Introduction to Computer Science:

Computer Components

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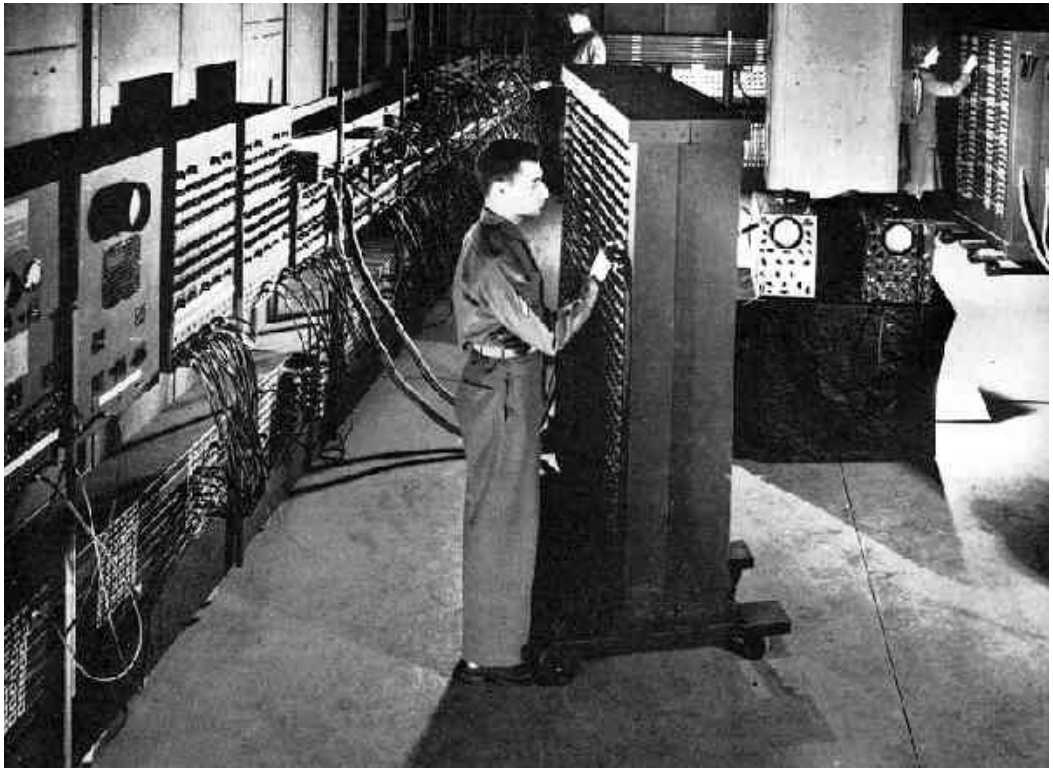
Review

- Two’s complement for integer representation
  - Assume : 5-bits
  - Range of two’s complement numbers ?

    - Binary sequence 00000 ~ 11111
    - Unsigned integer 0 ~ 31

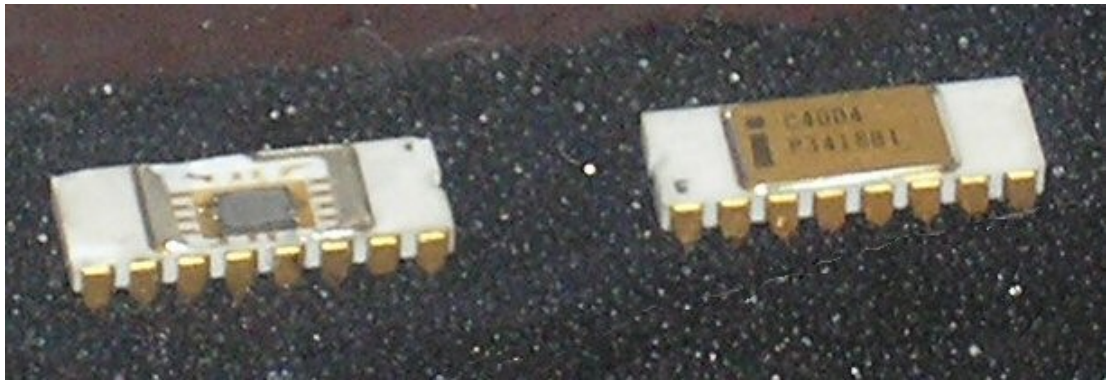
    - Two’s complement : positive (non-negative)
      - 00000 ~ 01111, 0 ~ 15
    - Two’s complement : negative
      - 11111 ~ 10000, -1 ~ -16

'ENIAC' (Electronic Numerical Integrator and Computer) - 1946



Intel chip -1971

The 4004 microprocessor



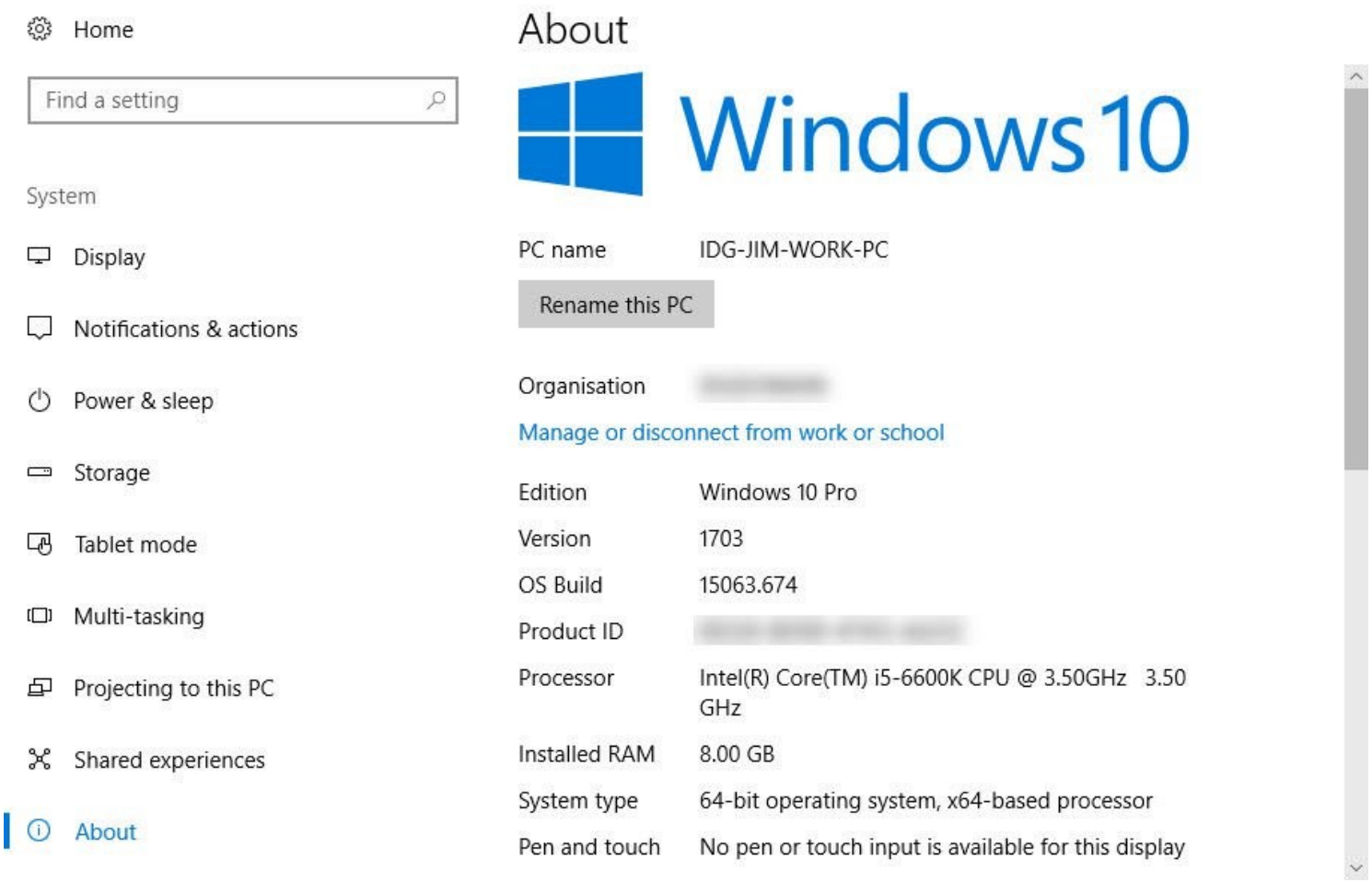
Today's Computer

Today's Computer

- Datacenter as a Computer
  - "we must treat the datacenter itself as one massive warehouse-scale computer (WSC)." (Google)

Computer Components

- **Processor**
- **Memory**
- **Storage**
- Input/Output (Mouse, Keyboard, Display)
- Multimedia(Audio, Graphics and Video Support)
- Connection and Expansion
- Battery and Power
- Communication
- :
- :



https://www.techadvisor.co.uk/how-to/pc-components/computer-specs-3512328/

Processor Specs

- *Intel Core i5 7200U 2.5GHGz*

- Intel : Manufacture
- Core i7, i5, i3 : family brand of chips
  - Higher, mid, lower range performance
- 7200U : chip model
  - 7 is the seventh generation (generation indicator)
  - 200 represents the performance
  - U : purpose of chip (product line) – for laptops and mobiles “ultra-low power”
    - K (high clock speed), G (built-in Graphics processor)
- 2 Cores : the number of physical cores that make up the processor
- 2.5GHz : chip standard (and boosted) frequency
  - Clock speed : Clock beats 2.5 billion times per second
  - E.g., 64bit processor can work on (manipulate) 64 bits at a time

Sizes in Perspective

- Time, Speed, Storage

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}	not enough room	tera	T	Greek for *monster*
10^{15}	2^{50}	not enough room	peta	P	Greek prefix for *five*

Processor

- What is a CPU and what does it do? Central Processing Unit (CPU), often just “Processor” is the ‘brain’ of the computer, it lets the other components of the computer know what they have to do
- Why do I need one? Having a better CPU (measured in GigaHertz) greatly improves the overall speed of your computer. The faster the processors speed, the more calculations your computer can do in a short space of time.
- What is available and what are the benefits of each?
  - Single Core Processors: one “core” allowing to process sets of instructions as they are transmitted to the CPU.
  - Dual Core processors: 2 “Cores” allowing to process of multiple instructions at the same time.
  - Quad Core Processors ?

Intel x86 Processors

- Dominate laptop/desktop/server market
- Evolutionary design
  - Backwards compatible up until 8086, introduced in 1978
  - Added more features as time goes on
- **Complex** instruction set computer (CISC)
  - Many different instructions with many different formats
  - Hard to match performance of **Reduced** Instruction Set Computers (RISC); but, Intel has done just that!

Intel x86 Evolution: Milestones

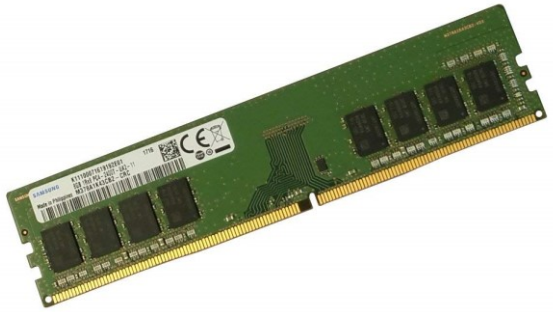
Name	*Date*	*Transistors*	*MHz*
• 8086	1978	29K	5-10
• First 16-bit Intel processor. Basis for IBM PC & DOS			
• 1MB address space			
• 386	1985	275K	16-33
• First 32 bit Intel processor, referred to as IA32			
• Added “flat addressing”, capable of running Unix			
• Pentium 4E	2004	125M	2800-3800
• First 64-bit Intel x86 processor, referred to as x86-64			
• Core 2	2006	291M	1060-3500
• First multi-core Intel processor			
• Core i7	2008	731M	1700-3900
• Four cores			

CPU, Cores, Hyper-Threading

- Modern CPUs offer features like **multiple cores** and hyper-threading
  - CPU with multiple cores can run multiple programs (processes) at the same time
- **Cores** : operate as separate processors within a single chip; read and execute program instructions individually
  - Why Multi-Cores than a single core ? Processor manufactures can increase the performance of a CPU without raising the processor Clock Speed (which is limited).
- CPU has two physical cores but can process four threads simultaneously through ***hyper-threading***. In reality, one physical core can only truly run one thread at a time, but using hyper-threading, the CPU exploits the idle stages in the pipeline to process another thread (e.g., virtual core)
  - Intel CPUs with two cores use hyper-threading to provide four threads

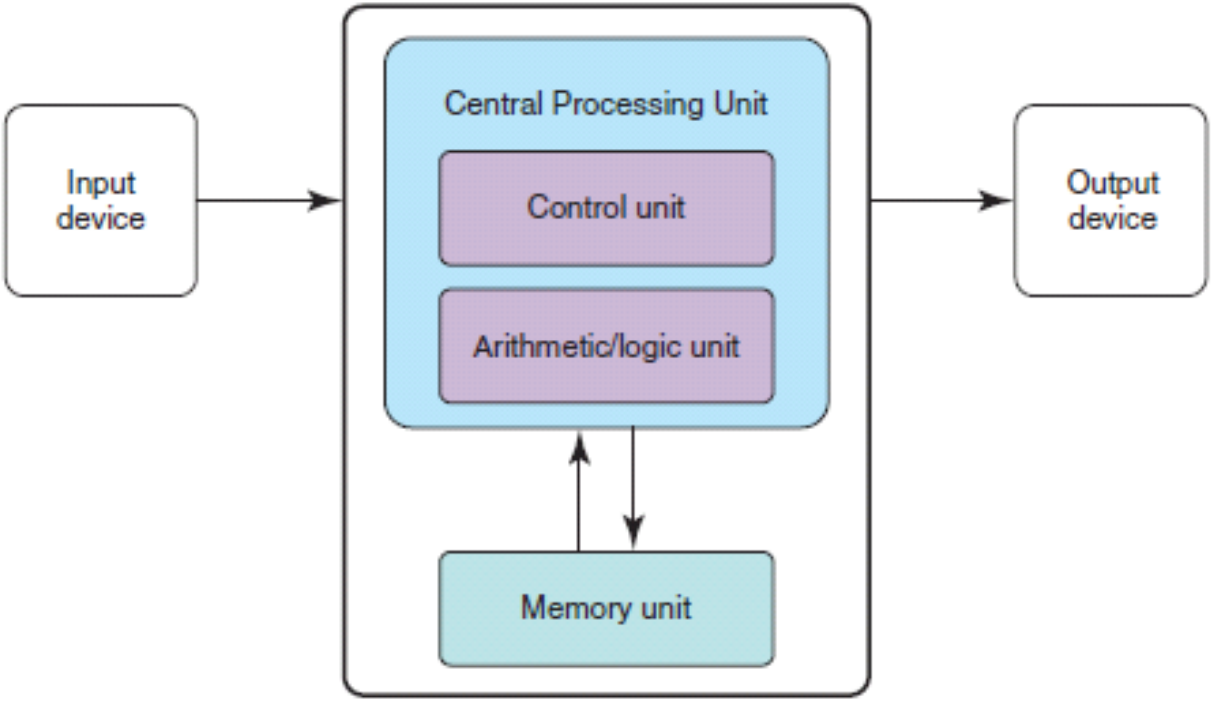
Memory

- RAM stands for **Random Access Memory.**
- Why do I need one? The more RAM your computer has, the quicker it can access your programs and files.
- Types:
  - SDRAM: Synchronous dynamic random access memory
  - DDR: Double Data Rate RAM. It is used in most computers and is faster than older SDRAM types.
  - DDR2, DDR3 …: Newer styles of DDR RAM which boasts extra performance due to the increased speed at which it runs.
- e.g., *SAMSUNG 8GB DDR4 PC4-19200*
  - 8GB : 8 * 2^30 bytes
  - PC4 : generation
  - 19200 : bandwidth in megabytes per sec.
    - 19200MB/s

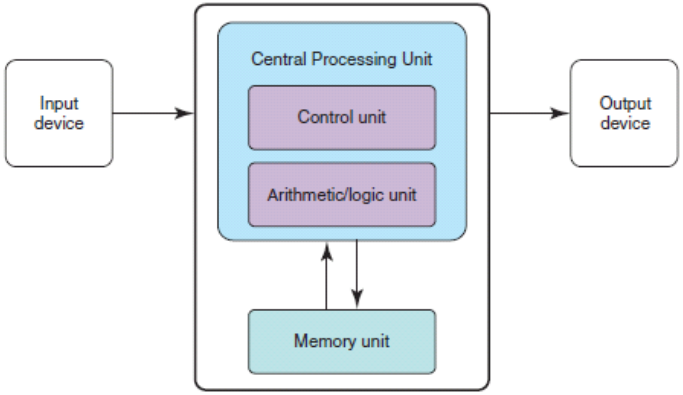


Stored-Program Concept

- von Neumann Architecture (John von Neumann)
  - Stored program computer : can carry out different tasks, once stored
  - Data and code instructions are all in the same place, and treated as same
  - Three basic units : CPU, Memory, Input/Output



Memory



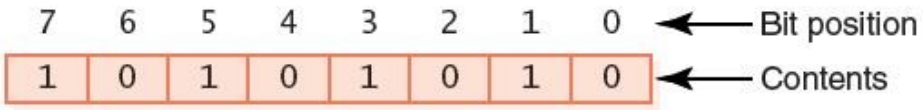
Memory

A collection of cells, each with a unique physical address

Most computers are **byte-addressable**

Cells at address 11111110 contains 10101010

"Little endian" bit numbering:



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

Memory

Memory

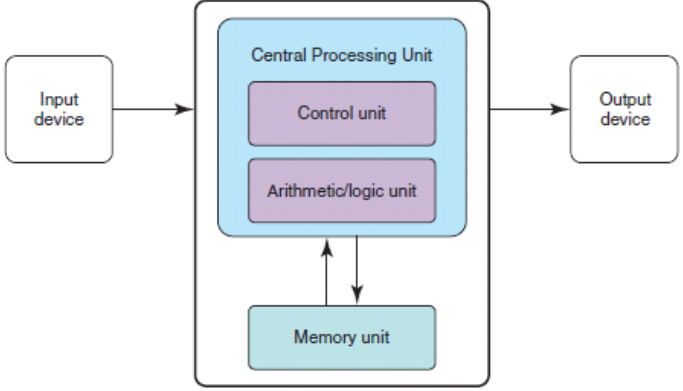
What does 10101010 mean?

No way to answer that …

Could be an instruction, a natural number, a signed integer, a character, part of an image, …

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

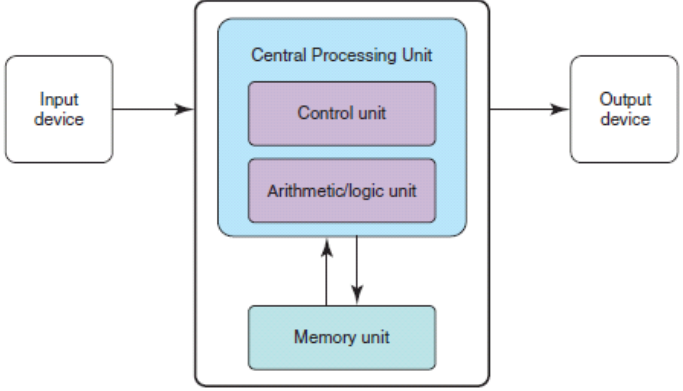
Arithmetic/Logic Unit



- Performs basic **arithmetic** operations such as addition and subtraction
- Performs **logical** operations such as AND, OR, and NOT
- Most modern ALUs have a small amount of special storage units called **registers** that can be accessed faster than main memory

- Word : historically, word length was “the number of bits processed at once by the ALU”
- But, Intel’s word length 16 bits, and the processor can work on **double (long) words** (32 bits), **quad words** (64 bits)

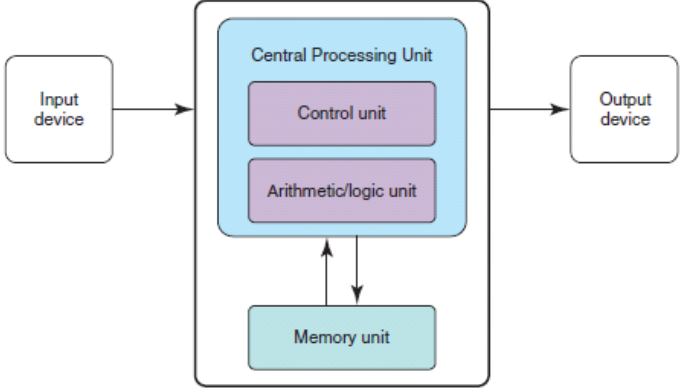
Control Unit



- **Control unit** : The organizing force in the computer
  - directs all input and output flow, fetches code for instructions and controlling how data moves around the system.
- **Instruction register** (IR) : Contains the instruction that is being executed (or CIR)
- **Program counter** (PC) : Contains the address of the next instruction to be executed

- **Central Processing Unit (CPU)** : ALU and the control unit

Input/Output Units



- **Input Unit:** A device through which data and programs from the outside world are entered into the computer
- **Output unit**: A device through which results stored in the computer memory are made available to the outside world

Flow of Information

Bus: A set of wires that connect all major sections

- In general: A communication system that transfers data between components inside a computer or between computers; the medium (wires, optical fiber, etc.) and the protocols (rules for sharing the medium nicely)

- The **bus**: Connects the CPU, main memory, I/O devices, and possibly other components (e.g. hard disk drive)

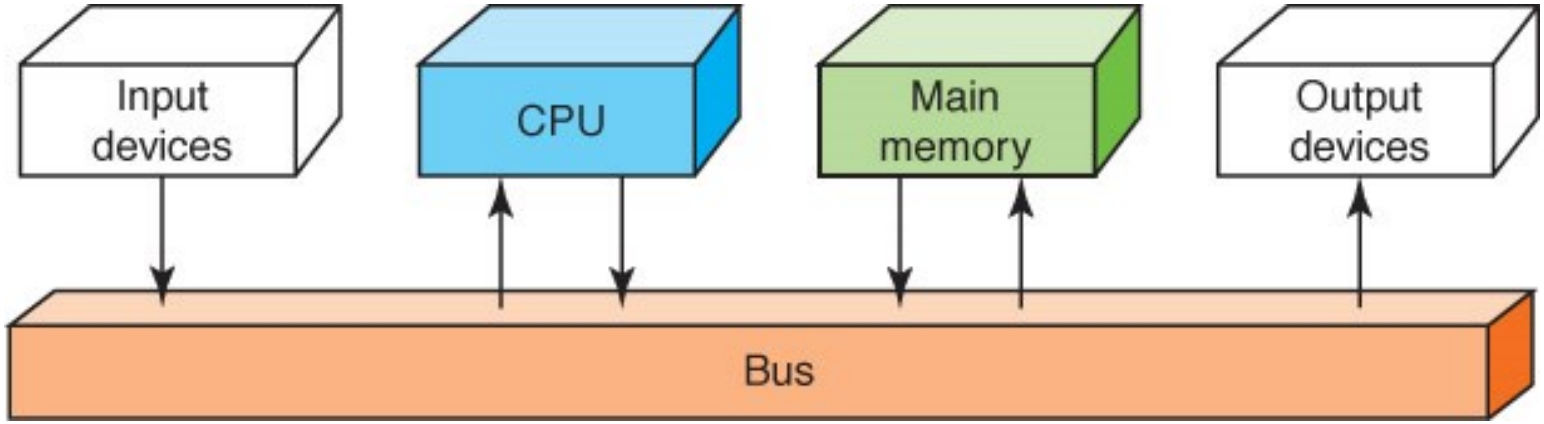
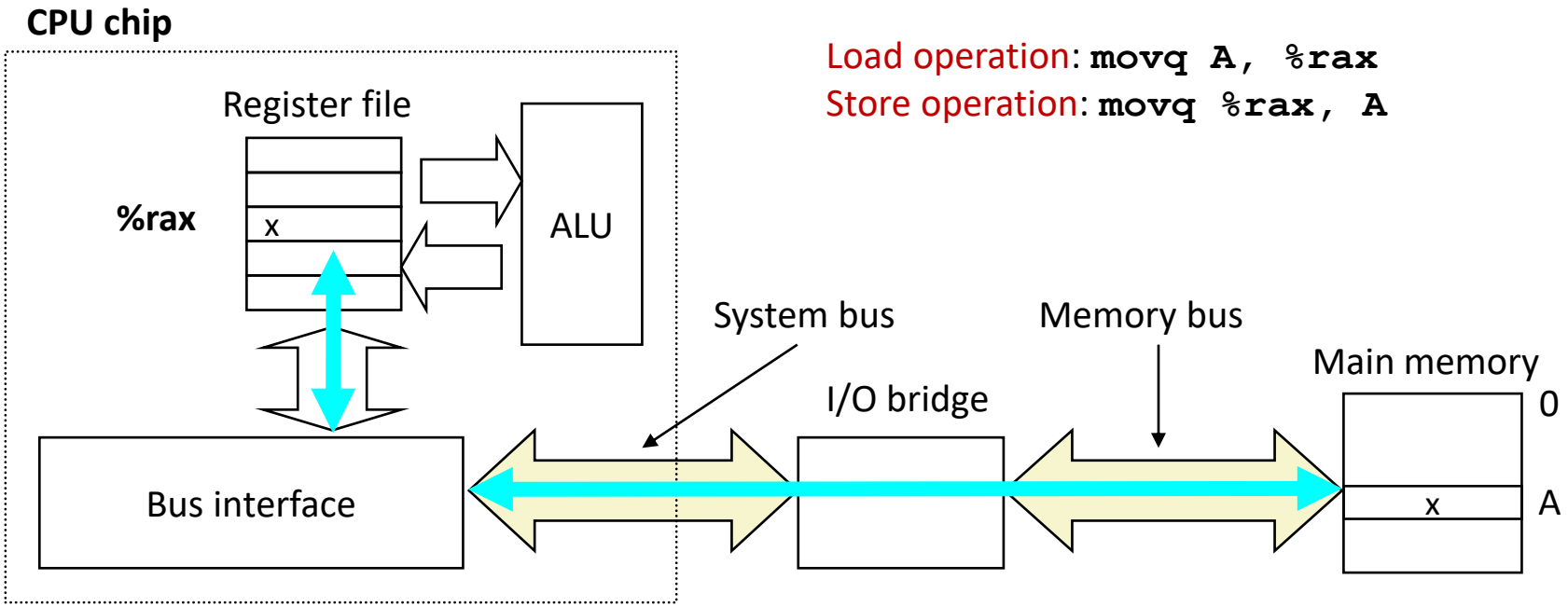


Figure 5.2 Data flow through a von Neumann architecture

Connecting CPU and Memory

- Traditional bus structure between CPU and memory

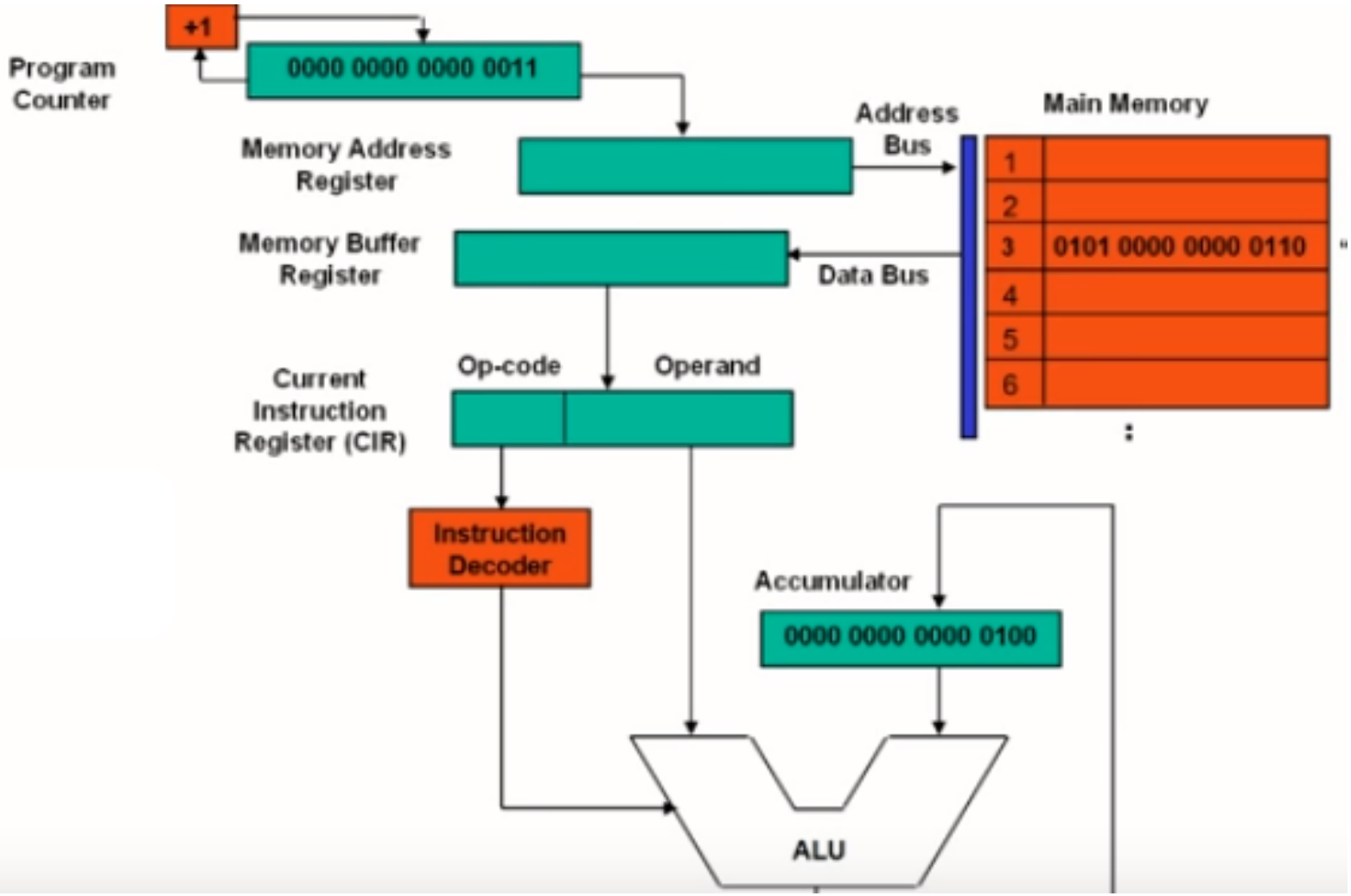


The Fetch-Execute Cycle

- A computer is a device that can store, retrieve, and process data. All of the instructions that we give to the computer relate to those operations

- Instruction cycle : the process of execution of an instruction within the computer, including four steps:
  - Fetch the next instruction from memory
  - Decode the instruction in control unit
  - Get data if needed
  - Execute the instruction

The Fetch-Execute Cycle - example



The Fetch-Execute Cycle

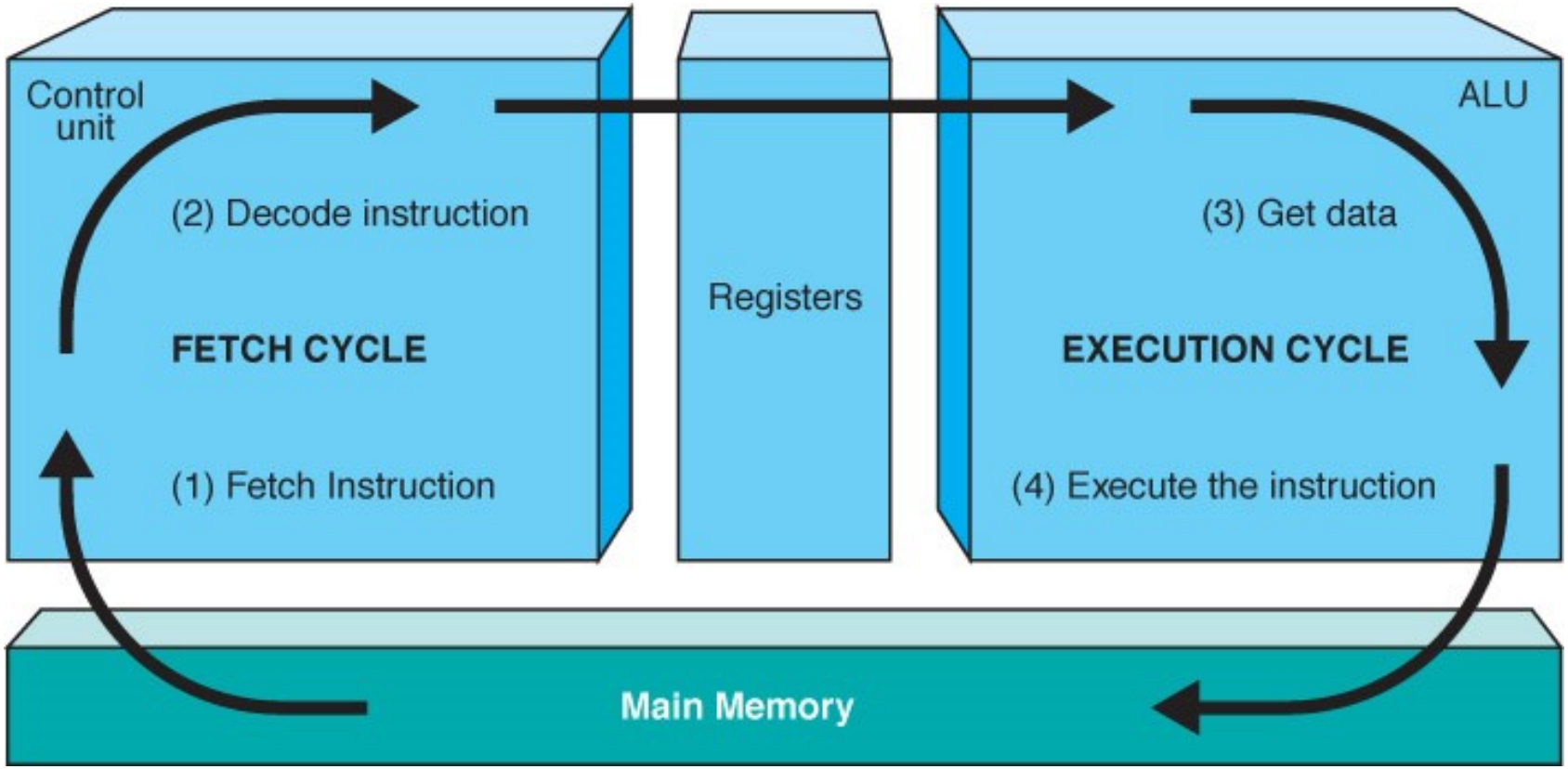
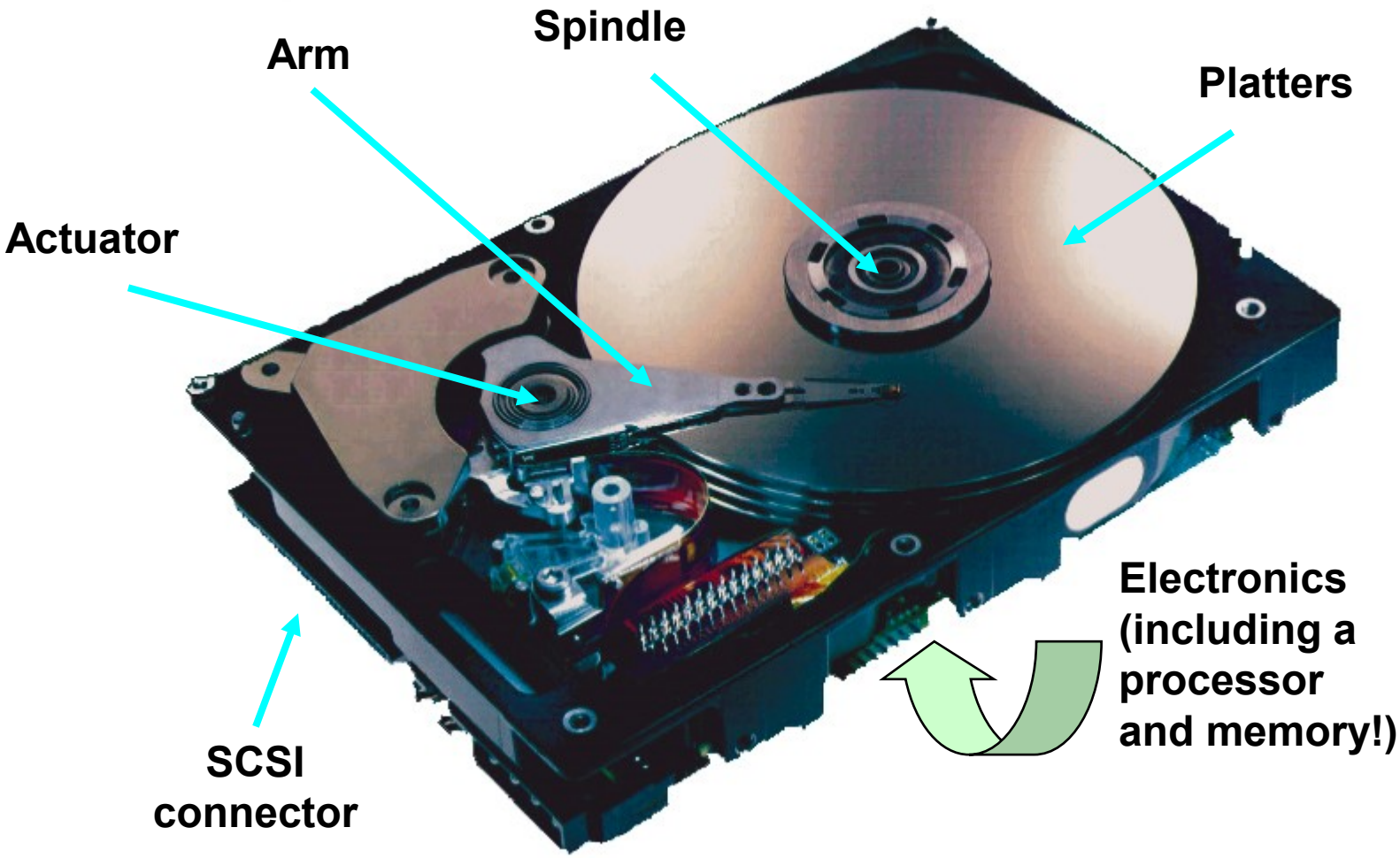


Figure 5.3 **The Fetch-Execute Cycle**

ROM

- **Read Only Memory** (ROM)
  - Memory in which each location can be accessed but *not* changed
- **Random Access Memory** (RAM)
  - Memory in which each location can be accessed and changed
- RAM is volatile, ROM is not
- *What does volatile mean?*

Disks : What's Inside Disk Drive?



[*Image courtesy of Seagate Technology*]

Disks

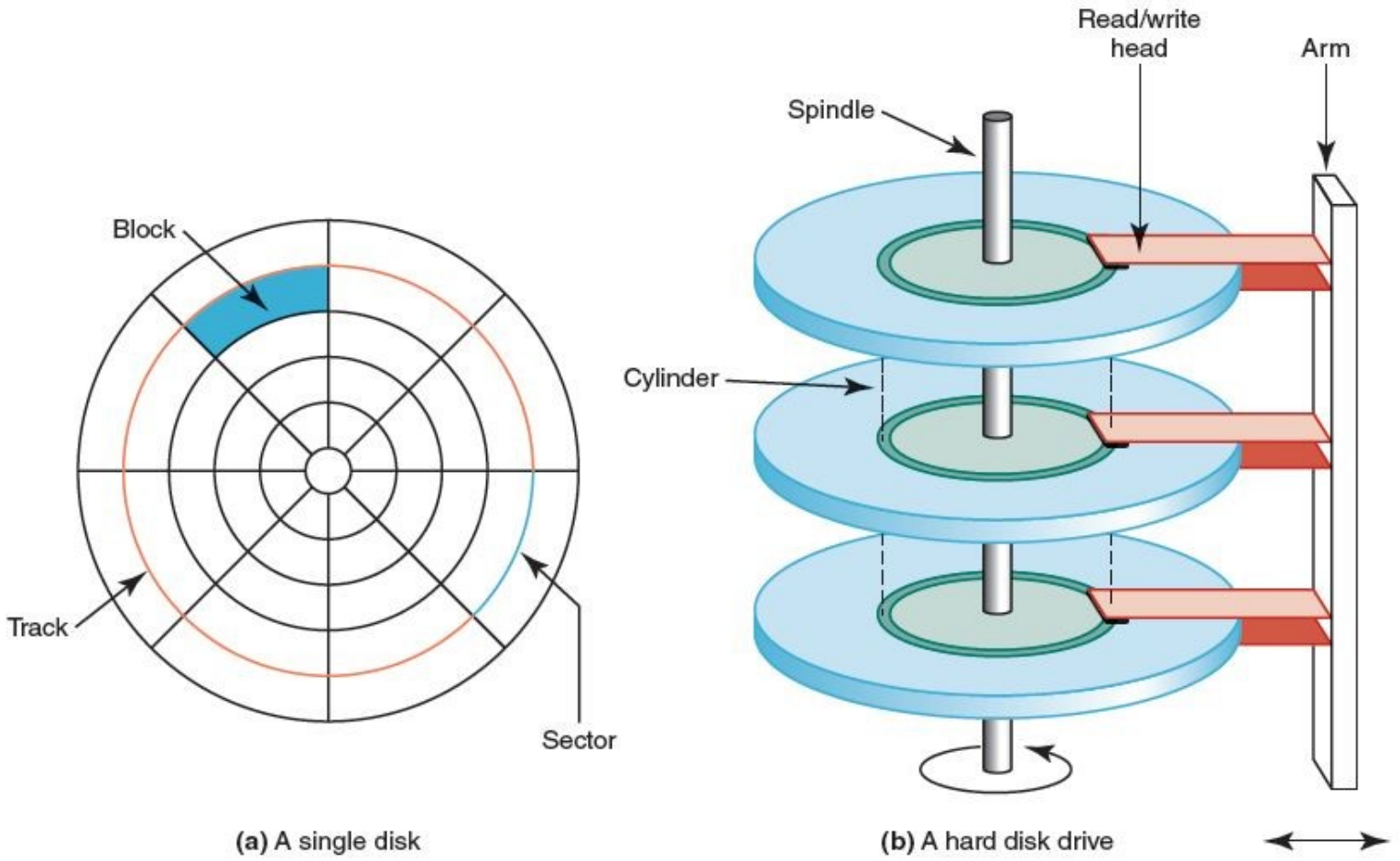
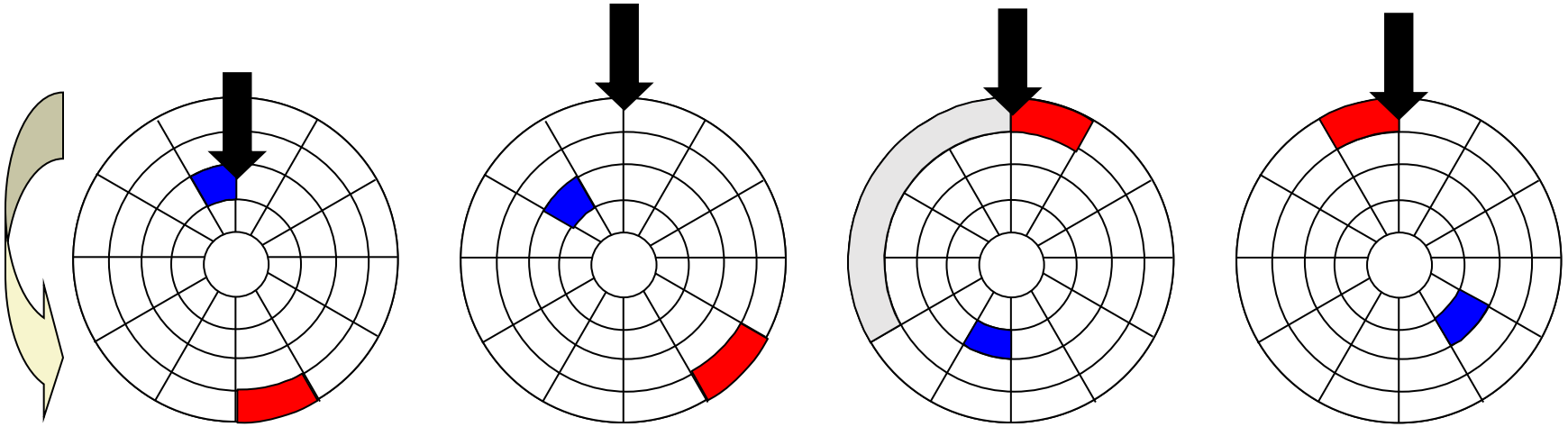


FIGURE 5.5 The organization of a magnetic disk

Disk Access Time Components



Flash Drives

- Flash Memory
  - Nonvolatile
  - Can be erased and rewritten
- Supports USB mass storage standard

FIGURE 5.6 Flash drive

Example Memory Hierarchy

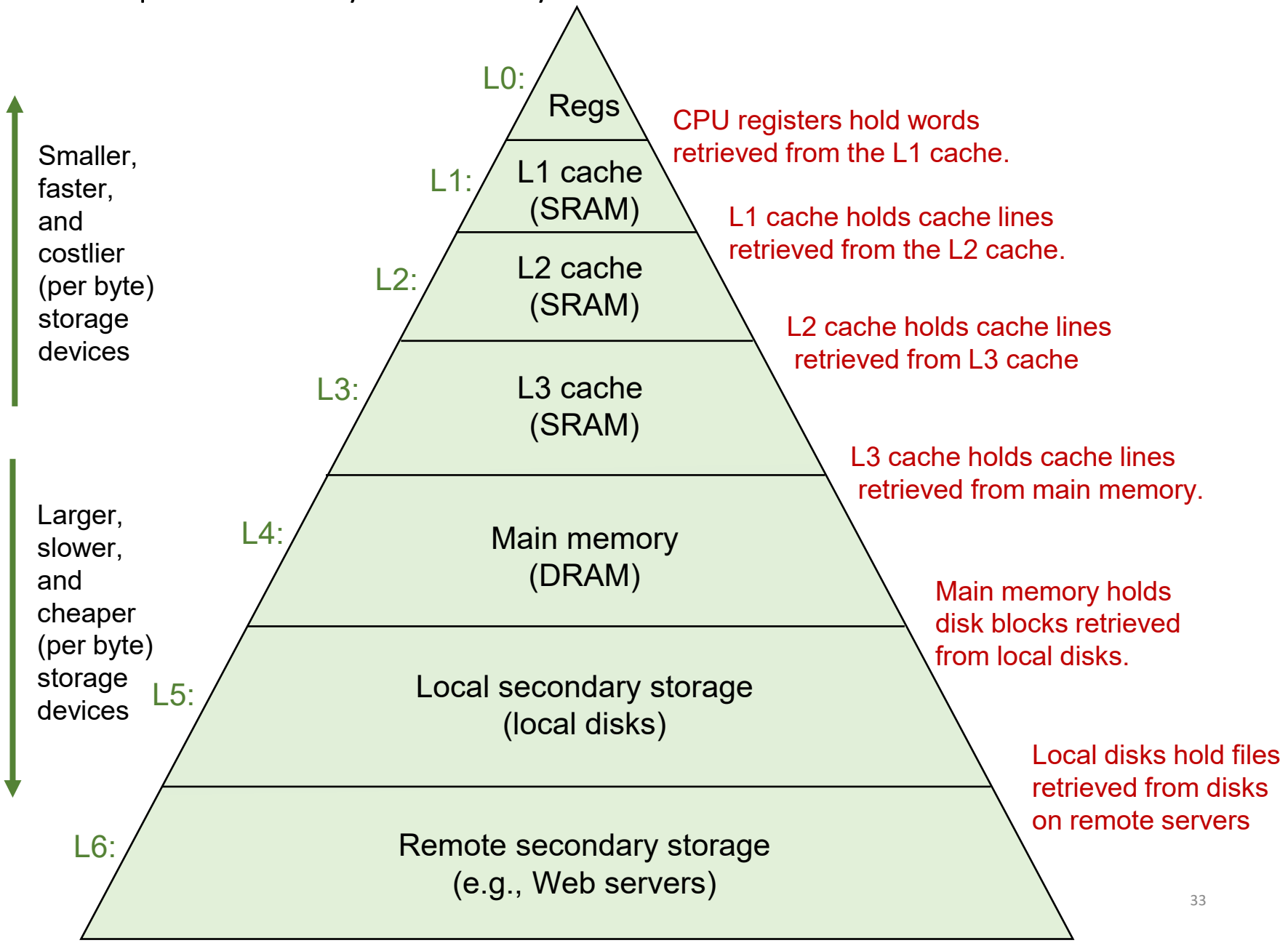


Figure: 1Q18 Global Branded DRAM Revenue Ranking Unit: Million USD

Ranking	Company	Revenue			Market Share	
		1Q18	4Q17	QoQ	1Q18	4Q17
1	Samsung	10,360	10,066	2.9%	44.9%	46.0%
2	SK Hynix	6,432	6,291	2.2%	27.9%	28.7%
3	Micron Group	5,213	4,562	14.3%	22.6%	20.8%
4	Nanya	642	558	15.1%	2.8%	2.5%
5	Winbond	175	173	1.2%	0.8%	0.8%
6	Powerchip	113	104	8.2%	0.5%	0.5%
	Others	143	144	-1.2%	0.6%	0.7%
	Total	23,076	21,898	5.4%	100.0%	100.0%

Table: 3Q17 Global NAND Flash Revenue from Branded Manufacturers

Company	Revenue (US$M)		Market Share(%)	
	3Q17	QoQ (%)	3Q17	2Q17
Samsung	5,619.9	19.5%	37.2%	35.6%
Toshiba	2,740.0	18.1%	18.1%	17.5%
WDC	2,523.4	8.9%	16.7%	17.5%
Micron	1,838.0	7.7%	12.2%	12.9%
SK Hynix	1,503.8	15.4%	9.9%	9.9%
Intel	891.0	1.9%	5.9%	6.6%
Total	15,116.0	14.3%	--	--