HOW COMPUTERS FUNCTION

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Introduction

Advent of the computers in Mid 20th century has been widely recognized as an event which could be consi- dered parallel or even overshadowing the events such as discovery of fire and invention of the wheel. The computer continues to change the way we work, learn and even think. Impact of the computer is visible in technical, economic, social, political and cultural activities of mankind.

The industrial revolution substituted mechanical power for human muscle power in the production of the goods. The computer substitutes electronic power for human brain power. The computer would perform several tasks more comprehensively, more speedily, more accurately and far more efficiently than the human brain. Its ability to store, retrieve and process data to produce information appears to give it powers previously thought to be uniquely possessed by the man. It helps us to solve our problems that we could not solve by ourselves. It has enhanced the capacities, accelerated development and re-defined the objectives of social, cultural and economic systems.

The computer keeps our accounts, plays games with us, directs our machines, helps to explore the universe and solve complex mathematical problems.

The computer technology and accompanying telecommunication technology are now propelling the world into an "information age" that will alter the entire course of man's development and the world works. During the last three decades the growth of the computer has shown remarkable progress. It has merged from a mere mathematical calculator to an automated equipment that performs complex jobs.

One would see the computer as a highly intelligent machine superseding the human brain and as a a highly skilled machine which overpowers human talents. However, when looking closely, one would realize that the computer is unable even to recognize any similarity between "Iam" and "I am". Also it is unskilled and unable even to do two simple tasks simultaneously.

Computer is a machine and hence it has to be operated. It cannot perform any task without instructions. Computers need electricity to work. Moment the power is disconnected, it becomes a dead machine. Computers can do only one task at a time. It can sense only two things; whether electricity is present or absent.

In contrary to the statements given in the introductory paragraphs, one would decide that computer is an electric machine which performs a single instruction at a time by recognizing the existence of electricity. On the other hand, one should not dispute the power of the computer to do complicated and complex

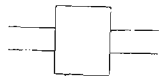
jobs effectively and efficiently. Power of the computer comes from accuracy and speed; simple tasks are carried out at a lightning speed with 100% accuracy.

1. Electronic Circuits

Early computers were built with valves or tubes. They were extremely large, needed a large volume of electricity and were unreliable. The invention of the transistor changed computers and other electric machines as well. Transistor was smaller, more reliable and consumed less electricity compared to the valve.

Transistors are built with substance having properties of neither a good conductor nor a good insulator. These substances which are called semiconductors makes the transistor act like a gate which allows only a little electricity to pass through it. Amount of current permitted to flow through the transistor depends on the substance used as the semiconductor. On the other hand a semiconductor could increase the electricity which flows through it. By combining various types of semi conductors, it is possible to create a transistor which allows a smaller current to pass through it in one direction while stops passing current in the reverse direction. By connecting other electronic components such as resistors, capacitors etc., an electronic circuit could be built. Design of a circuit can be changed by including different types of transistors, capacitors and resistors. It became clear that the production of electronic circuits could be made more efficient if the electronic components are built together. Circuits could be integrated using modern techniques. Thus the size of the electronic circuit was made smaller by inventing integrated circuits (IC). With the advancement of electronics the number of circuits in an integrated circuit was increased. Today, it is possible to build millions of circuits on a single chip of silicon crystal. A photolithographic process is used to print these integrated circuits.

Modern computers is composed of integrated circuits. Flow of electric current through the circuits can be manipulated by using different types of integrated circuits. Following diagram could illustrate how the flow is manipulated by one type of IC.



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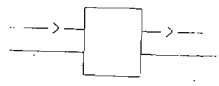

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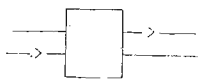

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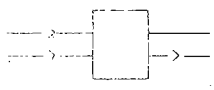

4.

The first output line carries current if either one of the input wires carry current (2,3) and the second output line carries current only when both input lines carrying current (4). Various types of electronic circuits are used by the computer to manipulate data.

2. Binary Codes

Data is generally expressed in symbols. These could be characters of an alphabet, punctuation marks, numbers, graphic symbols etc. The human eye has the capability of identifying different symbols by their shape. It could recognize minute changes in the shape of a symbol. Instead of using hundreds of different symbols, we could use a numeric code to represent symbols. For example, A = 001, B = 002, ? = 123, * = 126, etc. Hence data can be expressed in numeric codes which use only 10 symbols 0 - 9. For example, data 'LANKA' would be expressed in the numeric code as

L	A	N	K	A
0	0	0	0	0
1	0	1	1	0
2	1	4	1	1

In place of a numeric code, a binary code having only two symbols, 'O' and '1' can be used. The binary code needs more digits to represent different symbols.

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L	A	N	K	A
0	0	0	0	0
1	1	1	1	1
0	0	0	0	0
0	0	0	0	0
1	0	1	1	0
1	0	1	0	0
0	0	1	1	0
0	1	0	1	1

Electronic devices are largely two status devices. For example a switch is either on or off, a spot on the surface of a magnate tape is either magnetized or not magnetized, a particular location on a punched card or punched paper tape is either a hole or it is not, and a particular point on a wire at a particular instant either contains an electrical impulse or it does not. It therefore seems natural and reasonable to use the binary numbering system as the basic data representation method in the computer.

3. Data Representation

The main component of the computer is called the Central Processing Unit (CPU) which functions as its brain. The processing unit containing millions of electronic circuits which are integrated into units such as integrated circuits (IC), large scale integrated circuits (LSI), very large scale integrated circuits (VLSI) etc. These are arranged systematically in the processing unit so that any particular circuit in a given location (address) can be activated by supplying current to that circuit. Data expressed in a binary number is translated into a series of active/inactive circuits. If data 'L' is expressed in a binary number having binary digits 01001100, it can be 'stored' in the processing unit by activating/deactivating 8 circuits in a given location. Binary digit '0' is represented by an inactive circuit while 'I' is represented by an active one. Data stored in the processing unit remain unchanged until new data is stored by changing the activeness of circuits or by disconnecting power supply.

The processing unit can store millions of data values expressed in binary digits. In computer technology the word 'binary digit' is abbreviated as 'bit'.

Standard codes are used to express data in bit patterns. American Standards Code for Information Interchange (ASCII) is widely used for this purpose.

It should be noted that to each binary code the computer adds an additional bit which is used to ensure correctness of the pattern. This additional bit is called the parity bit.
Hence, the ASCII code would generate a pattern having 9 bits. Generally, when binary codes are discussed, for convenience, the parity bit is ignored.

Data is entered into the processing unit through the input component of the computer. Keyboard is the most used input unit. Each key in the keyboard is assigned a symbol. Data expressed in symbols can be 'key-in' to the processing unit by pressing the relevant keys. When a key is pressed a pattern of electric pulses is generated. This pattern is transmitted to the processing unit through a series of wires or a bus. The key 'L' which is represented by ASCII code 01001100 will generate electric pulses in the second, fourth and fifth wires of the bus.

A bit pattern is collectively referred to as a 'byte'. Usually a byte contains 8 bits. A byte generally represent one character.

Data stored in the processing unit can be used to generate new data or it can be copied into a new location. A data value can be changed by changing the Bit pattern. For example, Data 'L' which has ASCII code 01001100 can be changed to Data 'M' by changing the last bit to 1 or in other words by activating the last circuit. Copying of data is done by regenerating the pattern of electric pulses and transmitting it through a bus.

Data stored in the processing unit is output through an output unit such as the monitor or the printer. In the case of the monitor, a symbol is reproduced on the screen by illuminating a given position. In a printer, the pulse pattern will activate a key pr the print head to produce the relevant symbol.

Data stored in a given location of the processing unit is erased when new data is stored in the same location or when the power is discontinued. Hence the processing unit is used to store data temporarily. If data is required for future use, it should be stored permanently. A storage devise attached to the processing unit is used for this purpose.

Magnetic media such as a tape or disk is used as permanent storage of data. The surface of the disk or tape is coated with a magnetized material. Any spot on the surface can be magnetized by supplying electricity to that spot. Once a spot is magnetized, it would not change until electricity it supplied again. A magnetized spot can generate an electric pulse in a wire placed immediately over it. This phenomena is used for transmitting data from the processing unit to the storage unit

and for copying data in storage unit to the processing unit. A bus linking the processing unit and the storage unit communicates data.

Magnetic tape carries 9 tracks to record the 8-bit byte plus a parity bit. Spots on the magnetized surface of the tape represent data in the form of '0' and 'I' bits. Each vertical column of the tape represent a byte or a character of data. In a magnetic tape to access a date in a given location the tape has to be read sequentially until the location is reached. This process retards the processing speed.

Magnetic disks overcome this problem as any location on the disk surface can be accessed directly. Magnetic disk has several hundreds of circular tracking on its surface. Data is recorded along the tracks on strings of magnetized spots representing '0's and 'I's. Each track stores the same number of bytes even though the outer tracks are longer than the tracks near the centre of the disk.

4. Machine Language

Transmission of data from one unit to another and processing of data is done according to the instructions given to the computer. Instructions are codes expressed in binary digits. For example, binary code 1101 would be used to express the instruction to 'ADD' two numbers while 1011 would be used to display data on the screen.

Program is a set of instructions arranged logically to carry out a given task. In programming the desired task is analysed into minute actions. These actions are then sequentially arranged. Instructions are given to carry out each action. When the program is executed, the computer follows sequentially the list of instructions.

A hypothetical program for adding two numbers keyed-in to the computer and displaying the result on the screen is given below. First, the task is analysed into single action. These actions are then arranged logically. Instructions for carrying out each action is then written.

1. Connect keyboard and processing unit.
2. Transfer data from keyboard to location A in the processing unit.
3. Transfer data from keyboard to location B in the processing unit.
4. Transfer data in location A to location C.
5. Add data in location B to location C.
6. Connect monitor and procesiing unit
7. Transfer data in location C to monitor.

Above instructions should be given in binary codes as the computer can 'understand' only bit patterns. Codification is done according to a standard machine code. When expressed in a machine code, the program would appear as shown below:

1001	00101110
1010	01000100
1010	01000101
1100	00101110
1101	01000100
1001	00101111
1010	01000110

The machine code is the first programming language. Since writing program in machine language is cumbersome, more simplified iguage called assembling language is used. Assembly Language uses symbols instead of binary codes. In a Assembly language program, the word ADD rather than the binary code would be used. Above program could be written in Assembly as:

```
LDA   A
LDA   B
STA   C
ADD   A B
DPL   C
```

Programs written in assembly language has to be translated into the machine language. A conversion program named Assembler

However, the computer has limitations like any other machine. No matter how good it is, a computer will not make you more organized, will not make its own decisions, will not accept responsibility for any thing, will not improve basic data, can not define problems or set objectives. It will only perform things that you command it to do. If you get wrong output from the computer do not put the blame on the computer; you have given wrong instructions or wrong data.

is used for this purpose. Assembler will translate ADD into 1101 and LDA to 1010 and so on.

Assembly programs are less difficult to write than programs in machine language, for the need to remember storage locations and contents is eliminated. Also alphabetic operation codes are easier to remember than numeric codes. However attempts were made to further simplify the assembly language by replacing the symbolic codes with words.

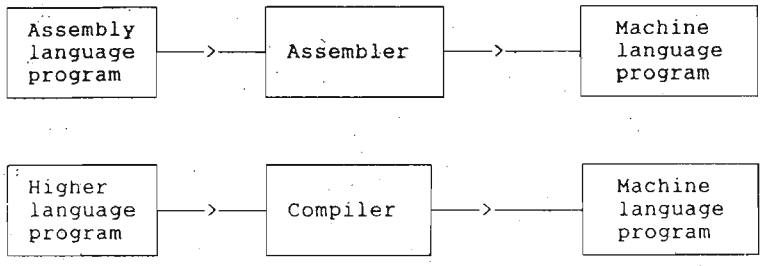
As a result, high level language which uses words for programming were introduced. As with assembly language, translation of the instruction into machine language had to be done. A special program called Compiler was used for this purpose. BASIC (Beginner's All-purpose Symbolic Instruction Code), COBOL (Common Business Oriented Language), FORTRAN (Formula Translation), PASCAL, C language are some of the higher level computer languages.

Above program written in BASIC would read as:

```
10      INPUT  A
20      INPUT  B
30      LET C  = A + B
40      PRINT  C
```

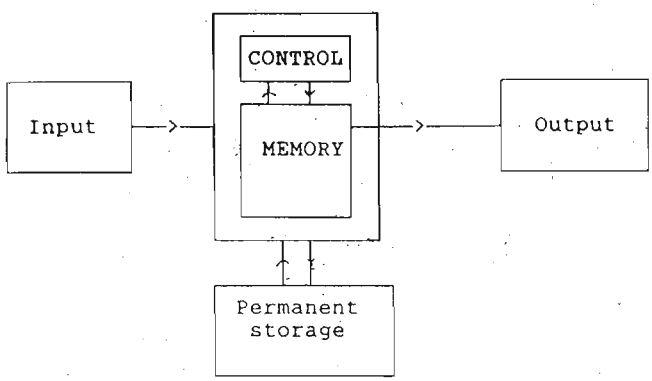
5. Structure of a Computer

As mentioned above, various components or units of the computer handles different functions such as accepting, storing, changing and output data. The Input unit is used to enter data into the system. Data entered to the system is temporarily stored in the Processing Unit until it is changed, output or stored permanently. The Storage Unit of the computer is used to keep the data for the future use. When data is needed for output or processing, it is first transferred to the Processing Unit. The Output Unit allows data to flow out of the Computer system either by displaying on the screen or by printing on paper.



The main component of the computer and data flow between units are shown below.

As illustrated in the above diagram, four main data paths are visible in the Computer system.



(i) Input ----> Process ----> Output
(ii) Input ----> Process ----> Store
(iii) Store ----> Process ----> Outut
(iv) Store ----> Process ----> Store

Keyboard is the common input device. Data is input to the System by pressing appropriate keys in the keyboard. Video Display Unit (VDU) or monitor and the printer are the popular output devices. Hard disk and Floppy disk (diskette) are the common devices for storage. Equipment in a Computer system are generally referred to as hardware.

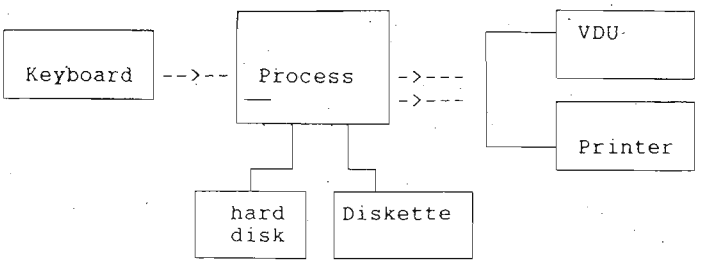
The hardware components of the System and the data flow are shown in the following diagram : As discussed above the processing unit is the key unit of a computer. the Processing unit is divided into four main components:

(a) control - Links various components of the computer system and selects the operation that should be executed.

(b) arithmetic and logical unit (A/L unit) - Handles mathematical calculations and comparison of data.

(c) Random Access Memory (RAM) Stores instructions and data input from the keyboard and transferred from the storage unit. Processing takes place in RAM.

(d) Read Only Memory (ROM) - Store instructions and data



provided by the computer manufacturer. When the computer is switched on, these instructions and data are transferred to ROM from the storage unit.

RAM and ROM are collectively referred to as Memory of the computer.

Since a Computer system can handle more than one storage unit it is possible to transfer (copy) data from one storage device to another.

Hard disk ----> process----> diskette
diskette----> process----> Hard disk

6. Computer Files

Computer storage is organized into files. A file is given a name for its identification. The computer system keeps a list of files (directory of files) in its storage with their location. Hence the computer can locate any file by the name.

A file can store programs or data. Hence two types of computer files are used : (a) program files (b) data files

Data files are associated with program files. A data file is useless without the relevant program file. Creation, storage, amendment, deletion, copying of data is done according to the programs. Data stored in the data file is interpreted into information by the program.

A program file should be loaded to the memory before execution. If the program is long, it needs more space in the memory.

When a program is executed it is processed sequentially. If data is required by the program, relevant data file is located and relevant data is copied to the memory.

7. Software

Programs and data are collectively referred to as software. Programs carry instructions for the processing of data to obtain the desired output. Four main types of software are used in a computer system.

(i) Operating systems - Operating system is the basic software required for the operation of a computer system. When the computer is switched on, the operating system software is automatically transferred to the memory from the storage unit and starts execution. The operation system helps to load other software, copy computer files from one storage unit to another, organize computer files logically in storage units. It links various components of the computer system and facilitate transfer of data.

(ii) Compiler/interpreter - A user who wishes to compile a program for a specific application is required to write the program using a computer language. Compilers and interpreters are software which facilitate writing application programs. For example, if the user wants to write a PASCAL program the computer should have a PASCAL compiler. The operating system can be used to transfer the PASCAL compiler from the storage unit (hard disk) to memory.

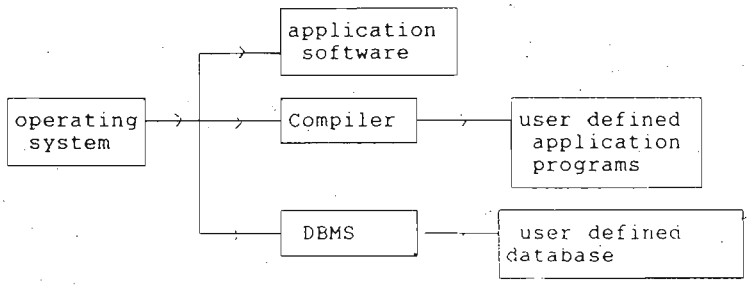
(iii) Application Software - Program compiled for a specific application is called an application software. There are two types of application software:
(a) User compiled program
(b) Software packages

User compiled programs are written by the user with the help of compiler/interpreter.

Software packages are those written on common applications. Most software packages are compiled using machine language (direct binary codes). Hence they do not require compilers,

(iv) Database Management Software (DBMS)
DBMS is a software package which allows the user to define the data files, retrieval methods and output designs. DBMS needs no programming knowledge for its operation but provides an advantage of an user compiled application program.

Organization of the software systems in the computer is illustrated below :



8. Conclusion

The computer can perform a lot of functions and tasks depending on how you know the systems and how many application programs (software packages) you are familiar with. Using several user friendly (easy-to-use) software you can command the computer process and store enormous quantity of information. One can record, to store or manipulate data efficiently and faster.

However, the computer has limitations like any other machine. No matter how good it is, a computer will not make you more organized, will not make its own decisions, will not accept responsibility for any thing, will not improve basic data, can not define problems or set objectives. It will only perform things that you command it to do. If you get wrong output from the computer do not put the blame on the computer; you have given wrong instructions or wrong data.