Lecture 2
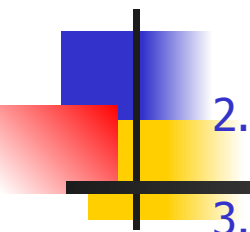
Topic: Introduction to computer systems. Architecture of a computer systems.

Plan of Lecture:

1. The development of computer architecture. Von Neumann architecture.

2. Types of computers.

3. The basic components of a computer.

4. The memory chips. Microchips processors and tires.
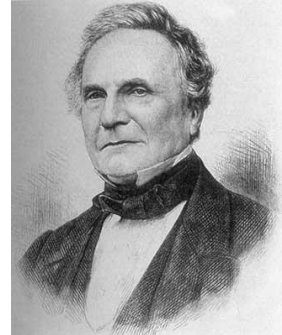
5. Presentation of data in computer memory.

Technology

- The technology is moving very quickly
  - 19th century: attempts to build **mechanical** computers
  - Early 20th century: mechanical counting systems (cash registers, etc.)
  - Mid 20th century: vacuum tubes as switches
  - Since: transistors, integrated circuits

3

Charles Babbage

- In the early 1800's **Charles Babbage** designed two machines: first the **Difference Engine** and then the **Analytical Engine** that were mechanical machines capable of performing calculations.

- The Difference Engine, most (but not all) of which was built in Babbage's time, was a **special purpose** machine (i.e. it could only do particular calculations).

- The Analytical Engine, which was designed but not built in Babbage's time, was more ambitious in that it was *programmable*.

4

Fast forward a hundred years

- In the 1940's the *Electronic Numerical Integrator And Computer* (**ENIAC**) was built at the Moore School of the University of Pennsylvania.

- It was completed in 1946 at the Moore School of the University of Pennsylvania.

- The two driving forces behind it were **John W. Mauchly** and **J. Presper Eckert**.

- There were other computers built during WWII notably the one developed at Bletchley Park, UK to aid in their code breaking mission.
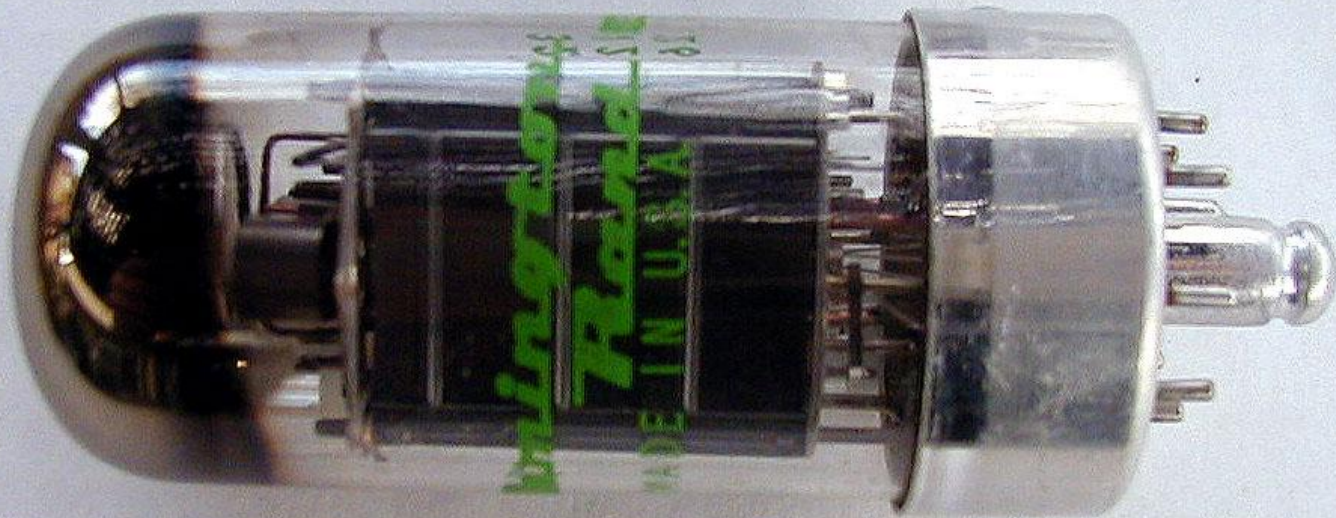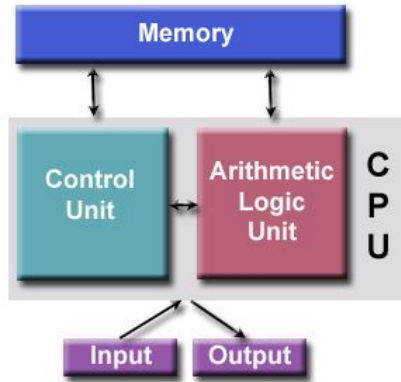
ENIAC

- The ENIAC consisted of 17,480 vacuum tubes operating at 100,000 pulses per second.

- **Vacuum tubes** play the same role that **transistors** do in modern computers (one can use them to "realize" **logic gates (**вентили))
  - The switch from vacuum tubes to transistors marked a dramatic shift in computer size and speed.
  - The Pentium 4 processor introduced in 2000 had 42,000,000 transistors. The Itanium 2 in 2004 had 592,000,000 transistors. The more recent Core i7 processor has a transistor count is 731 Million.

Vacuum tube

Von Neumann Architecture

- John von Neumann was a consultant to the ENIAC project. The team discussed changing the way computers were programmed. Von Neumann publicized these ideas.

- The instructions could be converted into numbers and placed in memory along with the data. This is known as the **stored program concept**.

- The combination of the basic units (ALU, control, memory, input and output) and the stored program concept give one the "_**von Neumann architecture.**_"

Types of computers:

personal computer: a small, single-user computer based on a microprocessor. In addition to the microprocessor, a personal computer has a keyboard for entering data, a monitor for displaying information, and a storage device for saving data.

- **workstation:** a powerful, single-user computer. A workstation is like a personal computer, but it has a more powerful microprocessor and a higher-quality monitor.

Types of computers:

- **minicomputer:** a multi-user computer capable of supporting from 10 to hundreds of users at the same time.

- **mainframe:** a powerful multi-user computer capable of supporting many hundreds or thousands of users at the same time.

- **supercomputer:** an extremely fast computer that can perform hundreds of millions of instructions per second.
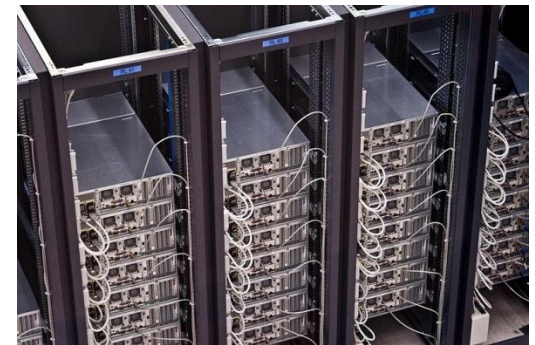
Types of Computers

Figure 15.2 Types of Computers
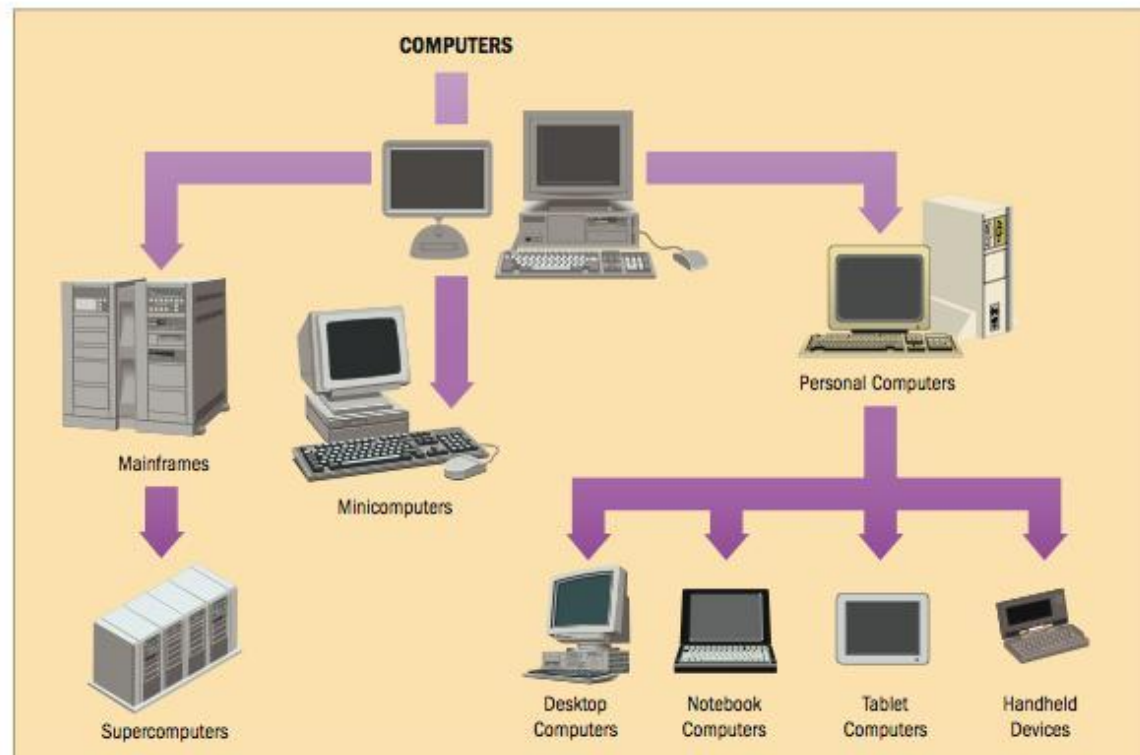
Servers

- Computers connected in a network environment.

- Manage network resources

- Holds and delivers an organization's web pages

- Stores and retrieves tasks for all of an organization's files

- A printer server handles all print requests.

Main Frame
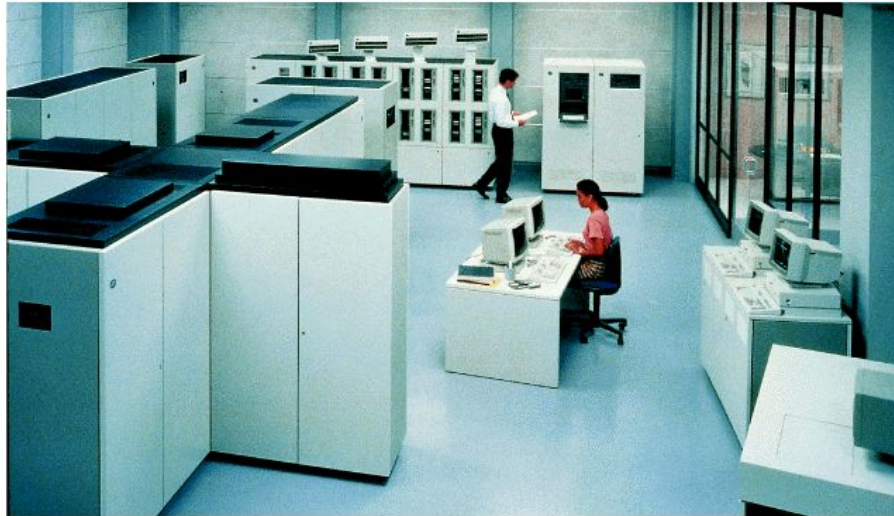
- First computers, introduced in 1950s
- Used by large businesses
- Typically supported hundreds or thousands of users
- Very expensive
- Used for very large processing tasks

Supercomputers

- **High capacity (**высокая емкость**)**
- **Used by very large organizations**
  - **Tracking space**
  - **Tracking weather**

Minicomputers
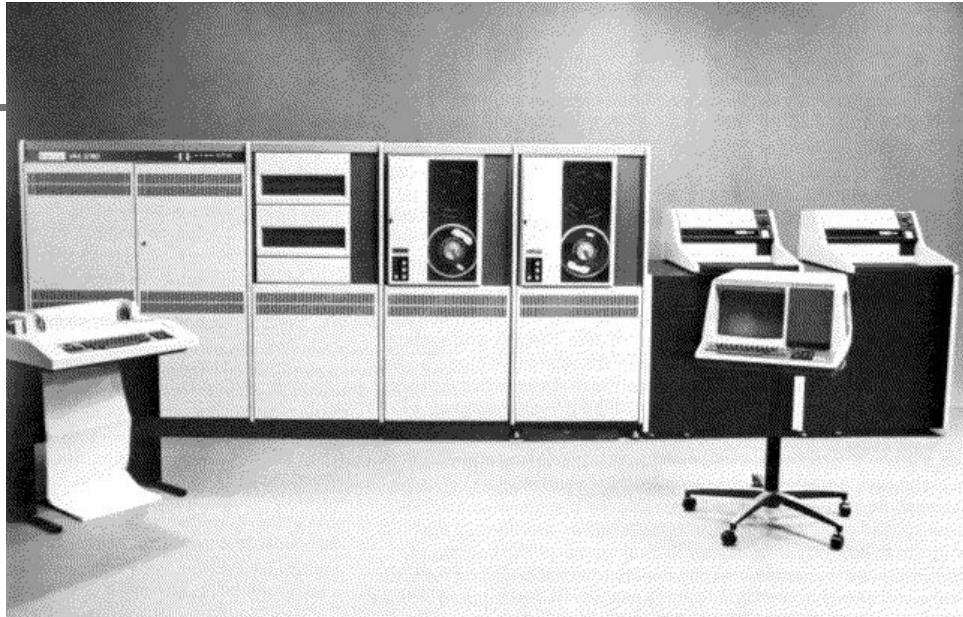
- Typically supported hundreds of users
- No longer a product line
- Smaller and less expensive than mainframes
- The real difference is relative in terms of price, power, marketing.
- Known as midrange computers

Computer Systems

System Unit

Output device

Output device

Output device

Input device

Input device

A computer System

Motherboard

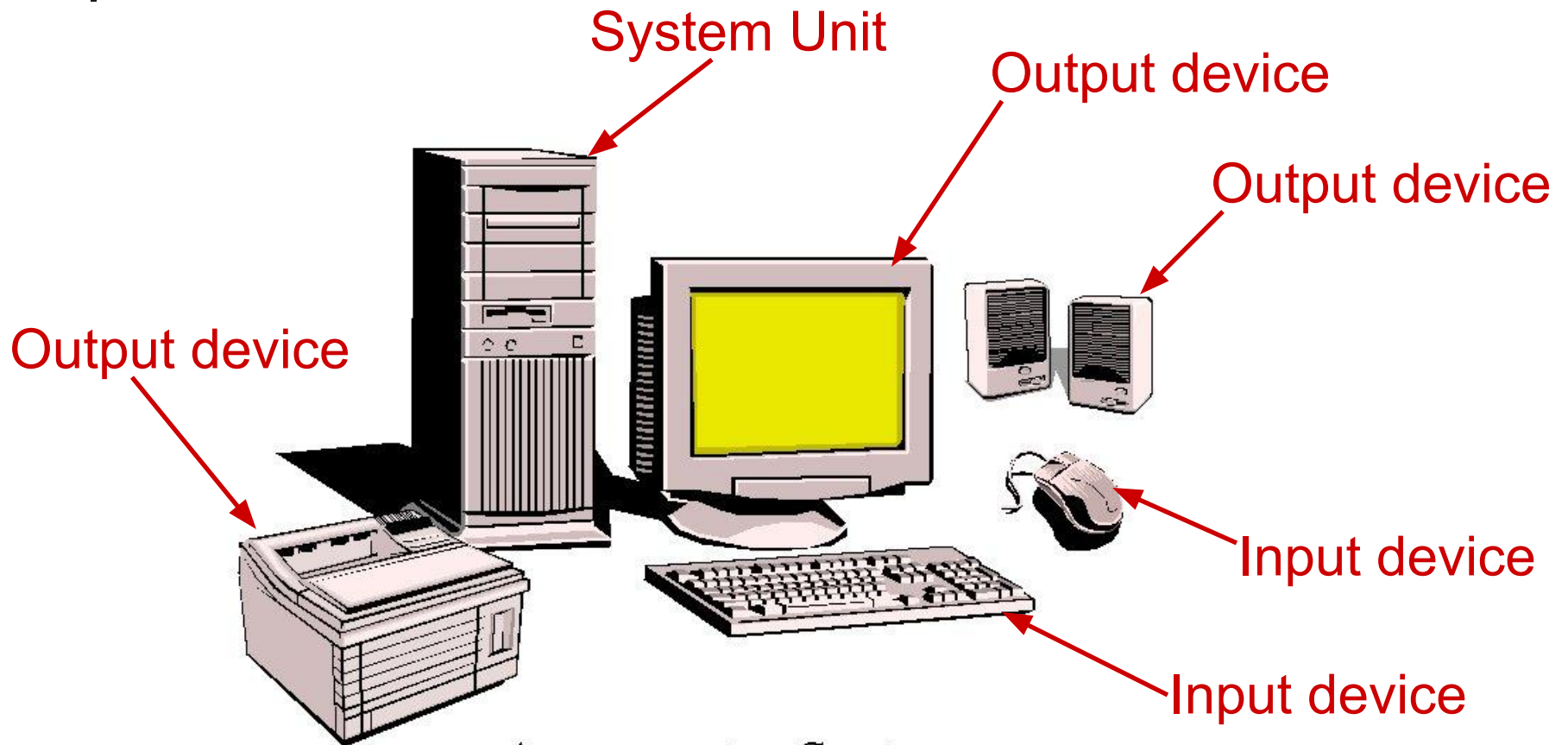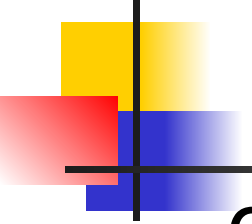A motherboard is the central printed circuit board (PCB) in many modern computers and holds many of the crucial components of the system, while providing connectors for other peripherals. The motherboard can be easily compared to the human body's nervous system. The wires (nerves) on it transfer data between all of the other components.

Main Components of a Computer System

- **Processor (CPU)**
  - Runs program instructions
- **Main Memory**
  - Storage for running programs and current data
- **Secondary Storage**
  - Long-term program & data storage (hard disk, CD, etc)
- **Input Devices**
  - Communication from the user to the computer(e.g. keyboard, mouse)
- **Output Devices**
  - Communication from the computer to the user (e.g. monitor, printer, speakers)

The Processor

- The **processor** is the "brain" of the computer system.

- Main processor is called the **Central Processing Unit** (**CPU**).

  - A particular computer will have a particular type of processor, such as a Pentium or a SPARC chip.

- **Co-processors** assist the CPU with some of the processing functions. Examples:

  - **Math co-processors** handle heavy duty math processing

  - **Graphics coprocessors** speed up the display of graphics onto the monitor

Component Interaction

The CPU controls all of the other resources within the system, in order to accomplish a task.

Central Processing Unit (CPU)

CPU
Arithmetic / Logic Unit
Control Unit
Registers
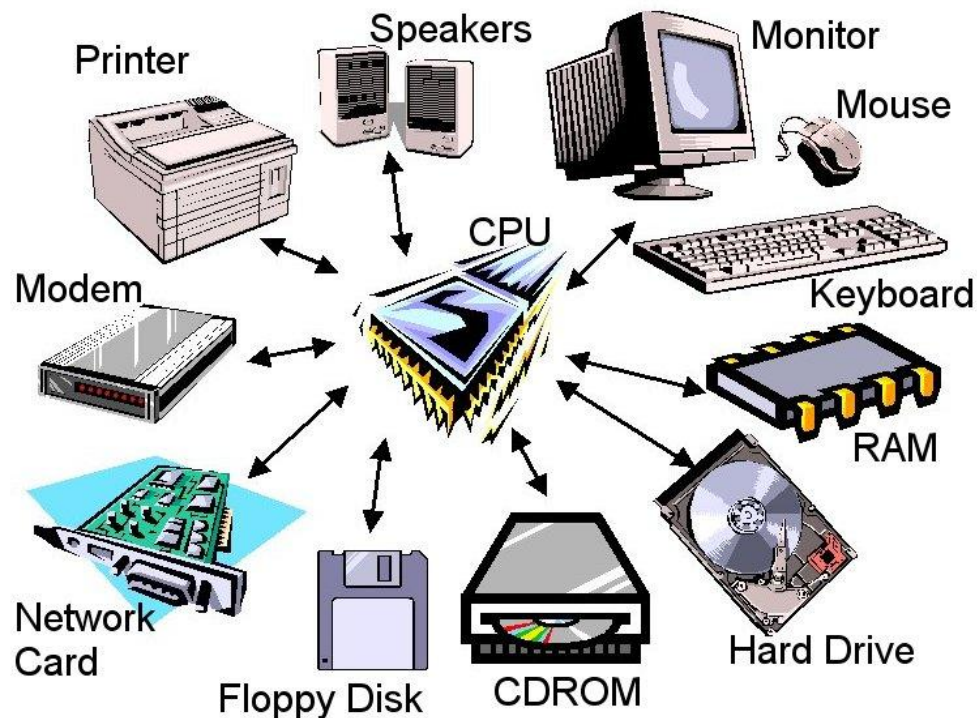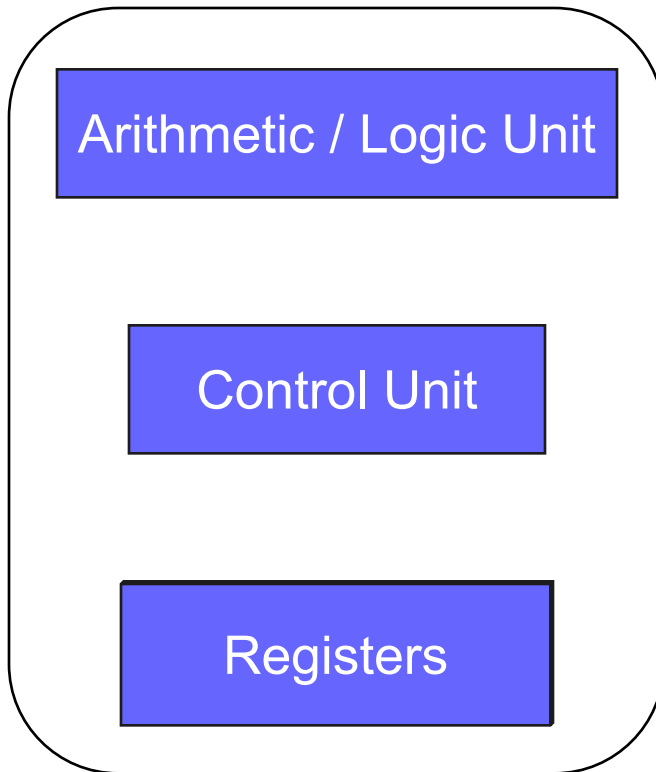
Performs calculations and decisions

Coordinates processing steps

Small, fast storage areas for instructions and data

Registers

- **Registers** are small, fast memory **within the CPU**
- Different registers hold different things
  - instructions and addresses of instructions
  - data (operands)
  - results of operations

CHARACTERISTICS of Processor

Counts - word size, equal to the number at the same time processed bits. The higher the bit processor, the more information it can handle per unit time, the above its effectiveness.

Clock frequency - the number of operations performed per unit time.

Address space - the maximum amount of memory, which can serve processor. Represents set of addresses used in this computer system. (максимальное количество памяти, которое может обслужить процессор. Представляет собой совокупность адресов, используемых в данной вычислительной системе.

Memory

Computer Memory -
millions/billions of on/off charges

Divided into:

- **Bits** 0 or 1

- **Bytes** Groups of 8 bits A byte is the smallest unit of storage. (Can hold one text character)

- **Words** Groups of bits/bytes (8, 16, 32, 64-bits)

Memory

Storage is usually too large to be expressed in **bytes** or **words**. Instead we use:

- **Kilobyte (KB)** = 1024 bytes(2^{10} bytes)

- **Megabyte (MB)** = 1024 x 1024 bytes or   one million bytes   (2^{20} bytes)

- **Gigabyte (GB)** = 1024 x 1024 x 1024 bytes or one trillion bytes (2^{30} bytes)

- **Terabyte (TB)** = 1024 x 1024 x 1024 x 1024 bytes one quadrillion bytes   (2^{40} bytes)

Main Memory

Each memory cell has a numeric address, which uniquely identifies its location

5248	
5249	`10011010`
5250	
5251	
5252	
5253	
5254	
5255	
5256	

Each memory cell stores a set number of bits (some computers use 8 bits/one byte, others use words)

A word is stored in consecutive memory bytes.

Main Memory Characteristics

- Very closely connected to the CPU.

- Contents are quickly and easily changed.

- Holds the programs and data that the processor is actively working with.

- Interacts with the processor millions of times per second.

- Nothing permanent is kept in main memory.

Program Instructions

- **Programs instructions** are stored in **secondary** storage (hard disks, CD-ROM, DVD).

- To process data, the CPU requires a working area

  - Uses **Main Memory**

  - Also called: **RAM** (random access memory), **primary** storage, and **internal** memory.

- Before a program is run, instructions must first be copied from the **slow** secondary storage into **fast** main memory

  - Provides the CPU with fast access to instructions to execute.

Instructions

- An instruction is a sequence of bits.
- A simple instruction format may consist of an operation code (op code) and an address or operands.

Op Code	Operands / Address

- Instructions tell the computer's CPU what to do.

Instructions

- The **operation code** specifies the operation the computer is to carry out (add, compare, etc)

- The operand/address area can store an operand or an address

  - An **operand** is a specific value or a register number

  - An **address** allows the instruction to refer to a location in main memory

- The CPU runs **each instruction** in the program, starting with instruction 0, using the **fetch-decode-execute** (выборки-декодирования-выполнение) cycle.

Fetch-Decode-Execute Diagram

CPU

Main Memory

Program Counter (PC)
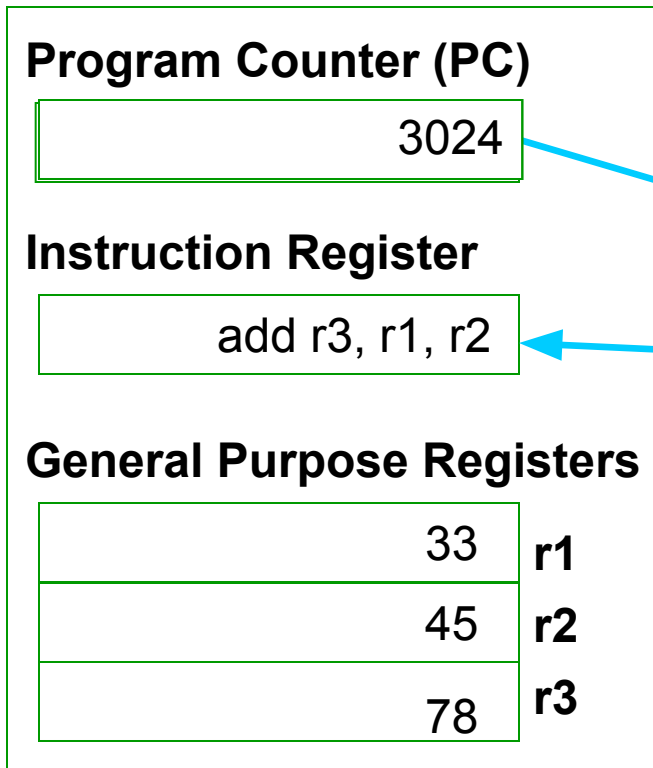
3024

Fetch
Get instruction and increment PC

Instruction Register

add r3, r1, r2

Decode
Determine what the instruction is (**add**)

General Purpose Registers

33	**r1**
45	**r2**
78	**r3**

Execute
In this case **add r1** and **r2** and put result in **r3**.

...
3020
3021
3022
add r3, r1, r2	3023
3024
3025
3026
3027
3028
...
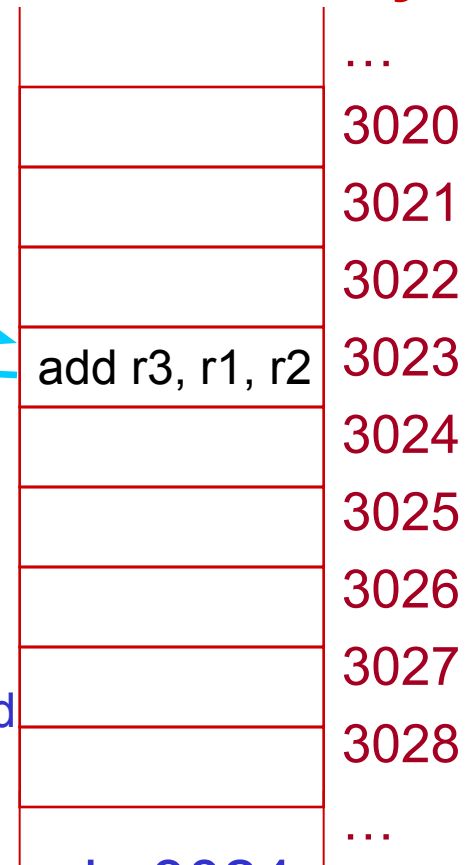
Then begin again by Fetching the instruction in 3024….

The main device of PC

ROM	RAM		Processor

HIGHWAY bus

Data bus

address

control bus

controller	controller	controller	controller

Keyboard	Printer	Display	Drive
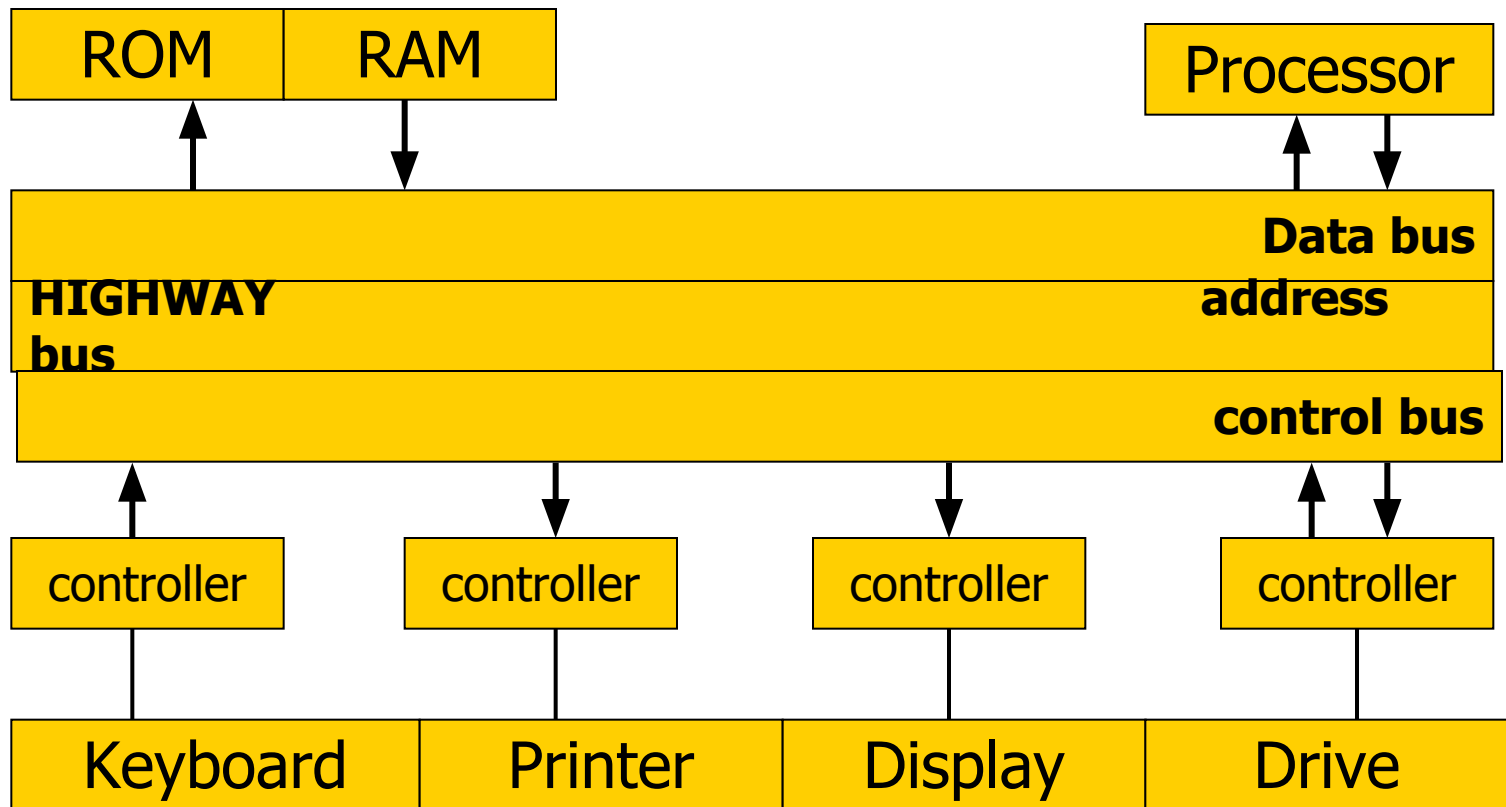
System bus

1. The processor sets the address bus memory address, which wants to read; (Процессор устанавливает на шине адреса адрес ячейки памяти, которую хочет прочитать);

2. On the control bus puts the processor ready signal and the read signal;   (На шине управления процессор выставляет сигнал готовности и сигнал чтения);

3. Noticing the ready signal, check all devices, whether or not on the bus addresses of their address; (Заметив сигнал готовности, все устройства проверяют, не стоит ли на шине адреса их адрес);

4. RAM, noting that exposed her address, reads the control signal; Memory read address; (Оперативная память, заметив, что выставлен ее адрес, считывает управляющий сигнал. Память читает адрес);

5. Memory Bus exposes the requested information data; (Память выставляет на шине данных требуемую информацию);
The memory puts the control ready signal bus;(Память выставляет на шине управления сигнал готовности);

6. A processor reads data from the data bus; (Процессор читает данные с шины данных).

The internal memory of the computer

RAM (Random Access Memory)

Located on the motherboard
It is used for temporary storage of data during the immediate PC
Provides recording modes, read, store information

ROM (Read Only Memory)
Used for permanent storage of data that do not require intervention
  user (Используется для постоянного хранения данных, не требующих вмешательства
 пользователя) (program start and stop the computer, Testing devices,
 the control operation of the processor, display, keyboard, printer, external memory)
It is intended for reading information

A cache memory (buffer memory unit)
Internal memory cache located inside the processor
External cache memory located on the motherboard
It used to increase the performance of your computer, matching
operation of devices with different speeds, the exchange of data between
Processor and memory

Cache Memory

Diagram of a Computer with Cache
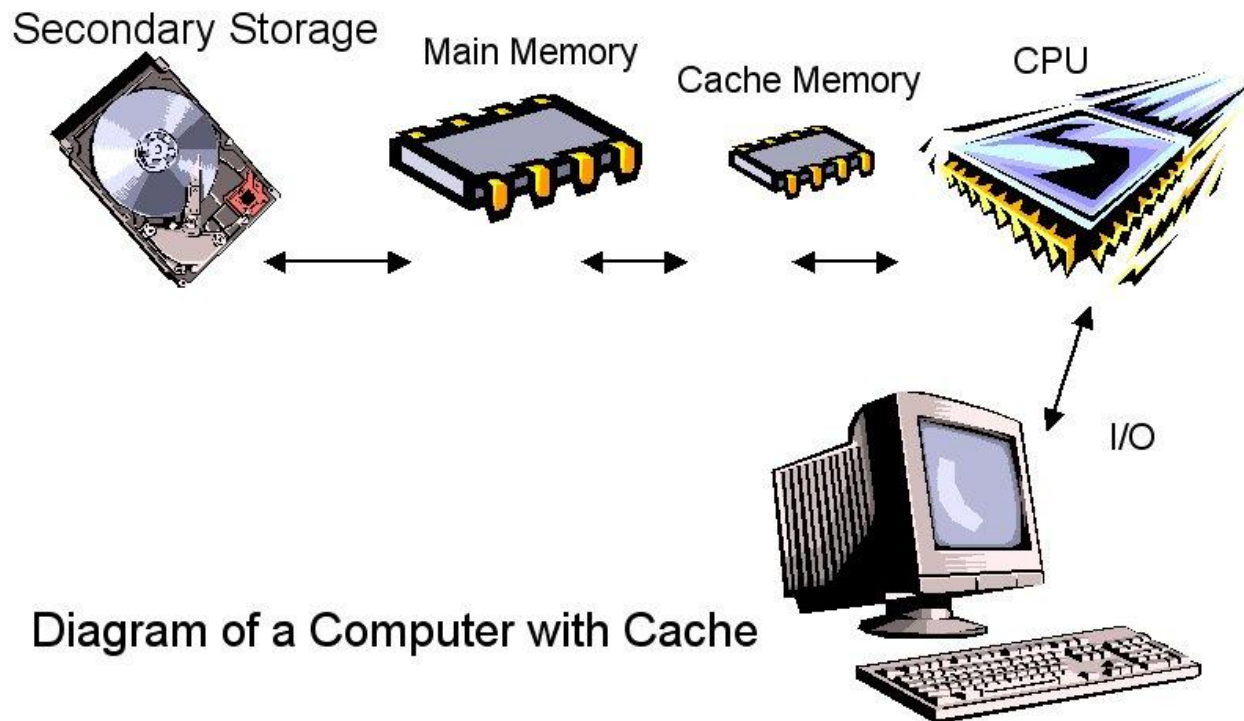
When an instruction or data is accessed from main memory, it is placed in the cache. Second and subsequent use of the same instruction/data will then be faster, since it is accessed directly from the cache.

Controllers

- Decodes the signal received from processor (Декодирует сигнал, поступающий от процессора)
- Sends the processed signal to the performance of its device

(Посылает обработанный сигнал для выполнения его устройством)

- The resulting signal is converted into a binary form of user-friendly (Полученный двоичный сигнал преобразует в вид понятный пользователю)
- Are inserted into the slots (slots) on the motherboard, and to their ports connect additional devices (Вставляются в разъемы (слоты) на материнской плате, а к их портам подключаются дополнительные устройства)

TEST

- Open Internet site **Socrative.com**
- Press button **Student login**
- Write Room Name **YERMAGANBETOVA**
- Write your **group** and **full name**
- Answer 20 questions