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S2
COMPUTER HARDWARE
Unit Two: Processing Devices

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Unit Two: Processing Devices

- **Unit Summary:-**

Devices inside the system Unit:

a) The system Unit
   - Definitions, Components and parts.

b) The Motherboard
   - Definitions, Components and parts.

c) The Central Processing Unit CPU
   - Definitions, Components and parts.

d) Memory (internal/primary storage)
   - RAM and ROM, Memory Cache, CMOS,
   - Units of Measuring Computer Memory
   - Computer Data representation & numbering systems

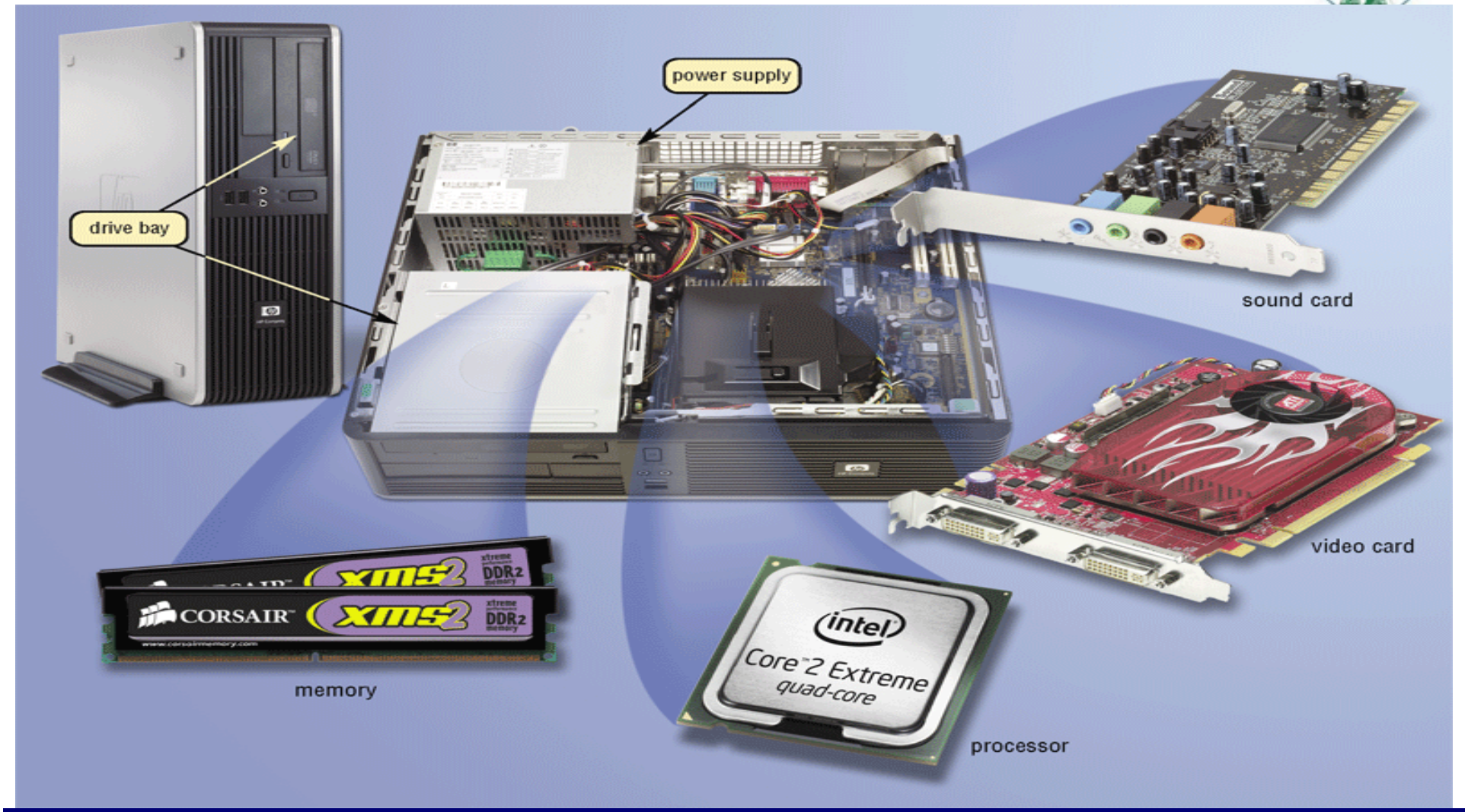
a) The system unit

- **Computer hardware Processing devices** are devices housed in the system unit used to process data using program instructions, manipulate functions, perform calculations and control other hardware devices.
- **The system unit** is a box-like case that houses the motherboard, the disks and drive bays, the power supply and cooling systems.
- The components in the system unit are connected to the **motherboard. A drive bay** is a rectangular opening inside the system unit that typically holds disk drives.

a) The system unit

All sizes of computers have a system unit

The system unit



A system unit contains numerous electronic components

b) The motherboard

- The motherboard is a single circuit board, that provides the path through which the processor communicates with internal and peripheral devices.

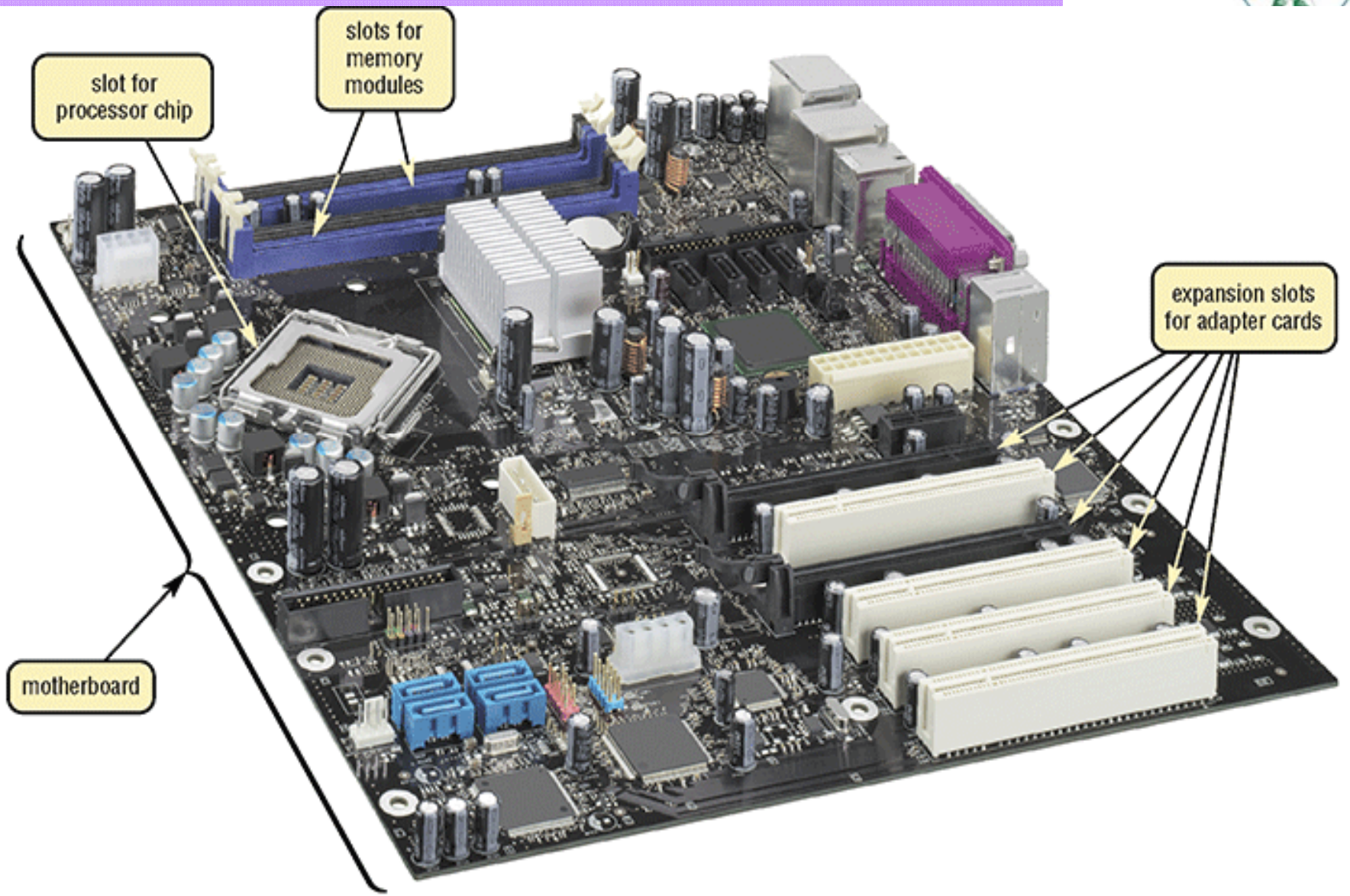
  The motherboard is the main printed circuit board (PCB) found in general purpose computers and other expandable systems.

  It holds, and allows communication between, many of the crucial electron components of a system, such as the central processing unit (CPU) and memory, and provides connectors for other peripherals.

The motherboard

- The motherboard is also called the system board. The components attached to the motherboard include the processor chip (the CPU), memory chips, support electronic circuitry, buses, and Expansion Slots for Adapter Cards.

Basic parts of a motherboard



Expansion slots and Adapter cards

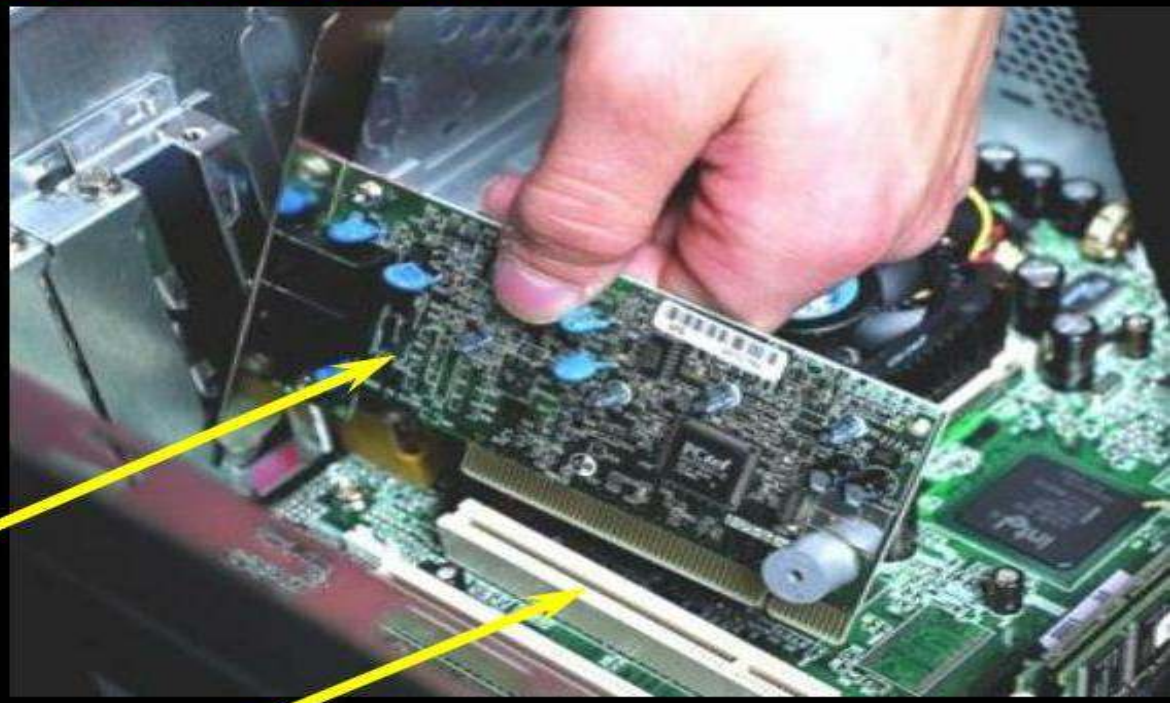
- An expansion slot is a socket on the motherboard that can hold an adapter card.
- An adapter card, also called expansion card, is a circuit board that increases the capabilities of the system or provides connections to peripherals.
- Some motherboards include all necessary capabilities and do not require adapter cards.
- Adapter cards are used for many supplemental capabilities, such as more memory, higher-quality sound devices, a modem, extra ports, or graphics capabilities.

An adapter card being inserted into an expansion slot

Expansion Slots and Expansion Cards

What is an expansion slot?

- An opening, or socket, where circuit board is inserted into motherboard
- Expansion card inserted in expansion slot



Commonly used adapter cards and their functions

Adapter Card	Purpose
Sound card	Connects speakers or a microphone
MIDI card	Connects musical instruments
Network interface card (NIC)	Connects other computers
Video card	Connects a monitor
USB card	Connects USB devices
TV tuner card	Allows viewing of television channels
Video capture card	Connects a video camera
Modem card	Converts telephone or cable analog signals to digital and vice versa
FireWire card	Connects FireWire devices

Plug and Play (PnP)

- In the past, installing a card was not easy and required you to set switches and other elements on the motherboard. Today, many computers support Plug and Play.

- PnP refers to the computer's capability to automatically configure adapter cards and other peripherals as you install them when the computer is still running.

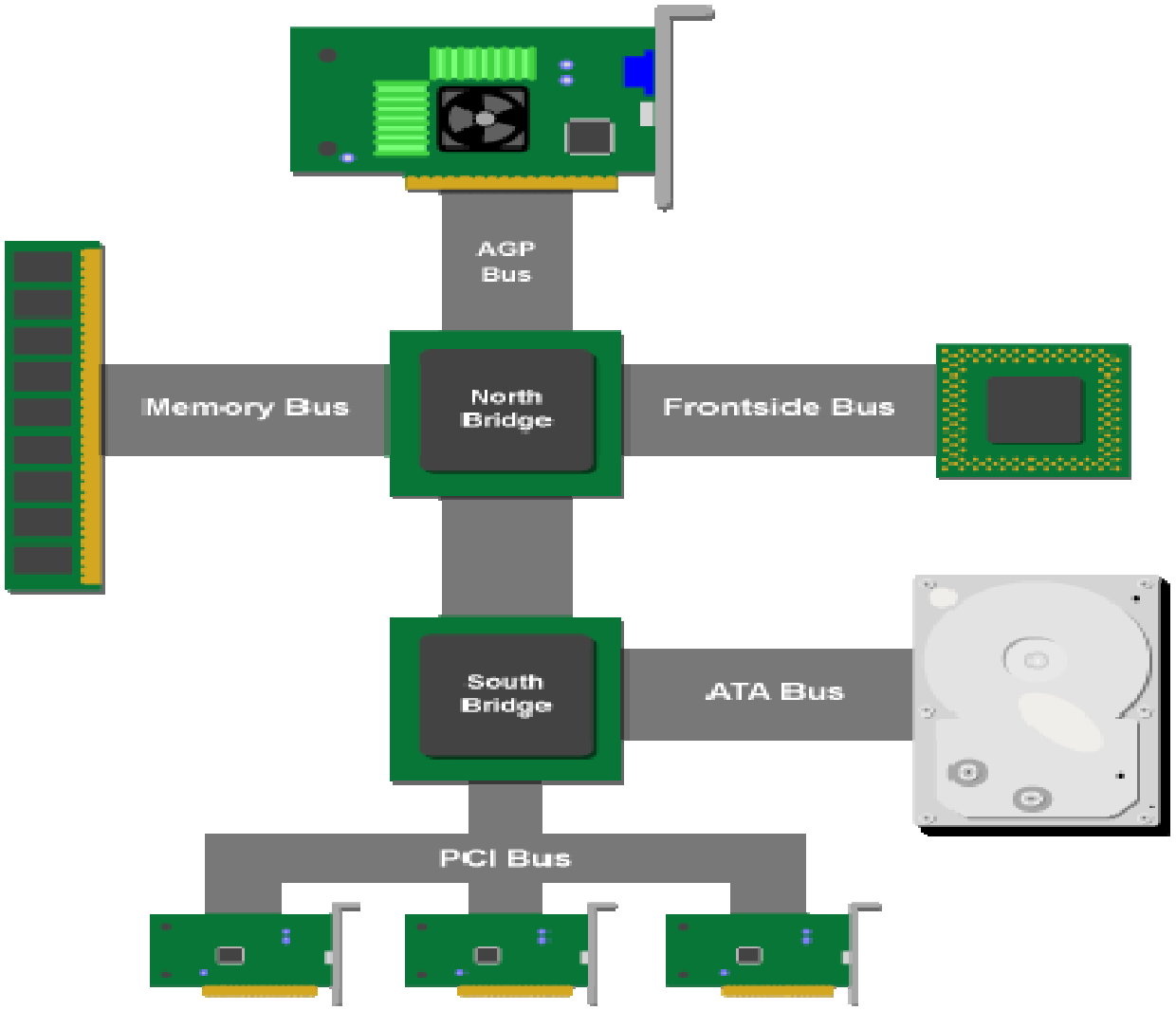
Buses

- **The bus** is a common electrical path, that enables data flow between the various system components. A bus, allows the various devices inside and attached to the system unit to communicate with each other.

Buses consist of two parts:

- The **data bus** which transfers actual data bits
- The **address bus** which transfers information about where the data should go in memory.

Motherboard architecture



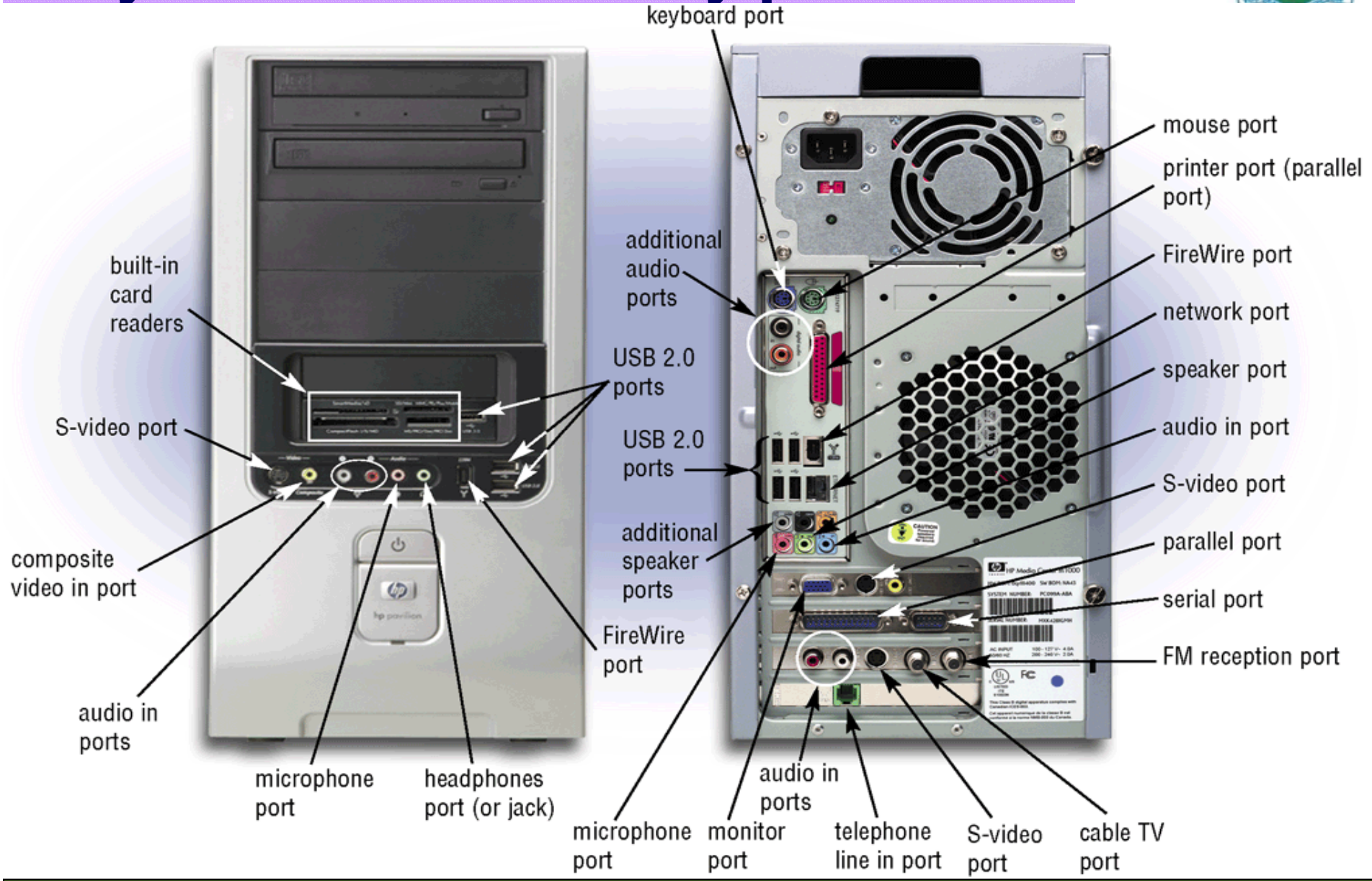
Buses allow the various devices inside and attached to the system unit to communicate with each other

Ports

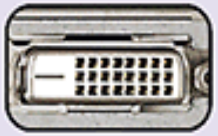
- A port is the point at which a peripheral attaches the system unit. Through a port, the peripheral can send data to or receive information from the computer.

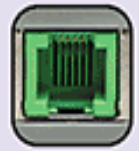
- A peripheral device is a device that attaches by a cable/wireless to a port on the system unit such as a keyboard, monitor, printer, mouse, digital camera, microphone etc.

A system unit has many ports



Examples of different types of ports on a system unit

Type	Picture	Type	Picture
Audio in		Monitor	
Cable TV		Mouse	
Center Surround Sound/Subwoofer		Network	
Composite video in		Printer	
Digital Video Interface (DVI)		Rear Surround Sound	
eSATA port		Serial	

FireWire		Side Surround Sound	
FM reception		S/PDIF	
HDMI port		Speaker	
Headphones		S-video	
Keyboard		Telephone line in	
Microphone		USB	

Common ports

- **Serial port** is a type of interface that connects a device to the system unit by transmitting data one bit at a time**.** It usually used to connect devices that do not required fast data transmission rates, such as a mouse or keyboard.
- **Parallel ports** are interfaces that allow the parallel transmission of data that is, several bits are transmitted simultaneously. These ports provide the interface for such devices as high-speed printers.
- **USB (Universal Serial Bus) ports** are used in high-speed device interfaces.
- **Bluetooth ports** use radio waves to transmit data between two devices, without using cables**.**

Connectors

- **A connector** joins a cable to a port. **A connector** at one end of a cable attaches to a port on the system unit, and a connector at the other end of the cable attaches to a port on the peripheral.

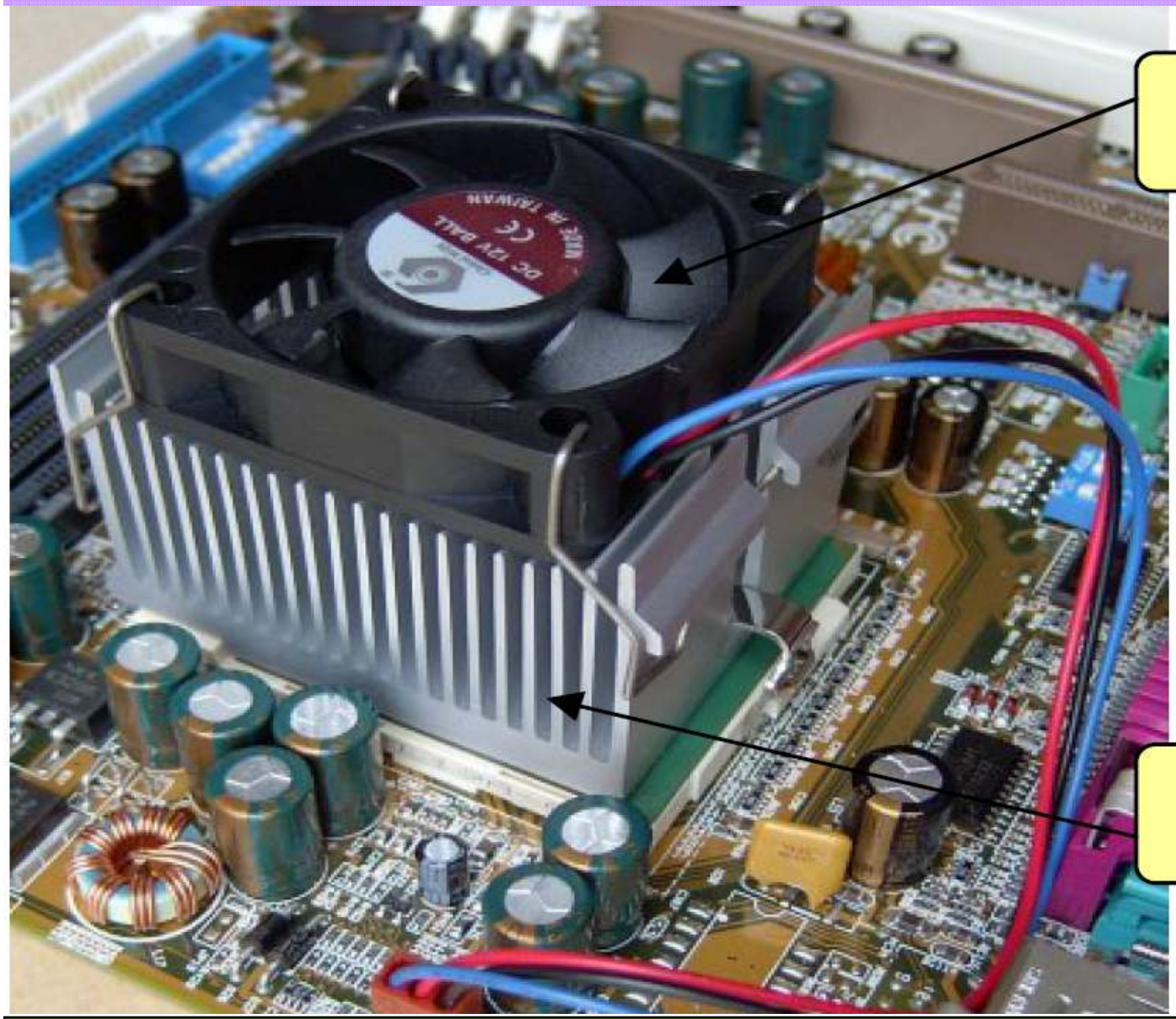
  Most connectors are available in one of two genders: male and female.

- **Male connectors** have one or more exposed pins.
- **Female connectors** have matching holes to accept the pins on a male connector.

Power Supply and Cooling Technology

- **The power supply** is the component of the system unit that converts the wall outlet AC power of 110 to 240 volts into DC power of 0.5 to 12 volts. Built into the power supply is a fan that keeps the power supply cool.
- **Processor chips** generate heat, which could cause the chip to burn up. A **heat sink** is a small ceramic or metal component with fins on its surface that absorbs and disperses heat produced by electrical components such as a processor.

Heat sink, fan on top of the processor



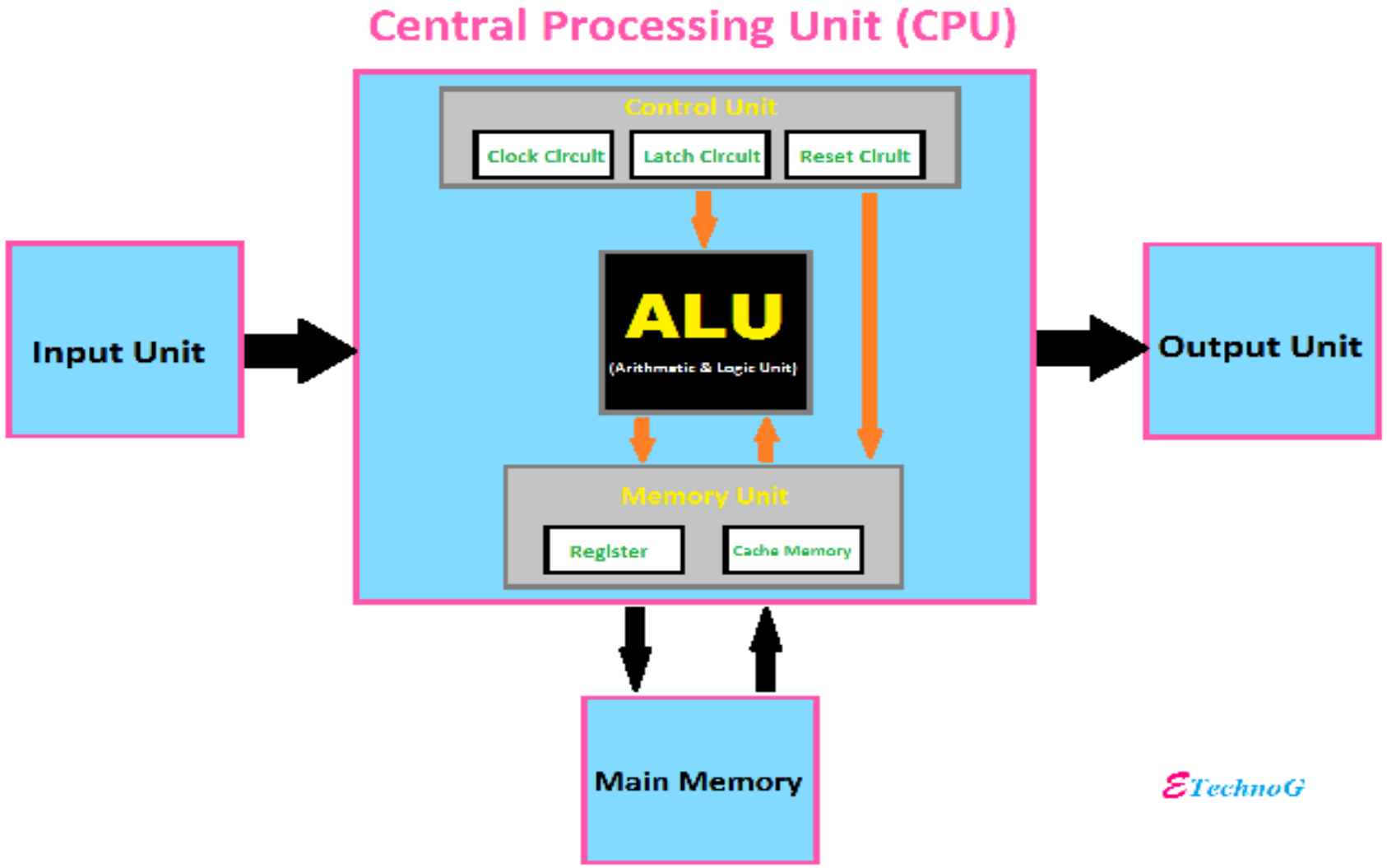
c) The CPU

- **The central processing unit (CPU)**, is a chip that interprets, carries out the basic instructions and manages most of the computer's operations. It is at times referred to as the 'brain' of the computer.

It has two basic sections:-

a) The control unit (CU)
b) The arithmetic/logic unit (ALU), which work together to perform the processing operations.
c) The Registers and the System Clock.

Components of a CPU.



The control unit (CU)

- **The control unit** is the component of the processor that directs and coordinates most of the operations in the computer. It interprets each instruction issued by programs and then initiates the appropriate action to carry out the instruction.

  For every instruction, the control unit repeats a set of four basic steps called the machine cycle steps:

The machine cycle steps

- **Step 1: Fetching the instruction**. The instruction to be executed is obtained from memory.
- **Step 2: Decoding the instruction**. The instruction is translated into commands the computer understand and sent to the ALU.
- **Step 3: Executing the instruction**. The commands are carried out.
- **Step 4: Storing results.** The results are stored in registers or memory.

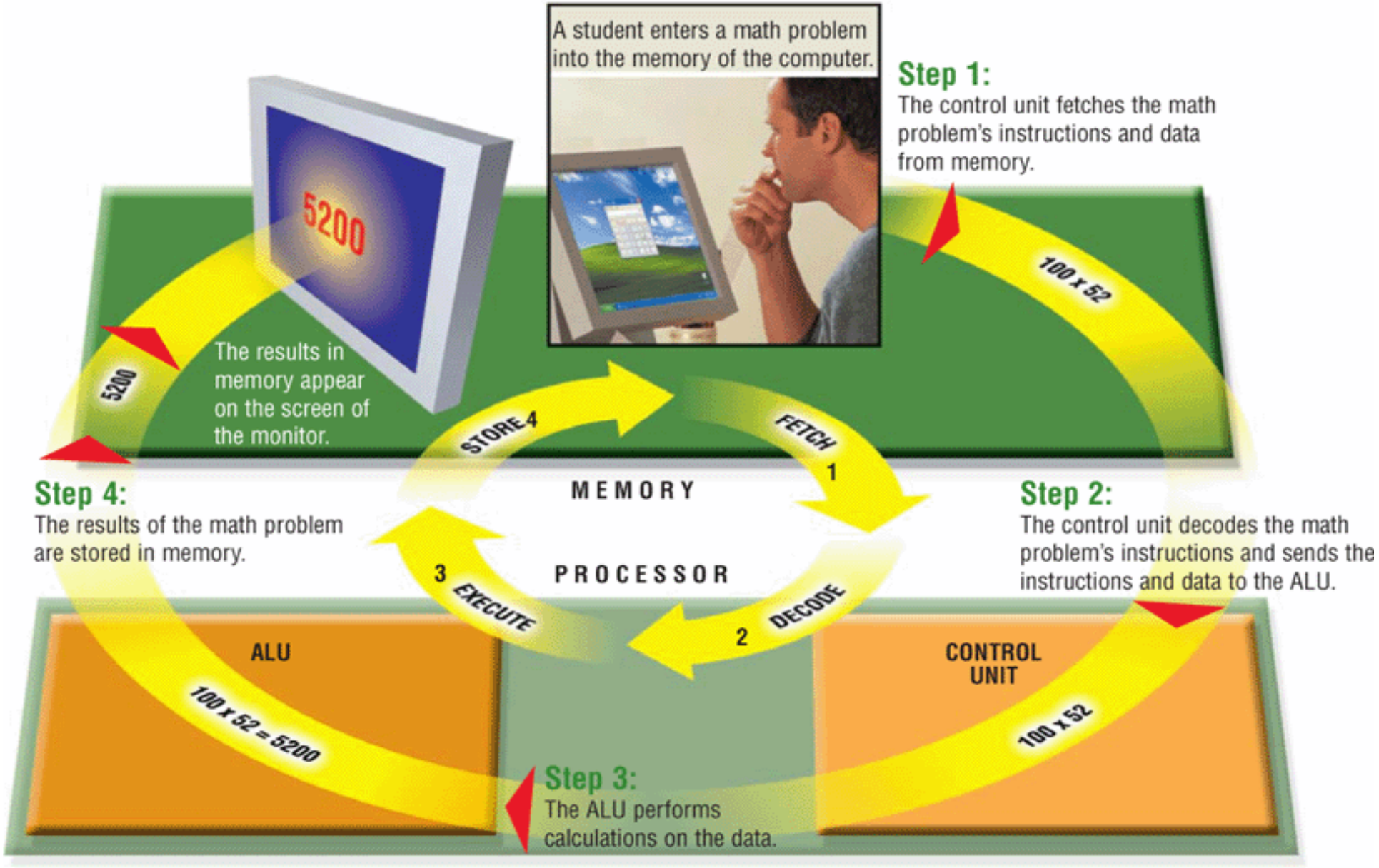
Arithmetic/logic unit (ALU),

- **The ALU** performs the arithmetic, comparison, and logical operations in a computer. It performs the execution step of a machine cycle. Arithmetic operations include addition, subtraction, multiplication, and division.

  Logical operations work with conditions and logical operators such as AND, OR, and NOT.

  For example, if you wanted to search a student database for Candidates of Computer studies, you would search for any students classified under 'Computer studies AND listed under Candidates.

An example of a machine cycle



Registers

- **Registers** are high-speed working **storage areas that temporarily** hold instructions and data. Registers work under the direction of the control unit to accept, hold, and transfer instruction or data and comparisons at high speed.
- **Registers** are not part of Memory or Secondary Storage: Registers hold data immediately related to the **operation being executed**. Memory is used to store data that will be used in the near future. Secondary storage holds data that may be needed later (in future)

Types of registers

- **Instruction register,** which contains the instruction being executed;
- **Address register**, which keeps track of where a given instruction or piece of data is stored in memory;
- **Storage register,** which temporarily holds data taken from or about to be sent to memory;
- **The Accumulator,** which collects the result of computations;
- **General-purpose register**, which is used for several functions, as assigned by the CU

The system clock

- **The system clock** is a small chip that is used by the CPU to synchronize the timing of all computer operations. **The system clock** generates electronic pulse or ticks at a fixed rate, which set the operating pace of components in the system unit.
- **Each tick** is called a **clock cycle**, which affects machine cycle time. The faster the clock, the more instructions the CPU can execute per second.

Clock speed.

Clock speed refers to the speed at which a processor executes instructions. Clock speed is measured in hertz.

A **hertz** is **one cycle or tick per second**. A Megahertz (MHz) equates to one million ticks of the system clock per second. Processor's speed is sometimes measured according to the number of **MIPS (millions of instructions per second)** it can process.

d) Memory (internal/primary storage)

- While performing a processing operation, a processor needs a place to temporarily store instructions to be executed and the data to be used with those instructions.

- The CPU cannot process data on an input device or disk directly; the data must first be available in memory.

d) Memory (internal/primary storage)

- **A computer's memory** in the system unit is located physically close to the CPU to decrease access time. It provides the CPU with a working storage area for program instructions, data and information.

- **Memory** is also known as primary storage or internal storage. Memory usually consists of one or more chips on the motherboard.

Types of memory:

The system unit contains two types of memory:

- **Volatile.**
- **Non volatile.**

- **Volatile.** The contents of volatile memory are lost when the computer power is turned off. RAM is the most common type of volatile memory
- **Non volatile**. The contents of nonvolatile memory are not lost when power is turned off. Examples of nonvolatile memory include ROM, flash memory, and CMOS.
- Below, we discuss these types of memory.

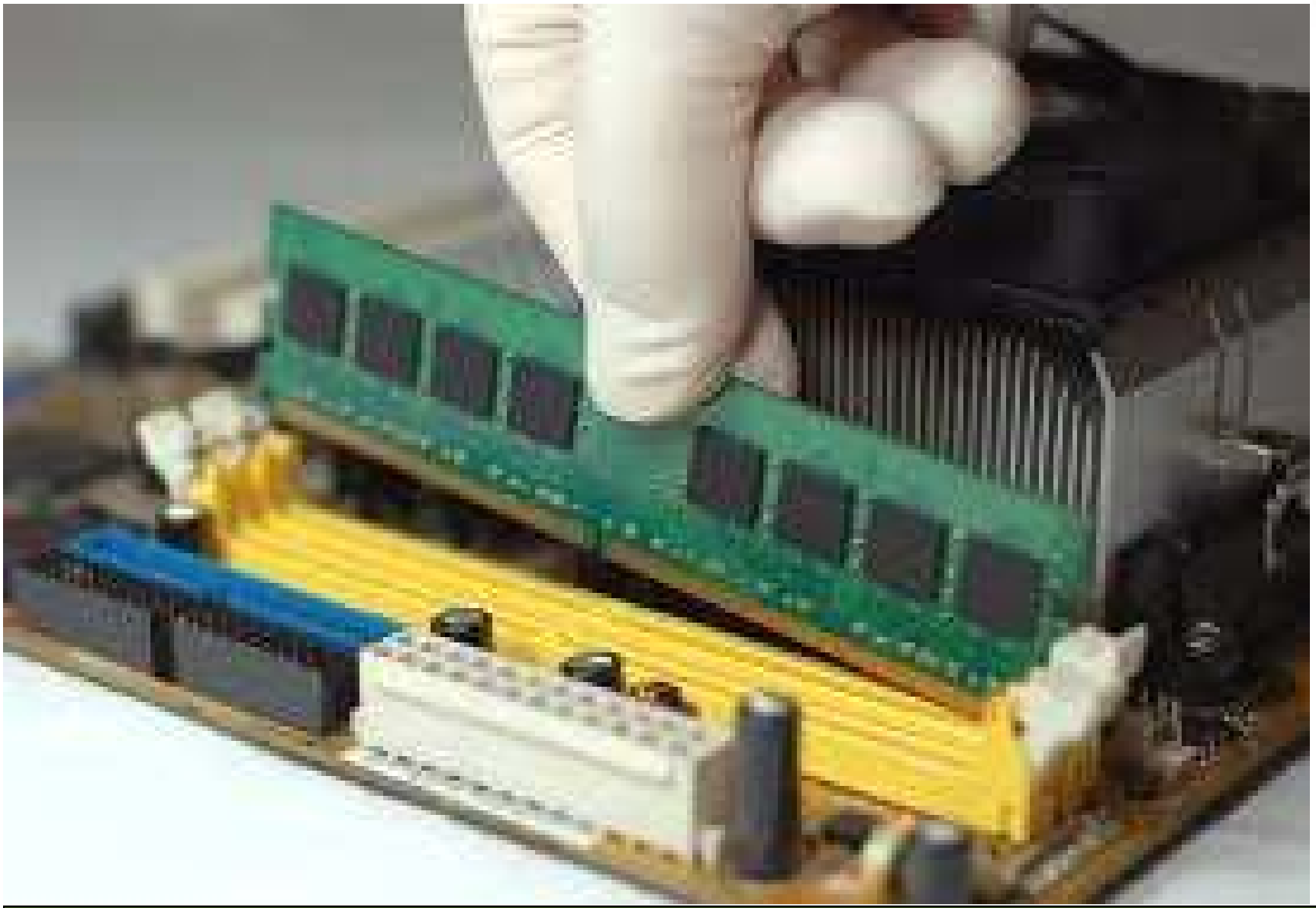
Random Access Memory (RAM)

- **Random Access Memory (RAM)** is the memory chips that are mounted directly on the motherboard or mounted on peripheral cards that plug into the motherboard.

  The RAM chips consist of millions of switches that are sensitive to changes in electric current. When the computer is powered on, certain operating system files are loaded from a storage device such as a hard disk into RAM.

  These files remain in RAM as long as the computer is running. As additional programs and data are requested, they are read from storage into RAM. The processor acts upon the data while it is in RAM. During the running time, the contents of RAM may change as the program is executed.

RAM chip being inserted into a motherboard



Random Access Memory (RAM)

- **The amount of RAM** a computer requires often depends on the types of applications you plan to use on the computer. A computer only can manipulate data that is in memory. A computer needs a certain amount of memory to store programs, data and information.
- The more RAM a computer has, the faster the computer will respond.
- A software package usually indicates the minimum amount of RAM it requires. RAM in computers purchased today ranges from 128MB, 512MB, 1GB to 64GB.

Basic types of RAM

a) **Dynamic RAM (DRAM)** must be refreshed (or recharged) constantly by the CPU.
b) **Static RAM (SRAM)** is faster and more reliable than any form of DRAM. The term static refers to the fact that it does not have to be re-energized as often as DRAM.
c) **Magneto resistive RAM (MRAM),** stores data using magnetic charges instead of electrical charges.
d) **MRAM** has greater storage capacity, consumes less power, and has faster access times.
e) **Virtual RAM (VRAM):** Modern operating systems can use spare storage space on the hard disk as if it is working memory and this is referred to as Virtual memory or Virtual RAM

Read-only memory (ROM)

- **Read-only memory (ROM)** refers to memory chips storing permanent data and instructions. That is, the items stored in ROM chips cannot be modified—then, the name read-only. ROM is usually nonvolatile.
- In ROM, the combination of circuit states is fixed, and therefore its contents are not lost if the power is removed. The data, instructions, or information stored on ROM chips often are recorded when the chip is manufactured. ROM chips that contain permanently written data, instructions, or information are called **firmware**. Firmware can be read and used, but cannot be changed by user as its inserted into the computer during manufacture.

Basic types of ROM

a) **Programmable read-only memory (PROM)** is a blank ROM chip on which you can permanently place data and programs. Once the data and instructions are programmed into PROM chip, the chip functions like a regular ROM and cannot be erased or changed. A variation of the PROM chip, called **electrically erasable programmable read-only memory (EEPROM)** chip, allows a programmer to erase the microcode with an electric signal.

Differences Between RAM and ROM

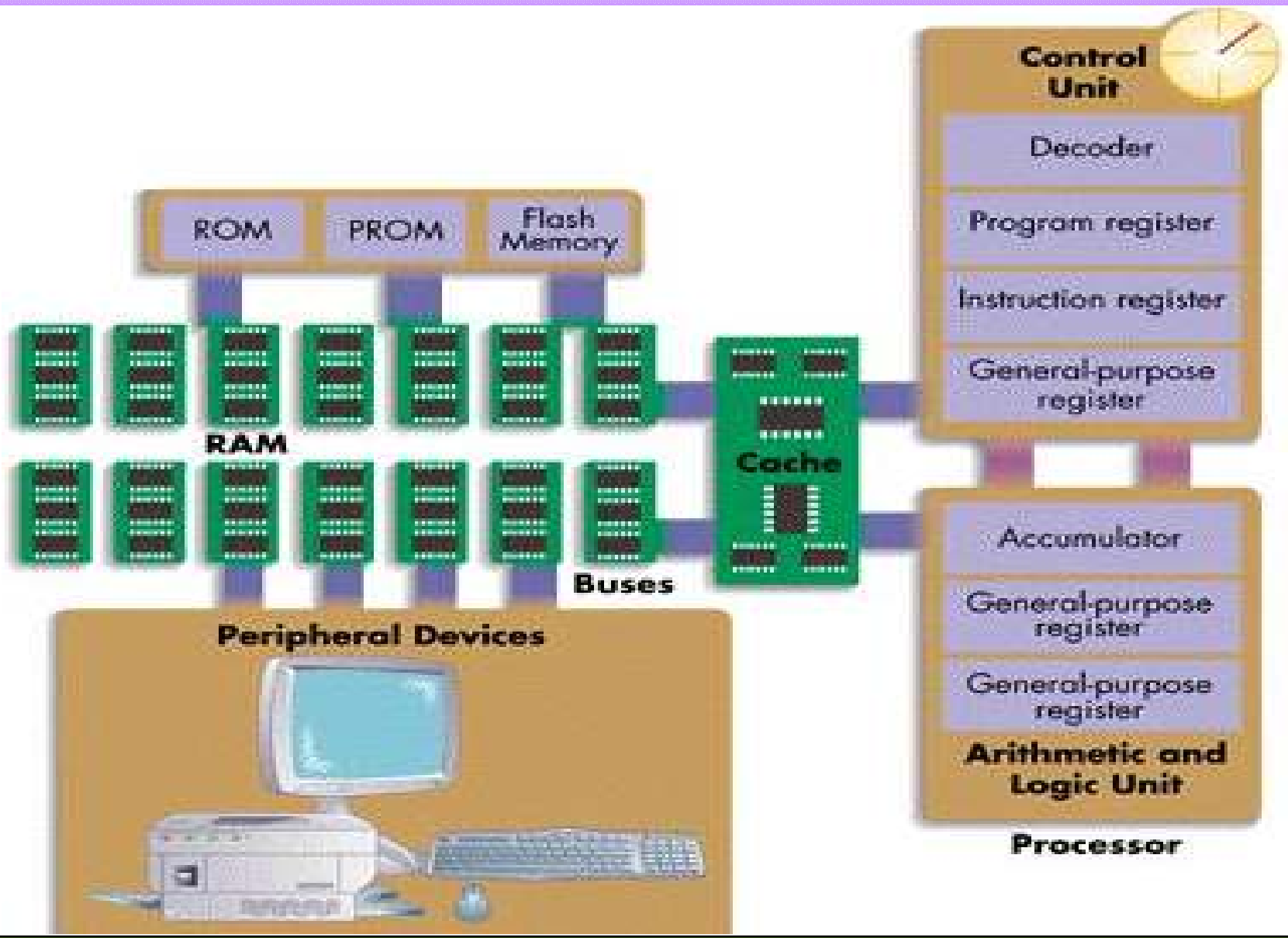
RAM	ROM
1. Volatile, temporally	1.Non Volatile, permanent
2. Contents lost when power goes off	2. Contents remain when power goes off
3. Read and Write	3. Read Only
4. Can be increased	4. Cant be Increased
5. Not installed at Factory	5. Installed at Factory

Memory cache

- **A cache** is a relatively small block of very fast memory designed for the specific purpose of speeding up the internal transfer of data and software instructions. Cache uses internal storage technologies that are much faster than conventional RAM.

  Cache speeds up processing time because it stores frequently used instructions and data.

The processor first checks cache, then RAM for needed data and instructions



Flash memory

- **Flash memory** is an electronic (solid-state) non-volatile computer memory storage medium that can be electrically erased and reprogrammed.

- Most computers use flash memory to hold their startup instructions because it allows the computer easily to update its contents.

CMOS

- **Complementary Metal-Oxide Semiconductor (CMOS)** technology provides high speeds and consumes little power. CMOS technology uses battery power to retain information even when the power to the computer is off.

  Battery-backed CMOS memory chips, for example, can keep the calendar, date, and time current even when the computer is off.

Units of Measuring Computer Memory

- **Binary digit(BIT)** refers to the smallest unit of measuring Computer Memory.
- **Binary digits** are the numbers **1** and **0** which can be represented in a computer by switching voltage **on** and **off**. Eight little bits(e.g 10100101) make one **Byte** which is one **character** or **number** or **symbol**.
- The storage capacity of computers (RAM and ROM) and that of auxiliary storage units like disks are generally given in bytes.

More units of Computer Memory:

- Kilobyte (1K or 1 Kb) is 2^{10} = 1024 bytes. (Approximately 1 thousand bytes)
- Megabyte (Mb) is 2^{10} = 1024 Kilobytes or 2^{20} bytes, (Approximately 1 million bytes)
- Gigabyte (GB) is 2^{10} = 1024 Megabytes or 2^{30} bytes, (Approximately 1 billion bytes)
- Terabyte (TB) is 2^{10} = 1024 Gigabytes or 2^{40} bytes, (Approximately 1 trillion bytes)
- Other higher prefixes are Peta(2^{50}), Exa(2^{60}), Zeta(2^{70}), Yotta(2^{80}), approximately equal to 10^{15}, 10^{18}, 10^{21}, and 10^{24} bytes respectively.
- NB In computing today, the approximation 1024 to 1000 has brought about confusion and many manufactures quote a disk with 1,000,000,000 bytes as 1 GB (10^9) instead of 1,073,741,824 bytes (2^{30})

Examples and Exercises

Qn1. How many bits are required to store the following words?

a) COMPUTING

b) NABISUNSA

c) 36^{o}C

d) U.N.E.B

Examples and Exercises

- **Qn.2** Does a text document with 1,000,000 characters fit onto a 1.4 MB floppy disk?
- **Qn. 3** Arrange the elements below in terms of their relative size in ascending order in a computer:
  a) Character> Document> Page> Word> Paragraph
  b) Gigabyte>Kilobyte>Megabyte>Bit>Byte
- **Qn. 4 Convert:**
  (i) 200 kb to bits
  (ii) 5,120,000 Bytes to Megabytes
  (iii) 2 GB to kb

Answer Q4

(ii) 5,120,000 Bytes to Megabytes

Ans: 1MB = 1000Kb=1,024,000bytes

Therefore, 1 byte = MB

So, 5,120,000 bytes = X5,120,000

=5MB

(iii) 2GB to kb Ans: 2,000,000

Computer Data representation & numbering systems

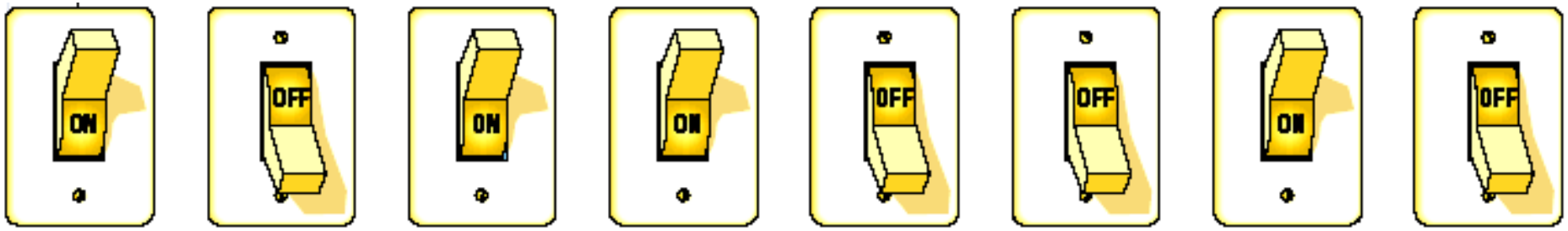
- Humans understand decimal (base ten) just because they have ten counting fingers.

- Digital electronics (computers) understand binary because binary consists of only two digits which correspond to the two power states. 0 representing electrical charge OFF and 1 representing electrical charge ON.
- **Octal (base 8)** and **Hexadecimal (base 16)** number systems are used to represent complex binary data in a more compact form.

Binary numbering system

- Binary is a numbering system that is a series of 1s and 0s only.
- The idea of binary was created in the 1600s.
- Binary has been used in nearly everything electronics; from calculators to supercomputers.
- Machine code language is in binary digits.

Binary numbering system



- As an example the following bit pattern represents the word 'HELLO‘.Computer does all that at very high speed during typing and you only see the resulting 'HELLO' on

H E L L O

Binary Coding Schemes

- A binary coding scheme is a method used for representing all of the digits, letters, special characters, and control characters available to a digital computer using a combination of bits 0 and 1.The off/on 0s and 1s are arranged in such a way that they can be made to represent each character uniquely.
- In a binary number, a digit 0 or 1 is called a bit. For example, 1001 is a 4-bit binary number, and, 11000110 is an 8-bit binary number.
- There are three commonly used binary coding schemes: **ASCII**, **EBCDIC** and **Unicode.**

ASCII:

- **ASCII** is an abbreviation for **American Standard Code for Information Interchange**.
- It is a character-encoding scheme based on the ordering of the English alphabet.
- **ASCII-7** includes coding for $2^7 = 128$ characters
- **ASCII-8** includes coding for $2^8 = 256$ characters.
- The name **ASCII-8** is often used for binary codes that use all values in a full byte (**8 binary digits**).

EBCDIC

- **Extended Binary Coded Decimal Interchange Code (EBCDIC)** uses 8 bits to represent a symbol in the data.EBCDIC was devised in the 1960s by IBM .EBCDIC allows 2^8 = 256 combinations of bits.
- 256 unique symbols are represented using EBCDIC code.
- EBCDIC codes are used mainly, mainly on IBM mainframe and midrange computer systems.

Unicode

- **Unicode** is a **universal character encoding standard** for the representation of text which also includes symbols in multi-lingual environments.
- Unicode uses 32 bits to represent a symbol in the data.Unicode allows **2^{32} = 4164895296 (~ 4 billion) combinations.**
- Unicode codes can uniquely represent any character or symbol present in any language like Chinese, Japanese etc.

Converting from binary to decimal

a) Multiply each bit of the binary number by its corresponding bit-weighting factor .

b) Sum up all of the products in step (a) to get the decimal number.

E.g. Convert 1011 binary to Decimal

Soln: 1011 binary = $1x2^3 + 0x2^2+1x2^1+1x2^0$

$8+0+2+1=11$

Converting from binary to decimal

a) Divide the decimal number by 2; and record the remainder.

b) If the quotation is zero, the conversion is complete. Otherwise repeat step (a) using the quotation as the decimal number. The new remainder is the next most significant bit of the binary number.

Convert 235 decimal to binary code

So, 235 decimal = 11101011 binary

B	N	R
2	235	1
2	117	1
2	58	0
2	29	1
2	14	0
2	7	1
2	3	1
2	1	1
2	0	-

The octal numbering system

- The **octal numeral system** is a **base 8 numeral** system. It uses the numerals 0 through 7.
- At one time, the octal system was used mainly for work with computers. It provided an easier way to work with binary numbers. As computers changed from using 24-bit systems to 32- and 64-bit systems, hexadecimal replaced octal for most uses.
- The octal numeral system uses a three-bit binary coding. Each digit in an octal numeral is the same as three digits in a binary numeral. The grouping of the binary digits is done from right to left.

Hexadecimal numeral system

- The **hexadecimal numeral system**, also known as just hex, is a numeral system made up of **16 symbols (base 16**). It uses the common symbols in the **decimal numeral system (0 through 9)** and includes six extra symbols. These symbols are characters taken from the English alphabet: A, B, C, D, E and F.
- The **hexadecimal system** replaced **the octal numeral system** for much of the work done on computers.

Advantages of using Hex

- **Hexadecimal numbers** are very compact .
- As computers become more advanced, they tend to use larger groups of bits but they use multiples of 8 (16, 24, 32, 64, and 1 GB+ etc). Hexadecimal makes it easier to write these large binary numbers.
- The **hexadecimal**, or base **16 number system** is important to programmers because it's a shorthand way of writing out and inputting binary. It's simpler and easier because you can work with fewer symbols, or "numbers".
- It is easy to convert from hex to binary and binary to hex.
- Octal is similar to hexadecimal because they are both easily converted to binary. Where octal is equal to three-digit binary, hexadecimal is equal to four-digit binary.

Decimal	Binary	Octal	Hexadecimal
0	0000	0	0
1	0001	1	1
2	0010	2	2
3	0011	3	3
4	0100	4	4
5	0101	5	5
6	0110	6	6
7	0111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F

Decimal, Binary, Octal and Hexadecimal Counting Table/ Chart

Examples

1.(a) What is the octal and hexadecimal equivalent off:

a) 111011101_{binary}

b) 10010101_{binary}

c) $45_{decimal}$

(b) What is the binary equivalent for :

i. $1A4C_{hex}$

ii. 4553_{oct}

PROCESSING HARDWARE

END

INQUIRES

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