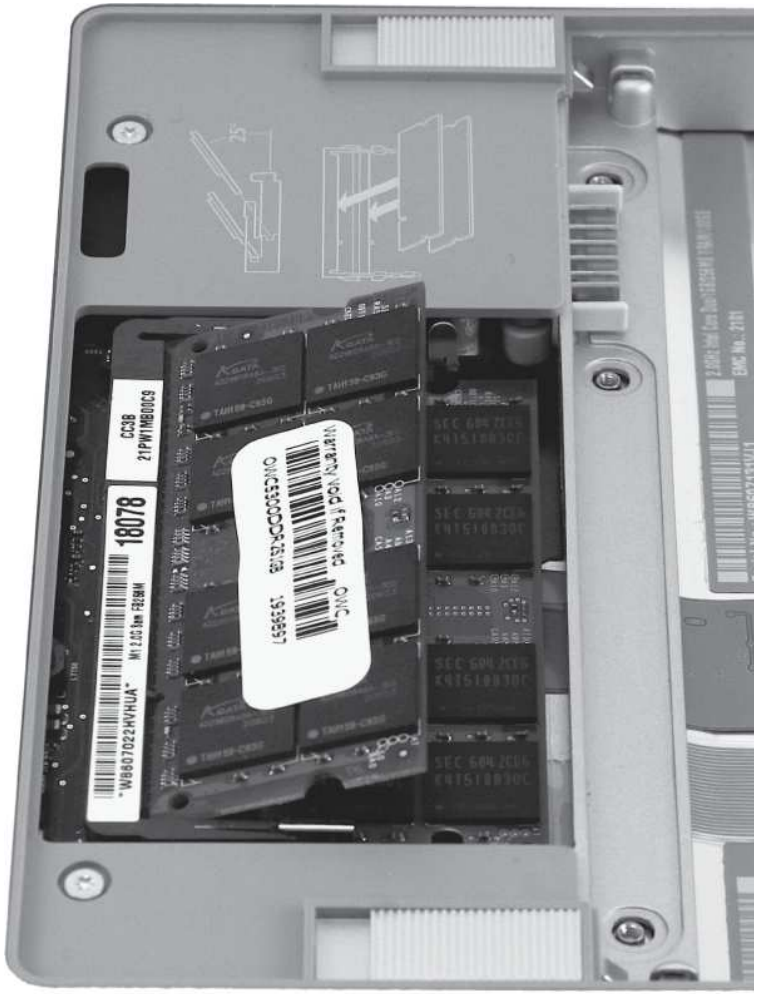
- CPU
  - Processes instructions
- Hard drive/Solid state drive (SSD)
  - Stores data, nonvolatile
- RAM
  - Stores data currently in use

What’s Inside a Computer

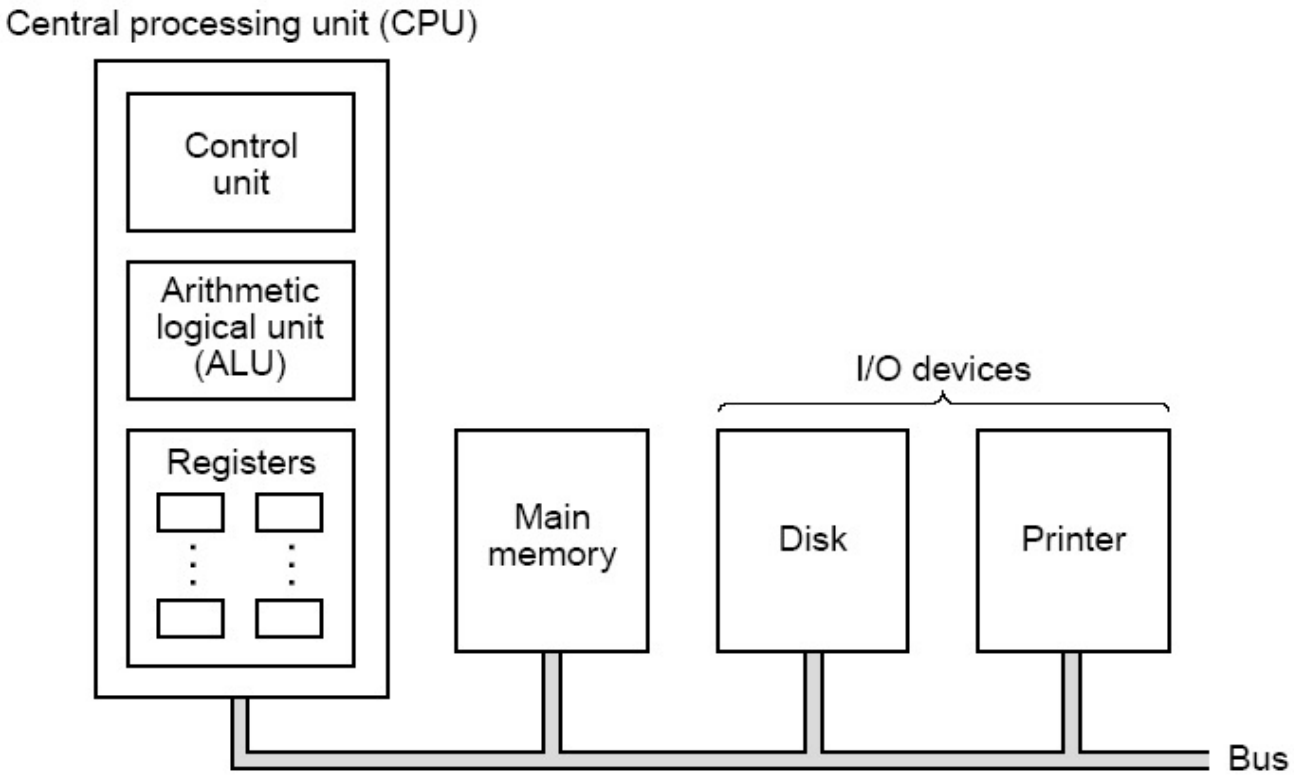
- Motherboard
  - Connects everything
- Graphics card, Networking Card
  - I/O devices
- Monitor, Keyboard
  - Peripherals

Opening the Box

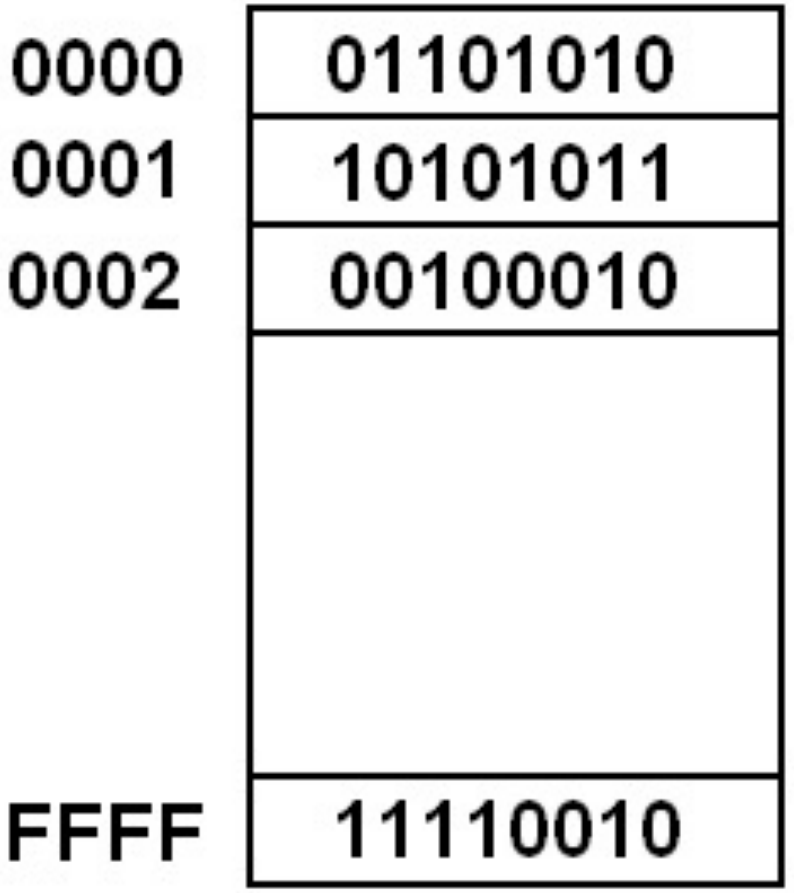




Inside the Computer



Main Memory



Basic structure: A 1-dimensional array of cells, each with a unique address. A cell is normally one byte (8 bits).

Basic Memory Operations

- read (load) the contents of the cell at a given location
- write (store) a given value to the cell at a given location
- Bytes may be grouped into 2-, 4-, or 8-byte words. A word is a basic unit of storage for binary integers, ALU operands, registers.

Cache Memory

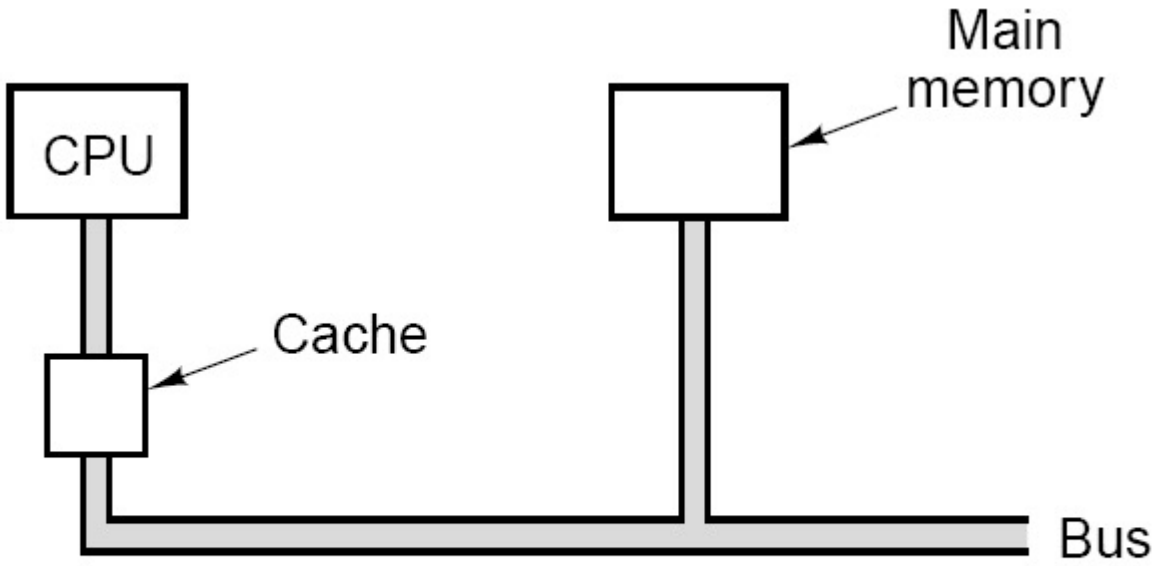
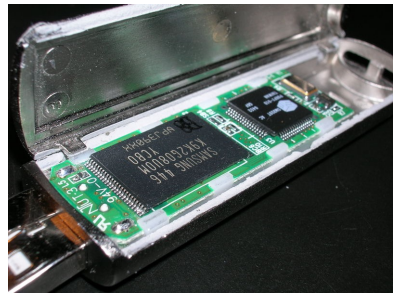


Figure 2-16. The cache is logically between the CPU and main memory. Physically, there are several possible places it could be located.

- Problem: Memory access is slower than CPU operations. Cache memory is used to speed up memory operations
- A cache is a small, fast memory positioned on the CPU, or between the CPU and the main memory
- Transparent to programmers

A Safe Place for Data

- Volatile main memory
  - Loses instructions and data when power off
- Non-volatile secondary memory
  - Magnetic disk
  - Flash memory
  - Optical disk (CDROM, DVD)



Why Don’t We Just Keep Everything In The Cache? (No Disk or Main Memory)

A. Cache is volatile.

B. Cache is slower than Main Memory.

C. Cache is more expensive than Main Memory.

D. More than one of the above.

Memory Hierarchy

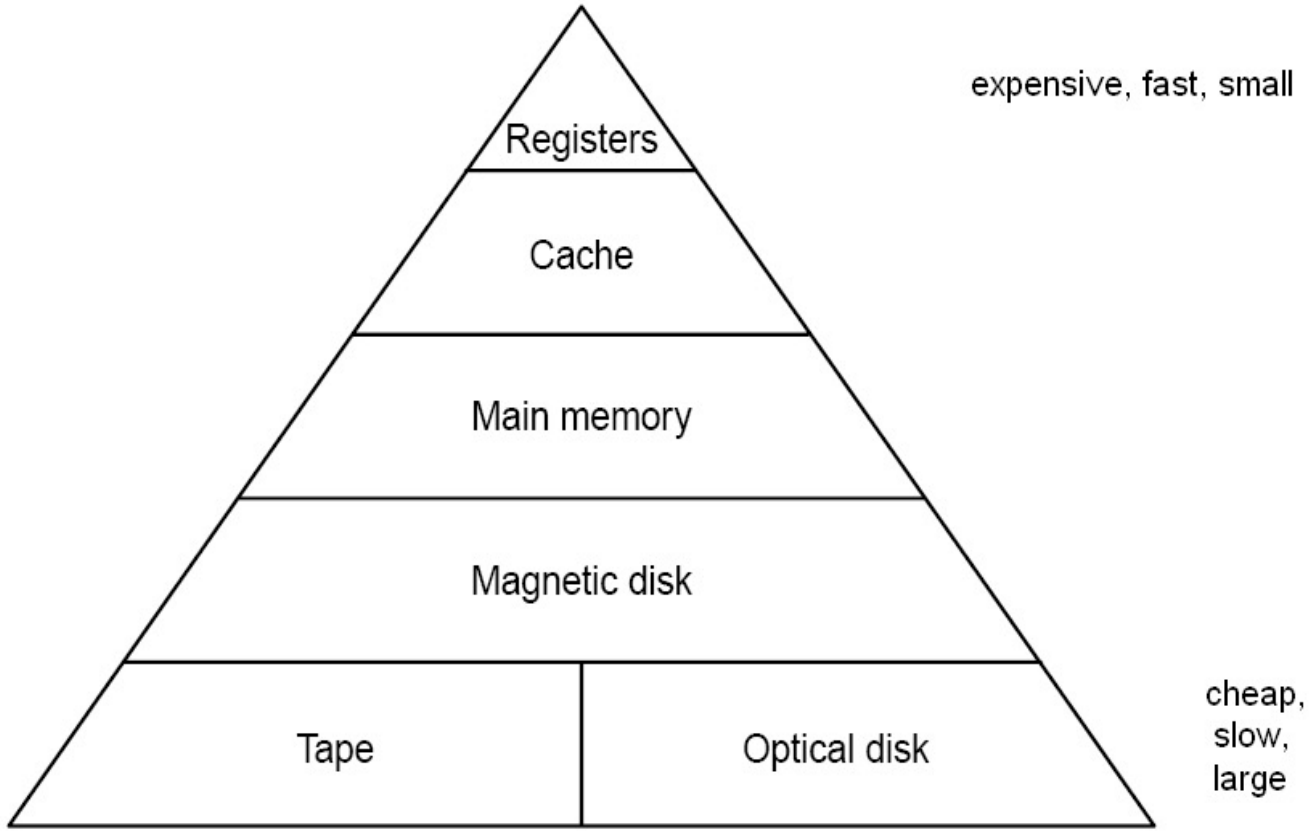
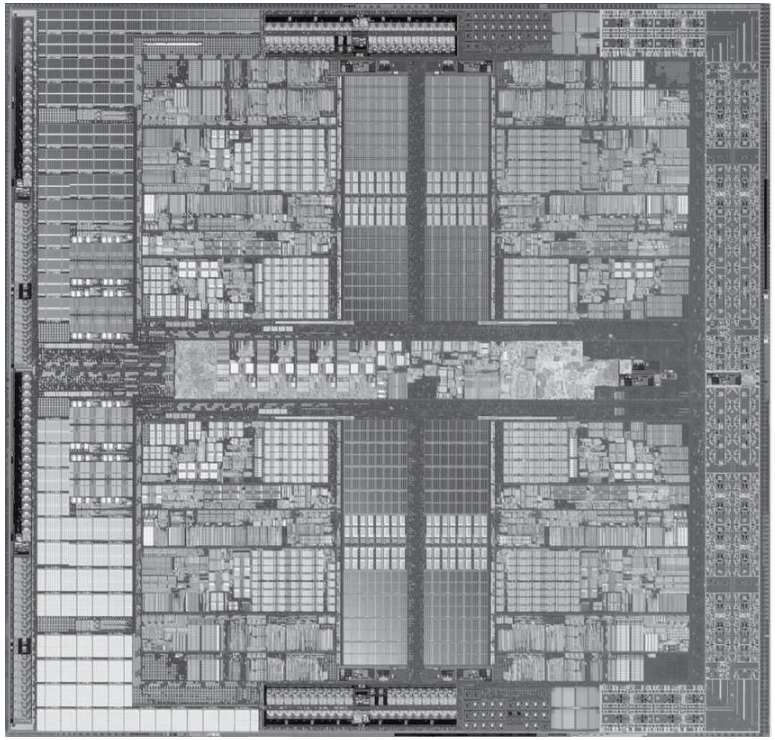
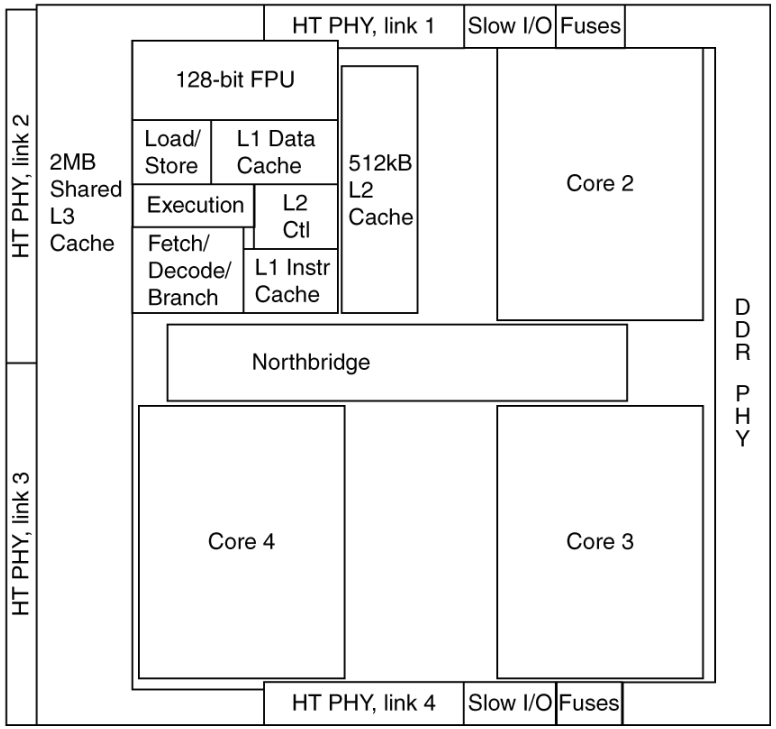


Figure 2-18. A five-level memory hierarchy.

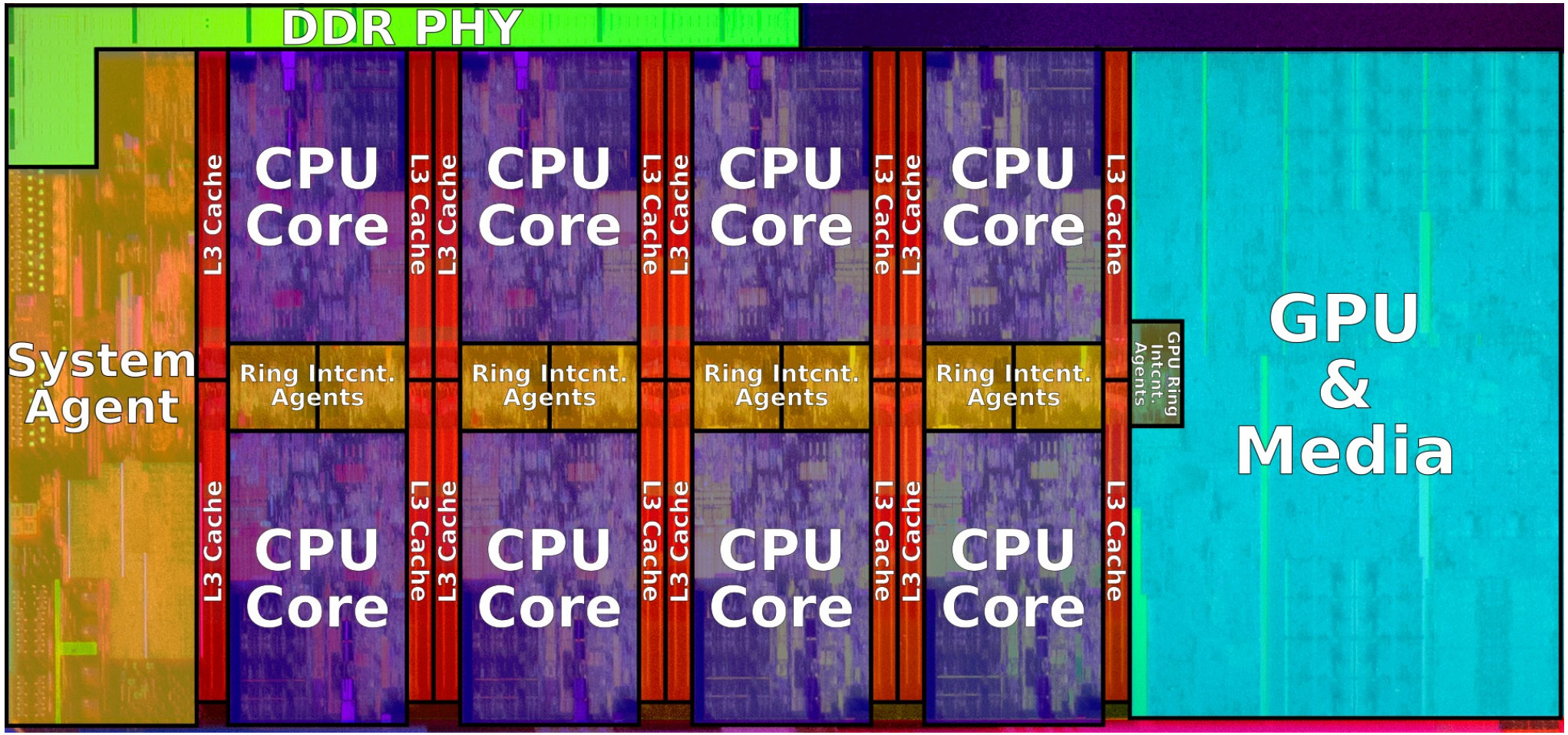
Inside the Processor

- AMD Barcelona: 4 processor cores

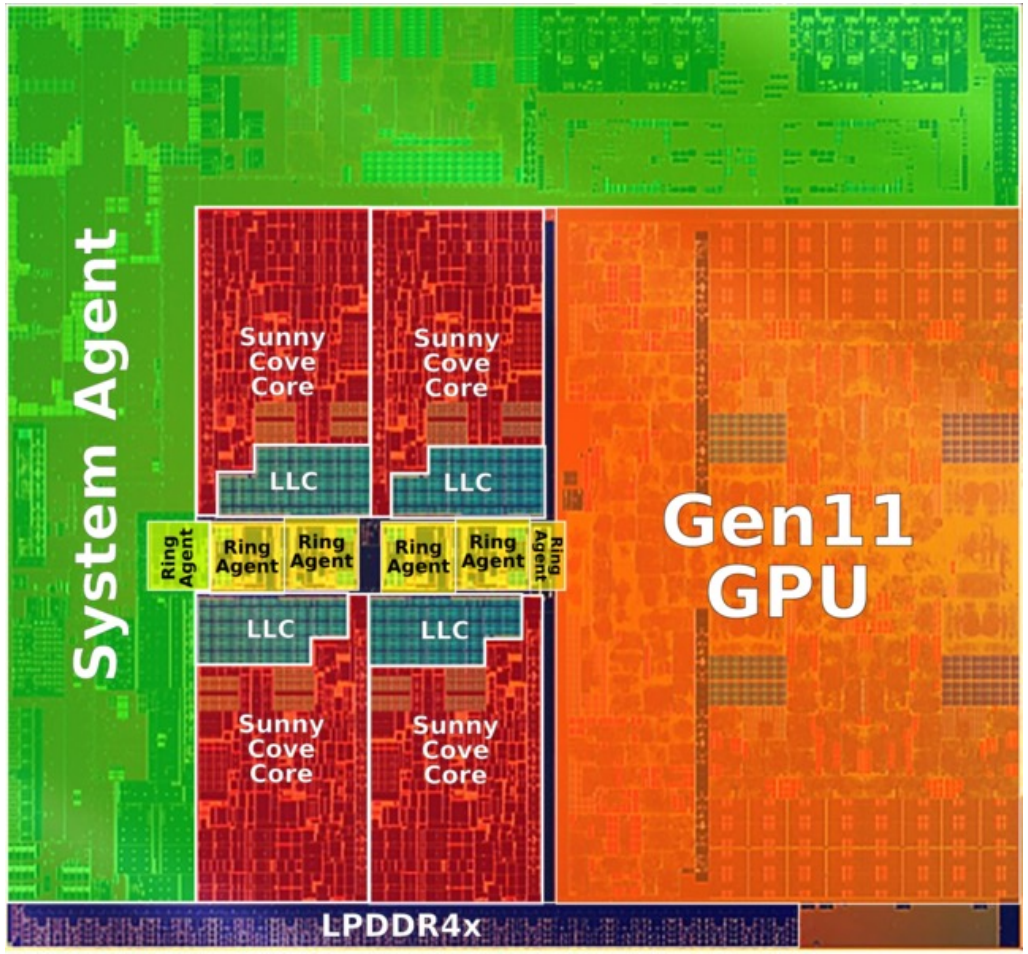


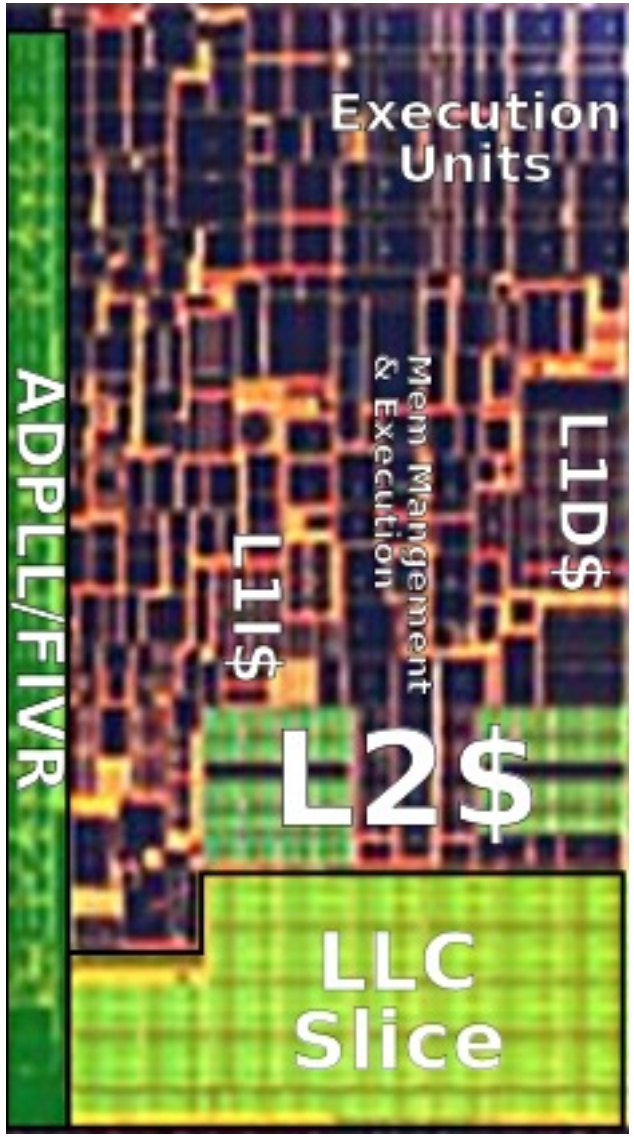


Inside the Intel Coffee Lake 8-core



Intel Ice Lake processor die





What does this mean?

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AMD

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Central Processing Unit

- The CPU contains
  - Registers — words of memory inside the CPU
  - ALU (Arithmetic and Logic Unit) — performs computations
  - Control Unit — issues control signals

- Its job is to execute (i.e., run) machine language programs, one instruction at a time.

How Programs Run

- A program is a sequence of machine language instructions, stored in consecutive memory locations.

- To execute programs, the CPU uses two special registers:

  – PC (program counter) — contains the memory address of the current or next instruction to be executed

  – IR (instruction register) — contains the current instruction being executed

How Programs Run

- Instructions are executed in a sequence of operations called the instruction cycle:
  - fetch (IR ← Memory[PC]; PC ← PC+1)
  - decode
  - execute
- The instruction cycle is repeated indefinitely, as long as the machine is on.

Incrementing the PC gets us the next instruction because

A. Instructions are stored in a linked list, and we are moving to the next node of the list.

B. Instructions are simply an array of numbers in memory, we are indexing into the array.

C. Instructions are stored in a special instruction array, and we are indexing into that array.

Input/Output

- Each device has an interface/controller, connected to the CPU by a bus.

- Controllers may use direct memory access (DMA) to transmit data between the device and main memory directly on the bus, without going through the CPU.

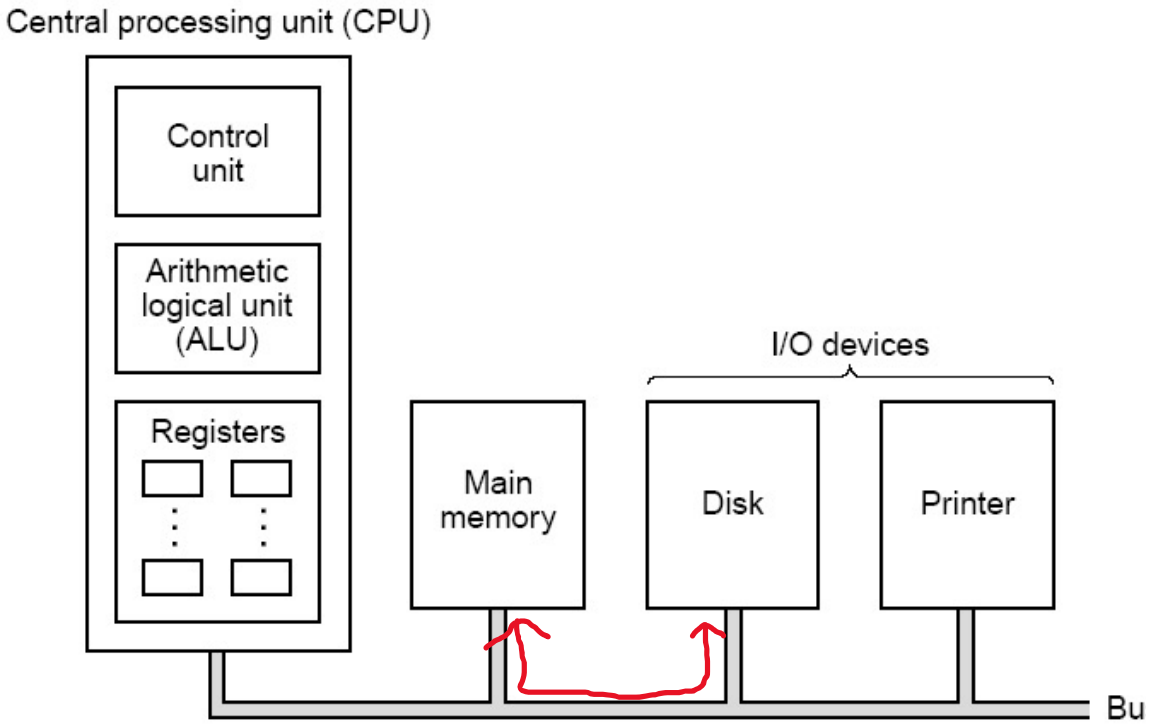

Figure 2-1. The organization of a simple computer with one CPU and two I/O devices.

Buses

- A bus is a broadcast medium. Protocols are used to control bus access and make it possible for two-way communications to occur. For example,
  - The actual destination is specified by an address.
  - A bus arbiter determines which device gets to use the bus next.
- Common buses for peripherals in computers
  - Universal Serial Bus (USB)
  - Peripheral Component Interconnect (PCI)

If someone with physical access to the machine attaches a device to the bus, they can record/access

A. Any message sent to that device.

B. Any message sent to any device on the bus.

C. Messages sent to devices after them on the bus.

Reading

- Next lecture: Assembly Programming
  - Sections 2.2-2.3

- Problem Set 0 due Friday