

COPPERBELT UNIVERSITY

SCHOOL OF INFORMATION AND COMMUNICATION TECHNOLOGY

CS 120 – Introduction to Computer Systems

Classification of Computers

Introduction

Nowadays, computers are an integral part of our lives. They are used for the reservation of tickets for airplanes and railways, payment of telephone and electricity bills, deposit and withdrawal of money from banks, processing of business data, forecasting of weather conditions, diagnosis of diseases, searching for information on the Internet, etc. Computers are also used extensively in schools, universities, organizations, music industry, movie industry, scientific research, law firms, fashion industry, etc. The term computer is derived from the word *compute*. The word *compute* means *to calculate*. A *computer* is an electronic machine that accepts data from the user, processes the data by performing calculations and operations on it, and generates the desired output results. Computer performs both simple and complex operations, with speed and accuracy.

This chapter discusses the history and evolution of computer, the concept of input-process-output and the characteristics of computer. This chapter also discusses the classification of digital computers based on their size and type, and the application of computer in different domain areas.

Digital and Analog Computers

A *digital computer* uses distinct values to represent the data internally. All information is represented using the digits 0s and 1s. The computers that we use at our homes and offices are digital computers. *Analog computer* is another kind of a computer that represents data as variable across a continuous range of values. The earliest computers were analog computers. Analog computers are used for measuring of parameters that vary continuously in real time, such as temperature, pressure and voltage. Analog computers may be more flexible but generally less precise than digital computers. Slide rule is an example of an analog computer. This book deals only with the *digital computer* and uses the term *computer* for them.

Characteristics of Computer

Speed, accuracy, diligence, storage capability and versatility are some of the key characteristics of a computer.

A brief overview of these characteristics are-

- *Speed* The computer can process data very fast, at the rate of millions of instructions per second. Some calculations that would have taken hours and days to complete otherwise, can be completed in a few seconds using the computer. For example, calculation and generation of salary slips of thousands of employees of an organization, weather forecasting that requires analysis of a large amount of data related to temperature, pressure and humidity of various places, etc.

- *Accuracy* Computer provides a high degree of accuracy. For example, the computer can accurately give the result of division of any two numbers up to 10 decimal places.
- *Diligence* When used for a longer period of time, the computer does not get tired or fatigued. It can perform long and complex calculations with the same speed and accuracy from the start till the end.
- *Storage Capability* Large volumes of data and information can be stored in the computer and also retrieved whenever required. A limited amount of data can be stored, temporarily, in the primary memory. Secondary storage devices like floppy disk and compact disk can store a large amount of data permanently.
- *Versatility* Computer is versatile in nature. It can perform different types of tasks with the same ease. At one moment you can use the computer to prepare a letter document and in the next moment you may play music or print a document.

Computers have several limitations too. Computer can only perform tasks that it has been programmed to do. Computer cannot do any work without instructions from the user. It executes instructions as specified by the user and does not take its own decisions.

History of Computer

Until the development of the first generation computers based on vacuum tubes, there had been several developments in the computing technology related to the mechanical computing devices. The key developments that took place till the first computer was developed are as follows—

Calculating Machines ABACUS was the first mechanical calculating device for counting of large numbers. The word ABACUS means calculating board. It consists of bars in horizontal positions on which sets of beads are inserted. The horizontal bars have 10 beads each, representing units, tens, hundreds, etc.

Napier's bones was a mechanical device built for the purpose of multiplication in 1617 by an English mathematician John Napier.

Slide Rule was developed by an English mathematician Edmund Gunter in the 16th century. Using the slide rule, one could perform operations like addition, subtraction, multiplication and division. It was used extensively till late 1970s. Figure 1.2 shows a slide rule.

Pascal's Adding and Subtraction Machine was developed by Blaise Pascal. It could add and subtract. The machine consisted of wheels, gears and cylinders.

Leibniz's Multiplication and Dividing Machine was a mechanical device that could both multiply and divide. The German philosopher and mathematician Gottfried Leibniz built it around 1673.

Punch Card System was developed by Jacquard to control the power loom in 1801. He invented the punched card reader that could recognize the presence of hole in the punched card as binary

one and the absence of the hole as binary zero. The 0s and 1s are the basis of the modern digital computer. A punched card is shown in Figure 1.3.

Babbage's Analytical Engine An English man Charles Babbage built a mechanical machine to do complex mathematical calculations, in the year 1823. The machine was called as difference engine. Later, Charles Babbage and Lady Ada Lovelace developed a general-purpose calculating machine, the analytical engine. Charles Babbage is also called the father of computer.

Hollerith's Punched Card Tabulating Machine was invented by Herman Hollerith. The machine could read the information from a punched card and process it electronically.

The developments discussed above and several others not discussed here, resulted in the development of the first computer in the 1940s.

Generations of Computer

The computer has evolved from a large-sized simple calculating machine to a smaller but much more powerful machine. The evolution of computer to the current state is defined in terms of the generations of computer. Each generation of computer is designed based on a new technological development, resulting in better, cheaper and smaller computers that are more powerful, faster and efficient than their predecessors. Currently, there are five generations of computer. In the following subsections, we will discuss the generations of computer in terms of—

1. The technology used by them (hardware and software),
2. Computing characteristics (speed, i.e., number of instructions executed per second),
3. Physical appearance and
4. Their applications.

First Generation (1940 to 1956): Using Vacuum Tubes

Hardware Technology The first generation of computers used vacuum tubes for circuitry and magnetic drums for memory. The input to the computer was through punched cards and paper tapes. The output was displayed as printouts.

Software Technology The instructions were written in machine language. Machine language uses 0s and 1s for coding of the instructions. The first generation computers could solve one problem at a time.

Computing Characteristics The computation time was in milliseconds.

Physical Appearance These computers were enormous in size and required a large room for installation.

Application They were used for scientific applications as they were the fastest computing device of their time.

Examples UNIVERSal Automatic Computer (UNIVAC), Electronic Numerical Integrator And Calculator (ENIAC), and Electronic Discrete Variable Automatic Computer (EDVAC).

The first generation computers used a large number of vacuum tubes and thus generated a lot of heat. They consumed a great deal of electricity and were expensive to operate. The machines were prone to frequent malfunctioning and required constant maintenance. Since first generation computers used machine language, they were difficult to program.

Second Generation (1956 to 1963): Using Transistors

Hardware Technology Transistors (Figure 1.5) replaced the vacuum tubes of the first generation of computers. Transistors allowed computers to become smaller, faster, cheaper, energy efficient and reliable. The second generation computers used *magnetic core technology* for primary memory. They used magnetic tapes and magnetic disks for secondary storage. The input was still through punched cards and the output using printouts. They used the concept of a stored program, where instructions were stored in the memory of computer.

Software Technology The instructions were written using the *assembly language*. Assembly language uses mnemonics like ADD for addition and SUB for subtraction for coding of the instructions. It is easier to write instructions in assembly language, as compared to writing instructions in machine language. High-level programming languages, such as early versions of COBOL and FORTRAN were also developed during this period.

Computing Characteristics The computation time was in microseconds.

Physical Appearance Transistors are smaller in size compared to vacuum tubes, thus, the size of the computer was also reduced.

Application The cost of commercial production of these computers was very high, though less than the first generation computers. The transistors had to be assembled manually in second generation computers.

Examples PDP-8, IBM 1401 and CDC 1604

Second generation computers generated a lot of heat but much less than the first generation computers. They required less maintenance than the first generation computers.

Third Generation (1964 to 1971): Using Integrated Circuits

Hardware Technology The third generation computers used the *Integrated Circuit (IC)* chips. Figure 1.6 shows IC chips. In an IC chip, multiple transistors are placed on a silicon chip. Silicon is a type of semiconductor. The use of IC chip increased the speed and the efficiency of computer, manifold. The keyboard and monitor were used to interact with the third generation computer, instead of the punched card and printouts.

Software Technology The keyboard and the monitor were interfaced through the *operating system*. Operating system allowed different applications to run at the same time. *High-level languages* were used extensively for programming, instead of machine language and assembly language.

Computing Characteristics The computation time was in nanoseconds.

Physical Appearance The size of these computers was quite small compared to the second generation computers.

Application Computers became accessible to mass audience. Computers were produced commercially, and were smaller and cheaper than their predecessors.

Examples IBM 370, PDP 11

The third generation computers used less power and generated less heat than the second generation computers. The cost of the computer reduced significantly, as individual components of the computer were not required to be assembled manually. The maintenance cost of the computers was also less compared to their predecessors.

Fourth Generation (1971 to present): Using Microprocessors

Hardware Technology They use the *Large Scale Integration (LSI)* and the *Very Large Scale Integration (VLSI)* technology. Thousands of transistors are integrated on a small silicon chip using LSI technology.

VLSI allows hundreds of thousands of components to be integrated in a small chip. This era is marked by the development of microprocessor.

Microprocessor is a chip containing millions of transistors and components, and, designed using LSI and VLSI technology. A microprocessor chip is shown in Figure 1.7. This generation of computers gave rise to Personal Computer (PC). Semiconductor memory replaced the earlier magnetic core memory, resulting in fast random access to memory. Secondary storage device like magnetic disks became smaller in physical size and larger in capacity. The *linking of computers* is another key development of this era. The computers were linked to form networks that led to the emergence of the Internet. This generation also saw the development of pointing devices like mouse, and handheld devices.

Software Technology Several new operating systems like the MS-DOS and MS-Windows developed during this time. This generation of computers supported *Graphical User Interface (GUI)*. GUI is a user friendly interface that allows user to interact with the computer via menus and icons. High-level programming languages are used for the writing of programs.

Computing Characteristics The computation time is in picoseconds.

Physical Appearance They are smaller than the computers of the previous generation. Some can even fit into the palm of the hand.

Application They became widely available for commercial purposes. Personal computers became available to the home user.

Examples The Intel 4004 chip was the first microprocessor. The components of the computer like Central Processing Unit (CPU) and memory were located on a single chip. In 1981, IBM introduced the first computer for home use. In 1984, Apple introduced the Macintosh.

The microprocessor has resulted in the fourth generation computers being smaller and cheaper than their predecessors. The fourth generation computers are also portable and more reliable. They generate much lesser heat and require less maintenance compared to their predecessors. GUI and pointing devices facilitate easy use and learning on the computer. Networking has resulted in resource sharing and communication among different computers.

Fifth Generation (Present and Next): Using Artificial Intelligence

The goal of fifth generation computing is to develop computers that are capable of learning and self-organization. The fifth generation computers use *Super Large Scale Integrated (SLSI)* chips that are able to store millions of components on a single chip. These computers have large memory requirements.

This generation of computers uses *parallel processing* that allows several instructions to be executed in parallel, instead of serial execution. Parallel processing results in faster processing speed. The Intel dual-core microprocessor uses parallel processing.

The fifth generation computers are based on *Artificial Intelligence (AI)*. They try to simulate the human way of thinking and reasoning. Artificial Intelligence includes areas like Expert System (ES), Natural Language Processing (NLP), speech recognition, voice recognition, robotics, etc.

Classification of Computer

The digital computers that are available nowadays vary in their sizes and types. The computers are broadly classified into four categories (Figure 1.8) based on their size and type—(1) Microcomputers, (2) Minicomputers, (3) Mainframe computers, and (4) Supercomputer.

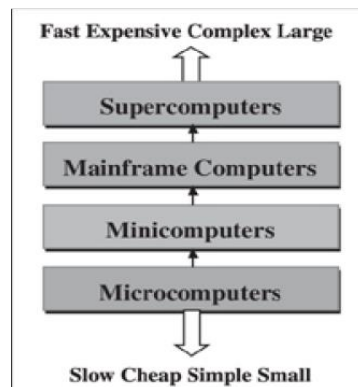


Figure 1.8

Microcomputers

Microcomputers are small, low-cost and single-user digital computer. They consist of CPU, input unit, output unit, storage unit and the software. Although microcomputers are stand-alone machines, they can be connected together to create a network of computers that can serve more than one user.

IBM PC based on Pentium microprocessor and Apple Macintosh are some examples of microcomputers. Microcomputers include desktop computers, notebook computers or laptop, tablet computer, handheld computer, smart phones and net book.

Desktop Computer or Personal Computer (PC) is the most common type of microcomputer. It is a stand-alone machine that can be placed on the desk. Externally, it consists of three units—keyboard, monitor, and a system unit containing the CPU, memory, hard disk drive, etc. It is not very expensive and is suited to the needs of a single user at home, small business units, and organizations. Apple, Microsoft, HP, Dell and Lenovo are some of the PC manufacturers.

Notebook Computers or Laptops resemble a notebook. They are portable and have all the features of a desktop computer. The advantage of the laptop is that it is small in size (can be put inside a briefcase), can be carried anywhere, has a battery backup and has all the functionality of the desktop. Laptops can be placed on the lap while working (hence the name). Laptops are costlier than the desktop machines.

Netbook These are smaller notebooks optimized for low weight and low cost, and are designed for accessing web-based applications. Starting with the earliest netbook in late 2007, they have gained significant popularity now. Netbooks deliver the performance needed to enjoy popular activities like streaming videos or music, emailing, Web surfing or instant messaging. The word *netbook* was created as a blend of *Internet* and *notebook*.

Tablet Computer has features of the notebook computer but it can accept input from a stylus or a pen instead of the keyboard or mouse. It is a portable computer. Tablet computer are the new kind of PCs.

Handheld Computer or Personal Digital Assistant (PDA) is a small computer that can be held on the top of the palm. It is small in size. Instead of the keyboard, PDA uses a pen or a stylus for input. PDAs do not have a disk drive. They have a limited memory and are less powerful. PDAs can be connected to the Internet via a wireless connection. Casio and Apple are some of the manufacturers of PDA. Over the last few years, PDAs have merged into mobile phones to create smart phones.

Smart Phones are cellular phones that function both as a phone and as a small PC. They may use a stylus or a pen, or may have a small keyboard. They can be connected to the Internet wirelessly. They are used to access the electronic-mail, download music, play games, etc. Blackberry, Apple, HTC, Nokia and LG are some of the manufacturers of smart phones.

Minicomputers

Minicomputers are digital computers, generally used in multiuser systems. They have high processing speed and high storage capacity than the microcomputers. Minicomputers can support 4–200 users simultaneously. The users can access the minicomputer through their PCs or terminal. They are used for real-time applications in industries, research centers, etc. PDP 11, IBM (8000 series) are some of the widely used minicomputers.

Mainframe Computers

Mainframe computers are multi-user, multi-programming and high performance computers. They operate at a very high speed, have very large storage capacity and can handle the workload of many users. Mainframe computers are large and powerful systems generally used in centralized databases. The user accesses the mainframe computer via a terminal that may be a dumb terminal, an intelligent terminal or a PC. A *dumb terminal* cannot store data or do processing of its own. It has the input and output device only. An *intelligent terminal* has the input and output device, can do processing, but, cannot store data of its own. The dumb and the intelligent terminal use the processing power and the storage facility of the mainframe computer. Mainframe computers are used in organizations like banks or companies, where many people require frequent access to the same data. Some examples of mainframes are CDC 6600 and IBM ES000 series.

Supercomputers

Supercomputers are the fastest and the most expensive machines. They have high processing speed compared to other computers. The speed of a supercomputer is generally measured in FLOPS (FLoating point Operations Per Second). Some of the faster supercomputers can perform trillions of calculations per second. Supercomputers are built by interconnecting thousands of processors that can work in parallel.

Supercomputers are used for highly calculation-intensive tasks, such as, weather forecasting, climate research (global warming), molecular research, biological research, nuclear research and aircraft design. They are also used in major universities, military agencies and scientific research laboratories. Some examples of supercomputers are IBM Roadrunner, IBM Blue gene and Intel ASCI red. PARAM is a series of supercomputer assembled in India by CDAC (Center for Development of Advanced Computing), in Pune. PARAM Padma is the latest machine in this series. The peak computing power of PARAM Padma is 1 Tera FLOP (TFLOP).