CSCU9A1: Systems 1

Leslie Smith

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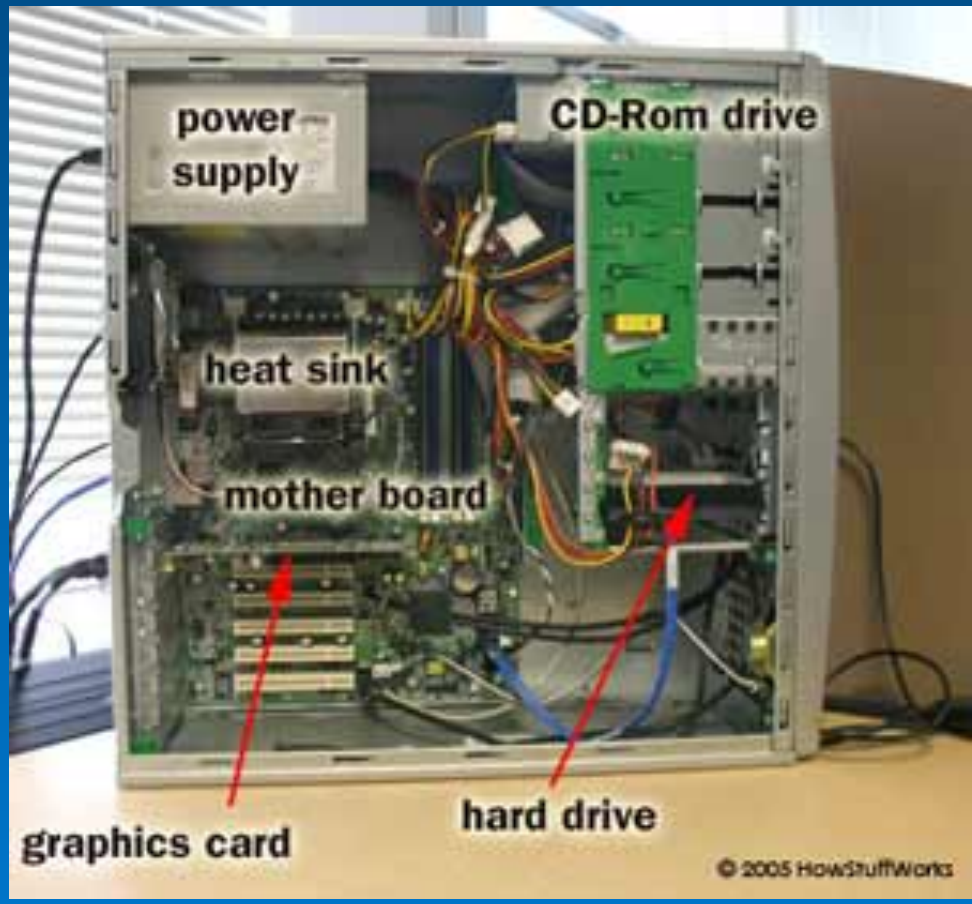
UNIVERSITY OF STIRLING

What's in this lecture

- Hardware architectures
  - Physically: what's in the box of a desktop PC
  - In essence: basic architectural components
  - Fetch/execute cycle
- Software architecture: Onion diagram
- Reading the specifications for a machine
  - And an aside on prefixes from pico to peta

What's in the PC box?

- Inside a fairly standard desktop PC.
- Bottom left is mother board, plus daughter boards
  - Most of computer
- Top left is power supply
- Right is disk drive & optical drive
- Lots of space to allow air circulation for cooling

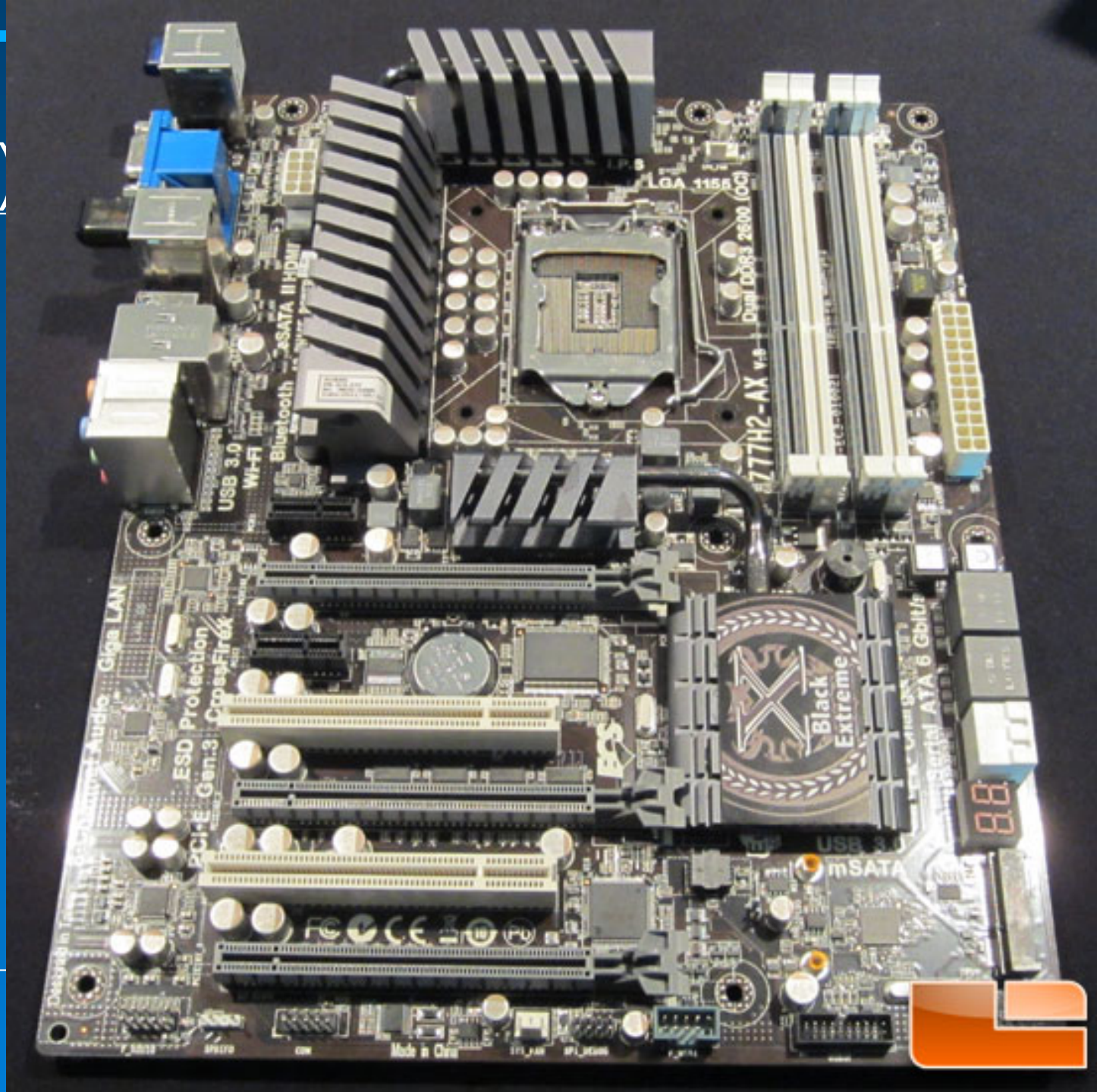


What's in the box (2)

Motherboard (Lenovo 2012)

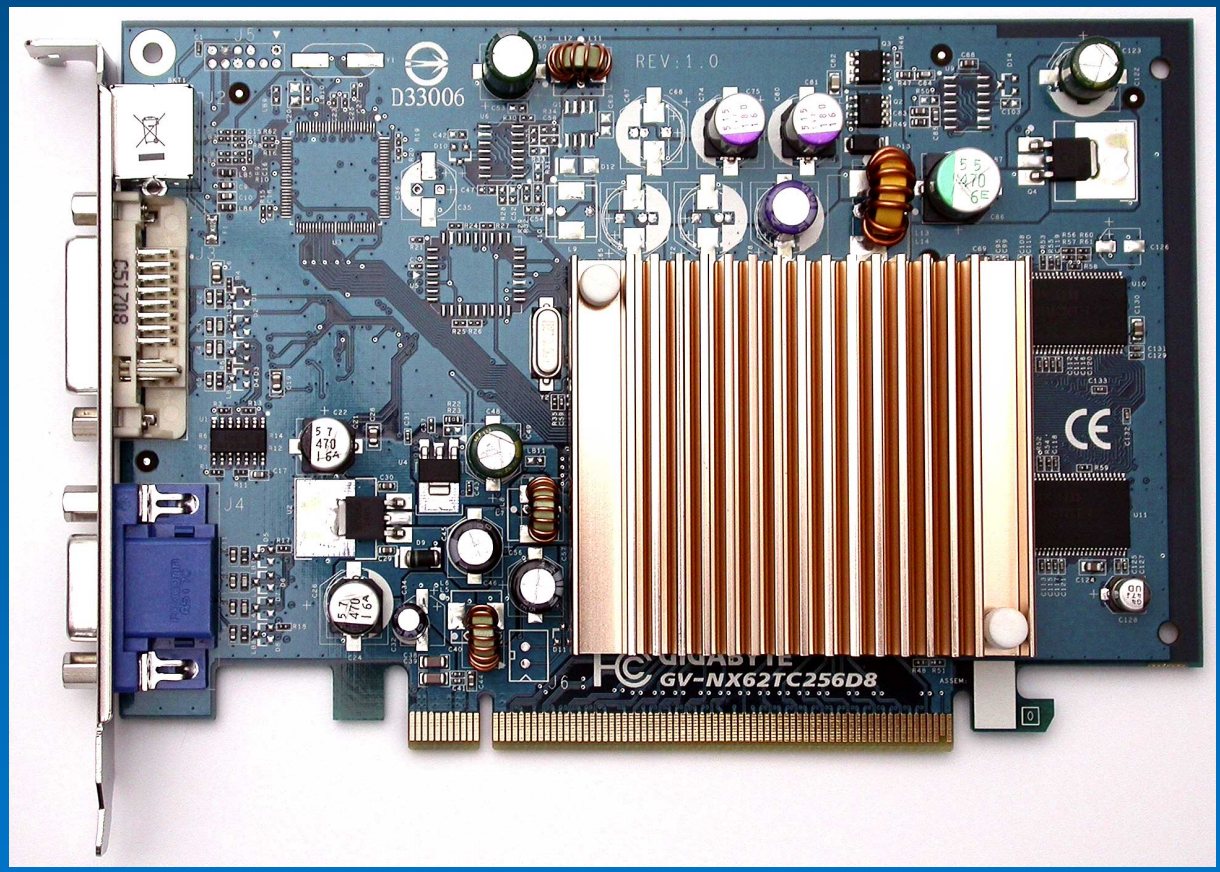
Main elements of computer

Plus connectors for other elements



And daughterboards

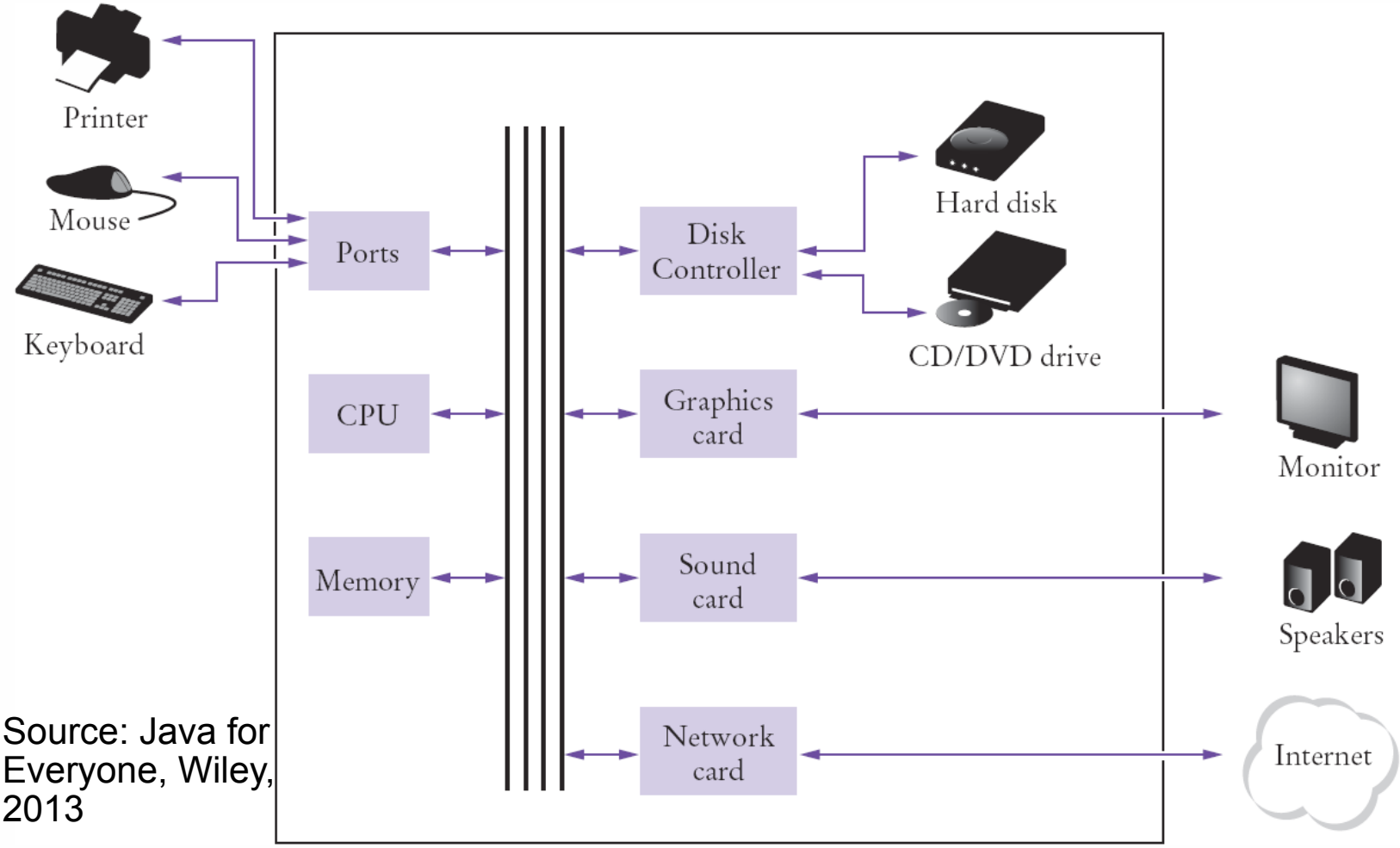
- PCI Express daughterboard
- (this one's a graphics card)
- Other daughterboards for disc controllers, and other peripheral devices



And in a laptop?

- Much less free space!
- Reducing power and removing heat becomes critical.

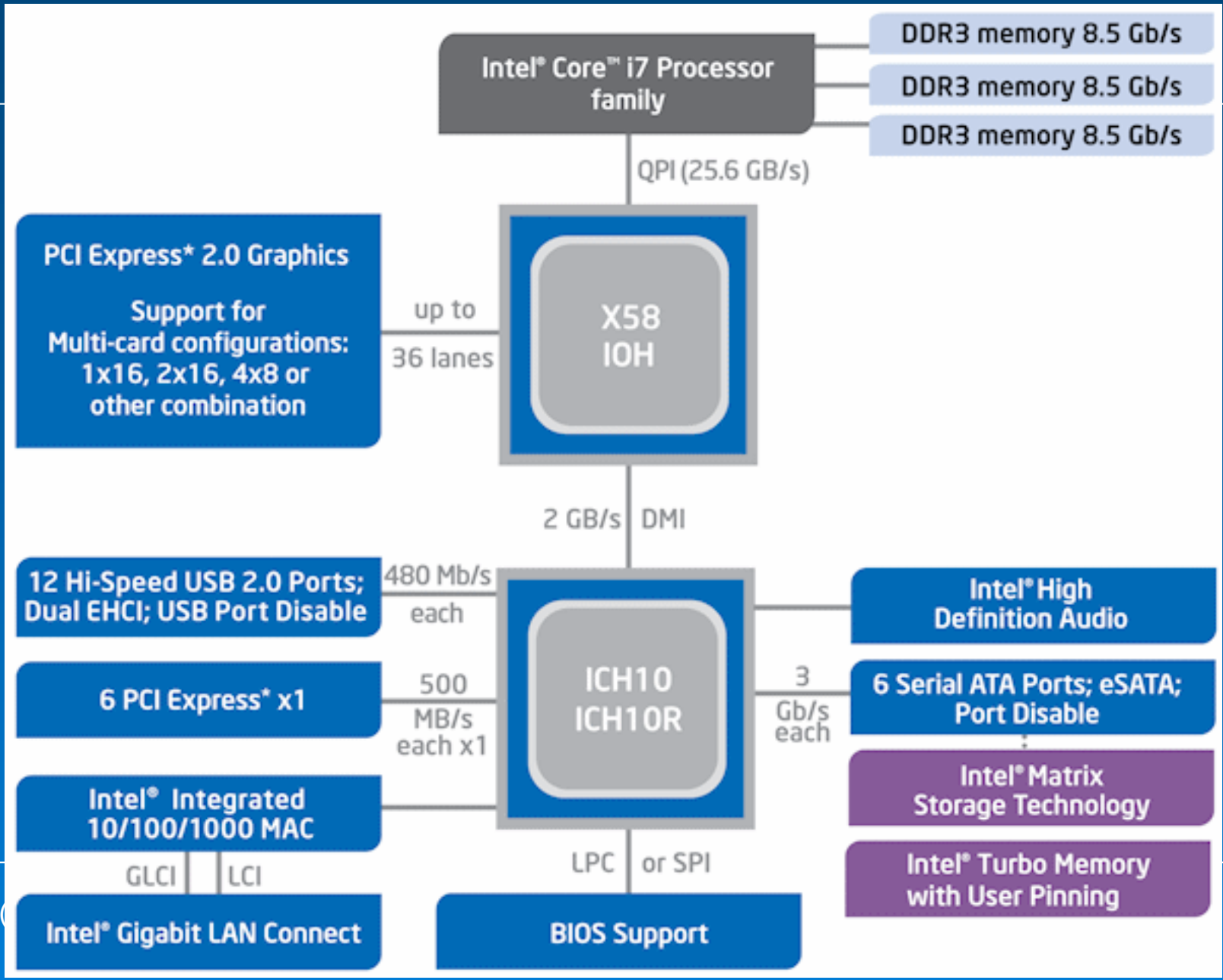
Schematically…



Source: Java for Everyone, Wiley, 2013

Or more precisely…

source:
Intel



Taking a step back …

- Computers have been around for about 60 years
  - There's been a lot of development of what was basically quite a simple concept
  - A *stored program digital computer* carries out instructions sequentially, applying them to data
    - Universal Turing machine (1936: conceptual)
    - Konrad Zuse patents in 1936
    - University of Manchester Small-scale experimental machine (1948)
      - EDSAC (Cambridge (May 6 1949)


MicroVAX 3300
SERVICEANMÄLAN
digital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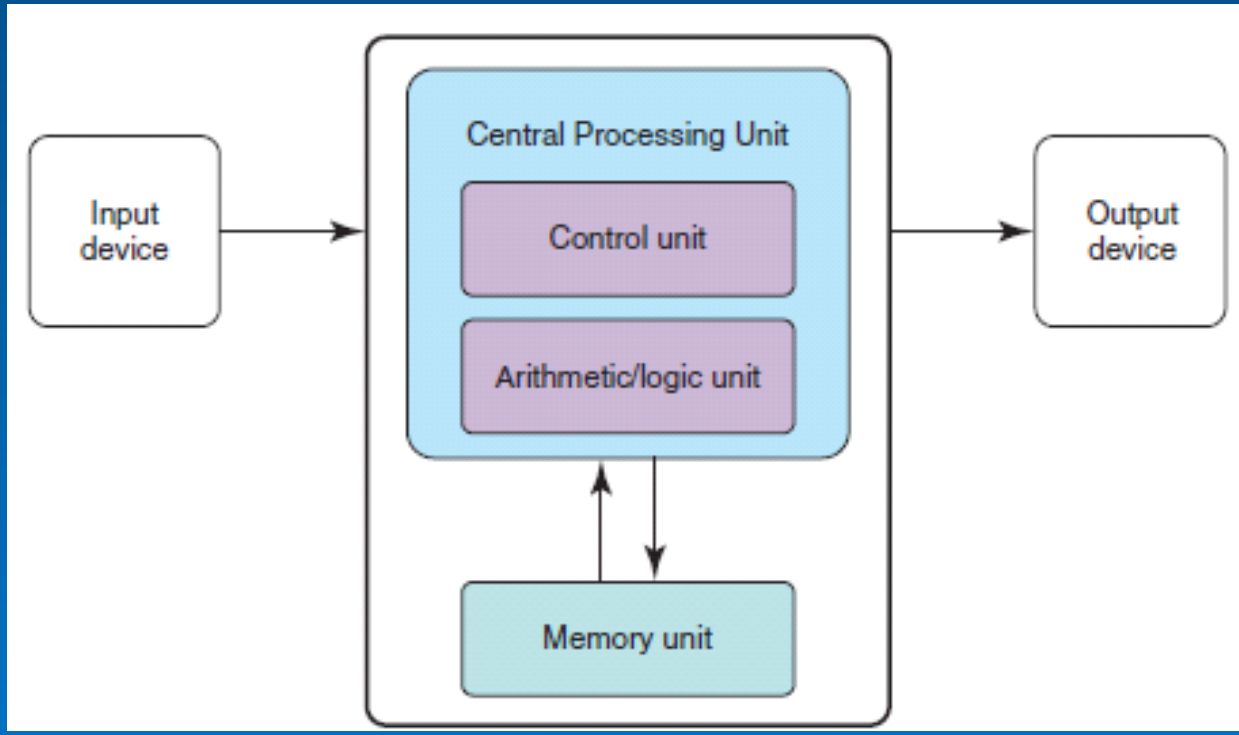
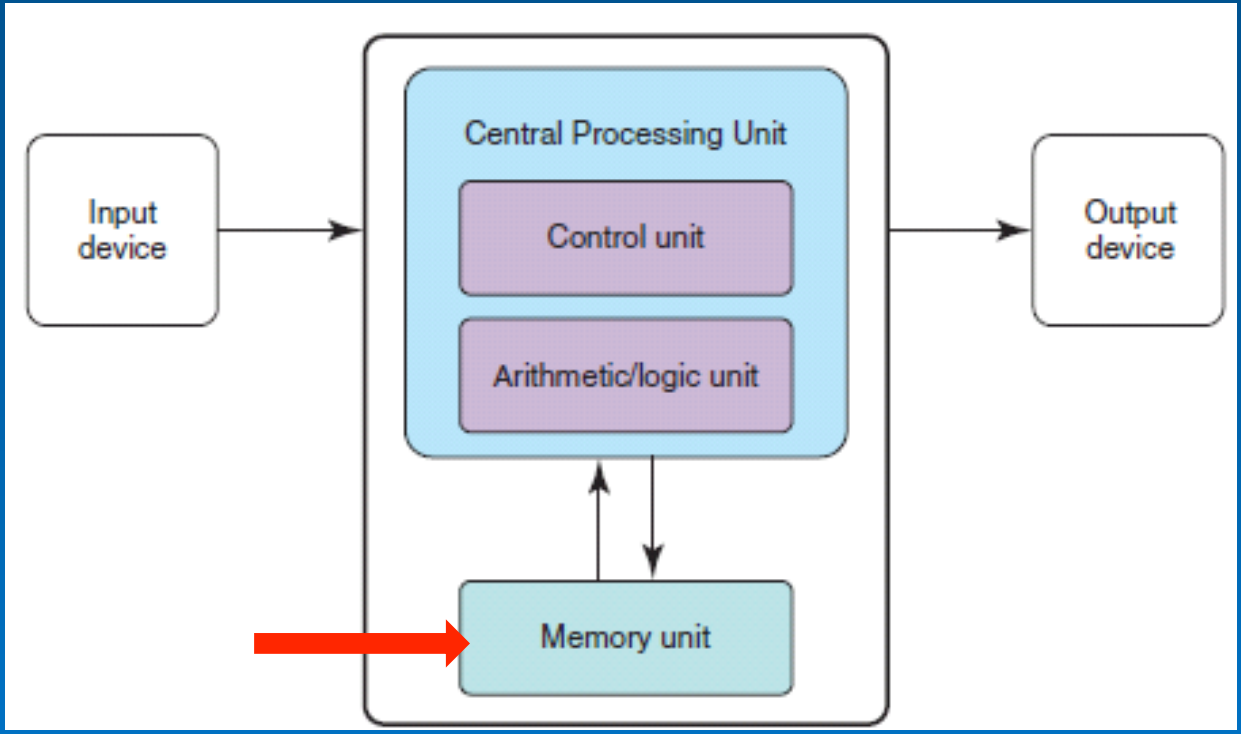
Basic architecture of a computer

- Memory unit contains both **programs** and **data**
- CPU runs the program by executing instructions using ALU.
- Conceptually, this is a **von Neumann** computer
- There are alternative designs, e.g. Harvard architecture: separate memory for data and instructions.



Architectural components: memory



Memory (or Storage): physical view

Here we are talking about RAM (Random Access Memory).

(We shall look at other kinds of memory later.)

Memory: programmer's view

Memory

A collection of cells,

- each with a unique physical address
- Each cell is made up of a number of bits

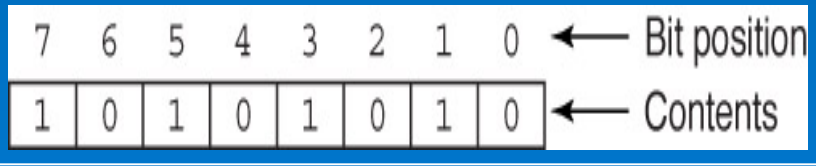
8, 16 24, 32, 64

binary digits (bits)

Addresses start at 0, and are usually contiguous

Both addresses and contents are in binary

Address	Contents
00000000	11100011
00000001	10101001
.	.
.	.
.	.
11111100	00000000
11111101	11111111
11111110	10101010
11111111	00110011



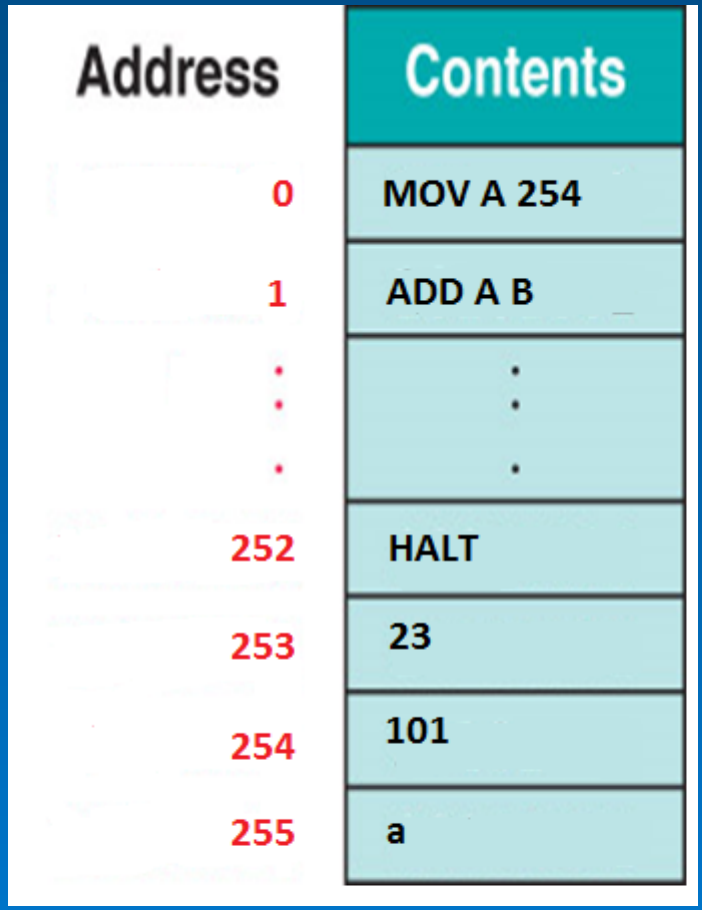
What do the contents mean?

In the von Neumann computer design, memory contains both:

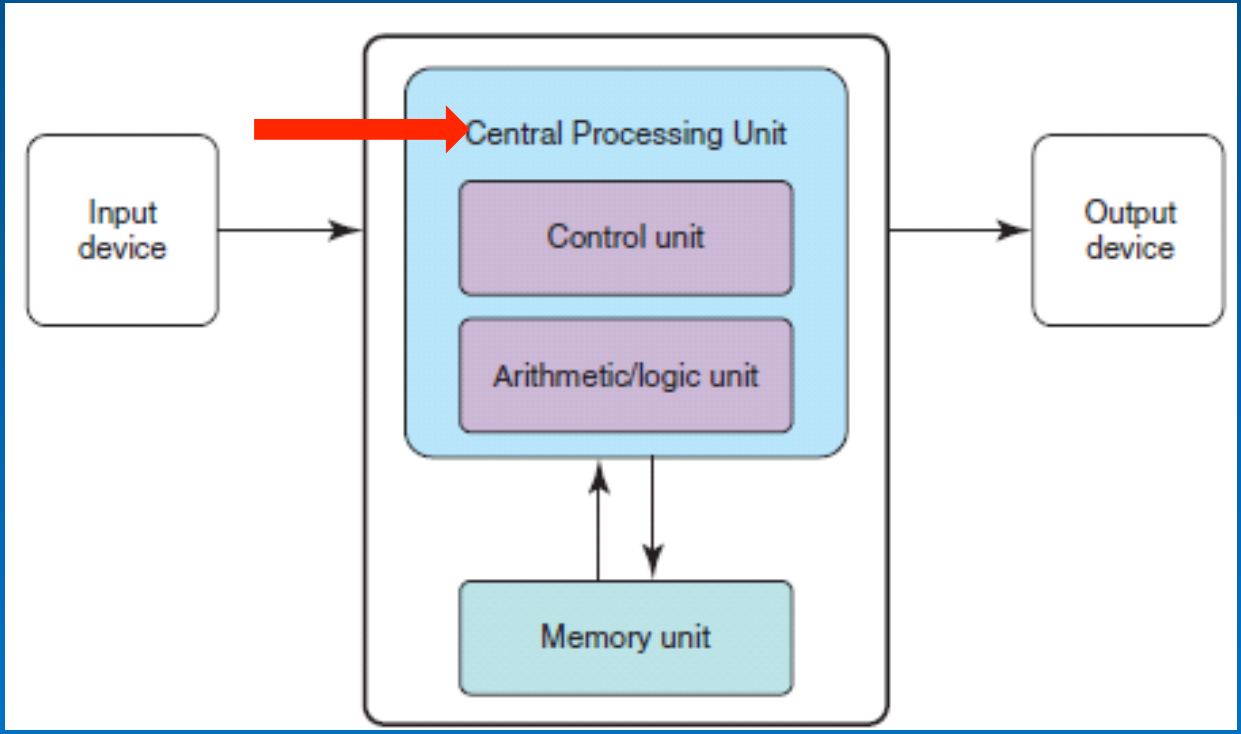
- **instructions** for the programs the computer is running, and…
- **data** used by those programs

Both instructions and data are coded as binary numbers.

The instructions are in **machine code**, an instruction set specific to the type of CPU.



Architectural components: Central processing unit: CPU.



Central Processing Unit (CPU)

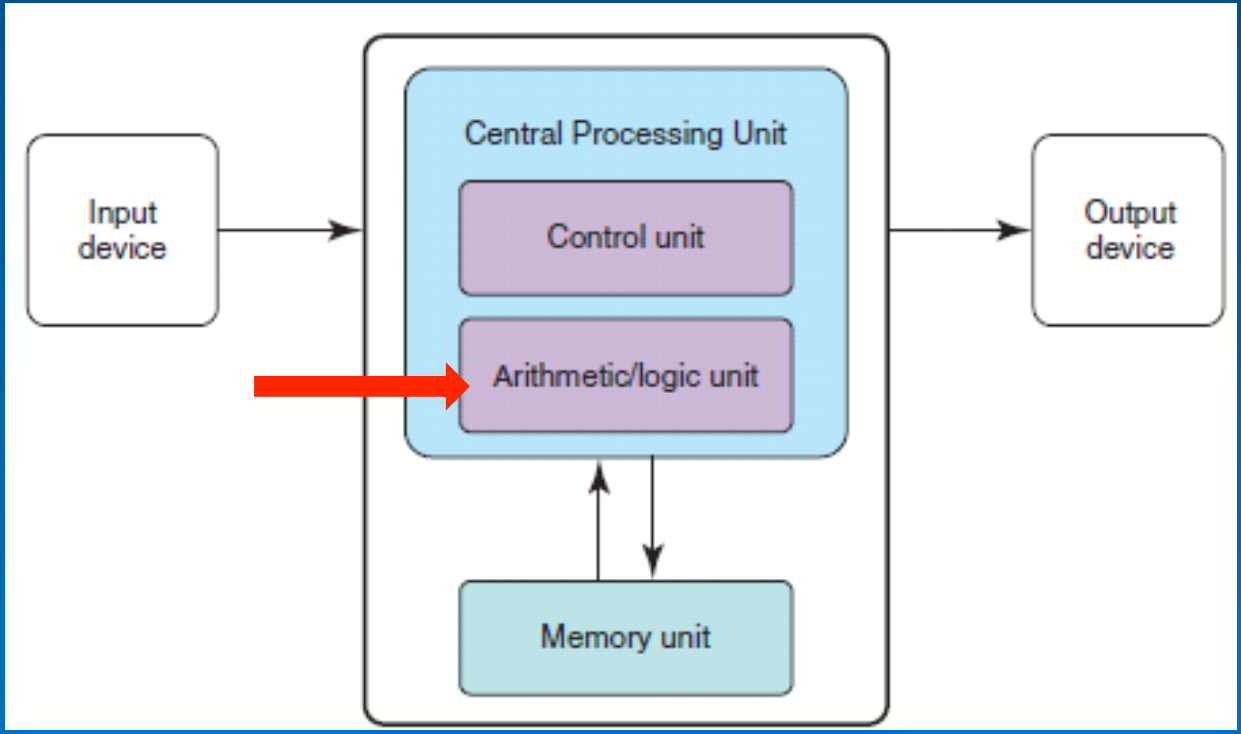
The CPU is where all the action happens when a program is run. Program instructions are loaded one at a time into the CPU and executed.

The CPU contains the Arithmetic and Logic Unit (ALU) and the Control Unit (CU).

The CPU also contains a few special-purpose small, high-speed, memory units called **registers**. These include:

- **Instruction register** (IR)
  - Contains the **instruction** that is being executed
- **Program counter** (PC)
  - Contains the **address** of the next instruction to be executed

Architectural components: Arithmetic and Logical Unit: ALU.



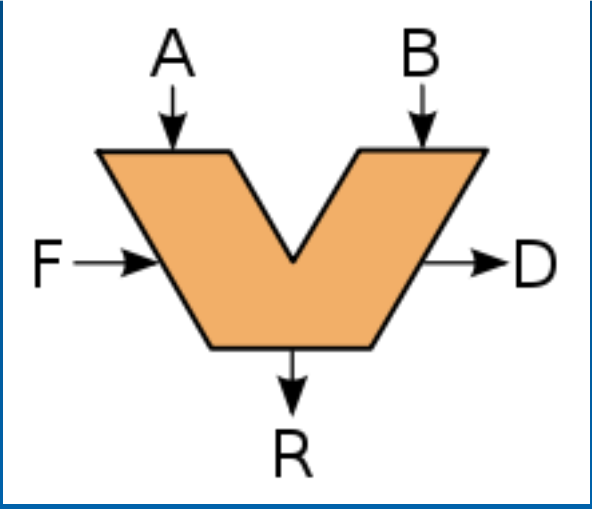
Arithmetic/Logic Unit (ALU)

Performs basic arithmetic operations such as adding, subtracting, etc.

Performs logical operations such as AND, OR, and NOT

ALUs have a small amount of special storage units called **registers**

used in calculations, and in accessing (addressing) memory.



ALU symbol

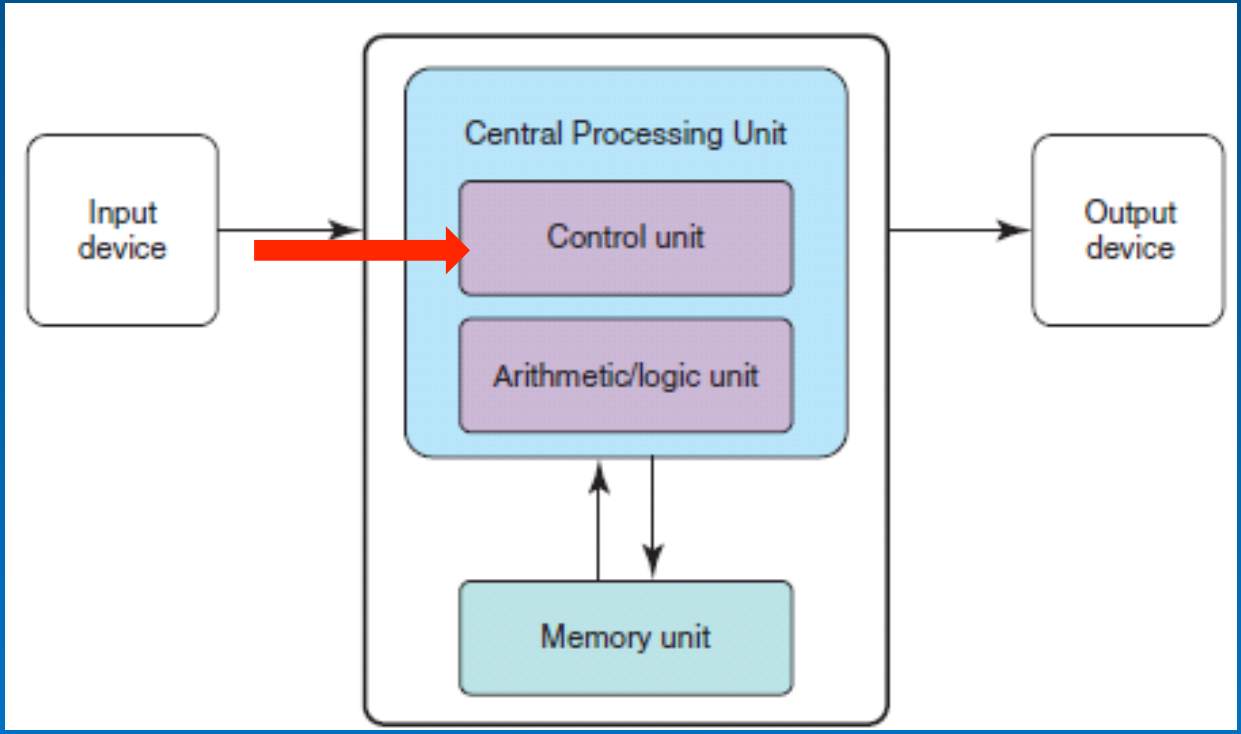
A, B input

R output (Result)

F Function

D Flags

Architectural components: Control Unit.



Control Unit

The Control Unit (CU) is the “boss” of the CPU.

It organizes the sequence of actions carried out by the CPU.

In particular, the Control Unit enforces the “**fetch-execute cycle**” which is the process by which the programs stored in memory are executed.

Central Processing Unit (CPU)

ALU and the control unit together are called the Central Processing Unit, or CPU

Control unit: part of the CPU

Organises how operations are carried out in the CPU

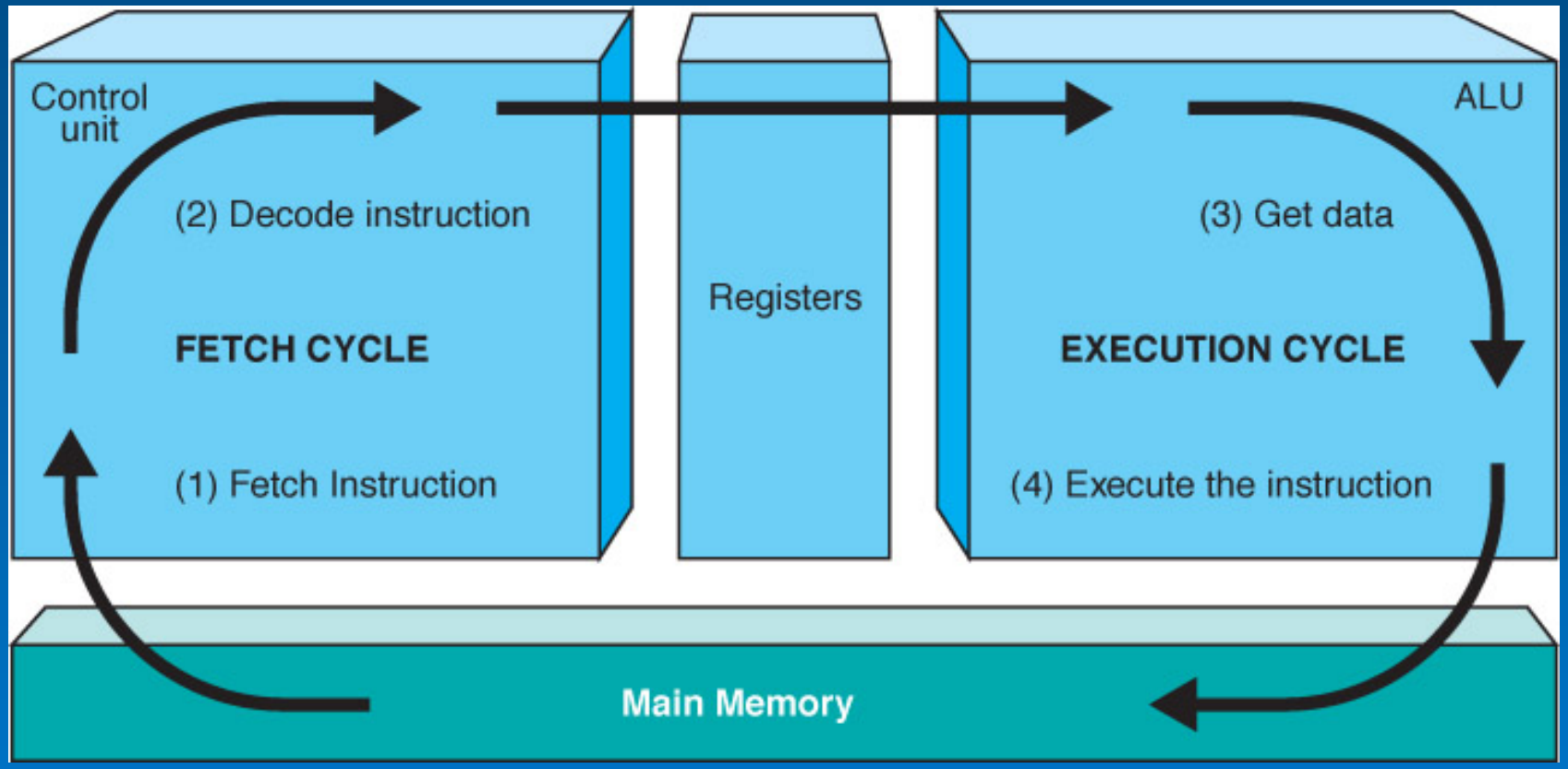
ALU: part of the CPU

ALU: carries out data changing operations

Special Registers in the CPU

- **Instruction register** (IR)
  - Contains the instruction that is being executed
- **Program counter** (PC)
  - Contains the address of the next instruction to be executed

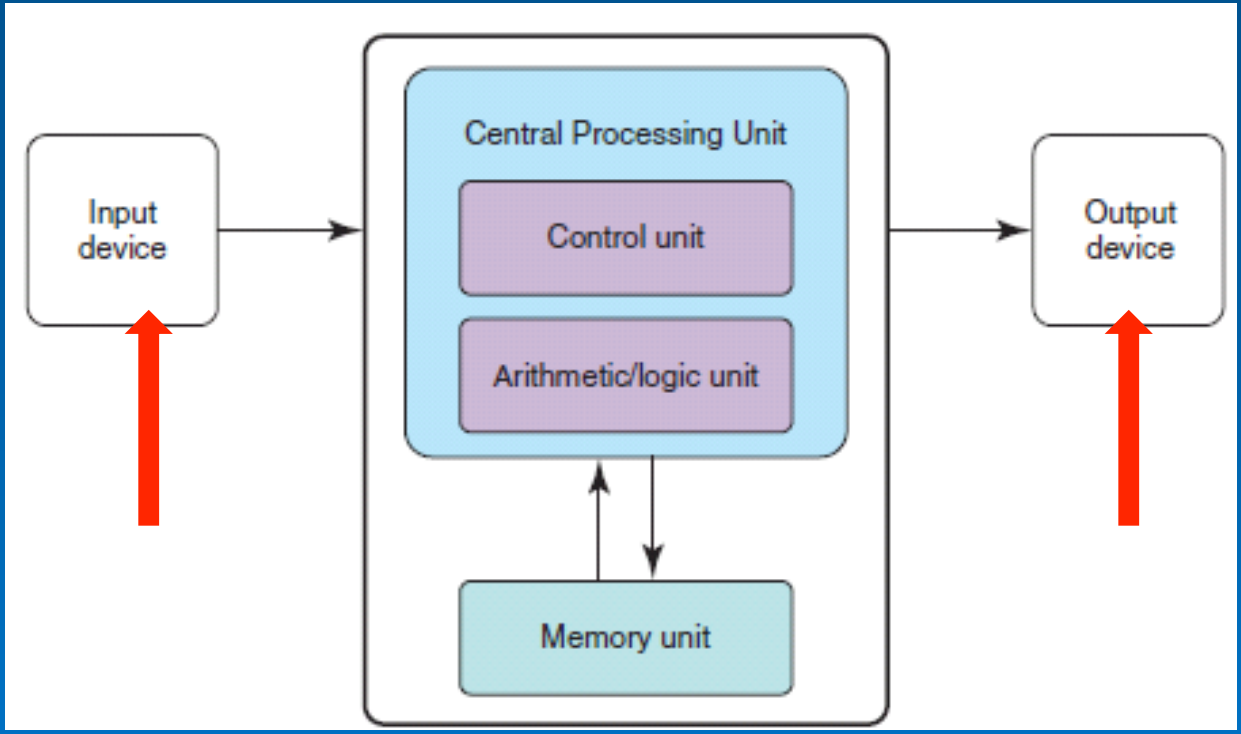
The Fetch-Execute Cycle



But how does it all work together?

- The control unit loads the next instruction …
  - From the address in the PC register
- … into the instruction register
- The control unit organises the execution of the instruction
  - Perhaps updating other registers and memory as part of this
  - Normally includes incrementing the PC register
- (repeat from start)

Architectural components: Input and output devices.



Input/Output devices

Input Unit

A device through which data and programs from the outside world are entered into the computer;

Can you name three examples?

Output unit

A device through which results stored in the computer memory are made available to the outside world

Can you name two examples?

Reading the PC specifications

- If you're considering buying a machine, you need to understand the specifications of the machine
  - To ensure that it is fit for purpose
  - To know what you are paying for (!)
  - (To enable bragging rights about the machine you have just purchased)

Example: Dell XPS 13 notebook

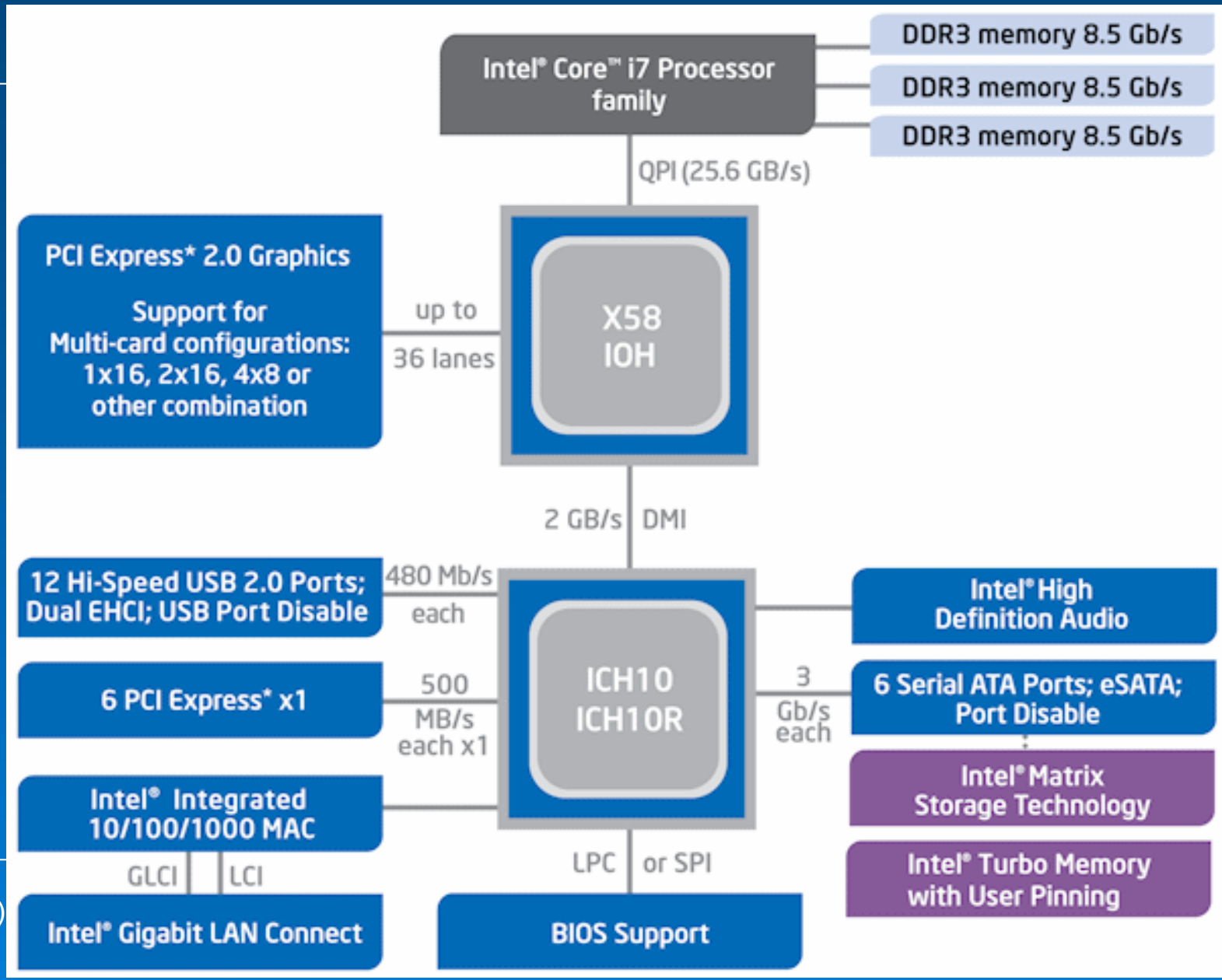
- Processor: 5th Generation Intel® Core™ i7-5500U processor (up to 3.0 GHz, 4M Cache)
- Operating System: English Windows® 10 Professional or Windows 8 (64 bit)
- Display: 13.3-inch UltraSharp™ QHD+ (3200 x 1800) InfinityEdge touch display
- Memory: 8GB DDR3L-RS SDRAM at 1600MHz
- Hard Drive: 256 or 512GB Solid State Drive
- Video Card: Intel HD Graphics 5500
- USB 3 ports (2 off), 3-in-1 Card Reader (SD, SDHC, SDXC)

Modern architecture… again

source: Intel

QPI: Quick path interconnect

DMI: Direct Media Interface



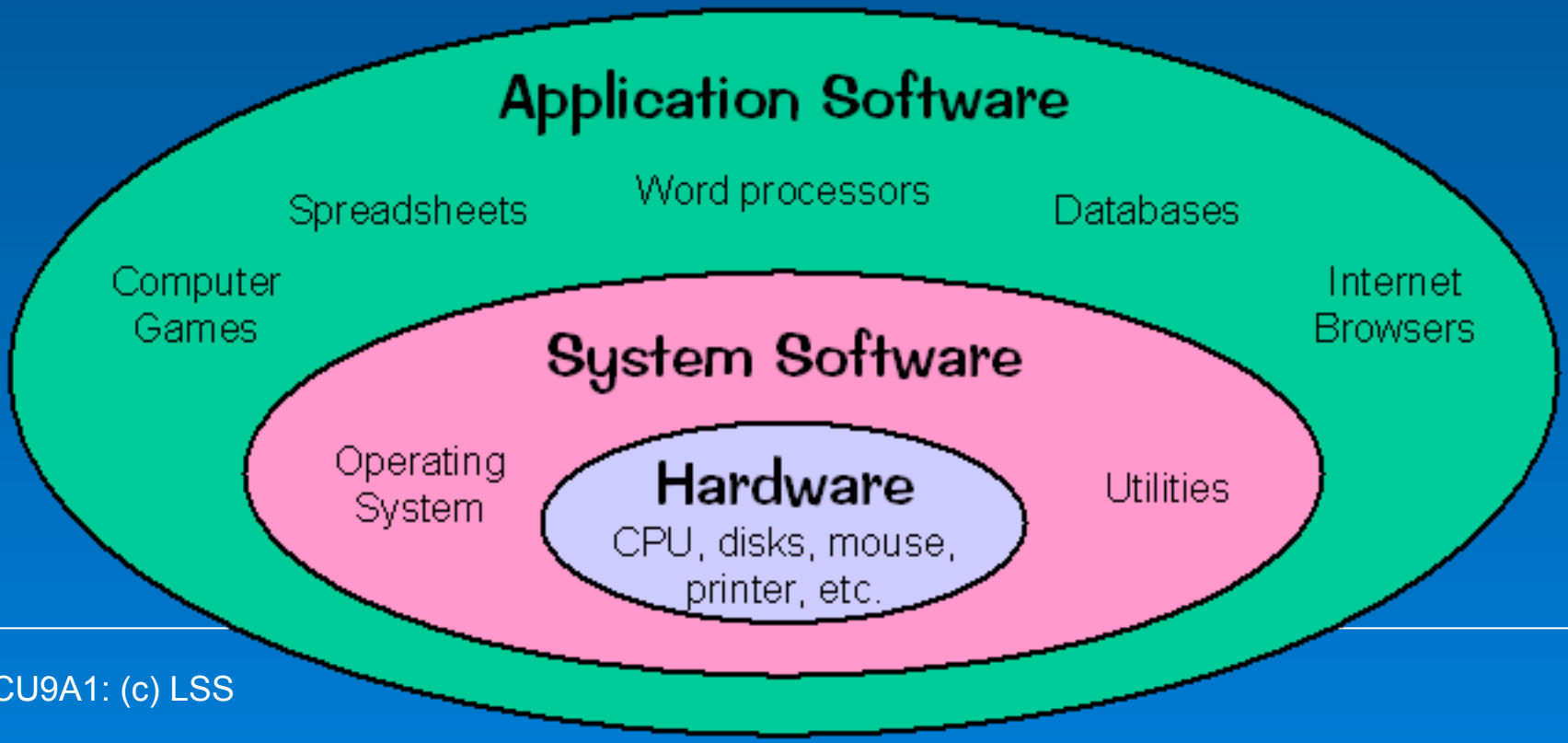
Addendum: size prefixes

Power of 10	Power of 2	Value of Power of 2	Prefix	Abbreviation	Derivation
10^{-12}			pico	p	Italian for little
10^{-9}			nano	n	Greek for dwarf
10^{-6}			micro	μ	Greek for small
10^{-3}			milli	m	Latin for thousandth
10^{3}	2^{10}	1024	kilo	K	Greek for thousand
10^{6}	2^{20}	1,048,576	mega	M	Greek for large
10^{9}	2^{30}	1,073,741,824	giga	G	Greek for giant
10^{12}	2^{40}	1,099,511,627,776	tera	T	Greek for monster
10^{15}	2^{50}	$1.125899*10^{15}$	peta	P	Greek prefix for five

- Note that 10^3 is approximately equal to 2^{10}
  - 1000 is approximately equal to 1024
  - 1Km = 1000 m, but 1Kbyte = 1024 bytes!
- Note that there are others too: atto, femto, … exa, zetta

Software architecture (1)

- Much of the development over the last 60 years has been in software
- Layers of software: onion diagram



Software architecture(2)

- Hardware:
  - Although primarily electronic, modern devices are often themselves programmed: hence software even here
- System Software
  - BIOS (Basic input/output software)
  - Operating System (Linux, Windows 8, Mac OSX, etc.)
- Application software
  - The software you actually work with: office, chrome, games, etc.