

# **Chapter One: Overview of Computer Science**

## **Objective:**

- Distinguish the difference between data and information
- Define the discipline computer science
- Define the term computer
- Identify the several characteristics of computer that made them useful and popular
- Application of Computers

## **1.1 Introduction to Information and Communication Technology**

### **Data versus Information**

#### **Data:**

- Simple facts and figures
- It is raw and unprocessed and therefore meaningless to us.
- Usually it is the result of experience , observation or experiment
- Numbers, characters, symbols, images etc., which can be processed by a computer.
- Data must be interpreted, by a human or machine, to derive meaning

#### **Information:**

- is data that has been processed for use
- is a human interpretation of knowledge
- It is processed and selected so that it is useful and applicable
- has meaning in some context for its receiver
- When information is entered into and stored in a computer, it is generally referred to as data. After processing (such as formatting and printing), output data can again be perceived as information.
- When information is packaged or used for understanding or doing something, it is known as knowledge. For example, there are a plenty of items listed on a Menu-Card, in a hotel (data). You don't order everything, you just order the dish you want to eat, (information).

### **Technology**

- Is a way of solving problems by the application of knowledge from multiple disciplines

### **Information Technology**

- is "the study, design, development, implementation, support or management of computer based information systems, particularly software applications and computer hardware."
- IT deals with the use of electronic computers and computer software to convert, store, protect, process, transmit, and securely retrieve information.
- The combination of computer and communication technologies
- a general term that describes any technology that helps to produce, manipulate, store, communicate, and/or disseminate information

## **1.2 Computer and Computer Science**

### **1.2.1 What is Computer Science?**

**Computer Science** is a science concerned with information i.e. representation, storage, manipulation or processing and presentation of information. Like any other science, which uses some devices for the practical aspect, computer science uses a special device called **COMPUTER**.

Computer science has different fields of specialization or sub-disciplines like other sciences. There are seven sub-disciplines of computer science. These are:

- **Software engineering:** Software engineering – It is concerned about the development of a better quality software by applying scientific & basic engineering principles.
- **Computer engineering (Architecture):** deals with studying, analyzing and designing of computer hardware (organization and interconnection of computer system components) and its working principle.
- **Automata theory:** Automata Theory Is The study of machines or devices which accept a certain inputs such that the output or at least the probabilities of outputs are determined by the input.

- **Formal Language Theory:** Embraces the study of programs of programming languages, which is important for the understanding, and construction of compilers.
- **Complexity theory:** concerned with the study and analysis of algorithms, which helps in measuring the efficiency of the algorithms.
- **Data base Architecture:** involves the study and design of efficient methods for information storage, process & retrieval.
- **Artificial intelligence:** Is concerned with means by which Computers may perform tasks that would be characterized as intelligent if performed by human beings.

### 1.2.2 What is Computer?

A **computer** is an electronic device that accepts data, performs computations, and makes logical decisions according to instructions that have been given to it; then produces meaningful information in a form that is useful to humans. The name computer comes from a Latin word **computator**, meaning, “to compute”

## 1.3 Characteristics of computers

Today, computers are everywhere – in our offices, homes, appliances, automobiles – the list is endless. Much of the world runs on computers, and computers have profoundly changed our lives, mostly for the better. The characteristics of a computer show the capability and the potential of the computer for processing data. This saves time, space, money, labors etc. And they answer the questions such as: Why computers are used? Why have they become so popular? Some of the characteristics of the computer are as follows:

### ➤ Speed

The ability of the computers to carry out their instructions in a very short period of time is one of the main reasons for their popularity. Computers can perform tasks within a matter of seconds or minutes that would be impossible for a person to complete by hand in lifetime.

Its speed is measured by the amount of time it took to perform or carry out a basic operation. And its speed measured in terms of micro second ( $10^{-6}$  - one millionths), nano

second ( $10^{-9}$  – one billionths), and Pico second ( $10^{-12}$  – one trillionths). Hence a computer with speed 1 microsecond can perform 1 million instructions in just 1 second. (For example in one second this computer can perform the following tasks:

- Calculate the grade point average for 3000 students
- Calculate the total value of all books used by students in a university

### ➤ **Accuracy**

Now a days, computers are being used in life-and-death situations (For example, jet pilots rely on computer computations for guidance, Hospitals rely on patient-monitoring systems in critical – care units) which needs almost hundred percent accuracy. From this we can understand that computer is accurate and consistent. Unless there is an error in the input data or unreliable program the computer processes its task accurately.

### ➤ **Capacity**

The ability of computers to store and process vast amounts of data continues to grow. A computer operating at 200 MHz can move data from one location to another at a rate excess of 1.2 billions characters (symbols) per second.

### ➤ **Durability and reliability**

Computers are durable and extremely reliable devices. They can operate error-free over long periods of time.

### ➤ **Diligence**

Computer, being a machine, does not suffer from the human traits of tiredness and lack of concentration. If four million calculations have to be performed, then the computer will perform the last four-millionth calculation with the same accuracy and speed as the first calculation.

### ➤ **Versatility**

Because of technological advancements in the computer industry, most computers today are considered to be general-purpose computers, that is, both their computation and input/output processing capabilities are used for almost any type of application. For example, the same computer that is used to handle engineering company's mathematics and design computations can also be efficiently used by the company to track inventory, process payroll, project earnings, and fulfill all its reporting needs.

Today's computers are versatile in what they can do; computers and their components are used in applications never before envisioned. For example; in home appliances (washing machines, ovens) home entertainment centers, traffic lights, automobiles, banking, assembly plants, space probes, art, music, education, hospitals, and agriculture, to name a few. The versatility of the computers and its use in a wide array of applications are limited only by the imagination of the human mind.

**Note:** Even if the above main characteristics of computers are increasing with time, the cost and size of computers are decreasing.

## 1.4 Types of computers

These days, computers are available in many sizes and types. You can have a computer that can fit in the palm of your hand to those that can occupy the entire room; single user computers can be used by hundreds of users simultaneously. Computers also differ on their data processing abilities. Hence, computers can be classified according to *purpose*, *data handling (processing)*, and *functionality*.

### Classification According to Type of Data handling (processing) Techniques

Different types of computers process the data in a different manner. According to the basic data handling principles, computers can be classified into three categories: *analog*, *digital*, and *hybrid*.

#### 1. Analog Computers

Analog computers operate by measuring. They deal with continuous variables; they don't compute directly with the numbers rather, they operate by measuring physical magnitude such as pressure, temperature, voltage, current etc.

**Examples:**

- Thermometer
- Voltmeter
- Speedometer
- Gasoline pump – Contains an analog Computer that converts the flow of pumped fuel into two measurements the price of the delivered gas and the quantity of pumped fuel.

Analog computers are used for scientific and engineering purposes. One of the characteristics of these computers is that they give approximate results since they deal with quantities that vary continuously.

The main feature of analog computers is that they are very fast in operation as all the calculations are done in parallel mode. It is very easy to get graphical results directly using analog computer. However, the accuracy of analog computers is less.

## **2. Digital Computers**

Digital computers deal with discrete variables; they operate by counting rather than measuring. Unlike analog computers, they operate directly on numbers (or digits) that represent numbers, letters, or other special symbols.

In digital computers, analog quantities must be converted into digital quantity before processing.

### ***Examples:***

- Abacus
- Desk top & pocket computers
- The general purpose computers

Digital computers have higher accuracy and speed than the analog ones.

## **3. Hybrid Computers**

These computers incorporated the measuring feature of analog computer and counting feature of a digital computer. For computational purposes, these computers use the analog components and for the storage of intermediate results, digital memories are used.

A hybrid computer processes the information by collecting input data with analog method, converts it into digital quantities, processes the digital values and converts the output from digital to analog form.

These computers are broadly used for scientific applications, various fields of engineering and industrial control processes.

### ***Example:***

Intensive Care Unit (ICU) section, in the hospital, uses analog devices to measure the patient's heart function, temperature and other vital signs. These measurements may then be converted into numbers and supplied to a digital component in the system. This

component is used to monitor the patient's vital signs and to send an immediate signal to the nurse's station if any abnormal readings are detected.

### **Classification According to Purpose**

Computers can be applied or used for different purposes. They can be used either for *special purposes* or *general-purposes*.

#### **1. Special Purpose Computers**

They are designed to solve a single type of problem, that is, their components and function are uniquely adapted to a specific situation involving specific application.

These computers can not be used for other applications unless their circuits are redesigned, that is, they lack versatility. However, being designed for specific tasks, they can provide the result very quickly and efficiently.

##### ***Example:***

- The public telephone box
- Traffic control system
- Ticket machines (used in grocery, super market etc.)
- Pocket calculators etc.
- Counters

Most analog computers are special purpose computers.

#### **2. General-purpose computers**

They are designed to solve a range of problems through the use of “store program concept”.

These machines can be used for various applications, ranging from scientific as well as business purpose applications. Though such computers are versatile and flexible, they generally lack in speed and efficiency.

##### **Examples**

- Micro computers
- Mini computers
- Super computers etc.

### **3. Classification According to Functionality**

At this stage, by a computer, we mean a general-purpose digital computer. Based on physical size, performance and application areas, we can divide computers generally into four major categories: *micro*, *mini*, *mainframe*, and *super computers*.

#### **1. Super computers**

These are the fastest, largest and most potential types of computer. They have speed of hundreds of millions of operations per second, a primary memory capacity of about 80 million characters, and a secondary memory of capacity of about 20 times its primary memory.

They are multi-user systems in intercontinental range. They can carry out enormously complex scientific calculations. They are used to process huge amount of data and are commonly used in space technology centers, meteorology stations, and astronomical observatories, inter continental communications, airline organizations.

#### **2. Mainframe computers**

These computers are smaller in size and capacity, lower in speed & memory capacity than super computers. However, they are multi-user systems and handle hundreds of users, usually used in large organizations.

#### **3. Mini computers**

They have relatively lower speed, capacity, and size than the above two types of computers. They can handle multi-users. They use terminals for inputs and output. Mini computers are used in small organizations.

#### **4. Micro computers**

A Micro computer (personal or desktop computer) is a small, low cost digital computer, which usually consists of a microprocessor, a storage unit, an input channel, and an output channel, all of which may be on one chip inserted into one or several PC boards.

*Microprocessor* is a processor all of whose components are on a single integrated-circuit chip. Since its CPU is integrated in a single circuit, it can serve only a single user at a time. Most of home and personal office computers are microcomputers.

Microcomputers include *desktop*, *laptop*, and *handheld* models such as PDA (Personal Digital Assistants).

**Desktop computers:** They are the most common micro computers. These micro computers typically consist of a system unit, a display monitor, a keyboard, internal hard disk storage, and other peripheral devices.

**Laptop Computers:** A laptop is a portable computer, that is, a user can carry it around. Since the laptop computer resembles a notebook, they are also known as **notebooks**. The main advantage of this computer is that one can use this computer anywhere and at anytime, especially when one is traveling and does not have a proper place to keep it. Moreover, these computers do not need any external power supply as a rechargeable battery is completely self-contained by them.

**Handheld Computers:** A hand-held computer is a computer that can conveniently be stored in a pocket and used while the user is holding it. A PDA user generally uses a pen or electronic stylus, instead of a keyboard for input. Since these computers can be easily fitted on the palmtop, they are also known as **palmtop computers**.

The performance and usage of personal computer is relatively increased with a very high rate.

## 1.5 Application of Computers

### *Why we use Computers?*

The following are some of the capability of Computers, which are reasons to use Computers.

- Store and process large amount of information with high speed and accuracy;
- Transmit information across continents via communication channels;
- Simulate events;
- Perform complex mathematical computations and make comparisons;
- Monitor ongoing industrial operations;
- Perform repetitive processes with great ease, speed, and reliability;

Therefore, computers are applicable for any functions or process that requires these abilities.

The main areas of computer applications can be listed as follows:

### **Learning Aids**

Example: learning toys, programs range from simple arithmetic to calculus, from English grammar to creative writing and foreign language, and from basic graphics to engineering design models,)

### **Entertainment**

Examples: Games

### **Commercial or business applications**

Computers are needed to perform business operations that require handling large amounts of data. Several computer applications are available to assist business in working with large volumes of data.

Examples are:

- Text processing
- Accounting and Finance management
- Inventory control
- Database management
- Statistical analysis

### **Scientific – engineering and research applications**

Computers are used for scientific research, complex mathematical calculations, design work, and analysis and control of physical systems.

Examples are:

- Space technology
- Meteorological observatory systems
- Astronomical investigations
- Design of machines and
- Control of manufacturing process

### **Information Utilities**

Information utilities companies use large computers that store huge amount of information about many different subjects. These computer systems and their vast amount of data are available for personal use. For example: information utilities can allow a computer user to read the daily news, research published works, send a letter to a

friend, play games, make airline reservations, obtain the latest stock market quotations, and perform many other activities.

Example: Internet.

Ethiopian airline is a member of World-Wide reservation system called ***Gabriel*** system.

- The main database is located at Atlanta, Georgia
- More than 48 airlines including EAL share /extract/transmit information using Gabriel

Facilities included:

- Booking of passengers on Domestic and International flight on EAL or Other carrier (EX. Lufthansa).
- Making hotel reservation for the travelers (i.e. the system is connected with major hotels & travel agents)
- Message correspondence with all stations which are members of Gabriel (i.e. reconfirmation space availability, etc)

Elements involved in the reservation system are:

- Computer Network;
- Computer terminal;
- Communication Channels ( telephone lines, satellite, etc)
- Modems

### **Electronic Banking and Service:**

Example:

- Teller Machine (customers are issued cards that permit them to use other banks teller machine's)
- Online banking (A bank customer can use his/ her computer to check account balances, transfer funds, pay bills)

### **Shopping from Home**

Individual may now shop by computer in the comfort of their home.

### **Household Control**

A growing number of the newer houses hold devices are computers controlled. For example: Security systems, refrigerators, microwave ovens, washers, stereos, and televisions. This computer controlled home security system monitors movements, broken

glass, unlawful entry without a security code, and so on, and alerts the local police department.

### **Weather and Environment**

Computer equipment may show temperature ranges, precipitation levels and wind flow and can be used in weather forecasting. Computer can also help in overcoming environmental hazards.

### **Transportation**

Computers have affected almost every kind of transportation. Many aircraft can fly under the control of the computer; in this situation, the captain simply serves as a manager by telling the computer what to do. In Cars, computers have provided functional controls such as spark and fuel control.

### **Medical and Health Care**

Computers have long been used by hospitals for routine record keeping. Today, however, many people owe their lives to the computer. Computers are used in hospitals as sensors (device that detect changes in blood pressure, heart rate, temperature), testing (scan the body and provide 3-D figure), patient treatment.

### **Routine and Dangerous Tasks**

Computers are used in routine tasks. And they can perform task in environments too dangerous for human workers.

### **Consultant (Expert system)**

An Expert system is a computer program, which can solve problems from a specific knowledge base. These systems don't replace expert humans because the knowledge base of expert system is given from the skilled specialist.

Example: Mycin (a medical diagnostic program by using sophisticated decision making process).

## Chapter 2: Development of Computers

### 2.1 History of Computers

We have all heard stories of primitive peoples counting their sheep by moving sticks or stones. Our base-ten number system undoubtedly grew from the use of 10 fingers as counting objects.

Together with the development of people, the need to calculate and keep track of information had become popular issue. So they soon develop a simple computing device and had a power of storing small information. However, many thousands of years elapsed before developing mechanical calculator.

Some of the calculating devises are mentioned bellow:

- a) **The Abacus:** - It is one of the earliest mechanical computational devices. It was in use in the Middle East as early as 2500 BC. The familiar Chinese abacus (dating approximately 1200 AD ) is composed of a frame and a number of wires. The wires correspond to position of digits in decimal number units: tens, hundreds, and so on- and the beads represent digits. Beads above the cross bar represent 5 and that bellow represent 1.

The abacus shows zero, if all the bead bellow the cross bar are at the lower frame and above are at the upper frame.

Addition of two numbers on the abacus can be performed by representing the first number and the second number without resetting the first. On any wire showing 10 or more, the two beads above the cross bar are moved back, and an extra 1 (the Cary) is added two the wire on the left.

This process can be easily generalized to addition and subtraction of more than two numbers.

- b) **Pascal's Calculator:** - It is the first true mechanical calculator. In 1642, at the age of 19, the French philosopher and mathematician Blaise Pascal developed a rotating wheel calculator, the predecessor of the latter popular desktop calculator. He built largely to assist his father, who was a tax collector in the town of Rouen, Pascal's calculator has one wheel corresponding to each power of 10; each wheel has 10 position, one for each of the digits (0,..9). Although, Pascal's calculator could only

add and subtract, it could be used indirectly for multiplication (by successive addition) and division (by successive subtraction) as well.

c) **The Difference Engine:** - It is the forerunner of the modern computer. Charles Babbage (1792-1871), a British mathematician and engineer, is considered by many to be the real father of today's computer was the developer of the difference engine and designer of the analytical engine. The difference engine also based on the rotating wheels principle and it was operated by means of a single crank. This device has a power of calculation and print the output without human intervention. He finally designed significantly improved version of the difference engine (but not built) called Analytic engine. It has different key components

- **The store:** A memory wheel consisting of set of counter wheels
- **The mill:** An arithmetic unit capable of performing the four basic arithmetic operations. It operated on pairs of mechanical registers and produced a result stored in another register, all of which were located in the store.
- **Operation cards:** These cards selected one of the four arithmetic operations by activating the mill to perform the selected function.
- **Variable cards:** These cards selected the memory locations to be used by the mill for a particular operation (a source of operand and the destination of the result).
- **Out put:** was to print or a card punch device.

But finally the design halt largely due to the technology of the day is not far enough to supply the required raw materials.

d) **Herman Hollerith's Tabulating Machine:** - Herman Hollerith was a statistician that in 1880 and develop his machine commissioned by the U.S. Census Bureau to develop a technique for speeding up the processing of census data that took at least 8 years before. He develops his machine that uses the punched card to punch the census data and tabulated by using his machine. This machine processes the 1890 American census data within 3 years. It was really a great development. He finally began the tabulating Machine Company, which later becomes the International Business Machine Corporation (IBM).

- e) **Mark I:** - Developed by Howard Aiken at Harvard University (1944) which was the first electromechanical computer. Instruction was provided by means of punched paper tape, which combined the functions of Babbage's operation cards and variable cards. Each instruction had the format **A1 A2 OP** where A1 and A2 are registers storing the operand, OP is the operation to be performed (e.g. +, -, x, ÷). Mark I could do a single addition in 6 seconds and division in 12 seconds.
- f) **ENIAC (Electronic Numerical Integrator And Computer):** - Developed by Eckert and Mauchly at the university of Pennsylvania. This was the first electronic calculator and first general purpose digital computer. This machine was enormous, weighing 30 tones. Occupying 15,000 square feet of floor space and containing over 18,000 vacuum tubes. When operating, it consumed over 140 KWPH of power. It had a capability of performing 5,000 additions per second. Its memory consisted of 20 "accumulators" each capable of holding a 10 digit decimal number. Each digit was represented by a ring of 10 vacuum tubes. At any time, only one of the 10 tubes was in ON state, representing one of the 10 digits.
- ENIAC did not use internally stored programs. Programs were wired on boards similar to a telephone switch board.
  - One of the major drawbacks of ENIAC was that it had to be programmed manually by setting switches and plugging and unplugging cables.
- g) **The Von Neumann Machine:** - The task of entering and altering programs for the ENIAC was extremely tedious. Von Neumann was the consultant on the ENIAC project and forward the *stored program concept*, i.e. designing the computer to get its instruction by reading them from memory alongside the data and a program could be set or altered by setting the values of a portion of a memory. Based on this concept, the first true electronic computers were developed by the name EDVAC (Electronic Discrete Variable Automatic Computer) and EDSAC( Electronic Delay Storage Automatic Computer).
- h) **Commercial Computers:** - The 1950s saw the birth of computers industry with two companies, Sperry and IBM, dominating the market place. In 1947, Eckert and Mauchly develop their successful commercial computer called UNIVAC I (Universal Automatic Computer). UNIVAC was division of Remington Rand (later Sperry Rand

Corporation). IBM also the major manufacturer of punched card processing equipment, delivered its first electronic stored program computer, the IBM 701, in 1953.

## ***2.2 Generation of Computers***

Although computer professionals do not agree on exact dates or specifics, computer developments are often categorized by generations. Actually there are four generations and major characteristics that distinguish these generations are the following:

- Dominant type of electronic circuit elements used.
- Major secondary storage media used.
- Computer language used.
- Types or characteristic of operating system used.
- Memory access time (time to store or retrieve a word or data from memory).

Computer generations are usually categorized by dramatic improvement in the hardware, typically refold or better increases in speed and reliability.

### **First generation (1950s)**

- Used vacuum tubes as components for the electronic circuit.
- Punched cards were the main source of inputs, and magnetic grams were used for internal storage.
- Operate in a speed of milliseconds (thousands of a second) and could handle more than 10,000 additions each second.
- Most applications were scientific calculations.

### **Second generations (early 1960s)**

- Transistors were the main circuit components. (Transistors are a solid state device made from silicon which is smaller, cheaper, faster, dissipate less energy and more reliable than vacuum tube but work in the same way with the vacuum tube.)
- Invented by Bell Labs.
- Magnetic tapes (similar with home tape caste), used for main storage,
- Operate in microseconds (millionths of a second) with more than 200,000 additions possible each second.

- Business applications become more commonplace, with large data files stored on magnetic tape and disk. (Magnetic disk: is a circular platter constructed of metal or plastic materials coated with magnetizable substance.)
- High-level languages COBOL and FORTRAN were introduced during this period. Batch operating systems are used that permitted rapid processing of magnetic tape files.

### **Third generation (late 1960s, early 1970s)**

- Characterized by solid-state logic and integrated circuit (IC). (A single, self-contained transistor is called discrete component. In early 1960 electronic equipment composed of discrete components transistors, capacitors, resistors, They are:
  - manufactured separately
  - Packed in their own containers and soldered (wired together) on a circuit board. So the entire manufacturing process was cumbersome and expensive. Do to these and other problems in 1958 the achievement that revolutionized electronics started the era of microelectronics: the invention of integrated circuit.
- Computer storage switched from magnetic cores to integrated circuit boards that provide modularity (expandable storage) and compatibility (interchangeable equipment)
- New input/output methods such as optical scanning and plotters.
- Software become more important with sophisticated operating systems, improved programming languages,

### **Fourth generation (late 1970s, early 1989s)**

- Greatly expanded storage capabilities and improved circuitry.
- Has a large-scale integrated circuits (LSI) which has several hundred thousands transistors placed on one tiny silicon chip.
- Computer memory operates at speeds of nano seconds (billionths of a second) with large computers capable of adding 15 million numbers per second.

**The fifth generation computer** is in progress. An architecture, which makes use of the changes in technology and allows a simple and natural methodology for solving problems, is being sought. These computers will have intelligent processors i.e., processors which can draw inferences. Users will also be able to interact with them in natural languages such as English, German etc. Japans are working intensively on the project for developing the 5<sup>th</sup> generation.

#### **Summary of generation of computers**

| <b>Generation</b> | <b>1st</b>           | <b>2nd</b>         | <b>3rd</b>           | <b>4th</b>           | <b>5th</b> |
|-------------------|----------------------|--------------------|----------------------|----------------------|------------|
| Circuit element   | Vacuum tube          | Transistor         | IC                   | LSI                  | VLSI       |
| SSD               | Punched card         | Magnetic Tape      | Magnetic disk        | Mass storage device  |            |
| Language          | Machine & assembly   | Fortran, COBOL etc | Structured language  | Application oriented |            |
| Operating system  | Operator control     | Batch system       | Application oriented | Time sharing         |            |
| Mem. Access time  | 1ms                  | 10 $\mu$ s         | 10ns                 | 1ns                  |            |
| Approx. date      | 1946-57              | 1958-64            | 1965-71              | From 1971 above      |            |
| examples          | ENIAC, UNIVAC, UDVAC | IBM7090, 7094      | IBM system           | Late IBM product     |            |