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CHAPTER

INTRODUCTION

INTRODUCTION

Computer is the most powerful tool man has ever created. Computers have made a great impact on our everyday life. Their presence is felt at almost every working place, viz. homes, schools, colleges, offices, industries, hospitals, banks, retail stores, railways, research and design organizations and so on. Computers, large and small, are used nowadays by all kinds of people for a variety of tasks in a modern and industrialized society.

A computer is basically a programmable computing machine. Earlier, computers were used for complex computations and used by only scientists and engineers. The trend was to design large and powerful computers to handle large data and solve complex problems. They were very costly and hence, only large organizations could afford them. The technological breakthrough in design and fabrication of semiconductor devices has made now possible to manufacture powerful microcomputers which are within the reach of small organizations and even individuals. These computers being very fast can be used not only for computation but also to store and retrieve information, to control certain processes and machines, to measure and display certain physical and electrical quantities and so forth. Developments in software allow massive applications of computers for non-computational jobs like text preparation, manipulation, storage and retrieval; transmission of texts, graphics and pictures from one place to another; and artificial intelligence and expert systems, for example, robots, and so on.

1.1 DIGITAL AND ANALOG COMPUTERS

Computers which are in use today are digital computers. They manipulate numbers. They operate on binary digits 0 and 1. They understand information composed of only 0s and 1s. In the case of alphabetic information, the alphabets are coded in binary digits. A binary digit is called *bit*. A group of 8 bits is called a *byte*. Computers do not operate on analog quantities directly. If any analog quantity is to be processed, it must be converted into digital quantity before processing. The output of a computer is also digital. If analog output is needed, the digital output has to be converted into analog quantity. If output is to be displayed in the form of text, the digital output is converted to alphabets. The components which convert alphanumeric characters to binary format and binary output to alphanumeric characters are the essential parts of a digital computer. But the electronic components which convert

analog quantity to digital quantity or digital quantity to analog quantity are connected to a digital computer as peripherals where needed. Processing of analog quantity is usually encountered in industrial control and instrumentation, not in general purpose computation, text manipulation or information storage, retrieval or transmission.

The computer which can process analog quantities is called an *analog computer*. Today, analog computers are rarely used. Earlier, analog computers were used to simulate certain systems. They were used to solve differential equations.

1.2 EVOLUTION OF DIGITAL COMPUTERS

Electronic computers using valves appeared in 1940s. The successful general purpose mechanical computers were developed in 1930s. Before 1930 mechanical calculators were built for automatic addition, subtraction, multiplication and division. A calculator is not a programmable device. Calculations are performed using step-by-step technique. The user does not prepare program for his calculation. A computer is a programmable machine. A program is to be prepared to solve a problem.

1.2.1 The Mechanical Era

The first mechanical calculator was developed in 1623 by Wilhelm Schickhard, a professor at the University of Tubingen. His machine did not become popular. A popular mechanical calculator was developed in 1642 by the great French philosopher and scientist Blaise Pascal. His machine was capable of performing addition and subtraction automatically. For this the machine employed counter wheels. There were two sets of six dials or counter wheels to represent decimal numbers. The calculator contained a mechanism for automatic transfer of carry while performing the sum of two numbers. The numbers were represented by the positions of the counter wheels. Around 1671 Pascal's machine was extended to perform multiplication and division automatically by German philosopher and scientist Gottfried Leibniz. This machine consisted of two parts: one part to perform addition and subtraction and the other part to perform multiplication and division. The part which performed addition and subtraction was similar to the calculating box of Pascal. It further included two additional sets of wheels to represent multiplier and multiplicand. Chains and pulleys were used to implement multiplication.

In 1823, Charles Babbage tried to build a mechanical computing machine capable of performing automatic multistep calculations. He named his machine a difference engine. This was designed to compute tables of functions such as logarithms and trigonometric functions. A polynomial was used to represent a function. The method of finite differences was used to evaluate a function. He could not complete the machine. Swede George Scheutz successfully built a difference engine which could handle third-degree polynomials and 15-digit numbers.

In 1830s Charles Babbage conceived of a much more powerful mechanical computer. He called this machine an analytical engine. This machine was designed to perform any mathematical calculation automatically. It contained all the essential components of a modern digital computer, namely:

(*i*) A processor capable of performing addition, subtraction, multiplication and division. He called it a 'mill'.

(*ii*) A memory unit. It was constructed from decimal counting wheels. Its capacity was 1000 numbers, each number consisting of 50 digits.

(*iii*) Several I/O devices such as a card punch, a punch-card reader and a printer.

The analytical machine was a programmable machine. It had a mechanism for enabling a program to change the sequence of its operations automatically. In other words there were conditional branches of instructions in the program. The condition was based on the sign of a number. One sequence of operations was to be performed if the sign were positive, and another one, if negative. Babbage's analytical machine was also not completed.

In the late nineteenth century punched cards were commercially used. Herman Hollerith was the inventor of punched-card tabulating machine. The major application of his machine came about in the 1890 United States Census. In 1896 he formed the Tabulating Machine Company to manufacture his machines. In 1911 his company was merged with several others to form the Computing-Tabulating Recording Company. This very company was renamed as the International Business Machines Corporation (IBM) in 1924.

Successful general purpose mechanical computers were built in 1930s. Konard Zuse developed a mechanical computer, the Z1, in 1938 in Germany. The Z1 used binary number system instead of decimal system. Konard was unaware of Babbage's work. He built several small mechanical computers. The Z3 was completed in 1941. It is believed to be the first operational general purpose computer. The Z3 employed relays (electromechanical binary switches) to construct arithmetic unit. The machine used floating-point number representation. Howard Aiken, a professor of Physics at Harvard University, designed a general purpose mechanical digital computer. This machine was called an Automatic Sequence Controlled Calculator and later as Harvard Mark I. It was constructed in cooperation with IBM, a leading manufacturer of office equipment at that time. Aiken was aware of Babbage's work. He used decimal counters wheels for its main memory. Its memory capacity was seventy two 23-digit decimal numbers. Punched paper tape was used to program and control the machine. Mark I started working in 1944. Later, Mark II was built by Aiken and his colleagues. Mark II employed electromechanical relays for its operation. Many computers using electromechanical relays were built in the 1940s. But they were quickly superseded by faster and more reliable electronic computers.

1.2.2 The Electronic Era

The first electronic computer using valves was developed by John V. Atanasoff in the late 1930s at Iowa State University. It contained an add-subtract unit. It was relatively a small computer and used about 300 valves. Its memory unit consisted of capacitors mounted on a rotating drum. It used binary numbers for its operation. Each capacitor was capable of storing one binary digit. It used a number of input/output (I/O) devices including a card punch and a card reader. It was completed in 1942. It was a special purpose computer to solve simultaneous equations. Several other electronic computers using valves were successfully constructed in the early 1940s. Some important computers were the series of computers called Colossus developed in England.

The first popular general purpose electronic digital computer was the ENIAC (Electronic Numerical Integrator and Calculator). It was developed at the University of Pennsylvania under the guidance of John W. Mauchly and J. Presper Eckert. John von Neumann was the consultant of the ENIAC project. It was a very large machine weighing about 30 tons and containing about 18000 vacuum tubes. It took 200 microseconds for addition and 3 milliseconds

to perform a 10-digit multiplication. It used decimal numbers for its operation rather than binary numbers. Its working memory was composed of 20 electronic accumulators. Each accumulator was capable of storing a signed 10-digit decimal number. A decimal digit was stored in a ring counter consisting of 10 vacuum-tube flip-flops connected in a closed loop. Like Analytical Engine and Mark I, in ENIAC also programs and data were stored in separate memories. Introducing a new program or modifying a program was an extremely tedious job with separate memories for program and data.

The ENIAC designers, most notably John von Neumann, gave an idea to use a high-speed memory to store both program as well as data during program execution. This idea is known as *stored program concept* and was first published by Neumann for a new computer EDVAC (Electronic Discrete Variable Automatic Computer) in 1945. This machine started operation in 1951. It used binary rather than decimal numbers for its operation. It used serial binary-logic circuits. It used a larger main memory (mercury-delay line) 1 K words and a slow secondary memory (magnetic wire memory) 20 K words (where K stands for Kilo which is equal to 1024 to be exact). Access to the main memory was bit by bit, i.e., serial.

Neumann and his colleagues designed and built a new computer called IAS (Institute of Advanced Studies) at the Institute for Advanced Studies in Princeton during 1946-1952. This machine had the features of a modern computer. It used random access main memory consisting of cathode-ray-tube. An entire word could be accessed in one operation. It used parallel binary circuits. The CPU contained several high-speed (vacuum tube) registers to store operands and results. This computer served as the prototype for most subsequent general purpose computers. The basic logical structure proposed by Neumann is still used in a standard computer. The term Neumann Computer became synonymous with standard computer architecture. A standard architecture includes a CPU, memory and input/output devices. In future the architecture may change; instead of a centralized processing, distributed processing may be used with corresponding other changes in the design and architecture.

The transistor was invented in 1948 at AT & T Bell Laboratories. In the 1950s the engineers started using transistors in place of vacuum tubes to construct computers. One of the earliest computers using transistors was TX-O. It was an experimental computer built at the Massachusetts Institute of Technology's Lincoln Laboratories. It started operation in 1953. Commercial computers using transistors were constructed in the late 1950s and early 1960s by many companies. For example, IBM introduced a large computer, the 7090, for scientific applications. It was a transistorized version of the IBM 709, a vacuum-tube computer. The transistorized computers used transistors as the components of CPU. These computers used ferrite core main memory and magnetic disk, drum and tapes as secondary memory. Ferrite core memories consist of tiny rings (cores) of magnetic material called ferrite. Each ferrite core stores a single bit of information. Transistorized computers were faster and compact, and consumed much less power compared to vacuum tube computers.

Integrated Circuits (ICs) were first designed and fabricated in 1958-1959 by Jack S. Kilby at Texas Instruments, and by Robert S. Noyce at Fairchild independently. The first commercial IC was introduced in 1961 by Fairchild. ICs began to replace transistor circuits since 1965. The examples of computers using ICs are IBM 370 and PDP-8. By 1970 all new computers used ICs, SSI and MSI as CPU components and LSI for main memory. SSI, MSI, LSI, VLSI and ULSI are the classification of ICs based on components density. SSI contains components, usually transistors, 1 to 100, MSI 100 to 1000, LSI 1000 to 10,000, VLSI more than 10,000 and ULSI millions.

The first LSI chips were introduced in 1970 in the form of computer memory units. With the advent of LSI and VLSI chips it became possible to fabricate the whole CPU unit on a single chip called microprocessor. The first microprocessor, the 4004 was introduced in 1971 by Intel Corporation. The first single-chip microcomputer TMS 1000, a 4-bit microcontroller, was developed by Texas Instruments in the year 1974. An 8-bit microcontroller, the 8048 was introduced in 1976 by Intel. Computers built in 1970s and onwards used microprocessors and other LSI, VLSI and ULSI components.

Computer Generations

First Generation (1946-1954). The digital computers using electronic valves (vacuum tubes) are known as first-generation computers. Some examples of the first-generation computers are: IBM 700 series-IBM 701, IBM 704, IBM 709, EDVAC and UNIVAC. The first-generation computers usually used vacuum tubes as CPU components. The high cost of vacuum tubes prevented their use for main memory. So less costly but slower devices such as acoustic delay lines were used for memory. They stored information in the form of propagating sound waves. Electrostatic memories have also been used in the first generation computers. Magnetic tape and magnetic drums were used as secondary memory. A first generation computer, Whirlwind I, constructed at MIT was the first computer to use ferrite core memory. The first generation computers used machine language and assembly language for programming. They used fixed-point arithmetic. Punched cards and paper tapes were developed to feed programs and data and to get results. Punched card and paper tape readers and printers were in use.

Second Generation (1955-1964). The second-generation computers used transistors for CPU components and ferrite cores for main memory, and magnetic disks and tapes for secondary memory. They used high-level languages such as FORTRAN (1956), ALGOL (1960) and COBOL (1960) for programming. Floating-point arithmetic hardware was widely used. I/O processor was included to control input/output operations. It relieved CPU from many time-consuming routine tasks. Examples of second generation computers are: IBM 1620 (1960), IBM 7090 (1960), IBM 7094I (1962), 7094II (1964); Control Data Corporation's CDC 1604; and Digital Data Corporation's PDP 1 (1957), PDP 5 (1963) and PDP 8 (1965). PDP (Programmed Data Processor) series is a series of minicomputers. PDP 8 was a 12-bit minicomputer. Its earlier units used transistors; IC version was introduced in 1967. Punched cards and paper tapes and their readers were used as I/O devices. Printers were in use.

Third Generation (1965-1974). The third-generation computers used ICs (SSI and MSI) for CPU components. In the beginning third generation computers used magnetic core memory, but later on semiconductor memories (RAMs and ROMs) were used. Semiconductor memories were LSI chips. Magnetic disks, and tapes were used as secondary memories. Cache memory was also incorporated in the computers of third generation. Microprogramming, parallel processing (pipelining, multiprocessor system, etc.), multiprocessing, multiprogramming, multiuser system (time-share system), etc. were introduced. The concept of virtual memory was also introduced. The examples of third generation computers are: IBM/370 series (1970), CDC 7600 (1969), PDP 11 (16-bit minicomputer, 1970), CDC's CYBER-175 and STAR-100, etc. I/O devices were punched cards, magnetic tapes and printers.

Fourth Generation (1975-1990). In the fourth-generation computers microprocessors were used as CPU. VLSI chips were used for CPU, memory and supporting chips. The electronic circuitry of up to 1.2 million transistors were placed on a single silicon chip.

Computers of earlier generation used separate ICs for cache memory, FPU (Floating-Point Unit *i.e.*, Match Processor), MMU (Memory Management Unit) etc. Now microprocessor chips contained all such units besides CPU on a single chip. They were packed in a single IC. Multifunctional peripheral chips were available. They contained interrupt controller, DMA controller, timer-counters, bus controller etc. in a single IC. These are essential components required for a computer. Computer of this generation were very fast. They performed internal operations in microseconds. 8, 16 and 32-bit microprocessors were developed during this period.

Main memory used fast semiconductor chips up to 4 Mbits size. Hard disks were used as secondary memory. Hard disk drives of hundreds of megabytes were available. Floppy disks and magnetic tapes were used as backup memory. Keyboard, CRT display (monitor), dot-matrix printers etc. were used as peripherals. Inkjet, laser and line printers, were developed during this period. PCs (Personal Computers) were available. Such computers can be easily placed on a desk and hence, they were also known as desk computers. They were single-user computers. During this period computers were within the reach of small organization, institutions, professionals and individuals. The desktop computers were more powerful than the mainframe computers of 1970s. Computers became very powerful and small in size. During this period computer network: LANs and WANs were also developed. Operating systems MS-DOS, UNIX, Apple's Macintosh etc. were available. Apple's Macintosh with GUI (Graphical User Interface) was developed. Object-oriented language C^{++} was developed. Single-chip microcomputers (microcontrollers) were available. They were widely used in industrial control, instrumentation, commercial appliances etc. Software packages for word processing, spread-sheet, database management etc. were developed. Examples of fourth-generation computers were: Intel's 8088, 80286, 80386 and 80486 based computers; Motorola's 6800, 68020, 68030 and 68040 based computers, IBM 3090, VAX 9000, Supercomputers-Cray-1, Cray-2, Cray X-MP, Cray Y-MP, Hitachi 828/80 etc.

Fifth-Generation (1991-Continued). Fifth-generation computer use ULSI (Ultra-Large Scale Integration) chips. Millions of transistors are placed in a single IC in ULSI chips. Intel's Pentium 4 Prescott contains 160 million transistors and Itanium 2 processor contains more than 400 million transistors. 64-bit microprocessors have been developed during this period. Data flow and EPIC architectures of processors have been developed. Intel's processors Pentium Pro onwards use data flow architecture and Itanium uses EPIC architecture. Von Neumann architecture are still used in less powerful CPUs. RISC and CISC both types of design are used in modern processors. Intel's up to Pentium 4 and AMD's processors use CISC design. SUN, MIPS, HP etc. use RISC design for their processors. 32-bit microcontrollers (Single-Chip Microcomputers) have been developed for industrial and commercial application. Nowadays multimedia computers are becoming common. A multimedia computer can accept text, sound and/or image as input and give output in the form of text, sound and/or images. They can handle animation. Computers using artifical intelligence (expert systems) are now available. Robots have been developed. They can work in environment where human beings can not do. Powerful handheld and notebook computers are now available. Fifth-generation computers use extensive parallel processing, multiple pipelines, multiple processors etc.

Memory chips and flash memory up to 1Gbits, hard disk drives up to 600 Gbytes and optical disks up to 50 GB have been developed. Inkjet and laser printers are commonly used. In some applications dot-matrix printers are still used. Computers with vision have been developed. Internet is becoming popular and people are getting all kinds of information from distant places using Internet. Video conferencing is also in use. Object-oriented language Java for Internet programming is widely used. Heterogeneous computers are connected to Internet.

Heterogeneous computers mean computers of different make and having different operating systems. Programs written in Java for one computer can run on any other computer. It means that Java is quite suitable for Internet programming for heterogeneous computers. Operating systems available today are : WINDOWS-95, 98, XP, 2000, 2003; Apple's Mac OS-8, 9, 10 and X; SUN's Solaris, LINUX etc. All OS now include GUI. Examples of processors are: Intel's Pentium to Pentium 4, Itanium; Motorola's Power PC, MIPS, Compaq's Alpha, SUN's Ultra SPARC III, AMD's Athlon, Athlon 64, ARM processors, Cell processors etc. Internal processing time is now in nanoseconds.

Superscalar processors, vector processors, DSP (Digital Signal Processor), symbolic processors, SIMD (Single Instruction Multiple Data) processors, multicore processors, expert systems employing artificial intelligence, etc. have been developed. Supercomputers available today are IBM's BlueGene/L DD2 Beta-system having speed of 70.7 TFLOPS, Columbia (NASA) having speed of 51.9 TFLOPS, Earth simulator (NEC) having speed of 40 TFLOPS etc.

1.3 MAJOR COMPONENTS OF A DIGITAL COMPUTER

The major components of a digital computer are: CPU (central processing unit), memory, input device and output device. The input and output devices are also known as peripherals. Fig. 1.1 shows a schematic diagram of a digital computer.

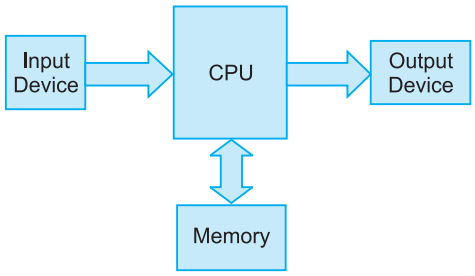

Fig. 1.1 Schematic diagram of a digital computer.

1.3.1 CPU

The CPU is the brain of a computer. Its primary function is to execute programs. Besides executing programs, the CPU also controls the operation of all other components such as memory, input and output devices. Under its control, programs and data are stored in the memory and displayed on the CRT screen or printed by the printer.

The CPU of a small computer is a microprocessor. Fig. 1.2 shows the schematic diagram of a microcomputer. The CPU of a large computer contains a number of microprocessors and other ICs on one or more circuit boards. Each microprocessor in a large CPU performs a specific task.

Fig. 1.3 shows the schematic diagram of a CPU or microprocessor. The major sections of a CPU are:

(i) Arithmetic and Logic Unit (ALU)

The function of an ALU is to perform arithmetic and logic operations such as addition, subtraction, multiplication, and division; AND, OR, NOT (complement) and EXCLUSIVE-OR operations. It also performs increment, decrement, shift and clear operations.

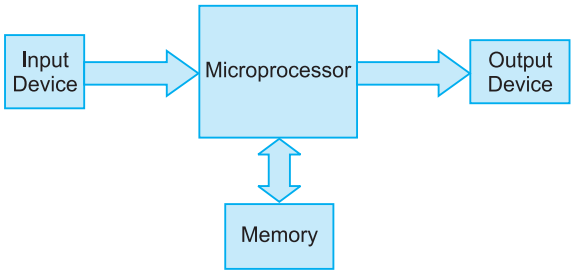

Fig. 1.2 Schematic diagram of a microcomputer.

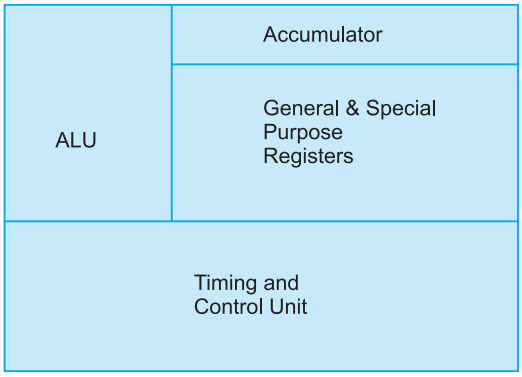

Fig. 1.3 Schematic diagram of a CPU or microprocessor

(ii) Timing and Control Unit

The timing and control unit generates timing and control signals necessary for the execution of instructions. It provides status, control and timing signals necessary for the operation of other parts of the CPU, memory and I/O devices. It controls the entire operation of a computer. It is actually the control section of the CPU, which acts as the brain of a computer.

(iii) Accumulator, General and Special Purpose Registers

The accumulator is a register which holds one of the operands prior to the execution of an instruction and services result of the most arithmetic and logical operations. It is the most frequently used register. Some CPUs contain a single accumulator, and some contain several accumulators. General purpose registers store data and intermediate results during the execution of a program. They are accessible to programmers through instructions if they are working in an assembly language. Special purpose registers are not accessible to users. They are used by the computer for different purposes during program execution. Examples of special purpose registers are: program counter, stack pointer, index registers, instruction register, etc.

1.3.2 Memory

The function of the memory is to store information. It stores program, data, results or any other kind of information. Two or three levels of memories such as main memory, secondary memory and cache memory are provided in a digital computer. The *main memory* (or primary memory) is a fast memory. It stores programs along with data, which are to be

executed. It also stores necessary programs of the system software, which are required to execute the user's program. The main memory is directly addressed by the CPU. Semiconductor memories, RAMs are used as main memory. It possesses random access property, and has smaller access time, about 50 ns (nanosecond). *Secondary* (or *auxiliary) memory* stores operating system, data files, compilers, assemblers, application programs, etc. The CPU does not read information (residing in the secondary memory) directly from the secondary memory. The programs and data (residing in secondary memory), if needed by CPU, are first transferred from the secondary memory to the primary memory. Then the CPU reads them from the primary memory. The results are also stored in the secondary memory. The secondary memory is a mass storage memory. It is slow but cheap. It is a permanent memory while the main memory (RAM) is volatile memory. The capacity of the main memory is comparatively much smaller than that of the secondary because of its high cost. Hard disks are used as secondary memory. Their access time is about 5-10 ms (millisecond).

The *cache memory* is placed in between the CPU and the main memory. It is much faster than the main memory; access time about 10 ns. It stores instructions and data which are to be immediately executed. It is much costlier than the main memory. Hence, from cost consideration its capacity is kept much less than that of the main memory.

Destructive and Nondestructive Readout

In some memories the process of reading the memory destroys the stored information. This property is called *destructive readout (DRO).* Example of a memory having DRO characteristic is a dynamic RAM. In some memories the process of reading information does not destroy the stored information. This characteristic of the memory is called *nondestructive read-out (NDRO).* Examples of memories having NDRO features are static RAM, hard disks, floppy disks, magnetic tapes, etc.

Real (or Physical) and Virtual Memory

The real or physical memory is the actual main memory available in a computer system. It is directly addressed by the CPU.

The technique which allows a program to use main memory more than a computer really has is called *virtual memory technique.* For example, the 80386 microprocessor can have the maximum physical memory capacity 4 gigabytes (GB) but its virtual memory capacity is much larger, 64 terabytes (TB) [see details in Chapter 6].

Direct Access Storage Devices (DASD), On-Line and Off-Line Memory Devices

While processing data it is often required to access any record at any time. It may be desired to access a single record, update it and put it back in its original place. This type of data processing is called direct processing or random processing. It needs locating, retrieving and updating any record stored in a file without reading the preceding or succeeding records in the file. These requirements can be fulfilled with direct access storage devices (DASD equipment). DASD includes hard disks, floppy disks and several forms of optical disks.

Memory devices which always remain connected to a computer system are called on-line devices. Hard disks are on-line secondary memory. The devices that can be connected to the system when needed are known as off-line memory. Magnetic tape is an example of off-line memory.

Memory Management

In a multiuser, multitasking or multiprogramming system, memory must be specifically managed to a handle multiple programs. The physical size of the main memory is usually not large enough to accommodate the operating system and all of the application programs which are needed to execute the programs of various users. In a multiuser system users should not interfere with one another, and also they should not interfere with the operating system. This is achieved by providing suitable memory management scheme. Memory management can be provided totally by the operating system or with the help of hardware called MMU (memory management unit).

In a uniprogramming system, the main memory is partitioned into two portions: one portion for the operating system and the other portion for the program currently being executed. In a multiprogramming system the user's portion of the memory must be further subdivided to accommodate multiple tasks. The task of subdivision is done dynamically by the memory management scheme. Modern MMUs provide virtual memory to handle large program or a large number of programs. This is achieved by using swapping technique.

Memory Devices. There are three types of memories from technology point of view: semiconductor, magnetic and optical memory. Semiconductor memory is static, faster, lighter, smaller in size and consumes less power. It is used as main memory of a computer. Magnetic memory is slower but cheaper than semiconductor memory. It is used as secondary and back up memory of a computer for mass storage of information. RAMs, ROMs, EPROMs, flash memory etc. are semiconductor memories, and hard disks, floppy disks and magnetic tapes are magnetic memories. Optical disks and tapes are used as mass storage and back up memory.

Semiconductor Memory

Semiconductor memories are of two types: RAM (random access memory) and ROM (read only memory). RAM is a read/write memory. Information can be written into and read from a RAM. It is s volatile memory. It stores information so long as power supply is on. When power supply goes off or interrupted the stored information in the RAM is lost. ROM is a permanent type memory. Its contents are not lost when power supply goes off. The user cannot write into a ROM. Its contents are decided by the manufacturer and written at the time of manufacture. RAMs up to 1 Gbits capacity are available. ROMs store permanent programs and other types of information which are needed by the computer to execute user's programs.

Programmable ROMs are also available. They are called PROMs. Further, different types of PROMs such as erasable PROM called EPROM, electrically erasable PROM called E^2 PROM are available. User can write permanent information in PROMs. Such information is required while executing user's programs. Flash memory which is electrically erasable and programmable, is available. It is similar to EEPROM, but has higher packing density, lower cost and greater reliability.

Magnetic Memory

Magnetic memories are nonvolatile memory. They store information permanently. They are slower than semiconductor memory. The commonly used magnetic memories are of three types: hard disks, floppy disks and tapes. These devices are bulk storage devices. They are used to store information at a lower cost compared to semiconductor devices. These are not static devices. They are rotated while reading or writing information.

Floppy Disks. These are thin circular plastic disks coated with magnetic material (iron oxide or barium ferrite) on the surface. They are used as backup memory. The capacity of a 3.5 inch floppy is 1.44 MB. The use of floppy disks is diminishing day by day. Now people prefer to use optical disks. Floppy disks are cheaper than optical disks.

Hard Disks. Hard disks are made of aluminium or other metal or metal alloy which are coated on both sides with magnetic material usually iron oxide. Unlike floppy disks, hard disks are not removable from the computer. To increase the storing capacity several disks are packed together and mounted on a common drive to form a **disk pack.** A disk is also called **platter.** The disks unit packed in a sealed container is called **Winchester** disk drive. As the sealed containers are dust-free, they allow very high speed, usually 7200 rpm-15,000 rpm. A hard disk is more stable as it is rigid and contained in dust-free environment. Its track and bit densities are much higher than those of floppy disks. A hard disk may have more than 10,000 tracks per surface and bit density 15,000 bits per inch of a track. The data transfer rate is 33.3-700 MB/sec. The average access time is about 5-10 ms. The reliability of data is 1 in 10^{11} which is much better than that of floppy disk, that is 1 in 10^{8}–10^{10}. Hard disks come in 2.5 inch and 3.5 inch diameter. The storing capacity per disk is upto 133 GB. The capacity of hard disk drive unit is upto 600 GB. A hard disk unit contains more than one platter.

Hard disk controllers are used to interface hard disks to a processor. An example of hard disk controller is Intel 82064. There are two types of hard disk controllers: IDE (Integrated Drive Electronics) and SCSI (Small Computer System Interface). SCSI are intelligent controller and they connect a number of I/O devices such as hard disks, floppy disks, tape drive, optical disks, printers, scanners etc. It is costlier than IDE controller. Actually, SCSI and IDE are not controllers; they are adapters. But people call them controllers. SATA (Serial ATA Interface) is now available for hard disk drives. Its data transfer rate is 3GB/s.

Magnetic Tape. Magnetic tape is a mass storage device. It is used as back up storage. It is serial access type storage device. Its main disadvantage is that it stores information sequentially. It is made up of plastic material. Standard sizes are 1/2 inch, 1/4 inch, 8 mm and 3 mm wide. Earlier, tapes used 9 tracks to store a byte with parity bit. Today tapes use 18 or 36 tracks to store a word or double word with parity bits. Newer tape is packed in cassette form which is called cartridge tape. The storing capacity is 2 GB-800 GB of compressed data. The data density of 18-track tape is about 40,000 characters per inch.

Optical Memory. Information is written to or read from an optical disk or tape using laser beam. Optical memory is used as archival and backup memory. Optical disks are not suitable for secondary memory because their access time is more than that of hard disks. Their advantage is that they have very high storage capacity. Types of optical memory are: CD-ROM, CD-R (CD Recordable), CD-RW, DVD-ROM, DVD-R and DVD-RW. CD-ROM is also called compact disk ROM. Information on CD-ROM is written at the time of manufacture. It is a read-only type memory. Disk size is 5.25 inch diameter. 650MB CD-ROMs are available. Their access time is 80 ms. Data transfer rate is 4800KB/s. A typical value of track density is 16000 tracks per inch.

CD-R/W (Read/Write) of 700 MB capacity are now available.

A DVD-ROM is similar to CD-ROM. It uses shorter wavelength of laser beam and hence, stores much more data than CD-ROM. DVD-ROMs of capacity 4.7 GB to 50 GB are now available.

1.3.3 Input Devices

Information is entered into a computer through input devices. An input device converts input information into suitable binary form acceptable to a computer. The commonly used input device is a keyboard. Several input devices which do not require typing of input information have been developed, for example, mouse, joystick, light pen, graphic tablet, touch screen and trackballs. Each of these allows users to select one of the items or images displayed on the screen. Therefore, these devices are called *pointing devices*. The required input is fed to the computer when control button is pressed. In industrial control electrical signals representing physical or electrical quantities such as temperature, pressure, force, current, voltage, frequency, etc. are entered a computer for their measurement and control. The sensors, transducers and data acquisition system act as input devices. Nowadays voice input systems have also been developed. A microphone is used as an input device. In many applications, computers with vision are required, for example, robots, computer-based security system, etc. The input systems for this type of computers use optical system, semiconductor devices sensitive to light, devices based on ultrasonic waves, etc. Such input devices produce digital signals corresponding to images, pictures etc. A multimedia computer accepts input in the form of text, images, graphics and voice.

1.3.4 Output Devices

The output devices receive results and other information from the computer and provide them to users. The computer sends information to an output device in the binary form. An output device converts it into a suitable form convenient to users such as printed form, display on a screen, voice output, etc. In some applications the computer's output may also be converted by an output unit in the form which can be used as an input to other devices, equipment, machines, etc. This is particularly true in industrial applications. The commonly used output devices are CRT screen and printers. Other output devices are LEDs (light emitting diodes), LCDs (liquid crystal displays), plasma displays, plotters, microfilm, microfiche, speaker or telephone system, etc.

The display screen is also called monitor or CRT (Cathode Ray Tube) display. Two types of display units are available: monochrome and colour monitor. Monochrome monitor displays texts in a single colour: blue, white, yellow or amber. A colour monitor displays text or graphics in multicolour. It may be desired in art/graphics applications. For graphics display, screens of higher resolutions are required. To provide higher resolution, screens contain more number of pixels to display text or images.

1.3.5 Buses

Memory and I/O devices are connected to the CPU through a group of lines called a *bus*. These lines are meant to carry information. There are three types of buses: address bus, data bus and control bus. An address bus carries the address of a memory location or an I/O device that the CPU wants to access. The address bus is unidirectional. The data and control buses are bidirectional because the data can flow in either direction; from CPU to memory, (or I/O device) or from memory (or I/O device) to the CPU. Examples of control signals are: $\overline{RD}$, $\overline{WR}$, ALE, etc. Fig. 1.4 shows the schematic diagram of I/O or memory connection to CPU.

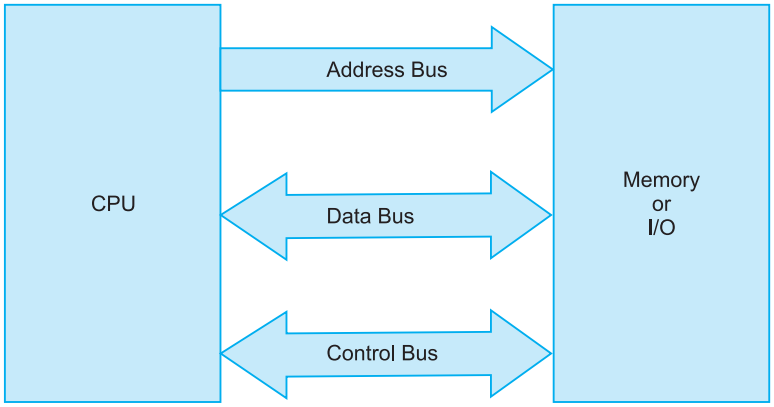

Fig. 1.4 I/O or Memory Connection to CPU.

Different types of bus architectures such as ISA, PCI, AGP, USB etc. have been described in Chapter 10.

1.4 MEMORY ADDRESSING CAPABILITY OF A CPU

The memory addressing capability of a CPU depends on the number of lines available in an address bus, that is, width of the address bus. With *n*-bit wide address bus a CPU can directly address up to 2^n memory locations. For example, a CPU with 20 bit wide address bus will address 2^{20} memory locations directly. 2^{20} = 1 million. One memory location stores one byte of information and hence a CPU with 20-bit address bus will directly address up to 1 MB memory, with 16-bit address bus 64 KB memory, with 24-bit address bus 16 MB memory and with 32-bit address bus 4 GB memory.

It can be very easily shown that with *n* address lines, 2^n memory locations can be addressed. First take a simple case of only 2 lines. A line carries either 0 or 1 binary digit. Using two lines only, possible memory addresses are: 00, 01, 10 and 11. These are $2^2 = 4$. If there are 3 lines, the possible addresses will be 000,001, 010, 011, ... 111 which are $2^3 = 8$. Similarly, with four address lines possible addresses are: 0000, 0001, 0010, 0011, 0100, ..., 1111 which come out to be $2^4 = 16$. Similarly, with *n* address lines up to 2^n memory locations can be addressed.

1.5 WORD LENGTH OF A COMPUTER

A digital computer operates on binary digits, 0 and 1. It can understand information only in terms of 0s and 1s. As already mentioned a binary digit is called a *bit*. The word bit is the short form of *binary digit*. A group of 8 bits is called a *byte*. The number of bits that a computer can process at a time in parallel is called its *word length*. The commonly used word lengths are: 8, 16, 32 or 64 bits. It is a measure of the computing power of a computer. Computer with longer word length are more powerful. When we talk of a 32-bit computer, it means that its word length is 32 bits. Similarly when we say 8-bit, 16-bit or 32-bit microprocessor, 8-bit, 16-bit or 32-bit indicates the word length of the microprocessor.

1.6 PROCESSING SPEED OF A MICROPROCESSOR

The processing speed of a microprocessor is usually measured in millions of instructions per second. In short it is written as **MIPS**. In computer literature term **throughput** is also used for the number of instructions executed per second. The MIPS rating is used to specify the integer computation performance of a processor. The processing speed of a microprocessor for floating-point computation is measured in millions of floating-point instructions per second, **MFLOPS**. As the instructions differ from microprocessor to microprocessor for a high-level language program, the MIPS rating does not give correct idea of processing speed of a microprocessor. If the same program runs on a RISC as well as on a CISC processor, the MIPS rating of the RISC processor will be higher because the instructions of a RISC processor are simpler than those of a CISC processor.

Further, to compare processors with different clock cycles and different instruction sets is not totally correct. Today **SPEC** ratings are widely used to specify processor's performance. SPEC is the abbreviation of System Performance Evaluation Committee. This committee was formed in 1989 to develop industry-standard benchmark to evaluate processor's rating. SPEC ratings are given in SPECint95 to measure integer performance, and SPECfp95 to measure floating-point performance. The 'int' stands for integer, 'fp' for floating-point, 95 is the year in which this standard was developed. SPECint95 is written in C language, and SPECfp95 in FORTRAN.

Some other ratings are as follows

TPS (Transactions Per Second). It is used for on-line processing application of a computer. On-line applications demand rapid interactive processing for large number of relative simple transactions. Each transaction may involve a database search, query, answering, and database update operations. They are supported by very large databases. Examples are: railways reservations, airlines reservations, automated teller machines, etc.

KLIPS. For a knowledge-based computer, performance can be measured in kilo logical inferences per second (KLIPS).

iCOMP. It is Intel's Comparative Mircroprocessor Performance. It consists of a collection of benchmarks to evaluate an index of relative performance of Intel microprocessors.

LINPACK Rating. It uses FORTRAN programs for solving linear system of equations of the order of 100 and higher. Its programs contain high percentage of floating-point operations. It is very sensitive to vector operation and the degree of vectorization by the computer. Hence, it is given with specific compiler and degree of linear equations. It is measured in MFLOPS or GFLOPS.

Dhyrstone. It is synthetic testing benchmark. It gives integer performance. Its unit is Kdhrystone per second. Its disadvantage is that it is sensitive to compilers.

Whetstone. It is a FORTRAN based synthetic testing benchmark. It measures both integer and floating-point performance. Its programs take into account array indexing, subroutine calls, parameter passing, conditional branching, and trigonometric/transcendental functions. Its unit is KWhetstone per second. It is sensitive to compilers. Whetstone tests do not perform I/O or system calls.

1.7 MICROPROCESSORS

With the advances in LSI and VLSI technology it became possible to build the whole CPU of a digital computer on a single IC. A CPU built on a single LSI, VLSI or ULSI chip

is called a *microprocessor*. It is the latest development in the field of computer technology as well as semiconductor technology. A digital computer has a microprocessor as its CPU. A microprocessor combined with memory, an input device and an output device forms a microcomputer. The CPU of a large computer contains a number of microprocessors. Each microprocessor performs a specified task within the CPU. The microprocessors in the CPU of a large computer operate in parallel.

Table 1.1 Important Intel Microprocessors

Microprocessor	*Year of Introduction*	*Word Length*	*Memory Addressing Capacity*	*Pins*	*Clock*	*Remarks*
4004	1971	4-bit	1 KB	16	750KHz	First microprocessor
8085	1976	8-bit	64KB	40	3-6MHz	Popular 8-bit microprocessor
8086	1978	16-bit	1 MB	40	5-10MHz	
8088	1980	16-bit	1 MB	40	5-8 MHz	Data bus 8-bit, Internal architecture 16-bit, widely used in PC XT.
80286	1982	16-bit	16MB real, 4GB Virtual	68	6-12.5MHz	Widely used in PC/AT
80386	1985	32-bit	4GB real, 64 TB Virtual	100	20MHz	Popular 32-bit Microprocessor
80486	1989	32-bit	4GB real, 64TB Virtual	168 (17×17)	25-100MHz	Improved 32-bit processor, contains FPU and cache on the chip.
Pentium	1993	32-bit	4GB real	237PGA	233MHz	Contains 2 ALUs, data bus 64-bit, address bus 32-bit.
Pentium Pro	1995	32-bit	64GB real	387 pin PGA	150-200MHz	Data flow architecture, contains 2nd-level cache, operates at 3.3V.
Pentium II		32-bit	64GB real		450MHz	Pentium Pro with MMX technology
Celeron	1998	32-bit			2.6MHz	Cheaper 32-bit processor, based on Pentium Pro core.
Pentium III	1999	32-bit	64GB real	370PGA	500-1000MHz	pentium II + 70 multimedia instructions.
Pentium 4	2000	32-bit	64 GB	423PGA	1.3-3.2 GHZ	
Pentium 4EE and Pentium 6XX series	2004	64-bit		–	3-3.7 GHZ	
Itanium	2001	64-bit		423PGA	–	EPIC Processor

Nowadays microprocessors also perform tasks other than those of a CPU. A number of microprocessors are also used to control input and output devices of a large computer. For example, a microprocessor is used to control the operation of a keyboard and CRT display unit. It is used to control the operation of a printer and so on.

The first microprocessor, Intel 4004, a 4-bit microprocessor, was introduced in 1971 by Intel Corporation. In 1972 Intel introduced the first 8-bit microprocessor, Intel 8008. These microprocessors used PMOS technology. A more powerful and faster microprocessor, the Intel 8080, using NMOS technology was introduced in 1973. The 8-bit microprocessors were introduced by a number of companies; examples are: Motorola's MC 6809, Zilog's Z80 and Z800, MOS Technology's 6500 series, National Semiconductor's NSC 800 etc. The latest 8-bit microprocessor of Intel is 8085 introduced in 1976. It is very popular and widely used. The first Indian 8-bit microprocessor was SCL 6502, manufactured by Semiconductor Complex Ltd. 8-bit microprocessors were soon followed by 16-bit microprocessors. Examples of 16-bit microprocessors are: Intel 8086, 80186 and 80286; Motorola's 68000, 68010, 68012; Texas Instrument's TMS 9900, Fairchild 9440, Digital Equipment's LSI 11 and so on. In the 1980s, 32-bit microprocessors were introduced, and they are still widely used. Examples of 32 bit microprocessors are Intel 80386, 80486, Pentium, Pentium Pro, Pentium II. Pentium III, Celeron and Pentium 4.

Pentium Pro, Pentium II, Pentium III and Pentium 4 use data flow architecture. Earlier, Intel's 4004 to Pentium were Von Neumann type processors. Pentium III is an improved version of Pentium II. It includes MMX pipeline to provide MMX features. Furthermore, it contains Internet Streaming SIMD instructions to enhance multimedia performance on the Internet such as streaming audio and video, animation, 3-D simulation, advanced imaging, speech recognition etc. Celeron processor is a low-cost 32-bit processor. It includes MMX features and Internet streaming SIMD instructions. Pentium 4 is an improved version of Pentium III. It contains more Internet Streaming SIMD instructions and it is faster than Pentium III. Pentium M is low-cost processor for notebook computers. 32-bit processors of other companies are: Motorola's 68020, 68030, 68040 and 68060, Power PC 601, 603, 604, 740 and 750, National Semiconductor's NS 32032, NS 32332 NS32C532 and M300, AMD's K5, K6 and Athlon (K7), Cyrix 586 and 686 etc.

Pentium 4 EE (Extreme Edition) and Pentium 4 6XX series are 64-bit processors. Pentium 4 EE 840 is a dual core processor suitable for servers. Itanium is a 64-bit processor of Intel Corporation. 64-bit processors of other companies are: AMD's Athlon 64, Athlon 64 FX series, Optiron, Athlon 64X2; PowerPC 620, PowerPC G4, IBM's G5, SUN's Ultra SPARC III, Compaq's Alpha 21264, MIPS 12000; C-DAC's Param 10,000 and Param Padma, HP's PA 8500 series etc. AMD's Optiron and Athlon 64X2 are dual core processors.

Table 1.2 Important Microprocessors of Companies other than Intel

Microprocessor	*Make*	*Year of Introduction*	*Word length*	*Clock*	*Number of Transistors*	*Remarks*
6809	Motorola	1979	8-bit	4-8 MHz		Popular 8-bit microprocessor
68000	Motorola	1979	32-bit internal architecture, 16-bit data bus	10-25 MHz	70,000	Popular and widely used

(Contd.)...

68040	Motorola	1989	32-bit	20-33 MHz	1.2 million	Contains FPU, MMU, on-chip data cache and instruction cache
Power PC 601	Motorola, IBM and Apple	1993	32-bit	120 MHz	2.8 million	RISC processor
Power PC 750	Motorola, IBM and Apple	1997	32-bit	400 MHz		Suitable for notebooks, mobile and desktop
K6-3, Athlon	AMD	1999	32-bit	500 MHz		Contains 2nd level and 3rd level cache. K7 is called Athlon
586, 686 and 6X86MX	Cyrix		32-bit	233 MHz		6X86MX outperforms Pentium II
Power PC 620	Motorola, IBM and Apple		64-bit	250 MHz	7×10^6	Suitable for workstation
Alpha 21164, 21264	DEC Compaq		64-bit	700 MHz-1000MHz for 21264	9.3×10^6 (21164)	RISC processor.
ULTRA-SPARC	SUN		64-bit	200 MHz	3.8×10^6	RISC processor
MIPS 10,000, 12000	MIPS	1999	64-bit	300 MHz	6.4×10^6 (MIPS 10000)	RISC processor. Suitable for work-stations.
PA 8500	H.P.	1999	64-bit	440 MHz		
68060	Motorola	1995	32-bit	–	–	Suitable for embedded application
Athlon 64, Athlon 64 FX	AMD	2003	64-bit	2.66 GHZ	–	0.13 micron process technology
Optiron, Athlon 64X2	AMD	2005	64-bit	2.4 GHZ	–	Dual-core processors

1.8 SINGLE-CHIP MICROCOMPUTERS (MICROCONTROLLERS)

With the development of VLSI technology it became possible to fabricate a digital computer on a single IC chip. A digital computer fabricated on a single IC chip is called **single-chip microcomputer.** Since it is widely used for control application, it is also called **microcontroller.** It is very small and compact. It forms the part of the device or equipment which is to be controlled. It is used for industrial control, process control, consumer and appliances control, instrumentation, etc. It contains a CPU, memory (RAM, and ROM/EPROM/ Flash memory) and I/O lines. A powerful microcontroller may contain some other components

which are needed for control applications such as analog-to-digital converter, digital-to-analog converter, interrupt controller, DMA controller, wave generator, etc.

Intel developed 8-bit microcontrollers 8048 series, in 1976. In 1980 improved 8-bit microcontrollers 8051 series was developed . 8-bit microcontrollers are used for simple and low-cost control applications. In 1983, Intel developed 16-bit microcontrollers, 8096 series. Later on, it developed 80196 series of 16-bit microcontrollers. These were more powerful and were used in sophisticated industrial control, intelligent computer peripherals, instrumentation, etc.

Other manufacturers also developed 4-bit, 8-bit, 16-bit and 32-bit microcontrollers. Motorola developed 32-bit microcontrollers, MPC-505. IBM developed 32-bit microcontrollers, 403GA. 32-bit microcontrollers are used for complex control applications. See more detail in Chapter 7.

1.9 COMPUTER CLASSIFICATION

Modern computers are classified as follows:

(*i*) Palmtop computers, also known as palm PCs or PDA (Personal Digital Assistant).

(*ii*) Notebook computers, also known as laptop computers. Some trade names of notebook computers are: IBM's Thinkpad 570, Compaq's Armada -E700, M700, M300 series, H.P.'s Omnibook, Siemen's Scenic mobile 750 AGB (high-end multimedia notebook), Apple's *i*book, etc.

(*iii*) Desktop Computers

(*iv*) Workstations

(*v*) Servers

(*vi*) Super Computers

Palmtop or Handheld Computers. These are the smallest computers available. They can be held in palm and hence, they are called palmtop computers. They can easily be kept in a shirt pocket. They are used for tracking appointments, maintaining lists, jotting notes, etc. They use tiny keyboard and have small disk memory. They can be connected to wireless network. Some palmtops use touch screen. Palmtops also accept handwritten inputs using an electronic pen which can be used to write on the palmtop screen. The system has to be trained on the user's handwriting before it can be used. A palmtop can be used as a mobile phone, fax and E-mail. Some palmtops use a proprietary operating system, but it can swap data with a WINDOWS PC. Some palmtops use Microsoft's WINDOWS-CE operating system. WINDOWS-CE is a stripped-down version of Microsoft WINDOWS. It is designed to provide a WINDOWS interface for palm PC's, some other types of very small computers, and tools and appliances other than PCs.

Notebook PCs or Notebook Computers (Laptop Computers). These are portable computers. They contain 32-bit CPU, hard disks, floppy disks, CD-ROM drive, modem and flat LCD screen. Colour displays are available. They consume less power and use batteries for their operation. They are used for word processing and spreadsheet computing while a person is travelling. They can be connected to computer network. Wireless connection can be provided to laptop computers so that they can get information from large stationary computers. They generally use WINDOWS-XP operating system. Notebook PC with LINUX operating system has also been developed. Hard disk capacity up to 60 GB, RAM capacity up to 256 MB,

etc. are available on a notebook. Multimedia system is now available. Some notebook computers are provided with finger recognition system.

Centrino Notebooks. The notebooks which are manufactured using Intel's Pentium M processor, Intel's mobile chipset (the 855 GME or 915 M) and Intel PROSet wireless LAN card, are said to have **Centrino technology.**

Centrino Duo Mobile Technology (NAPA)

Intel India has launched Centrino Duo Mobile technology in January, 2006. Its code name is NAPA. Centrino Duo is the next generation of mobile computing platform. It consists of the following three parts:

(*i*) **Intel Core Duo Processor Called Yonah.** It uses 65 nm (nanometer) process technology. It is a dual core processor designed for mobile computers. It has on-die 32 KB instruction cache and 32 KB data cache. A 2 MB L2 cache is shared by two cores using the Intel Smart Cache technology which allows dynamic allocation of cache to the cores depending on processing load on the cores.

(*ii*) **Mobile Intel 945 Express chipset family.** It gives dual channel DDR2 667 support. This chipset has two variants-945 GM and 945 PM. The 945 PM is pure performance chipset which consumes less power. The 945 GM offers Intel Media Accelerator 950 to deliver improved graphics performance.

(*iii*) **Intel PRO/Wireless 3945ABG Network Connection.** It is a smarter, smaller and sleeker wireless solution. It is compatible with the latest 802.11e standard.

Desktop Computers. These computers are single-user personal computers (PCs) and can be placed on a desk and hence, they are called desktop computers. They use 32-bit processors such as Pentium 4, Celeron, Athlon-XP etc. The hard disk capacity of 80GB and RAM capacity of 512 MB are used. Optical disks and 3.5 inch floppy disks are used as backup memory. Operating system used are: WINDOWS-XP, WINDOWS-NT, LINUX, Mac OS-X etc. Some desktop computers use fingerprint recognition system to provide better security. Such a system falls under "Biometry". For finger recognition, the user has to slide his fingers across a scanner, which senses the patterns caused by the ridges and furrows on the fingertip.

Workstation. Workstations are more powerful computers than desktop computers. They are suitable for numeric and graphic intensive applications. They are used in scientific and engineering applications such as computer aided design (CAD), simulation etc., which require greater processing power, larger storage capacity and better graphics capability. They have longer colour video display unit (monitor of 19 inch or more). They have hard disk and RAM capacity more than those of a desktop computer. The RAM capacity may be of a few GB and hard disk capacity of a few hundred GB. They use RISC processors such as SUN's UltraSPARC III, HP's PA-8500 or 8800, Compaq's Alpha 21264, MIPS 12000, etc. Operating systems used are multiuser such as UNIX, SUN's Solaris, HP's HP-UX etc.

Servers. These are powerful computers. A number of PCs and terminals can be connected to a server. Servers are provided with large disk and RAM capacity. In a low-end server only one microprocessor is used to act as a CPU. On the other hand in a high-end server, a number of microprocessors are provided in the CPU. Microprocessors in a multiprocessor CPU operate in parallel. The user working on a PC connected to a server, makes simple computation on his own PC, but for more complex computation he can connect his PC to the server through the LAN, WAN or Internet. He can utilize computing power, all facilities and database available with the server. He can also avail the facilities available at other PCs

connected to the server. The computer connected to the server through a network is called **client.** The aforesaid type of computing is known as client-server computing. Recently multicore 64-bit processors have been developed by many companies. These are quite suitable for server computers. Servers use multiuser operating systems such as UNIX, LINUX, HP-UX, SUN's Solaris etc.

Super Computers. These are the most powerful computers. They are used for very complex computation work. They use vector processors. Intensive parallelism is used in supercomputers. A number of RISC microprocessors are used in the CPU of a supercomputer. Supercomputers are used for weather forecasting, in aerodynamics, seismology; atomic, plasma and nuclear analysis; for weapons research and development, sending rockets into space, etc. In some applications in aerodynamics and nuclear physics, as many as 10^{13} arithmetic operations are needed for a single problem. This may take a number of hours of computing time on a supercomputer. Hence, there is a constant demand to increase the power of a supercomputer. Examples of supercomputers are: Cray-1 (1976), Cray 2 (1985), Cray T3D (1993), NEC's SX-S/44 (1991), Fujitsu VP 2600/10 (1991), Hitachi 820/80 (1987), C-DAC's PARAM series of supercomputers etc. Current world's top supercomputers are: BlueGene/L DD2 Beta-system of IBM which has a speed of 70.7 TFLOPS and uses 400 PowerPC processors; Columbia (NASA) which has a speed of 51.9 TFLOPS and uses 10,240 Itanium 2 processors; Earth Simulator (NEC) with a speed of 40 TFLOS and uses 5120 NEC CPUs; etc. C-DAC's PARAM 10,000 uses 160 UltraSPARC III processors. Its computing power is 100 GFLOPS. It has open frame architecture and can scale upto TFLOPS level. It uses C-DAC's own designed communication processor and network. C-DAC's PARAM Padma supercomputer has a peek computing power of 1 TFLOPS and 5 terabytes of storage. It is powered by 248 IBM's Power 4 RISC processors of 1 GHZ clock frequency. It runs AIX 5.1L operating system. Its primary interconnect is ParamNet-II, 2.5 GFLOPS, full duplex with backup gigabyte Ethernet network. Its parallel programming is done through C-DAC HPCC software. It ranked 171 in June 2003 list of top 500 supercomputers in the world. Other Indian supercomputers are: C-Dot's (Center for Development of Telemetics) Chip-152, National Aeronautical Laboratory's Mark-3, Bhabha Atomic Research Centre's (BARC) Anupam; PACE series of supercomputers of Defence Research and Development Organization (DRDO), Hyderabad, etc.

Earlier Classification. Earlier, computers were classified as microcomputers, minicomputers, mainframe (or large) computers and supercomputers. This classification is no longer used. Microcomputers are low-cost small computers. They include portable computers, personal computers i.e., PCs (single-user desktop computers), computers for dedicated applications like industrial control, instrumentation, appliance control etc. Minicomputers are more powerful multiuser computers. They contain more RAM and hard disk capacity compared to microcomputers. High-end minicomputers contain more than one microprocessor in their CPU. Large or mainframe computers are more powerful than minicomputers. They use very large capacity of RAM and hard disk. They use UNIX and other multiuser operating system. Examples of mainframe computers are: IBM's ES-9000, DEC's VAX-9000, CDC Cyber-2000 V, etc. Supercomputers have already been described in new classification.

1.9.1 Computer Pen

It is a computer housed within a pen. It can function as a diary, alarm, notetaker and can receive E-mail and pager messages. Unlike a conventional handheld computer, it has no keyboard. It does not need a screen to work. It saves in its memory what user is writing. It links to a printer, mobile phone, modem or PC allowing handwritten notes to be transmitted.

It has been developed by BI, a research laboratory in U.K. The prototype is called SmartQuill. It has ability to record handwriting not only on paper but also on any flat surface-horizontal or vertical. A tiny light at the tip allows writing in dark. SmartQuill can even translate invisible writing in the air.

1.10 USER INTERFACE

User interface provides communication means between an user and the computer. There are two types of user interface : text/typing type and icon/mouse type. In text/typing type user interface, the user has to type commands using a keyboard. In DOS operating system the user has to type commands. It provides text/typing type user interface. In icon (small graphical symbol) type user interface, the user tells the computer to carry out certain commands by pointing to an icon. Such user interface is also called **GUI** (Graphical User Interface). A pointing device such as mouse can be used to point to an icon. Such system also provides a list of available commands called a **menu.** The user can point to a command in the menu. Today GUI is commonly used by most of the operating systems.

1.11 HARDWARE, SOFTWARE, FIRMWARE, MIDDLEWARE AND FREEWARE

The physical components of a computer are called *hardware*. A physical component may be electronic, electrical, magnetic, mechanical or optical. Examples of hardware are microprocessors and other ICs, hard disks, floppy disks, optical disks, cathode ray tube (CRT), keyboard, printer, plotter, etc.

A sequence of instructions given to a computer to perform a particular task is called a *program*. A set of programs written for a computer is called *software*. The software required to execute user's program is known as *system software*. The term software includes both system software and user's programs. The system software includes operating system, assembler, compiler, interpreter, debugging programs, text editors, etc. The *operating system* is a collection of programs which controls the overall operation of a computer. The programs stored in ROMs, PROMs, EPROMs or Flash memory are called *firmware*. Nowadays a large variety of prewritten programs are available to solve specific tasks. Users need not prepare programs for such tasks. They should simply know how to use such prewritten programs. Prewritten programs for specific tasks are called *application programs* or *application packages*. Important application packages available are WordStar and MS-Word for text manipulation, LOTUS 1-2-3 and MS-Excel for preparation of spreadsheet; MS-ACCESS, ORACLE, UNIFY and FOXBASE for handling database, etc. MS-Office is an integrated package. It includes a word processing package-Word, a spreadsheet package-Excel, a database management package-Access, a presentation package-PowerPoint, and a Scheduling and Organization package-Outlook. Software package for designing buildings, structures, power systems, inventory control, accounting, dealing with projects, etc. are available.

Middleware. It is software that operates at the level between an application program and a network. It can mediate the interaction between separate applications across heterogeneous computing platforms on a network.

Some software are available free of cost. They can be downloaded form Internet. Such software are called **freeware**.

1.11.1 Operating System

An operating system is a collection of programs which controls the overall operation of a computer. It manages files on a disk. It permits users to create, print, copy, delete, read, write to files. It formats disks and controls input and output devices. It executes programs, allocates memory space to users, schedules jobs, provides user interface to computers, prevents interference between users in a multiuser system, it processes user's commands, and so on and so forth.

Several operating systems have been developed over the years. Some important operating systems which are for single-user systems are: MS-DOS, OS/2, WINDOWS-98, WINDOWS-XP etc. At present WINDOWS-XP is commonly used. Operating systems for multiuser system are: UNIX, LINUX, Novell Netware, SUN's Solaris, WINDOWS-2003, Mac OS X(ten), etc.

1.11.2 Programming Languages

A computer understands information composed of only zeros and ones. A program written in terms of 0s and 1s is called a *machine language program*. Computer instructions are written in binary codes. A machine language uses only binary codes. The writing of programs in machine language is a very difficult, tiresome and very boring job. Moreover, it is errorprone. To overcome this difficulty a program can be written in alphanumeric symbols instead of 0s and 1s. Meaningful symbols called *mnemonics* are used for this purpose. For example, ADD is used for addition, SUB for subtraction, CMP for comparison, etc. A language which uses mnemonics is called an *assembly language*. A program written in an assembly language is called an assembly language program.

An *instruction* is a command given to a computer to perform specified task. The instruction set of a processor is the collection of instructions that the processor is designed to execute. In assembly language a mnemonic is an instruction. Instructions are classified into groups like data transfer, arithmetic, logical, branch control, and I/O and machine control instructions.. Data transfer group includes instructions for transferring data from register to register, register to memory and memory to register. Instruction of arithmetic group perform addition, subtraction, multiplication, division, etc. on data placed in a register or memory. Logical group instructions perform AND, OR, EX-OR, comparison, rotate, etc. operations on the contents of registers. Instructions of branch control group perform conditional and unconditional jumps, subroutine call and return, and restart. I/O and machine control group instructions perform input, output, stack and machine control operations.

When a program is written in a language other than machine language, the computer will not understand this. Therefore, a program written in other langauges must be translated into machine language before it is executed. The task of translation is done by software. A program which translates an assembly language program into a machine language program is called an *assembler*.

A language in which each statement or an instruction is directly translated into a single machine code is known as a *low-level* language. Each mnemonic of an assembly language has a unique machine code. An assembly language is a low-level language. A machine language is also a low-level language. An assembly language depends on the internal architecture of a processor. Each processor has its own assembly language. Assembly language of one processor cannot be used for another processor. In other words it is not *portable*. To write an assembly language program, a programmer must have the detailed knowledge of the instruction set of the particular processor, its internal architecture, registers, and connection of pheripherals

to ports etc. It is not very fast and efficient programming language. To overcome the difficulties associated with assembly language, high-level (procedure-oriented/object-oriented) languages have been developed. In a high-level language an instruction is called *statement* rather than mnemonic. Statements more closely resemble English and Mathematics than mnemonics. High-level languages permit programmers to describe tasks in the forms which are problem oriented rather than computer oriented. Programming in a high-level language does not require precise knowledge of the architecture of a computer which is to be used. A program written in a high-level language will run on any computer which has a compiler for that language. In other words a high-level language is portable.

A program which translates a high-level language program into a machine language program is called a *compiler*. An *interpreter* is also a program which translates a high-level language program into machine language program. It reads one statement at a time, translates it into machine codes, executes it and then goes to the next statement of the program. On the other hand a compiler reads an entire program once or twice and then translates it. A compiler is faster and more powerful than an interpreter. A compiler is a larger program and occupies more memory space. It is costlier than interpreter.

Important high-level languages are: BASIC, FORTRAN, COBOL, PASCAL, C and C^{++} languages, PROLOG, JAVA etc. BASIC is a abbreviation for Beginners All-purpose Symbolic Instruction Code. It is a very simple and easy language for beginners. It is suitable for scientific calculation. FORTRAN stands for Formula Translation. It is a powerful language for scientific and engineering computations. COBOL stands for Common Business Oriented Language. It is suitable for business data processing. PASCAL is a multipurpose language suitable for both scientific and business applications. This language has been named in honour of Blaise Pascal, a great mathematician and inventor. PROLOG stands for Programming in LOGIC. It is suitable for artificial intelligence applications. It has been chosen for fifth generation computers. A large number of high-level languages have been developed. A particular language may be very efficient for a particular field. JAVA is an object oriented language. It is suitable for Internet applications.

1.12 BATCH PROCESSING, MULTIPROGRAMMING AND MULTIUSER SYSTEM

In a batch processing system a computer serves one user at a time. When the program of one user is completed, then only, another program is started. This type of system does not allow a user to interact with the computer. The large computers used in the 1960s, executed programs one by one using this method.

In multiprogramming several programs are processed by a computer simultaneously. Usually, a CPU is much faster as compared to I/O devices. While I/O devices are performing certain tasks the CPU may not be doing any task, it may be lying idle. To keep CPU busy for most of the time, it is desirable to process a number of programs concurrently. This is achieved by overlapping CPU and I/O operations when several programs are running simultaneously. The multiprogramming is an improvement over batch processing, but it still does not allow users to interact with the computer.

In a *multiuser system* a number of users can work simultaneously. It allows each user to interact with the computer. It is also known as *time-shared system*. A number of video terminals are connected to a computer. Users enter data at very slow rate, and computer processes data at very fast rate. Making use of this fact a computer serves several users

simultaneously by attending them in turn. It usually gives 20 milliseconds time to each user. Each user feels that he is using the computer exclusively because the computer processes his data as fast as he enters it. Each user can utilize the common resources such as high-speed printer, computer's memory, etc. A demerit of a multiuser system is that when computer is down all computing jobs are stopped. They can be resumed only when the computer is up and running again. Another demerit is that its response time to each user becomes unreasonably long when the number of users becomes more. Server-client type of computing is also a kind of system. Nowadays it is widely used. Time-shared type multiuser systems were used earlier.

In an industry a number of processes are controlled by a computer simultaneously. This is called *multitasking*. The term multitasking is more often used in real-time control in industry. When this term is used elsewhere in general sense, it simply means multiprogramming. The time-shared approach of multiuser system is not suitable for multitasking system. In a multiuser system all users are attended at approximately equal time intervals. In multitasking system for industrial control priority-based job scheduling is used. A high priority task can interrupt a low priority task.

1.13 MULTITHREADING

Multithreading. A thread is the smallest executable element of an application. Therefore, if an application has the ability to execute, at least two threads simultaneously, it will run twice as fast on a dual-core processor. So a dual-core is beneficial, if an application is multithreaded. But most applications which are available today are not multithreaded. However, some PC users run more applications at a time, so they will be benefited by using dual-core processor.

1.14 COMPUTER NETWORK

A processing complex consisting of two or more interconnected computers is called a *computer network*. When the computers of a computer network are within a building or campus, they are interconnected through a local area network (LAN). If computer units are situated at large distances, they are interconnected through telecommunication links. Satellites are also used for this purpose. A computer network spread over a wide area is known as WAN. The Internet is also a kind of WAN.

1.15 DISTRIBUTED PROCESSING (COMPUTING) OR MULTIPROCESSING

In a computer network each computer operates independently on separate tasks. When a number of users work on separate computers interconnected in a computer network, the processing technique is known as *distributed processing* (computing) or multiprocessing. The term multiprocessing is also used in case of a multiprocessor system (i.e., when a computer contains several processors). For distributed processing a large powerful central computer with large memory and high-speed printer is used in a computer network (LAN or WAN). A number of PCs or workstations are connected to the central computer (Server). Each user with a PC, performs his task locally in an independent manner. If he wants to use the server for complex computation or to access database available with the server, he can do so. In this system the user can select the local computer best suited to the local computational needs.

A company or organization also can use distributed computation technique. The company's work are done partwise at different computers which are connected through a LAN or WAN or Internet.

Disadvantages of a time-shared system is eliminated to a great extent in a distributed processing system. If the large computer is down, all the jobs are not stopped. Most of the tasks are carried out on the local microcomputer. The burden on the large computer is reduced to a great extent, as much of the computing work is done by local microcomputers.

1.16 LOCAL AREA NETWORK (LAN) AND WIDE AREA NETWORK (WAN)

In an industry, commercial organization or an office which has several computers in a building or a campus, need may arise to transmit data between computers. In such a situation a high-speed interconnecting network called *local area network* (LAN) is needed to interconnect the computers so that they can communicate with each other. There are various ways for interconnecting computers such as star, common-bus, ring type LAN, and so on. In a star type LAN there is a central controller that coordinates all communication between computers on the LAN. The common-bus type LAN also known as **Ethernet,** does not have any central controller. Rather, the control of the bus is spread among all the computers connected to the common-bus. The common-bus is simply a wire usually a co-axial cable to which any number of computers can be easily connected. Any computer can take over the bus to transmit data. Two computers are not allowed to transmit data at the same time. Also, in the ring type LAN, the control is distributed among all of the computers on the network. A binary code called *token* is passed around the ring from workstation to workstation. All workstations are linked to form a continuous loop. A computer which wants to transmit data must possess the token. It takes the token from the bus, to prevent any other computer from transmitting. After the transmission is completed, it puts the token on the ring so that another computer which has to transmit data can receive it.

LANs are classified according to their data transfer speed, as: high speed, medium-speed and low-speed LANs. In high-speed LANs data are transmitted at the rate a few gigabits per second (Mbps). Such LANs are designed to link server computers. In medium-speed LANs data are transmitted at the rate of about a gigabits per second. Such LANs are suitable to link smaller servers and PCs. Example of a medium-speed LAN is Ethernet. Its speed is 1 Gbits/s. Low-speed LANs transmit data at a few hundred Mbps. They are suitable to link PCs and other workstations. Wireless LAN, called WLAN has also been developed.

WAN. When computers/terminals are spread over a wide area, they can be connected through public or private communication system. This type of network is called *wide area network* (WAN). Internet is also a kind of WAN.

1.16.1 Internet

A worldwide computer network is called Internet. Any two computers on the Internet can communicate to each other. Each computer on the Internet has an address which is universally recognized throughout the network. Web, also called World Wide Web (WWW) is a collection of resources that one can access from anywhere in the world, over the Internet. These resources can provide textual documents, static graphic images, video clips, programs, database or any other kind of information. Web is just one of the many services available on

the Internet. The services available on the Internet other than Web are : E-mail, FTP, Mailing lists, Usenet news and articles, Chat sessions, etc. The WWW is a vast library of information in the field of art, science, engineering, commerce and so on. On Internet exchange of information takes place on client/server model. A **client** is a computer which receives information from the server. A **server** is a computer which gives information to other computers on the Internet. Servers and clients communicate through a protocol, **HTTP** (Hyper Text Transfer Protocol). The set of rules for information exchange between server and client is called **protocol.**

Important terminologies related to Internet are given below:

URL (Uniform Resource Locator). It is pronounced as earl. It is descriptive address for a Web page or any other file on the Internet. An example is http://www. intel.com/Pentium III/

This address is to obtain information regarding Pentium III microprocessor from Intel Corporation. A simple URL for a Web page includes (*i*) the name of the Web protocol (http), (*ii*) a colon, (*iii*) two forward slashes, (*iv*) a domain name and (*v*) a final slash. The domain name is the Internet name of the server which serves information.

HTML (Hyper Text Markup Language). It is a computer language to prepare Web pages. Hypertext is a text with extra features like formatting, images, multimedia and links to other documents. **Markup** is the process of adding extra symbols to ordinary text. Each symbol which is used in HTML has its own syntax, slang and rules. It is not a programming language. It is a markup language. It classifies the parts of a document according to their function. In other words it indicates which part is title, which part is a subheading, which part is the name of the author, and so on.

Web Site. Web server is known as Web site. It is the location at which pages are stored.

Web Page and Home Page. Web page is an information (document) written in HTML, which can be put on a Web server. It may give information about a person, a company, a group of people, an organization, a product, and so on. Web pages provide easy and efficient method for distributing information, files and softwares. **Home page** contains introductory information and/or master menu of the document.

Web Browser. The client software package called Web browser accesses the Web and contacts a server computer on the Internet, and exchanges information with the server. It understands how to communicate to a Web server through HTTP protocol, displays information and gives a way to represent hyper text links. The two most popular Web browsers are: Netscape's Navigator and Microsoft's Internet Explorer (IE). These Web browsers use graphical user interface. Other services can also be used from a Web browser such as Usenet, FTP, etc. The server computer is also provided with proper software to facilitate the exchange of information. Such a software is known as **Web server software.** Netscape's Navigator and Internet Explorer also allow user to use other services on the Internet, such as E-mail, to download files from FTP servers, read and post articles to Usenet newsgroups, etc.

Some other Web browsers are : Lynx (a text-only browser), Mosaic (the first graphical browser on which Navigator and IE are based), Web TV (runs on a television set), Amaya, UdiWWW, GNUscape, Opera, Arena, DOSLynx, etc.

Usenet News. It is forum for online discussion or exchange of information. Information may be on any topic. News client programs such as Microsoft's Internet News, Netscape News, etc. are available, which allow you to get news or information or article on any topic

from news servers through Usenet. Netscape News comes with Netscape Navigator. The Usenet service is available on Internet. NNTP (Network News Transfer Protocol) is used to distribute news on Internet.

FTP (File Transfer Protocol). It is a service used on Internet to exchange files. Files may be text file, programs or images. There are FTP servers. FTP client can access a FTP server.

Telnet. It is a protocol to connect users to database, library catalogs and other information resources on the Internet. WINDOWS-95 has telnet program which can be used to access telnet servers on the Internet. Neither Navigator nor IE include telnet.

Gopher. It is an Internet service that allows users to access gopher servers on the Internet. A few gopher servers still exist on the Internet, but it is almost extinct now.

TCP/IP (Transmission Control Protocol/Internet Protocol). TCP works with IP. They are simply different layers of control. They work on both LANs and WANs. They provide error checking, flow control (to prevent swamping of an user by another faster or more powerful user), and status and synchronization control. TCP is a transport layer. IP is a network layer which handles routing and delivery. To connect a computer to the Internet, TCP/IP is installed. Then ISP or online service is required to connect the computer to the Internet. TCP/IP includes standards for many common applications including E-mail, FTP, remote login, etc.

ISP (Internet Service Provider). In India Videsh Samachar Nigam Limited (VSNL) provides access to the Internet through the Gateway Internet Access (GIAS). Some other companies are also ISP, for example, Satyam, MTNL (Mahanager Telephone Nigam Ltd.), Bharti BT, etc.

Search Engine. A search engine is a program which looks through its database for information that matches your request. Information in the database are about Web sites and their contents. Examples of search engines are : Alta Vista, Yahoo, HotJava, Excite, Infoseek, AOL NetFind, Lycos, HotBot, LookSmart, SEARCH.COM, etc. Some Indian search engines are : Jadoo, Khoj, I Love India, 123 India, etc. Alta Vista is for Web and Usenet. Yahoo is for Web, Usenet, E-mail addresses, current news, people search, city maps and stocks. Yahoo is not a search engine. It has a huge list of Web sites, stored into categories. Yahoo provides links to search engines. HotBot is good to find site which uses a particular technology, such as JavaScript or VRML. HotJava is written in Java. It has been developed by SUN Microsystems. It is available for SPARC/Solaris platform as well as WINDOWS platform.

Web Crawler. It is a program that crawls through the Web and collects information regarding the Web sites. These information are put into the database of a search engine. Worms, Spiders or robots are the types of crawlers.

Packet. It is the basic data building block. A packet is self-contained data structure which can be sent over the network. It consists of two parts : the header and data. The header includes address information regarding the origination, destination and the type of the packet. The data is a block of data.

Applets. These are small Java application programs developed for Internet applications. One can develop new application programs using applets. Applets can be combined for an application using a scripting language JavaScript. Applets available at Web sites can be down loaded via Internet, and executed on the local computer.

Hub. It is central place to connect computers to a network, traditionally for a star topology. There are two types of hub: passive and smart. A passive hub simply connects the various nodes. A smart hub can be remotely controlled by the system operator. It can send back the information of packet traffic for analysis.

Bridge. A bridge connects networks (or two segments of LAN) that have the same Network Operating System (NOS), but different hardware.

Gateways. Gateways are similar to bridges except that they can translate protocol and convert data. They connect networks which operate at different network operating systems. The connected networks through a gateway may or may not have similar hardware. For example, a gateway can allow a Token Ring running IPX packet and an Ethernet running TCP/IP packet to communicate freely.

Routers. They control and direct network traffic. A network can be segmented into small networks using a router. The small networks are known as zones. If the packet's destination is in the same zone, the packet is not exposed to the other zones. This limits traffic across the entire network.

Intranet. A corporate or organizational network which uses the same protocols, (namely TCP/IP) as used on the Internet to share files and send E-mail, is called Intranet. An Intranet is cut off from the outside world. It permits its users to access the Internet, but it prevents outside access to internal files by hiding behind a security system known as a **firewall.** In many large organization intranet is a wide area network.

Extranet. When computers of many organization are connected through TCP/IP protocol, such a network is called Extranet.

1.17 SOME TERMINOLOGIES OF MOBILE PHONE STANDARDS AND DATA COMMUNICATION

Broadband. The minimum bandwidth for broadband must be 256 kbps (kilobits per second). Using broadband multiple channels can be sent over a single link. If there is insufficient bandwidth, then multiple services can not run reliably over the same connection (link). With broadband the user can go beyond Web browsing, E-mail and downloads; for example, now he can go for audio/video streaming to listen to songs or watch movies etc.

DSL (Digital Subscriber Line). It is a broadband technology. It uses existing telephone lines to transmit data. Its data transmission rate lies in the range of 1.5-8 mbps.

ADSL (Asymmetrical DSL). In ADSL the data flow is faster in one direction than in the other. Usually, downloads rates are higher than upload (outwards rates) rates.

DTH (Direct To Home). In DTH a dish antenna is used. One can get a number of channels on his TV, say 100 channels or more. Electricity consumption is 40 watts. It is cheap and compact. The diameter of the dish is 45-60 cm. It is based on digital technology. A set-top-box is also there with the dish to control channels. It is not connected through cable. It receives signals directly from a satellite.

Wi-Fi. Wireless LAN standards IEEE 802.11, namely 802.11 b, g and a are called Wi-Fi. Wireless LAN is abbreviated as WLAN. In Wi-Fi, Wi is for wireless but Fi is not meaningful. Wi-Fi is similar to Hi-Fi. 802.11a, b and c operate at 2.4 GHZ, 2.4 GHZ and 5 GHZ respectively. Their throughputs are 54 Mbits/s, 11 Mbits/s and 54 Mbits/s respectively.

WEP (Wired Encripted Piracy). It is a built-in security method in Wi-Fi. Improved security methods described below have been developed for Wi-Fi.

RADIUS (Remote Authentication Dial-In User Service). It is a security protocol for Wi-Fi.

VPN. It is a point-to point tunneling Protocol (PPTP) to provide encription over Wi-Fi network. It is a security measure for Wi-Fi network.

WPA (Wi-Fi Protected Access). It is an extension of 802.11 wireless LAN standards, 802.11i, which is for more robust security.

WiMAX. IEEE 802.16 standard is also called WiMax (Worldwide Interoperability for Microwave Access). Microwave radio or terrestrial wireless can be used to build wireless LAN and by ISPs to provide wireless Internet services. Microwave wireless system work in the 900 MHZ to 40 GHZ frequency band. It can be used in a point-to-point (P-T-P) or point-to-multipoint (P-T-M) configurations.

FSO (Free Space Optics). It uses laser technology to provide wireless data communication. It imposes line of sight limitation.

VSAT. Internet access to remote areas can be provided by satellite.

D-AMPS (Digital Advanced Mobile Phone System). It was a second-generation mobile phone standard. It was widely used in USA.

GSM (Global System for Mobile Communication). It is a second-generation mobile phones standard. The first-generation of mobile phones was analog voice. The second-generation was for digital voice. It was used everywhere in the world except USA. In USA, D-AMPS was used. The GSM channels are much wider (200 KHZ) than the D-AMPS (30KHZ).

CDMA (Code Division Multiple Access). It is a standard for mobile phones and technically superior to D-AMPS and GSM. It is the basis for third-generation mobile phone systems. It is also a second-generation digital scheme. Its speed is 144 kbps.

GPRS (General Packet Radio Service). It is a mobile phone standard in between the second-generation and the third-generation. It is called 2.5G scheme. It is an overlay packet network on the top of D-AMPS or GSM. Its maximum speed is 56 kbps. For GSM users, Internet access is provided through GPRS.

EDGE (Enhanced Data rates for GSM Evolution). It is also called 2.5G scheme. Its maximum data transmission speed is 230 kbps. It is a radio based high-speed mobile data standard.

W-CDMA (Wideband CDMA). It is a third-generation (3G) mobile phone standard. It runs at 5MHZ bandwidth and its speed is 1920 kbps. It is designed to interwork with GSM networks although it is not backward compatible with GSM. Furthermore, it has the property that a caller can leave a W-CDMA cell and enter a GSM cell without losing the call. The W-CDMA does not work with CDMA. The third-generation schemes are for digital voice and data. With 3G, users have the facilities for video through the Internet, video conferencing etc.

EV-DO (Evolution Date Only). It is a 3G mobile phone standard. It provides 2.4 mbps bandwidth to mobile users on a CDMA network.

UMTS (Universal Mobile Telecommunication System). It is a 3G mobile technology. Its data transfer speed is 1920 kbits/s.

1.18 SHORT RANGE WIRELESS

Short range wireless system is used for communication between personal digital devices. There is a term PAN (Personal Area Network) which is used when personal devices are connected in a network. Wireless PAN is called **WPAN**. Nowadays, people can connect their PDA to their PC or laptop, answer mobile calls through a wireless headset, do shooting a video with a digital camera and streaming it to a television etc. All this type of things can be done using WPAN. The three technologies, namely Bluetooth 2.0, WUSB (Wireless USB) and ZigBee are used nowadays for WPAN.

Bluetooth 2.0. It operates in the frequency band of 2.45 GHZ. It is same as that for its previous version Bluetooth 1.2. But data transfer rate of Bluetooth 2.0 is 2.1 Mbps against 1 Mbps for version 1.2. Increased data transfer rate enables faster transmission of music and video. Bluetooth 2.0 consumes less power and the maximum distance can go up to 100 metres. It gives improved quality of service for better audio and video streaming. It also supports multicast using which one Bluetooth device can simultaneously transfer data to many Bluetooth devices.

WUSB (Wireless USB). It gives up to 480 Mbps throughput. It is suitable for transferring large amount of data over wireless system. It uses Ultra-Wideband technology for transferring data. It can use a band which is 7 GHZ wide ranging from 3.1 to 10.6 GHZ.

ZigBee. It is suitable for remote monitoring applications such as home, building and industrial automation. It is used for sensor devices for air conditioning, cooling, smoke alarms etc. For such applications very high throughputs are not required. Such applications require low power consumption so that batteries can go for longer periods.

1.19 CONTROL FLOW AND DATA FLOW COMPUTERS

The basic architecture of a conventional computer consists of a CPU, memory and input-output devices. This architecture was given by John von Neumann in mid 1940s, and hence such an architecture is called von Neumann architecture. The program is stored in the memory. The CPU fetches one instruction from the memory at a time and executes it. Thus the instructions are executed sequentially which is inherently a slow process. Neumann machines are called *control flow* computers because instructions are executed sequentially as controlled by a program counter. The speed of a sequential machine is limited by the speed at which the CPU fetches instructions and data from the memory, and the speed at which the CPU executes instructions. To increase the speed of data processing parallel computers have been developed in which several CPUs are connected in parallel to solve a problem. Even in parallel computers the basic building blocks are Neumann processors. The parallelism is not tackled at basic level. The entire burden of solving a problem using parallel processing rests on the programming technique.

The data flow design approach treats the issue of parallelism at a fundamental level. In data flow approach an instruction is executed whenever its required operands become available. No program counter is needed in a data flow computer. Operations are carried out asynchronously as soon as operands required for the operation become available. The fetch/decode unit of the processor, fetches 20 to 30 instructions in advance. The instructions are decoded and their opcodes are kept in an **instruction pool.** The dispatch/execute unit of the

processor checks the opcode of an instruction in the instruction pool, and examines whether its data are available for its execution. If data are available, the instruction is executed. If data are not available for the execution of an instruction, dispatch unit goes ahead and examines the next instruction in the instruction pool. Thus it executes only those instructions for which data are available. The instruction which are not executed due to non-availability of data, are executed in the next round of checking of the instructions in the instruction pool. Whenever data become available remaining instructions are executed. Thus it is seen that the processor does not wait, when data are not available for some instructions. This technique increases the speed of the processor. Pentium Pro, Pentium II, Pentium III and Pentium 4 are data flow processors.

1.20 RISC, CISC AND EPIC PROCESSORS

RISC stands for Reduced Instruction Set Computer. CISC stands for Complex Instruction Set Computer. Where RISC and CISC are used as adjective 'C' in RISC and CISC stands for 'Computing'. There are two techniques of designing a control unit of a processor : hardware technique and software technique. For the execution of an instruction a number of steps are needed. For each step a number of control signals are generated by the control unit of the processor. In a RISC processor, all the necessary signals for the execution of an instruction are generated by an electronic circuit of the control unit. For each instruction there is an electronic circuit in the control unit, to generate necessary control signals. This is a hardware technique of designing a control unit. In this technique microprograming is not used.

In CISC processor, a microprogram is executed to generate necessary control signals for the execution of an instruction. A microprogram is written for each instruction using a sequence of microinstructions. This technique is known as **microprograming.** When a microinstruction is executed a set of control signals is produced for the operation of certain step of an instruction. The microinstructions of a microprogram are executed one by one, and in turn, the necessary control signals are produced in steps for the execution of an instruction. For each microinstruction, there is a microcode. Microcodes are stored in a ROM which is within the processor. More details are given in Chapter 5.

The checking of microinstructions can be done more easily than the checking of computer instructions to see that they work properly. If there is an error in a computer instruction, the designer can correct it by changing microinstructions. On the other hand in a RISC processor (hard-wired CPU), if an instruction is erroneous, the designer has to change complex connections or the chip design. In a micrcoprogrammed design of computer, new instructions can be implemented by writing new sets of microinstructions. This is similar to writing various programs using an instruction set of a computer. Such a computer can also be made to execute the instructions of an another computer. This process is known as **emulation.** These advantages of microprograming are achieved at the cost of processing speed.

EPIC (Explicitly Parallel Instruction Computing) processor has been discussed in Section 5.11.

1.20.1 Microprogrammed Control Unit

Microprogramming has already been explained in the Section 1.20. Fig 1.5 shows a schematic diagram of microprogrammed control unit. The instruction register contains the operation control code (opcode) of an instruction which is to be executed. The decoder decodes

the opcode and gives starting address of the microprogram. The microprogram counter, µPC contains the address of the next microinstruction to be executed. It is also called control address register. The control memory stores the sets of microinstructions. The microinstruction is read from the control memory and sent to the control buffer register. Then the microinstruction is decoded and control signals are generated and issued. The control signals activate the necessary arithmetic and logic unit etc. to perform the required operations defined by the microinstruction code. In this way a microinstruction is executed. The next address information is also issued and sent to the sequencing logic. The sequencing logic unit sends the address of next microinstruction to µPC. It also sends a read command to the control memory. In this way the microinstructions of a microprogram are executed one bye one to execute an instruction.

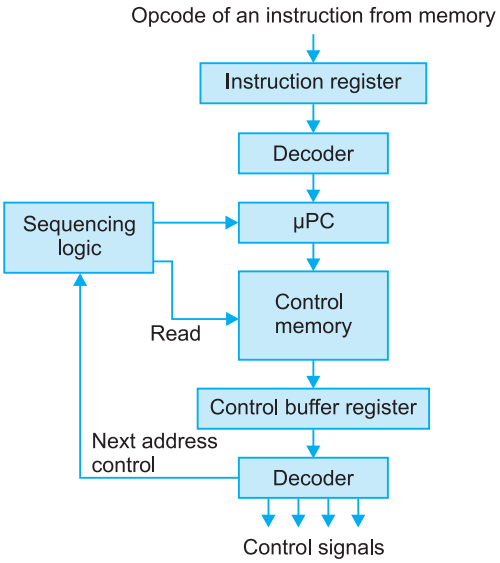

Fig. 1.5 Microprogrammed Control Unit

1.21 COMPUTER APPLICATIONS

Computer is the most versatile tool man has ever created. Nowadays they are being used almost in every sphere of our life. Earlier, a computer was used only for scientific and engineering computational work. But nowadays, besides computational work computers are extensively used for non-computational work such as storing information, transmitting information, creating and handling files in offices, controlling industrial machines and processes, controlling home, business and commercial appliances; ticket reservation in planes and railways, telephone exchange, diagnosing diseases, recording games events, composition of music, painting, book printing, printing newspapers, preparing drawings, in security arrangements to watch and supervise certain areas, to help police in crime investigation, in education, and so on. About 75% of the work done by computers today is of non-computational nature.

Computers are extensively used in offices for handling files, storing information, creating files, administrative purposes, in keeping records of staff, preparing salary bills and for communication. If all work of an office are done by computers, it is called an *electronic office*. The term 'office automation' is used when computers are extensively used for office work.

Wordprocessing softwares are used for creating, manipulating and storing text such as letters, notes, invoices, reports, legal briefs, etc.

Computers are being widely used for preparing accountant's ledger, budget, inventory control; analysis of profit and loss in an investment scheme, purchasing shares and debentures of a company, and many other accounting work. Accounting tasks are quickly analyzed and results may be tabulated or produced in graphical forms.

Modern computer systems can store huge amount of information. A collection of information may be kept in the form of a database. A large collection of data is called a **database.** From a database the required information can be sorted in the desired manner. To handle database special programs called database programs have been developed. Various organizations build and maintain their databases for their work. Some organizations do business to supply information in certain specialized areas such as medicine, engineering, business, etc. Customer becoming a subscriber can get information from such organization through the Internet.

Banks are also using computers for office work, accounting work and dealing with customers. Computers allow customers to make deposits and withdrawals. Cash dispensing machines are also used to make payment in cash and also to receive cash. These are also computer-based machines, called ATM (Automatic Teller Machine).

Computers are now widely used in home and office appliances such as washing machines, TV, telephone receivers, mobile phones etc.

In the medical field computers are used in the diagnosis of diseases, in clinical tests, in office work; in keeping records of cases of patients, treatments, drugs, etc. Some computer expert systems have been developed to diagnose diseases and prescribe medicines. These expert computers are based on the expert knowledge of specialists. Their knowledge is kept updated. The doctors have to supply information such as symptoms, medical history, clinical test results etc. At present expert systems are used to help doctors, not to substitute doctors.

Robots are computer-controlled programmable machines. They have hands, legs, optical sensors to see objects etc. They are used in industry to move materials, parts; to assemble machines etc. They can work in places where human beings cannot work, for example in places where temperature is unbearable and where nuclear radiation are present. They can handle harmful chemicals, radioactive materials and so on.

Internet is a worldwide computer network. There are a large number of Web sites to provide different kinds of information through the Internet in almost all spheres of life. Information is available in the field of arts, science, engineering, commerce, and so on.

Presently, there are numerous more applications of computers. For more details see Chapter 9.

1.22 IMPACT OF COMPUTERS ON SOCIETY

Nowadays computers are being widely used in industries, offices, schools, colleges, universities and research organizations; games, military, communications, hospitals, banks, hotels, homes and so on. They are being used in almost every field concerning the society. They have a great impact on the society. They are changing the way of our working, even the way of life. The use of computers in industries has improved their efficiency. The cost of production goes down. The quality of products is improved. Unpleasant and hazardous work can be performed by robots. Working hours of labourers are reduced; they get more leisure.

The use of computers in offices improves their working efficiency. Record keeping becomes very easy. Information can be searched immediately. Reports, notes, memos, etc. can be prepared immediately. The bureaucratic delay can be minimized to a great extent. It improves office administration. The management task becomes easy.

Computers are capable of manipulating and transmitting texts at very fast rate. They have revolutionized the field of communications. A person sitting at home can contact any office, bank and information supplying organizations through a computer. Instead of using a computer he may use his television set and an adapter and a keyboard attached to it for such purposes. Sitting at home, he may do office work, bank transactions, marketing, purchase of shares, reservation of plane and bus tickets and so on. Officers and manages can contact any branch office anywhere in the world through the computer network. Text, voice, data and picture can easily be transmitted nowadays using modern communication systems which heavily depend upon computers. Information is transmitted over long distances through satellites. Video conferencing allows two-way communication between persons. They can see each other on the screen. Nowadays video conferences are being arranged. People participate in conference while sitting at their homes or offices. Electronic mail is being used to transmit information. Information can be stored if a person is physically not available. Later, he can have the information. Information may be either in text form displayed on the screen or voice form.

Many organizations have set up information centres. They have created databases for specialized as well as general services. Professionals can get information in specialized fields such as engineering, medicine, law etc. for their guidance. General people can get information regarding certain products, stock exchange, market information, reservations for tours, weather information, news and so on.

Computers enable people getting better services from government or private organizations. There will be shorter waiting lines in queue in banks, railway ticket reservation counters, airline ticket offices; better and fast services at hospitals, improved clinical tests and diagnosis of diseases and so on.

Computers are playing an important role in education. One can get lessons on certain topics, special lectures prepared by experts etc. on the screen as many times as he wants until he understands the topic. Computers are working as teachers or helping teachers in educational institutions.

Thus we see that computers have great impact on our society. They are even changing the way we work. There are certain disadvantages also. There may be cases of embezzlement in banks, leakage or misuse of personal information, etc. When a person is using computer for marketing, office work, collection of information, etc. his activity is recorded. One can misuse this record. So individual privacy is not guaranteed. An efficient security measure has to be taken. Hardwares and softwares are available for such purposes. Someone can play mischief on computer. He can erase certain important data. He may take away some important and private data. Extensive use of computers for the job which is labour oriented will cause unemployment. But in industries computers can be used for machine control and process control etc. for which electronic or electromechanical control systems were employed in the past. Such applications of computers do not much affect labour employment.

Industrial revolution changed our society from an agricultural society to an industrial society. Now computer is changing our society from an industrial society to an information society. In U.S.A., around 1900, 35% of labour force was engaged in agriculture, 27 per cent in industries and 13% in information sector. By 1980, about 50% were engaged in information sector, 23% in industries and only 2% in agriculture.

The technology itself does not decide the future of the society. The way we apply the technology for the welfare of mankind is important. This is also true for computers. As we use automobiles and electric motors today extensively, computers will also be widely used by us. As computers are more powerful, their impact on the society will be much more than the application of any other tools.

1.23 FUTURE DEVELOPMENTS

At present silicon is used as semiconductor material to manufacture semiconductor devices: LSI and VLSI chips. Electrons can move more easily in gallium-arsenide (GaAs) than in silicon. Research is going on to use GaAs to manufacture semiconductor components of a computer. Fujitsu of Japan is making efforts in this direction. It introduced a supercomputer VP-200 in 1982, which incorporates GaAs technology to some extent.

Research is also going on to use light beam instead of electrons in semiconductor devices. Bell Labs. Research worker Devid Miller has developed an optical transistor or chip. It controls light beam in the same way as a transistor controls electric current in it. Computers which will use photons (that is, light beam) instead of electrons for their operation will be called optical computer or quantum computer. An optical computer will be much more faster and powerful than computers using silicon technology.

Further, research is also going on to develop biochips. Such chips will use organic material for their fabrication. Molecules of a substance will be organized to act as electronic memory or switching devices. Research is also going on in Japan and U.S.A. to study the behaviour of some worms, which will be helpful to develop computers of tomorrow. It has been observed that some worms are more intelligent than today's computers and more dexterous than robots. Some show information processing capability and can learn something which today's computer cannot do. For details the reader may refer to the book mentioned in Ref. 4.

1.24 VIRUS

A computer virus is a small program written with bad motive to affect badly the operation of a computer. Viruses are prepared by antisocial elements to damage other's computers, their important files etc. They may corrupt files, erase files, make a computer slow and so on. Such harmful programs are called virus because they can spread from one computer to another computer. They reproduce themselves and then cause damage. They infect other files and then spread. They spread via E-mail or through files which are downloaded. When virus is present in a file that is stored in a CD or floppy, it will spread to another computer which uses that CD/floppy.

A virus hiding in a program is known as Trojan horse. When the Trojan horse program is run, the virus loads itself into the computer's memory. Once it is there, it can secretly attach itself to other files/programs or store itself on any other disks run on the computer including the hard disk.

To protect computer from viruses, anti-virus softwares are available. Before downloading any file from Web, it must be scanned whether it if free from viruses. When any file is to be copied from CD or floppy, it must be scanned.

1.25 MP3 COMPRESSION STANDARD

MP3 is a standard method of compression of audio signals. It is the short form for Moving Pictures Expert Group-Version2-Layer 3 audio compression standard. The memory space requirement is reduced by a factor about 10 when MP3 standard is used to store an audio file. A 60 minutes MP3 music file requires only about 50 MB memory space. Without compression, 60 minutes music file in digital form requires about 600 MB memory space.

1.26 MPEG COMPRESSION STANDARD

MPEG is a standard compression method for video signals. It is short form for Motion Pictures Group. It is pronounced as 'em-peg'. It is not a single standard, but a series of standards. MPEG-1 is for TV quality video and low resolutions visual display unit (VDU) of a personal computer (640 X 480 pixels resolution). MPEG-2 supports HDTV (High Definition TV). HDTV is a form of digital transmission. It gives better quality of pictures and exceptional sound. Earlier, most routine broadcasts used analog television signals, which were transmitted like radio signals. MPEG-2 is an emerging new standard for TV broadcasts.

1.27 PERSONAL MEDIA PLAYER PMP

After MP3, it is the personal media player taking portable entertainment world by storm. PMPs play almost all kinds of digital audio and video formats depending upon the device capability. A PMP contains a mini hard drive, a LCD screen and a removable rechargeable battery. The user can view video files on the LCD screen. Most of the PMPs contains at least 20 GB hard drive. A 20 GB hard drive can carry about 15 Div X movies along with 500 songs.

1.28 DIV X

Div X is a media format. A new package 'Div X Create Bundle' is available. It is video compression utility. It includes the new improved Div X 6 codec, Div X converter and Div X pro. The new version of the Div X codec represents a significant update over version 5 and offers better image quality. The Div X converter converts a video file in Div X format. The user can select Div X profile. If there are a number of video files having same resolution and frame rate, they can be combined into one single file with the selection of menu. There is an extension to Div X which allows to add menu, chapter titles, subtitles etc. A Div X player plays a Div X-encoded file.

PROBLEMS

1. What are the essential components of a computer? Draw the schematic block diagram of a computer showing its essential components. Discuss the function of each component.
2. Discuss the important features of various generations of computers. Give some examples of computers for each generation.

3. Explain primary memory, secondary memory and cache memory. What type of memory devices are used in each of these categories of memory?
4. Explain what you understand by real and virtual memory.
5. Discuss the features of direct access storage devices and serial access storage devices.
6. Show that the memory addressing capability of a CPU is equal to 2^n bytes, where n is the number of address lines of the CPU.
7. Explain what are MIPS, MFLOPS, SPECint, SPECfp, KLIPS, Dhrystone and Whetstone.
8. Which microprocessor is suitable for (*i*) Client computer, (*ii*) Server, (*iii*) Workstation and (*iv*) Supercomputer?
9. Discuss the important features of (*a*) Palm PC, (*b*) Notebook (*c*) Desktop, (*d*) Server, (*e*) Workstation and (*f*) Supercomputer.
10. Explain the terms hardware, software, firmware and freeware.
11. Explain what you understand by system software and operating system. Give examples of some important operating systems.
12. What are application programs? What is their utility? Discuss the features of an integrated package.
13. What is an assembler, compiler and interpreter?
14. Explain what you understand by low-level language and high-level language. Give examples of each.
15. Discuss multiprogramming, multitasking and multiuser system.
16. Explain (*i*) Computer network and (*ii*) Distributed processing.
17. What is multithreading? Explain.
18. What is LAN, WAN and Internet? What is Ethernet?
19. What do you understand by the term, 'broadband';
20. Discuss Wi-Fi and DTH.
21. What is computer virus? Explain.
22. What are RISC, CISC and EPIC processors?
23. Explain MP3, MPEG, PMP and DivX.
24. Distinguish between controlflow and dataflow computers.
25. Discuss the important applications of computers in different areas.
26. What is the impact of computers on our society?
27. What is artificial intelligence? Give examples and application of some systems employing artificial intelligence.
28. What is a search engine? Give some examples of search engines. What is the role of a Web crawler?
29. Define client and server computers?
30. What is Web browser? Give its examples.
31. Explain the following :

    URL, Webpage, Website, FTP, TCP/IP, HTML, Applets, Packets, and ISP
32. Explain the following:

    Bridge, Gateways, Routers and Hub.
33. What are Usenet and FTP?
34. What is Intranet? Where is it used.