1

Introduction to Computers

LEARNING OBJECTIVES

Unit 1:

By the end of this Chapter, Student will be able to know:

- Different Generations of Computers and their evolution.
- Classification of computers.
- Features of computers, their advantages and limitations.
- Basic components of a computer system.
- Types of Storage devices, their use and capacity.
- Types of RAM and their working.

Unit 2:

- Different types of Input and Output devices available and how to use them.
- Where to use the right kind of Input and output device.
- Add-ons required for the Input and Output devices.

Unit 3:

- Meaning of software.
- Classifications of software.
- Types of Operating Systems and their features.
- Various types of software available in the market for scientific and business usages.

In this Chapter, we shall discuss what we understand by the term 'computer', its functions and various generations through which computer technology has advanced. Various categorizations of computers according to their purpose and size etc. shall also be discussed in this chapter. We will also overview hardware and software requirements. Hardware consists of the mechanical and electronic components, which one can see and touch. Computer hardware falls into two categories: processing hardware, which consists of the central processing unit, and the peripheral devices. The software comprises of system and application programs, the operating systems and various other general purpose software.

UNIT 1 : INTRODUCTION TO COMPUTERS

1.1 Historical Development of Computers

The modern computer with the power and speed of today was not a solitary invention that sprang completed from the mind of a single individual. It is the end result of countless inventions, ideas, and developments contributed by many people throughout the last several decades.

The history of the modern computer begins with two separate technologies—automated calculation and programmability, but no single device can be identified as the earliest computer, partly because of the inconsistent application of that term. An example of early mechanical calculating devices was *abacus*.

The **abacus** was an early aid for mathematical computations. With *abacus,* a person can work on addition and subtraction problems at the speed of a person equipped with a hand calculator (multiplication and division are slower). The device is capable to perform simple addition and subtraction rapidly and efficiently by positioning the ring on a wooden rack holding two horizontal wires with beads strung on them. When these beads are moved around, according to programming rules memorized by the user, all regular arithmetic problems can be done.

The first mechanical digital calculating machine was built in 1642 by the French scientist-philosopher Blaise Pascal. And since then the ideas and inventions of many mathematicians, scientists, and engineers paved the way for the development of the modern computer in following years.

In 1671, Gottfried Wilhelm Von Leibniz invented a computer that was built in 1694. It could add and multiply, after changing some things around. Leibniz invented a special stepped gear mechanism for introducing the addend digits, and this is still being used. The prototypes made by Pascal and Leibniz were not used in many places, and considered weird until a little more than a century later, when Thomas of Colmar (A.K.A. Charles Xavier Thomas) created the first successful mechanical calculator that could add, subtract, multiply, and divide. A lot of improved desktop calculators were mainly made for commercial users, and not for the needs of science.

In 1801, Joseph Marie Jacquard made an improvement to the textile loom by introducing a series of punched paper cards as a template which allowed his loom to weave intricate patterns automatically. The resulting Jacquard loom was an important step in the development of computers because the use of punched cards to define woven patterns can be viewed as an early, albeit limited, form of programmability.

It was the fusion of automatic calculation with programmability that produced the first recognizable computers. In 1837, Charles Babbage was the first to conceptualize and design a fully programmable mechanical computer. Babbage was a mathematician who taught at Cambridge University in England. He began planning his calculating machine calling it the

Analytical Engine. The idea for this machine was amazingly like the computer we know today. It was to read a program from punched cards, figure and store the answers to different problems, and print the answer on paper.

In the late 1880s, Herman Hollerith invented the recording of data on a machine readable medium. After some initial trials with paper tape, he settled on punched cards. To process these punched cards, he invented the tabulator, and the keypunch machines. These three inventions were the foundation of the modern information processing industry. Large-scale automated data processing of punched cards was performed in 1890 for United States Census by Hollerith's company, which later became the core of IBM. By the end of the 19th century a number of technologies that would later prove useful in the realization of practical computers had begun to appear: the punched card, Boolean algebra, the vacuum tube (thermionic valve) and the teleprinter.

In 1944, IBM Automatic Sequence Controlled Calculator (ASCC), called the Mark I was developed at Harvard University by Howard H. Aiken, was an electro-mechanical computer which would automatically sequence the operations and calculations performed. It was very reliable, much more so than early electronic computers. The Mark I computer was very much like the design of Charles Babbage's having mainly mechanical parts, but with some electronic parts. His machine was designed to be programmed to do many computer jobs. This all-purpose machine is what we now know as the PC or personal computer. The Mark I was the first computer financed by IBM and was about 50 feet long and 8 feet tall. It used mechanical switches to open and close its electric circuits. It contained over 500 miles of wire and 750,000 parts. It has been described as "the beginning of the era of the modern computer" and "the real dawn of the computer age".

ENIAC (pronounced /ˈɛniæk/), short for **Electronic Numerical Integrator And Computer**, was the first general-purpose, electronic computer built in 1946 by J. Presper Eckert and John Mauchly. It was complete digital computer capable of being reprogrammed to solve a full range of computing problems. It boasted speeds one thousand times faster than electro-mechanical machines, a leap in computing power that no single machine has since matched. This mathematical power, coupled with general-purpose programmability, excited scientists and industrialists.

The ENIAC was a modular computer, composed of individual panels to perform different functions. Twenty of these modules were accumulators, which could not only add and subtract but hold a ten-digit decimal number in memory. Numbers were passed between these units across a number of general-purpose buses, or trays, as they were called. In order to achieve its high speed, the panels had to send and receive numbers, compute, save the answer, and trigger the next operation—all without any moving parts. Key to its versatility was the ability to branch; it could trigger different operations that depended on the sign of a computed result.

The size of ENIAC's numerical "word" was 10 decimal digits, and it could multiply two of these numbers at a rate of 300 per second, by finding the value of each product from a multiplication table stored in its memory. ENIAC was therefore about 1,000 times faster then the previous generation of relay computers. ENIAC used 18,000 vacuum tubes; about 1,800 square feet of floor space, and consumed about 180,000 watts of electrical power. It had punched card I/O, 1 multiplier, 1 divider/square rooter, and 20 adders using decimal ring counters, which served as adders and also as quick-access (.0002 seconds) read-write register storage. ENIAC is commonly accepted as the first successful high – speed electronic digital computer (EDC) and was used from 1946 to 1955.

Modern type computer began with John von Neumann's development of software written in binary code. It was Von Neumann who began the practice of storing data and instructions in binary code and initiated the use of memory to store data, as well as programs. A computer called the EDVAC (Electronic Discrete Variable Computer) was built using binary code in 1950. Before the EDVAC, computers like the ENIAC could do only one task then they had to be rewired to perform a different task or program. The EDVAC's concept of storing different programs on punched cards instead of rewiring computers led to the computers that we know today.

1.2 The Computer Generations

The history of computer development is often referred to in reference to the different generations of computing devices. A generation refers to the state of improvement in the product development process. This term is also used in the different advancements of new computer technology. With each new generation, the circuitry has gotten smaller and more advanced than the previous generation before it. As a result of the miniaturization, speed, power, and computer memory has proportionally increased. New discoveries are constantly being developed that affect the way we live, work and play.

Each generation of computers is characterized by major technological development that fundamentally changed the way computers operate, resulting in increasingly smaller, cheaper, and more powerful, efficient and reliable devices.

First Generation computers (1940-56): The first generation electrical computers employed vacuum tubes. The computers were using vacuum tubes for circuitry and magnetic drums for memory, and were often enormous, taking up entire rooms. They were very expensive to operate and in addition to using a great deal of electricity, generates a lot of heat, which was often the cause of malfunctions. (Refer to fig. 1.2.1)

First generation computers relied on machine language to perform operations, and they could only solve one problem at a time. Machine languages are the only languages understood by computers. Programs written in high-level languages are translated into assembly language or machine language by a compiler. Assembly language programs are translated into machine language by a program called an **Assembler**.

The input and output units were the punched card reader and the card punches. The most popular first generation computer and was introduced in 1950 with magnetic drum memory and punched cards for input and output. It was intended for both business and scientific applications.

The UNIVAC and ENIAC computers are examples of first-generation computing devices. The UNIVAC was the first commercial computer delivered to a business client, the U.S. Census Bureau in 1951.

General characteristics of first generation computers

- These computers uses vacuum tube for data processing and storage.
- They had a memory size of 20 bytes and speed of 5 mbps.
- They produced a lot of heat.
- These computers were unreliable and could not work fast with a lot of data.
- They use punch card for data storage.
- The programmers were machine dependent.
- These computers consume a lot of power.

Figure 1.2.1: Vacuum Tubes*

Second Generation computers (1956-1963): These computers employed transistors (see fig. 1.2.2) and other solid state devices. Their circuits were smaller than the vacuum tubes, and generated less heat. Hence the second-generation computers required less power, were faster and more reliable.

Transistors replaced vacuum tubes and ushered in the second generation of computers. Transistor is a device composed of semiconductor material that amplifies a signal or opens or closes a circuit.

The transistor was invented in 1947, but did not see widespread use in computers until the late 50s. The transistor was far superior to the vacuum tube, allowing computers to become smaller, faster, cheaper, more energy-efficient and more reliable than their first-generation predecessors. Though the transistor still generated a great deal of heat that subjected the computer to damage, it was a vast improvement over the vacuum tube. Second-generation computers still relied on punched cards for input and printouts for output.

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* www.wikipedia.org

Second-generation computers moved from cryptic binary machine language to symbolic, or assembly languages, which allowed programmers to specify instructions in words. High-level programming languages were also being developed at this time, such as early versions of COBOL and FORTRAN. These were also the first computers that stored their instructions in their memory, which moved from a magnetic drum to magnetic core technology. The first computers of this generation were developed for the atomic energy industry.

General characteristics of second generation computers

- They were capable of translating, process and store data.
- They were much smaller in size than first generation computers.
- They had got memory size of 32 bytes and speed of 10 mbps.
- They were reliable compared to first generation computers.
- They produced less heat compared to first generation computers.
- They use punch card for data storage.
- They consumed less energy compared to first generation computers.
- They were less expensive to produce.

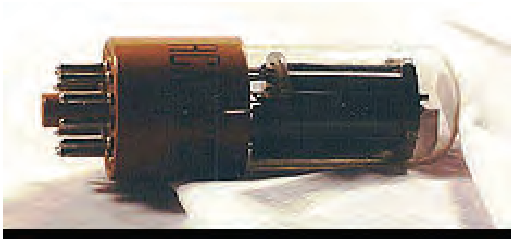

Figure 1.2.2: Transistor*

Third Generation computers (1963-71): The development of the integrated circuit was the hallmark of the third generation of computers. Transistors were miniaturized and placed on silicon chips, called semiconductors, which drastically increased the speed and efficiency of computers. The third generation employed integrated circuits in which all the elements of an electronic circuit are contained in a tiny silicon wafer. A chip is a small piece of semi conducting material (usually silicon) on which an integrated circuit is embedded. A typical chip is less than ¼ square inches and can contain millions of electronic components (transistors). Computers consist of many chips placed on electronic boards called printed circuit boards. There are different types of chips. For example, CPU chips (also called microprocessors) contain an entire processing unit, whereas memory chips contain blank memory. Computer chips, both for CPU and memory, are composed of semiconductor materials. Instead of punched cards and print outs, users interacted with third generation computers through

* www.crews.org

keyboards and monitors and interfaced with an operating system, which allowed the device to run many different applications at one time with a central program that monitored the memory. Computers for the first time became accessible to a mass audience because they were smaller and cheaper than their predecessors

The third generation computers are much cheaper and more reliable than the second-generation computers. They are speedier with much vaster capacity and admit connection of a wide variety of peripherals particularly magnetic disk units. They are based on the principles of standardization and compatibility. The third generation computers can be used for both scientific and business applications.

The third generation computers permit multi-programming which is interleaved processing of several programmes to enhance the productivity of the computer, time-sharing which is the use of the computer by several customers at a time, operating systems which optimize the man-machine capabilities and such data communications facilities as remote terminals. They also permit use of such high level languages as FORTRAN and COBOL. The mini computers are also one of the developments in the third generation computers.

Each generation of computers has an effect on the MIS centralization and decentralization issue. The first generation computers were high in costs and large in size; therefore information systems were sought to be centralized to serve benefits of hard ware economies. The second-generation computers were substantially cheaper and the trend was towards MIS decentralization. Third generation computers however, offered communication capabilities and the use of remote terminals and the trend was reversed to centralization.

General characteristics of third generation computers

- They were much more powerful and smaller in size than second generation computers.
- They used integrated circuit (I.C.) to store data which consisted of many transistors.
- The hardware cost and maintenance cost was much lower than second generation of computer.
- They were generally used for business and scientific purposes.
- They uses storage disk for data storage e.g. magnetic disks, tapes.
- Third generation computers were more reliable compared to other previous generations.
- They produced less heat.
- The operating systems were introduced in this era.
- In this generation, high level programming languages were used. For e.g. Fortran, COBOL, PASCAL and BASIC.

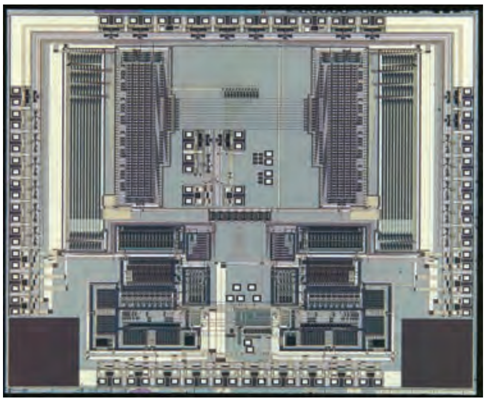

Figure 1.2.3: Integrated Circuits*

Fourth Generation computers (1971-90): Fourth generation machines appeared in 1971 utilizing still newer electronic technology which enabled them to be even smaller and faster than those of the third generation. Many new types of terminals and means of computer access were also developed at this time.

The microprocessor brought the fourth generation of computers, as thousands of integrated circuits were built onto a single silicon chip that contains a CPU. In the world of personal computers, the terms microprocessor and CPU are used interchangeably. At the heart of all personal computers and most workstations sits a microprocessor. Microprocessors also control the logic of almost all digital devices, from clock radios to fuel-injection systems for automobiles.

Three basic characteristics that differentiate one microprocessor from others are:

- **Instruction Set**: The set of instructions that the microprocessor can execute.
- **Bandwidth**: The number of bits processed in a single instruction.
- **Clock Speed**: Given in megahertz (MHz), the clock speed determines how many instructions per second the processor can execute.

The Intel 4004 chip, developed in 1971, located all the components of the computer - from the central processing unit and memory to input/output controls - on a single chip.

In 1981, IBM introduced its first computer for the home user, and in 1984 Apple introduced the Macintosh. Microprocessors also moved out of the realm of desktop computers and into many areas of life as everyday more and more products began to use microprocessors.

As these small computers became more powerful, they could be linked together to form networks, which eventually led to the development of the Internet. Fourth generation computers also saw the development of GUIs, the mouse and hand held devices.

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* www.techiwarehouse.com

Microcomputers have many of the features and capabilities of the larger system. The cost of microcomputers has dropped substantially since their introduction. Many now sell a microcomputer for as low as ₹ 15,000. This reduction in cost will bring about a significant increase in the number of microcomputers in use. The major application for microcomputer lies in the field of industrial automation, where they are used to monitor and control various manufacturing processes. Their low cost and lightweight make it feasible to carry them on site or into a field or to package them with other portable equipments as part of larger system.

The second decade (1986- present) of the fourth generation observed a great increase in the speed of microprocessors and the size of main memory. Many of the mainframe CPU features became part of the microprocessor architecture in 90s. In 1995 the most popular CPUs were Pentium, Power PC etc. Also RISC (Reduced Instruction Set Computers) microprocessors are preferred in powerful servers for numeric computing and file services.

The hard disks are also available of the sizes up to 160 GB or more. For larger disks RAID technology (Redundant Array of Inexpensive Disks) gives storage up to hundreds of GB. The CD-ROMs (Compact Disk-Read Only Memory) and DVDs (Digital Video Disk) are becoming popular day by day. The DVDs of today can store up to 17 Giga bytes of information.

The computer networks came of age and are one of the most popular ways of interacting with computer chains of millions of users. The computers are being applied in various areas like simulation, visualization, parallel computing, virtual reality, multimedia etc. These are computers in use today; they use sophisticated micro-electronic devices.

General characteristics of fourth Generation computers

- This generation of computers was much smaller and cheaper than third generation of computers.
- They used large primary and secondary storage for storing program and data.
- They consume less power, generate less heat and took less space than third generation of computer.
- These computers use microprocessors to process the data.
- The microprocessors are single chip which perform computer operation.
- They were more reliable and less prone to hardware failure.
- They use high level programming languages known as object oriented languages to develop software modules faster than earlier procedural oriented languages.
- The GUI features of the computer made system user friendly in this generation.
- The concept of resource sharing had been introduced using LAN, WAN and MAN in this generation.

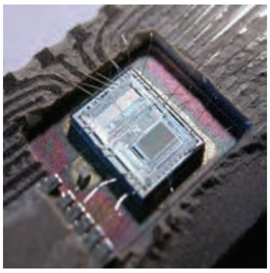

Figure 1.2.4: Chips[*]

Fifth Generation computers (1990 and Beyond): Fifth generation computing devices, based on artificial intelligence, are still in development, though there are some applications, such as voice recognition, that are being used today.

Artificial Intelligence is the branch of computer science concerned with making computers behave like humans. The term was coined in 1956 by John McCarthy at the Massachusetts Institute of Technology. Artificial intelligence includes:

- **Games playing**: programming computers to play games such as chess and checkers.
- **Expert Systems**: programming computers to make decisions in real-life situations. (for example, some expert systems help doctors diagnose diseases based on symptoms)
- **Natural Language**: programming computers to understand natural human languages.
- **Neural Networks**: Systems that simulate intelligence by attempting to reproduce the types of physical connections that occur in animal brains
- **Robotics**: programming computers to see and hear and react to other sensory stimuli.

Currently, no computers exhibit full artificial intelligence (i.e., are able to simulate human behavior). The greatest advances have occurred in the field of games playing. The best computer chess programs are now capable of beating humans. In May, 1997, an IBM super-computer called Deep Blue defeated world chess champion Gary Kasparov in a chess match.

Natural-language processing offers the greatest potential rewards because it would allow people to interact with computers without needing any specialized knowledge. We could simply walk up to a computer and talk to it. Unfortunately, programming computers to understand natural languages has proved to be more difficult than originally thought. Some rudimentary translation systems that translate from one human language to another are in existence, but they are not nearly as good as human translators. There are also voice recognition systems that can convert spoken sounds into written words, but they do not understand what they are writing; they simply take dictation. Using recent engineering advances, computers are able to accept spoken word instructions (voice recognition) and imitate human reasoning. The ability to translate a foreign language is also moderately

[*] www.wikipedia.org

possible with fifth generation computers.

In the early 1980s, expert systems were believed to represent the future of artificial intelligence and of computers in general. To date, however, they have not lived up to expectations. Many expert systems help human experts in such fields as medicine and engineering, but they are very expensive to produce and are helpful only in special situations.

Today, the hottest area of artificial intelligence is neural networks, which are proving successful in a number of disciplines such as voice recognition and natural-language processing. There are several programming languages that are known as AI languages because they are used almost exclusively for AI applications. The two most common are LISP and Prolog.

Figure 1.2.5: Robotics*

1.3 Classification of Computers

Now let us discuss the varieties of computers that we see today. Although they belong to the fifth generation, they can be divided into different categories depending upon the size, efficiency, memory and number of users. Broadly they can be divided it to the following categories.

Computers are generally classified on the basis of various factors:

1. On the basis of working principals
2. On the basis of Size and data processing

1.3.1 On the Basis of Working Principals

On the basis of working principals of computers, they can be categorized into **Analog, Digital and Hybrid** computers.

a) Analog Computer: An Analog computer (spelt analogue in British English) is a form of computer that uses continuous physical phenomena such as electrical, mechanical, or hydraulic quantities to model the problem being solved. It is different from the digital computer

* www.wikipedia.org

in that it can perform numerous mathematical operations simultaneously. It is also unique in terms of operation, as it utilizes continuous variables for the purpose of mathematical computation. (Refer to Fig. 1.3.1.)

 Thermometer	 Speedometer
 Petrol Pump Indicator	 Multimeter

Figure 1.3.1: Analog Computers*

b) Digital Computer: A computer that performs calculations and logical operations with quantities represented as digits, usually in the binary number system. A digital computer is designed to process data in numerical form; its circuits perform directly the mathematical operations of addition, subtraction, multiplication, and division. The numbers operated on by a digital computer are expressed in the binary system; binary digits, or bits, i.e. 0 and 1, so that 0, 1, 10, 11, 100, 101, etc., correspond to 0, 1, 2, 3, 4, 5, etc. Binary digits are easily expressed in the computer circuitry by the presence (1) or absence (0) of a current or voltage. A series of eight consecutive bits is called a “byte”; the eight-bit byte permits 256 different “on-off” combinations. Each byte can thus represent one of up to 256 alphanumeric characters, and such an arrangement is called a “single-byte character set” (SBCS); the de facto standard for this representation is the extended ASCII character set. A digital computer can store the results of its calculations for later use, compare results with other data, and on the basis of such comparisons, it can change the series of operations it performs. Digital computers are used for reservations systems, scientific investigation, data-processing and word-processing applications, desktop publishing, electronic games, and many other purposes. (Refer to Fig. 1.3.2).

* www.wikipedia.org

Figure 1.3.2: Digital Computer

c) Hybrid Computer (Analog + Digital) : A combination of computers those are capable of inputting and outputting in both digital and analog signals. A hybrid computer system setup offers a cost effective method of performing complex simulations. Hybrid computer is a digital computer that accepts analog signals, converts them to digital and processes them in digital form. This integration is obtained by digital to analog and analog to digital converter. A hybrid computer may use or produce analog data or digital data. It accepts a continuously varying input, which is then converted into a set of discrete values for digital processing. A hybrid computer system setup offers a cost-effective method of performing complex simulations. A hybrid computer capable of real-time solution has been less expensive than any equivalent digital computer. Hybrid computers have been necessary for successful system development. An example of a hybrid computer is the computer used in hospitals to measure the heartbeat of the patient. Hybrid Machines are generally used in scientific applications or in controlling industrial processes. (Refer to Fig. 1.3.3).

Figure 1.3.3 : Hybrid Computers*

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* www.wikipedia.org

1.3.2 On the Basis of Size and Data Processing Power

Computer systems are often categorized into Personal / Micro computers, Minicomputers, Mainframe computers and Super computers. Besides these categories, computers can also be categorized as Servers and Workstations.

1. Personal / Micro computer: A small computer also known as microcomputer is a full-fledged computer system that uses a microprocessor as its CPU. Microcomputers were first available for widespread use in the 1970s, when it became possible to put the entire circuitry of computers (CPU) onto a small silicon chip called microprocessor. A microprocessor is a product of the microminiaturization of electronic circuitry; it is literally a "computer on a chip". Chip refers to any self-contained integrated circuit. The size of chips, which are about 30 thousandths of an inch thick, vary in area from fingernail size (about 1/4 inch square) to postage-stamp size (about 1-inch square).

The microprocessor is sometimes confused with its famous offspring, the microcomputer. A microprocessor, however, is not a computer. It only provides a part of CPU circuitry. This chip must be mounted together with memory, input and output chips on a single circuit board to make it a microcomputer. Thus, a microcomputer often called a micro is a small computer consisting of a processor on a single silicon chip which is mounted on a circuit board with other chips containing the computer's internal memory in the form of read-only-memory (ROM) and random-access-memory (RAM).

The terms *microcomputer* and *personal computer* are interchangeable; however, PC - which stands for personal computer has a more specific meaning. In 1981, IBM called its first microcomputer the IBM PC. Within a few years, many companies were copying the IBM design, creating "clones" or "compatible computers" that aimed at functioning just like the original. For this reason, the term PC has come to mean that family of computers that includes IBM and its compatibles. The Apple Macintosh computer, however, is neither an IBM nor its compatible. It is another family of microcomputers made by Apple computers. Apple computers are mainly used for Multimedia applications.

The earliest microcomputers were capable of supporting only a *single user at a time*. Now-a-days, multi-user microcomputer systems are also available and are becoming more prevalent. In multi-user systems, a powerful microcomputer may be used to substitute for Mainframe or minicomputer. Single-user personal computers are also being connected to one another to form network. Multi-user microcomputers play key roles in some of the networks that are developed.

A microcomputer including optional peripherals and other add-on-units may consist of the elements listed below.

(a) 8, 16, or 32 bit processor,

(b) Internal memory 256 MB expandable to 512 MB and more;

(c) Backing storage-cassette, floppy disc, microfloppy discs, micro-drive, silicon disc or hard disc, CD-ROMS, DVDs, pen drives etc.;

(d) Keyboard and screen (input and output);

(e) Interface (for the connection of peripherals);

(f) Bus (communication and control channels);

(g) Printer and/or plotter (multicolor text and graphics);

(h) Pulse generator (clock);

(i) Light pens, mouse, paddles/joysticks, Multimedia (graphics and games);

(j) Software (programs)

Microcomputer systems are used by even the smallest of business; however their primary market is the personal home computer market. In the home, these computers can be used for a wide variety of tasks-from keeping track of the family budget to storing recipes to monitoring the home burglar alarm system. Currently, a small microcomputer system can be purchased for approximately ₹ 30,000. A more sophisticated microcomputer system with a 160 Giga Bytes hard disk and 512 MB or more of primary storage can be purchased for approximately ₹ 20,000 to ₹ 40,000. With high-quality printer and additional memory (up to 1 GB), these microcomputer systems can cost in the vicinity of ₹ 35,000 to ₹ 50,000.

Examples of microcomputers are IBM PCs, PS/2 and Apple's Macintosh.

Types of Personal / Micro computers: Personal computers are generally classified by their size and chassis / case. The chassis or case is the metal frame that provides structural support for electronic components. Based on the usages, there are various types of computer model like tower model, desktop model, notebook computer, laptop computer, palmtop computer, PDAs and now-a-days pocket computer which are small enough for the people to carry and work on it.

Figure 1.3.4: Personal Computers*

* www.wikipedia.org

2. Mini computer: A minicomputer is a class of multi-user computers that lies in the middle range of the computing spectrum, in between the largest multi-user systems (mainframe computers) and the smallest single-user systems (microcomputers or personal computers). The class at one time formed a distinct group with its own hardware and operating systems, but the contemporary term for this class of system is midrange computer, such as the higher-end SPARC, POWER and Itanium-based systems from Sun Microsystems, IBM and Hewlett-Packard.

The term evolved in the 1960s to describe the "small" third generation computers that became possible with the use of integrated circuit and core memory technologies. They usually took up one or a few cabinets the size of a large refrigerator or two, compared with mainframes that would usually fill a room. The first successful minicomputer was Digital Equipment Corporation's 12-bit PDP-8, which cost from US$16,000 upwards when launched in 1964. The important precursors of the PDP-8 include the PDP-5, LINC, the TX-0, the TX-2, and the PDP-1. Digital Equipment gave rise to a number of minicomputer companies along Massachusetts Route 128, including Data General, Wang Laboratories, Apollo Computer, and Prime Computer. Mini computers were also known as midrange computers. They had relatively high processing power and capacity that mostly fit the needs of mid range organizations. They were used in manufacturing processes or handling email that was sent and received by a company. In the 70's they were the hardware that was used to launch the computer aided design, CAD, industry and other similar industries where a smaller dedicated system was needed.

The most popular minicomputer or minis are the Data General Nova, DEC, PDP-11 and the IBM series/1. These systems can serve as information processors in small-to-medium sized firms or as processors in computer networks for large firms. Primary storage capacity starts at about 640K and can go as high as few mega bytes (MB). A minicomputer system consists of a CPU, several disk drives, a high-speed printer, perhaps a few magnetic tape units, and number of terminals. A mini computer supports programming languages that includes BASIC, PASCAL COBOL, C and FORTRAN. Much prewritten application software is also used in mini computers.

Originally minicomputers were developed for process control and system monitoring etc. They were complicated to program and had minimal input/output capabilities as they were mainly concerned with "number crunching" rather than handling large amounts of data relating to business transactions. However, they are now fully developed, powerful computers with a wide range of peripherals to perform a wide range of data processing and computing activities. Minicomputer systems can be equipped with most of the input/output (I/O) devices and secondary storage devices that the large mainframe systems can handle, such as terminals and rigid disks. They are also making possible the installation of distributed data processing systems. Instead of a company having one large mainframe computer, it may have mini-computer at each of its remote locations and connect them to each other through telecommunications.

Figure 1.3.5: Mini computer*

3. Mainframe computer: Mainframes are powerful computers used mainly by large organizations for critical applications, typically bulk data processing such as census, industry and consumer statistics, enterprise resource planning, and financial processing. The term originally referred to the large cabinets that housed the central processing unit and main memory of early computers. Later the term was used to distinguish high-end commercial machines from less powerful units.

They are more powerful and costlier than Mini computers. However, they are big general-purpose computers capable of handling all kinds of scientific and business applications. Mainframes can process at several million instructions per second. A Mainframe can support more than 1,000 remote terminals.

Figure 1.3.6: Mainframe Computer*

Mainframes have large on-line secondary storage capacity. A number of different types of peripheral devices like magnetic tape drive, hard disk drive, visual display units, plotters, printers and telecommunication terminals can be attached with main-frame computers. They have high-speed cache memory which enables them to process applications at a faster rate than mini or microcomputers. They also offer the facility of multiprogramming and time-sharing.

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* www.wikipedia.org

* www.piercefuller.com

Prices of Mainframe computers range between 1 crore to 5 crores depending upon the configuration. It is customary of Mainframe computer manufacturers to produce models ranging in size from small to very large, under a family designation. Computers belonging to a family are compatible *i.e.,* program prepared for one model of a family can run on another bigger model of the family. Major suppliers of Mainframe computers are IBM, Honey well, Burroughs, NCR, CDC and Sperry etc. Mainframes can be used for a variety of applications. A typical application of these computers is airline reservation or railway reservation system.

History and Evolution of Mainframes: Some of the early mainframes which were developed starting from the year of 1942 are ENIAC, MARK1, BINAC, UNIVAC. ENIAC mainframe machine weighed in tones and consumed enormous electric power. It had thousands of vacuum tubes, relays resistors, capacitors, and inductors inside it.

In the year 1951, UNIVAC-I was developed specially for the US Census Bureau. The major difference between UNIVAC and ENIAC was the processing of digits. In UNIVAC, processing was done in serial mode, yet the speed of UNIVAC was higher than ENIAC with one disadvantage of vacuum tubes generating enormous amount of heat which made the mandatory requirement of a large good air conditioning system.

Later in 1954, UNIVAC-II was developed. In 1962, the concept of virtual memory, a powerful feature which shall be discussed in later sections, was introduced in mainframes making the system even more powerful.

In 1964, the first third generation computer named as Burroughs B5000 came into market. This mainframe system had various powerful specialized features like multiprogramming, multiprocessing and virtual memory.

Later on various improved versions of Burroughs series came into market with new features in each. Among this the most notable one was B6700 which came in the year 1971 and this supported the feature of dynamic linking of programs at runtime.

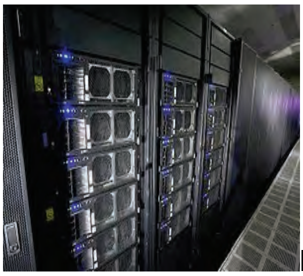
IBM was producing and releasing mainframes in the market at all periods from past till present with the successive development of IBM Series starting with System/360.

One of the biggest factors associated with mainframes is its huge cost which made its usage only possible for big companies and corporate. There are still many technical terms one must get familiarized with mainframe systems to understand about mainframe systems in depth.

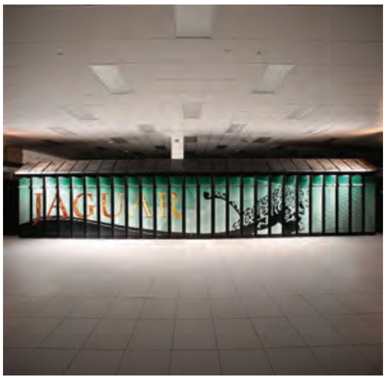
4. Super computer: Supercomputers are very expensive and are employed for specialized applications that require immense amounts of mathematical calculations. They are the largest and fastest machines typically used in specialized areas. They have high processing speed compared to other computers. They have also multiprocessing technique. One of the ways in which supercomputers are built is by interconnecting hundreds of microprocessors. Supercomputers are mainly being used for Defense, whether forecasting, biomedical research, remote sensing, aircraft design and other areas of science and technology. Examples of supercomputers are CRAY YMP, CRAY2, NEC SX-3, CRAY XMP and PARAM from India. Various suppliers of super computers are CRAY, CDC, Fujit su, Intel Corporation, Thinking Machine Corporation, NEC, SGI, Hitachi, IBM and Sun Microsystem, etc.

In the medical field, super computers are used to study the structure of viruses, such as those causing AIDS. Designing an aircraft involves simulating and analyzing the airflow around the aircraft. This again requires a super computer. Fig. 1.3.5 displays list of 3 Super Computers.

IBM Blue Gene/P



IBM Road Runner



Cray Jaguar XT5

Figure 1.3.7: List of 3 Super computers*

Supercomputers were introduced in the 1960's as the worlds most advanced computer. These computers were used for intense calculations such as weather forecasting and quantum physics. Today, supercomputers are one of a kind, fast, and very advanced. The term supercomputer is always evolving where tomorrow's normal computers are today's supercomputer.

Today, supercomputers are typically one-of-a-kind custom designs produced by "traditional" companies such as Cray, IBM and Hewlett-Packard, who had purchased many of the 1980s companies to gain their experience. As of May 2010, the Cray Jaguar is the fastest supercomputer in the world.

In general, the speed of a supercomputer is measured in "FLOPS" (*FLoating Point Operations Per Second*).The FLOPS is a measure of a computer's performance, especially in fields of scientific calculations that make heavy use of floating point calculations, similar to the older, simpler, instructions per second. The supercomputer can process the data commonly used

* www.wikipedia.org

with an SI prefix such as tera, combined into the shorthand "TFLOPS" (10^{12} FLOPS, pronounced *teraflops*), or peta, combined into the shorthand "PFLOPS" (10^{15} FLOPS, pronounced *petaflops*). This mimics a class of real-world problems, but is significantly easier to compute than a majority of actual real-world problems. "Petascale" supercomputers can process one quadrillion (10^{15}) (1000 trillion) FLOPS.

5. Workstations: Workstation is a high-end microcomputer designed for technical or scientific applications. Intended primarily to be used by one person at a time, they are commonly connected to a local area network and run multi-user operating systems. The term *workstation* has also been used to refer to a mainframe computer terminal or a PC connected to a network.

Historically, workstations had offered higher performance than personal computers, especially with respect to CPU and graphics, memory capacity and multitasking capability. They are optimized for the visualization and manipulation of different types of complex data such as 3D mechanical design, engineering simulation (e.g. computational fluid dynamics), animation and rendering of images, and mathematical plots. Workstations are the first segment of the computer market to present advanced accessories and collaboration tools.

Perhaps the first computer that might qualify as a "workstation" was the IBM 1620, a small scientific computer designed to be used interactively by a single person sitting at the console. It was introduced in 1959. One peculiar feature of the machine was that it lacked any actual arithmetic circuitry. To perform addition, it required a memory-resident table of decimal addition rules. This saved on the cost of logic circuitry, enabling IBM to make it inexpensive.

Early examples of workstations were generally dedicated minicomputers; a system designed to support a number of users would instead be reserved exclusively for one person. A notable example was the PDP-8 from Digital Equipment Corporation, regarded to be the first commercial minicomputer.

Although workstations are still more powerful than the average personal computer, the differences in the capabilities of these types of machines are growing smaller.

Workstations differ significantly from microcomputer in two areas. Internally, workstations are constructed differently than microcomputers. They are based on different architecture of CPU called R*educed Instruction Set Computing* (RISC), which results in faster processing of instructions.

The other difference between workstations and microcomputers in that most microcomputers can run any of the four major operating systems namely DOS, Unix, OS/2, and Microsoft Windows NT), but workstations generally run the Unix Operating Systems or a variation of it.

The biggest manufacturer of workstations is Sun Microsystems. Other manufacturers include Dell, IBM, DEC, Hewlett Packard and Silicon Graphics.

These days, a workstation is powerful RISC - based computer that runs the Unix Operating System and is generally used by scientists and engineers.

Figure 1.3.8: Sun SPARCstation RISC processor ,1990s*

6. Server: A server computer is a computer, or series of computers, that link other computers or electronic devices together. They often provide essential services across a network, either to private users inside a large organization or to public users via the Internet.

Many servers have dedicated functionality such as web servers, print servers, and database servers. Enterprise servers are servers that are used in a business context.

It provides services to other computing systems called clients over a network. The typical server is a computer system that operates continuously on a network and waits for requests for services from other computers on the network. Many servers are dedicated to this role, but some may also be used simultaneously for other purposes, particularly when the demands placed upon them as servers are modest. For example, in a small office, a large desktop computer may act as both a desktop workstation for one person in the office and as a server for all the other computers in the office.

Servers today are physically similar to most other general-purpose computers, although their hardware configurations may be particularly optimized to fit their server roles, if they are dedicated to that role. Many use hardware identical or nearly identical to that found in standard desktop PCs. However, servers run software that is often very different from that used on desktop computers and workstations.

Servers often run for long periods without interruption and availability. Although servers can be built from commodity computer parts, mission-critical servers uses specialized hardware with low failure rates in order to maximize uptime. For example, servers may incorporate faster, higher-capacity hard drives, larger computer fans or water cooling to help remove heat, and uninterruptible power supplies that ensure the servers continue to function in the event of a power failure. These components offer higher performance and reliability at a correspondingly higher price.

Some popular operating systems for servers such as FreeBSD, Solaris and Linux are derived from or are similar to UNIX. UNIX was originally a minicomputer operating system, and as servers gradually replaced traditional minicomputers, UNIX was a logical and efficient choice of operating system. Many of these derived OSs are free in both senses, and popular.

* www.qwiki.org

Server-oriented operating systems tend to have certain features in common that make them more suitable for the server environment, such as

- GUI not available or optional,
- Ability to reconfigure and update both hardware and software to some extent without restart,
- Advanced backup facilities to permit regular and frequent online backups of critical data,
- Transparent data transfer between different volumes or devices,
- Flexible and advanced networking capabilities,
- Automation capabilities such as daemons in UNIX and services in Windows, and
- Tight system security, with advanced user, resource, data, and memory protection.

Server oriented operating systems can, in many cases, interact with hardware sensors to detect conditions such as overheating, processor and disk failure, and consequently alert an operator and/or take remedial measures itself.

Because servers must supply a restricted range of services to perhaps many users while a desktop computer must carry out a wide range of functions required by its user, the requirements of an operating system for a server are different from those of a desktop machine. While it is possible for an operating system to make a machine both provide services and respond quickly to the requirements of a user, it is usual to use different operating systems on servers and desktop machines. Some operating systems are supplied in both server and desktop versions with similar user interface.

Servers frequently host hardware resources that they make available on a controlled and shared basis to client computers, such as printers *(print servers)* and file systems *(file servers)* This sharing permits better access control (and thus better security) and can reduce costs by reducing duplication of hardware.

Figure 1.3.9: Server*

*www.wikipedia.org

1.4 Advantages and Limitations of Computers

Advantages of Computer System: Now-a-days computer is playing a main role in every field of life and has become the need of people just like television, telephone or other electronic devices at home. It solves the human problems very quickly as well as accurately. The important characteristics of a computer are described below:

(i) **Speed:** The computer is a very high speed electronic device. The operations on the data inside the computer are performed through electronic circuits according to the given instructions. The data and instructions flow along these circuits with high speed that is close to the speed of light. Computer can perform million of operations on the data in one second. The computer generates signals during the operation process therefore the speed of computer is usually measure in mega hertz (MHz) or gega hertz (GHz). It means million cycles units of frequency per second. Different computers have different speed.

(ii) **Accuracy:** In addition to being very fast, computer is also very accurate device. It gives accurate output result provided that the correct input data and set of instructions are given to the computer. It means that output is totally depended on the given instructions and input data. If input data is in-correct then the resulting output will be in-correct. In computer terminology it is known as garbage-in garbage-out.

(iii) **Reliability:** The electronic components in modern computer have very low failure rate. The modern computer can perform very complicated calculations without creating any problem and produces consistent (reliable) results. In general, computers are very reliable. Many personal computers have never needed a service call. Communications are also very reliable and generally available whenever needed.

(iv) **Storage:** A computer has internal storage (memory) as well as external or secondary storage. In secondary storage, a large amount of data and programs (set of instructions) can be stored for future use. The stored data and programs are available any time for processing. Similarly information downloaded from the internet can be saved on the storage media.

(v) **Automation:** A computer can automatically perform operations without interfering the user during the operations. It controls automatically different devices attached with the computer. It executes automatically the program instructions one by one.

(vi) **Versatility:** Versatile means flexible. Modern computer can perform different kind of tasks one by one or simultaneously. It is the most important feature of computer. At one moment we can play games on computer, the next moment we can compose and send emails etc. In colleges and universities computers are used to deliver lectures to the students. The talent of computer is dependent on the software.

(vii) **Communications:** Today computer is mostly used to exchange messages or data through computer networks all over the world. For example the information can be received or send through the internet with the help of computer. It is most important feature of the modern information technology.

(viii) **Diligence:** A computer can continually work for hours without creating any error. It does not get tired while working after hours of work it performs the operations with the same accuracy as well as speed as the first one.

(ix) **No Feelings:** Computer is an electronic machine. It has no feelings. It detects objects on the basis of instructions given to it. Based on our feelings, taste, knowledge and experience, we can make certain decisions and judgments in our daily life. On the other hand, computer can not make such judgments at its own. Their judgments are totally based on instructions given to them.

(x) **Consistency:** People often have difficulty to repeat their instructions again and again. For example, a lecturer feels difficulty to repeat a same lecture in a class room again and again. Computer can repeat actions consistently (again and again) without loosing its concentration. A computer will carry out the activity with the same way every time.

(xi) **Precision:** Computers are not only fast and consistent but they also perform operations very accurately and precisely. For example, in manual calculations and rounding fractional values (The value with decimal point can change the actual result). In computer however, we can keep the accuracy and precision upto the level that we desire. The length calculations remain always accurate.

Limitations of Computer Systems: Computer is one of the major inventions we have seen in our life. Initially long and tough calculations could not be solved by calculators or hands or other devices. We needed something extra powerful to perform the task of calculations and hence process the data into meaningful results. So with the invention of computers, our problems were solved and it began to be used in various business purposes, home purposes, even scientific and educational purposes. Today, computers have become a part of our life and we are so addicted to it that without it we will have to suffer a great loss in our life. The Limitations of computer in different areas has been discussed as under:

(i) **Programmed by human:** Though computer is programmed to work efficiently and accurately, but it is programmed by human beings to do so. Without a program, computer is nothing. A program is a set of instructions which perform particular task and if the instructions are not accurate, the working of computer will not be accurate.

(ii) **No Intelligence:** Although computer is faster, more diligent, accurate and versatile than human beings, it cannot replace them. Unlike human beings, computers do not have any intelligence. Its performance is depends on instructions given to it. It cannot carry any task at its own.

(iii) **No decision making power:** Computer cannot make any decisions nor can it render any help to solve a problem at its own like that if we plays chess with computer, the computer can take only those steps which is entered by the programmer. It cannot move at its own.

(iv) **Emotionless:** Computers are emotionless. They do not have emotions as human beings are having. They are simply machines which work as per the instruction given to them.

(v) **Curtail human Capabilities:** Although computers are great help to human beings. It is commonly felt that we people have become so dependant on calculator that we cannot make very simple calculation without calculator. Sometimes, find it difficult to instantly speak out even those telephone numbers which they use every now and then as they have got the habit of using them by retrieving the storage. Further, excessive use of computers is causing various type of health injuries such as cervical and back pain, pain in eye, headache.

1.5 Basic Computer Architecture

1.5.1 Basic computer functions: In Computer System, different parts of a computer are organized in such a way that, it helps to perform various operations to complete the given specific task. A computer is a sort of electric brain, which is capable to solve mathematical problems within a movement or produce desired information or a controlling order. More technically, a computer is a high-speed electronic data processing machine. Widely computers are use to perform arithmetic calculations. However, now-a-days computer is used for many other purposes. A computer as shown in Fig 1.5.1 performs basically five major operations or functions irrespective of their size and make. These are

(i) It accepts data or instructions by way of input,

(ii) It stores data,

(iii) It can process data as required by the user,

(iv) It gives results in the form of output, and

(v) It controls all operations inside a computer.

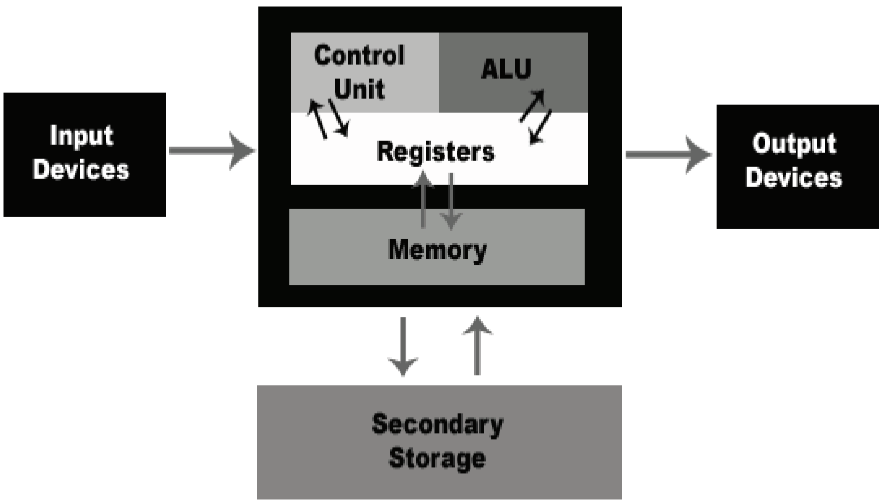


Figure 1.5.1: Basic computer operations

(i) **Input:** It is the process of entering data and programs into the computer system. As computer is an electronic machine like any other machine which takes as inputs raw data and performs some processing giving out processed data. Therefore, the input unit takes data from us to the computer in an organized manner for processing.

(ii) **Storage:** The process of saving data and instructions permanently is known as storage. Data has to be fed into the system before the actual processing starts. It is because of the processing speed of Central Processing Unit (CPU) which is so fast that the data has to be provided to CPU with the same speed. Therefore the data is first stored in the storage unit for faster access and processing. This storage unit or the primary storage of the computer system is designed to do the above functionality. It provides space for storing data and instructions.

The storage unit performs the following major functions:

- All data and instructions are stored here before and after processing.
- Intermediate results of processing are also stored here.

(iii) **Processing:** The task of performing operations like arithmetic and logical operations is called processing. The Central Processing Unit (CPU) takes data and instructions from the storage unit and makes all sorts of calculations based on the instructions given and the type of data provided. It is then sent back to the storage unit.

(iv) **Output:** This is the process of producing results from the data for getting useful information. Similarly the output produced by the computer after processing must also be kept somewhere inside the computer before being given to in human readable form. Again the output is also stored inside the computer for further processing.

(v) **Control:** The manner how instructions are executed and the above operations are performed. Controlling of all operations like input, processing and output are performed by control unit. It takes care of step by step processing of all operations inside the computer.

1.5.2 Components of a Computer System- CPU: The hardware are the parts of computer itself including the Central Processing Unit (CPU) and related microchips or micro-circuitry, keyboards, monitors, case and drives (floppy, hard, CD, DVD, optical, tape, etc.). Other extra parts are called peripheral components or devices include mouse, printers, modems, scanners, digital cameras and cards (sound, colour, video) etc. Together they are often referred to as a personal computers or PCs. A system consisting of interconnected computers that share a central storage system and various peripheral devices such as a printer, scanner, or router. Each computer connected to the system can operate independently, but has the ability to communicate with other external devices and computers.

The schematic diagram of a computer is given below:

Figure 1.5.2: Block diagram of computer system*

We will now briefly discuss each of the above components.

1.5.2.1 Central Processing Unit: The Central Processing Unit (CPU), also known as the processor, is the heart, soul and brain of the computer. It is the portion of a computer system that carries out the instructions of a computer program, and is the primary element carrying out the computer's functions. It is the unit that reads and executes program instructions. The data in the instruction tells the processor what to do. The instructions are very basic things like reading data from memory or sending data to the user display, but they are processed so rapidly that we experience the results as the smooth operation of a program. The form, design and implementation of CPUs have changed dramatically since the earliest examples, but their fundamental operation remains much the same. In a microcomputer, the entire CPU is contained on a tiny chip called a microprocessor. Though the term relates to a specific chip or the processor a CPU's performance is determined by the rest of the computer’s circuitry and chips. Currently the Pentium chip or processor, made by Intel, is the most common CPU though there are many other companies that produce processors for personal computers. One example is the CPU made by Motorola which is used in Apple computers. It is the most important component on the system’s motherboard. The processor computes and processes data and delivers the results based on the instructions that are fed to the PC. Every CPU has at least two basic parts, the control unit and the arithmetic logic unit.

(i) The Control Unit: The control unit is one of the most important components of the CPU that implements the microprocessor instruction set. It extracts instructions from memory and decodes and executes them, and sends the necessary signals to the ALU to perform the operation needed. Control Units are either *hardwired* (instruction register is hardwired to rest of the microprocessor) or *micro-programmed*. All the computer’s resources are managed from the control unit.

* www.coolnerds.com & www.circuitprotection.com

Figure 1.5.3: Processor of Computer (CPU)*

The CPU's instructions for carrying out commands are built into the control unit. The instructions, or instruction set, list all the operations that the CPU can perform. Each instruction in the instruction set is expressed in microcode- a series of basic directions that tell the CPU how to execute more complex operations. Before a program can be executed, every command in it must be broken down into instructions that correspond to the ones in the CPU's instruction set. When the program is executed, the CPU carries out the instructions, in order, by converting them into microcode. Although the process is complex, the computer can accomplish it at an incredible speed, translating millions of instructions every second.

Different CPUs have different instruction sets. Manufacturers, however, tend to group their CPUs into "families" that have similar instruction sets. Usually, when a new CPU is developed, the instruction set has all the same commands as its predecessor plus some new ones. This allows software written for a particular CPU to work on computers with newer processors of the same family – a design strategy known as **upward compatibility**. Upward compatibility saves consumers from having to buy a whole new system every time a part of their existing system is upgraded. The reverse is also true. When a new hardware device or piece of software can interact with all the same equipment and software its predecessor could, it is said to have **downward**, or **backward** compatibility.

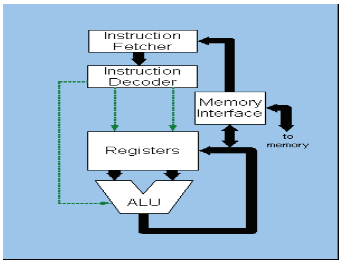


Figure 1.5.4: Block diagram of Control Unit*

* www.library.thinkquest.org & www.compu-crafts.com

* www.boddunan.com

(ii) The Arithmetic Logic Unit: The actual processing of the data and instruction are performed by Arithmetic Logical Unit. The major operations performed by the ALU are addition, subtraction, multiplication, division, logic and comparison. Data is transferred to ALU from storage unit when required. After processing the output, it is returned back to storage unit for further processing or getting stored. Because computers store all the data in the form of numbers, a lot of the processing that takes place involves comparing numbers or carrying out mathematical operations. In addition to establishing ordered sequences and changing those sequences, the computer operations can be divided into two types: **Arithmetic operations** and **Logical operations**. Arithmetic operations include addition, subtraction, multiplication, and division. Logical operations include comparisons, such as determining whether one number is equal to, greater than, or less than another number. Also, every logical operation has an opposite operation. For example, in addition to "equal to" there is "not equal to".

Many instructions carried out by the control unit involve simply moving data from one place to another i.e. from memory to storage, from memory to the printer, and so forth. However, when the control unit encounters an instruction that involves arithmetic or logical operation, it passes that instruction to the second component of the CPU, the arithmetic logical unit, or ALU. The ALU includes a group of registers having high-speed memory locations built directly into the CPU that are used to hold the data currently being processed. For example, the control unit might load two numbers from memory into the registers in the ALU. Then, it might tell the ALU to divide the two numbers (an arithmetic operation) or to see whether the numbers are equal (a logical operation) or not.

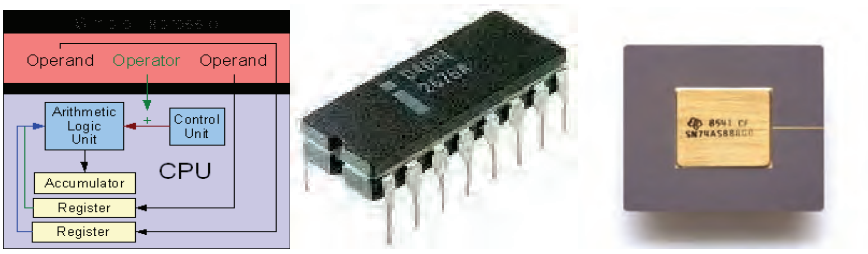


Figure 1.5.5: Diagram of ALU[*]

1.5.2.2 Various features of the Central Processing Unit: Over a period of time, the processor has evolved from slow 286s or 386s running at speeds as low as 20 MHz to present day Pentium III and IV running at a whooping 3.8 GHz .Now we take a closer look at the various features that the Central Processing Unit of a PC offers.

Clock Speed: Clock speed is a measure of how quickly a computer completes basic computations and operations. It is measured as a frequency in hertz, and most commonly refers to the speed of the computer's CPU, or **C**entral **P**rocessing **U**nit. Since the frequency of most clock speed measures is very high, the terms megahertz and gigahertz are used. A megahertz is one-million

[*] www.wikipedia.org

cycles per second, while a gigahertz is one-billion cycles per second. So a computer with a clock speed of 800 MHz is running 800,000,000 cycles per second, while a 2.4 GHz computer is running 2,400,000,000 cycles per second. Higher the clock's speed, the faster the processor, the better the system performance. Also, some microprocessors are super scalar, which means that they can execute more than one instruction per clock cycle.

A micro processor speed is rated by its frequency of oscillation, or the number of clock cycles per second. Earlier personal computers rated between 5 and 50 megahertz, or MHz (millions of clock cycles). Normally several clock cycles are required to retrieve, decode, and execute a single program instruction. The shorter the clock cycle, the faster the processor is.

The first commercial PC, the Altair 8800 (by MITS), used an Intel 8080 CPU with a clock rate of 2 MHz (2 million cycles/second). The original IBM PC in 1981 had a clock rate of 4.77 MHz (4,772,727 cycles/second). In 1995, Intel's P5 Pentium chip ran at 100 MHz (100 million cycles/second), and in 2002, an Intel Pentium 4 model was introduced as the first CPU with a clock rate of 3 GHz (three billion cycles/second).

Cache: Processors incorporate their own internal cache memory. The cache acts as temporary memory and boosts processing power significantly. The cache that comes with the processor is called Level One (L1) cache. This cache runs at the processor's clock speeds, and therefore is very fast. The L1 cache is divided into 2 sections—one for data, the other for instructions. Generally, more the L1 cache, faster the processor.

Additionally, PCs also include a much slower secondary, or Level Two (L2) cache. This cache resides on the motherboard and delivers slower performance when compared with the L1 cache.

Level three cache memory (called **L3 Cache** or **Level 3 Cache**) is located on the motherboard. Level 3 cache is now the name for the extra cache built into motherboards between the microprocessor and the main memory. L3 cache is specialized memory that works hand-in-hand with L1 and L2 cache to improve computer performance. The advantage of having on-board cache is that it's faster, more efficient and less expensive than placing separate cache on the motherboard.

All these levels of cache reduce the latency time of various memory types when processing or transferring information. While the processor works, the level one cache controller can interface with the level two controllers to transfer information without impeding the processor. As well, the level two cache interfaces with the RAM (level three cache) to allow transfers without impeding normal processor operation.

Architecture: The CPUs architecture determines the manner in which it processes data. New CPUs employ multi-staged pipelines for transmitting data. To ensure proper data flow through these lines, the CPU includes a kind of prediction and error correction mechanism.

Slot: A **CPU socket** or **CPU slot** is an electrical component that is attached to a printed circuit board (PCB) and is designed to house a microprocessor. It is a special type of integrated circuit socket designed for very high pin counts. A CPU socket provides many functions, including providing a physical structure to support the CPU, providing support for a heat sink, facilitating replacement (as well as reducing cost) and most importantly forming an electrical interface both with the CPU and the PCB. CPU sockets can most often be found in most desktop and server computers (laptops typically use surface mount CPUs), particularly those based on the Intel x86 architecture on the motherboard. CPU sockets provide an advantage over directly attaching CPUs to the PCB by making it easier to replace the processor in the event of a failure. The CPU is often the most expensive component in the system and the cost of a CPU socket is relatively low which makes this popular among computer system manufacturers. Different processors use different sockets or slots to fit onto the motherboard. Based on the type of processors, there are various types of slots for connecting to the motherboard or PCB. Socket H, G32 and G34 are most popular socket used in computer system now-a-days.

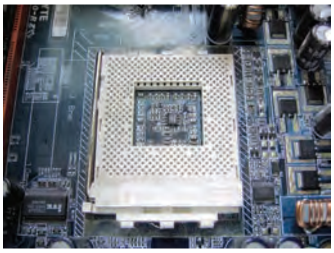


Figure 1.5.6: CPU Socket or Slot*

Density: A CPU is made up of millions of small transistors. A CPU performs all the calculation and manipulation operations by synchronizing between the transistors. Therefore, the shorter the distance between two transistors on a CPU, the faster the performance is. Older CPUs had a distance of one micron between the transistors. But, newer CPUs have a distance as small as 0.35 micron between two transistors, delivering faster performance.

MMX: MMX stands for Multimedia Extension, a set of instructions built into the CPU, specifically intended for improving the performance of multimedia or graphic applications. MMX is a single instruction, multiple data (SIMD) instruction set designed by Intel in 1996.

1.6 Motherboards

A **motherboard** is the central printed circuit board (PCB) in many modern computers and holds many of the crucial components of the system, while providing connectors for other peripherals. The motherboard is sometimes alternatively known as the **main board** or **system board.** It acts as a direct channel for the various components to interact and communicate with each other. There are various types of motherboards available (depending on the processors that are used). The motherboard contains the connectors for attaching additional boards. Typically, the motherboard contains the CPU, BIOS, memory, mass storage interfaces, serial and parallel ports, expansion slots, and all the controllers required to control

* www.wikipedia.org

standard peripheral devices, such as the display screen, keyboard, and disk drive. Collectively, all these chips that reside on the motherboard are known as the motherboard's chipset. During the late 1980s and 1990s, it became economical to move an increasing number of peripheral functions onto the motherboard. In the late 1980s, motherboards began to include single ICs (called Super I/O chips) capable of supporting a set of low-speed peripherals: keyboard, mouse, floppy disk drive, serial ports, and parallel ports. As of the late 1990s, many personal computer motherboards supported a full range of audio, video, storage, and networking functions without the need for any expansion cards at all; higher-end systems for 3D gaming and computer graphics typically retained only the graphics card as a separate component. A typical desktop computer has its microprocessor, main memory, and other essential components connected to the motherboard. Other components such as external storage, controllers for video display and sound, and peripheral devices may be attached to the motherboard as plug-in cards or via cables, although in modern computers it is increasingly common to integrate some of these peripherals into the motherboard itself.An important component of a motherboard is the microprocessor's supporting chipset, which provides the supporting interfaces between the CPU and the various buses and external components. This chipset determines, to an extent, the features and capabilities of the motherboard.

We now provide with an overview of the system motherboard, and about the various components that fit on it.

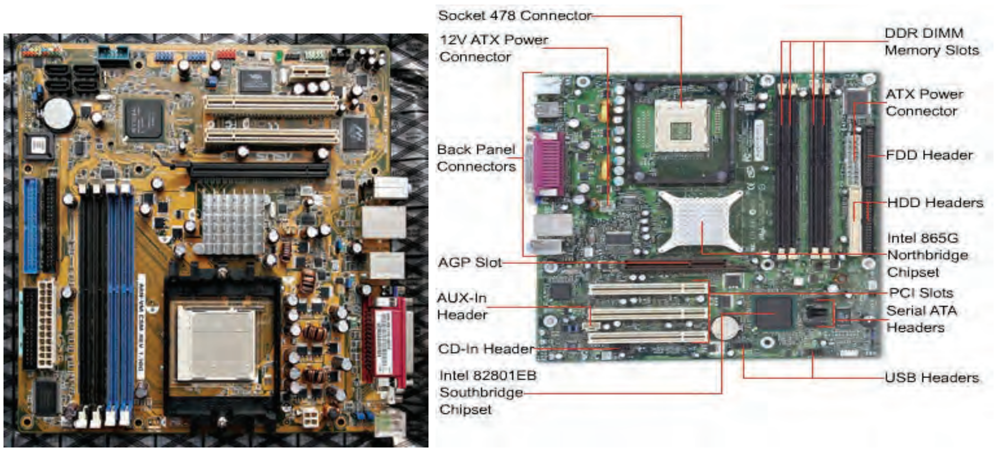


Figure 1.6.1: Mother board*

1.6.1 Processor slot: The processor slot houses the processor. It is rectangular connector into which the processor is mounted vertically. In addition to being the general term, it also refers more specifically to a square-shaped connector with many small connectors into which the processor is directly inserted. Fig. 1.6.2 shows the Process or Slot.

* www.techiwarehouse.com

Figure 1.6.2: Processor Slot or Socket**

BIOS: BIOS stands for **Basic Input Output System**—a small chip on the motherboard that loads the hardware settings required loading various devices like keyboards, monitors, or disk drives. It is a basic program used as an interface between the operating system and the motherboard. The BIOS is stored in ROM (read-only memory, which can not be rewritten), so it uses data contained within the CMOS to find out what the system's hardware configuration is. The BIOS can be configured using an interface (named the BIOS setup), which can be accessed when the computer boots just by pressing a key. Most new PCs come with a Flash BIOS—these BIOS can be software upgraded to support new devices. Figure 1.6.3 shows a BIOS chip.

Figure 1.6.3: BIOS Chip*

CMOS: CMOS stands for **Complementary Metal-Oxide Semiconductor**; sometimes called the *BIOS CMOS* is used to store the date, time and system setup parameters. These parameters are loaded every time the computer is started. A small Lithium Ion battery located on the motherboard powers the CMOS as well as the BIOS. Figure 1.6.4 shows the CMOS chip.

Figure 1.6.4: CMOS Chip**

1.6.2 Expansion Slots and Boards: PCs are designed so that users can adapt, or configure the machines to their own particular needs. PC motherboards have two or more expansion slots, which

** www.elec-intro.com

* www.digitalcontentpoducer.com

** www.neis.in

are extensions of the computer's bus that provide a way to add new components to the computer. The slots accept circuit board, also called cards, adapters, or sometimes-just boards. An expansion slot expands the computer's functionality by allowing for plugging in expansion cards built performing specific functions. There have been several expansion slot standards over the past decades including PCI, PCI Express, AGP, PC Card/Card Bus/PCMCIA, ExpressCard and CompactFlash. Expansion slots are widely used throughout the world in desktop and portable computer systems. Modern notebook computers are too small to accept the same type of cards that fit into desktop models. Instead, new components for notebooks come in the form of PC cards, small devices – about the size of credit cards – that fit into a slot on the back or side of the notebook. Figure 1.6.5 shows a PC expansion board being installed. The board is attached to the motherboard – the main system board to which the CPU, memory, and other components are attached.

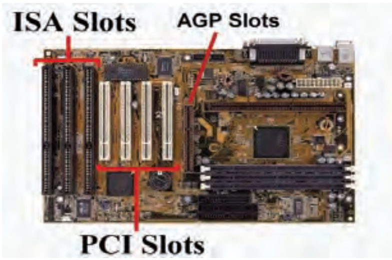


Figure 1.6.5: Expansion Slots*

The expansion slots on the motherboard are used for three purposes:

1. To give built–in devices such as hard disks and diskette drives access to the computer's bus via controller cards.
2. To provide I/O (input/output) ports on the back of the computer for external devices such as monitors, external modems, printers, and the mouse (for computers that do not have a built-in mouse port)
3. To give special-purpose devices access to the computer. For example, a computer can be enhanced with an accelerator card, a self contained device that enhances processing speed through access to the computer'' CPU and memory by way of the bus.

The first and second of these are input/output (I/O) functions. Adapters that serve these purposes provide a port to which devices can be attached and serve as a translator between the bus and the device itself. Some adapters also do a significant amount of data processing. For example, a video controller is a card that provides a port on the back of the PC into which one can plug the monitor. It also contains and manages the video memory and does the processing required to display images on the monitor. Other I/O devices that commonly require the installation of a card into an expansion slot include sound cards, internal modems or fax/modems, network interface cards, and scanners. The third type, the accelerator cards, is often installed to speed up the CPU or the

* www.wikipedia.org

display of video. Some of the slots and connectors are briefly discussed below:

ISA: Industry Standard Architecture was a computer bus standard for IBM compatible computers. This is most ancient type of expansion slot ever used in the computer system. The ISA enables controllers connect directly to the bus to communicate directly with the other peripherals without going through the processor. However, the ISA bus only allows hardware to address the first 16 megabytes of RAM.

Figure 1.6.6: ISA slot*

SIMM/DIMM slots: SIMM stands for Single Inline Memory Modules, while DIMM stands for Dual Inline Memory Module. SIMM/DIMM slots are used to house RAM modules.

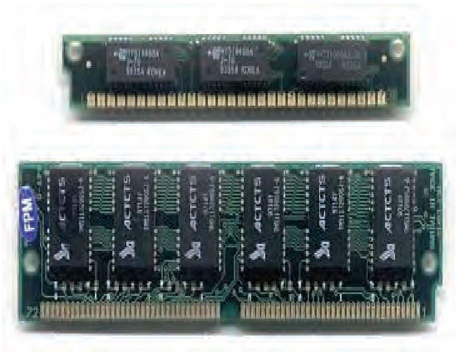


Figure 1.6.7: SIMM Slot*

PCI / PCI Express slots: PCI, Short for peripheral component interconnect, is one of the most widely used expansion slots on motherboards. PCI is the predecessor to PCI Express, a smaller and faster version with the same basic functions. These slots are most commonly used to connect sound cards and network cards but have other uses, such as adding extra USB ports. As computer game graphics get more advanced, PCI is less capable of handling graphics cards as well, yet PCI Express can handle the more powerful video cards of today.

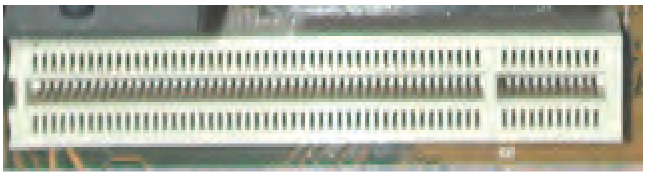


Figure 1.6.8: PCI Slots*

* www.wikipedia.org

AGP slot: AGP is a dedicated slot meant to provide faster access to AGP-based graphic accelerator cards, thus enhancing the visual experience for the user. AGP, short for advanced graphics port, is a slot used specifically for graphics cards. These slots allow AGP card to directly access computer system memory, which speeds up graphics processing. When it comes to performance, AGP slots are less advanced than PCI Express, which does the same things AGP does but are faster.

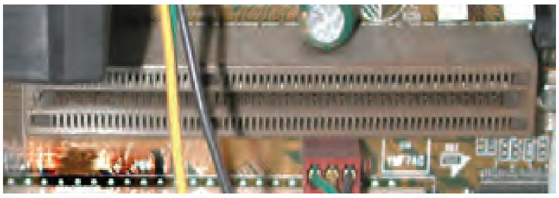


Figure 1.6.9: AGP Slots*

SCSI: It is a device interface that is used to solve the problem of a finite and possibly insufficient number of expansion slots. It is called S*mall Computer System Interface (SCSI pronounced "scuzzy").* Instead of plugging interface cards into the computer's bus via the expansion slots, SCSI extends the bus outside the computer by way of a cable. In other words, SCSI is like an extension cord for computer bus. IBM developed SCSI in 1970s. The current standard is SCSI - 3, which allows upto seven devices to be chained on a single SCSI port. Now-a-days many devices support the SCSI interface. Fast, high-speed hard disk drives often have SCSI interfaces, so do scanners, tape drives and optical storage devices.

Figure 1.6.10: SCSI Connector*

1.6.3 Cards: Cards are components added to computers to increase their capability. When adding a peripheral device one should ensure that the computer has a slot of the type needed by the device. We will discuss the commonly used cards in computer system.

Sound cards: A **sound card** (also known as an **audio card**) is a computer expansion card that facilitates the input and output of audio signals to and from a computer under control of computer programs. Typical uses of sound cards include providing the audio component for multimedia applications such as music composition, editing video or audio presentation, education, and entertainment (games). Many computers have sound capabilities built in, while others require additional expansion cards to provide for audio capability. It allows computers to produce sound like music and voice. The older sound cards were 8 bit. Now-a-days 32 bit

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* www.wikipedia.org

or more sound cards are being used.

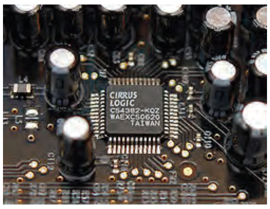

Figure 1.6.11: Sound card*

Color cards: It allows computers to produce colors and graphics on the screen. The first color cards were 2 bit which produced 4 colors [CGA]. It was amazing what could be done with those 4 colors. Next came 4 bit and 6 bit allowing for 16 and 64 [EGA] colors. Then came 8 bit allowing for 256 [VGA] colors. Then MCGA was introduced which is similar to VGA , had a 256-color mode, but that was the extent of the chipset's abilities which produces almost 17 million colors and now XGA allowing monitors to display almost a billion separate colors.

Video cards: It allows computers to display video and animation. It is an expansion card whose function is to generate output images to a display. Many video cards offer added functions, such as accelerated rendering of 3D scenes and 2D graphics, video capture, TV-tuner adapter, MPEG-2/MPEG-4 decoding, FireWire, light pen, TV output, or the ability to connect multiple monitors (multi-monitor). Other modern high performance video cards are used for more graphically demanding purposes, such as PC games. A video card with a digital video camera allows computers users to produce live video. A high speed network connection is needed for effective video transmission.

Figure 1.6.12: Video card*

Network card is a computer hardware component designed to allow computers to communicate over a computer network. It allows users to connect to each other either by using cables or wirelessly. Network cards have connections for cable, thin wire or wireless networks.

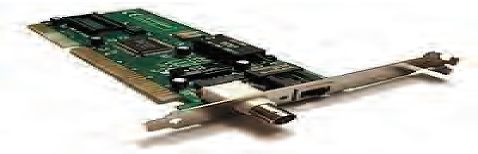

Figure: 1.6.13: Network Interface Card

*www.wikipedia.org

1.6.4 Ports and connectors: Ports and connectors serves as an interface between the computers or peripheral devices. The user connects external devices like printers, keyboards or scanners using various interfaces with the PC. The physical interfaces for the ports and connectors are located on the outside—typically at the back of the PC, but they are directly or indirectly (using a connector card) connected to the motherboard. There are various types of ports or connectors, each providing different data transfer speeds to connect various external peripherals. Electronically, hardware ports can always be divided into two groups based on the signal transfer: Serial and Parallel port.

Parallel ports: A parallel port is a parallel communication physical interface. It is also known as a **printer port** or **Centronics port**. The IEEE 1284 standard defines the bi-directional version of the port, which allows the transmission and reception of data bits at the same time. Parallel ports are used to connect external input/output devices like scanners or printers. Parallel ports facilitate the parallel transmission of data, usually one byte (8 bits) at a time.

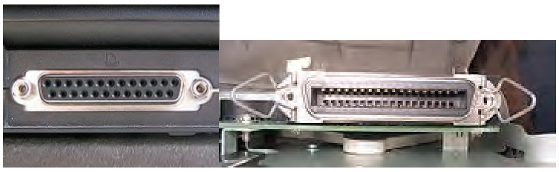

Figure 1.6.14: Parallel Port IEEE 1284*

Com/Serial ports: A serial port is a serial communication physical interface through which information transfers in or out one bit at a time. They are used for connecting communication devices like modems or other serial devices like mice. In modern personal computers the serial port has largely been replaced by USB and Firewire for connections to peripheral devices. Serial ports are commonly still used in applications such as industrial automation systems, scientific analysis, shop till systems and some industrial and consumer products. Server computers may use a serial port as a control console for diagnostics. Network equipment (such as routers and switches) often use serial console for configuration. Serial ports are still used in these areas as they are simple, cheap and their console functions are highly standardized and widespread. A serial port requires very little supporting software from the host system.

Figure 1.6.15: Serial Port RS-232*

IDE drive connector: IDE devices like CD-ROM drives or hard disk drives are connected to the motherboard through the IDE connector.

*www.wikipedia.org

Floppy drive connector: The floppy drive connectors are used for connecting the floppy drive to the motherboard, to facilitate data exchange.

USB connectors: USB stands for Universal Serial Bus. These ports provide the user with higher data transfer speeds for different USB devices like keyboards, mice, scanners or digital cameras.

PS/2 Connectors: PS/2 stands for Personal System/2. PS/2 connectors are used to connect PS/2 based input devices like PS/2 keyboards or mice.

In addition to the common components that are found on the motherboard, newer motherboards also come with integrated graphics accelerator cards or sound cards as there is no need to install a separate card to get the work done.

1.6.5 The bus: If one takes a close look at the system motherboard, one will notice a maze of golden electric circuits etched on both sides of the motherboard. This very maze of circuits etched on the motherboard forms the bus of the PC. A bus acts as the system's expressway which transmits data between the various components on the motherboard. Theoretically, a bus is a collection of wires through which data is transmitted between the various components of a PC. A bus connects the various components of the PC with the CPU and the main memory (RAM). Logically, a bus consists of three parts—an address bus, a data bus and a control bus.

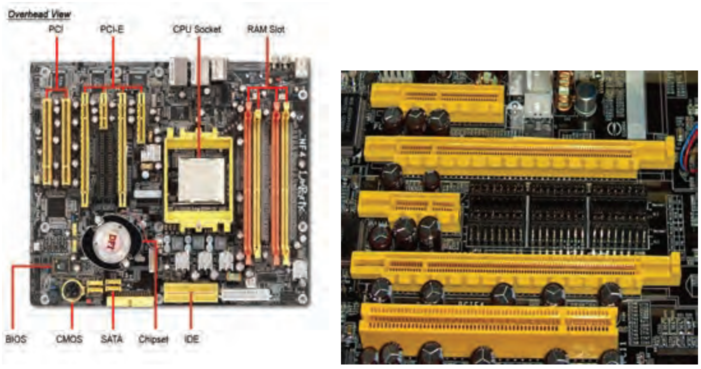

Figure 1.6.16: Computer buses*

Data Bus: The Data Bus is an electrical path that connects the CPU, memory, and the other hardware devices on the motherboard. Actually, the bus is a group of parallel wires. The number of wires in the bus affects the speed at which data can travel between hardware components, just as the number of lanes on a highway affects how long it takes people to get to their destinations. Because each wire can transfer one bit at a time, an eight-wire bus can move eight bits at a time, which is a full byte. A 16-bit bus can transfer two bytes, and a 32-bit bus can transfer four bytes at a time.

PC buses are designed to match the capabilities of the devices attached to them. When CPUs

* www.wikipedia.org

could send and receive only one byte of data at a time, there was no point in connecting them to a bus that could move more data. As microprocessor technology improved, however, chips were built that could send and receive more data at once, and improved bus designs created wider paths through which the data could flow.

When IBM introduced the PC-AT in 1984, the most dramatic improvement was an enhanced data bus that was matched with the capabilities of a new microprocessor, the Intel 80286. The data bus of the AT was 16 bits wide and became the de facto standard in the industry. It is still used for PC devices that do not require more than a 16 -bit bus. The AT bus is commonly known as the Industry Standard Architecture, or ISA bus.

Two years later, however, when the first 80386 chips (commonly abbreviated as the 386) began shipping, a new standard was needed for the 386's 32-bit bus. The first contender was Micro Channel Architecture, or the MCA bus, from IBM. Then came the Extended Industry Standard Architecture (EISA) bus from a consortium of hardware developers who opposed IBM's new standard because it was not backward compatible. The winner of the bus wars was neither MCA nor EISA. It was the Peripheral Component Interconnect, or PCI, bus. Intel designed the PCI and PCI Express bus specifically to make it easier to integrate new data types, such as audio, video, and graphics.

Address Bus: The second bus that is found in every microcomputer is the address bus. The address bus is a set of wires similar to the data bus that connects the CPU and RAM and carries the memory addresses. (Remember, each byte in RAM is associated with a number, which is the memory address)

The reason the address bus is important is that the number of wires in it determines the maximum number of memory addresses. For example, recall that one byte of data is enough to represent 256 different values. If the address bus could carry only eight bits at a time, the CPU could address only 256 bytes of RAM. Actually, most of the early PCs had 20-bit address buses, so the CPU could address 1024 x 1024 bytes, or 1 MB, of data. Today, most CPUs have 32-bit address buses that can address 4 GB (over 4 million bytes) of RAM. Some of the latest models can address even more.

One of the biggest hurdles in the evolution of PCs was that DOS, the operating system used in the vast majority of PCs for more than a decade, was designed for machines that could address only 1 MB of RAM. When PCs began to contain more RAM, special software had to be devised to address it. Programmers came up with two devices called expanded memory and extended memory. Windows 95 largely did away with these, although extended memory still exists in the operating system for purposes of backward compatibility.

Control Bus: (or *Command Bus*) transports orders and synchronize signals coming from the control unit and traveling to all other hardware components. It is a bidirectional bus, as it also transmits response signals from the hardware. A **control bus** is a computer bus, used by CPUs for communicating with other devices within the computer. The control bus is used by the CPU to direct and monitor the actions of the other functional areas of the computer. It is used to transmit a variety of individual signals (read, write, interrupt, acknowledge, and so forth) necessary to control and coordinate the operations of the computer. The individual signals transmitted over the control bus and their functions are covered in the appropriate functional area description.

1.7 Storage Devices

The CPU contains the basic instructions needed to operate the computer, but it does not have the capability to store programs or large sets of data permanently. Just like the human brain, which helps to determine what to do and when, computers need blocks of space that it can address from time to time to help in processing arithmetical and logical operations and also hold programs and data being manipulated. This area is called memory or storage.

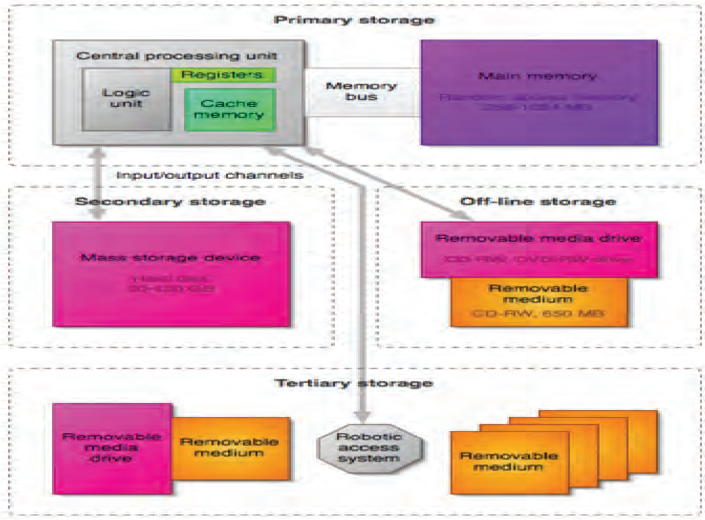

Figure 1.7.1: Types of Storage*

1.7.1 Types of storage: Various forms of storage, based on various natural phenomenons, have been invented. So far, no practical universal storage medium exists, and all forms of storage have some drawbacks. Therefore a computer system usually contains several kinds of storage, each with an individual purpose, as shown in Figure 1.7.1.

(i) Primary storage: Primary storage is directly connected to the central processing unit of the computer. It must be present for the CPU to function correctly, just as in a biological analogy the lungs must be present (for oxygen storage) for the heart to function (to pump and oxygenate the blood). As shown in the figure, primary storage typically consists of three kinds of storage:

Processor registers are internal to the central processing unit. Registers contain information that the arithmetic and logic unit needs to carry out the current instruction. They are technically the fastest of all forms of computer storage, being switching transistors integrated on the CPU's silicon chip, and functioning as electronic "flip-flops".

* www.wikipedia.org

Main memory contains the programs that are currently being run and the data on which the programs are operating. The arithmetic and logic unit can very quickly transfer information between a processor register and locations in main storage, also known as a "memory addresses". In modern computers, electronic solid-state random access memory is used for main storage, and is directly connected to the CPU via a "memory bus" (shown in the Figur 1.7.2) and a "data bus". The memory bus is also called an address bus or front side bus and both buses are high-speed digital "superhighways". Access methods and speed are two of the fundamental technical differences between memory and mass storage devices. (Note that all memory sizes and storage capacities shown in the diagram will inevitably be exceeded with advances in technology over time)

Figure 1.7.2: Main Memory*

Cache memory is a special type of internal memory used by central processing units to increase their performance or "throughput". Some of the information in the main memory is duplicated in the cache memory, which is slightly slower but of much greater capacity than the processor registers, and faster but much smaller than main memory. Multi-level cache memory is also commonly used in CPU. The "primary cache" is smallest, fastest and closest to the processing device; "secondary cache" is larger and slower, but still faster and much smaller than main memory.

(ii) Secondary, tertiary, off-line and robotic storage*:* Secondary storage requires the computer to use its input/output channels to access the information, and is used for long-term storage of persistent information. Now-a-days most computer operating systems also use secondary storage devices as virtual memory - to artificially increase the apparent amount of main memory in the computer.

Secondary storage is also known as "mass storage", which is typically of much greater capacity than primary storage (main memory), but it is also very much slower. In modern computers, hard disks are usually used for mass storage. The time taken to access a given byte of information stored on a hard disk is typically a few thousandths of a second, or milliseconds. By contrast, the time taken to access a given byte of information stored

* www.wikipedia.org

in random access memory is measured in thousand-millionths of a second, or nanoseconds. This illustrates the very significant speed difference which distinguishes solid-state memory from rotating magnetic storage devices: hard disks are typically about a million times slower than memory. Rotating optical storage devices (such as CD and DVD drives) are typically even slower than hard disks, although their access speeds are likely to improve with advances in technology.

Some other examples of secondary storage technologies are: flash memory (e.g. USB flash drives or keys), floppy disks, magnetic tape, paper tape, punched cards, standalone RAM disks, and Iomega Zip drives.

Figure 1.7.3: Secondary Storage Device (Hard Disk)*

Tertiary storage is a system where a robotic arm will "mount" (connect) or "dismount" off-line mass storage media according to the computer operating system's demands. It is primarily used for archival of rarely accessed information and large data storage since it is much slower than secondary storage (e.g. 5–60 seconds vs. 1-10 milliseconds). Typical examples include tape libraries and optical jukeboxes.Tertiary storage is used in the realms of enterprise storage and scientific computing on large computer systems and business computer networks.

Figure 1.7.4: Tertiary Storage*

Off-line storage is a system where the storage medium can be easily removed from the storage device. Off-line storage is used for data transfer and archival purposes. In modern computers, floppy disks, optical discs and flash memory devices including "USB drives" are commonly used for off-line mass storage purposes. "Hot-pluggable" USB hard

* www.wikipedia.org

disks are also available. Off-line storage devices used in the past include magnetic tapes in many different sizes and formats, and removable Winchester disk /drums.

Robotic storage is a new type of storage method used for backups, and for high-capacity archives in imaging, medical, and video industries. Robotic-access storage devices may have a number of slots, each holding individual media, and usually one or more picking robots that traverse the slots and load media to built-in drives. The arrangement of the slots and picking devices affects performance.

(iii) Network storage*:* A network storage system helps organize and save critical information created on a computer in an efficient and accessible manner. The most basic form of network storage is saving a computer's content to a disk or CD-ROM and storing it somewhere safe. Network storage arguably allows to centralize the information management in an organization, and to reduce the duplication of information. Network storage includes:

Direct Attached Storage (DAS) refers to a network storage system on which data is saved to the server computer's internal hard drive. The network workstations access the server to connect to the storage. These files are saved directly onto the computer's disk space and can be readily pulled up at any time. This is the most commonly used means of network storage. The disadvantages of DAS include its inability to share data or unused resources with other servers.

Network Attached Storage (NAS) is a type of network storage system that saves data onto another computer system attached to a group of computers through a network, or onto a special server attached to the network. A NAS device is typically a stand alone, high performance, single purpose system or component. It serves specific storage needs with its own operating system and integrated hardware and software. NAS devices are well suited to serve heterogeneous networks. The advantages of NAS over other methods of storage are performance and connectivity.

Storage Area Network (SAN) is an architecture to attach remote computer data storage devices (such as disk arrays, tape libraries, and optical jukeboxes) to servers so the devices appear as locally attached to the operating system. A SAN typically has its own network of storage devices that are generally not accessible through the regular network by regular devices. SAN reduces data traffic and improves data access by using Fiber connections.

1.7.2 Characteristics of storage: The division to primary, secondary, tertiary, off-line and robotic storage is based on memory hierarchy, or *distance from the central processing unit*. There are also other ways to characterize various types of storage.

(i) **Volatility of information**

Volatile memory requires constant power to maintain the stored information. Volatile memory is typically used only for primary storage.

Non-volatile memory will retain the stored information even if it is not constantly supplied with electric power. It is suitable for long-term storage of information, and therefore used for secondary, tertiary, and off-line storage.

(ii) **Differentiation of Information**

Dynamic memory is volatile memory which also requires that stored information is periodically refreshed, or read and written without modification.

Static memory is a form of volatile memory similar to DRAM with the exception that it never needs to be refreshed as long as power is applied. (It loses its content if power is removed).

(iii) **Ability to access non-contiguous information**

Random access means that any location in storage can be accessed at any moment in the same, usually small, amount of time. This makes random access memory well suited for primary storage.

Sequential access means that the accessing a piece of information will take a varying amount of time, depending on which piece of information was accessed last. The device may need to *seek* (e.g. to position the read/write head correctly), or *cycle* (e.g. to wait for the correct location in a constantly revolving medium to appear below the read/write head)

(iv) **Ability to change information**

Read/write storage, or **mutable storage**, allows information to be overwritten at any time. A computer without some amount of read/write storage for primary storage purposes would be useless for many tasks. Modern computers typically use read/write storage also for secondary storage.

Read only storage retains the information stored at the time of manufacture, and **write once storage** (WORM) allows the information to be written only once at some point after manufacture. These are called **immutable storage**. Immutable storage is used for tertiary and off-line storage. Examples include CD-R.

Slow write, fast read storage is read/write storage which allows information to be overwritten multiple times, but with the write operation being much slower than the read operation. Examples include CD-RW.

(v) **Addressability of information**

In **location-addressable storage**, each individually accessible unit of information in storage is selected with its numerical memory address. In modern computers, location-addressable storage usually limits to primary storage, accessed internally by computer programs, since location-addressability is very efficient, but burdensome for humans.

In **file system storage**, information is divided into *files* of variable length, and a particular file is selected with human-readable directory and file names. The underlying device is still location-addressable, but the operating system of a computer provides the file system abstraction to make the operation more understandable. In modern computers, secondary, tertiary and off-line storage use file systems.

In **content-addressable storage**, each individually accessible unit of information is selected with a hash value, or a short identifier with no pertaining to the memory address the information is stored on. Content-addressable storage can be implemented using software (computer program) or hardware (computer device), with hardware being faster but more expensive option.

(vi) **Capacity and performance**

Storage capacity is the total amount of stored information that a storage device or medium can hold. It is expressed as a quantity of bits or bytes (e.g. 10.4 megabytes)

Storage density refers to the compactness of stored information. It is the storage capacity of a medium divided with a unit of length, area or volume (e.g. 1.2 megabytes per square centimeter)

Latency is the time it takes to access a particular location in storage. The relevant is typically nanosecond for primary storage, millisecond for secondary storage, and second for tertiary storage. It may make sense to separate *read latency* and *write latency*, and in case of sequential access storage, *minimum*, *maximum* and *average latency*.

Throughput is the rate at which information can read from or written to the storage. In computer storage, throughput is usually expressed in terms of *megabytes per second* or *MB/s*, though bit rate may also be used. As with latency, *read rate* and *write rate* may need to be differentiated.

1.7.3 Primary Storage

(i) **Semi-conductor memories or integrated circuits:** An integrated circuit (IC), sometimes called a chip or microchip, is a semiconductor wafer on which thousands or millions of tiny resistors, capacitors, and transistors are fabricated. The very thin silicon chip contains a number of small storage cells that can hold data. Instead of being made up of a series of discrete components, these units are constructed as integrated circuits, meaning that a number of transistors are integrated or combined together on a thin silicon wafer to form a complete set of circuits. The faster and more expensive bipolar semi conductor chips are often used in the arithmetic-logic unit and high-speed buffer storage sections of the CPU, while the slower and less expensive chips that employ metal-oxide semi-conductor (MOS) technology are used in the main memory section. An IC can function as an amplifier, oscillator, timer, counter, computer memory, or microprocessor.

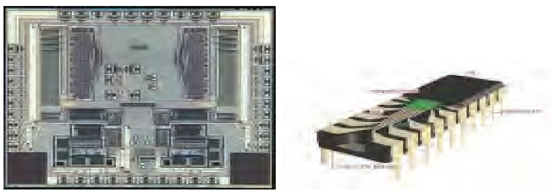

Figure 1.7.5: Integrated Chips*

*www.techiwarehouse.com

Integrated circuits are used for a variety of devices, including microprocessors, audio and video equipment, and automobiles. Integrated circuits are often classified by the number of transistors and other electronic components. The ICs can be scaled according to the capacity of the chip used in storing the data in computer system.

- **SSI (small-scale integration):** Up to 100 electronic components per chip.
- **MSI (medium-scale integration):** From 100 to 3,000 electronic components per chip.
- **LSI (large-scale integration):** From 3,000 to 100,000 electronic components per chip.
- **VLSI (very large-scale integration):** From 100,000 to 1,000,000 electronic components per chip.
- **ULSI (ultra large-scale integration):** More than 1 million electronic components per chip.

(ii) **Random-Access-Memory (RAM):** Random access memory or *RAM* most commonly refers to computer chips that temporarily store dynamic data to enhance computer performance. The purpose of RAM is to hold programs and data while they are in use. It is called random access memory since access time in RAM is independent of the address of the word, that is, each storage location (address) inside the memory is as easy to reach as any other location and takes the same amount of time. One can reach into the memory at random and insert or remove numbers in any location at any time. A random access memory is extremely fast but can also be quite expensive.

Random access memory is volatile memory, meaning it loses its contents once power is cut. This is different from non-volatile memory such as hard disks and flash memory, which do not require a power source to retain data. When a computer shuts down properly, all data located in random access memory is committed to permanent storage on the hard drive or flash drive. At the next boot-up, RAM begins to fill with programs automatically loaded at startup, and with files opened by the user.

RAMs can be further divided according to the way in which the data is stored, into dynamic RAMs and static RAMs. The computer designer's decision which to use where depends on what their function is to be, and on their speed and cost.

Figure 1.7.6: Random Access memory*

* www.wikipedia.org

Dynamic RAM: Dynamic RAM (DRAM) is the most common type of main memory. It is dynamic because each memory cell quickly loses its charge so it must be refreshed hundreds of times each second to prevent data from being lost. Here are some of the types of DRAM generally used in most of the desktop systems (listed from oldest to newest):

– Fast Page Mode (FPM) DRAM Introduced in 1987, this is an early form of DRAM that was once very common because it was slightly faster than DRAM. This computer memory type was frequently mounted on a SIMM in 486 and early Pentium computers.

– Extended Data Out (EDO) DRAM is slightly faster than FPM. EDO offers a slight performance boost over FPM DRAM by cutting a few steps when addressing memory. Introduced in 1995, EDO requires a specific chip set and is limited to bus speeds of 66 MHz. Once again, these chips are mounted on SIMM modules.

  Burst EDO (BEDO) DRAM is a slightly faster variant of the EDO RAM chip in which read and write operations send bursts of data in batches of four. It assumes that the next data address to be requested by the CPU follows the current one so it sends that also.

– Synchronous DRAM (SDRAM) can synchronize itself with the clock that controls the CPU. This makes data transfers more reliable and faster because timing delays are eliminated. It is anticipated that this form of memory will replace EDO as the most common form of memory.

– Rambus DRAM (RDRAM) is the latest design and Intel has announced that all of their future systems will require it. RDRAM is very fast, but the system must be slightly redesigned to use it. RDRAM sends data down a high-band width “channel” 10 times faster than standard DRAM.

_ Double Data Rate SDRAM (DDR SDRAM) is a newer form of SDRAM that can theoretically improve memory clock speed to 200 megahertz (MHz) or more. DDR shuffles data over the bus over both the rise and fall of the clock cycle, effectively doubling the speed over that of standard SDRAM. Due to its advantages over RDRAM, DDR-SDRAM support was implemented by almost all major chipset manufacturers, and quickly became the new memory standard for the majority of PC’s.

Static RAM: Static RAM (SRAM) is like DRAM but it’s a lot faster, larger, and more expensive. It’s static because it doesn’t need to be continually refreshed. Because of its speed, SRAM is used mainly in a special area of memory called a cache.

The Static RAM retains the stored data as long as the power remains in, whereas with dynamic RAM, the stored information disappears after a few milliseconds have elapsed. The data must, therefore be repeatedly refreshed before it disappears. SRAM is also easier to control (interface to) and generally more truly *random access* than modern types of DRAM. Due to a more complex internal structure, SRAM is less dense than DRAM and is therefore not used for high-capacity, low-cost applications such as the main memory in personal computers. The power consumption of a dynamic RAM is less than that of a static RAM, which has the advantage of making a higher degree of integration possible. The computer does the refreshing process itself, taking time out from other chores every few milliseconds. It will read all the RAM memory positions while they are still readable and put appropriate new charge on each capacitor. Some dynamic RAM memory circuits include built-in "refresh circuits" to relieve the computer. SRAM can be of 3 types as discussed below.

Asynchronous RAM: It is an older type of SRAM used in many PC's for L2 cache. It is asynchronous, meaning that it works independently of the system clock. This means that the CPU itself waiting for data from the L2 cache.

Synchronous RAM: This type of SRAM is synchronous, meaning it is synchronized with the system clock. While this speeds it up, it makes it rather expensive at the same time.

Pipeline Burst SRAM: This is Commonly used SRAM that requests pipelined data processing method, meaning larger packets of data is resent to the memory at once, and acted on very quickly. This breed of SRAM can operate at bus speeds higher than 66 MHz, so is often used.

(iii) **Read-Only-Memory (ROM):** Another type of computer memory is the read-only-memory (ROM), used for micro-programs not available to normal programmers. The term read-only means that the storage cannot be altered by regular program instructions. The information is stored permanently in such memory during manufacture. The information from the memory may be read out but fresh information cannot be written into it.

The micro programs in read-only-memory may be used for a variety of purposes, but a common use is to hold a set of instructions that are needed frequently, for executing small, extremely basic operations, which are not otherwise available in the computer circuitry. One set of instructions found in ROM is called the ROM-BIOS which stand for Read-Only Memory Basic Input Output System. These programs perform the basic control and supervisory operations for the computer. It also handles the basic needs of the hardware involved, which include all I/O devices. The various types of ROM are:

PROM: Programmable Read Only Memory is a non-volatile memory which allows the user to program the chip with a PROM write. The chip can be programmed once, there after, it can not be altered.

EPROM: EPROM stands for Erasable Programmable Read Only Memory. EPROM chips can be electrically programmed. Unlike ROM and PROM chips, EPROM chips can be erased and reprogrammed. Erasure is performed by exposing the chip to Ultra-violet light.

EEPROM: It stands for Electrically Erasable Programmable Read Only Memory which is a kind of EPROM. However, the data can be erased by applying electrical charges.

(iv) **Bubble Memory:** Bubble memory is composed of small magnetic domains (bubbles) formed on a thin single-crystal film of synthetic garnet. These magnetic bubbles, which are actually magnetically, charged cylinders, only a few thousandths of a centimeter in size, can be moved across the garnet film by electric charges. The presence or absence of a bubble can be used to indicate whether a bit is "on" or "off".

Since data stored in bubble memory is retained when power to the memory is turned off, it can be used for auxiliary storage. Bubble memory has high potential because of its low production costs and its direct access capabilities, thus it may become widely employed as a main memory technology. Since it is small, lightweight, and does not use very much power, bubble memory is finding a great deal of use as an auxiliary storage in portable computers. It is expected that as more portable computers are developed, bubble memory will become more widely used.

(v) **Flash Memory:** A non-volatile computer storage technology through which data can be erased electrically and reprogrammed. Flash memory primarily used in memory cards, USB flash drives, and solid-state drives for general storage and transfer of data between computers and other digital products. It is specific types of EEPROM .Flash memory costs are less than other storage devices. They provide limited storage capacity. Examples include PDAs (Personal Digital Assistants), laptop computers, digital audio players, digital cameras and mobile phones. It has also gained popularity in console video game hardware, where it is often used instead of EEPROMs or battery-powered static RAM (SRAM) for game save data.

Since flash memory is non-volatile, no power is needed to maintain the information stored in the chip. In addition, flash memory offers fast read access times and better kinetic shock resistance than hard disks.

(vi) **Video RAM:** It is used to accelerate the display of graphics on the screen. It does this by using two “ports,” one connected to the CPU and the other to the screen. Data flows in one port and out the other very smoothly. A variation of this is Window RAM (WRAM) that supports memory.

1.8 Secondary Storage Devices

As discussed in section 1.7.1, there are different types of computer storage. Primary storage is built into the CPU whereas secondary storage or auxiliary storage is usually housed in a separate unit or units. Primary storage is very fast-its contents can be accessed in millionth or billionths of a second. But primary storage has a limited capacity. Although the cost per byte has continued to decrease, there is not enough capacity to store all of firms’ files. Secondary storage supplements the capacity of primary storage. Secondary storage has an almost infinite capacity measured in millions and billions of bytes. Some secondary storage media (such as magnetic storage) offer direct access to data whereas tape devices offer sequential access. The access speed of secondary storage is slower than that of primary storage. It may be noted that these auxiliary storage media such as floppy disk, magnetic disk, Compact Disk etc. can be used for both input and output purpose. The various types of auxiliary storage media used to store large amount of data are discussed in next section.

1.8.1 Tape Devices: Magnetic tape is probably the oldest secondary storage technology still in wide use. Utilized as a storage device since the early days of radio, magnetic tape is an external storage device that can be used for making copies of audio, video, and data. In addition to data storage, magnetic tape has been used over the years to make master copies of audio recordings that would be replicated for vinyl, cassette, and more recently compact disk recording formats. The tape is employed with the use of a machine referred to as a tape drive. A tape drives run the magnetic tape during the recording process and also stores the tape onto a reel for easy retrieval. A device that stores computer data on magnetic tape is a tape drive (tape unit, streamer). It is a key technology in early computer development, allowing unparalleled amounts of data to be mechanically created, stored for long periods, and to be rapidly accessed.

Today, other technologies can perform the functions of magnetic tape. In many cases these technologies are replacing tape. Despite this, innovation in the technology continues and tape is still widely used.

Its biggest drawback is that it can only access data sequentially. However, many data processing operations are sequential or batch oriented in nature, and tape is still economical.

Modern magnetic tape is most commonly packaged in cartridges and cassettes. The device that performs actual writing or reading of data is a tape drive. Here we will look at the two most popular forms of magnetic tape for large system MIS applications: detachable reel magnetic tapes and tape cartridges.

Figure 1.8.1: Magnetic Tape[*]

1.8.1.1 Detachable Reel Magnetic Tapes: Many of the tapes used with mainframes and minicomputers are stored on detachable reels. These plastic tapes are, like disks, coated with a magnetizable surface (often iron oxide) that can be encoded with 0 and 1 bits. Tapes come in various widths, lengths, and data densities. A common specification is a 2400 feet reel of ½ inch diameter tape that packs data at 6250 bytes per inch. Recording densities of tapes are often cited as bytes per inch (bpi) because in most instances, a character (byte) is represented as a vertical slice of bits across the tracks of tape surfaces.

[*] www.wikipedia.org

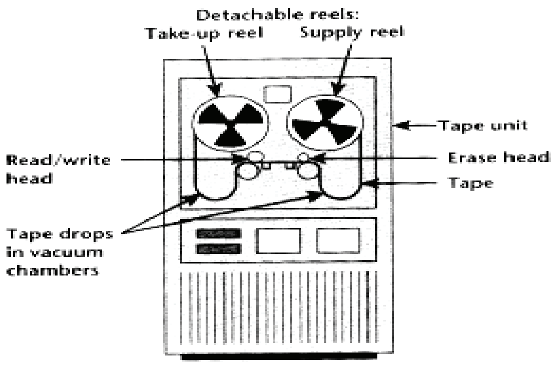

Figure 1.8.2: Detachable Reel Magnetic Tapes

Tapes are read on a hardware device called a tape unit (Figure 1.8.2). Basically, this unit works the same way as the reel-to-reel tape units that were once popular on home stereo systems. An empty take-up reel, running at the same speed as the supply reel on which the tape is initially wound, accepts the tape as it is being processed. The tape is processed by passing it under read/write heads located between the two reels. Depending on the instructions given to the computer system, data can then either be read from the tape or written to it.

1.8.1.2 Tape Cartridge Systems: Cartridge tapes represent the leading edge of tape technology. Tape cartridges are available for both large and small computer systems.

Tape cartridges for microcomputer systems, which resemble cassette tapes in appearance, are frequently used to back up hard disks. These tapes, which are not designed for processing purposes, are sometimes called streaming tapes. The capacities of these tapes vary, but several megabytes of storage are typical. Streaming tapes can usually back up the contents of a hard disk in a few minutes. Among the leading tape cartridge system vendors are Colorado Memory Systems, Everex Systems, Micro Solutions Summit Memory Systems, and Tallgrass Technologies Corporation.

In 1986, IBM introduced a tape cartridge system, the IBM 3480, for its 3090 line of mainframes. Each of these cartridges has a capacity of 200 MB and a data-transfer rate of 3 MB/Sec. further, data and cleaning cartridges are available for the IBM 3570, 3590, 3590E, and 3592 tape drives ranging from 800 MB to 60 GB of storage capacity.

Figure 1.8.3: Tape Cartridge*

* www.03.ibm.com

1.8.2 Floppy Diskettes: In the early 1970's IBM introduced a new medium for storing data. This medium consisted of a circular piece of thin plastic material, approximately eight inches in diameter, which was coated with an oxide material. The circular piece of plastic, called a disk, is enclosed in a square protective jacket with a cut out so that the magnetic surface is exposed. When inserted in the appropriate hardware device, the disk is rotated inside the protective jacket, allowing keyed data or data from main computer memory to be stored on the rotating disk. Once data is stored on the disk, it can be read from the disk into main computer. This medium for input and auxiliary storage is called *a floppy disk or diskette.* .

Diskettes are available in a number of different sizes. The original diskette was of the size of 8 inches. During the 1980, most PCs used 5.25-inch diskettes. The disks could store up to 360 kilobytes (KB) of data, or about one third of a single megabyte. Later, *high-density* floppy disks held 1.2 megabytes (MB) of data. Today, the 3.5-inch diskette has largely replaced its 5.25-inch cousin. The most common sizes for PCS are 720K (double-density) and 1.44MB (high-density).

Figure 1.8.4: Floppy Disk (8-inch, 5¼-inch, and 3½-inch)*

The surfaces of diskettes (or disks) are coated with millions of tiny iron particles so that the data can be stored on them. Each of these particles can act as a magnet, taking on a magnetic field when subjected to an electromagnet. The read/write heads of a diskette drive (or a hard disk/ tape drive) contain electromagnets, which generate magnetic field in the iron on the storage medium as the head passes over the diskette (or disk).

Floppy diskettes spin at around 300 revolutions per minute. Therefore, the longest it can take to position a point on the diskette under the read/write heads is the amount of time required for one revolution -about 0.2 second. The farthest the head would ever have to move is from the centre of the diskette to the outside edge. The heads can move from the center to the outside edge in even less time - about 0.17 second. Since both operations (rotating the disk and moving the heads) take place simultaneously, the maximum time to position the heads over a given location on the diskette - known as the maximum access time remains the greater of the two times or 0.2 second.

* www.flickr.com

Today other storage devices those are more convenient and robust, such as compact disks and memory sticks, have largely replaced floppy disks. A CD can hold upwards up 600 MB, and even the smallest capacity memory stick holds several hundred times the amount of a single floppy disk. Some memory sticks now compete with smaller hard drives for disk capacity, making them ideal for transferring files, programs, or even entire volumes.

A real sign that floppy disks are all but obsolete is that most laptops no longer come with a floppy drive, and many desktop systems do not include a floppy drive unless requested. Nevertheless, many people continue to use diskettes for backing up and transferring small files. These devices are not available commonly and are recommended on need basis.

1.8.2.1 How data is organised on a disk: When the new diskettes (or a new hard drive) are purchased, the disks inside are nothing more than simple, coated disks encased in plastic. Before the computer can use them to store data, they must be magnetically mapped so that the computer can go directly to a specific point on the diskette without searching through data.

The process of mapping a diskette is called **formatting** or **initializing**.

The first thing a disk drive does when formatting a disk is to create a set of magnetic concentric circles called *tracks.* The number of tracks on a disk varies with the type (most high-density diskettes have 80) .The tracks on a disk do not form a continuous spiral like those on a phonograph record - each one is a separate circle. Most tracks are numbered from the outermost circle to the innermost, starting from zero.

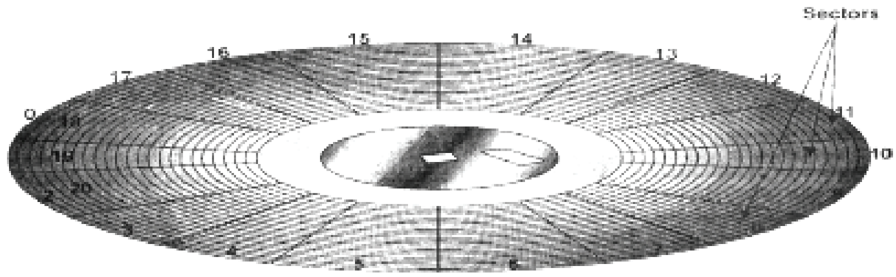

Figure 1.8.5: Tracks & Sectors

Each track on a disk is also split into smaller parts. Imagine slicing up a disk the way a pie is cut. As shown in Fig. 1.8.5, each slice would cut across all the disk's tracks, resulting in short segments, or *sectors*. All the sectors on the disk are numbered in one long sequence, so the computer can access each small area on the disk with a unique number. This scheme effectively simplifies what would be a set of two-dimensional coordinates into a single numeric address.

Like any flat object, a disk has two sides. Some early drives could read data on only one side, but today, all disk drives can read and write data on both sides of a disk. To the computer, the second side is just a continuation of the sequence of sectors. For example, the 3.5 inch, 1.44-MB diskette has a total of 2880 sectors (80 tracks per side × 2 sides × 18 sectors per track)

On most diskettes, a sector contains 512 bytes, or 0.5 KB.

A sector is the smallest unit with which any disk drive (diskette drive or hard drive) can work. Each bit and byte within a sector can have different values, but the drive can read or write only whole sector at a time. If the computer needs to change just one byte out of 512, it must rewrite the entire sector.

The number of characters that can be stored on a diskette by a disk drive is dependent on following three basic factors:

1. **The number of sides of the diskette used:** The earlier diskettes and drives were designed so that data could be recorded on only one side of the diskette. These drives were called single-sided drives. Now-a-days diskette drives are manufactured that can read and write data on both sides of the diskette. Such drives are called *double-sided drives.* The use of double-sided drives and diskettes approximately doubles the number of characters that can be stored on the diskette.

2 **The recording density of the bits on a track:** The recording density refers to the number of bits that can be recorded on a diskette in one inch circumference of the innermost track on the diskette. This measurement is referred to as bits per inch (bpi). For the user, the diskettes are identified as being either *single density* (SD) or *double density (DD).*A single density drive can store 2,768 bits per inch on the innermost track. Double density can store 5,876 bits per inch. With improved technology, it is anticipated that recording densities in excess of 10,000 bits per inch will be possible.

3 **The number of tracks on the diskette:** The number of tracks is dependent upon the drive being used. Many drives record 40 tracks on the surface of the diskette. Other drives, however, can record 80 tracks on the diskette. These drives are sometimes called double track drives.

1.8.3 Magnetic Disc: Magnetic discs are the most popular direct access medium for storing the data. By direct access we mean that a record can be accessed without having to plod through the preceding records. The other direct access medium is floppy disc (discussed earlier).

Like diskettes, hard disks store data in tracks that are divided into sectors. Physically, however, hard disks look quite different from diskettes.

A hard disk is a stack of one or more metal platters that spin on one spindle like a stack of rigid diskettes. Each platter is coated with iron oxides, and the entire unit is encased in a sealed chamber. Unlike diskettes, where the disk and drive are separate, the hard disk and drive is a single unit. It includes the hard disk, the motor that spins the platters, and a set of read/write heads. Since the disk can not be removed from its drive (unless it is a removable hard disk, which will be discussed later), the terms hard disk and hard drive are used interchangeably.

Hard disks have become the primary storage device for PCs because they are convenient and cost-efficient. In both speed and capacity, they far outperform diskettes. A high-density 3.5-inch diskette can store 1.44 MB of data. Hard disks, in contrast, range in capacity from about

20 GB onward. Most PCs now come with hard disks of at least 80 GB and more.

The rigidity of the hard disk allows it to spin much faster - typically more than ten times faster than floppy diskettes. Thus, a hard disk spins between 3,600 rpm and 7,200 rpm, instead of a floppy diskette's 300 rpm. The speed at which the disk spins is a major factor in the overall performance of the drive. The rigidity of the hard disk and the high speed at which it rotates allow a lot of data to be recorded on the disk's surface.

Figure 1.8.6: Magnetic Disk or Hard Disk*

1.8.3.1 Data Storage: Not only do hard disks pack data more closely together, they also hold more data, because they often include several platters, stacked one on top of another to create large capacity disk storage system.

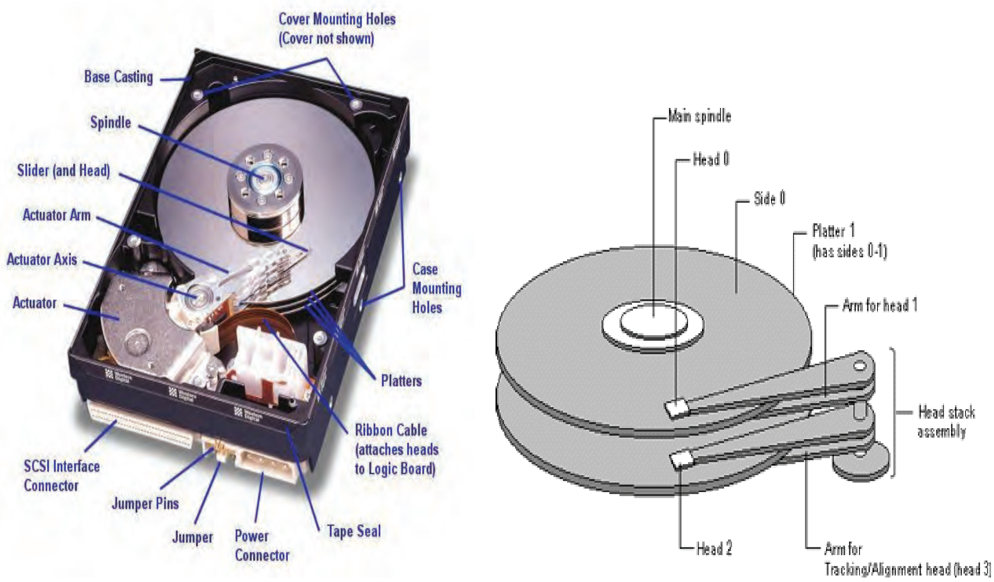

Figure 1.8.7: Hard Disk Storage Structure**

With hard disks, the number of read/write heads specifies the number of sides that the disk uses. For example, a particular hard disk drive might have six disk platters (that is, 12 sides),

*www.sharif.edu

** www.microsoft.org

but only eleven heads, indicating that one side is not used to store data. Often, this is the bottom side of the bottom disk.

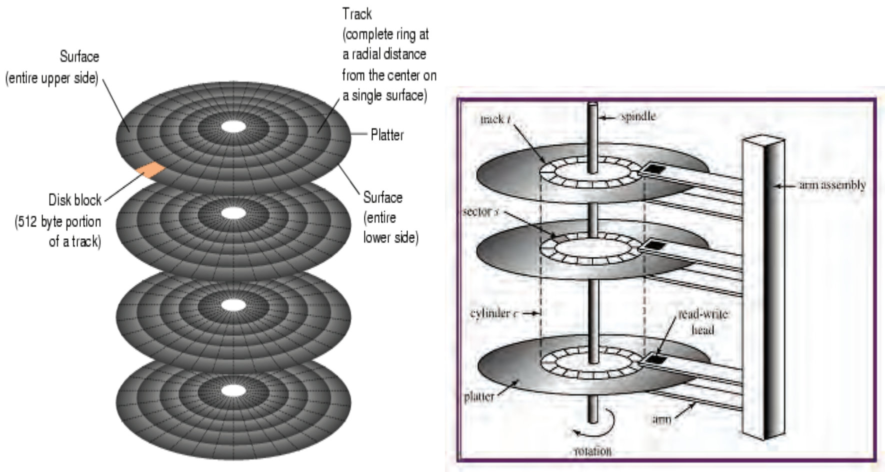

Figure 1.8.8: Hard Disk Cylinder*

The other point of importance is the fact that read/write heads move in and out simultaneously. Because of the simultaneous movement of the read/write heads, it is to be desired that the records are arranged sequentially in cylinders so that when the first cylinder (*i.e.,* first track of all eleven faces) has been read, the heads move to the next cylinder *i.e.,* reading or writing is performed cylinder wise.

Like floppy diskettes, hard disks generally store 512 bytes of data in a sector, but because of their higher tolerances, hard disks can have more sectors per track-54, 63, or even more sectors per track are not uncommon.

The computation of a hard disk's capacity is identical to that for floppy diskettes-but the numbers are larger. The breakdown of the storage capacity for a disk is given below:

Storage Capacity = No. of recording platters x No. of tracks per platter x No. of sectors per track x No. of bytes per sector

For Example, a disk has 12 plates each having 3000 tracks. Each track is having 200 sectors per track, and each sector can store 512 bytes. The total recording surface would be 11 (total 22 recording surfaces, 11 x 2) since upper and lower disk surface does not have recording (r/w) heads.

Total storage capacity = 22 x 3000 x 200 x 512 i.e.

675,840,0000 bytes which is equivalent to approximately 6 GB of data.

The time required in accessing a record has generally three components.

* www.cns.org

(i) ***Seek Time**:* This is the time required to position a movable read-write head over the recording track to be used. If the read-write head is fixed, this time will be zero.

(ii) ***Rotational time***: This is the rotational delay also termed latency, to move the storage medium underneath the read-write head.

(iii) ***Data transfer time**:* This is the time taken to activate the read/write head, read the requested data, and transmit them to primary memory for processing.

The total of these three components is known as the access time and typically ranges from, 8 to 12 milliseconds.

In spite of all the capacity and speed advantages, hard disks have one major drawback. To achieve optimum performance, the read/write head must be extremely close to the surface of the disk. In fact, the heads of hard disks fly so close to the surface of the disk that if a dust particle, a human hair, or even a fingerprint were placed on the disk it would bridge the gap between the head and the disk, causing the heads to crash. A head crash, in which the head touches the disk, destroys the data stored in the area of the crash and can destroy a read/write head, as well.

1.8.3.2 Advantages and disadvantages of magnetic disk

The advantages of magnetic disk include:

1. Magnetic rigid disk is direct access storage medium; therefore, individual records can be retrieved without searching through the entire file.
2. The costs of disks are steadily declining.
3. For real-time systems where direct access is required, disks are currently the only practical means of file storage. Other new types of storage, such as bubble storage, are not widely used yet.
4. Records can be readily updated by writing the new information over the area where the old information was stored.
5. With removable disk packs, a single disk drive can store large quantities of data although all but one of the disks is offline at any given point in time. However, being offline is not a disadvantage for many applications, especially batch applications.
6. Interrelated files stored on magnetic disk can allow a single transaction to be processed against all of these files simultaneously.
7. Data corruption rate is much less then other storage media like floppy disk, magnetic tapes.

The disadvantages of magnetic disk include:

1. Security of information stored on magnetic disks which are used as shared, is major concern.
2. Regular 'head' crashes can damage the surface of the disk, leading to loss of data in that sector.
3. The disk is fixed inside the computer and cannot easily be transferred to another computer.

4. Updating a master file stored on disk destroys the old information. Therefore, disk does not provide an automatic audit trail. When disk is used, back-up and audit trail require that each old master file records be copied to another medium prior to update.

1.8.4 Optical Laser Disks: Optical laser disk storage is capable of storing vast amount of data. Some industry analysts have predicted that optical laser disk technology may eventually make magnetic disk and tape storage obsolete. With this technology, the read/write head used in magnetic storage is replaced by two lasers. One laser beam writes to the recording surface by scoring macroscopic pits in the disk, and another laser reads the data from the light sensitive recording surface. A light beam is easily deflected to the desired place on the optical disk, so a mechanical access arm is not needed.

There are five main categories of optical laser disks.

1.8.4.1 CD-ROM Disks: CD-ROM, a spin-off of audio CD technology stands for compact-disk-read-only memory. The name implies its applications; CD-ROM disks are created as a mastering facility. Most of the commercially produced read-only CD-ROM disks contain reference material. The master copy is duplicated or "pressed" at the factory and copies are distributed with their pre-recorded contents. Once inserted into the CD-ROM disk drive, the text, video images, and so on can be read into primary storage for processing or display. However, the data on the disk are fixed, they can not be altered.

The capacity of a single CD-ROM is over 650 MB which is equivalent to 250,000 pages of text, or 1500 floppy disks. The tremendous storage capacity has opened the door to a variety of multimedia applications. Multimedia can provide needed flexibility during a presentation. Unlike a video tape, CD-ROM gives the presenter instant random access to any sequence of images on the disk.

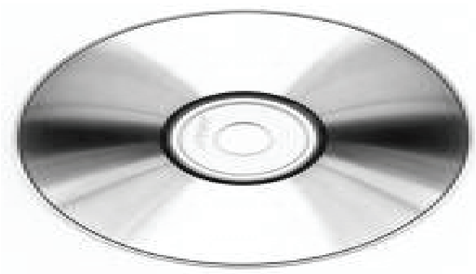

Figure 1.8.9: CD-ROM*

CDs may soon take a new direction with the advent of DVD, digital video disk, a high density medium that is capable of storing a full-length movie on a single disk side of a CD (actually, it uses both sides of the disk) DVDs look like CDs and DVD - ROM drives are able to play current CD-ROMs. A slightly different player, the DVD movie player connects to the TV and plays movies like a VCR. The DVD movie player will also play audio CDs.

* www.wikipedia.org

Each side of a DVD can hold up to 4.7 GB. Therefore, these two-sided disks can contain as much as 9.4 GB of data. There are three basic types of optical disks:

CD-ROM: CD-ROM, an acronym of "compact disc read-only memory" is an optical disk storage that contains text, graphics and hi-fi stereo sound with different capacity. The data is permanent and can be read any number of times, but CD-ROMs cannot be modified.CD-ROMs are popularly used to distribute computer software, including games and multimedia applications, though any data can be stored up to the capacity limit of a disc.

CD Rewritable: Hewlett Packard has introduced the next generation of CD Rewritable (CD-RW) drive. The rewriteable compact disc is called a CD-RW. This disc allows for repeated recordings on a disc. It is relatively more expensive than the CD-R. However, in certain circumstances the benefits outweigh the cost. This is the third generation in CD technology which began with CD-ROM and was then followed by the CD-Recordable (CD-R). These disks are used in creation of test disks, short or mid-term backups, and where an online and offline storage schemes is required.

CD-R: It stands for compact disc, recordable. CD-R is a Write Once Read Many (WORM) optical medium, though the whole disk does not have to be entirely written in the same session.CD-R retains a high level of compatibility with standard CD readers, unlike CD-RW - which can be re-written, but is not capable of playing on many readers, and also uses more expensive media.A person can only write once on this CD, though it can be read as many times as wished. It can be played in CD players and CD-ROM drives. In a normal CD, polycarbonate plastic substrate, a thin reflective metal coating, and protective outer coating layers are present. However, in a CD-R, an extra layer is present and is an organic polymer dye lying between the polycarbonate and metal layers and serves as a recording medium. A pregrooved spiral track guides the laser for recording data, which is encoded from the inside to the outside of a CD in a continuous spiral, much like the way it is read. The laser makes that are not dissimilar from the pits and lands of a normal CD. After the encoding process is completed, the data can be read as a normal CD. The 120 mm disc has a storage capacity of 74 minutes of audio or 650 MiB of data. CD-R/RWs are available with capacities of 80 minutes of audio or 737,280,000 bytes (703 MiB), which they achieve by molding the disc at the tightest allowable tolerances specified in the Orange Book CD-R/CD-RW standards.

1.8.4.2 WORM Disks: It stands for Write Once, Read Many optical laser disks, or WORM disks. It is an optical disk technology that allows the drive to store and read back data but prevents the drive from erasing information once it has been written. WORM (Write Once, Read Many) storage had emerged in the late 1980s and was popular with large institutions for the archiving of high volume sensitive data. When data is written to a WORM drive, physical marks are made on the media surface by a low-powered laser and since these marks are permanent, they cannot be erased. While WORM can be an inconvenient property when it comes to re-using recorded media, WORM was discovered as a desirable property for data backups and archives, to prevent erasure (accidental or deliberate) and tampering. Various regulatory agencies require data such as health information and transaction records to be archived reliably and securely over a long period of time.

Therefore, WORM capability has been intentionally added to otherwise rewritable media such as magnetic tape data storage and hard disk drives. The media can be written to, but the written portion immediately becomes read-only. These are used by end user companies to store their own proprietary information. Once the data have been written to the medium, they only can be read, not updated or changed. The PC version of a WORM disks cartridge, which looks like a 5¼ inch version of the 3½ inch diskette, has a capacity of 200 MB.

Access times for CD-ROM and WORM drives tend to be quite slow by hard disk drive standards, ranging from 100 to 300 milliseconds.

The WORM disks cartridge is a feasible alternative to magnetic tape for archival storage, for example, a company might wish to keep a permanent record of all financial transactions during the last year. Another popular application of WORM disks is in information systems that require the merging of text and images that do not change for a period of time. A good example is an “electronic catalogue”. A customer can peruse retailer’s electronic catalogue on a VDT, or perhaps a PC, and see the item while he or she reads about it. And, with a few keystrokes, the customer can order the item as well. The Library of Congress is using WORM technology to alleviate a serious shelf-space problem.

1.8.4.3 Magneto-Optical Disks: The magneto-optical (MO) drive is a popular way to backup the files on a personal computer. As the term implies, an MO device employs both magnetic and optical technologies to obtain ultra-high data density. A typical MO cartridge is slightly larger than a conventional 3.5-inch floppy diskette, and looks similar. But while the older type of floppy diskette can store 1.44 megabytes (MB) of data, an MO diskette can store many times that amount, ranging from 100 MB up to several gigabytes (GB). A MO disc comes in 3.5" and 5.25" cartridges. The later are double sided, but must be removed and flipped over. Capacities of 3.5" cartridges are 128 MB, 230 MB, 640 MB, and 1.3 GB. For 5.25", they are 650 MB, 1.3 GB, 2.6 GB, 5.2 GB, and 9.1 GB.

Figure 1.8.10: WORM Disk*

Magneto-Optical Technology: An MO system achieves its high data density by using a laser and a magnetic read/write head in combination. Both the laser and the magnet are used to write data onto the diskette. The laser heats up the diskette surface so it can be easily magnetized, and also to allow the region of magnetization to be precisely located and

* www.wikipedia.org

confined. A less intense laser issued to read data from the diskette. Data can be erased and/or overwritten an unlimited number of times, as with a conventional 3.5-inch diskette.

Examples of magneto-optical drives are the Fujitsu DynaMO, a 230 MB drive used in the PowerPC Apple Powerbook, a note book computer, and the Pinnacle Micro Vertex, a 2.6 GB drive.

The chief assets of MO drives include convenience, modest cost, reliability, and (for some models) widespread availability approaching industry standardization. The chief limitation of MO drives is that they are slower than hard disk drives, although they are usually faster than conventional 3.5-inch diskette drives.

Magneto-optical drive is a kind of optical disc drive capable of writing and rewriting data upon a **magneto-optical disc**. Both 5.25" and 3.5" form factors exist. The technology was introduced at the end of the 1980s. Although optical, they appear as hard drives to the operating system and do not require a special file system (they can be formatted as FAT, HPFS, NTFS, etc.)

Figure 1.8.11: Magneto Optical Disk*

The disc consists of a ferromagnetic material sealed beneath a plastic coating. There is never any physical contact during reading or recording. During reading, a laser projects a beam on the disk and according to the magnetic state of the surface, the reflected light varies due to the magneto-optical Kerr effect. During recording, the light becomes stronger so it can heat the material up to the Curie point in a single spot. This allows an electromagnet positioned on the opposite side of the disc to change the local magnetic polarization, and the polarization is retained when temperature drops.

Each write cycle requires both a pass for the laser to erase the surface, and another pass for the magnet to write the information, and as a result it takes twice as long to write data as it does to read it. In 1996, a *Direct Overwrite* technology was introduced for 3.5" discs, to avoid the initial erase pass when writing. This requires special media.

Magneto-optical drives by default check information after writing it to the disc, and are able to immediately report any problems to the operating system. This means that writing can actually take three times longer than reading, but it makes the media extremely reliable, unlike the CD-

*www.wikipedia.org

R or DVD-R technologies upon which data is written to media without any concurrent data integrity checking.

1.8.4.4 Digital Video Disk: DVD (also known as "**Digital Versatile Disc**" or "**Digital Video Disc**") is an optical disc storage media format that can be used for data storage, including movies with high video and sound quality. DVD is an optical disc technology with a 4.7 gigabyte storage capacity on a single-sided, one-layered disk, which is enough for a 133-minute movie. DVDs can be single or double-sided, and can have two layers on each side; a double-sided, two-layered DVD will hold up to 17 gigabytes of video, audio, or other information. This compares to 650 megabytes (.65 gigabyte) of storage for a CD-ROM disk.

Variations of the term *DVD* often indicate the way data is stored on the discs: DVD-ROM (read only memory) has data that can only be read and not written; DVD-R and DVD+R (recordable) can record data only once, and then function as a DVD-ROM; DVD-RW (re-writable), DVD+RW, and DVD-RAM (random access memory) can all record and erase data multiple times.

Various types of DVDs can be used for storing images, text, movies, high resolution graphics etc.

1. DVD-5 holds 4.7 GB data and is supported by the DVD+R/RW and DVD-R/RW formats. It is also known as Single-Sided Single Layer.
2 DVD-9 holds 8.5 GB data and is supported by the DVD+R and DVD-R formats. It is also known as Single-Sided Double Layer (sometimes called Dual Layer). The official names are DVD-R DL and DVD+R DL.
3. DVD-10 holds 8.75 GB data and is supported by the DVD+R/RW and DVD-R/RW formats. It is also known as Double-Sided Single Layer.
4. DVD-18 holds 15.9 GB data and is supported by the DVD+R format. It is also known as Double-Sided Double Layer (or Double-Sided Dual Layer).

DVDs resemble compact discs as their physical dimensions are the same- 120 mm (4.72 inches) or occasionally 80 mm (3.15 inches) in diameter, but they are encoded in a different format and at a much higher density. A video disk can store text, video, and audio data. Video disks can be accessed a frame at a time (to provide still information) or played like a phonograph record (to supply up to an hour of moving action). Any of the 54,000 tracks on the surface of typical video disk can be accessed in about three seconds.

A digital video disk (DVD) is a 5 inch plastic disk that uses a laser to encode microscopic pits in its substrate surface. But the pits on a DVD are much smaller and are encoded much closer together than those on a CD-ROM. Also, a DVD can have as many as two layers on each of its two sides (compared to the single-layered, single-sided CD-ROM). The end result is a medium that can hold as much as 17 gigabytes of data, over 25 times the capacity of a standard CD-ROM disk. The advantages of DVDs are therefore self-evident i.e. a huge storage capacity that enables users to archive large amounts of data on a single, lightweight, removable, reliable, easily-transportable medium. Although DVDs are now used mostly for entertainment, for example, storing video movies or large amounts of prerecorded music.

Video disk was first introduced in 1983, as a video game product. Today, however, they can provide companies with a competitive advantage. Various usage of DVD has been described which caters the needs of present day requirements.

1. Video disk systems were developed to help real estate agents conduct better searches for homes and properties for their clients.
2. Video disks are widely used for training applications. At a growing number of companies– Ford, Chrysler, Xerox, Pfizer, and Massachusetts Mutual Life Insurance, to name just a few-video disk systems take on such training tasks as showing how to boost factory performance, helping service technicians do a safer and better job, and training clerks to analyze insurance applications. The U.S. Army has also made extensive use of video disks for training purposes.
3. Video disks are also used by automobile manufacturers to show their lines and by travel agents to interest clients in resorts.
4. Product Catalogues - This saves money on postage and printing for the company.
5. Shops and post offices - Shops and post offices have small TVs showing promotions and local businesses. They serve as a marketing tool.
6. Business Presentations - Some businesses have started to use the power of DVD to show more aesthetically pleasing presentations. These presentations provide a very professional outlook for the business and allow the company to save pictures, text, graphics; video and audio - all of which can be very large in file size.
7. VHS to DVD Conversion - Converting old training videos to DVD is a good practice. This is because videos have a limited life span. Eventually the quality is reduced, making it very unpleasant to watch. Also, if all videos were converted to DVD, the old training videos could be destroyed. This will make more office space as DVD's take far less space than a VHS video.
8. Legal - DVD's are becoming a tool in the legal profession. DVD's are being used to record video evidence of a witness. These are used if a witness would like to remain anonymous. This type of evidence is used a lot in high profile cases, where there can be repercussions to the witnesses.
9. Trade Show Demonstrations - For a business to attract crowds, DVDs helps in performing the same. DVD's could be used to show demonstrations to the crowds. After all, a product will very unlikely sell unless if a demonstration of some sort is shown. A DVD is an excellent tool to show off a product demonstration.
10. Magazine/Programme DVDs - Magazines and programmes are now being converted to DVD format. A consumer will almost always rather see an interview with a pop star for example, rather than read it.

Some industry observers predict that many businesses will develop automatic customer service centers equipped with video disk components in near future so that consumers do not have to depend only on clerks and showrooms.

Figure 1.8.12: Digital Video Disk (DVDs) and Drive*

1.8.4.5 Blu Ray Disc: Blu-ray (not Blue-ray) also known as Blu-ray Disc (BD), is the name of a next-generation optical disc format jointly developed by the Blu-ray Disc Association (BDA), a group of the world's leading consumer electronics, personal computer and media manufacturers .The format was developed to enable recording, rewriting and playback of high-definition video (HD), as well as storing large amounts of data. The format offers more than five times the storage capacity of traditional DVDs and can hold up to 25 GB on a single-layer disc and 50 GB on a dual-layer disc. This extra capacity combined with the use of advanced video and audio codes that will offer consumers an unprecedented HD experience.

While current optical disc technologies such as DVD, DVD±R, DVD±RW, and DVD-RAM rely on a red laser to read and write data, the new format uses a blue-violet laser instead, hence the name Blu-ray. Despite the different type of lasers used, Blu-ray products can easily be made backwards compatible with CDs and DVDs through the use of a BD/DVD/CD compatible optical pickup unit. The benefit of using a blue-violet laser (405nm) is that it has a shorter wavelength than a red laser (650nm), which makes it possible to focus the laser spot with even greater precision. This allows data to be packed more tightly and stored in less space, so it's possible to fit more data on the disc even though it's the same size as a CD/DVD. This together with the change of numerical aperture to 0.85 is what enables Blu-ray Discs to hold 25 GB/50 GB data. Recent development by Pioneer has pushed the storage capacity to 500 GB data on a single disc by using 20 layers.

* www.wikipedia.org

Figure 1.8.13: Blu Ray Disc*

Blu-ray is currently supported by about 200 of the world's leading consumer electronics, personal computer, recording media, video game and music companies.

Consumers initially were also slow to adopt Blu-ray due to the cost. By 2009, 85% of stores were selling Blu-ray Discs. A high-definition television and appropriate connection cables are also required to take advantage of Blu-ray disc. Some analysts suggest that the biggest obstacle to replacing DVD is due to its installed base; a large majority of consumers are satisfied with DVDs.

Summary

The first unit of this chapter introduces the basic concepts of computers, their types, features, advantages and limitations and various generations and their evolution. It also explains detailed architecture of a computer that includes various components, their functionality, usage and compatibility with the computer system. Various hardware devices have been discussed (like CPU, ALU, CU and motherboard) in detail. In addition to the above discussion, this unit talks about various types of storage devices, their capacities and usage, advantages and disadvantages of both primary and secondary storage devices. The functionality of hardware devices like RAM, ROM, Magnetic disk, DVD etc. which are used to store the data are also explained in detail.

* www.circuitstoday.com

UNIT 2 : INPUT AND OUTPUT DEVICES

An I/O device (short for input/output devices) is a general term for devices that send computers information from the outside world and that return the results of computations. These results can either be viewed directly by a user, or they can be sent to another machine, whose control has been assigned to the computer. The first generation of computers was equipped with a fairly limited range of input devices. A punch card reader, or something similar, was used to enter instructions and data into the computer's memory, and some kind of printer, usually a modified teletype, was used to record the results. Over the years, other devices have been added. For the personal computer, for instance, keyboards and mice are the primary ways people directly enter information into the computer; and monitors are the primary way in which information from the computer is presented back to the user, though printers, speakers, and headphones are common, too. There is a huge variety of other devices for obtaining other types of input. One example is the digital camera, which can be used to input visual information.

We will now discuss some of these I/O devices in detail.

1.1 On-Line Entry

1.1.1 Keyboard: A keyboard is primary input and control device that allows the user to enter alphabets, numbers and other characters. One can enter data and issue commands via the keyboard. The keyboard is used to feed the information into the computer. There are many different keyboard layouts and sizes with the most common for Latin based languages being the QWERTY layout (named for the first 6 keys). The standard keyboard has 101 keys. A keyboard typically has characters engraved or printed on the keys and each press of a key typically corresponds to a single written symbol. However, to produce some symbols requires pressing and holding several keys simultaneously or in sequence. While most keyboard keys produce letters, numbers or signs (characters), other keys or simultaneous key presses can produce actions or computer commands.

In normal usage, the keyboard is used to type text and numbers into a word processor, text editor or other program. In a modern computer, the interpretation of key presses is generally left to the software. A computer keyboard distinguishes each physical key from every other and reports all key presses to the controlling software. Keyboards are also used for computer gaming, either with regular keyboards or by using keyboards with special gaming features, which can expedite frequently used keystroke combinations. A keyboard is also used to give commands to the operating system of a computer, such as Windows' Control-Alt-Delete combination, which brings up a task window or shuts down the machine.

Besides the standard typewriter keyboard, most micro keyboards have function keys, also called soft keys. When tapped, these function keys trigger the execution of software, thus the name “soft key.” For example, tapping one function key might call up a displayed list of user options commonly referred to as a **menu**. Another function key might cause a word processing document to be printed. Function keys are numbered and assigned different functions in different software packages. For example, HELP (context-sensitive user assistance) is often assigned to F1, or Function key 1. Most keyboards are equipped with key pad and cursor-control keys. The keypad permits rapid numeric data entry. It is normally positioned to the right of the standard alphanumeric keyboard.

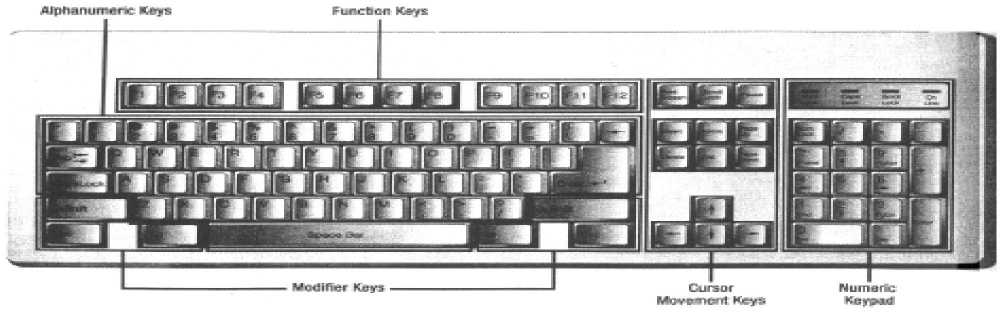

Figure 1.1.1: Keyboard*

The cursor-control keys, or “arrow” keys, allow the user to move the text cursor up (↑) and down (↓), usually a line at a time, and left (←) and right (→), usually a character at a time. The text cursor always indicates the location of the next keyed-in-character on the screen. The text cursor can appear as several shapes depending on the application, but frequently, one will encounter an underscore (_), a vertical line (|), or a rectangle(▭).To move the text cursor rapidly about the screen, simply hold down the appropriate arrow key.

For many software packages, one can use the arrow keys to view parts of a document or worksheet that extend past the bottom, top, or sides of the screen. This is known as **scrolling**.

In summary, the keyboard provides three basic ways to enter commands:

- Key in the command using the alphanumeric portion of the keyboard.
- Tap a function key.
- Use the arrow keys to select a menu option from the displayed menu.

Other important keys common to most keyboards are the ENTER, HOME, END, PAGE UP AND PAGE DOWN (abbreviated as PGUP and PGDN), DELETE (DEL), BACKSPACE (BKSP), Insert - type over toggle (INS), ESCAPE (ESC), SPACEBAR, Shift Control (CTRL), Alternate (ALT), TAB, SCROLLLOCK, CAPSLOCK, NUMLOCK, and PRINT SCREEN keys (see Figure 1.1.1)

1.1.2 Mouse: Mouse is a pointing device that controls the movement of the cursor on a display screen. The user pushes across a desk surface in order to point to a place on a display screen and to select one or more actions to take from that position. Today, the mouse

* www.wikipedia.org

is an integral part of the graphical user interface (GUI) of any personal computer. The mouse apparently got its name by being about the same size and color as a toy mouse.

A mouse consists of a metal or plastic housing or casing, a ball that sticks out of the bottom of the casing and is rolled on a flat surface, one or more buttons on the top of the casing, and a cable that connects the mouse to the computer. As the ball is moved over the surface in any direction, a sensor sends impulses to the computer that causes a mouse-responsive program to reposition a visible indicator (called a *cursor*) on the display screen. The positioning is relative to some variable starting place. Viewing the cursor's present position, the user readjusts the position by moving the mouse.

Figure 1.1.2: Computer Mouse*

A mouse may have one, two or three buttons. Generally, left button is used to select objects and text, middle button is used for scrolling the pages to text and the right button is used to access menus. If the mouse has one button (Mac for instance), it controls all the activity and a mouse with a third buttons can be used by specific software programs.

The function of each button is determined by the program that uses the mouse. In its simplest form, a mouse has one button. Moving the mouse moves the cursor on the screen, and clicking the button results in selecting an option. A mouse normally has two or three buttons, but the software package used by the user may use one, two or all three of them.

A mouse may be classified as a mechanical mouse, Optomechanical and an optical mouse, depending on the technology it uses. In a *mechanical mouse*, that project through the bottom surface rotates as the mouse is moved along a flat surface. The direction of rotation is detected and relayed to the computer by the switches inside the mouse. Microsoft, IBM, and Logitech are some well-known makers of mechanical mouse.

Optomechanical mouse is the same as the mechanical mouse except that it uses optical sensors to the motion of the ball. A mouse pad should be used under the mouse to run on.

An *optical mouse* uses a laser instead of a rotating ball to detect movement across a specially patterned mouse pad. Optical mouse do not have any mechanical moving parts. The optical mouse responds more quickly and precisely than the mechanical and optomechanical mice. It is more expensive than the two other types. The optical mouse offer more precision and speed and even can be used on any surface.

* www.wikipedia.org

Mouse connects to PCs in one of several ways:

1. **Serial mice** connect directly to an RS-232C serial port or a PS/2 port. This is the simplest type of connection.
2. **PS/2 mice** connect to a PS/2 port.
3. **USB mice.**

The mouse can be connected to the PCs through several channels. A *serial mouse or PS/2 mouse* is connected to the PC through a serial port like RS-232C or PS/2 port. This is the simplest type of connection which can be done very easily.

The USB interface receives various types of Mouse through a USB connector. One of these advantages to use the USB mouse is the possibility to plug-and-play in front or in the back of computer case, when it contains these kinds of port.

Cordless mice aren't physically connected at all. Instead they rely on infrared or radio waves to communicate with the computer. Cordless mice are more expensive than both serial and bus mice, but they do eliminate the cord, which can sometimes get in the way.

One of the most interesting mouse technologies invented is the **wireless mouse** which relies infrared, radio signals or Bluetooth to communicate with the computer. Using no cord, the wireless mouse contains a transmitter to send information to a receiver itself connected to the computer. The wireless mouse is usable from 2m to 10m of the computer.

The **cordless mouse** uses the wireless communication technology (via infrared, radio or *Bluetooth*) to transmit data to the computer. And like the wireless, it doesn't use any cord.

1.1.3 Touch Screen: The 'Touch Screen' is a Hewlett Packard innovation and was introduced on their 100 series microcomputers in 1984. An invisible microwave beam 'matrix' criss crosses the screen, emanating from holes along the bottom and sides of the display unit. By pressing the finger against a function or program displayed on the screen, the infrared beam is broken at that intersection and the system activated. In many ways, this is more effective than the 'Mouse' and very popular with users.

Two popular technologies exist for touch screens. In one, the screen is made sensitive to touch and the exact position is detected. In the other, the screen is lined with light emitting devices on its vertical sides; photo-detectors are placed on the horizontal sides. When the user's finger approaches the screen, the light beam is broken and is detected by the photo-detectors.

Touch screens are used in information-providing systems. For example, while performing an operation, if the doctor wants to see some test reports of the patient that have been stored in a computer, he can get the information just by touch of his finger. It is also used in airline and railway reservation counters. The user has to indicate the current place of stay and the destination by touching the screen (may be on a map), and all the possible routes with timings, rates, etc. are displayed. These interfaces are also used in travel agents offices to display the names and addresses of all hotels, restaurants, and other places of interest, at a desired destination. Touch screens are also used in stock exchanges where buying and selling of stock is done.

Figure 1.1.3 : Touch Screen*

1.1.4 Light Pen: A light pen is a pointing device which can be used to select an option by simply pointing at it, or draw figures directly on the screen and move the figures around.

A light pen has a photo-detector at its tip. This detector can detect changes in brightness of the screen. When the pen is pointed at a particular point on the screen, it records the instant change in brightness that occurs and informs the computer about this. The computer can find out the exact spot with this information. Thus, the computer can identify where the user is pointing on the screen.

Light-pens are useful for menu-based applications. Instead of moving the mouse around or using a keyboard, the user can select an option by pointing at it. A light pen is also useful for drawing graphics in CAD. An engineer, architect or a fashion designer can draw sketches or pictures directly on the screen with the pen. Using a keyboard and a light pen, the designer can select colors and line thickness, reduce or enlarge drawings, and edit drawings.

These are also used to read the bar charts that are now appearing so frequently on the goods which are available in big departmental stores. By using a laser beam, computers are able to 'read' the information stored on the bar chart or on a thin strip of magnetic material and this is used to keep stock records and check costs, etc.

Figure 1.1.4: Light Pen*

1.1.5 The Track Ball: A track ball is a pointing device that works like an upside-down mouse. The user rests his thumb on the exposed ball and his fingers on the buttons. To move the cursor around the screen, the ball is rolled with the thumb. Since the whole device is not

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* www.wikipedia.org
* www.csse.monash.edu.au and www.sixdec.wordpress.com

moved, a track ball requires less space than a mouse. So when space is limited, a track ball can be a boom. Track balls are particularly popular among users of notebook computers, and are built into Apple Computer's Power Book and IBM ThinkPad notebooks.

Figure 1.1.5: Track Ball**

1.1.6 Joystick: The joystick is a vertical stick which moves the graphic cursor in a direction the stick is moved. It typically has a button on top that is used to select the option pointed by the cursor. Joystick is used as an input device primarily used with video games, training simulators and controlling robots.

The joystick is used for flight control in the cockpit of many aircraft, controlling machines such as cranes, trucks, underwater unmanned vehicles, wheelchairs and surveillance cameras. Miniature finger-operated joysticks have been adopted as input devices for smaller electronic equipment such as mobile phones.

Joystick Elements:
1. Stick
2. Base
3. Trigger
4. Extra Buttons
5. Autofire switch
6. Throttle
7. Hot switch
8. Suction cup

Figure 1.1.6: Joystick*

1.1.7 Scanner: It is an input device used for optically scans images, printed text, handwriting, or an object, and converts it to a digital image. The common examples found in offices are variations of the *desktop (or flatbed) scanner* where the document is placed on a glass window for scanning.

Capturing information like this reduces the possibility of errors typically experienced during large data entry. Hand-held scanners are also commonly seen in big stores to scan codes and price information for each of the items. They are also termed the bar code readers. Mechanically driven scanners that move the document are typically used for large-format documents, where a flatbed design would be impractical.

** www.wikipedia.org

*www.wikipedia.org

Figure 1.1.7: Scanner

1.1.8 Camera: Two types of cameras are used for input on a computer. The digital camera is a device that takes digital images and saves them to memory. The user then connects the camera to the computer where images are uploaded and saved. Web cams are the other type of camera that is known as video capture device that is connected to a computer or computer network, often using a USB port. Web cams are ways for people to take images from the computer and communicate visually with other users on the Internet.

Figure 1.1.8: Web Cam and Digital Camera*

1.1.9 Microphone and Speech recognition: The "Microphones - Speech Recognition" is a speech Input device. Now that sound capabilities are a standard part of computers, microphones are becoming increasingly important as input devices. Sound is used most often in multimedia, where the presentation can benefit from narration, music, or sound effects. In software, sounds are used to alert the user to a problem or to prompt the user for input.

For this type of sound input, basically a digitized recording is required. All that one needs to make such a recording are a microphone (or some other audio input device, such as a CD player) and a sound card that translates the electrical signal from the microphone into a digitized form that the computer can store and process. Sound cards can also translate digitized sounds back into analog signals that can then be sent to the speakers.

Microphones are used in many applications such as telephones, tape recorders, hearing aids, motion picture production, live and recorded audio engineering, megaphones, in radio and television broadcasting and in computers for recording voice, speech recognition, VoIP, and for non-acoustic purposes such as ultrasonic checking or knock sensors.

There is also a demand for translating spoken words into text, much as there is a demand for translating handwriting into text. Translating voice to text is a capability known as **voice recognition** (or speech recognition). With it, one can speak to the computer rather than having to type. The user can also control the computer with oral commands, such as "shut down" or "print status report".

* www.wikipedia.org

Voice recognition software takes the smallest individual sounds in a language, called phonemes, and translates them into text or commands. Even though English uses only about 40 phonemes, a sound can have several different meanings ("two" versus "too," for example) making reliable translation difficult.

Figure 1.1.9: Microphone*

1.1.10 Digitizing Tablets: It is also known as graphics tablet which is a computer input device that allows hand-draw images and graphics, similar to the way one draws images with a pencil and paper. These tablets may also be used to capture data or handwritten signatures. It can also be used to trace an image from a piece of paper which is taped or otherwise secured to the surface. Capturing data in this way, either by tracing or entering the corners of linear poly-lines or shapes is called digitizing.

A graphics tablet consists of a flat surface upon which the user may "draw" or trace an image using an attached stylus, a pen-like drawing apparatus. The image generally does not appear on the tablet itself but, rather, is displayed on the computer monitor.

Figure 1.1.10: Digitizing Tablets*

1.1.11 MIDI Devices: MIDI (Musical Instrument Digital Interface) is a system designed to transmit information between electronic musical instruments. A MIDI musical keyboard can be attached to a computer and allow a performer to play music that is captured by the computer system as a sequence of notes with the associated timing (instead of recording digitized sound waves).

Figure 1.1.11: MIDI Controller*

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*www.wikipedia.org

* www.wikipedia.org

1.1.12 Display Devices: Virtually everyone who interacts with a computer system today uses some type of display device. These peripheral hardware units consist of a television like viewing screen, to which computer output is sent. The two most common types of display devices found today are monitors and terminals.

Monitors are the devices found most commonly with microcomputer systems. As mentioned previously, a monitor is just a "box with a viewing screen". On the screen, the user is able to see not only what is entered into the computer, but the computer output as well.

A **computer terminal** or video display terminal (VDT) generally combines input and output functions. It consists of a QWERTY keyboard for inputting information direct to the computer, and either a printer or a TV screen for displaying information from the computer. Terminals are most commonly found in settings that are remote from the main computer and they interact with the computer through communications lines or networks. Airline agents are familiar examples of people who use communications terminals. Tellers in banks and cashiers in many retail settings also use terminals to perform their work duties.

There can be several types of terminals as discussed below:

Dumb terminal: It is an input/output (I/O) device that provides for data entry and information exit when connected to a computer but has no additional capability.

Intelligent terminal: It has an in-built processing capability. It is also user-programmable. It contains not only a storage area but also a microprocessor. The terminal can be programmed to communicate with and instruct the user who is entering data. It can also do some processing of the data internally such as sorting, summarizing, checking both input and computed values for reasonableness and so on, rather than relying on the mini-computer or the main-frame CPU. This feature can reduce the load on the central CPU. Thus, intelligent terminals can be used on a stand-alone basis or can be part of a distributed network of terminals. The cost of Intelligent terminals are several times more than non-intelligent terminals but the savings they provide for many companies is much more than their cost. Savings come about because the amount of data to be transmitted to the central CPU and the number of times it is interrupted are both reduced. Intelligent terminals also provide a type of back up to the main computer because the terminal can handle some of the processing.

Smart terminal: It additionally, contains a microprocessor and some internal storage. They have data editing capability and can consolidate input data before sending it to CPU. These terminals are non-programmable by users.

Remote job terminal (also referred to as Remote Job entry or RJE): It groups data into blocks for transmission to a computer from a remote site. Some RJE terminals have the capability of receiving back and printing the results of the application program. Such a unit is in itself a small computer, which can be used either as job entry terminal or as a stand-alone computer. A terminal may be situated at the computer site or situated at a remote place where the data to be input is more readily available. Terminals linked to the computer system by a direct cable are known as *hard-wired terminals.* However, for remote terminals, communication to the main system can be established via *telecommunication* lines such as ordinary telephone lines.

Keyboard printer terminal: The keyboard printer terminal or *teletypewriter* consists of a keyboard for sending information to the computer and a printer, for providing a copy of the input and for receiving information from the computer. The output is normally typed on a continuous role of paper at speeds typically between 20 to 50 characters per second. A paper tape reader/punch is sometimes incorporated in the design of a terminal to enable information to be keyed in and punched on to paper tape for retention of data or for subsequent input to the computer. In place of the paper tape reader/punch, some more recently designed machines may have magnetic tape cassettes incorporated for the same purpose.

Hundreds of different display devices are now available. Although a number of important features distinguish one display device from another, the three that follow are among the most significant.

Figure 1.1.12: Computer terminals*

(a) Screen Resolution: One of the most important features used to differentiate display devices is the clarity, or resolution, of the images that are formed on the screen. Most display devices form images from tiny dots, called pixels that are arranged in a rectangular pattern. A pixel is a single point in a graphic image. Graphics monitors display pictures by dividing the display screen into thousands (or millions) of pixels, arranged in rows and columns. The pixels are so close together that they appear connected. The more dots that are available to display any image on the screen, the sharper the image (the greater the resolution) is. The quality of a display system largely depends on its resolution, how many pixels it can display, and how many bits are used to represent each pixel.

Images are formed on monitor's screen by a card called the display adaptor card. If a user wishes to change the kind of display, e.g., from black and white to color, the display adaptor card must be changed. The key elements of display adaptor card are the video controller and the memory. A variety of display adaptor cards exist in the market, each with its own special features. Some of the popular display adaptors reported by personal computers are discussed below:

1. MGA- MGA or Monochrome Graphics Adapter is one of first adapters. It is a text -only adapter which generates very clear, easy-to-read characters. It works only with monochrome monitor.
2. CGA - CGA or Color Graphics Adapter works in both text and graphics mode. It supports both

* www.rockfordfosgate.com & www.tekscope-museum.de

color and monochrome modes with various resolutions. However, it has relatively poor display quality in text mode. A CGA adapter provides following two combinations of resolutions

(i) 640 x 200 pixels with 16 colors.

(ii) 320 x 200 pixels with 4 palettes.

Each of these palettes has 4 different colors. Only one palette can be used at a given time.

3. EGA- An EGA or Enhanced Graphics Adapter combines all features of a MGA & CGA with higher resolutions. It supports up to 16 colours at a time. An EGA usually has a high resolution of either 640 x 200 pixels or 640 x 350 pixels.
4. VGA - VGA or Video Graphics Adapter is a high quality graphics adapter which provides upto 256 colors and also a high resolution. Following are the two typical combinations of resolutions and colors that a VGA provides.

   (i) 640 x 480 pixels with 16 colors.

   (ii) 320 x 200 pixels with 256 colors.
5. SVGA- SVGA or Super Video Graphics adapter is an improvement on the VGA. The two combinations of resolutions and colors provided by SVGA are

   (i) 640 x 480 pixels with 256 colors.

   (ii) 1024 x 480 pixels with 16 colors

Beside these early versions of Super Video Graphics Adapter(SVGA), variations include Wide SVGA (WSVGA) ,eXtended GA(XGA), Super eXtended GA(SXGA), Wide eXtended GA(WXGA), and UXGA which are commonly used technology ranging from 1024 x 600 pixels to 1600 x 1200 pixels that covers a wide range of computer display standards now-a-days.

Digital monitors such as small flat panel LCD monitors comes in usually XGA, SXGA and other formats. These monitors usually have resolution rates of either 1024 x 768 or 1280 x 800. While digital computer monitors can handle the enhanced resolution, it is up to the end user to choose the settings. Many people choose a SVGA setting of only 800 x 600 resolutions.

Digital TV sets such as HDTV sets have increased screen resolution. Because HDTV sets can handle more lines per screens, their image quality is dramatically increased.

(b) Text and Graphics: Many display devices made today (principal exceptions are inexpensive terminals such as those used in dedicated transaction processing applications) can produce both text and graphics output. Text output is composed entirely of alphabetic characters, digits, and special characters. Graphics output includes such images as drawings, charts, photographs, and maps.

Display devices that are capable of producing graphics output commonly employ a method called **bit mapping**. Bit-mapped devices allow each individual pixel on the screen to be controlled by the computer. Thus, any type of image that can be formed from the rectangular grid of dots on the screen (for example, a 640 x 480 grid) is possible. Character-addressable devices are not bit-mapped and partition the screen into standard character widths, for example, a series of 5 x 7 dot widths, used to display text.

Perhaps the most important business related use for graphics is presentation graphics. Presentation graphics enable managers to easily construct such information intensive images as bar charts, pie charts, and line charts on their display devices and have these images sent to a printer, plotter, or slide-making machine so that they can be used later for presentations in meetings. Because these types of graphical images are relatively simple, a super high resolution workstation that can display photographs and sophisticated artwork is not needed.

Graphics display devices have been widely used for many years in the engineering and scientific disciplines. The display devices used for applications in these areas are extremely sophisticated and expensive.

(c) CRT versus Flat-Panel: Most of the display devices used today is of the cathode ray tube (CRT) type. These devices use a large tube type element that looks like the picture tube in a standard TV set. Inside the tube is a gun that lights up the phosphorescent pixels on the screen surface. Although CRT technology is relatively inexpensive and reliable, CRT-type display devices are rather bulky and limited in the resolution that they provide.

Currently challenging the CRT in the display device marketplace is the flat-panel display. The most common of these devices use either a liquid crystal display (LCD) or gas-plasma technology. To form images, LCD devices use crystalline materials sandwiched between two panes of glass. When heat or voltage is applied, the crystals line up. This prevents light from passing through certain areas and produces the display. Gas-plasma displays, which provide better resolution but are more expensive than liquid crystal displays, use gas trapped between glasses to form images.

The biggest advantage of flat-panel displays is that they are lightweight and compact. This makes them especially useful for laptop, notebook, and pocket personal computers.

The Video Controller: As mentioned earlier, the quality of the images that a monitor can display is defined as much by the video controller as by the monitor itself. The video controller is an intermediary device between the CPU and the monitor. It contains the video-dedicated memory and other circuitry necessary to send information to the monitor for display on the screen. It consists of a circuit board, usually referred to simply as a card ("video card" and "video controller" mean the same thing), which is attached to the computer's motherboard. The processing power of the video controller determines, within the constraints of the monitor, the refresh rate, the resolution, and the number of colors that can be displayed.

The result of these processing demands is that video controllers have increased dramatically in power and importance. There is a microprocessor on the video controller, and the speed of the chip limits the speed at which the monitor can be refreshed. Most video controllers today also include at least 128 MB of video RAM, or VRAM. (This is in addition to the RAM that is connected to the CPU.)VRAM is "dual-ported," meaning that it can send a screenful of data to the monitor while at the same time receiving next screenful of data from the CPU. It's faster and more expensive than DRAM (Dynamic RAM). Users with larger monitors or with heavy graphics needs usually will want even more than 128 MB that can go upto 4 GB of VRAM.

1.2 Direct Data Entry

Direct Data Entry (DDE) refers to entry of data directly into the computers through machine readable source documents. DDE does not require manual transcription of data from original paper documents. DDE devices can scan source documents magnetically or optically to capture data for direct entry into the computer. Magnetic ink character readers and optical character readers are examples of such devices.

We will now describe each of the above devices.

1.2.1 Magnetic Ink Character Recognition (MICR): MICR employs a system of printed characters which are easily decipherable by human beings as well as a machine reader. These character recognition techniques uses special printing font to represent characters. In this font, each character is basically composed of vertical bars as shown in the figure. The characters are printed in special ink, which contains a magnetizable material. In Figure 1.2.1, there are four small gaps and two big gaps.

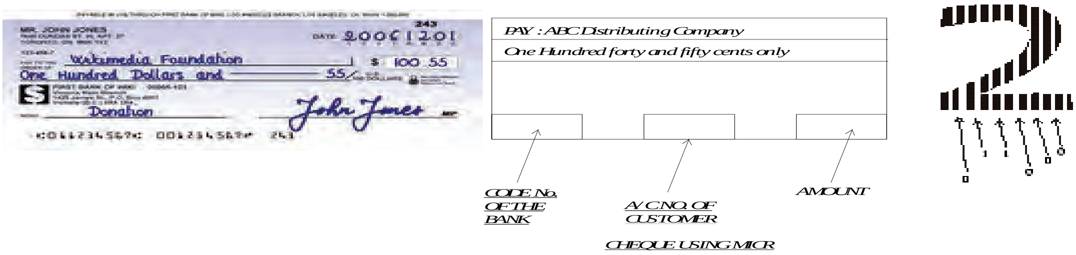

Figure 1.2.1: Cheque using MICR*

When a character is subsequently read it is passed beneath a reading head and big and small gaps send in different types of impulses represented by 1 bit and 0 bit respectively. The use of magnetic printing allows the characters to be read reliably even if they have been overprinted or obscured by other marks, such as cancellation stamps. The error rate for the magnetic scanning of a typical cheque is smaller than with optical character recognition systems. For well printed MICR documents, the "can't read" rate is usually less than 1% while the substitution rate (misread rate) is in the order of 1 per 100,000 characters.

This method is primarily used in banking industry, and most cheques are now processed under the MICR approach. The data printed across the bottom of a blank cheque are recorded in MICR form; the characters represent the bank on which the cheque is drawn, the customer's account number and the amount of the cheque.

MICR data are used for input purposes. Unlike other media (floppy disk and magnetic disk), MICR can not be used for output purposes.

***Advantages of MICR*:**

(*i*) MICR possesses a very high reading accuracy. Cheques may be smeared, stamped, roughly handled yet they are accurately read.

* www.wikipedia.org

(*ii*) Cheques can be handled directly without transcribing them on floppy disk, magnetic tape etc.

(*iii*) Cheques can be read both by human beings and machines.

***Disadvantages of MICR*:**

(*i*) MICR has not found much favour from business.

(*ii*) Damaged documents, cheques not encoded with amount etc. have still to be clerically processed.

(iii) MICR readers and encoders are expensive.

1.2.2 Optical Character reading (OCR): It employs mechanical or electronic translation of scanned images of handwritten, typewritten or printed text into machine-encoded text. It is widely used to convert books and documents into electronic files, to computerize a record-keeping system in an office, or to publish the text on a website. Through OCR, it is possible to edit the text, search for a word or phrase, store it more compactly, display or print a copy free of scanning artifacts, and apply techniques such as machine translation, text-to-speech and text mining to it.

OCR also employs a set of printing characters with standard font that can be read by both human and machine readers. The machine reading is done by light scanning techniques in which each character is illuminated by a light source and the reflected image of the character is analyzed in terms of the light-dark pattern produced.

Optical character readers can read upper and lower case letters, numerics and certain special characters from handwritten, typed and printed paper documents. The specific characters that can be read and whether the characters must be handwritten, typed or printed depend upon the type of OCR being used. Obviously OCR annihilates the time consuming step of transcription.

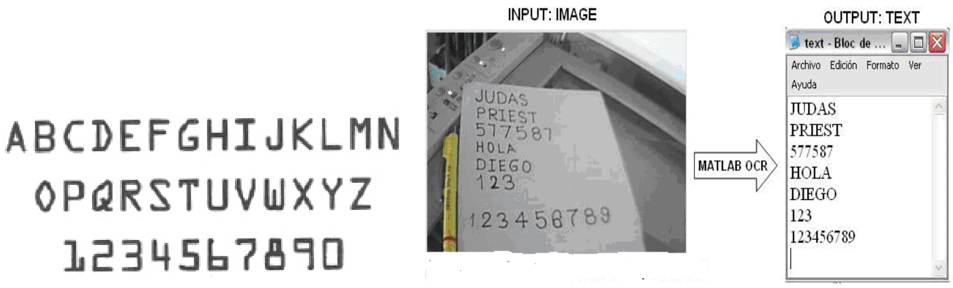

Figure 1.2.2: OCR System*

The optical character readers have slightly irregular type face and some handwritten characters that can be read by the recognition devices. Most optical character readers can be used to sort out forms as well as to read data into computer storage as shown in the figure1.2.2. They can read the characters printed by computer printers, cash registers, adding

* * www.wikipedia.org

machines and typewriters. Some readers can also read hand-written documents.

Large volume billing applications (*e.g.* the bills of utility companies, credit-card organisations, and magazine subscription outfits) increasingly are being adapted to OCR methods. The customer returns the paid bill, which has OCR data (*e.g.* customer number and amount of the bill) recorded on it, along-with payment to the billing organisation. Thus, the billing organization's bill (or the part returned by the customer) becomes input for recording cash payments received from the customer. This procedure sometimes referred to as the use of "**turn-around documents**" has the advantage of minimizing or eliminating the keying process when cash receipts are received from customers.

Today OCR software and ICR Software technology are analytical artificial intelligence systems that consider sequences of characters rather than whole words or phrases. Based on the analysis of sequential lines and curves, OCR and ICR make 'best guesses' at characters using database look-up tables to closely associate or match the strings of characters that form words.

Advantages of OCR

(i) OCR eliminates the human effort of transcription.

(ii) Paper work explosion can be handled because OCR is economical for a high rate of input.

(iii) Since documents have only to be typed or handwritten, not very skilled staff (like the keypunch operators) is required.

(iv) Furthermore, these input preparation devices (typewriters etc.) are much cheaper than the keypunch or the key-to-tape devices.

Limitations of OCR

(i) Rigid input requirements - There are usually specific (and rather inflexible requirements for type font and size of characters to be used. In typing there is always the scope for strike-over, uneven spacing, smudges and erasures; and the form design, ink specifications, paper quality, etc. become critical and have to be standardized.

(ii) Most optical readers are not economically feasible unless the daily volume of transactions is relatively high. However, further developments in OCR are likely to make optical readers much cheaper.

OCR characters can be sent as input to the CPU. Also, printers can be used to generate OCR output. Optical character readers can read from both cut form and continuous sheets.

1.2.3. **Optical Mark Recognition (OMR):** It is the process of capturing human-marked data from document forms such as surveys and tests. Optical marks are commonly used for scoring tests. The optical mark reader when on-line to the computer systems can read up to 2,000 documents per hour. Seemingly this rate is slow but the fact that transcription has been eliminated, the overall time is less than those of the conventional file media.

OMR can also be used for such applications as order writing, payroll, inventory control, insurance, questionnaires, etc. However, it is to be noted that designing the documents for OMR is rather a tough task. They should be simple to understand otherwise errors may result more perhaps than would occur in using traditional source documents and keypunching from them.

Earlier, Optical Mark Recognition systems were designed to use dedicated scanners and special pre-printed forms with drop-out colors and registration marks. But today, OMR software makes OMR possible on a desktop computer by using an image scanner to process surveys, tests, attendance sheets, checklists, and other plain-paper forms printed on a laser printer. The use of OMR is not only limited to schools or data collection agencies; many businesses and health care agencies use OMR to streamline their data input processes and reduce input error .

There are also some limitations to OMR. If the user wants to gather large amounts of text, then OMR complicates the data collection. There is also the possibility of missing data in the scanning process, and incorrectly or unnumbered pages can lead to their being scanned in the wrong order. Also, unless safeguards are in place, a page could be rescanned providing duplicate data and skewing the data. For the most part OMR provides a fast, accurate way to collect and input data; however, it is not suited for everyone’s needs.

As a result of the widespread adoption and ease of use of OMR, standardized examinations consist primarily of multiple-choice questions, changing the nature of what is being tested.

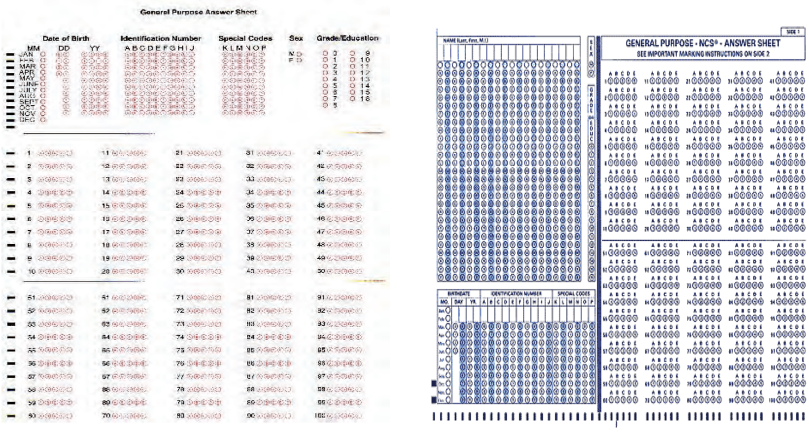

Figure 1.2.3: Optical Mark Recognition*

Technical details of optical scanning: In all optical readers, the printed marks and/or characters must be scanned by some type of photo-electric device, which recognizes characters by the absorption or reflectance of light on the document (characters to be read are non-reflective).Reflected light patterns are converted into electric impulses, which are

* www.wikipedia.org

transmitted to the recognition logic circuit — there they are compared with the characters the machine has been programmed to recognize, and, if valid, are then recorded for input to the CPU. If no suitable comparison is possible, the document may be rejected.

1.2.4 Smart Card Systems- Smart cards resemble credit cards in size and shape; however, they contain a microprocessor chip and memory, and some include a keypad as well. These were pioneered in France and many organizations are still just experimenting with them. In many instances, smart cards make it possible for organizations to provide new or enhanced services for customers.

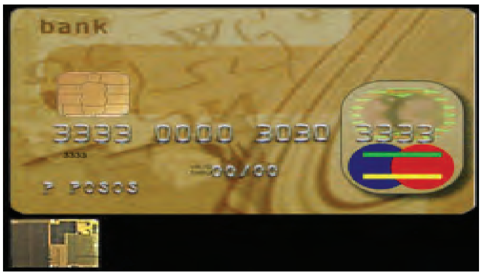

Figure 1.2.4: Smart Card*

So far, smart cards are used most frequently to make electronic purchases and to electronically transfer funds between accounts. However, the potential applications for these are abound. For example, in the health care industry, smart cards could be used to store the holder's identity, address, insurance data, relatives' details, allergies, and even a brief medical history. If the cardholder was disabled by an accident or illness, the card could be used immediately to assist with treatment. Smart cards could also be used for security applications. For example, a card could contain the digitized fingerprint of the cardholder, which could be compared at a security checkpoint to fingerprints of people who are authorized to enter a secured area.

1.2.5 Bar Code Reader: The most widely used input device after the keyboard and mouse is the bar code reader commonly found in supermarkets and departmental stores. These devices convert the bar code, which is a pattern of printed bars on products, into a product number by emitting a beam of light – frequently a laser beam – which reflects off the bar code image. A light-sensitive detector identifies the bar code image by recognizing special bars at both ends of the image. Once the detector has identified the bar code, it converts the individual bar patterns into numeric digits. The special bars at each end of the image are different, so the reader can tell whether the bar code has been read right side up or upside down.

* www.wikipedia.org

Figure 1.2.5: Bar Code Reader*

After the bar code reader has converted a bar code image into a number, it feeds that number to the computer, just as though the number had been typed on a keyboard.

Bar codes provide the advantages of improved accuracy of data entry, better customer service through faster checkout at the point of sale, and greater control and reliability of inventory records. They are used in industries and organizations that must count and track inventory, such as retail, medical, libraries, military and other government operations, transportation facilities, and the automobile industry. There are five basic kinds of barcode readers - pen wands, slot scanners, Charge-Couple Device (CCD) scanners, image scanners, and laser scanners.

- A pen wand is the simplest barcode reader. It contains no moving parts and is known for its durability and low cost. A pen wand can present a challenge to the user, however, because it has to remain in direct contact with the bar code, it must be held at a certain angle, and has to be moved over the bar code at a certain speed.
- A slot scanner remains stationary and the item with the bar code on it is pulled by hand through the slot. Slot scanners are typically used to scan bar codes on identification cards.
- A CCD scanner has a better read-range than the pen wand and is often used in retail sales. Typically, a CCD scanner has a "gun" type interface and has to be held not more than one inch from the bar code. Each time the bar code is scanned; several readings are taken to reduce the possibility of errors. A disadvantage of the CCD scanner is that it cannot read a bar code that is wider than its input face.
- An image scanner, also called a camera reader, uses a small video camera to capture an image of the bar code and then uses sophisticated digital image processing techniques to decode the bar code. It can read a bar code from about 3 to 9 inches away and generally costs less than a laser scanner.
- A laser scanner, either hand-held or stationary, does not have to be close to the bar code in order to do its job. It uses a system of mirrors and lenses to allow the scanner to read the bar code regardless of orientation, and can easily read a bar code up to 24 inches away. To reduce the possibility of errors, a laser scanning may perform up to 500 scans per second. Specialized long-range laser scanners are capable of reading a bar code up to 30 feet away.

Two-dimensional (2D) bar codes have been developed that store the equivalent of two text pages in the same amount of space as a traditional UPC. One of the first uses of 2D bar coding was handing barrels of hazardous toxic waste. Now it is commonly used in a variety of industries. For example, every shipping carton sent to one of Wal-Mart's distribution centers must have a 2D bar code. The bar code contains the purchase order, stock numbers, the contents of each box, a product's origin, its destination, and how it should be handled during shipping. These bar codes automate many of the mundane and time-consuming shipping tasks.

1.2.6 Image Processing (Data scanning devices): Image Processing captures an electronic image of data so that it can be stored and shared. Imaging systems can capture almost anything, including key stroked or handwritten documents (such as invoices or tax returns), flowcharts, drawings, and photographs. Image scanners are optical scanners that use optical technology for processing of data in electronic form. Two commonly used images scanners are: Flat bed and Hand held scanner. Many companies that use document imaging are making significant progress toward paperless offices. There are five distinct steps to document imaging:

Step1: **Data capture.** The most common means of converting paper documents into electronic images is to scan them. The scanning device converts the text and pictures into digitized electronic code. This scanner can range from a simple hand held device to a high-end, high-speed scanner capable of scanning more than 2,500 pages an hour. *Hand held scanners* could transform text or graphical images into machine-readable data. Organisations such as publishers and law firms, that frequently receive documents, may use such scanners to convert the typed pages into word processing files. These can also be used for entering logos and other graphics for desk top publishing application. Fax modems are also used to receive electronic images of documents. Some of today's low speed printers and fax machines have removable print heads that can be replaced with a scanning head, enabling the printer to work as an image scanner.

Step2: **Indexing**. Document images must be stored in a manner that facilitates their retrieval. Therefore, important document information, such as purchase order numbers or vendor numbers, is stored in an index. Great care is needed in designing the indexing scheme, as it affects the ease of subsequent retrieval of information.

Step 3: **Storage.** Because images require a large amount of storage space, they are usually stored on an optical disk. One 5.25-inch optical platter can store 1.4 gigabytes, or about 25,000 documents (equivalent to 3 four-drawer filing cabinets). A 12-inch removable optical disk stores up to 60,000 documents, and up to 100 optical disks can be stored in devices called jukeboxes.

Step 4: **Retrieval**. Keying in any information stored in an index can retrieve documents. The index tells the system which optical disk to search and the requested information can be quickly retrieved.

Step 5: **Output**. An exact replica of the original document is easily produced on the computer's monitor or on paper, or is transmitted electronically to another computer.

Advantages of Image Processing: It has been estimated that 90% of the work accountants and others do today is done using paper. It is also estimated that the volume of information required by companies doubles every three or four years. As a result we are faced with being buried by paper. One solution is to make better use of document imaging. More companies are moving to this technology and it is estimated that by 2020 only 20% of our work will be paper-based; 80% will be electronic. The move to document imaging provides the following advantages:

(i) ***Accessibility***: Documents can be accessed and reviewed simultaneously by many people, even from remote locations.

(ii) ***Accuracy****:* Accuracy is much higher because costly and error-prone manual data-entry processes are eliminated.

(iii) ***Availability****:* There are no more lost or misfiled documents.

(iv) ***Capacity****:* Vast amounts of data can be stored in very little space, which significantly reduces storage and office space.

(v) ***Cost****:* When large volumes of data are stored and processed, the cost per document is quite inexpensive. As a result, the costs to input file, retrieve, and re-filing of documents are reduced significantly.

(vi) ***Customer satisfaction****:* When waiting time is significantly reduced (due to lost or misfiled documents, queue time, etc.), customers can get the information almost immediately.

(vii) ***Security****:* Various levels of passwords (network, data base, files, etc.) and clearances can be assigned to restrict document access.

(viii) ***Speed****:* Data can be retrieved at fantastic speeds. Stored documents can be indexed using any number of identifying labels, attributes, or keywords.

(ix) ***Versatility****:* Handwritten or types text can be added to an image, as can voice messages. Documents can be added to word processing files; the data can be included in a spreadsheet or data base.

1.3 Types of Computer Output

Computer Output devices are pieces of computer hardware that allow a computer system to communicate information to a user or another system. This information can be in any form, and includes sound, images, written documents etc. Output devices can usually only be used to send data from the computer; items called input devices allow users and other systems to send data to the computer.

Some of the most common output devices allow computers to present information visually. The visual display unit called a monitor that can be found connected to almost every personal computer is the best example of this. Text, pictures, and other images are displayed on the monitor, allowing users to interact with computer programs and receive data. Video projectors are another type of output device. They function in a way similar to monitors, but display images over a much larger area. Computer printers are another type of output device that can be easily found. Printers allow the computer to produce documents, pictures, and images on paper through the use of inks and other dyes.

Audio output devices are also common. Computer speakers are the primary source of this form of output. They allow the computer to emit sounds that include music, audio tracks to digitized television shows, and even the voices of other users. Headphones also do the same thing, but are placed closer to the ears so that the sounds can not be heard by others.

The various types of output from a computer system may be chosen from the following list according to specific requirements:

- Monitors
- Printers
- COM(Computer Output on Microfilm)
- Audio System (Speaker)
- Graphical

1.3.1 Monitors: A monitor is also called as video display terminal (VDT). The visual display of the processed data, which the users can view, is got through the monitor. Computer monitors come in a variety of screen sizes. There are two types of computer monitors available, namely CRT and Flat panel. CRT stands for *cathode ray tube*, describing the technology inside an analog computer monitor or television set. The CRT monitor creates a picture out of many rows or lines of tiny colored dots. These are technically not the same thing as pixels, but the terms are often used interchangeably. The more lines of dots per inch, the higher and clearer the resolution is. Therefore, 1024 x 768 resolutions will be sharper than 800 x 600 resolutions because the former uses more lines creating a denser, more detailed picture. Higher resolutions are important for displaying the subtle detail of graphics.

The *refresh rate* indicates how many times per second the screen is repainted. Though, monitors differ in their capabilities, lower resolutions normally have higher refresh rates because it takes less time to paint a lower resolution. Therefore, a setting of 800 x 600 might have a refresh rate of 85 Hz, (the screen will be repainted or refresh 85 times per second), while a resolution setting of 1024 x 768 may have a refresh rate of 72 Hz. Still higher resolutions usually have refresh rates closer to 60 Hz. Anything less than 60 Hz is generally considered inadequate, and some people will detect "flicker" even with acceptable refresh rates. Generally speaking, high-end monitors have higher refresh rates overall than lower-end models.

Flat panel displays (usually called **Flat screen**) encompass a growing number of technologies enabling video displays that are much lighter and thinner than traditional television and video displays that use cathode ray tubes, and are usually less than 100 mm (4 inches) thick. They can be divided into two general categories; *volatile* and *static*. The first ever flat panel television was introduced in 1998 by Philips. LCD monitors and plasma television sets, or *flat panel* displays, use newer digital technologies.

All monitors rely on a video card, which is located on the motherboard to display the information. It is the video card, which processes the data into images, which is eventually displayed on the monitor.

Figure 1.3.1: Flat panel and CRT monitor*

Advantages and imitations of CRT, LCD and Plasma display devices

CRT	LCD	Plasma
Advantages 1. Having high dynamic range of colors, wide gamut and low black level. 2. It can display natively in almost any resolution and refresh rate. 3. It has low response time generally in Sub-milliseconds. 4. It has zero color, saturation, contrast or brightness distortion as well as excellent viewing angle. 5. Usually much cheaper than LCD or Plasma screens.	**Advantages** 1. Very compact and light weighted. 2. Low power consumption. 3. No geometric distortion. 4. Little or no flicker depending on backlight technology.	**Advantages** 1. Compact and light weighted. 2. High contrast ratios, excellent color, wide gamut and low black level. 3. High speed response time. 4. Near zero color, saturation, contrast or brightness distortion as well as excellent viewing angle. 5. No geometric distortion. 6.Highly scalable, with less weight gain per increase in size (from less than 30 inches (760 mm) wide to the world's largest at 150 inches (3,800 mm)).
Disadvantages 1. Large size and weight, especially for bigger screens	**Disadvantages** 1. Limited viewing angle, causing color, saturation,	**Disadvantages** 1. Large pixel pitch, meaning either low resolution or a

* www.elecdoc.com.au

(a 20-inch unit weighs about 20 to 30 Kg). 2. High power consumption. 3. Geometric distortion caused by variable beam travel distances. 4. Older CRTs are prone to screen burn-in. 5. Produces noticeable flicker at low refresh rates.	contrast and brightness to vary, even within the intended viewing angle, by variations in posture. 2. Uneven backlighting in some monitors, causing brightness distortion, especially toward the edges. 3. Slow response times, which cause smearing and ghosting artifacts. Modern LCDs have response times of 8 mini seconds or less. 4. Only one native resolution. Displaying resolutions either requires a video scalar, lowering perceptual quality, or display at 1:1 pixel mapping, in which images will be physically too large or won't fill the whole screen. 5. Fixed bit depth, many cheaper LCDs are incapable of producing true color. 6. In a constant on situation, thermalization may occur, which is when only part of the screen has overheated and therefore looks discolored compared to the rest of the screen.	large screen. 2. Noticeable flicker when viewed at close range. 3. High operating temperature and power consumption. 4. Only has one native resolution. Displaying other resolutions requires a video scalar, which degrades image quality at lower resolutions. 5. Fixed bit depth, many cheaper Plasma are incapable of producing true color. 6. Dead pixels are possible during manufacturing.

1.3.2 Printers: These are most commonly used output devices that are used to get documents print on the paper. It provides the user with a permanent visual record of the data output from the computer. The output printed on the paper is called hard copy. The hard copy is also called as print out. The print out resolution is measured in dots per inch. A printer is connected to a parallel port or a USB port of a system unit by a cable. Printers can print on ordinary paper or on specially prepared forms such as dispatch notes, invoices or packing slips. Printers have been developed that are capable of printing from 150 to 2,500 lines per minute, each line consisting of as many as 150 characters.

The printing mechanism differentiates the printer types from one another. Therefore, printers are classified into 2 categories depending upon their printing mechanisms. These are: impact and non-impact printers. The former are the most common type of printer.

1.3.2.1 Impact printers: Impact printers can be described as printers which utilize some form of striking device to transfer ink from an inked ribbon onto the paper being printed to form images or characters. The characters printed are formed by one of two methods : (*i*) they are either distinct, whole alphanumeric images produced by a process known as full character or formed character printer or, (*ii*) they are formed by a dot matrix method which arranges a series of dots to assume the shape of each character being printed.

Impact printers fall into two basic categories-Serial or Line printing.

(a) Serial Printers: Regardless of which character generation method is used, serial printers print one character at a time, usually from left to right. Some printers, however, can also print in a bidirectional format at an increased speed. In most business organisations two types of serial printers are used:

(i) Dot-matrix Printers: In the early 1970's, a new print system called dot matrix printing was developed for use with data processing systems. These small, compact printers offered high speed, relatively low price and greater programmability for graphics and illustrations due to their method of character generation. They became the standard printers for many minicomputers and nearly all microcomputers and, consequently, were also used for word processing requirements. Dot matrix printers utilize wire needles or pins which strike the ribbon against the paper in the pattern necessary to produce each character image. The printing head is a matrix block which consists of rows and columns of holes through which pins appear. The characters being printed are formed by activating the printing head so that certain pins appear through the holes to from a pattern which resembles each character. The pins are formed into the shape of the character to be printed, then pressed against an inked ribbon and the pattern printed on the paper. The character, whether they are letters, numbers or grammatical symbols are printed as a series of dots which merge together to form the character.

Figure 1.3.2: Dot-matrix printer*

*www.wikipedia.org

The matrices of these printers can vary in size from printer to printer depending on the print quality required. Some may have 11 rows of pins with 9 columns in each row; while others may have as many as 23 rows with 18 columns per row. The characters can, therefore, be formed from matrices using any combination from 99 to 414 dots printed by the pins. The greater the number of dots printed on the paper, the better the quality of the copy. An example of how a lower case letter 'd' is formed is shown in Figure 1.3.3.

```
0 0 0 0 0 0   0 0
0 0 0 0 0 0   0 0
0 0 0 0 0 0   0 0
0 0 0         0 0
0 0   0 0 0   0 0
0 0   0 0 0   0 0
0 0   0 0 0   0 0
0 0   0 0 0   0 0
0 0 0       0 0 0
```

Figure 1.3.3 : Dot Matrix Character Formation*

Dot matrix printers are fast and cheap but their print quality is relatively poor. They are only really suitable for printing draft copies and documents, which are usually retained within an organisation. The printing also varies according to the type of matrix printer used. Most employ an ink ribbon, similar to conventional typewriter ribbons, to print documents. Although not of a high quality, when compared to letter quality printers, dot matrix printers do have the advantage of being able to print a much wider range and size of typeface and, in addition, can print graphs, illustrations and drawings. This type of printer can also be used to print color.

Manufacturers of dot matrix printers include: Brother, Canon, Centronics, Commodore, Epson, Facit, General Electric, Hewlett Packard, Mannesheim Tally, NEC, OKI, Seikosha, Shinwa, Star, and TEC.

(ii) Daisywheel Printers: 'Daisywheel' printers work in a similar manner to an electronic typewriter. The major difference is that they use a new type of printing element called a 'daisywheel'. This is a molded metal or plastic disc-shaped printing element which looks very much like a daisy - hence the name. (See Figure 1.3.4) It is about 65 mm in diameter and has a number of stalks or petals which radiate from a central core. On the end of each stalk is a type character set in a similar manner to the keys as on a typewriter. This type of printer works by rotating the print element until the required character is positioned in front of the sheet of paper at the point where it will be printed.

*www.wikipedia.org

A small hammer hits the back of the stalk forcing that character against an inked ribbon and through onto the paper. All this happens at anything from 10 to 80 characters per second, which is far faster than a typist can type. A similar device shaped like and called a ‘Thimble’ printer is used by the Japanese company NEC on the 'Spinwriter' printer. There printers enable users to change the typeface elements very quickly giving far more scope to the typing of important documents.

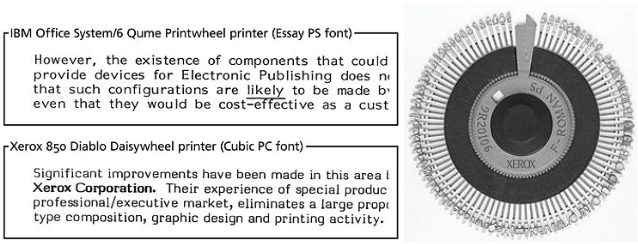

Figure 1.3.4: Daisywheel Printer[*]

Quite recently cheaper daisywheel printers have appeared on the market. Major manufacturers of the daisywheel printers include: Brother, Data point, Diablo, Fujitsu, NEC, Olivetti, Olympia, TEC and Wang etc.

(b) Line Printers: A line printer operates at much higher speeds and prints what appears to be a full line at a time. It is a form of high speed impact printer in which one line of type is printed at a time. They are mostly associated with the early days of computing, but the technology is still in use. The printing can be done at a speed of 600 to 1200 lines-per-minute (approximately 10 to 20 pages per minute) were common. It is a high-speed printer capable of printing an entire line at one time. A fast line printer can print as many as 3,000 lines per minute. Line printers are only used where high speed and volume is necessary rather than quality of printing. The disadvantages of line printers are that they cannot print graphics, the print quality is low, and they are very noisy. Two types of line printers are discussed below:

Figure 1.3.5: Line Printer[**]

(i) Chain Printers: It has a chain that revolves at a constant speed in a horizontal plane. The complete chain has a complement of 48 numbers, alphabets and special symbols cast on 5 times over. It is confronted by a set of as many hammers as the number of print position say,

[*] www.ask.com
[**] www.wikipedia.org

160. These hammers are magnetically controlled. The continuous stationery and ribbon are inter posed between a segment of the chain and the set of hammers. When a required character on the chain faces its print position, the corresponding hammer is actuated. The other variations of chain printers are Band, Bar and Comb printers.

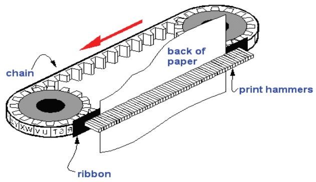

Figure 1.3.6: Chain printer Schematic*

(ii) Drum Printers: These printers use a solid cylinder. There are as many bands on it as the number of print positions. Each band has cast on it the complement of 48 numerals, alphabets and special characters. The drum rotates at a constant speed confronted by a set of as many hammers as the number of bands with the inked ribbon and continuous stationery interposed. In one rotation of the drum there would be appropriate strikes by the set of the hammers. In the first strike A's are printed in the appropriate print positions, followed by B, C, Z, 0, 1.........9 and special symbols one by one.

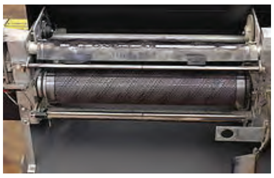

Figure 1.3.7: Drum printer schematic*

Various Characteristics of Printers

(i) ***Speed***: The speed of a printer is measured in terms of cps (characters per second), lps (lines per second) or PPM (pages per minute). The speed of a dot-matrix printer is measured in CPS. While the speed can vary widely, it is generally 200 CPS. A line printer prints a line at a time. Its speed can be any where from 5 to 50 lps.

(ii) ***Quality of output***: Depending on the type of characters formed, printers can be classified as draft, near letter quality (NLQ) or letter quality printers.

- In a *draft quality printer,* a character is formed by arranging dots to resemble it. Although the characters can be distinguished, the output is not as good as that of near letter quality printouts. A dot-matrix printer is an example of a draft printer.
- *Near letter quality printers* use a special character which resembles that of a typewriter. A daisy wheel printer is an example of a NLQ printer. Most dot-matrix printers can also be set to produce near letter quality printouts.

* www.wikipedia.org

- *Letter quality printers* use a character set in which each letter or character is fully formed. The quality of output is the best in such printers. A *laser* printer discussed in next section is an example of a letter quality printer.

(iii) ***Direction***: Printers can be unidirectional or bi-directional. In a unidirectional printer, printing takes place in one direction only. After printing a line from left to right, the print head returns to the left without printing. A bi-directional printer prints both ways.

(iv) ***Capacity***: Most modern printers use FireWire or USB to connect to personal computers. Older printers use serial cable connections, but they did not allow the speed and bandwidth as computer processors grew in speed and hard drives increased in capacity.

(v) ***Buffer***: Printer buffers are used to store print jobs within the printer, freeing up the computer to continue work. With faster computers and larger print file sizes such as photographs, modern computer printers have much larger buffers than their predecessors.

1.3.2.2 Non-impact printers: The printers that produce the output on a paper without striking the paper are known as non-impact printers. They use electro static, chemicals, ink jet and thermal technologies for printing. A non-impact printer forms characters by chemical or electronic means. *Non-impact printers* are the most widely used printers for PCs today. Non impact printers can produce both text and graphics. The main features of non-impact printers are:

- Faster than impact printers.
- Print high quality output.
- Produce no noise during printing.

However, three types of non-impact printers are worth mentioning because they are expected to become more important in the future, as the technology becomes cheaper. These are

- **Thermal printers**
- **Ink-jet printers**
- **Laser printers**

They are fast in operation, printing a page, or even more in a second but currently they are too expensive to be widely used. The laser printer produces very high quality prints from a wide selection of character fonts. Not many business organisations can justify the present high cost of laser printing but costs are falling sharply and laser printing is likely to become more common place. We have discussed below each of these briefly:

(i) **Thermal Printers:** These printers use thermal printing facility i.e. the printer forms each character on the matrix printing head in the normal way but, instead of the printing head being impacted physically against an inked ribbon to print the character, the pins are heated by the electric element and then pressed against the paper. When the pins touch the paper, the area heated by the pins changes color, usually to black or brown to form the character.

Figure 1.3.8: Thermal Printers*

(ii) Ink-Jet Printers: The Inkjet printer is non-impact character printer that prints one character at a time. The Inkjet printer has fine spray nozzles that create the image of character or graphics on the paper (without striking the paper) by spraying tiny or small drops of ink onto the paper.

The print head of Inkjet printer contains ink filled print cartridges. Each cartridge has fifty to several hundreds small ink nozzles. Each nozzle in the printer cartridge is similar to an individual pin on a dot matrix printer. The combination of the nozzles is activated to form the shape of character or image on the paper. Most Inkjet printers have at least 2 print cartridges: one containing black ink and the other containing color. A single cartridge can print upto 300 pages.

Color Inkjet printer has 4 ink nozzles: Blue, Red, Yellow and Black. These 4 colors are used in almost all color printing because it is possible to combine them to create any color. Inkjet printers have become the most popular type of color printers for use in offices and business because of their lower cost.

Figure 1.3.9: InkJet Printer**

The printing quality of Inkjet printer is measured by the number of tiny ink of drops per inch (dpi) it can spray. Most Inkjet printers range from 300 to 2400 dpi. Printers with higher dpi usually are more expensive but having high printing quality.

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* www.zdnet.com
** www.printer-tech.net

The speed of an Inkjet printer is measured by the number of pages per minute (ppm) it can print. It has the capability to print 15 ppm.

An excellent example of such a printer is the Hewlett Packard" Thinkjet" originally developed for the Hewlett Packard HP 150 "Touch-Screen" microcomputer. HP 670C and HP 810C have now been made available for use with the IBM PC and other micro-computers. Other examples include Canon's PJ 1080 A, the Diablo C-150 and the Olivetti Spark Ink Jet Printer, which can operate at 50 lines per minute.

Inkjet printers are very quiet and provide laser-like quality at a much lower cost although supplies are relatively expensive. Although one can print on regular paper, better results are obtained by using special paper that doesn't allow the ink to soak in.

There are two types of inkjet printers:

- *Liquid inkjet:* Color inkjet printers use three separate inkjets, one for each of the primary colors (red, green, and blue) .Liquid inkjet printers use ink cartridges from which they spray ink onto the paper. A cartridge of ink attached to a print head with 50 or so nozzles, each thinner than a human hair, moves across the paper. The number of nozzles determines the printer's resolution. A digital signal from the computer tells each nozzle when to propel a drop of ink onto the paper. On some printers, this is done with mechanical vibrations.
- *Solid inkjet:* Solid inkjet printers use solid ink sticks that are melted into a reservoir and sprayed in precisely controlled drops onto the page where the ink immediately hardens. High- pressure rollers flatten and fuse the ink to the paper to prevent smearing. This produces an exceptionally high-quality image with sharp edges and good colour reproduction. Solid inkjet printers are also the best for producing low-cost but high-quality transparencies. These printers are sometimes referred to as phase-change printers because the ink moves from a solid to a liquid phase to be printed then back to a solid phase on the page. As a final step, the paper moves between two rollers to cold-fuse the image and improves the surface texture.

(iii) Laser Printers: Laser printer uses a combined system which utilizes laser and Xerographic photocopying technology. In a laser printer, a beam from a small laser scans horizontally across a charged xerographic selenium drum to build up an invisible electrostatic image of a whole page of text. Using standard photocopier techniques, the formed image is then transferred to the paper being printed. Toner is attracted to the electrostatic image and it is then permanently fixed using heat. A wide variety of typefaces are available.

Very competitively priced laser printers have been introduced by various companies such as Hewlett Packard. These printers, which can be used by most personal computers and the microcomputers, have an excellent print quality. Laser printer produces not only alphanumeric characters but also drawings, graphics and other requirements. Its output can be very close to professional printing quality. The dots making up the image are so closely spaced that they look like characters typed on a typewriter. The laser printer prints a page at a time. A high-end fast color laser printer will have between 16 PPM and 26 PPM for color prints, and perhaps even higher for black-and-white prints. The resolution of laser printers is measured in dots per inch (DPI). The most common laser printers have resolutions of 600 DPI to 1200 DPI, both horizontally and vertically. Some laser printers have a resolution of 2400 DPI also.

Figure 1.3.10: Laser printer*

Factors determining purchase of printer (laser and inkjet): When deciding between an inkjet and a laser printer, it is a good idea to evaluate several factors before proceeding with the purchase. Here are some things to keep in mind to help users to decide if an inkjet or a laser printer would serve well.

1. One of the main considerations when looking at both inkjet printers and laser printers is the amount of usage one can anticipate with the device. An inkjet printer works very well for relatively low demands that are primarily text documents. Also, usage that may require some type of color on an occasional basis can be handled very well with an inkjet printer. However, inkjets are not designed for a large amount of production each day. Also, the cost of new ink cartridges can be prohibitive when the volume of printing is higher. Ink cartridges for inkjet types of printers simply do not last that long.

   For environments where there will be a high volume of daily usage, there is no doubt that the laser printer is the better option. The laser printer is built to hold up to repeated daily usage and large print jobs. Also, the ink cartridges that are manufactured for the laser type of printer will produce quite a few more pages than the ones created for inkjets. Color is also a factor when it comes to the laser printer. Laser printers simply produce a higher quality of color graphic or image, which make it ideal when the print job involves the printing of sales brochures or a mass mail out to customers. When deciding on whether to purchase an inkjet or a laser printer, volume usage will be a key factor.

2. Another important consideration when choosing between an inkjet and a laser printer is the initial cost. Good quality inkjets can be purchased for a relatively low amount of money. If the budget is tight, going with an inkjet, at least until cash flow improves, may be a wise move. Keep in mind that while the initial purchase is low, replacing the ink

* www.wikipedia.org

cartridges can become cost prohibitive if our average print usage continues to increase over time.

3. Lastly, the type of paper that will be used is also important when deciding whether to purchase an inkjet or a laser printer. A laser printer usually can accommodate various weights of paper with little or no problem. Inkjets tend to work best with standard twenty-weight paper. If the idea is to use the printer to create sales and marketing material, small posters for trade shows, and other print jobs that require a stiffer paper product, then the laser printer is definitely the best option.

A good rule of thumb when it comes to choosing between an inkjet or a laser printer is to remember usage, paper type, and amount of color. If all three of these factors are highly important, then the laser printer is the best choice. For price, low usage, little color and use of only standard paper, then the inkjet printer will work very well.

Other Types of Printer:

Multifunctional Printers (MFP): Short for *multifunction peripheral,* a single device that serves several functions, including printing. Typically, multifunction printers can act as a printer, a scanner, a fax machine and a photocopier. It provides centralized document management/ distribution/production in a large-office setting. These devices are becoming a popular option for SOHO users(Short for *small office/home office*, a term that refers to the small or home office environment and the business culture that surrounds it) because they're less expensive than buying three or four separate devices .A SOHO is also called a *virtual office*.

MFP manufacturers traditionally divided MFPs into various segments. The segments roughly divide the MFPs according to their speed in pages per minute (ppm) and duty cycle/robustness. Despite this, many manufacturers are beginning to avoid the segment definition for their products, as speed and basic functionality alone are often not sufficient to differentiate the many features that the devices are capable of. Two color MFPs of a similar speed will be in the same segment, despite having potentially very different feature sets, and therefore very different prices. Many MFP types, regardless of the category they fall into, also come in a "printer only" variety, which is the same model without the scanner unit included. This is even the case with devices where the scanner unit physically appears to be highly integrated into the product.

Today, Multifunction printers are available from just about all printer manufacturers. They are designed for home, small business, enterprise and commercial use. Naturally, the cost, usability, robustness, throughput, output quality, etc. all vary with the various use cases. However, they all generally do the same functions; Print, Scan, Fax, and Photocopy. In the commercial/enterprise area, most MFP have used Laser Printer technology, while in the personal, SOHO environments, Inkjet Printer technology has been used. Typically Inkjet printers have struggled with delivering the performance and color saturation demanded by enterprise/large business use. However, HP has recently launched a business grade MFP using Inkjet technology.

Figure 1.3.11: Multi Function Printer*

1.3.3 Computer Output Microfilm (Microfiche): Computer output microfilm (COM) is an output technique that records output from a computer as microscopic images on roll or sheet film. The images stored on COM are the same as the images, which would be printed on paper. The COM recording process reduces characters 24, 42 or 48 times smaller than would be produced from a printer. The information is then recorded on sheet film called 16 mm, 35 mm microfilm or 105 mm microfiche.

The data to be recorded on the microfilm can come directly from the computer (online) or from magnetic tape, which is produced by the computer (off-line).The data is read into a recorder where, in most systems, it is displayed internally on a CRT. As the data is displayed on the CRT, a camera takes a picture of it and places it on the film. The film is then processed, either in the recorder unit or separately. After it is processed, it can be retrieved and viewed by the user.

COM has several advantages over printed reports or other storage media for certain applications. Some of these advantages are:

1. Data can be recorded on the film at up to 30,000 lines per minute-faster than all except very high-speed printers.
2. Reader/printer copies of COM images tend to be more legible than traditionally produced microfilm. This means that data is arranged and images are reduced in a consistent manner and reputable standards for pagination, titling, and indexing are followed. Thus it improves the image quality of data storage.
3. Less space is required to store microfilm than printed materials. A microfilm that weighs an ounce can store the equivalent of 10 pounds of paper.
4. Microfilm provides a less expensive way to store data than other media provide.

The major disadvantage of COM systems is that, because of the reduced visual size of the output, special equipment—that is, a microfilm/ microfiche reader—is needed to read the output.

To access data stored on microfilm, a variety of readers are available which utilize indexing techniques to provide a ready reference to data. Some microfilm readers can perform

*www.wikipedia.org

automatic data lookup, called computer-assisted retrieval, under the control of an attached minicomputer. With powerful indexing software and hardware now available, a user can usually locate any piece of data within a 200,000,000 characters database in less than 10 seconds at a far lower cost per inquiry than using an on-line inquiry system consisting of a CRT, hard disk, and computer.

Though both microfilm and microfiche are created on a continuous negative film and one can make as many copies of the film as one desire, there are certain basic differences between the two. The Physical difference between a microfilm and microfiche is that a microfilm stays in a continuous form while a microfiche is cut into pieces. A microfilm is 16 millimeters (mm) or 35 mm roll of film contained in cartridges. Each roll can hold 2,000 to 5,000 pages of information. A microfiche, on the other hand, is 105-mm film cut in 4 × 6 inch sheet, each sheet capable of reproducing up to 270 page sized images. The operational difference between the two is that a microfilm has to be read sequentially until the desired record is retrieved whereas a microfiche allows direct access to data through hunt and storage procedure. For certain applications, COM is a viable way to store and retrieves data.

Figure 1.3.12: COM*

1.3.4 Speaker: Just as microphones are now important input devices, speakers and their associated technology are key output systems. Today, when one buys a multimedia PC, one gets a machine that includes a CD-ROM drive, a high quality video controller (with plenty of VRAM), speakers, and a sound card.

The speakers attached to these systems are similar to ones that are connected to a stereo. The only difference is that they are usually smaller and they contain their own small amplifiers. Otherwise, they do the same thing that any speaker does. They transfer a constantly changing electric current to a magnet, which pushes the speaker cone back and forth. The moving speaker cone creates pressure vibrations - in other words, sound.

The more complicated part of the sound output system is in the **sound card**. The sound card translates digital sounds into the electric current that is sent to the speakers. Sound is defined as air pressure varying over time. To digitize sound, the waves are converted to an electric current measured thousands of times per second and recorded as a number. When the sound is played back, the sound card reverses this process, translating the series of numbers into electric current that is sent to the speakers. The magnet moves back and fourth with the changing current, creating vibrations.

*www.wikipedia.org

Figure 1.3.13: Speaker*

1.3.5 Graph Plotter: A graph plotter is a device capable of tracing out graphs, designs and maps into paper and even into plastic or metal plates. A high degree of accuracy can be achieved, even upto one thousandth of an inch. Plotters may be driven *on-line or off-line*. Computer systems dedicated to design work often operate plotter on-line but systems used for other applications as well as graphic applications operate them off-line. There are two types of plotters:

Figure 1.3.14: Graph Plotter**

Drum : A drum plotter plots on paper affixed to a drum. The drum revolves back and forth, and a pen suspended from a bar above moves from side-to-side taking up new plot positions or plotting as it moves. This device is suitable for routine graph plotting and also for fashion designs.

Flat-bed: On a flat-bed plotter, the paper lies flat. The bar on which the pen is suspended itself moves on a gantry to provide the necessary two-way movement. Colour plotting is usually possible.

Plotters are now increasingly being used in application like CAD, which requires high quality graphics on paper. A plotter can be connected to a PC through the parallel port. A plotter is more software dependent than any other peripheral, and needs much more instructions than the printer for producing output.

Many of the plotters now available in the market are desktop models that can be used with PCs. Business generally use plotters to present an analysis in visual terms (bar charts, graphs, diagrams) etc. as well as for engineering drawings.

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*www.wikipedia.org

** www.aykzj.com

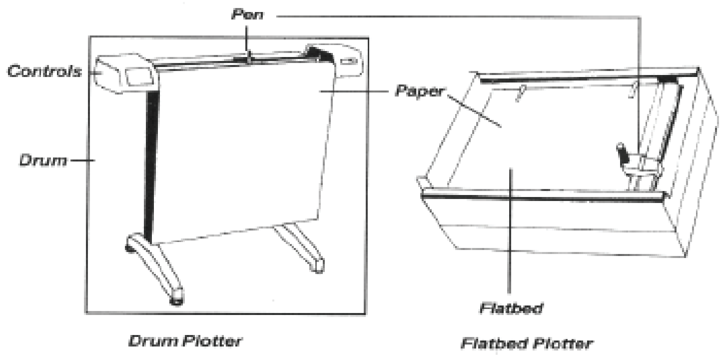

Figure 1.3.15: Drum and Flat-bed Graph Plotter

Summary

The second unit of this chapter introduces different types of Input and Output devices available in the market and how they are suited to user's requirements. Various features, functionality and usage of commonly used input devices are discussed in detail. Besides these, Direct Data Entry Devices most frequently used in banking, retail, insurance, education etc. sectors have been discussed in detail. This unit explains various technical details about commonly used output devices like printer and monitor. The viability of using output devices by the users in different perspectives have been explained in detail.

UNIT 3 : SOFTWARE

What is Software?

Software is a term used for the various kinds of programs, used to operate computers and related devices. It is different from the term hardware which describes the physical aspects of computers and related devices. A set of instructions is called a computer *program*. Software refers to the set of computer programs, procedures that describe the programs, how they are to be used. We can say that it is the collection of programs, which increase the capabilities of the hardware. Software guides the computer at every step where to start and stop during a particular job. The process of software development is called *programmin*g.

Software can be thought of as the variable part of a computer and hardware the invariable part. Software is often divided into **Application software** (programs that do work users are directly interested in) and **System Software** (which includes operating systems and any program that supports application software). The term middleware is sometimes used to describe programming that mediates between application and system software or between two different kinds of application software (for example, sending a remote work request from an application in a computer that has one kind of operating system to an application in a computer with a different operating system).

Computer software is the collection of computer programs and related data that provide the instructions to the computer what to do. In contrast to hardware, software is intangible that cannot be touched. Software is also sometimes used in a more narrow sense, meaning application software only. Sometimes the term includes data that has not traditionally been associated with computers, such as film, tapes, and records.

There are basically three types of software: Systems software, Applications software and General purpose software. We will now discuss each of these in detail.

1.1 Systems Software

It comprises of those programs that control and support the computer system and its data processing applications. **System software** is computer software designed to operate the computer hardware and to provide and maintain a platform for running application software. Therefore system software may be defined as a set of one or more programs designed to control the operation of computer system.

System software helps use the operating system and computer system. It includes diagnostic tools, compilers, servers, windowing systems, utilities, language translator, data communication programs, database systems and more. The purpose of system software is to insulate the application programmer as much as possible from the details of the computer, especially memory and other hardware features, and devices like printers, readers, displays, keyboards, etc.

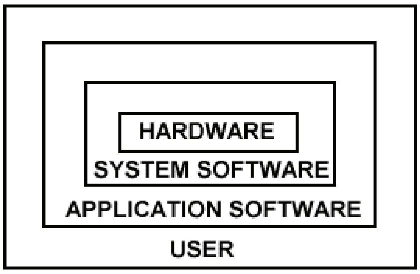

Figure 1.1.1: System Software Architecture

It includes the following:

- Programming languages.
- Operating systems.
- Device Drivers.
- Utility programs.
- Language translators.

They are general programs designed for performing tasks such as controlling all operations required to move data into and out of the computer. Also system software is essential for the development of applications software. System Software allows application packages to be run on the computer with less time and effort. *Without system software, application software can not run.*

Development of system software is a complex task and it requires extensive knowledge of computer technology. Due to its complexity it can not be developed in-house. Computer manufactures build and supply system software with the computer system. DOS, UNIX and WINDOWS are some of the widely used system software. Out of these UNIX is a multi-user operating system whereas DOS and WINDOWS are PC-based.

Now we will discuss each of the aforesaid software in detail.

1.1.1 Programming Languages: Programming Languages are vocabulary and set of grammatical rules for instructing a computer to perform specific tasks. The term *programming language* usually refers to high-level languages, such as BASIC, C, C++, COBOL, FORTRAN, Ada, and Pascal. Each language has a unique set of keywords (words that it understands) and a special syntax for organizing program instructions.

High-level programming languages, while simple compared to human languages, are more complex than the languages the computer actually understands, called *machine languages*. Each different type of CPU has its own unique machine language. Lying between machine languages and high-level languages are languages called assembly languages. Assembly languages are similar to machine languages, but they are much easier to program in because they allow a programmer to substitute names for numbers. Machine languages consist of numbers only. Lying above high-level languages are languages called *fourth-generation* *languages* (usually abbreviated *4GL*). 4GLs are far removed from machine languages and represent the class of computer languages closest to human languages.

The programming languages are part of the software or programming aids provided by the manufacturer. A programming language is a language used in writing programs to direct processing steps to be carried out by a computer.

A wide variety of computer programming languages are available as mentioned above. The programmer must be familiar with one or more of them in order to write a computer program. Each programming language has very specific standards and rules of use, which the programmer must know and adhere to when developing a program. The programming languages can be hierarchically divided as follows.

Hierarchy of programming languages

(A) Machine Language or First Generation Languages: In the early days of computer, all programs were written in machine codes. Each particular computer model has a machine language, which is based on the internal engineering architecture of the equipment, and which is developed and provided to user by the computer manufacturer. Simply a machine level language is the language of the computer, the only language the computer understands without translation. If such a language is used in writing a program (say a user's payroll program), the programmer must be familiar with the specific machine-level language as well as with the details of the computer equipment to be used. Programs written in machine-level language can only be used on the computer model for which that language is written. That is why this language is called machine-oriented.

Writing programs in machine language is not only difficult for humans to do but is also subject to error. The earlier machine language employed the binary code *i.e.,* the instructions were codified in series of 1's and 0's in accordance with the bit pattern of the instruction to be performed. The binary code is now being abandoned in favour of the decimal code which is far easier for the programmer and therefore, we shall not pursue the binary code any more.

The computer manufacturer supplies a manual of the codes know as operation code or op code for the various operations which are unique to that computer.

Advantage: The only advantage is that program of machine language run very fast because no translation program is required for the CPU.

Disadvantages

1. It is very difficult to program in machine language. The programmer has to know details of hardware to write program.
2. The programmer has to remember a lot of codes to write a program which results in program errors.
3. It is difficult to debug the program.

(B) Assembler Languages or Second Generation Languages: *Assembler Languages* are at the next level in improvement over the machine languages. They are also known as symbolic languages because they employ symbols for both arithmetic and logical operations and even location addresses. Such standard symbols for the various operations are supplied by the computer manufacturer who creates the assembly language for his computer.

Since mnemonic symbols are being used, this eases up the programmer's task greatly. But the computer follows its machine language only and the program written in the assembler language has to be translated. This is accomplished by a special program usually supplied by the computer manufacturer and known as the *assembler.* The assembler simply translates each instruction in symbolic language to its machine language equivalent. Thus, there is a one-for-one correspondence between the two languages. Another advantage possessed by the assembly language is that of flexibility.

Advantages and disadvantages of assembler language

Advantages:

1. The symbolic programming of Assembly Language is easier to understand and saves a lot of time and effort of the programmer.
2. It is easier to correct errors and modify program instructions.
3. Assembly Language has the same efficiency of execution as the machine level language. Because this is one-to-one translator between assembly language program and its corresponding machine language program.

Disadvantages:

1. One of the major disadvantages is that assembly language is machine dependent. A program written for one computer might not run in other computers with different hardware configuration
2. An assembler language programmer will normally have to write a large number of statements to solve a given problem than will a programmer using other high-level programming languages.
3. Also, because of the concise symbolic notation used in assembler language, assembler language programs are often more difficult to write, read and maintain than programs written in high-level languages.
4. Assembler languages are not normally used to write programs for generalized business application software such as payroll, account receivable, billing, and similar applications. Other languages are available that are more appropriate for programming these types of applications.

(C) Compiler languages (High-level-languages) or Third Generation Languages: Compiler languages are also known as high level languages or procedural languages. They are procedure oriented (*viz.,* a business application oriented language COBOL and a scientific application oriented language FORTRAN). They employ plain English like and mathematical expressions. They are detached from the machine design and therefore the nomenclature

'High level' Languages. Since they are procedure oriented and detached from the machine design, instructions of these languages may be equivalent to more than one instruction in a machine language. An instruction in these languages is usually called a statement.

A computation X+Y=Z would be written as below in FORTRAN (Formula Translation) and COBOL (Common Business Oriented Language).This example is intended to bring out the similarity between the statements of these languages to plain English and mathematical expressions.

FORTRAN :		Z = X + Y	X, Y, Z designate
COBOL :	COMPUTE	Z = X + Y	storage locations.

Whereas each computer has its own machine language and assembly language devised by its manufacturer, the compiler languages are universal.

Since these languages employ plain English and mathematical expressions, it is easy to learn and write relatively error free programs. This is further facilitated because of the fact that the programs written in them are much more compact than those in the low level (machine and assembly) languages. But they have to be translated to the machine language for the computer on hand which is accomplished by an especial program known as the **compiler**, written and provided by the computer manufacturer. It usually occupies more storage space and requires more processing time than the assembler. It however, also possesses the diagnostic capabilities.

Thus, programs written in high-level language are cheaper than the low level languages in terms of learning and writing programs but this advantage is offset to an extent by more time on translation. Usually, therefore, an organisation would write frequently used programs in low level language and infrequently used programs in high level languages provided of course, they are not constrained to favour one of them in view of available programmers being skilled in only that one.

Besides FORTRAN and COBOL there are several more high-level languages such as BASIC, PASCAL and C-language etc.

(D) The Fourth Generation Languages (4GLs): The trend in software development is toward using high level user friendly Fourth Generation Languages (4 GLs). There are two types of 4GLs:

(i) ***Production Oriented 4GLs* -** Production-Oriented 4GLs are designed primarily for computer professionals. They use 4GLs such as ADR's, Ideal, Software AG's Natural 2, and Cincoms Mantis to create information systems. Professional programmers who use 4GLs claim productivity improvements over Third Generation procedure oriented languages such as (COBOL, FORTRAN, BASIC and so on) of 200% to 1000%.

(ii) ***User Oriented 4GLs* -** This type of 4GLs is designed primarily for end users. Users write 4GL programs to query (extract information from) a database and to create personal or

departmental information systems. User-oriented 4GLs include Mathematical Products Group's RAMIS-II and Information Builders' FOCUS.

4GL are languages that consist of statements similar to statements in a human language. Fourth generation languages are commonly used in database programming and scripts. One example of a 4GL is structured query language (SQL). Structured query language is a standard language for manipulating databases. Users can write simple SQL programs to create a database, enter data, retrieve data, and delete data.

4GLs use high level English like instructions to retrieve and format data for enquiries and reporting. Most of the procedure portion of 4GL program is generated automatically by the computer and the language software.

The features of a 4GL include English like instructions, limited mathematical manipulation of data, automatic report formatting, sequencing (sorting) and record selection by the user given criteria. However, 4GLs are less efficient than third generation languages. 4GLs require more computer capacity to perform a particular operation and users end up fitting their problems to the capabilities of the software. Large programs that support many simultaneous on-line users are better handled by a 3GL or an assembly language. When being executed, 4GL programs often consume significantly more machine cycles than 3GL program that perform the same task. This may result in slow response time. Faster and more powerful processors, along with 4GL product refinement, are likely to compensate for these deficiencies over time. However, managers should carefully consider both advantages and disadvantages of 4GL programs before deciding whether the organisation should adopt them on a wide scale.

Third-Generation Languages (3GLs)	Fourth-Generation Languages (4GLs)
❖ Intended for use by professional programmer	❖ May be used by a end user as well as a professional programmer
❖ Require specification of how to perform the task	❖ Require specification of what task to perform (system determines how to perform the task
❖ Require that all alternatives be specified	❖ Have default alternatives built in; end user need not specify these alternatives
Require large number of procedural instructions	❖ Require far fewer instructions (less than one-tenth in most cases)
❖ Code may be difficult to read, understand and maintain	❖ Code is easy to understand and maintain because of English-like commands
❖ Language developed originally for batch operation	❖ Language developed primarily for on-line use
❖ Can be difficult to learn	❖ Many features can be learned quickly
❖ Difficult to debug	❖ Errors easier to locate because of shorter programs, more structured

	code, and use of defaults and English-like language
❖ Typically file-oriented	❖ Typically data base oriented

(E) The Fifth Generation Languages (5GLs): A fifth-generation programming language (abbreviated 5GL) is a programming language based around solving problems using constraints given to the program, rather than using an algorithm written by a programmer. Most constraint-based and logic programming languages and some declarative languages are fifth-generation languages. While fourth-generation programming languages are designed to build specific programs, fifth-generation languages are designed to make the computer solve a given problem without the programmer. This way, the programmer only needs to worry about what problems need to be solved and what conditions need to be met, without worrying about how to implement a routine or algorithm to solve them.

Fifth-generation languages are used mainly in Artificial intelligence research, fuzzy logic and neural networks. This means computers can in the future have the ability to think for themselves and draw their own inferences using programmed information in large databases. Complex processes like understanding speech would appear to be trivial using these fast inferences and would make the software seem highly intelligent. In fact, these databases programmed in a specialized area of study would show a significant expertise greater than humans. Also, improvements in the fourth generation languages now carried features where users did not need any programming knowledge. Little or no coding and computer aided design with graphics provides an easy to use product that can generate new applications. Prolog, OPS5, and Mercury are the best known fifth-generation languages.

Other Programming Languages: *Object -Oriented Languages***:** With traditional programming approaches, developing a new program means writing entirely new code, one line at a time. The program may be hundreds of lines long and can take years to complete. Since each program is written from scratch, quality is often poor, productivity of programmers is low, and programs are usually behind schedule. When program modifications are needed, the code must be rewritten and tested. As programs become longer and more complex, achieving a reasonable quality level becomes a formidable task.

One solution to these problems is a new way of developing software using an object-oriented language (OOL). An object is a predefined set of program code that, after having been written and tested, will always behave the same way, so that it can be used for other applications. All programs consist of specific tasks such as saving or retrieving data and calculating totals. In object-oriented programming, an object is written for each specific task and saved in a library so that anyone can use it.

Using object-oriented programming (OOP), objects are combined and the small amount of code necessary for finishing the program is written. Rather than writing a program line by line, programmers select objects by pointing to a representative icon and then linking these objects together. Objects can be modified, reused, copies, or created. When an object is updated, all programs using that object can be automatically updated as well.

These objects are then sent messages telling them what to do; the objects complete the task accordingly. For example, selecting an object that looks like a fax machine would mean that data are to be sent by fax. This programmer-machine interface is more natural, powerful, and easy to understand and use than more traditional methods.

The advantages of OOP are its graphical interface, ease of use, faster program development, and enhanced programmer productivity (up to tenfold increase). The programs produced by OOP are more reliable and contain fewer errors, since the modules being used have already been extensively tested. Its disadvantages are its steep initial development costs and a more extensive start-up time. OOP produced large programs are slower, and use more memory and other computer resources than traditional methods. As a result, it requires power PCs and workstations. Investing in OOP is cheaper than hiring additional programming staff, however, and the increase in productivity makes up for the additional costs. Many companies are moving to OOP. Adherents of OOP claim that the future software market will deal in objects rather than in software packages. In other words, software applications will be sold as collections of objects. Eventually a do-it-yourself software situation will result that has users purchasing the necessary objects from a computer store, assembling them, and adding a little coding to tie up loose ends. Some common object-oriented languages are small talk, C++, Visual Basic and Java.

1.1.2 Operating or (Executive) Systems: An operating system is a program designed to run other programs on a computer. It is system software; act as an interface between hardware and user. It has two goals:

- Resource allocator
- Control Program

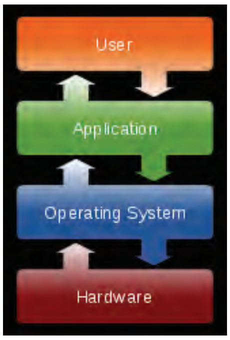

Figure 1.1.2: Operating System[*]

It is considered to be the backbone of a computer, managing both software and hardware resources. Operating systems are responsible for everything from the control and allocation of memory to recognizing input from external devices and transmitting output to computer

[*]www.wikipedia.org

displays. They also manage files on computer hard drives and control peripherals, like printers and scanners.

The operating system of a large computer system has even more work to do. Such operating systems monitor different programs and users, making sure everything runs smoothly, without interference, despite the fact that numerous devices and programs are used simultaneously. An operating system also has a vital role to play in security. Its job includes preventing unauthorized users from accessing the computer system.

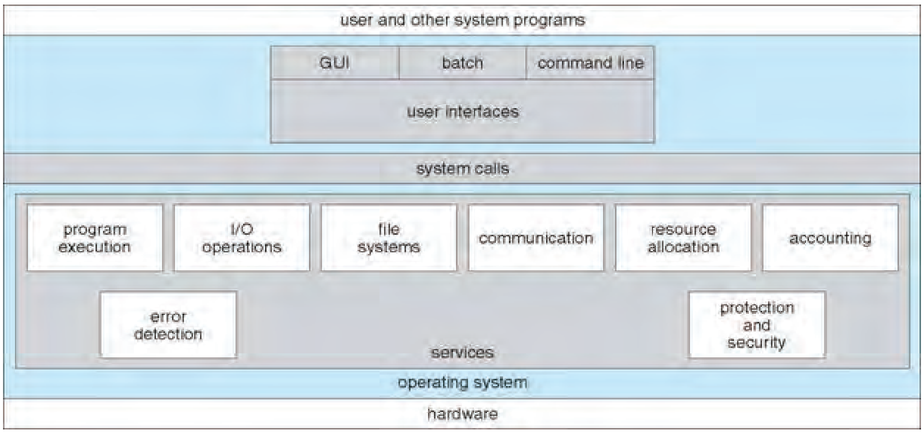

Figure 1.1.3: Operating System as an Interface*

There are six basic functions that an operating system can perform

(*i*) *Schedule Jobs:* They can determine the sequence in which jobs are executed, using priorities established.

(*ii*) *Manage Hardware and Software Resources:* They can first cause the user's application program to be executed by loading it into primary storage and then cause the various hardware units to perform as specified by the application.

(*iii*) *Maintain System Security:* They may require users to enter a password - a group of characters that identifies users as being authorised to have access to the system.

(*iv*) *Enable Multiple User Resource Sharing:* They can handle the scheduling and execution of the application programs for many users at the same time, a feature called multiprogramming.

(*v*) *Handle Interrupts:* An interrupt is a technique used by the operating system to temporarily suspend the processing of one program in order to allow another program to be executed. Interrupts are issued when a program requests an operation that does not require the CPU, such as input or output, or when the program exceeds some predetermined time limit.

(*vi*) *Maintain Usage Records:* They can keep track of the amount of time used by each user

*www.wikipedia.org

for each system unit - the CPU, secondary storage, and input and output devices. Such information is usually maintained for the purpose of charging users' departments for their use of the organization's computing resources.

1.1.2.1 Various Types of Operating Systems

We all know that the operating system is the most important software running on our computer without which one cannot run even the application software's which are designed to communicate with the hardware through the operating system. Are we aware that there are many types of operating systems available in the market to suit various needs and machines?

The types of the operating systems can be classified as single-tasking and multi-tasking. A single-tasking operating system allows only one program to run at a time. This was the operating system that was improved on to as multi-tasking operating systems as it was not practical to close one application and to open another, for example, close a word document to open power point, especially if we are required to copy some texts from word to power point.

Multi-tasking operating systems enable a single user to have two or more applications open at the same time. It gives the computer the option to decide on how many time slots each program is allocated. The active program gets the most, and the rest is divided according to the factors of which programs are doing tasks although not active, and the last priority is given to programs and applications that are left open but are not doing anything.

The most commonly used operating systems that fall under the above categories are, Windows 95, Windows 98, Windows Me, Windows NT, Windows 2000, Windows XP (Which is an upgrade of all the earlier and comes in two versions as Home and Professional. The professional version is the same as the home edition but has additional features, like networking and security features.), Windows Vista, Windows CE, Apple Macintosh, Unix, etc.

There are several types of operating system, defined according to whether they can simultaneously manage information measuring 16 bits, 32 bits, 64 bits or more.

System	Programming	Single user	Multi-user	Single task	Multi-task
DOS	16 bits	X		X	
Windows 3.1	16/32 bits	X			not pre-emptive
Windows 95/98/Me	32 bits	X			cooperative
Windows NT/2000	32 bits		X		pre-emptive
Windows XP	32/64 bits		X		pre-emptive
Unix / Linux	32/64 bits		X		pre-emptive
MAC/OS X	32 bits		X		pre-emptive
VMS	32 bits		X		pre-emptive

MS/PC-DOS: Short for **Microsoft Disk operating system**, **MS-DOS** is a non-graphical command line operating system created for IBM compatible computers that was first introduced by Microsoft in August 1981 and was last updated in 1994 when MS-DOS 6.22 was released. Unlike Microsoft Windows, which most users are familiar with today, MS-DOS requires the user to type commands instead of using a mouse. MS-DOS is a single user operating system that runs one program at a time and is limited to working with one megabyte of memory, 640 kilobytes of which is usable for the application program. IBM and Microsoft both released versions of DOS. Microsoft released their versions under the name "MS-DOS", while IBM released their versions under the name "PC-DOS" with MS/PC DOS 1.0 to MS/PC DOS 6.22. MS-DOS grew to include more features from other operating systems. MS-DOS 2.0 introduced features from UNIX such as subdirectories, command input/output redirection, and pipes.

OS/2: In 1987 IBM and Microsoft announced a new PC OS called OS/2 (Operating System Two). Unfortunately, the original OS/2 was not very successful. Hindsight suggests that, as with the early versions of Windows, one of the reasons for the slow uptake of OS/2 was that the considerable hardware demand of this particular application.

Another more serious problem with the original OS/2 is that it was unable to support many existing PC applications. So users faced problems due to lack of compatibility between their original applications and OS/2. Predictably, the initial lack of interest in the original OS/2 resulted in a considerable strain on the IBM - Microsoft alliance. Not long after the launch of OS/2, IBM and Microsoft began to go their separate ways. Microsoft effectively abandoned OS/2 to IBM and choose instead to concentrate on MS-DOS and Windows.

Microsoft Windows: Microsoft windows is one of the most popular operating system, its success is often attributed because of Graphical User Interface (GUI) feature. In this system we click on icons with mouse button rather than writing the command as in MS-DOS. Microsoft windows have the following features:

- Simple and user friendly.
- No need to write the command.
- Screen quite animated and attractive.
- It has the multitasking feature because of that more than one program can be executed concurrently.

Flavors of Windows Operating System: Microsoft Windows Operating Systems were developed for the home users and the other has been for the professional IT users. The dual routes have generally led to home versions having greater multimedia support and less functionality in networking and security, and professional versions having inferior multimedia support and better networking and security.

Windows 95: Windows 95, a 32 bit OS was released in August 1995. It took Microsoft three and a half years to develop. It was a gigantic task as far as computer projects go and was estimated to have taken 75 million hours of testing prior to its release. It was greeted enthusiastically by the computer industry, which saw it as a significant launch platform which would enable it to sell even more sophisticated computers.

The significance of a 32-bit OS as opposed to a 16-bit OS can be measured by the amount of internal main memory that can be directly access by the user/program. For example, with a 16-bit version of MS-DOS, the maximum amount of directly accessible memory is 1 MB. However, with a 32 bit OS, the user has direct access to 4 GB of main memory. To run Windows 95 users need a computer equipped with a 386DX or higher processor with a minimum of 4 Mb of memory (8Mb is recommended) along with a hard disk of 50 MB as well as 3.5 inch disk drive or a CD-ROM.

Windows 95 was designed to have certain critical features over and above what was already supplied by Windows 3.1 or Windows for Workgroups. These included:

(a) A 32-bit architecture which provides for a multitasking environment allowing the user to run multiple programs or execute multiple tasks concurrently. This architecture also enables faster data / file access as well as an improvement in printing delivery.

(b) A friendlier interface fitted with what is described as ‘one click' access. One click access refers to the fact that users didn't have to double click on the mouse every time that they wanted to activate an application. Other congenial attributes include the ability to employ long file names, easy navigation routes and ‘plug and play technology' enabling users to connect various peripheral devices or add-ons with the minimum of fuss.

(c) Windows 95 is also network ready. In other words the OS is designed for easy access to network resources. The OS also facilitates gateways to e-mail and fax facilities and access to the Internet via the Microsoft Network. In addition Windows 95 is backwardly compatible with most 3.1 Windows / DOS applications so enabling users to migrate from previous systems / applications.

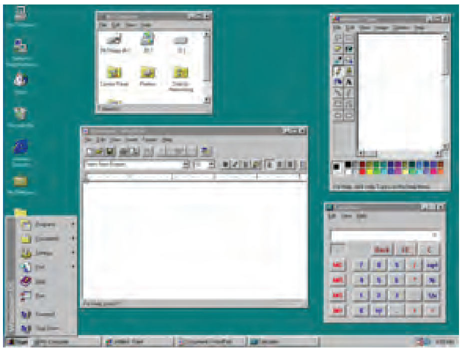

Figure 1.1.4: Microsoft Windows 95 Operating System*

The changes Windows 95 brought to the desktop were revolutionary, as opposed to evolutionary, such as those in Windows 98 and Windows Me. The next in the consumer line was Microsoft Windows 98 released in 1998. As part of its "professional" line, Microsoft

* www.wikipedia.org

released Windows 2000 in 2000. The consumer version following Windows 98 was Windows Me (Windows Millennium Edition) released in 2000 having "Universal Plug and Play" technology. Windows Me was heavily criticized due to slowness, freezes and hardware problems.

Windows NT: Unlike Windows 3.0 and Windows 95, Windows New Technology (NT) is what is known as an industry standard mission critical OS. As a 32 bit OS, Windows NT represents the preferred platform for Intel's more powerful Pentium range of processors. Although not exactly the same, Windows NT 4.0 is, as might be expected, very similar in appearance to Windows 95. Critical features that allow the program to context the commercial OS market include:

- A stable multitasking environment
- Enhanced security features
- Increased memory
- Network utilities
- Portability: NT can operate on microprocessors other than those designed for the PC.

Windows NT is, as might be expected, more expensive than the other Windows OS and makes greater processing demands. However, it should be pointed out that Windows NT is making massive inroads into the corporate computing market and is fully recognised as being a competent useful OS.

Windows 2000 : A operating systems produced by Microsoft for use on personal computers, business desktops, laptops, and servers released on 17 February 2000.It was the successor to Windows NT 4.0, and is the final release of Microsoft Windows to display the "Windows NT" designation. It was succeeded by Windows XP for desktop systems in October 2001 and Windows Server 2003 for servers in April 2003. Windows Me was designed for home use, while Windows 2000 was designed for business.

Windows XP : It is an operating system produced by Microsoft for use on personal computers, including home and business desktops, laptops, and media centers. It was first released in August 2001, and is currently one of the most popular versions of Windows. The name "XP" is short for "eXPerience." Microsoft released Windows XP, a version built on the Windows NT kernel that also retained the consumer-oriented usability of Windows 95 and its successors. This new version came in two distinct editions: Home and Professional. The former lacking many of the superior security and networking features of the Professional edition.

Windows XP has new features to the Windows line, including:

- Faster start-up,
- More user-friendly interface, including the framework for developing themes for the desktop environment,

- *Fast user switching*, which allows a user to save the current state and open applications of their desktop and allow another user to log on without losing that information,
- The *ClearType* font rendering mechanism, which is designed to improve text readability on liquid crystal display (LCD) and similar monitors,
- *Remote Desktop* functionality, which allows users to connect to a computer running Windows XP Pro from across a network or the Internet and access their applications, files, printers, and devices,
- Support for most DSL modems and IEEE 802.11 connections, as well as networking over FireWire, and Bluetooth.

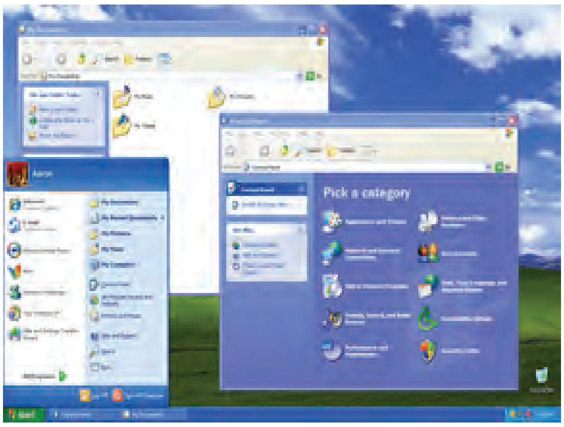

Figure 1.1.5: Microsoft Windows XP Operating System*

In April 2003, Windows Server 2003 was introduced, replacing the Windows 2000 line of server products with a number of new features and a strong focus on security; this was followed in December 2005 by Windows Server 2003 R2.

Windows Vista: In 2007 Microsoft released Windows Vista. It contains a number of new features, from a redesigned shell and user interface to significant technical changes, with a particular focus on security features. Windows Vista contains many changes and new features, including an updated graphical user interface and visual style dubbed Aero, a redesigned search function, multimedia tools including Windows DVD Maker, and redesigned networking, audio, print, and display sub-systems. Vista aims to increase the level of communication between machines on a home network, using peer-to-peer technology to simplify sharing files and media between computers and devices. Windows Vista includes version 3.0 of the .NET Framework, allowing software developers to write applications without traditional Windows APIs. It is available in a number of different editions, and has been subject to some criticism.

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*www.wikipedia.org

Figure 1.1.6: Microsoft Windows Vista Operating Systems*

Windows 7.0: It is the latest release of Microsoft Windows, a series of operating systems produced by Microsoft for use on personal computers, including home and business desktops, laptops, notebook, tablet PCs, and media center PCs. Windows 7 was released for general retail availability on October 22, 2009, less than three years after the release of its predecessor, Windows Vista. Windows 7's server counterpart, Windows Server 2008 R2, was released at the same time.

Unlike its predecessor, Windows Vista, which introduced a large number of new features, Windows 7 was intended to be a more focused, incremental upgrade to the Windows line, with the goal of being compatible with applications and hardware which Windows Vista wasn't at the time. Presentations given by Microsoft in 2008 focused on multi-touch support, a redesigned Windows shell with a new taskbar, referred to as the Superbar, a home networking system called HomeGroup, and performance improvements. Some standard applications that have been included with prior releases of Microsoft Windows, including Windows Calendar, Windows Mail, Windows Movie Maker, and Windows Photo Gallery, are not included in Windows 7; most are instead offered separately at no charge as part of the Windows Live Essentials suite.

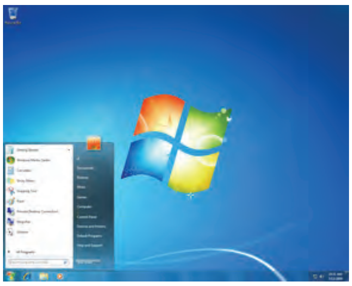

Figure 1.1.7: Microsoft Windows 7.0 Operating System*

UNIX OS: Unix is a computer operating system originally developed in 1969 by a group of AT&T employees at Labs. Today's UNIX systems are split into various branches, developed over time by AT&T as well as various commercial vendors and non-profit organizations. The

*www.wikipedia.org

UNIX environment and the client–server program model were essential elements in the development of the Internet and the reshaping of computing as centered in networks rather than in individual computers. As a result, UNIX became synonymous with "open systems".

Generally, UNIX is seen as the operating system on a workstation or a network server. UNIX systems formed the backbone of the early Internet, and they continue to play an important part in keeping the Internet functioning. UNIX originally set out to be an incredibly portable system, capable of allowing a computer to have multiple processes going on at once, and with multiple users logged in at the same time. UNIX was designed to be portable, multi-tasking and multi-user in a time-sharing configuration. UNIX systems are characterized by various concepts: the use of plain text for storing data; a hierarchical file system; treating devices and certain types of inter-process communication (IPC) as files; and the use of a large number of software tools, small programs that can be strung together through a command line interpreter using pipes, as opposed to using a single monolithic program that includes all of the same functionality. These concepts are collectively known as the UNIX philosophy.

The UNIX system is composed of several components that are normally packed together. By including — in addition to the kernel of an operating system — the development environment, libraries, documents, and the portable, modifiable source-code for all of these components, UNIX was a self-contained software system. This was one of the key reasons it emerged as an important teaching and learning tool and has had such a broad influence.

The inclusion of these components did not make the system large — the original V7 UNIX distribution, consisting of copies of all of the compiled binaries plus all of the source code and documentation occupied less than 10 MB, and arrived on a single 9-track magnetic tape.

MAC OS: It is a graphical user interface-based operating systems developed by Apple Inc. (formerly Apple Computer, Inc.) for their Macintosh line of computer systems. The Macintosh user experience is credited with popularizing the graphical user interface. The original form of what Apple would later name the "Mac OS" was the integral and unnamed system software first introduced in 1984 with the original Macintosh, usually referred to simply as the System software.

Early versions of the Mac OS were compatible only with Motorola 68000-based Macintoshes. As Apple introduced computers with PowerPC hardware, the OS was upgraded to support this architecture as well. Mac OS X, which has superseded the "Classic" Mac OS, is compatible with both PowerPC and Intel processors through version 10.5 ("Leopard"). Version 10.6 ("Snow Leopard") supports only Intel processors.

The "classic" Mac OS is characterized by its total lack of a command line; it is a completely graphical operating system. Noted for its ease of use and its cooperative multitasking, it was criticized for its very limited memory management, lack of protected memory, and susceptibility to conflicts among operating system "extensions" that provide additional functionality (such as networking) or support for a particular device. Some extensions may not work properly together, or work only when loaded in a particular order. Troubleshooting Mac OS extensions could be a time-consuming process of trial and error.

The server edition, Mac OS X Server, is architecturally identical to its desktop counterpart but usually runs on Apple's line of Macintosh server hardware. Mac OS X Server includes work group management and administration software tools that provide simplified access to key network services, including a mail transfer agent, a Samba server, an LDAP server, a domain name server, and others.

Figure 1.1.8: Mac OS X*

Linux OS: Linux is the generic name for a UNIX-like operating system that can be used on a wide range of devices from supercomputers to wristwatches. The Linux kernel is released under an open source license, so anyone can read and modify its code. It has been modified to run on a large variety of electronics. Although estimates suggest it is used on only 0.5-2% of all personal computers, it has been widely adopted for use in servers and embedded systems (such as cell phones). Linux has superseded UNIX in most places, and is used on the 10 most powerful supercomputers in the world.

Figure 1.1.9: Linux OS*

Operating systems for mid-range and mainframe systems are often more complex than those for microcomputers. Nearly all mainframes have the ability to run (or host) multiple operating systems, and thereby operate not as a single computer but as a number of virtual machines. In this role, a single mainframe can replace dozens or even hundreds of smaller servers. While mainframes pioneered this capability, virtualization is now available on most families of computer systems, though not always to the same degree or level of sophistication. MVS is the most common operating system used on IBM mainframe. OS/400, an operating system for the IBM AS/400 line of midrange computers, is used at most of the sites where AS/400 is installed. VMS is the operating system used most frequently on DEC midrange and mainframe systems.

*www.wikipedia.org

1.1.2.2 Features of Operating System: Large centralized systems often support multiple simultaneous users. The users' terminals may have limited processing capabilities and actual processing may be done entirely on the large computer that is connected to the terminals. Hence, this computing configuration requires an operating system that enables many users to concurrently share the central processor. To do this, the operating systems on large computer systems often combine (interleave) the processing work of multiple simultaneous users or applications in a manner that achieves the highest possible resource efficiency. The interleaving techniques commonly used are multiprogramming, multithreading, multi-tasking, virtual memory, multi-processing and time-sharing.

1. Multiprogramming: The purpose of multiprogramming is to increase the utilization of the computer system as a whole. We might have noted when a program issues an input/output command, the program and hence the CPU is placed in a wait state until the execution of the command has been completed. When the transfer of data between main memory and the input/output devices has been completed, the device generates an *interrupt*, which is a signal that the data has been transferred. Till then the CPU remains idle and only after it receives the interrupt signal, it continues processing. Hence, in a way, the speed of the CPU is restricted by the speed of I/O devices and most of the time the CPU keeps waiting for the I/O operations to be completed. In order to utilize the computer more effectively, a technique known as *multiprogramming* has been developed. It is a module that is available in an operating system.

Multiprogramming is defined as execution of two or more programs that all reside in primary storage. Since the CPU can execute only one instruction at a time, it cannot simultaneously execute instructions from two or more programs. However, it can execute instructions from one program then from second program then from first again, and so on. This type of processing is referred to as "concurrent execution". Using the concept of concurrent execution, multiprogramming operates in the following way:

When processing is interrupted on one program, perhaps to attend an input or output transfer, the processor switches to another program. This enables all parts of the system, the processor, input and output peripherals to be operated concurrently thereby utilizing the whole system more fully. When operating on one program at a time, the processor or peripherals would be idle for a large proportion of the total processing time even though this would be reduced to some extent by buffering. **Buffering** enables the processor to execute another instruction while input or output is taking place rather than being idle while transfer was completed. Even then, when one program is being executed at a time, basic input and output peripherals such as floppy disk drive and line printers are slow compared with the electronic speed of the processor and this causes an imbalance in the system as a whole. However, in a multi-programming environment, the CPU can execute one program's instructions while a second program is waiting for I/O operations to take place.

In a system of multiprogramming, storage is allocated for each program. The areas of primary storage allocated for individual programs are called "partitions". Each partition must have some form of storage protection and priority protection to ensure that a program in one portion will not accidentally write over and destroy the instructions of another partition and priority (when two or more programs are residing in primary storage) because both programs will need access to the CPU's facilities (*e.g.*, the arithmetic and logic section). A system of priority-a method that will determine which program will have first call on the computer's facilities-is normally determined by locating the programs in specific partitions.

2. Multi-threading: An application typically, implemented as a separate process with several threads of control. In some situations a single application may be required to perform several similar tasks, for example a web server accepts client requests for web pages, images, sound, and so forth. A busy web server may have several of clients concurrently accessing it. If the web server runs as a traditional single-threaded process, it would be able to service only one client at a time. The amount of time that a client might have to wait for its request to be serviced could be enormous. So it is efficient to have one process that contains multiple threads to serve the same purpose. This approach would multithread the web-server process. The server would create a separate thread that would listen for client requests when a request was made rather than creating another process it would create another thread to service the request. To get the advantages like responsiveness, resource sharing economy and utilization of multiprocessor architectures multithreading concept can be used. Multithreading allows a process to keep running even if some threads within the process are stalled, working on a lengthy task, or awaiting user interaction, thus improve the performance of processing the task.

3. Multi-tasking: Multi-tasking refers to the operating system's ability to execute two or more of a single user's tasks concurrently. Multitasking operating systems are often contrasted with single-user operating systems. *Single-user operating systems* have traditionally been the most common type of operating system for microcomputers. These only allow the user to work on one task at a time. For example, with many single-user operating systems for microcomputer systems, a word-processing user cannot effectively type in a document while another document is being printed out on an attached printer. For microcomputers, multi-tasking operating systems provide single users with multiprogramming capabilities. This is often accomplished through foreground/background processing. Multitasking operating systems for microcomputers-Such as Windows, OS/2, UNIX, Xenix, and Macintosh System 7 – only run on the more powerful microprocessors that were developed; older machines with less powerful microprocessors typically have single-user operating systems.

4. Virtual Memory: A programmer has to take into account the size of the memory to fit all his instructions and the data to be operated in the primary storage. If the program is large, then the programmer has to use the concept of virtual memory. Virtual memory systems, sometimes called virtual storage systems, extend primary memory by treating disk storage as a logical extension of RAM. The technique works by dividing a program on disk into fixed-length pages or into logical, variable-length segments.

Virtual memory is typically implemented as follows. Programs stored on disk are broken up into fixed-length pages. When a program needs to be processed, the first few pages of it are brought into primary memory. Then, the computer system starts processing the program. If the computer needs a page it does not have, it brings that page in from secondary storage and overwrites it onto the memory locations occupied by a page it no longer needs. Processing continues in this manner until the program finishes. This is known as *overlaying.*

By allowing programs to be broken up into smaller parts, and by allowing only certain parts to be in main memory at any one time, virtual memory enables computers to get by with less main memory than usual. Of course, during page swapping in multiprogramming environments, the system may switch to other programs and tasks.

Thus, virtual memory is primary storage-that does not actually exist. It gives the programmers the illusion of a primary storage that is for all practical purposes never ending. It uses the hardware and software features, which provide for automatic segmentation of the program and for moving the segments from secondary storage to primary storage when needed. The segments of the program are thus spread through the primary and secondary (on-line) storage, and track of these segments is kept by using tables and indices. So far as the programmer is concerned, the virtual memory feature allows him to consider unlimited memory size, though not in physical term.

5. Multiprocessing: The term multiprogramming is sometimes loosely interchanged with the term multiprocessing, but they are not the same. Multiprogramming involves concurrent execution of instructions from two or more programs sharing the CPU and controlled by one supervisor. Multiprocessing (or parallel processing) refers to the use of two or more central processing units, linked together, to perform coordinated work simultaneously.

Instructions are executed simultaneously because the available CPUs can execute different instructions of the same program or of different programs at any given time.

Multiprocessing offers data-processing capabilities that are not present when only one CPU is used. Many complex operations can be performed at the same time. CPU can function on complementary units to provide data and control for one another. Multiprocessing is used for nation’s major control applications such as rail road control, traffic control, or airways etc.

Although parallel processing is not widespread yet, multiprocessing should be the wave of the future. Because of the availability of cheaper but more powerful processors, many computer manufacturers are now designing hardware and software systems to do multiprocessing. Since several machines can work as a team and operate in parallel, jobs can be processed much more rapidly than on a single machine.

6. Time-sharing: Time sharing is a methodology created to satisfy the processing needs of multiprogramming and batch operating system. In time sharing systems, the execution time is divided into small slots called "time slice". Each process is processed for a time slice and then the other process is taken for processing by the processor. This process goes on till all the jobs are processed. The process of shifting a microprocessor from processing of one job to the other is so rapid that the user can't even notice it. Each user feels like the processor is dedicatedly processing his job only. In these systems, the processes that are waiting for processor time are placed in a special memory area called "ready queue". When a process has some input or output requirements, it is shifted from this area. Whenever the time slice becomes over, the processor looks for the next ready process for processing and starts its processing.

The main objective of the time sharing systems is to reduce the response time. The response time is time in which the operating system responds to the commands supplied by the user. Generally, the response time for these systems is less than 1 second. By allowing a large number of users to interact concurrently with a single computer, time-sharing dramatically lowered the cost of providing computing capability, made it possible for individuals and organizations to use a computer without owning one, and promoted the interactive use of computers and the development of new interactive applications.

Time sharing systems are more complex than multiprogramming operating systems. In these systems, a large amount of memory is required to store various running processes. Several memory management schemes are used. Methods like virtual memory are used to use a part of secondary memory as main memory.

Other Systems Software

1.1.3 Device Drivers: Device drivers are small files that act as a interface between hardware in a computer system and the operating system (OS). Hardware requires device drivers so that the OS can "see" the devices and handle them effectively and efficiently. A driver typically communicates with the device through the computer bus or communications subsystem to which the hardware connects. When a calling program invokes a routine in the driver, the driver issues commands to the device. Once the device sends data back to the driver, the driver may invoke routines in the original calling program.

Common components that require drivers include keyboards, mice, controllers, graphics cards, audio hardware, Ethernet hardware, wireless cards, ports, card readers, card slots and CD/DVD drives. Windows operating systems typically include many device drivers by default so that the OS can recognize many types of desktop hardware components instantly and implement functionality. Hardware that's added later might require drivers be installed before it can be used.

1.1.4. Utility Programs or Service Programs: Utility programs are systems programs that perform general system support tasks. These programs are provided by the computer manufacturers to perform tasks that are common to all data processing installations. Some of them may either be programs in their own right or subordinates to be assembled / compiled in the application programs. The following tasks are performed by the utility programs.

(i) Sorting and storing the data.

(ii) Checking or scanning the data stored on hard disk for security reason.

(iii) Making a copy of all information stored on a disk, and restore either the entire disk.

(iv) Performing routine data management tasks, such as deleting, renaming, moving, copying, merging, generating and modifying data sets.

(v) Providing encryption and decryption of data.

(vi) Analyzing the computer's network connectivity, configure network settings, check data transfer or log events.

(vii) Partitioning of drive into multiple logical drives, each with its own file system which can be mounted by the operating system and treated as an individual drive.

(viii) Converting data from one recording medium to another, viz., floppy disk to hard disc, tape to printer, etc.

(ix) Dumping of data to disc or tape.

(x) Tracing the operation of program.

In many instances, it is unclear what differentiates an operating system routine from a utility program. Some programs that one vendor bundles into an operating system might be offered by another vendor as separately priced and packaged utility programs.

A wide variety of utilities are available to carry out special tasks. Three types of utility programs found in most computer systems: sort utilities, spooling software, and text editors are discussed below:

(a) Sort utilities: Sort utility programs are those that sort data. For example, suppose we have a file of student records. We could declare "name" the *primary sort key* and arrange the file alphabetically on the name field. This would be useful for, perhaps, producing a student directory. Alternatively, we could sort the file by name, and then within name, by date-of-birth. Hence, we would declare name as the primary sort key and date-of-birth as the *secondary sort key*. Although the examples described here use only one or two sort keys, many sorting packages enable the user to identify 12 or more sort keys and to arrange outputted records in either ascending or descending order on each declared key.

Sort utilities are often found in mainframe and minicomputer environments. In the micro-computing world, it is typical for sort routines to be bundled into application packages; for example, sort routines are commonly found in spreadsheet and database management software.

(b) Spooling software: The purpose of spooling software is to compensate for the speed differences between the computer and its peripheral devices. Spooling software is usually encountered in large system and network computing environments. For instance, during the time it takes to type in or print out all the words on this page, the computer could begin and finish processing dozens of programs. The computer would be horribly bottlenecked if it had to wait for slow input and output devices before it could resume processing. It just does not make sense for a large computer, which may be worth lacs of rupees, to spend any time sitting idle because main memory is full of processed but unprinted jobs and the printer attached to the system cannot move fast enough.

To preclude the computer from being slowed down by input and output devices, many computer systems employ **spooling** software. These programs take the results of computer programs and move them from primary memory to disk. The area on the disk where the program results are sent is commonly called the output spooling area. Thus, the output device can be left to interact primarily with the disk unit, not the CPU. Spooling utilities can also be used on the input side, so that programs and data to be processed are temporarily stored in an input spooling area on disk.

Assume for example that a floppy disc, a line printer and a disk are used in a spooling operation on a computer system to process the pay-roll and prepare invoices by loading both programs into the main memory. While the line printer is printing an invoice line, the processor switches to the pay roll application and transfers input data from floppy disc to magnetic disk. Afterwards the processor reverts back to the invoice application. As the printer is being used for printing invoices, pay roll application will be executed and output data would be recorded on the Magnetic disk for later conversion when the printer becomes available. As a result, the CPU can give the output at the maximum speed, while several relatively slow input and output units operate simultaneously to process it.

(c) Text editors: Text editors are programs that allow text in a file to be created and modified. These utilities are probably most useful to professional programmers, who constantly face the problems of cutting and pasting programs together, changing data files by eliminating certain data fields, changing the order of certain data fields, adding new data fields, and changing the format of data. Although text editors closely resemble word processors, they are not the same. Word processors are specifically designed to prepare such "document" materials as letters and reports, where text editors are specifically designed to manipulate "non-document" instructions in computer programs or in data files. Text editors lack the extensive text-formatting and document-printing capabilities found on most word processors.

Some of the other commonly used utilities for microcomputer operating systems are discussed below:

(i) *Disk copy program* - This program allows an user to copy the entire contents of one diskette to another diskette. It is generally used to make a backup or archive copy of a data diskette or an application program. The disk copy program can also be used to transfer data stored from one size or capacity diskette to another. For example, it can be used to transfer data from a 360 KB diskette to a 1.2MB diskette or from a 5¼ inch diskette to a 3½ inch diskette.

(ii) *File copy program* - This program allows an user to copy just one file or a group of files, rather than the entire contents of the diskette, to be copied to another diskette. It has the same functions as a disk copy utility except that it allows an individual file or group of files to be copied.

(iii) *Disk formatting program* - This program allows an user to prepare a new, blank diskette to receive data from the computer system. The data can not be stored on a diskette until it is formatted or initialized. The formatting process writes the sectors on the diskette so that the operating system is able to place data in these locations.

(iv) *File deletion program* - It allows an user to delete a file stored on a diskette.

(v) *File viewing program* - This program is used to view the contents of a file on the display screen of the microcomputer.

(vi) *Directory program* - This program allows an user to view the names of the data and program files which are stored on a disk/diskette. It will not only list the files, but also will show the amount of kilobytes of memory these files occupy, the time and day they were last revised and the amount of unused storage space available on the disk/diskette.

(vii) Debugging Program: These programs are usually written and provided by the computer manufacturers. They assist in program debugging. They usually trace the processing of the program being debugged. In personal computer, if a user wants to know anything regarding the processing equipments in his computers, he/she can consult the Microsoft Diagnostic Program, a utility built into the Windows 3.1 and DOS version 6.0 Operating System. **MSD** (Microsoft Diagnostics) was a software tool developed by Microsoft, to assist in the diagnostics of 1990s era computers. The primary use of this tool was to provide detailed technical information about the user's software and hardware and then print the gathered information, usually to be used by support technicians in resolving user troubleshooting. The diagnostic routines are however also often treated as a category of the utility or service programs

1.1.5 Language translators: A language translator or language processor is a general term used for any assembler, compiler or other routine that accepts statements in one language and produces equivalent statements in another language. The language processor reads the source language statements one at a time and prepares a number of machine instructions to perform the operations specified or implied by each source statement. Most computer installations have several language processors available, one for each programming language the computer can accept.

The three most widely used types of language translators are compilers, interpreters, and assemblers.

Compilers: A compiler translates the entire program into machine language before the program is executed. Compilers are most commonly used system software to translate high-level languages such as COBOL, FORTRAN, and Pascal into Low level language. Compilers typically result in programs that can be executed much more swiftly than those handled by interpreters. Since either a compiler or an interpreter can be developed to translate most languages, compilers would be preferred in environments where execution speed is important.

Compilers work in the manner illustrated in Fig. 1.1.10. Program is entered into the computer system and submitted to the appropriate compiler. For instance, A COBOL program is input to a COBOL compiler; a Pascal program, to a Pascal compiler. The program submitted for compilation is called a ***source program*** (or source module). The compiler then translates the program into machine language, producing *an object program* (or object module). Then, another software program called a **linkage editor** binds the object module of this program to object modules of any subprograms that must be used to complete processing. The resultant program, which is ready for computer execution, is called a ***load program*** (or load module). It is the load program that the computer actually executes.

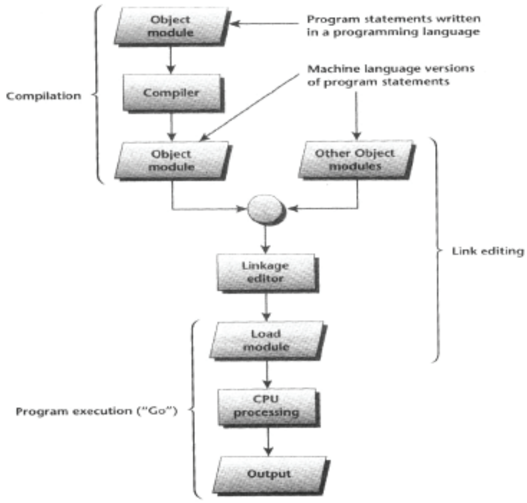

Figure 1.1.10: Compiling Process

The entire process is sometimes referred to as "compile/link-edit/go," corresponding to the compilation, link-editing, and execution stages that the user must go through to get a program processed. Programs can be saved on disk for processing either in source, object, or load-module form. Frequently run applications will often be saved in load module form to avoid repeated compilation and link-editing.

Interpreters: Whereas compilers translate programs into machine language all at once before programs are run, *interpreters* translate programs a line at a time as they are being run. For instance, if a user has a program in which a single statement is executed a thousand times during the course of the program's run, the interpreter would translate that statement a thousand different times into machine language. With an interpreter, each statement is translated into machine language just before it is executed. No object module or storable load module is ever produced.

Although interpreters have the glaring weakness of inefficiency because they translate statements over and over, they do have some advantages over compilers.

- First, they are usually easier and faster to use, since the user is not bothered with distinct and time-consuming compile, link-edit, and execution stages.
- Second, they typically provide users with superior error messages. When a program contains an error and "blows up," the interpreter knows exactly which statement triggered the error – the one it last translated. Because interpreters stop when errors are encountered, they help programmers debug their programs. This boosts programmer productivity and reduces program development time. Syntax errors encountered by compilers during the program translation process are counted, but the diagnostic routines and error messages associated with most compilers do not help programmers locate errors as readily as interpreters.

- Third, an interpreter for a 3GL typically requires less storage space in primary memory than a compiler for that language. So they may be ideal for programming environments in which main memory is limited, such as on low-end microcomputers.
- Fourth, interpreters are usually less expensive than compilers.

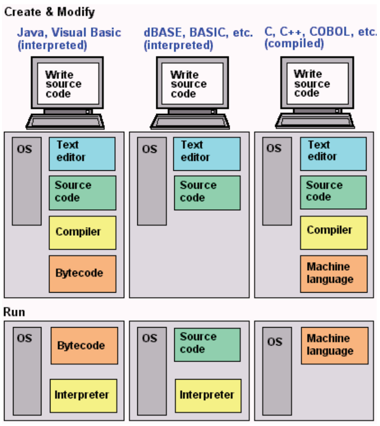

Figure 1.1.11: Compiler and Interpreter comparison*

Assemblers: A program written in assembly language consists of a series of *instructions* called-mnemonics that correspond to a stream of executable instructions, when translated by an assembler, which can be loaded into memory and executed. A utility program called an *assembler* is used to translate assembly language statements into the target computer's machine code. The assembler performs a one-to-one mapping from mnemonic statements into machine instructions and data. This is in contrast with high-level languages, in which a single statement generally results in many machine instructions. Assemblers are used exclusively with assembly languages. They work similarly to compilers, translating an assembly language program into object code. Because assembly language programs are usually more machine efficient than those written in high-level languages, a two-step translation process may take place. First, the high-level language is translated to assembly language; then, using an assembler, it is converted to machine language.

1.2 General Purpose Software/Utilities

This software provides the framework for a great number of business, scientific, and personal applications. Spreadsheet, Databases, Computer-Aided Design (CAD) and Word processing software etc. fall into this category. Most general-purpose software is sold as a package. The software is accompanied by user-oriented documentation such as reference manuals, keyboard templates, and so on. It is then upto the user of the software to create the application. For example, an accountant can use spreadsheet software to create a template

* www.zdnet.com

for preparing a balance sheet of a company. An aeronautical engineer can use CAD software to design an airplane or an airport. A personnel manager can use word processing software to create a letter and so on.

The three basic types of software are: commercial, shareware and open source software. Some software is also release into the public domain without a license.

Commercial software comes prepackaged and is available from software stores and through the Internet.

Shareware is software developed by individual and small companies that cannot afford to market their software world wide or by a company that wants to release a demonstration version of their commercial product. Shareware software often is disabled in some way and has a notice attached to explain the legal requirements for using the product.

Open Source software is created by generous programmers and released into the public domain for public use. There is usually a copyright notice that must remain with the software product. Open Source software is not public domain in that the company or individual that develops the software retains ownership of the program but the software can be used freely. Many popular Open Source applications are being developed and upgraded regularly by individuals and companies that believe in the Open Source concept.

1.2.1 Word Processor: A word processor (more formally a document preparation system) is a computer application used for the production (including composition, editing, formatting, and possibly printing) of any sort of printable material. Word processors are descended from early text formatting tools (sometimes called text justification tools, from their only real capability). Word processing was one of the earliest applications for the personal computer in office productivity.

Although early word processors used tag-based markup for document formatting, most modern word processors take advantage of a graphical user interface. Most are powerful systems consisting of one or more programs that can produce any arbitrary combination of images, graphics and text, the latter handled with type-setting capability.

Microsoft Word is the most widely used computer word processing system; Microsoft estimates over five million people use the Office suite. There are also many other commercial word processing applications, such as WordPerfect. Open-source applications such as OpenOffice's Writer and KWord are rapidly gaining in popularity.

1.2.2 Spreadsheet Program: A spreadsheet is a computer application that generally simulates accounting and financial information on the worksheet. It displays multiple cells that together make up a grid consisting of rows and columns, each cell containing alphanumeric text, numeric values or formulas. A formula defines how the content of that cell is to be calculated from the contents of any other cell (or combination of cells) each time any cell is updated. Spreadsheets are frequently used for financial information because of their ability to re-calculate the entire sheet automatically after a change to a single cell is made. Visicalc is usually considered the first electronic spreadsheet (although this has been challenged), and it helped turn the Apple II computer into a success and greatly assisted in their widespread application. Lotus 1-2-3 was the leading spreadsheet when DOS was the dominant operating system. Excel now has the largest market share on the Windows and Macintosh platforms.

1.2.3 Database Management System: A database management system (DBMS) is a system or software designed to manage a database, and run operations on the data requested by numerous clients. Typical examples of DBMS use include accounting, human resources and customer support systems. DBMSs have more recently emerged as a fairly standard part of any company back office.

1.2.4 Internet Browser: An Internet Browser or a web browser is a software application that enables a user to display and interact with text, images, and other information typically located on a web page at a website on the World Wide Web or a local area network. Text and images on a web page can contain hyperlinks to other web pages at the same or different websites. Web browsers allow a user to quickly and easily access information provided on many web pages at many websites by traversing these links.

Web browsers available for personal computers include Microsoft Internet Explorer, Mozilla Firefox, Apple Safari, Netscape, and Opera. Web browsers are the most commonly used type of HTTP user agent. Although browsers are typically used to access the World Wide Web, they can also be used to access information provided by web servers in private networks or content in file systems.

1.2.5 Electronic mail, abbreviated as **email**, is a method of composing, sending, storing, and receiving messages over electronic communication systems. The term e-mail applies both to the Internet e-mail system based on the Simple Mail Transfer Protocol (SMTP) and to intranet systems allowing users within one company to e-mail each other. Often these workgroup collaboration organizations may use the Internet protocols for internal e-mail service.

1.3 Application Software

Application software is the computer software designed to help the user to perform single or multiple tasks. Examples include enterprise software, accounting software, office suites, graphics software, and media players. It is a loosely defined subclass of computer software that employs the capabilities of a computer directly to a task that the user wishes to perform. This should be contrasted with system software which is involved in integrating the computer's various capabilities, but typically does not directly apply them in the performance of tasks that benefit the user. The term application refers to both the application software and its implementation. A simple, if imperfect, analogy in the world of hardware would be the relationship of an electric light—an application—to an electric power generation plant—the system. The power plant merely generates electricity, itself not really of any use until harnessed to an application like the electric light which performs a service that the user desires. Multiple applications bundled together as a package are sometimes referred to as an application suite. The separate applications in a suite usually have a user interface that has some commonality making it easier for the user to learn and use each application. And often they may have some capability to interact with each other in ways beneficial to the user.

User-written software tailors systems to meet the user's specific needs. User-written software includes spreadsheet templates, word processor macros, scientific simulations, graphics and animation scripts. Even email filters are a kind of user software. Users create this software themselves and often overlook how important it is.

The program usually solves a particular application or problem. Examples of such programs are payroll, General accounting, sales statistics and inventory control etc. Usually different organisations require different programs for similar application and hence it is difficult to write standardized programs. However, tailor-made application software can be written by software houses on *modular* design to cater to the needs of different users.

1.3.1 Enterprise Resource Planning systems: (ERPs) integrate (or attempt to integrate) all data and processes of an organization into a single unified system. A typical ERP system will use multiple components of computer software and hardware to achieve the integration. A key ingredient of most ERP systems is the use of a single, unified database to store data for the various system modules.

The term ERP originally implied systems designed to plan the utilization of enterprise-wide resources. Although the acronym ERP originated in the manufacturing environment, today's use of the term ERP systems has much broader scope. ERP systems typically attempt to cover all basic functions of an organization, regardless of the organization's business or charter. Business, non-profit organizations, governments, and other large entities utilize ERP systems.

Additionally, it may be noted that to be considered an ERP system, a software package generally would only need to provide functionality in a single package that would normally be covered by two or more systems. Technically, a software package that provides both Payroll and Accounting functions (such as QuickBooks) would be considered an ERP software package.

However; the term is typically reserved for larger, broader based applications. The introduction of an ERP system to replace two or more independent applications eliminates the need for interfaces previously required between systems, and provides additional benefits that range from standardization and lower maintenance (one system instead of two or more) to easier and/or greater reporting capabilities (as all data is typically kept in one database).

Examples of modules in an ERP which formerly would have been stand-alone applications include: Manufacturing, Supply Chain, Financials, CRM, Human Resources, and Warehouse Management.

1.3.2 Decision Support Systems: Decision support systems are information processing systems frequently used by accountants, managers, and auditors to assist them in the decision-making process. The concept of decision support systems evolved in the 1960s from studies of decision making in organisations. These studies noted that managers required flexible systems to respond to less well-defined questions than those addressed by operational employees. Advances in hardware technology, interactive computing design, graphics capabilities, and programming languages contributed to this evolution. Decision support systems have achieved broad use in accounting and auditing today.

Characteristics of Decision Support Systems: Although decision support system applications vary widely in their level of sophistication and specific purpose, they possess several characteristics in common.

(1) Decision support system support management decision making – Although most heavily used for management planning decisions, operational managers can use them (e.g., to solve scheduling problems), as can top managers (e.g., to decide whether to drop a product line). Decision support systems enhance decision quality. While the system might point to a particular decision, it is the user who ultimately makes the final choice.

(2) Decision support systems solve relatively unstructured problems – problems that do not have easy solution procedures and therefore problems in which some managerial judgment is necessary in addition to structured analysis. Thus, in contrast to transaction processing systems, decision support systems typically use non-routine data as input. These data are not easy to gather and might require estimates. For example, imagine that the manager is selecting accounting software for his company's use. This problem is unstructured because there is no available listing of all the features that are desirable in accounting software for his particular company. Furthermore, he will need to use his judgment to determine what features are important.

Because managers must plan for future activities, they rely heavily on assumptions of future interest rates, inventory prices, consumer demand, and similar variables. But what if managers' assumptions are wrong? A key characteristic of many decision support systems is that they allow users to ask what-if questions and to examine the results of these questions. For instance, a manager may build an electronic spreadsheet model that attempts to forecast future departmental expenditures. The manager cannot know in advance how inflation rates might affect his or her projection figures, but can examine the consequences of alternate assumptions by changing the parameters (here, growth rates) influenced by these rates. Decision support systems are useful in supporting this type of analysis.

Although systems designers may develop decision support systems for one-time use, managers use them to solve a particular type of problem on a regular basis. The same is true of expert systems. However, decision support systems are much more flexible and may handle many different types of problems. Accountants might use a spreadsheet model developed to calculate depreciation only for depreciation problems, but many more general decision support system tools such as Expert Choice (discussed later as an example of a decision support system) are sufficiently flexible and adaptive for ongoing use. Another example is decision support systems that perform data mining tasks.

(3) Finally, a "friendly" computer interface is also a characteristic of a decision support system – Because managers and other decision makers who are non programmers frequently use decision support systems, these systems must be easy to use. The availability of nonprocedural modeling languages, eases communication between the user and the decision support system.

Components of Decision Support Systems: A decision support system has four basic components: (1) the user, (2) one or more databases, (3) a planning language, and (4) the model base.

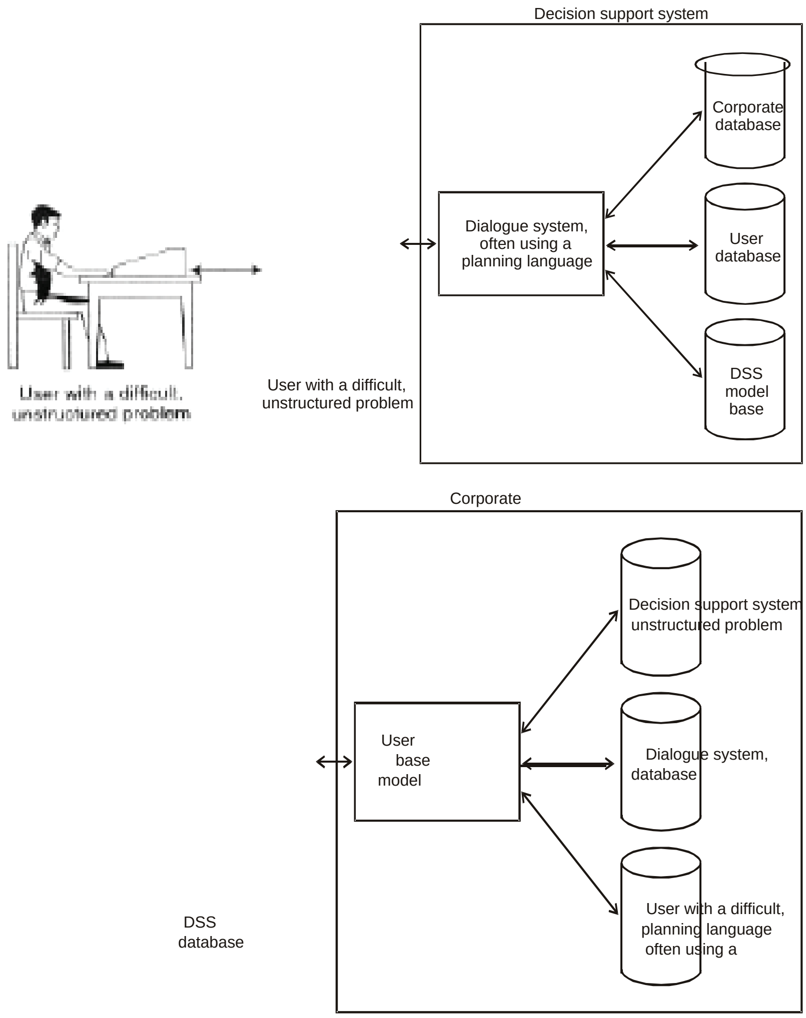

Figure 1.3.1: Components of Decision Support System

(i) The users: The user of a decision support system is usually a manager with an unstructured or semi-structured problem to solve. The manager may be at any level of authority in the organisation (e.g., either top management or operating management). Typically, users do not need a computer background to use a decision support system for problem solving. The most important knowledge is a thorough understanding of the problem and the factors to be considered in finding a solution. A user does not need extensive education in computer programming in part because a special planning language performs the communication function within the decision support system. Often, the planning language is nonprocedural, meaning that the user can concentrate on what should be accomplished rather than on how the computer should perform each step.

(ii) Databases: Decision support systems include one or more databases. These databases contain both routine and non-routine data from both internal and external sources. The data from external sources include data about the operating environment surrounding an organisation – for example, data about economic conditions, market demand for the organization's goods or services, and industry competition.

Decision support system users may construct additional databases themselves. Some of the data may come from internal sources. An organization often generates this type of data in the normal course of operations – for example, data from the financial and managerial accounting systems such as account, transaction, and planning data. The database may also capture data from other subsystems such as marketing, production, and personnel. External data include assumptions about such variables as interest rates, vacancy rates, market prices, and levels of competition.

(iii) Planning languages: Two types of planning languages that are commonly used in decision support systems are: (1) general –purpose planning languages and (2) special-purpose planning languages. General-purpose planning languages allow users to perform many routine tasks – for example, retrieving various data from a database or performing statistical analyses. The languages in most electronic spreadsheets are good examples of general-purpose planning languages. These languages enable user to tackle a broad range of budgeting, forecasting, and other worksheet-oriented problems. Special-purpose planning languages are more limited in what they can do, but they usually do certain jobs better than the general-purpose planning languages. Some statistical languages, such as SAS, SPSS, and Minitab, are examples of special purpose planning languages.

(iv) Model base: The planning language in a decision support system allows the user to maintain a dialogue with the model base. The model base is the "brain" of the decision support system because it performs data manipulations and computations with the data provided to it by the user and the database. There are many types of model bases, but most of them are custom-developed models that do some types of mathematical functions-for example, cross tabulation, regression analysis, time series analysis, linear programming and financial computations. The analysis provided by the routines in the model base is the key to supporting the user's decision. The model base may dictate the type of data included in the database and the type of data provided by the user. Even where the quantitative analysis is simple, a system that requires users to concentrate on certain kinds of data can improve the effectiveness of decision making.

Examples of Decision Support Systems in Accounting: Decision support systems are widely used as part of an organization's AIS. The complexity and nature of decision support systems vary. Many are developed in-house using either a general type of decision support program or a spreadsheet program to solve specific problems. Below are several illustrations of these systems.

***Cost Accounting system**:* The health care industry is well known for its cost complexity. Managing costs in this industry requires controlling costs of supplies, expensive machinery, technology, and a variety of personnel. Cost accounting applications help health care organisations calculate product costs for individual procedures or services. Decision support systems can accumulate these product costs to calculate total costs per patient. Health care managers many combine cost accounting decision support systems with other applications, such as productivity systems. Combining these applications allows managers to measure the effectiveness of specific operating processes. One health care organisation, for example, combines a variety of decision support system applications in productivity, cost accounting, case mix, and nursing staff scheduling to improve its management decision making.

Capital Budgeting System: Companies require new tools to evaluate high-technology investment decisions. Decision makers need to supplement analytical techniques, such as net present value and internal rate of return, with decision support tools that consider some benefits of new technology not captured in strict financial analysis. One decision support system designed to support decisions about investments in automated manufacturing technology is AutoMan, which allows decision makers to consider financial, nonfinancial, quantitative, and qualitative factors in their decision-making processes. Using this decision support system, accountants, managers, and engineers identify and prioritize these factors. They can then evaluate up to seven investment alternatives at once.

Budget Variance Analysis System: Financial institutions rely heavily on their budgeting systems for controlling costs and evaluating managerial performance. One institution uses a computerized decision support system to generate monthly variance reports for division comptrollers. The system allows these comptrollers to graph, view, analyse, and annotate budget variances, as well as create additional one-and five-year budget projections using the forecasting tools provided in the system. The decision support system thus helps the controllers create and control budgets for the cost-center managers reporting to them.

General Decision Support System: As mentioned earlier, some planning languages used in decision support systems are general purpose and therefore have the ability to analyze many different types of problems. In a sense, these types of decision support systems are a decision maker's tools. The user needs to input data and answer questions about a specific problem domain to make use of this type of decision support system. An example is a program called Expert Choice. This program supports a variety of problems requiring decisions. The user works interactively with the computer to develop a hierarchical model of the decision problem. The decision support system then asks the user to compare decision variables with each other. For instance, the system might ask the user how important cash inflows are versus initial investment amount to a capital budgeting decision. The decision maker also makes judgments about which investment is best with respect to these cash flows and which requires the smallest initial investment. Expert Choice analyzes these judgments and presents the decision maker with the best alternative.

1.3.3 Artificial Intelligence: Artificial intelligence (AI) is software that tries to emulate aspects of human behavior, such as reasoning, communicating, seeing, and hearing. AI software can use its accumulated knowledge to reason and, in some instances, learn from experience and thereby modify its subsequent reasoning. There are several types of AI, including natural language, voice and visual recognition, robotics, neural networks, and expert systems.

Natural language, voice and visual recognition both focus on enabling computers to interact more easily and naturally with users. Robotics focuses on teaching machines to replace human labour. Both neural networks and expert systems aim to improve decision-making. Expert systems are one of the most important type of AI that we will discuss in next section.

Artificial intelligence (**AI**) is the study and design of intelligent agents where an intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success. It is the science and engineering of making intelligent machines.

1.3.4 Expert Systems: An expert system (ES) is a computerized information system that allows non-experts to make decisions comparable to those of an expert. Expert systems are used for complex or ill-structured tasks that require experience and specialized knowledge in narrow, specific subject areas, as shown in Figure 1.1.13, expert systems typically contain the following components:

1. **Knowledge base:** This includes the data, knowledge, relationships, rules of thumb (heuristics), and decision rules used by experts to solve a particular type of problem. A knowledge base is the computer equivalent of all the knowledge and insight that an expert or a group of experts develop through years of experience in their field.
2. **Inference engine:** This program contains the logic and reasoning mechanisms that simulate the expert logic process and deliver advice. It uses data obtained from both the knowledge base and the user to make associations and inferences, form its conclusions, and recommend a course of action.
3. **User interface:** This program allows the user to design, create, update, use, and communicate with the expert system.
4. **Explanation facility:** This facility provides the user with an explanation of the logic the ES used to arrive at its conclusion.

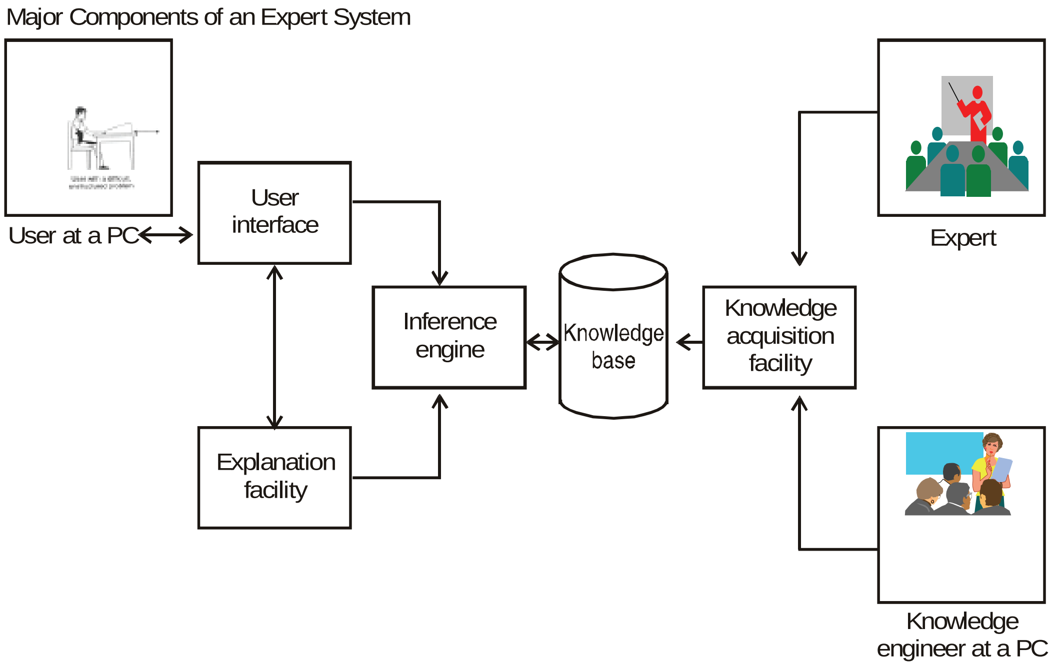

Figure 1.3.2: Expert System Components

5. **Knowledge acquisition facility:** Building a knowledge base, referred to as knowledge engineering, involves both a human expert and a knowledge engineer. The knowledge engineer is responsible for extracting an individual's expertise and using the knowledge acquisition facility to enter it into the knowledge base.

Expert systems can be example-based, rule based, or frame based.

In example-based system, developers enter the case facts and results. Through induction the ES converts the examples to a decision tree that is used to match the case at hand with those previously entered in the knowledge base.

Rule-based systems are created by storing data and decision rules as if- then -else rules. The system asks the user questions and applied the if-then-else rules to the answers to draw conclusions and make recommendations. Rule -based systems are appropriate when a history of cases is unavailable or when a body of knowledge can be structured within a set of general rules.

Frame-based systems organize all the information (data, descriptions, rules etc.) about a topic into logical units called frames, which are similar to linked records in data files. Rules are then established about how to assemble or inter-relate the frames to meet the user's needs.

Expert systems offer the following benefits:

- They provide a cost-effective alternative to human experts.
- They can outperform a single expert because their knowledge is representative of numerous experts. They are faster and more consistent and do not get distracted,

overworked, or stressed out.

- They produce better-quality and more consistent decisions. Expert systems assist users in identifying potential decision making problems, which increases the probability that sound decisions will be made.
- They can increase productivity.
- They preserve the expertise of an expert leaving the organization.

Although expert systems have many advantages and great promise, they also have a significant number of limitations

- Development can be costly and time-consuming. Some large systems required upto 15 years and millions of dollars to develop.
- It can be difficult to obtain knowledge from experts who have difficulty specifying exactly how they make decisions.
- Designers have not been able to program what humans consider common sense into current systems. Consequently, rule-based systems break down when presented with situations they are not programmed to handle.
- Until recently, developers encountered skepticism from businesses due to the poor quality of the early expert systems and the high expectations of users.

As technology advances, some of these problems will be overcome and expert systems will play an increasingly important role in accounting information systems. Here are specific examples of companies that have successful used expert systems:

- The IRS analyzes tax returns to determine which should be passed on to tax fraud investigators.
- IBM designs and evaluates internal controls in both new and existing applications.
- Americans Express authorizes credit card purchases to minimize fraud and credit losses. Its ES replaced 700 authorization clerks and saved tens of millions of dollars.

Summary

The third unit of this chapter introduces basic concepts of software and their classifications (like System software, Application software and Utility software). Various types of programming languages and their advantages and disadvantages are discussed in detail. In this unit, one of the most important concept i.e. Operating System is introduced. Various OS functionality, their features and types have been discussed in detail. The basic concepts of other System software like Device Drivers, Service programs and language translators have also been explained. Spread sheets, databases, CAD, CAM and word processing etc. provide the framework for a great number of businesses, scientific and personal applications. Finally, Application software is explained in the context of ERP, DSS, AI and Expert Systems in detail.