IT #college-studies #computer

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Computer

- It is an electronic device, which takes data as an input and store's it, process it and gives a desirable output.
- Computer is a calculator.
- A Computer is a programmable machine designed to perform logical operations on the input given by the user and give us the desired output.

Computer components are divided in two:

- *Hardware:*
  - It is the machine itself and it's connected devices such as keyboard, CPU , mouse, etc.
- *Software:*
  - It is the set of program that make use of hardware for performing various functions.

Characteristics of Computer:

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1. *Speed:* Computer work at an incredible speed. A powerful computer (Supercomputer) is capable of performing about 3-4 million simple instructions per second.
2. *Accuracy:* Unlike human beings computers are highly consistent. They don't suffer human traits of tiredness resulting in lack of concentration.
3. *Versatility:* Computers are versatile machines and are capable of performing any as long as it can be broken down into a series of logical steps.
4. *Storage:* Today's Computer can store large volume of data. A piece of information once recorded in the computer, can never be forgotten and can be retrieved.
5. *Power of Remembering:* Computer has a power of storing any amount of information and data.
6. No feeling
7. *No IQ:* Computer is a dump machine and it can't any without instructions.

Block Diagram of Computer

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                        Central Processing Unit
                      --------------------------------
                      |      C.U (Control Unit)      |
          Input -->   | A.L.U (Arithmetic Logic Unit) | --> Output
                      |      M.U (Memory Unit)       |
                      --------------------------------
Memory Unit:
    - Primary Memory Unit
    - Secondary Memory Unit
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Input Unit:

Computer need to receive data and instructions in order to solve any problem. The Input Unit consist of one or more input devices. Keyboard is one of the commonly used input device. All the input devices perform following function:

- Accept the data and instructions from outside world.
- Convert it to a form that computer will understand.
- Supply the converted data to the computer system for further processing.

Storage Unit (Memory Unit):

The storage unit of the computer holds data and instructions that the input unit, before they are processed. It preserves the intermated and final result before this are sent the final result before this are sent the output devices.

It has divided into two categories:

- *Primary:*
  - It stores and provides very fast.
  - This memory is generally used to hold the program being currently executed in the computer.
- *Secondary:*
  - It stores several programs and docs, database etc.
  - The program that you can run on the computer are first transferred the primary memory before it actually run.
  - The secondary memory is slower and cheaper than primary memory.
    - e.g: Hard drive, CD etc.

Output Unit:

- This Unit of computer provides the information and result after processing the input data.
- Printers, monitors, speakers etc are output devices.

ALU (Arithmetical Logical Unit):

- All calculations are performed in ALU computer.
- The ALU can perform basic operations such as addition, subtraction, multiplication, and division and logical operations. (<, >, &, = etc)

CU (Control Unit):

- It controls all units of units of computer.
- It instructs the input unit where to store the input data after receiving it from user.
- It controls flow of data and instructions to storage unit.
- It also controls the flow of result to from ALU to SU.
- It generally perform an central nervous sytem.

CPU (Central Processing Unit):

- The CU, ALU and MU of computer together known as CPU.
- The CPU is like brain which performs following functions.
  - It performs all calculations.
  - It takes all the decisions'.
  - It controls all units of computer.

Types of Computers

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1. *Analog Computers:*
   - Analog Computer is a computer which is used to measure physical quantity.
   - It is used to measure electric current, frequency and resistance .
   - Physical quantities are temp. , pressure, speed, length etc.
   - We use these computer in daily life like speedometer.
2. *Digital Computers:*
   - Computer that work on binary numbers (0,1) are called Digital Computers.
   - The first Digital computer was developed in 1940s, it was developed for only mathematical work.
3. *Micro Computers:*
   - A micro computer is a small computer that can be used by only one person at a time. It is known as *Personal Computer*.
   - First micro computer was build with 8 bit processor.
4. *Super Computer:*
   - Most Powerful , most expensive computer.
   - Used for most scientific applications that requires huge processing power.
   - They are special purpose computer that are designed to perform some specific task.
   - The cost of super computer is depended on processing capacity and configuration.
     - e.g: PARAM, EKA etc
5. *Mainframe Computer:*
   - Every powerful computer which is capable of supporting thousands of users simultaneously.
   - It is capable to run multiple and expensive computers with having larger internal storage capacity and high processing speed.
   - Mainly used to handle bulk of data and information for processing.
   - IBM are major vendors of mainframes.
     - e.g: IBM, HP, HCL.
6. *Mini Computer:*
   - Less expensive than mainframe computer, capable of supporting 2 to 100 user simultaneously .
   - In 1970s it contains 8 bit and 12 bit processor.
   - Gradually it has grown and got 16, 32, 64 bit processor.
     - e.g: IBM AS500
7. *Hybrid Computer:*
   - It combines good features of both analog and digital computer.
   - It has a speed of analog computer and accuracy of digital computer.

Generation of Computer

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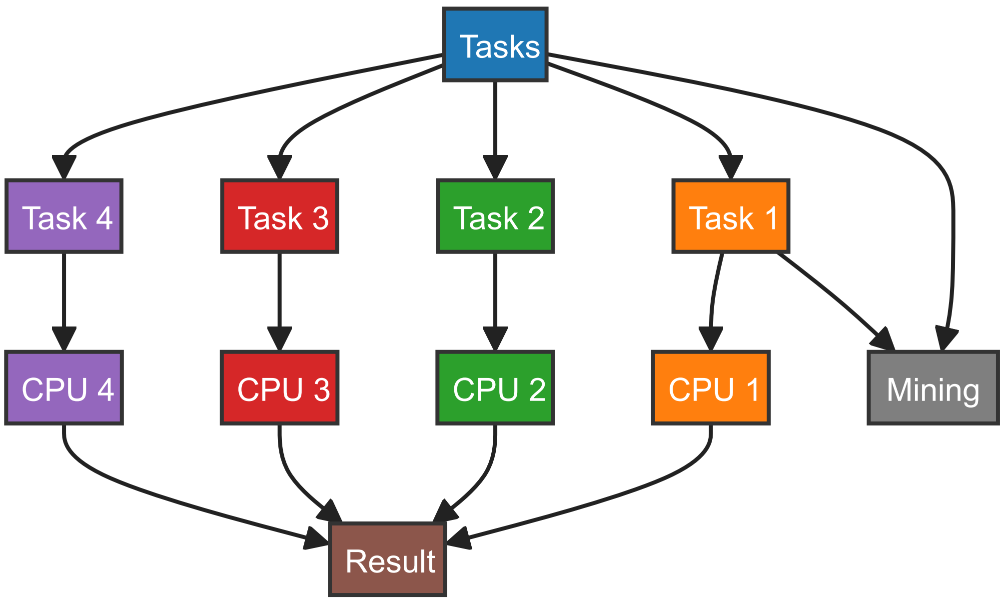
1. *First Generation:*
   - Duration: 1940s to 1950s
   - Technology: Vacuum Tube
   - Used as calculating device.
   - Too bulky in size and complex design.
   - Require large room.
   - Generates too much heat.

- Air conditioner rooms are required.
- Limited commercial use
  - e.g: ENIAC, EDVAC

2. *Second Generation:*
   - Duration: 1950s - 1960s
   - Technology: Transistor
   - Ten times smaller in size than 1st Generation computer.
   - Less heat than first generation computer.
   - Consume less power than first generation computers.
   - Air conditioner is required.
   - Wider commercial Use.
   - Large and fast primary, secondary storage than first generation.
3. *Third Generation:*
   - Duration: 1960s - 1970s
   - Technology: IC Chips
   - Smaller than first and second generation.
   - Perform More Calculations than first and second generation.
   - Large and fast primary/ Secondary storage than 1^{st} & 2^{nd} .
   - Air Conditioner is required.
   - High level languages like COBAL/FORTAN are allowed to write program.
4. *Forth Generation:*
   - Duration: 1970s - 1980s
   - Technology: Micro-processor chip
   - Based on LSI & VLSI microprocessor chip
   - small in size
   - possible to use network concept to connect computers together
   - No air conditioners required
   - cheapest in price
5. *Fifth Generation:*
   - Duration: 1990s -
   - Technology: ULSI , microprocessor chip
   - Much handle and small
   - speed increased
   - consume less power
   - more user friendly
   - high level languages are allowed to write a program

Parallel Computing



- Parallel Computing usages various processing elements to solve a problem.

- Problem gets divided into chunks and are processed parallelly using multiple processor. The multiple processor intercommunicate through shared memory and result are merged later.
- To manage the excessive amount of data in the real world, parallel computing is key concept.
- It reduces line, cost and memory utilization.
- Managing complex and large data set efficiently require parallel computing models.

Distributed Computing

- The team distributed computing/system refers to a system that is composed of components located on multiple machines.
- All components interact in a coordinated way as a unified system.
- *Sharing of Resources:* Resources are shared among different nodes in a network.
- *Open Software:* Many software are developed and shared with others.
- *Transparency:* The degree too which one node can locate and communicate with other nodes in system.

Memory

- Memory is a just like human brain it stores data and instructions.
- Memory is a collection of memory cells.

Memory Cells

- A Memory cell if of 1 bit.
- A Memory cell is a device which can store a symbol

```
                    Write
                      ⬆️
                +-----------------+
Input -->       |     Memory      |
                |     Cells       | --> Output
                +-----------------+
                      ⬇️
                    Read
```

- The time taken to read a symbol, from a cell is called Read time, and time taken to write a symbol is write time.

Types of Memory

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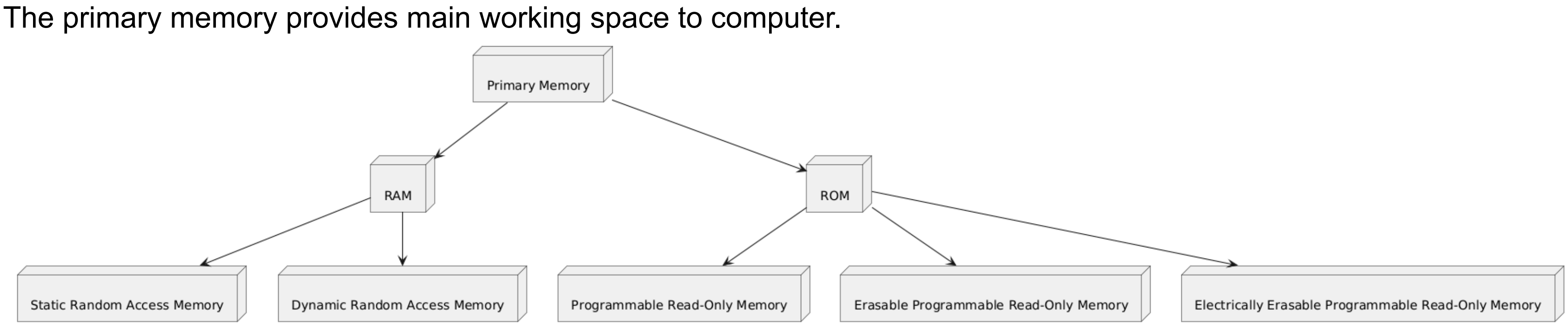
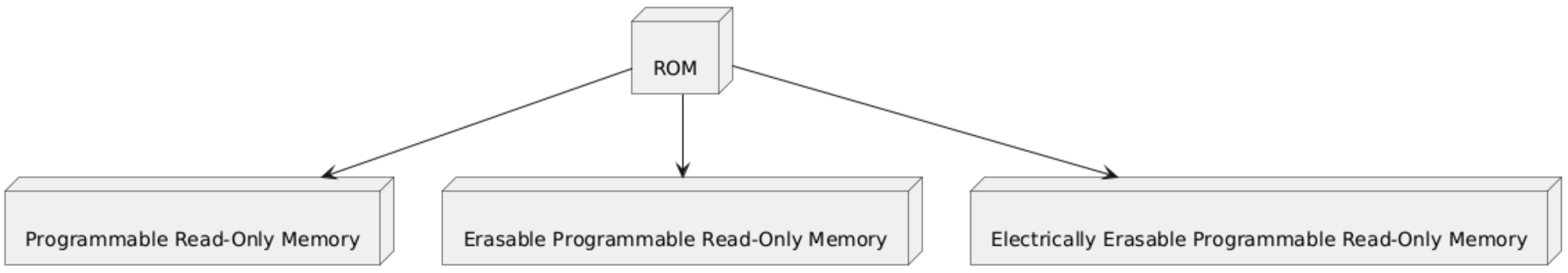
1. *Primary Memory*
    - Is Called as Main Memory.
    - It is internal memory of computer.
    - The primary memory provides main working space to computer.



    - *RAM (Random Access Memory)*

- Volatile Memory: Loses its data when power is turned Off.
  - Fast read/write : Essential for running applications and the operating system.
  - Types: SRAM (Static Random Access Memory) & DRAM (Dynamic Random Access Memory)
  - Uses: Main memory in computers and devices for temporary data storage.
- *SRAM (Static RAM)*
  - Volatile Memory: Loses its data when power is turned Off.
  - No need for refresh: Retains data as long as power is supplied.
  - Fast and reliable : Faster than DRAM, used in cache memory.
  - More expensive: Higher cost due to complexity and larger size of cells.
- *DRAM (Dynamic RAM)*
  - Volatile Memory: Loses its data when power is turned Off.
  - Needs to refresh: Must be periodically refreshed to Retains data.
  - Dense and cheaper: More cost-effective and can store more data per chip than SRAM.
  - Common Use: Main system memory in computers.
- *ROM (Read-Only Memory)*
  - Non-volatile Memory: Retains its data even when power is turned off.
  - Used to store firmware and system-level software that does not change frequently.
  - Types: PROM (Programmable Read-Only Memory), EPROM (Erasable Programmable Read-Only Memory), and EEPROM (Electrically Erasable Programmable Read-Only Memory).
  - Provides essential instructions for hardware boot-up processes.



- ***PROM (Programmable Read-Only Memory)***
  - Non-volatile Memory: Retains data when power is turned off.
  - Once programmed, it cannot be modified.
  - Useful for hardware programming, but lacks flexibility for updates.
  - Common Use: Embedded systems, microcontrollers.
- ***EPROM (Erasable Programmable Read-Only Memory)***
  - Non-volatile Memory: Retains data when power is turned off.
  - Can be erased and reprogrammed by exposing it to ultraviolet light.
  - Used for systems that need updates but require manual intervention for erasing.
  - Common Use: BIOS chips, early microcontrollers.
- ***EEPROM (Electrically Erasable Programmable Read-Only Memory)***
  - Non-volatile Memory: Retains data when power is turned off.
  - Can be erased and reprogrammed electrically, allowing for easy updates.
  - Often used for systems that need frequent updates or modifications.
  - Common Use: Firmware updates, small-scale data storage like configuration settings.

Differences between Primary Memory and Secondary Memory:

Aspect	Primary Memory	Secondary Memory
Also Known As	Main Memory	External or Auxiliary Memory
Volatility	Volatile (e.g., RAM)	Non-volatile
Data Retention	Loses data when power is turned off (for most types)	Retains data even when power is turned off
Speed	Faster (nanoseconds access time)	Slower (milliseconds access time)
Capacity	Limited (typically in GBs)	Larger (can range from GBs to TBs)
Cost	More expensive per unit of storage	Less expensive per unit of storage
Usage	Used for active processes and tasks	Used for long-term data storage
Examples	RAM (Random Access Memory), ROM	Hard Disk Drives (HDD), Solid State Drives (SSD), CDs, DVDs

Aspect	Primary Memory	Secondary Memory
Data Access	Directly accessible by the CPU	Requires intermediate steps for access
Power Dependency	Requires power to maintain data (for RAM)	Independent of power for data retention
Physical Location	Internal (mounted on the motherboard)	External or internal (storage drives)
Read/Write Operations	Fast read/write operations	Slower read/write operations

- ***Cache Memory***
  - Volatile Memory: Loses its data when power is turned off.
  - Extremely fast: Faster than RAM, helps in reducing the CPU's time to access data.
  - Stores frequently accessed data: Holds the most recently used instructions and data for quick retrieval by the CPU.
  - Common Use: Speeding up data access for the CPU to improve system performance.

2. ***Secondary Memory***
   - Non-volatile Memory: Retains data even when power is turned off.
   - Large capacity: Can store vast amounts of data, ranging from gigabytes to terabytes.
   - Slower access: Compared to primary memory, secondary memory has slower read/write speeds.
   - Used for long-term storage: Ideal for storing large files and data that don't need to be accessed frequently by the CPU.
   - Examples: Hard Disk Drives (HDD), Floppy Disks (FD), CDs, DVDs, and Magnetic Tape.
   - ***FD (Floppy Disk)***
     - Non-volatile Memory: Retains data without power.
     - Small storage capacity: Typically 1.44 MB, now largely obsolete.
     - Portable: A small, removable storage device used in the early days of personal computing.
     - Slow access: Much slower than modern storage devices.
     - Common Use: Data transfer between computers before USB drives and modern storage took over.
   - ***HDD (Hard Disk Drive)***
     - Non-volatile Memory: Retains data when power is turned off.
     - Large storage capacity: Ranges from hundreds of gigabytes to several terabytes.
     - Magnetic storage: Uses spinning platters coated with magnetic material to store data.
     - Slower than SSDs but cost-effective: HDDs are cheaper per gigabyte than SSDs but have slower read/write speeds.
     - Common Use: Long-term storage of files, applications, and operating system data in computers.
   - ***Magnetic Tape***
     - Non-volatile Memory: Retains data even when power is turned off.
     - Sequential access: Data is read in sequence, making it slower to access specific files.
     - High durability and capacity: Can store large amounts of data, used for archival purposes.
     - Common Use: Long-term data backup and archiving in industries due to its large capacity and durability.
   - ***CD (Compact Disc)***
     - Non-volatile Memory: Retains data when power is off.
     - Optical storage: Uses laser technology to read and write data.
     - Capacity: Typically holds 700 MB of data.
     - Common Use: Music, software distribution, and small file storage.
   - ***DVD (Digital Versatile Disc)***
     - Non-volatile Memory: Retains data without needing power.
     - Optical storage: Similar to CDs but with a higher data capacity.
     - Capacity: Typically holds 4.7 GB (single-layer) or up to 8.5 GB (dual-layer).
     - Common Use: Movies, video games, software, and large file storage.

Number System

In a number system of base (n), the digits range from (0) to (n-1). The base is also referred to as the **radix** of the number system. Each number is represented as a sequence of digits, and the base (n) is written as a subscript.

Common Number Systems:

- *Binary (Base 2):*
  Digits are $((0,1))$ and the representation is written as: $((0,1)_2)$
- *Octal (Base 8):*
  Digits are $((0,1,2,3,4,5,6,7))$ and the representation is written as: $((0,1,\ldots,7)_8)$
- *Decimal (Base 10):*
  Digits are $((0,1,2,3,4,5,6,7,8,9))$ and the representation is written as: $((0,1,\ldots,9)_{10})$
- *Hexadecimal (Base 16):*
  Digits are $((0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F))$
  The representation is written as: $((0,1,\ldots,9,A,B,C,D,E,F)_{16})$

Conversions

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1. *Converting from Binary to Decimal:*

   - Multiply each binary digit by 2 raised to the power of its position, starting from 0 on the right.
   - Sum all the products to get the decimal equivalent.

   Example:
   Convert (1101_2) to decimal:

   $$(1\times 2^3)+(1\times 2^2)+(0\times 2^1)+(1\times 2^0)=8+4+0+1=13$$

   Thus, $1101_2 = 13_{10}$

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2. *Converting from Binary to Octal:*

   - Group the binary number into sets of three digits, starting from the right.
   - Convert each group to its octal equivalent.

   Example:
   Convert (110101_2) to octal:

   $$\begin{array}{ccc|c} 1 & 1 & 0 & 1 \\ 0 & 1 & & 5 \end{array}$$

   Grouped as: $((110)(101))$ gives $((6)(5))$
   Answer: $110101_2 = 65_8$

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3. *Converting from Binary to Hexadecimal:*

   - Group the binary number into sets of four digits, starting from the right.
   - Convert each group to its hexadecimal equivalent.

   Example:
   Convert (11010101_2) to hexadecimal:

   $$\begin{array}{cccc} 1 & 1 & 0 & 1 = D \\ 0 & 1 & 0 & 1 = 5 \end{array}$$

   Grouped as: $((1101)(0101))$ gives $((D)(5))$
   Thus, $11010101_2 = D5_{16}$

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4. *Converting from Decimal to Binary:*

   - Take the decimal number you want to convert.
   - Divide the number by 2 (the base of binary) and note the remainder.
   - Continue dividing the quotient by 2 until the quotient becomes zero.
   - Collect the remainders in reverse order to get the binary equivalent.

Example:
Convert 13 to binary:

$$\begin{array}{c|c|c} 2 & 13 & 1 \\ \hline 2 & 6 & 0 \\ \hline 2 & 3 & 1 \\ \hline 2 & 1 & \end{array}$$

Read the remainders from bottom to top: $13_{10} = 1101_2$

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5. *Converting from Decimal to Octal:*

    - Divide the decimal number by 8 (the base of octal) and note the remainder.
    - Continue dividing the quotient by 8 until the quotient becomes zero.
    - Collect the remainders in reverse order to get the octal equivalent.

Example:
Convert 65 to octal:

$$\begin{array}{c|c|c} 8 & 65 & 1 \\ \hline 8 & 8 & 0 \\ \hline 8 & 1 & 1 \\ \hline & 0 & \end{array}$$

Read the remainders from bottom to top: $65_{10} = 101_8$

Convert 12345 to octal:

$$\begin{array}{c|c|c} 8 & 12345 & 1 \\ \hline 8 & 1543 & 7 \\ \hline 8 & 192 & 0 \\ \hline 8 & 24 & 0 \\ \hline 8 & 3 & \end{array}$$

Read the remainders from bottom to top: $12345_{10} = 30071_8$

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6. *Converting from Decimal to Hexadecimal:*

    - Divide the decimal number by 16 (the base of hexadecimal) and note the remainder.
    - Continue dividing the quotient by 16 until the quotient becomes zero.
    - Convert any remainder greater than 9 into its hexadecimal letter equivalent (A = 10, B = 11, etc.).
    - Collect the remainders in reverse order to get the hexadecimal equivalent.

Example:
Convert 255 to hexadecimal:

$$\begin{array}{c|c|c} 16 & 255 & 15 \\ \hline 16 & 15 & \end{array}$$

Remainder 15 corresponds to F in hexadecimal: $255_{10} = FF_{16}$

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7. *Converting from Octal to Binary:*

    - Convert each octal digit to its binary equivalent, using three binary digits for each octal digit.

Example:
Convert (47_8) to binary:

$$\begin{array}{c|c} 4 & 100 \\ \hline 7 & 111 \end{array}$$

Answer: $47_8 = 100111_2$

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8. *Converting from Octal to Decimal:*

- Multiply each octal digit by 8 raised to the power of its position, starting from 0 on the right.
- Sum all the products to get the decimal equivalent.

Example:
Convert (101_8) to decimal:

$$(1 \times 8^2) + (0 \times 8^1) + (1 \times 8^0) = 64 + 0 + 1 = 65$$

Thus, $101_8 = 65_{10}$

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9. *Converting from Hexadecimal to Binary:*
    - Convert each hexadecimal digit to its binary equivalent, using four binary digits for each hexadecimal digit.
      Example:
      Convert $(2F_{16})$ to binary:

$$\begin{array}{c|c} 2 & 0010 \\ \hline F & 1111 \end{array}$$

Answer: $2F_{16} = 00101111_2$

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10. *Converting from Hexadecimal to Decimal:*

- Multiply each hexadecimal digit by 16 raised to the power of its position, starting from 0 on the right.
- Convert any letters (A = 10, B = 11, etc.) to their decimal equivalents before multiplying.
- Sum all the products to get the decimal equivalent.
  Example:
  Convert (FF_{16}) to decimal:

$$(15 \times 16^1) + (15 \times 16^0) = 240 + 15 = 255$$

Thus, $FF_{16} = 255_{10}$

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11. *Converting from Hexadecimal to Octal:*
    - Convert the hexadecimal number to decimal first, then convert from decimal to octal.

    Example:
    Convert $(2A_{16})$ to octal:
    Convert to decimal:

$$(2 \times 16^1) + (10 \times 16^0) = 32 + 10 = 42_{10}$$

Now, convert 42 to octal:

$$\begin{array}{c|c|c} 8 & 42 & 2 \\ \hline 8 & 5 & 0 \end{array}$$

Answer: $2A_{16} = 52_8$

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12. *Converting from Octal to Hexadecimal:*

    - Convert the octal number to decimal first, then convert from decimal to hexadecimal.

Example:
Convert (27_8) to hexadecimal:
Convert to decimal:

$$(2 \times 8^1) + (7 \times 8^0) = 16 + 7 = 23_{10}$$

Now, convert 23 to hexadecimal:

$$\begin{array}{c|c|c} 16 & 23 & 7 \\ \hline 16 & 1 & \end{array}$$

Answer: $27_8 = 17_{16}$

Binary Addition:

Rules for Binary Addition:

- **0 + 0 = 0**
- **0 + 1 = 1**
- **1 + 0 = 1**
- **1 + 1 = 10** (which means 0 is written and 1 is carried over to the next higher bit)

Example:

Add (1011_2) and (1101_2):

$$\begin{array}{cccccc} \text{Carry:} & 1 & 1 & 1 & & \\ & 1 & 0 & 1 & 1 & \\ + & 1 & 1 & 0 & 1 & \\ \hline & 1 & 1 & 0 & 0 & 0 \end{array}$$

Thus, $1011_2 + 1101_2 = 11000_2$

Binary Subtraction:

Rules for Binary Subtraction:

- **0 - 0 = 0**
- **1 - 0 = 1**
- **1 - 1 = 0**
- **0 - 1 = 1** with a borrow from the next higher bit

Example:

Subtract (1101_2) from (10101_2):

$$\begin{array}{cccccc} \text{Borrow:} & 1 & 0 & 1 & 0 & \\ & 1 & 0 & 1 & 0 & 1 \\ - & 1 & 1 & 0 & 1 & \\ \hline & 0 & 0 & 0 & 0 & 0 \end{array}$$

Thus, $10101_2 - 1101_2 = 1000_2$

Binary Subtraction Using 1's Complement:

Steps for 1's Complement Subtraction:

1. **Find the 1's complement** of the binary number to be subtracted.
2. **Add** the 1's complement to the other binary number.
3. If there’s a **carry**, add it back to the least significant bit (LSB).
4. If there’s no carry, the result is negative, and you need to find the 1’s complement of the result.

Example:

Subtract (1010_2) from (1101_2) using 1's complement:

1. **Find 1's complement** of 1010_2:
   $1010_2 \rightarrow 0101_2$
2. **Add** the 1's complement of 1010_2 to 1101_2:

$$\begin{array}{r} 1 \ 1 \ 0 \ 1 \\ + \ 0 \ 1 \ 0 \ 1 \\ \hline 1 \ 0 \ 0 \ 1 \ \ (\text{no carry}) \end{array}$$

3. Since there's **no carry**, the result is negative. **Find 1's complement** of the result:

$$1001_2 \rightarrow 0110_2$$

   Thus, $1101_2 - 1010_2 = -0110_2 = -6_{10}$

Binary Subtraction Using 2's Complement:

Steps for 2's Complement Subtraction:

1. **Find the 2's complement** of the binary number to be subtracted.
2. **Add** the 2's complement to the other binary number.
3. If there's a **carry**, discard it.
4. If there's no carry, the result is negative, and you need to take the 2's complement of the result to find its magnitude.

Example:

Subtract (1010_2) from (1101_2) using 2's complement:

1. **Find 2's complement** of 1010_2:
   - First, find the 1's complement: $1010_2 \rightarrow 0101_2$
   - Now, add 1 to get the 2's complement:

$$0101_2 + 1 = 0110_2$$

2. **Add** the 2's complement of 1010_2 to 1101_2:

$$\begin{array}{r} 1 \ 1 \ 0 \ 1 \ \\ + \ 0 \ 1 \ 1 \ 0 \ \\ \hline 1 \ 0 \ 0 \ 1 \ 1 \end{array}$$

3. There's a **carry**, so discard it:
   $10011_2 \rightarrow 0011_2$

   Thus, $1101_2 - 1010_2 = 0011_2 = 3_{10}$

Processor: The Brain of the Computer

- The processor, commonly known as the Central Processing Unit (CPU), is often referred to as the "brain" of the computer because of its crucial role in executing instructions and processing data. It interprets and executes commands from software applications, making it a vital component in all computing devices.
- The CPU handles various tasks, including arithmetic calculations, logical operations, and controlling data flow between different components of the system. With technological advancements, modern processors are designed to manage multiple tasks simultaneously through multi-core architectures, significantly enhancing both computing power and efficiency.
- Key performance indicators for a processor include its clock speed, measured in gigahertz (GHz), the number of cores, and other specifications that determine how efficiently it can execute instructions and process data.

Components of a Computer

A typical computer processor consists of several essential components that collaborate to perform calculations and execute instructions.

1. **Control Unit (CU)**: This component directs the operations of the processor, managing instruction execution and coordinating activities within the CPU. It decodes instructions fetched from memory and controls data flow between the processor and other system components.
2. **Arithmetic Logic Unit (ALU)**: The ALU performs essential mathematical and logical operations, such as addition, subtraction, and logical comparisons. It is crucial for executing the arithmetic computations required by various programs.
3. **Registers**: These are small, high-speed storage locations within the CPU that temporarily hold data and instructions during processing. Registers allow for quick access to frequently used information, which reduces the time needed to retrieve data from slower memory sources.
4. **Cache Memory**: Cache memory is designed to store copies of frequently accessed data and instructions, improving processing speed and efficiency. It acts as a buffer between the CPU and main memory, enabling faster data access.
5. **Control Bus**: The Control Bus consists of electrical pathways that carry control signals between the CPU and other components, facilitating the management of operations within the computer.
6. **Data Bus**: The Data Bus is a set of electrical pathways that transfer actual data between the CPU, memory, and other devices connected to the computer. It allows the CPU to transfer data to and from memory and peripheral devices.
7. **Clock Generator**: The Clock Generator produces timing signals that synchronize all components within the processor, ensuring they operate in harmony.

Features of a Processor

The performance of a processor is characterized by several key features, each playing a critical role in its efficiency and capabilities.

1. **Clock Speed**: This is one of the primary indicators of a processor's performance, measured in gigahertz (GHz). A higher clock speed means that the processor can execute more cycles per second, resulting in faster performance in computational tasks.
2. **Cores**: Cores are the individual processing units within a CPU. Modern processors often feature multiple cores, allowing them to handle multiple tasks or threads simultaneously. This multi-core architecture is particularly beneficial for multitasking and running complex applications requiring significant processing power.
3. **Threads**: Threads are virtualized versions of cores that facilitate parallel processing, enhancing the CPU's ability to perform several operations simultaneously. Each core can manage multiple threads, improving the overall throughput of the processor.
4. **Cache Memory**: The amount of cache memory in a processor significantly influences its performance. Larger cache sizes enable the CPU to store more frequently used data closer to its processing units, reducing the time required to access data from the main memory.
5. **Instruction Set Architecture (ISA)**: The ISA defines the set of instructions a processor can execute. It serves as the interface between hardware and software, determining how software applications communicate with the processor.
6. **Thermal Design Power (TDP)**: TDP refers to the maximum amount of heat generated by a CPU that a cooling system must dissipate. Effective thermal management is crucial for maintaining optimal performance and preventing overheating.
7. **Integrated Graphics Processing Unit (IGPU)**: Many modern processors include an IGPU, allowing them to handle basic graphics processing without needing a dedicated graphics card.
8. **Fabrication**: This term refers to the manufacturing process of the CPU, typically measured in nanometers (nm). Advances in fabrication technology lead to smaller, more efficient, and powerful processors.
9. **Architecture**: The overall architecture of a processor encompasses its design and organization, which can significantly impact performance and energy efficiency.
10. **Bus Speed**: The bus speed indicates how quickly data can be transferred between the CPU and other components. Higher bus speeds facilitate faster communication and data transfer across the system.

Structure of Instruction

The instruction structure in a computer architecture refers to how machine instructions are formatted and organized. It is essential for the processor's execution cycle, affecting how efficiently instructions are fetched, decoded, and executed. The structure typically consists of several fields, each serving a specific purpose.

1. **Opcode Field**: The opcode (operation code) field specifies the operation that the processor must perform, such as addition, subtraction, data movement, or logical operations. The opcode is the key part of the instruction, determining the function to be executed.
2. **Operand Field**: The operand field contains the data or addresses of data that the operation will use. Depending on the instruction set architecture (ISA), operands can be immediate values, memory addresses, or registers. The operand field's size can vary, allowing flexibility in how much data can be directly manipulated.
3. **Addressing Modes**: Addressing modes define how the operands are interpreted. Different modes can affect where the operands are located and how they are accessed. Common addressing modes include immediate addressing, direct addressing, indirect addressing, and indexed addressing. Each mode serves specific purposes and can optimize instruction execution based on the program's needs.
4. **Instruction Length**: The length of an instruction can vary based on the architecture. Some architectures use fixed-length instructions, where every instruction has the same size (e.g., 32 bits), while others use variable-length instructions, allowing for more compact encoding of frequently used operations.
5. **Control Bits**: Some instructions may include control bits that provide additional information about the operation to be performed. For example, control bits can indicate whether an operation should be executed conditionally or unconditionally.
6. **Encoding**: The binary encoding of instructions must be precise to ensure that the hardware can decode and execute them correctly. Efficient encoding minimizes the number of bits required while maximizing the instruction set's expressiveness.
7. **Instruction Cycle**: The structure of instructions is closely tied to the instruction cycle, which involves fetching the instruction from memory, decoding it, executing it, and then storing the result. The efficiency of this cycle can be significantly impacted by the structure of the instructions.

The design of the instruction structure is crucial in defining how effectively a processor can execute programs. A well-structured instruction set enhances the CPU's performance, making it essential for computer architects to consider the trade-offs between complexity and efficiency when designing instruction formats.

RISC (Reduced Instruction Set Computer)

Description: RISC architectures are designed to simplify the instruction set, allowing for a smaller number of simple instructions. The aim is to execute these instructions in a single cycle, enhancing performance and efficiency.

Characteristics:

- **Simple Instructions**: RISC processors use a small set of simple instructions that are easy to decode and execute.
- **Load/Store Architecture**: Data manipulation occurs only through registers, with separate instructions for loading from memory and storing to memory.
- **Fixed Instruction Length**: Instructions are typically of uniform length, simplifying the instruction fetch and decode stages.
- **Registers**: RISC architectures usually have a larger number of general-purpose registers, allowing more data to be kept in fast-access memory.

Advantages:

- **High Performance**: The simplicity of instructions allows for faster execution and pipelining, enabling multiple instructions to be processed simultaneously.
- **Efficiency in Compilers**: RISC architectures allow for easier compiler optimization due to the predictable instruction set.
- **Lower Power Consumption**: The simplified operations can lead to reduced power consumption, making RISC suitable for mobile and embedded systems.

Disadvantages:

- **Code Size**: Programs may take up more memory due to the use of many simple instructions compared to complex instructions in CISC architectures.
- **Increased Number of Instructions**: More instructions are required to perform complex tasks, which can lead to increased instruction fetch overhead.

CISC (Complex Instruction Set Computer)

Description: CISC architectures are designed to include a wide variety of instructions that can perform complex tasks. Each instruction can execute multiple operations, often in a single command.

Characteristics:

- **Complex Instructions**: CISC processors support a large number of complex instructions that can operate on multiple data types and execute multi-step operations.
- **Variable Instruction Length**: Instructions can vary in length, leading to more compact code but increasing the complexity of instruction decoding.
- **Memory-to-Memory Operations**: CISC architectures often allow direct operations between memory locations, reducing the need for explicit load/store instructions.

Advantages:

- **Reduced Code Size**: The ability to perform complex operations in a single instruction can lead to more compact programs, saving memory space.
- **Ease of Programming**: High-level programming languages can map more directly to the CISC instruction set, making programming easier and more intuitive.
- **Compatibility with Legacy Systems**: CISC architectures often maintain backward compatibility with older instruction sets, allowing legacy applications to run on modern systems.

Disadvantages:

- **Slower Execution**: The complexity of decoding and executing instructions can lead to longer execution times, particularly for complex instructions.
- **Higher Power Consumption**: The additional circuitry required to handle complex instructions can lead to higher power consumption, making CISC less suitable for low-power applications.
- **Compiler Complexity**: Compiling for a complex instruction set can be challenging, making it difficult to optimize code effectively.

Types of Processors

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1. Single Core Processors

- A single-core processor has one core that performs all the processing tasks. It executes instructions one at a time, meaning that it can handle only one thread of execution at any given moment.
- Single-core processors were common in early computers and are sufficient for basic tasks such as word processing, web browsing, and simple applications. However, they can struggle with multitasking and more demanding applications that require simultaneous processing.
- The performance of a single-core processor is often measured in clock speed (GHz), which indicates how many cycles it can perform in a second.
- While single-core processors are generally simpler and cheaper to produce, they may not meet the needs of modern software, which often requires more processing power and multitasking capabilities.

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2. Dual Core Processors

- Dual-core processors contain two cores on a single chip, allowing them to process two threads simultaneously.
- This design effectively doubles the processing capability compared to a single-core processor, making dual-core CPUs ideal for multitasking.
- They can handle multiple applications running at once, providing smoother performance for tasks such as gaming, video editing, and data-intensive applications.
- Dual-core processors maintain a balance between performance and power consumption, making them popular in laptops and desktops.
- They also support various technologies like hyper-threading, which can further improve performance by allowing each core to handle multiple threads.
- Dual-core processors have become the standard for most consumer-level computers, striking a good balance between price and performance.

3. Quad-Core Processors

- Quad-core processors feature four cores on a single chip, significantly enhancing processing power and multitasking capabilities compared to their dual-core and single-core counterparts.
- They can execute multiple threads simultaneously, allowing for seamless performance in resource-intensive applications such as gaming, 3D rendering, and video editing.
- Quad-core processors are designed to handle demanding tasks efficiently, distributing workloads across their cores to maximize performance.
- The rise of quad-core technology has made it easier for users to run complex software and perform multiple tasks without experiencing lag or slowdown.
- These processors often come equipped with advanced power management features that optimize energy usage based on workload, making them suitable for both desktops and laptops.
- Quad-core processors represent a significant leap in processing capability, meeting the increasing demands of modern software and multitasking environments.

Internet

- The Internet is a vast network of interconnected computers and devices that communicate with each other using standardized protocols.
- It enables the sharing of information and resources, providing users with access to a wealth of content, services, and applications.
- The Internet operates on a decentralized model, allowing anyone to connect and share data across the globe.
- It has revolutionized communication, education, commerce, and entertainment, making it an essential part of modern life.

World Wide Web (WWW)

- The World Wide Web (WWW) is a system of interlinked hypertext documents and multimedia content accessed via the Internet.
- It was invented by Tim Berners-Lee in 1989 and has become a crucial part of the Internet experience.
- The WWW allows users to navigate between web pages using hyperlinks and provides a user-friendly interface for accessing information.
- Websites on the WWW are hosted on servers and can be viewed using web browsers, enabling a seamless browsing experience for users.

Protocols

1. **TCP/IP (Transmission Control Protocol/Internet Protocol)**
   - TCP/IP is a set of communication protocols that enable data transmission over the Internet.
   - TCP ensures reliable, ordered, and error-checked delivery of data packets, while IP is responsible for addressing and routing these packets to their destination.
   - Together, they facilitate the communication between devices on the Internet, ensuring that information is transmitted accurately and efficiently.
2. **HTTP (Hypertext Transfer Protocol)**
   - HTTP is an application protocol used for transmitting hypertext documents, such as web pages, over the Internet.
   - It defines how messages are formatted and transmitted, as well as the actions web servers and browsers should take in response to various requests.
   - HTTP enables users to interact with web resources and is the foundation for data communication on the World Wide Web.

3. **FTP (File Transfer Protocol)**
    - FTP is a standard network protocol used for transferring files between a client and a server on a computer network.
    - It allows users to upload, download, and manage files on remote servers. FTP is commonly used for website maintenance, allowing web developers to transfer files to and from their hosting servers easily.

Webpages/HTML

- Web pages are documents that are displayed in a web browser and are created using HTML (Hypertext Markup Language).
- HTML provides the structure and layout for web content, allowing for the inclusion of text, images, videos, and other multimedia elements.
- Web pages can be static (fixed content) or dynamic (content generated in real-time), and they often include interactive features.

Contents of a Webpage

A typical webpage includes various elements such as:

- Text: Information presented in paragraphs, headings, and lists.
- Images: Visual content that enhances the overall user experience.
- Videos: Multimedia content that can be embedded or linked.
- Forms: Interactive elements that allow users to submit information.
- Links: Connections to other web pages or external resources.

Hypertext and Hyperlink

- Hypertext refers to text displayed on a computer or other electronic device that contains links to other texts.
- A hyperlink is an embedded link that allows users to navigate from one webpage to another with a simple click.
- Hyperlinks can be found in various forms, such as buttons, images, or text.

Web Browser

A web browser is a software application that enables users to access, retrieve, and view content on the World Wide Web. Popular web browsers include Google Chrome, Mozilla Firefox, Microsoft Edge, and Safari. Browsers interpret HTML, CSS, and JavaScript code to render web pages visually.

How Does a Web Browser Work?

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1. **User Input**: The user enters a URL (Uniform Resource Locator) into the browser’s address bar.
2. **DNS Resolution**: The browser communicates with a DNS (Domain Name System) server to translate the URL into an IP address.
3. **Sending Request**: The browser sends an HTTP request to the server hosting the webpage.
4. **Receiving Response**: The server responds by sending back the requested HTML document, along with any associated resources (images, CSS, etc.).
5. **Rendering**: The browser processes the HTML and renders the webpage for the user to view.

Website Cookies

- Cookies are small pieces of data stored on a user's device by a web browser while browsing a website.
- They are used to remember user preferences, login information, and other settings, enhancing the user experience.
- Cookies can be categorized as session cookies (temporary, deleted after the browser is closed) and persistent cookies (stored on the device for a specified duration).

Applications of the Internet

The Internet has a wide range of applications, including:

- **Communication**: Email, instant messaging, and video conferencing enable real-time communication.
- **Education**: Online courses, e-learning platforms, and educational resources are widely available.
- **E-commerce**: Online shopping, banking, and financial transactions are facilitated through secure web platforms.
- **Social Networking**: Social media platforms allow users to connect and share content with others.
- **Information Access**: Search engines and online databases provide vast amounts of information on various topics.