

1. Introduction to Computer Technology

Introduction

Computers have become an indispensable part of our daily life. Be it connecting with our friends, shopping, gaming, booking tickets, getting the score updates, listening music, watching movies as well as live TV programs and so on (refer Figure 1.1, 1.2, 1.3 and 1.4). Computers have made our life not only easier but more interesting also. It is an advantage to us that we are living in the period of such technological revolutions. So let us explore what Computer Technology actually is and how it works.



Figure 1.1 : Connecting with friends, shopping, gaming



Figure 1.2 : Booking Tickets, Getting Score updates, listening music



Figure 1.3 : Watch Movies



Figure 1.4 : Live news and TV programs

1.1. What is a Computer

A computer is a machine that executes a set of arithmetic or logical instructions. The sequence of these instructions can be changed to perform a variety of operations and get various outputs. For example, it can perform arithmetic instructions (instructions used for calculations) like Add, Multiply, Subtract or Divide. It can calculate and store $2 + 3 = 5$ as result in the memory.

Logical instructions have some conditions that evaluate to either true or false (called Boolean values). Based on these conditions they derive a result. For example, We want to calculate the grade of a student based on the total marks as follows: If total marks is greater than 180 then Grade of Student should be A. Else if total marks is between 150 to 180 then Grade of Student should be B. Otherwise (that is both the previous conditions evaluated to false) the Grade of the Student will be C. So, if Tom has his total marks as 175 then his grade will be B as the second logical condition evaluates to true in this case.

Simply put, we can describe computer as an electronic device which takes some input like your name and birth date and displays your age. Also it can remember your name and greet you the next time you start it. Hence it uses information to calculate results. Also it stores and remembers information.

For example, if you have entered name as Tom and birth date as 1st January 1995 and if the current year is 2013, the computer will display the result as Welcome Tom. Your age is 18 years.

The evolution of Computer Technology has been an interesting journey and starts with its pioneer Charles Babbage. Charles Babbage, the father of computer, designed the first automatic computing engine. It was to operate on steam and was called the Difference Engine (refer Figure 1.5).

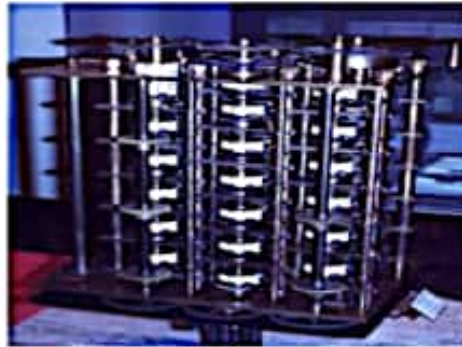


Figure 1.5: Difference Engine

Harvard Mark-I (refer Figure 1. 6) computer was built as a partnership between Harvard and IBM in 1944. It was the first programmable digital computer made in the U.S. But it was not a purely electronic computer. The Mark-I computer was constructed out of switches, clutches, relays and rotating shafts. The machine weighed 5 tons, contained 500 miles of wire, was 51 feet long and 8 feet tall, and had a 50 ft rotating shaft, turned by a 5 horsepower electric motor.

The first completely electronic computer is well known as ENIAC (Electronic Numerical Integrator and Calculator - refer Figure 1.9 on next page) and was developed by University of Pennsylvania in 1946. This was followed by many evolutions and then came Apple I Computer (refer Figure 1.7) in 1976, which could be setup as a Do It Yourself Kit.



Figure 1.7: Apple I Home Computer

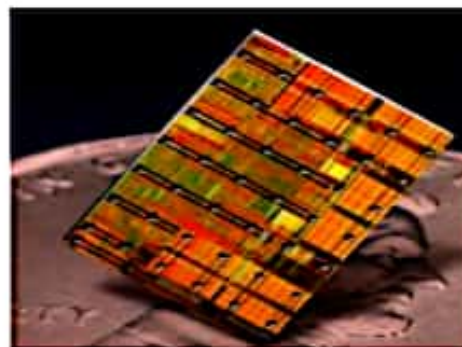


Figure 1.8: Integrated Circuit

The computers that we use today is a transformation which was a result of the invention of the microprocessor. A microprocessor (μP) is a computer that is fabricated on an integrated circuit (IC - refer Glossary).

It is a single integrated circuit that is sufficiently complex enough to perform the processing part of the information processing cycle (that is the arithmetic and logical calculations discussed above in section 2.1. where considering information like marks, we have derived the grade of a student.). In other words, it must have enough circuitry to process data, perform calculations, and facilitate interface with memory, input, output and storage devices. (Refer section 2.2 for more details on Input, Output and Storage devices).

A microprocessor can perform calculation at a super speed with accuracy. For example, the following calculation is performed really fast producing accurate results.

$$147369852 * 58937.42 * 698532.47 * 65893.6598 \\ = 399788222207794191356873.69597904$$

Computers had been around for 20 years before the first microprocessor was developed by Intel (one of the leading companies that manufactures hardware) in 1971. The micro in the name microprocessor refers to the small physical size. Intel did not invent the electronic computer. But they were the first to succeed in designing an entire computer on a single chip (IC).

Thus Intel 4004, the first microprocessor (μP) came into existence. The 4004 consisted of 2300 transistors and was clocked at 108 kHz (108,000 times per second). Compare this to the 42 million transistors and the 2 GHz clock rate (2,000,000,000 times per second) used in a Pentium 4. Pioneer 10 spacecraft, the man-made object farthest from the earth has Intel's 4004 chips.

Intel followed the 4004 with the 8008 and 8080. The Intel Pentium 4 used in today's PCs is still compatible with the Intel 8088 used in IBM's first PC.

In 1993 Apple released its first tablet computer named Newton Message Pad 100 and then iPad in 2010 followed by a series of tablets (refer Figure 1. 9) and we still have more innovations on the way.

The evolution of computer has changed it from that of the size of a room to the one that fits in your palm with multiple times more computational ability and speed.



Figure 1.9: Evolution from ENIAC to Desktop Computer to Laptop and Tablet

Few of the latest use of computer technology can be listed as below. (Refer glossary for details)

- Digital Signature verification
- Natural Language Speech to Text
- Augmented Reality
- Cloud Computing
- Phablets
- Omnidirectional Imaging
- Social Networking

1.2. Components in a Computer System

A computer consists of following components:

- Hardware
- Software
- Firmware

1.2.2 Hardware

Hardware constitutes the tangible parts of computer like its keyboard, mouse, visual display unit (VDU or monitor), circuits, etc. It is best described as all the physical parts of a computer, the parts you can actually see and touch.

Hardware constitutes the following parts of computer:

- I. Case or body of computer
- II. Power supply
- III. Input peripherals
 - i. Mouse
 - ii. Keyboard
- IV. Output peripherals
 - i. Monitor
- V. Memory Device
- VI. Motherboard
 - i. Central Processing Unit
 - ii. RAM
 - iii. Ports
- VII. Expansion cards



Figure 1.10: Hardware Components

Out of the components listed above, we will focus our discussion on the following parts of hardware:

- I. Mouse
- II. Keyboard
- III. Monitor
- IV. Memory Device
- V. Central Processing Unit

1.2.1.1. Mouse

A Mouse is an input device and probably has at least two buttons on it. The left button is called the primary mouse button, the right button is called the secondary mouse button or just the right mouse button. There can be a small wheel called Scroller between the two mouse buttons. The mouse can be used as follows:

- **Click:** Point to the item, then tap (press and release) the left mouse button. Like you click links on a website
- **Double-click:** Here, point to the item and press the left mouse button twice in rapid succession.
- **Right-click:** Point to the item, then tap the right mouse button.
- **Drag:** Point to an item, then hold down the left mouse button as you move the mouse. Then release the left mouse button to drop the item.
- **Right-drag:** Point to an item, then hold down the right mouse button as you move the mouse. Then release the right mouse button to drop the item.



Figure 1.11: Mouse

1.2.1.2. Keyboard

A Keyboard is an input device and is usually used when we need to type some text input or fill a form. Various keys are explained below.

- The function keys have some definite function depending on the application or program that you are using on your computer. There are twelve function keys from F1 to F12. F1 can always be used to display help for your current application, F2 can be used to change name of any file, and F3 can be used to search any text or file on the computer. Similarly each function key can be used to perform a specific action.
- The direction keys or Arrow keys can be used to move the typing cursor (the blinking short vertical line on monitor that indicates the position of text insertion) at desired location.
- The numeric keys can be used to enter numbers if we have pressed the Num-Lock key which can be indicated by the light on Lock Key indicators. Otherwise, the Numeric keys behave as direction keys and allows you to change your cursor location.
- Ctrl and Alt keys are generally used in combination with other keys to perform some specific task that is, you can press all these combination keys together to produce a single input.
- Shift Key is also a special key which can be used to change the lower case letter to upper case and vice-versa while typing. It is also used to display the parenthesis (), the question mark (?), the exclamation point (!), and the colon (:). Also, it helps in displaying other special characters like @, \$, # that are present on the horizontal numeric keypad.
- Tab key allows you to move the cursor by a fixed number of spaces. It is helpful if you want to write something in a tabulated form. It can also be used to move to the next input field while filling a form.
- Caps Lock Key sets an input mode in which typed letters are uppercase (in capital letters) by default. The keyboard remains in caps lock mode until the key is pressed again. It can be useful when you are typing a heading or filling a form which requires only capital letters.
- Enter Key causes a form, or any other computer operation to perform its default function. This is typically an alternative to pressing an OK button. It can also be used to move to next line starting position while typing.
- Esc (Escape) key can be used to cancel a task or to go back to a previous task.



Figure 1.12: Keyboard

1.2.1.3. Monitor

Also called VDU (Visual Display Unit), the Monitor is the primary output device. It looks like a Television and has the similar purpose of displaying videos or output of programs. Monitors are built using technologies like Cathode Ray Tube (CRT monitors- refer Glossary) and Thin Film Transistor Liquid Crystal Display (TFT- LCD monitors - refer Glossary) . We now generally have these monitors or screens made of TFT-LCD.



Figure 1.13: Computer Monitor

1.2.1.4. Memory Devices

These are the devices which store the information. The term primary memory is used for the information in physical systems which functions at high-speed. For example, it is capable of performing complex calculations and displaying the results at the same time.

Secondary memory devices are physical devices for program and data storage which are slow to access but offer higher memory capacity. Primary memory stored on secondary memory is called virtual memory.

RAM (refer Figure 1. 14, Glossary), and Computer cache (refer Glossary) are examples of Primary memory storage. Magnetic tapes, Compact Disks (CDs), Digital Versatile Disks (DVDs - refer Figure 1. 15) are all examples of Secondary Memory Storage.

The memory is organized into memory cells each storing one binary bit (0 or 1). The memory cells are grouped into words of fixed length, for example 1, 2, 4, 8, 16, 32, 64 or 128 bit. Each word in the memory can be accessed by a binary address (refer Glossary) of N bit, making it possible to store 2^N words.



Figure 1.14: RAM Storage Device



Figure 1.15: DVD: Digital Versatile Disk

1.2.1.5. Central Processing Unit

The Central Processing Unit (CPU) or the computer processor performs calculations, processes information, stores data in memory and controls the flow of data. The conventional processors are small in size and have all the circuits integrated on a single chip. Because of its small size, the processor is also known as microprocessor. It is also called the Brain of computer.

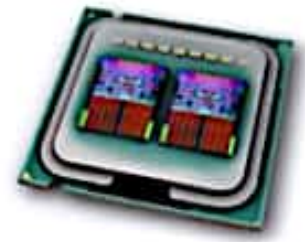


Figure 1. 16 : Dual Core Processor

- A minimal hypothetical microprocessor might only include an arithmetic logic unit (ALU) and a control logic section.
- The ALU performs mathematical operations such as addition of two numbers, and logical operations such as AND or OR (refer Glossary). Each operation of the ALU sets one or more flags in a status register (a small memory within the CPU), which indicates the result of the last operation.
- The control logic section retrieves instruction codes from memory, and initiates the sequence of operations that the ALU requires to carry out the instruction. It may happen that a single operation code affects many registers (refer Glossary) at the same time. It is like executing a flow chart (refer Glossary) and depending on the condition encountered in the flow chart an appropriate decision will be taken and the flow will jump to some other operation to be triggered in the ALU.
- Garrett AiResearch's Central Air Data Computer (CADC) (1968), Texas Instruments (TI) TMS 1000 (1971 September), and Intel's 4004 (1971 November) are the three projects that delivered a microprocessor at about the same time.
- We also have multi-core processors that have a single chip containing more than one microprocessor. This effectively multiplies the processor's potential performance by the number of cores (the independent actual central processing units).
- The first dual-core processors (microprocessors having two separate microprocessors on single Integrated Chip -refer Figure 1. 16) for personal computer were announced in 2005.
- As of 2013, dual-core and quad-core processors (microprocessors having four separate microprocessors on single Integrated Chip) are widely used in home PCs and laptops while six, eight, ten, twelve, and sixteen-core processors are common in the professional and enterprise markets with workstations and servers (refer Glossary).

1.2.2 Software

Software is the non-material part of computer like data, programs, protocols, etc. It is a non-physical component that runs on your computer and can be changed by a set of programmed instructions.

For example you watch a movie on a DVD using the DVD drive in your computer. Here the DVD and DVD drive are both hardware, but the program in your computer that you use to watch this movie is called software. Thus as movie is stored on a DVD, similarly there is a program like Media Player stored on your computer to watch that movie. The application that you are currently using to read this text is also a software.

Software can be categorized into three types as follows:

- System Software
- Utility Software
- Application Software

1.2.2.1 System Software

It is the software used to manage and control the hardware components and which allow interaction between the hardware and the other types of software (refer Figure 1. 17). The most obvious type of system software is the computer's operating system. We will see Operating System in detail.

All the programs and software run on computer using the main software – The Operating System. Some popular modern operating systems are Android, iOS, Unix, Linux, Mac OS X, Microsoft Windows and IBM z/OS (refer Figure 1. 18).



Figure 1.17 : System Software- Operating System Layer



Figure 1.18 : System Software- Operating Systems

Operating system has various categories as listed below:

- Real-time: Real-time operating systems often use specialized scheduling algorithms (refer Glossary). The main objective of real-time operating systems is their quick and predictable response to events. Their design is called event-driven or time-sharing design. An event-driven design system switches between tasks based on their priorities or external events while time-sharing operating systems switch tasks based on clock interrupts.

- **Multi-user:** A multi-user operating system allows multiple users to access a computer system at the same time. Time-sharing systems or Internet servers are examples of multi-user systems as they enable multiple-user access to a computer through the sharing of time.
- **Multi-tasking:** A multi-tasking operating system allows more than one program to run at a given time. Multi-tasking can be of two types: pre-emptive and co-operative.
 - Pre-emptive multitasking is the act of temporarily interrupting a task being carried out by a computer system, with the intention of resuming the task at a later time. Unix-like operating systems such as Solaris and Linux support pre-emptive multitasking. For example, you are talking on a land line phone to someone and the doorbell rings. In this case you would keep the phone caller on hold and visit the person on door and then come back and continue with the telephone call. It shows here that the ringing of the doorbell was a task having higher priority for which you could suspend the current normal priority phone call.
 - Cooperative multitasking is achieved by relying on each process to give time to the other processes in a defined manner. 16-bit versions of Microsoft Windows (Microsoft Windows 1.0 to 3.0 and 9x versions which still support the older windows versions. These systems usually hang or stop responding in case one running program does not cooperate to yield the processor to some other program) used cooperative multi-tasking. Mac OS versions before to OS X used to support cooperative multitasking.
- **Single-tasking:** A Single Tasking system has only one running program (refer Glossary). The Palm OS for Palm handheld computers is an example of a single-user and single-task operating system.
- **Distributed:** A distributed operating system manages a group of independent computers and makes them appear to be a single computer. The networked computers working as a group in cooperation, make a distributed system.
- **Embedded:** Embedded operating systems are designed to be used in embedded computer systems. These are designed to operate on machines like PDAs with less autonomy. They operate with a limited number of resources, are very compact and extremely efficient by design. Minix 3 and Windows CE are examples of embedded operating systems.

1.2.2.2 Utility Software

It is software such as anti-virus software like Norton and McAfee, or Microsoft Security Essentials which help to maintain and protect the computer system but may not directly interface with the hardware. Utilities like Winzip help to combine and compress data files so that they occupy less memory and can be easily sent in mails.

1.2.2.3 Applications Software

Also known as apps, these are designed to allow the user of the system complete a specific task or set of tasks. Apps include programs like web browsers, games and office software. They are usually the reason you bought the computer system in the first place. Refer Figure 1. 19.



Figure 1.19: Application Software

1.2.3 Firmware

It is the combination of persistent memory (long term or permanent storage which is preserved even when the power supply is unavailable), program code and the data stored in it.

- It is software stored in hardware.
- Examples include embedded systems like traffic lights and remote control.
- Let us understand firmware using remote control. When you open a remote control you see a set of circuits which along with the body of the remote control constitutes the hardware part. Now you can move or switch channels using the remote control or you can put a child lock for the same. Also you can use the swap button on the remote control to go back to the previous viewed channel. So the remote control is able to remember that which is the most recent channel you viewed or your colour preferences. This part constitutes the software and data, stored in your remote control.
- Changing the firmware of a device may rarely or never be done during its lifetime. Some firmware memory devices are permanently installed and cannot be changed at all. Devices like printers, scanners, cameras and USB drives have firmware stored internally.



Figure 1.20 : Firmware

1.3 Computer Language

The term computer language includes a wide variety of languages used to communicate with computers (refer Figure 1. 21). Programming languages are a subset of computer languages. For example, HTML is a mark-up language (refer Glossary) and a computer language, but it is not considered a programming language.

Machine code is a computer language. It is a sequence of binary digits (binary digits contain only 0 and 1) which instructs the computer to do the required task. It can technically be used for programming (as for Altair BASIC), but a sequence of binary numbers cannot be considered as a programming language.

Programming language is a convention based set of instructions that you execute on the machine to store or manipulate any information or to perform any logical operation.

Programming languages can be further categorized as follows:

- **Low Level Programming Languages:** These languages are very close to the hardware. They can be directly converted to machine code without any intermediate steps and hence have faster execution. For example: Assembly language. C language can be used for low level programming as it can directly interface with memory, hardware and the CPU. It can also be used to create Operating Systems, and because of its user-friendly programming features, it can be considered as Middle Level Language also.
- **High Level Programming Languages:** They provide a very high level of abstraction from the detail of memory management, and may go through two stages of processing before they can be understood and executed by the computer. These stages are called Compilation and Interpretation (refer Glossary). They are easier and have more user-friendly programming features. For example: java, C++, C#.
- **Scripting Languages:** These languages are directly interpreted or executed by other programs or on-the fly and have a relatively simple syntax, easy to pick up and program in. They are called scripting languages because they are used to write scripts or programs that automate the execution of tasks which could alternatively be executed one-by-one by a human operator. Scripting languages are very useful for web-based programming. For example: JavaScript, Perl.



Figure 1.21 : Computer Languages

Summary

A Computer is a machine that executes a set of arithmetic or logical instructions and usually provides a visual output. It has evolved from Charles Babbage's Difference Engine design to the modern day Laptops and Tablets.

The different Components of a Computer are:

- **Hardware** – The tangible or physical parts of the computer.
 - Mouse – the device used for pointing the target or double clicking a folder to open it.
 - Keyboard – the primary input device with all alphabets and numbers on it.
 - Screen – the primary output device which is like the TV screen.
 - Memory devices store all the information and data.
 - Microprocessor or Central Processing Unit - the electronic brain of computer responsible for all computation logic.
- **Software** – It is the non-tangible part of computer like programs and applications.
 - System Software - It is the main software on the computer which enables execution of other programs and software. For example - Operating system.
 - Utility Software - Used as an add-on or protection of computer from virus attacks. For example - Anti-virus software.
 - Application Software – Apps help in performing any task on the computer. For example - Web browser internet use.
- **Firmware** – The embedded systems that store software and data inside the hardware as the hardware's inseparable part.

Glossary

Term used	Description
And – OR logical operators	If we have two expressions expr1, expr2 then logical AND will always check that if both expressions are true only then the logical result will be true. Also if expr1 is false then expr2 is not checked at all and result becomes false whereas in case of logical OR even if either of expressions is true, the result will be true and only if both expressions are false, the result will be false
Augmented Reality	Augmented Reality (AR) is a direct or indirect live view of a physical real-world environment whose elements are augmented by computer-generated sensory input like sound, graphics or video.
Binary Address	It is a memory address that is represented in the form of a binary number (i.e. 0 or 1).
Cache	A cache is a component that transparently stores data so that future requests for that data can be served in a faster way. The data stored within a cache are the values that have been computed earlier or duplicates of original values that are stored elsewhere.
Cathode Ray Tube	The cathode ray tube (CRT) is a vacuum tube containing a source of electrons or electron emitter and a fluorescent screen used to view images. In television sets and computer monitors, the front area of the tube is repetitively scanned systematically in a fixed pattern called a raster. Images are produced by controlling the intensity of the three electron beams (red, green, and blue).

Cloud Computing	Cloud computing is the use of computing resources (hardware and software) that are delivered as a service over a network (typically the Internet).
Compilation	A computer process that converts the human readable form of code written in any programming language into machine code that is the form that can be understood by the computer.
Digital Signature Verification	It is a mathematical scheme or program for checking the authenticity of an electronically generated signature. It is especially used in cases of financial transactions where any forgery or tampering is very important to be detected.
Expansion Cards	It is a printed circuit board and can be inserted into an electrical connector or expansion slot on the motherboard of a computer. The primary purpose of an expansion card is to provide or expand on features not offered by the motherboard.
Flow Chart	A flowchart is a type of diagram that represents an algorithm or process. It shows the steps as boxes of various shapes, and connects them with arrows in a certain order. This representation gives a step-by-step solution to a given problem. Process operations are represented in the boxes and arrows connecting them represent the control flow. Flowcharts are used for analyzing, designing, documenting as well as managing a process.
Integrated Circuit	An integrated circuit is an electronic circuit designed to perform some function in which the electronic components (i.e. resistors, transistors, diodes, capacitors, etc.) are miniaturized into a small silicon (a material found in quartz rocks) chip, and are interconnected through tiny aluminum strands. Integrated circuits are also referred to as microchips or IC chips.
Interpretation	An interpreter is a computer program that executes instructions written in a programming language. It uses one of the following strategies for program execution: Execute the source code directly Translate source code into some efficient intermediate representation and immediately execute this Explicitly execute stored precompiled code generated by a compiler
Markup Language	A markup language is a combination of words and symbols which give instructions on how a document should appear. For example, <code><i></code> tag may be used to indicate that words are written in italics. <code></i></code>
Natural Language Speech to Text	Natural language processing (NLP) is a field of computer science and linguistics concerned with the interactions between computers and human (natural) languages. It enables computers to derive meaning and textual representation from a given sound clip of human speech. It can then use this text for further processing like in case of a phone it can dial a spoken number, or search on Internet for the name of restaurant you specified as voice input.

Omnidirectional Imaging	An omnidirectional imaging apparatus obtains images over an entire hemispherical field and uses a mapping matrix to define a relationship between pixels in a user-defined perspective or panoramic viewing window and pixel locations on the original omnidirectional image. This allows the computation of non-distorted images in real-time. For example - panorama photography in some latest mobile phones.
Phablet	It is an informal term for consumer touch-screen devices with screens that are between five to seven inches. These devices have the combined capabilities of a smart phone and mini tablet. It may also incorporate a stylus. A phablet is usually larger than smartphones, but smaller than tablet or mini-tablet.
Program	A program is a sequence of instructions written to perform a specified task with a computer.
RAM	Random-access memory (RAM) is a type of computer data storage. It allows stored data to be accessed quickly in any random order.
Scheduling Algorithms	Scheduling algorithms are the steps by which various computer processes or data flows are given access to system resources like processor time and input/output channels.
Server	A server is a computer dedicated to run one or more services (as a host), to serve the needs of the users of other computers on a network.
Social Networking	Social networking is an online service or site that focuses on facilitating the building of social relations among people who may share interests, hobbies, activities, backgrounds, or real-life connections. It is now extensively used for promoting various business and supporting causes.
Thin Film Transistor Liquid Crystal Display	A liquid-crystal display (LCD) is a flat panel display that uses the light modulating properties of liquid crystals. A thin-film transistor (TFT) used in LCD monitors is a special kind of transistor made by depositing thin films of a semiconductor active layer over glass.
Workstation	A workstation is a computer designed for technical, scientific or clerical applications. It is intended primarily to be used by one person at a time and is usually connected with other computers.