

# CSCI 210: Computer Organization

## Lecture 3: Inside Your Computer

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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?

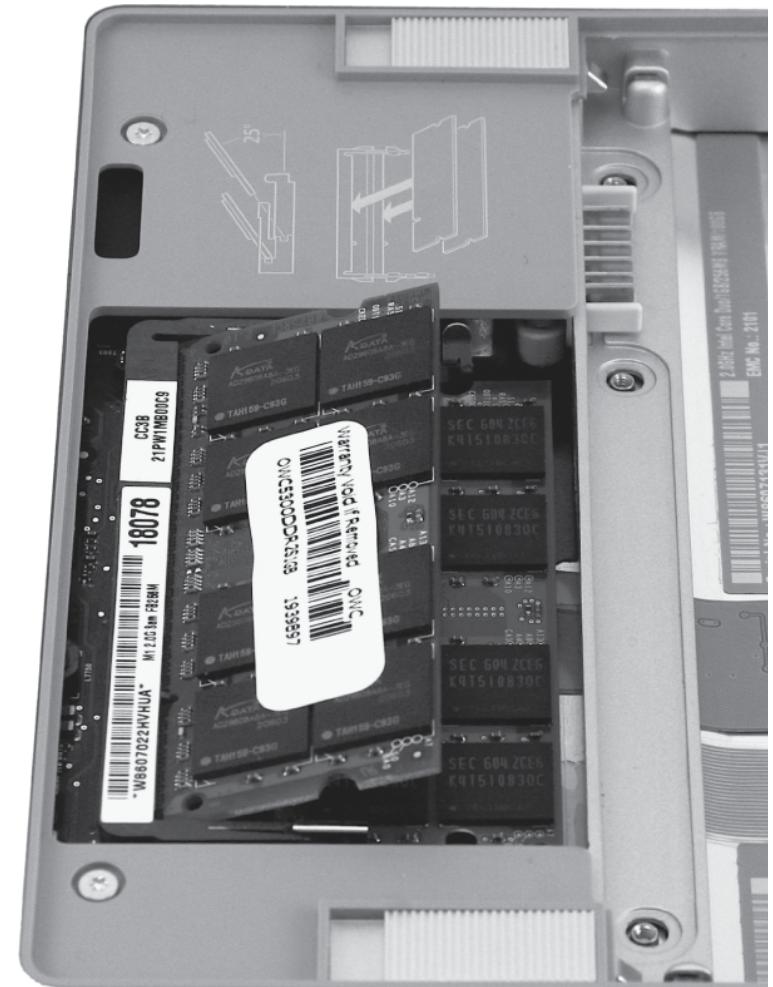
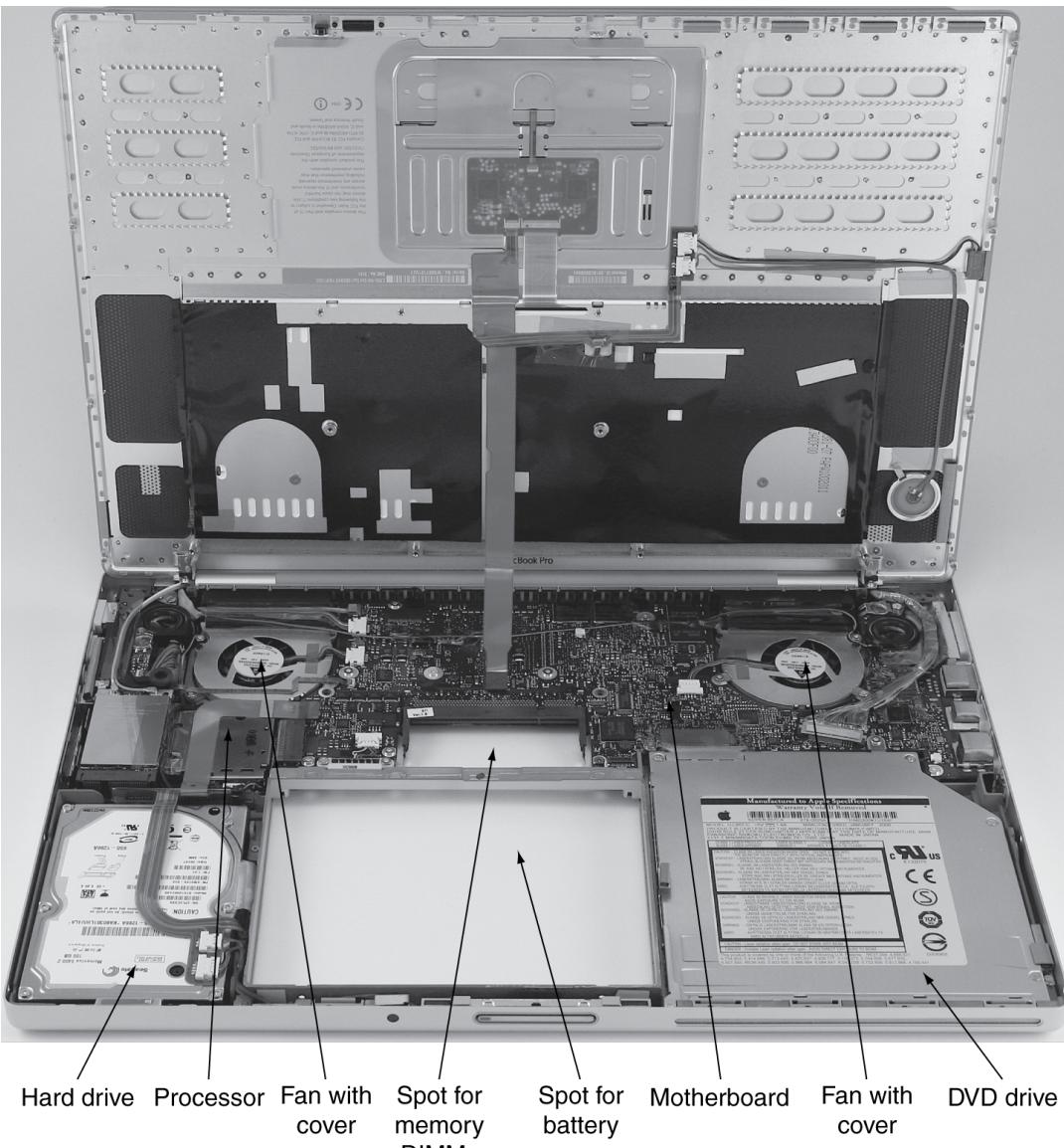
# What's Inside a Computer

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

# What's Inside a Computer

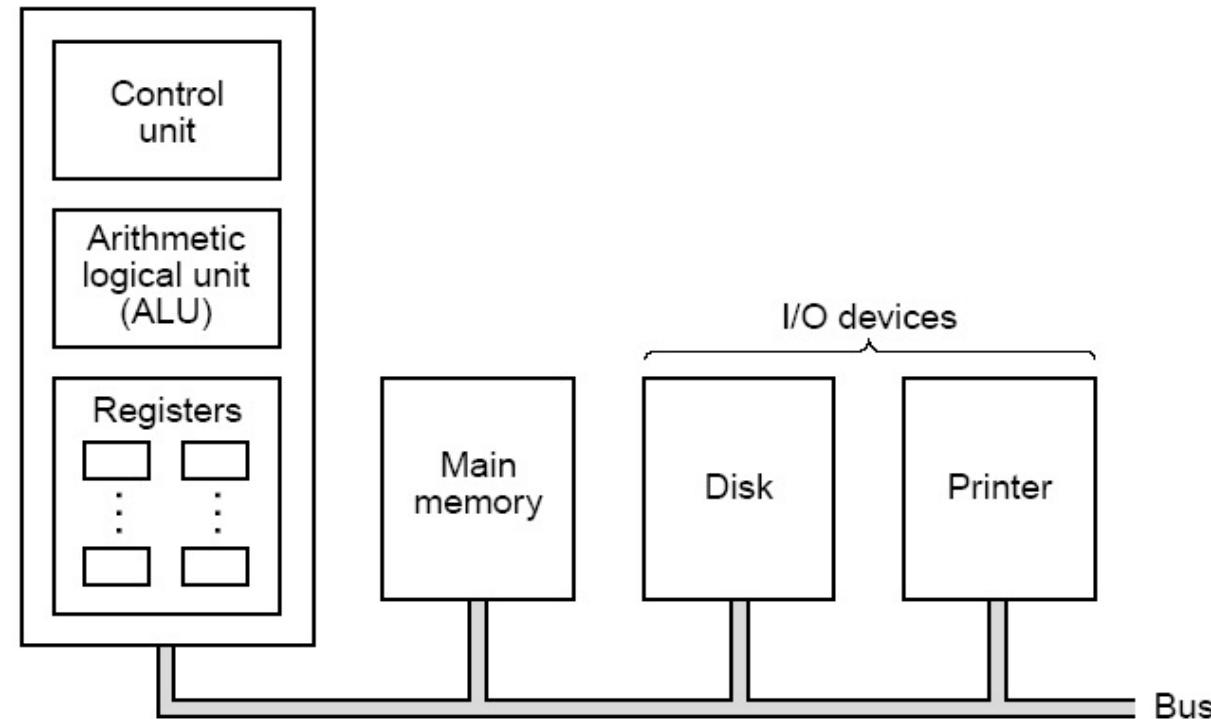
- Motherboard
  - Connects everything
- Graphics card, Networking Card
  - I/O devices
- Monitor, Keyboard
  - Peripherals

# Opening the Box



# Inside the Computer

Central processing unit (CPU)



# Main Memory

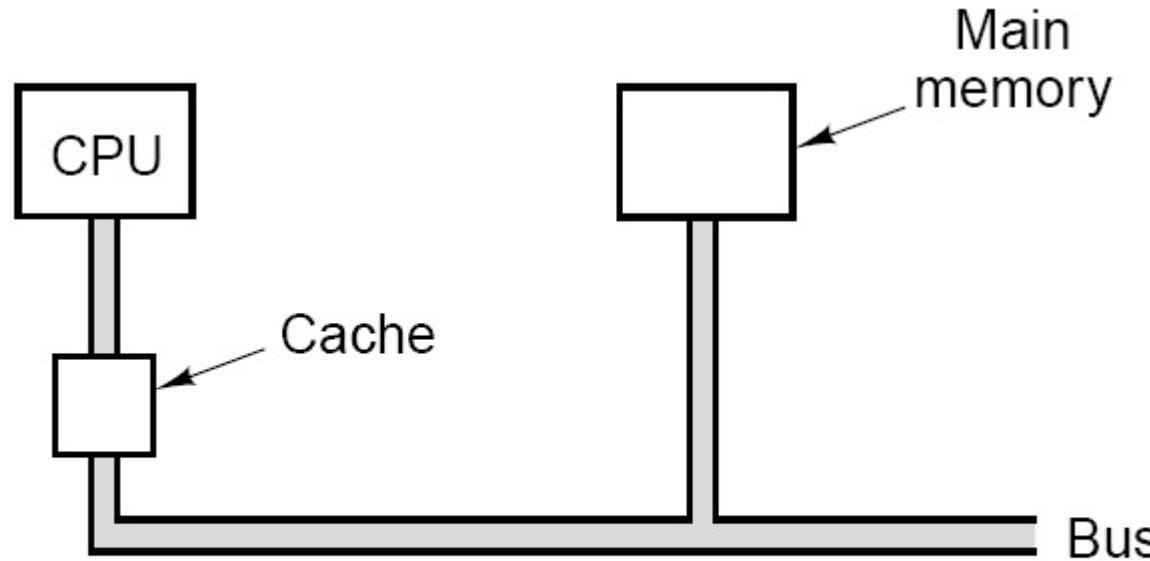
0000	01101010
0001	10101011
0002	00100010
FFFF	11110010

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

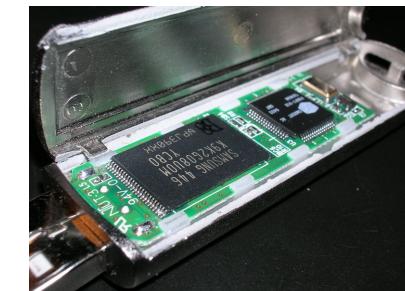


**Figure 2-16.** The cache is logically between the CPU and main memory. Physically, there are several possible places it could be located.

- 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

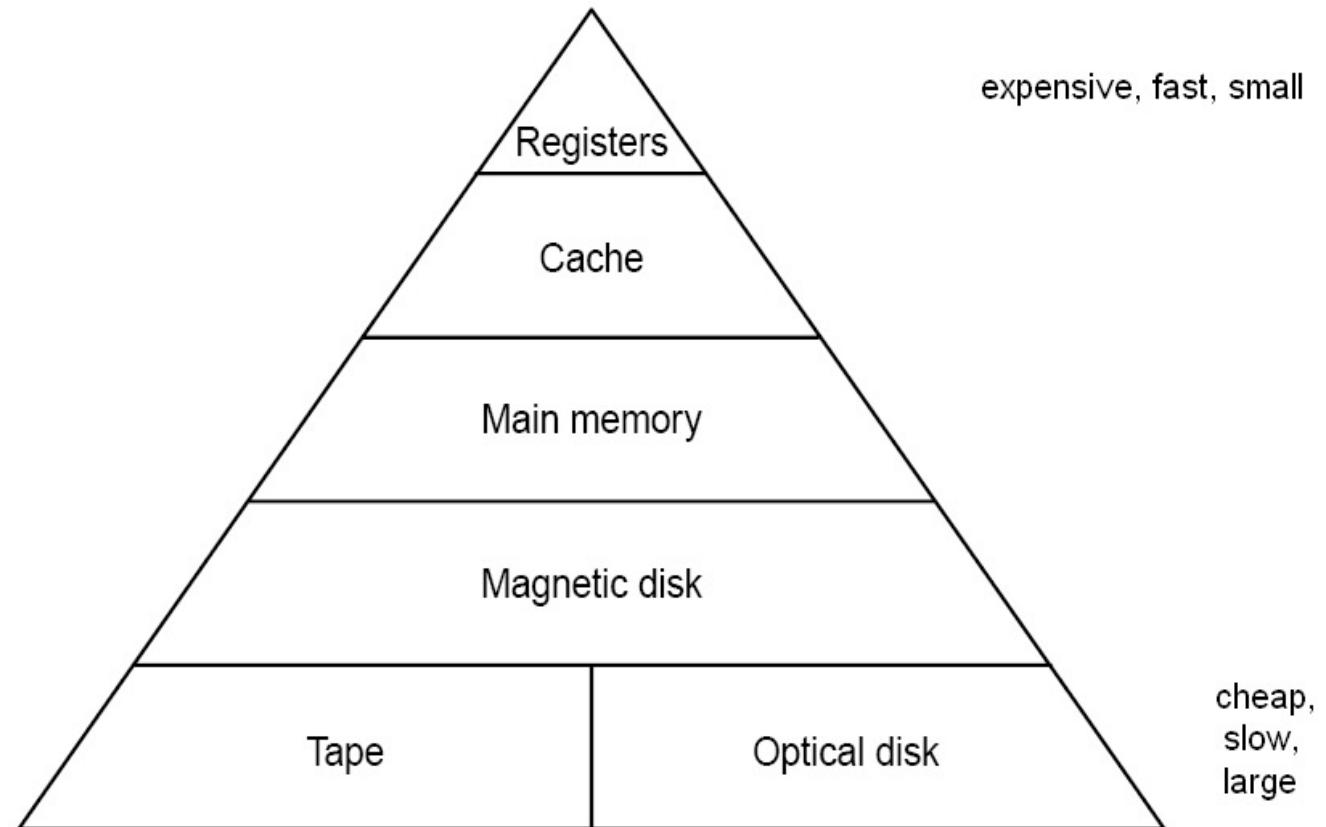
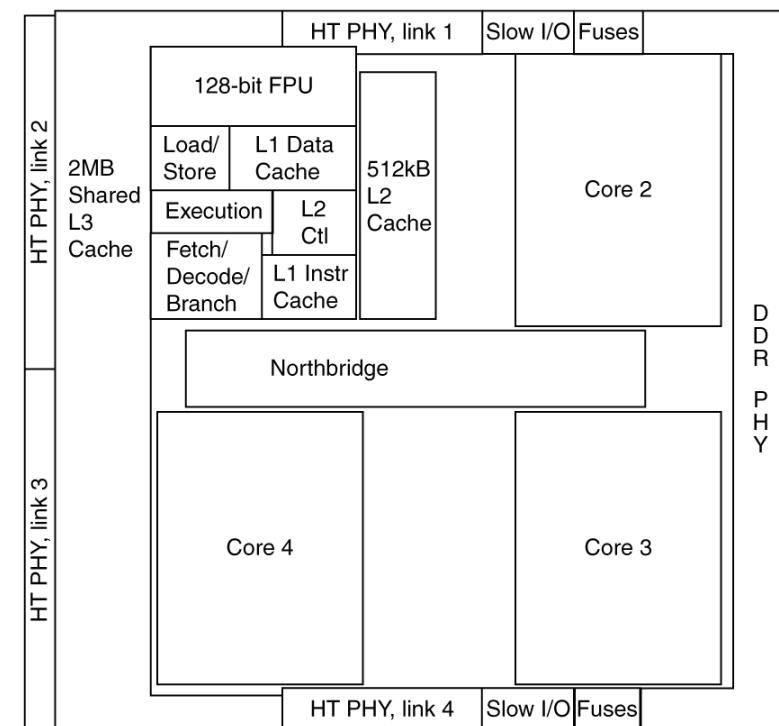
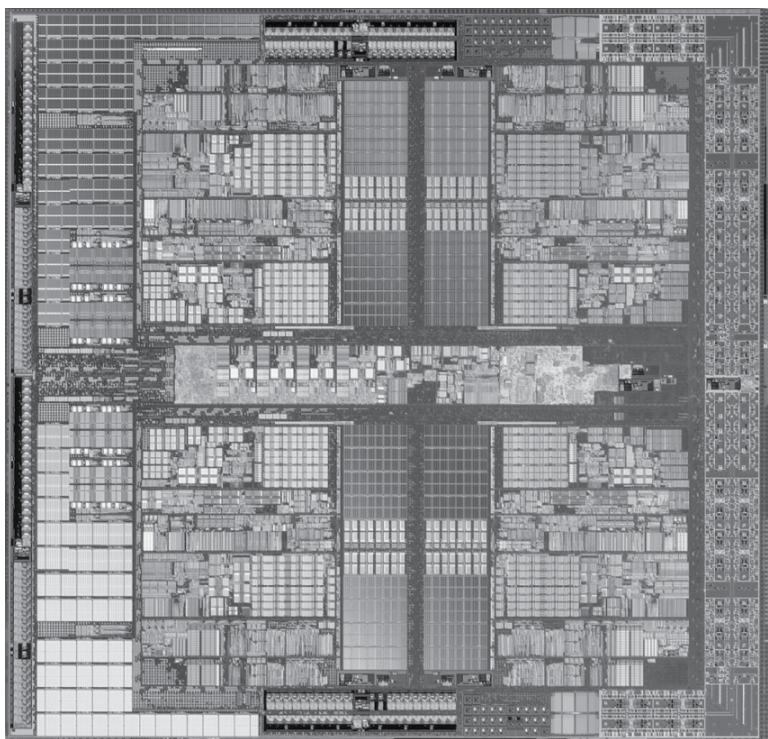


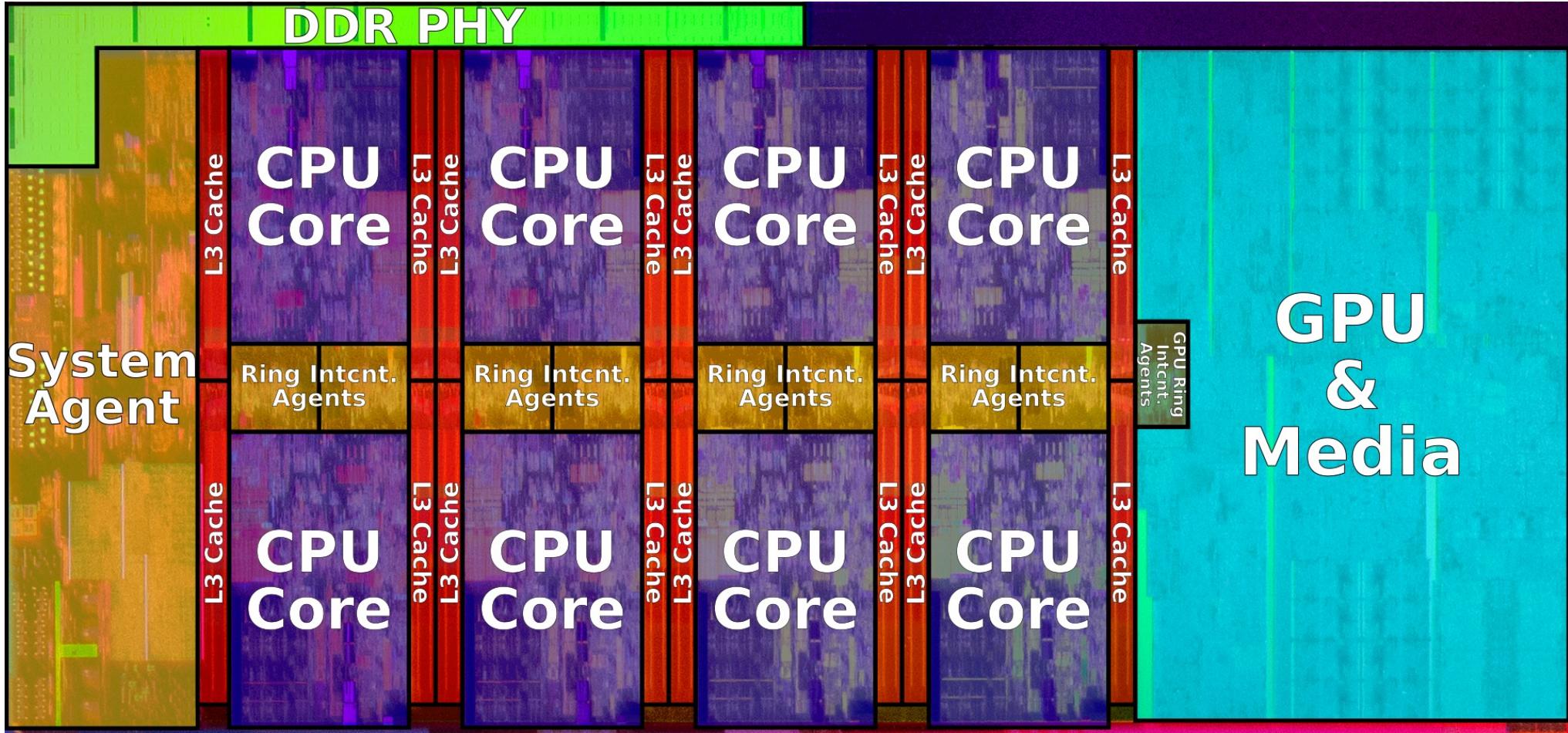
Figure 2-18. A five-level memory hierarchy.

# Inside the Processor

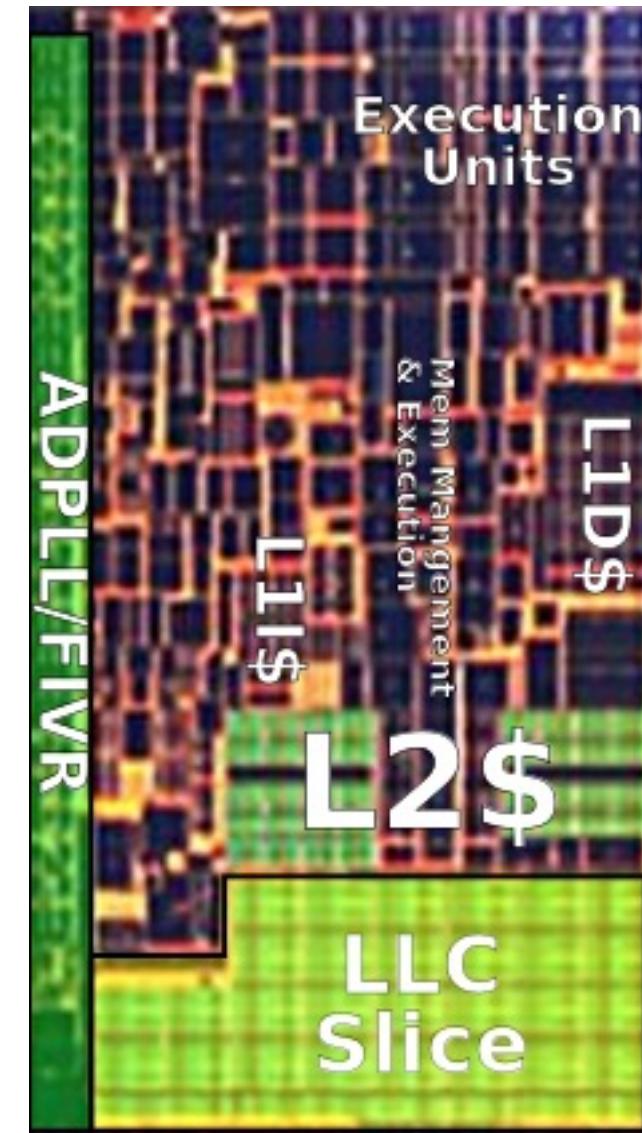
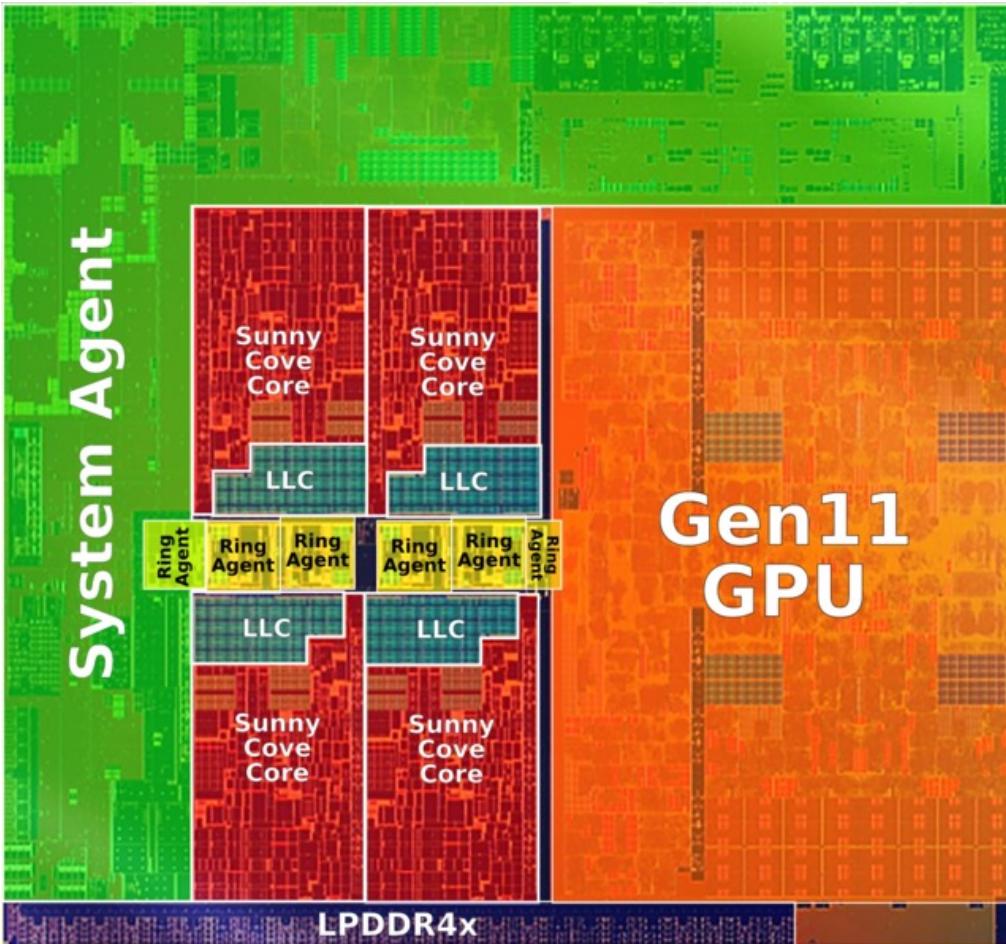
- AMD Barcelona: 4 processor cores



# Inside the Intel Coffee Lake 8-core



# Intel Ice Lake processor die



# What does this mean?

Item#: N82E16819113103



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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

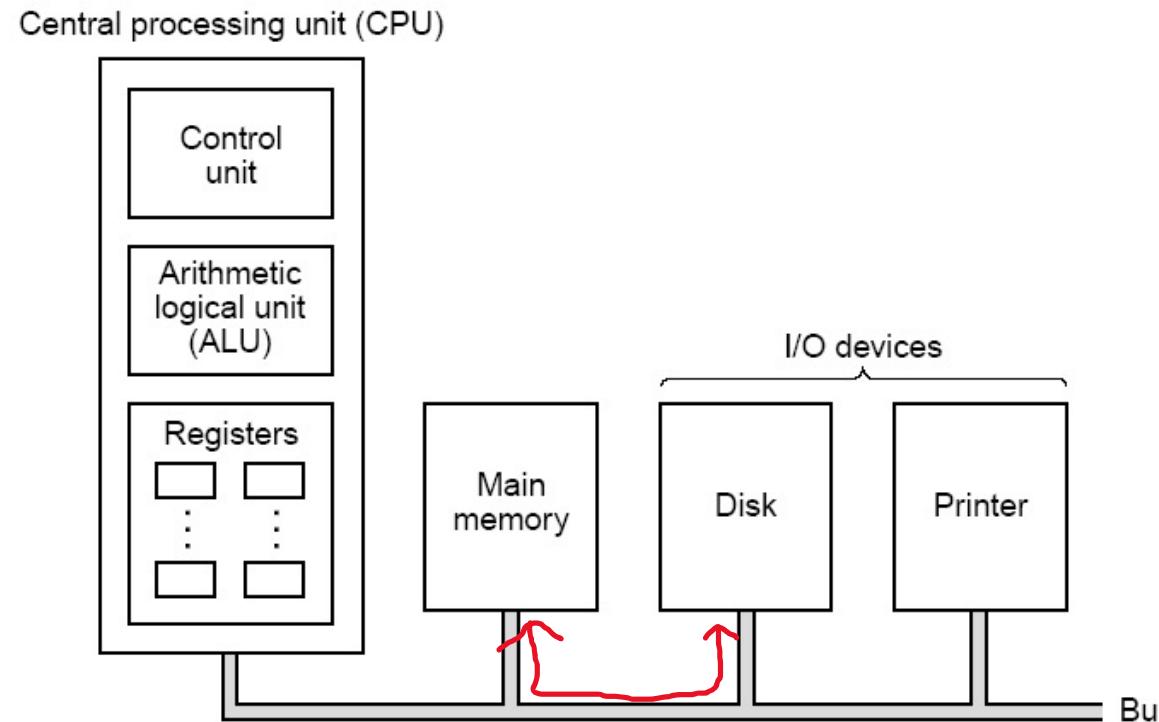
- Instructions are executed in a sequence of operations called the instruction cycle:
  - fetch ( $IR \leftarrow Memory[PC]$ ;  $PC \leftarrow PC+1$ )
  - decode
  - execute
- The instruction cycle is repeated indefinitely, as long as the machine is on.

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