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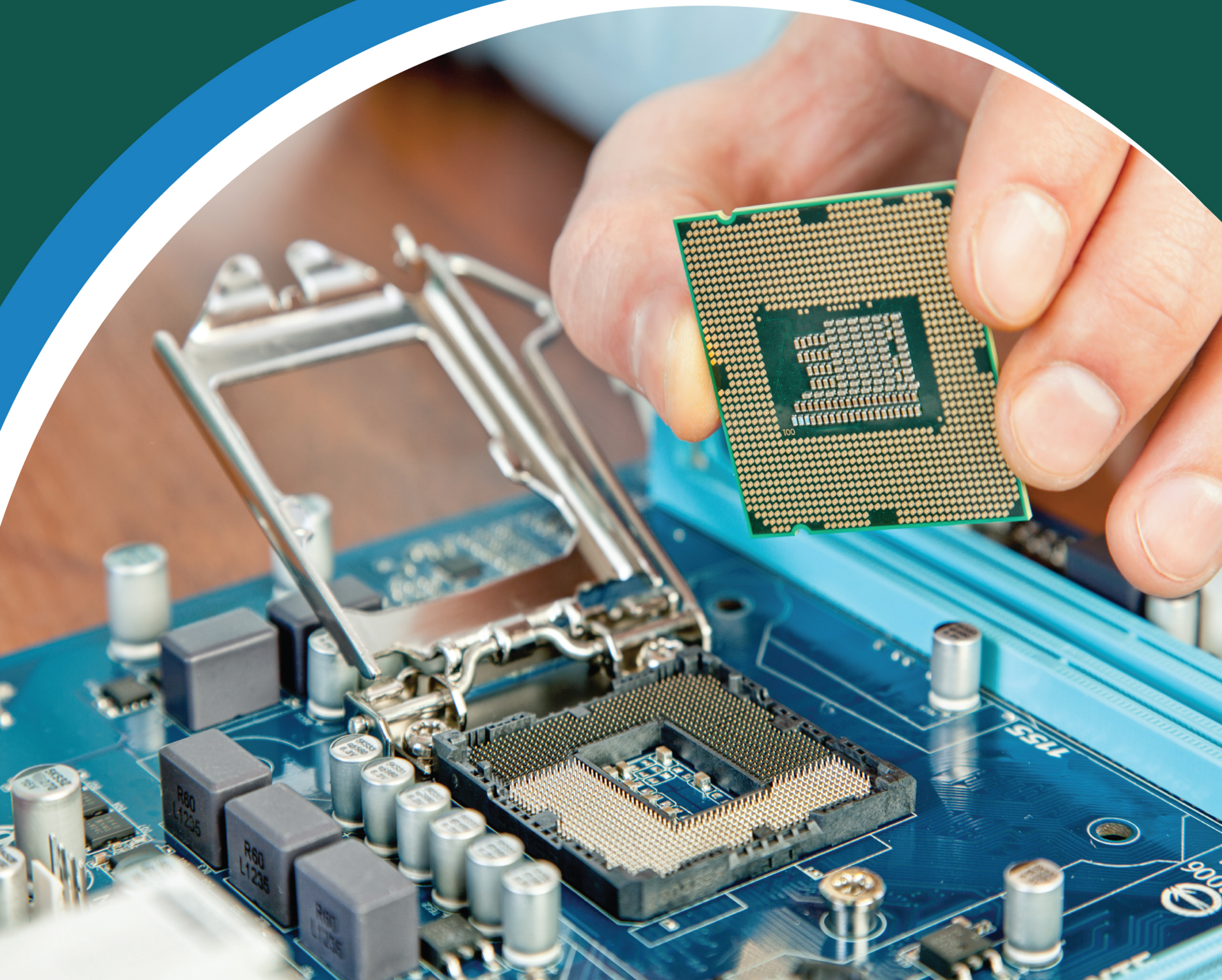

COMPUTER HARDWARE & SOFTWARE TOOLS

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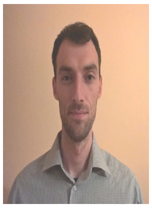
EDITORIAL BOARD

Fozia Parveen has a Dphil in Sustainable Water Engineering from the University of Oxford. Prior to this she has received MS in Environmental Sciences from National University of Science and Technology (NUST), Islamabad Pakistan and BS in Environmental Sciences from Fatima Jinnah Women University (FJWU), Rawalpindi.



Igor Krunic 2003-2007 in the School of Economics. After graduating in 2007, he went on to study at The College of Tourism, at the University of Belgrade where he got his bachelor degree in 2010. He was active as a third-year student representative in the student parliament.Then he went on the Faculty of science, at the University of Novi Sad where he successfully defended his master's thesis in 2013. The crown of his study was the work titled Opportunities for development of cultural tourism in Cacak". Later on, he became part of a multinational company where he got promoted to a deputy director of logistic. Nowadays he is a consultant and writer of academic subjects in the field of tourism.

Dr. Jovan Pehcevski obtained his PhD in Computer Science from RMIT University in Melbourne, Australia in 2007. His research interests include big data, business intelligence and predictive analytics, data and information science, information retrieval, XML, web services and service-oriented architectures, and relational and NoSQL database systems. He has published over 30 journal and conference papers and he also serves as a journal and conference reviewer. He is currently working as a Dean and Associate Professor at European University in Skopje, Macedonia.

Dr. Tanjina Nur finished her PhD in Civil and Environmental Engineering in 2014 from University of Technology Sydney (UTS). Now she is working as Post-Doctoral Researcher in the Centre for Technology in Water and Wastewater (CTWW) and published about eight International journal papers with 80 citations. Her research interest is wastewater treatment technology using adsorption process.

Stephen obtained his PhD from the University of North Carolina at Charlotte in 2013 where his graduate research focused on cancer immunology and the tumor microenvironment. He received postdoctoral training in regenerative and translational medicine, specifically gastrointestinal tissue engineering, at the Wake Forest Institute of Regenerative Medicine. Currently, Stephen is an instructor for anatomy and physiology and biology at Forsyth Technical Community College.

Michelle holds a Masters of Business Administration from the University of Phoenix, with a concentration in Human Resources Management. She is a professional author and has had numerous articles published in the Henry County Times and has written and revised several employee handbooks for various YMCA organizations throughout the United States.

HOW TO USE THE BOOK

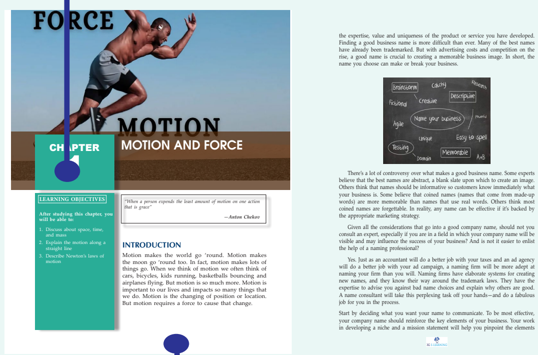
This book has been divided into many chapters. Chapter gives the motivation for this book and the use of templates. The text is presented in the simplest language. Each paragraph has been arranged under a suitable heading for easy retention of concept. Keywords are the words that academics use to reveal the internal structure of an author's reasoning. Review questions at the end of each chapter ask students to review or explain the concepts. References provides the reader an additional source through which he/she can obtain more information regarding the topic.

LEARNING OBJECTIVES

See what you are going to cover and what you should already know at the start of each chapter

ABOUT THIS CHAPTER

An introduction is a beginning of section which states the purpose and goals of the topics which are discussed in the chapter. It also starts the topics in brief.

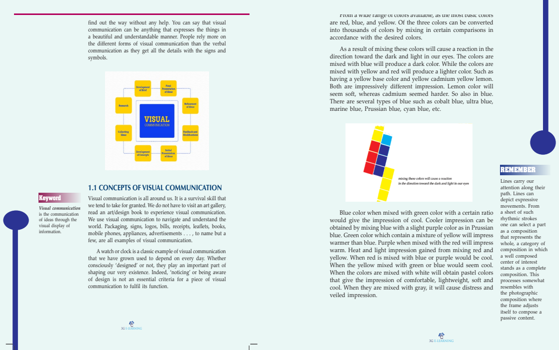


REMEMBER

This revitalizes a must read information of the topic.

KEYWORDS

This section contains some important definitions that are discussed in the chapter. A keyword is an index entry that identifies a specific record or document. It also gives the extra information to the reader and an easy way to remember the word definition.



DID YOU KNOW?

This section equip readers the interesting facts and figures of the topic.

EXAMPLE

The book cabinets' examples to illustrate specific ideas in each chapter.

ROLE MODEL

A biography of someone who has/had acquired remarkable success in their respective field as Role Models are important because they give us the ability to imagine our future selves.

CASE STUDY

This reveals what students need to create and provide an opportunity for the development of key skills such as communication, group working and problem solving.

KNOWLEDGE CHECK

This is given to the students for progress check at the end of each chapter.

REVIEW QUESTIONS

This section is to analyze the knowledge and ability of the reader.

REFERENCES

References refer those books which discuss the topics given in the chapters in almost same manner.

TABLE OF CONTENTS


Windows 11

Chapter 6 Linux 197

Chapter 7 Word Processing 235

Chapter 10 Software Testing and Quality 403

PREFACE

Every hardware component is very important to the operation of the computer. Computer hardware is the bits and pieces that make up computers. For example, the hard disk drive, its processors, video cards etc. Peripherals like the monitor, mouse and printer, or storage devices - which you plug into your computer - are also considered hardware. Hardware requires software to run correctly. Without the correct hardware, your software may not run efficiently or at all. It is important to consider both when making decisions about your IT systems, as this can affect the way you work, your productivity and your business' bottom line.

Organization of the Book

This edition contains ten chapters. Information is completely revised and new chapters are added in this edition. By providing a wide-ranging overview of general hardware and software principles, tools, and applications, this book provides satisfactory insight into the current technology and imminent developments in the field of hardware and software.

Chapter 1 begins with the basics of computer. Furthermore, an overview of computer system is given as well as an emphasis on number systems is provided.

Chapter 2 focuses on computer memory representation for data storage that can be directly accessed by the CPU using the data and address buses. However, the information stored in the secondary memory is not directly accessible.

Chapter 3 gives an emphasis on input and output devices that play a capital role in the functioning of a computer.

Chapter 4 describes the basic elements and types of multimedia typically used to mean the combination of text, sound, and/or motion video.

Chapter 5 gives an overview of windows and essential accessories of windows as well as the different versions of windows are provided.

Chapter 6 starts with a brief history of Linux Development. Furthermore, Linux Kernel and its architecture are presented. An overview of Linux processes is also delivered with the guidelines of installation process of Linux.

Chapter 7 covers the Word processing program that allows you to create letters, reports, newsletters, tables, form letters, brochures, and Web pages. Using this application program you can add pictures, tables, and charts to your documents. You can also check spelling and grammar.

Chapter 8 focuses on spreadsheet package. A spreadsheet is an accounting ledger page that shows various quantitative information useful for managing a business.

Chapter 9 highlights on relevant tools, standards, and/or engineering constraints. It focuses on history and overview software engineering.

Chapter 10 explores on software testing and quality. Software testing is an investigation conducted to provide stakeholders with information about the quality of the software product or service under test. Software testing can also provide an objective, independent view of the software to allow the business to appreciate and understand the risks of software implementation.

CHAPTER 1

INTRODUCTION TO COMPUTER

LEARNING OBJECTIVES

After studying this chapter, you will be able to:

1. Understand the Basics of Computer
2. Discuss about Computer System
3. Explain Computer Number Systems

> *"Computer science is no more about computers than astronomy is about telescopes."*
>
> *– Edsger Dijkstra*

INTRODUCTION

A computer is a programmable machine. The two principal characteristics of a computer are: It responds to a specific set of instructions in a well-defined manner and it can execute a pre-recorded list of instructions (a program).

A computer is a machine that can be programmed to carry out sequences of arithmetic or logical operations automatically. Modern computers can perform generic sets of operations known as programs. These programs enable computers to perform a wide range of tasks. A computer system is a "complete" computer that includes the hardware, operating system (main software), and peripheral equipment needed and used for "full" operation. This term may also refer to a group of computers that are linked and function together, such as a computer network or computer cluster. A broad range of industrial and consumer products use computers as control systems. Simple special-purpose devices like microwave ovens and remote controls are included, as are factory devices like industrial robots and computer-aided design, as well as general-purpose devices like personal computers and mobile devices like smartphones. Computers power the Internet, which links hundreds of millions of other computers and users.

Early computers were meant to be used only for calculations. Simple manual instruments like the abacus have aided people in doing calculations since ancient times. Early in the Industrial Revolution, some mechanical devices were built to automate long tedious tasks, such as guiding patterns for looms. More sophisticated electrical machines did specialized analog calculations in the early 20th century. The first digital electronic calculating machines were developed during World War II. The first semiconductor transistors in the late 1940s were followed by the silicon-based MOSFET (MOS transistor) and monolithic integrated circuit (IC) chip technologies in the late 1950s, leading to the microprocessor and the microcomputer revolution in the 1970s. The speed, power and versatility of computers have been increasing dramatically ever since then, with transistor counts increasing at a rapid pace (as predicted by Moore's law), leading to the Digital Revolution during the late 20th to early 21st centuries. Conventionally, a modern computer consists of at least one processing element, typically a central processing unit (CPU) in the form of a microprocessor, along with some type of computer memory, typically semiconductor memory chips. The processing element carries out arithmetic and logical operations, and a sequencing and control unit can change the order of operations in response to stored information. Peripheral devices include input devices (keyboards, mice, joystick, etc.), output devices (monitor screens, printers, etc.), and input/output devices that perform both functions (e.g., the 2000s-era touchscreen). Peripheral devices allow information to be retrieved from an external source and they enable the result of operations to be saved and retrieved.

1.1 BASICS OF COMPUTER

A computer is a programmable machine designed to perform arithmetic and logical operations automatically and sequentially on the input given by the user and gives the desired output after processing. Computer components are divided into two major categories namely hardware and software. Hardware is the machine itself and its connected devices such as monitor, keyboard, mouse etc. Software are the set of programs that make use of hardware for performing various functions.

1.1.1 Characteristics of Computers

A computer is an intelligent amplifier that performs the above-mentioned operations in a much taster, accurate and efficient way. Thus, it gives us ample time to use it in matters involving creativity & judgment. The characteristics of computers that have made them so powerful and universally useful are speed, accuracy, diligence, versatility and storage capacity. Let us discuss them briefly.

Keyword

Logic error is a bug in a program that causes it to operate incorrectly, but not to terminate abnormally.

Speed

A computer can add and subtract numbers, compare letters to determine alphabetic sequence, move and copy numbers and letters. As such, there is nothing profound in these operations. What is significant is the speed with which computers carry out these operations. This speed varies from a few microseconds (millionth of second) to Nano (billionth of second). For instance, People would need to do a lot of waiting in queues for grocery payments, for making telephone calls, for making travel reservations, etc. but with the help of computers the processing can be done in a fraction of a second. The speed of a computer at performing a single operation can be measured in terms of:

- Milliseconds - One thousandth of a second (1/1000)
- Microsecond - One millionth of a second (1/1000000)
- Nanosecond - One billionth of a second (1/1000000000). The speed at which a computer performs logical operations is measured in nanoseconds.
- Picoseconds - One trillionth of a second (1/1000000000000).

Accuracy

You may work for years before experiencing a system error, such as an updating of the wrong record or an incorrect addition. Errors do occur in computer-based information but precious few can be directly attributed to the computer systems. The vast majority of these errors can be traced to a program **logic error**, a procedural error, or erroneous data. These are human errors. Hardware errors are usually detected and corrected by the computer system itself. Computers are very accurate. They can perform their hundreds of thousands of operations with great accuracy. They can run error less for days at a time.

Reliability

Computer output is generally very reliable, subject to the condition that the input data entering the computer should be correct and the program of instructions should be reliable and correct. Incorrect input data and unreliable programs give us computer errors and wrong results. Hence, the phrase GARBAGE IN-GARBAGE OUT (GIGO).

Storage Capability

Computer systems have total and instant recall of data and an almost unlimited capacity to store these data. A typical mainframe computer system will have many billions of characters, and perhaps thousands of graphic images, stored and available for-instant recall. When properly used, a computer can improve the efficiency of an organization. It provides a fast, accurate, and reliable device with which to process data. Similarly, computers enable companies to provide customers with instantaneous services, such as airline flight availability and charge account status. The result is that these companies can offer far more customer services than would be possible without computer. Because various computer media can store millions of characters of data in a condensed form. There is tremendous savings in the storage area required to maintain the vital records necessary in a business environment. The storing capacity of a computer is measured in terms of bytes, kilobytes and gigabytes.

Bit	Byte	Kilobyte	Megabyte	Gigabyte
8	1	-	-	-
8,192	1,024	1	-	-
8,388,608	1,048,576	1,024	1	-
8,589,934,592	1,073,741,824	1,048,576	1,024	1

Automation

Computers are quite capable of functioning automatically, once the process is given to the computer. They do not require any instruction from the operator at any stage of the process. Computers can be programmed to perform a series of complex tasks involving multiple programs. Computers will execute the programs in the correct sequence, provided they are programmed correctly.

Diligence

Human beings suffer from physical and mental fatigue. They cannot perform the same task over and over again with the same speed, accuracy and enthusiasm as in the first time. This will affect the performance. Being a machine, a computer does not suffer from such weaknesses. The computer is capable of performing task repeatedly at the same level of speed and accuracy even if it has to carry complex operation for a long period of time.

Versatile

Computers are versatile *(can do many types of jobs)*. It can carry out processes ranging from simple mathematical calculations to highly complex and logical evaluations for any extended period of time. Computers can communicate with other computers and can receive and send data in various forms such as text, video, etc. This ability of computer to communicate to one another has led to the development of computer networks. Internet, and so on. All this is possible because of computers and other related technologies.

Keyword

A **microprocessor** is a computer processor wherein the data processing logic and control is included on a single integrated circuit, or a small number of integrated circuits.

Scientific Approach

The entire approach to solving problems is highly scientific, objective and sequentially carried out, leaving no room for emotional and subjective evaluations made by man, which are sources of potential errors and unjustified results.

Intangible Benefits

There are many companies that utilize computers for intangible benefits such as flexibility, ability to accommodate growth and the psychological factor that may give them a competitive edge in attracting consumers to buy their products or services.

Reduced Cost

With the ever increasing advances being made in the state of the art. The cost of computer equipment has dropped drastically over the years. Hardware costs have been decreasing at an estimated annual rate of 25%. Thus. Companies that at one time could not justify the cost of acquiring their own computer system may now find it not only feasible to acquire a system. But cost effective as well.

1.1.2 The Computer Generations

The evolution of computer started from 16th century and resulted in the form that we see today. The present day computer, however, has also undergone rapid change during the last fifty years. This period, during which the evolution of computer took place, can be divided into five distinct phases, basis of the type of switching circuits known as Generations of Computers.

Keyword

Machine language is a set of instructions executed directly by a computer's central processing unit (CPU).

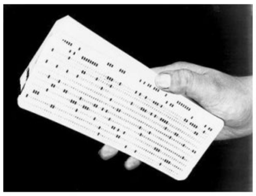
The computers of today are vastly different in appearance and performance as compared to the computers of earlier days. But where did this technology come from and where is it heading? To fully understand the impact of computers on today's world and the promises they hold for the future, it is important to understand the evolution of computers.

The First Generation:

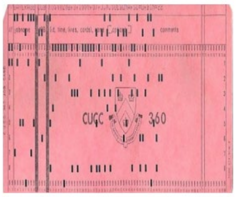
The first generation computers made use of:

- Vacuum tube technology,
- Punched cards for data input,
- Punched cards and paper tape for output,
- **Machine Language** for writing programs,

- Magnetic tapes and drums for external storage.



Punched cards



Paper tape

Vacuum tube

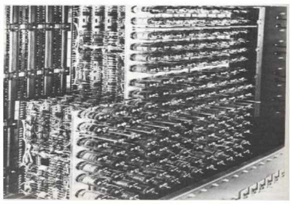
Figure 1.1: The first Generation Computer technology.

REMEMBER

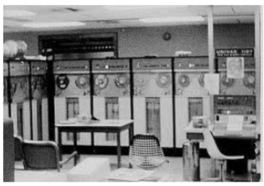
For output, the machine would have a printer, a curve plotter and a bell. The machine would also be able to punch numbers onto cards to be read in later.

The computers of the first generation were very bulky and emitted large amount of heat which required air conditioning. They were large in size and cumbersome to handle. They had to be manually assembled and had limited commercial use. The concept of operating systems was not known at that time. Each computer had a different binary coded program called a machine language that told it how to operate.

The Abacus, which emerged about 5000 years ago in Asia Minor and is still in use today, allows users to make computations using a system of sliding beads arranged on a rack. Early merchants used Abacus to keep trading transactions.



Abacus



Pascaline

Figure 1.2: the first Generation Computers.

Blaise Pascal, a French mathematician invented the first mechanical machine, a rectangular brass box, called Pascaline which could perform addition and subtraction on whole numbers. This was in the seventeenth century. Colmar, a Frenchman invented a machine that could perform the four basic arithmetic functions of addition, subtraction, multiplication and division. Colmar's mechanical calculator, "Arithmometer", presented a more practical approach to computing. With its enhanced versatility, the "Arithmometer" was widely used until the First World War, although later inventors refined Colmar's calculator, together with fellow inventors, Pascal and Leibniz, he helped define the age of mechanical computation.

Charles Babbage a British mathematician at Cambridge University invented the first analytical engine or difference engine. This machine could be programmed by instructions coded on punch cards and had mechanical memory to store the results. For his contributions in this field Charles Babbage is known as 'the father of modern digital computer.

Some of the early computers included:

Mark I –

This was the first fully automatic calculating machine. It was designed by Howard Aiken of Harvard University in collaboration with IBM. This machine was an electronic relay computer. Electromagnetic signals were used for the movement of mechanical parts. Mark I could perform the basic arithmetic and complex equations. Although this machine was extremely reliable, it was very slow (it took about 3-5 seconds per calculation) and was complex in design and large in size.

Atanasoff-Berry Computer (ABC) –

This computer developed by John Atanasoff and Clifford Berry was the world's first general purpose electronic digital computer. It made use of vacuum tubes for internal logic and capacitors for storage.

ENIAC (Electronic Numeric Integrator and Calculator) –

The first all-electronic computer was produced by a partnership between the US Government and the University of Pennsylvania. It was built using 18,000 vacuum tubes, 70,000 resistors and 1,500 relays and consumed 160 kilowatts of electrical power. The ENIAC computed at speed about thousand times faster than Mark I. However, it could store and manipulate only a limited amount of data. Program modifications and detecting errors were also difficult.

Figure 1.3: ENIAC.

EDVAC –

In the mid 1940's Dr. John von Neumann designed the Electronic Discrete Variable Automatic Computer with a memory to store both program and data. This was the first machine which used the stored program concept. It had five distinct units - arithmetic, central control, memory, input and output. The key element was the central control. All the functions of the computer were co-ordinate through this single source, the central control. The programming of the computers was done in machine language.

UNIVAC I –

Remington Rand designed this computer specifically for business data processing applications. The Universal Automatic Computer was the first general purpose commercially available computer.

Figure 1.4: UNIVAC.

The Second Generation:

In the second generation computers:

- Vacuum tube technology was replaced by transistorized technology,
- Size of the computers started reducing,
- Assembly language started being used in place of machine language,
- Concept of stored program emerged,
- High level languages were invented.

This was the generation of Transistorized Computers. Vacuum tubes were replaced by transistors. As a result, the size of the machines started shrinking. These computers were smaller, faster, more reliable and more energy efficient. The first transistorized computer was TX-0. The first large scale machines that took advantage of the transistor technology were the early supercomputers, Stretch by IBM and LARC by Sperry Rand. These machines were mainly developed for atomic energy laboratories. Typical computers of the second generation were the IBM 1400 and 7000 series, Honeywell 200 and General Electric.

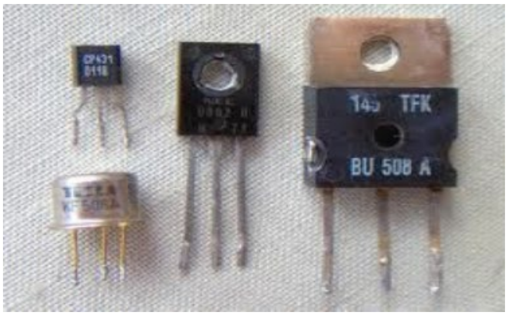


Figure 1.5: Transistors.

IBM 1401 was universally accepted throughout the industry and most large businesses routinely processed financial information using second generation computers. The machine language was replaced by assembly language. Thus the long and difficult binary code was replaced with abbreviated programming code which was relatively easy to understand.

The stored program concept and programming languages gave the computers flexibility to finally be cost effective and productive for business use. The stored program concept implied that the instructions to run a computer for a specific task were held inside the computer's memory and could quickly be modified or replaced by a different set of instructions for a different function. High level languages like COBOL, FORTRAN and AL- GOL were developed. Computers started finding vast and varied applications. The entire software industry began with the second generation computers.

The Third Generation:

The third generation computers were characterized by:

- Use of Integrated circuits,
- Phenomenal increase in computation speed,
- Substantial reduction in size and power consumption of the machines,
- Use of magnetic tapes and drums for external storage,
- Design-of Operating systems and new higher level languages,
- Commercial production of computers.

This generation was characterized by the invention of Integrated Circuits (ICs). The 1C combined electronic components onto a small chip which was made from quartz.

REMEMBER

In most computers, individual instructions are stored as machine code with each instruction being given a unique number. The command to add two numbers together would have one opcode; the command to multiply them would have a different opcode, and so on.

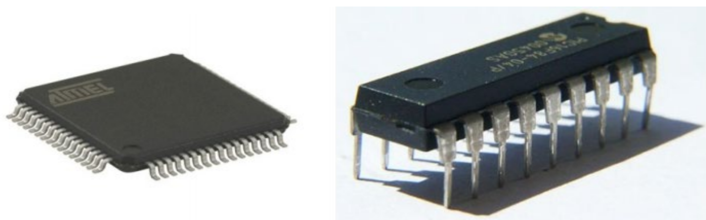


Figure 1.6: Integrated Circuit.

Later, even more components were fitted onto a single chip, called a semiconductor. This reduced the size even further. The weight and power consumption of computers decreased and the speed increased tremendously. Heavy emphasis was given to the development of software. Operating systems were designed which allowed the machine to run many different programs at once. A central program monitored and co-ordinate the computer s memory. Multiprogramming was made possible, whereby the machine could perform several jobs at the same time. Computers achieved speeds of executing millions of instructions per second. Commercial production became easier and cheaper. Higher level languages like Pascal and Report Program Generator (RPG) were introduced and applications oriented languages like FORTRAN, COBOL, and PL/1 were developed.

The Fourth Generation:

The general features of the fourth generation computers were:

- Use of Very Large Scale Integration,
- Invention of microcomputers,
- Introduction of Personal Computers,
- Networking,
- Fourth Generation Languages.

Figure 1.7: VLSI.

The third generation computers made use of 'Integrated Circuits that had 10- 20 components on each chip, this was Small Scale Integration (SSI). The Fourth Generation realized Large Scale Integration (LSI) which could fit hundreds of components on one chip and Very Large Scale integration (VLSI) which squeezed thousands of components on one chip. The Intel 4004 chip, located all the components of a computer (central processing unit, memory, input and output controls) on a single chip and microcomputers were introduced. Higher capacity storage media like magnetic disks were developed. Fourth generation languages emerged and applications software's started becoming popular.

Computer production became inexpensive and the era of Personal Computers (PCs) commenced. In 1981, IBM introduced its personal computer for use in office, home and schools. In direct competition, the Macintosh was introduced by Apple in 1984. Shared interactive systems and user friendly environments were the features of these computers.

As the computers started becoming more and more powerful, they could be linked together or networked to share not only data but also memory space and software. The networks could reach enormous proportions with local area networks. A global web of computer circuitry, the Internet, links the computers worldwide into a single network of information.

The Fifth Generation:

Defining the fifth generation computers is somewhat difficult because the field is still in its infancy. The computers of tomorrow would be characterized by **Artificial Intelligence** (AI). An example of Al is Expert Systems. Computers could be developed which could think and reason in much the same way as humans. Computers would be able to accept spoken words as input (voice recognition).

Keyword

Artificial intelligence is an area of computer science that emphasizes the creation of intelligent machines that work and react like humans.

Many advances in the science of computer design and technology are coming together to enable the creation of fifth generation computers. Two such advances are parallel processing where many CPUs work as one and advance in superconductor technology which allows the flow of electricity with little or no resistance, greatly improving the speed of information flow.

1.1.3 Classification of Computers

Computers differ based on their data processing abilities. They are classified according to purpose, data handling and functionality. According to purpose, computers are either general purpose or specific purpose. General purpose computers are designed to perform a range of tasks. They have the ability to store numerous programs, but lack in speed and efficiency. Specific purpose computers are designed to handle a specific problem or to perform a specific task. A set of instructions is built into the machine.

According to data handling, computers are analog, digital or hybrid. Analog computers work on the principle of measuring, in which the measurements obtained are translated into data. Modern analog computers usually employ electrical parameters, such as voltages, resistances or currents, to represent the quantities being manipulated. Such computers do not deal directly with the numbers. They measure continuous physical magnitudes. Digital computers are those that operate with information, numerical or otherwise, represented in a digital form. Such computers process data into a digital value (in 0s and 1s). They give the results with more accuracy and at a faster rate. Hybrid computers incorporate the measuring feature of an analog computer and counting feature of a digital computer. For computational purposes, these computers use analog components and for storage, digital memories are used. Computers are broadly classified into two categories depending upon the logic used in their design as:

1. Analog Computer
2. Digital Computer

According to the operational principle of computers, they are categorized as analog, digital and hybrid computers.

Analog Computers:

These are almost extinct today. These are different from a digital computer because an analog computer can perform several mathematical operations simultaneously. It uses continuous variables for mathematical operations and utilizes mechanical or electrical energy.

Digital Computers:

They use digital circuits and are designed to operate on two states, namely bits 0 and 1. They are analogous to states ON and OFF. Data on these computers is represented as a series of 0s and 1s. Digital computers are suitable for complex computation and have higher processing speeds. They are programmable. Digital computers are either general purpose computers or special purpose ones. General purpose computers, as their name suggests, are designed for specific types of data processing while general purpose computers are meant for general use.

Hybrid Computers:

These computers are a combination of both digital and analog computers. In this type of computers, the digital segments perform process control by conversion of analog signals to digital ones.

According to the sizes of the computers, the computers are classified as follows.

Supercomputers:

The highly calculation-intensive tasks can be effectively performed by means of supercomputers. Quantum physics, mechanics, weather forecasting, molecular theory are best studied by means of supercomputers. Their ability of parallel processing and their well-designed memory hierarchy give the supercomputers, large transaction processing powers.

Servers:

They are computers designed to provide services to client machines in a computer network. They have larger storage capacities and powerful processors. Running on them are programs that serve client requests and allocate resources like memory and time to client machines. Usually they are very large in size, as they have large processors and many hard drives. They are designed to be fail-safe and resistant to crash.

Quantum computers can potentially break some modern encryption algorithms (by quantum factoring) very quickly.

Mainframe Computers:

Large organizations use mainframes for highly critical applications such as bulk data processing and ERP. Most of the mainframe computers have capacities to host multiple operating systems and operate as a number of virtual machines. They can substitute for several small servers.

Wearable Computers:

A record-setting step in the evolution of computers was the creation of wearable computers. These computers can be worn on the body and are often used in the study of behavior modeling and human health. Military and health professionals have incorporated wearable computers into their daily routine, as a part of such studies. When the users' hands and sensory organs are engaged in other activities, wearable computers are of great help in tracking human actions. Wearable computers do not have to be turned on and off and remain in operation without user intervention.

REMEMBER

A computer will solve problems in exactly the way it is programmed to, without regard to efficiency, alternative solutions, possible shortcuts, or possible errors in the code.

Minicomputers:

In terms of size and processing capacity, minicomputers lie in between mainframes and microcomputers. Minicomputers are also called mid-range systems or workstations. The term began to be popularly used in the 1960s to refer to relatively smaller third generation computers. They took up the space that would be needed for a refrigerator or two and used transistor and core memory technologies. The 12-bit PDP-8 minicomputer of the Digital Equipment Corporation was the first successful minicomputer.

Microcomputers:

A computer with a microprocessor and its central processing unit is known as a microcomputer. They do not occupy space as much as mainframes do. When supplemented with a keyboard and a mouse, microcomputers can be called personal computers. A monitor, a keyboard and other similar input-output devices, computer memory in the form of RAM and a power supply unit come packaged in a microcomputer. These computers can fit on desks or tables and prove to be the best choice for single-user tasks.

Figure 1.8: Small Computers.

Desktops:

A desktop is intended to be used on a single location. The spare parts of a desktop computer are readily available at relatively lower costs. Power consumption is not as critical as that in laptops. Desktops are widely popular for daily use in the workplace and households.

Laptops:

Similar in operation to desktops, laptop computers are miniaturized and optimized for mobile use. Laptops run on a single battery or an external adapter that charges the computer batteries. They are enabled with an inbuilt keyboard, touch pad acting as a mouse and a liquid crystal display. Their portability and capacity to operate on battery power have proven to be of great help to mobile users.

Notebooks:

They fall in the category of laptops, but are inexpensive and relatively smaller in size. They had a smaller feature set and lesser capacities in comparison to regular laptops, at the time they came into the market. But with passing time, notebooks too began featuring almost everything that notebooks had. By the end of 2008, notebooks had begun to overtake notebooks in terms of market share and sales.

Personal Digital Assistants (PDAs):

It is a handheld computer and popularly known as a palmtop. It has a touch screen and a memory card for storage of data. PDAs can also be used as portable audio players, web browsers and smart phones. Most of them can access the Internet by means of Bluetooth or Wi-Fi communication.

Tablet Computers:

Tablets are mobile computers that are very handy to use. They use the touch screen technology. Tablets come with an onscreen keyboard or use a stylus or a digital pen. Apple's iPad redefined the class of tablet computers.

REMEMBER

Seemingly, multitasking would cause a computer that is switching between several programs to run more slowly, in direct proportion to the number of programs it is running, but most programs spend much of their time waiting for slow input/output devices to complete their tasks.

1.1.4 Applications of Computers

Today computers find widespread applications in all activities of the modern world. In this section, we will discuss the application of computers in various fields.

Business

A computer has high speed of calculation, diligence, accuracy, reliability, or versatility which has made it an integrated part in all business organizations.

Computer is used in business organizations for −

- Payroll calculations
- Budgeting

- Sales analysis
- Financial forecasting
- Managing employee database
- Maintenance of stocks, etc.

Banking

Today, banking is almost totally dependent on computers.

Banks provide the following facilities –

- Online accounting facility, which includes checking current balance, making deposits and overdrafts, checking interest charges, shares, and trustee records.
- ATM machines which are completely automated are making it even easier for customers to deal with banks.

Insurance

Insurance companies are keeping all records up-to-date with the help of computers. Insurance companies, finance houses, and stock broking firms are widely using computers for their concerns.

Insurance companies are maintaining a database of all clients with information showing –

- Procedure to continue with policies
- Starting date of the policies
- Next due installment of a policy
- Maturity date
- Interests due
- Survival benefits
- Bonus

Education

The use of computers in education is increasing day by day. The students develop the habit of thinking more logically and are able to formulate problem solving techniques. CDs on a variety of subjects are available to impart education. On line training programs for students are also becoming popular day by day. All the major encyclopedias, dictionaries and books are now available in the digital form and therefore are easily accessible to the student of today. Creativity in drawing, painting, designing, decoration, music etc. can be well developed with computers.

The computer helps in providing a lot of facilities in the education system.

- The computer provides a tool in the education system known as CBE (Computer Based Education).
- CBE involves control, delivery, and evaluation of learning.
- Computer education is rapidly increasing the graph of number of computer students.
- There are a number of methods in which educational institutions can use a computer to educate the students.
- It is used to prepare a database about performance of a student and analysis is carried out on this basis.

Marketing

In marketing, uses of the computer are following –

- *Advertising* – With computers, advertising professionals create art and graphics, write and revise copy, and print and disseminate ads with the goal of selling more products.
- *Home Shopping* – Home shopping has been made possible through the use

of computerized catalogues that provide access to product information and permit direct entry of orders to be filled by the customers.

Healthcare

Computers have become an important part in hospitals, labs, and dispensaries. They are being used in hospitals to keep the record of patients and medicines. It is also used in scanning and diagnosing different diseases. ECG, EEG, ultrasounds and CT scans, etc. are also done by computerized machines.

Following are some major fields of health care in which computers are used.

- *Diagnostic System* – Computers are used to collect data and identify the cause of illness.
- *Lab-diagnostic System* – All tests can be done and the reports are prepared by computer.
- *Patient Monitoring System* – these are used to check the patient's signs for abnormality such as in Cardiac Arrest, ECG, etc.

- *Pharma Information System* – Computer is used to check drug labels, expiry dates, harmful side effects, etc.
- *Surgery* – Nowadays, computers are also used in performing surgery.

Engineering Design

Computers are widely used for engineering purpose. One of the major areas is CAD (Computer Aided Design) that provides creation and modification of images. Some of the fields are –

- *Structural Engineering* – requires stress and strain analysis for design of ships, buildings, budgets, airplanes, etc.
- *Industrial Engineering* – Computers deal with design, implementation, and improvement of integrated systems of people, materials, and equipment.
- *Architectural Engineering* – Computers help in planning towns, designing buildings, determining a range of buildings on a site using both 2D and 3D drawings.

Military

Computers are largely used in defense. Modern tanks, missiles, weapons, etc. Military also employs computerized control systems. Some military areas where a computer has been used are –

- Missile Control
- Military Communication
- Military Operation and Planning
- Smart Weapons

Communication

Communication is a way to convey a message, an idea, a picture, or speech that is received and understood clearly and correctly by the person for whom it is meant. Some main areas in this category are –

- E-mail
- Chatting
- Usenet
- FTP
- Telnet
- Video-conferencing

Government

Computers play an important role in government services. Some major fields in this category are –

- Budgets
- Sales tax department
- Income tax department
- Computation of male/female ratio
- Computerization of voters lists
- Computerization of PAN card
- Weather forecasting

1.1.5 Advantages and Disadvantages of Computers

Today, the computer is used in every field and has made our day to day tasks very easy but there are some advantages and disadvantages of computers.

Advantages of Computer

Computers can quickly process huge amount of data. Computers can complete various tasks more effectively than most human-beings. It has automated complex tasks that were once considered boring and tedious for humans. Hence, Computer has greatly increased our efficiency to do various tasks. The advantages of computer is given below:

- **Stores data in digital format:** Computers can store millions of pages of information in digital format.
- **Huge storage:** We can store huge information. The present day hard-disks can store 100s of Gigabytes (GB) of information. Large businesses store their marketing and sales data in their computer systems. Even sensitive data of customers are securely protected in a computerized environment.

- **Play games:** When it comes to games, the choices are almost unlimited.
- **Calculations:** Businesses are increasingly using spreadsheets and other software as a tool for performing mathematical calculations.
- **Prepare and store official documents:** You can use a word processing software to prepare, edit and save any text document. The concept of paperless offices is finally taking its shape. excel- calculations
- **Presentations:** If your office demands that you prepare presentations, you can prepare it in a PowerPoint.
- **Internet:** You can connect your computer to Internet and browse through huge data. People use internet for various purposes. Students can use internet to download study materials. A research analyst can do market research over internet. A marketing person can gather relevant data across various geographical boundaries. A prospective customer can find a service provider over internet.
- **Multimedia:** Computer can also be used as an entertainment device. We can play various multimedia applications such as music, video, etc.
- **Prepare books of accounts:** With the help of accounting software, we can prepare our books of accounts.
- **Reduced cost:** The introduction of computer has resulted into a reduction of cost to perform various complicated tasks.

Disadvantages of Computer

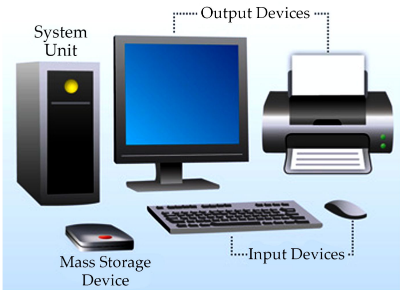
It is true that even computer is not free from defects. The disadvantages of computer is given below:

- **Ever changing technology:** The technology that is new today, may soon become obsolete. We need to regularly upgrade the hardware and software in a computerized environment. This involves additional time and cost.
- **Increased manpower cost:** The computer needs to be operated by skilled person. This has led to an increase in manpower cost for organizations. Due to the inherent risks, huge expenditure are made ensure data security.
- **Computer stops responding:** At times the operating system of the computer may stop responding or functioning. Though this problem is generally solved by restarting the computer, but sometimes you may have to take the support of the technician.
- **Viruses:** The threat of virus and malware attack always remains in the computerized environment. To cope up with these risks, various anti-virus software are available in the market. If you are using a good antivirus, you are almost sure that your private information and other sensitive data are secured.

- **Reduction in employment opportunity:** The introduction of computers has negatively impacted the employability of computer illiterate people.

1.2 A COMPUTER SYSTEM

Any system is defined as a group of integrated parts which are designed to achieve a common objective. Thus, a system is made up of more than one element or part, where each element performs a specific function and where all the elements (parts) are logically related and are controlled in such a way that the goal (purpose) of the system is achieved.



A computer is made up of a number of integrated elements like

- The central processing unit,
- The input and output devices and
- The storage devices.

Each of these units performs a specific task. However, none of them can function independently on their own. They are logically related and controlled to achieve a specific goal. When they are thus integrated they form a fully-fledged computer system.

1.2.1 Components of a Computer System

The Computer mainly consists the functions input, process, output and storage. These functions were described in the manner of diagram as follows. The Block diagram of computer consists mainly i.e.,

- Input unit
- CPU(Control unit, Main Memory and ALU)
- Output unit,
- Secondary Storage unit

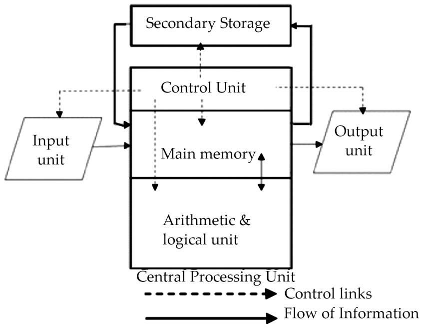


Figure 1.9: Block Diagram of Computer.

The Input Unit:

Input devices are the devices which are used to feed programs and data to the computer. The input system connects the external environment with the computer system. The input devices are the means of communication between the user and the computer system. Typical input devices include the keyboard, floppy disks, mouse, microphone, light pen, joy stick, magnetic tapes etc. The way in which the data is fed into the computer through each of these devices is different. However, a computer can accept data only in a specific form. Therefore these input devices transform the data fed to them, into a form which can be accepted by the computer. These devices are a means of communication and inter station between the user and the computer systems.

Thus the functions of the input unit are:

- Accept information (data) and programs.
- Convert the data in a form which the computer can accept.
- Provide this converted data to the computer for further processing.

The Central Processing Unit:

The Central Processing Unit (CPU) takes data and instructions from the storage unit and makes all sorts of calculations based on the instructions given and the type of data provided. It is then sent back to the storage unit. CPU includes Arithmetic logic unit (ALU) and control unit (CU). This is the brain of any computer system. The central processing unit or CPU is made of three parts:

- The control unit.
- The arithmetic logic unit
- The primary storage unit

These parts discuss below.

- *The Control Unit*: The Control Unit controls the operations of the entire computer system. The control unit gets the instructions from the programs stored in primary storage unit interprets these instruction and subsequently directs the other units to execute the instructions. Thus it manages and coordinates the entire computer system.
- *The Arithmetic Logic Unit*: The Arithmetic Logic Unit (ALU) actually executes the instructions and performs all the calculations and decisions. The data is held in the primary storage unit and transferred to the ALU whenever needed. Data can be moved from the primary storage to the arithmetic logic unit a number of times before the entire processing is complete. After the completion, the results are sent to the output storage section and the output devices.
- *The Primary Storage Unit*: This is also called as Main Memory. Before the actual processing starts the data and the instructions fed to the computer through the input units are stored in this primary storage unit. Similarly, the data which is to be output from the computer system is also temporarily stored in the primary memory. It is also the area where intermediate results of calculations are stored. The main memory has the storage section that holds the computer programs during execution. Thus the primary unit:
    - Stores data and programs during actual processing
    - Stores temporary results of intermediate processing
    - Stores results of execution temporarily

Output Unit:

The output devices give the results of the process and computations to the outside world. The output units accept the results produced by the computer, convert them into a human readable form and supply them to the users. The more common output devices are printers, plotters, display screens, **magnetic tape** drives etc.

Keyword

Magnetic tape is a medium for magnetic recording, made of a thin, magnetizable coating on a long, narrow strip of plastic film.

Secondary Storage

It is also known as auxiliary memory. It is closely linked with the main memory. Since main memory cannot be flooded with unwanted data at particular moment, same is stored in auxiliary memory from which desired data is fed to main memory as and when required by it. Thus secondary storage is used to hold mass of information i.e., system software, application programs, cinemas, games and data files. Obviously the capacity of secondary storage is very high compared to main memory. Auxiliary memory usually in the form of Magnetic disk, Magnetic tape, CD's, Memory cards, Pen drives etc.

1.2.2 Similarities and Difference between Human and Computer

Computer is a very effective and efficient machine which performs several activities in few minutes, which otherwise would have taken several days if performed naturally. Besides there would have been a doubt about the accuracy, finish etc. The computer may be faster; more accurate but it cannot compete with human brain.

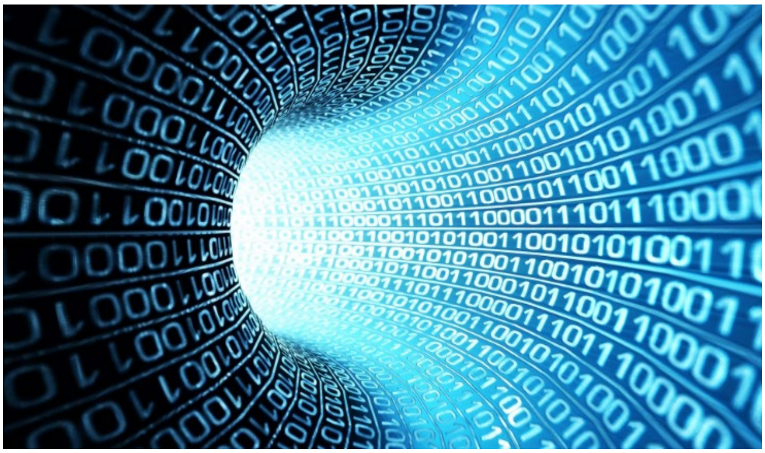
However there are some similarities between the human and the computer which would make the computer more understandable.

The computer has storage devices like floppies, hard disks, compact disks to store and retrieve information. However computer does not understand emotions, it does not understand meaning beyond words, and it cannot read between the lines like the human. We learn many things unknowingly, certain things knowingly; we call it as upbringing. But computers can learn everything only knowingly.

Human	Computer
# Like human beings has ears, nose, eyes etc.	Computers have input devices such as keyboard, scanner, touch screen, mouse etc to get information.
# Like we remember things	Computer also stores information.
#We recollect certain information as required.	The computer also retrieves information when times,
#We express ourselves by speech, writing etc	Computer expresses through screen, Printouts etc which We call as output.
#When we watch, hear, learn certain things and analyze.	with the help of software, computer also can analyze Information and draw conclusions.
#The place where we store, analyze,	The computer brain is known as CPU conclude information is known as the brain (Central Processing Unit) where it analyses information.

1.3 COMPUTER NUMBER SYSTEMS

Number systems are the technique to represent numbers in the computer system architecture, every value that you are saving or getting into/from computer memory has a defined number system.



A number system is a system of writing for expressing numbers. It is the mathematical notation for representing numbers of a given set by using digits or other symbols in a consistent manner. It provides a unique representation to every number and represents the arithmetic and algebraic structure of the figures. It also allows us to operate arithmetic operations like addition, subtraction, and division.

REMEMBER

Bugs are usually not the fault of the computer. Since computers merely execute the instructions they are given, bugs are nearly always the result of programmer error or an oversight made in the program's design.

1.3.1 Types of Number System

The data representation of computer consists alphabets, numerals, and special symbols. Here we discuss about the numerals (numbers). In our daily life we use decimal system, whereas computer use only binary system .But there are four types of number systems. Different number systems are mentioned below.

- Binary number system (Base- 2)
- Octal number system (Base-8)
- Decimal number system (Base- 10)
- Hexadecimal number system (Base- 16)

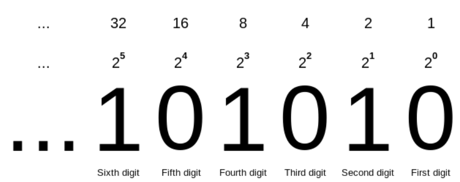
Table 1.1: The Numbers Systems with Base, Used Digits, Representation, C language representation

Number system	Base	Used digits	Example	C Language assignment
Binary	2	0,1	$(11110000)_2$	int val=0b11110000;
Octal	8	0,1,2,3,4,5,6,7	$(360)_8$	int val=0360;
Decimal	10	0,1,2,3,4,5,6,7,8,9	$(240)_{10}$	int val=240;
Hexadecimal	16	0,1,2,3,4,5,6,7,8,9, A,B,C,D,E,F	$(F0)_{16}$	int val=0xF0;

Different number systems are define below.

Binary Number System:-

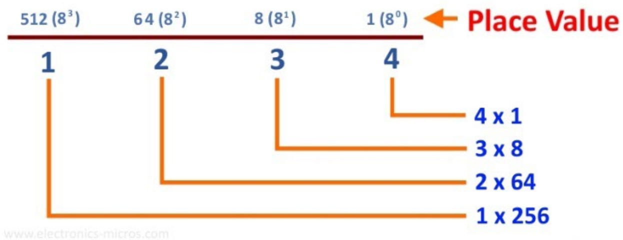
It is base (radix) of 2 and it has only two digits i.e. 0 and 1. The value of the numbers is represented as power of 2 i.e. the radix of the system. These power increases with the position of the digits as follows.



Value of digits in the "Binary numeral system"

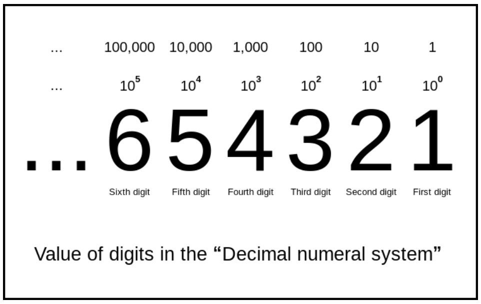
Octal Number System:-

It is base of 8 and it has only eight digits i.e. 0 ,1,2,3,4,5,6 and 7. The value of the numbers is represented as power of 8 i.e. the radix of the system. These power increases with the position of the digits as follows.



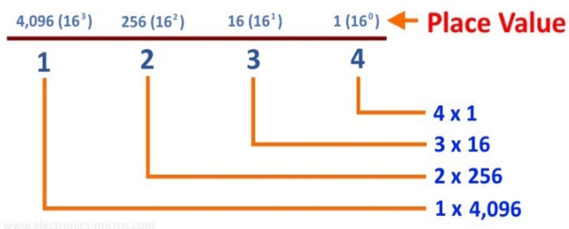
Decimal Number system:-

It is base of 10 and it has only ten digits i.e. 0 ,1,2,3,4,5,6,7,8 and 9. The value of the numbers is represented as power of 10 i.e. the radix of the system. These power increases with the position of the digits as follows.



Hexa Decimal Number System:-

It is base of 16 and it has only sixteen digits i.e. 0 ,1,2,3,4,5,6,7,8,9, A(10),B(11), C(12), D(13),E(14) and F(15). The value of the numbers is represented as power of 16 i.e. the radix of the system. These power increases with the position of the digits as follows.



1.3.2 Number System Conversions

There are three types of conversion:

- Decimal Number System to Other Base
  [For example: Decimal Number System to Binary Number System]
- Other Base to Decimal Number System
  [For example: Binary Number System to Decimal Number System]
- Other Base to Other Base
  [For example: Binary Number System to Hexadecimal Number System]

We can convert from any system to any other system as follows.

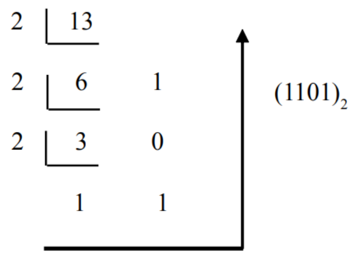
REMEMBER

When fixed precision numbers are used, (as they are in virtually all computer calculations) the concept of overflow must be considered. An overflow occurs when the result of a calculation cannot be represented with the number of bits available.

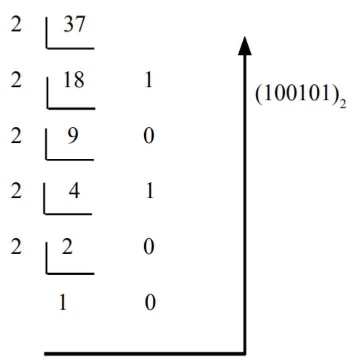
Decimal to Binary

Divide the decimal number by 2 repeatedly and note the remainders from bottom to top.

Example: Convert $(13)_{10}$ to $(?)_2$



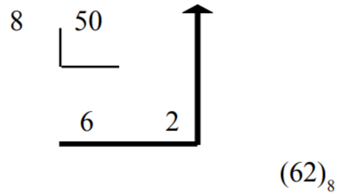
Example: Convert $(37)_{10}$ to $(?)_2$



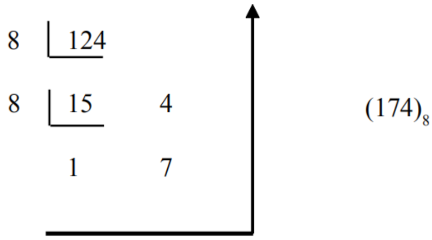
Decimal to Octal

Divide the decimal number by 8 repeatedly and note the remainders from bottom to top.

Example: convert $(50)_{10}$ to $(?)_8$



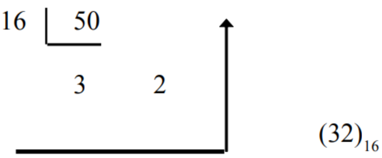
Example: convert $(124)_{10}$ to $(?)_8$



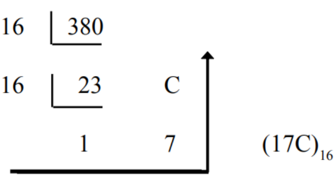
Decimal to hexadecimal

Divide the decimal number by 16 repeatedly and note the remainders from bottom to top.

Example: Convert $(50)_{10}$ to $(?)_{16}$



Example: Convert $(380)_{10}$ to $(?)_{16}$



When adding the two eight bit quantities: 150 + 170, the result is 320. This is outside the range 0-255, and so the result cannot be represented using 8 bits. The result has overflowed the available range. When overflow occurs, the low order bits of the result will remain valid, but the high order bits will be lost. This results in a value that is significantly smaller than the correct result.

Binary to Decimal

Multiply the binary number with the weights of binary system according to their position and note the sum.

Example: Convert $(11010)_2$ to $(?)_{10}$

$$11010 = 1 \text{ x } 2^4 + 1 \text{ x } 2^3 + 0 \text{ x } 2^2 + 1 \text{ x } 2^1 + 0 \text{ x } 2^0$$

$$= 1 \text{ x } 16 + 1 \text{ x } 8 + 0 \text{ x } 4 + 1 \text{ x } 2 + 0 \text{ x } 1$$

$$= 16 + 8 + 0 + 2 + 0 = (26)_{10}$$

Example: Convert $(1101)_2$ into $(?)_{10}$

$$1101 = 1 \text{ x } 2^3 + 1 \text{ x } 2^2 + 0 \text{ x } 2^1 + 1 \text{ x } 2^0$$

$$= 1 \text{ x } 8 + 1 \text{ x } 4 + 0 \text{ x } 2 + 1 \text{ x } 1$$

$$= 8 + 4 + 0 + 1 = (13)_{10}$$

Octal to Decimal

Multiply the Octal number with the weights of octal system according to their position and note the sum.

Example: Convert $(62)_8$ into $(?)_{10}$

$$(62)_8 = 6 \text{ x } 8^1 + 2 \text{ x } 8^0$$

$$= 6 \text{ x } 8 + 2 \text{ x } 1$$

$$= 48 + 2 = (50)_{10}$$

Example: Convert $(174)_8$ into $(?)_{10}$

$$(174)_8 = 1 \text{ x } 8^2 + 7 \text{ x } 8^1 + 4 \text{ x } 8^0$$

$$= 1 \text{ x } 64 + 7 \text{ x } 8 + 4 \text{ x } 1$$

$$= 64 + 56 + 4 = (124)_{10}$$

Hexadecimal to Decimal

Multiply the hexadecimal number with the weights of hexadecimal system according to their position and note the sum.

Example: Convert $(5D)_{16}$ into $(?)_{10}$

$$\begin{aligned}(5D)_{16} &= 5 \times 16^1 + D \times 16^0\\ &= 5 \times 16 + 13 \times 1\\ &= 80 + 13 = (93)_{10}\end{aligned}$$

Example: Convert $(1A5)_{16}$ into $(?)_{10}$

$$\begin{aligned}(1A5)_{16} &= 1 \times 16^2 + A \times 16^1 + 5 \times 16^0\\ &= 1 \times 256 + 10 \times 16 + 5 \times 1\\ &= 256 + 160 + 5 = (421)_{10}\end{aligned}$$

ROLE MODEL

JOHN V. ATANASOFF: PHYSICIST, SCIENTIST, INVENTOR(1903–1995)

John Vincent Atanasoff (JVA) was born on 4 October 1903 a few miles west of Hamilton, New York. His father was a Bulgarian immigrant named Ivan Atanasov. Ivan's name was changed to John Atanasoff by immigration officials at Ellis Island, when he arrived with an uncle in 1889.

JVA's mother was Iva Lucena Purdy, an English teacher from upstate New York. She and John married in 1900, following John's graduation from Colgate College with a degree in philosophy. He got a job as an industrial engineer in New Jersey and they started their family. John took electrical engineering correspondence courses at night and on weekends to further his education. After JVA's birth in 1903, his father moved the family to Florida, accepting an electrical engineering position in a newly established town called Brewster, now an empty ghost town, but back then, the home of the phosphate mines of chemical conglomerate American Cyanamid. In Brewster, JVA completed grade school at a two room schoolhouse, and later attended middle and high school at an accelerated pace, graduating with his high school diploma at age 15.

Throughout his developmental years, JVA exhibited the characteristics of an inventive personality, and was encouraged by his mother and father to exercise his wide interests in subjects ranging from crochet and British Literature to electrical circuits and the workings of farm machinery. He developed a fascination with calculating devices when his father gave him a slide rule, with which JVA used to solve simple math problems. Amazed at the precision achieved, he experimented with more complex equations and began studying logarithms, algebra, and differential calculus. His mother helped him to understand number bases other than base-10 and he eventually learned how to make calculatations using a variety of bases, including base-2, also known as binary math. This early exposure to different methods of calculation would later inform his work on the ABC.

As the first two decades of the 1900s are often considered the "golden age of physics," JVA's inquiring mind did not fail to investigate the subject, and in his early high school years he decided that theoretical physics would be his life's work. Upon his entrance at the University of Florida in 1921, JVA's major was electrical engineering, because they did not offer a degree program in physics—electrical engineering was the most theoretical program he could find at the university. While taking these courses, he became interested in electronics and continued on to higher mathematics. He graduated from the University of Florida in 1925 with a Bachelor of Science degree in electrical engineering. He had a straight "A" academic average. Even though he had many offers of teaching fellowships, including one from Harvard, he accepted the one from Iowa State College, because it was the first one he received and because of the institution's fine reputation in engineering and sciences.

So it was, that one day in the summer of 1925 the 22-year-old boarded the train that took him to Ames, Iowa, home of Iowa State College. He was ready to make his mark in the world of science. From September to November he was busy working on his master's degree and teaching two undergraduate mathematics classes. Even though his social life was minimal due to his busy schedule, he was familiar with one campus organization, the Dixie Club, a club organized for southern students away from home. One evening, he decided to drop by the club to see what was going on. There he met Lura Meeks, a beautiful, brown-haired, blue-eyed 25-year-old home economics major from Oklahoma. This chance meeting led to another date, and then another. Soon they were best friends, seeking each other's company.

In June 1926, JVA received his master's degree in mathematics from Iowa State College, and a few days later, he married Lura. Iowa State had hired him to teach mathematics. A little over a year later, their oldest daughter Elsie, was born. When Elsie was one, the family moved to Madison, Wisconsin, where John had been accepted as a doctoral candidate. Two other children, Joanne and John, were later born to the couple.

The work on his doctoral thesis, *The Dielectric Constant of Helium*, gave JVA his first experience in serious computing. He spent hours on a Monroe calculator, one of the most advanced calculating machines of the time. During the hard weeks of calculations to complete his thesis JVA acquired an interest in developing a better and faster computing machine. After receiving his Ph.D. in theoretical physics from the University of Wisconsin (under John Hasbrouck Van Vleck, later a Nobel laureate), in July 1930 he returned to Iowa State College with a determination to try to create a faster, better computing machine.

In the fall of 1930 he became a member of the Iowa State College faculty as an assistant professor in mathematics and physics. During the period that he was doing experiments with vacuum tubes and radio, and examining the field of electronics, he was promoted to associate professor of both mathematics and physics and moved from Beardshear Hall to the Physics Building. JVA's research continued to involve complex mathematical equations, for which there were no truly efficient methods for solving.

After examining many mathematical devices available at the time, Atanasoff concluded that they fell into two classes--analog and digital. Since the term "digital" was not used until much later, Atanasoff contrasted the analog devices to what he called "computing machines proper." In 1936 he engaged in his last effort to construct a small analog calculator. With Glen Murphy, then an atomic physicist at Iowa State College, he built the "Laplaciometer," a small analog calculator. It was used for analyzing the geometry of surfaces. Atanasoff regarded this machine as having the same flaws as other analog devices, where accuracy was dependent upon the performance of other parts of the machine.

The obsession with finding a solution to the computing problem built to a frenzy in the winter months of 1937. One night, frustrated after many discouraging events, he got into his car and started driving without a destination in mind. Two hundred miles later, he pulled onto a roadhouse in the state of Illinois. Here, he had a drink of bourbon and continued thinking about the creation of the machine. No longer nervous and tense, he realized that this thoughts were coming together clearly. He began generating ideas on how to build this computer, writing them down on a cocktail napkin. His four main ideas that came together that night, and were later critical for establishing he as inventor, and the ABC as the first electronic digital computer, including:

- He would use electricity and electronics for the media of the computer, which would give it speed.
- He would use base-2, or the binary number system, which would simplify its computational process.
- He would use regenerative memory, which would reduce the cost of building the machine.
- He would compute with direct logical action rather than enumeration, which would give it increased accuracy.

After receiving a grant of $650 from Iowa State College in March 1939, JVA was ready to undertake the construction of the computer. To help him accomplish his goal, he hired a particularly bright electrical engineering student, Clifford E. Berry. From 1939 until 1941 they worked at developing and improving the device, later named the Atanasoff Berry Computer (ABC). In 1942 JVA left Ames, Iowa and Iowa State on leave for a defense-related position at the Naval Ordnance Laboratory in Washington, D.C. Near the same time, Clifford Berry accepted a defense-related job in California. Although Iowa State College had hired Chicago patent lawyer Richard R. Trexler, the patenting of the ABC was never completed.

He thought he would spend a few months, or at most a few years in government, and then return to Iowa State College. Lura and their three children remained in Ames, but he made frequent trips home to see his family.

He had become Chief of the Acoustics Division at the Naval Ordnance Laboratory, a position that was paying him a salary well above the $10,000 cap on government salaries at the time. He was in charge of developing a computer for the United States Navy. At the same time, he became involved in the first atomic test in the Pacific, a project that he liked very much.

In 1948, on one of his return visits to Ames, JVA was surprised and disappointed to learn that the ABC had been removed from the Physics Building and dismantled. Neither he nor Clifford Berry had been notified that the computer was going to be destroyed. Only a few parts of the computer were saved.

The long separation from his family was beginning to take its toll. He and Lura had drifted apart. In 1949 they were divorced and Lura moved with the children to Denver, Colorado. In the same year, JVA married Alice Crosby, an Iowan who had also gone to Washington to work during the war years.

In 1949 he became chief scientist for the Army Field Forces in Fort Monroe, Virginia. After one year, he returned to Washington as director of the Navy Fuse Program at the Naval Ordnance Laboratory. He stayed in that position until late 1951. In 1952 he established The Ordnance Engineering Corporation, a research and engineering company in Rockville, Maryland, with his old friend and student, David Beecher. The company was sold to Aerojet General Corporation in 1957, and he became Manager of its Atlantic Division from 1957-1959 and Vice President from 1959-1961. In 1961 he retired.

Throughout the years following WWII, Atanasoff received several indications from individuals and industry that the builders of the ENIAC had patents on elements of computer design that originated with Atanasoff and the ABC. Two events are said to have motivated JVA's interest and involvement in the patent issues surrounding the ENIAC. 1) Clifford Berry's suspicous death in 1963, and; 2) The publication of R. K. Richard's book *Electronic Digital Systems* in 1966 in which a serious assertion of origination was made in favor of the ABC as the first electronic digital computer. JVA spent the next several years cooperating with Honeywell Corporation in challenging the ENIAC patents, now held by Sperry Rand Corporation.

The suit *Honeywell v. Sperry Rand* was filed 26 May 1967 in the U.S. District Courthouse in Minneapolis, MN. The trial began 1 June 1971. The decision, handed down officially on 19 October 1973, held that "Mauchly's basic ENIAC ideas were derived from Atanasoff, and the invention claimed in ENIAC was derived from Atanasoff."

Following the establishment of JVA as inventor of the first digital electronic computer, press recognition was slow to publicize the fact, partly due to the media attention focus on the Watergate Scandal, news of which was released the same day as the announcement of the court decision. Clark Mollenhoff, Des Moines Register correspondent, published the first major story about JVA as inventor, Iowa State as the site, and the details of the court case that established the ABC as the first digital electronic computer. In 1974, JVA returned to Iowa State University (the name changed to "university" in 1959) to be guest of honor and grand marshall for VEISHEA, the largest student-run celebration in the nation.

In the late 1970s, Carl Hamilton, vice president and director of information and public affairs for ISU, encouraged the creation of a documentary on the construction of the Atanasoff-Berry Computer. The film *From One John Vincent Atanasoff* was completed in 1981. On 21 October 1983 (the 10th anniversary of Judge Larson's historic decision), the film was released. JVA was given a Distinguished Achievement Citation by the Iowa State University Alumni Association. Cliff Berry's widow, Jean Berry, and his mother, Grace Berry, were recognized as relatives of the co-inventor of the ABC.

After a long illness, Atanasoff died of a stroke on 15 June 1995 at his home in Maryland. Since the landmark Honeywell v. Sperry Rand, JVA has been celebrated by many as a man who helped to change the face of the world through developments in computing. Many of the concepts that originated with the ABC are still used as basic components of the computers we use today.

SUMMARY

- A computer is a machine that can be programmed to carry out sequences of arithmetic or logical operations automatically.
- The processing element carries out arithmetic and logical operations, and a sequencing and control unit can change the order of operations in response to stored information.
- Computers are quite capable of functioning automatically, once the process is given to the computer. They do not require any instruction from the operator at any stage of the process. Computers can be programmed to perform a series of complex tasks involving multiple programs.
- Computers differ based on their data processing abilities. They are classified according to purpose, data handling and functionality. According to purpose, computers are either general purpose or specific purpose.
- A desktop is intended to be used on a single location. The spare parts of a desktop computer are readily available at relatively lower costs. Power consumption is not as critical as that in laptops.
- Communication is a way to convey a message, an idea, a picture, or speech that is received and understood clearly and correctly by the person for whom it is meant.
- Any system is defined as a group of integrated parts which are designed to achieve a common objective.
- Computer is a very effective and efficient machine which performs several activities in few minutes, which otherwise would have taken several days if performed naturally.
- The data representation of computer consists alphabets, numerals, and special symbols. Here we discuss about the numerals (numbers).

KNOWLEDGE CHECK

1. **UNIVAC is**
   a. Universal Automatic Computer
   b. Universal Array Computer
   c. Unique Automatic Computer
   d. Unvalued Automatic Computer
2. **The basic operations performed by a computer are**
   a. Arithmetic operation
   b. Logical operation
   c. Storage and relative
   d. All the above
3. **The two major types of computer chips are**
   a. External memory chip
   b. Primary memory chip
   c. Microprocessor chip
   d. Both b and c
4. **Microprocessors as switching devices are for which generation computers**
   a. First Generation
   b. Second Generation
   c. Third Generation
   d. Fourth Generation
5. **What is the main difference between a mainframe and a super computer?**
   a. Super computer is much larger than mainframe computers
   b. Super computers are much smaller than mainframe computers
   c. Supercomputers are focused to execute few programs as fast as possible while mainframe uses its power to execute as many programs concurrently
   d. Supercomputers are focused to execute as many programs as possible while mainframe uses its power to execute few programs as fast as possible.
6. **A computer is a programmable machine.**
   a. True
   b. False

7. **Computers are quite capable of functioning automatically, once the process is given to the computer.**
    a. True
    b. False

REVIEW QUESTIONS

1. List and explain in brief the characteristics of computers.
2. Write short notes on First Generation of computers.
3. Explain the classification of computers on the basis of their capacity to access memory and size.
4. List the applications of computers.
5. Define the components of a computer system.

Check Your Result

1. (a) 2. (d) 3. (d) 4. (d) 5. (c)

6. (a) 7. (a)

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CHAPTER 2 MEMORY

LEARNING OBJECTIVES

After studying this chapter, you will be able to:

1. Discuss the memory representation
2. Explain the main memory
3. Define secondary storage device

> *"Although computer memory is no longer expensive, there's always a finite size buffer somewhere. When a big piece of news arrives, everybody sends a message to everybody else, and the buffer fills."*
>
> ***– Benoit Mandelbrot***

INTRODUCTION

Computers are used not only for processing of data for immediate use, but also for storing of large volume of data for future use. In order to meet these two specific requirements, computers use two types of storage locations—one, for storing the data that are being currently handled by the CPU and the other, for storing the results and the data for future use. The storage location where the data are held temporarily is referred to as the primary memory while the storage location where the programs and data are stored permanently for future use is referred to as the secondary memory. The primary memory is generally known as "memory" and the secondary memory as "storage".

The data and instructions stored in the primary memory can be directly accessed by the CPU using the data and address buses. However, the information stored in the secondary memory is not directly accessible to CPU. Firstly, the information has to be transferred to the primary memory using I/O channels and then, to the CPU.

Computers also use a third type of storage location known as the internal process memory. This memory is placed either inside the CPU or near the CPU (connected through special fast bus). Figure 2.1 illustrates all the three categories of computer memory and their relative speed, storage capacity and cost.

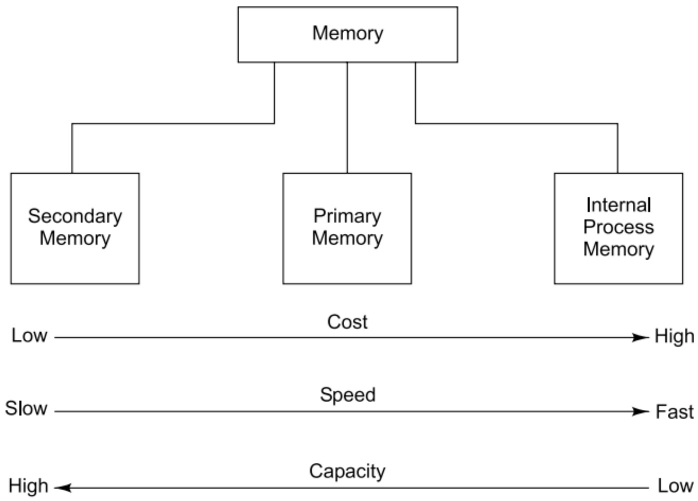


Figure 2.1: Memory categories.

Primary memory (also known as main memory) includes two types, namely, Random Access Memory (RAM) and Read Only Memory (ROM). The data stored in RAM are lost when the power is switched off and therefore, it is known as volatile memory. However, the data stored in ROM stay permanently even after the power is switched off and therefore ROM is a non-volatile memory.

Secondary memory (also known as auxiliary memory) includes primarily magnetic disks and magnetic tapes. These storage devices have much larger storage capacity than the primary memory. Information stored on such devices remains permanent (until we remove it).

Internal process memory usually includes cache memory and registers both of which store data temporarily and are accessible directly by the CPU. This memory is placed inside or near the CPU for the fast access of data

2.1 MEMORY REPRESENTATION

Data being worked on is stored in the **computer memory**. In the memory, values are represented by sequences of binary digits, known as bits. Most computers use a group of eight bits, known as a byte, to represent a character. How does the computer know what any particular sequence of bits represents? We can think of memory as a "bunch" of bytes or cells into which we can place data. Each cell, known as a data item, is assigned a unique number known as address (which is like the index in an array). The CPU can identify each cell by its address as shown in Figure 2.2.

Keyword

Computer memory is any physical device capable of storing information temporarily or permanently.

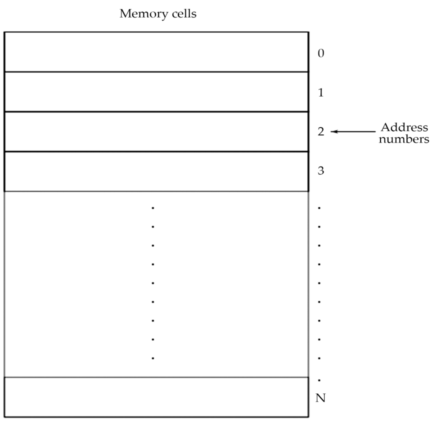


Figure 2.2: Memory representation.

The byte is defined as the "smallest addressable unit" of memory. Most computers use groups of bytes, usually 2 or 4, known as "words" to represent information.

Computer memories are often rated in terms of their capacity to store information. Typically, capacities are described using the unit of byte as follows:

1 KB (Kilobyte) = 1,024 bytes

1 MB (Megabyte) = 1,048,576 bytes

1 GB (Gigabyte) = 1,073,741,824 bytes

1 TB (Terabyte) = 1,099,511,627,776 bytes

2.2 MAIN MEMORY

The main memory of the computer is also known as RAM, standing for Random Access Memory. It is constructed from integrated circuits and needs to have electrical power in order to maintain its information. When power is lost, the information is lost too! It can be directly accessed by the CPU. The access time to read or write any particular byte are independent of whereabouts in the memory that byte is, and currently is approximately 50 nanoseconds (a thousand millionth of a second). This is broadly comparable with the speed at which the CPU will need to access data. Main memory is expensive compared to external memory so it has limited capacity. The capacity available for a given price is increasing all the time. For example many home Personal Computers now have a capacity of 16 megabytes (million bytes), while 64 megabytes is commonplace on commercial workstations. The CPU will normally transfer data to and from the main memory in groups of two, four or eight bytes, even if the operation it is undertaking only requires a single byte.

Keyword

Semiconductor memory is an electronic data storage device, often used as computer memory, implemented on a semiconductor-based integrated circuit.

2.2.1 Cache Memory

Cache memory is a very high speed **semiconductor memory** which can speed up the CPU. It acts as a buffer between the CPU and the main memory. It is used to hold those parts of data and program which are most frequently used by the CPU. The parts of data and programs are transferred from the disk to cache memory by the operating system, from where the CPU can access them.

Advantages

The advantages of cache memory are as follows −

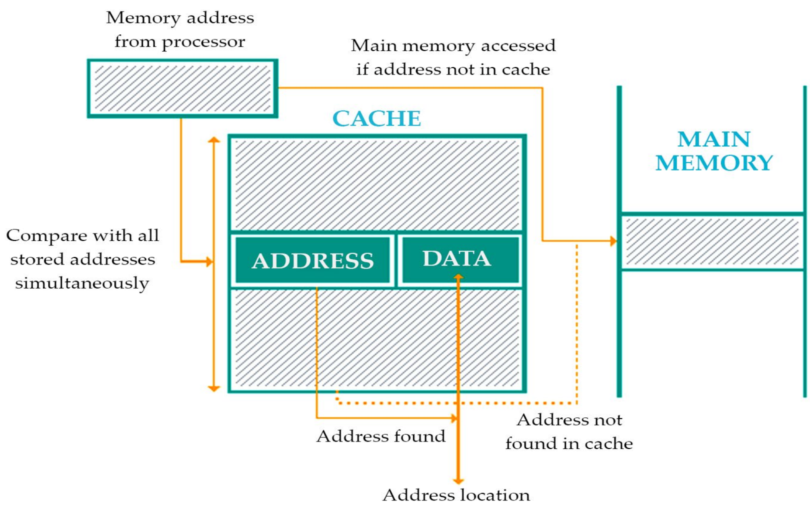
- Cache memory is faster than main memory.
- It consumes less access time as compared to main memory.
- It stores the program that can be executed within a short period of time.
- It stores data for temporary use.

Disadvantages

The disadvantages of cache memory are as follows –

- Cache memory has limited capacity.
- It is very expensive.

Cache Memory



2.2.2 Cache Memory Organization

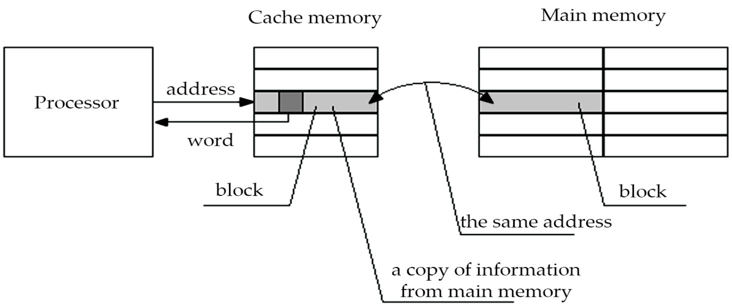
A cache memory is a fast random access memory where the computer hardware stores copies of information currently used by programs (data and instructions), loaded from the main memory. The cache has a significantly shorter access time than the main memory due to the applied faster but more expensive implementation technology. The cache has a limited volume that also results from the properties of the applied technology. If information fetched to the cache memory is used again, the access time to it will be much shorter than in the case if this information were stored in the main memory and the program will execute faster.

Time efficiency of using cache memories results from the locality of access to data that is observed during program execution. We observe here time and space locality:

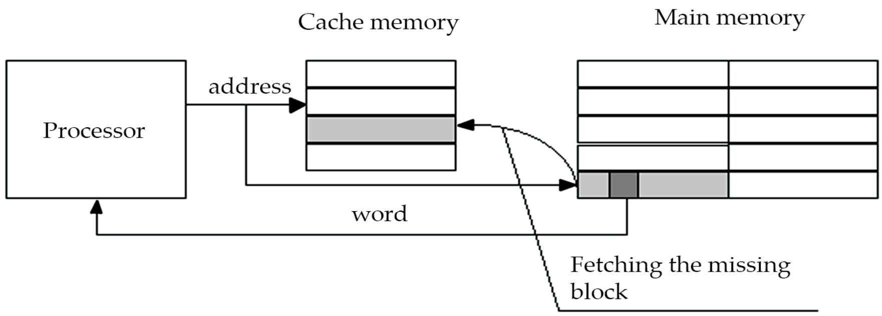
- **Time locality** consists in a tendency to use many times the same instructions and data in programs during neighboring time intervals,
- **Space locality** is a tendency to store instructions and data used in a program in short distances of time under neighboring addresses in the main memory.

The information loaded to the cache memory is used several times and the execution time of programs is much reduced. Cache can be implemented as a multi-level memory. Contemporary computers usually have two levels of caches. In older computer models, a cache memory was installed outside a processor (in separate integrated circuits than the processor itself). The access to it was organized over the processor external system bus. In today's computers, the first level of the cache memory is installed in the same integrated circuit as the processor. It significantly speeds up processor's co-operation with the cache. Some microprocessors have the second level of cache memory placed also in the processor's integrated circuit. The volume of the first level cache memory is from several thousands to several tens of thousands of bytes. The second level cache memory has volume of several hundred thousand bytes. A cache memory is maintained by a special processor subsystem called cache controller.

If there is a cache memory in a computer system, then at each access to a main memory address in order to fetch data or instructions, processor hardware sends the address first to the cache memory. The cache control unit checks if the requested information resides in the cache. If so, we have a "hit" and the requested information is fetched from the cache. The actions concerned with a read with a hit are shown in the figure below.



If the requested information does not reside in the cache, we have a "miss" and the necessary information is fetched from the main memory to the cache and to the requesting processor unit. The information is not copied in the cache as single words but as a larger block of a fixed volume. Together with information block, a part of the address of the beginning of the block is always copied into the cache. This part of the address is next used at readout during identification of the proper information block. The actions executed in a cache memory on "miss" are shown below.



If there are two cache levels, then on "miss" at the first level, the address is transferred in a hardwired way to the cache at the second level. If at this level a "hit" happens, the block that contains the requested word is fetched from the second level cache to the first level cache. If a "miss" occurs also at the second cache level, the blocks containing the requested word are fetched to the cache memories at both levels. The size of the cache block at the first level is from 8 to several tens of bytes (a number must be a power of 2). The size of the block in the second level cache is many times larger than the size of the block at the first level.

The cache memory can be connected in different ways to the processor and the main memory:

- As an additional subsystem connected to the system bus that connects the processor with the main memory,
- As a subsystem that intermediates between the processor and the main memory,
- As a separate subsystem connected with the processor, in parallel regarding the main memory.

There are three basic methods used for mapping of information fetched from the main memory to the cache memory:

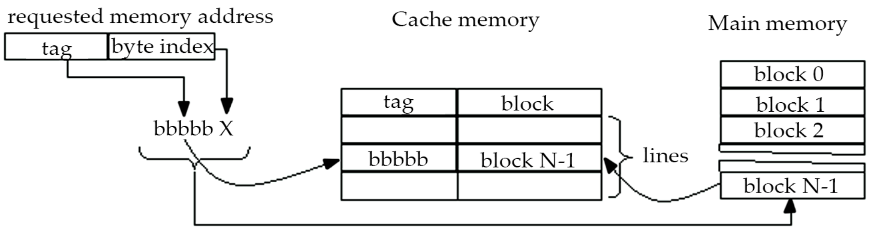
- Associative mapping
- Direct mapping
- Set-associative mapping.

Caches and main memories are byte-addressed, so we will refer to byte-addressed organization in the sections on cache memories that follow.

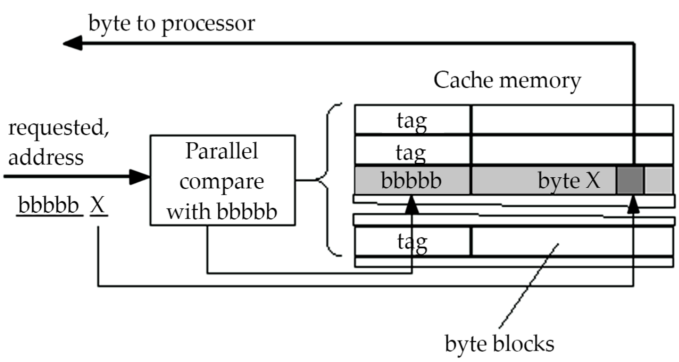
Cache memory with Associative Mapping

With the associative mapping of the contents of cache memory, the address of a word in the main memory is divided into two parts: the tag and the byte index (offset). Information is fetched into the cache in blocks. The byte index determines the location of the byte in the block whose address is generated from the tag bits, which are extended by zeros in the index part (it corresponds to the address of the first byte in the block. In the number of bits in the byte index is *n* then the size of the block is a power of 2 with the exponent *n*. The cache is divided into lines. In each line one block can be written together with its tag and usually some control bits. It is shown in the figure below.

When a block is fetched into the cache (on miss), the block is written in an arbitrary free line. If there is no free line, one block of information is removed from the cache to liberate one line. The block to be removed is determined according to a selected strategy, for example the least used block can be selected. To support the block selection, each access to a block residing in the cache, is registered by changing the control bits in the line the block occupies.



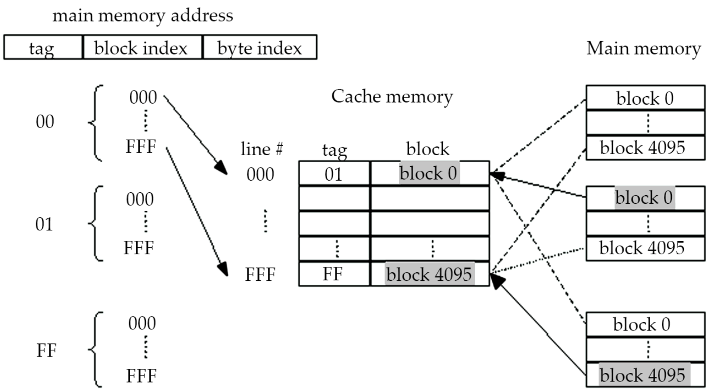
The requested address contains the tag (bbbbb) and the byte index in the block (X). The tag is compared in parallel with all tags written down in all lines. If a tag match is found in a line, we have a hit and the line contains the requested information block. Then, based on the byte index, the requested byte is selected in the block and read out into the processor. If none of the lines contains the requested tag, the requested block does not reside in the cache. The missing block is next fetched from the main memory or an upper level cache memory.



The functioning of a cache with associative mapping is based on the associative access to memory. The requested data are found by a parallel comparison of the requested tag with tags registered in cache lines. For a big number of lines, the comparator unit is very large and costly. Therefore, the associative mapping is applied in cache memories of a limited sizes (i.e. containing not too many lines).

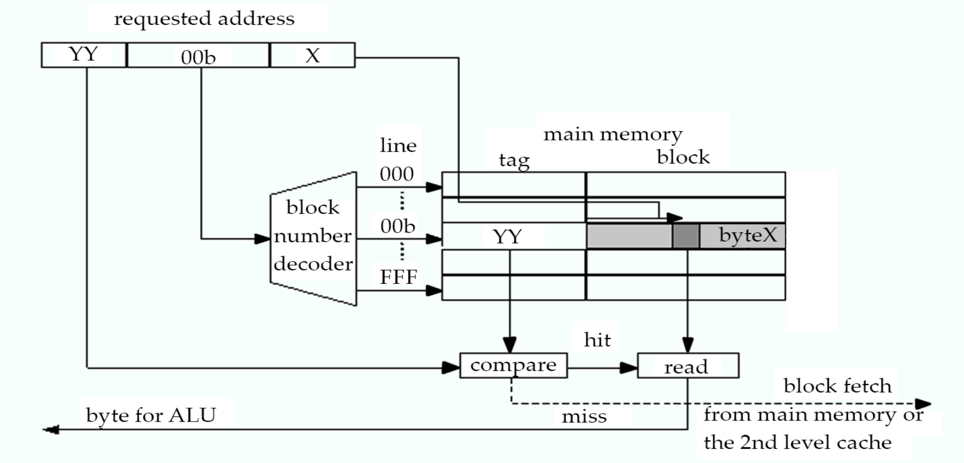
Cache Memory with Direct Mapping

The name of this mapping comes from the direct mapping of data blocks into cache lines. With the direct mapping, the main memory address is divided into three parts: a tag, a block index and a byte index. In a given cache line, only such blocks can be written, whose block indices are equal to the line number. Together with a block, the tag of its address is stored. It is easy to see that each block number matches only one line in the cache.



The block index (middle part of the address) is decoded in a decoder, which selects lines in the cache. In a selected line, the tag is compared with the requested one. If a match is found, the block residing in the line is exactly that which has been requested, since in the main memory there are no two blocks with the same block indices and tags.

We have a hit in this case and the requested byte is read in the block. If there was no tag match, it means that either there is no block yet in the line or the residing block is different to the requested one. In both cases, the requested block is fetched from the main memory or the upper level cache. Together with the fetched block, its tag is stored in the cache line.

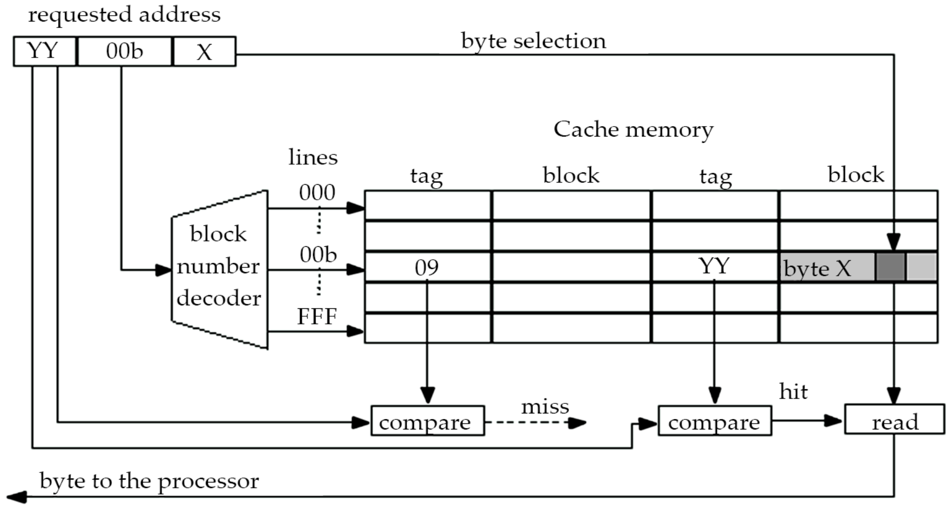


With direct mapping, all blocks with the same index have to be written into the same cache line. It can cause frequent block swapping in cache lines, since only one block can reside in a line at a time. It is called block thrashing in the cache. For large data structures used in programs, this phenomenon can substantially decrease the efficiency of cache space use.

Cache Memory with set Associative Mapping

With this mapping, the main memory address is structured as in the previous case. We have there a tag, a block index and a byte index. The block into line mapping is the same as for the direct mapping. But in a set associative mapping many blocks with different tags can be written down into the same line (a set of blocks). Access to blocks written down in a line is done using the associative access principle, i.e. by comparing the requested tag with all tags stored in the selected line. From both mentioned features, the name of this mapping is derived. The figure below shows operations during a read from a cache of this type.

First, the block index of the requested address is used to select a line in a cache. Next, comparator circuits compare the requested tag with all stored in the line. On match, the requested byte is fetched from the selected block and sent to the processor. On miss (no match), the requested block is fetched from the main memory or the upper level cache. The new block is stored in a free block slot in the line or in the slot liberated by a block sent back to the main memory (or the upper level cache). To select a block to be removed, different strategies can be applied. The most popular is the LRU (least-recently used) strategy, where the block not used for the longest time is removed. Other strategies are: FIFO (first-in-first-out) strategy - the block that is stored during the longest time is selected or LFU (least-frequently used) strategy where the least frequently modified block is selected. To implement these strategies, some status fields are maintained associated with the tags of blocks.



Due to the set associative mapping, block thrashing in cache is eliminated to the large degree. The number of blocks written down in the same cache line is from 2 to 6 with the block size of 8 to 64 bytes.

Memory Updating Methods after Cache Modification

A cache memory contains copies of data stored in the main memory. When a change of data in a cache takes place (ex. a modification due to a processor write) the contents of the main memory and cache memory cells with the same address, are different. To eliminate this lack of data coherency two methods are applied:

- **write through**, the new cache contents is written down to the main memory immediately after the write to the cache memory,
- **write back**, the new cache contents is not written down to the main memory immediately after the change, but only when the given block of data is replaced by a new block fetched from the main memory or an upper level cache. After a data write to the cache, only state bits are changed in the modified block, indicating that the block has been modified (a dirty block).

2.2.3 Random Access Memory (RAM)

Random Access Memory (RAM) is a volatile memory and loses all its data when the power is switched off. It is the main memory of the computer system that stores the data temporarily and allows the data to be accessed in any order. As compared to the secondary storage, the data can be accessed at a faster speed in RAM because it is the internal memory of the computer. Figure 2.3 shows RAM with ICs.

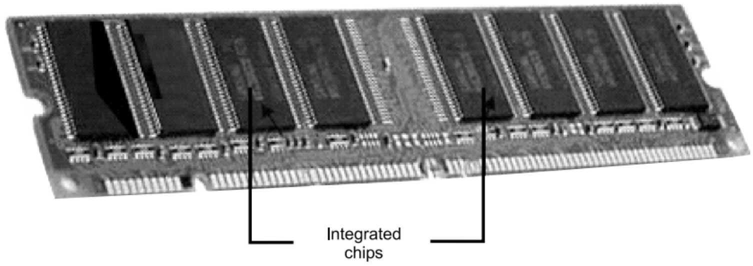


Figure 2.3: Random access memory with ICs.

Keyword

Floppy disk is a magnetic storage medium for computer systems. The floppy disk is composed of a thin, flexible magnetic disk sealed in a square plastic carrier.

RAM is made up of different ICs, which are mounted on a printed circuit board. RAM stores the application programs and the data on which the user is currently working so that the processor can easily access the required application program and data in a less amount of time. RAM is also known as read/write memory because it can perform both read as well as write operations. The speed of RAM is faster than the other memory devices, such as hard disk, **floppy disk**, etc. The programs, which are being currently executed by the computer system, are stored in RAM. RAM is volatile and, therefore, the programs and the data stored in the RAM get lost when the power supply is switched off. The storage capacity of RAM is usually less than the secondary storage devices.

RAM can be categorized into two main types, namely, Static RAM (SRAM) and Dynamic RAM (DRAM), which can be further divided into various types for storing data. Figure 2.4 shows the hierarchy of RAM memory.

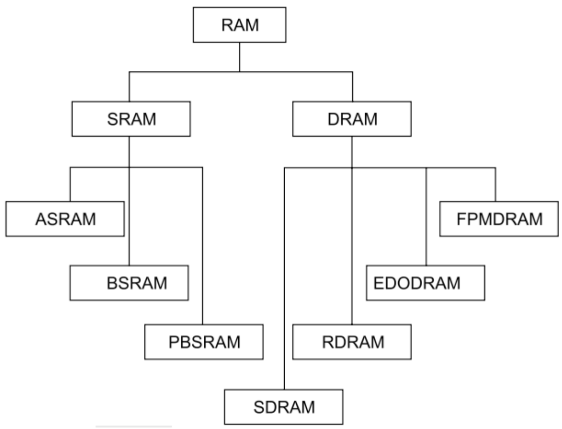


Figure 2.4: Types of random access memory.

Static RAM

Static RAM (SRAM) is a type of RAM in which data is stored till the power of the computer system is switched on. SRAM uses a number of transistors to store a single bit of digital information. Figure 2.5 shows the organization of data in a cell of SRAM.

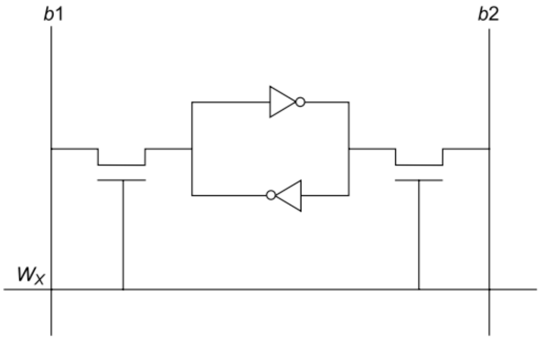


Figure 2.5: Organization of data in a cell of static random access memory.

In the figure, b_1 and b_2 represent the two bit lines and W_x represents the word line. In the memory, the data is stored in the form of a two dimensional array, containing rows and columns. The row can be accessed globally by a line (known as word line) and the column can be accessed individually by a line (known as bit line). Depending on the function performed by SRAM, it can be divided into the following three types:

- Asynchronous SRAM (ASRAM): ASRAM performs its operations without the use of system clock. It makes use of three signals for working, namely, Chip Select (CS), Write Enable (WE) and Output Enable (OE). The CS signal enables the processor to select the memory for performing read and write operations. If the value of CS signal equals zero, then the memory is enabled to perform the operations. On the other hand, if the value of the CS signal equals one, then the memory is disabled and operations—such as reading and writing in ASRAM—cannot be performed. The signal WE makes the decisions related to data, i.e., whether it should be read from or write to the memory. If the value of WE signal equals zero, then no data can be read from or written to the memory. The signal OE is an active low signal that enables the processor to give the output for the data. If the value of OE signal equals zero, then only it will output the data.
- Burst SRAM (BSRAM): BSRAM works in association with the system clock and is also known as synchronous SRAM. BSRAM is most commonly used with high-speed applications because the read and write cycles are synchronized

with the clock cycles of the processor. The access-waiting time gets reduced after the read and write cycles are synchronized with the clock cycles. The speed and the cost of BSRAM increases or decreases simultaneously.

- Pipeline Burst SRAM (PBSRAM): PBSRAM makes use of the pipeline technology in which a large amount of data is broken up in the form of different packets containing data. These packets are arranged in a sequential manner in the pipeline and are sent to the memory simultaneously. PBSRAM can handle a large amount of data at a very high speed. It is the fastest type of SRAM because it can operate at bus rates as high as 66 MHz.

Dynamic RAM

DRAM is the RAM in which data is stored in a storage cell, consisting of a transistor and a capacitor. Unlike SRAM, the DRAM needs to be continuously refreshed with power supply because the capacitor has the tendency to get discharged. DRAM retains the data for a very short span of time, even after the power supply is switched off. Figure 2.6 shows the organization of data in a cell of DRAM.

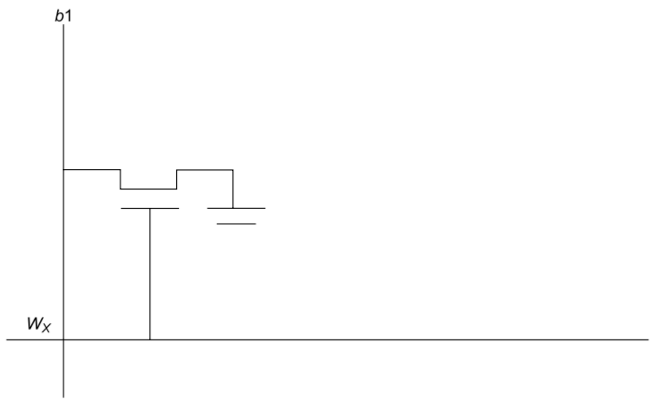


Figure 2.6: Organization of data in a cell of dynamic random access memory.,

In Figure 2.6, b1 represents a bit line and W_x represents a word line. The DRAM can be divided into the following types:

- Synchronous DRAM (SDRAM): SDRAM performs its operations in the synchronous mode, i.e., in association with the clock cycle of the processor bus. It consists of two internal memory banks such that if the address lines are sent from the first bank, then the address can be read by using the second bank. The internal banks are used because the row and the column address lines need to be charged for reading an address. SDRAM provides a synchronous interface in which it waits for a clock signal before responding to a control input. Generally, it is used with the processors for storing the data in a continuous manner. The continuous form of data storage helps in processing more number of instructions per unit time that increases the speed of data access.

- Rambus DRAM (RDRAM): RDRAM designed by Rambus Inc. works at a faster speed, as compared to SDRRAM. It is compact in size and uses 16-bit address bus. It provides the facility to transfer data at a maximum speed of 800 MHz. It contains multiple address and data lines that help in increasing the speed of data access. These multiple address and data lines help in performing different read and write operations simultaneously. It is not popular among the users because of its high cost and low compatibility.
- Extended Data Out DRAM (EDODRAM): EDODRAM can access more than one bit of data at one time which helps in achieving faster data access rates. It provides the facility to perform various operations at one time such as reading, writing, etc. It starts accepting the next bit of data immediately after getting the fi rst bit of data for performing read or write operation.
- Fast Page Mode DRAM (FPMDRAM): FPMDRAM makes use of paging in which read or write operation is performed by selecting the address of the data from the rows and the columns of a matrix. Once the data is read, the address of the particular column is incremented, so that the user can read the next part of the data. The use of paging concept in FPDRAM does not allow to work with the buses at the memory speed more than 66 MHz. As a result, a lot of time is consumed in reading and writing the data from the matrix.

2.2.4 Read Only Memory (ROM)

Read only memory devices are a special case of memory where, in normal system operation, the memory is read but not changed. Read only memories are non-volatile, that is, stored information is retained when the power is removed. The main read only memory devices are listed are:

How The Device Works

The read only memory cell usually consists of a single transistor (ROM and EPROM cells consist of one transistor, EEPROM cells consist of one, one-and-a-half, or two transistors). The threshold voltage of the transistor determines whether it is a “1” or “0.” During the read cycle, a voltage is placed on the gate of the cell. Depending on the programmed threshold voltage, the transistor will or will not drive a current. The sense amplifier will transform this current, or lack of current, into a “1” or “0.” Figure 2.7 shows the basic principle of how a Read Only Memory works.

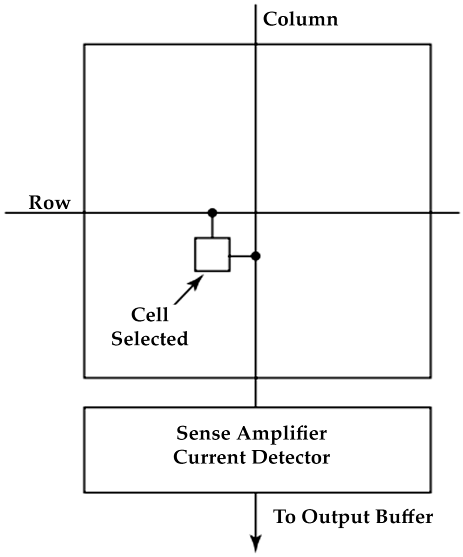


Figure 2.7: Read Only Memory Schematic.

Mask Programmable ROMs

Mask programmable read-only memories (ROMs) are the least expensive type of solid state memory. They are primarily used for storing video game software and fixed data for electronic equipment, such as fonts for laser printers, dictionary data in word processors, and sound data in electronic musical instruments.

ROM programming is performed during IC fabrication. Several process methods can be used to program a ROM. These include

- Metal contact to connect a transistor to the bit line.
- Channel implant to create either an enhancement-mode transistor or a depletion-mode transistor.
- Thin or thick gate oxide, which creates either a standard transistor or a high threshold transistor, respectively.

The choice of these is a trade-off between process complexity, chip size, and manufacturing cycle time. A ROM programmed at the metal contact level will have the shortest manufacturing cycle time, as metallization is one of the last process steps. However, the size of the cell will be larger.

Figure 2.8 shows a ROM array programmed by channel implant. The transistor cell will have either a normal threshold (enhancement-mode device) or a very high threshold (higher than VCC to assure the transistor will always be off). The cell array architecture is NOR. The different types of ROM architectures (NOR, NAND, etc.) are detailed in the flash memory section as they use the same principle.

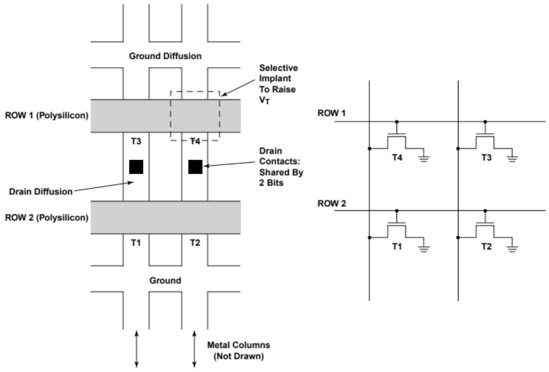


Figure 2.8: ROM Programmed by Channel Implant

Figure 2.9 shows an array of storage cells (NAND architecture). This array consists of single transistors noted as devices 1 through 8 and 11 through 18 that is programmed with either a normal threshold (enhancement-mode device) or a negative threshold (depletion-mode device).

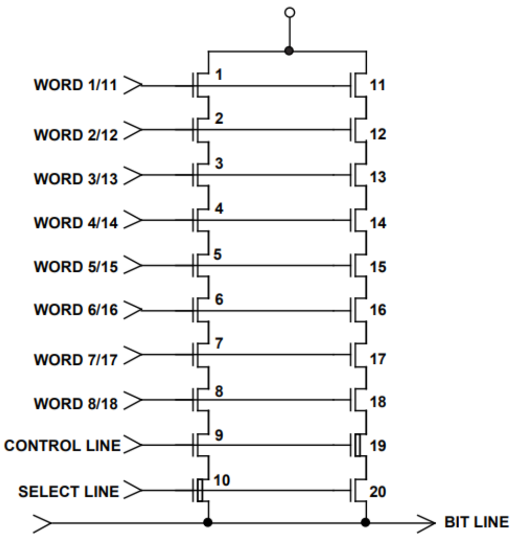


Figure 2.9: Memory Cell Schematic.

ROM Cell Size and Die Size

The cell size for the ROM is potentially the smallest of any type of memory device, as it is a single transistor. A typical 8Mbit ROM would have a cell size of about 4.5μm2 for a 0.7μm feature size process, and a chip area of about 76mm^2. An announced 64Mbit ROM, manufactured with a 0.6μm feature size, has a 1.23μm^2 cell on a 200mm^2 die.

The ROM process is the simplest of all memory processes, usually requiring only one layer of polysilicon and one layer of metal. There are no special film deposition or etch requirements, so yields are the highest among all the equivalent-density memory chips.

EPROM

EPROM (UV Erasable Programmable Read Only Memory) is a special type of ROM that is programmed electrically and yet is erasable under UV light.

The EPROM device is programmed by forcing an electrical charge on a small piece of polysilicon material (called the floating gate) located in the memory cell. When this charge is present on this gate, the cell is "programmed," usually a logic "0," and when this charge is not present, it is a logic "1." Figure 2.10 shows the cell used in a typical EPROM. The floating gate is where the electrical charge is stored.

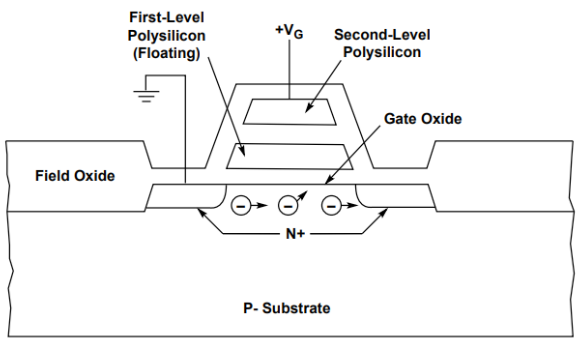


Figure 2.10: Double-Poly Structure (EPROM/Flash Memory Cell).

Prior to being programmed, an EPROM has to be erased. To erase the EPROM, it is exposed to an ultraviolet light for approximately 20 minutes through a quartz window in its ceramic package. After erasure, new information can be programmed to the EPROM. After writing the data to the EPROM, an opaque label has to be placed over the quartz window to prevent accidental erasure. Programming is accomplished through a phenomenon called hot electron injection. High voltages are applied to the select gate and drain connections of the cell transistor. The select gate of the transistor is pulsed "on" causing a large drain current to flow. The large bias voltage on the gate connection attracts electrons that penetrate the thin gate oxide and are stored on the floating gate.

EPROM Floating Gate Transistor Characteristic Theory

The following explanation of EPROM floating gate transistor characteristic theory also applies to EEPROM and flash devices. Figures 2.11 (a) and (b) show the cross section of a conventional MOS transistor and a floating gate transistor, respectively. The upper gate in Figure 2.11 (b) is the control gate and the lower gate, completely isolated within the gate oxide, is the floating gate.

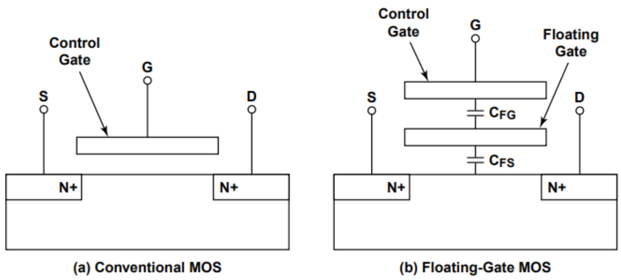


Figure 2.11: Cross Section of a Conventional MOS Transistor and a Floating-Gate MOS Transistor.

C_{FG} and C_{FS} are the capacitances between the floating gate and the control gate and substrate, respectively. V_G and V_F are the voltages of the control gate and the floating gate, respectively. $-Q_F$ is the charge in the floating gate. (As electrons have a negative charge, a negative sign was added). In an equilibrium state, the sum of the charges equals zero.

$$(V_G - V_F)\,C_{FG} + (0 - V_F)\,C_{FS} - Q_F = 0$$

$$V_F\left(\frac{C_{FG}}{C_{FG} + C_{FS}}\right)V_G - \frac{Q_F}{C_{FG} + C_{FS}}$$

V_{TC} is the threshold voltage of the conventional transistor, and V_{TCG} is the threshold voltage of the floating gate transistor.

$$V_{TCG} = \left(\frac{C_{FG}}{C_{FG} + C_{FS}}\right) V_{TC} - \frac{Q_F}{C_{FG} + C_{FS}}$$

$$V_{TCG} = V_{TO} - \frac{Q_F}{C_G}$$

$$\text{Where} \quad V_{TO} = \left(\frac{C_{FG}}{C_{FG} + C_{FS}}\right) V_{TC} \quad \text{and} \quad C_G = C_{FG} + C_{FS}$$

The threshold voltage of the floating gate transistor (V_{TCG}) will be V_{TO} (around 1V) plus a term depending on the charge trapped in the floating gate. If no electrons are in the floating gate, then $V_{TCG} = V_{TO}$ (around 1V). If electrons have been trapped in the floating gate, then $V_{TCG} = V_{TO} - Q_F/C_G$ (around 8V for a 5V part). This voltage is process and design dependent. Figure 2.12 shows the threshold voltage shift of an EPROM cell before and after programming.

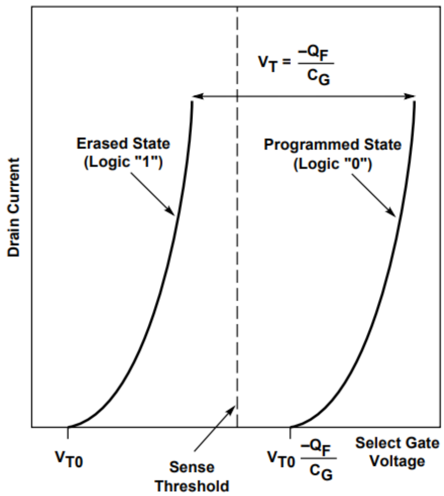


Figure 2.12: Electrical Characteristics of an EPROM.

The programming (write cycle) of an EPROM takes several hundred milliseconds. Usually a byte—eight bits—is addressed with each write cycle. The read time is comparable to that of fast ROMs and DRAMs (i.e., several tens of nanoseconds). In those applications where programs are stored in EPROMs, the CPU can run at normal speeds.

Field programmability is the EPROM's main advantage over the ROM. It allows the user to buy mass-produced devices and program each device for a specific need.

This characteristic also makes the EPROM ideal for small-volume applications, as the devices are usually programmed in very small quantities. Also, the systems supplier can program any last minute upgrades to the program just before shipment. EPROM cells may be configured in the NAND structure shown previously, or, more commonly, in the NOR configuration shown in Figure 2.13.

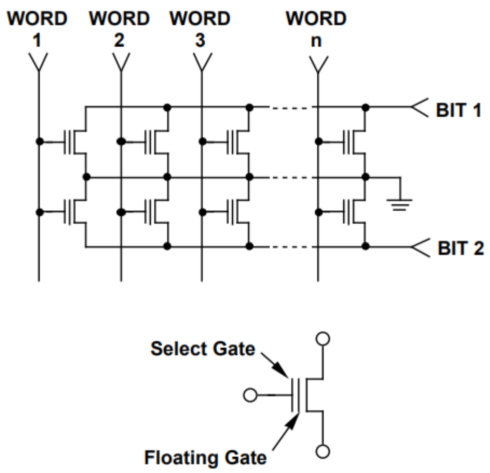
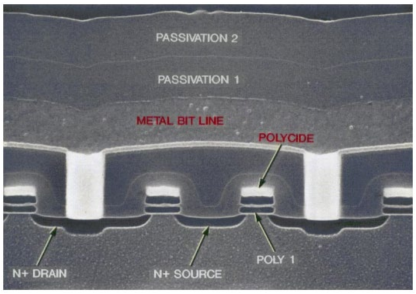


Figure 2.13: NOR EPROM Configuration.

EPROMs were created in the 1970s and have long been the cornerstone of the non-volatile memory market. But the development of flash memory devices will lead to a loss of EPROM marketshare. EPROM uses a mature technology and design and is on the decline part of its lifecycle. For this reason there is not a lot of R&D expenditure made for EPROM devices. Figure 2.14 shows a cross section of a 1Mbit EPROM cell from two different manufacturers. The main difference between the processes is the polysilicon gate. One manufacturer uses a polycide to improve the speed.

EPROM Cell Size and Die Size

The cell size of the EPROM is also relatively small. The EPROM requires one additional polysilicon layer, and will usually have slightly lower yields due to the requirement for nearly perfect (and thin) gate oxides.



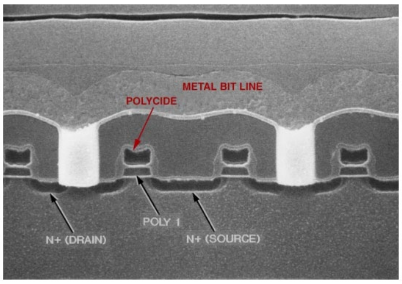


Figure 2.14: Typical 1Mbit EPROM Cells.

These factors, plus the fact that an EPROM is encased in a ceramic package with a quartz window, make the EPROM average selling price three to five times the price of the mask ROM. Figure 2.15 shows the main feature sizes of 1Mbit EPROM analyzed by ICE's laboratory.

Manufacturer	Density	Date Code	Cell Size (μm^2)	Die Size (mm^2)	Min. Gate Length (μm)
Atmel	1Mbit	9428	4.40	14.6	0.6
AMD	1Mbit	9634	5.52	15.9	0.7
ST	1Mbit	9514	3.60	11.5	0.5
ISSI	1Mbit	94/95	6.80	18.0	0.7

Figure 2.15: EPROM Feature Sizes.

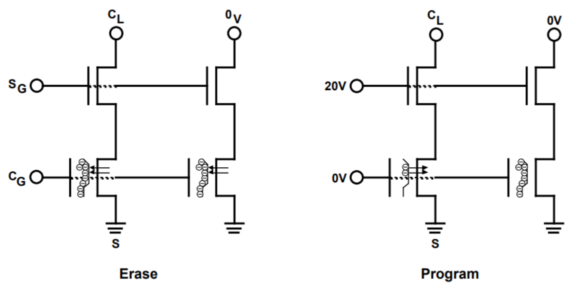
EEPROM

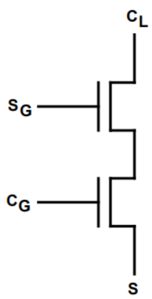
EEPROM (Electrically Erasable Programmable ROM) offer users excellent capabilities and performance. Only one external power supply is required since the high voltage for program/erase is internally generated. Write and erase operations are performed on a byte per byte basis. The EEPROM uses the same principle as the UV-EPROM. Electrons trapped in a floating gate will modify the characteristics of the cell, and so a logic "0" or a logic "1" will be stored.

The EEPROM is the memory device that implements the fewest standards in cell design. The more common cell is composed of two transistors. The storage transistor has a floating gate (similar to the EPROM storage transistor) that will trap electrons. In addition, there is an access transistor, which is required for operations. Figure 2.16 shows the voltages applied on the memory cell to program/erase a cell. Note that an EPROM cell is erased when electrons are removed from the floating gate and that the EEPROM cell is erased when the electrons are trapped in the floating cell. To have products electrically compatible, the logic path of both types of product will give a "1" for erase state and a "0" for a programmed state. Figure 2.17 shows the electrical differences between EPROM and EEPROM cells.

REMEMBER

In laying out the EEPROM cell, the designer must take into consideration the elements of size, performance, and process complexity.





	S_G	C_L	C_G	S
Erase	V_{PP}	0	V_{PP}	0
Program	V_{PP}	V_{PP}	0	0
Read	V_{CC}	1	V_{CC}	0
Unselected	0	X	0	0

Figure 2.16: EEPROM Cell Program/Erase.

EPROM programming: Hot electron
- **High V_{PP} Current**
- **High ISUB**
- **V_{PP} must be an external supply**
- **No V_{BB} generator**

EEPROM programming: Tunneling
- **V_{PP} is generated by an internal pump.**

Figure 2.17: V_{PP} EPROM Versus V_{PP} EEPROM.

Manufacturer	Density	Date Code	Cell Size (μm^2)	Die Size (mm^2)	Min Gate Length (μm)
Microchip	16K	9540	60.5	6.0	2.0
Xicor	2K	9432	100.0	4.0	2.0
ST	1K	9618	286.0	2.6	1.2

Figure 2.18: EEPROM Serial Configuration Feature Sizes.

REMEMBER

Computers use both non-volatile and volatile memory.

2.3 SECONDARY STORAGE DEVICE

A secondary storage device refers to any volatile storage device that is internal or external to the computer. It can be any storage device beyond the primary storage that enables permanent data storage. A secondary storage device is also known as an auxiliary storage device or external storage. Secondary storage devices are primarily referred to a storage devices that serve as an addition to the computer's primary storage, RAM and **cache memory**. Typically, secondary storage allows for the storage of data ranging from a few megabytes to petabytes. These devices store virtually all programs and applications stored on a computer, including the operating system, device drivers, applications and general user data. Most of the secondary storage devices are internal to the computer such as the hard disk drive, the tape disk drive and even the compact disk drive and floppy disk drive.

2.3.1 Types of Secondary storage Devices

Magnetic Tape

- Tapes are used for recording and storing data for computer processing. It is plastic reel similar to long lengths of movie film. A tape is usually ½" wide and 2400 feet in length and it is coated with particles of ferric oxide on which data can be recorded magnetically.
- The process of reading and writing of data is carried out on a device called Tape Drive and the records on magnetic tape are stored in sequential order.

If the payroll file is to be stored on a magnetic tape, the records would likely to be stored in the sequence of employee numbers. Hence, magnetic tapes are referred to as sequential access device.

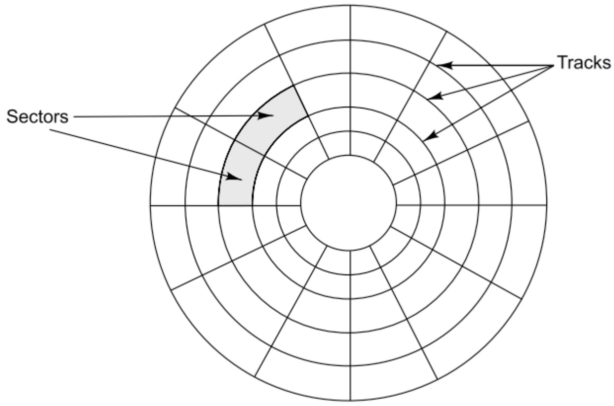
example

Magnetic Disk

- Magnetic disk is another type of secondary storage device known as random (direct) access as it permits direct accessing of data. An individual disk is a circular metal plate coated on both side by ferrous oxide material.
- Data is recorded in the form of magnetized spots on the tracks of the disk, a spot representing the presence by "1" and its absence by "0" enabling representing of data in binary form.
- The surface of the magnetic disk is divided into number of invisible concentric circles called "tracks" and these tracks are further subdivided into "sectors", "blocks" etc. each its own unique addresses to facilitate the location of data and the Disk moves on a vertical rotating spindle.
- Reading /writing on the disks is accomplished by means of series of read/write heads which are placed close to the surfaces of the disks.
- It is good to know that data on the magnetic disk can be accessed again and again. It can also be recorded erasing the older information.

Keyword

Cache memory is a small-sized type of volatile computer memory that provides high-speed data access to a processor and stores frequently used computer programs, applications and data.

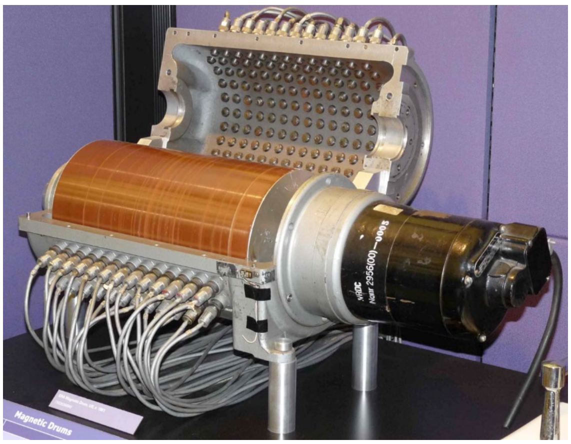


REMEMBER

The data of any size can be recorded on a magnetic tape but the length and the storage capacity of the magnetic tape should be considered before storing the data.

Magnetic Drum

- It is a metallic cylinder coated with a special magnetic alloy.
- Data is stored in this surface as minute magnetized spoke arranged in binary form in a series of parallel circular tracks.
- The drum rotates at a constant speed and data is recorded (or) retrieved by the read/write head. One for each track.
- The magnetic drum provides random access storage.



Advantages

- Very fast access
- Random access capability

- Stored data is not destroyed until new data is written in the same location.

Disadvantages

- Drums cannot be removed from the unit and stored.
- Storage capacity is limited.
- Requires machine interpretation to read the information as it is not humanly readable.

CD-ROM

- CD-ROM (Compact Disc Read Only Memory) is a Compact Disc contains data accessible by a computer. While the Compact Disc format was originally designed for music storage and play back, the format was later adapted to hold any form of **binary data**.
- The CR-ROM is also known as a laser disc, which is shiny metal like disk. The diameter of the disk is 5.25 inches or 12 cm disk. Information of 650 MB can be stored which is equal to nearly 2, 50,000 pages of printed text.
- The data is recorded as deep holes on the disk surface or burning microscopic bits.
- The plain and shiny disk surface and the microscopic bits help to represent the binary numbers 0 and 1, as required by the concentric tracks.
- CD-ROMs are popularly used to distribute computer software, including games and multimedia applications, though any data can be stored.
- Some CDs hold both computer data and audio with the latter capable of being played on a CD player, while data is only usable on a computer. These are called Enhanced CDs.
- The CD-ROMs are pre-recorded disks used for storing a large amount of data and information. Hence, the CD-ROM drive has become a standard peripheral device used for retrieval of stored data on the CD-ROM.
- A CD-ROM sector contains 2352 bytes, divided into 98 [ninety-eight], 24-byte frames.

Keyword

Binary data is data whose unit can take on only two possible states, traditionally termed 0 and +1 in accordance with the binary numeral system and Boolean algebra.

- A mode-1 CD-ROM, which has the full three layers of error correction data, contains a net 2048 bytes of the available 2352 per sector.
- On a mode-2 CD-ROM, which is mostly used for video files, there are 2336 user available bytes per sector. A device called CD-Writer is necessary to record information onto a CD-ROM.

Hard Disk

- A hard disk drive [HDD], commonly referred to as a hard drive, hard disk or fixed disk drive. It is a non-volatile secondary storage device which stores digitally encoded data on rapidly rotating platters with magnetic surfaced. The hard disk is an electro mechanical device. The hard disk is also known as Winchester disk. HDDs record data by magnetizing a ferromagnetic material directionally to represent either a "0" or "1" binary digit. They read the data by detecting the magnetization of the material.
- The magnetic hard disk is an electro-mechanical device which consists of some smooth metal plates and disks coated on either sides or surfaces with a thin-film of magnetic material. The set of such magnetic disks are fixed on one spindle, one above the other, like a stack of disks. This is called a disk pack, which is sealed into one unit and mounted on a disk drive.
- The hard disk drive has a set of magnetic heads or read/write heads for both surfaces of each disk, on the spindle.
- The disk drive consists of a motor to rotate the disk pack at a speed of about 3600 revolutions per minute [rpm] about a spindle.
- Each magnetic head (or) magnetic read/write heads mounted on arm can move in and out rapidly on the disk surface to perform read and write operations. The

information is recorded and stored or retrieved that is read from the magnetic recording surface, while the disk rotates about the spindle at high-speed.

- The information is stored on the magnetic surfaces as bits 0's and 1's on the concentric circles as tracks.
- Each track is divided into sectors of the same density.
- The set of corresponding tracks of all the surfaces of all the disks constitute a cylinder.
- The magnetic disk pack is connected to controller by an electronic circuit called as a disk controller (or) hard disk controller HDC. The controllers accept control signals from the control unit of the computer for specific read and write operation.
- Now days the capacity of hard disk begins from 20 GB, 40 GB and so on, to fulfill the need of large data information storage.
- Hard disk drives are sealed to prevent dust and other sources of contamination from interfering with the operation of the hard disk heads.
- The hard drives are not air tight, but rather utilize an extremely fine air filter, to allow for air inside the hard drive enclosure. The spinning of the disks causes the air to circulate forcing any particulars to become trapped on the filter. The same air currents also as a gas bearing which enables the heads to float on a cushion of air above the surfaces of the disks.

Floppy Disks

These are also called as flexible disks. These are used in the smallest microcomputer systems as well as mini computers. Floppy disks have higher storage capacity and offer direct access capability. The floppy disk is permanently sealed in a plastic coated jacket and the whole package is inserted the floppy drive for data recording and retrieval.

The jacket of the disk has a small slot to permit the read/write head to contact the disk. They are 5.25 inch (or) 3.5 inch in diameter. They come in single and double density and recorded on one or both surface of the diskette. The capacity of a 5.25 inch floppy is 1.2 mega bytes whereas for 3.5 inch floppy it is 1.44 mega bytes.

It is cheaper than that of any other secondary storage devices and is portable too. The floppy is a low-cost device particularly suitable for personal computer system. Once data has been recorded, a floppy disk reader can be used to enter data into CPU. Again, the disk is loaded and rotated at a constant speed inside its envelope. Tiny magnetic heads in the disk reader access data through the slot in the jacket.

ROLE MODEL

J. PRESPER ECKERT: INVENTION OF THE MERCURY DELAY LINE MEMORY

J. Presper Eckert, Jr., in full John Presper Eckert, Jr. (born April 9, 1919, Philadelphia, Pa., U.S.—died June 3, 1995, Bryn Mawr, Pa.), American engineer and coinventor of the first general-purpose electronic computer, a digital machine that was the prototype for most computers in use today.

Eckert was educated at the Moore School of Electrical Engineering at the University of Pennsylvania, Philadelphia (B.S., 1941; M.S., 1943), where he and his professor, John W. Mauchly, made several valuable improvements in computing equipment. In 1946 the pair fulfilled a government contract to build a digital computer, which they called ENIAC (Electronic Numerical Integrator and Computer). In primitive form, ENIAC contained virtually all the circuitry used in present-day high-speed digital computers. It was used by the U.S. Army for military calculations.

In 1948 Eckert and Mauchly established a computer-manufacturing firm; a year later, they introduced BINAC (Binary Automatic Computer), which stored information on magnetic tape rather than on punched cards. Designed to handle business data, UNIVAC I (Universal Automatic Computer), Eckert and Mauchly's third model, found many uses in commerce and may be said to have started the computer boom. Between 1948 and 1966 Eckert received 85 patents, mostly for electronic inventions.

Eckert remained in executive positions at his company when it was acquired by Remington Rand, Inc., in 1950 and when that firm was, in 1955, merged into the Sperry Rand Corp. (later Unisys Corp.). Eckert was elected to the National Academy of Engineering in 1967 and was awarded the National Medal of Science in 1968.

SUMMARY

- Memory is a device or system that is used to store information for immediate use in a computer or related computer hardware and digital electronic devices.
- Computer memory operates at a high speed compared to storage that is slower but offers higher capacities.
- The main memory of the computer is also known as RAM, standing for Random Access Memory. It is constructed from integrated circuits and needs to have electrical power in order to maintain its information.
- Cache memory is a very high speed semiconductor memory which can speed up the CPU. It acts as a buffer between the CPU and the main memory.
- Random Access Memory (RAM) is a volatile memory and loses all its data when the power is switched off.
- It is the main memory of the computer system that stores the data temporarily and allows the data to be accessed in any order.
- Read only memory devices are a special case of memory where, in normal system operation, the memory is read but not changed. Read only memories are non-volatile, that is, stored information is retained when the power is removed.
- EEPROM (Electrically Erasable Programmable ROM) offer users excellent capabilities and performance. Only one external power supply is required since the high voltage for program/erase is internally generated.

KNOWLEDGE CHECK

1. **Secondary storage memory type is**
   a. volatile memory
   b. non volatile memory
   c. backup memory
   d. impact memory
2. **Which one of the following is not a secondary storage?**
   a. magnetic disks
   b. magnetic tapes
   c. RAM
   d. none of the mentioned
3. **Which of the following memories must be refreshed many times per second?**
   a. Static RAM
   b. Dynamic RAM
   c. EPROM
   d. ROM
   e. None of these
4. **RAM stands for**
   a. Random origin money
   b. Random only memory
   c. Read only memory
   d. Random access memory
   e. None of these
5. **Which of the following is a temporary primary memory?**
   a. A PROM
   b. B.RAM
   c. C.EPROM
   d. D.ROM
   e. E. None of these
6. **Which of the following is used as a primary storage device?**
   a. Magnetic drum
   b. PROM
   c. Floppy disk

d. All of these
e. None of these

7. Which of the following memories not needs refresh?

a. SRAM
b. DRAM
c. ROM
d. All of above
e. None of these

8. The two kinds of main memory are:

a. Primary and secondary
b. Random and sequential
c. ROM and RAM
d. All of above
e. E. None of these

9. Magnetic disks are the most popular medium for

a. Direct access
b. Sequential access
c. Both of above
d. None of above
e. None of these

10. CD-ROM stands for

a. Compactable Read Only Memory
b. Compact Data Read Only Memory
c. Compactable Disk Read Only Memory
d. Compact Disk Read Only Memory
e. None of these

11. The term memory is often synonymous with the term primary storage or main memory

a. True
b. False

12. It is the main memory of the computer system that stores the data temporarily and allows the data to be accessed in any order.

a. True
b. False

REVIEW QUESTIONS

1. What are the types of memory?
2. What is cash memory?
3. Why is memory important or needed for a computer?
4. Differentiate between RAM memory and ROM memory.
5. Discuss the secondary storage device. Explain the types of secondary storage device.

Check Your Result

1. (b)	2. (d)	3. (b)	4. (d)	5. (b)	6. (b)
7. (a)	8. (c)	9. (c)	10. (d)	11. (a)	12. (a)

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CHAPTER 3

INPUT DEVICES AND OUTPUT DEVICES

LEARNING OBJECTIVES

After studying this chapter, you will be able to:

1. Discuss the basic concept of input devices for computer
2. Explain the computer - output devices

"A computer is a machine for constructing mappings from input to output."

– Michael Kirby

INTRODUCTION

An input/output device, often known as an IO device, is any hardware that allows a human operator or other systems to interface with a computer. Input/output devices, as the name implies, are capable of delivering data (output) to and receiving data from a computer (input).

An input/output (I/O) device is a piece of hardware that can take, output, or process data. It receives data as input and provides it to a computer, as well as sends computer data to storage media as a storage output.

In computing, input/output (I/O is the communication between an information processing system, such as a computer, and the outside world, possibly a human or another information processing system. Inputs are the signals or data received by the system and outputs are the signals or data sent from it. The term can also be used as part of an action; to "perform I/O" is to perform an input or output operation. I/O devices are the pieces of hardware used by a human (or other system) to communicate with a computer. For instance, a keyboard or computer mouse is an input device for a computer, while monitors and printers are output devices. Devices for communication between computers, such as modems and network cards, typically perform both input and output operations.

The designation of a device as either input or output depends on perspective. Mice and keyboards take physical movements that the human user outputs and convert them into input signals that a computer can understand; the output from these devices is the computer's input. Similarly, printers and monitors take signals that computers output as input, and they convert these signals into a representation that human users can understand. From the human user's perspective, the process of reading or seeing these representations is receiving output; this type of interaction between computers and humans is studied in the field of human–computer interaction. A further complication is that a device traditionally considered an input device, e.g., card reader, keyboard, may accept control commands to, e.g., select stacker, display keyboard lights, while a device traditionally considered as an output device may provide status data, e.g., low toner, out of paper, paper jam.

In computer architecture, the combination of the CPU and main memory, to which the CPU can read or write directly using individual instructions, is considered the brain of a computer. Any transfer of information to or from the CPU/memory combo, for example by reading data from a disk drive, is considered I/O. The CPU and its supporting circuitry may provide memory-mapped I/O that is used in low-level computer programming, such as in the implementation of device drivers, or may provide access to I/O channels. An I/O algorithm is one designed to exploit locality and perform efficiently when exchanging data with a secondary storage device, such as a disk drive.

3.1 BASIC CONCEPT OF INPUT DEVICES FOR COMPUTER

In computing, an input device is used to provide data and control signals to an information processing system such as a computer or information appliance.

Examples of input devices include keyboards, mouse, scanners, digital cameras and joysticks.

Input devices can be categorized based on:

- Modality of input (e.g. mechanical motion, audio, visual, etc.)
- whether the input is discrete (e.g. pressing of key) or continuous (e.g. a mouse's position, though digitized into a discrete quantity, is fast enough to be considered continuous)
- the number of degrees of freedom involved (e.g. two-dimensional traditional mice, or three-dimensional navigators designed for CAD applications)

Pointing devices, which are input devices used to specify a position in space, can further be classified according to:

- Whether the input is direct or indirect. With direct input, the input space coincides with the display space, i.e. pointing is done in the space where visual feedback or the pointer appears. Touchscreens and light pens involve direct input. Examples involving indirect input include the mouse and trackball.
- Whether the positional information is absolute (e.g. on a touch screen) or relative (e.g. with a mouse that can be lifted and repositioned)

Direct input is almost necessarily absolute, but indirect input may be either absolute or relative.

Digitizing graphics tablets that do not have an embedded screen involve indirect input and sense absolute positions and are often run in an absolute input mode, but they may also be set up to simulate a relative input mode like that of a touchpad, where the stylus or puck can be lifted and repositioned.

example

3.1.1 Keyboard

Keyboard is the most common and very popular input device which helps to input data to the computer. The layout of the keyboard is like that of traditional typewriter, although there are some additional keys provided for performing additional functions. Keyboards are of two sizes 84 keys or 101/102 keys, but now keyboards with 104 keys or 108 keys are also available for Windows and Internet.

The keys on the keyboard are as follows –

S. No	Keys & Description
1	**Typing Keys** These keys include the letter keys (A-Z) and digit keys (09) which generally give the same layout as that of typewriters.
2	**Numeric Keypad** It is used to enter the numeric data or cursor movement. Generally, it consists of a set of 17 keys that are laid out in the same configuration used by most adding machines and calculators.
3	**Function Keys** The twelve function keys are present on the keyboard which are arranged in a row at the top of the keyboard. Each function key has a unique meaning and is used for some specific purpose.
4	**Control keys** These keys provide cursor and screen control. It includes four directional arrow keys. Control keys also include Home, End, Insert, Delete, Page Up, Page Down, Control(Ctrl), Alternate(Alt), Escape(Esc).
5	**Special Purpose Keys** Keyboard also contains some special purpose keys such as Enter, Shift, Caps Lock, Num Lock, Space bar, Tab, and Print Screen.

Keyboard is used in the input phase of a computer-based information system. Keyboard is most common input device is used today. The data and instructions are input by typing on the keyboard. The message typed on the keyboard reaches the memory unit of a computer. It's connected to a computer via a cable. Apart from alphabet and numeral keys, it has other function keys for performing different functions.

REMEMBER

A computer that uses memory-mapped I/O accesses hardware by reading and writing to specific memory locations, using the same assembly language instructions that computer would normally use to access memory.

3.1.2 Mouse

Mouse is the most popular pointing device. It is a very famous cursor-control device having a small palm size box with a round ball at its base, which senses the movement of the mouse and sends corresponding signals to the CPU when the mouse buttons are pressed.

Generally, it has two buttons called the left and the right button and a wheel is present between the buttons.

Optical Mouse

An optical mouse uses camera technology and digital processing to compare and track the position of the mouse, rather than a ball and rollers used on older devices. This technology, first introduced by Agilent technologies in 1999, helps give users more precise performance without the maintenance and cleaning needed on older models.

Inside each optical mouse is a small camera that takes more than a thousand snapshot pictures every second. A small light-emitting diode (LED) provides light underneath the mouse, helping to highlight slight differences in the surface underneath it. Those differences are reflected back into the camera, where digital processing is used to compare the pictures and determine the speed and direction of movement. This differs from older-technology mice, in which a round ball rolled against a pad to indicate movement.

Optical mice have a number of benefits over older technologies. One of the biggest benefits is the elimination of the mouse ball, which frequently required cleaning to scrape accumulated grime off the ball or the rollers inside. As the optical model has no moving parts, almost no maintenance or regular cleaning is required. Another benefit is that digital processing often results in smoother, more accurate performance than prior technologies. These mice typically do not require a mouse pad and can be used on many surfaces, including those that are not entirely flat.

These pointing devices are becoming increasingly common today in both homes and businesses. As technology and competition evolved, prices have dropped to affordable levels, similar to ball-technology mice. There are typically no special PC requirements for optical mice and installation is usually as simply plugging the device in to the computer. A variety of options can be found for both Windows, Macintosh, and Linux platforms and are available with either PS/2 or USB plugs.

REMEMBER

A mouse can be used to control the position of the cursor on the screen, but it cannot be used to enter text into the computer.

Wireless Mouse

A wireless mouse is a computer mouse that needs no wires to send signals from the mouse to a computer. Over time, different technologies have led to the emergence of different types of wireless mice on the market. The cordless mouse offers obvious advantages over its tethered brethren, such as being able to point and click on a computer screen from across the room and run on multiple surfaces.

Wireless mouse technology predominantly uses radio frequencies (RF) to send signals from the mouse to the computer. Like other radio technologies, this requires a transmitter and a receiver. The mouse transmits radio signals to a receiver, which is itself connected to the computer hardware, normally via a wire. This kind of wireless mouse is very reliable, and capable of transmitting the mouse's movements to the receiver from across a room.

The emergence of Bluetooth wireless technology offers a different spin on RF wireless mice. Using short-length radio waves, this kind of wireless mouse transmits signals to a receiver. It does not change the basic RF technology, but it does allow for flexibility in set-up. With Bluetooth, the receiver does not have to be a housing unit connected to the computer by wire. For example, the transmitter can be a small USB plug-in. Or, with some PCs and laptops, the Bluetooth receiver is internally embedded in the hardware. This makes it easy for a user to sync up their computer with the wireless mouse, thus removing the extra clutter of an external transmitter. The range on a Bluetooth mouse is comparable to other RF computer mice, allowing one to point and click easily from across a standard-sized room.

In regard to the technology used to record movement, wireless mice are similar to corded mice. Mechanical, optical and laser mice are the three main types of both wireless and corded mice. Mechanical mice are the most traditional, and perhaps outdated, using tracking balls to detect movement. Tracking balls are generally less reliable than optical and laser mice, and typically need mouse pads to function accurately.

Optical wireless mice don't use tracking balls; instead the rely on optical light to detect movement. This allows the mouse to detect movement accurately on a variety of smooth, hard surfaces. Laser mice, which use laser light to calculate position and movement, are generally regarded as fast and accurate. Laser mice are particularly well-suited for wireless use, as they can detect movement accurately over the widest variety of surfaces, including something as convenient as a pant leg.

Wireless mice are well-suited for presentation settings. With a wireless mouse, a presenter can operate a Microsoft PowerPoint presentation from any point in a room. Wireless mice can also come equipped with laser pointers, for directing an audience's attention. Some wireless mice are also equipped with multiple buttons, such as play and stop controls, to run video and programs on a computer. Given their mobility and flexibility, wireless mice are also convenient for laptop use.

Advantages

- Easy to use
- Not very expensive
- Moves the cursor faster than the arrow keys of the keyboard.

3.1.3 Trackball

Track ball is an input device that is mostly used in notebook or laptop computer, instead of a mouse. This is a ball which is half inserted and by moving fingers on the ball, the pointer can be moved.

Since the whole device is not moved, a track ball requires less space than a mouse. A track ball comes in various shapes like a ball, a button, or a square.

A trackball is a specific style of computer mouse that allows the user to keep his hand and arm in one place, while manipulating a ball that moves the on-screen pointer. The computer mouse is a critical element to any home or office PC set up. The mouse provides the user a way to move the pointer on the computer screen to the desired location, as well as the means to select an object. Used in all applications from office software to gaming and web surfing, mouse comfort and ease of use is paramount.

REMEMBER

This reduces the arm and wrist movement previously required to maneuver the original style mouse and prevents the user from having to reposition the mouse frequently.

The traditional computer mouse is a "point and click" tool, where the user physically moves the mouse across a mouse pad, desktop, or other surface with either left or right hand until the pointer (or cursor) is at the correct position on the screen. Once there, the user clicks either the right or the left button to select the location and place the cursor. This type of navigation requires arm and wrist movement, and the location of the mouse assembly is variable.

The trackball mouse performs the same functions as the original style mouse, but instead of moving the entire mouse to position the cursor, a small, solid ball is located left of center or directly on the top of the mouse, which is used to navigate the cursor across the screen. Using this style of mouse allows the PC user to roll the ball with the thumb (or fingers or palm) and move the cursor to the desired location without moving the complete assembly.

In addition to the diminished need for arm movement while manipulating the mouse, the thumb controlled trackball offers greater accuracy in placing the cursor at the anticipated location. Unlike some conventional desktop computer mouse tools, it navigates smoothly and does not "jump" or stick on the mouse pad or desktop surface. Excellent for using when arm movement is constrained, the trackball does not need a mouse pad or smooth surface underneath it to operate efficiently, as it does not depend on contact with anything other than the user moving the ball itself.

Though not proven to prevent computer-related injuries, such as repetitive stress injuries, users with physical constraints may find this style of mouse a better choice than the conventional point and click tool. Prior to choosing a computer mouse, users should consider what applications are used most frequently, duration of use, space constraints and physical limitations.

REMEMBER

To compare conventional and trackball versions makes and models, a user should consult his local computer store or research online.

3.1.4 Joystick

Joystick is also a pointing device, which is used to move the cursor position on a monitor screen. It is a stick having a spherical ball at its both lower and upper ends. The lower spherical ball moves in a socket. The joystick can be moved in all four directions.

The function of the joystick is similar to that of a mouse. It is mainly used in Computer Aided Designing (CAD) and playing computer games.

A joystick is a type of gaming controller that may mimic the appearance of an aircraft flight stick. One typically consists of a stick, mounted on a base of some kind that can be articulated in two or three directions. One of the oldest control methods for video games, joysticks are prevalent on arcade machines and may also be available for home use. Most home video game systems have had a variety of joysticks available as optional peripherals, with older systems even using them as the primary controller. They are often sought out in situations where a game requires precise inputs and a great deal of control, such as in flight simulators or games in the fighting genre.

While the joystick is typically an analog input device, digital versions have also existed. An analog **joystick** typically works by transmitting an angle reading to a video game system or computer. This way, the device can detect where the stick is moved, along both x and y axes, at any time. Models with a z axis are also able to transmit this additional date along with the x and y positions.

Analog joysticks often have what may be known as gates. These are a part of the movement mechanism, and allow the user of the stick to easily lock it into four or eight different cardinal positions. While the movement remains analog, this may be useful to some people that use a joystick for fighting-type games. Round gates may also be available, and it is often possible to modify a joystick with a different style of gate according to personal preference.

Keyword

Joystick is an input device consisting of a stick that pivots on a base and reports its angle or direction to the device it is controlling.

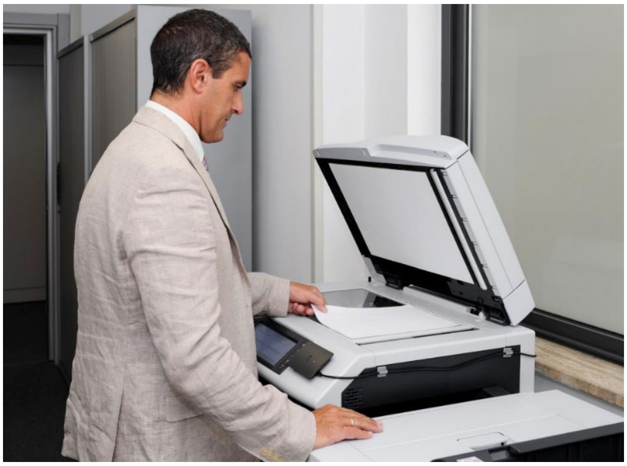
Digital joysticks operate in much the same way as the analog variety, though they are only capable of reporting that a movement has occurred, rather than the distance the stick was moved in that direction. These may still be capable of reporting in-between movements, such as an up-left movement, a down-right movement, or anything in between. They were commonly seen in many of the earliest home video game systems.

Many home computers may have a port that was originally designed specifically for a joystick connection. This port was later used for all kinds of game controllers, including console-like gamepads in addition to traditional joysticks. While most computers still have this port, modern joysticks may often be connected via universal serial bus (USB) or other ports, like IEEE 1394. Joysticks using these types of connections may include features like force feedback, with which the game can send a signal for the joystick to vibrate or resist movement.

3.1.5 Scanner

Scanner is an input device, which works more like a photocopy machine. It is used when some information is available on paper and it is to be transferred to the hard disk of the computer for further manipulation.

Scanner captures images from the source which are then converted into a digital form that can be stored on the disk. These images can be edited before they are printed.



A scanner is a device that captures images from photographic prints, posters, magazine pages, and similar sources for computer editing and display. Scanners come in hand-held, feed-in, and flatbed types and for scanning black-and-white only, or color. Very high resolution scanners are used for scanning for high-resolution printing, but lower resolution scanners are adequate for capturing images for computer display. Scanners usually come with software, such as Adobe's Photoshop product, that lets you resize and otherwise modify a captured image.

Scanners usually attach to your personal computer with a Small Computer System Interface (SCSI). An application such as PhotoShop uses the TWAIN program to read in the image. Some major manufacturers of scanners include: Epson, Hewlett-Packard, Microtek, and Relisys.

3.1.6 Optical Mark Recognition (OMR)

Short for Optical Mark Recognition, OMR is the process of gathering information from human beings by recognizing marks on a document. OMR is accomplished by using a hardware device (scanner) that detects a reflection or limited light transmittance on or through a piece of paper.

OMR allows for the processing of hundreds or thousands of documents per hour. *For example*, students may recall taking tests or surveys where they filled in bubbles on paper (shown right) with a pencil. Once the form had been completed, a teacher or teacher's assistant would feed the cards into a system that grades or gathers information from them.

Many traditional OMR devices work with a dedicated scanner device that shines a beam of light onto the form paper. The contrasting reflectivity at predetermined positions on a page is then used to detect these marked areas because they reflect less light than the blank areas of the paper.

Keyword

Processor is an integrated electronic circuit that performs the calculations that run a computer.

Some OMR devices use forms which are preprinted onto 'transoptic' paper and measure the amount of light which passes through the paper, thus a mark on either side of the paper will reduce the amount of light passing through the paper.

In contrast to the dedicated OMR device, desktop OMR software allows a user to create their own forms in a word **processor** and print them on a laser printer. The OMR software then works with a common desktop image scanner with a document feeder to process the forms once filled out.

OMR is generally distinguished from optical character recognition (OCR) by the fact that a complicated pattern recognition engine is not required. That is, the marks are constructed in such a way that there is little chance of not reading the marks correctly. This does require the image to have high contrast and an easily recognizable or irrelevant shape. A related field to OMR and OCR is the recognition of barcodes such as the UPC bar code found on product packaging.

One of the most familiar applications of optical mark recognition is the use of #2 pencil (HB in Europe) bubble optical answer sheets in multiple choice question examinations. Students mark their answers, or other personal information, by darkening circles marked on a pre-printed sheet. Afterwards the sheet is automatically graded by a scanning machine. In the United States and most European countries, a horizontal or vertical 'tick' in a rectangular 'lozenge' is the most commonly used type of OMR form, the most familiar application being the UK National lottery form. Lozenge marks are a later technology and have the advantage of being easier to mark and easier to erase. The large 'bubble' marks are legacy technology from the very early OMR machines that were so insensitive a large mark was required for reliability. In most Asian countries, a special marker is used to fill in an optical answer sheet. Students, likewise mark answers or other information via darkening circles marked on a pre-printed sheet. Then the sheet is automatically graded by a scanning machine.

Many of today's OMR applications involve people filling in specialized forms. These forms are optimized for computer scanning, with careful registration in the printing, and careful design so that ambiguity is reduced to the minimum possible. Due to its extremely low error rate, low cost and ease-of-use, OMR is a popular method of tallying votes.

OMR marks are also added to items of physical mail so folder inserter equipment can be used. The marks are added to each (normally facing/odd) page of a mail document and consist of a sequence of black dashes that folder inserter equipment scans in order to determine when the mail should be folded then inserted in an envelope.

3.1.7 Bar-Code reader

Bar Code Reader is a device used for reading bar coded data (data in the form of light and dark lines). Bar coded data is generally used in labelling goods, numbering the books, etc. It may be a handheld scanner or may be embedded in a stationary scanner.

Keyword

Optical mark recognition is the process of capturing human-marked data from document forms such as surveys and tests.

Bar Code Reader scans a bar code image, converts it into an alphanumeric value, which is then fed to the computer that the bar code reader is connected to.

Barcodes consisting of black lines with spaces between them are often used to keep track of inventory and simplify other aspects of running certain businesses, especially grocery stores and other places where complex tracking is necessary. A barcode reader provides a quick way to translate the codes, and using one requires very little effort on the part of workers. Barcodes represent numbers that can be linked to items in a database, and the readers have an ability to measure light reflections, allowing them to pick up the barcodes off the surfaces of packaging. Most barcode readers are shaped either like a gun or a pen, but some are set up in fixed positions.

Prior to the invention of barcodes and the barcode reader, grocery stores and other kinds of shops had much more difficulty keeping track of inventory, relying more heavily on manual methods. Knowing exactly how many items are available in a store is often crucial for retailers because it allows them to keep a tally of how well things are selling and simplifies the process of making decisions about quantity when making another order. Typically, a barcode reader is set up at each cash register, connected to a computerized database with information on all the items in the store. When the clerk scans items during a purchase, the system registers the sold item in the database, keeping a real-time inventory estimate.

Keyword

Barcode reader is an electronic device that can read and output printed barcodes to a computer.

Barcodes are always made up of black lines because of the way readers work. Since black surfaces are typically known to absorb more light and brighter surfaces are more reflective, bouncing light off a barcode generates a simple pattern of spaces and lines that can be registered with relatively simple equipment. The actual technology used in barcode readers has changed over time, including the use of lasers, light emitting diodes (LEDs), and even actual cameras with the ability to pick up codes from a greater distance or read multiple codes simultaneously.

The form factor for a **barcode reader** is often dependent on its use. Many are designed so that clerks and other operators can maneuver them for easier access to barcodes, and these are often shaped a lot like guns or pens. Others are set up so that they remain stationary and the barcode is moved into a position where the scanner can read it, including the kind that are set up inside the conveyer belt tables in some grocery stores.

3.1.8 MICR Digitizer

MICR input device is generally used in banks as there are large number of cheques to be processed every day. The bank’s code number and cheque number are printed on the cheques with a special type of ink that contains particles of magnetic material that are machine readable.

This reading process is called Magnetic Ink Character Recognition (MICR). The main advantages of MICR is that it is fast and less error prone.

Digitizer

Digitizer is an input device which converts analog information into digital form. Digitizer can convert a signal from the television or camera into a series of numbers that could be stored in a computer. They can be used by the computer to create a picture of whatever the camera had been pointed at. Digitizer is also known as Tablet or Graphics Tablet because it converts graphics and pictorial data into binary inputs. A graphic tablet as digitizer is used for doing fine works of drawing and image manipulation applications.

Microphone

Microphone is an input device to input sound that is then stored in digital form. The microphone is used for various applications like adding sound to a multimedia presentation or for mixing music.

Optical Character Reader (OCR)

OCR is an input device used to read a printed text. OCR scans the text optically, character by character, converts them into a machine readable code, and stores the text on the system memory.

3.1.9 Card Reader

A card reader is a data input device that reads data from a card-shaped storage medium. The first were punched card readers, which read the paper or cardboard punched cards that were used during the first several decades of the computer industry to store information and programs for computer systems. Modern card readers are electronic devices that can read plastic cards embedded with either a barcode, magnetic strip, computer chip or another storage medium.

A memory card reader is a device used for communication with a smart card or a memory card. A magnetic card reader is a device used to read magnetic stripe cards, such as credit cards. A business card reader is a device used to scan and electronically save printed business cards

Light Pen

Light pen is a pointing device similar to a pen. It is used to select a displayed menu item or draw pictures on the monitor screen. It consists of a photocell and an optical system placed in a small tube.

When the tip of a light pen is moved over the monitor screen and the pen button is pressed, its photocell sensing element detects the screen location and sends the corresponding signal to the CPU.

3.1.10 Video Cameras

A video camera is a camera used for electronic motion picture acquisition (as opposed to a movie camera, which records images on film), initially developed for the television industry but now common in other applications as well.

The earliest video cameras were those of John Logie Baird, based on the mechanical Nipkow disk and used in experimental broadcasts through the 1918s-1930s. All-electronic designs based on the video camera tube, such as Vladimir Zworykin's Iconoscope and Philo Farnsworth's image dissector, supplanted the Baird system by the 1930. These remained in wide use until the 1980s, when cameras based on solid-state image sensors such as CCDs (and later CMOS active pixel sensors) eliminated common problems with tube technologies such as image burn-in and made digital video workflow practical. The transition to digital TV gave a boost to digital video cameras and by the 2010s, most video cameras were digital.

With the advent of digital video capture, the distinction between professional video cameras and movie cameras has disappeared as the intermittent mechanism has become the same. Nowadays, mid-range cameras exclusively used for television and other work (except movies) are termed professional video cameras.

Video cameras are used primarily in two modes. The first, characteristic of much early broadcasting, is live television, where the camera feeds real time images directly to a screen for immediate observation. A few cameras still serve live television production, but most live connections are for security, military/tactical, and industrial operations where surreptitious or remote viewing is required. In the second mode the images are recorded to a storage device for archiving or further processing; for many years, videotape was the primary format used for this purpose, but was gradually supplanted by optical disc, hard disk, and then flash memory. Recorded video is used in television production, and more often surveillance and monitoring tasks in which unattended recording of a situation is required for later analysis.

3.2 COMPUTER - OUTPUT DEVICES

An output device is any piece of computer hardware item which utilizes whatever data and commands from your computer in order to perform a task. This leads to the results of data processing carried out by an information processing system (such as a computer) which converts the electronically generated information into human-readable form.

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

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

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

Computers can even communicate with users through the sense of touch. Refreshable Braille displays, or Braille terminals, allow computers to send information by way of raised dots that are "read" with the fingertips. Force feedback devices, or haptic devices, are sometimes built into joysticks and mice so that users can feel vibrations and pressure. Tactile output devices are less common than many other types, but can still be extremely important to users.

Rarely, output devices can also be input devices. A storage device such as a CD-RW drive is an excellent example of this. The computer uses it as an output device when it is writing information to a CD-ROM or other media that can be read by other computers. However, the computer uses it as an input device when reading information from a CD-ROM or other piece of storage media that has data written on it from another system.

3.2.1 Monitors

The monitor is the piece of computer hardware that displays the video and graphics information generated by the computer through the video card. Monitors are very similar to televisions but usually display information at a much higher resolution. Also unlike televisions, monitors are not usually mounted on a wall but instead sit atop a desk.

There are two kinds of viewing screen used for monitors.

- Cathode-Ray Tube (CRT)
- Flat-Panel Display

Cathode-Ray Tube (CRT) Monitor

A cathode ray tube (CRT) is a type of analog display device. It is a special, electronic vacuum tube that uses a focused electron beam to display images. Though tubes of this type are used for many purposes, CRTs are most famous for their use in such things as televisions, oscilloscopes, computer and radar displays, and automated teller machines. They are also used in video game equipment.

A cathode or negatively charged terminal in a cathode ray tube is a heated filament, much like the filament seen in a light bulb. The filament is contained inside a vacuum within a glass tube. Inside the tube, a beam of electrons is allowed to flow from the filament into the vacuum. The flow of the electrons is natural, not forced.

When used inside a television set, a CRT's electrons are concentrated into a tight beam by a positively charged terminal, called an anode. An accelerating anode is then used to speed up the movement of the electrons. These fast-moving electrons fly through the tube's vacuum, hitting the phosphor-coated screen and making it glow.

A German physicist named Karl Ferdinand Braun is credited with inventing the cathode ray tube in 1897. His invention consisted of a tube with a fluorescent screen. This new technology was called a cathode ray oscilloscope. The screen of this tube would display a light when a beam of electrons touched it. Braun's cathode ray oscilloscope is considered the predecessor of modern tubes used in television sets.

In 1929, Vladimir Kosma Zworykin created another type of CRT. Called the kinescope, it was designed for used with some of the earliest televisions. Two years later, Allen B. Du Mont introduced the first tube that was considered practical for use in a television set. It was also more durable than some of the previously introduced CRTs.

The cathode ray tube still plays a major part in television sets and many other electronic devices. However, there have been many new developments in display technology, such as plasma screens, liquid crystal display televisions (LCD TVs), and digital light processing (DLP) devices. Organic light-emitting diode (OLED) displays are also used to produce images. Still, the CRT maintains its popularity in television systems, as evidenced by the fact that the television is frequently referred to as "the tube."

The CRT display is made up of small picture elements called pixels. The smaller the pixels, the better the image clarity or resolution. It takes more than one illuminated pixel to form a whole character, such as the letter 'e' in the word help.

A finite number of characters can be displayed on a screen at once. The screen can be divided into a series of character boxes - fixed location on the screen where a standard character can be placed. Most screens are capable of displaying 80 characters of data horizontally and 25 lines vertically.

There are some disadvantages of CRT –

- Large in Size
- High power consumption

Features of CRT Monitors

CRT (cathode ray tube) monitors used to be the primary devices for computer use. Within the last decade or so, the majority of daily computer users have upgraded to LCD monitors, and manufacturers have slowly ceased production of CRTs. Although the use of CRT technology has quickly declined since the introduction of LCDs, CRTs are still unbeatable in certain ways.

Physical Size

The most obvious feature of the CRT monitor is its large size. This is an unavoidable attribute of all CRT monitors, due to the limitations of the technology they use. Along with its large size comes heavy weight, according to PC Tech Guide. This is mainly due to the glass used both on the surface of the screen and inside of the monitor itself. Flat-panel LCDs of the same screen size can be a fraction of the weight.

Keyword

Cathode ray tube is a vacuum tube that contains one or more electron guns and a phosphorescent screen, and is used to display images.

Flat-Panel Display Monitor

A flat panel monitor can refer to either a computer or television monitor that does not use **cathode ray tube** (CRT) technology, but commonly LCD or plasma technology. This allows the monitor to have a thin profile, which is how the monitor gets its name. Because of its light weight, small footprint, clarity and digital technology, it has become the monitor of choice.

Prior to the flat panel monitor, the CRT monitor was standard. These monitors are easily recognizable by the bulging back or picture tube. Vacuum tube monitors are not only bulky and heavy, but they are environmentally unfriendly and emit more radiation than LCD or plasma monitors.

While there are many advantages to a flat panel monitor, there are also one or two potential disadvantages. A limited viewing angle can be one, although this is easily avoided by shopping carefully, as the viewing range is included in the specifications of these products. A second potential disadvantage is being bound to the "native resolution."

A CRT monitor will display sharp text in any supported resolution, but a flat panel only delivers perfectly clear text in the native resolution. On a 19-inch screen this might be 1280 x 1024 pixels. Switching to a lower resolution will make text appear slightly blurred or fuzzy.

Why would anyone want to switch to a lower resolution? In higher resolutions, images improve but they also become smaller.

For instance, the icons on a desktop, toolbars within software, and menus within the operating system are all reduced at higher resolutions. Though many of these items can be adjusted up, some people prefer a lower resolution to get overall larger images on screen. This might be a particular concern for those with visual disabilities.

REMEMBER

One should carefully view the flat panel monitor prior to purchase to be sure the native resolution will be comfortable.

Flat panel monitors have decreased steadily in price while improving in quality. Gamers and video-editing professionals tended to avoid these monitors initially because of "ghosting" with fast moving graphics, but this is no longer an issue. A faster response time and increased viewing angle have made them more popular than ever. With its clear digital picture, space-saving footprint, and ultra-light weight, the flat panel is a welcome improvement over its CRT predecessor.

The flat-panel display refers to a class of video devices that have reduced volume, weight and power requirement in comparison to the CRT. You can hang them on walls or wear them on your wrists. Current uses of flat-panel displays include calculators, video games, monitors, laptop computer, and graphics display.

The flat-panel display is divided into two categories –

- *Emissive Displays* – Emissive displays are devices that convert electrical energy into light. For example, plasma panel and LED (Light-Emitting Diodes).
- *Non-Emissive Displays* – Non-emissive displays use optical effects to convert sunlight or light from some other source into graphics patterns. For example, LCD (Liquid-Crystal Device).

3.2.2 Other Names of a Monitor

A monitor is sometimes referred to as a screen, display, video display, video display terminal, video display unit, or video screen.

A monitor is sometimes incorrectly referred to as the computer, as in the hardware within the computer case, like the hard drive, video card, etc. *For example*, shutting down the computer is not the same thing as turning off the monitor. It's important for that distinction to be made.

Important Monitor Facts

A monitor, no matter the type, usually connects to either an HDMI, DVI, or VGA port. Other connectors include USB, DisplayPort, and Thunderbolt. Before investing in a new monitor, make sure that both devices support the same type of connection.

For example, you do not want to buy a monitor that has only an HDMI port when your computer is only capable of accepting a VGA connection. Although most video cards and monitors have multiple ports so as to work with various kinds of both devices, it's still important to check their compatibility. Monitors are not typically user serviceable. For your safety, it's not usually wise to open and work on a monitor.

Monitor Description

Monitors are display devices external to the computer case and connect via a cable to a port on the video card or motherboard. Even though the monitor sits outside the main computer housing, it is an essential part of the complete system.

Monitors come in two major types - LCD or CRT. CRT monitors look much like old-fashioned televisions and are very deep in size. LCD monitors are much thinner, use less energy, and provide a greater graphics quality.

LCD monitors have completely obsoleted CRT monitors due to their higher quality, smaller "footprint" on the desk, and decreasing price.

Most monitors are in a widescreen format and range in size from 17" to 24" or more. This size is a diagonal measurement from one corner of the screen to the other.

Monitors are built-in as part of the computer system in laptops, tablets, netbooks, and all-in-one desktop machines. However, you can buy one separately if you are looking to upgrade from your current monitor.

Although monitors are considered output devices since they usually only serve the purpose of outputting information to the screen, some of them are touch screens as well. This type of monitor is considered both an input and output device, which is usually called an *input/output device*, or an I/O device.

3.2.3 Printers

A printer is a peripheral which makes a persistent human-readable representation of graphics or text on paper or similar physical media. The first computer printer design was a mechanically driven apparatus by Charles Babbage for his difference engine in the 19th century; his mechanical printer design was not built until 2000. The first electronic printer was the EP-101, invented by Japanese company Epson and released in 1968. The first commercial printers generally used mechanisms from electric typewriters and Teletype machines. The demand for higher speed led to the development of new systems specifically for computer use. In the 1980s were daisy wheel systems similar to typewriters, line printers that produced similar output but at much higher speed, and dot matrix systems that could mix text and graphics but produced relatively low-quality output. The plotter was used for those requiring high quality line art like blueprints.

Printer is an output device, which is used to print information on paper.

There are two types of printers –

- Impact Printers
- Non-Impact Printers

Impact Printers

Impact printers print the characters by striking them on the ribbon, which is then pressed on the paper.

Characteristics of Impact Printers are the following –

- Very low consumable costs
- Very noisy
- Useful for bulk printing due to low cost
- There is physical contact with the paper to produce an image

These printers are of two types –

- Character printers
- Line printers

Character Printers

Character printers are the printers which print one character at a time.

These are further divided into two types:

- Dot Matrix Printer(DMP)
- Daisy Wheel

Non-impact Printers

Non-impact printers print the characters without using the ribbon. These printers print a complete page at a time, thus they are also called as Page Printers.

These printers are of two types –

- Laser Printers
- Inkjet Printers

Characteristics of Non-impact Printers

- Faster than impact printers
- They are not noisy
- High quality
- Supports many fonts and different character size

Laser Printers

These are non-impact page printers. They use laser lights to produce the dots needed to form the characters to be printed on a page.

Advantages

- Very high speed
- Very high quality output
- Good graphics quality
- Supports many fonts and different character size

Disadvantages

- Expensive
- Cannot be used to produce multiple copies of a document in a single printing

3.2.4 Dot Matrix Printer

In the market, one of the most popular printers is Dot Matrix Printer. These printers are popular because of their ease of printing and economical price. Each character printed is in the form of pattern of dots and head consists of a Matrix of Pins of size (5*7, 7*9, 9*7 or 9*9) which come out to form a character which is why it is called Dot Matrix Printer.

Advantages

- Inexpensive
- Widely Used

- Other language characters can be printed

Disadvantages

- Slow Speed
- Poor Quality

Daisy Wheel

Head is lying on a wheel and pins corresponding to characters are like petals of Daisy (flower) which is why it is called Daisy Wheel Printer. These printers are generally used for word-processing in offices that require a few letters to be sent here and there with very nice quality.

Advantages

- More reliable than DMP
- Better quality
- Fonts of character can be easily changed

Disadvantages

- Slower than DMP
- Noisy
- More expensive than DMP

3.2.5 Line Printers

Line printers are the printers which print one line at a time.

These are of two types –

- Drum Printer
- Chain Printer

Drum Printer

This printer is like a drum in shape hence it is called drum printer. The surface of the drum is divided into a number of tracks. Total tracks are equal to the size of the paper, i.e. for a paper width of 132 characters, drum will have 132 tracks. A character set is embossed on the track. Different character sets available in the market are 48 character set, 64 and 96 characters set. One rotation of drum prints one line. Drum printers are fast in speed and can print 300 to 2000 lines per minute.

Advantages

- Very high speed

Disadvantages

- Very expensive
- Characters fonts cannot be changed

Chain Printer

In this printer, a chain of character sets is used, hence it is called Chain Printer. A standard character set may have 48, 64, or 96 characters.

REMEMBER

The computer will be of no use unless it is able to communicate with the outside world. Input/ Output devices are required for users to communicate with the computer.

Advantages

- Character fonts can easily be changed.
- Different languages can be used with the same printer.

Disadvantages

- Noisy

3.2.6 Inkjet Printers

Inkjet printers are non-impact character printers based on a relatively new technology. They print characters by spraying small drops of ink onto paper. Inkjet printers produce high quality output with presentable features.

They make less noise because no hammering is done and these have many styles of printing modes available. Color printing is also possible. Some models of Inkjet printers can produce multiple copies of printing also.

Advantages

- High quality printing

- More reliable

Disadvantages

- Expensive as the cost per page is high
- Slow as compared to laser printer

SUMMARY

- An input/output device, often known as an IO device, is any hardware that allows a human operator or other systems to interface with a computer.
- In computing, input/output (I/O is the communication between an information processing system, such as a computer, and the outside world, possibly a human or another information processing system.
- A wireless mouse is a computer mouse that needs no wires to send signals from the mouse to a computer.
- A trackball is a specific style of computer mouse that allows the user to keep his hand and arm in one place, while manipulating a ball that moves the on-screen pointer.
- Joystick is also a pointing device, which is used to move the cursor position on a monitor screen. It is a stick having a spherical ball at its both lower and upper ends.
- Scanner is an input device, which works more like a photocopy machine. It is used when some information is available on paper and it is to be transferred to the hard disk of the computer for further manipulation
- OMR is the process of gathering information from human beings by recognizing marks on a document.
- Bar Code Reader is a device used for reading bar coded data (data in the form of light and dark lines). Bar coded data is generally used in labelling goods, numbering the books, etc.
- MICR input device is generally used in banks as there are large number of cheques to be processed every day.
- Digitizer is an input device which converts analog information into digital form. Digitizer can convert a signal from the television or camera into a series of numbers that could be stored in a computer.
- Microphone is an input device to input sound that is then stored in digital form. The microphone is used for various applications like adding sound to a multimedia presentation or for mixing music.
- A monitor is sometimes referred to as a screen, display, video display, video display terminal, video display unit, or video screen.
- A printer is a peripheral which makes a persistent human-readable representation of graphics or text on paper or similar physical media.
- In the market, one of the most popular printers is Dot Matrix Printer. These printers are popular because of their ease of printing and economical price.

KNOWLEDGE CHECK

1. **The most widely used input device is the ____**
   a. Mouse
   b. Keyboard
   c. Modem
   d. Monitor
2. **The term used to define all input and output devices in a computer system is ____**
   a. Monitor
   b. Software
   c. Shared resources
   d. Hardware
3. **Information that comes from an external source and is fed into computer software is called ____**
   a. Input
   b. Output
   c. Throughput
   d. Reports
4. **The most common method of entering text and numerical data into a computer system is through the use of a ____**
   a. Plotter
   b. Scanner
   c. Printer
   d. Keyboard
5. **Which of the following is not an output device?**
   a. Plotter
   b. Printer
   c. Scanner
   d. Monitor
6. **Devices that let the computer communicate with you.**
   a. Input
   b. Output
   c. Type
   d. Print

7. Devices that allow you to put information into the computer.

a. Input

b. Output

c. Type

d. Print

8. Which of the following is not an example of hardware?

a. Scanner

b. Printer

c. Monitor

d. Interpreter

9. Using output devices one can ____

a. Input data

b. Store data

c. Scan data

d. View or print data

10. The wheel located between the two standard buttons on a mouse is used to ____

a. Click on web pages

b. Shutdown

c. Click and select items

d. Scroll

11. The small element at the base of a mouse is called _________.

a. Roller

b. Ball Pin

c. TrackBall

d. RollerBall

12. An input/output (I/O) device is a piece of hardware that can take, output, or process data.

a. True

b. False

REVIEW QUESTIONS

1. Discuss about keyboard, mouse and trackball
2. What do you mean by joystick and scanner?
3. Focus on optical mark recognition (OMR) and bar-code reader.
4. What are Monitors? Explain the cathode-ray tube (CRT) monitor.
5. What do you understand by printers? Explain dot matrix printer.

Check Your Result

1. (b)	2. (d)	3. (a)	4. (d)	5. (c)	6. (b)
7. (a)	8. (d)	9. (d)	10. (d)	11. (c)	12. (a)

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CHAPTER 4

MULTIMEDIA

LEARNING OBJECTIVES

After studying this chapter, you will be able to:

1. Understand basics of multimedia
2. Explain the basic elements of multimedia
3. Identify the types of multimedia
4. Discuss about stages of production in multimedia

"Multimedia is not more media, but the employment of various kinds of media (and hybrid media) for what they each offer to advance the narrative."

– Fred Ritchin

INTRODUCTION

Multimedia is a form of communication that combines different content forms such as text, audio, images, animations, or video into a single interactive presentation, in contrast to traditional mass media which featured little to no interaction from users, such as printed material or audio recordings. Popular examples of multimedia include video podcasts, audio slideshows and animated videos. Multimedia can be recorded for playback on computers, laptops, smartphones, and other electronic devices, either on demand or in real time (streaming). In the early years of multimedia, the term "rich media" was synonymous with interactive multimedia. Over time, hypermedia extensions brought multimedia to the World Wide Web.

Multimedia is the term used to describe two or more types of media combined into a single package—usually denoting a combination of some or all of the following: video, sound, animation, text, and pictures. Multimedia gives the user the opportunity to influence the presentation of material. The selection and manipulation of various aspects of the presentation material is the interactive aspect of a multimedia presentation. Interactive features could range from a question-and-answer function to choosing from a menu of particular subjects or aspects of a presentation. One application of multimedia, for example, involves presenting the user with a "what if" scenario, in which the choices the user makes affect the outcome of the presentation. This affords the user a degree of control, not unlike directing a motion picture and having the opportunity to make changes to the plot at various junctures.

4.1 BASICS OF MULTIMEDIA

Multimedia is the media that uses multiple forms of information content and information processing (e.g. text, audio, graphics, animation, and video, interactivity) to inform or entertain the user. Multimedia also refers to the use of electronic media to store and experience multimedia content. Multimedia is similar to traditional mixed media in fine art, but with a broader scope. The term "rich media" is synonymous for interactive Multimedia.

4.1.1 History of Multimedia

A traditional way of thinking through something that is new is to recover its histories. The histories of multimedia are still being negotiated and include the histories of different media, the history of computing, and the history of the critical theories applied to multimedia. One history of multimedia is the history of the personal computer as it evolved from an institutional machine designed for numerical processing to a multimedia personal computer that most of us can afford. The modern computer as it emerged after World War II is a general-purpose machine that can be adapted to new purposes through programming and peripherals. The history of the computer since the ENIAC (1946) can be seen as the working out of this idea in different ways, including the techniques for managing different media. While the first computers were designed solely to do scientific and applied numerical calculations, they were eventually extended to handle alphanumeric strings (text), raster and **vector graphics**, audio, moving pictures (video and animation), and finally, three-dimensional objects and space. Today's personal computer can handle all these media with the appropriate peripherals, making multimedia development and consumption available to the home user.

Keyword

Vector graphics is the creation of digital images through a sequence of commands or mathematical statements that place lines and shapes in a given two-dimensional or three-dimensional space.

Numbers and Text

If the first computers were designed for number crunching and data processing for military, scientific, and then business applications, they soon became adapted to text editing or the manipulation of alphanumeric strings. The first commercial word processor was the IBM MT/ST (magnetic tape / Selectric typewriter), which was marketed by IBM as a "word processor" and released in 1964. It stored text on a tape for editing and reprinting through a Selectric typewriter. A word processor, as opposed to a text editor, was meant for producing rhetorical documents while text editors were for programming and interacting with the system. By the late 1970s, personal computers had primitive word processing programs that allowed one to enter, edit, and print documents. MicroPro International's WordStar (1979) was one of the first commercially successful word processing programs for a personal computer, expanding the media that could be handled by a home user from numbers to text.

Images

Keyword

Adobe Photoshop is a raster graphics editor developed and published by Adobe Systems for macOS and Windows.

The next step was access to graphics on a personal computer, a development that came with the release of the Apple Macintosh in 1984. The Macintosh (Mac), which made innovations from the Xerox Palo Alto Research Center accessible on a commercially successful personal computer, was designed from the start to handle graphics. It came bundled with a "paint" program, MacPaint, and a mouse for painting and interacting with the graphical user interface (GUI). While it was not the first computer with graphical capabilities, it was the first widely available computer with standard graphical capabilities built-in so that anyone could paint simple images, edit them, print them or integrate them into other documents like word processing documents created with Mac-Write, a WYSIWIG (what-you-see-is-what-you-get) word processor also bundled with the early Macs.

Desktop Publishing

In 1986, the capabilities of the Macintosh were extended with the release of the Mac Plus, Aldus PageMaker and the PostScript capable Apple LaserWriter. The combination of these three technologies made "desktop publishing" accessible on the personal computer where before it had been limited to very expensive specialized systems. While MacPaint was a playful tool that could not compete with commercial graphics systems, a designer outfitted with PageMaker and a LaserWriter could compete with professional designers working on dedicated typesetting systems for low-end, monochrome publishing jobs like manuals and newsletters. It was not long before a color-capable Macintosh was released (the Mac II), which, when combined with image-editing software like **Adobe PhotoShop**, helped the Mac replace dedicated systems as the industry standard for graphic design and publishing. Now, just about any publication, from newspapers to glossy annual reports, is created, edited, and proofed on personal computer systems. The only components still beyond the budget of the home user are the high-resolution digital cameras, scanners, and printers necessary to produce top-quality publications. But even these components are slowly moving into the reach of everyday computer users.

Desktop publishing is the precursor to multimedia, even though desktop publishing aims at rhetorical artifacts that are not viewed on a computer. Computer-aided graphic design and desktop publishing are arts that use computers instead of traditional technologies to produce rhetorical artifacts that combine media, such as text and images. The challenge of combining two media, each with different creative and interpretative traditions, predates desktop publishing – designers before the computer struggled to design the word and image. What was new, however, was that the personal computer user now had the opportunity to experiment with the design and placement of content in two-dimensional space. The initial result was a proliferation of horrid, over-designed newsletters and posters that frequently exhibited unrestrained use of fonts and visual styles.

Authoring Environments

Further, the desktop publishing tools were themselves multimedia environments that provided for the direct manipulation of images and text. Desktop publishing was a precursor to multimedia; desktop publishers typically spent most of their time viewing the for-print documents they manipulated on the interactive screen, not on paper. Graphic designers comfortable with design for print (but on a screen) were ready when the first authoring tools became available for the design of screen-based media. They knew how to work with images and text in the two-dimensional screen space and were competent with the graphics tools needed to lay out and create computer graphics. When Apple released HyperCard in 1987, the graphics community was positioned to take advantage of their new skills in screen-based design. HyperCard, developed by the creator of MacPaint (Andy Hertzfield), was an immediate success, especially since it came free with every Macintosh and allowed multimedia authors to distribute HyperCard stacks without licensing costs to other Macintosh users. Given the high penetration of Macs in schools, it is not surprising that within a year of the release of HyperCard there were thousands of simple educational multimedia works that combined text, images, simple animations, and simple interactivity.

REMEMBER

Multimedia authoring tools provide the important framework you need for organizing and editing the elements of multimedia like graphics, sounds, animations and video clips.

Authoring environments like HyperCard are important to the growth of multimedia as they were easier to learn than the programming languages needed previously to create multimedia, and they were designed specifically for the combination of media into interactive works. HyperCard, as its name suggests, was inspired by hypertext theory. The metaphor of HyperCard was that authors created a stack of cards (nodes of information), which could have text, graphics, and buttons on them. The buttons were the hypertext links to other cards. HyperCard had a scripting language with which one could create more complex behaviors or add extensions to control other media devices like audio CDs and videodisk players. One of the most popular computer games of its time, *Myst* (1993), was first developed on HyperCard. The card stack metaphor was quickly imitated by Asymetrix ToolBook, one of the more popular multimedia authoring environments for the IBM PC. ToolBook's metaphor was a book of pages with text, graphics, and buttons and it added color capability.

Today, the most popular authoring environments other than HTML editors such as Dreamweaver and GoLive are tools like Macromedia Director and Macromedia Flash. Both Director and Flash use a cell and timeline metaphor that evolved out of animation environments. Flash is used extensively to add animations and interactive components to websites while Director is used for more complex projects that are typically delivered on a CD-ROM. The Flash file format (SWF) has been published so that other tools can manipulate SWF.

Sound

The Macintosh also incorporated sound manipulation as a standard feature. The first Macs released in the mid-1980s had built-in sound capabilities beyond a speaker for beeps. The 128K Mac had 8-bit mono sound output capability. By 1990, Apple was bundling microphones with standard Macs. HyperCard could handle audio, though it could not edit it. The standard Macintosh thus had simple audio capabilities suitable for interactive multimedia. With the addition of Musical Instrument Digital Interface (MIDI) controllers and software, Macintoshes became popular in the electronic music community along with the now discontinued Atari ST (1985), which came with a built in MIDI port.

One of the first multimedia works to make extensive use of audio was Robert Winter's interactive Beethoven's *Ninth Symphony.* This 1989 work came with HyperCard stacks on floppy disk, which could control a commercial audio CD of Beethoven's *Ninth Symphony.* The user could navigate the audio and read critical notes that were synchronized to the symphony.

Digital Video

The latest media threshold to be overcome in affordable personal computers is digital video. The challenge of multimedia is to combine not just asynchronous media like text and images, neither of which need to be played over time, but also time-dependent media like audio, animation, and video. Video puts the greatest stress on computer systems because of the demands of accessing, processing, and outputting the 29.97 frames-per-second typical of television-quality video. Only recently, with the introduction of computers with Fire Wire or IEEE-1394 ports, has it become easy to shoot video, download it to the personal computer for editing, and transfer it back to tape, CD, or DVD, or even to stream it over the Internet. Given the challenge of integrating video, there have been some interesting hybrid solutions. One of the first multimedia works, the *Aspen Movie Map* (1978), by Andrew Lippman (and others) from what is now called the MIT Media Lab, combined photographs on a videodisk with computer control so that the user could wander through Aspen, going up and down streets in different seasons. With the release of digital video standards like MPEG (MPEG-1 in 1989, MPEG-2 in 1991) and Apple QuickTime (1991), it became possible to manage video entirely in digital form. An early published work that took advantage of QuickTime was the Voyager CD-ROM of the Beatles' *A Hard Day's Night* (1993). This was built around a digital video version of the innovative Beatles' music movie. It is now common for multimedia works to include low-resolution digital video elements.

REMEMBER

The use of computers to present text, graphics, video, animation, and sound in an integrated way. Long touted as the future revolution in computing, multimedia applications were, until the mid-90s, uncommon due to the expensive hardware required.

Virtual Space and Beyond

Current multimedia systems present the user with a two-dimensional graphical user interface. While such systems can manipulate three-dimensional information (3-D), they do not typically have the 3-D input and output devices associated with virtual reality (VR) systems. Is VR the next step in the evolution of the multimedia computer and user interface? In the 1990s it seemed that cyberspace, as described by William Gibson in *Neuromancer* (1984), was the next frontier for multimedia computing. Gibson's vision was implemented in systems that combine head-tracking systems, data gloves, and 3-D goggles to provide an immersive experience of a virtual space. The metaphor for computing would no longer be the desktop, but would be virtual spaces filled with avatars representing people and 3-D objects. The relationship between user and computer would go from one of direct manipulation of iconographic representations to immersion in a simulated world. Space and structure were the final frontier of multimedia.

Keyword

Personal digital assistant is a term for a small, mobile, handheld device that provides computing and information storage and retrieval capabilities for personal or business use, often for keeping schedules, calendars and address book information handy.

While this projected evolution of the multimedia interface is still the subject of academic research and development, it has been miniaturization and the Internet that have driven the industry instead. The desktop multimedia systems of the 1990s are now being repackaged as portable devices that can play multiple media. The keyboard and the mouse are being replaced by input devices like pen interfaces on **personal digital assistants** (PDAs). Rather than immersing ourselves in virtual caves, we are bringing multimedia computing out of the office or lab and weaving it in our surroundings. The challenge to multimedia design is how to scale interfaces appropriately for hand-held devices like MP3 players and mobile phones.

4.1.2 Characteristics of a Multimedia System

A Multimedia system has four basic characteristics:

- Multimedia systems must be *computer controlled*.
- Multimedia systems are *integrated*.
- The information they handle must be represented *digitally*.
- The interface to the final presentation of media is usually *interactive*.

REMEMBER

In multimedia system, memory management has to provide access to data within a guaranteed timing delay and efficient data manipulation function.

4.1.3 The Advantages and Disadvantages of Multimedia

There are a couple of advantages and disadvantages to using multimedia in communication.

Advantages

- It is very user-friendly. It does not take much energy out of the user, in the sense that you can sit and watch the presentation, you can read the text and hear the audio.
- It is multi sensorial. It uses a lot of the user's senses while making use of multimedia, for example hearing, seeing and talking.
- It is integrated and interactive. All the different mediums are integrated through the digitization process. Interactivity is heightened by the possibility of easy feedback.
- It is flexible. Being digital, this media can easily be changed to fit different situations and audiences.
- It can be used for a wide variety of audiences, ranging from one person to a whole group.

Disadvantages

- Information overload. Because it is so easy to use, it can contain too much information at once.

- It takes time to compile. Even though it is flexible, it takes time to put the original draft together.
- It can be expensive. Multimedia makes use of a wide range of resources, which can cost you a large amount of money.
- Too much makes it unpractical. Large files like video and audio has an effect of the time it takes for your presentation to load. Adding too much can mean that you have to use a larger computer to store the files.
- In case you want to upload it onto the Internet, there are a few factors to keep in mind, for example bandwidth and the user's abilities.

4.2 THE BASIC ELEMENTS OF MULTIMEDIA

Multimedia applications can include many types of media. The primary characteristic of a multimedia system is the use of more than one kind of media to deliver content and functionality. Web and desktop computing programs can both involve multimedia components. As well as different media items, a multimedia application will normally involve programming code and enhanced user interaction. Multimedia items generally fall into one of five main categories and use varied techniques for digital formatting.

REMEMBER

Information exchange media includes all information carrier for transmission, i.e. all storage and transmission media.

4.2.1 Text

Text is the most common medium of presenting information. It is also used to communicate a concept or an idea. It should effectively complement the other media. Factors that influence the textual communication are typeface, font and style, kerning, antialiasing, animation, special effects, special characters and hypertext .While dealing with text in multimedia it is very important to note that it is not the only means of communication. In multimedia, text is most often used for titles, headlines, menus, navigation and content. Overcrowding of text on a single page should be avoided.

REMEMBER

Communication and synchronization between processes must meet the restriction of the real-time requirement and timing relations between different Medias.

It is recommended that text should be presented in combination with graphics.

Typeface

Typefaces are broadly categorized into two types - 'serif' and "sans-serif". Serif is the small decoration at the end of the letter stroke while sans serif is the letter without a decoration. Serif fonts are commonly used in the body of the text, while sans-serif fonts are used for headlines and bold statements.

Fonts

A font is a collection of characters of single size belonging to particular typeface family. Style and size are the main attributes of a font. Common font styles are bold and italic. Font sizes are expressed in points. A point is approximately 1/72 of an inch.

In the usage of fonts, it is recommended to vary as few number fonts as possible on the same page. The style, size and kerning may be adjusted as and when necessary. Anti-aliased text may be used for titles and headlines. Bold text may be more suitable to convey an idea or a concept. Text can be made attractive and pleasing to the eye by choosing the combination of colors for the font and background. Care should be taken for selecting the appropriate type of fonts on menus and buttons, symbols and special characters.

Text Animation

Presentation of text can be more fun and interesting through animation. A wide variety of methods are available to animate the text. Some of the methods are: scrolling (vertical and horizontal), zoom-in and zoom-out, fade-in and fade-out, dissolve etc. 3D text also has an impressive look. Care should be taken to introduce animation only at selected places where the presentation is most impressive. Authoring Programmes like Macromedia's Director have built in tools to animate text.

Kerning

It refers to adjustment of the space between two characters. Kerning makes certain combinations of letters, such as WA, MW, TA, and VA, look better. Only the most sophisticated word processors and desktop publishing systems perform kerning. Normally, you can activate or deactivate kerning for particular fonts.

Anti-Aliasing

Aliasing is the well-known effect on computer screens, in fact, on all pixel devices where distortions occur at the edges of letters, in the case of text presentation. Anti-aliasing is the technique of making the edges smooth. Antialiased text is often called "grey-scale" text. Certain adaptations of anti-aliasing have enhanced both the legibility and aesthetics of on-screen type.

Hypertext

The function of hypertext is to build links and generate an index of words. The index helps to find and group words as per user's search criteria. Hypertext systems are very useful in multimedia interactive education courseware. Hypertext systems provide both unidirectional and bi-directional navigation. Navigations can be through buttons or through simple, plain text. The simple and easy navigation is through linear hypertext where information is organized in linear fashion. Non-linear hypertext, however, is the ultimate goal of effective navigation.

DID YOU KNOW ?

In the intervening forty years, the word has taken on different meanings. In the late 1970s, the term referred to presentations consisting of multi-projector slide shows timed to an audio track. However, by the 1990s 'multimedia' took on its current meaning.

4.2.2 Images

An image is a visual representation of something. Digital image files appear in many multimedia applications. Digital photographs can display application content or can alternatively form part of a user interface. Interactive elements, such as buttons, often use custom images created by the designers and developers involved in an application. Digital image files use a variety of formats and file extensions. Among the most common are JPEGs and PNGs. Both of these often appear on websites, as the formats allow developers to minimize on file size while maximizing on picture quality. Graphic design software programs such as Photoshop and Paint.NET allow developers to create complex visual effects with digital images. In information technology, the term has several usages:

- An image is a picture that has been created or copied and stored in electronic form. An image can be described in terms of vector graphics or raster graphics. An image stored in raster form is sometimes called a bitmap. An image map is a file containing information that associates different locations on a specified image with hypertext links.

Common image file formats online include:

- JPEG (pronounced JAY-peg) is a graphic image file produced according to a standard from the Joint Photographic Experts Group, an ISO/IEC group of experts that develops and maintains standards for a suite of compression algorithms for computer image files. JPEGs usually have a .jpg file extension.
- GIF (pronounced JIF by many, including its designer; pronounced GIF with a hard G by many others) stands for Graphics Interchange Format. The GIF uses the 2D raster data type and is encoded in binary. GIF files ordinarily have the .gif extension.
- GIF89a is an animated GIF image, formatted according to GIF Version 89a. One of the chief advantage format is the ability to create an animated image that can be played after transmitting to a viewer page that moves - for example, a twirling icon or a banner with a hand that waves or letters that magically get larger. A GIF89a can also be specified for interlaced GIF presentation.
- PNG (pronounced *ping*) is a Portable Network Graphics) is a file format for image compression that was designed to provide a number of improvements over the GIF format. Like a GIF, a PNG file is compressed in lossless fashion (meaning all image information is restored when the file is decompressed during viewing). Files typically have a .png extension.
- SVG is Scalable Vector Graphics, the description of an image as an application of XML. Any program such as a browser that recognizes XML can display the image using the information provided in the SVG format. **Scalability** means that the file can be viewed on a computer display of any size and resolution, whether the small screen of a smartphone or a large widescreen display in a PC. Files usually have .svg extension.
- TIFF (Tag Image File Format) is a common format for exchanging raster graphics (bitmap) images between application programs, including those used for scanner images. A TIFF file can be identified as a file with a .tiff or ".tif" file name suffix.
  - A disk image is a copy of the entire contents of a storage device, such as a hard drive or DVD. The

Keyword

Scalability is the capability of a system, network, or process to handle a growing amount of work, or its potential to be enlarged to accommodate that growth.

disk image represents the content exactly as it is on the original storage device, including both data and structure information.

- Another use of the term *image* is for a section of random access memory (RAM) that has been copied to another memory or storage location.

4.2.3 Audio

Audio is sound within the acoustic range available to humans. An audio frequency (AF) is an electrical alternating current within the 20 to 20,000 hertz (cycles per second) range that can be used to produce acoustic sound. In computers, audio is the sound system that comes with or can be added to a computer. An audio card contains a special built-in processor and memory for processing audio files and sending them to *speakers* in the computer. An audio file is a record of captured sound that can be played back. Sound is a sequence of naturally analog signals that are converted to digital signals by the audio card, using a microchip called an analog-to-digital converter (ADC). When sound is played, the digital signals are sent to the speakers where they are converted back to analog signals that generate varied sound.

REMEMBER

Data management is an important component in multimedia system, however database management system abstracts the details of storing data on the secondary media storage. Therefore database management should depend on file management services provided by multimedia operating system.

Audio files are usually compressed for storage or faster transmission. Audio files can be sent in short stand-alone segments - for example, as files in the Wave file format. In order for users to receive sound in real-time for a multimedia effect, listening to music, or in order to take part in an audio or video conference, sound must be delivered as streaming sound. More advanced audio cards support wavetable, or precaptured tables of sound. The most popular audio file format today is MP3 (MPEG-1 Audio Layer-3).

Why Use Audio

Perhaps the most obvious advantage of using audio is that it can provide an interface for visually disabled users, however using audio offers a number of other advantages for all users:

- It can convey meaning, providing an extra channel of information. It allows redundancy to be incorporated into the presentation of information, so that if the meaning is unclear to a user using visual information alone, the audio may clarify it.
- Different learners use different learning strategies, and audio can provide additional information to support different learning styles, for example some users may learn more by hearing than reading a piece of text.
- Audio can add a sense of realism. Cultural associations with music allow you to convey emotion, time period, geographic location, etc. However, when using audio in this way you must be aware that meanings may differ in different cultures. Methods of sound specialization are now available, giving the effect of 3D sound, and allowing environmental acoustic effects, such as reverberation, to be added. For example, for the Windows platform, Microsoft has defined the device-independent DirectSound interface for spatial sound as part of DirectX.
- It is useful for directing attention to important events. Non-speech audio may be readily identified by users, for example the sound of breaking glass to signify an error. Since audio can grab the users attention so successfully, it must be used carefully so as not to unduly distract from other media.
- It can add interest to a presentation or program.
- Ease of communication - users may respond better to the spoken word than other media. For example in a company presentation, 'sound bytes' from satisfied customers can be used.

There are however a number of disadvantages to using audio:

- Like most media, files can be large. However files sizes can be reduced by various methods, and streamed audio can be delivered over the Web.

REMEMBER

If you have recorded and edited your sounds at 16 bit sampling rates but are using lower rates you must resample or down sample the file.

- Audio can be easily overused, and when sounds are continually used users tend to tune them out. When used in a complex environment it can increase the likelihood of cognitive overload. Studies have shown that while congruent use of audio and video can enhance comprehension and learning, incongruent material can significantly reduce it. That is, where multiple media are used they should be highly related to each other to be most effective.
- For most people, audio is not as memorable as visual media.
- Good quality audio can be difficult to produce, and like other media most commercial audio, particularly music, is copyright.
- Users must have appropriate hardware and software. In an open plan environment this must include headphones.

File Formats

There are a large number of audio formats, but in all the file size (and quality) depend on:

- Sampling frequency
- Bit depth
- Number of channels (mono, stereo)
- Lossiness of compression

The easiest way to reduce file size is to switch from stereo to mono. You immediately lose half the data, and for many audio files it will have only a small effect on perceived quality.

Bit depth, or sample size, is the amount of information stored for each point - equivalent to the bits/pixel in an image file. This is usually 8 or 16 bits.

Frequency is the number of times per second the sound was sampled - the higher the frequency, the better the quality. In practice the frequency is usually set at one of a number of predetermined figures, most commonly 11KHz, 22KHz and 44KHz. 22kHz is very common in computer sound file formats, 44kHz is the standard for audio compact discs

The total size of a mono, uncompressed sound file will be the sample rate * bit depth * duration. Stereo sound will be twice this. For example, a CD quality sound file will be 16 bit, 44KHz, and uncompressed will be about 10.5Mb per minute.

The most common sound formats found on the Web are WAV, a Microsoft format, and AU, primarily a UNIX based format, AIFF (Audio Interchange File Format) mainly used on Mac and SGIs, and streamed formats such as RealAudio (.ra).

Recently MP3 files have become more popular, particularly for storing CD quality audio. MP3 refers to the MPEG (Motion Picture Expert Group) layer 3 audio encoding scheme, which is defined within both the MPEG-1 and MPEG-2 standards. The audio encoding scheme in MPEG-2 only differs from that in MPEG-1 in that it was extended to support very low bitrate applications. MP3 can provide about 12:1 compression from an 44kHz 16-bit stereo WAV file without noticeable degradation of sound quality, much higher compression rates can be obtained, but at a cost of poorer sound quality. However, it is reasonably CPU intensive, encoding much more so than decoding. MP3 playback is not recommended on machines slower than a Pentium or equivalent.

MIDI (Musical Instrument Digital Interface) files are different from the audio formats described above. MIDI is a communications standard developed for electronic musical instruments and computers. In some ways it is the sound equivalent of vector graphics. It is not digitized sound, but a series of commands which a MIDI playback device interprets to reproduce the sound, for example the pressing of a piano key. Like vector graphics MIDI files are very compact, however, how the sounds produced by the MIDI file depend on the playback device, and it may sound different from one machine to the next. MIDI files are only suitable for recording music; they cannot be used to store dialogue. They are also more difficult to edit and manipulate than digitized sound files, though if you have the necessary skills every detail can be manipulated.

Streaming

Until relatively recently to listen to an audio file or play a video over the Web, the whole file first had to be downloaded. This changed with the release of Real Audio from Progressive Networks. Real Audio, and other similar products that have followed for both audio and video, allow streaming over the Internet. Streaming means that the audio or video file is played in real-time on the user's machine, without the need to store it as a local file first.

To play a RealMedia file, a link is included in the HTML document to a metafile, which contains the location of the media file, which is held on a RealServer. When the link is selected, the RealMedia player is invoked on the client, and the player begins to stream the media file. Generally the web browser plug-ins to play the streamed media files are freely available, but the server to deliver the files must be purchased.

Keyword

Word processor is an electronic device or computer software application, that performs the task of composing, editing, formatting, and printing of documents.

VRML

The Virtual Reality Modelling Language (VRML) was designed to allow 3D 'worlds' to be delivered over the World Wide Web (WWW). Although it is usually thought of in the context of graphics only, VRML 97 supports the inclusion of spatialised, 3D audio, giving the listener a sense of the location of a virtual sound source in a virtual listening space.

A VRML file consists of a collection of objects, called nodes, containing parameters or fields which modify the node. Audio is supported through the use of several nodes:

- Sound node, which allows you to specify the spatial details for the sound, with fields such as direction, intensity and location.
- Audioclip node, which provides the source of sound data for the Sound node
- MovieTexture node, which can be used as the source of sound data for a Sound node, as a MPEG1 file

Audio Interfaces

There are a number of scenarios in which an audio interface or combined audio/visual interface may be more useful than a standard visual only interface. For example, in the increasingly popular Personal Digital Assistants (PDAs). These are no longer restricted to simple address books and electronic diaries, but can now also act as Internet terminals, **word processors**, etc. The main problem with PDAs is their very small screen size, where an audio interface may be more useful than a traditional GUI (graphical user interface).

Aural Style Sheets

Aural Cascading Style Sheets are currently being investigated by the WWW Consortium. These are being designed to make WWW documents more accessible to visually impaired users. This group of users will include not only the blind and partially sighted, but anyone for whom visual presentation is not appropriate, where eyes are engaged in another task, e.g., driving. Properties proposed in the aural CSS include:

- Volume
- Pause, before and/or after an element
- Cue, play an auditory cue before and/or after an element
- Play-during - play a background sound during an element
- Cue and Play-during can both help to distinguish various semantic elements.
- Several spatial properties are defined. These can be used to generate stereo sound, for example to distinguish between two different 'voices'.
- Speech properties allow different voices to be specified, speed of speech etc.

Wearable Audio Computing

The need for a "hands-and-eyes free" interface was recognized in the development of Nomadic Radio, a distributed computing platform designed to be worn round the neck giving access to a variety of functions through an auditory interface. This uses various auditory cues and speech input/output. It makes use of the "Cocktail Party Effect", which means humans can listen to several audio streams simultaneously, and selectively focus on the one that is of interest, and tune the rest into the background. This allows the users to be aware of messages or events without the interface requiring their full attention.

4.2.4 Video

Although video requires lots of bandwidth to download, it is very useful for conveying certain information. Using video in e-learning helps realistically demonstrate equipment and processes among other things. For instance, an e-learning course in botany might show a video of a sprouting seed. A course about the features of an airplane might show a video of a crewmember properly closing and securing a door for takeoff. The intricate level of detail visible in video is also ideal for illustrating subtle, nonverbal information. For example, to teach sales skills you could use a video to demonstrate an interaction between a salesperson and a customer, then have the learners analyze the body language of the people involved in the transaction.

REMEMBER

The primary difference between the animation software program is in how much must be drawn by the animator and how much is automatically generated by the software.

Video Formats

There are three standard digital video formats: Quick Time, Video for Windows, and MPEG. Video files tend to be large so they really are not appropriate for delivery on modem connections. You may choose to include video in your e-learning course if you are delivering it over an intranet or to users with relatively high bandwidth connections. There are many open source video editing tool and open shot is one such popular tool.

4.2.5 Animation

Animation illustrates concepts with movement, shows processes, or draws attention to a region or elements of a screen. Since animations usually involve graphics, they are highly dependent upon the size and file type of the graphics that are being animated.

Animation Formats

There are many ways you can create animations. Authorware, Dreamweaver, Director and Flash can all create animations. An animation created within an authoring program is usually smaller and more efficient than an animation created in another tool and then imported in your authoring program. This is particularly true when an animation is based on shapes created with the software's drawing tools rather than with imported bitmaps. For example, Flash excels at creating vector graphics and animations. Although Flash can animate bitmap graphics, animations made predominately with vector graphics in Flash are considerably smaller than animations created with bitmap graphics. Simple 2D animations can be created using open source tools like pencil or tupi and more advance tools like blender.

4.3 TYPES OF MULTIMEDIA

Multimedia may be broadly divided into Linear and Non-linear Multimedia.

4.3.1 Linear Multimedia

Modern multimedia is a huge part of nearly everyone's daily life. While the term multimedia is typically thought of as only covering things such as movies or video games, it is also a powerful tool that can be used by businesses and organizations to display a wide range of content to employees or group members.

History

The word "Multimedia" was first coined by Andy Warhol in 1965 in reference to his music, video, and art presentation show titled the "Exploding Plastic Inevitable." Multimedia later came to mean business presentations or slide shows and eventually morphed into its modern interpretation of any presentation that combines different elements such as text, video, and sound. In the 1990's the term was split into the classifications of linear and non-linear.

Identification

Linear multimedia can be distinguished from non-linear multimedia because it has literally no interactivity of any kind. It lacks any extra features that a user can take advantage of, such as the ability to choose different options, click on icons, control the flow of the media, or change the pace at which the media is displayed.

Keyword

Seminar is a form of academic instruction, either at an academic institution or offered by a commercial or professional organization.

Types

The two main types of linear multimedia are movie presentations, such as pre-recorded instructional videos or fictional movies recorded for entertainment purposes, and printed books and magazines. Live video feeds can also be considered linear multimedia because the viewer has no ability to speed up or slow down the presentation or skip to different segments.

Benefits

The main reason to use linear multimedia over the more interactive and fun non-linear types of multimedia is to aid in teaching or training. Linear multimedia works exceedingly well for providing information to large groups of people such as at training sessions, **seminars**, workplace meetings, study groups, or church gatherings.

Considerations

Multimedia ceases to be classified as linear when any interactive elements at all are introduced, such as the ability to skip to different chapters in a DVD, rewind or fast-forward a video, move a character in a game, or navigate to different sections of a website.

4.3.2 Non-linear Multimedia

Unlike linear interactivity, non-linear interactivity allows the user to interact with the content according to what the user wants from the content. In other words, it is a two-way communication.

The user can control the progress and sequence of the multimedia content by using buttons or links. Non-linear interactivity uses tools like "hypertext" to connect a word or a phrase to another screen.

An electronic book with links to another screen is considered as having non-linear multimedia content. **Hypermedia** is also used in non-linear interactivity. This tool is similar to hypertext. However, it connects to different media elements such as audio and video.

Examples may include:

- A Website
- A search engine's home page
- A DvD menu screen
- A Youtube Channel
- An anime or Korean drama streaming site

Keyword

Hypermedia is an extension to what is known as hypertext, or the ability to open new Web pages by clicking text links on a Web browser.

Advantages

The person is in control and may use the multimedia according to his preferences and needs.

Disadvantages

- Requires a level of computer literacy from the user
- May be unorganized if not used well.

Multimedia in Context

One of the best examples of non-linear multimedia would be the Internet. It is a network of websites that are all connected and users can navigate from one webpage to the next without any sort of order or structure required. The Internet would be very frustrating to use if it was to follow a linear structure.

4.4 STAGES OF PRODUCTION IN MULTIMEDIA

Multimedia projects are complex; they often involve the skills and efforts of multiple teams or people. During the development process, a project moves through the specialized parts of the team, from story creation to technical editing, with regular collective review sessions Each stage is designed to refine the project with attention to the client's needs, technical requirements and audience preferences.

4.4.1 Planning Meeting

A planning meeting is a crucial part of the multimedia development process; it creates a shared vision for everyone working on the project. The meeting usually kicks off a project, bringing together the team. During the meeting, the project manager communicates the major goals and lays out the milestones. The meeting may include a discussion of the target audience and how each division can help support the overarching goal.

4.4.2 Script Writing

Most multimedia projects have a story behind them. After the initial meeting, the people in charge of the background story write a script, creative brief or outline. The text hits the main points of the project and uses language that appeals to the audience in jargon, tone and style.

4.4.3 Story Boarding

A multimedia project usually includes multiple pieces: audio, video, imagery, text for voiceovers and on-screen titles. Story boarding ties everything together; a story board panel for a scene includes a sketch of the visual elements, the voiceover or title text, and any production notes. It guides the process, keeps everyone in check and gives structure to the project.

4.4.4 Designing

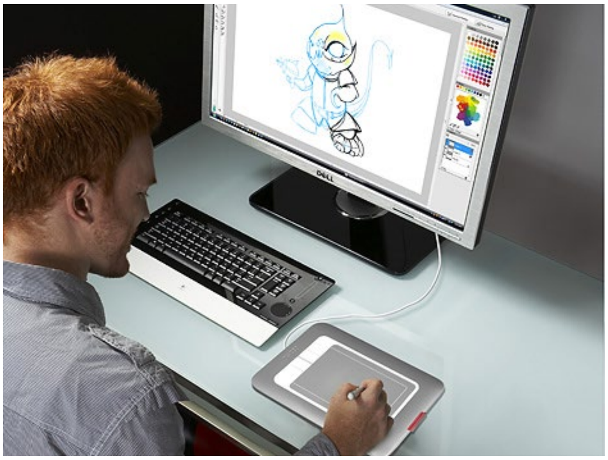
During the design stage, designers take over the visual aspects of the project to determine how it looks and feels. Using the notes from the storyboard, they create graphics, design the navigation and give direction to photographers and videographers regarding the correct shots. Depending on the project, the design stage might include graphic design, **web design**, information design, photography or image collection. Design is always done with an eye toward the audience.

Keyword

Web design encompasses many different skills and disciplines in the production and maintenance of websites.

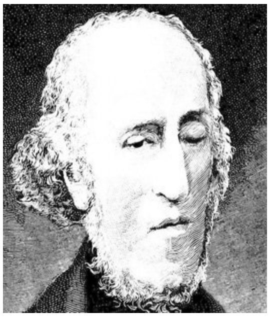
4.4.5 Editing

Editing is one of the most involved and complex stages of the multimedia development process. The people responsible for editing the project turn the various pieces into a cohesive product, taking into consideration the time constraints, story line and creative specifications. Depending on the scope of the project, pieces of the project may be edited separately. For projects with a large amount of video, editing is often the longest stage of the process; a minute of final video can take hours of editing. The editing stage usually involves internal review iterations and may also include rounds of client review and editing.



4.4.6 Production

The production stage is when all the parts of a multimedia project come together. The production staff gathers all of the edited assets in one place and puts them together in a logical sequence, using the story board as a guide. The rough draft is then put through rounds of review and final edits, both internally and with the client. To ensure that a project has the desired impact on the target audience, a company may engage in user testing as part of production. During this stage, test members of the audience use the multimedia piece while team members observe. Depending on the goals of the project, the staff might observe users' reactions or have them answer questions to see if the project hits the right marks. After user testing, there are usually further adjustments to the project. Once the team and clients are satisfied, the project goes out for distribution.



ROLE MODEL

JOSEPH PLATEAU: FIRST PERSONS TO DEMONSTRATE THE ILLUSION OF A MOVING IMAGE

Plateau was one of the best-known Belgian scientists of the nineteenth century. The son of an artist, he received his early education at schools in Brussels. In 1822 he entered the University of Lix00E8;ge as a student in the law faculty. He became interested in science; and in 1824, after he received a diploma in law, he enrolled as a candidate for an advanced degree in the physical sciences and mathematics.

Since Plateau had been orphaned at the age of fourteen, he had to support himself during his studies by serving as professor of elementary mathematics at the *athénée* in Liège. He received his *docteur ès sciences* in 1829 and the following year returned to Brussels, where he became professor of physics at the Institut Gaggia, then one of the most important teaching institutions in Belgium. In 1835 he was called to the State University of Ghent, as professor of experimental physics. He accepted the offer, and in 1844 became *professeur ordinaire*—a post that he held until his retirement in 1872. He was a successful teacher and was also active in organizing the physics laboratory at the university.

In 1834 Plateau was elected a corresponding member of the Royal Academy of Belgium and in 1836 a full member. He was also a member of a large number of foreign scientific organizations, including the Institut de France, the royal academies of Berlin and Amsterdam, and the Royal Society. In Belgium his honors included the office of *chevalier de l'ordre de Léopold* (1841), and in 1872 he rose to the rank of commander. In 1854 and in 1869 he also won the Prix Quinquennal des Sciences Physiques et Mathématiques of the Royal Academy of Belgium.

Plateau's long (he continued to do research even after his retirement) and productive career is especially remarkable because he was totally blinded in 1843. This was apparently the result of an 1829 experiment in physiological optics, during which he stared into the sun for twenty-five seconds. At that time he was blinded for several days, but his sight returned partially. In 1841 he showed signs of serious inflammation of the cornea, which became steadily worse and ended in blindness. During his blindness he was aided in his work by colleagues—particularly, E. Lamarle, F. Duprez, his son Felix Plateau (a noted naturalist), and his son-in-law G. Van der Mensbrugghe.

Plateau's early work was in the field of physiological optics. The basis of much of this work was his observation that an image takes an appreciable time to form on, and to disappear from, the retina. In his dissertation (1829) Plateau showed, among other things, that the total length of an impression, from the time it acquires all its force until it is scarcely sensible, is approximately a third of a second. He applied his results to the study of the principles of the color mixture produced by the rapid succession of colors. This led to the formulation of the law (now known as the Talbot-Plateau law) that the effect of a color briefly presented to the eye is proportional both to the intensity of the light and the time of presentation. Plateau also studied various optical illusions that result from the persistence of the image on the retina. In 1832 he invented one of the earliest stroboscopes, which he called a "phénakistiscope." Plateau's device consisted of pictures of a dancer that were placed around a wheel. When the wheel was turned, the dancer was seen to execute a turn. Plateau sent his stroboscope to Michael Faraday.

Plateau studied in great detail the phenomena of accidental colors and irradiation, both of which he considered as arising from a similar cause related to the persistence of the image on the retina. Accidental colors are those that appear after staring for some time at a colored object and then at a black surface, or closing one's eyes and pressing one's hands over them. An image of the object appears, usually in complementary color and slightly diminished in size. Plateau's results include his discovery that accidental colors combine both with each other and with real colors according to the usual laws of color mixture. In irradiation luminous objects on a dark background appear enlarged, a factor clearly of interest to astronomers, among whom the question of the extent of the enlargement was causing controversy. Plateau showed that enlargement occurs regardless of the distance from the object and—explaining the varied experiences of the controversialists—that the mean amount of enlargement from the same source varied considerably from one individual to another.

Plateau was one of the first to attempt to measure sense distance. He used the method of bisection, presenting artists with white and black papers and asking them to produce a color midway between the two. Throughout his career, Plateau was interested in visual perception, and between 1877 and 1882 he published a critical bibliography of what he called "subjective phenomena of vision." He analyzed works from antiquity to the end of the eighteenth century, and listed, with short summaries, nineteenth-century works. Plateau's optical work has been neglected, perhaps because it contained theoretical errors, but his experiments were imaginative and interesting and earn him a name as a pioneer in physiological psychology.

In the 1840's Plateau turned his major energies to the study of molecular forces, through the consideration of a weightless mass of liquid. By immersing a quantity of oil in a mixture of water and alcohol, the density of which was equal to that of the oil, Plateau effectively annulled the action of gravity and showed that under these conditions the oily mass formed a perfect sphere. He then introduced centrifugal force and found that the sphere flattened at the poles and bulged at the equator. By controlling the velocity, he transformed the sphere into a ring, then a ring with a sphere at the center. He also formed a system of small spheres, which rotated about a central axis, each rotating around its own axis; this corresponded strikingly with the image of the formation of the rings of Saturn, and with that of the formation of the planets in Laplace's nebular hypothesis. (There are, of course, essential differences between conditions of the experiment and the astronomical situation, as Plateau himself indicated.)

Plateau also varied the conditions of his experiment by introducing metal wires to which the oil could adhere. He studied the forms of equilibrium that occurred, particularly the cylinder. Based on the assumption that the action was due to a very thin layer at the surface, he concluded that these forms should have surfaces of constant mean curvature. He obtained five different forms and showed geometrically that these were the only possible ones. He was, despite his blindness, a superb geometer, with a gift both for visualizing physical results and for physically interpreting geometric results.

Another way in which Plateau studied the effects of molecular forces—not influenced by the force of gravity—was by using thin films. In these studies he employed a treated mixture of soapy water and glycerin that he himself had developed. This liquid had the property that, with proper precautions, a bubble or film would last up to eighteen hours. Among other things Plateau studied the films that formed within wire contours dipped into the solution. His theoretical work led him to conclude that the surfaces formed were always minimal surfaces, and his experimental results confirmed this. But because his mathematical analysis was not rigorous, other mathematicians were led to formulate what is known as the problem of Plateau—to show that across any Jordan space curve there may be stretched a minimal surface. The question led to the study of functions of a complex variable and attracted the attention of Riemann, Weierstrass, and Schwarz. In 1931 Jesse Douglas gave the first mathematical solution.

Plateau's work on molecular forces was published in a series of memoirs between 1843 and 1868, and again, with some revision, as a book in 1873. In the work on thin films Plateau was drawn to the question of surface tension. He concluded that molecular forces alone were not sufficient to account for it. This probably indicates why Plateau is not as well-known as he was in his own time. He was nonetheless an able and ingenious experimenter and his work on thin films is remarkable for the results he obtained with the simplest of apparatus. His theoretical explanations, both in his optical investigations and in the study of molecular forces, are not, however, generally accepted.

Plateau also did interesting work in magnetism, proving that it is impossible to suspend something in the air using magnetic forces alone. His mathematical writings include papers on the theory of numbers. In addition he was the coauthor, with Adolphe Quetelet, of a long article on physics in t*he Encyclopédie populaire*.

SUMMARY

- Multimedia is a form of communication that combines different content forms such as text, audio, images, animations, or video into a single interactive presentation, in contrast to traditional mass media which featured little to no interaction from users, such as printed material or audio recordings.
- Multimedia is the term used to describe two or more types of media combined into a single package—usually denoting a combination of some or all of the following: video, sound, animation, text, and pictures.
- Desktop publishing is the precursor to multimedia, even though desktop publishing aims at rhetorical artifacts that are not viewed on a computer. Computer-aided graphic design and desktop publishing are arts that use computers instead of traditional technologies to produce rhetorical artifacts that combine media, such as text and images.
- The latest media threshold to be overcome in affordable personal computers is digital video. The challenge of multimedia is to combine not just asynchronous media like text and images, neither of which need to be played over time, but also time-dependent media like audio, animation, and video.
- The primary characteristic of a multimedia system is the use of more than one kind of media to deliver content and functionality. Web and desktop computing programs can both involve multimedia components.
- Text is the most common medium of presenting information. It is also used to communicate a concept or an idea. It should effectively complement the other media.
- An image is a visual representation of something. Digital image files appear in many multimedia applications. Digital photographs can display application content or can alternatively form part of a user interface.
- Audio files are usually compressed for storage or faster transmission. Audio files can be sent in short stand-alone segments - for example, as files in the Wave file format.
- While the term multimedia is typically thought of as only covering things such as movies or video games, it is also a powerful tool that can be used by businesses and organizations to display a wide range of content to employees or group members.
- Multimedia projects are complex; they often involve the skills and efforts of multiple teams or people. During the development process, a project moves through the specialized parts of the team, from story creation to technical editing, with regular collective review sessions Each stage is designed to refine the project with attention to the client's needs, technical requirements and audience preferences.

KNOWLEDGE CHECK

1. A multimedia file

a. is same as any other regular file
b. must be accessed at specific rate
c. stored on remote server cannot be delivered to its client
d. none of the mentioned

2. In which type of streaming multimedia file is delivered to the client, but not shared?

a. real-time streaming
b. progressive download
c. compression
d. none of the mentioned

3. Which one of the following is the characteristic of a multimedia system?

a. high storage
b. high data rates
c. both (a) and (b)
d. none of the mentioned

4. The delay that occur during the playback of a stream is called

a. stream delay
b. playback delay
c. jitter
d. event delay

5. Which algorithm can be optimized to meet the timing deadlines and rate requirements of continuous media?

a. Earliest-Deadline-First scheduling
b. SCAN-EDF scheduling
c. both (a) and (b)
d. none of the mentioned

6. A video consists of a sequence of

a. Frames
b. Signals
c. Packets
d. Slots

7. If frames are displayed on screen fast enough, we get an impression of

a. Signals

b. Motions

c. Packets

d. Bits

8. H.323 uses G.71 or G.723.1 for

a. Compression

b. Communication

c. Controlling

d. Conferencing

9. To receive signal, a translator is needed to decode signal and encode it again at a

a. High Quality

b. Lower Quality

c. Same Quality

d. Bad Quality

10. Session Initiation Protocol (SIP), is very

a. Independent

b. Flexible

c. Important

d. Layered

11. Multimedia gives the user the opportunity to influence the presentation of material.

a. True

b. False

12. The latest media threshold to be overcome in affordable personal computers is digital video.

a. True

b. False

REVIEW QUESTIONS

1. Define Multimedia. List four Multimedia applications.
2. What are the elements of multimedia? Mention.
3. What are the types of images based on multimedia? Explain.

4. How objects are defined for multimedia system? Discuss.
5. Explain the classification of multimedia giving suitable example for each.
6. Explain how multimedia is used in various fields.
7. List the stages in multimedia production. Write about each in brief.
8. List various file formats used for the following files:
   - Audio
   - Video
   - Image

Check Your Result

1. (b)	2. (a)	3. (c)	4. (c)	5. (c)	6. (a)
7. (b)	8. (a)	9. (b)	10. (b)	11. (a)	12. (a)

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CHAPTER 5

MICROSOFT WINDOWS

LEARNING OBJECTIVES

After studying this chapter, you will be able to:

1. Learn about the overview of windows
2. Know about essential accessories of windows
3. Focus on the different versions of windows

"Using Microsoft Windows 10 has been marked by extremely poor computer performance whenever background updates are in progress."

– Steven Magee

INTRODUCTION

Microsoft Windows, commonly referred to as Windows, is a group of several proprietary graphical operating system families, all of which are developed and marketed by Microsoft. Each family caters to a certain sector of the computing industry. Active Microsoft Windows families include Windows NT and Windows IoT; these may encompass subfamilies, (e.g. Windows Server or Windows Embedded Compact) (Windows CE). Defunct Microsoft Windows families include Windows 9x, Windows Mobile and Windows Phone. Microsoft introduced an operating environment named Windows on November 20, 1985, as a graphical operating system shell for MS-DOS in response to the growing interest in graphical user interfaces (GUIs). [6] Microsoft Windows came to dominate the world's personal computer (PC) market with over 90% market share, overtaking Mac OS, which had been introduced in 1984.

Apple came to see Windows as an unfair encroachment on their innovation in GUI development as implemented on products such as the Lisa and Macintosh (eventually settled in court in Microsoft's favor in 1993). On PCs, Windows is still the most popular operating system in all countries. However, in 2014, Microsoft admitted losing the majority of the overall operating system market to Android, because of the massive growth in sales of Android smartphones. In 2014, the number of Windows devices sold was less than 25% that of Android devices sold. This comparison, however, may not be fully relevant, as the two operating systems traditionally target different platforms. Still, numbers for server use of Windows (that are comparable to competitors) show one third market share, similar to that for end user use.

5.1 AN OVERVIEW OF WINDOWS

When referring to an operating system, Windows or win is an operating environment created by Microsoft that provides an interface, known as a Graphical User Interface (GUI), for computers. Windows eliminates the need to memorize commands for the command line (MS-DOS) by using a mouse to navigate through menus, dialog boxes, buttons, tabs, and icons. If you are using a PC (IBM) computer you are most likely using a version of Windows. If you are on an Apple computer you are using macOS. Microsoft Windows was first introduced with version 1.0 on November 10, 1983. Since its release, there have been over a dozen versions of Windows. The most current version of Windows for end users is Windows 10.

Before the release of Microsoft Windows, Microsoft users were used to the single-task command line operating system MS-DOS. Because Microsoft names most of its products with one word, it needed a word that best described its new GUI operating system. Microsoft chose "Windows" because of the multiple windows that allow different tasks and programs to be run at the same time. Because you cannot trademark a common name like "Windows" it is officially known as "Microsoft Windows". The first version of Microsoft Windows was version 1.0, released in 1985.

Windows is a collection of programs known as an operating system (OS) that controls a PC (personal computer). First produced by Microsoft in November 1985, it has been frequently updated since, as computer memory has got bigger, as processing chips have got faster and, of course, when the internet was invented. Prior to Windows, PCs were operated by a series of text commands.

- Allows the user to interact with the computer (through the keyboard, mouse, microphone, etc.).
- Controls the storage of data (images, files, music).
- Controls hardware attached to the computer such as webcams, scanners and printers.
- Helps to open and close programs (word processors, games, photo editors, etc.), and gives them part of the computer's memory to allow them to work.
- Controls what access to a computer different users have and the computer's security.
- Deals with errors and user instructions, and issues simple error messages.
- Promotes multitasking by allowing the user to do several things on the computer at once for example, watch a video while writing a letter.

Other operating systems are available, notably the Apple OS X used in Mac computers. In addition, with the increased use of smartphones, notepads and tablets, there are systems aimed directly at mobile devices. However, most people who learn to use computers do so on a system running Windows.

Microsoft Windows is a series of operating systems and environments developed and marketed by Microsoft Corporation. The first version of Windows was released in 1985 as a graphical user interface to MS-DOS, providing multiple document support, mouse support, drop down menus, and color video drivers. Later versions gradually replaced many of MS-DOS's built-in hardware functions with their own enhanced functions, until Windows fully assimilated MS-DOS and became a full-fledged operating system. Microsoft Windows is now often referred to as an integrated **operating system** due to the high level of integration between the core kernel functions and other Microsoft software such as Outlook, Windows Explorer and Internet Explorer.

Despite it's poor security record caused by this integration, Microsoft Windows is today the most widely used OS on personal home computers, laptop computers, and small business machines. The latest version, Windows Vista, was released in late 2006 to large businesses while the consumer version was delayed until early 2007.

Keyword

Operating system (OS) is system software that manages computer hardware and software resources and provides common services for computer programs.

As an integrated operating system, all Microsoft Windows versions come with preinstalled software that is ready to use upon installation. Basic text editors and calculators have been available since the first versions of Windows. Windows 98 added Media Player, Internet Explorer and Outlook Express. Windows Vista expands this with the Windows Mobility Center, Photo Gallery, DVD Maker, and the Linux-like Windows Sidebar. Vista is also the first version of Windows to have built-in security features. Although the second Windows XP service pack added a firewall and anti-virus monitoring service, Vista implements these features and more at the kernel level. Individual programs are 'sandboxed' and cannot access each other's memory. Critical drivers are executed in user mode, so crashes and malicious behavior cannot cause system-wide instability or security breaches. Even third-party anti-virus and anti-spyware software runs outside the kernel, further protecting it from bugs and backdoors in those programs. In addition to the common desktop consumer versions of Microsoft Windows, Microsoft has released server, mobile, and embedded versions of the operating system. Windows Mobile is a series of operating systems designed for PDA devices and smartphones. This is the only version of Windows to include any version of Microsoft Office bundled with the OS. Microsoft Windows Embedded is a relatively lightweight version of Windows custom tailored to the hardware on which it runs. While closely related to Windows Mobile, Windows Embedded is not targeted at consumer end-user devices. Rather, Windows Embedded is intended for use in portable medical equipment, industrial machinery, third-party automobile controllers, and similar job-specific applications.

REMEMBER

Windows Server System is a compete IT administration package that includes the Windows Server operating system, Updates Services, Storage Server, IIS webserver, Windows Media Services, and more. This package is intended for large organizations that must administer local area networks and integrate different types of computers for different purposes.

5.1.1 Basic Windows Elements

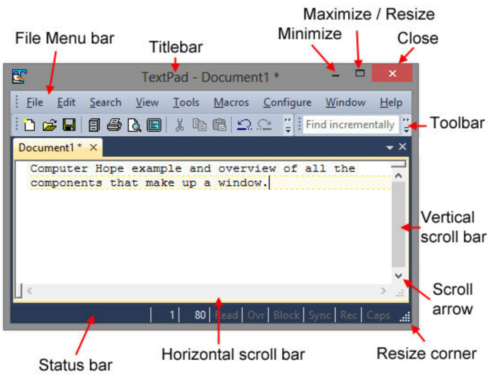
The different parts of a window are sometimes referred to as "window elements." While the appearance of windows can differ between applications and operating systems, most windows have the following standard elements:

Title Bar

This is the top part of the window, which includes the window's title, as well as the close button, minimize button, and zoom button. On Macintosh computers, these buttons are on the left, while on Windows systems, these buttons are on the right side of the title bar.

The title bar is a bar located at the top of a window or a dialog box that displays the name of the window or software program being used. For example, in the picture below, the title bar displays the name of the program (Textpad) and document (Document1) currently being edited.

Example of a Microsoft Windows window



Besides giving a description of the open program or window, the title bar may also contain other useful features that depend on the operating system and program showing the title bar.

Basic features of the title bar

As illustrated in the above picture, the title bar typically has a minimize, maximize, and close button, usually located on the right side. Also, in the top-left corner of a Microsoft Windows program window, there is typically an icon of the program that can be clicked to also show these options.

Extra features and functions of a title bar

Below is a list of some of the functions of the title bar. Keep in mind that not all of these are available in all operating systems and programs.

- Click and hold down the mouse button on the title bar to move the window.
- Double-click the title bar to maximize the window or set the window into window mode.
- Windows 7 introduced side-by-side that allows you to click and drag the title bar to any edge of the screen and attach the window to that portion of the screen.

Scroll Bar

The vertical scroll bar is located on the right side of the window and allows you to scroll up and down through the contents of the window. If the window content does not fit within the width of the window, a horizontal scroll bar will also appear, allowing you to scroll left and right.

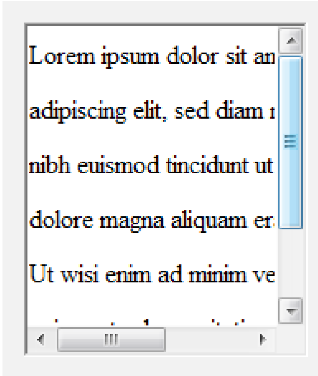
A window can display a data object, such as a document or a bitmap, that is larger than the window›s client area. When provided with a scroll bar, the user can scroll a data object in the client area to bring into view the portions of the object that extend beyond the borders of the window.

Scroll bars should be included in any window for which the content of the client area extends beyond the window›s borders. A scroll bar›s orientation determines the direction in which scrolling occurs when the user operates the scroll bar. A horizontal scroll bar enables the user to scroll the content of a window to the left or right. A vertical scroll bar enables the user to scroll the content up or down.

A scroll bar consists of a shaded shaft with an arrow button at each end and a scroll box (sometimes called a thumb) between the arrow buttons. A scroll bar represents the overall length or width of a data object in a window›s client area; the scroll box represents the portion of the object that is visible in the client area. The position of the scroll box changes whenever the user scrolls a data object to display a different portion of it. The system also adjusts the size of a scroll bar›s scroll box so that it indicates what portion of the entire data object is currently visible in the window. If most of the object is visible, the scroll box occupies most of the scroll bar shaft. Similarly, if only a small portion of the object is visible, the scroll box occupies a small part of the scroll bar shaft.

The user scrolls the content of a window by clicking one of the arrow buttons, by clicking the area in the shaded scroll bar shaft, or by dragging the scroll box. When the user clicks an arrow button, the application scrolls the content by one unit (typically a single line or column). When the user clicks the shaded areas, the application scrolls the content by one window. The amount of scrolling that occurs when the user drags the scroll box depends on the distance the user drags the scroll box and on the scrolling range of the scroll bar. For more information about the scrolling range, see Scroll Box Position and Scrolling Range.

The following screen shot shows a rich edit control with vertical and horizontal scroll bars, as they might appear in Windows Vista. The vertical scroll bar is currently «hot» because the mouse pointer was hovering over it when the screen shot was taken.



Status Bar

Some windows include a status bar along the bottom of the window, which provides information about the contents of the window. In Web browsers, the status bar typically displays the page loading status as well as the location of links when you roll over them.

A status bar is a horizontal window at the bottom of a parent window in which an application can display various kinds of status information. The status bar can be divided into parts to display more than one type of information. The following screen shot shows the status bar in the Microsoft Windows Paint application. In this case, the status bar contains the text "For Help, click Help Topics on the Help Menu". The status bar is the area at the bottom of the window that contains Help text and coordinate information.

Status bars, and status lines before them, have been used for years to display advisory messages in a predefined area, predating dialog boxes which can block the view of related information behind the pop-up messages. The use of status bars (or status lines) involves both advantages and disadvantages:

Advantages of status bars:

- They allow viewing messages while also viewing the entire screen (although they take space away from the screen for their own display)
- They allow typing information while viewing status data
- They allow other menu options while viewing status data
- They continually show status during operation

Disadvantages of status bars:

- Status bars might restrict information to a one-line display (although a variable multi-line status bar/region could be used);
- Status bars typically cannot pop to the surface for critical messages when its parent window is layered below others (but are always visible in the parent window, which can be raised).
- Their location at the edge of the display may make them less noticeable than a dialog box

Keyword

Webpage is a document that is suitable for the World Wide Web and web browsers. A web browser displays a web page on a monitor or mobile device.

Content Area

The content area is where the contents of the window are displayed. This is the main part of the window, which typically takes up the majority of the space. In folder windows, the content area displays a list of files and other folders. In images editing programs, the current image is displayed in the content area. In Web browsers, the content area is used to display the current **webpage**.

5.1.2 File management through Windows

The Microsoft Windows File Manager is the graphical user interface (GUI) through which end users could see and manipulate files and folders on early-version Windows computers.

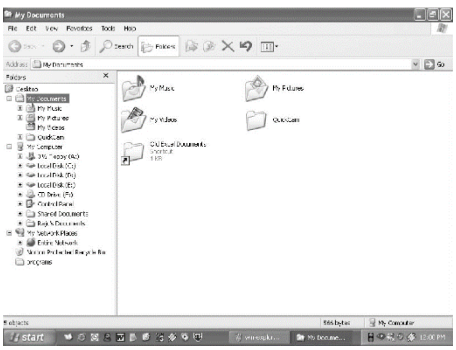
In actual practice, the File Manager proved to be a powerful and intuitive move away from traditional DOS command-line interface (CLI). Users could view the computer's directory structure in a left window, while the file and sub-folder contents of the selected directory would appear in the right window.

End users could then move, copy, rename, print, delete and search files and folders. Users could also define the attributes (the permissions) for files and folders such as read-only, system, hidden or archive, and make associations between files and applications. Windows File Manager also allowed users to format disks and manage network file sharing.

Filename formation proved to be a major limitation of Windows File Manager, which supported only traditional DOS-type 8.3 filenames. Extended filenames (names longer than 8 characters and supporting spaces) displayed in File Manager would simply appear truncated with a tilde and a number in the last two spaces.

A filename like "Original_computer.doc" would appear in File Manager such as "Origin~1. doc". Later file managers would support extended filenames.

Windows File Manager (the WINFILE.EXE utility) was included with Windows versions prior to Windows 95 and Windows NT 4.0, but is no longer in service. The file management function in Windows 95/NT 4.0 and later versions was replaced with the Windows Explorer interface accessible through the My Computer icon. When files or folders are deleted from hard disk, Windows places them in the Recycle Bin, from where they can be retrieved, until the Recycle Bin is made empty. Files or folders deleted from a removable storage media such as network drive are permanently deleted and are not sent to the Recycle Bin.



Using Windows Explorer

Windows offer another utility "Windows Explorer" which helps you in working with files and folders on your computer.

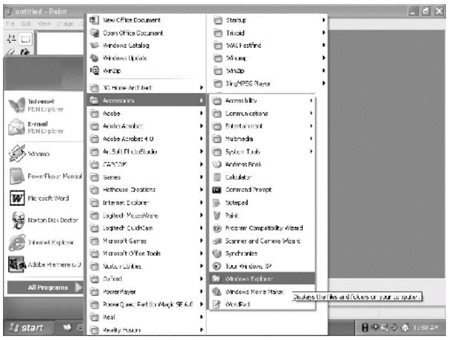
To open Windows Explorer,

Click on Start,

Point to All Programs,

Point to Accessories, and then click on Windows Explorer

The left pane of the Explorer window shows a hierarchy of all the drives, folders and desktop items on your computer. A drive or folder that contains other folders has a plus sign to the left of the icon. Click the plus sign to expand it and see the folders inside.



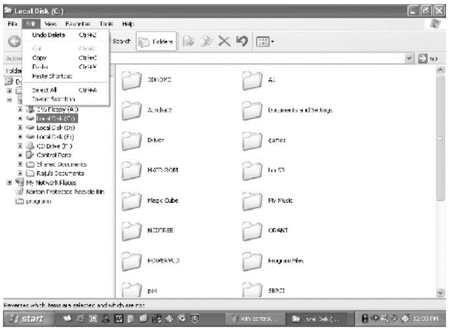
Opening drives and folders

Two drives nearly all computers have are a floppy drive (drive A:) and a hard drive (drive C:). If you have more than one drive, then they are named D:, E: and so on. If you have a CD drive or a DVD drive, it also is named with a letter. Opening a hard drive is easy. Just double click the icon representing the drive you want to open. Files and folders contained in the drive are now shown in the opened window. Now for opening a folder, double click its icon.

- Coping or Moving a file or Folder using My Document
- Click on Start, and then click on My Documents.
- Click the file or folder to be copied. More than one file or folder can be copied at a time.

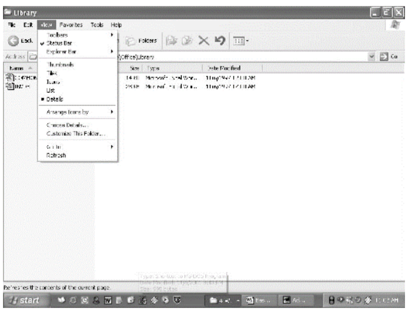
To select more than one consecutive files or folders, click the first file or folder, press and hold down SHIFT key, and then click the last files or folders.

- To select non-consecutive files or folders, press and hold down CTRL key, and then click each of the files or folders to be copied.
- Under Edit menu, select Copy.
- Select the target drive or folder to which you want to copy the files
- Under Edit menu, select Paste to copy the desired file or folder to the target drive.



View file details

- Click on Start, and then click on My Documents.
- Double-click the folder that contains the files to be viewed.
- On the View menu, click Details.
- It will display all the details about the files such as Name, Type, size etc.



Copying and moving files using Explorer

Click Start, point to All Programs, point to Accessories, and then click Windows Explorer.

Make sure the destination for the file or folder you want to move is visible.

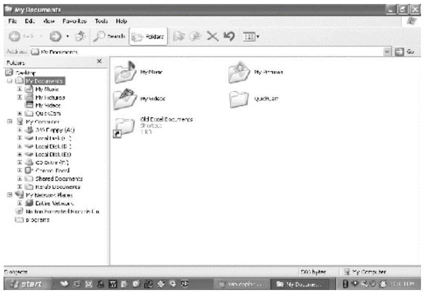
Drag the file or folder from the right pane and drop it on to the destination folder in the left pane to move the file or folder there.

If you drag an item while pressing the right mouse button, you can move, copy, or create a shortcut to the file in its new location.

To copy the item instead of moving it, press and hold down CTRL while dragging.

If you drag an item to another disk, it is copied, not moved. To move the item, press and hold down SHIFT while dragging.

Dragging a program to a new location creates a shortcut to that program. To move a program, right-click and then drag the program to the new location.



Create a new folder

Folders help you to organize your files. You can create a folder either by using My Computer window or through Windows Explorer. You can create a Folder in any existing disk drive or folder or on the windows desktop. The steps for creating a folder are:

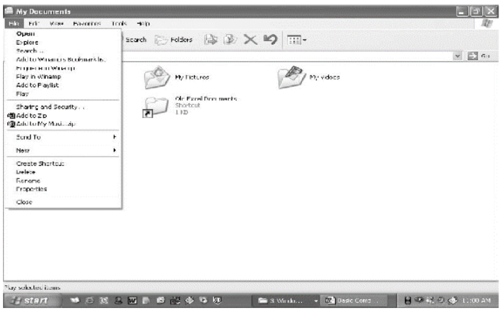
1. Click on Start, and then click on My Documents
2. Under File menu click New and select Folder.
3. A new folder is displayed with the default name, New Folder.
4. Type a name for the new folder, and then press ENTER.
5. A new folder can also be created directly on the desktop by right-clicking a blank area on the desktop, pointing to New, and then clicking Folder.

Rename a file or folder

1. Click on Start, and then click on My Documents
2. Click on the file or folder you want to rename.
3. Under File menu click on Rename.
4. Type the new name, and then press ENTER key.
5. Alternately file or folder can also be renamed by right-clicking it and then clicking on Rename.

Delete a file or folder

1. Click on Start, and then click on My Documents
2. Click on the file or folder you want to delete.
3. Under File menu click on Delete.
4. Files or folders can also be deleted by right-clicking the file or folder and then clicking Delete.
5. Deleted files or folders are stored in the Recycle Bin, till they are permanently removed from the Recycle Bin.
6. To retrieve a deleted file, double-click the Recycle Bin icon on the desktop. Right-click on the file to be retrieved, and then click Restore.
7. To permanently delete a file, press and hold down SHIFT key and drag it to the Recycle Bin.



5.2 ESSENTIAL ACCESSORIES OF WINDOWS

Windows operating system ships with some handy applications known as Windows accessories. Calculator, Notepad, Paint, Explorer, WordPad are some of the most frequently used accessories.

Apart from above mentioned applications, Windows has a few tools for Ease of Access and some System Tools. We'll be briefly talking about them here.

In the Windows Accessories you will also find some very handy tools that will help you keep your system running smoothly. It's a good idea to get acquainted with these tools and how to use them.

REMEMBER

In general, a window is a fundamental part of a computer GUI (graphical user interface). A window is an area of the display containing a single running application.

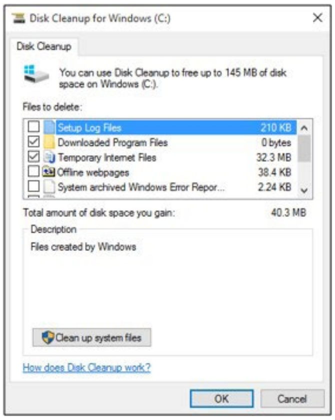
5.2.1 Systems tools

For a smooth performance of a system, periodic maintenance is necessary. Tools like Disk Check, Disk Derangement, etc., helps in system maintenance. Windows includes some of the system utilities such as Disk Cleanup, Disk Defragment, System Restore, Control Panel and so on.

Disk cleanup

Disk Cleanup is a Microsoft software utility first introduced with Windows 98 and included in all subsequent releases of Windows. It allows users to remove files that are no longer needed or that can be safely deleted. Removing unnecessary files, including temporary files, can help to speed up and improve the performance of the computer. Running Disk Cleanup at least once a month is an excellent maintenance task and frequency.

As can be seen in the picture, Disk Cleanup can delete Temporary Internet Files (associated with Internet Explorer), Downloaded Program Files, and Offline webpages. Disk Cleanup also allows you to empty the Recycle Bin, delete Temporary Files, and delete Thumbnails.



How to open Microsoft Disk Cleanup

Microsoft Disk Cleanup can be opened by following these steps.

Windows 10 and Windows 8

- On the Desktop screen, press Windows key + X to open the Power User Task Menu.
- In the menu, tap or click the Run option.

- In the Run text field, type cleanmgr and press Enter.

Windows 7 and earlier

- Open the Start Menu.
- Click on Programs > Accessories > System Tools.
- In System Tools, click the Disk Cleanup utility.

or

- Open the Start Menu.
- Click the Run option.
- In the Run text field, type cleanmgr and press Enter.

What to do in Disk Cleanup

Once Disk Cleanup opens, the initial window will ask you which drive you want to clean up. Select the appropriate drive and click OK. In the next window that opens, check each of the boxes you want to clean up. To the right of each item is the disk drive space each of the items are taking up on the hard drive.

REMEMBER

Disk Cleanup is a computer maintenance utility included in Microsoft Windows designed to free up disk space on a computer's hard drive. The utility first searches and analyzes the hard drive for files that are no longer of any use, and then removes the unnecessary files.

Disk defragmenter

Disk Defragmenter is a utility in Microsoft Windows designed to increase access speed by rearranging files stored on a disk to occupy contiguous storage locations, a technique called defragmentation. Defragmenting a disk minimizes head travel, which reduces the time it takes to read files from and write files to the disk. Beginning with Windows XP, Disk Defragmenter also reduces system startup times

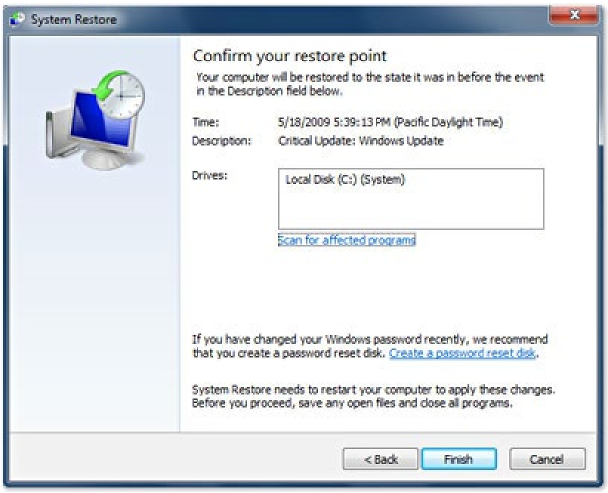
Defragmentation is the process of locating the noncontiguous fragments of data into which a computer file may be divided as it is stored on a hard disk, and rearranging the fragments and restoring them into fewer fragments or into the whole file. Defragmentation reduces data access time and allows storage to be used more efficiently. Some operating systems automatically defragment storage periodically; others require that the user occasionally use a special utility for this purpose. Windows 98 comes with a built-in defragmenter as a "system tool" that the user can run. Windows NT did not come with a defragmenter because its file system, NTFS, was designed to minimize fragmentation; however, NT users often find one necessary and several vendors provide defragmenters. Windows 2000 comes with a "light" version of the Diskeeper defragmenter; some users (especially corporate users) use Diskeeper or some other full-function defragmentation program to manage storage efficiency and performance. Windows XP comes with a utility called "Disk Defragmenter."

System Restore

Keyword

Hardware is the physical parts or components of a computer, such as the monitor, keyboard, computer data storage, graphic card, sound card and motherboard.

System restore is a feature of Windows that allows you to roll back the system to the same configuration it had at an earlier time. If this feature is turned on (which it is by default) Windows will take periodic snapshots (called restore points) of your installation. It can use the information gathered in these snapshots to restore your system to a previous configuration. It is a good idea to create a restore point before you make major changes to your system, such as before installing new **hardware** or doing any major updates.



To run System Restore:

- Go to Start > Programs > Accessories > System Tools > System Restore.
- The System Restore screen will com up.
- Follow the on screen instructions

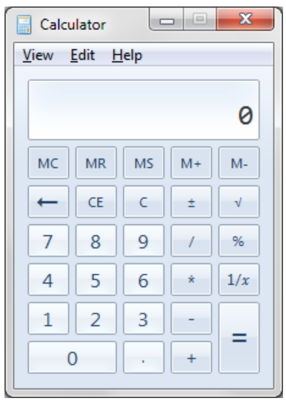
Calculator

Windows Calculator is a calculating application included in all the versions of Windows. It can be used to perform simple calculation, scientific calculation and Programming calculation.

- Choose Start >> Programs >> Accessories >> Calculator to start Calculator application, or
- Alternately you can open Run dialog box (Start >> Run) dialog box then type **calc** and hit enter.
- From View menu choose the required type of calculator – Standard, Scientific, Programmer, Statistical
- Edit >> Copy and Paste commands can be used to input the numbers into calculator or paste the result to other applications

Calculator was first included with Windows 1.0 as a simple arithmetic calculator. In Windows 3.0, a Scientific mode was added, which included exponents and roots, logarithms, factorial-based functions, trigonometry (supports radian, degree and gradians angles), base conversions (2, 8, 10, 16), logic operations, Statistic functions such as single variable statistics and linear regression.

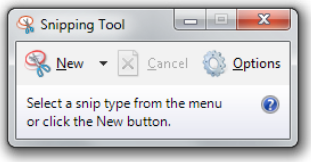
In Windows 7, separate Programmer, Statistics, Unit Conversion, Date Calculation, and Worksheets modes were added. Calculator's interface was revamped for the first time since its introduction.



On the right of the main Calculator, one can add a panel with Date Calculation, Unit Conversion, and Worksheets. The included Worksheets allow one to calculate a result of a chosen field based on the values of other fields. Pre-defined templates include calculating a car's fuel economy (mpg and L/100 km), a vehicle lease, and a mortgage. In pre-beta versions of Windows 7, Calculator also provided a Wages template.

Snipping Tool

Snipping Tool is another useful of Windows accessories included in Windows 7, Windows Vista, and Experience Pack for Windows XP Tablet PC Edition 2005. It was originally released as a powertoy for the Tablet PC. The program is a screen-capture tool that allows taking screenshots (called snips) of an open window, rectangular areas, a free-form area, or the entire screen. Snips can then be annotated using a mouse or a tablet, saved as an image file (PNG, GIF, or JPEG file) or an HTML page, or e-mailed.



The Snipping Tool captures all or part of the computer display screen as a picture. You can save the picture and attach it to an e-mail or paste the picture into a document. Click the Start button, type snip, and click the Snipping Tool from the search results. The screen fades slightly, and the Snipping Tool toolbar appears. Snipping tool can be used toPrintScreen, annotate and use in other applications.

Control Panel

The Control Panel is a part of the Microsoft Windows graphical user interface. It allows users to view and manipulate basic system settings and controls via applets. You can use control panel for the tasks such as adding hardware, adding and removing software, controlling user accounts, and changing accessibility options. Additional applets can be provided by third party software.

In recent versions of Windows, the Control Panel has two views, Classic View and Category View, and it is possible to switch between these through an option that appears on either the left side or top of the window.

The classic view consists of shortcuts to the various control panel applets, usually without any description (other than the name). The categories are seen if the user use “Details” view.

The category view consists of categories, which when clicked on display the control panel applets related to the category. In Windows Vista, the category used applets below the name of the category.

5.2.2 Imaging

Windows Imaging Component provides an extensible architecture for image codecs, pixel formats, and metadata, with automatic run-time discovery of new formats. It supports reading and writing of arbitrary metadata in image files, with the ability to preserve unrecognized metadata during editing. While working with images, it preserves high bit depth image data, up to 32 bits per channel, throughout the revamped high dynamic range image processing pipeline built into Windows Vista.

Windows Imaging Component (WIC) is a Component Object Model based imaging codec framework introduced in Windows Vista (and later available in Windows XP Service Pack 3) for working with and processing digital images and image metadata. It allows applications supporting the framework to automatically get support of installed codecs for graphics file formats.

It is similar to DirectShow, or ACM/VCM, in that it can be extended using image codecs and can support third-party graphics formats on a system-wide basis. Additionally, Windows Presentation Foundation applications also automatically support the installed image codecs. Codecs for RAW image formats used by high-end professional digital cameras are also supported in this manner.

Fax

A fax (short for facsimile and sometimes called telecopying) is the telephonic transmission of scanned-in printed material (text or images), usually to a telephone number associated with a printer or other output device. The original document is scanned with a fax machine, which treats the contents (text or images) as a single fixed graphic image, converting it into a bitmap. In this digital form, the information is transmitted as electrical signals through the telephone system. The receiving fax machine reconverts the coded image and prints a paper copy of the document.

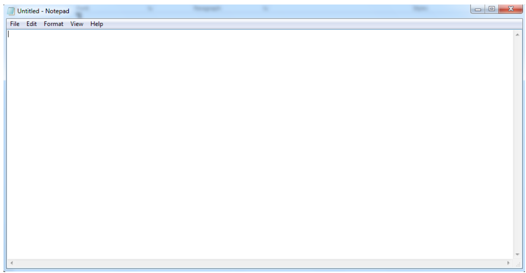
Almost all modems manufactured today are capable of sending and receiving fax data. Fax/modem software generates fax signals directly from disk files or the screen. Even if a document is text only, it is treated by the computer as a scanned image and is transmitted to the receiver as a bitmap. Faxing a message online works well if the recipient wants only to read the message. However, if the document requires editing, it must be converted into ASCII text by an OCR (optical character recognition) program, or it must be retyped manually into the computer. A more efficient method of sending documents that require modification is through the e-mail system. E-mail files are already ASCII text so they can be edited immediately in any text editor or word processing program.

The Internet now provides a new and cheaper way to send faxes in some cases. A number of free and commercial companies provide arrangements for using the Internet rather than the public telephone system for most or part of the path to the fax point. Some services also provide the ability to broadcast a fax to multiple addresses.

Notepad

Notepad is a common text-only (plain text) editor. The resulting files—typically saved with the .txt extension—have no format tags or styles, making the program suitable for editing system files that are to be used in a DOS environment.

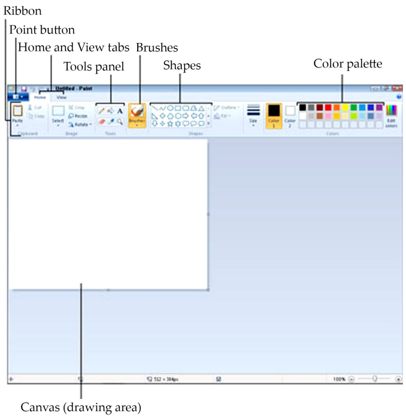
Notepad supports both left-to-right and right-to-left based languages, and one can alternate between these viewing formats by using the right or left Ctrl+Shift keys to go to right-to-left format or left-to-right format, respectively.



Notepad is a common text-only (plain text) editor. The resulting files—typically saved with the .txt extension—have no format tags or styles, making the program suitable for editing system files to use in a DOS environment and, occasionally, source code for later compilation or execution, usually through a command prompt. It is also useful for its negligible use of system resources; making for quick load time and processing time, especially on under-powered hardware. Notepad supports both left-to-right and right-to-left based languages. Unlike WordPad, Notepad does not treat newlines in Unix- or classic Mac OS-style text files correctly. Notepad offers only the most basic text manipulation functions, such as finding text. Only newer versions of Windows include an updated version of Notepad with a search and replace function. However, it has much less functionality in comparison to full-scale editors.

Paint

Paint (formerly Paintbrush for Windows) is a simple graphics painting program that has been included with all versions of Microsoft Windows. It is often referred to as MS Paint or Microsoft Paint. The program opens and saves files as Windows bitmap (24-bit, 256 color, 16 color, and monochrome) .BMP, JPEG, GIF. Paintbrush supports GIF without animation or transparency. Since Windows 98 Paint supports GIF with transparency. It also supports PNG (without alpha channel), and TIFF (without multiple page support).



The program can be in color mode or two-color black-and-white, but there is no grayscale mode. For its simplicity, it rapidly became one of the most used applications in the early versions of Windows—introducing many to painting on a computer for the first time—and still has strong associations with the immediate usability of the old Windows workspace.

Keyword

Graphics are visual images or designs on some surface, such as a wall, canvas, screen, paper, or stone to inform, illustrate, or entertain.

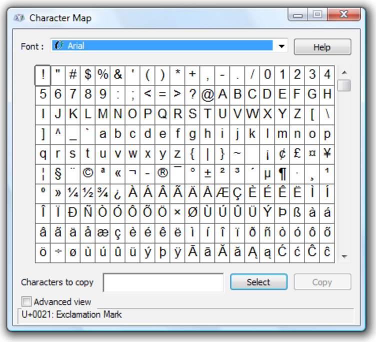
WordPad

Microsoft WordPad is a free rich text editor included with Microsoft Windows 95 and the later. Earlier to Windows 95 there used to be an application called Write for the same task. Although capable of doing much more than Notepad, WordPad is not as advanced as Microsoft Word.

WordPad can format and print text, but lacks intermediate features such as a spell checker, thesaurus, and support for tables. As such, it is suitable for writing letters or short pieces, but underpowered for work that relies heavily on **graphics** or typesetting.

Character Map

Character Map is a utility included with Microsoft Windows operating systems and is used to view the characters in any installed font, to check what keyboard input (Alt code) is used to enter those characters, and to copy characters to the clipboard in lieu of typing them. The tool is usually useful for entering special characters. It can be opened via the command line or Run Command dialog using the ‘charmap’ command.



5.3 AN OVERVIEW OF DIFFERENT VERSIONS OF WINDOWS

Microsoft Windows began as a GUI add-on to DOS. The early versions of Windows required DOS to be installed first. The first version that did not require DOS to be pre-installed was Windows 95. Early on, Windows split into two branches - the DOS-based branch and the NT based branch. Today, The DOS-based branch has been discontinued due to bugs (errors in software), Lack of hardware support, and instability. All versions of Windows since Windows NT 3.1 (these are Windows NT 3.1, NT 4.0, Windows 2000, XP, Vista, 7, and 8) are NT based.

Windows OS, computer operating system (OS) developed by Microsoft Corporation to run personal computers (PCs). Featuring the first graphical user interface (GUI) for IBM-compatible PCs, the Windows OS soon dominated the PC market. Approximately 90 percent of PCs run some version of Windows.

The first version of Windows, released in 1985, was simply a GUI offered as an extension of Microsoft's existing disk operating system, or MS-DOS. Based in part on licensed concepts that Apple Inc. had used for its Macintosh System Software, Windows for the first time allowed DOS users to visually navigate a virtual desktop, opening graphical "windows" displaying the contents of electronic folders and files with the click of a mouse button, rather than typing commands and directory paths at a text prompt.

Subsequent versions introduced greater functionality, including native Windows File Manager, Program Manager, and Print Manager programs, and a more dynamic interface. Microsoft also developed specialized Windows packages, including the networkable Windows for Workgroups and the high-powered Windows NT, aimed at businesses. The 1995 consumer release Windows 95 fully integrated Windows and DOS and offered built-in Internet support, including the World Wide Web browser Internet Explorer.

With the 2001 release of Windows XP, Microsoft united its various Windows packages under a single banner, offering multiple editions for consumers, businesses, multimedia developers, and others. Windows XP abandoned the long-used Windows 95 kernel (core software code) for a more powerful code base and offered a more practical interface and improved application and memory management. The highly successful XP standard was succeeded in late 2006 by Windows Vista, which experienced a troubled rollout and met with considerable marketplace resistance, quickly acquiring a reputation for being a large, slow, and resource-consuming system. Responding to Vista's disappointing adoption rate, Microsoft in 2009 released Windows 7, an OS whose interface was similar to that of Vista but was met with enthusiasm for its noticeable speed improvement and its modest system requirements.

Windows 8 in 2012 offered a start screen with applications appearing as tiles on a grid and the ability to synchronize settings so users could log on to another Windows 8 machine and use their preferred settings. In 2015 Microsoft released Windows 10, which came with Cortana, a digital personal assistant like Apple's Siri, and the Web browser Microsoft Edge, which replaced Internet Explorer. Microsoft also announced that Windows 10 would be the last version of Windows, meaning that users would receive regular updates to the OS but that no more large-scale revisions would be done.

5.3.1 Early Versions of Windows

Microsoft's Windows operating system was first introduced in 1985. Over 29 years later a lot has changed, but what things have stayed the same? Microsoft Windows has seen nine major versions since its first release in 1985. Over 29 years later, Windows looks very different but somehow familiar with elements that have survived the test of time, increases in computing power and – most recently – a shift from the keyboard and mouse to the touchscreen. Here's a brief look at the history of Windows, from its birth at the hands of Bill Gates with Windows 1 to the latest arrival under new Microsoft chief executive Satya Nadella.

The history of Windows dates back to September 1981, when Chase Bishop, a computer scientist, designed the first model of an electronic device and project Interface Manager was started. It was announced in November 1983 (after the Apple Lisa, but before the Macintosh) under the name "Windows", but Windows 1.0 was not released until November 1985. Windows 1.0 was to compete with Apple's operating system, but achieved little popularity. Windows 1.0 is not a complete operating system; rather, it extends MS-DOS. The shell of Windows 1.0 is a program known as the MS-DOS Executive. Components included Calculator, Calendar, Cardfile, Clipboard viewer, Clock, Control Panel, Notepad, Paint, Reversi, Terminal and Write. Windows 1.0 does not allow overlapping windows. Instead all windows are tiled. Only modal dialog boxes may appear over other windows.

Windows 2.0 was released in December 1987, and was more popular than its predecessor. It features several improvements to the user interface and memory management. Windows 2.03 changed the OS from tiled windows to overlapping windows. The result of this change led to Apple Computer filing a suit against Microsoft alleging infringement on Apple's copyrights. Windows 2.0 also introduced more sophisticated keyboard shortcuts and could make use of expanded memory.

Windows 2.1 was released in two different versions: Windows/286 and Windows/386. Windows/386 uses the virtual 8086 mode of the Intel 80386 to multitask several DOS programs and the paged memory model to emulate expanded memory using available extended memory. Windows/286, in spite of its name, runs on both Intel 8086 and Intel 80286 processors. It runs in real mode but can make use of the high memory area.

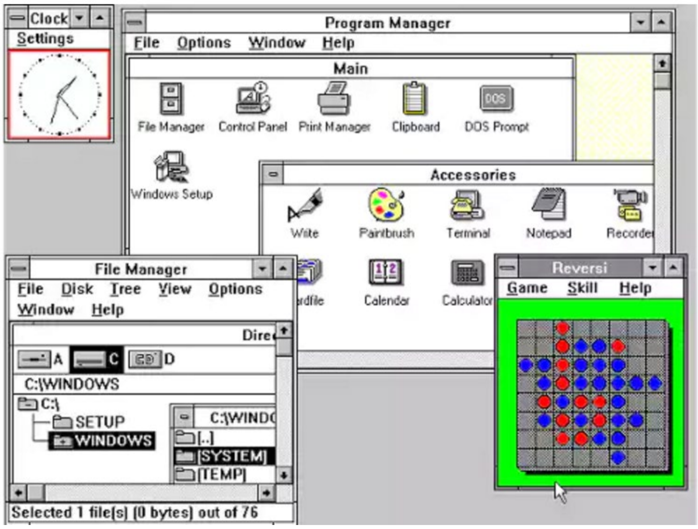
In addition to full Windows-packages, there were runtime-only versions that shipped with early Windows software from third parties and made it possible to run their Windows software on MS-DOS and without the full Windows feature set.

The early versions of Windows are often thought of as graphical shells, mostly because they ran on top of MS-DOS and use it for file system services. However, even the earliest Windows versions already assumed many typical operating system functions; notably, having their own executable file format and providing their own device drivers (timer, graphics, printer, mouse, keyboard and sound). Unlike MS-DOS, Windows allowed users to execute multiple graphical applications at the same time, through cooperative multitasking. Windows implemented an elaborate, segment-based, software virtual memory scheme, which allows it to run applications larger than available memory: code segments and resources are swapped in and thrown away when memory became scarce; data segments moved in memory when a given application had relinquished processor control.

5.3.2 Windows 3.x

Windows 3.x refers to the third version of Microsoft Windows. It was not actually a full-blown operating system but was a 16-bit GUI program that ran on top of MS-DOS. Windows 3.x quickly became the first-ever widely accepted version of Windows. It consisted of two versions: Windows 3.0 and Windows 3.1x.

Windows 3.x was the predecessor of Windows 2.x; unlike MS-DOS, it had multitasking (non-preemptive) capabilities, which means that it could run multiple programs concurrently, as well as run more than one instance of the same program simultaneously. Windows 3.0 was launched in 1990; it was then followed by Windows 3.1, Windows 3.11 (Windows for Workgroups) and Windows 3.2 (basically the Chinese version of 3.1), which were released between 1992 and 1995. Windows 3.x included a variety of programs including File Manager, Notepad, Paintbrush, Solitaire, etc. Windows Media Player was first introduced in Windows 3.0 with Multimedia Extensions, which was released in 1991.



The first Windows that required a hard drive launched in 1990. Windows 3 was the first version to see more widespread success and be considered a challenger to Apple's Macintosh and the Commodore Amiga graphical user interfaces, coming pre-installed on computers from PC-compatible manufacturers including Zenith Data Systems.

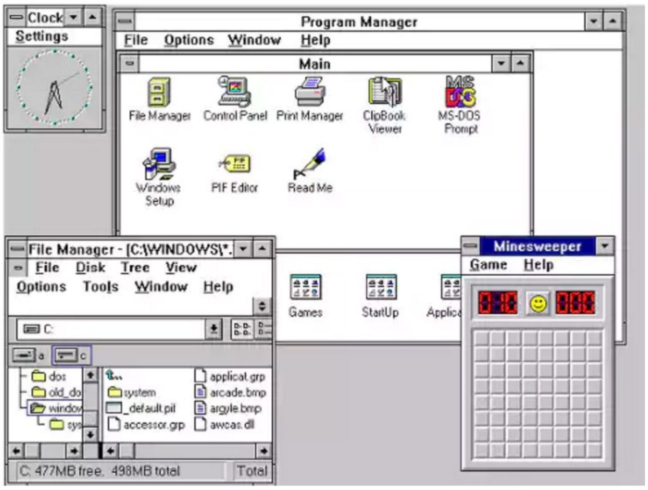
Windows 3 introduced the ability to run MS-DOS programmes in windows, which brought multitasking to legacy programmes, and supported 256 colours bringing a more modern, colourful look to the interface.

More important - at least to the sum total of human time wasted - it introduced the card-moving timesink (and mouse use trainer) Solitaire.

Windows 3.1

Windows 1 and 2 both had point release updates, but Windows 3.1 released in 1992 is notable because it introduced TrueType fonts making Windows a viable publishing platform for the first time.

Minesweeper also made its first appearance. Windows 3.1 required 1MB of RAM to run and allowed supported MS-DOS programs to be controlled with a mouse for the first time. Windows 3.1 was also the first Windows to be distributed on a CD-ROM, although once installed on a hard drive it only took up 10 to 15MB (a CD can typically store up to 700MB).



5.3.3 Windows 9x

Windows 9x (Win9x) refers to the series of versions of Microsoft Windows released between 1995 and 2000. Windows 9x comprises Windows 95 (and the various "OS-R" updates to Windows 95, which were provided only via PC makers), Windows 98, Windows 98 Second Edition (SE) and Windows Millennium Edition (Me).

Windows 9x differed from previous Windows versions (1.1, 2.0 and 3.0) by their device driver, virtual memory management and the MSDOS.SYS and MS-DOS kernel. A variety of fonts as well as improved graphics were a part of the 9x series. The GUI experienced a complete overhaul from its predecessors and the kernel supported bigger VFAT (virtual file allocation tables) which significantly increased the speed of the system. Moreover, file names in Windows 9x were allowed to have up to 255 characters, in contrast to previous versions which were limited to MS-DOS-style 8.3 letter filenames (up to eight letters naming the file and three as the file extension). Windows XP's release in 2001 marked the end of the Windows 9x era.

Architecture

The Windows 9x architecture was a step up in many ways from its predecessors. The GUI was redesigned, the kernel supported virtual memory and had a VFAT{virtual file allocation table} filesystem unlike its FAT16 and FAT12 filesystems before. Windows 95b was the 3rd version of 95 released and included support for FAT32. All versions of 9x supported FAT16 drive compression through Drivespace, a program originally from MS-DOS 6.22

The Kernel

The kernel was just a different version of the MS-DOS kernel, with added virtual memory and memory protection that was lacking in Windows 1.0+. It was of monolithic architecture, different from its successors NT 3.1+.

Keyword

Internet Information Services (IIS) is a flexible, general-purpose web server from Microsoft that runs on Windows systems to serve requested HTML pages or files.

The Registry

The registry acted as a temporary and convenient holding place for program and system data. The directories are conventionally named as follows: HKEY_CLASSES_ROOT, HKEY_CURRENT_USER, HKEY_LOCAL_MACHINE, HKEY_USERS, HKEY_CURRENT_CONFIG, and HKEY_PERFORMANCE_DATA. Each one of these stored specific types of data like, hardware configuration data, application data, performance data, and user data. The system can access this anytime and the current user is allowed to access and edit it also.

File Names

File names in Windows 9x were allowed to have up to 255 characters, a special feature in the VFAT filesystem. Previous versions of Windows were limited to MS-DOS style 8.3 letter filenames.

Graphical User Interface

The GUI was one significantly changed in the Windows 9x series. With the start button, the toolbar and taskbar both by default on the bottom of the screen, allowing running program to be selected. There was also a new widget set (that is, a different standard look and feel to the applications) and many new fonts are available.

5.3.4 Windows NT

Windows NT is a Microsoft Windows personal computer operating system designed for users and businesses needing advanced capability. NT's technology is the base for the Microsoft successor operating system, Windows 2000. Windows NT (which may originally have stood for "New Technology," although

Microsoft doesn't say) is actually two products: Microsoft NT Workstation and Microsoft NT Server. The Workstation is designed for users, especially business users, who need faster performance and a system a little more fail-safe than Windows 95 and Windows 98. The Server is designed for business machines that need to provide services for network-attached computers. The Server is required, together with an Internet server such as Microsoft's **Internet Information Server (IIS),** for a Windows system that plans to serve Web pages.

Windows NT Workstation: Microsoft says that 32-bit applications run 20% faster on this system than on Windows 95 (assuming both have 32 megabytes of RAM). Since older 16-bit applications run in a separate address space, one can crash without crashing other applications or the operating system. Security and management features not available on Windows 95 are provided. The Workstation has the same desktop user interface as Windows 95.

Windows NT Server: The NT Server is probably the second most installed network server operating system after Novell's NetWare operating system. Microsoft claims that its NT servers are beginning to replace both NetWare and the various UNIX-based systems such as those of Sun Microsystems and Hewlett-Packard. NT Server 5.0. Essentially became what was renamed Windows 2000. Notable features of the Windows 2000 products are:

- A fully-customizable administrative console that can be based on tasks rather than files, applications, or users
- A new file directory approach called Active Directory that lets the administrator and other users view every file and application in the network from a single point-of-view.
- Dynamic Domain Name Server (DNS), which replicates changes in the network using the Active Directory Services, the Dynamic Host Configuration Protocol (DHCP), and the Windows Internet Naming Service (WINS) whenever a client is reconfigured.
- The ability to create, extend, or mirror a disk volume without having to shut down the system and to back up data to a variety of magnetic and optical storage media.
- A Distributed File System (DFS) that lets users see a distributed set of files in a single file structure across departments, divisions, or an entire enterprise.
- Close integration with and support for Microsoft's Message Queue Server, Microsoft Transaction Server, and Internet Information Server (IIS).

Windows XP

Windows XP is a version of the Windows desktop operating system for the PC. Windows

XP, which is built on the Windows 2000 kernel, brought a more personalized look to the desktop that made it easier for end users to scan or import images, acquire music files on the Web and transfer them to portable devices.

Windows XP, which is available in Professional version and a Home Edition version, will no longer be supported by Microsoft after April 8, 2014. Although PCs can continue to run Windows XP after that date, they may become more vulnerable to viruses and other security risks. Microsoft recommends that their customers should consider purchasing a new computer if their old computer running XP is not capable of upgrading to Windows 8.1.

Windows XP is an operating system introduced in 2001 from Microsoft's Windows family of operating systems, the previous version of Windows being Windows Me. The "XP" in Windows XP stands for eXPerience. Microsoft called the XP release its most important product since Windows 95. Along with a redesigned look and feel to the user interface, the new operating system was built on the Windows 2000 kernel, giving users a more stable and reliable environment than previous versions of Windows.

Windows Vista

Vista, formerly code named Longhorn, is a Microsoft Windows desktop operating systems. Vista was released for businesses, the holders of most volume licenses, on November 30, 2006. Bill Gates hosted the worldwide launch of Windows Vista and Microsoft Office 2007 in Times Square on January 29, 2007. Vista ships in nine different versions that fall under the main categories of home edition and business edition.

The most noticeable change from user interface called Aero, which stands for "authentic, energetic, reflective and open." Other additions include a faster and customizable search engine and an XML-based specification for creating documents similar to Portable Document Format (PDF) files.

Microsoft has also identified several underlying technology improvements that distinguish Vista, including:

- Enhancements to the basic structure of the operating system and the . NETframework.
- A new audio system.
- A simplified application deployment engine and application installer.
- Increased support for digital rights management (DRM)
- A messaging system that allows programs to interoperate similarly to Web services
- Built-in IPv6 and peer-to-peer networking capabilities.

- The multi-vendor security initiative previously known as Palladium.

Microsoft offered the beta 2 version of Vista for public download In early June 2006. This release targeted experts and tech enthusiasts, rather than the general public. Microsoft hoped to get useful feedback from beta testers in preparation for broader release of the OS in 2007. According to Bill Gates, over 5 million users downloaded and tested Vista.

Windows 7

Windows 7 is the Microsoft Windows operating system released commercially in October 2009. In development, Windows 7 was known by the code names “Blackcomb” and “Vienna.” Windows 7 is built on the Vista kernel. To many end users the biggest changes between Vista and Windows 7 are faster boot times, new user interfaces and the addition of Internet Explorer 8. The OS is widely available in three retail editions: Windows 7 Home Premium, Professional and Ultimate. Starter, OEM and Enterprise editions are available in some markets.

Windows 7 features:

- DirectAccess for Mobile Workers - Allows IT administrators to update Group Policy settings and distribute software updates any time the mobile device has Internet connectivity, whether or not the user is logged on. DA supports multi-factor authentication and encryption.
- XP mode - Allows older applications designed for Windows XP to use a virtualized version of the XP operating system. To the end user, the applications seem to be running right on the Windows 7 desktop.
- BranchCache - WAN optimization through more effective use of local, read-only caches.
- BitLocker To Go - Extends on-disk encryption and key management techniques to portable storage devices.
- Virtual hard disk support - Allows you to mount a virtual hard disk (VHD) and interact with it as if it were a physical drive.
- Enterprise Search - Extends search to remote document repositories, SharePoint sites and Web applications.
- AppLocker - Allows IT administrators to use Group Policy to specify rules about what software applications can be run on a particular user’s desktop.
- Enhanced VDI - Allows administrators to use the same master image for both remote clients using virtual desktop infrastructure and traditional desktop computers.
- According to Microsoft, Windows 7 requires 1 GHz processor (32- or 64-bit),

1 GB of RAM (32-bit) / 2 GB of RAM (64-bit), 16 GB of available disk space (32-bit) / 20 GB of available disk space (64-bit) and a DirectX 9 graphics device with WDDM 1.0 or higher driver.

Windows 8 and 8.1

Windows 8.1 and Windows RT 8.1 build on Windows 8 and Windows RT to bring you enhancements in personalization, search, apps, the Windows Store, and cloud connectivity and has the security and reliability features you expect from Windows.

If your PC is currently running Windows 8 or Windows RT, it's free to update to Windows 8.1 or Windows RT 8.1. And unlike previous updates to Windows, you'll get this update from the Windows Store.

Before you begin

The system requirements for Windows 8.1 and Windows RT 8.1 are nearly the same as the requirements for Windows 8—if your PC is already running Windows 8 (or Windows RT), in most cases, you can get the free update to Windows 8.1 (or Windows RT 8.1).

Before you begin, here are some things to keep in mind.

- **Your files, desktop apps, user accounts, and settings come with you**. Windows 8.1 and Windows RT 8.1 come with some new built-in apps and will update or replace some of your existing built-in apps. Your existing Windows Store apps don't come with you, but once the update is complete, you can reinstall all of these apps at once—or just the ones you want.
- **We'll check your desktop apps and devices for you**. As part of the update, we check your current desktop apps and connected devices. We'll let you know what you'll need to do to get them ready for the update or to get them working again after the update. In most cases, you won't need to do anything—most desktop apps, devices (like printers), and network connections will work normally after the update.
- **Consider using a Microsoft account to sign in to your PC**. If you already use a Microsoft account to sign in to Windows 8 or Windows RT, you'll use that same account to sign in to Windows 8.1 or Windows RT 8.1. If you don't, we recommend that you start using a Microsoft account in Windows 8.1 or Windows RT 8.1. If you already have an account you use with Outlook.com, Xbox LIVE, Windows Phone, or Skype, then you already have a Microsoft account.
- **You can keep working while the update is installing**. Download and installation times vary from about 30 minutes to several hours, depending on your Internet connection speed and the speed and configuration of your PC, but you can

still use your PC while the update is installing in the background. During this time, make sure to save your work and close any apps you have open before leaving your PC unattended in case your PC needs to restart automatically while you're away. After it restarts, you won't be able to use your PC for a little while (from about 20 minutes to an hour) while the updates are being applied. After that phase is complete, we'll walk you through choosing a few basic settings and then Windows will finish applying any final updates that are needed.

Prepare your PC

There are a few things you should do before you start installing:

- **Back up your files**. Although your files and apps come with you when you update to Windows 8.1 or Windows RT 8.1, it's a good idea to back up your important files to an external drive or the cloud.
- **Make sure you have enough free disk space**. If you're currently running Windows 8, you need 3,000 MB of available space to install the 32-bit version of Windows 8.1 and 3,850 MB of available space to install the 64-bit version of Windows 8.1. On a Windows RT device, you need 2,250 MB of available disk space to install Windows RT 8.1.
- **Plug in your laptop or tablet**. It's important to keep your PC plugged in throughout the update process, because if you lose power before it's done, the update might not install properly.
- **Connect to the Internet**. It's best to stay connected until the update is done. If you don't, you'll need to connect again to finish setting up later and setup will take longer.
- **Get the latest critical and important updates**. There are some updates you might need before you can install Windows 8.1. In most cases, the latest updates will be installed automatically using Windows Update. But if you don't have automatic updates turned on and you need to check for updates manually, or if you'd like to check to see when the latest updates were installed, you can do this from Windows Update.
- **Temporarily turn off your antivirus program**. Some antivirus software might interfere with the installation. After you install Windows 8.1 or Windows RT 8.1, remember to turn your antivirus program back on.

Get the free update

You can download the free update from the Windows Store.

- Go to the Start screen, and select the Store tile.

- In the Store, select the Windows 8.1 or Windows RT 8.1 update and then select **Download**.
- The update will download and install in the background while you use your PC to do other things. The installer will check to make sure you have enough disk space, that your apps and devices will work with Windows 8.1 or Windows RT 8.1, and that you have all the required updates. In some cases, the installer might find something you need to take care of before you can continue installing the update. If so, you'll see a message telling you what you need to do.

Windows 10

Windows 10 is a personal computer operating system developed and released by Microsoft as part of the Windows NT family of operating systems. It was officially unveiled in September 2014 following a brief demo at Build 2014. The first version of the operating system entered a public beta testing process in October, leading up to its consumer release on July 29, 2015. Unlike previous versions of Windows, Microsoft has branded Windows 10 as a "service" that receives ongoing "feature updates"; devices in enterprise environments can receive these updates at a slower pace, or use long-term support milestones that only receive critical updates, such as security patches, over their five-year lifespan of mainstream support.

Windows 10 introduces what Microsoft described as "universal apps"; expanding on Metro-style apps, these apps can be designed to run across multiple Microsoft product families with nearly identical code—including PCs, tablets, smartphones, embedded systems, Xbox One, Surface Hub and Mixed Reality. The Windows user interface was revised to handle transitions between a mouse-oriented interface and a touchscreen-optimized interface based on available input devices—particularly on 2-in-1 PCs; both interfaces include an updated Start menu which incorporates elements of Windows 7's traditional Start menu with the tiles of Windows 8. The first release of Windows 10 also introduces a virtual desktop system, a window and desktop management feature called Task View, the Microsoft Edge web browser, support for fingerprint and face recognition login, new security features for enterprise environments, and DirectX 12 and WDDM 2.0 to improve the operating system's graphics capabilities for games.

Windows 10 received mostly positive reviews upon its original release in July 2015; critics praised Microsoft's decision to provide a desktop-oriented interface in line with previous versions of Windows, contrasting the tablet-oriented approach of 8, although Windows 10's touch-oriented user interface mode was panned for containing regressions upon the touch-oriented interface of Windows 8. Critics also praised the improvements to Windows 10's bundled software over Windows 8.1, Xbox Live integration, as well as the functionality and capabilities of Cortana personal assistant and the replacement of Internet Explorer with Microsoft Edge. However, media outlets have been critical of changes to operating system behaviors, including mandatory update installation, privacy concerns over data collection performed by the OS for Microsoft and its partners, and the adware-like tactics used to promote the operating system on its release.

Microsoft aimed to have Windows 10 installed on at least one billion devices in the two to three years following its release. Up to August 2016, Windows 10 usage was increasing, with it then plateauing, and with previous versions of Windows declining in their share of total usage as measured by web traffic. The operating system is running on more than 400 million active devices and has an estimated usage share of 27.72% on traditional PCs and 12.53% across all platforms (PC, mobile, tablet, and console).

5.3.5 Windows CE

REMEMBER

A typical Windows CE-powered device can have less than a megabyte of memory, no disk storage and can also be placed directly into ROM.

Windows CE is based on the Microsoft Windows operating system but is designed for including or embedding in mobile and other space-constrained devices. Although Microsoft does not explain the "CE," it is reported to have originally stood for "Consumer Electronics." Windows CE is used in several brands of handheld computers and as part of cable TV set-top boxes built for TCI. It competes with EPOC and also with similar operating systems from 3Com (for its PalmPilot) and other companies. Like the full-scale Windows systems, Windows CE is a 32-bit multitasking, multithreading operating system. Microsoft emphasizes that the system was "built from scratch" while taking advantage of Windows architectural concepts and interfaces. Microsoft argues that Windows desktop system users will find that products with Windows CE provide a familiar user interface.

In addition to handheld computers and cable TV boxes, Windows CE is also offered as the operating system for the Auto PC, Microsoft's concept of controlling applications (such as selecting radio channels) while driving, using interactive speech technology.

Windows CE is an operating system developed by Microsoft and designed for small footprint devices or embedded systems. Windows CE is different from the Windows operating systems for desktops but they share similar application programming interfaces for a considerable number of classes. Some of the devices that run Windows CE include industrial controllers, point of sale terminals, cameras, Internet appliances, cable set-top boxes and communications hubs.

Using Microsoft Platform Builder, developers can build customized Windows CE operating systems as well as components for embedded systems. Platform Builder is an integrated development environment that comes with development tools for designing, creating, building, testing and debugging. Most parts of Windows CE are offered in source code form, enabling hardware vendors to alter it in order to fit the specific needs of their device.

Developers who create Windows CE-based OS designs perform the following:

- Create BSP or board support packages specifically designed for the target device.
- Create an OS design, based on either a standard or customized board support package (BSP), that is used for creating a run-time image.
- Create customized device drivers for the BSP using projects and catalog items.
- Build the runtime image and download to the standard development board for debugging and testing.
- Export a software development kit for application developers.

5.3.6 Xbox OS

Xbox OS, is the operating system for the eighth-generation home video game console, Xbox One. It is a Windows-based operating system using the Hyper-V virtual machine monitor and contains separate operating systems for games and applications that can run on the console. It is located on the internal HDD for day-to-day usage, while also being duplicated on the internal NAND storage of the console for recovery purposes and factory reset functionality.

The Xbox One allows users to download applications that add to the functionality of the dashboard. From June 2014 onwards, entertainment apps no longer required the user to be signed into a valid Xbox Live Gold account in order to use the features advertised for the given app.

Since launch, Microsoft has been updating the OS monthly, with updates downloaded from the Xbox Live service directly to the Xbox One and subsequently installed, or by using offline recovery images downloaded via a PC. In November 2015, a major system update known as the New Xbox One Experience was released, which brought very significant changes to the design and functionality of the system. The Windows 10-based Core had replaced the Windows 8-based one in this update, and the new system is sometimes referred to as “Windows 10 on Xbox One”.

System

The Xbox One console runs on an operating system that includes the Windows 10 core, although initially it included the Windows 8 core at the Xbox One's release. The Xbox One system software contains a heavily modified Hyper-V hypervisor as its host OS and two partitions. One of the partitions, the "Exclusive" partition is a custom virtual machine (VM) for games; the other partition, the "Shared" partition is a custom VM for running multiple apps. The Shared Partition contained the Windows 8 Core at launch until November 2015, where via a system update known as the "New Xbox One Experience", it was upgraded to the Windows 10 Core. With Windows 10, Universal Windows Platform apps became available on Xbox One. According to the current head of Microsoft's Xbox division, Phil Spencer, "The importance of entertainment and games to the Windows ecosystem has become really prevalent to the company". The program that Microsoft launched allows developers to build a single app that can run on a wide variety of devices, including personal computers and Xbox One video game consoles. According to *Polygon*, Microsoft is removing the distinction between Xbox One and Windows PC.

Starting in February 2014, Microsoft invited select users to join a preview program that enables them to receive early builds of upcoming system updates and experiment with the features prior to the public launch of the software. Once registered for the Xbox One Preview Program, participants will be able to test the early features included in the update and provide feedback on a private forum and can opt out of future waves. Through its Xbox Feedback website, Microsoft has been soliciting input from consumers on its features and taking requests for future additions to the console. Low battery notifications and Blu-ray 3D support are two examples of ideas that have been among the top vote-getters on the site.

User interface

The Xbox One system software's interface uses a geometrical placement of squares and rectangular items that scrolls as a continuous horizontal line, using the Metro design language that is also seen in Windows 8, Windows 10, and other Microsoft products. The dashboard is divided into "Home", "Community", "OneGuide", and "Store" sections; the "Home" section contains a recent apps and games list, and shortcuts to "pinned" apps and games. The "Community" section allows users to view their friends' in-game activities and captures, post status updates, as well as view trending content. The "OneGuide" section aggregates television and online video content, while the "Store" section serves as a portal to the games, video, music, and app marketplaces. In general, the top level menu of the Xbox One feels a lot less cluttered than the Xbox 360's dashboard. For example, the friends tab has been removed and replaced with a dedicated app that users can load up to see what their connections are doing. There are a couple of columns for settings options and an area for "pinned" favorites, a "main" screen showing current and recent apps and games that the user played or used, and a small "What's New" section highlighting some recently added content. In total, the interface is very clean and sparse. Microsoft also introduced a new way to multitask called Snap, which allows Xbox One users to open multiple panes in a single window.

When Microsoft upgraded the Windows 8-based Core to a Windows 10-based one, they made a tour of the new user interface up on Xbox Wire, promising faster, easier navigation, improved community features and, the return of Xbox Avatars. The main feature on the home screen is a list of most recently played games. Selecting any given title will give users more information about announcements, achievements, social activity and so forth. It is also more focused on the actual games they are playing, which is part and parcel of the company's new direction under Phil Spencer, the current head of Microsoft's Xbox division.

Multimedia features

While like other video game consoles the Xbox One is primarily designed for playing games, it is more than a game console. It is an entertainment hub for games, television, music, and videos. Mainly the console focuses on functionality and entertainment as a whole. At Gamescom 2014 Microsoft unveiled a new plan to remedy this and make earnest on the Xbox One's label as the "all-in-one entertainment" solution by way of expanding its media support. The Xbox One's media player is quite similar to the Xbox 360's playback suite in terms of form and function, however the newer console now supports more than 30 formats including the MKV container and GIF files. The Xbox One console also does some unique things. For example, its owners can control their television broadcasts using the device, as well as use it as a functioning DVR. Apart from streaming music and videos via Play (Charms > Devices > Play), there is also a networked approach. There are two primary ways to do this. The first is to stream media from a computer or tablet, and the second is to play it directly off of a USB flash drive. The advantage of this method over the Play system is that users can do it all from wherever they sit via the Xbox One, instead of sending the video from a PC to their console. Aside from multimedia files, Xbox One plays CDs, DVDs and Blu-ray Discs, and it also comes with DLNA and MKV support, which means that downloaded video files can be streamed via the PC or transported via external hard drive and USBs. Meanwhile, the interactive TV Guide allows users to turn on and control television with their voice. Furthermore, the system comes with a comprehensive range of applications related to multimedia features. In the United States, video channels include for example the Amazon Instant Video, Crackle, Hulu Plus and Netflix. Microsoft had announced that the Xbox One was awarded for its multimedia capabilities at the 66th Annual Technology & Engineering Emmy Awards in early 2015, and the prize was given for the Xbox One's television-on-demand functions.

ROLE MODEL

William Henry Gates III: *He is the co-founder of the* ***Microsoft Corporation****, and held the positions of chairman, CEO and chief software architect.*

Biography

William Henry Gates III (born October 28, 1955) is a co-founder of the Microsoft Corporation and is an American business magnate, investor, author and philanthropist. Bill Gates is an American business magnate and computer programmer who is the co-founder of Microsoft, the world's largest PC software company. Since the company's formation in 1975, Gates has held several positions including those of the chairman, CEO and chief software architect. One of the most famous entrepreneurs of the personal computer revolution, he has been consistently ranked among the world's wealthiest people starting from 1987. Born as the son of a successful lawyer, Bill Gates was encouraged from a young age to be competitive. Bright and curious, he developed an interest in computers while in school and wrote his first computer program as a young teenager. After completing his schooling, he enrolled at the prestigious Harvard College though he did not stay there long enough to complete his studies. He dropped out to pursue his passion in computers and teamed up with Paul Allen, a former schoolmate, to form Microsoft. The company proved to be highly successful and within years Gates became an internationally known entrepreneur. Currently the wealthiest person in the world, he is a renowned philanthropist who along with his wife has created the charity organization "Bill & Melinda Gates Foundation". He has also authored and co-authored several books.

Childhood & Early Life

- Born as William Henry "Bill" Gates III on October 28, 1955, he is the son of William H. Gates, Sr. and Mary Maxwell Gates. His father was a prominent lawyer while his mother served on the board of directors for First Interstate BancSystem and the United Way. He has two sisters.

- He studied at the Lakeside School where he developed an interest in computing. He was just 13 when he wrote his first software program on the school's computer and by the time he was in high school he, along with some of his friends, had computerized their school's payroll system.
- His future business collaborator, Paul Allen, was a senior at Lakeside. At the age of 17, Gates teamed up with Allen to form a venture called Traf-O-Data, to make traffic counters based on the Intel 8008 processor.
- He graduated from high school in 1973. He was a National Merit Scholar and scored 1590 out of 1600 on the SAT. He enrolled at Harvard College later the same year. As a college student he spent a lot of time on the computers though he was not much interested in studying other subjects. His friend Allen suggested that Bill drop out of college to start a business.

Career

- Bill Gates and Paul Allen collaborated to found Microsoft (initially called Micro-Soft) in 1975. In the beginning they adapted BASIC, a popular programming language for use on microcomputers. It proved to be a success and they continued to develop programming language software for various systems.
- In 1980, the duo was approached by International Business Machine (IBM) with a proposal that Microsoft write the BASIC interpreter for IBM's upcoming personal computer, the IBM PC. Microsoft created the PC DOS operating system which they delivered to IBM in exchange for a one-time fee of $50,000.
- Soon Microsoft's operating systems became very popular and the company introduced an operating environment named Windows on November 20, 1985, as a graphical operating system shell for MS-DOS. Over the following years Windows came to dominate the world's personal computer market acquiring over 90% market share. The company saw phenomenal financial success, and being the company's largest individual shareholder, Bill Gates amassed a great fortune.
- Microsoft introduced Microsoft Office in 1989. The package integrated several applications like Microsoft Word and Excel into one system that was compatible with all Microsoft products. The success of MS Office gave Microsoft a virtual monopoly on operating systems for PCs.
- In the mid 1990s when the use of the internet spread throughout the globe at an alarming speed, Gates focused Microsoft on the development of consumer and enterprise software solutions for the Internet. Windows CE operating system platform and the Microsoft Network were among the innovative solutions developed during this time.

- In January 2000, Gates stepped down as Chief Executive Officer of Microsoft though he retained his position as chairman. He created the new position of Chief Software Architect for himself. Over the next few years he gradually transferred his duties to others at Microsoft and started spending more time in philanthropic works. He stepped down as Chairman of Microsoft in February 2014, and currently serves as technology advisor to support CEO Satya Nadella.

Major Works

- Bill Gates is best known as the co-founder of Microsoft, the multinational technology company which is today considered one of the world's most valuable companies. It is the world's largest software maker measured by revenues

Awards & Achievements

- In 2002, Bill and Melinda Gates received the Jefferson Award for Greatest Public Service Benefiting the Disadvantaged.
- Gates received the Bower Award for Business Leadership from The Franklin Institute in 2010 in recognition of his achievements at Microsoft and his philanthropic work.
- Bill and Melinda Gates jointly received India's third highest civilian honor Padma Bhushan in 2015 for their foundation's philanthropic activities in India.

Personal Life & Legacy

- Bill Gates met Melinda French, a young woman working at Microsoft, in 1989. The couple grew close over a period of time and got married in 1994. They have three children.

Philanthropic Works

- In 1999, he donated US$20 million to the Massachusetts Institute of Technology (MIT) for the construction of a computer laboratory which was named the "William H. Gates Building" in his honor.
- Along with his wife, Melinda, Bill Gates formed the Bill & Melinda Gates Foundation (BMGF or the Gates Foundation) in 2000. It is the largest private foundation in the world and aims to enhance healthcare and reduce extreme poverty worldwide.
- In 2010, Gates along with fellow billionaire investors Warren Buffett, and Facebook founder and CEO Mark Zuckerberg signed the "Gates-Buffet Giving Pledge", committing to donate at least half of their wealth over the course of time to charity.

Net Worth

- As of 2015, Bill Gates has a net worth of US $79.3 billion

Top 10 Facts You Did Not Know About Bill Gates

- His childhood nickname was "Trey".
- The first computer program that Bill Gates wrote was a tic-tac-toe game.
- As a school student he used to brag that he would be a millionaire by the time he was 30—he actually became one by the time he was 31!
- Gates was once arrested in New Mexico in 1977 for driving without a license.
- He acquired the Codex Leicester—a collection of writings by Leonardo da Vinci—at an auction for $30.8 million, in 1994.
- Bill Gates' biggest regret is that he doesn't know any foreign languages.
- He is not active on Facebook despite being friends with Facebook co-founder Mark Zuckerberg.
- Had Microsoft failed to work out, he would have been a researcher for artificial intelligence.
- Gates says his kids will only inherit $10 million each despite his immense wealth.
- His all-time favorite business book is 'Business Adventures' by John Brooks, published in 1969.

SUMMARY

- Microsoft Windows, commonly referred to as Windows, is a group of several proprietary graphical operating system families, all of which are developed and marketed by Microsoft.
- Apple came to see Windows as an unfair encroachment on their innovation in GUI development as implemented on products such as the Lisa and Macintosh.
- A horizontal scroll bar enables the user to scroll the content of a window to the left or right. A vertical scroll bar enables the user to scroll the content up or down.
- A status bar is a horizontal window at the bottom of a parent window in which an application can display various kinds of status information. The status bar can be divided into parts to display more than one type of information.
- Windows operating system ships with some handy applications known as Windows accessories. Calculator, Notepad, Paint, Explorer, WordPad are some of the most frequently used accessories.
- System restore is a feature of Windows that allows you to roll back the system to the same configuration it had at an earlier time.
- Windows Imaging Component provides an extensible architecture for image codecs, pixel formats, and metadata, with automatic run-time discovery of new formats.
- Windows NT is a Microsoft Windows personal computer operating system designed for users and businesses needing advanced capability.
- Windows XP, which is built on the Windows 2000 kernel, brought a more personalized look to the desktop that made it easier for end users to scan or import images, acquire music files on the Web and transfer them to portable devices.

KNOWLEDGE CHECK

1. **Windowing and graphics system implements the**
   a. Graphical User Interface
   b. User Interface
   c. Computer Interface
   d. Resource Manager
2. **Executive contains base services of**
   a. Operating System
   b. I/O Devices
   c. Programmed I/O
   d. I/O Modules
3. **Configuration manager responsible for implementing and managing the**
   a. System Control
   b. System Damage
   c. System registry
   d. System Access
4. **Environment subsystems provide different operating system**
   a. Applications
   b. Services
   c. Functions
   d. Responsibilities
5. **Cache manager improves performance of**
   a. Programmed I/O
   b. File base I/O
   c. I/O device
   d. I/O Modules
6. **The title bar is a bar located at the top of a window or a dialog box that displays the name of the window or software program being used.**
   a. True
   b. False
7. **Windows operating system ships with some handy applications known as Windows accessories.**
   a. True
   b. False

REVIEW QUESTIONS

1. Write the basic elements of windows.
2. Explain how to manage file through windows.
3. Give an overview on disk cleanup and disk defragmenter.
4. Describe the features of early version windows.
5. What are the different between Windows 3.x and Windows 9x series? Detail.
6. Demonstrate the various changes in Windows NT series.

Check Your Result

1. (a) 2. (a) 3. (c) 4. (d) 5. (b)

6. (c) 7. (a)

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CHAPTER 6

LINUX

LEARNING OBJECTIVES

After studying this chapter, you will be able to:

1. Concept of Linux
2. A brief history of Linux Development
3. Linux Kernel and Its Architecture
4. Overview of Linux processes
5. Linux process environment
6. Installation of Linux

"All operating systems sucks, but Linux just sucks less"

*– **Linus Torvalds***

INTRODUCTION

Linux is a family of open-source Unix-like operating systems based on the Linux kernel, an operating system kernel first released on September 17, 1991, by Linus Torvalds. Linux is typically packaged in a Linux distribution. Distributions include the Linux kernel and supporting system software and libraries, many of which are provided by the GNU Project. Many Linux distributions use the word "Linux" in their name, but the Free Software Foundation uses the name "GNU/Linux" to emphasize the importance of GNU software, causing some controversy. Popular Linux distributions include Debian, Fedora, and Ubuntu. Commercial distributions include Red Hat Enterprise Linux and SUSE Linux Enterprise Server. Desktop Linux distributions include a windowing system such as X11 or Wayland, and a desktop environment such as GNOME or KDE Plasma. Distributions intended for servers may omit graphics altogether, or include a solution stack such as LAMP. Because Linux is freely redistributable, anyone may create a distribution for any purpose.

Linux was originally developed for personal computers based on the Intel x86 architecture, but has since been ported to more platforms than any other operating system. Because of the dominance of the Linux-based Android on smartphones, Linux also has the largest installed base of all general-purpose operating systems. Although it is used by only around 2.3 percent of desktop computers, the Chromebook, which runs the Linux kernel-based Chrome OS, dominates the US K–12 education market and represents nearly 20 percent of sub-$300 notebook sales in the US. Linux is the leading operating system on servers (over 96.4% of the top 1 million web servers' operating systems are Linux), leads other big iron systems such as mainframe computers, and is the only OS used on TOP500 supercomputers (since November 2017, having gradually eliminated all competitors).

6.1 CONCEPT OF LINUX

Keyword

An operating system (OS) is system software that manages computer hardware and software resources and provides common services for computer programs.

Just like Windows XP, Windows 7, Windows 8, and Mac OS X, Linux is an operating system. An operating system is software that manages all of the hardware resources associated with your desktop or laptop. To put it simply – the **operating system** manages the communication between your software and your hardware. Without the operating system (often referred to as the "OS"), the software wouldn't function.

The OS is comprised of a number of pieces:

- **The Bootloader:** The software that manages the boot process of your computer. For most users, this will simply be a splash screen that pops up and eventually goes away to boot into the operating system.

- **The kernel:** This is the one piece of the whole that is actually called "Linux". The kernel is the core of the system and manages the CPU, memory, and peripheral devices. The kernel is the "lowest" level of the OS.
- **Daemons:** These are background services (printing, sound, scheduling, etc.) that either start up during boot, or after you log into the desktop.
- **The Shell:** You've probably heard mention of the Linux command line. This is the shell – a command process that allows you to control the computer via commands typed into a text interface. This is what, at one time, scared people away from Linux the most (assuming they had to learn a seemingly archaic command line structure to make Linux work). This is no longer the case. With modern desktop Linux, there is no need to ever touch the command line.
- **Graphical Server:** This is the sub-system that displays the graphics on your monitor. It is commonly referred to as the X server or just "X".
- **Desktop Environment:** This is the piece of the puzzle that the users actually interact with. There are many desktop environments to choose from (Unity, GNOME, Cinnamon, Enlightenment, KDE, XFCE, etc). Each desktop environment includes built-in applications (such as file managers, configuration tools, web browsers, games, etc).
- **Applications:** Desktop environments do not offer the full array of apps. Just like Windows and Mac, Linux offers thousands upon thousands of high-quality software titles that can be easily found and installed. Most modern **Linux** distributions (more on this in a moment) include App Store-like tools that centralize and simplify application installation.

Keyword

Linux is a Unix-like computer operating system assembled under the model of free and open-source software development and distribution.

How does Linux differ from other operating systems?

In many ways, Linux is similar to other operating systems you may have used before, such as Windows, OS X, or iOS. Like other operating systems, Linux has a graphical interface, and types of software you are accustomed to using on other operating systems, such as word processing applications, have

Linux equivalents. In many cases, the software's creator may have made a Linux version of the same program you use on other systems. If you can use a computer or other electronic device, you can use Linux. But Linux also is different from other operating systems in many important ways. First, and perhaps most importantly, Linux is open source software. The code used to create Linux is free and available to the public to view, edit, and—for users with the appropriate skills—to contribute to.

Linux is also different in that, although the core pieces of the Linux operating system are generally common, there are many distributions of Linux, which include different software options. This means that Linux is incredibly customizable, because not just applications, such as word processors and web browsers, can be swapped out. Linux users also can choose core components, such as which system displays graphics, and other user-interface components.

Keyword

UNIX is a family of multitasking, multiuser computer operating systems that derive from the original AT&T Unix, developed starting in the 1970s at the Bell Labs research center by Ken Thompson, Dennis Ritchie, and others.

What is the difference between UNIX and Linux?

You may have heard of Unix, which is an operating system developed in the 1970s at Bell Labs by Ken Thompson, Dennis Ritchie, and others. UNIX and Linux are similar in many ways, and in fact, Linux was originally created to be similar to **UNIX**. Both have similar tools for interfacing with the systems, programming tools, file system layouts, and other key components. However, UNIX is not free. Over the years, a number of different operating systems have been created that attempted to be "Unix-like" or "Unix-compatible," but Linux has been the most successful, far surpassing its predecessors in popularity.

Who uses Linux?

You're probably already using Linux, whether you know it or not. Depending on which user survey you look at, between one- and two-thirds of the webpages on the Internet are generated by servers running Linux. Companies and individuals choose Linux for their servers because it is secure, and you can receive excellent support from a large community of users, in addition to companies like Canonical, SUSE, and Red Hat, which offer commercial support. Many of the devices you own probably, such as Android phones, digital storage devices, personal video recorders, cameras, wearables, and more, also run Linux. Even your car has Linux running under the hood.

Who "owns" Linux?

By virtue of its open source licensing, Linux is freely available to anyone. However, the trademark on the name "Linux" rests with its creator, Linus Torvalds. The source code for Linux is under copyright by its many individual authors, and licensed under the GPLv2 license. Because Linux has such a large number of contributors from across multiple decades of development, contacting each individual author and getting them to agree to a new license is virtually impossible, so that Linux remaining licensed under the GPLv2 in perpetuity is all but assured.

How was Linux created?

Linux was created in 1991 by Linus Torvalds, a then-student at the University of Helsinki. Torvalds built Linux as a free and open source alternative to Minix, another Unix clone that was predominantly used in academic settings. He originally intended to name it "Freax," but the administrator of the server Torvalds used to distribute the original code named his directory "Linux" after a combination of Torvalds' first name and the word Unix, and the name stuck.

6.1.1 How can you contribute to Linux?

Most of the Linux kernel is written in the C programming language, with a little bit of assembly and other languages sprinkled in. If you're interested in writing code for the Linux kernel itself, a good place to get started is in the Kernel Newbies FAQ, which will explain some of the concepts and processes you'll want to be familiar with.

But the Linux community is much more than the kernel, and needs contributions from lots of other people besides programmers. Every distribution contains hundreds or thousands of programs that can be distributed along with it, and each of these programs, as well as the distribution itself, need a variety of people and skill sets to make them successful, including:

- Testers to make sure everything works on different configurations of hardware and software, and to report the bugs when it does not.
- Designers to create user interfaces and graphics distributed with various programs.
- Writers who can create documentation, how-tos, and other important text distributed with software.

- Translators to take programs and documentation from their native languages and make them accessible to people around the world.
- Packagers to take software programs and put all the parts together to make sure they run flawlessly in different distributions.
- Evangelists to spread the word about Linux and open source in general.
- And of course developers to write the software itself.

How can you get started using Linux?

There's some chance you're using Linux already and don't know it, but if you'd like to install Linux on your home computer to try it out, the easiest way is to pick a popular distribution that is designed for your platform (for example, laptop or tablet device) and give it a shot. Although there are numerous distributions available, most of the older, well-known distributions are good choices for beginners because they have large user communities that can help answer questions if you get stuck or can't figure things out. Popular distributions include Debian, Fedora, Mint, and Ubuntu, but there are many others.

REMEMBER

Finally, the most important benefit that partitioning provides is protection of your file systems. If something should happen to a file system (either through user error or system failure), on a partitioned system you would probably only lose files on a single file system. On a non-partitioned system, you would probably lose them on all file systems.

Where can I learn more about Linux?

Opensource.com has a huge archive of Linux-related articles. To view our entire archive, browse our Linux tag. Or check out some of our favorites below.

- Do you need programming skills to learn Linux? by Jen Wike Huger
- Test drive Linux with nothing but a flash drive by Scott Nesbitt
- Building a Linux lab and its great potential in education by Don Watkins
- Want a fulfilling IT career? Learn Linux by Shawn Powers
- Install Linux on a used laptop by Phil Shapiro
- 8 Linux file managers to try by David Both

- Who helps your Linux distribution run smoothly? Thank a packager today by Luis Ibanez
- 4 Linux distros for kids by Aseem Sharma
- 6 reasons people with disabilities should use Linux by Spencer Hunley
- The current state of video editing for Linux by Chris Long
- How to do fast, repeatable Linux installations by David Both

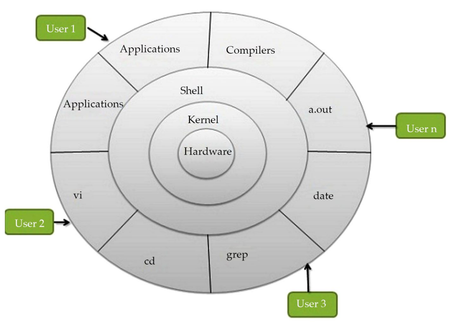
6.2 A BRIEF HISTORY OF LINUX DEVELOPMENT

Linus Torvalds was a student at the University of Helsinki, he was using a version of the UNIX operating system called 'Minix'. When Linus and other users found that some modifications can make the OS even better he and the other users sent requests for modifications and improvements to Minix's creator, Andrew Tanenbaum, but Andrew felt that these changes are not necessary and didn't make the changes. That was the time when Linus decided to create his own operating system that would take into account user's comments and suggestions for improvements.

As Linus was a student of C Language he started writing the codes in C, around 95% of the Linux was written in C, and 2nd most used language for the Linux development was '*Assembly*' language i.e. around 2.8%.

Language	Code Lines	Comment Lines	Comment Ratio	Blank Lines	Total Lines	Total Percentage
C	16,092,123	3,371,474	17.3%	3,084,476	22,548,073	94.5%
Assembly	484,074	101,110	17.3%	79,103	664,287	2.8%
C++	261,671	116,950	30.9%	54,013	432,634	1.8%
XML	89,775	496	0.5%	7,226	97,497	0.4%
Make	42,008	12,146	22.4%	11,223	65,377	0.3%
Perl	23,472	3,703	13.6%	4,611	31,786	0.1%
shell script	9,935	3,934	28.4%	1,707	15,576	0.1%
Python	6,203	1,046	14.4%	888	8,137	0.0%
TeX/LaTeX	1,822	6	0.3%	216	2,044	0.0%
HTML	1,128	0	0.0%	116	1,244	0.0%

Linux falls under the category of the Layered Architecture OS, consists of following layers:



6.2.1 Basic Features of Linux OS

Linux is fast, free and easy to use, power laptops and servers around the world. Linux has many more features to amaze its users such as:

- **Live CD/USB:** Almost all Linux distributions have Live CD/USB feature by which user can run/try the OS even without installing it on the system.
- **Graphical user interface (X Window System):** People think that Linux is a command line OS, somewhere its true also but not necessarily, Linux have packages which can be installed to make the whole OS graphics based as Windows.
- **Support's most national or customized keyboards:** Linux is used worldwide and hence available in multiple languages, and supports most of their custom national keyboards.
- **Application Support:** Linux has its own software repository from where users can download and install thousands of applications just by issuing a command in Linux Terminal or Shell. Linux can also run **Windows** applications if needed.

Keyword

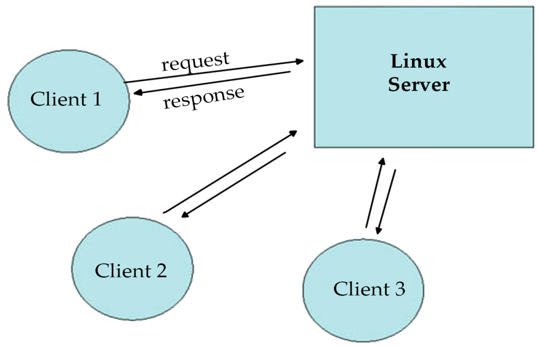
Windows, is a metafamily of graphical operating systems developed, marketed, and sold by Microsoft

6.2.2 Characteristics of Linux OS

Linux has several silent features, some of the important ones are:

Multiuser Capability: This is a capability of Linux OS where, the same computer resources – hard disk, memory, etc. are accessible to multiple users. Of course, not on a single terminal, they are given different terminals to operate from. A terminal will consist of at least a Monitor/VDU, keyboard and mouse as input devices. All the terminals are then connected to the main Linux Server or Host Machine, whose resources and connected peripheral devices such as printer, can be used.

Client/Server Architecture



Client/Server Architecture is an example of multiuser capability of Linux, where different clients are connected to a Linux server. The client sends request to the server with a particular data and server requests with the processed data or the file requested, client terminal is also known as a Dumb Terminal.

Multitasking: Linux has the ability to handle more than one job at a time, say for example you have executed a command for sorting for a huge list and simultaneously typing in a notepad. This is managed by dividing the CPU time intelligently by the implementation of scheduling policies and the concept of context switching.

Portability: Portability was the one of the main features that made Linux so popular among the users, but portability doesn't mean that it is smaller in file size and can be carried on pen drive, CDs and memory cards. Instead, here portability means that Linux OS and its application can work on different types of hardware's in the same way. Linux kernel and application programs support their installation even on very least hardware configuration.

Security: Security is a very important part of any OS, for the organizations/user who is using the system for their confidential works, Linux does provide several security concepts for protecting their users from unauthorized access of their data and system.

Linux provide 3 main security concepts are:

- **Authentication:** This simply implies claiming the person whom you are by assigning passwords and login names to individual users, ensuring that nobody can gain access to their work.
- **Authorization:** At the file level Linux has authorization limits to users, there are read, write and execute permissions for each file which decide who can access a particular file, who can modify it and who can execute it.
- **Encryption:** This feature encodes your files into an unreadable format that is also known as '*cyphertext*', so that even if someone succeeds in opening it your secrets will be safe.

Keyword

A computer network or data network is a digital telecommunications network which allows nodes to share resources.

Communication: Linux has an excellent feature for communicating with the fellow users, it can be within the network of a single main computer, or between two or more such **computer networks**. The users can easily exchange mail, data, and program through such networks.

6.2.3 Argument on Linux is '*Kernel*' not an '*OS*'

Later on when different Linux distros like Arc Linux, Ubuntu, Debian and Fedora started to come into existence with better GUI (Graphical User Interface) and system softwares, which were basically customized versions of the Linux, users started to say that Linux is a Kernel not an operating system. Which has been now proved to be true :

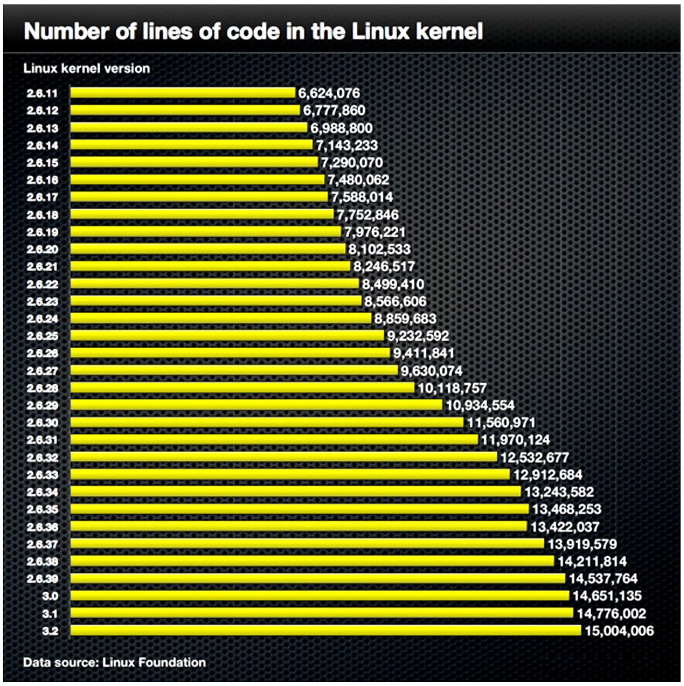
example

For those who are still confused between Linux being an OS or kernel, Linux in true sense as written by Linus was a kernel that was written by referring to book on Unix internals (Though the Linux kernel has adopted best features from many other Unix like kernels too) while the commercially available distributions that contain utilities like graphical desktop, text editors, compilers etc. on top of the Linux kernel are complete operating systems.

6.3 LINUX KERNEL AND ITS ARCHITECTURE

Linux is a Unix-like computer operating system assembled under the model of free and open source software development and distribution. The defining component of Linux is the Linux kernel, an operating system kernel first released 5 October 1991 by Linus Torvalds.

Linux arguably the most popular open source operating system, has many advantages, one of them is that their internals are open to for all to view. The operating system, once a dark and mysterious area whose code was restricted to a small number of programmers, can now be readily examined, understood, and modified by anybody with the requisite skills. Linux has helped to democratize operating systems.

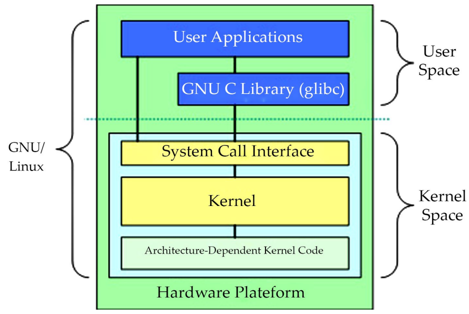


Linux quickly evolved from a single-person project to a world-wide development project involving thousands of developers.

Without forgetting the goal of this article let's get to the introduction of Linux Kernel and explore its architecture and its various components.

6.3.1 Introduction to the Linux Kernel

We can think of Linux Kernel architecture to be divided into two levels – User Space and Kernel Space.



At the top is the user space. Below the user space is the kernel space. Here, the Linux kernel exists.

User Space:

This is where the user applications are executed. There is also the GNU C Library (glibc). This provides the system call interface that connects to the kernel and provides the mechanism to transition between the user-space application and the kernel.

Kernel Space:

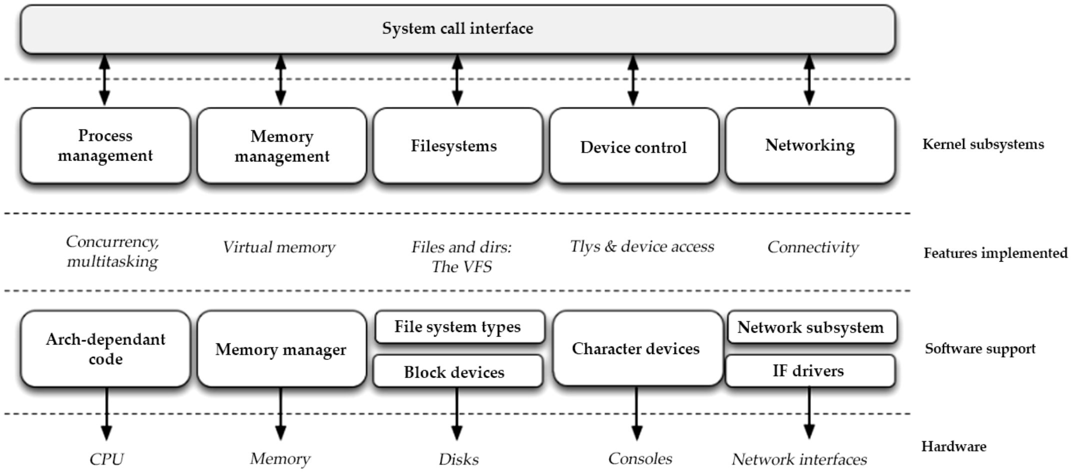
Here, the Linux Kernel exists which can be further divided into three levels. At the top is the system call interface, which implements the basic functions such as read and write. Below the system call interface is the kernel code, which can be more accurately defined as the architecture-independent kernel code. This code is common to all of the processor architectures supported by Linux. Below this is the architecture-dependent code, which forms what is more commonly called a BSP (Board Support Package). This code serves as the processor and platform-specific code for the given architecture.

6.3.2 Properties of the Linux Kernel

The kernel is layered into a number of distinct subsystems. Linux can also be considered monolithic because it lumps all of the basic services into the kernel. This differs from a microkernel architecture where the kernel provides basic services such as communication, I/O, and memory and process management, and more specific services are plugged in to the microkernel layer.

6.3.3 Functions of the Kernel

Now let's look at some of the functions of the Linux kernel.



System Call Interface

The SCI is a thin layer that provides the means to perform function calls from user space into the kernel. As discussed previously, this interface can be architecture dependent, even within the same processor family. You can find the SCI implementation in ./linux/kernel, as well as architecture-dependent portions in ./linux/arch.

Process Management

The kernel is in charge of creating and destroying processes and handling their connection to the outside world (input and output). Communication among different processes (through signals, pipes, or inter process communication primitives) is basic to the overall system functionality and is also handled by the kernel. In addition, the scheduler, which controls how processes share the CPU, is part of process management.

Memory management

Another important resource that's managed by the kernel is memory. For efficiency, given the way that the hardware manages virtual memory, memory is managed in what are called *pages* (4KB in size for most architectures). Linux includes the means to manage the available memory, as well as the hardware mechanisms for physical and virtual mappings.

File systems

Linux is heavily based on the file system concept; almost everything in Linux can be treated as a file. The kernel builds a structured file system on top of unstructured hardware, and the resulting file abstraction is heavily used throughout the whole system. In addition, Linux supports multiple file system types, that is, different ways of organizing data on the physical medium. For example, disks may be formatted with the

Linux standard ext3 file system, the commonly used FAT file system or several others.

DID YOU KNOW ?

The UNIX operating system was conceived and implemented in 1969, at AT&T's Bell Labs, in the United States by Ken Thompson, Dennis Ritchie, Douglas McIlroy, and Joe Ossanna. First released in 1971, Unix was written entirely in assembly language, as was common practice at the time.

Device control

Almost every system operation eventually maps to a physical device. With the exception of the processor, memory, and a very few other entities, any and all device control operations are performed by code that is specific to the device being addressed. That code is called a device driver. The kernel must have embedded in it a device driver for every peripheral present on a system, from the hard drive to the keyboard and the tape drive.

Networking

Networking must be managed by the operating system, because most network operations are not specific to a process: incoming packets are asynchronous events. The packets must be collected, identified, and dispatched before a process takes care of them. The system is in charge of delivering data packets across program and network interfaces, and it must control the execution of programs according to their network activity. Additionally, all the routing and address resolution issues are implemented within the kernel.

6.3.4 Interesting features of the Linux kernel

While much of Linux is independent of the architecture on which it runs, there are elements that must consider the architecture for normal operation and for efficiency. The ./linux/arch subdirectory defines the architecture-dependent portion of the kernel source contained in a number of subdirectories that are specific to the architecture (collectively forming the BSP). For a typical desktop, the i386 directory is used. Each architecture subdirectory contains a number of other subdirectories that focus on a particular aspect of the kernel, such as boot, kernel, memory management, and others. You can find the architecture-dependent code in ./linux/arch.

6.3.5 Even though, Why Linux Kernel?

If Linux is doing the same thing as other Operating Systems then Why to use it? Why not continue with the existing operating systems. Linux, being an open source operating system, is a great test bed for new protocols and advancements of those protocols. Linux supports a large number of networking protocols, including the typical TCP/IP, and also extension for high-speed networking. Linux also supports protocols such as the Stream Control Transmission Protocol (SCTP), which provides many advanced features above TCP (as a replacement transport level protocol). Linux is also a dynamic kernel, supporting the addition and removal of software components on the fly. These are called dynamically loadable kernel modules, and they can be inserted at boot when they're needed (when a particular device is found requiring the module) or at any time by the user.

6.4 OVERVIEW OF LINUX PROCESSES

A Process is one of the most important fundamental concepts of the Linux operating system. This article focuses on the basics of Linux processes. A process is an instance of a program running in Linux. This is the basic definition that you might have heard before. Though it's simple enough to understand but still let's elaborate a bit for the beginners. Let's quickly create a hello world program in C language:

```
#include<stdio.h>

int main(void)

{

printf("\n Hello World\n");

// Simulate a wait for some time

for(i=0; i<0xFFFFFFFF; i++);

return 0;

}
```

Compile the code above:

```
$ gcc -Wall hello_world.c -o hello_world
```

Run the executable:

$ ./hello_world

The command above will execute the hello world program. Since the program waits for some time, so quickly go to the other terminal and check for any process named 'hello_world':

$ ps -aef | grep hello_world

himanshu 2260 2146 95 20:38 pts/0 00:00:13 ./hello_world

So we see that a process named 'hello_world' is running in the system. Now, try to run the same program in parallel from 2-3 locations and again run the above command. I tried running the program in parallel from three different terminals and here is the output of the above command:

$ ps -aef | grep hello_world

himanshu 2320 2146 99 20:43 pts/0 00:00:03 ./hello_world

himanshu 2321 2261 67 20:43 pts/1 00:00:02 ./hello_world

himanshu 2322 2287 72 20:43 pts/2 00:00:00 ./hello_world

So you see that each instance of the hello_world program created a separate process. Hence we say that process is running instance of a program.

6.4.1 Identifiers associated with a Linux process

Describe the identifiers associated with a Linux process

Each process has following identifiers associated with it:

Process Identifier (PID)

Each process has a unique identifier associated with it known as process ID. This ID remains unique across the system. For example, if you run the ps command on your Linux box, you will see something like:

UID	PID	PPID	C	STIME	TTY	TIME	CMD
root	1	0	0	19:43	?	00:00:00	/sbin/init
root	2	0	0	19:43	?	00:00:00	[kthreadd]

root	3	2	0	19:43	?	00:00:00	[migration/0]
root	4	2	0	19:43	?	00:00:00	[ksoftirqd/0]
root	5	2	0	19:43	?	00:00:00	[watchdog/0]
root	6	2	0	19:43	?	00:00:00	[migration/1]
root	7	2	0	19:43	?	00:00:00	[ksoftirqd/1]
root	8	2	0	19:43	?	00:00:00	[watchdog/1]
root	9	2	0	19:43	?	00:00:00	[events/0]
root	10	2	0	19:43	?	00:00:00	[events/1]

The above output is from my Linux box. The second column (PID) gives the process ID of the process being described in the row. You may notice another similar looking column PPID. Well, this gives information of the parent process ID of this process. Any process in the Linux system will have a parent.

User and group Identifiers (UID and GID)

The category of identifiers associated with a process is the user and group identifiers. The user and group ID can further be classified into:

Real user ID and real group ID

These identifiers give information about the user and group to which a process belongs. Any process inherits these identifiers from its parent process.

Effective user ID, effective group ID and supplementary group ID

Ever got an error like “Permission denied”? Well this is a common error that is encountered many times. This error usually occurs when a process does not have sufficient permissions to carry out a task. These three IDs are used to determine the permission that a process has to do stuff that requires special permissions. Usually the effective user ID is same as real user ID but in case its different then it means that process is running with different privileges then what it has by default (ie inherited from its parent). If a process is running with effective user ID ‘0’, this means that this process has special privileges. The processes that have zero effective user ID are known as privileged processes as they are running as superuser. These processes bypass all the permission checks that kernel has in place for all the unprivileged processes.

The init process

In Linux every process has a parent process. Now, one would ask that there has to be some starting point, some process that is created first. Yes, there is a process known as 'init' that is the very first process that Linux kernel creates after system boots up. All the process there-on are children of this process either directly or indirectly. The init process has special privileges in the sense that it cannot be killed. The only time it terminates is when the Linux system is shut down. The init process always has process ID 1 associated with it.

Zombie and orphan processes

Suppose there are two processes. One is parent process while the other is child process. In a real time, there can be two scenarios:

The parent dies or gets killed before the child.

In the above scenario, the child process becomes the orphan process (as it has lost its parent). In Linux, the init process comes to the rescue of the orphan processes and adopts them. This means after a chile has lost its parent, the init process becomes its new parent process.

The child dies and parent does not perform wait() immediately

Whenever the child is terminated, the termination status of the child is available to the parent through the wait() family of calls. So, the kernel does waits for parent to retrieve the termination status of the child before its completely wipes out the child process. Now, In a case where parent is not able to immediately perform the wait() (in order to fetch the termination status), the terminated child process becomes zombie process. A zombie process is one that is waiting for its parent to fetch its termination status. Although the kernel releases all the resources that the zombie process was holding before it got killed, some information like its termination status, its process ID etc. are still stored by the kernel. Once the parent performs the wait() operation, kernel clears off this information too.

Daemon process

A process that needs to run for a long period of time and does not require a controlling terminal, these type of processes are programmed in a way that they becomes a daemon processes.

For example, monitoring software like key-logger etc are usually programmed as daemon processes. A daemon process has no controlling terminal.

Memory layout of a process

A process can broadly be defined into following segments:

Stack

Stack contains all the data that is local to a function like variables, pointers etc. Each function has its own stack. Stack memory is dynamic in the sense that it grows with each function being called.

Heap

Heap segment contains memory that is dynamically requested by the programs for their variables.

Data

All the global and static members become part of this segment.

Text

All the program instructions, hard-coded strings, constant values are a part of this memory area.

If we extend the above hello world program to something like:

```
#include<stdio.h>

#include<stdlib.h>

#include<string.h>

int a;

int main(void)

{

   int i = 0;

   char *ptr = (char*)malloc(15);

   memset(ptr, 0, 15);
```

```
    memcpy(ptr, "Hello World", 11);

    printf("\n %s \n", ptr);

    // Simulate a wait for some time

    for(i=0; i<0xFFFFFFFF; i++);

    free(ptr);

    return 0;

}
```

In the example above: - The variable 'a' goes into the data segment (specifically into BSS segment that contains all the uninitialized globals) - The variables 'i' and 'ptr' lie on stack segment. Each function call like memset, memcpy, printf and free will have their separate stack once they get called. - The constant values like "Hello World", '15', '11', '0', '0XFFFFFFFF' and all the instructions are part of text segment. - The 15 bytes of memory allocated by the malloc function is allocated on heap. So the pointer 'ptr' holds the address of a memory location on heap. Note that heap is shared by all processes, so overuse or corruption of heap might affect other programs running in the system.

6.5 LINUX PROCESS ENVIRONMENT

Environment in Linux is a list of 'variable=value' information that is used for variety of purposes. Programs, scripts, shells etc use this information for their smooth operation.

The home directory of the user which is presently logged-in can be accessed by the 'HOME' environment variable. List of these environment variables along with their values can be viewed using the 'env' command.

For example, on my Linux box I could see the following output of the env command:

```
ORBIT_SOCKETDIR=/tmp/orbit-himanshu

SSH_AGENT_PID=1653
```

TERM=xterm

SHELL=/bin/bash

XDG_SESSION_COOKIE=b8b52be9a0280f3c8b48fcf04d7ac5a3-1341925217.889152-1390765341

WINDOWID=62917358

GNOME_KEYRING_CONTROL=/tmp/keyring-6UEJQ4

GTK_MODULES=canberra-gtk-module

USER=himanshu

SSH_AUTH_SOCK=/tmp/keyring-6UEJQ4/ssh

DEFAULTS_PATH=/usr/share/gconf/gnome.default.path

SESSION_MANAGER=local/himanshu-laptop:@/tmp/.ICE-unix/1619,unix/himanshu-laptop:/tmp/.ICE-unix/1619

USERNAME=himanshu

XDG_CONFIG_DIRS=/etc/xdg/xdg-gnome:/etc/xdg

DESKTOP_SESSION=gnome

PATH=/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin:/usr/games

PWD=/home/himanshu

GDM_KEYBOARD_LAYOUT=us

LANG=en_IN

GNOME_KEYRING_PID=1601

MANDATORY_PATH=/usr/share/gconf/gnome.mandatory.path

GDM_LANG=en_IN

GDMSESSION=gnome

SPEECHD_PORT=7560

SHLVL=1

HOME=/home/himanshu

GNOME_DESKTOP_SESSION_ID=this-is-deprecated

REMEMBER

The Linux kernel is a free and open-source, monolithic, modular, multitasking, and Unix-like operating system kernel.

LOGNAME=himanshu

XDG_DATA_DIRS=/usr/share/gnome:/usr/local/share/:/usr/share/

DBUS_SESSION_BUS_ADDRESS=unix:abstract=/tmp/dbus-AWvAHVEXeC,guid=62c39aae57aa4bfc10e80e444ffc2762

DISPLAY=:0.0

XAUTHORITY=/var/run/gdm/auth-for-himanshu-yxPNRW/database

COLORTERM=gnome-terminal

_=/usr/bin/env

So we can see that there is a wide list of environment variables available. A user can add an environment variable using the 'export' command. In C language, an extern variable char**environ can be used to access this list in a program. A list of functions like getenv(), setenv() etc are available to manipulate the process environment.

6.5.1 Manipulating Linux resource limits

Any process in Linux can get hold of resources like files, memory etc. As always there is a limit to these resources per process. Each resource has a soft and a hard limit associated with it. A soft limit is a temporary limit associated with a resource and can be changed while a hard limit is the cap up to which the soft limit can be changed. Linux provides command line utilities like 'ulimit' to manipulate these resource limits. On the other hand the system calls like getrlimit() and setrlimit() can be used to play with these limits from within a C code.

6.6 INSTALLATION OF LINUX

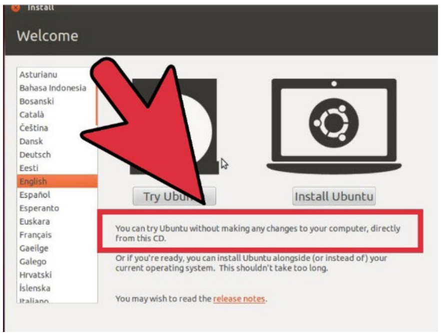
Linux is the foundation of thousands of open source operating systems designed to replace Windows and Mac OS. It is free to download and install on any computer. Because it is open source, there are a variety of different versions, or distributions, available developed by different groups. Follow this guide for basic instructions on how to install any version of Linux, as well as specific instructions for some of the most popular ones.

6.6.1 Installing Any Linux Distribution

1. Download the Linux distribution of your choice

If you're new to Linux, consider trying a lightweight and easy to use distribution, such as Ubuntu, Lubuntu, etcetera. Linux distributions (known as "distros") are typically available for free to download in ISO format. You can find the ISO for the distribution of your choice at the distribution's website. This format needs to be burned to a CD or USB stick before you can use it to install Linux. This will create a Live CD or Live USB.

- A Live CD or Live USB is a disk that you can boot into, and often contains a preview version of the operating system that can be run directly from the CD or USB stick.
- Install an image burning program, or use your system's built-in burning tool if you are using Windows 7, 8, or Mac OS X. Pen Drive Linux and UNetBootin are two popular tools for burning ISO files to USB sticks.



2. Boot into the Live CD or Live USB

Most computers are set to boot into the hard drive first, which means you will need to change some settings to boot from your newly-burned CD or USB. Start by rebooting the computer.

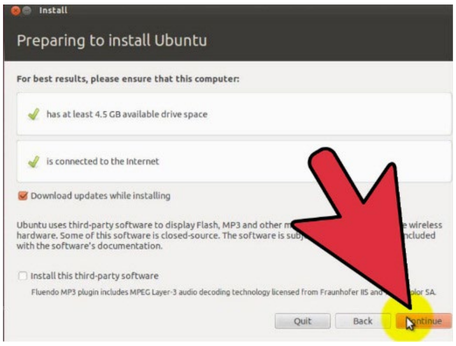
- Once the computer reboots, press the key used to enter the boot menu. The key for your system will be displayed on the same screen as the manufacturer's logo. Typical keys include F12, F2, or Del.
  - For Windows 8 users, hold the Shift key and click restart. This will load the Advanced Startup Options, where you can boot from CD.
  - If your computer doesn't give you direct access to the boot menu from the manufacturer's splash screen, it's most likely hidden in the BIOS menu. You can access the BIOS menu in the same way that you would get to the boot menu. At the manufacturer splash screen, the key should

be listed in one of the bottom corners.

- Once you're in the boot menu, select your live CD or USB. Once you've changed the settings, save and exit the BIOS setup or boot menu. Your computer will continue with the boot process.

3. Try out the Linux distribution before installing

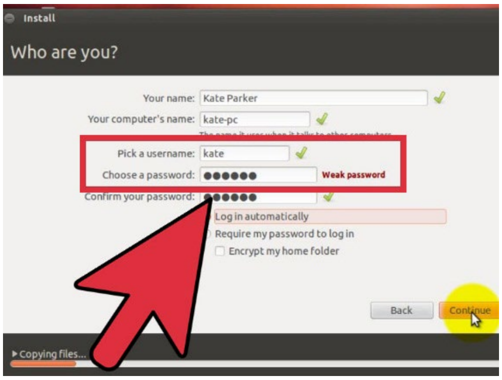
Most Live CDs and USBs can launch a "live environment", giving you the ability to test it out before making the switch. You won't be able to create files, but you can navigate around the interface and decide if it's right for you.



4. Start the installation process

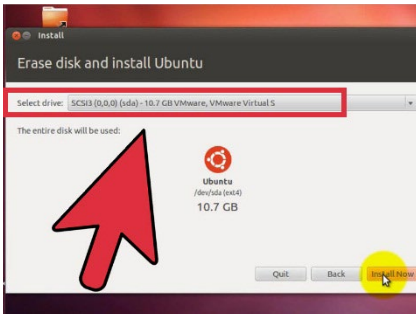
If you're trying out the distro, you can launch the installation from the application on the desktop. If you decided not to try out the distribution, you can start the installation from the boot menu.

- You will be asked to configure some basic options, such as language, keyboard layout, and timezone.



5. *Create a username and password*

You will need to create login information to install Linux. A password will be required to log into your account and preform administrative tasks.



6. *Set up the partition*

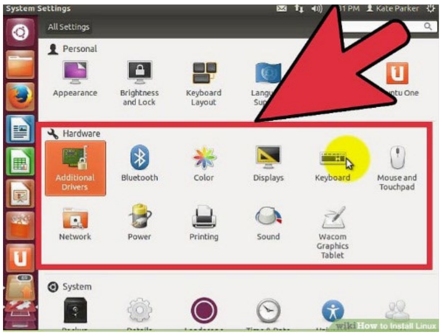
Linux needs to be installed on a separate partition from any other operating systems on your computer if you intend dual booting Linux with another OS. A partition is a portion of the hard drive that is formatted specifically for that operating system. You can skip this step if you don't plan on dual booting.

- Distros such as Ubuntu will set a recommended partition automatically. You can then adjust this manually yourself. Most Linux installations require at least 20 GB, so be sure to set aside enough room for both the Linux operating system and any other programs you may install and files you may create.
- If the installation process does not give you automatic partitions, make sure that the partition you create is formatted as Ext4. If the copy of Linux you are installing is the only operating system on the computer, you will most likely have to manually set your partition size.

7. Boot into Linux

Once the installation is finished, your computer will reboot. You will see a new screen when your computer boots up called "GNU GRUB". This is a boot loader that handles Linux installations. Pick your new Linux distro from the list. This screen may not show up if you only have one operating system on your computer. If this screen isn't being presented to you automatically, then you can get it back by hitting shift right after the manufacturer splash screen

- If you install multiple distros on your computer, they will all be listed here.

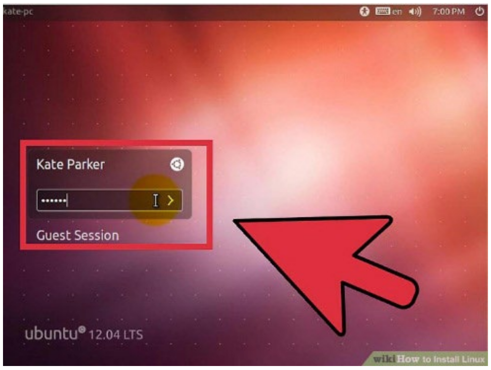


8. Check your hardware

Most hardware should work out of the box with your Linux distro, though you may need to download some additional drivers to get everything working.

- Some hardware requires proprietary drivers to work correctly in Linux. This is most common with graphics cards. There is typically an open source driver that will work, but to get the most out of your graphics cards you will need to download the proprietary drivers from the manufacturer.

- In Ubuntu, you can download proprietary drivers through the System Settings menu. Select the Additional Drivers option, and then select the graphics driver from the list. Other distros have specific methods for obtaining extra drivers.
- You can find other drivers from this list as well, such as Wi-Fi drivers.



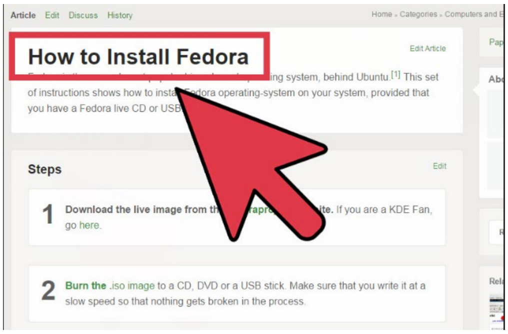
9. Start using Linux

Once your installation is complete and you've verified that your hardware is working, you're ready to start using Linux. Most distros come with several popular programs installed, and you can download many more from their respective file repositories.

6.6.2 Installing Specific Linux Distributions

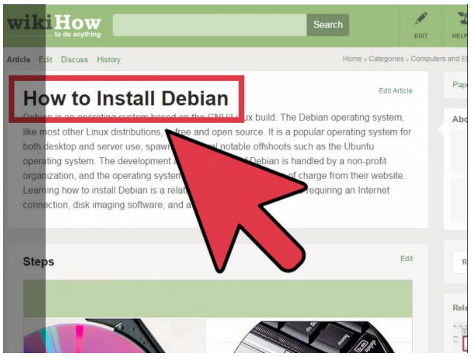
1. Install Ubuntu

Ubuntu is one of the most popular Linux distros currently available. There are two releases available: a long term release and a short term release with the latest features. The long term release has more software support.



2. Install Fedora

Fedora is another very popular distribution. Fedora is much more common in enterprise systems and business settings



3. Install Debian

Debian is another popular distro for Linux enthusiasts. It is considered one of the most bug-free versions of Linux. Debian also has a large number of software packages available.

4. Install Linux Mint

Linux Mint is one of the newest distros available, and is quickly growing in popularity. It is built off of the Ubuntu system, but contains many tweaks based on user feedback.

Partitioning Hard Drive(s)

Why partition, anyway? Well, although it is possible to get a perfectly functioning Linux system running on a single-partition system, and, in fact, is a bit easier to configure this way, there are a number of benefits from partitioning one or more of your storage devices into multiple partitions.

While it is true that Linux will operate just fine on a disk with only one large partition defined, there are several advantages to partitioning your disk for at least the four main file systems (root, usr, home, and swap). These include:

First, it may reduce the time required to perform file system checks (both upon bootup and when doing a manual fsck), because these checks can be done in parallel. (By the way, NEVER run an fsck on a mounted file system!!! You will almost certainly regret what happens to it. The exception to this is if the file system is mounted read-only, in which case it is safe to do so.) Also, file system checks are a lot easier to do on a system with multiple partitions. For example, if I knew my /home partition had problems, I could simply unmount it, perform a file system check, and then remount the repaired file system (as opposed to booting my system with a rescue diskette into single-user mode and doing the repairs).

Second, with multiple partitions, you can, if you wish, mount one or more of your partitions as read-only. For example, if you decide that everything in /usr will not be touched even by root, you can mount the /usr partition as read-only.

Finally, since Linux allows you to set up other operating system(s) (such as Windows 95/98/NT, BeOS, or what-have-you), and then dual- (or triple-, ...) boot your system, you might wish to set up additional partitions to take advantage of this. Typically, you would want to set up at least one separate partition for each operating system. Linux includes a decent boot loader (called LILO on Intel-based systems, although much the same thing is available as MILO on Alpha, and SILO on Sparc) which allows you to specify which operating system you want to boot at power on, with a time-out default boot of your favorite operating system (probably Linux, right?)

Given:

A given disk of X Mb/Gb (eg. 2 Gb)

(Or, more than one disk with a combined total of X Mb/Gb)

Calculate:

(swap) about double main RAM (eg. 64 Mb system gets 128 Mb swap)

/ (root) about 10% of available (eg. 200 Mb)

/home about 20% of available (eg. 400 Mb)

/usr any remaining space (eg. 1272 Mb)

/var (optional -- see below)

/boot (optional -- see below)

/archive (optional -- see below)

Of course, the above amounts are approximate guidelines only. Obviously you are going to want to juggle those percentages around a bit depending on what you are going to use your Linux system for. If you are going to be doing stuff like adding lots of bulky applications such as WordPerfect or Netscape, or perhaps adding Japanese character support, you would probably benefit from a bit more /usr space.

Here is a description of the various mount points and file system information, which may give you a better idea of how to best define your partition sizes for your own needs:

- */ (root)* - used to store things like temporary files, the Linux kernel and boot image, important binary files (things that are needed before Linux can mount the /usr partition), and more importantly log files, spool areas for print jobs and outgoing e-mail, and user›s incoming e-mail. It is also used for temporary space when performing certain operations, such as building RPM packages from source RPM files. Therefore, if you have a lot of users with a lot of e-mail, or think you will need plenty of temporary space, you might want more space available. The partition type should be left as the default of 83 (Linux native). In addition, you›ll probably toggle the bootable flag on this partition to allow boot information to be stored here.
- */usr/* - should be the largest partition, because most of the binary files required by Linux, as well as any locally installed software, web pages, Squid proxy cache, Samba share services, some locally-installed software log files, etc. are stored here. The partition type should be left as the default of 83 (Linux native).
- */home/* - typically if you aren’t providing shell accounts to your users, you don’t need to make this partition very big. The exception is if you are providing

user home pages (such as school web pages), in which case you might benefit from making this partition larger. Again, the partition type should be left as the default of 83 (Linux native).

- *(swap)* - Linux provides something called «virtual memory» to make a larger amount of memory available than the physical RAM installed in your system.

If you have more than one physical hard drive in your system, you can create multiple swap partitions. This can improve the performance of swapping by taking advantage of parallel disk access. For example, on a 256 Mb system with four drives, I would probably create four 128 Mb swap partitions, for a total of 256 Mb RAM, 512 Mb swap (for a combined total of 768 Mb available as virtual memory). The partition type needs to be changed to 82 (Linux swap).

REMEMBER

The swap partition is used with main RAM by Linux to accomplish this. As a rule of thumb, your swap partition should be at least double the amount of physical RAM installed in your system.

- */var/* (optional) - You may wish to consider splitting up your / (root) partition a bit further. The /var directory is used for a great deal of runtime storage, including mail spools (both ingoing and outgoing), print jobs, process locks, etc. Having this directory mounted under / (root) may be a bit dangerous because a large amount of incoming e-mail (for example), may suddenly fill up the partition. Since bad things can happen (eg. system crash?) when the / (root) partition fills up, having /var on its own partition may avoid such problems. I›ve had success in taking whatever space I›ve allocated to / (root), perhaps doubling it, and then creating separate partitions for / (root) and for /var. The partition type should be left as the default of 83 (Linux native).
- */boot/* (optional) - In some circumstances (such as a system set up in a software RAID configuration) it may be necessary to have a separate partition from which to boot the Linux system. This partition would allow booting and then loading of whatever drivers are required to read the other file systems. The size of this partition can be as small as a couple Mb; I recommend approximately 10 Mb (which should give you plenty of room to store the kernel, initial RAMdisk image, and perhaps a backup kernel or two). The partition type should be left as the default of 83 (Linux native).

- */archive/* (optional) - If you have any extra space lying around, perhaps you would benefit from a partition for a directory called, for example, /archive. You can then use the /archive directory to store backup material, large or infrequently accessed files, samba file services, or whatever else you can find a use for it. The partition type can be left as the default of 83 (Linux native), or if you want to access it from both Linux as well as from another operating system, you could change it to a different ID, such as 6 (DOS 16-bit >=32M).

As extra drive(s) are added, further partitions can be added to the new drives, mounted at various mount-points as required -- this means a Linux system never needs to worry about running out of space. As an example, if in the future it is clear that sda6 is starting to get filled up, we could add another drive, set a nicely sized partition with a mount-point at /usr/local -- and then transfer all the information from /usr/local over to the new drive. But no system or application component would «break» because Linux would see /usr/local no matter where it was located.

Device Boot	Begin	Start	End	Blocks	Id	System
/dev/hda1 *	1	1	254	1024096+	6	DOS 16-bit >=32M
/dev/hda2	255	255	782	2128896	5	Extended
/dev/hda5	255	255	331	310432+	83	Linux native
/dev/hda6	332	332	636	1229728+	83	Linux native
/dev/hda7	637	637	749	455584+	83	Linux native
/dev/hda8	750	750	782	133024+	82	Linux swap

The first partition, */dev/hda1*, is a DOS-formatted file system used to store the alternative operating system (Windows 95). This gives me 1 Gb of space for that operating system.

The second partition, */dev/hda2*, is a physical partition (called "extended") that encompasses the remaining space on the drive. It is used only to encapsulate the remaining logical partitions (there can only be 4 physical partitions on a disk; in my case I required more than 4 partitions, therefore I had to use a logical partitioning scheme for the others).

The third through fifth partitions, */dev/hda5*, */dev/hda6*, and */dev/hda7*, are all e2fs-formatted file systems used for the / (root), /usr, and the /home partitions, respectively.

Finally, the sixth partition, /dev/hda8, is used for the swap partition.

For yet another example, this time an Alpha box with two hard drives (sole boot, Linux only), I have chosen the following partitioning scheme:

Device Boot	Begin	Start	End	Blocks	Id	System
/dev/sda1	1	1	1	2046	4	DOS 16-bit <32M
/dev/sda2	2	2	168	346859	83	Linux native
/dev/sda3	169	169	231	130851	82	Linux swap
/dev/sda4	232	232	1009	1615906	5	Extended
/dev/sda5	232	232	398	346828	83	Linux native
/dev/sda6	399	399	1009	1269016	83	Linux native
/dev/sdb1	1	1	509	2114355	83	Linux native
/dev/sdb2	510	510	1019	2118540	83	Linux native

The first partition, /dev/sda1, is a DOS-formatted file system used to store the MILO boot loader. The Alpha platform has a slightly different method of booting than an Intel system does, therefore Linux stores its boot information in a FAT partition. This partition only needs to be as large as the smallest possible partition allowed -- in this case, 2Mb.

- The second partition, /dev/sda2, is an e2fs-formatted file system used for the / (root) partition.
- The third partition, /dev/sda3, is used for the swap partition.
- The fourth partition, /dev/sda4, is an "extended" partition (see previous example for details).
- The fifth and sixth partitions, /dev/sda5, and /dev/sda6, are e2fs-formatted file systems used for the /home and /usr partitions, respectively.
- The seventh partition, /dev/sdb1, is an e2fs-formatted file system used for the /archive partition.
- The eighth and final partition, /dev/sdb2, is an e2fs-formatted file system used for the /archive2 partition.

After you finish setting up your partition information, you'll need to write the new partition to disk. After this, the Red Hat installation program reloads the partition table into memory, so you can continue on to the next step of the installation process.

SUMMARY

- Linux is typically packaged in a Linux distribution. Distributions include the Linux kernel and supporting system software and libraries, many of which are provided by the GNU Project.
- Although it is used by only around 2.3 percent of desktop computers, the Chromebook, which runs the Linux kernel-based Chrome OS, dominates the US K–12 education market and represents nearly 20 percent of sub-$300 notebook sales in the US.
- To put it simply – the operating system manages the communication between your software and your hardware.
- Linux has a graphical interface, and types of software you are accustomed to using on other operating systems, such as word processing applications, have Linux equivalents.
- All the terminals are then connected to the main Linux Server or Host Machine, whose resources and connected peripheral devices such as printer, can be used.
- Linux has the ability to handle more than one job at a time, say for example you have executed a command for sorting for a huge list and simultaneously typing in a notepad.
- The kernel builds a structured file system on top of unstructured hardware, and the resulting file abstraction is heavily used throughout the whole system.
- These are called dynamically loadable kernel modules, and they can be inserted at boot when they're needed (when a particular device is found requiring the module) or at any time by the user.

KNOWLEDGE CHECK

1. **The dmesg command**
   a. Shows user login logoff attempts
   b. Shows the syslog file for info messages
   c. kernel log messages
   d. Shows the daemon log messages
2. **The command "mknod myfifo b 4 16"**
   a. Will create a block device if user is root
   b. Will create a block device for all users
   c. Will create a FIFO if user is not root
   d. None of the above
3. **Which command is used to set terminal IO characteristic?**
   a. tty
   b. ctty
   c. ptty
   d. stty
4. **Which command is used to record a user login session in a file**
   a. macro
   b. read
   c. script
   d. none of the above
5. **Which command is used to display the operating system name**
   a. os
   b. Unix
   c. kernel
   d. uname
6. **Which command is used to display the unix version**
   a. uname -r
   b. uname -n
   c. uname -t
   d. kernel
7. **Which command is used to print a file**
   a. print

b. ptr
c. lpr
d. none of the above

8. Using which command you find resource limits to the session?

a. rlimit
b. ulimit
c. setrlimit
d. getrlimit

9. Which option of ls command used to view file inode number

a. –l
b. -o
c. –a
d. –i

10. find / -name '*' will

a. List all files and directories recursively starting from /
b. List a file named * in /
c. List all files in / directory
d. List all files and directories in / directory

11. An operating system is software that manages all of the hardware resources associated with your desktop or laptop.

a. True
b. False

12. Linux is heavily based on the file system concept; almost everything in Linux can be treated as a file.

a. True
b. False

REVIEW QUESTIONS

1. How does Linux differ from other operating systems?
2. What is the difference between UNIX and Linux?
3. Explain the basic features of Linux OS.
4. Describe the characteristics of Linux OS.
5. Discuss about process identifier (PID)

Check Your Result

1. (c)	2. (a)	3. (d)	4. (c)	5. (d)	6. (a)
7. (c)	8. (b)	9. (d)	10. (a)	11. (a)	12. (a)

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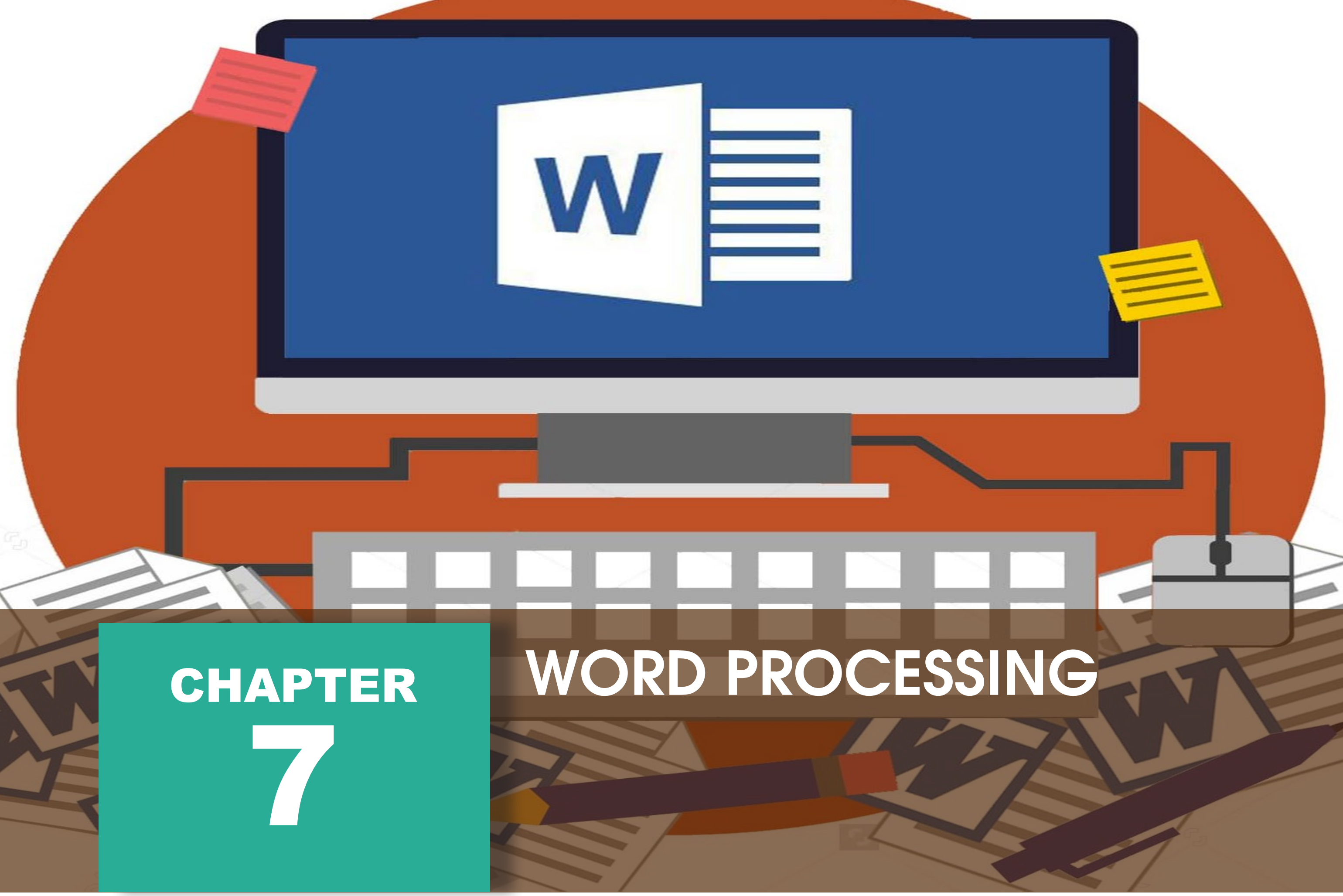


CHAPTER 7

WORD PROCESSING

LEARNING OBJECTIVES

After studying this chapter, you will be able to:

1. Discuss on concept of word processing
2. Understand the managing documents
3. How to editing and proofing tools

"The term, information at your fingertips, is to remind people what a broad role the personal computer will be playing. It's not a computation device, it's not a word processing or a spreadsheet device. It's a window onto the world of information."

– Bill Gates

INTRODUCTION

Word processing is the ability to create documents using a word processor. It can also refer to advanced shorthand techniques, sometimes used in specialised contexts with a specially modified typewriter. These were primarily aimed at typists, particularly in offices where other workers sent handwritten notes to be transcribed into documents for printing which were returned for reviewing. The word processing operators achieved considerable time saving largely due to: the faster typing speeds achieved as a result of electronic keyboards

The assistance of the word processing software for functions like layout and spell check, etc.

Today, there are different word processors available; some are proprietary like Microsoft Word, WordPerfect Office, Star Office Writer, etc., while others are open source like Kwrite, Openoffice.org Writer, etc. Basic functions in all remain more or less similar and do not require advanced computer or typing skills for use. However, a complete word processor is that which lets us work with text and other features, for example, pictures, tables, artistic texts, to create interesting and meaningful pages. We can make our own posters for bulletin board, type letters and attach them as documents to an e-mail, etc. Since MS Word, an integral component of MS-Office, is one of the programs which provides all these features and many more and is also being mostly used due to its ease of usage, we have taken it as a sample Word Processing Tool.

7.1 CONCEPT OF WORD PROCESSING

Word processing is the process of adding text to a word processing unit such as a computer or typewriter. The typed words are stored in the computer or word processor temporarily to allow for editing before a hard copy of the document. The term "word processing" is a fairly general term, so it may refer to several types of writing without the use of pen and paper. Typewriters, for example, process words directly onto a paper without storing the data, while computers use specific programs to store the typed data before printing.

Modified typewriters have been commonly used in the past for word processing. The typewriter would store the data usually with the use of a computer chip before printing the words onto a page. The person using the word processor could then check the writing for errors before printing the final draft. When computers became common in the workplace and at home, word processors became mostly obsolete, though some models are still used for a wide range of purposes, including as educational devices for students with special needs.

Computers have generally taken over word processing duties. The computers feature specific programs in which a person can type manuscripts of any length. The data is stored as an electronic document that can be opened, closed, saved, and edited at any time. This allows the user to make corrections or changes to a document multiple times before printing out a hard copy of the document. In many cases, the document is not printed out onto hard copy paper at all; instead, it can be used on the internet, in e-mails, or for other digital purposes.

Simpler programs, such as text editors or notepads, can be used to record text quickly without excess formatting options, such as multiple fonts or font sizes. Such programs are easy to use and do not come loaded with formatting features, such as color, multiple fonts, line spacing options, and so on. They are meant to be used for quick word processing that will not need to be formatted for presentation.

Word processing software often includes several features unavailable on typewriters or older word processors. Such features may include the ability to manipulate the layout of the text, the size and color of the font, the type of font used, line spacing, margin adjustments, and the ability to insert photos, web links, graphs, charts, and other objects directly into the document.

7.1.1 Main Features of Word Processing

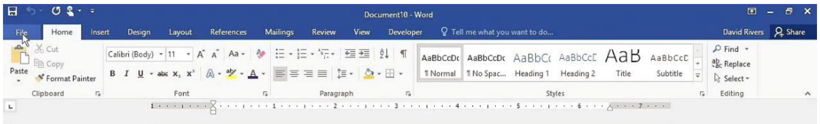
The main features are:

- You can create professional documents fast, using built-in and custom templates.
- You can easily manage large documents using various features like the ability to create table of contents, index, and cross-references.
- You can work on multiple documents simultaneously
- With the help of mail merge, you can quickly create merge documents like mass mailings or mailing labels. AutoCorrect and AutoFormat features catch typographical errors automatically and allow you to use predefined shortcuts and typing patterns to quickly format your documents.
- The print zoom facility scales a document on different paper sizes, and allows you to print out multiple pages on a single sheet of paper.
- The nested tables feature supports putting one table inside another table.
- You can export and save your word documents in PDF and XPS file format.

7.1.2 Features of Word 2016

MS Word 2016 has useful features and tools introduced to produce professionally created documents.

You can easily create, format, edit professional-looking user document using comprehensive set of easy to use tools provided by MS Word. It uses the MS Office Fluent user Interface concept. This interface uses a new component called Ribbon to group the tools by task, within task by sub tasks and related commands that are used more frequently. The new user result oriented interface presents the tools to you in a more organized and efficient manner, which are easy to locate.



- Tabs are more task oriented such as Home, Insert, Page Layout
- Within each tab, the related sub-tasks are grouped together
- Related command button 1 are also grouped together to execute a command or to display a command menu

Keyword

Portable Document Format (PDF) is a file format used to present documents in a manner independent of application software, hardware, and operating systems.

The MS Word 2016 provides a lot of pre-formatted template to produce documents, reports etc. While using the pre-formatted template, you can select already available cover page, header and footer to give the documents a professional look without spending much time in formatting a new one. MS Word 2007 also provides features for creating chart and diagram which include three-dimensional shapes, transparency, drop shadows, and other effects. This helps create highly professional documents with flexibility in representing data more efficiently and professionally.

Using MS Word 2016 digital signature feature, you can ensure the authenticity, integrity, and origin of the document. The same can be done either by adding an invisible digital signature to a document, or inserting a Microsoft Office Signature Line, which capture a visible representation of a signature along with a digital signature. Similarly, before sharing a document which is in its final form with others, you can use MS Word 2016 "Mark As Final" features to protect the document from any changes. "Mark as Final" command makes the document "read-only" making the typing, editing and proofing command disabled. But just to remember, "Mark As Final" is a security feature as anyone can edit a document that is marked as final by turning off Mark as Final. MS Word 2016 also provides the feature and tools to export your document to either **Portable Document Format (PDF)** or XPS (XML Paper Specification) format.

Starting MS Word Program

You can start your Word program different ways. One way is using Start button:

- Click on the Start button.
- In the menu that appears select All Programs→Microsoft Office→Microsoft Office Word 2016. In few seconds you will see Word screen on the monitor.

You can also start your MS Word program by double clicking on Microsoft Word icon, which lies on the Microsoft Office Shortcut Bar (MOSB).

7.1.3 Word Screen Layout

The Word screen (Window) contains a number of objects such as Tabs, Menus, Sub menus, short-cut commands etc. We will describe the Word's default screen layout (Fig. 7.1) here.

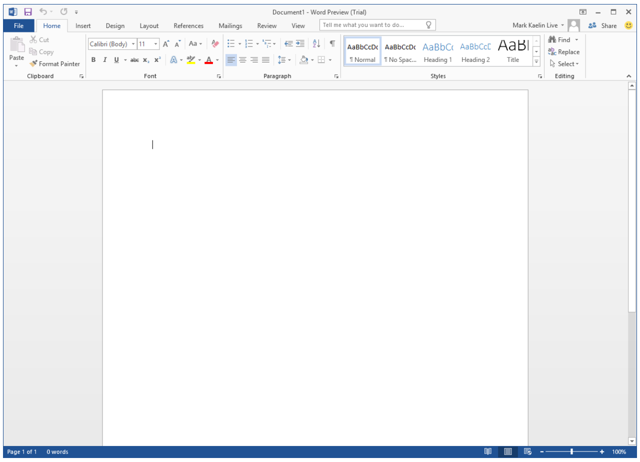


Figure 7.1: Word's default screen layout.

Menus

If you are familiar with previous versions of Word, when you begin to explore Word 2016, you will notice a significant change in the menu structure, look and feel. The features in Word 2016 display as various tabs such as Home, Insert, Page Layout, References etc. To view all sub tasks/options (expanded form) in each menu, you must click the required option. For example, the images in Figure 7.2 show the Border menu in collapsed form (Figure 7.2a) and in expanded form (Figure 7.2b).

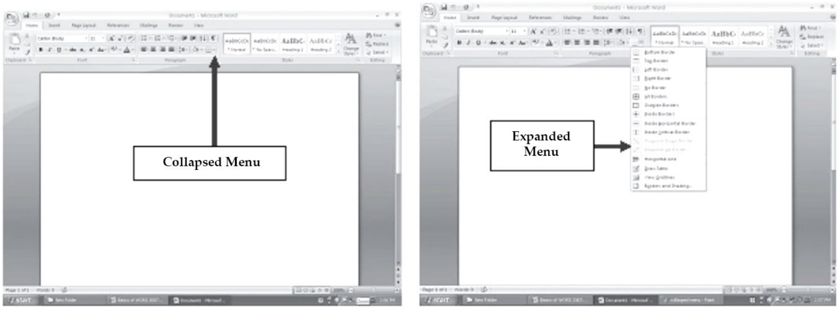
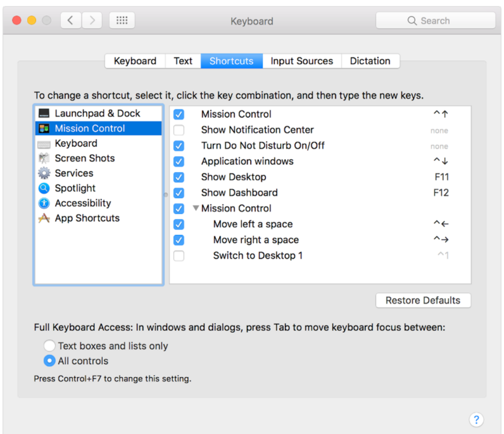


Figure 7.2: (a) Collapsed menu, (b) Expanded menu

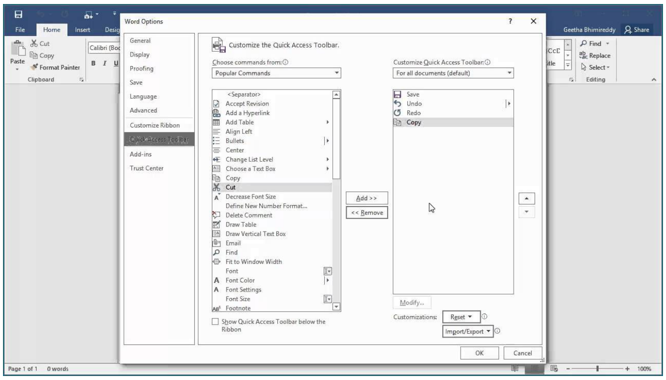
Shortcut Menus

These features allow you to access various Word commands faster than using the options on the menu bar. When the menu is expanded, the shortcut menu is displayed with short-cut command option for each of the short-cut menu item. The options on this menu will vary depending on the sub-task that was clicked or selected. For example, the **shortcut menu** on the side is produced by selecting or expanding the Border option of the paragraph sub-task of the Home Tab from the Tab bar.

The shortcut menus are helpful because they display only those options that can be applied to the item that was selected and, therefore, prevent searching through the many menu options.



Toolbars MS Word 2016 provides a customized quick access toolbar to organize the tools available for easy and fast access of the commands. Many toolbars displaying shortcut buttons are also available to make editing and formatting quicker and easier. The toolbars that are already displayed on the screen are Checked. To add/modify simply click on the "More Commands" option which will display the following menu for customized selection of tools as per your requirement.

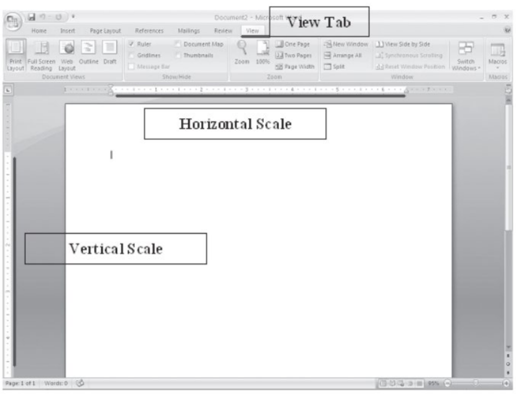


Keyword

Shortcut menu is a menu that appears when you right-click an object. In Microsoft Forms, the following objects have shortcut menus: The Toolbox, each page in the Toolbox, and each item on a page of the Toolbox.

Rulers

The rulers display horizontal and vertical scales that reflect the width and height of your typing area. The horizontal scale is invaluable when you want to quickly set tabs, margins, and indents. Select the View tab on the main MS word 2016 screen to be able to select/deselect the Ruler/Gridlines and other options.



Typing Screen Objects

The open area below the rulers and toolbars is writing or typing area. There are certain objects that are a permanent part of the typing area. These are: (a) Insertion Point, (b) Mouse Pointer, and (c) End-of-Document Marker.

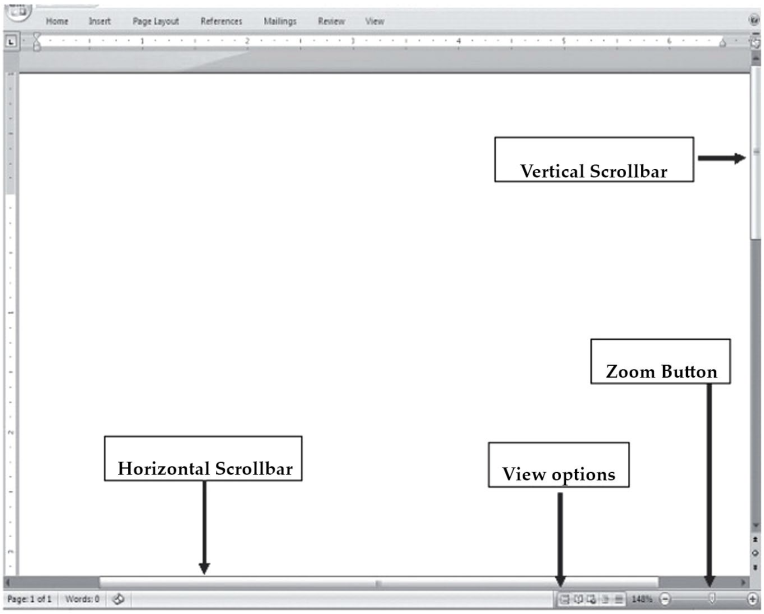
Insertion Point: The black vertical blinking line is the insertion point that is initially at the top left side of the typing area. It indicates the place where your typing is inserted into the document. As you type, the blinking line continuously moves along towards right inserting in that line whatever is typed. When the up, down, left, or right arrows of the keyboard is used, the insertion point moves accordingly. When you move and place the cursor any where in the text and click, the insertion point shifts to that place from its current location indicating that it is ready to accept your typing.

Mouse Pointer: When you move the mouse around in the typing area, the mouse pointer is in the shape of a thin I-beam. As you move the mouse near the menu bar and toolbars, the mouse pointer becomes a pointing arrow. If you move the mouse pointer to some existing piece of text and click the mouse, you will see the insertion point in that spot of the text.

End-of-Document Marker: The horizontal line (like a short underline) at the end of the document (seen only when Word is in Normal view) is called end-of-document marker. This marker lets you know where the end of document occurs.

Vertical and Horizontal Scrollbars

The typing area is bordered on the right side by the vertical scroll bar with a scroll button and arrows. The single down arrow scrolls through the document line by line. The double down arrow allows you to move to the top of the next page. The double up arrow allows you to move to the top of the previous page. The double down arrow allows you to move to the top of the next page. You can also drag the vertical scroll button up and down the scroll bar to move up and down through the document. The first bar along the bottom of the typing area is the horizontal scroll bar. To see the text that is off the right side of the screen, use the left arrow button. To see the text that is off the left side of the screen, use the right arrow button. You can also drag the horizontal scroll button to move left or right of the document. In Word 2016, the options such as view documents and zoom is also available on the bottom bar for easy access.



7.2 MANAGING DOCUMENTS

The Document Information Panel makes it easy to view and edit document properties while you work on your Word document. The Document Information Panel displays at the top of your document in Word. You can use the Document Information Panel to view and edit both standard Microsoft Office document properties and properties for files that are saved to a document management server. If you use the Document Information Panel to edit the document properties for a server document, the updated properties will be saved directly to the server.

Open a new/ existing document, save a document, print a document, working with multiple documents, protecting a document, finding a document, and closing an opened document. There are several ways to create new documents, open existing documents, and save documents in Word. Click on the Office Button to use one the following.

Create a New Document

To open a new document, follow one of the following methods:

Click the New Document button on the menu bar.

Press CTRL+N keys on the keyboard.

Open an Existing Document

Click on the office 2016 button at the top left corner of your screen to open an existing document, follow one of the following methods:

- Click the Open File button on the menu bar. 
- Press CTRL+O keys on the keyboard.
- Each of the above method will show the Open dialog box. Choose the file and click the Open button.

Save a New/Existing Document

To save a new/existing document that is opened, follow one of the following methods:

- Click the Save button on the menu bar. 
- Press CTRL+S keys on the keyboard.

If the document is already named and saved earlier, it will simply save the document. On the other hand, if the file is a new document then it will prompt you by opening Save As dialog box. Select the folder where you want to place your document in Save In: box, type the name of the document in File Name: box, and then click OK. You can also save a new document by choosing CTRL→A on the keyboard and then selecting the above actions in Save As dialog box.

Working on Multiple Documents

Several documents can be opened simultaneously if you are typing or editing multiple documents simultaneously. All open documents can be arranged under the View Tab.

Protecting a Document

You can protect your document from being accidentally changed its format and text or from other users to get access to it.

Protecting a Document from Accessing

If you want to protect a document from other users accessing to it, give a password to your file. Follow the steps given below:

- When the file is open, select Office Button→Save As command on the menu bar. The Save As dialog box appears. Move the cursor on the Tools tab on the down left side of Save As dialog box and click. A submenu will appear (see Figure 7.3).

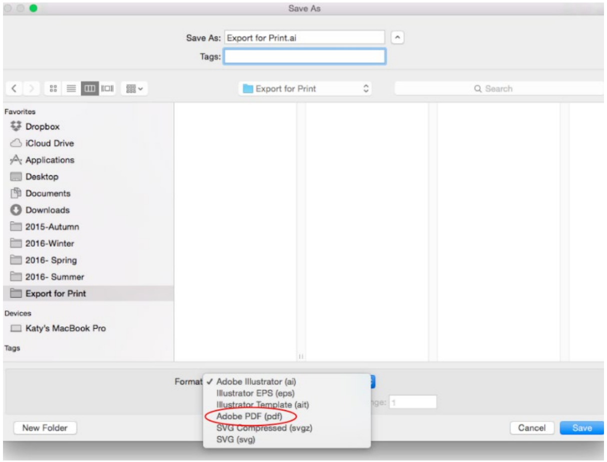


Figure 7.3: Save As dialog box.

- Click on General Options. The Save dialog box opens. You will see two boxes: Password to open and Password to modify.
- Type a password in Password to open box. (A password can include up to 15 character case-sensitive letters, numerals, spaces and symbols. As you type the password, Word displays an asterisk (*) for each character you type.)
- Click OK. The Confirm Password dialog box appears (see Save dialog box and Confirm Password dialog box in Figure 7.4). Retype the password you typed earlier. Click OK on Confirm Password dialog box and then click OK on Save dialog box and then click OK on Save As dialog box.

Figure 7.4: Save dialog box and Confirm Password dialog box.

- When you open the file again next time it will ask you to type the password. Remember, you will not be able to open that file without the password. Also, don't forget that the passwords are case sensitive; that is, 'XYZ' and 'xyz' are two different passwords.

Protecting a Document from Accessing (Read Only)

With this feature you can have double protection to your document. Sometimes you yourself may accidentally change the format of your document. You can protect your document from being accidentally changed its format as well as from other users accessing it.

Protecting a Document as Read Only Document

If you want your document be protected only for accidental changes in the format, follow the steps given below:

- When the file is open, select Office Button→Save As command on the menu bar. The Save As dialog box appears. Move the cursor on the Tools tab on the down left side of Save As dialog box and click. A submenu will appear.
- Click on General Options. The Save dialog box opens. You will see Read only recommended check box at the left side bottom of the Save dialog box.
- Check-mark (√) the Read only recommended check box. Click OK on Save dialog box and then click OK on Save as dialog box.

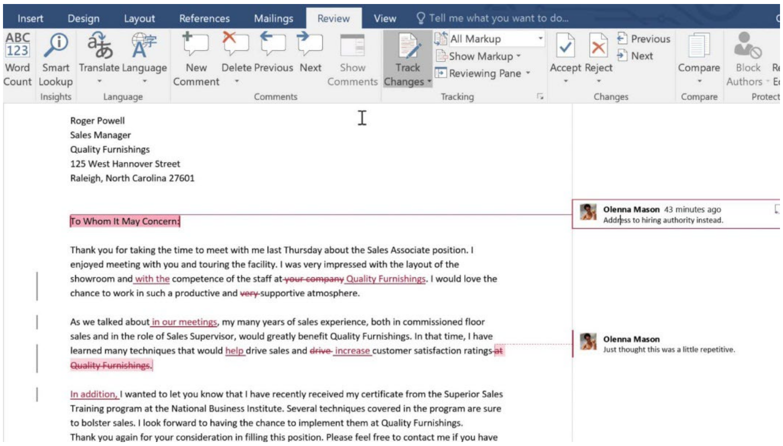
Next time when you open the document after giving password it will prompt you with a message 'Open as read-only. If you accidentally make changes and then try to save the document, the file will not be saved. Instead, you will be prompted by a message 'This file is read-only'. If you want to make changes to a document remove the check mark by clicking on Read-only recommended box, which lies below Password to open box under save **dialog box**.

Modifying a Password Given to Protect a Document

If you suspect that some one knows your password and you want to change it, modify it by typing present password in Password to open: box and new password in Password to modify: box in the Save dialog box.

Protect a Document for Track changes, Comments, and Forms

Sometimes you may feel that your document should be reviewed by others to improve the document's contents. The reviewers of your document can suggest some changes or comments without modifying the original document. After the review, if you wish that the changes were necessary you can incorporate them. Track changes: Selecting this option from the Review Tab and Tracking sub-task, let other users to change the document but highlights all changes so that you can track changes. While a document is protected for track changes, you cannot turn off change tracking nor can you accept or reject track changes.



Keyword

Dialog box is a small window that communicates information to the user and prompts them for a response.

Find Documents

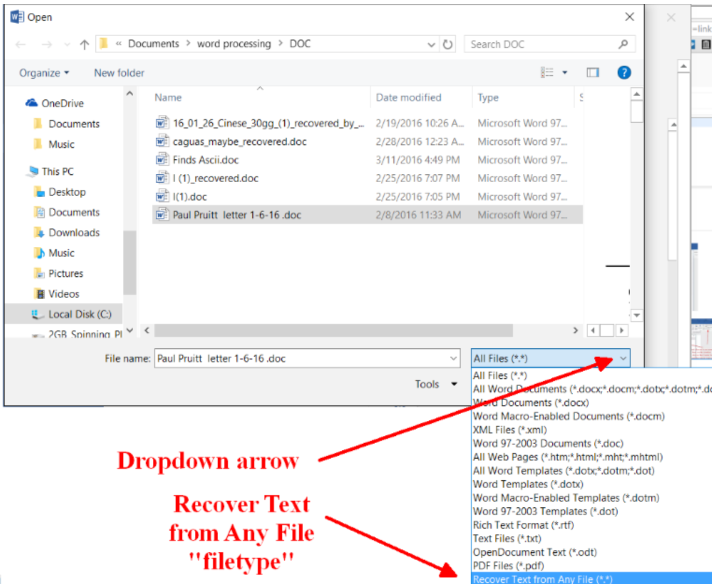
When you forgot the name of a file, but you remember a few letters in a word that may be in the file name, use Open dialog box. Word will search through the list of files in the selected folder or device for your particular file. For example, if your file name is 'Annual paper' you can type the letters annual. Word will locate this file. Follow these steps to find files:

Select Office Button Open command on the menu bar. The Open dialog box will be displayed.

In Look in: box, select the folder or click where you suspect your file will be located. Type few letters you remember that match with file name in File Name: box (Remember you can type upper case or lower case letters, since search is not case sensitive). If the typed letters are beginning letters of your file name, the file name will appear in the File Name: box. Click Open to open the document.

If you don't see your file name appearing in the File Name: box as you type, move the cursor on the Tools tab on the top right side of Open dialog box. If the typed letters in the File

Name: box matches with some part of your file name, all the file names matching with your typed letters along with other files will appear in Name box in the Open dialog box. If you trace your file in the box, double-click on the file name or select the file name and then click Open in Find dialog box to open the document.



Close a Document

Close the current document by selecting Office Button→Close command on the menu bar or click the Close icon if it is visible on the Standard toolbar.

7.2.1 Printing Documents

While printing a document you have the following options in Print dialog box: (see Figure 7.5).

- Name of the printer (if you have more than one printers).
- Choose paper size, orientations, resolution etc. by pressing Properties button.
- Print the entire document or only current page or specific pages
- Print a draft copy, which omits graphics to allow faster printing.
- Number of copies to be printed, etc.

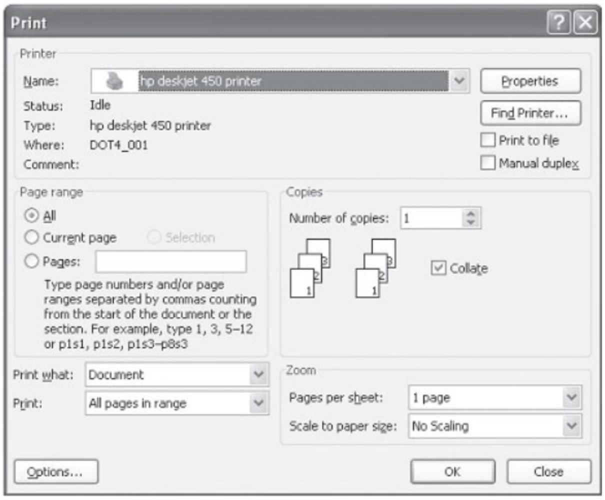


Figure 7.5: Print dialog box.

Printing a Document

To print a document or selected pages follow the steps given below:

- Open the document to be printed.
- Choose Office Button→Print command on the menu bar. The Print dialog box will open. Select the Options like print range, Number of copes, Printer name etc. See that printer is switched on and the paper is available in the printer tray.
- Click OK.

Printing a Document on a Different Paper Size

You might have created a document using some selected paper size. You may want to print that document in a different paper size or multiple pages in a single sheet of paper without disturbing the general format. You can do it using Zoom feature in Print dialog box. Follow the steps given below to resize your document to fit into a new paper size. If you want to print a document in a different paper size, follow the steps given below:

- Open the document to be printed.
- Choose Office Button→Print command on the menu bar. The Print dialog box will open. Select the Options like print range, Number of copes, Printer name etc. See that printer is switched on and the paper is available in the printer tray.
- Select the appropriate paper size in Scale to paper size: under Zoom in Print dialog box.
- Click OK.

Printing a Document's Multiple Pages in a Single Sheet of Paper

If you want to print multiple pages of a document in a single sheet of paper, follow the steps given below:

- Open the document to be printed.
- Choose Office Button→Print command on the menu bar. The Print dialog box will open. Select the Options like print range, Number of copies, Printer name etc. See that printer is switched on and the paper is available in the printer tray.
- Select the appropriate paper size in Pages per sheet: under Zoom in Print dialog box.
- Click OK.

7.3 EDITING AND PROOFING TOOLS

A Microsoft Word 2002 document to others, you should always proofread it carefully. Proofreading involves correcting all spelling and grammar errors and making any other final changes to the document. Fortunately, Word's spelling and grammar capabilities can do some of this work for you.

The dictionary contains all words that Microsoft identifies as correct when you check the spelling of a document, including many proper nouns and acronyms. If you type our plans is to send the document after it has been proofread, Microsoft will mark plans is as a grammatical error. On the other hand, if you type Too whom it may concern, Word will not mark the word Too as being a grammatical error. The bottom line: even after you use Word's spelling and grammar checking features to make corrections in a document, you still need to read through the document carefully to look for any additional errors.

Additionally, once you give a document to others, they need a way to provide you with feedback. Word's Comment feature allows them to give you this feedback and make suggestions without altering the content of the document.

7.3.1 Checking Spelling in a Document

There are three ways to check spelling in a document, depending on whether you want to correct errors as soon as Word identifies them or whether you want to wait and check spelling for the entire document after you have created it:

- Right-click a word that has a red wavy underline, and then select a suggested correction from the list.
- On the Standard toolbar, click the Spelling and Grammar button to check spelling and grammar in the entire document.

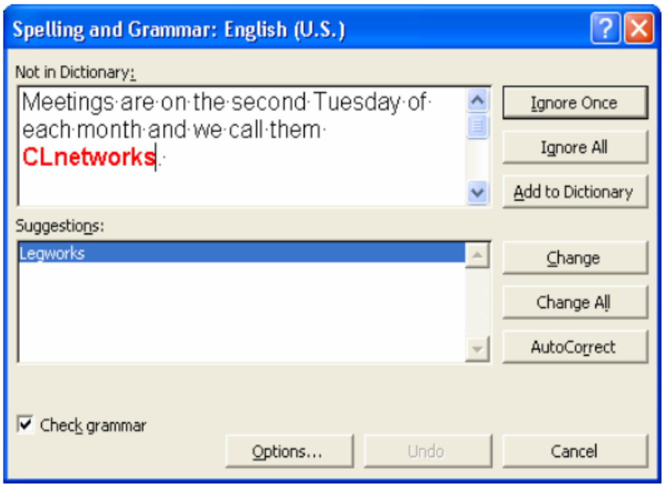
- On the Tools menu, click Spelling and Grammar to check spelling and grammar in the entire document.

When you check the spelling for a complete document, Word compares each word in the document with words in its standard dictionary. If an error is found, the word is selected in the document window, and alternative selections are listed in the Suggestions list. After a possible misspelled word has been located, the following options are available, some of which appear as buttons in the Spelling and Grammar dialog box.

Button	***Function***
Ignore Once	Ignores only that occurrence of the selected word.
Ignore All	Ignores all occurrences of the word.
Add to Dictionary	Adds the word to the custom dictionary.
Change	Replaces the selected word with the selected word in the Suggestions list.
Change All	Replaces all occurrences of the word with the selected word in the Suggestions list.
Suggestions	Lists alternative suggestions for the misspelled word in the list.
AutoCorrect	Adds the word to a list that Word uses to automatically correct spellings of the word as you type it.
Undo	Returns a spelling correction to its previous state.
Delete	Appears if a double occurrence of a word is detected (such as *to to modify the document*), and can be used to delete the second occurrence.
Options	Customizes spelling and grammar checking. For example, you can specify whether you want Word to ignore certain words with uppercase characters or words with numbers when Word checks spelling.

You correct a single spelling error, check a complete document for spelling errors, and then correct or ignore the potential errors that Word identifies.

- On the Standard toolbar, click the Open button. The Open dialog box appears.
- Click the Look in down arrow, double-click the icon for your hard drive, and double-click the Word Processing Practice folder.
- Word and the Open dialog box closes.
- In the first line of the second paragraph, right-click the misspelled word each, and click each in the list of possible corrections that appears. The word is corrected in the document.
- On the Standard toolbar, click the Spelling and Grammar button. The Spelling and Grammar dialog box appears with the word CLnetworks selected in the document window. Word has only one suggestion for this term and it is obviously not the correct substitution.



- Clear the Check grammar check box if it is currently selected.
- Click the Ignore All button. The word and all future instances of it in the document are ignored, and the word an is selected. Because this is an occurrence of a double word and not a misspelling, no alternative spellings are offered.
- Click the Delete button. The second occurrence of the word an is deleted, and the capitalization error MEmbership is selected. The correct usage of the capitalized word is displayed and selected in the Suggestions list.
- Click the Change button to change the capitalization to Membership.
- Word continues to check the document for spelling errors. When an error occurs, choose the best choice in the Suggestions list and click the Change button. Continue making the necessary corrections in the document. When Word has finished locating all potential spelling errors, the Spelling and Grammar dialog box closes and the following message box appears.

Keyword

File menu is a graphical control element formerly common to most file-handling computer programs, but more recently often replaced by a toolbar or ribbon.

- Click OK. The message box closes.
- On the **File menu**, click Save As. Word saves the document.

7.3.2 Using the Shortcut Menu for Words and Phrases

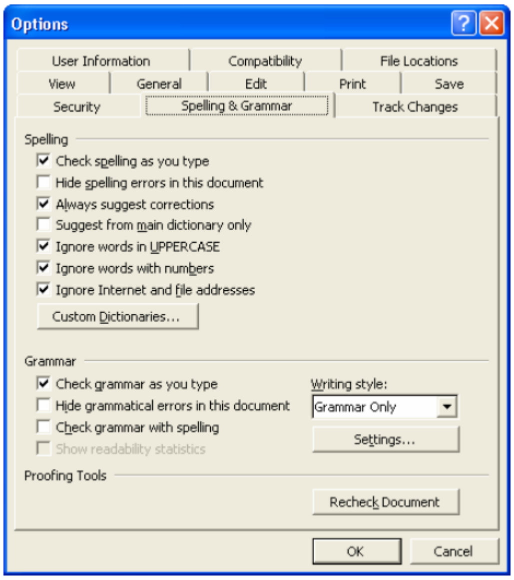
To identify the cause of a single grammatical error, you can right-click any word marked with a green wavy line to display a shortcut menu, and then make a selection from the shortcut menu as desired. The first item on the menu is a brief description of the error. If you click the About This Sentence item on the shortcut menu, Word displays a more thorough explanation of the grammatical problem and suggests ways to correct it. If a red wavy line appears under a word that you know is spelled correctly (such as a proper name), you can add that word to the dictionary. To add a word to the dictionary and remove the red wavy line from all instances of that particular spelling, right-click the word to display a shortcut menu, and click Add to Dictionary.

7.3.3 Checking for Grammatical Errors

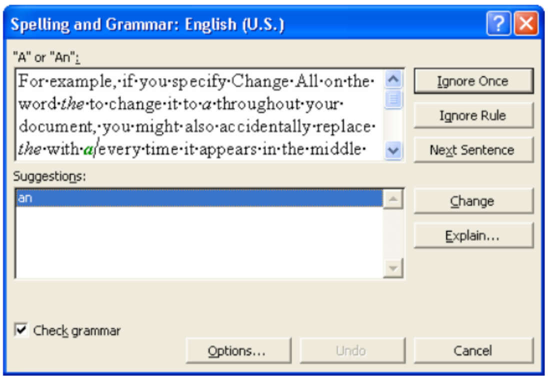
After you have typed your document, you can use Word to check the entire document for grammar and spelling errors. If an error is found, the word or phrase is selected in the Sentence box, and alternative words or phrases appear in the Suggestions list. You can ignore the error, check the grammar rule, or make changes to the existing document. Normally Word checks for spelling and grammatical errors at the same time with one exception. If you clear the Check grammar with spelling check box, Word checks only for spelling errors. You cleared this check box in the previous exercise to check for spelling errors only, so grammatical errors might still occur in your document. You can still check for grammatical errors at a later time.

REMEMBER

You can undo spelling corrections one-by-one immediately after closing the Spelling and Grammar dialog box. On the Standard toolbar, click the Undo button to undo the most recently corrected word. Click the Undo button again to undo the next corrected word. Repeat this procedure to undo any other spelling corrections.



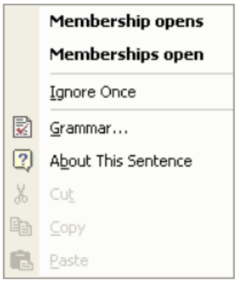
To check grammar in a document (after you've turned on grammar checking), on the Standard toolbar, click the Spelling and Grammar button to display the Spelling and Grammar dialog box. Click the Ignore Once button to ignore an error; click the Ignore All button to ignore the error wherever it occurs; or click the Change button to make the suggested replacement that appears in the Suggestions list. Change All will review the document and find any other spellings that are the same and replace them with the text chosen in the Suggestions list. If Word identifies a grammatical problem that can't be corrected with a simple replacement (such as a sentence fragment or words that appear to be out of order), the Change button will be grayed out (made unavailable). However, the dialog box will suggest that you consider revising the sentence.



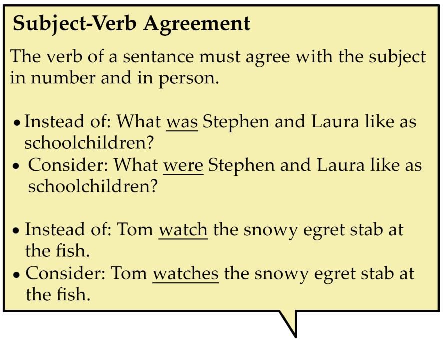
You check the grammar in a document.

- Press Ctrl+Home to position the insertion point at the beginning of the document.
- On the Tools menu, click Options. The Options dialog box appears.

- In the Options dialog box, click the Spelling & Grammar tab, if necessary.
- In the Grammar section, select the Check grammar with spelling check box, and click OK.
- Scroll down until you see the words that are underlined with a green wavy line (the sentence begins Membership open to individuals).
- Right-click anywhere in the underlined area. Word displays a shortcut menu that shows suggested corrections as well as provides access to further information.



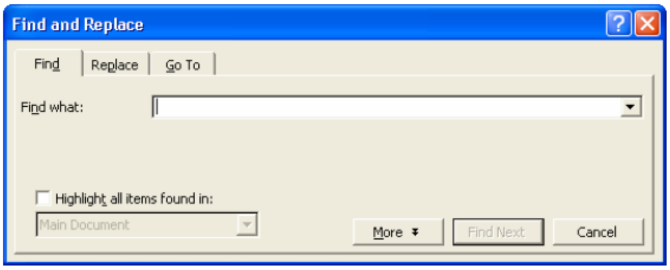
- On the shortcut menu, click About This Sentence. The Office Assistant appears and explains the meaning of subjectverb agreement and suggests ways to correct the grammatical error.



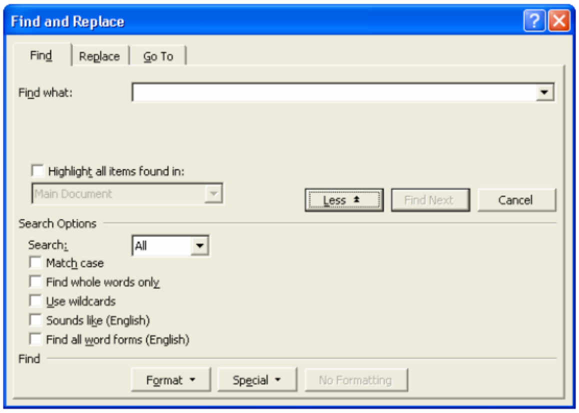
- Click after the space following the word Membership, type is, and then press the spacebar. The error is corrected by adding a verb to the sentence, and the green wavy line no longer appears. Keep this file open for the next exercise.

7.3.4 Finding Specific Text

When you edit long documents, you might want to move quickly to a particular location in the document so that you can review or edit text at this location. If you know the location of the document contains a unique word or phrase, you can use Word's Find and Replace dialog box to locate the word or phrase.



In the Find and Replace dialog box, you can click the More button to display additional search options. These search options allow you to define settings such as whether you are using wildcards or the Sounds like feature.



A wildcard character stands for any character that appears in one or more positions within a word or string of text. To use wildcards, in the Find and Replace dialog box, click the More button, and select the Use Wildcards check box. Use the question mark (?) wildcard symbol in a search string to represent any character in a single position within the word or text string. For example, the string h?t finds hat, hit, hot, and hut. Use the asterisk (*) wildcard symbol to represent any string of characters. For example, the string h*t finds hat, hurt, and even had sent.

You can use the Sounds like feature to find words that sound similar to the text string you are searching for, but which might be spelled differently. For example, when you use the Sounds like feature for the word meet, Word identifies meet, meat, and mete as matching the Sounds like rule.

In this exercise, you find a string of text within the current document, and you expand the Find and Replace dialog box to display additional search options.

- Press Ctrl+Home to position the insertion point at the beginning of the document.
- On the Edit menu, click Find. The Find and Replace dialog box appears.

- In the Find what box, type meetings, and click the Find Next button. The word meetings at the beginning of the second paragraph is now selected. The Find and Replace dialog box remains unchanged.
- In the Find and Replace dialog box, click the Find Next button to display the next occurrence of the word meetings. The word meetings at the end of the second paragraph is now selected. The Find and Replace dialog box still remains unchanged.
- Click the Find Next button again. Word searches again for the word meetings and displays a message box indicating that Word has finished searching the document.
- Click OK. The message box closes.
- In the Find and Replace dialog box, click the More button. The dialog box expands to show the Search Options section.
- In the Find and Replace dialog box, click the Cancel button. The dialog box closes. Keep this file open for the next exercise.

REMEMBER

You can also display the Find and Replace dialog box by pressing Ctrl+F or by clicking the Select Browse Object button (lower-right corner of the Word window) and then clicking Find.

7.3.5 Replacing Specific Text

The Replace command allows you to quickly locate any string of characters, such as a word or phrase. The string of text, when found, can be replaced by a different string using the Find and Replace dialog box.

The marketing department is revising a brochure about the organization and services provided by Contoso, Ltd. The company used to be commonly referred to as Contoso; however, now the company wants to use the full company name Contoso, Ltd. in all communications. The marketing manager now must find every instance of Contoso in the brochure and change it to Contoso, Ltd.

The marketing manager could scroll through the brochure to visually search for text and replace each instance of Contoso with Contoso, Ltd., but this task is time consuming and is not a foolproof way to guarantee that all corrections will be made. A better approach is to use Word's feature for replacing specific text.

You find and replace text within the current document.

- On the Edit menu, click Replace. The Find and Replace dialog box opens with the Replace tab selected.

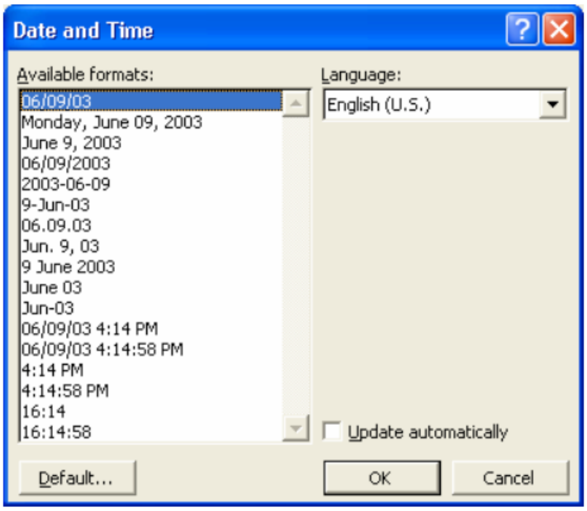
- Press Delete. The word meetings is removed from the Find what box.
- Press the Tab key, or click in the Replace with box.
- Click the Find Next button.
- Click the Find Next button.
- Click the Replace button.
- Continue clicking Replace or Find Next as appropriate.
- In the message box, click No. The message box closes
- In the Find and Replace dialog box, click Close. The Find and Replace dialog box closes.
- On the Standard toolbar, click the Save button. Word saves the document.

7.3.6 Inserting the Date and Time

You can also use Word to insert the current date and time into a document. The date and time is inserted within the footers of the document so that the employees know that they are reading the most current version of the policies. Date and time information is available in numerous formats and can be inserted as text or as a field. A field is a formula that generates specific results within your document. You add the field where you want the information to appear; the field inserts information when you open the document. For example, if the date or time is inserted as a field, it's updated automatically when a particular action is performed, such as opening, saving, or printing the document.

You insert the current date into the document as text and as a field.

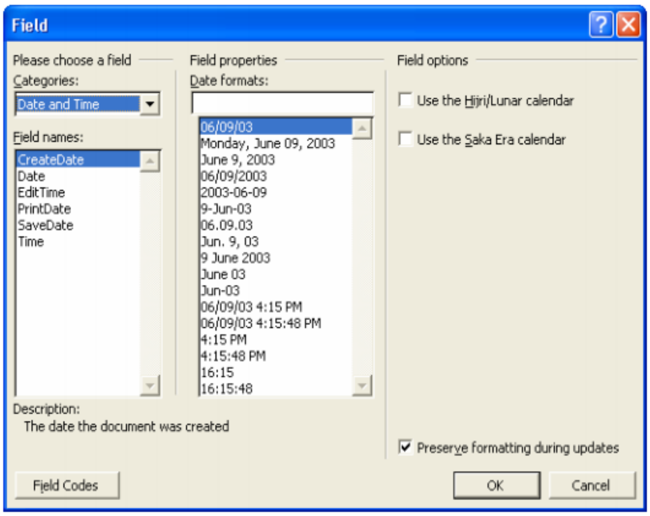
- Press Ctrl+Home to position the insertion point at the beginning of the document.
- On the View menu, click Header and Footer. The Header and Footer toolbar is displayed.
- On the Header and Footer toolbar, click the Switch between Header and Footer button.
- On the Insert menu, click Date and Time.
- Click the third available format (the month that is spelled out, date, and the year), and click OK. The current date is inserted, and the dialog box closes.



REMEMBER

You can also insert the date or the time from the Headers and Footers toolbar by clicking the Insert Date or Insert Time button.

- Press Tab twice to move to the right edge of the footer, type Last update on, and then press the spacebar.
- On the Insert menu, click Field. The Field dialog box appears.
- Click Date and Time in the Categories list. The Field names list displays the options that are available for the Date and Time category.



- In the Field names list, click SaveDate, and click OK.
- Click the Close button on the Header and Footer toolbar.
- On the Standard toolbar, click the Save button.

7.3.7 Inserting Special Characters

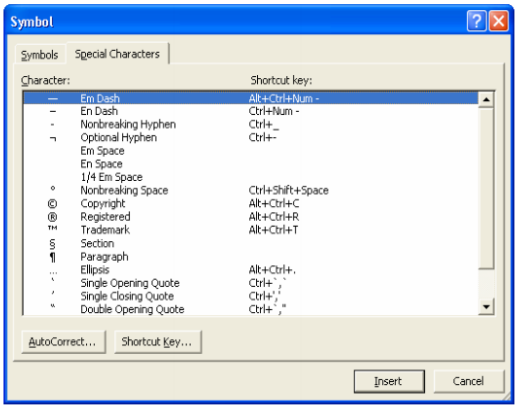
Special characters are symbols and punctuation marks that do not have a key on most keyboards, such as an em dash (—), an ellipsis (...), a copyright symbol (©), or a trademark (™) symbol. You can insert these special characters by using the Symbol command on the Insert menu. Many symbols also have shortcut keys listed next to them in the dialog box.

You insert the trademark symbol into the current document.

REMEMBER

You can also find many common symbols on the Symbols tab. Click to position the insertion point in the document where you want to insert the symbol, on the Symbol tab, click the symbol, and click Insert. Word inserts the symbol in the document. Click Close to close the Symbol dialog box.

- Press Ctrl+End to ensure that the insertion point is at the end of the document.
- Click to position the insertion point between the t and the period in ICorrect.
- On the Insert menu, click Symbol. The Symbol dialog box appears.
- Click the Special Characters tab. The contents of the Special Characters tab appear.



- Click Trademark, and click the Insert button. The trademark symbol is inserted in the document at the current position of the insertion point.
- Click the Close button. The dialog box closes.

7.3.8 Handling Graphics

There a three ways of inserting graphics into a Word document:

- As a link to a separate file.

- As an inline object (an object that exists within the text).
- As a floating object. Floating objects don't exist within the text, they exist in the drawing layer.

Linked graphics are the easiest to deal with. They appear as fields in the text, so you can simply replace them with appropriate tags (one way to do this is with replacement rules).

Inline graphics can be handled by looking for the markers that appear in the text and finding the corresponding graphic object. The markers appear as "&A001;" (since Word inserts a character with ASCII value "1"). The graphics objects in a paragraph can be retrieved with the getGraphics method in MS::WordParagraph.

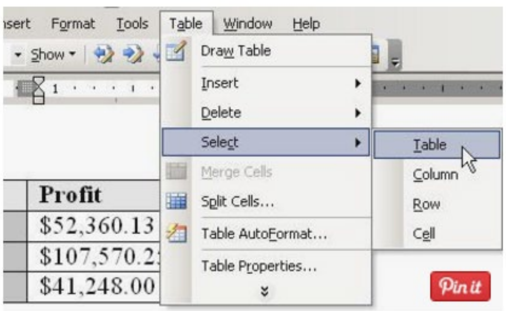
Once you have a reference to a graphic object, you need to write its contents as a file so you can refer to it in the XML. The most general way of doing this is to copy it to the clipboard, then use a suitable application to write it to a file. The XMetaL Open Word Document feature includes an application that can write BMP and WMF graphics to files, but any application that has a COM interface could also be used.

Floating objects are much more difficult. They cannot be selected and copied in the same way as inline graphics. In addition, it can be difficult to determine where to place the tag in the XML data, since the anchor point in the text may not be the most appropriate position. If you discover a reliable way of processing floating graphics.

7.3.9 Creating Charts from Table Data

Selecting the Table for the Chart

Word has a handy feature that allows you to create charts from table data in your existing document. It ensures that your charts are formatted nicely with a minimum of effort. You don't need to go to a graphics program to create charts for your professional documents. You can create a chart by using existing data that is contained within a table in your document.



To create a chart based on table data, select the table by clicking inside it. Then click Table>>Select>>Table.

Inserting the Chart

With the entire table selected, click Insert>>Picture>>Chart.

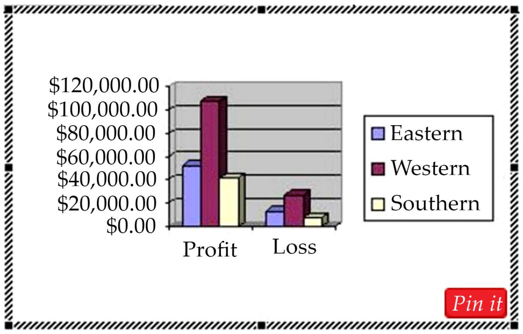
The Chart is Placed in Your Document

Word will launch Microsoft Graph, which automatically creates a chart based on your table.

Additionally, Word adds two new menus, Data and Chart, to the **menu bar**. These menus provide additional help with working with your chart.

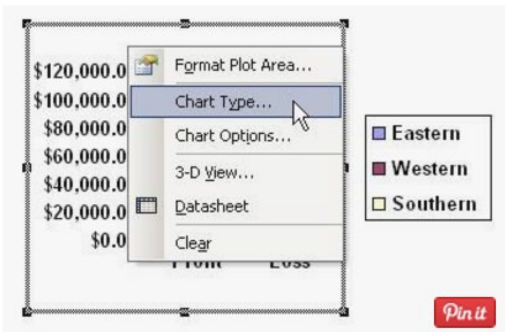
Keyword

Menu bar is a graphical control element which contains drop-down menus.



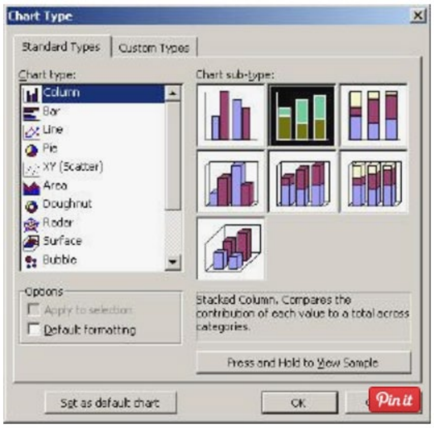
Changing the Chart Type

A column chart is the default chart type. But you aren't restricted to that. To change chart types, double-click your chart. Right-click inside the chart and select Chart Type.



Changing the Chart Style

The Chart Type dialog box provides you with a number of different chart styles. Select the type of chart you would like and click OK. Word returns to your document; the chart is updated automatically.



Viewing the Chart Datasheet

When you create a chart, Word opens a datasheet that allows you to modify the chart information. The first column of the datasheet contains the data series. These items are plotted on the graph. The first row of the datasheet contains the categories. The categories appear along the horizontal axis of the chart. Values are contained in the cells where the rows and columns intersect.

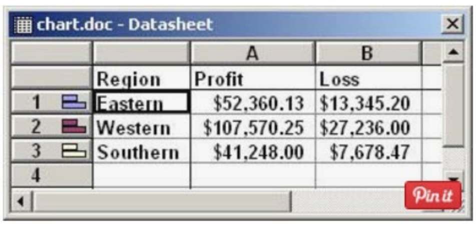


chart.doc - Datasheet

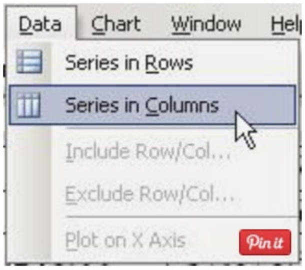
		A	B
	Region	Profit	Loss
1	Eastern	$52,360.13	$13,345.20
2	Western	$107,570.25	$27,236.00
3	Southern	$41,248.00	$7,678.47
4			

Keyword

Toolbar is a graphical control element on which on-screen buttons, icons, menus, or other input or output elements are placed.

Changing the Arrangement of Chart Data

But you can change the way Word arranges your chart data. Simply double-click the chart and choose Data from the menubar and select Series in Columns or Series in Rows.



CASE STUDY

ACS EPUB, XPUB AND PREDECESSORS

OpenOffice.org can run in "server mode" where it waits for connections from other programs that instruct it to carry out various operations. Programs can be written in any language that has a binding to the OpenOffice UNO (Universal Network Objects) API. Supported languages include C++, Java and Python (but there may be more by now). In 2003, following a suggestion from Tom Worthington, I used some sample Java code from the OpenOffice Software Developer's Kit to open Word documents that had been written using the Australian Computer Society's journal article template, and save them in the OpenOffice .sxw format. This was followed by applying one or more XSLT stylesheets to transform the documents into clean, simple XHTML. In 2004 Tom and I supervised Tim Wilson-Brown, a third-year ANU software engineering student, for a short research and development project. Tim extended my earlier work and created the xPub online document conversion tool. The main technology used in this project was PHP. xPub is available under the GPL. In 2005, Tim led a group of 3rd and 4th year students in their full-year team software engineering project, with Tom and the ACS as clients, developing the conversion and formatting component of a full electronic publishing system, taking Word documents that conform to a template, and producing both good PDF output for printing and good HTML output for the online version of the journal.

First

Each year the School of Creative Communication at the University of Canberra produces First, an anthology of student writing. I did the technical production for this publication for the three years 2003-5.

The process is:

- Use OpenOffice to convert around 30 Microsoft Word documents into the old OpenOffice .sxw format (the predecessor of Open Document Format).
- Use unzip to extract the content.xml file from each .sxw file.
- Use (a few stages of) XSLT to convert each document into a simple custom XML language and from there to LaTeX.
- Typeset LaTeX to PDF using the PDFTeX program.

This has been quite successful. We shouldn't rule out the possibility of using TeX/LaTeX/PDFTeX for rendering XML to PDF. It is a more mature technology than XSL-FO at the moment, particularly as far as free implementations go.

ANU ePress

Brendon McKinley, formerly of the ANU ePress, has been doing XML-based publishing for several years. The focus is on high-quality PDF output for creating books. Brendon experimented with using OpenOffice to convert Word documents into XML. He now uses UpCast, a commercial product. UpCast converts from RTF to XML and runs cross-platform. If you are running Windows and Word, UpCast has an extension (basically a Word plugin) that allows you to convert directly from Word to XML. Like OpenOffice, UpCast has an API that allows you to drive it from software. Brendon's experience is that that UpCast API is cleaner and easier to use, and that UpCast conversion gives better fidelity to the original document. Of course the disadvantage is that UpCast is commercial software, so it would probably not be feasible to deploy it to every desktop in the university. Site licences are available but are expensive and still seem restrictive.

Here is a typical workflow at the ePress, for publishing the proceedings of a conference:

- Receive around 15 unstyled Word documents.
- Editor does content-editing and adds some styles.
- Brendon adds more styles to indicate the document structure.
- Use UpCast to convert to DocBook XML.
- Use the Norm Walsh stylesheets, heavily customised, to produce XSL-FO (Extensible Stylesheet Language Formatting Objects, an XML language for expressing page layout).
- Use the XEP FO processor (another commercial product, by RenderX) to render the XSL-FO as PDF. (They tried using the open source FO processor FOP, but found that it sometimes breaks on the complex FO generated by DocBook and Norm Walsh. It also doesn't handle tables well.)
- Use the Norm Walsh stylesheets, unchanged, to convert the DocBook to HTML, and use CSS to customise the appearance.

In the future, the ePress plans to add depositing the DocBook XML versions of their publications in the ANU's digital repository to this workflow. For book publishing, the quality of the typeset output from this sort of workflow is marginal. Traditional publishing people aren't completely happy with it. The ePress uses B5 paper rather than A5 so as to give the FO processor more scope in finding good line breaks. They also print on thicker paper than most publishers, to compensate for not setting on a grid. Presumably, over time, FO processors will improve. Brendon believes that the complexity of DocBook is a significant obstacle to doing this sort of work. For most of their projects, however, the full complexity of DocBook is not needed. He suggests that it might be worthwhile to develop a simplified version of DocBook aimed at simple prose.

USQ ICE project

The University of Southern Queensland has many years of experience delivering distance education, first through printed course "bricks" and more recently also over the web. Peter Sefton is leading the development of their latest effort, called ICE, which builds on this experience.

Authors create documents in a word processor (either Word or Writer), using a generic template. They must use styles, and only the special styles in the template, not the standard built-in styles. The key to effective web publishing like this is to have a fast feedback loop. Instead of authors sending their work to a web publisher and getting the result back weeks later, they save their document and click "Refresh" in their browser to see the results. If they have done something wrong, they see it straight away. Some of the messier processing is done using Python. There's also a lot of XSLT. The system uses Subversion to give authors version control on all documents it manages. (This lets you roll back changes to any previous version at any time.) It also lets multiple authors collaborate on documents. At the moment the closest thing to an archival format produced is XHTML, but we're talking about maybe integrating with my work (see below) on converting ICE documents into DocBook.

National Archives Xena Project

Xena stands for XML Electronic Normalising of Archives. It is a preservation tool developed by the Australian National Archives. With most resources it simply recodes the contents in Base64 and wraps the result in XML, including some metadata. With Word documents, Xena uses OpenOffice.org to convert them to Open Document Format. They are making no attempt to take documents out of this word processing format (flat structure, visual formatting) and into a structured XML document format like DocBook or TEI. Xena is a Java GUI application, complete with menus and toolbars and so on. This infrastructure is expensive to set up, but relatively easily extended. One possibility might be to use the existing Xena software as the basis for an "electronic document archivist's workbench".

SUMMARY

- Word processing is the ability to create documents using a word processor. It can also refer to advanced shorthand techniques, sometimes used in specialised contexts with a specially modified typewriter.
- The typing area is bordered on the right side by the vertical scroll bar with a scroll button and arrows. The single down arrow scrolls through the document line by line.
- The Document Information Panel makes it easy to view and edit document properties while you work on your Word document. The Document Information Panel displays at the top of your document in Word.
- To identify the cause of a single grammatical error, you can right-click any word marked with a green wavy line to display a shortcut menu, and then make a selection from the shortcut menu as desired.
- A wildcard character stands for any character that appears in one or more positions within a word or string of text. To use wildcards, in the Find and Replace dialog box, click the more button, and select the Use Wildcards check box.
- A field is a formula that generates specific results within your document. You add the field where you want the information to appear; the field inserts information when you open the document.
- To check grammar in a document (after you've turned on grammar checking), on the Standard toolbar, click the Spelling and Grammar button to display the Spelling and Grammar dialog box.
- The date and time is inserted within the footers of the document so that the employees know that they are reading the most current version of the policies. Date and time information is available in numerous formats and can be inserted as text or as a field.

KNOWLEDGE CHECK

1. **The ability to combine name and addresses with a standard document is called ________**
   a. document formatting
   b. database management
   c. mail merge
   d. form letters
2. **Which enables us to send the same letter to different persons?**
   a. macros
   b. template
   c. mail merge
   d. none
3. **A word processor would most likely be used to do**
   a. keep an account of money spent
   b. do a computer search in media center
   c. maintain an inventory
   d. type a biography
4. **Which can be used for quick access to commonly used commands and tools?**
   a. Status bar
   b. Tool bar
   c. Menu bar
   d. Title bar
5. **Which of the following is not essential component to perform a mail merge operation?**
   a. Main document
   b. Data source
   c. Merge fields
   d. Word fields
6. **AutoCorrect was originally designed to replace ________ words as you type.**
   a. short, repetitive
   b. grammatically incorrect
   c. misspelled
   d. none of the above

7. "Ctrl + Right Arrow" is used to

a. Moves the cursor one word right

b. Moves the cursor end of the line

c. Moves the cursor end of the document

d. Moves the cursor one Paragraph down

8. Which file starts MS Word?

a. winword.exe

b. word.exe

c. msword.exe

d. word2003.exe

9. Ctrl + N

a. Save Document

b. Open Document

c. New Document

d. Close Document

10. What are inserted as cross-reference in Word?

a. Placeholders

b. Bookmarks

c. Objects

d. Word fields

11. Word processing is the process of adding text to a word processing unit such as a computer or typewriter.

a. True

b. False

12. Word will search through the list of files in the selected folder or device for your particular file.

a. True

b. False

REVIEW QUESTIONS

1. What are the steps to print a document on a different paper size in Print dialog box?
2. What are the shortcuts key using keyboard for opening a new document?
3. Write any two uses of rulers in Word Program.

4. How do you modify a password given to protect a document?
5. What are the steps in printing a document's multiple pages in a single sheet of paper?
6. How do you specify a date format when you insert the current date into a document?
7. How can you use the Find and Replace dialog box to display a specific page in the current document?
8. Describe the steps to open the spelling and grammar window in MS-Word.

Check Your Result

1. (c)	2. (c)	3. (d)	4. (b)	5. (d)
6. (c)	7. (a)	8. (a)	9. (c)	10. (d)
11. (a)	12. (a)			

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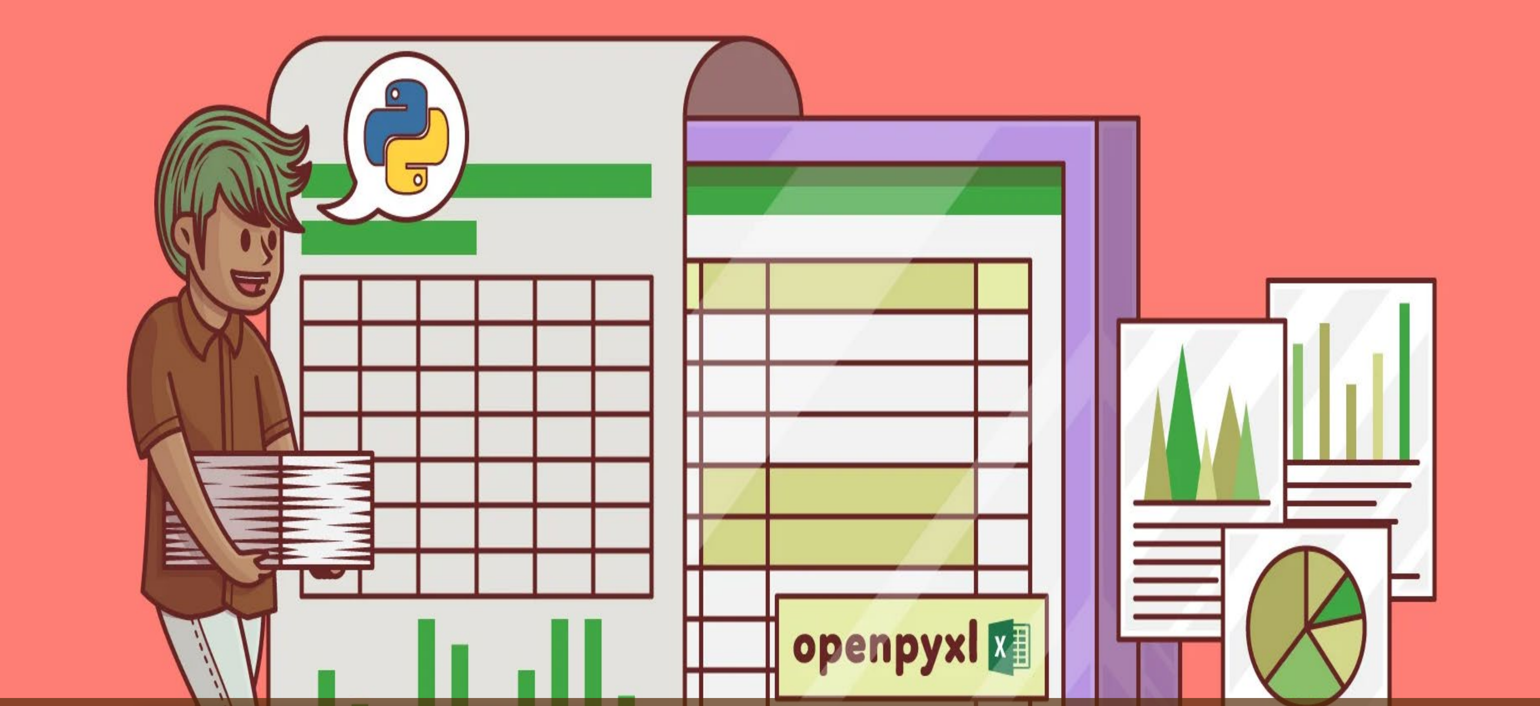


CHAPTER 8

SPREADSHEET PACKAGE

LEARNING OBJECTIVES

After studying this chapter, you will be able to:

1. Give the overview of spreadsheet package
2. What is Worksheet?
3. Learn about function wizard
4. Explain the information technology and society

> *"Spreadsheets are corporate poetry; when constructed elegantly enough, they can be used to communicate sophisticated ideas to audiences who wouldn't otherwise be receptive to details."*
>
> *– Eric Seufert*

INTRODUCTION

Spreadsheet, computer program that represents information in a two-dimensional grid of data, along with formulas that relate the data. Historically, a spreadsheet is an accounting ledger page that shows various quantitative information useful for managing a business. Electronic spreadsheets all but replaced pen-and-ink versions by the end of the 20th century. Spreadsheets are not limited to financial data, however, and are frequently used to represent scientific data and to carry out computations.

The first spreadsheet program was VisiCalc, written for the Apple II computer in 1979. In the view of many users, it was the application that most vividly showed the utility of personal computers for small businesses—in some cases turning a 20-hour-per-week bookkeeping chore into a few minutes of data entry. *For example*, a simple spreadsheet might hold payroll information with columns for employees' names and addresses, social security numbers, hourly pay, hours worked, tax deductions, and net pay. Cells in the last column could have a formula attached to them to compute pay as a function of cells in the three preceding columns for each employee. The spreadsheet would show the net pay and, upon request, its formula. If tax-withholding rates were changed, all the net pay cells would be recomputed.

Spreadsheets are also invaluable in "what if" computations. Once a set of formulas have generated data in spreadsheet cells as functions of other cells, one can experiment by changing one parameter, such as the price of a part, to observe its effect on the cost of a product. With appropriate forecasting formulas, the market for the product, and hence the total profit to expect at the old and new price, can then be projected. Used this way, spreadsheets serve the needs of managers, economists, and anyone who works with relationships between types of quantitative information.

Since spreadsheets can be programmed, they can also be used for general computations. They are used for modeling in science and engineering, and they are well suited to educational uses—for example, to display the synthesis of sound from simple audio waveforms. Furthermore, since they are two-dimensional grids of cells, they can readily be programmed as cellular automata, systems of cells whose state depends on the states of their neighbors. "Game of Life" is a simple example, and other cellular automata can model complex physical or biological processes. Today spreadsheets for personal computers generally include the ability to convert data into various types of graphs (such as pie charts and bar graphs) and are often integrated with other software, such as word processors and database programs.

8.1 OVERVIEW OF SPREADSHEET PACKAGE

A spreadsheet is a computer application for organization, analysis, and storage of data in tabular form. Spreadsheets were developed as computerized analogs of paper accounting worksheets. The program operates on data entered in cells of a table. Each cell may contain either numeric or text data, or the results of formulas that automatically calculate and display a value based on the contents of other cells. A spreadsheet may also refer to one such electronic document.

Spreadsheet users can adjust any stored value and observe the effects on calculated values. This makes the spreadsheet useful for "what-if" analysis since many cases can be rapidly investigated without manual recalculation. Modern spreadsheet software can have multiple interacting sheets and can display data either as text and numerals or in graphical form. Besides performing basic arithmetic and mathematical functions, modern spreadsheets provide built in functions for common financial accountancy and statistical operations. Such calculations as net present value or standard deviation can be applied to tabular data with a pre-programmed function in a formula. Spreadsheet programs also provide conditional expressions, functions to convert between text and numbers, and functions that operate on strings of text.

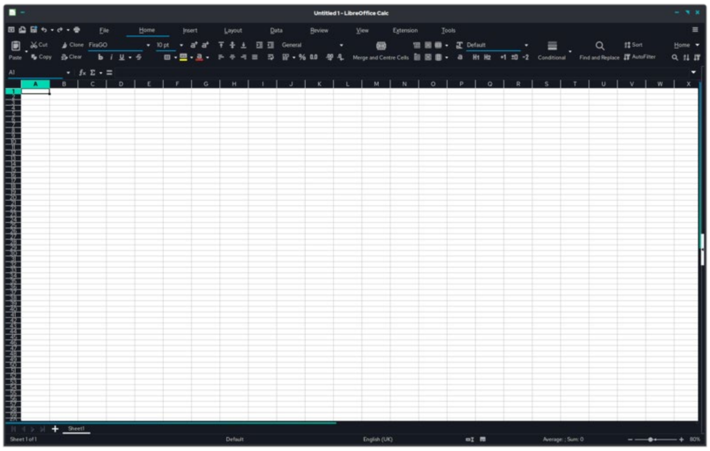
Spreadsheets have replaced paper-based systems throughout the business world. Although they were first developed for accounting or bookkeeping tasks, they now are used extensively in any context where tabular lists are built, sorted, and shared.

LANPAR, available in 1969, was the first electronic spreadsheet on mainframe and time sharing computers. LANPAR was an acronym: LAN guage for Programming Arrays at Random. VisiCalc (1979) was the first electronic spreadsheet on a microcomputer, and it helped turn the Apple II computer into a popular and widely used system. Lotus 1-2-3 was the leading spreadsheet when DOS was the dominant operating system. Microsoft Excel now has the largest market share on the Windows and Macintosh platforms. A spreadsheet program is a standard feature of an office productivity suite; since the advent of web apps, office suites now also exist in web app form.

8.1.1 Usage

A spreadsheet consists of a table of *cells* arranged into rows and columns and referred to by the X and Y locations. X locations, the columns, are normally represented by letters, "A," "B," "C," etc., while rows are normally represented by numbers, 1, 2, 3, etc. A single cell can be referred to by addressing its row and column, "C10". This electronic concept of cell references was first introduced in LANPAR (Language for Programming Arrays at Random) (co-invented by Rene Pardo and Remy Landau) and a variant used in VisiCalc and known as "A1 notation". Additionally, spreadsheets have the concept of a *range*, a group of cells, normally contiguous. For instance, one can refer to the first ten cells in the first column with the range "A1:A10". LANPAR innovated forward referencing/natural order calculation which didn't re-appear until Lotus 123 and Microsoft's MultiPlan Version 2.

In modern spreadsheet applications, several spreadsheets, often known as *worksheets* or simply *sheets*, are gathered together to form a *workbook*. A workbook is physically represented by a file containing all the data for the book, the sheets, and the cells with the sheets. Worksheets are normally represented by tabs that flip between pages, each one containing one of the sheets, although Numbers changes this model significantly. Cells in a multi-sheet book add the sheet name to their reference, for instance, "Sheet 1!C10". Some systems extend this syntax to allow cell references to different workbooks.



Users interact with sheets primarily through the cells. A given cell can hold data by simply entering it in, or a formula, which is normally created by preceding the text with an equals sign. Data might include the string of text hello world, the number 5 or the date 16-Dec-91. A formula would begin with the equals sign, =5*3, but this would normally be invisible because the display shows the *result* of the calculation, 15 in this case, not the formula itself. This may lead to confusion in some cases.

The key feature of spreadsheets is the ability for a formula to refer to the contents of other cells, which may, in turn, be the result of a formula. To make such a formula, one replaces a number with a cell reference. For instance, the formula =5*C10 would produce the result of multiplying the value in cell C10 by the number 5. If C10 holds the value 3 the result will be 15. But C10 might also hold its formula referring to other cells, and so on.

The ability to chain formulas together is what gives a spreadsheet its power. Many problems can be broken down into a series of individual mathematical steps, and these can be assigned to individual formulas in cells. Some of these formulas can apply to ranges as well, like the SUM function that adds up all the numbers within a range.

Spreadsheets share many principles and traits of databases, but spreadsheets and databases are not the same things. A spreadsheet is essentially just one table, whereas a database is a collection of many tables with machine-readable semantic relationships. While it is true that a workbook that contains three sheets is indeed a file containing multiple tables that can interact with each other, it lacks the relational structure of a database. Spreadsheets and databases are interoperable—sheets can be imported into databases to become tables within them, and database queries can be exported into spreadsheets for further analysis.

A spreadsheet program is one of the main components of an office productivity suite, which usually also contains a word processor, a presentation program, and a database management system. Programs within a suite use similar commands for similar functions. Usually, sharing data between the components is easier than with a non-integrated collection of functionally equivalent programs. This was particularly an advantage at a time when many personal computer systems used text-mode displays and commands instead of a graphical user interface.

REMEMBER

To create a new sheet tab in a worksheet (workbook), see: Create, delete, rename, copy, and move a worksheet in Excel.

8.1.2 History of Spreadsheets

A spreadsheet is a file that exists of cells in rows and columns and can help arrange, calculate and sort data. Data in a spreadsheet can be numeric values, as well as text, formulas, references and functions.

Paper spreadsheets

The word "spreadsheet" came from "spread" in its sense of a newspaper or magazine item (text or graphics) that covers two facing pages, extending across the centerfold and treating the two pages as one large page. The compound word 'spread-sheet' came to mean the format used to present book-keeping ledgers—with columns for categories of expenditures across the top, invoices listed down the left margin, and the amount of each payment in the cell where its row and column intersect—which were, traditionally, a "spread" across facing pages of a bound ledger (book for keeping accounting records) or on oversized sheets of paper (termed 'analysis paper') ruled into rows and columns in that format and approximately twice as wide as ordinary paper.

Early implementations: Batch spreadsheet report generator BSRG

A batch "spreadsheet" is indistinguishable from a batch compiler with added input data, producing an output report, *i.e.*, a 4GL or conventional, non-interactive, batch computer program. However, this concept of an electronic spreadsheet was outlined in the 1961 paper "Budgeting Models and System Simulation" by Richard Mattessich. The subsequent work by Mattessich and its companion volume, Mattessich applied computerized spreadsheets to accounting and budgeting systems (on mainframe computers programmed in FORTRAN IV). These batch Spreadsheets dealt primarily with the addition or subtraction of entire columns or rows (of input variables), rather than individual *cells*.

In 1962, this concept of the spreadsheet, called BCL for Business Computer Language, was implemented on an IBM 1130 and in 1963 was ported to an IBM 7040 by R. Brian Walsh at Marquette University, Wisconsin. This program was written in Fortran. Primitive timesharing was available on those machines. In 1968 BCL was ported by Walsh to the IBM 360/67 timesharing machine at Washington State University. It was used to assist in the teaching of finance to business students. Students were able to take information prepared by the professor and manipulate it to represent it and show ratios etc. In 1964, a book entitled *Business Computer Language* was written by Kimball, Stoffells and Walsh and both the book and program were copyrighted in 1966 and years later that copyright was renewed.

Applied Data Resources had a FORTRAN preprocessor called Empires. In the late 1960s, Xerox used BCL to develop a more sophisticated version for their timesharing system.

LANPAR Spreadsheet Compiler

A key invention in the development of electronic spreadsheets was made by Rene K. Pardo and Remy Landau, who filed in 1970 U.S. Patent 4,398,249 on a spreadsheet automatic natural order calculation algorithm. While the patent was initially rejected by the patent office as being a purely mathematical invention, following 12 years of appeals, Pardo and Landau won a landmark court case at the Predecessor Court of the Federal Circuit (CCPA), overturning the Patent Office in 1983 — establishing that "something does not cease to become patentable merely because the point of novelty is in an algorithm." However, in 1995 the United States Court of Appeals for the Federal Circuit ruled the patent unenforceable.

The actual software was called LANPAR — LANguage for Programming Arrays at Random. This was conceived and entirely developed in the summer of 1969, following Pardo and Landau's recent graduation from Harvard University. Co-inventor Rene Pardo recalls that he felt that one manager at Bell Canada should not have to depend on programmers to program and modify budgeting forms, and he thought of letting users type out forms in any order and having an electronic computer calculate results in the right order ("Forward Referencing/Natural Order Calculation"). Pardo and Landau developed and implemented the software in 1969.

LANPAR was used by Bell Canada, AT&T, and the 18 operating telephone companies nationwide for their local and national budgeting operations. LANPAR was also used by General Motors. Its uniqueness was Pardo's co-invention incorporating forward referencing/natural order calculation (one of the first "non-procedural" computer languages) as opposed to left-to-right, top to bottom sequence for calculating the results in each cell that was used by VisiCalc, SuperCalc, and the first version of MultiPlan. Without forward referencing/natural order calculation, the user had to refresh the spreadsheet until the values in all cells remained unchanged. Once the cell values stayed constant, the user was assured that there were no remaining forward references within the spreadsheet.

Autoplan/Autotab spreadsheet programming language

In 1968, three former employees from the General Electric computer company headquartered in Phoenix, Arizona set out to start their own software development house. A. Leroy Ellison, Harry N. Cantrell, and Russell E. Edwards found themselves doing a large number of calculations when making tables for the business plans that they were presenting to venture capitalists. They decided to save themselves a lot of effort and wrote a computer program that produced their tables for them. This program, originally conceived as a simple utility for their personal use, would turn out to be the first software product offered by the company that would become known as Capex Corporation. "AutoPlan" ran on GE's Time-sharing service; afterward, a version that ran on IBM mainframes was introduced under the name *AutoTab*. (National CSS offered a similar product, CSSTAB, which had a moderate timesharing user base by the early 1970s. A major application was opinion research tabulation.)

AutoPlan/AutoTab was not a WYSIWYG interactive spreadsheet program, it was a simple scripting language for spreadsheets. The user-defined the names and labels for the rows and columns, then the formulas that defined each row or column. In 1975, Autotab-II was advertised as extending the original to a maximum of "*1,500 rows and columns, combined in any proportion the user requires...*"

GE Information Services, which operated the time-sharing service, also launched its own spreadsheet system, Financial Analysis Language (FAL), circa 1974. It was later supplemented by an additional spreadsheet language, TABOL, which was developed by an independent author, Oliver Vellacott in the UK. Both FAL and TABOL were integrated with GEIS's database system, DMS.

IBM Financial Planning and Control System

The IBM Financial Planning and Control System was developed in 1976, by Brian Ingham at IBM Canada. It was implemented by IBM in at least 30 countries. It ran on an IBM mainframe and was among the first applications for financial planning developed with APL that completely hid the programming language from the end-user. Through IBM's VM operating system, it was among the first programs to auto-update each copy of the application as new versions were released. Users could specify simple mathematical relationships between rows and between columns. Compared to any contemporary alternatives, it could support very large spreadsheets. It loaded actual financial planning data drawn from the legacy batch system into each user's spreadsheet monthly. It was designed to optimize the power of APL through object kernels, increasing program efficiency by as much as 50 fold over traditional programming approaches.

APLDOT modeling language

An example of an early "industrial weight" spreadsheet was APLDOT, developed in 1976 at the United States Railway Association on an IBM 360/91, running at The Johns Hopkins University Applied Physics Laboratory in Laurel, MD. The application was used successfully for many years in developing such applications as financial and costing models for the US Congress and for Conrail. APLDOT was dubbed a "spreadsheet" because financial analysts and strategic planners used it to solve the same problems they addressed with paper spreadsheet pads.

VisiCalc

VisiCalc running on an Apple II

Because Dan Bricklin and Bob Frankston implemented VisiCalc on the Apple II in 1979 and the IBM PC in 1981, the spreadsheet concept became widely known in the early 1980s. VisiCalc was the first spreadsheet that combined all essential features of modern spreadsheet applications (except for forward referencing/natural order recalculation), such as WYSIWYG interactive user interface, automatic recalculation, status and formula lines, range copying with relative and absolute references, formula building by selecting referenced cells. Unaware of LANPAR at the time *PC World* magazine called VisiCalc the first electronic spreadsheet.

Bricklin has spoken of watching his university professor create a table of calculation results on a blackboard. When the professor found an error, he had to tediously erase and rewrite several sequential entries in the table, triggering Bricklin to think that he could replicate the process on a computer, using the blackboard as the model to view results of underlying formulas. His idea became VisiCalc, the first application that turned the personal computer from a hobby for computer enthusiasts into a business tool.

VisiCalc went on to become the first "killer application", an application that was so compelling, people would buy a particular computer just to use it. VisiCalc was in no small part responsible for the Apple II's success. The program was later ported to a number of other early computers, notably CP/M machines, the Atari 8-bit family and various Commodore platforms. Nevertheless, VisiCalc remains best known as an Apple II program.

SuperCalc

SuperCalc was a spreadsheet application published by Sorcim in 1980, and originally bundled (along with WordStar) as part of the CP/M software package included with the Osborne 1 portable computer. It quickly became the de facto standard spreadsheet for CP/M and was ported to MS-DOS in 1982.

Keyword

Graphics are visual images or designs on some surface, such as a wall, canvas, screen, paper, or stone to inform, illustrate, or entertain.

Lotus 1-2-3 and other MS-DOS spreadsheets

The acceptance of the IBM PC following its introduction in August 1981, began slowly because most of the programs available for it were translations from other computer models. Things changed dramatically with the introduction of Lotus 1-2-3 in November 1982, and release for sale in January 1983. Since it was written especially for the IBM PC, it had a good performance and became the killer app for this PC. Lotus 1-2-3 drove sales of the PC due to the improvements in speed and **graphics** compared to VisiCalc on the Apple II.

Lotus 1-2-3, along with its competitor Borland Quattro, soon displaced VisiCalc. Lotus 1-2-3 was released on January 26, 1983, started outselling then-most-popular VisiCalc the very same year, and for several years was the leading spreadsheet for DOS.

Microsoft Excel

Microsoft released the first version of Excel for the Macintosh on September 30, 1985, and then ported it to Windows, with the first version being numbered 2.05 (to synchronize with the Macintosh version 2.2) and released in November 1987. The Windows 3.x platforms of the early 1990s made it possible for Excel to take market share from Lotus. By the time Lotus responded with usable Windows products, Microsoft had begun to assemble their Office suite. By 1995, Excel was the market leader, edging out Lotus 1-2-3, and in 2013, IBM discontinued Lotus 1-2-3 altogether.

Web-based spreadsheets

Notable current web-based spreadsheet software:

- Collabora Online Calc is a free, open-source and cross-platform enterprise-ready edition of LibreOffice.
- Google Sheets
- Microsoft Excel Online

Mainframe spreadsheets

- The Works Records System at ICI developed in 1974 on IBM 370/145

Other Spreadsheets

Notable current spreadsheet software:

- Apache OpenOffice Calc is a free and open-source.
- Calligra Sheets (formerly KCalc)
- Collabora Online Calc for mobile and desktop apps are free, open-source, cross-platform enterprise-ready editions of LibreOffice.
- Corel Quattro Pro (WordPerfect Office)
- Gnumeric is free and cross-platform, it is part of the GNOME Free Software Desktop Project.
- Kingsoft Spreadsheets
- LibreOffice Calc is free, open-source and cross platform.
- NeoOffice
- Numbers is Apple Inc.'s spreadsheet software, part of iWork.
- PlanMaker (SoftMaker Office)
- Pyspread

Discontinued spreadsheet software:

- 20/20
- 3D-Calc for Atari ST computers
- Framework by Forefront Corporation/Ashton-Tate (1983/84)
- GNU Oleo – A traditional terminal mode spreadsheet for UNIX/UNIX-like systems
- IBM Lotus Symphony (2007)
- Javelin Software
- KCells
- Lucid 3-D
- Lotus Improv
- Lotus Jazz for Macintosh
- Lotus Symphony (1984)
- MultiPlan
- Claris' Resolve (Macintosh)
- Resolver One
- Borland's Quattro Pro
- SIAG
- SuperCalc
- T/Maker
- Target Planner Calc for CP/M and TRS-DOS
- Trapeze for Macintosh
- Wingz for Macintosh

Other products

Several companies have attempted to break into the spreadsheet market with programs based on very different paradigms. Lotus introduced what is likely the most successful example, Lotus Improv, which saw some commercial success, notably in the financial world where its powerful data mining capabilities remain well respected to this day. Spreadsheet 2000 attempted to dramatically simplify formula construction, but was generally not successful.

8.1.3 Types of Spreadsheet Packages

Spreadsheets are used for organizing and analyzing numeric data. While many spreadsheet packages are designed to work on specific operating systems, some can be used cross-platform. Excel from Microsoft is the gold standard which other spreadsheet packages are designed to emulate. Before Excel reached the pinnacle of popularity, Lotus 1-2-3 was the spreadsheet program most widely used.

Microsoft Excel

Excel from Microsoft has set the standard for all other spreadsheet packages. Excel was the first to divide spreadsheets into workbooks. In 1984, Excel was written for the Apple Macintosh computer. It was one of the first spreadsheets to use a graphical interface. In 1987, when Windows was first released, Excel was the first application designed to run on the new operating system. By late in the 1980s, other companies had released their own versions of spreadsheet programs, many of them attempting to emulate Excel in appearance and functionality.

Lotus 1-2-3 Release 9.8

In February 2008, Lotus 1-2-3 Release 9.8 became available and is now known as Lotus SmartSuite. This version has a new tool using speech-enabled SmartMaster templates, which allow users to perform common tasks using speech. The Functions have been improved to be more compatible with Microsoft Excel, and users can skip typing formulas, since this new version recognizes terms such as “total” and “average” along with dozens of other terms to return a result.

Quattro Pro from Corel

Corel’s offering into the spreadsheet arena as part of the Word Perfect Office Suite is Quattro Pro. Quattro Pro contains notebooks that are divided into worksheets. As with other spreadsheet packages, additional worksheets can be added to the notebooks, and a notebook can contain only one spreadsheet or multiple spreadsheets which are compatible with Excel.

GS-Calc

This spreadsheet package is not as powerful as some of the others but does contain some interesting features. GS-Calc is downloadable to most portable devices and contains more than 2 million rows and over 2,000 columns. The program contains around 300 built-in formulas. This package features password protection and encryption and in the read-only mode formulas can be hidden. Text created in dBase III and IV and Excel ‘02 files can be imported. GS-Calc features an amazing 20,000 undo and redo levels.

Bye Design Ltd.

A Microsoft partner, Bye Design Ltd., developed a freeware spreadsheet program primarily for personal data assistants which can also be used on desktop computing devices. The spreadsheet package supports hundreds of spreadsheet functions including file editing, formatting, macro creation and form tools including check boxes, drop-down lists and combo boxes. Spreadsheets created using Excel 95/97 and Pocket Excel files can easily be imported into this program.

8.1.4 How to Sort Alphabetically in OpenOffice

OpenOffice.org is a free, open-source software suite that includes applications for creating reports, spreadsheets, slideshow presentations, databases and illustrations. OpenOffice Calc can create or modify spreadsheets. The application shares some of the same features and functions as Microsoft Excel. Users can organize spreadsheets and sort lists in ascending or descending order based on certain criteria. To sort a column alphabetically in OpenOffice Calc, highlight the column and use the sort function.

Step 1

Launch “OpenOffice Calc” from the “Start” menu. Click “File.” Click “Open.” Navigate to the folder where the spreadsheet you want to modify is saved.

Step 2

Select the file and click “Open.” Select the column or columns to sort.

Step 3

Select the “Sort Ascending” or “Sort Descending” button from the toolbar. OpenOffice Calc will organize the column or columns in alphabetical or reverse-alphabetical order.

8.1.5 Concepts of Spreadsheets

The main concepts are those of a grid of cells, called a sheet, with either raw data, called values, or formulas in the cells. Formulas say how to mechanically compute new values from existing values. Values are general numbers, but can also be pure text, dates, months, etc. Extensions of these concepts include logical spreadsheets. Various tools for programming sheets, visualizing data, remotely connecting sheets, displaying cells' dependencies, etc. are commonly provided.

Cells

A "cell" can be thought of as a box for holding data. A single cell is usually referenced by its column and row (C2 would represent the cell containing the value 30 in the example table below). Usually rows, representing the dependent variables, are referenced in decimal notation starting from 1, while columns representing the independent variables use 26-adic bijective numeration using the letters A-Z as numerals. Its physical size can usually be tailored to its content by dragging its height or width at box intersections (or for entire columns or rows by dragging the column- or row-headers).

My Spreadsheet				
	A	**B**	**C**	**D**
01	Sales	100000	30000	70000
02	Purchases	25490	30	200

An array of cells is called a *sheet* or *worksheet*. It is analogous to an array of variables in a conventional computer program (although certain unchanging values, once entered, could be considered, by the same analogy, constants). In most implementations, many worksheets may be located within a single spreadsheet. A worksheet is simply a subset of the spreadsheet divided for the sake of clarity. Functionally, the spreadsheet operates as a whole and all cells operate as global variables within the spreadsheet (each variable having 'read' access only except its containing cell). A cell may contain a value or a formula, or it may simply be left empty. By convention, formulas usually begin with = sign.

Values

A value can be entered from the computer keyboard by directly typing into the cell itself. Alternatively, a value can be based on a formula, which might perform a calculation, display the current date or time, or retrieve external data such as a stock quote or a database value.

The Spreadsheet Value Rule

Computer scientist Alan Kay used the term *value rule* to summarize a spreadsheet's operation: a cell's value relies solely on the formula the user has typed into the cell. The formula may rely on the value of other cells, but those cells are likewise restricted to user-entered data or formulas. There are no 'side effects' to calculating a formula:

the only output is to display the calculated result inside its occupying cell. There is no natural mechanism for permanently modifying the contents of a cell unless the user manually modifies the cell's contents. In the context of programming languages, this yields a limited form of first-order functional programming.

Automatic recalculation

A standard of spreadsheets since the 1980s, this optional feature eliminates the need to manually request the spreadsheet program to recalculate values (nowadays typically the default option unless specifically 'switched off' for large spreadsheets, usually to improve performance). Some earlier spreadsheets required a manual request to recalculate since the recalculation of large or complex spreadsheets often reduced data entry speed. Many modern spreadsheets still retain this option.

Recalculation generally requires that there are no circular dependencies in a spreadsheet. A dependency graph is a graph that has a vertex for each object to be updated, and an edge connecting two objects whenever one of them needs to be updated earlier than the other. Dependency graphs without circular dependencies form directed acyclic graphs, representations of partial orderings (in this case, across a spreadsheet) that can be relied upon to give a definite result.

Real-time update

This feature refers to updating a cell's contents periodically with a value from an external source—such as a cell in a "remote" spreadsheet. For shared, Web-based spreadsheets, it applies to "immediately" updating cells another user has updated. All dependent cells must be updated also.

Locked cell

Once entered, selected cells (or the entire spreadsheet) can optionally be "locked" to prevent accidental overwriting. Typically this would apply to cells containing formulas but might apply to cells containing "constants" such as a kilogram/pounds conversion factor (2.20462262 to eight decimal places). Even though individual cells are marked as locked, the spreadsheet data are not protected until the feature is activated in the file preferences.

Data format

A cell or range can optionally be defined to specify how the value is displayed. The default display format is usually set by its initial content if not specifically previously set, so that for example "31/12/2007" or "31 Dec 2007" would default to the cell format of *date*. Similarly adding a % sign after a numeric value would tag the cell as a percentage cell format. The cell contents are not changed by this format, only the displayed value.

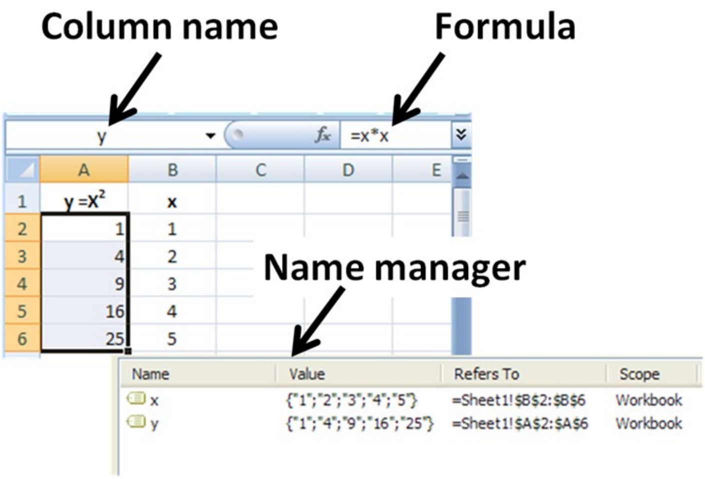
Some cell formats such as "numeric" or "currency" can also specify the number of decimal places. This can allow invalid operations (such as doing multiplication on a cell containing a date), resulting in illogical results without an appropriate warning.

Cell formatting

Depending on the capability of the spreadsheet application, each cell (like its counterpart the "style" in a word processor) can be separately formatted using the attributes of either the content (point size, color, bold or italic) or the cell (border thickness, background shading, color). To aid the readability of a spreadsheet, cell formatting may be conditionally applied to data; for example, a negative number may be displayed in red.

A cell's formatting does not typically affect its content and depending on how cells are referenced or copied to other worksheets or applications, the formatting may not be carried with the content.

Named cells



Use of named column variables *x* & *y* in Microsoft Excel. Formula for $y=x^2$ resembles Fortran, and *Name Manager* shows the definitions of *x* & *y*.

In most implementations, a cell, or group of cells in a column or row, can be "named" enabling the user to refer to those cells by a name rather than by a grid reference. Names must be unique within the spreadsheet, but when using multiple sheets in a spreadsheet file, an identically named cell range on each sheet can be used if it is distinguished by adding the sheet name. One reason for this usage is for creating or running macros that repeat a command across many sheets. Another reason is that formulas with named variables are readily checked against the algebra they are intended to implement (they resemble Fortran expressions).

REMEMBER

The use of named variables and named functions also makes the spreadsheet structure more transparent.

Cell reference

In place of a named cell, an alternative approach is to use a cell (or grid) reference. Most cell references indicate another cell in the same spreadsheet, but a cell reference can also refer to a cell in a different sheet within the same spreadsheet, or (depending on the implementation) to a cell in another spreadsheet entirely, or a value from a remote application.

A typical **cell reference** in "A1" style consists of one or two case-insensitive letters to identify the column (if there are up to 256 columns: A–Z and AA–IV) followed by a row number (e.g., in the range 1–65536). Either part can be relative (it changes when the formula it is in is moved or copied), or absolute (indicated with $ in front of the part concerned of the cell reference). The alternative "R1C1" reference style consists of the letter R, the row number, the letter C, and the column number; relative row or column numbers are indicated by enclosing the number in square brackets. Most current spreadsheets use the A1 style, some providing the R1C1 style as a compatibility option.

When the computer calculates a formula in one cell to update the displayed value of that cell, cell reference(s) in that cell, naming some other cell(s), causes the computer to fetch the value of the named cell(s).

A cell on the same "sheet" is usually addressed as:

=A1

A cell on a different sheet of the same spreadsheet is usually addressed as:

=SHEET2!A1 (that is; the first cell in sheet 2 of the same spreadsheet).

Some spreadsheet implementations in Excel allow cell references to another spreadsheet (not the currently open and active file) on the same computer or a local network. It may also refer to a cell in another open and active spreadsheet on the same computer or network that is defined as shareable. These references contain the complete filename, such as:

='C:\Documents and Settings\Username\My spreadsheets\[main sheet]Sheet1!A1

In a spreadsheet, references to cells automatically update when new rows or columns are inserted or deleted. Care must be taken, however, when adding a row immediately before a set of column totals to ensure that the totals reflect the values of the additional rows—which they often do not.

A circular reference occurs when the formula in one cell refers—directly, or indirectly through a chain of cell references—to another cell that refers back to the first cell. Many common errors cause circular references. However, some valid techniques use circular references. These techniques, after many spreadsheet recalculations, (usually) converge on the correct values for those cells.

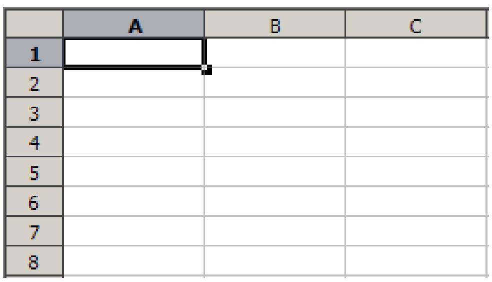
Cell ranges

Likewise, instead of using a named range of cells, a range reference can be used. Reference to a range of cells is typical of the form (A1:A6), which specifies all the cells in the range A1 through to A6. A formula such as "=SUM(A1:A6)" would add all the cells specified and put the result in the cell containing the formula itself.

Sheets

In the earliest spreadsheets, cells were a simple two-dimensional grid. Over time, the model has expanded to include a third dimension, and in some cases a series of named grids, called sheets. The most advanced examples allow inversion and rotation operations which can slice and project the data set in various ways.

Formulas



Animation of a simple spreadsheet that multiplies values in the left column by 2, then sums the calculated values from the right column to the bottom-most cell. In this example, only the values in the A column are entered (10, 20, 30), and the remainder of cells are formulas. Formulas in the B column multiply values from the A column using relative references, and the formula in B4 uses the SUM() function to find the sum of values in the B1:B3 range.

Keyword

Animation is a method in which figures are manipulated to appear as moving images.

A formula identifies the calculation needed to place the result in the cell it is contained within. A cell containing a formula, therefore, has two display components; the formula itself and the resulting value. The formula is normally only shown when the cell is selected by "clicking" the mouse over a particular cell; otherwise, it contains the result of the calculation.

A formula assigns values to a cell or range of cells, and typically has the format:

=expression

where the expression consists of:

- values, such as 2, 9.14 or 6.67E-11;
- references to other cells, such as, e.g., A1 for a single cell or B1:B3 for a range;
- arithmetic operators, such as +, -, *, /, and others;
- relational operators, such as >=, <, and others; and,
- functions, such as SUM(), TAN(), and many others.

When a cell contains a formula, it often contains references to other cells. Such a cell reference is a type of variable. Its value is the value of the referenced cell or some derivation of it. If that cell in turn references other cells, the value depends on the values of those. References can be relative (e.g., A1, or B1:B3), absolute (e.g., $A$1, or $B$1:$B$3) or mixed row– or column-wise absolute/relative (e.g., $A1 is column-wise absolute and A$1 is row-wise absolute).

The available options for valid formulas depend on the particular spreadsheet implementation but, in general, most arithmetic operations and quite complex nested conditional operations can be performed by most of today's commercial spreadsheets. Modern implementations also offer functions to access custom-build functions, remote data, and applications.

A formula may contain a condition (or nested conditions)—with or without an actual calculation—and is sometimes used purely to identify and highlight errors. It is assumed the sum of a column of percentages (A1 through A6) is tested for validity and an explicit message put into the adjacent right-hand cell.

=IF(SUM(A1:A6) > 100, “More than 100%”, SUM(A1:A6))

Further examples:

=IF(AND(A1<>””,B1<>””),A1/B1,””) means that if both cells A1 and B1 are not <> empty “”, then divide A1 by B1 and display, other do not display anything.

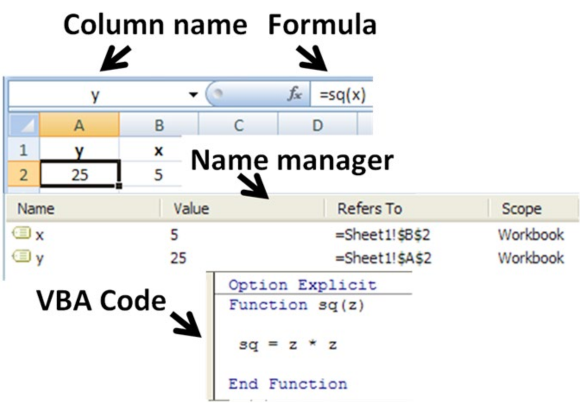
=IF(AND(A1<>””,B1<>””),IF(B1<>0,A1/B1,”Division by zero”),””) means that if cells A1 and B1 are not empty, and B1 is not zero, then divide A1 by B1, if B1 is zero, then display “Division by zero”, and do not display anything if either A1 and B1 are empty.

=IF(OR(A1<>””,B1<>””),”Either A1 or B1 show text”,””) means to display the text if either cells A1 or B1 are not empty.

The best way to build up conditional statements is step by step composing followed by trial and error testing and refining code.

A spreadsheet does not have to contain any formulas at all, in which case it could be considered merely a collection of data arranged in rows and columns (a database) like a calendar, timetable, or simple list. Because of its ease of use, formatting, and hyperlinking capabilities, many spreadsheets are used solely for this purpose.

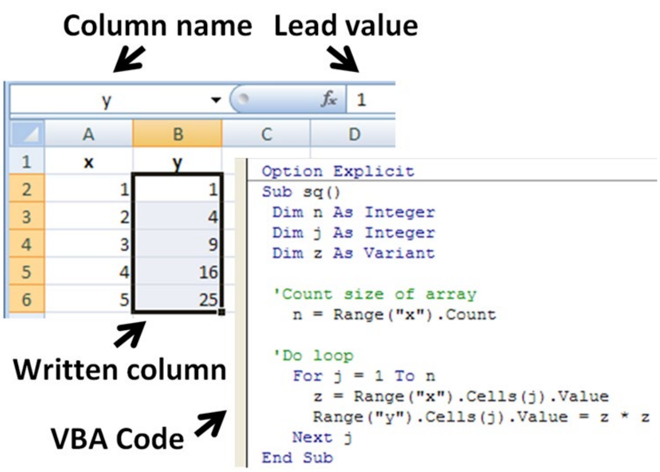
Functions



Use of user-defined function *sq(x)* in Microsoft Excel.

Spreadsheets usually contain several supplied functions, such as arithmetic operations (for example, summations, averages, and so forth), trigonometric functions, statistical functions, and so forth. In addition there is often a provision for *user-defined functions*. In Microsoft Excel, these functions are defined using Visual Basic for Applications in the supplied Visual Basic editor, and such functions are automatically accessible on the worksheet. Also, programs can be written that pull information from the worksheet, perform some calculations, and report the results back to the worksheet. In the figure, the name *sq* is user-assigned, and the function *sq* is introduced using the *Visual Basic* editor supplied with Excel. *Name Manager* displays the spreadsheet definitions of named variables x & y.

Subroutines



Subroutine in Microsoft Excel writes values calculated using x into y.

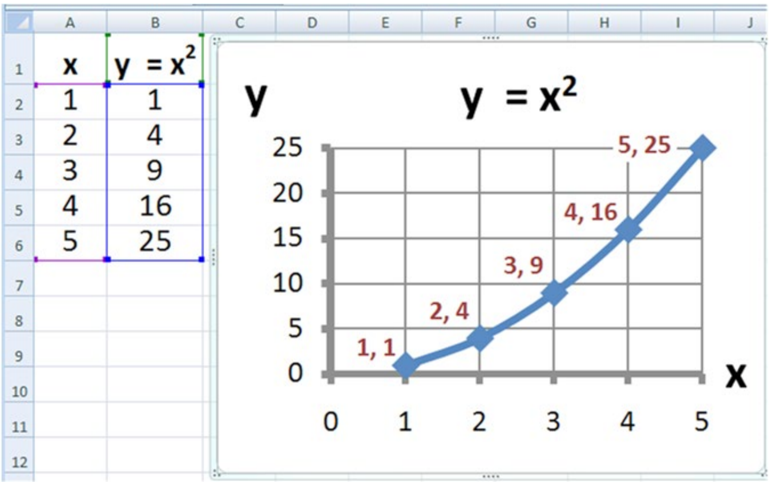
Functions themselves cannot write into the worksheet but simply return their evaluation. However, in Microsoft Excel, subroutines can write values or text found within the subroutine directly to the spreadsheet. The figure shows the Visual Basic code for a subroutine that reads each member of the named column variable x, calculates its square, and writes this value into the corresponding element of named column variable y. The y column contains no formula because its values are calculated in the subroutine, not on the spreadsheet, and simply are written in.

Remote spreadsheet

Whenever a reference is made to a cell or group of cells that are not located within the current physical spreadsheet file, it is considered as accessing a "remote" spreadsheet.

The contents of the referenced cell may be accessed either on the first reference with a manual update or more recently in the case of web-based spreadsheets, as a near real-time value with a specified automatic refresh interval.

Charts



Graph made using Microsoft Excel

Many spreadsheet applications permit charts and graphs (e.g., histograms, pie charts) to be generated from specified groups of cells that are dynamically re-built as cell contents change. The generated graphic component can either be embedded within the current sheet or added as a separate object. To create an Excel histogram, a formula based on the REPT function can be used.

Multi-dimensional spreadsheets

In the late 1980s and early 1990s, first Javelin Software and Lotus Improv appeared. Unlike models in a conventional spreadsheet, they utilized models built on objects called variables, not on data in cells of a report. These multi-dimensional spreadsheets enabled viewing data and algorithms in various self-documenting ways, including simultaneous multiple synchronized views. For example, users of Javelin could move through the connections between variables on a diagram while seeing the logical roots and branches of each variable. This is an example of what is perhaps its primary contribution of the earlier Javelin—the concept of traceability of a user's logic or model structure through its twelve views. A complex model can be dissected and understood by others who had no role in its creation.

In these programs, a time series, or any variable, was an object in itself, not a collection of cells that happen to appear in a row or column. Variables could have many attributes, including complete awareness of their connections to all other variables, data references, and text and image notes. Calculations were performed on these objects, as opposed to a range of cells, so adding two-time series automatically aligns them in calendar time, or in a user-defined time frame. Data were independent of worksheets—variables, and therefore data, could not be destroyed by deleting a row, column, or entire worksheet. For instance, January's costs are subtracted from January's revenues, regardless of where or whether either appears in a worksheet. This permits actions later used in pivot tables, except that flexible manipulation of report tables, was but one of many capabilities supported by variables. Moreover, if costs were entered by week and revenues by month, the program could allocate or interpolate as appropriate. This object design enabled variables and whole models to reference each other with user-defined variable names and to perform multidimensional analysis and massive, but easily editable consolidations.

Trapeze, a spreadsheet on the Mac, went further and explicitly supported not just table columns, but also matrix operators.

Logical Spreadsheets

Spreadsheets that have a formula language based upon logical expressions, rather than arithmetic expressions are known as logical spreadsheets. Such spreadsheets can be used to reason deductively about their cell values.

8.1.6 Programming Issues

Just as the early programming languages were designed to generate spreadsheet printouts, programming techniques themselves have evolved to process tables (also known as spreadsheets or matrices) of data more efficiently in the computer itself.

End-user development

Spreadsheets are a popular end-user development tool. EUD denotes activities or techniques in which people who are not professional developers create automated behavior and complex data objects without significant knowledge of a programming language. Many people find it easier to perform calculations in spreadsheets than by writing the equivalent sequential program. This is due to several traits of spreadsheets.

- They use spatial relationships to define program relationships. Humans have highly developed intuitions about spaces, and of dependencies between items.

Sequential programming usually requires typing line after line of text, which must be read slowly and carefully to be understood and changed.

- They are forgiving, allowing partial results and functions to work. One or more parts of a program can work correctly, even if other parts are unfinished or broken. This makes writing and debugging programs easier, and faster. Sequential programming usually needs every program line and character to be correct for a program to run. One error usually stops the whole program and prevents any result. Though this user-friendliness is benefit of spreadsheet development, it often comes with increased risk of errors.
- Modern spreadsheets allow for secondary notation. The program can be annotated with colors, typefaces, lines, etc. to provide visual cues about the meaning of elements in the program.
- Extensions that allow users to create new functions can provide the capabilities of a functional language.
- Extensions that allow users to build and apply models from the domain of machine learning.
- Spreadsheets are versatile. With their boolean logic and graphics capabilities, even electronic circuit design is possible.
- Spreadsheets can store relational data and spreadsheet formulas can express all queries of SQL. There exists a query translator, which automatically generates the spreadsheet implementation from the SQL code.

Spreadsheet Programs

A "spreadsheet program" is designed to perform general computation tasks using spatial relationships rather than time as the primary organizing principle.

It is often convenient to think of a spreadsheet as a mathematical graph, where the nodes are spreadsheet cells, and the edges are references to other cells specified in formulas. This is often called the dependency graph of the spreadsheet. References between cells can take advantage of spatial concepts such as relative position and absolute position, as well as named locations, to make the spreadsheet formulas easier to understand and manage.

Spreadsheets usually attempt to automatically update cells when the cells depend on change. The earliest spreadsheets used simple tactics like evaluating cells in a particular order, but modern spreadsheets calculate following a minimal recomputation order from the dependency graph. Later spreadsheets also include a limited ability to propagate values in reverse, altering source values so that a particular answer is reached in a certain cell. Since spreadsheet cell formulas are not generally invertible, though, this technique is of somewhat limited value.

Many of the concepts common to sequential programming models have analogs in the spreadsheet world. For example, the sequential model of the indexed loop is usually represented as a table of cells, with similar formulas (normally differing only in which cells they reference).

Spreadsheets have evolved to use scripting programming languages like VBA as a tool for extensibility beyond what the spreadsheet language makes easy.

8.1.7 Shortcomings

While spreadsheets represented a major step forward in quantitative modeling, they have deficiencies. Their shortcomings include the perceived unfriendliness of alpha-numeric cell addresses.

- Research by ClusterSeven has shown huge discrepancies in the way financial institutions and corporate entities understand, manage and police their often vast estates of spreadsheets and unstructured financial data (including comma-separated values (CSV) files and Microsoft Access databases). One study in early 2011 of nearly 1,500 people in the UK found that 57% of spreadsheet users have never received formal training on the spreadsheet package they use. 72% said that no internal department checks their spreadsheets for accuracy. Only 13% said that Internal Audit reviews their spreadsheets, while a mere 1% receive checks from their risk department.
- Spreadsheets have significant reliability problems. Research studies estimate that roughly 94% of spreadsheets deployed in the field contain errors, and 5.2% of cells in unaudited spreadsheets contain errors.

Despite the high error risks often associated with spreadsheet authorship and use, specific steps can be taken to significantly enhance control and reliability by structurally reducing the likelihood of error occurrence at their source.

- The practical expressiveness of spreadsheets can be limited unless their modern features are used. Several factors contribute to this limitation. Implementing a complex model on a cell-at-a-time basis requires tedious attention to detail. Authors have difficulty remembering the meanings of hundreds or thousands of cell addresses that appear in formulas.

These drawbacks are mitigated by the use of named variables for cell designations, and employing variables in formulas rather than cell locations and cell-by-cell manipulations. Graphs can be used to show instantly how results are changed by changes in parameter values. The spreadsheet can be made invisible except for a transparent user interface that requests pertinent input from the user, displays results requested by the user, creates reports, and has built-in error traps to prompt correct input.

- Similarly, formulas expressed in terms of cell addresses are hard to keep straight and hard to audit. Research shows that spreadsheet auditors who check numerical results and cell formulas find no more errors than auditors who only check numerical results. That is another reason to use named variables and formulas employing named variables.

Specifically, spreadsheets typically contain many copies of the same formula. When the formula is modified, the user has to change every cell containing that formula. In contrast, most computer languages allow a formula to appear only once in the code and achieve repetition using loops: making them much easier to implement and audit.

- The alteration of a dimension demands major surgery. When rows (or columns) are added to or deleted from a table, one has to adjust the size of many downstream tables that depend on the table being changed. In the process, it is often necessary to move other cells around to make room for the new columns or rows and to adjust graph data sources. In large spreadsheets, this can be extremely time-consuming.
- Adding or removing a dimension is so difficult, one generally has to start over. The spreadsheet as a paradigm forces one to decide on dimensionality right of the beginning of one's spreadsheet creation, even though it is often most natural to make these choices after one's spreadsheet model has matured. The desire to add and remove dimensions also arises in parametric and sensitivity analyses.
- Collaboration in authoring spreadsheet formulas can be difficult when such collaboration occurs at the level of cells and cell addresses.

Other problems associated with spreadsheets include:

- Some sources advocate the use of specialized software instead of spreadsheets for some applications (budgeting, statistics)
- Many spreadsheet software products, such as Microsoft Excel (versions prior to 2007) and OpenOffice.org Calc (versions prior to 2008), have a capacity limit of 65,536 rows by 256 columns (2^{16} and 2^{8} respectively). This can present a problem for people using very large datasets, and may result in data loss. In spite of the time passed, a recent example is the loss of COVID-19 positives in the British statistics for September and October 2020.
- Lack of auditing and revision control. This makes it difficult to determine who changed what and when. This can cause problems with regulatory compliance. Lack of revision control greatly increases the risk of errors due to the inability to track, isolate and test changes made to a document.
- Lack of security. Spreadsheets lack controls on who can see and modify particular data. This, combined with the lack of auditing above, can make it easy for someone to commit fraud.

- Because they are loosely structured, it is easy for someone to introduce an error, either accidentally or intentionally, by entering information in the wrong place or expressing dependencies among cells (such as in a formula) incorrectly.
- The results of a formula (example "=A1*B1") applies only to a single cell (that is, the cell the formula is located in—in this case perhaps C1), even though it can "extract" data from many other cells, and even real-time dates and actual times. This means that to cause a similar calculation on an array of cells, an almost identical formula (but residing in its own "output" cell) must be repeated for each row of the "input" array. This differs from a "formula" in a conventional computer program, which typically makes one calculation that it applies to all the input in turn. With current spreadsheets, this forced repetition of near-identical formulas can have detrimental consequences from a quality assurance standpoint and is often the cause of many spreadsheet errors. Some spreadsheets have array formulas to address this issue.
- Trying to manage the sheer volume of spreadsheets that may exist in an organization without proper security, audit trails, the unintentional introduction of errors, and other items listed above can become overwhelming.

While there are built-in and third-party tools for desktop spreadsheet applications that address some of these shortcomings, awareness, and use of these is generally low. A good example of this is that 55% of Capital market professionals "don't know" how their spreadsheets are audited; only 6% invest in a third-party solution

8.1.8 Spreadsheet Risk

Spreadsheet risk is the risk associated with deriving a materially incorrect value from a spreadsheet application that will be utilized in making a related (usually numerically-based) decision. Examples include the valuation of an asset, the determination of financial accounts, the calculation of medicinal doses, or the size of a load-bearing beam for structural engineering. The risk may arise from inputting erroneous or fraudulent data values, from mistakes (or incorrect changes) within the logic of the spreadsheet or the omission of relevant updates (e.g., out of date exchange rates). Some single-instance errors have exceeded US$1 billion. Because spreadsheet risk is principally linked to the actions (or inaction) of individuals it is defined as a sub-category of operational risk.

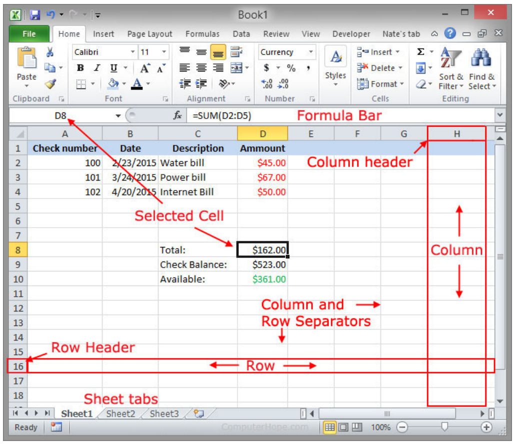
Despite this, research carried out by ClusterSeven revealed that around half (48%) of c-level executives and senior managers at firms reporting annual revenues over £50m said there were either no usage controls at all or poorly applied manual processes over the use of spreadsheets at the firms.

In 2013 Thomas Herndon, a graduate student of economics at the University of Massachusetts Amherst found major coding flaws in the spreadsheet used by the economists Carmen Reinhart and Kenneth Rogoff in *Growth in a Time of Debt*, a very influential 2010 journal article. The Reinhart and Rogoff article was widely used as justification to drive 2010–2013 European austerity programs.

8.2 WHAT IS WORKSHEET?

Worksheet is a file made of rows and columns that help sort, organize, and arrange data efficiently, and calculate numerical data. What makes a spreadsheet software program unique is its ability to calculate values using mathematical formulas and the data in cells. An example of how a spreadsheet may be utilized is creating an overview of your bank's balance.

Below is a basic example of what a Microsoft Excel spreadsheet looks like, with all the important features of a spreadsheet highlighted.



In the above example, this spreadsheet is listing three different checks, the date, their description, and the value of each check. These values are then added together to get the total of $162.00 in cell D6. That value is subtracted from the check balance to give an available $361.00 in cell D8.

8.2.1 Difference between a Workbook, Worksheet, and Spreadsheet

Because the terms spreadsheet, workbook, and worksheet are so similar, there often is confusion when trying to understand their differences. When you open Microsoft Excel (a spreadsheet program), you're opening a workbook. A workbook can contain one or more different worksheets that are accessed through the tabs at the bottom of the worksheet you are currently viewing. What's often most confusing is that a worksheet is synonymous with a spreadsheet. In other words, a spreadsheet and worksheet mean the same thing. However, most people only refer to the program as a spreadsheet program and the files it creates as spreadsheet files or worksheets.

8.2.2 Examples of Spreadsheet Programs

Today, Microsoft Excel is the most popular and widely used spreadsheet program, but there are also many alternatives. Below is a list of spreadsheet programs used to create a spreadsheet.

- Google Sheets - (online and free).
- iWork Numbers - Apple Office Suite.
- LibreOffice -> Calc (free).
- Lotus 1-2-3 (discontinued).
- Lotus Symphony - Spreadsheets.
- Microsoft Excel.
- OpenOffice -> Calc (free).
- VisiCalc (discontinued).

8.2.3 Examples and uses of a Spreadsheet

Although spreadsheets are most often used with anything containing numbers, the uses of a spreadsheet are almost endless. Below are some other popular uses of spreadsheets.

Finance

Spreadsheets are ideal for financial data, such as your checking account information, budgets, taxes, transactions, billing, invoices, receipts, forecasts, and any payment system.

Forms

Form templates can be created to handle inventory, evaluations, performance reviews, quizzes, time sheets, patient information, and surveys.

School and grades

Teachers can use spreadsheets to track students, calculate grades, and identify relevant data, such as high and low scores, missing tests, and students who are struggling.

Lists

Managing a list in a spreadsheet is a great example of data that does not contain numbers, but still can be used in a spreadsheet. Great examples of spreadsheet lists include telephone, to-do, and grocery lists.

Sports

Spreadsheets can keep track of your favorite player stats or stats on the whole team. With the collected data, you can also find averages, high scores, and statistical data. Spreadsheets can even be used to create tournament brackets.

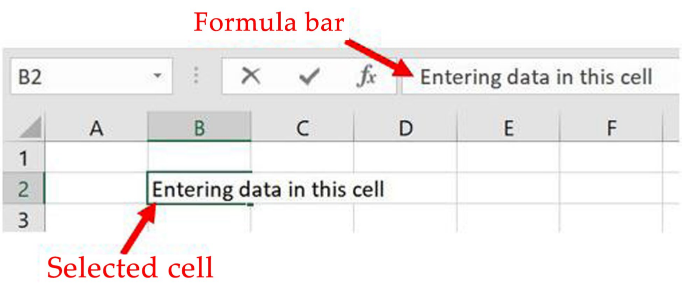
8.2.4 How do I enter data in a spreadsheet?

In a spreadsheet, data is entered in one or more cells. To enter data in a cell, follow the steps below.

- Click the cell where you want to enter data.
- Start typing the data using your keyboard. The data is automatically entered in the selected cell.

or

- Click the cell where you want to enter additional data.
- Click in the formula bar, located between the Ribbon and all cells, where you want to start entering the additional data.
- Type the data using your keyboard. The data is automatically entered in the selected cell.



If you want to add additional data to a cell that already has data entered in it, follow the steps below.

- Click the cell where you want to enter additional data.
- Click in the formula bar, located between the Ribbon and all cells, where you want to start entering the additional data.
- Type the data using your keyboard. The data is automatically entered in the selected cell where the mouse cursor is placed in the formula bar.

Why not use a word processor instead of a spreadsheet?

Although some uses above could be done in a word processor, spreadsheets have a considerable advantage over word processors when using numbers. It would be impossible to calculate multiple numbers in a word processor and have the value of the calculation immediately appear. Spreadsheets are also more dynamic with the data and can hide, show, and sort information to make processing lots of information easier.

What is an active worksheet?

An active worksheet is the worksheet that is currently open. For example, in the earlier Excel picture, the sheet tabs at the bottom show "Sheet1," "Sheet2," and "Sheet3," with *Sheet1* being the active worksheet. The active tab usually has a white background behind the tab name.

How many worksheets open by default?

In Microsoft Excel 2016 and earlier and OpenOffice Calc, by default, there are *three* sheet tabs that open (*Sheet1*, *Sheet2*, and *Sheet3*). In Google Sheets, your spreadsheets starts with one sheet (Sheet1).

In Microsoft Excel 365, by default, there is only one sheet tab that opens (*Sheet1*).

What is the length limit of a worksheet name?

Not to be confused with the file name, in Microsoft Excel, there is a 31 character limit for each worksheet name.

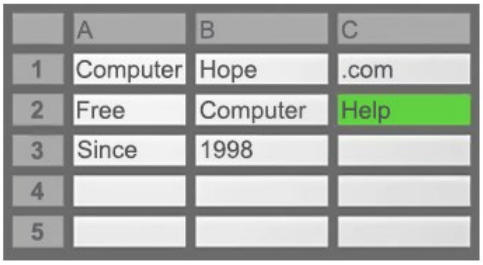
How are rows and columns labeled?

In all spreadsheet programs, including Microsoft Excel, rows are labeled using numbers (e.g., 1 to 1,048,576). All columns are labeled with letters from A to Z, then with two letters. For example, after the letter Z, the next column is AA, AB, AC, ..., AZ and then incrementing to BA, BB, BC, etc., to the last column XFD.

When working with a cell, you combine the column with the row. For example, the very first cell is in column A and on row 1, so the cell is labeled as A1.

8.2.5 How to Create a Spreadsheet?

To create a spreadsheet, you must either have a spreadsheet program installed on your computer, or use an online service.



The most common and widely used spreadsheet program is Microsoft Excel. However, because of all of the different needs of users today, we have included additional options that are available for creating a spreadsheet.

Windows computers do not generally include a spreadsheet program by default (although a trial version of Microsoft Excel can be used for a limited time to create a spreadsheet). The only exception was the Microsoft Surface with Windows RT, which is no longer available. There are also many versions of Linux that include LibreOffice.

Create a spreadsheet with Google Sheets

Google Sheets is free, easy to access, supports collaborative editing, and can open other spreadsheet files. It can be accessed from any device.

To use Google Sheets, follow the steps below.

- Visit the Google Sheets website.
- If prompted, log into your Google account.

- Click the green plus to start a new blank spreadsheet or select from one of the pre-made templates.

After creating and opening a new spreadsheet, any information can be added. As you continue to work, Google automatically saves all changes. To name the spreadsheet, click untitled spreadsheet in the top-left corner and enter a new name. You can also click the share button in the top-right corner to share the spreadsheet to work collaboratively.

Create a spreadsheet with Microsoft Excel

To use Microsoft Excel to create a spreadsheet, follow the steps below.

Open Excel in Windows

- Open Microsoft Excel. If you are not sure how to open or find Excel, skip to the finding Microsoft Excel section.
- Once Excel is open, any new information and formulas can be entered.
- Once complete or while working on the spreadsheet, you can Save your work through the File tab to the destination of your choice.

How to find Microsoft Excel in Windows

- In Windows, click **Start**.
- In the search box, type **excel**. If Excel is installed on the computer, it is shown in the search results. For example, you may see Microsoft Excel 2010, Microsoft Excel 2013, or Microsoft Excel 365.

In Windows 10, the search box is on the Taskbar next to Start. In Windows 8, start typing **excel** on the Start page and the search results show on the right side of the screen.

How to install Microsoft Excel

If Excel is not installed, it would need to be installed on the computer. Today, the latest version of Excel is included in Office 365 and requires a subscription. You can download Office 365, which includes Excel, Word, and other Office applications, from the Office 365 website.

If you've purchased Office or Excel in the past, older versions of Office can also be installed on newer computers, even those running Windows 8 or Windows 10. You must have the installation discs to install Office or Excel again.

Create a spreadsheet with LibreOffice

LibreOffice Calc is a great free office program, designed to work like Excel. Below are the steps on how to run LibreOffice in Windows.

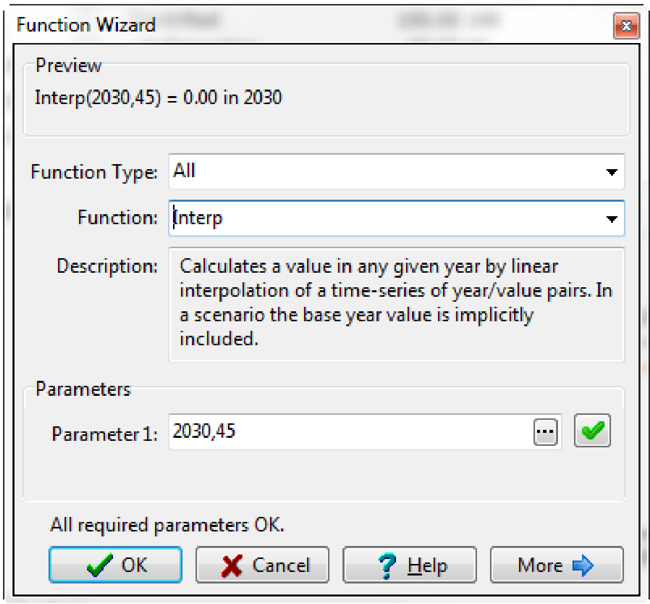
Open LibreOffice in Windows

- If you have not yet installed LibreOffice, download it from the official LibreOffice website. Run the installer, and install it with the default options.
- To open LibreOffice, open your **Start menu**. Scroll down to the **L** listing. Click the **LibreOffice** folder, then click **LibreOffice Calc**.

By default, LibreOffice installs the entire LibreOffice Suite, including the word processor ("Writer") and presentation software ("Impress"). If you don't want to install the full suite, you can uncheck the checkboxes for those apps during installation.

8.3 FUNCTION WIZARD

The Function Wizard is a popup tool that helps you to write the expressions that define the data and models entered in LEAP's Analysis View. The Function Wizard can be invoked when creating an expression by clicking Ctrl-F or by selecting Function from the drop-down menu attached to every expression in the Analysis View data tables. It can also be invoked in a similar way from the Expression Builder tool. The function wizard can also be invoked by clicking a function in an existing expression and pressing Ctrl-Space or Ctrl-**F**.



The Function wizard is displayed as a popup dialog containing a series of selection and edit boxes.

- *Function Type:* This selection box is used to select among different classes of functions. LEAP has over one hundred functions that you can include in your expressions divided into five main categories: modeling functions, mathematical functions, logical functions, statistical functions, and financial functions. The Functions Wizard also lets you create references to the properties of the fuels located at branch in the LEAP tree, and references to constant values, created in the General: Constants screen.
- *Function***:** The Function selection box is used to select a specific function from a drop down menu. The functions are listed alphabetically and filtered by the class of functions selected in the Function Type selection box. To see all functions, choose All in the Function Type selection box.

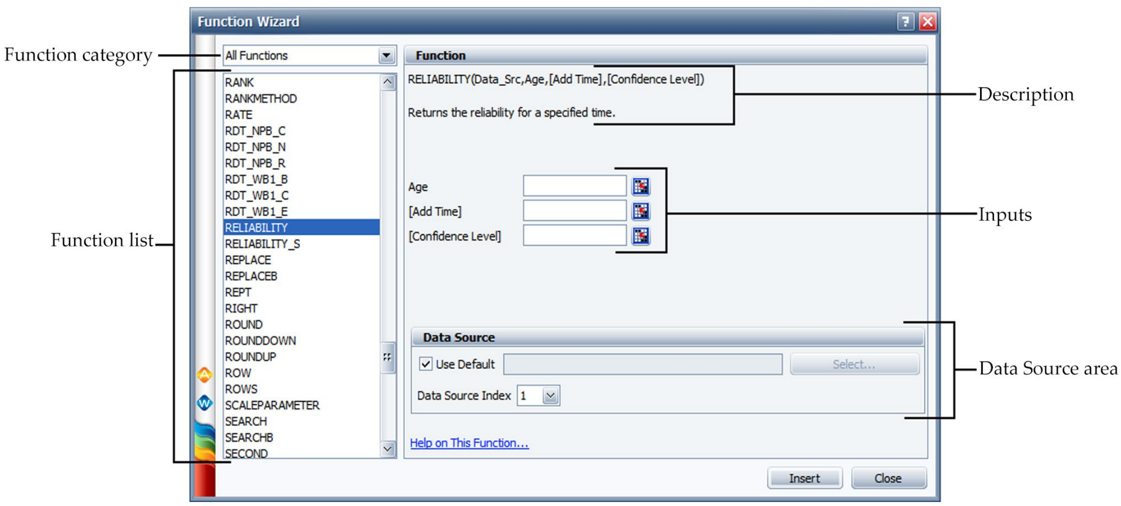
Once you have selected a specific function, the wizard displays a short description of that function. More detailed help on the function including detailed syntax and examples of how it can be applied are available by clicking the More button to expand the window. Below the function name, a series of edit boxes are displayed in which you can specify the parameters required by the Function. Parameters can either be specified as simple numeric values or they can be entered using a series of additional popup windows that are used to select LEAP branch/variable references, Excel spreadsheet ranges or time series of values (selected using the Time-Series Wizard).

When the Function wizard is invoked with the cursor placed within an existing function, then the Function Wizard will be displayed with the function wizard populated with the parameters for that function.

As you enter the data for each parameter, LEAP will check those parameters. Errors in parameter specifications are highlighted in red text. A preview of the function and its parameters and its evaluated numeric value are shown at the top of the Function Wizard. Once the required minimum set of parameters has been completed, you can press the **OK** button to add the completed function to your overall expression.

The Function Wizard generates a variety of results based on your inputs and, when applicable, a referenced analysis. To open the Function Wizard from an analysis workbook or a general spreadsheet, choose Sheet > Sheet Actions > Function Wizard. From a Word report template, choose Home > Report > Function Wizard. The wizard can also be opened by clicking the icon in the control panel.

The contents of the Function Wizard window will vary depending on where you are using it. The following picture shows the full functionality of the wizard in Weibull++/ALTA, which is available from analysis workbooks. Similar functionality is available in the wizards for RGA, BlockSim and DOE++.



There are three steps to use this tool:

- Select the function and enter the inputs

- Select the data source (if applicable)
- Insert the function

Select the Function and Enter the Inputs

First select one of the available functions from the panel on the left side. The list of functions will vary depending on where you're using the wizard. The right side of the wizard displays some information about the function that is currently selected and allows you to make relevant inputs, if any.

Note that:

- The Help on this Function link provides a quick reference with additional information about any inputs that may be used in the function.
- For analysis workbook functions, when applicable, brackets indicate that the input is optional. For example, the Add Time and Confidence Level parameters are optional in this Weibull++ analysis workbook function:

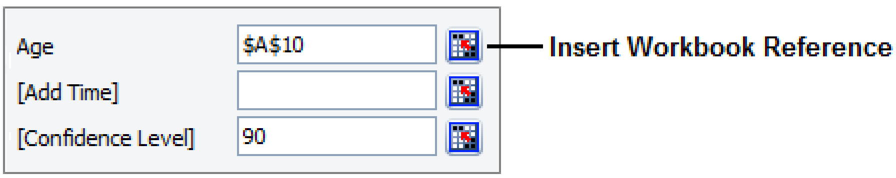
  RELIABILITY(Data_Src,Age,[Add Time],[Confidence Level])

- For Word report templates functions, the brackets are part of the function field and are not optional.

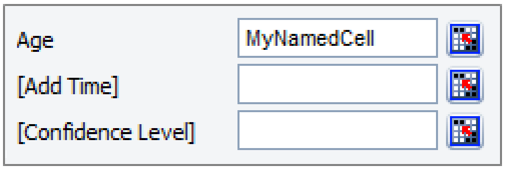
  [RELIABILITY(Source Number)(Time)]

- When you are working in an analysis workbook, you can use cell references as inputs, if desired. For example, instead of entering 1000 for a time input, you could specify to use whatever time is currently entered into cell A10, using either the relative reference (A10) or the absolute reference ($A$10).

The Insert Workbook Reference icon provides a quick way to insert a reference to the cell that is currently selected in the sheet. Note that you can move the cursor in the sheet while the Function Wizard is open. Pressing **CTRL** while clicking this icon inserts an absolute reference to the currently selected cell.



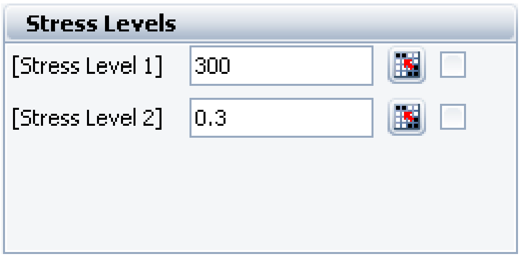
- When you are working in an analysis workbook, you can also use variable names as inputs. Specifically:
  - Variable names representing specific spreadsheet cells can be used in the input fields.



- Variable names representing specific data sheets or diagrams can be used in the Data Source field by entering a caret then the name (e.g., ^MyNamedSheet).

- In ALTA only, some data source functions in spreadsheets require you to enter one or more stress levels in the Input area. The number of stresses to be entered in such cases depends on the number of stresses used in calculating the data sheet. The functions that require stress level inputs are those where the results can change depending on the given stress value (i.e., the result returned by the ACT_ENERGY function does not change based on the stress values while the result returned by the RELIABILITY_S function does depend on the stress values).

In ALTA PRO, if cumulative damage was used to calculate the parameters in the selected data sheet, then independent check boxes will appear beside each stress level input, as shown next.



Select the check box if you want to use the stress level as defined in the stress profile. The input field will become a drop-down list, allowing you to select any stress profile in the project to use as the input value.

Select the Data Source (If Applicable)

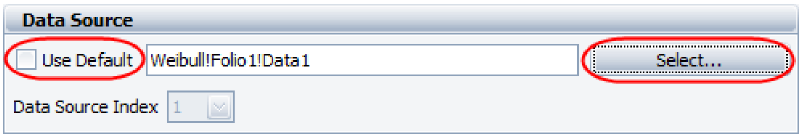
When you are creating a function that obtains **data** or results from an existing analysis in Weibull++, ALTA, RGA or BlockSim, there are two ways to specify the data source. Both options are available in analysis workbooks. The data source name option is used with general spreadsheets and the data source index option is used with Word reports. (This is not applicable for the Function Wizard in DOE++.)

Keyword

Data are measured, collected, reported, and analyzed, and used to create data visualizations such as graphs, tables or images.

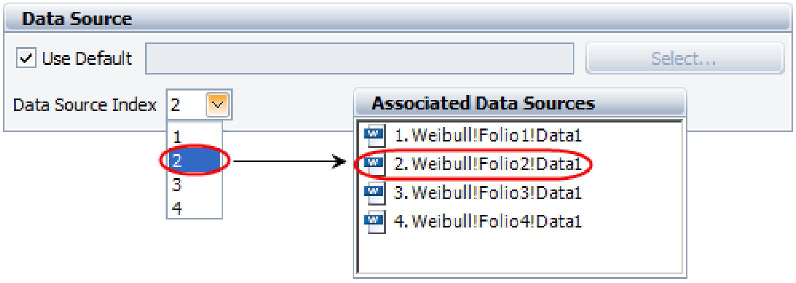
- *Using the Data Source Name* (analysis workbooks and general spreadsheets only): If you want to ensure that the function always returns the result from a specific data sheet or diagram, you can place the name directly in the function expression. For example, =MODEL("Weibull!Folio1!Data1") will always return the distribution that was used to calculate the data sheet called "Data1" in the Weibull++ standard folio called "Folio1."

To do this in the analysis workbook's function wizard, clear the **Use Default** check box and use the **Select** button to choose the data source, as shown next. (In the general spreadsheet's function wizard, you will always need to choose a specific data source.)



- *Using a Data Source Index* (analysis workbooks and Word reports only): If you anticipate that you will be reusing the same template with a variety of different data sets, you can configure the function expression to use a data source index number. For example, =MODEL (Default2) will return the distribution or model that was used to calculate whatever data source is currently second in the list of associated data sources.

To do this in the analysis workbook's Function Wizard, select the Use Default check box and choose a number from the Data Source Index drop-down list, as shown next. In the Word report's function wizard, you will always need to choose the appropriate index from the drop-down list.



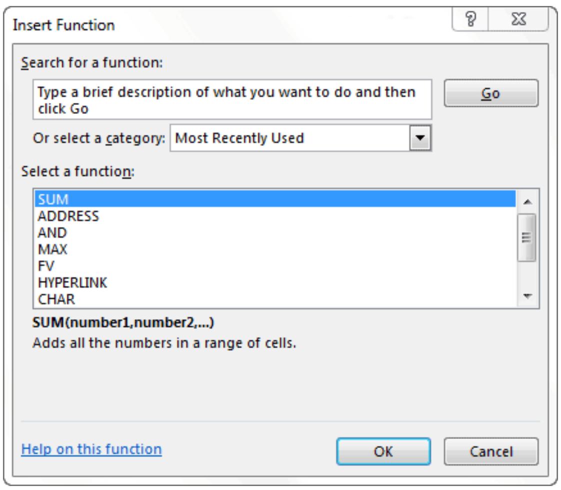
Insert the Function

When the function is fully defined, click Insert to place it into the report at the current cursor location. You can move and/or modify the defined function expression after it has been inserted. Note that the functions inserted in a Word report template will not return any results until the report is generated.

For analysis workbooks and general spreadsheets, you can also type the function expressions directly in the cell once you are familiar with the syntax. For Word report templates, you must use the Function Wizard to initially add a function to a report as the functions are inserted as fields. After doing so, you may copy the function and change its inputs.

8.3.1 Use the Function Wizard

The Function Wizard can help you find the function you want and provide you with step-by-step guidance on how to use it. To access the Function Wizard, click the Insert Function button on the Formula Bar or click the Insert Function button on the Formulas tab.



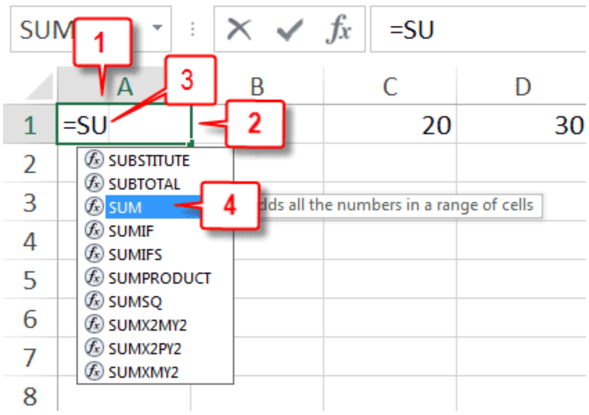
To locate the function you want, type a description in the Search for a Function field and then click Go. Excel will display all the functions that meet your description in the Select a Function Field. Click the function you want and then click OK. Excel will open a dialog box specifically designed for the function you clicked.

Alternatively, use the Or Select a Category Field to select the category your function is in. Excel will display all of the functions in that category in the Select a Function Field. Click the function you want and then click OK. Excel will open a dialog box specifically designed for the function you clicked.

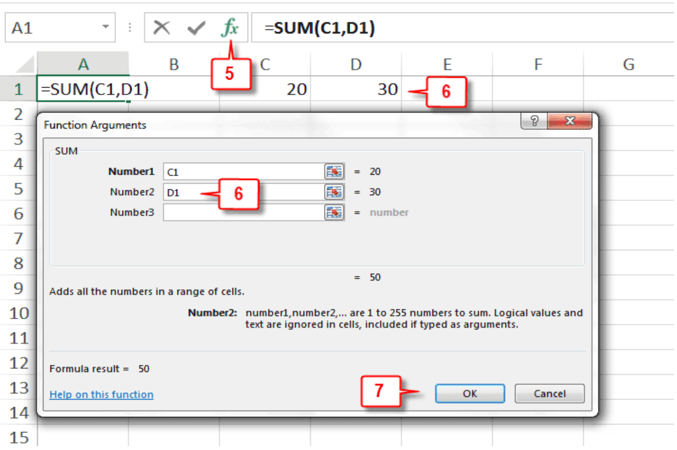
Each function has its own dialog box. I call that dialog box the Function Specific dialog box. The Function Specific dialog box has a field for each of the function's arguments. Type the proper value in each field or click in the field and then click and drag to select a range. When you have completed entering the arguments, click OK. Excel will enter the function in your formula.

When typing a formula into a cell or into the Formula Bar, you can access the Function Wizard at any time by clicking the Insert Function button. If you type the function name or select the function from the AutoComplete List and then click the Insert Function button, Excel will take you directly to the Function Specific dialog box.

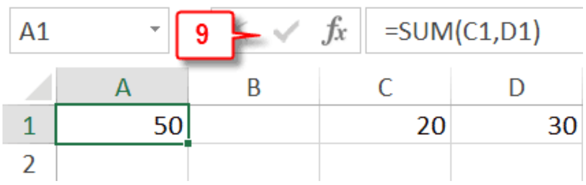
Use the Function Wizard



- Move to the cell where you want the results of your formula to appear.
- Begin typing in the cell or in the Formula Bar.
- When you need to use a function, begin typing the function name.
- When you see the function name on the AutoComplete list, click it.



- Click the Insert Function button. The dialog box for the function you selected opens.
- Enter your arguments. When you want to reference a cell, click the cell. When you want to reference a range, click and drag to select the range.
- When you complete your function, click OK.
- Continue entering your formula.
- Press Enter or click the Enter button on the Formula Bar when you have completed your entry.



8.3.2 How to Use Function Wizard in Excel

Excel's Insert Function provides the user with a list of all possible Excel functions and makes them easy to implement. When you're manually writing a function-based formula in a cell, you're prone to make syntax errors. Also, it requires you to remember the syntax for each function. The Microsoft Excel Function Wizard, on the other hand, provides the user with a list of predefined formulas and makes them easy to implement. It is perfect for quickly creating valid functions.

The function wizard is handy when you can't remember which function to use, or how to use it. In this article, we will show you how to use Insert Function Wizard in Excel.

Today's tip is about how you can discover some of Excel's power on your own. Built into Excel are many helpful tools called *functions*. Functions are shortcuts that make it easier for you to accomplish things that would otherwise require long, complex formulas. For example, the best known function is *Sum*. You've probably used it many times via the Auto Sum button. Without the sum function what we now think of as one of the simplest spreadsheet functions, adding a column of numbers, would be ridiculously tedious as you would need to write a formula referencing every cell you want to add, such as *=A1+A2+A3+A4+A5+A6+A7+A8+A9+A10*. *Sum* lets you enter the much simpler formula *=Sum(A1:A10)*.

There are well over 300 functions available in categories such as date, math, financial, text, database, and more. But how do you find them and learn how to use them? That's where the function wizard comes in. There is a small button to the left of the formula bar with the letters *fx* on it. That button launches the wizard. You can also get to it from the *Formulas* tab of the ribbon. The first button on it uses the same *fx* as the other button but with "Insert Function" under it. The wizard lists all functions by category and gives a brief description of each one. Choose one from the list and you'll get a new window that walks you through entering the "arguments" for that function.

Arguments are simply the information and options needed to perform the function, such as which cells you want the Sum function to total. Below the list of arguments, an explanation of the currently selected argument will appear. When you need to enter a cell or range of cells in an argument, you can click back on the spreadsheet and select cells without closing the wizard. As you fill in each blank, the formula result shows in the lower left corner. When you click OK, the wizard enters the formula into the current cell for you. If you launch the wizard while your cursor is on a cell that already contains a formula, you will go directly to the list of arguments for that formula so you can make changes to it.

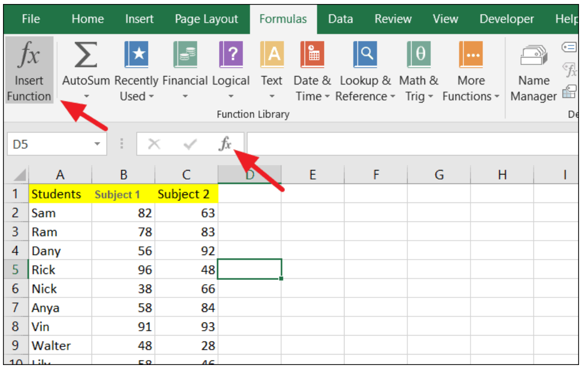
How to create a formula in Excel by using the Insert Function Wizard

An Excel function is a predefined formula or an expression that performs specific calculations in a cell or a range of cells.

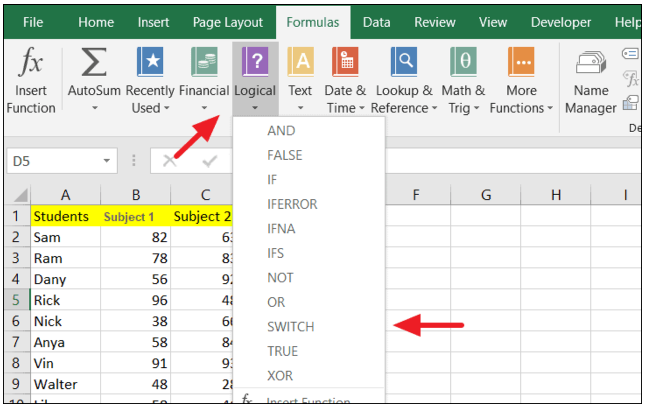
Function Wizard allows you to access all Excel's pre-defined data analysis functions.

First, select the cell where you the output (answer) to appear.

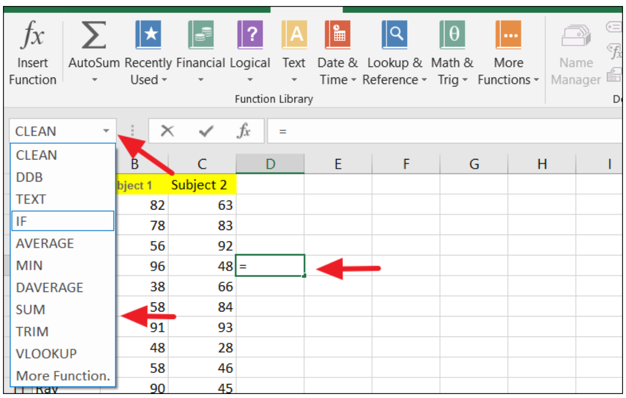
Then to open the function wizard, go to the Formulas tab and click the 'Insert Function' option on the Function Library group. Or, you can click the Insert Function button 'fx' to the left of the formula bar.



You can also choose a function from any one of the categories available in the 'Function Library' under the Formulas tab.



Alternatively, type an equal sign (=) in the cell where you want the output and select a function from the drop-down (from the Name box) to the left of the formula bar.



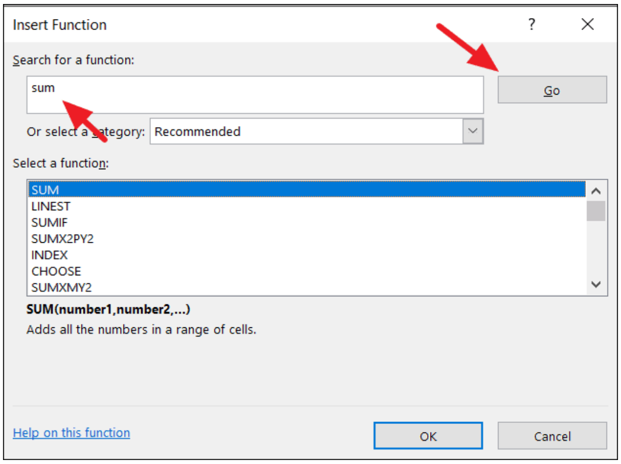
This drop-down menu will display 10 most recently used functions by you.

8.3.3 Inserting an Excel Function

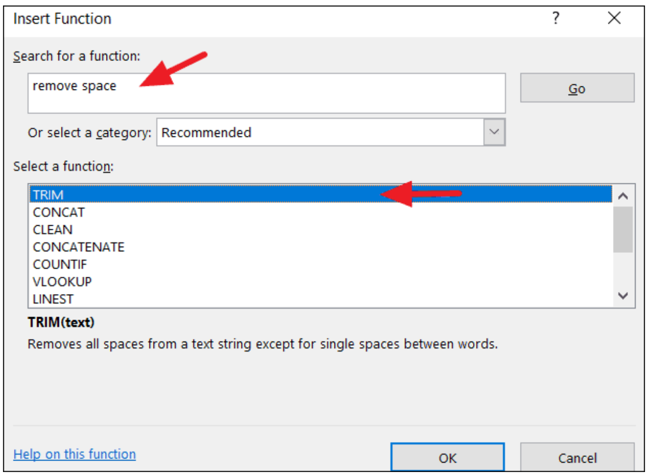
The structure of a function always starts with an equal sign (=), followed by the function name, and the parameters of the function enclosed in parentheses.

When the Insert function wizard opens up, you can insert a function in three different ways.

If you already know the function name, enter it in the 'Search for a function' field and click the 'Go' button.

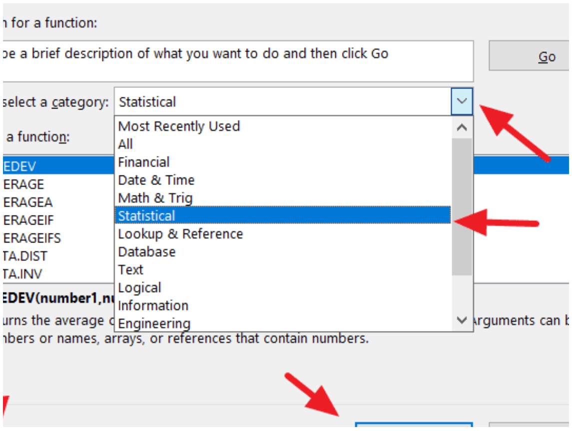


If you forgot the function or not sure exactly what function you need to use, type a brief description of what you want to do in the 'Search for a function' field and click 'Go'. For example, you can type something like this: 'remove space' for removing extra spaces in the text string, or 'current date and time' for returning the current date and time.



Although you won't find an exact match for the description, you would at least get a list of closely related functions in the 'Select a function' box. If you click on a function, you can read a short description of that function right under the 'Select a function' box.

If you know what category the function belongs to, click on the drop-down menu next to 'Select a category' and pick one of the 13 categories listed there. All the functions under the selected category will be listed in the 'Select a function' box.



If you want to know more about the selected function, click the 'Help on this function' link at the bottom left corner of the dialog box. This will take you to the Microsoft 'Support' page where you can learn the description of the formula syntax and usage of the function. Once you've found the right function for your task, select it and click 'OK'.

Specify the Arguments

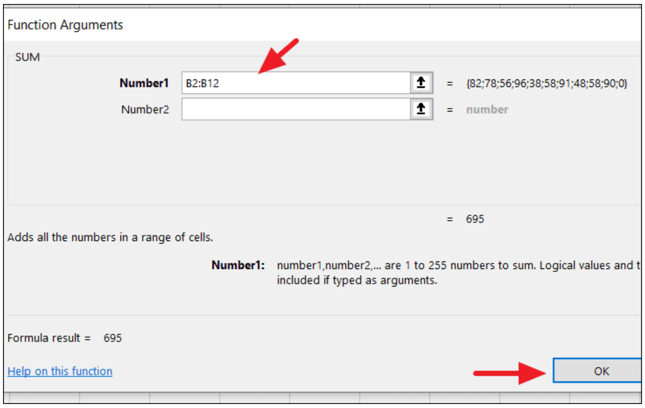
Function arguments are the values that functions need to perform calculations, they can be numbers, text strings, logical values, arrays, error values, or cell references. They can also use constants, formulas, or other functions as arguments.

example

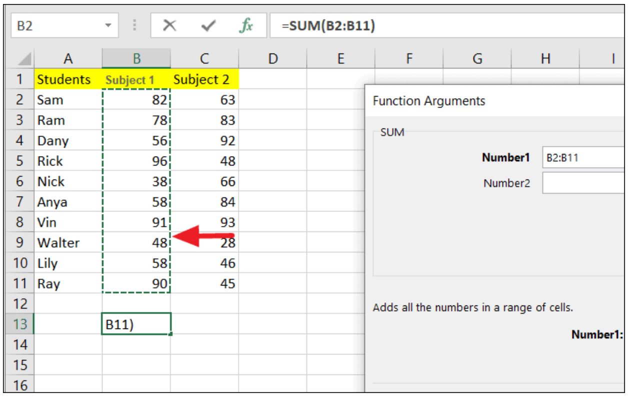
You will see how to insert SUM (one of the most frequently used functions in Excel) in the formula to add all the values in a range of cells.

Once you selected a function in the function 'Insert Function' wizard and clicked 'OK', it will take you to another wizard called 'Function Arguments'.

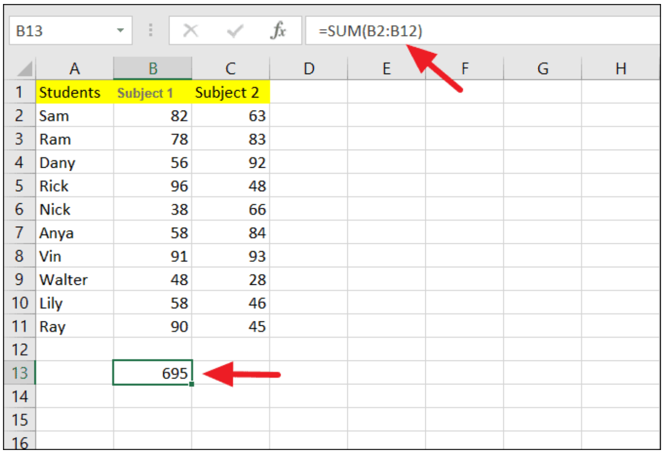
There, you need to enter the function's arguments. To enter an argument, just type a cell reference or a range, or constants directly into the argument box. You can insert as many arguments as you want by clicking on the next box.



Alternatively, click in the argument's box, and then select a cell or a range of cells in the spreadsheet using the mouse. Then, click 'OK'.



After you have specified all the arguments, click the 'OK' button. The answer will be displayed in the selected cell and the completed formula will be displayed in the Formula bar.



	A	B	C	D	E	F	G	H
1	Students	Subject 1	Subject 2					
2	Sam	82	63					
3	Ram	78	83					
4	Dany	56	92					
5	Rick	96	48					
6	Nick	38	66					
7	Anya	58	84					
8	Vin	91	93					
9	Walter	48	28					
10	Lily	58	46					
11	Ray	90	45					
12								
13		695						
14								
15								
16								

DID YOU KNOW ?

However, this concept of an electronic spreadsheet was outlined in the 1961 paper "Budgeting Models and System Simulation" by Richard Mattessich.

8.4 INFORMATION TECHNOLOGY AND SOCIETY

Information technology (IT) is the use of any computers, storage, networking and other physical devices, infrastructure and processes to create, process, store, secure and exchange all forms of electronic data. Typically, IT is used in the context of business operations, as opposed to technology used for personal or entertainment purposes. The commercial use of IT encompasses both computer technology and telecommunications. The Harvard Business Review coined the term information technology to make a distinction between purpose-built machines designed to perform a limited scope of functions, and general-purpose computing machines that could be programmed for various tasks. As the IT industry evolved from the mid-20th century, computing capability increased, while device cost and energy consumption decreased, a cycle that continues today when new technologies emerge.

Information technology (IT) is the use of computers to create, process, store, and exchange all kinds of electronic data and information. IT is typically used within the context of business operations as opposed to personal or entertainment technologies. IT is considered to be a subset of information and communications technology (ICT). An information technology system (IT system) is generally an information system, a communications system, or, more specifically speaking, a computer system including all hardware, software, and peripheral equipment – operated by a limited group of IT users.

Technology society and life or technology and culture refers to the inter-dependency, co-dependence, co-influence, and co-production of technology and society upon one another. Evidence for this synergy has been found since humanity first started using simple tools. The inter-relationship has continued as modern technologies such as the printing press and computers have helped shape society. The first scientific approach to this relationship occurred with the development of technology, the “science of organization”, in early twentieth century Imperial Russia. In modern academia, the interdisciplinary study of the mutual impacts of science, technology, and society, is called science and technology studies. The simplest form of technology is the development and use of basic tools. The prehistoric discovery of how to control fire and the later Neolithic Revolution increased the available sources of food, and the invention of the wheel helped humans to travel in and control their environment. Developments in historic times have lessened physical barriers to communication and allowed humans to interact freely on a global scale, such as the printing press, telephone, and Internet.

Technology has developed advanced economies, such as the modern global economy, and has led to the rise of a leisure class. Many technological processes produce by-products known as pollution, and deplete natural resources to the detriment of Earth’s environment. Innovations influence the values of society and raise new questions in the ethics of technology. Examples include the rise of the notion of efficiency in terms of human productivity, and the challenges of bioethics. Philosophical debates have arisen over the use of technology, with disagreements over whether technology improves the human condition or worsens it. Neo-Luddism, anarcho-primitivism, and similar reactionary movements criticize the pervasiveness of technology, arguing that it harms the environment and alienates people. However, proponents of ideologies such as trans humanism and techno-progressivism view continued technological progress as beneficial to society and the human condition.

8.4.1 Business Models, Commerce and Market Structure

One important way in which information technology is affecting work is by reducing the importance of distance. In many industries, the geographic distribution of work is changing significantly. For instance, some software firms have found that they can overcome the tight local market for software engineers by sending projects to India or other nations where the wages are much lower. Furthermore, such arrangements can take advantage of the time differences so that critical projects can be worked on nearly around the clock. Firms can outsource their manufacturing to other nations and rely on telecommunications to keep marketing, R&D, and distribution teams in close contact with the manufacturing groups. Thus the technology can enable a finer division of labor among countries, which in turn affects the relative demand for various skills in each nation. The technology enables various types of work and employment to be decoupled from one another. Firms have greater freedom to locate their economic activities, creating greater competition among regions in infrastructure, labor, capital, and other resource markets. It also opens the door for regulatory arbitrage: firms can increasingly choose which tax authority and other regulations apply.

Computers and communication technologies also promote more market-like forms of production and distribution. An infrastructure of computing and communication technology, providing 24-hour access at low cost to almost any kind of price and product information desired by buyers, will reduce the informational barriers to efficient market operation. This infrastructure might also provide the means for effecting real-time transactions and make intermediaries such as sales clerks, stock brokers and travel agents, whose function is to provide an essential information link between buyers and sellers, redundant. Removal of intermediaries would reduce the costs in the production and distribution value chain. The information technologies have facilitated the evolution of enhanced mail order retailing, in which goods can be ordered quickly by using telephones or computer networks and then dispatched by suppliers through integrated transport companies that rely extensively on computers and communication technologies to control their operations. Nonphysical goods, such as software, can be shipped electronically, eliminating the entire transport channel. Payments can be done in new ways. The result is disintermediation throughout the distribution channel, with cost reduction, lower end-consumer prices, and higher profit margins.

The impact of information technology on the firms' cost structure can be best illustrated on the electronic commerce example. The key areas of cost reduction when carrying out a sale via electronic commerce rather than in a traditional store involve physical establishment, order placement and execution, customer support, staffing, inventory carrying, and distribution. Although setting up and maintaining an e-commerce web site might be expensive, it is certainly less expensive to maintain such a storefront than a physical one because it is always open, can be accessed by millions around the globe, and has few variable costs, so that it can scale up to meet the demand. By maintaining one 'store' instead of several, duplicate inventory costs are eliminated. In addition, e-commerce is very effective at reducing the costs of attracting new customers, because advertising is typically cheaper than for other media and more targeted. Moreover, the electronic interface allows e-commerce merchants to check that an order is internally consistent and that the order, receipt, and invoice match. Through e-commerce, firms are able to move much of their customer support on line so that customers can access databases or manuals directly. This significantly cuts costs while generally improving the quality of service. **E-commerce** shops require far fewer, but high-skilled, employees. E-commerce also permits savings in inventory carrying costs. The faster the input can be ordered and delivered, the less the need for a large inventory. The impact on costs associated with decreased inventories is most pronounced in industries where the product has a limited shelf life (e.g. bananas), is subject to fast technological obsolescence or price declines (e.g. computers), or where there is a rapid flow of new products (e.g. books, music). Although shipping costs can increase the cost of many products purchased via electronic commerce and add substantially to the final price, distribution costs are significantly reduced for digital products such as financial services, software, and travel, which are important e-commerce segments.

Although electronic commerce causes the disintermediation of some intermediaries, it creates greater dependency on others and also some entirely new intermediary functions. Among the intermediary services that could add costs to e-commerce transactions are advertising, secure online payment, and delivery. The relative ease of becoming an e-commerce merchant and setting up stores results in such a huge number of offerings that consumers can easily be overwhelmed. This increases the importance of using advertising to establish a brand name and thus generate consumer familiarity and trust. For new e-commerce start-ups, this process can be expensive and represents a significant transaction cost. The openness, global reach, and lack of physical clues that are inherent characteristics of e-commerce also make it vulnerable to fraud and thus increase certain costs for e-commerce merchants as compared to traditional stores. New techniques are being developed to protect the use of credit cards in e-commerce transactions, but the need for greater security and user verification leads to increased costs. A key feature of e-commerce is the convenience of having purchases delivered directly. In the case of tangibles, such as books, this incurs delivery costs, which cause prices to rise in most cases, thereby negating many of the savings associated with e-commerce and substantially adding to transaction costs.

Keyword

E-commerce is the activity of electronically buying or selling of products on online services or over the Internet

8.4.2 Private Life and Society

Increasing representation of a wide variety of content in digital form results in easier and cheaper duplication and distribution of information. This has a mixed effect on the provision of content. On the one hand, content can be distributed at a lower unit cost. On the other hand, distribution of content outside of channels that respect intellectual property rights can reduce the incentives of creators and distributors to produce and make content available in the first place. Information technology raises a host of questions about intellectual property protection and new tools and regulations have to be developed in order to solve this problem. Many issues also surround free speech and regulation of content on the Internet, and there continue to be calls for mechanisms to control objectionable content. However it is very difficult to find a sensible solution. Dealing with indecent material involves understanding not only the views on such topics but also their evolution over time. Furthermore, the same technology that allows for content filtering with respect to decency can be used to filter political speech and to restrict access to political material. Thus, if censorship does not appear to be an option, a possible solution might be labeling. The idea is that consumers will be better informed in their decisions to avoid objectionable content.

The rapid increase in computing and communications power has raised considerable concern about privacy both in the public and private sector. Decreases in the cost of data storage and information processing make it likely that it will become practicable for both government and private data-mining enterprises to collect detailed dossiers on all citizens. Nobody knows who currently collects data about individuals, how this data is used and shared or how this data might be misused. These concerns lower the consumers' trust in online institutions and communication and, thus, inhibit the development of electronic commerce. A technological approach to protecting privacy might by cryptography although it might be claimed that cryptography presents a serious barrier to criminal investigations. It is popular wisdom that people today suffer information overload. A lot of the information available on the Internet is incomplete and even incorrect. People spend more and more of their time absorbing irrelevant information just because it is available and they think they should know about it. Therefore, it must be studied how people assign credibility to the information they collect in order to invent and develop new credibility systems to help consumers to manage the information overload.

Technological progress inevitably creates dependence on technology. Indeed the creation of vital infrastructure ensures dependence on that infrastructure. As surely as the world is now dependent on its transport, telephone, and other infrastructures, it will be dependent on the emerging information infrastructure. Dependence on technology can bring risks. Failures in the technological infrastructure can cause the collapse of economic and social functionality. Blackouts of long-distance telephone service, credit data systems, and electronic funds transfer systems, and other such vital communications and information processing services would undoubtedly cause widespread economic disruption. However, it is probably impossible to avoid technological dependence. Therefore, what must be considered is the exposure brought from dependence on technologies with a recognizable probability of failure, no workable substitute at hand, and high costs as a result of failure?

8.4.3 What does information technology encompass?

It's been said that data is what powers industries worldwide. That may be hyperbole, but few businesses large or small can remain competitive without the ability to collect data and turn it into useful information. IT provides the means to develop, process, analyze, exchange, store and secure information.

The IT department ensures that the organization's systems, networks, data and applications all connect and function properly. The IT team handles three major areas:

- deploys and maintains business applications, services and infrastructure (servers, networks, storage);
- monitors, optimizes and troubleshoots the performance of applications, services and infrastructure; and
- Oversees the security and governance of applications, services and infrastructure.

Most IT staff have different responsibilities within the team that break into several key areas including:

- ***Administration.*** Administrators handle the day-to-day deployment, operation and monitoring of an IT environment, including systems, networks and applications. Admins often perform a range of other duties such as software upgrades, user training, software license management, procurement, security, data management and observing adherence to business process and compliance requirements.
- ***Support.*** Help desk staff specialize in answering questions, gathering information and directing troubleshooting efforts for hardware and software. IT support often includes IT asset and change management, helping admins with procurement, handling backup and recovery of data and applications, monitoring and analyzing logs and other performance monitoring tools and following established support workflows and processes.
- ***Applications.*** Businesses rely on software to perform work. Some applications are procured and deployed from third parties, such as email server applications. But many organizations retain a staff of skilled developers that create the applications and interfaces -- such as APIs -- needed to deliver critical business capabilities and services. Applications might be coded in a wide array of popular languages and integrated with other applications to create smooth and seamless interactions between different applications. Developers might also be tasked with creating interactive business websites and building mobile applications. The trend toward agile or continuous development paradigms require developers to be increasingly involved with IT operations, such as deploying and monitoring applications.

- ***Compliance.*** Businesses are obligated to observe varied government- and industry-driven regulatory requirements. IT staff play a major role in securing and monitoring access to business data and applications to ensure that such resources are used according to established business governance policy that meets regulatory requirements. Such staff are deeply involved with security tasks and routinely interact with legal and business teams to prevent, detect, investigate and report possible breaches.

Data processing plays a significant role in these core business practices, among others, including:

- product development and design;
- marketing and market research;
- sales and invoicing;
- customer development and retention;
- accounting and taxes;
- human resources and payroll; and
- Regulatory compliance.

Computing has penetrated practically every part of business and much of our personal lives. The ubiquity of computing -- also referred to as pervasive computing -- is another reason why IT is critical. Computing devices have evolved well beyond personal computers and servers. Today, all businesses and most individuals have and use multiple computing devices, including phones, tablets, laptops, game consoles and even doorbells, thermostats, vacuums and many kitchen appliances.

Virtually all these devices, many of which are part of the IoT, tap into the internet, which interconnects billions of devices worldwide. It's a complex and, potentially, perilous environment that requires IT expertise for management, security, maintenance and reliability.

Examples of Information Technology

So how is IT actually involved in day-to-day business? Consider five common examples of IT and teams at work:

- ***Server upgrade.*** One or more data center servers near the end of their operational and maintenance lifecycle. IT staff will select and procure replacement servers, configure and deploy the new servers, backup applications and data on existing servers, transfer that data and applications to the new servers, validate that the new servers are working properly and then repurpose or decommission and dispose of the old servers.

- ***Security monitoring.*** Businesses routinely employ tools to monitor and log activity in applications, networks and system IT staff receive alerts of potential threats or noncompliant behavior -- such as a user attempting to access a restricted file -- check logs and other reporting tools to investigate and determine the root cause of the alert and take prompt action to address and remediate the threat, often driving changes and improvements to security posture that can prevent similar events in the future.
- ***New software.*** The business determines a need for a new mobile application that can allow customers to log in and access account information or conduct other transactions from smartphones and tablets. Developers work to create and refine a suitable application according to a planned roadmap. Operations staff posts each iteration of the new mobile application for download and deploy the back-end components of the app to the organization's infrastructure.
- ***Business improvement.*** A business requires more availability from a critical application to help with revenue or business continuance strategies. The IT staff might be called upon to architect a high-availability cluster to provide greater performance and resilience for the application to ensure that the application can continue to function in the face of single outages. This can be paired with enhancements to data storage protection and recovery.
- ***User support.*** Developers are building a major upgrade for a vital business application. Developers and admins will collaborate to create new documentation for the upgrade. IT staff might deploy the upgrade for limited beta testing -- allowing a select group of users to try the new version -- while also developing and delivering comprehensive training that prepares all users for the new version's eventual release.

8.4.4 Information System

Information system, an integrated set of components for collecting, storing, and processing data and for providing information, knowledge, and digital products. Business firms and other organizations rely on information systems to carry out and manage their operations, interact with their customers and suppliers, and compete in the marketplace. Information systems are used to run interorganizational supply chains and electronic markets. For instance, corporations use information systems to process financial accounts, to manage their human resources, and to reach their potential customers with online promotions. Many major companies are built entirely around information systems. These include eBay, a largely auction marketplace; Amazon, an expanding electronic mall and provider of cloud computing services; Alibaba, a business-to-business e-marketplace; and Google, a search engine company that derives most of its revenue from keyword advertising on Internet searches. Governments deploy information systems to provide services cost-effectively to citizens. Digital goods—such as electronic books, video products, and software—and online services, such as gaming and social networking, are delivered with information systems. Individuals rely on information systems, generally Internet-based, for conducting much of their personal lives: for socializing, study, shopping, banking, and entertainment.

As major new technologies for recording and processing information were invented over the millennia, new capabilities appeared, and people became empowered. The invention of the printing press by Johannes Gutenberg in the mid-15th century and the invention of a mechanical calculator by Blaise Pascal in the 17th century are but two examples. These inventions led to a profound revolution in the ability to record, process, disseminate, and reach for information and knowledge. This led, in turn, to even deeper changes in individual lives, business organization, and human governance.

The first large-scale mechanical information system was Herman Hollerith's census tabulator. Invented in time to process the 1890 U.S. census, Hollerith's machine represented a major step in automation, as well as an inspiration to develop computerized information systems.

One of the first computers used for such information processing was the UNIVAC I, installed at the U.S. Bureau of the Census in 1951 for administrative use and at General Electric in 1954 for commercial use. Beginning in the late 1970s, personal computers brought some of the advantages of information systems to small businesses and to individuals. Early in the same decade the Internet began its expansion as the global network of networks. In 1991 the World Wide Web, invented by Tim Berners-Lee as a means to access the interlinked information stored in the globally dispersed computers connected by the Internet, began operation and became the principal service delivered on the network. The global penetration of the Internet and the Web has enabled access to information and other resources and facilitated the forming of relationships among people and organizations on an unprecedented scale. The progress of electronic commerce over the Internet has resulted in a dramatic growth in digital interpersonal communications (via e-mail and social networks), distribution of products (software, music, e-books, and movies), and business transactions (buying, selling, and advertising on the Web). With the worldwide spread of smartphones, tablets, laptops, and other computer-based mobile devices, all of which are connected by wireless communication networks, information systems have been extended to support mobility as the natural human condition. As information systems enabled more diverse human activities, they exerted a profound influence over society. These systems quickened the pace of daily activities, enabled people to develop and maintain new and often more-rewarding relationships, affected the structure and mix of organizations, changed the type of products bought, and influenced the nature of work. Information and knowledge became vital economic resources. Yet, along with new opportunities, the dependence on information systems brought new threats. Intensive industry innovation and academic research continually develop new opportunities while aiming to contain the threats.

8.4.5 Components of Information Systems

The main components of information systems are computer hardware and software, telecommunications, databases and data warehouses, human resources, and procedures. The hardware, software, and telecommunications constitute information technology (IT), which is now ingrained in the operations and management of organizations.

Computer hardware

Today throughout the world even the smallest firms, as well as many households, own or lease computers. Individuals may own multiple computers in the form of smartphones, tablets, and other wearable devices. Large organizations typically employ distributed computer systems, from powerful parallel-processing servers located in data centers to widely dispersed personal computers and mobile devices, integrated into the organizational information systems. Sensors are becoming ever more widely distributed throughout the physical and biological environment to gather data and, in many cases, to effect control via devices known as actuators. Together with the peripheral equipment—such as magnetic or solid-state storage disks, input-output devices, and telecommunications gear—these constitute the hardware of information systems. The cost of hardware has steadily and rapidly decreased, while processing speed and storage capacity have increased vastly. This development has been occurring under Moore's law: the power of the microprocessors at the heart of computing devices has been doubling approximately every 18 to 24 months. However, hardware's use of electric power and its environmental impact are concerns being addressed by designers. Increasingly, computer and storage services are delivered from the cloud—from shared facilities accessed over **telecommunications** networks.

Keyword

Telecommunication is the transmission of information by various types of technologies over wire, radio, optical, or other electromagnetic systems.

Computer software

Computer software falls into two broad classes: system software and application software. The principal system software is the operating system. It manages the hardware, data and program files, and other system resources and provides means for the user to control the computer, generally via a graphical user interface

(GUI). Application software is programs designed to handle specific tasks for users. Smartphone apps became a common way for individuals to access information systems. Other examples include general-purpose application suites with their spreadsheet and word-processing programs, as well as "vertical" applications that serve a specific industry segment—for instance, an application that schedules, routes, and tracks package deliveries for an overnight carrier. Larger firms use licensed applications developed and maintained by specialized software companies, customizing them to meet their specific needs, and develop other applications in-house or on an outsourced basis. Companies may also use applications delivered as software-as-a-service (SaaS) from the cloud over the Web. Proprietary software, available from and supported by its vendors, is being challenged by open-source software available on the Web for free use and modification under a license that protects its future availability.

Telecommunications

Telecommunications are used to connect, or network, computer systems and portable and wearable devices and to transmit information. Connections are established via wired or wireless media. Wired technologies include coaxial cable and fiber optics. Wireless technologies, predominantly based on the transmission of microwaves and radio waves, support mobile computing. Pervasive information systems have arisen with the computing devices embedded in many different physical objects. For example, sensors such as radio frequency identification devices (RFIDs) can be attached to products moving through the supply chain to enable the tracking of their location and the monitoring of their condition. Wireless sensor networks that are integrated into the Internet can produce massive amounts of data that can be used in seeking higher productivity or in monitoring the environment.

Various computer network configurations are possible, depending on the needs of an organization. Local area networks (LANs) join computers at a particular site, such as an office building or an academic campus. Metropolitan area networks (MANs) cover a limited densely populated area and are the electronic infrastructure of "smart cities." Wide area networks (WANs) connect widely distributed data centers, frequently run by different organizations. Peer-to-peer networks, without a centralized control, enable broad sharing of content. The Internet is a network of networks, connecting billions of computers located on every continent. Through networking, users gain access to information resources, such as large databases, and to other individuals, such as coworkers, clients, friends, or people who share their professional or private interests. Internet-type services can be provided within an organization and for its exclusive use by various intranets that are accessible through a browser; for example, an intranet may be deployed as an access portal to a shared corporate document base. To connect with business partners over the Internet in a private and secure manner, extranets are established as so-called virtual private networks (VPNs) by encrypting the messages.

A massive “Internet of things” has emerged, as sensors and actuators have been widely distributed in the physical environment and are supplying data, such as acidity of a square yard of soil, the speed of a driving vehicle, or the blood pressure of an individual. The availability of such information enables a rapid reaction when necessary as well as sustained decision making based on processing of the massive accumulated data.

Extensive networking infrastructure supports the growing move to cloud computing, with the information-system resources shared among multiple companies, leading to utilization efficiencies and freedom in localization of the data centers. Software-defined networking affords flexible control of telecommunications networks with algorithms that are responsive to real-time demands and resource availabilities.

Databases and Data Warehouses

Many information systems are primarily delivery vehicles for data stored in databases. A database is a collection of interrelated data organized so that individual records or groups of records can be retrieved to satisfy various criteria. Typical examples of databases include employee records and product catalogs. Databases support the operations and management functions of an enterprise. Data warehouses contain the archival data, collected over time, that can be mined for information in order to develop and market new products, serve the existing customers better, or reach out to potential new customers. Anyone who has ever purchased something with a credit card—in person, by mail order, or over the Web—is included within such data collections.

Massive collection and processing of the quantitative, or structured, data, as well as of the textual data often gathered on the Web, has developed into a broad initiative known as “big data.” Many benefits can arise from decisions based on the facts reflected by big data. Examples include evidence-based medicine, economy of resources as a result of avoiding waste, and recommendations of new products (such as books or movies) based on a user’s interests. Big data enables innovative business models. For example, a commercial firm collects the prices of goods by crowdsourcing (collecting from numerous independent individuals) via smartphones around the world. The aggregated data supplies early information on price movements, enabling more responsive decision making than was previously possible.

The processing of textual data—such as reviews and opinions articulated by individuals on social networks, blogs, and discussion boards—permits automated sentiment analysis for marketing, competitive intelligence, new product development, and other decision-making purposes.

Human resources and procedures

Qualified people are a vital component of any information system. Technical personnel include development and operations managers, business analysts, systems analysts and designers, database administrators, programmers, computer security specialists, and computer operators. In addition, all workers in an organization must be trained to utilize the capabilities of information systems as fully as possible. Billions of people around the world are learning about information systems as they use the Web.

REMEMBER

In the autonomous computing initiative, data centers are increasingly run automatically, with the procedures embedded in the software that controls those centers.

Procedures for using, operating, and maintaining an information system are part of its documentation. For example, procedures need to be established to run a payroll program, including when to run it, who is authorized to run it, and who has access to the output.

8.4.6 Types of Information Systems

Information systems support operations, knowledge work, and management in organizations. (The overall structure of organizational information systems is shown in the figure.) Functional information systems that support a specific organizational function, such as marketing or production, have been supplanted in many cases by cross-functional systems built to support complete business processes, such as order processing or employee management. Such systems can be more effective in the development and delivery of the firm's products and can be evaluated more closely with respect to the business outcomes.

Information systems consist of three layers: operational support, support of knowledge work, and management support. Operational support forms the base of an information system and contains various transaction processing systems for designing, marketing, producing, and delivering products and services. Support of knowledge work forms the middle layer; it contains subsystems for sharing information within an organization. Management support, forming the top layer, contains subsystems for managing and evaluating an organization's resources and goals.

Operational Support and Enterprise Systems

Transaction processing systems support the operations through which products are designed, marketed, produced, and delivered. In larger organizations, transaction processing is frequently accomplished with large integrated systems known as enterprise systems. In this case, the information systems that support various functional units—sales and marketing, production, finance, and human resources—are integrated into an enterprise resource planning (ERP) system, the principal kind of enterprise system. ERP systems support the value chain—that is, the entire sequence of activities or processes through which a firm adds value to its products. For example, an individual or another business may submit a custom order over the Web that automatically initiates just-in-time production to the customer's specifications through an approach known as mass customization. This involves sending orders from the customers to the firm's warehouses and perhaps to suppliers to deliver input materials just in time for a batched custom production run. Financial accounts are updated accordingly, and delivery logistics and billing are initiated.

Along with helping to integrate a firm's own value chain, transaction processing systems can also serve to integrate the overall supply chain of which the organization is a part. This includes all firms involved in designing, producing, marketing, and delivering the goods and services—from raw materials to the final delivery of the product. A supply chain management (SCM) system manages the flow of products, data, money, and information throughout the entire supply chain, which starts with the suppliers of raw materials, runs through the intermediate tiers of the processing companies, and ends with the distributors and retailers. For example, purchasing an item at a major retail store generates more than a cash register receipt: it also automatically sends a restocking order to the appropriate supplier, which in turn may call for orders to the supplier's suppliers. With an SCM system, suppliers can also access a retailer's inventory database over the Web to schedule efficient and timely deliveries in appropriate quantities.

The third type of enterprise system, customer relationship management (CRM), supports dealing with the company's customers in marketing, sales, service, and new product development. A CRM system gives a business a unified view of each customer and its dealings with that customer, enabling a consistent and proactive relationship. In cocreation initiatives, the customers may be involved in the development of the company's new products.

Many transaction processing systems support electronic commerce over the Internet. Among these are systems for online shopping, banking, and securities trading. Other systems deliver information, educational services, and entertainment on demand. Yet other systems serve to support the search for products with desired attributes (for example, keyword search on search engines), price discovery (via an auction, for example), and delivery of digital products (such as software, music, movies, or greeting cards). Social network sites, such as Facebook and LinkedIn, are a powerful tool for supporting customer communities and individuals as they articulate opinions, evolve new ideas, and are exposed to promotional messages. A growing array of specialized services and information-based products are offered by various organizations on the Web, as an infrastructure for electronic commerce has emerged on a global scale.

Transaction processing systems accumulate the data in databases and data warehouses that are necessary for the higher-level information systems. Enterprise systems also provide software modules needed to perform many of these higher-level functions.

Support of knowledge work

A large proportion of work in an information society involves manipulating abstract information and knowledge (understood in this context as an organized and comprehensive structure of facts, relationships, theories, and insights) rather than directly processing, manufacturing, or delivering tangible materials. Such work is called knowledge work. Three general categories of information systems support such knowledge work: professional support systems, collaboration systems, and knowledge management systems.

Professional support systems

Professional support systems offer the facilities needed to perform tasks specific to a given profession. For example, automotive engineers use computer-aided engineering (CAE) software together with virtual reality systems to design and test new models as electronic prototypes for fuel efficiency, handling, and passenger protection before producing physical prototypes, and later they use CAE in the design and analysis of physical tests. Biochemists use specialized three-dimensional modeling software to visualize the molecular structure and probable effect of new drugs before investing in lengthy clinical tests. Investment bankers often employ financial software to calculate the expected rewards and potential risks of various investment strategies. Indeed, specialized support systems are now available for most professions.

Collaboration systems

The main objectives of collaboration systems are to facilitate communication and teamwork among the members of an organization and across organizations. One type of collaboration system, known as a workflow system, is used to route relevant documents automatically to all appropriate individuals for their contributions.

Development, pricing, and approval of a commercial insurance policy is a process that can benefit from such a system. Another category of collaboration systems allows different individuals to work simultaneously on a shared project. Known as groupware, such systems accomplish this by allowing controlled shared access, often over an intranet, to the work objects, such as business proposals, new designs, or digital products in progress. The collaborators can be located anywhere in the world, and, in some multinational companies, work on a project continues 24 hours a day.

Other types of collaboration systems include enhanced e-mail and videoconferencing systems, sometimes with telepresence using avatars of the participants. Yet another type of collaboration software, known as wiki, enables multiple participants to add and edit content. (Some online encyclopaedias are produced on such platforms.) Collaboration systems can also be established on social network platforms or virtual life systems. In the open innovation initiative, members of the public, as well as existing and potential customers, can be drawn in, if desired, to enable the cocreation of new products or projection of future outcomes.

REMEMBER

Organizational knowledge is often tacit, rather than explicit, so these systems must also direct users to members of the organization with special expertise.

Knowledge management systems

Knowledge management systems provide a means to assemble and act on the knowledge accumulated throughout an organization. Such knowledge may include the texts and images contained in patents, design methods, best practices, competitor intelligence, and similar sources, with the elaboration and commentary included. Placing the organization's documents and communications in an indexed and cross-referenced form enables rich search capabilities. Numerous application programs, such as Microsoft's SharePoint, exist to facilitate the implementation of such systems.

Management Support

A large category of information systems comprises those designed to support the management of an organization. These systems rely on the data obtained by transaction processing systems, as well as on data and information acquired outside the organization (on the Web, for example) and provided by business partners, suppliers, and customers.

Management reporting systems

Information systems support all levels of management, from those in charge of short-term schedules and budgets for small work groups to those concerned with long-term plans and budgets for the entire organization. Management reporting systems provide routine, ed, and voluminous information reports specific to each manager's areas of responsibility. These systems are typically used by first-level supervisors. Generally, such reports focus on past and present activities, rather than projecting future performance. To prevent information overload, reports may be automatically sent only under exceptional circumstances or at the specific request of a manager.

Decision support systems and business intelligence

All information systems support decision making, however indirectly, but decision support systems are expressly designed for this purpose. As these systems are increasingly being developed to analyze massive collections of data (known as big data), they are becoming known as business intelligence, or business analytics, applications. The two principal varieties of decision support systems are model-driven and data-driven.

In a model-driven decision support system, a preprogrammed model is applied to a relatively limited data set, such as a sales database for the present quarter. During a typical session, an analyst or sales manager will conduct a dialog with this decision support system by specifying a number of what-if scenarios. For example, in order to establish a selling price for a new product, the sales manager may use a marketing decision support system. It contains a model relating various factors—the price of the product, the cost of goods, and the promotion expense in various media—to the projected sales volume over the first five years on the market. By supplying different product prices to the model, the manager can compare predicted results and select the most profitable selling price.

The primary objective of data-driven business intelligence systems is to analyze large pools of data, accumulated over long periods of time in data warehouses, in a process known as data mining. Data mining aims to discover significant patterns, such as sequences (buying a new house, followed by a new dinner table), clusters, and correlations (large families and van sales), with which decisions can be made. Predictive analytics attempts to forecast future outcomes based on the discovered trends. Data-driven decision support systems include a variety of statistical models and may rely on various artificial intelligence techniques, such as expert systems, neural networks, and machine learning. In addition to mining numeric data, text mining is conducted on large aggregates of unstructured data, such as the contents of social media that include social networks, wikis, blogs, and microblogs. As used in electronic commerce, for example, text mining helps in finding buying trends, targeting advertisements, and detecting fraud.

An important variety of decision support systems enables a group of decision makers to work together without necessarily being in the same place at the same time. These group decision systems include software tools for brainstorming and reaching consensus.

Another category, geographic information systems, can help analyze and display data by using digitized maps. Digital mapping of various regions is a continuing activity of numerous business firms. Such data visualization supports rapid decision making. By looking at a geographic distribution of mortgage loans, for example, one can easily establish a pattern of discrimination.

Executive information systems

Executive information systems make a variety of critical information readily available in a highly summarized and convenient form, typically via a graphical digital dashboard. Senior managers characteristically employ many informal sources of information, however, so that formal, computerized information systems are only of partial assistance. Nevertheless, this assistance is important for the chief executive officer, senior and executive vice presidents, and the board of directors to monitor the performance of the company, assess the business environment, and develop strategic directions for the future. In particular, these executives need to compare their organization's performance with that of its competitors and investigate general economic trends in regions or countries.

8.4.7 Acquiring Information Systems and Services

Information systems are a major corporate asset, with respect both to the benefits they provide and to their high costs. Therefore, organizations have to plan for the long term when acquiring information systems and services that will support business initiatives. At the same time, firms have to be responsive to emerging opportunities. On the basis of long-term corporate plans and the requirements of various individuals from data workers to top management, essential applications are identified and project priorities are set. For example, certain projects may have to be carried out immediately to satisfy a new government reporting regulation or to interact with a new customer's information system. Other projects may be given a higher priority because of their strategic role or greater expected benefits.

Once the need for a specific information system has been established, the system has to be acquired. This is generally done in the context of the already existing information systems architecture of the firm. The acquisition of information systems can either involve external sourcing or rely on internal development or modification. With today's highly developed IT industry, companies tend to acquire information systems and services from specialized vendors. The principal tasks of information systems specialists involve modifying the applications for their employer's needs and integrating the applications to create a coherent systems architecture for the firm. Generally, only smaller applications are developed internally. Certain applications of a more personal nature may be developed by the end users themselves.

8.4.8 Acquisition from External Sources

There are several principal ways to acquire an information system from outside the organization. Many firms have resorted to outsourcing their information systems. Outsourcing entails transferring the major components of the firm's systems and operations—such as data centers, telecommunications, and software development and maintenance—to a specialized company that provides its services under long-term contracts specifying the service levels (that is, the scope and the quality of service to be provided). In some cases the outsourcing entails moving the services abroad—i.e., offshoring in pursuit of the cost or expertise advantages. Responsibility for the acquisition of new applications then falls to the outside company. In other cases the company may outsource just the development or maintenance of their information systems, with the outside company being a systems developer.

Cloud computing is increasingly being adopted as a source of information services. It offers on-demand access via the Internet to services furnished by a provider that runs data centers with the necessary software and other resources. The services can be provided at one of three levels: as the infrastructure for running existing applications, as the platform for developing new applications, or as software-as-a-service (SaaS) to be used by the firm over the network. In particular, SaaS has become a cost-effective way to use enterprise systems. Generally, cloud computing is provided by external vendors, although some firms implement their own private clouds in order to share resources that employees can access over the network from a variety of devices, often including smartphones. Scalability and avoidance of capital expenditures are notable advantages of public clouds; the partial loss of control is a drawback.

Companies may choose to acquire an application by leasing a proprietary package from a vendor under a license and having the software customized internally or externally by the vendor or another outside contractor. Enterprise systems are generally leased in this way. An alternative is to deploy an open-source application, whose program code is free and open for all to modify under a different type of license that enforces the openness of the application in perpetuity. Generally, the costs of the use of open-source software include the technical support from specialized vendors.

8.4.9 Internal Information Systems Development

When an information system is developed internally by an organization, one of two broad methods is used: life-cycle development or rapid application development (RAD).

The same methods are used by software vendors, which need to provide more general, customizable systems. Large organizational systems, such as enterprise systems, are generally developed and maintained through a systematic process, known as a system life cycle, which consists of six stages: feasibility study, system analysis, system design, programming and testing, installation, and operation and maintenance. The first five stages are system development proper, and the last stage is the long-term exploitation. Following a period of use (with maintenance as needed), the information system may be either phased out or upgraded. In the case of a major upgrade, the system enters another development life cycle.

The principal objective of a feasibility study is to determine whether the system is desirable on the basis of long-term plans, strategic initiatives, and a cost-benefit analysis. The next stage, system design, results in an extensive blueprint for how the new system will be organized. During the programming and testing stage, the individual software modules of the system are developed, tested, and integrated into a coherent operational system. Further levels of testing ensure continuing quality control. Installation includes final testing of the system in the work environment and conversion of organizational operations to the new system, integrating it with other systems already in place. The later stages of development include such implementation activities as training users and modifying the organizational processes in which the system will be used.

Life-cycle development is frequently faulted for its long development times and voluminous documentation requirements—and, in some instances, for its failure to fulfill the user's requirements at the end of the long development road.

Increasingly, life-cycle development is being replaced by RAD. In various RAD methodologies a prototype—a preliminary working version of an application—is built quickly and inexpensively, albeit imperfectly. This prototype is turned over to the users, their reactions are collected, suggested modifications are incorporated, and successive prototype versions eventually evolve into the complete system. Formal processes for the collaboration between system developers and users, such as joint applications development (JAD), have been introduced by some firms. Sometimes RAD and life-cycle development are combined: a prototype is produced to determine user requirements during the initial system analysis stage, after which life-cycle development takes over. A version of RAD known as agile development aims to dispense with the notion of a prototype: an initial version of the system is built, released to users, and then subject to frequent modifications as needs arise.

Industrial methods of software production and reuse have been implemented in systems development. Thus, reusable software components are developed, tested, and catalogued to be deployed as parts of future information systems. A particularly important method of component-based development is the use of Web services, which are software objects that deliver a specific function (such as looking up a customer's order in a database) and can be stitched together into interorganizational information systems enabling business partners to cooperate.

After an installed system is handed over to its users and operations personnel, it will almost invariably be modified extensively over its useful life in a process known as system maintenance. A large system will typically be used and maintained for some 5 to 10 years or even longer. Most maintenance is to adjust the system to the organization's changing needs and to new equipment and other software, but inevitably some maintenance involves correcting design errors and exterminating software "bugs" as they are discovered.

Keyword

Information, in a general sense, is processed, organized and structured data.

8.4.10 Managing information systems

For an organization to use its **information** services to support its operations or to innovate by launching a new initiative, those services have to be part of a well-planned infrastructure of core resources. The specific systems ought to be configured into a coherent architecture to deliver the necessary information services. Many organizations rely on outside firms—that is, specialized IT companies—to deliver some, or even all, of their information services. If located in-house, the management of information systems can be decentralized to a certain degree to correspond to the organization's overall structure.

Information system infrastructure and architecture

A well-designed information system rests on a coherent foundation that supports responsive change—and, thus, the organization's agility—as new business or administrative initiatives arise. Known as the information system infrastructure, the foundation consists of core telecommunications networks, databases and data warehouses, software, hardware, and procedures managed by various specialists. With business globalization, an organization's infrastructure often crosses many national boundaries. Establishing and maintaining such a complex infrastructure requires extensive planning and consistent implementation to handle strategic corporate initiatives, transformations, mergers, and acquisitions. Information system infrastructure should be established in order to create meaningful options for future corporate development.

When organized into a coherent whole, the specific information systems that support operations, management, and knowledge work constitute the system architecture of an organization. Clearly, an organization's long-term general strategic plans must be considered when designing an information system infrastructure and architecture.

Organization of information services

Information services of an organization are delivered by an outside firm, by an internal unit, or by a combination of the two. Outsourcing of information services helps with such objectives as cost savings, access to superior personnel, and focusing on core competencies.

An information services unit is typically in charge of an organization's information systems. When the systems are largely outsourced, this unit is of a limited size and concentrates on aligning the systems with the corporate competitive strategy and on supervising the outside company's services. When information services are provided in-house and centralized, this unit is responsible for planning, acquiring, operating, and maintaining information systems for the entire organization. In decentralized structures, however, the central unit is responsible only for planning and maintaining the infrastructure, while business and administrative specialists supervise systems and services for their own units. A variety of intermediate organizational forms are possible.

In many organizations, information systems are headed by a chief information officer (CIO) or a chief technology officer (CTO). The activities of information services are usually supervised by a steering committee consisting of the executives representing various functional units of the organization. Steering committees set the priorities for the development of future systems. In the organizations where information systems play a strategic role, boards of directors need to be involved in their governance. A vital responsibility of an information services unit is to ensure uninterrupted service and integrity of the systems and information in the face of many security threats.

8.4.11 Information Systems Security and Control

With the opening of information systems to the global Internet and with their thorough infusion into the operation and management of business and government organizations and into the infrastructure of daily life across the world, information security issues have moved to the forefront of concerns about global well-being.

Information Systems Security

Information systems security is responsible for the integrity and safety of system resources and activities. Most organizations in developed countries are dependent on the secure operation of their information systems. In fact, the very fabric of societies often depends on this security. Multiple infrastructural grids—including power, water supply, and health care—rely on it. Information systems are at the heart of intensive care units and air traffic control systems. Financial institutions could not survive a total failure of their information systems for longer than a day or two. Electronic funds transfer systems (EFTS) handle immense amounts of money that exist only as electronic signals sent over the networks or as spots on storage disks. Information systems are vulnerable to a number of threats and require strict controls, such as continuing countermeasures and regular audits to ensure that the system remains secure. (The relationship among security measures is shown in the figure.)

Although instances of computer crime and abuse receive extensive media attention, human error is estimated to cause greater losses in information systems operation. Disasters such as earthquakes, floods, and fires are the particular concern of disaster recovery planning, which is a part of a corporate business continuity plan. A contingency scheme is also necessary to cover the failure of servers, telecommunications networks, or software.

8.4.12 Computer crime and abuse

Computer crime—illegal acts in which computers are the primary tool—costs the world economy many billions of dollars annually. Computer abuse does not rise to the level of crime, yet it involves unethical use of a computer. The objectives of the so-called hacking of information systems include vandalism, theft of consumer information, governmental and commercial espionage, sabotage, and cyberwar. Some of the more widespread means of computer crime include phishing and planting of malware, such as computer viruses and worms, Trojan horses, and logic bombs.

Phishing involves obtaining a legitimate user's login and other information by subterfuge via messages fraudulently claiming to originate with a legitimate entity, such as a bank or government office. A successful phishing raid to obtain a user's information may be followed by identity theft, an impersonation of the user to gain access to the user's resources.

Computer viruses are a particularly common form of attack. These are program instructions that are able not only to perform malicious acts but also to insert copies of themselves into other programs and thus spread to other computer systems. Similar to viruses, worms are complete computer programs that replicate and propagate through telecommunications networks. Because of their ability to spread rapidly and widely, viruses and worms can inflict immense damage. The damage can be in the form of tampering with system operation, theft of large volumes of data (e.g., credit card numbers), known as data breach, or denial of service by overloading systems with a barrage of spurious requests.

In a Trojan horse attack, the malefactor conceals unauthorized instructions within an authorized program. A logic bomb consists of hidden instructions, often introduced with the Trojan horse technique, that stay dormant until a specific event occurs, at which time the instructions are activated. In one well-known case, in 1985 a programmer at an insurance company in Fort Worth, Texas, placed a logic bomb in his company's human resources system; when he was fired and his name was deleted from the company's employee database, the entire database was erased.

Once a system connected to the Internet is invaded, it may be used to take over many others and organize them into so-called botnets that can launch massive attacks against other systems to steal information or sabotage their operation. There is a growing concern that, in the "Internet of things," computer-controlled devices such as refrigerators or TV sets may be deployed in botnets. The variety of devices makes them difficult to control against malware.

8.4.13 Information systems controls

To ensure secure and efficient operation of information systems, an organization institutes a set of procedures and technological measures called controls. Information systems are safeguarded through a combination of general and application controls.

General controls apply to information system activities throughout an organization. The most important general controls are the measures that control access to computer systems and the information stored there or transmitted over telecommunications networks. General controls include administrative measures that restrict employees' access to only those processes directly relevant to their duties. As a result, these controls limit the damage that any individual employee or employee impersonator can do. Fault-tolerant computer systems installed in critical environments, such as in hospital information systems or securities marketplaces, are designed to control and isolate problems so that the system can continue to function. Backup systems, often in remote locations, may be activated in the case of failure of the primary information system.

Application controls are specific to a given application and include such measures as validating input data, logging the accesses to the system, regularly archiving copies of various databases, and ensuring that information is disseminated only to authorized users.

Securing information

Controlling access to information systems became profoundly more difficult with the spread of wide area networks (WANs) and, in particular, the Internet. Users, as well as interlopers, may access systems from any unattended computer within an organization or from virtually anywhere over the Internet. As a security measure, each legitimate user has a unique name and a regularly changed password. Another security measure is to require some form of physical authentication, such as an object (a physical token or a smart card) or a personal characteristic (fingerprint, retinal pattern, hand geometry, or signature). Many systems combine these types of measures—such as automatic teller machines, which rely on a combination of a personal identification number (PIN) and an identification card. Security measures placed between an organization's internal networks and the Internet are known as firewalls. These combinations of hardware and software continually filter the incoming, and often outgoing, data traffic.

A different way to prohibit access to information is via data encryption, which has gained particular importance in electronic commerce. Public key encryption is used widely in such commerce. To ensure confidentiality, only the intended addressee has the private key needed to decrypt messages that have been encrypted with the addressee's public key. Furthermore, authentication of both parties in an electronic transaction is possible through the digital certificates issued to both parties by a trusted third party and the use of digital signatures—an additional code attached to the message to verify its origin. A type of antitampering code can also be attached to a message to detect corruption. Similar means are available to ensure that parties to an electronic transaction cannot later repudiate their participation. Some messages require additional attributes. For example, a payment in electronic cash is a type of message, with encryption used to ensure the purchaser's anonymity, that acts like physical cash.

To continually monitor information systems, intrusion detection systems are used. They detect anomalous events and log the information necessary to produce reports and to establish the source and the nature of the possible intrusion. More active systems also attempt to prevent the intrusion upon detection in real time.

Information systems audit

The effectiveness of an information system's controls is evaluated through an information systems audit. An audit aims to establish whether information systems are safeguarding corporate assets, maintaining the integrity of stored and communicated data, supporting corporate objectives effectively, and operating efficiently. It is a part of a more general financial audit that verifies an organization's accounting records and financial statements. Information systems are designed so that every financial transaction can be traced. In other words, an audit trail must exist that can establish where each transaction originated and how it was processed. Aside from financial audits, operational audits are used to evaluate the effectiveness and efficiency of information systems operations, and technological audits verify that information technologies are appropriately chosen, configured, and implemented.

8.4.14 Impacts of information systems

Computerized information systems, particularly since the arrival of the Web and mobile computing, have had a profound effect on organizations, economies, and societies, as well as on individuals whose lives and activities are conducted in these social aggregates.

Organizational impacts of information systems

Essential organizational capabilities are enabled or enhanced by information systems. These systems provide support for business operations; for individual and group decision making; for innovation through new product and process development; for relationships with customers, suppliers, and partners; for pursuit of competitive advantage; and, in some cases, for the business model itself (e.g., Google). Information systems bring new options to the way companies interact and compete, the way organizations are structured, and the way workplaces are designed. In general, use of Web-based information systems can significantly lower the costs of communication among workers and firms and cost-effectively enhance the coordination of supply chains or webs. This has led many organizations to concentrate on their core competencies and to outsource other parts of their value chain to specialized companies. The capability to communicate information efficiently within a firm has led to the deployment of flatter organizational structures with fewer hierarchical layers.

Nevertheless, information systems do not uniformly lead to higher profits. Success depends both on the skill with which information systems are deployed and on their use being combined with other resources of the firm, such as relationships with business partners or superior knowledge in the industrial segment.

The use of information systems has enabled new organizational structures. In particular, so-called virtual organizations have emerged that do not rely on physical offices and standard organizational charts. Two notable forms of virtual organizations are the network organization and the cluster organization.

In a network organization, long-term corporate partners supply goods and services through a central hub firm. Together, a network of relatively small companies can present the appearance of a large corporation. Indeed, at the core of such an organization may be nothing more than a single entrepreneur supported by only a few employees. Thus, network organization forms a flexible ecosystem of companies, whose formation and work is organized around Web-based information systems.

In a cluster organization, the principal work units are permanent and temporary teams of individuals with complementary skills. Team members, who are often widely dispersed around the globe, are greatly assisted in their work by the use of Web resources, corporate intranets, and collaboration systems. Global virtual teams are able to work around the clock, moving knowledge work electronically "to follow the sun." Information systems delivered over mobile platforms have enabled employees to work not just outside the corporate offices but virtually anywhere. "Work is the thing you do, not the place you go to" became the slogan of the emerging new workplace. Virtual workplaces include home offices, regional work centers, customers' premises, and mobile offices of people such as insurance adjusters. Employees who work in virtual workplaces outside their company's premises are known as teleworkers.

8.4.15 Information Systems in the Economy and Society

Along with the global transportation infrastructure, network-based information systems have been a factor in the growth of international business and corporations. A relationship between the deployment of information systems and higher productivity has been shown in a number of industries when these systems complement other corporate resources. Electronic commerce has moved many relationships and transactions among companies and individuals to the Internet and the Web, with the resulting expansion of possibilities and efficiencies. The development of the Internet-based ecosystem—accompanied by the low cost of hardware and telecommunications, the availability of open-source software, and the mass global access to mobile phones—has led to a flowering of entrepreneurial activity and the emergence to prominence and significant market value of numerous firms based on new business models. Among the examples are electronic auction firms, search engine firms, electronic malls, social network platforms, and online game companies. Because of the vast opportunities for moving work with data, information, and knowledge in electronic form to the most cost-effective venue, a global redistribution of work has been taking place.

As the use of information systems became pervasive in advanced economies and societies at large, several societal and ethical issues moved into the forefront. The most important are issues of individual privacy, property rights, universal access and free speech, information accuracy, and quality of life.

Individual privacy hinges on the right to control one's personal information. While invasion of privacy is generally perceived as an undesirable loss of autonomy, government and business organizations do need to collect data in order to facilitate administration and exploit sales and marketing opportunities. Electronic commerce presents a particular challenge to privacy, as personal information is routinely collected and potentially disseminated in a largely unregulated manner. The ownership of and control over the personal profiles, contacts, and communications in social networks are one example of a privacy issue that awaits resolution through a combination of market forces, industry self-regulation, and possibly government regulation. Preventing invasions of privacy is complicated by the lack of an international legal standard.

Intellectual property, such as software, books, music, and movies, is protected, albeit imperfectly, by patents, trade secrets, and copyrights. However, such intangible goods can be easily copied and transmitted electronically over the Web for unlawful reproduction and use. Combinations of legal statutes and technological safeguards, including antipiracy encryption and electronic watermarks, are in place, but much of the abuse prevention relies on the ethics of the user. The means of protection themselves, such as patents, play a great role in the information society. However, the protection of business methods (e.g., Amazon's patenting of one-click ordering) is being questioned, and the global enforcement of intellectual property protection encounters various challenges.

Access to information systems over the Web is necessary for full participation in modern society. In particular, it is desirable to avoid the emergence of digital divides between nations or regions and between social and ethnic groups. Open access to the Web as a medium for human communication and as a repository for shared knowledge is treasured. Indeed, many people consider free speech a universal human right and the Internet and Web the most widely accessible means to exercise that right. Yet, legitimate concerns arise about protecting children without resorting to censorship. Technological solutions, such as software that filters out pornography and inappropriate communications, are partially successful.

Of concern to everyone is the accuracy and security of information contained in databases and data warehouses—whether in health and insurance data, credit bureau records, or government files—as misinformation or privileged information released inappropriately can adversely affect personal safety, livelihood, and everyday life. Individuals must cooperate in reviewing and correcting their files, and organizations must ensure appropriate security, access to, and use of such files.

Information systems have affected the quality of personal and working lives. In the workplace, information systems can be deployed to eliminate tedious tasks and give workers greater autonomy, or they can be used to thoughtlessly eliminate jobs and subject the remaining workforce to pervasive electronic surveillance. Consumers can use the Web for shopping, networking, and entertainment—but at the risk of contending with spam (unsolicited e-mail), interception of credit card numbers, and attack by computer viruses.

Information systems can expand participation of ordinary citizens in government through electronic elections, referendums, and polls and also can provide electronic access to government services and information—permitting, for instance, electronic filing of taxes, direct deposit of government checks, and viewing of current and historical government documents. More transparent and beneficial government operations are possible by opening the data collected by and about governments to public scrutiny in a searchable and easy-to-use form. With the Web, the public sphere of deliberation and self-organization can expand and give voice to individuals. However, information systems have also conjured Orwellian images of government surveillance and business intrusion into private lives. It remains for society to harness the power of information systems by strengthening legal, social, and technological means.

With the exponentially growing power of computers, driven by Moore's law, and the development of ever more-sophisticated software—in particular, systems deploying the techniques of artificial intelligence (AI)—job markets and professions have been affected. Flexible and inexpensive robotics reduces some opportunities in the labor markets. Cognitive computing, with systems relying on AI techniques—such as computer learning, pattern recognition in multiple media, and massive amounts of stored information—emerged as a competitor to human professionals.

The emergence of the "on-demand economy," enabled by information system platforms, has raised concerns about the quality of jobs. Providing instant access to services, such as transportation, the platforms (for example, Uber and Lyft) connect the service suppliers, usually individuals, with those seeking the service. Although claimed to erode stable workplaces, such business models offer flexibility, a larger measure of independence to the suppliers, and convenience to the demanders.

Information systems as a field of study

Information systems is a discipline of study that is generally situated in business schools. The essential objective of the discipline is to develop and study the theories, methods, and systems of using information technology to operate and manage organizations and to support their marketplace offerings. The discipline employs a sociotechnical approach, placing the study of information technology in the context of management, organizations, and society. The academic study of information systems originated in the 1960s. The scholarly society furthering the development of the discipline is the Association for Information Systems (AIS).

SUMMARY

- Spreadsheet, computer program that represents information in a two-dimensional grid of data, along with formulas that relate the data.
- A spreadsheet is a computer application for organization, analysis, and storage of data in tabular form. Spreadsheets were developed as computerized analogs of paper accounting worksheets.
- Spreadsheets are used for organizing and analyzing numeric data. While many spreadsheet packages are designed to work on specific operating systems, some can be used cross-platform.
- The main concepts are those of a grid of cells, called a sheet, with either raw data, called values, or formulas in the cells. Formulas say how to mechanically compute new values from existing values.
- This object design enabled variables and whole models to reference each other with user-defined variable names and to perform multidimensional analysis and massive, but easily editable consolidations.
- Spreadsheets are a popular end-user development tool. EUD denotes activities or techniques in which people who are not professional developers create automated behavior and complex data objects without significant knowledge of a programming language.
- Spreadsheet risk is the risk associated with deriving a materially incorrect value from a spreadsheet application that will be utilized in making a related (usually numerically-based) decision.
- The main components of information systems are computer hardware and software, telecommunications, databases and data warehouses, human resources, and procedures.
- Many information systems are primarily delivery vehicles for data stored in databases. A database is a collection of interrelated data organized so that individual records or groups of records can be retrieved to satisfy various criteria.

KNOWLEDGE CHECK

1. The files that are created with Spreadsheet software are called

a. Package
b. Program
c. Worksheet
d. Spreadsheet

2. Which is used to calculate and analyze a set of numbers?

a. Improve
b. StarCalc
c. Spreadsheet
d. Database

3. A Spreadsheet, sometimes is called as

a. Cells
b. Worksheet
c. Menus
d. Notebook pages

4. Which of the following isn't a part of a spreadsheet?

a. row number
b. column number
c. column letter
d. cell address

5. Spreadsheets cannot:

a. do calculations
b. create graphics
c. plot graphs
d. plot charts

REVIEW QUESTIONS

1. Discuss about history of spreadsheets.
2. Explain the types of spreadsheet packages.
3. Discuss about shortcomings and spreadsheet risk.
4. Differentiate between a workbook, worksheet, and spreadsheet.

5. What is an active worksheet?
6. How to Create a Spreadsheet?
7. How to Use Function Wizard in Excel?
8. Explain the types of information systems.

Check Your Result

1. (c) 2. (c) 3. (b) 4. (b) 5. (b)

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CHAPTER 9

RELEVANT TOOLS, STANDARDS, AND/OR ENGINEERING CONSTRAINTS

LEARNING OBJECTIVES

After studying this chapter, you will be able to:

1. Overview of CASE tools
2. Focus on software standard
3. Explain the Engineering constraints
4. Focus on history and overview software engineering

"It is essential to have good tools, but it is also essential that the tools should be used in the right way."

–Wallace D. Wattles

INTRODUCTION

Software development is the process of conceiving, specifying, designing, programming, documenting, testing, and bug fixing involved in creating and maintaining applications, frameworks, or other software components. Software development is a process of writing and maintaining the source code, but in a broader sense, it includes all that is involved between the conception of the desired software through to the final manifestation of the software, sometimes in a planned and structured process. Therefore, software development may include research, new development, prototyping, modification, reuse, re-engineering, maintenance, or any other activities that result in software products. A computer program that is used by the software developers for creating, editing, maintaining, supporting and debugging other applications, frameworks and programs – is termed as a Software Development Tool or a Software Programming Tool. Development tools can be of many forms like linkers, compilers, code editors, GUI designer, assemblers, debugger, performance analysis tools etc. There are certain factors to be considered while selecting the corresponding development tool, based on the type of the project.

9.1 OVERVIEW OF CASE TOOLS

CASE stands for Computer Aided Software Engineering. It means, development and maintenance of software projects with help of various automated software tools.

CASE tools are set of software application programs, which are used to automate SDLC activities. CASE tools are used by software project managers, analysts and engineers to develop software system.

REMEMBER

CASE tools can be grouped together if they have similar functionality, process activities and capability of getting integrated with other tools.

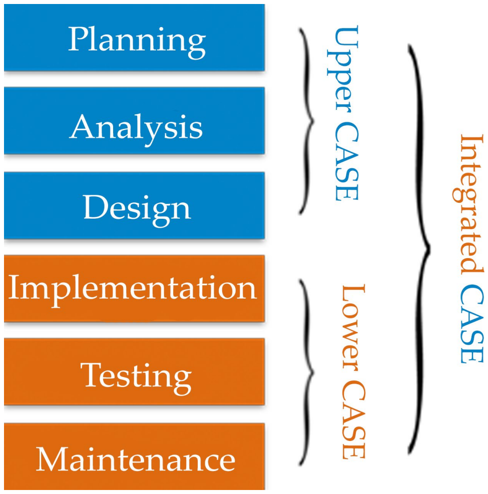
There are number of CASE tools available to simplify various stages of Software Development Life Cycle such as Analysis tools, Design tools, Project management tools, Database Management tools, Documentation tools are to name a few.

Use of CASE tools accelerates the development of project to produce desired result and helps to uncover flaws before moving ahead with next stage in software development.

9.1.1 Components of CASE Tools

CASE tools can be broadly divided into the following parts based on their use at a particular SDLC stage:

- **Central Repository** - CASE tools require a central repository, which can serve as a source of common, integrated and consistent information. Central repository is a central place of storage where product specifications, requirement documents, related reports and diagrams, other useful information regarding management is stored. Central repository also serves as data dictionary.



- **Upper Case Tools** - Upper CASE tools are used in planning, analysis and design stages of SDLC.
- **Lower Case Tools** - Lower CASE tools are used in implementation, testing and maintenance.
- **Integrated Case Tools** - Integrated CASE tools are helpful in all the stages of SDLC, from Requirement gathering to Testing and documentation.

9.1.2 Scope of Case Tools

The scope of CASE tools goes throughout the SDLC.

Case Tools Types

Now we briefly go through various CASE tools

Diagram Tools

These tools are used to represent system components, data and control flow among various software components and system structure in a graphical form. For example, Flow Chart Maker tool for creating state-of-the-art flowcharts.

Process Modeling Tools

Process modeling is method to create software process model, which is used to develop the software. Process modeling tools help the managers to choose a process model or modify it as per the requirement of software product. For example, EPF Composer.

Project Management Tools

These tools are used for project planning, cost and effort estimation, project scheduling and resource planning. Managers have to strictly comply project execution with every mentioned step in software project management. Project management tools help in storing and sharing project information in real-time throughout the organization. For example, Creative Pro Office, Trac Project, Basecamp.

Documentation Tools

Documentation in a software project starts prior to the software process, goes throughout all phases of SDLC and after the completion of the project.

Documentation tools generate documents for technical users and end users. Technical users are mostly in-house professionals of the development team who refer to system manual, reference manual, training manual, installation manuals etc. The end user documents describe the functioning and how-to of the system such as user manual. For example, Doxygen, DrExplain, Adobe RoboHelp for documentation.

Analysis Tools

These tools help to gather requirements, automatically check for any inconsistency, inaccuracy in the diagrams, data redundancies or erroneous omissions. For example, Accept 360, Accompa, CaseComplete for requirement analysis, Visible Analyst for total analysis.

Design Tools

These tools help software designers to design the block structure of the software, which may further be broken down in smaller modules using refinement techniques. These tools provides detailing of each module and interconnections among modules. For example, Animated Software Design.

Configuration Management Tools

An instance of software is released under one version. Configuration Management tools deal with –

- Version and revision management
- Baseline configuration management
- Change control management

CASE tools help in this by automatic tracking, version management and release management. For example, Fossil, Git, Accu REV.

Change Control Tools

These tools are considered as a part of configuration management tools. They deal with changes made to the software after its baseline is fixed or when the software is first released. CASE tools automate change tracking, file management, code management and more. It also helps in enforcing change policy of the organization.

Programming Tools

These tools consist of programming environments like IDE (Integrated Development Environment), in-built modules library and simulation tools. These tools provide comprehensive aid in building software product and include features for simulation and testing. For example, Cscope to search code in C, Eclipse.

Prototyping Tools

Software prototype is simulated version of the intended software product. Prototype provides initial look and feel of the product and simulates few aspect of actual product.

Prototyping CASE tools essentially come with graphical libraries. They can create hardware independent user interfaces and design. These tools help us to build rapid prototypes based on existing information. In addition, they provide simulation of software prototype. For example, Serena prototype composer, Mockup Builder.

Web Development Tools

These tools assist in designing web pages with all allied elements like forms, text, script, graphic and so on. Web tools also provide live preview of what is being developed and how will it look after completion. For example, Fontello, Adobe Edge Inspect, Foundation 3, Brackets.

Quality Assurance Tools

Quality assurance in a software organization is monitoring the engineering process and methods adopted to develop the software product in order to ensure conformance of quality as per organization standards. QA tools consist of configuration and change control tools and software testing tools. For example, SoapTest, AppsWatch, JMeter.

Maintenance Tools

Software maintenance includes modifications in the software product after it is delivered. Automatic logging and error reporting techniques, automatic error ticket generation and root cause Analysis are few CASE tools, which help software organization in maintenance phase of SDLC. For example, Bugzilla for defect tracking, HP Quality Center.

9.1.3 Relevant Tools of Software Development

A software or a programming tool is a set of computer programs that are used by the developers to create, maintain, debug, or support other applications and programs.

Keyword

Performance Analysis is the process of studying or evaluating the performance of a particular scenario in comparison of the objective which was to be achieved.

Software development tools are simply tools (generally software themselves) that programmers practice to create other software. For Example – language libraries, code editors, debuggers, etc. Any software deploy tool that enables a programmer to build stable software matching the needs or goals of a customer is placed into this category.

Agile development tools can be of different types like linkers, compilers, code editors, GUI designers, assemblers, debuggers, **performance analysis** tools, and many others. There are some factors that need to consider while selecting the corresponding development tool, based on the type of design

Few of such factors are displayed below –

- Company criteria
- Usefulness of tool
- Integration of one tool with another

- Choosing an appropriate environment
- Learning curve

9.1.4 Why Do Software Development Tools Matter?

All professionals need software designing tools in order to do their jobs. A carpenter needs an assortment of hammers, saws, planes, tape measures and the like. An auto mechanic needs wrenches and sockets, ratchets and impact tools. A plumber needs pipe wrenches, brazing tools, saws, etc. Same way, software developers need the right software planning tools for accomplishing their respective assignments. Software development tools play a very important role in the IT field, although they are less substantial than the tools used by other professionals.

Software development tools can be things like interpreters that work directly with code, but they can also be tools that help to make the lives of developers simpler and easier. For instance, while a user panel assigned to answering the questions of programmers and sharing knowledge might not have a direct influence on the development of a particular piece of software, but it does provide relevant solutions for developers who necessitate answers to vital questions.

So, you can find a very wide variety of other options in the category of software development tools. Anything that might help to boost the efficiency and accuracy can be conceivably be added to this category, including communication tools like Slack, libraries like Stack Overflow, and repositories like GitHub.

In other words, the selection of software engineering tools to be used in its development process can completely shape or break a project. Once the targeted ecosystem and programming language(s) are chosen, and the requirements and end goals are also well-enough understood, the next task is starting the work of a software development project is to choose the tools that will be utilized throughout the process. It's also important to be knowledgeable of the types of tools that are available for employment, their benefits, and the implications for using them.

Where Are Development Tools Found?

You can find software development tools in many different places, and in numerous different configurations. For instance, APIs comprises of tools that enable software developers to achieve a specific goal, such as programming language libraries. SDKs include a very wide range of programming tools that allow programmers to create software for specific platforms and systems. Integrated development environments provide entire toolbars for programmers, allowing them to create programs in a single environment, test them in the same environment and even deploy them at the opportune time.

9.1.5 The Evolution of Software Development Tools

Many changes in IT happen as an indirect result of the development or induction of some other technological innovation. Some changes in the development of IT systems come and go faster as compared to fashion in clothing. IT trends are less like a straight timeline of incremental advances, and more like a churning cycle of twirling ideas that gain fame and then fall out of service as people strive to see what works and what doesn't, what's more effective, and vice versa.

Originally, software development tools hold only of those tools that are used during the actual design and testing phases of software development. However, today, there are software management tools that can be used throughout the software development life cycle. The original software development toolbox might have contained a basic text editor, as well as a linking loader, a compiler, and a tool for debugging software.

Today, things are much more complicated, with tools that can be used during quality assurance, all phases of testing, and even during the design and deployment phases. Some examples of project management solution that helps developers organize and stay productive during projects are Microsoft Project, Wrike, etc.

Software development tools continue to evolve and change, as the needs of programmers grow. In the near future, we may be using more of our development efforts in developing systems that can emerge and acquire by themselves (machine learning), but someone still has to process those systems. Human power is still like to be needed to operate the tools.

9.1.6 Best Software Development Tools

There are tons of Software Development tools and selecting the best could be a challenge. Following is a curated list of the 21 top software development tools.

We have covered Software Development tools in the following categories

- Recommended Tool
- IDE (Integrated Development Environment)
- Frameworks
- Cloud Tools
- Data Science
- Source Control
- Prototyping
- DevOps

- Notifications
- UML

Recommended Tool

1). Linx

Linx is a low code IDE and server. IT pros use Linx to quickly create custom automated business processes, integrate applications, expose web services, and to efficiently handle high workloads.

- Easy-to-use, drag-and-drop interface
- Over 100 pre-built functions and services for rapid development
- One-click deployment to any local or remote Linx Server directly from the IDE
- Input and outputs include nearly any SQL & NoSQL databases, numerous file formats (text and binary) or REST and SOAP Web services
- Live debugging with step through logic
- Automate backend processes via timer, directory events or message queue or expose web services, and call APIs via HTTP requests

2). Buddy

Buddy is a smart CI/CD tool for web developers designed to lower the entry threshold to DevOps. It uses delivery pipelines to build, test and deploy software. The pipelines are created with over 100 ready-to-use actions that can be arranged in any way – just like you build a house of bricks.

- 15-minute configuration in clear & telling UI/UX
- Lightning-fast deployments based on changesets
- Builds are run in isolated containers with cached dependencies
- Supports all popular languages, frameworks & task managers
- Dedicated roster of Docker/Kubernetes actions

- Integrates with AWS, Google, DigitalOcean, Azure, Shopify, WordPress & more
- Supports parallelism & YAML configuration

IDE (Integrated Development Environment)

3). NetBeans

NetBeans is a popular, Free, open-source IDE. It allows developing desktop, mobile and web applications.

Features:

- Support for fast & smart code editing
- Easy & Efficient Project Management process
- Rapid User Interface Development
- Helps to write bug-free code
- NetBeans IDE offers superior support for C/C++ and PHP developers
- It can be installed on any OS which supports Java, from Windows to Linux to Mac OS X systems

4). Cloud9 IDE

Cloud9 IDE is an online integrated software development environment. It supports many programming languages like C, C++, PHP, Ruby, **Perl**, Python, JavaScript and Node.js.

Features:

- Allows to clone entire development environment
- Built-In Terminal for command-line wizard
- Code Completion suggestions helps software developers to code faster and avoid typos
- The Debugger helps developers to set breakpoints, and inspect variables of any JS/Node.js app
- Simply drag any file or Terminal to create multiple split views
- Developers can select an extensive set of default Runners to execute app, such as Ruby, Python, PHP/Apache

Keyword

Perl is a family of two high-level, general-purpose, interpreted, dynamic programming languages.

5). Zend Studio

Zend Studio allows software developers to code faster, debug more easily. It is next-generation PHP IDE designed to create apps for boosting developers' productivity. It scales according to the DPI settings of the underlying operating system.

Features:

- Code faster with up to performance improvements in indexing, validation, searching for PHP code
- Offering debugging capabilities with Xdebug, Zend Debugger, and Z-Ray integration
- Extensive plugin provided by the large Eclipse eco-system
- It supports development tools including Docker and Git Flow
- Deploy PHP applications on any server for Amazon AWS and Microsoft Azure

6). Atom

Keyword

CONFIG file is a configuration file used by various applications. It contains plain text parameters that define settings or preferences for building or running a program. CONFIG files are often referenced by software development programs to configure applications.

ATOM

Atom is a solid all-around text-editor. It is fully free and open source. It can be customized to do anything but without a need of modifying the **CONFIG file**.

Features:

- Atom works across many popular operating systems like OS X, Windows, or Linux
- It helps developers to write code faster with a smart, flexible autocomplete
- Easily browse and open whole project or multiple projects in one window
- It is possible to split Atom interface into multiple panes to compare and edit code across files
- Find, preview, and replace text type in a file or across the entire project

7). Spiralogics Application Architecture

Spiralogics

Spiralogics Application Architecture (SAA) is a cloud-based software development tool. It allows users to build and customize their applications online and deploy them. It also allows users to choose from a set of prebuilt applications or customize them it from scratch.

Features:

- Create customized pages
- Built-in HTML editor
- Interactive Dashboard builder

- Preview Changes before publishing the application
- Predefined processes like Save, Delete, Accept, Reject, and Email
- Allows customization of look and feel of page components
- Create custom processes not already defined

8). CodeLobster

Codelobster streamlines and simplifies PHP software development process. It supports CMS like Wordpress, Drupal, Joomla, and Magento.

Features:

- PHP, HTML, JavaScript, CSS code highlighting
- Autocomplete of tags, attributes for a current tag, closing tags.
- Inspector makes it simple to find HTML elements and their styles buried deep in the page
- Autocomplete of style property names and values
- It allows autocompleting of keywords, DOM elements, and their properties
- It offers PHP Advanced autocomplete

9) CodeCharge Studio

CodeCharge Studio offers the fastest way to build applications. This tool helps to develop data-driven Web sites or enterprise Internet and Intranet systems.

Features:

- Avoid costly errors and misspellings by generating consistent, well-structured code

- Eliminate time-consuming programming tasks and build scalable, robust **Web Applications**
- Helps to convert any database into a web application in very less amount of time
- Analyze and modify generated code to learn web technologies and take on programming projects in any environment

Keyword

Web application is an application program that is stored on a remote server and delivered over the Internet through a browser interface.

Frameworks

10) Bootstrap

Bootstrap is a responsive framework for developing with HTML, CSS, and JS. It has many in-builds components, which you can easily drag and drop to assemble responsive web pages.

Feature:

- Bootstrap enables utilization of ready- made blocks of code
- It ensures consistency irrespective of who's working on the project
- It offers extensive list of components
- Base Styling for most HTML Elements
- Bootstrap can be customized according to the specific need of the project

11) Expression Studio

Expression Studio is a set of a family of tools for professional designer's developers. It is a robust professional design tool which gives creative freedom to developers.

Features:

- It revolutionizes the speed of prototyping
- It allows creation of effective UI with sample data
- Fast, flexible, seamless workflow helps to excel the entire development process
- These tools save time of creating web sites to deliver faster results
- Advanced visual diagnostics speed debugging
- It offers team Foundation Server integration
- Rich standards-based web design & technologies
- It provides precision layout control and supports a broad range of technologies.
- It helps to speeds up cross-browser debugging with advanced visual diagnostics

12) HTML5 Builder

HTML5 Builder is a software solution for building the web and mobile apps. It can develop an app using a single HTML5, CSS3, JavaScript and PHP codebase. It helps to target multiple mobile operating systems, devices and Web browsers.

Features:

- It is the fastest way to develop cross-platform Apps with flexible Cloud services
- Increased speed of development with a single visual framework
- Brings Designers and Developers in a Collaborative Workflow
- Create Enterprise or ISV web and mobile apps
- Create location-based browser and mobile applications using geolocation components in HTML5 Builder

13) Visual Online

Visual Studio Online is a collection of services. It is fast and easy to plan, build and ship software across a variety of platforms. These software development tools allow the organization to create the perfect development environment.

Features:

- Track and manage all ideas on kanban or scrum boards with agile tools
- Improve code quality and catch issues early
- Build, manage, secure and share software components
- Automate and simplify Azure deployments
- Tools for manual, performance and automated testing
- It offers a centralized version control system with free private repositories.

Cloud Tools

14) Kwatee

Kwatee Agile Deployment is a software development tool. It automates applications or micro services to any number of servers. It fully automates deployments of text and binary files from any number of target servers.

Features:

- It allows managing environment-specific configuration parameters for your application
- It allows generating command-line installers to be used for deployments on environments
- This software development tool eliminates the need for installation & configuration. It also takes out many operational risks in the software development process
- It is a friendly web interface lets configure deployments efficiently and painlessly
- It supports a broad range operating systems including Linux, Windows, Mac OS X, Solaris, etc.

15) Azure

Microsoft Azure is widely used by developers to build, deploy and manage web applications.

Features:

- It supports wide range of operating systems, programming languages, frameworks, and devices
- Allows to build apps quickly and easily
- It easily detect and mitigate threats
- Rely on the most trusted cloud
- Allows to manage app proactively
- Helps to deliver mobile apps seamlessly

Data Science

16) Data studio

Dataiku DSS is a collaborative data science software platform. It is used by data scientists, data analysts, and engineers to explore, prototype, build and deliver their data products.

Features:

- Profile the data visually at every stage of the analysis
- Prepare, enrich, blend, and clean data using more than 80+ built-in functions
- Bundle whole workflow as a single deployable package for real-time predictions
- Build & optimize models in Python or R and integrate any external ML library through code APIs

Source Control

17) Github

GitHub allows developers to review code, manage projects, and build software. It offers right tool for different development jobs.

Features:

- Coordinate easily, stay aligned, and get done with GitHub's project management tools
- Easy documentation alongside quality coding
- Allows all code in a single place
- Developers can host their documentation directly from repositories

18) BitBucket

Bitbucket is a version control tool. It facilitates easy collaboration amongst software development team. It integrates very well with JIRA, a famous project and issue-managing app.

Features:

- Branch permissions access to ensure that the only right people can make changes to the code
- Helps development team to focus on a goal, product or process by organizing repositories into projects
- It can display build results from CI system
- Integrate into existing workflow to streamline software development process

19) Cloudforge

CloudForge is a software-as-a-service product for application development. It Integrates and manages various development tools.

Features:

- Integrate and manage various development tools
- Elastically scale development teams, projects, and processes
- Deploy code to public and private clouds
- Deploy source-code with a single click using various protocols including FTP, SCP, SSH, and Rsync to run-time environment
- CloudForge Publisher allows deployment to multiple servers in parallel

Prototyping

20) Axure

Axure provides the capability to produce wireframes, prototypes, and create documentation. This tool is used by business analysts, product managers, and IT consultants around the world.

Features:

- Axure RP generates prototype in HTML and provides link for sharing
- It allows multiple people to work on the same file at the same time
- It can runs on Microsoft IIS with a MySQL or Microsoft SQL Server database
- It helps to create and maintain widget libraries

DevOps

21) Codenvy

Codenvy automates applications or micro services to any number of servers. It fully automates deployments of text and binary files from any number of target servers.

Features:

- It allows managing environment-specific configuration parameters for your application
- It allows generating command-line installers to be used for deployments on any environment
- This software development tool eliminates the need for installation & configuration.
- It takes out many operational risks in the software development process
- The friendly web interface lets configure deployments efficiently and painlessly
- It supports a broad range operating systems including Linux, Windows, Mac OS X, Solaris, etc.

Notifications

22) SendBird

Sendbird is used as a messaging and Chat API for Mobile Apps and Websites. It offers scalability for a massive audience. It also prevents spam flooding of chat rooms.

Features:

- Read and track the status of the messages sent to users
- Integrate bots to assist with customer support and product recommendations

- Offers Push Notifications & Callbacks
- Read Receipt & Delivery Status
- Automatically split or merge chat rooms on the audience volume to offer continues engagement

UML

23) Enterprise Architect

Enterprise Architect is a requirement management tool. It integrates seamlessly with other development tools by creating requirements in the model.

Features:

- Allows to build robust and maintainable systems
- It loads extremely large models in seconds
- Collaborate effectively globally
- Offers complete traceability
- Improve business outcomes
- Model and manage complex Data effectively
- Supports Single click HTML and document generation
- Code execution to visual diagrams

Keyword

Computer program is a collection of instructions that performs a specific task when executed by a computer.

9.2 SOFTWARE STANDARD

A software standard is a standard, protocol, or other common format of a document, file, or data transfer accepted and used by one or more software developers while working on one or more than one **computer programs**. Software standards enable interoperability between different programs created by different developers.

9.2.1 Use of Standards

Software standards consist of certain terms, concepts, data formats, document styles and techniques agreed upon by software creators so that their software can understand the files and data created by a different computer program. To be considered a standard, a certain protocol needs to be accepted and incorporated by a group of developers who contribute to the definition and maintenance of the standard.

Some developers prefer using standards for software development because of the efficiencies it provides for code development and wider user acceptance and use of the resulting application.

For example, the protocols HTML, TCP/IP, SMTP, POP and FTP are software standards that application designers must understand and follow if their software expects to interface with these standards. For instance, in order for an email sent from Microsoft Outlook can be read from within the Yahoo! Mail application, the email will be sent using SMTP, which the different receiving program understands and can parse properly to display the email. Without a standardized technique to send an email, the two different programs would be unable to accurately share and display the delivered information.

Some widely used data formats, while understood and used by a variety of computer programs, are not considered a software standard. Microsoft Office file formats, such as .doc and .xls, are commonly converted by other computer programs to use, but are still owned and controlled by Microsoft, unlike text files (TXT or RTF.)

Creation

In order for all parties to agree to a certain software standard that they all should use to make their software connect with each other, there are software standards organizations like W3C and ISOC that consist of groups of larger software companies like Microsoft and Apple Inc.. Representatives of these companies contribute their ideas about how to make a single, unified software standard to address the data problem they are trying to handle.

Complexity of a standard can vary depending on what kind of problem that they are trying to solve. For instance FTP (file transfer protocol) tries to solve a different problem than SMTP, which is concerned with sending and receiving email. Standards also need to be simple, maintainable and understandable. The software standard document that they create needs to detail every possible condition, types, elements, etc. in order to retain utility and serve the role for which it was created.

9.2.2 Open Versus Closed Standards

A standard can be a closed standard or an open standard. The documentation for an open standard is open to the public and anyone can create a software that implements and uses the standard. The documentation and specification for closed standards are not available to the public, enabling its developer to sell and license the code to manage their data format to other interested software developers. While this process increases the revenue potential for a useful file format, it may limit acceptance and drive the adoption of a similar, open standard instead.

9.3 ENGINEERING CONSTRAINTS

Constraints are conditions that we need to happen or would like to happen with a design. In the early stages of a design task they may tend to be negative. For example, a car engine cannot exceed the size the space in which it fits, yet it cannot produce less than a specified power. As a design proceeds, they may become more positive. For example, a bearing must have the same diameter as the shaft it supports.

Each constraint defines a subset of the set of all possible designs in which it is satisfied. When several constraints are specified, it is only the possibilities within the intersection of all the subsets that we are interested in. This intersection becomes smaller as more constraints are added. If it becomes empty, then there is no design which satisfies all the constraints. The designer's skill is now in deciding which constraints it is safe to relax.

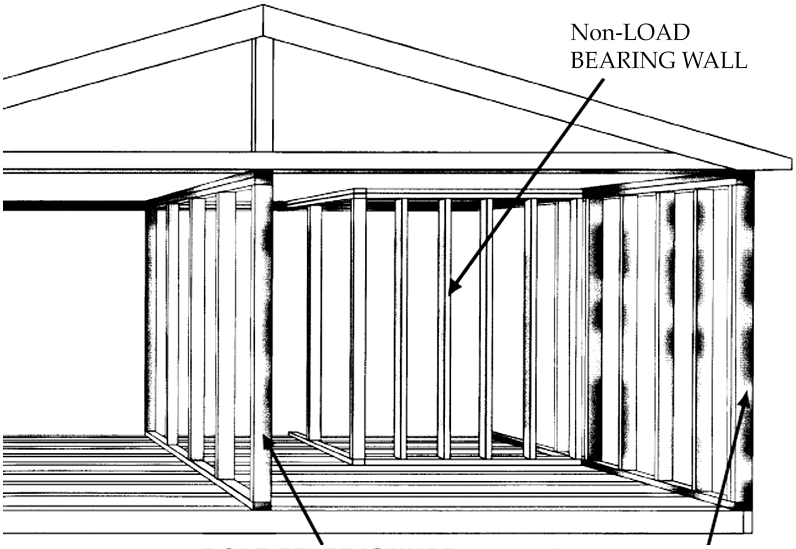
There are only three constraints on software development.

- Schedule
- Resources
- Quality

9.3.1 Dealing with Constraints in Software Architecture Design

In software architecture design, constraints come in two basic flavors - technical and business. On most projects there are only a handful of constraints, but these constraints are a highly influential architectural driver. Constraints, as the dictionary definition above indicates, are a limiting factor and severely restrict options for making design decisions. They are also fixed design decisions that cannot be changed and must be satisfied. You could think of constraints as the ultimate non-negotiable, "must have" requirement. It is for this reason that architecture design constraints must be created and accepted with care.

Anthony Lattanze of Carnegie Mellon University, author of the Architecture Centric Design Methodology and one of the ATAM creators, likens design constraints in software architecture to "load bearing walls" employed in traditional building architecture. Load bearing walls of a building are extremely strategic and strongly influence the shape and form of the building. What's more, once these essential walls are placed and bearing weight it becomes cost prohibitive to move them.



Technical and business constraints are similarly load bearing. Many design decisions will hang on fixed constraints, further cementing them into your system's design. Adding a component or even refactoring architectural styles might be costly but it can still be done. Deciding to jump from .Net to the JVM requires demolition and rebuilding.

As architecture design constraints are so important it's worth taking some time to understand them in greater detail so you can properly deal with them when they arise.

9.3.2 Technical Constraints in Software Architecture

Technical constraints are fixed technical design decisions that absolutely cannot be changed. Most often technical constraints are provided by stakeholders (perhaps after some digging) at the outset of the project. Sometimes a team may choose to create a constraint, perhaps to simplify the world in which they are working. Regardless of the origin, these architecture drivers are technical in nature and are considered unchangeable and indeed very soon become so.

There are many common examples of technical constraints that you've likely seen.

- ***Programming language*** - often times a specific programming language will be required for various reasons. For example, the customer may be a Java or Ruby or Microsoft shop. You might simply prefer a certain language over another, or have specific expertise that dictates using a particular programming language. Nearly always, once you've picked a language you are stuck with that choice for the remainder of the project,

- ***Operating system or platforms supported*** - It must work on Windows, or Linux, or iOS, or Qt on Solaris, or IE 6 on Windows XP, or ... building software that does not satisfy the platform constraint means you have failed to design a software system that satisfies stakeholders' key concerns.
- ***Use of a specific library or framework*** - Sometimes a specific library might be required to be used. The specific origin might come from the business but the influence is very technical. A common example at many companies is the use of specific open source libraries. Some companies might require that open source always be used. Other companies, might have an approved list indicating which open source software may be used. An interesting example at IBM is that we are required to target the "Blue" JVM, IBM's JDK for all JVM-based projects.

Business Constraints

Business constraints are unchangeable business decisions that in some way restrict the software architecture design. Business constraints are similar to technical constraints in that they are decisions that cannot be changed, but rather than influencing structures directly through technology, the influence occurs indirectly through business decisions. It might be easiest to discuss some examples.

- ***Schedule*** - "We have to be ready to demo at the trade-show in November." The final delivery date is fixed based on input from the business and cannot be changed. It is now up to you to design a system that can be built within the required schedule.
- ***Budget*** - I've found that this is less true for product development, but nearly every development contractor must learn to deal with budget constraints. In some cases you might be able to increase the budget, but often budgets, whether fixed through contract or expectations, become constraints on the project and team building the software.
- ***Team composition and make-up*** - In some cases there may be requirements that specific personnel be used or not used during project.
- ***Software licensing restrictions or requirements*** - Often times you will be required to use specific software components because they are already owned. I've also seen situations where components have been used in very... interesting... ways to satisfy specific licensing restrictions. Legal considerations are extremely constraining.

Someone may be unavailable, already committed to another project or you may be required to include specific individuals, perhaps for training purposes.

9.4 HISTORY AND OVERVIEW SOFTWARE ENGINEERING

Software engineering is a detailed study of engineering to the design, development and maintenance of software. Software engineering was introduced to address the issues of low-quality software projects. Problems arise when a software generally exceeds timelines, budgets, and reduced levels of quality. It ensures that the application is built consistently, correctly, on time and on budget and within requirements. The demand of software engineering also emerged to cater to the immense rate of change in user requirements and environment on which application is supposed to be working.

9.4.1 History of Software Engineering

From its beginnings in the 1960s, writing software has evolved into a profession concerned with how best to maximize the quality of software and of how to create it. Quality can refer to how maintainable software is, to its stability, speed, usability, testability, readability, size, cost, security, and number of flaws or "bugs", as well as to less measurable qualities like elegance, conciseness, and **customer satisfaction**, among many other attributes. How best to create high quality software is a separate and controversial problem covering software design principles, so-called "best practices" for writing code, as well as broader management issues such as optimal team size, process, how best to deliver software on time and as quickly as possible, work-place "culture", hiring practices, and so forth. All this falls under the broad rubric of software engineering.

Keyword

Customer satisfaction is defined as a measurement that determines how happy customers are with a company's products, services, and capabilities.

The evolution of software engineering is notable in a number of areas:

- **Emergence as a profession**: By the early 1980s, software engineering professionalism, to stand beside computer science and traditional engineering.
- R**ole of women**: Before 1970 men filling the more prestigious and better paying hardware engineering roles

often delegated the writing of software to women, and legends such as Grace Hopper or Margaret Hamilton filled many computer programming jobs.

Today, fewer women work in software engineering than in other professions, a situation whose cause is not clearly identified. Many academic and professional organizations consider this situation unbalanced and are trying hard to solve it.

- **Processes**: Processes have become a big part of software engineering. They are hailed for their potential to improve software but sharply criticized for their potential to constrict programmers.
- **Cost of hardware**: The relative cost of software versus hardware has changed substantially over the last 50 years. When mainframes were expensive and required large support staffs, the few organizations buying them also had the resources to fund large, expensive custom software engineering projects. Computers are now much more numerous and much more powerful, which has several effects on software. The larger market can support large projects to create commercial off the shelf software, as done by companies such as Microsoft. The cheap machines allow each programmer to have a terminal capable of fairly rapid compilation. The programs in question can use techniques such as **garbage collection**, which make them easier and faster for the programmer to write. On the other hand, many fewer organizations are interested in employing programmers for large custom software projects, instead using commercial off the shelf software as much as possible.

Keyword

Garbage collection is a form of automatic memory management. The garbage collector, or just collector, attempts to reclaim garbage, or memory occupied by objects that are no longer in use by the program.

1945 to 1965: The Origins

Putative origins for the term *software engineering* include a 1965 letter from ACM president Anthony Oettinger, lectures by Douglas T. Ross at MIT in the 1950s. Margaret H. Hamilton "is the person who came up with the idea of naming the discipline, software engineering, as a way of giving it legitimacy."

The NATO Science Committee sponsored two conferences on software engineering in 1968 and 1969, which gave the field its initial boost. Many believe these conferences marked the official start of the profession of *software engineering*.

1965 to 1985: The Software Crisis

Software engineering was spurred by the so-called *software crisis* of the 1960s, 1970s, and 1980s, which identified many of the problems of software development. Many projects ran over budget and schedule. Some projects caused property damage. A few projects caused loss of life. The software crisis was originally defined in terms of productivity, but evolved to emphasize quality. Some used the term *software crisis* to refer to their inability to hire enough qualified programmers.

- Cost and Budget Overruns: The OS/360 operating system was a classic example. This decade-long project from the 1960s eventually produced one of the most complex software systems at the time. OS/360 was one of the first large (1000 programmers) software projects. Fred Brooks claims in *The Mythical Man-Month* that he made a multimillion-dollar mistake of not developing a coherent architecture before starting development.
- Property Damage: Software defects can cause property damage. Poor software security allows hackers to steal identities, costing time, money, and reputations.
- Life and Death: Software defects can kill. Some embedded systems used in radiotherapy machines failed so catastrophically that they administered lethal doses of radiation to patients. The most famous of these failures is the *Therac-25* incident.

Peter G. Neumann has kept a contemporary list of software problems and disasters. The software crisis has been fading from view, because it is psychologically extremely difficult to remain in crisis mode for a protracted period (more than 20 years). Nevertheless, software – especially real-time embedded software – remains risky and is pervasive, and it is crucial not to give in to complacency. Over the last 10–15 years Michael A. Jackson has written extensively about the nature of software engineering, has identified the main source of its difficulties as lack of specialization, and has suggested that his problem frames provide the basis for a "normal practice" of software engineering, a prerequisite if software engineering is to become an engineering science.

DID YOU KNOW ?

The term "software engineering" appeared in a list of services offered by companies in the June 1965 issue of COMPUTERS and AUTOMATION and was used more formally in the August 1966 issue of Communications of the ACM "letter to the ACM membership" by the ACM President Anthony A. Oettinger;, it is also associated with the title of a NATO conference in 1968 by Professor Friedrich L. Bauer, the first conference on software engineering.

1985 to 1989: "No Silver Bullet"

For decades, solving the software crisis was paramount to researchers and companies producing software tools. The cost of owning and maintaining software in the 1980s was twice as expensive as developing the software.

- During the 1990s, the cost of ownership and maintenance increased by 30% over the 1980s.
- In 1995, statistics showed that half of surveyed development projects were operational, but were not considered successful.
- The average software project overshoots its schedule by half.
- Three-quarters of all large **software products** delivered to the customer are failures that are either not used at all, or do not meet the customer's requirements.

Keyword

Software Products are nothing but software systems delivered to the customer with the documentation that that describe how to install and use the system.

Software Projects

Seemingly, every new technology and practice from the 1970s through the 1990s was trumpeted as a *silver bullet* to solve the software crisis. Tools, discipline, formal methods, process, and professionalism were touted as silver bullets:

- **Tools**: Especially emphasized were tools: structured programming, object-oriented programming, CASE tools such as ICL's CADES CASE system, Ada, documentation, and standards were touted as silver bullets.
- **Discipline**: Some pundits argued that the software crisis was due to the lack of discipline of programmers.
- **Formal methods**: Some believed that if formal engineering methodologies would be applied to software development, then production of software would become as predictable an industry as other branches of engineering. They advocated proving all programs correct.
- **Process**: Many advocated the use of defined processes and methodologies like the Capability Maturity Model.
- Professionalism: This led to work on a code of ethics, licenses, and professionalism.

In 1986, Fred Brooks published his *No Silver Bullet* article, arguing that no individual technology or practice would ever make a 10-fold improvement in productivity within 10 years.

Debate about silver bullets raged over the following decade. Advocates for Ada, components, and processes continued arguing for years that their favorite technology would be a silver bullet. Skeptics disagreed. Eventually, almost everyone accepted that no silver bullet would ever be found. Yet, claims about *silver bullets* pop up now and again, even today.

Some interpret *no silver bullet* to mean that software engineering failed. However, with further reading, Brooks goes on to say: "We will surely make substantial progress over the next 40 years; an order of magnitude over 40 years is hardly magical ..."

The search for a single key to success never worked. All known technologies and practices have only made incremental improvements to productivity and quality. Yet, there are no silver bullets for any other profession, either. Others interpret *no silver bullet* as proof that software engineering has finally matured and recognized that projects succeed due to hard work.

However, it could also be said that there are, in fact, a range of *silver bullets* today, including lightweight methodologies, spreadsheet calculators, customized browsers, in-site search engines, database report generators, integrated design-test coding-editors with memory/differences/undo, and specialty shops that generate niche software, such as information web sites, at a fraction of the cost of totally customized web site development. Nevertheless, the field of software engineering appears too complex and diverse for a single "silver bullet" to improve most issues, and each issue accounts for only a small portion of all software problems.

1990 to 1999: Prominence of the Internet

The rise of the Internet led to very rapid growth in the demand for international information display/e-mail systems on the World Wide Web. Programmers were required to handle illustrations, maps, photographs, and other images, plus simple animation, at a rate never before seen, with few well-known methods to optimize image display/storage.

The growth of browser usage, running on the HyperText Markup Language (HTML), changed the way in which information-display and retrieval was organized. The widespread network connections led to the growth and prevention of international **computer viruses** on MS Windows computers, and the vast proliferation of spam e-mail became a major design issue in e-mail systems, flooding communication channels and requiring semi-automated pre-screening. Keyword-search systems evolved into web-based search engines, and many software systems had to be re-designed, for international searching, depending on search engine optimization (SEO) techniques. Human natural-language translation systems were needed to attempt to translate the information flow in multiple foreign languages, with many software systems being designed for multi-language usage, based on design concepts from human translators. Typical computer-user bases went from hundreds, or thousands of users, to, often, many-millions of international users.

Keyword

Computer virus is a type of computer program that, when executed, replicates itself by modifying other computer programs and inserting its own code.

2000 to 2015: Lightweight Methodologies

With the expanding demand for software in many smaller organizations, the need for inexpensive software solutions led to the growth of simpler, faster methodologies that developed running software, from requirements to deployment, quicker & easier. The use of rapid-prototyping evolved to entire *lightweight methodologies*, such as Extreme Programming (XP), which attempted to simplify many areas of software engineering, including requirements gathering and reliability testing for the growing, vast number of small software systems. Very large software systems still used heavily documented methodologies, with many volumes in the documentation set; however, smaller systems had a simpler, faster alternative approach to managing the development and maintenance of software calculations and algorithms, information storage/retrieval and display.

Current Trends in Software Engineering

Software engineering is a young discipline, and is still developing. The directions in which software engineering is developing include:

Aspects

Aspects help software engineers deal with quality attributes by providing tools to add or remove boilerplate code from many areas in the source code. Aspects describe how all objects or functions should behave in particular circumstances. For example, aspects can add debugging, logging, or locking control into all objects of particular types. Researchers are currently working to understand how to use aspects to design general-purpose code. Related concepts include generative programming and templates.

Agile

Agile software development guides software development projects that evolve rapidly with changing expectations and competitive markets. Proponents of this method believe that heavy, document-driven processes (like TickIT, CMM and ISO 9000) are fading in importance. Some people believe that companies and agencies export many of the jobs that can be guided by heavy-weight processes. Related concepts include extreme programming, scrum, and lean software development.

Experimental

Experimental software engineering is a branch of software engineering interested in devising experiments on software, in collecting data from the experiments, and in devising laws and theories from this data. Proponents of this method advocate that the nature of software is such that we can advance the knowledge on software through experiments only.

Software Product Lines

Software product lines, aka product family engineering, is a systematic way to produce *families* of software systems, instead of creating a succession of completely individual products. This method emphasizes extensive, systematic, formal code reuse, to try to industrialize the software development process.

The Future of Software Engineering conference (FOSE), held at ICSE 2000, documented the state of the art of SE in 2000 and listed many problems to be solved over the next decade. The FOSE tracks at the ICSE 2000 and the ICSE 2007 conferences also help identify the state of the art in software engineering.

Software Engineering Today

The profession is trying to define its boundary and content. The Software Engineering Body of Knowledge SWEBOK has been tabled as an ISO standard during 2006 (ISO/IEC TR 19759).

In 2006, *Money Magazine* and *Salary.com* rated software engineering as the best job in America in terms of growth, pay, stress levels, flexibility in hours and working environment, creativity, and how easy it is to enter and advance in the field.

9.4.2 Overview of Software Engineering

The term software engineering is composed of two words, software and engineering. Software is more than just a program code. A program is an executable code, which serves some computational purpose. Software is considered to be a collection of executable programming code, associated libraries and documentations. Software, when made for a specific requirement is called software product.

Engineering on the other hand, is all about developing products, using well-defined, scientific principles and methods.

Software engineering is an engineering branch associated with development of software product using well-defined scientific principles, methods and procedures. The outcome of software engineering is an efficient and reliable software product.

Software project management has wider scope than software engineering process as it involves communication, pre and post-delivery support etc.

IEEE defines software engineering as: The application of a systematic, disciplined, quantifiable approach to the development, operation and maintenance of software.

We can alternatively view it as a systematic collection of past experience. The experience is arranged in the form of methodologies and guidelines. A small program can be written without using software engineering principles. But if one wants to develop a large software product, then software engineering principles are absolutely necessary to achieve a good quality software cost effectively.

Without using software engineering principles it would be difficult to develop large programs. In industry it is usually needed to develop large programs to accommodate multiple functions. A problem with developing such large commercial programs is that the complexity and difficulty levels of the programs increase exponentially with their sizes. Software engineering helps to reduce this programming complexity. Software engineering principles use two important techniques to reduce problem complexity:

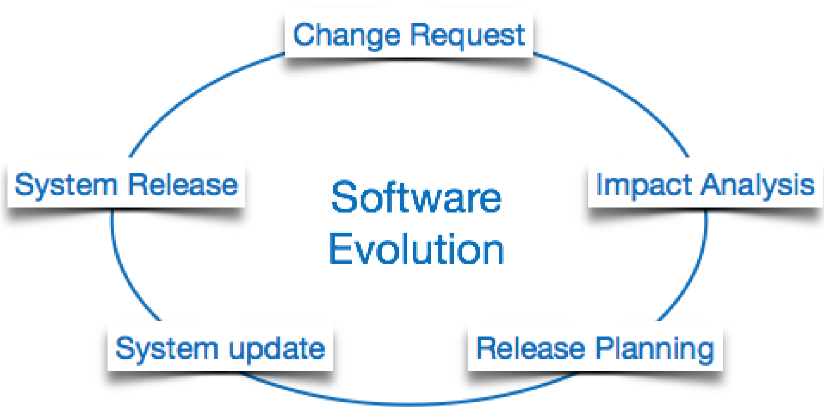
abstraction and decomposition. The principle of abstraction implies that a problem can be simplified by omitting irrelevant details. In other words, the main purpose of abstraction is to consider only those aspects of the problem that are relevant for certain purpose and suppress other aspects that are not relevant for the given purpose. Once the simpler problem is solved, then the omitted details can be taken into consideration to solve the next lower level abstraction, and so on. Abstraction is a powerful way of reducing the complexity of the problem. The other approach to tackle problem complexity is decomposition. In this technique, a complex problem is divided into several smaller problems and then the smaller problems are solved one by one. However, in this technique any random decomposition of a problem into smaller parts will not help. The problem has to be decomposed such that each component of the decomposed problem can be solved independently and then the solution of the different components can be combined to get the full solution. A good decomposition of a problem should minimize interactions among various components.

REMEMBER

If the different subcomponents are interrelated, then the different components cannot be solved separately and the desired reduction in complexity will not be realized.

9.4.3 Software Evolution

The process of developing a software product using software engineering principles and methods is referred to as software evolution. This includes the initial development of software and its maintenance and updates, till desired software product is developed, which satisfies the expected requirements.



Evolution starts from the requirement gathering process. After which developers create a prototype of the intended software and show it to the users to get their feedback at the early stage of software product development. The users suggest changes, on which several consecutive updates and maintenance keep on changing too. This process changes to the original software, till the desired software is accomplished.

Even after the user has desired software in hand, the advancing technology and the changing requirements force the software product to change accordingly. Re-creating software from scratch and to go one-on-one with requirement is not feasible. The only feasible and economical solution is to update the existing software so that it matches the latest requirements.

Software Evolution Laws

Lehman has given laws for software evolution. He divided the software into three different categories:

- **S-type (static-type) -** This is a software, which works strictly according to defined specifications and solutions. The solution and the method to achieve it, both are immediately understood before coding. The s-type software is least subjected to changes hence this is the simplest of all. For example, calculator program for mathematical computation.
- **P-type (practical-type) -** This is a software with a collection of procedures. This is defined by exactly what procedures can do. In this software, the specifications can be described but the solution is not obvious instantly. For example, gaming software.
- **E-type (embedded-type) -** This software works closely as the requirement of real-world environment. This software has a high degree of evolution as there are various changes in laws, taxes etc. in the real world situations. For example, online trading software.

E-Type Software Evolution

Lehman has given eight laws for E-Type software evolution -

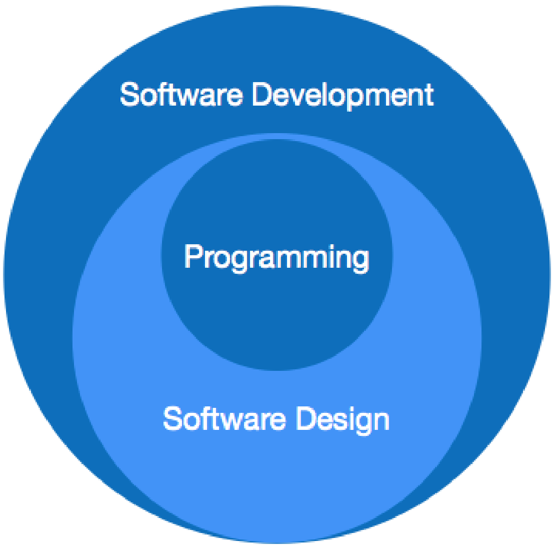
- **Continuing change -** An E-type software system must continue to adapt to the real world changes, else it becomes progressively less useful.
- **Increasing complexity -** As an E-type software system evolves, its complexity tends to increase unless work is done to maintain or reduce it.
- **Conservation of familiarity -** The familiarity with the software or the knowledge about how it was developed, why was it developed in that particular manner etc. must be retained at any cost, to implement the changes in the system.
- **Continuing growth-** In order for an E-type system intended to resolve some

business problem, its size of implementing the changes grows according to the lifestyle changes of the business.

- **Reducing quality -** An E-type software system declines in quality unless rigorously maintained and adapted to a changing operational environment.
- **Feedback systems-** The E-type software systems constitute multi-loop, multi-level feedback systems and must be treated as such to be successfully modified or improved.
- **Self-regulation -** E-type system evolution processes are self-regulating with the distribution of product and process measures close to normal.
- **Organizational stability -** The average effective global activity rate in an evolving E-type system is invariant over the lifetime of the product.

9.4.4 Software Paradigms

Software paradigms refer to the methods and steps, which are taken while designing the software. There are many methods proposed and are in work today, but we need to see where in the software engineering these paradigms stand. These can be combined into various categories, though each of them is contained in one another:



Programming paradigm is a subset of Software design paradigm which is further a subset of Software development paradigm.

Software Development Paradigm

This Paradigm is known as software engineering paradigms where all the engineering concepts pertaining to the development of software are applied. It includes various researches and requirement gathering which helps the software product to build. It consists of –

- Requirement gathering
- Software design
- Programming

Software Design Paradigm

This paradigm is a part of Software Development and includes –

- Design
- Maintenance
- Programming

Programming Paradigm

This paradigm is related closely to programming aspect of **software development**. This includes –

- Coding
- Testing
- Integration

Keyword

Software development is the process of conceiving, specifying, designing, programming, documenting, testing, and bug fixing involved in creating and maintaining applications, frameworks, or other software components.

9.4.5 Need of Software Engineering

The need of software engineering arises because of higher rate of change in user requirements and environment on which the software is working.

- **Large software** - It is easier to build a wall than to a house or building, likewise, as the size of software become large engineering has to step to give it a scientific process.
- **Scalability**- If the software process were not based on scientific and engineering concepts, it would be easier to re-create new software than to scale an existing one.
- **Cost**- As hardware industry has shown its skills and huge manufacturing has lower down the price of computer and electronic hardware. But the cost of software remains high if proper process is not adapted.
- **Dynamic Nature**- The always growing and adapting

nature of software hugely depends upon the environment in which the user works. If the nature of software is always changing, new enhancements need to be done in the existing one. This is where software engineering plays a good role.

- **Quality Management**- Better process of software development provides better and quality software product.

9.4.6 Characteristics of Good Software

A software product can be judged by what it offers and how well it can be used. This software must satisfy on the following grounds:

- Operational
- Transitional
- Maintenance

Well-engineered and crafted software is expected to have the following characteristics:

Operational

This tells us how well software works in operations. It can be measured on:

- Budget
- Usability
- Efficiency
- Correctness
- Functionality
- Dependability
- Security
- Safety

Transitional

This aspect is important when the software is moved from one platform to another:

- Portability
- Interoperability
- Reusability
- Adaptability
-

Maintenance

This aspect briefs about how well a software has the capabilities to maintain itself in the ever-changing environment:

- Modularity
- Maintainability
- Flexibility
- Scalability

In short, Software engineering is a branch of computer science, which uses well-defined engineering concepts required to produce efficient, durable, scalable, in-budget and on-time software products

ROLE MODEL

FRED BROOKS

Frederick Phillips "Fred" Brooks Jr. (born April 19, 1931) is an American computer architect, software engineer, and computer scientist, best known for managing the development of IBM's System/360 family of computers and the OS/360 software support package, then later writing candidly about the process in his seminal book The Mythical Man-Month. Brooks has received many awards, including the National Medal of Technology in 1985 and the Turing Award in 1999.

Education

Born in Durham, North Carolina, he attended Duke University, graduating in 1953 with a Bachelor of Science degree in physics, and he received a Ph.D. in applied mathematics (computer science) from Harvard University in 1956, supervised by Howard Aiken.

Brooks served as the graduate teaching assistant for Ken Iverson at Harvard's graduate program in "automatic data processing", the first such program in the world.

Career and Research

Brooks joined IBM in 1956, working in Poughkeepsie, New York, and Yorktown, New York. He worked on the architecture of the IBM 7030 Stretch, a $10 million scientific supercomputer of which nine were sold, and the IBM 7950 Harvest computer for the National Security Agency. Subsequently, he became manager for the development of the IBM System/360 family of computers and the OS/360 software package. During this time he coined the term "computer architecture".

In 1964, Brooks accepted an invitation to come to the University of North Carolina at Chapel Hilland founded the University's computer science department. He chaired it for 20 years. As of 2013he was still engaged in active research there, primarily in virtual environments and scientific visualization.

A few years after leaving IBM he wrote *The Mythical Man-Month*. The seed for the book was planted by IBM's then-CEO Thomas Watson Jr., who asked in Brooks's exit interview why it was so much harder to manage software projects than hardware projects. In this book Brooks made the now-famous statement: "Adding manpower to a late software project makes it later." This has since come to be known as *Brooks's law*. In addition to *The Mythical Man-Month*, Brooks is also known for the paper *No Silver Bullet – Essence and Accident in Software Engineering*.

In 2004 in a talk at the Computer History Museum and also in a 2010 interview in *Wired* magazine, Brooks was asked "What do you consider your greatest technological achievement?" Brooks responded, "The most important single decision I ever made was to change the IBM 360 series from a 6-bit byte to an 8-bit byte, thereby enabling the use of lowercase letters. That change propagated everywhere."

A "20th anniversary" edition of *The Mythical Man-Month* with four additional chapters was published in 1995.

As well as *The Mythical Man-Month*, Brooks has authored or co-authored many books and peer reviewed papers including *Automatic Data Processing*, "No Silver Bullet", *Computer Architecture*, and *The Design of Design*.

His contributions to human–computer interaction are described in Ben Shneiderman's HCI pioneers website.

Service and Memberships

Brooks has served on a number of US national boards and committees.

- Defense Science Board (1983–86)
- Member, Artificial Intelligence Task Force (1983–84)
- Chairman, Military Software Task Force (1985–87)
- Member, Computers in Simulation and Training Task Force (1986–87)
- National Science Board (1987–92)

Personal Life

Brooks is an evangelical Christian who is active with InterVarsity Christian Fellowship.

Brooks named his eldest son after Kenneth E. Iverson.

SUMMARY

- Software development is a process of writing and maintaining the source code, but in a broader sense, it includes all that is involved between the conception of the desired software through to the final manifestation of the software, sometimes in a planned and structured process.
- A software or a programming tool is a set of computer programs that are used by the developers to create, maintain, debug, or support other applications and programs.
- Software development tools are simply tools (generally software themselves) that programmers practice to create other software.
- Agile development tools can be of different types like linkers, compilers, code editors, GUI designers, assemblers, debuggers, performance analysis tools, and many others.
- A software standard is a standard, protocol, or other common format of a document, file, or data transfer accepted and used by one or more software developers while working on one or more than one computer programs.
- Software standards consist of certain terms, concepts, data formats, document styles and techniques agreed upon by software creators so that their software can understand the files and data created by a different computer program.
- Software engineering is a detailed study of engineering to the design, development and maintenance of software. Software engineering was introduced to address the issues of low-quality software projects.
- Software is more than just a program code. A program is an executable code, which serves some computational purpose. Software is considered to be a collection of executable programming code, associated libraries and documentations. Software, when made for a specific requirement is called software product.
- Software engineering is an engineering branch associated with development of software product using well-defined scientific principles, methods and procedures. The outcome of software engineering is an efficient and reliable software product.

KNOWLEDGE CHECK

1. **Abbreviate the term CASE.**
   a. Computer Authorized Software Engineering
   b. Computer Aided Software Engineering
   c. Common Authorized Software Engineering
   d. Common Aided Software Engineering
2. **CASE Tool stands for....................**
   a. Computer Aided Software Engineering
   b. Component Aided Software Engineering
   c. Constructive Aided Software Engineering
   d. Computer Analysis Software Engineering
3. **What stores all changes and info related to the project from development through maintenance in CASE tools?**
   a. Database
   b. Repository
   c. Registers
   d. None of the mentioned
4. **Which of the following is not a type of CASE tool?**
   a. Lower
   b. Classic
   c. Real
   d. Middle
5. **The benefits for standardization are represented by which of the following?**
   a. Greater availability of suitable products
   b. More vendor competition
   c. Affordable prices
   d. All of the mentioned
6. **What is Software?**
   a. Set of computer programs, procedures and possibly associated document concerned with the operation of data processing.
   b. A set of compiler instructions
   c. A mathematical formula
   d. None of above

7. Which of these software engineering activities are not a part of software processes ?

a. Software development

b. Software dependence

c. Software validation

d. Software specification

8. ……………. is a sub discipline of computer Science that attempts to apply engineering principles to the creation, operation, modification and maintenance of the software components of various systems.

a. Computer Engineering

b. Hardware Engineering

c. Software Engineering

d. Component Engineering

9. …………….. is actually a multi-step process that focuses on four distinct attributes of a program, data structure, software architecture, interface representations and procedural detail.

a. Software analysis

b. Software design

c. Coding

d. Testing

10. The fundamental notions of software engineering does not account for?

a. Software Security

b. Software reuse

c. Software processes

d. Software Validation

REVIEW QUESTIONS

1. What are CASE tools? What are the components of CASE tools?
2. Discuss about the evolution of software development tools.
3. Distinguish between open versus closed standards.
4. What are the design constraints for software development?
5. Write short notes on following:
    - Design tools

- Programming tools
- Prototyping tools
- Web development tools.

Check Your Result

1. (b)	2. (a)	3. (b)	4. (d)	5. (d)
6. (a)	7. (b)	8. (c)	9. (b)	10. (d)

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CHAPTER 10

SOFTWARE TESTING AND QUALITY

LEARNING OBJECTIVES

After studying this chapter, you will be able to:

1. Focus on basic concept of software testing
2. Explain the software quality

"Testing is not responsible for the bugs inserted into software any more than the sun is responsible for creating dust in the air."

– Dorothy Graham

INTRODUCTION

Software testing is a process of executing a program or application with the intent of finding the software bugs. In software testing, quality is defined as "conformance to requirements." Every use case, functional requirement, and other software requirement defines a specific behavior that the software must exhibit. When the software does not behave the way that the requirements say it must behave, that is a defect. This means that your software testers are responsible for figuring out whether the software that was produced by the team behaves in the way that the requirements it was built from say that it should. Software testing is an investigation conducted to provide stakeholders with information about the quality of the software product or service under test. Software testing can also provide an objective, independent view of the software to allow the business to appreciate and understand the risks of software implementation. Test techniques include the process of executing a program or application with the intent of finding software bugs (errors or other defects), and verifying that the software product is fit for use. Software quality measures how well software is designed (quality of design), and how well the software conforms to that design (quality of conformance), although there are several different definitions. It is often described as the 'fitness for purpose' of a piece of software. Whereas quality of conformance is concerned with implementation, quality of design measures how valid the design and requirements are in creating a worthwhile product.

10.1 BASIC CONCEPT OF SOFTWARE TESTING

It is the process of critical analysis to identify and evaluate whether the developed application meets the Business Requirement Specifications. It is a continuous process, namely Software Testing Lifecycle (STLC) works along with the software development life cycle. Over each phase, it verifies the functionalities and validates the app performance with the requirement. Besides, to deliver bug-free software, software testing helps to improvise the functionalities and usability of applications. There are different types, methods, and techniques to test software, and it involves multiple levels to verify and validate it.

This means that if an organization does not have good requirements engineering practices, then it will be very hard to deliver software that fills the users' needs, because the product team does not really know what those needs are. It's not a coincidence that many problems that seem to originate with the software testers are really requirements problems that simply have not been caught yet. This chapter gives an overview of what testers do in a software organization, and clears up some misconceptions about what they do not do. By putting in place good software testing practices based on solid software requirements specifications, a project manager can help assure the quality of the software.

10.1.1 Importance of Software Testing

To put it simply, the importance of software testing can be traced from the user's response. It assures the quality of the product and satisfies the customers as well as users. Also, it promises better business optimization (less maintenance cost), reliability, and superior user experience. Substantially, the iterative efforts spending to mold a powerful yet error-free software are far and wide.

Despite the designers and developers, software testing plays a decisive role in the process. As the development process follows the software development life cycle, the testing process lines up right behind the queue to compile the units to verify and validates.

Altogether, it is a continuous process of verification and validation to deliver an excellent product. Each phase of the test determines the performance and efficiency of the system/application. As a result, it helps to ensure whether the software application aligns with all the technical and business parameters.

The importance of software testing is evident in the final quality assurance report. By successfully passing through the diversified levels of testing, the final products could perform beyond the expected outcomes. At each level, the testers can not only figure out the errors but also prevent such snags in the future. Besides, exploring each mistake makes for the birth of an improvised version of the software.

What is Testing?

Testing is the process of evaluating a system or its component(s) with the intent to find whether it satisfies the specified requirements or not. In simple words, testing is executing a system in order to identify any gaps, errors, or missing requirements in contrary to the actual requirements.

According to ANSI/IEEE 1059 standard, Testing can be defined as - A process of analyzing a software item to detect the differences between existing and required conditions (that is defects/errors/bugs) and to evaluate the features of the software item.

Who does Testing?

It depends on the process and the associated stakeholders of the project(s). In the IT industry, large companies have a team with responsibilities to evaluate the developed software in context of the given requirements. Moreover, developers also conduct testing which is called Unit Testing. In most cases, the following professionals are involved in testing a system within their respective capacities:

- Software Tester
- Software Developer
- Project Lead/Manager
- End User

Different companies have different designations for people who test the software on the basis of their experience and knowledge such as Software Tester, Software Quality Assurance Engineer, QA Analyst, etc.

When to Start Testing?

An early start to testing reduces the cost and time to rework and produce errorfree software that is delivered to the client. However in Software Development Life Cycle (SDLC), testing can be started from the Requirements Gathering phase and continued till the deployment of the software. It also depends on the development model that is being used. For example, in the Waterfall model, formal testing is conducted in the testing phase; but in the incremental model, testing is performed at the end of every increment/iteration and the whole application is tested at the end.

Testing is done in different forms at every phase of SDLC:

- DURING the requirement gathering phase, the analysis and verification of requirements are also considered as testing.
- Reviewing the design in the design phase with the intent to improve the design is also considered as testing.
- Testing performed by a developer on completion of the code is also categorized as testing.

When to Stop Testing?

It is difficult to determine when to stop testing, as testing is a never-ending process and no one can claim that a software is 100% tested. The following aspects are to be considered for stopping the testing process:

- Testing Deadlines
- Completion of test case execution
- Completion of functional and code coverage to a certain point
- Bug rate falls below a certain level and no high-priority bugs are identified
- Management decision

10.1.2 Software Testing Objectives

Software Testing has different goals and objectives. The major objectives of Software testing are as follows:

- Finding defects which may get created by the programmer while developing the software.

- Gaining confidence in and providing information about the level of quality.
- To prevent defects.
- To make sure that the end result meets the business and user requirements.
- To ensure that it satisfies the BRS that is Business Requirement Specification and SRS that is System Requirement Specifications.
- To gain the confidence of the customers by providing them a quality product.

Software testing helps in finalizing the software product against business and user requirements. It is very important to have good test coverage in order to test the software application completely and make it sure that it's performing well and as per the specifications.

While determining the test coverage the test cases should be designed well with maximum possibilities of finding the errors or bugs. The test cases should be very effective. This objective can be measured by the number of defects reported per test cases. Higher the number of the defects reported the more effective are the test cases.

Once the delivery is made to the end users or the customers they should be able to operate it without any complaints. In order to make this happen the tester should know as how the customers are going to use this product and accordingly they should write down the test scenarios and design the test cases. This will help a lot in fulfilling all the customer's requirements.

Software testing makes sure that the testing is being done properly and hence the system is ready for use. Good coverage means that the testing has been done to cover the various areas like functionality of the application, compatibility of the application with the OS, hardware and different types of browsers, performance testing to test the performance of the application and load testing to make sure that the system is reliable and should not crash or there should not be any blocking issues. It also determines that the application can be deployed easily to the machine and without any resistance. Hence the application is easy to install, learn and use.

10.1.3 Principles of Testing

There are seven principles of testing. They are as follows:

- **Testing shows presence of defects:** Testing can show the defects are present, but cannot prove that there are no defects. Even after testing the application or product thoroughly we cannot say that the product is 100% defect free. Testing always reduces the number of undiscovered defects remaining in the software but even if no defects are found, it is not a proof of correctness.
- **Exhaustive testing is impossible:** Testing everything including all combinations of inputs and preconditions is not possible. So, instead of doing the exhaustive

testing we can use risks and priorities to focus testing efforts. For example: In an application in one screen there are 15 input fields, each having 5 possible values, then to test all the valid combinations you would need 30 517 578 125 (5^{15}) tests. This is very unlikely that the project timescales would allow for this number of tests. So, accessing and managing risk is one of the most important activities and reason for testing in any project.

- **Early testing:** In the software development life cycle testing activities should start as early as possible and should be focused on defined objectives.
- **Defect clustering:** A small number of modules contains most of the defects discovered during pre-release testing or shows the most operational failures.
- **Pesticide paradox:** If the same kinds of tests are repeated again and again, eventually the same set of test cases will no longer be able to find any new bugs. To overcome this “Pesticide Paradox”, it is really very important to review the test cases regularly and new and different tests need to be written to exercise different parts of the software or system to potentially find more defects.
- **Testing is context depending:** Testing is basically context dependent. Different kinds of sites are tested differently. For example, safety – critical software is tested differently from an e-commerce site.
- **Absence – of – errors fallacy:** If the system built is unusable and does not fulfil the user’s needs and expectations then finding and fixing defects does not help.

10.1.4 Types of Software Testing

The different types of testing that may be used to test a software during SDLC.

Manual Testing

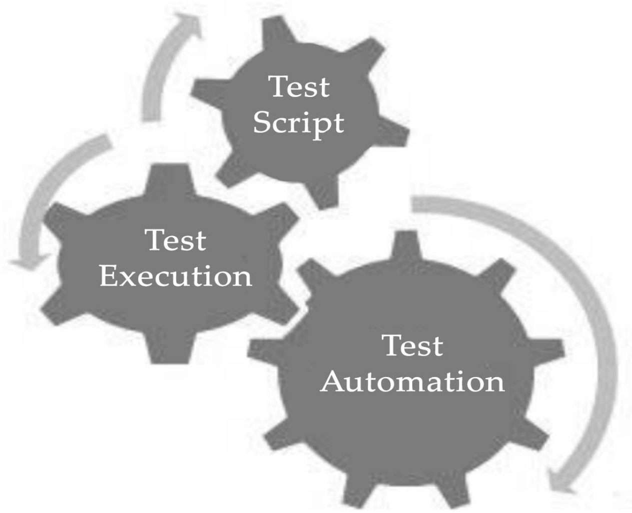
Manual testing includes testing a software manually, i.e., without using any automated tool or any script. In this type, the tester takes over the role of an end-user and tests the software to identify any unexpected behavior or bug. There are different stages for manual testing such as unit testing, integration testing, system testing, and user acceptance testing. Testers use test plans, test cases, or test scenarios to test a software to ensure the completeness of testing. Manual testing also includes exploratory testing, as testers explore the software to identify errors in it.

Automation Testing

Automation testing, which is also known as Test Automation, is when the tester writes scripts and uses another software to test the product. This process involves automation of a manual process. Automation Testing is used to re-run the test scenarios that were performed manually, quickly, and repeatedly.

Keyword

Test automation is the use of special software (separate from the software being tested) to control the execution of tests and the comparison of actual outcomes with predicted outcomes.



Apart from regression testing, automation testing is also used to test the application from load, performance, and stress point of view. It increases the test coverage, improves accuracy, and saves time and money in comparison to manual testing.

What to Automate?

It is not possible to automate everything in a software. The areas at which a user can make transactions such as the login form or registration forms, any area where large number of users can access the software simultaneously should be automated. Furthermore, all GUI items, connections with databases, field validations, etc. can be efficiently tested by automating the manual process.

When to Automate?

Test Automation should be used by considering the following aspects of a software:

- Large and critical projects
- Projects that require testing the same areas frequently
- Requirements not changing frequently
- Accessing the application for load and performance with many virtual users
- Stable software with respect to manual testing
- Availability of time

How to Automate?

Automation is done by using a supportive computer language like VB scripting and an automated software application. There are many tools available that can be used to write automation scripts. Before mentioning the tools, let us identify the process that can be used to automate the testing process:

- Identifying areas within a software for automation
- Selection of appropriate tool for test automation
- Writing test scripts
- Development of test suits
- Execution of scripts
- Create result reports
- Identify any potential bug or performance issues

10.1.5 Software Testing Tools

The following tools can be used for automation testing:

- HP Quick Test Professional
- Selenium
- IBM Rational Functional Tester

- SilkTest
- TestComplete
- Testing Anywhere
- WinRunner
- LaodRunner
- Visual Studio Test Professional
- WATIR

10.1.6 Testing Methods

There are different methods that can be used for software testing.

Black-Box Testing

The technique of testing without having any knowledge of the interior workings of the application is called black-box testing. The tester is oblivious to the system architecture and does not have access to the source code. Typically, while performing a black-box test, a tester will interact with the system's user interface by providing inputs and examining outputs without knowing how and where the inputs are worked upon.

The following table lists the advantages and disadvantages of black-box testing.

Advantages	Disadvantages
Well suited and efficient for large code segments.	Limited coverage, since only a selected number of test scenarios is actually performed.
Code access is not required.	Inefficient testing, due to the fact that the tester only has limited knowledge about an application.
Clearly separates user's perspective from the developer's perspective through visibly defined roles.	Blind coverage, since the tester cannot target specific code segments or error-prone areas.
Large numbers of moderately skilled testers can test the application with no knowledge of implementation, programming language, or operating systems.	The test cases are difficult to design.

White-Box Testing

White-box testing is the detailed investigation of internal logic and structure of the code. White-box testing is also called glass testing or open-box testing. In order to perform white-box testing on an application, a tester needs to know the internal workings of the code.

The tester needs to have a look inside the source code and find out which unit/ chunk of the code is behaving inappropriately.

The following table lists the advantages and disadvantages of white-box testing.

Advantages	Disadvantages
As the tester has knowledge of the source code, it becomes very easy to find out which type of data can help in testing the application effectively.	Due to the fact that a skilled tester is needed to perform white-box testing, the costs are increased.
It helps in optimizing the code.	
Extra lines of code can be removed which can bring in hidden defects.	Sometimes it is impossible to look into every nook and corner to find out hidden errors that may create problems, as many paths will go untested.
Due to the tester's knowledge about the code, maximum coverage is attained during test scenario writing.	It is difficult to maintain white-box testing, as it requires specialized tools like code analyzers and debugging tools.

Grey-Box Testing

Grey-box testing is a technique to test the application with having a limited knowledge of the internal workings of an application. In software testing, the phrase the more you know, the better carries a lot of weight while testing an application.

Mastering the domain of a system always gives the tester an edge over someone with limited domain knowledge. Unlike black-box testing, where the tester only tests the application's user interface; in grey-box testing, the tester has access to design documents and the database. Having this knowledge, a tester can prepare better test data and test scenarios while making a test plan.

Advantages	Disadvantages
Offers combined benefits of black-box and white-box testing wherever possible.	Since the access to source code is not available, the ability to go over the code and test coverage is limited.
Grey box testers don't rely on the source code; instead they rely on interface definition and functional specifications.	The tests can be redundant if the software designer has already run a test case.
Based on the limited information available, a grey-box tester can design excellent test scenarios especially around communication protocols and data type handling.	Testing every possible input stream is unrealistic because it would take an unreasonable amount of time; therefore, many program paths will go untested.
The test is done from the point of view of the user and not the designer.	

A Comparison of Testing Methods

The following table lists the points that differentiate black-box testing, **grey-box testing**, and white-box testing.

Black-Box Testing	**Grey-Box Testing**	**White-Box Testing**
The internal workings of an application need not be known.	The tester has limited knowledge of the internal workings of the application.	Tester has full knowledge of the internal workings of the application.
Also known as closed-box testing, data-driven testing, or functional testing.	Also known as translucent testing, as the tester has limited knowledge of the insides of the application.	Also known as clear-box testing, structural testing, or code-based testing.
Performed by end-users and also by testers and developers.	Performed by end-users and also by testers and developers.	Normally done by testers and developers.
Testing is based on external expectations -Internal behavior of the application is unknown.	Testing is done on the basis of high-level database diagrams and data flow diagrams.	Internal workings are fully known and the tester can design test data accordingly.
It is exhaustive and the least time-consuming.	Partly time-consuming and exhaustive.	The most exhaustive and time-consuming type of testing.
Not suited for algorithm testing.	Not suited for algorithm testing.	Suited for algorithm testing.
This can only be done by trial-and-error method.	Data domains and internal boundaries can be tested, if known.	Data domains and internal boundaries can be better tested.

10.1.7 Testing Levels

There are different levels during the process of testing. A brief description is provided about these levels.

Levels of testing include different methodologies that can be used while conducting software testing. The main levels of software testing are:

- Functional Testing
- Non-functional Testing

Functional Testing

This is a type of black-box testing that is based on the specifications of the software that is to be tested. The application is tested by providing input and then the results are examined that need to conform to the functionality it was intended for. Functional testing of a software is conducted on a complete, integrated system to evaluate the system's compliance with its specified requirements.

Keyword

Gray box testing is a strategy for software debugging in which the tester has limited knowledge of the internal details of the program.

There are five steps that are involved while testing an application for functionality.

- The determination of the functionality that the intended application is meant to perform.
- The creation of test data based on the specifications of the application.
- The output based on the test data and the specifications of the application.
- The writing of test scenarios and the execution of test cases.
- The comparison of actual and expected results based on the executed test cases.

Unit Testing

This type of testing is performed by developers before the setup is handed over to the testing team to formally execute the test cases. Unit testing is performed by the respective developers on the individual units of source code assigned areas. The developers use test data that is different from the test data of the quality assurance team.

The goal of unit testing is to isolate each part of the program and show that individual parts are correct in terms of requirements and functionality.

Limitations of Unit Testing

Testing cannot catch each and every bug in an application. It is impossible to evaluate every execution path in every software application. The same is the case with unit testing. There is a limit to the number of scenarios and test data that a developer can use to verify a source code. After having exhausted all the options, there is no choice but to stop unit testing and merge the code segment with other units.

Integration Testing

Integration testing is defined as the testing of combined parts of an application to determine if they function correctly. Integration testing can be done in two ways: Bottom-up integration testing and Top-down integration testing.

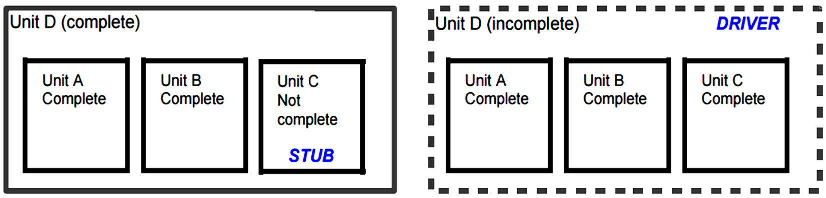
- **Bottom-up integration:** This testing begins with unit testing, followed by tests of progressively higher-level combinations of units called modules or builds.
- **Top-down integration:** In this testing, the highest-level modules are tested first and progressively, lower-level modules are tested thereafter.

In a comprehensive software development environment, bottom-up testing is usually done first, followed by top-down testing. The process concludes with multiple tests of the complete application, preferably in scenarios designed to mimic actual situations.

REMEMBER

Software testing methodologies should not be setup just for the sake of testing software code. The big picture should be considered and the prime goal of the project should be satisfied by the testing methodology.

For example, if units A, B and C constitute the major parts of unit D then the overall assembly could be tested by assembling units A and B and a simulation of C, if C were not complete. Similarly if unit D itself was not complete it could be represented by a "driver" or a simulation of the super-unit.



As successive areas of functionality are completed they can be evaluated and integrated into the overall project. Without integration testing you are limited to testing a completely assembled product or system which is inefficient and error prone. Much better to test the building blocks as you go and build your project from the ground up in a series of controlled steps.

System Testing

System testing tests the system as a whole. Once all the components are integrated, the application as a whole is tested rigorously to see that it meets the specified Quality Standards. This type of testing is performed by a specialized testing team.

System testing is important because of the following reasons:

- System testing is the first step in the Software Development Life Cycle, where the application is tested as a whole.
- The application is tested thoroughly to verify that it meets the functional and technical specifications.
- The application is tested in an environment that is very close to the production environment where the application will be deployed.
- System testing enables us to test, verify, and validate both the business requirements as well as the application architecture.

Regression Testing

Whenever a change in a software application is made, it is quite possible that other areas within the application have been affected by this change. Regression testing is performed to verify that a fixed bug hasn't resulted in another functionality or business rule violation.

Regression testing is important because of the following reasons:

- Minimize the gaps in testing when an application with changes made has to be tested.
- Testing the new changes to verify that the changes made did not affect any other area of the application.
- Mitigates risks when regression testing is performed on the application.
- Test coverage is increased without compromising timelines.
- Increase speed to market the product.

The intent of regression testing is to ensure that a change, such as a bug fix should not result in another fault being uncovered in the application.

Acceptance Testing

This is arguably the most important type of testing, as it is conducted by the Quality Assurance Team who will gauge whether the application meets the intended specifications and satisfies the client's requirement. The QA team will have a set of pre-written scenarios and test cases that will be used to test the application.

More ideas will be shared about the application and more tests can be performed on it to gauge its accuracy and the reasons why the project was initiated. Acceptance tests are not only intended to point out simple spelling mistakes, cosmetic errors, or interface gaps, but also to point out any bugs in the application that will result in system crashes or major errors in the application. By performing acceptance tests on an application, the testing team will deduce how the application will perform in production. There are also legal and contractual requirements for acceptance of the system.

Alpha Testing

This test is the first stage of testing and will be performed amongst the teams (developer and QA teams). Unit testing, integration testing and system testing when combined together is known as alpha testing. During this phase, the following aspects will be tested in the application:

- Spelling Mistakes
- Broken Links
- Cloudy Directions
- The Application will be tested on machines with the lowest specification to test loading times and any latency problems.

Beta Testing

This test is performed after alpha testing has been successfully performed. In beta testing, a sample of the intended audience tests the application. Beta testing is also known as pre-release testing. Beta test versions of software are ideally distributed to a wide audience on the Web, partly to give the program a "real-world" test and partly to provide a preview of the next release. In this phase, the audience will be testing the following:

- Users will install, run the application and send their feedback to the project team.
- Typographical errors, confusing application flow, and even crashes.
- Getting the feedback, the project team can fix the problems before releasing the software to the actual users.
- The more issues you fix that solve real user problems, the higher the quality of your application will be.
- Having a higher-quality application when you release it to the general public will increase customer satisfaction.

Non-Functional Testing

Non-functional testing involves testing a software from the requirements which are nonfunctional in nature but important such as performance, security, user interface, etc. Some of the important and commonly used non-functional testing types are discussed are.

Performance Testing

It is mostly used to identify any bottlenecks or performance issues rather than finding bugs in a software. There are different causes that contribute in lowering the performance of a software:

- Network delay
- Client-side processing
- Database transaction processing
- Load balancing between servers
- Data rendering

Performance testing is considered as one of the important and mandatory testing type in terms of the following aspects:

- Speed (i.e. Response Time, data rendering and accessing)
- Capacity
- Stability
- Scalability

Performance testing can be either qualitative or quantitative and can be divided into different sub-types such as Load testing and Stress testing.

Load Testing

It is a process of testing the behavior of a software by applying maximum load in terms of software accessing and manipulating large input data. It can be done at both normal and peak load conditions. This type of testing identifies the maximum capacity of software and its behavior at peak time. Most of the time, load testing is performed with the help of automated tools such as Load Runner, AppLoader, IBM Rational Performance Tester, Apache JMeter, Silk Performer, Visual Studio Load Test, etc.

Virtual users (VUsers) are defined in the automated testing tool and the script is executed to verify the load testing for the software. The number of users can be increased or decreased concurrently or incrementally based upon the requirements.

Stress Testing

Stress testing includes testing the behavior of a software under abnormal conditions. For example, it may include taking away some resources or applying a load beyond the actual load limit. The aim of stress testing is to test the software by applying the load to the system and taking over the resources used by the software to identify the breaking point. This testing can be performed by testing different scenarios such as:

- Shutdown or restart of network ports randomly
- Turning the database on or off
- Running different processes that consume resources such as CPU, memory, server, etc.

Usability Testing

Usability testing is a black-box technique and is used to identify any error(s) and improvements in the software by observing the users through their usage and operation.

According to Nielsen, usability can be defined in terms of five factors, i.e. efficiency of use, learn-ability, memory-ability, errors/safety, and satisfaction. According to him, the usability of a product will be good and the system is usable if it possesses the above factors.

Nigel Bevan and Macleod considered that usability is the quality requirement that can be measured as the outcome of interactions with a computer system. This requirement can be fulfilled and the end-user will be satisfied if the intended goals are achieved effectively with the use of proper resources.

Keyword

Graphical User Interface is a program interface that takes advantage of the computer's graphics capabilities to make the program easier to use.

Molich in 2000 stated that a user-friendly system should fulfill the following five goals, i.e., easy to Learn, easy to remember, efficient to use, satisfactory to use, and easy to understand.

In addition to the different definitions of usability, there are some standards and quality models and methods that define usability in the form of attributes and sub-attributes such as ISO-9126, ISO-9241-11, ISO-13407, and IEEE std.610.12, etc.

UI vs. Usability Testing

UI testing involves testing the **Graphical User Interface** of the Software. UI testing ensures that the GUI functions according to the requirements and tested in terms of color, alignment, size, and other properties. On the other hand, usability testing ensures a good and user-friendly GUI that can be easily handled. UI testing can be considered as a sub-part of usability testing.

Security Testing

Security testing involves testing a software in order to identify any flaws and gaps from security and vulnerability point of view. Listed below are the main aspects that security testing should ensure:

- Confidentiality
- Integrity
- Authentication
- Availability
- Authorization
- Non-repudiation
- Software is secure against known and unknown vulnerabilities
- Software data is secure
- Software is according to all security regulations
- Input checking and validation
- SQL insertion attacks
- Injection flaws
- Session management issues
- Cross-site scripting attacks
- Buffer overflows vulnerabilities
- Directory traversal attacks

Portability Testing

Portability testing includes testing a software with the aim to ensure its reusability and that it can be moved from another software as well. Following are the strategies that can be used for portability testing:

- Transferring an installed software from one computer to another.
- Building executable (.exe) to run the software on different platforms.

Portability testing can be considered as one of the sub-parts of system testing, as this testing type includes overall testing of a software with respect to its usage over different environments. Computer hardware, operating systems, and browsers are the major focus of portability testing. Some of the pre-conditions for portability testing are as follows:

- Software should be designed and coded, keeping in mind the portability requirements.

- Unit testing has been performed on the associated components.
- Integration testing has been performed.
- Test environment has been established.

A software product should only be released after it has gone through a proper process of development, testing and bug fixing.

10.1.8 Testing Documentation

Testing documentation involves the documentation of artifacts that should be developed before or during the testing of Software. Documentation for software testing helps in estimating the testing effort required, test coverage, requirement tracking/tracing, etc. This method describes some of the commonly used documented artifacts related to software testing such as:

- Test Plan
- Test Scenario
- Test Case
- Traceability Matrix

Test Plan

A test plan outlines the strategy that will be used to test an application, the resources that will be used, the test environment in which testing will be performed, and the limitations of the testing and the schedule of testing activities. Typically the Quality Assurance Team Lead will be responsible for writing a Test Plan.

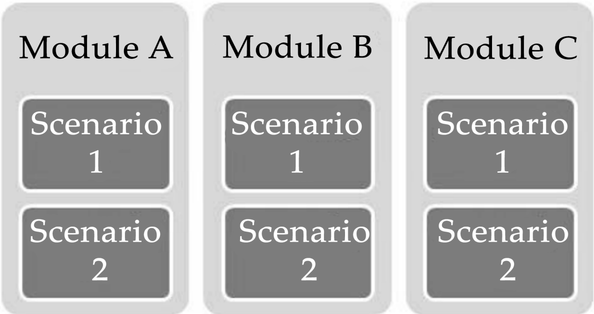
A test plan includes the following:

- Introduction to the Test Plan document
- Assumptions while testing the application
- List of test cases included in testing the application
- List of features to be tested
- What sort of approach to use while testing the software
- List of deliverables that need to be tested
- The resources allocated for testing the application
- Any risks involved during the testing process
- A schedule of tasks and milestones to be achieved

Test Scenario

It is a one line statement that notifies what area in the application will be tested. Test scenarios are used to ensure that all process flows are tested from end to end. A particular area of an application can have as little as one test scenario to a few hundred scenarios depending on the magnitude and complexity of the application.

The terms 'test scenario' and 'test cases' are used interchangeably, however a test scenario has several steps, whereas a test case has a single step. Viewed from this perspective, test scenarios are test cases, but they include several test cases and the sequence that they should be executed. Apart from this, each test is dependent on the output from the previous test.



Test Case

Test cases involve a set of steps, conditions, and inputs that can be used while performing testing tasks. The main intent of this activity is to ensure whether a software passes or fails in terms of its functionality and other aspects. There are many types of test cases such as functional, negative, error, logical test cases, physical test cases, UI test cases, etc. Furthermore, test cases are written to keep track of the testing coverage of a software. Generally, there are no formal templates that can be used during test case writing. However, the following components are always available and included in every test case:

- Test case ID
- Product module.
- Product version
- Revision history
- Purpose
- Assumptions
- Pre-conditions

- Steps
- Expected outcome.
- Actual outcome
- Post-conditions

Many test cases can be derived from a single test scenario. In addition, sometimes multiple test cases are written for a single software which are collectively known as test suites.

Traceability Matrix

Traceability Matrix (also known as Requirement Traceability Matrix - RTM) is a table that is used to trace the requirements during the Software Development Life Cycle. It can be used for forward tracing (i.e. from Requirements to Design or Coding) or backward (i.e. from Coding to Requirements). There are many user-defined templates for RTM. Each requirement in the RTM document is linked with its associated test case so that testing can be done as per the mentioned requirements. Furthermore, Bug ID is also included and linked with its associated requirements and test case.

The main goals for this matrix are:

- Make sure the software is developed as per the mentioned requirements.
- Helps in finding the root cause of any bug.
- Helps in tracing the developed documents during different phases of SDLC.

10.2 OVERVIEW OF SOFTWARE QUALITY

Software quality is defined as conformance to explicitly state functional and performance requirements, documents, and standards. The factors that affect software quality are a complex combination of conditions that can be measured based on data, such as audit-ability, completeness, consistency, error tolerance, and expandability. Quality software is reasonably bug or defect free, delivered on time and within budget, meets requirements and/or expectations, and is maintainable. ISO 8402-1986 standard defines quality as "the totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs."

Key aspects of quality for the customer include:

- **Good design – looks and style:** It is very important to have a good design. The application or product should meet all the requirement specifications and at the same time it should be user friendly. The customers are basically attracted by the good looks and style of the application. The right color combinations, font size and the styling of the texts and buttons are very important.

- **Good functionality – it does the job well:** Along with the good looks of the application or the product it is very important that the functionality should be intact. All the features and their functionality should work as expected. There should not be any deviation in the actual result and the expected result.
- **Reliable – acceptable level of breakdowns or failure:** After we have tested for all the features and their functionalities it also very important that the application or product should be reliable. For example: There is an application of saving the students records. This application should save all the students records and should not fail after entering 100 records. This is called reliability.
- **Consistency:** The software should have consistency across the application or product. Single software can be multi-dimensional. It is very important that all the different dimensions should behave in a consistent manner.
- **Durable – lasts as long as it should:** The software should be durable. For example if software is being used for a year and the number of data has exceed 5000 records then it should not fail if number of records increases. The software product or application should continue to behave in the same way without any functional breaks.
- **Good after sales service:** Once the product is shipped to the customers then maintenance comes into the picture. It is very important to provide good sales services to keep the customers happy and satisfied. For example if after using the product for six months the customer realizes to make some changes to the application then those changes should be done as fast as possible and should be delivered to the customers on time with quality.
- **Value for money:** It is always important to deliver the product to the customers which have value for money. The product should meet the requirement specifications. It should work as expected, should be user friendly. We should provide good services to the customers. Other than the features mentioned in the requirement specifications some additional functionality could be

DID YOU KNOW ?

Historically, the structure, classification and terminology of attributes and metrics applicable to software quality management have been derived or extracted from the ISO 9126-3 and the subsequent ISO 25000:2005 quality model, also known as SQuaRE.

given to the customers which they might not have thought of. These additional functionalities should make their product more user friendly and easy to use. This also adds value for money.

10.2.1 Quality Concept

Competition to provide specialized products and services results in breakthroughs as well as long-term growth and change. Quality assurance verifies that any customer offering, regardless if it is new or evolved, is produced and offered with the best possible materials, in the most comprehensive way, with the highest standards. The goal to exceed customer expectations in a measurable and accountable process is provided by quality assurance.

Definition of Quality and Quality Assurance

The term 'quality' is often used in a vague, blurred way. If someone talks about 'working on quality', they may simply mean activities designed to improve the organization and its services. Quality is essentially about learning what you are doing well and doing it better. It also means finding out what you may need to change to make sure you meet the needs of your service users. Quality is about:

- knowing what you want to do and how you want to do it
- learning from what you do
- using what you learn to develop your organization and its services
- seeking to achieve continuous improvement
- Satisfying your stakeholders - those different people and groups with an interest in your organization.

Quality assurance is the process of verifying or determining whether products or services meet or exceed customer expectations. Quality assurance is a process-driven approach with specific steps to help define and attain goals. This process considers design, development, production, and service. PDCA (Plan, Do, Check, and Act) is an effective method for monitoring quality assurance because it analyzes existing conditions and methods used to provide the product or service customers. The goal is to ensure that excellence is inherent in every component of the process. Quality assurance also helps determine whether the steps used to provide the product or service are appropriate for the time and conditions. In addition, if the PDCA cycle is repeated throughout the lifetime of the product or service, it helps improve internal company efficiency.

Quality assurance demands a degree of detail in order to be fully implemented at every step. Planning, for example, could include investigation into the quality of the raw materials used in manufacturing, the actual assembly, or the inspection processes used. The Checking step could include customer feedback, surveys, or other marketing vehicles to determine if customer needs are being exceeded and why they are or are not. Acting could mean a total revision in the manufacturing process in order to correct a technical or cosmetic flaw.

Quality Control: The terms "quality assurance" and "quality control" are often used interchangeably to refer to ways of ensuring the quality of a service or product. The terms, however, have different meanings.

example

When the SQA team receives the SR (software requirements document) the intensity of quality control should be at the start. Of course quality control will still be executed until the end but developers should take into account that anything that starts out real bad could never take off. It is better to know what is wrong at first than to find that out later.

Quality Factors

The various factors, which influence the software, are termed as software factors. They can be broadly divided into two categories. The classification is done on the basis of measurability. The first category of the factors is of those that can be measured directly such as number of logical errors and the second category clubs those factors which can be measured only indirectly for example maintainability but the each of the factors are to be measured to check for the content and the quality control. Few factors of quality are available and they are mentioned below.

- Correctness - extent to which a program satisfies its specification and fulfills the client's objective.
- Reliability - extent to which a program is supposed to perform its function with the required precision.
- Efficiency - amount of computing and code required by a program to perform its function.
- Integrity - extent to which access to software and data is denied to unauthorized users.
- Usability- labor required to understand, operate, prepare input and interpret output of a program
- Maintainability- effort required to locate and fix an error in a program.
- Flexibility- effort needed to modify an operational program.
- Testability- effort required to test the programs for their functionality.
- Portability- effort required to run the program from one platform to other or to different hardware.
- Reusability- extent to which the program or its parts can be used as building blocks or as prototypes for other programs.
- Interoperability- effort required to couple one system to another.

Now as you consider the above-mentioned factors it becomes very obvious that the measurements of all of them to some discrete value are quite an impossible task. Therefore, another method was evolved to measure out the quality. A set of metrics is defined and is used to develop expressions for each of the factors as per the following expression

$$Fq = C1*M1 + C2*M2 + \ldots\ldots\ldots\ldots\ldots Cn*Mn$$

Where Fq is the software quality factor, Cn are regression coefficients and Mn is metrics that influences the quality factor. Metrics used in this arrangement is mentioned below –

- Audit ability- ease with which the conformance to standards can be verified.
- Accuracy- precision of computations and control
- Communication commonality- degree to which standard interfaces, protocols and bandwidth are used.
- Completeness- degree to which full implementation of functionality required has been achieved.
- Conciseness- program's compactness in terms of lines of code.

- Consistency- use of uniform design and documentation techniques throughout the software development.
- Data commonality- use of standard data structures and types throughout the program.
- Error tolerance – damage done when program encounters an error.
- Execution efficiency- run-time performance of a program.
- Expandability- degree to which one can extend architectural, data and procedural design.
- Hardware independence- degree to which the software is de-coupled from its operating hardware.
- Instrumentation- degree to which the program monitors its own operation and identifies errors that do occur.
- Modularity- functional independence of program components.
- Operability- eases of programs operation.
- Security- control and protection of programs and database from the unauthorized users.
- Self-documentation- degree to which the source code provides meaningful documentation.
- Simplicity- degree to which a program is understandable without much difficulty.
- Software system independence- degree to which program is independent of nonstandard programming language features, operating system characteristics and other environment constraints.
- Traceability- ability to trace a design representation or actual program component back to initial objectives.
- Training- degree to which the software is user-friendly to new users.

REMEMBER

A software team must identify a set of SQA activities that will filter errors out of work products before they are passed on.

There are various 'checklists' for software quality. One of them was given by Hewlett-Packard that has been given the acronym FURPS – for Functionality, Usability, Reliability, Performance and Supportability. Functionality is measured via the evaluation of the feature set and the program capabilities, the generality of the functions that are derived and the overall security of the system.

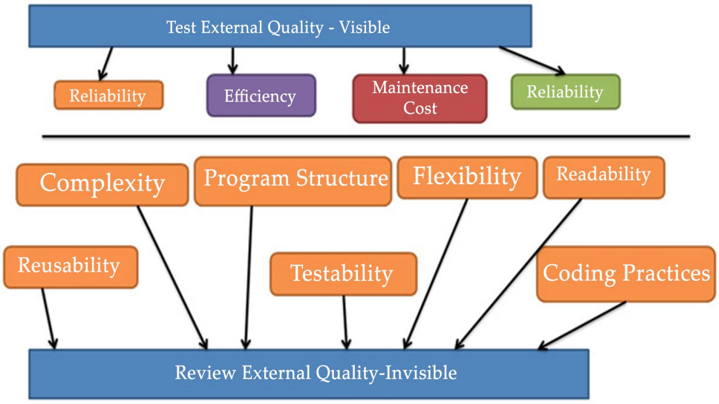
Considering human factors, overall aesthetics, consistency and documentation assesses usability. Reliability is figured out by evaluating the frequency and severity of failure, the accuracy of output results, the mean time between failures (MTBF), the ability to recover from failure and the predictability of the program.

Performance is measured by measuring processing speed, response time, resource consumption, throughput and efficiency. Supportability combines the ability to extend the program, adaptability, serviceability or in other terms maintainability and also testability, compatibility, configurability and the ease with which a system can be installed.

10.2.2 Software Quality Assurance

Software quality assurance involves testing computer software design and implementation and ensuring that it meets a minimum standard of quality. At the core of the quality assurance process is testing, which is the method by which every step of the development cycle is analyzed in order to find defects, such as malfunctions or security problems. The most commonly known part of the software quality assurance process is software and code testing; however, it also covers other aspects of the engineering cycle. Other aspects of software engineering that are subject to quality analysis include the design and implementation stages.

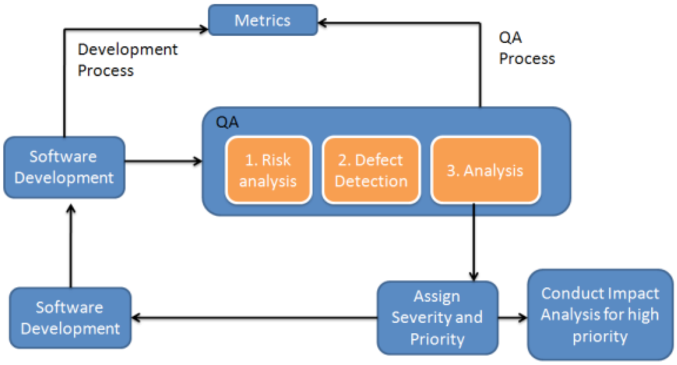
When we talk about software quality, we are actually talking about the evaluation of the software based on certain attributes. A software quality is defined based on the study of external and internal features of the software. The external quality is defined based on how software performs in real time scenario in operational mode and how useful it is for its users. The internal quality on the other hand focuses on the intrinsic aspects that are dependent on the quality of the code written. The user focuses more on how the software works at the external level, but the quality at external level can be maintained only if the coder has written a meaningful good quality code.



Presently there are two important approaches that are used to determine the quality of the software:

- Defect Management Approach
- Quality Attributes approach

As mentioned before anything that is not in line with the requirement of the client can be considered as a defect. Many times the development team fails to fully understand the requirement of the client which eventually leads to design error. Besides that, the error can be caused due to poor functional logic, wrong coding or improper data handling. In order to keep a track of defect a defect management approach can be applied. In defect management, categories of defects are defined based on severity. The number of defects is counted and actions are taken as per the severity defined. Control charts can be created to measure the development process capability.



Defect Management Approach

Quality Attribute Approach on the other hand focuses on six quality characteristics that are listed below:

Quality Attribute Approach

- *Functionality*: refers to complete set of important functions that are provided by the software
  - Suitability: whether the functions of the software are appropriate
  - Accurateness: are the functions implemented correctly?
  - Interoperability: how does the software interact with other components of the system?
  - Compliance: is the software in compliance with the necessary laws and guidelines?
  - Security: Is the software able to handle data related transaction securely?
- *Reliability*: this refers to the capability of software to perform under certain

conditions for a defined duration. This also defines the ability of the system to withstand component failure.

- Maturity: Frequency of failure of software
- Recoverability: this gives an idea of a system's ability to get back into full operation after failure.

■ *Usability*: refers to the ease of use of a function.

- Understandability: how easily the functions can be understood
- Learn ability: How much effort the users of different level need to put in to understand the functions.

■ *Efficiency*: generally depends on good architecture and coding practices followed while developing software.

■ *Maintainability*: also known as supportability. It is greatly dependent on code readability and complexity and refers to the ability to identify and fix a fault in a software:

- Analyzability: identification of the main cause of failure.
- Changeability: defines the effort that goes in modification of code to remove a fault.
- Stability: how stable a system is in its performance when there are changes made to it
- Testability: how much effort goes in testing the system?

■ *Portability*: Ability of the system to adopt to changes in its environment

- Adaptability: how easily a system adapts to the changes made in specifications
- Installability: how easily a system can be installed.
- Conformance: this is same as compliance in functionality.
- Replaceability: how easy it is to replace a component of the system in a given environment.

SQA Objectives

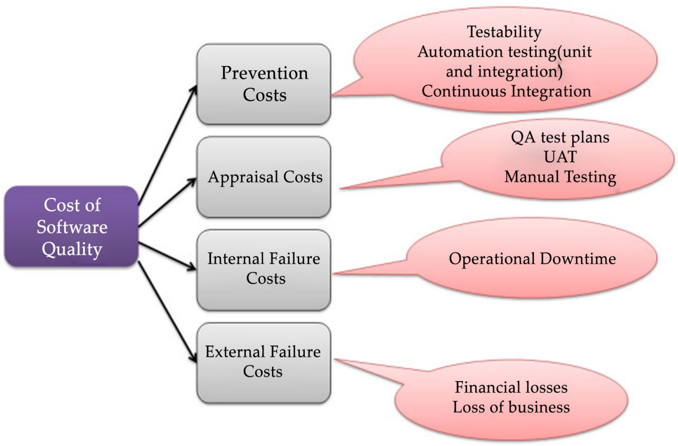
Software Quality Assurance was created with the following objectives:

■ ***Small to Zero Defects after Installation*** – One of the biggest goals of SQA is to prevent any possible defects when the output is made. Developers and engineers have to use universally approved steps to ensure that the program was built up to expectations but also to prevent errors in the system. Although some standards allow as much as .04 errors in the system, zero-error is still the system's target. When there is zero-error, the program is more likely to have zero crash scenarios. The ability to handle stress of a program is different from the errors it has but crashes usually comes from defects so prevention of defects will most likely yield a continuously working application.

- ***Customer Satisfaction*** – Everything else will be just nothing if the customers do not like what they see. Part of SQA is to ensure that software development was made according to their needs, wants and exceeding their expectations. Even if the bugs and errors are minimized by the system, customer satisfaction is more important and should be emphasized.
- ***Well Structured*** – SQA takes care of the stages of application construction. Anyone could be easily build an application and launch it in their environment without any glitches. However, not everyone could easily build an application that could be understood well. SQA ensures that each application are built in an understandable manner. Their applications could easily be transferred from one developer to another.

Cost of Software Quality

Cost of quality is important because when you decide to conduct software testing for your product you are actually going to invest your time, money and effort in getting quality checks done. By conducting an analysis of cost of software quality you would know what the return on that investment (ROI) is.



Cost of quality is calculated by analyzing the conformance costs and non-conformance costs. A conformance cost is related to:

- *Prevention costs*: amount spent on ensuring that all quality assurance practices are followed correctly. This includes tasks like training the team, code reviews and any other QA related activity etc.

- *Appraisal costs*: this is the amount of money spent on planning all the test activities and then carrying them out such as developing test cases and then executing them.

The non-conformance cost on the other hand is the expense that arises due to:

- *Internal failures*: it is the expense that arises when test cases are executed for the first time at internal level and some of them fail. The expenses arise when the programmer has to rectify all the defects uncovered from his piece of code at the time of unit or component testing.
- *External failures*: it is the expense that occurs when the defect is found by the customer instead of the tester. These expenses are much more than what arise at internal level, especially if the customer gets unsatisfied or escalates the software failure.

Cost of Software Failure

We know that a software failure is caused when:

- *It displays lack of ability to keep up*: this generally happens when the software starts aging. As it grows old the size increases because the easiest way of adding a feature is by adding new code without touching any part of code written earlier. Over a period of time it becomes bulky and it becomes difficult to identify the sections of code that need to be changed.
- *Performance drop is observed*: Every application generally slows down with age and tends to occupy more and more computer memory therefore it is better to switch to other software.
- *It does not seem to be reliable*: It is a known fact that every time when changes are made to the code of the software to fix an error, more defects are introduced in the system. Surprisingly, this is one of the major reasons for increased failure rates and in order to save situation it is always better to ditch the project or give up bug fixing.

Software Testing VS Quality Assurance

In IT industry it is often observed that people generally do not differentiate between the software quality assurance and software testing. Testers are often looked upon as Software Quality Assurance professionals because the objectives of software testing as well as quality assurance are the same .i.e. to ensure that the software is of top quality.

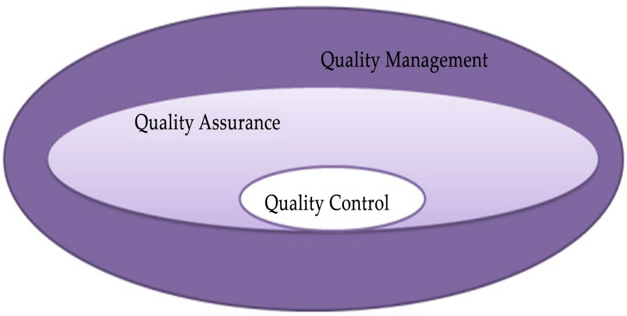
As the name suggests quality assurance processes are carried out to assure the quality of the product is in line with the requirement of the client. The quality assurance professionals work on development and implementation of all the necessary processes to ensure that all the necessary procedures of software development lifecycle are followed correctly. Quality assurance is a proactive activity that is focused on:

- Defect Prevention
- Processes
- Continuous improvement of this processes

Software testing on the other hand is carried to identify or uncover defect and errors in the software. It involves actual rigorous testing of the software to see if there are any defects or variations from the client's requirement that needs to be fixed. Software testing is a part of quality control process and it focuses only on product oriented activities. Software testing is carried out during the testing phase and only defects are identified and not corrected in this process. Fixing defects is not a part of software testing.

Quality Assurance VS Quality Control

Another subject that is closely related to quality assurance is quality control. People often get confused between the two but there is a huge difference. While quality assurance is all about preventive activities, quality control focuses on corrective processes. Here is what you need to understand: software testing is a subset of quality control and quality control is a subset of quality assurance. The entire focus of Quality assurance is on implementation of processes and procedures that are required for the verification of the software under development and the requirements of the client.



Quality control on the other hand deals with actual activities that ensure that the product is being developed as per the defined requirements. It deals with all the actions that are important to control and verify certain characteristics of the product including testing. Examination and testing of the products is the most important aspect of quality control. Companies employ quality control team to identify if there is any product or service that does not meet the company's standard of quality. If there is an issue the quality control team has the authority to stop the production of that product till the issue is resolved.

Importance of Audit and Inspection

Audit comprises of some very systematic processes that define how the software testing is taking place in the organization. The audit team examines all the processes that are conducted at the time of testing. IEEE defines audit as a review of documented processes to ensure that the organization or a team is following all the processes as per the defined standards.

Inspection can be a formal or an informal review of software requirement, designer or code. It is conducted by a team or an individual person other than the designer to check if there are any violations or deviations from the defined development standards. The following processes are considered as part of Inspection:

- Planning
- Overview Preparation
- Inspection Meeting
- Rework
- Follow up

10.2.3 Software Quality Metrics

We best manage what we can measure. Measurement enables the Organization to improve the software process; assist in planning, tracking and controlling the software project and assess the quality of the software thus produced. It is the measure of such specific attributes of the process, project and product that are used to compute the software metrics. Metrics are analyzed and they provide a dashboard to the management on the overall health of the process, project and product. Generally, the validation of the metrics is a continuous process spanning multiple projects. The kind of metrics employed generally account for whether the quality requirements have been achieved or are likely to be achieved during the software development process.

As a quality assurance process, a metric is needed to be revalidated every time it is used. Two leading firms namely, IBM and Hewlett Packard have placed a great deal of importance on software quality. The IBM measures the user satisfaction and software acceptability in eight dimensions which are capability or functionality, usability, performance, reliability, ability to be installed, maintainability, documentation, and availability. For the Software Quality Metrics the Hewlett-Packard normally follows the five Juran quality parameters namely the functionality, the usability, the reliability, the performance and the serviceability. In general, for most software quality assurance systems the common software metrics that are checked for improvement are the Source lines of code, cyclical complexity of the code, Function point analysis, bugs per line of code, code coverage, number of classes and interfaces, cohesion and coupling between the modules etc.

Metrics

There are many forms of metrics in SQA but they can easily be divided into three categories: product evaluation, product quality, and process auditing.

- ***Product Evaluation Metrics*** – Basically, this type of metric is actually the number of hours the SQA member would spend to evaluate the application. Developers who might have a good application would solicit lesser product evaluation while it could take more when tackling an application that is rigged with errors. The numbers extracted from this metric will give the SQA team a good estimate on the timeframe for the product evaluation.
- ***Product Quality Metrics*** – These metrics tabulates all the possible errors in the application. These numbers will show how many errors there are and where do they come from. The main purpose of this metric is to show the trend in error. When the trend is identified the common source of error is located. This way, developers can easily take care of the problem compared to answering smaller divisions of the problem. There are also metrics that shows the actual time of correcting the errors of the application. This way, the management team who are not entirely familiar with the application.
- ***Process Audit Metrics*** – These metrics will show how the application works. These metrics are not looking for errors but performance. One classic example of this type of metric is the actual response time compared to the stress placed on the application. Businesses will always look for this metric since they want to make sure the application will work well even when there are thousands of users of the application at the same time.

There are lots of options on what standard to be used in developing the plan for Software Quality Assurance. But on metrics, the numbers are always constant and will be the gauge whether the application works as planned.

Common software metrics include:

- Bugs per line of code
- Code coverage
- Cohesion
- Coupling
- Cyclomatic complexity
- Function point analysis
- Number of classes and interfaces
- Number of lines of customer requirements
- Order of growth
- Source lines of code
- Robert Cecil Martin's software package metrics

Software Quality Metrics focus on the process, project and product. By analyzing the metrics the organization the organization can take corrective action to fix those areas in the process, project or product which are the cause of the software defects.

The de-facto definition of software quality consists of the two major attributes based on intrinsic product quality and the user acceptability. The software quality metric encapsulates the above two attributes, addressing the mean time to failure and defect density within the software components. Finally it assesses user requirements and acceptability of the software. The intrinsic quality of a software product is generally measured by the number of functional defects in the software, often referred to as bugs, or by testing the software in run time mode for inherent vulnerability to determine the software "crash" scenarios. In operational terms, the two metrics are often described by terms namely the defect density (rate) and mean time to failure (MTTF).

Although there are many measures of software quality, correctness, maintainability, integrity and usability provide useful insight.

- *Correctness*: A program must operate correctly. Correctness is the degree to which the software performs the required functions accurately. One of the most common measures is Defects per KLOC. KLOC means thousands (Kilo) Of Lines of Code.) KLOC is a way of measuring the size of a computer program by counting the number of lines of source code a program has.
- *Maintainability*: Maintainability is the ease with which a program can be correct if an error occurs. Since there is no direct way of measuring this an indirect way has been used to measure this. MTTC (Mean time to change) is one such measure. It measures when an error is found, how much time it takes to analyze the change, design the modification, implement it and test it.

- *Integrity*: This measure the system's ability to with stand attacks to its security. In order to measure integrity two additional parameters are threat and security need to be defined. Threat – probability that an attack of certain type will happen over a period of time. Security – probability that an attack of certain type will be removed over a period of time
- *Usability*: How usable is your software application? This important characteristic of your application is measured in terms of the following characteristics:
  - Physical / Intellectual skill required to learn the system
  - Time required to become moderately efficient in the system.
  - The net increase in productivity by use of the new system.
  - Subjective assessment (usually in the form of questionnaire on the new system).

10.2.4 Software Process Improvement

The Software Process Capability Maturity Model (CMM) deals with the capability of software organizations to consistently and predictably produce high quality products. It is closely related to such topics as software process, quality management, and process improvement. The drive for improved software quality is motivated by technology, customer need, regulation, and competition. Although industry's historical quality improvement focus has been on manufacturing, software quality efforts must concentrate on product development and improvement.

REMEMBER

To develop an efficient software requirement document, the developers should use a known method to determine this type requirement for software development.

Process capability is the inherent ability of a process to produce planned results. A capable software process is characterized as mature. The principle objective of a mature software process is to produce quality products to meet customers' needs. For such human-intensive activities as software development, the capability of an overall process is determined by examining the performance of its defined sub processes. As the capability of each sub process is improved, the most significant causes of poor quality and productivity are thus controlled or eliminated. Overall process capability steadily improves and the organization is said to mature.

Process Areas in Capability Maturity Model (CMM)

The Capability Maturity Model Integration (CMMI), based process improvement can result in better project performance and higher quality products. A Process Area is a cluster of related practices in an area that, when implemented collectively, satisfy a set of goals considered important for making significant improvement in that area.

In CMMI, Process Areas (PAs) can be grouped into the following four categories to understand their interactions and links with one another regardless of their defined level:

- ***Process Management***: It contains the cross-project activities related to defining, planning, resourcing, deploying, implementing, monitoring, controlling, appraising, measuring, and improving processes. Process areas are: -
  - Organizational Process Focus
  - Organizational Process Definition
  - Organizational Training
  - Organizational Process Performance
  - Organizational Innovation and Deployment
- ***Project Management***: The process areas cover the project management activities related to planning, monitoring, and controlling the project. Process areas are:
  - Project Planning.
  - Project Monitoring and Control.
  - Supplier Agreement Management.

- Integrated Project Management for IPPD (or Integrated Project Management).
- Risk Management.
- Integrated Teaming.
- Integrated Supplier Management.
- Quantitative Project Management.

■ ***Engineering:*** Engineering process areas cover the development and maintenance activities that are shared across engineering disciplines. Process areas are:

- Requirements Development.
- Requirements Management.
- Technical Solution.
- Product Integration.
- Verification.
- Validation.

■ ***Support:*** Support process areas cover the activities that support product development and maintenance. Process areas are:

- Process and Product Quality Assurance.
- Configuration Management.
- Measurement and Analysis.
- Organizational Environment for Integration.
- **Decision Analysis** and Resolution.
- Causal Analysis and Resolution.

Keyword

Decision analysis utilizes a variety of tools to evaluate all relevant information to aid in the decision making process.

Process and Product Quality Assurance (PPQA) Process Area in CMMI

The purpose of Process and Product Quality Assurance (PPQA) is to provide staff and management with objective insight into processes and associated work products.

The Process and Product Quality Assurance process area involves the following activities:

■ Objectively evaluating performed processes, work products, and services against applicable process descriptions, standards, and procedures.

- Identifying and documenting noncompliance issues.
- Providing feedback to project staff and managers on the results of quality assurance activities.
- Ensuring that noncompliance issues are addressed.

The Process and Product Quality Assurance process area supports the delivery of high-quality products and services by providing project staff and managers at all levels with appropriate visibility into, and feedback on, processes and associated work products throughout the life of the project.

Specific Goals and Practices

Objectively Evaluate Processes and Work Products

- Adherence of the performed process and associated work products and services to applicable process descriptions, standards, and procedures is objectively evaluated.
- *Objectively Evaluate Processes*: Objectively evaluate the designated performed processes against the applicable process descriptions, standards, and procedures. Objectivity in quality assurance evaluations is critical to the success of the project. A description of the quality assurance reporting chain and how it ensures objectivity should be defined.
- *Objectively Evaluate Work Products and Services*: Objectively evaluate the designated work products and services against the applicable process descriptions, standards, and procedures. The intent of this sub practice is to provide criteria, based on business needs, such as the following:
    - What will be evaluated during the evaluation of a work product?
    - When or how often a work product will be evaluated?
    - How the evaluation will be conducted?
    - Who must be involved in the evaluation?

Provide Objective Insight

Noncompliance issues are objectively tracked and communicated, and resolution is ensured.

- *Communicate and Ensure Resolution of Noncompliance Issues*. Communicate quality issues and ensure resolution of noncompliance issues with the staff and managers. Noncompliance issues are problems identified in evaluations that reflect a lack of adherence to applicable standards, process descriptions, or procedures. The status of noncompliance issues provides an indication of quality trends. Quality issues include noncompliance issues and results of trend analysis.

When local resolution of noncompliance issues cannot be obtained, use established escalation mechanisms to ensure that the appropriate level of management can resolve the issue. Track noncompliance issues to resolution.

- *Establish Records*. Establish and maintain records of the quality assurance activities. Typical Work Products are evaluation logs, quality assurance reports, status reports of corrective actions and reports of quality trends.

The SEI Process Capability Maturity Model, ISO, Six-Sigma

SEI = 'Software Engineering Institute' at Carnegie-Mellon University; initiated by the U.S. Defense Department to help improve software development processes.

CMM = 'Capability Maturity Model', now called the CMMI ('Capability Maturity Model Integration'), developed by the SEI. It is a model of 5 levels of process 'maturity' that determine effectiveness in delivering quality software. It is geared to large organizations such as large U.S. Defense Department contractors. However, many of the QA processes involved are appropriate to any organization, and if reasonably applied can be helpful. Organizations can receive CMMI ratings by undergoing assessments by qualified auditors.

- Level 1 - characterized by chaos, periodic panics, and heroic efforts required by individuals to successfully complete projects. Few if any processes in place; successes may not be repeatable.
- Level 2 - software project tracking, requirements management, realistic planning, and configuration management processes are in place; successful practices can be repeated.
- Level 3 - standard software development and maintenance processes are integrated throughout an organization; a Software Engineering Process Group

is in place to oversee software processes, and training programs are used to ensure understanding and compliance.

- Level 4 - metrics are used to track productivity, processes, and products. Project performance is predictable, and quality is consistently high.
- Level 5 - the focus is on continuous process improvement. The impact of new processes and technologies can be predicted and effectively implemented when required.

Perspective on CMM ratings: During 1997-2001, 1018 organizations were assessed. Of those, 27% were rated at Level 1, 39% at 2, 23% at 3, 6% at 4, and 5% at 5. (For ratings during the period 1992-96, 62% were at Level 1, 23% at 2, 13% at 3, 2% at 4, and 0.4% at 5.) The median size of organizations was 100 software engineering / maintenance personnel; 32% of organizations were U.S. federal contractors or agencies. For those rated at Level 1, the most problematical key process area was in Software Quality Assurance.

ISO = 'International Organization for Standardization' - The ISO 9001:2008 standard (which provides some clarifications of the previous standard 9001:2000) concerns quality systems that are assessed by outside auditors, and it applies to many kinds of production and manufacturing organizations, not just software. It covers documentation, design, development, production, testing, installation, servicing, and other processes. The full set of standards consists of:

- Q9001-2008 - Quality Management Systems: Requirements;
- Q9000-2005 - Quality Management Systems: Fundamentals and Vocabulary;
- Q9004-2009

Quality Management Systems:

Guidelines for Performance Improvements. To be ISO 9001 certified, a third-party auditor assesses an organization, and certification is typically good for about 3 years, after which a complete reassessment is required. Note that ISO certification does not necessarily indicate quality products - it indicates only that documented processes are followed.

ISO 9126 is a standard for the evaluation of software quality and defines six high level quality characteristics that can be used in software evaluation. It includes functionality, reliability, usability, efficiency, maintainability, and portability.

IEEE = 'Institute of Electrical and Electronics Engineers' - among other things, creates standards such as 'IEEE Standard for Software Test Documentation' (IEEE/ANSI Standard 829), 'IEEE Standard of Software Unit Testing (IEEE/ANSI Standard 1008), 'IEEE Standard for Software Quality Assurance Plans' (IEEE/ANSI Standard 730), and others.

ANSI = 'American National Standards Institute', the primary industrial standards body in the U.S.; publishes some software-related standards in conjunction with the IEEE and ASQ (American Society for Quality).

Six-Sigma

Six Sigma is a methodology of quality management that gives a company tools for business processes improvement. This approach allows to manage quality assurance and business processes more effectively, and reduce costs and increase company profits. The fundamental principle of Six Sigma approach is the customer satisfaction through implementing defects-free business processes and products. Six Sigma approach determines factors that are important for product and **service quality**. This approach contributes to reduction of the business process deviation, improvement of opportunities and increase of production stability.

Keyword

Service quality (SQ) is a comparison of expectations (E) about a service with performance (P) SQ=P-E.

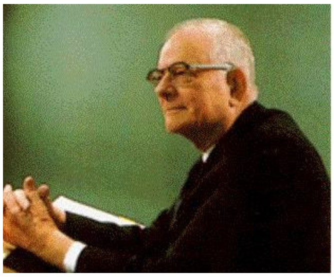
There are five stages in Six Sigma Project:

- *Defining*: The first stage of Six Sigma project is to define the problem and deadlines to solve this problem. The team of specialists considers a business process (e.g., production process) in details and identifies defects that should be erased. Then the team generates a list of tasks to improve the business process, project boundaries, customers, their product and service requirements and expectations.
- *Measuring*: On the second stage the business process is to be measured and current performance is to be defined. The team collects all data and compares it to customer requirements and expectations. Then the team prepares measures for future large-scale analysis.
- *Analyzing*: As soon as the data is put together and the whole process is documented, the team starts analysis of the business process. The data collected on stage two "Measuring" are determine root reasons of defects/problems and identify gaps between current performance and new goal performance. Usually the team specialists begin with defining the fields in which employees make mistakes and cannot take effective control of the process.

- *Improving*: On this stage the team analyzes the business process and works up some recommendations, solutions and improvements to erase defects/problem or achieve desired performance level.
- *Controlling*: On the final stage of Six Sigma Project the team creates means of control of the business process. It allows the company to hold and extend scale of transformations.

Other software development/IT management process assessment methods besides CMMI and ISO 9000 include SPICE, Trillium, TickIT, Bootstrap, ITIL, MOF, and CobiT.

ROLE MODEL



WILLIAM EDWARDS DEMING

William Edwards Deming (October 14, 1900 – December 20, 1993) was an American engineer, statistician, professor, author, lecturer, and management consultant. Educated initially as an electrical engineer and later specializing in mathematical physics, he helped develop the sampling techniques still used by the U.S. Department of the Census and the Bureau of Labor Statistics.

W. Edwards Deming was an American statistician, professor, author, lecturer, and consultant. He created the new quality-control methods and developed the sampling techniques for U.S. Census. He was then made a member of the five-man Emergency Technical Committee to work on the compilation of the American War Standards. He is best known for his work in Japan after the Second World War. There he taught top business managers how to improve service, product quality, testing, and sales by various means, including the application of statistical methods. His contribution to Japanese economy made him into somewhat a hero in Japan, which is why he was awarded Japan's Order of the Sacred Treasure, Second Class in 1960. Apart from that, he won the National Medal of Technology and the Distinguished Career in Science award from the National Academy of Sciences. Around the time of his death, he founded the W. Edwards Deming Institute in Washington, D.C., where the Deming Collection at the U.S. Library of Congress includes an extensive audiotape and videotape archive. The motto of the Institute is to promote understanding of the Deming System of Profound Knowledge to advance business, success, and harmony.

Childhood and Early Life

- William Edwards Deming was born on October 14, 1900 in Sioux City, Iowa, to William Albert and Pluma Irene Edwards. His father was an insurance agent and lawyer and his mother was a piano teacher.
- His parents were quite well-read, his father had studied mathematics and law and his mother was a learned musician from San Francisco, which is why they always emphasized on Deming's education.

- Deming started his education at the University of Wyoming in 1917, then enrolled at the University of Colorado and then at Yale University, where he finished his studies with the Ph.D. in Mathematical Physics.

Career

- Deming edited a series of lectures delivered by Walter A. Shewhart of the Bell Telephone Laboratories, at USDA, 'Statistical Method from the Viewpoint of Quality Control', into a book published in 1939.
- In the following year, he developed the sampling techniques that were used for the first time during the 1940 U.S. Census, formulating the Deming-Stephan algorithm for iterative proportional fitting in the process.
- He was made the member of the five-man Emergency Technical Committee to work on the compilation of the American War Standards and taught statistical process control techniques to the workers involved in wartime production.
- In 1946, Deming joined the staff at New York University's graduate school of business administration as a professor of statistics. In the following year, he was engaged in early planning for the 1951 Japanese Census.
- He became a part of the Japanese Union of Scientists and Engineers (JUSE) and from 1950, he started training hundreds of engineers, managers and scholars in statistical process control (SPC) and concepts of quality.
- The Prime Minister of Japan (Nobusuke Kishi) awarded Deming Japan's Order of the Sacred Treasure, Second Class in 1960. The quotation on the medal recognizes Deming's contributions to Japan's industrial revival and its global accomplishments.
- After coming back to America, Deming ran his own consultancy business from Washington D.C. and in 1980, he was featured in an NBC TV documentary, 'If Japan can…Why can't we?'. This invariably increased the demand for his expertise.
- In 1981, he was hired by Ford Motor Company's newly appointed Division Quality Manager, John. A. Manoogian to help Ford increase its sales. With the help of Deming's insights, by 1986 Ford became the most profitable American auto company.
- Deming's book 'Quality, Productivity, and Competitive Position' was published by the MIT Center for Advanced Engineering in 1982, and was renamed 'Out of the Crisis' later.
- In 1982, Deming along with Paul Hertz and Howard Gitlow of the University Of Miami Graduate School Of Business in Coral Gables founded the W. Edwards Deming Institute for the Improvement of Productivity and Quality.
- He joined the Graduate School of Business at Columbia University in 1988

and founded the W. Edwards Deming Center for Quality, Productivity, and Competitiveness at Columbia Business School.

- Deming published his final book, 'The New Economics for Industry, Government, and Education' in 1993, which included the 'System of Profound Knowledge' and the '14 Points for Management'.

Major Works

- His work in Japan is considered as the most important contribution of his life. He taught top business managers how to improve service, product quality, testing, and sales by various means, including the application of statistical methods.
- His contribution to Japanese economy made him into somewhat a hero in Japan, and he was awarded Deming Japan's Order of the Sacred Treasure, Second Class in 1960.

Awards and Achievements

- Deming has been awarded accolades like: Japan's Order of the Sacred Treasure, Second Class, the National Medal of Technology, the Distinguished Career in Science award from the National Academy of Sciences, etc.

Personal Life and Legacy

- Deming got married to Agnes Bell in 1922. They adopted a daughter named Dorothy together but a few years later Bell died.
- In 1932, he got married to Lola Elizabeth Shupe, a teacher for mathematics and co-author of his several papers, and the couple had two children together: Diana and Linda.
- Deming died in his sleep at the age of 93 in his Washington home on December 20, 1993 due to natural causes.

Trivia

- For some time, Deming studied under Sir Ronald Aylmer Fisher and Jerzy Neyman at University College, London, England.
- In the beginning of his career, Deming taught at different Universities and worked for the United States Department of Agriculture.
- Marshall Industries CEO Robert Rodin trained with the 90-year-old Deming and his colleague Nida Backaitis. Marshall Industries' striking conversion and growth from $400 million to $1.8 billion in sales, due to Deming's insights, was recorded in Deming's last book 'The New Economics', a Harvard Case

Study, and Rodin's book, 'Free Perfect and Now'.

- 'Plan-Do-Check-Act' cycle is named after him.

CASE STUDY

MOBILE SOFTWARE TESTING

Background

With over 98 million Americans owning Smartphones and research indicating a 1% monthly increase in the number of mobile subscribers who text, download applications, and use browsers, mobile testing is one of the most in-demand forms of software testing. O&A has made the most of this exciting opportunity in the market and expanded practice by offering high quality mobile testing solutions.

Challenge

One of the United States' leading insurance providers engaged an O&A testing team to support their mobile web and device testing project. O&A leveraged our mobile testing methodology to implement customized mobile device framework which addressed the following challenges:

- Configurations to test
- Testing effort which is notorious for time consumption
- Costly hardware
- Extensive mobile device service providers and phone options
- Mobile test environment

Solution

O&A developed a framework based on three mobile testing tools:

- Actual devices such as iPads, iPods, and Smartphones
- Emulators
- Cloud services such as Device Anywhere

While testing actual devices produces the most accurate and comprehensive results, O&A utilized virtual tools as well to mitigate costs of devices and to expedite testing. Emulators perform similarly to the physical device and test different variables: device, browser, and operating system. Emulators are free software and use web connections, avoiding data charges. Cloud services can test from a desktop with remote access to a wide range of carriers.

The actual devices are connected to the internet, and test engineers can text, download applications, and make calls as when using a physical device. O&A conducted functional, system, and user acceptance testing on different platforms and browsers using Device Anywhere.

SUMMARY

- Software testing is an investigation conducted to provide stakeholders with information about the quality of the software product or service under test.
- Software testing is a process of executing a program or application with the intent of finding the software bugs.
- Testing is the process of evaluating a system or its component(s) with the intent to find whether it satisfies the specified requirements or not. In simple words, testing is executing a system in order to identify any gaps, errors, or missing requirements in contrary to the actual requirements.
- Manual testing includes testing a software manually, i.e., without using any automated tool or any script.
- Automation testing, which is also known as Test Automation, is when the tester writes scripts and uses another software to test the product. This process involves automation of a manual process.
- The technique of testing without having any knowledge of the interior workings of the application is called black-box testing. The tester is oblivious to the system architecture and does not have access to the source code.
- White-box testing is the detailed investigation of internal logic and structure of the code. White-box testing is also called glass testing or open-box testing. In order to perform white-box testing on an application, a tester needs to know the internal workings of the code.
- Grey-box testing is a technique to test the application with having a limited knowledge of the internal workings of an application. In software testing, the phrase the more you know, the better carries a lot of weight while testing an application.
- Software quality is defined as conformance to explicitly state functional and performance requirements, documents, and standards. The factors that affect software quality are a complex combination of conditions that can be measured based on data, such as audit-ability, completeness, consistency, error tolerance, and expandability.
- The term ‘quality’ is often used in a vague, blurred way. If someone talks about ‘working on quality’, they may simply mean activities designed to improve the organization and its services. Quality is essentially about learning what you are doing well and doing it better.
- Quality assurance is the process of verifying or determining whether products or services meet or exceed customer expectations. Quality assurance is a process-driven approach with specific steps to help define and attain goals. This process considers design, development, production, and service.

KNOWLEDGE CHECK

1. Which Testing is performed first?

a. Black box testing

b. White box testing

c. Dynamic testing

d. Static testing

2. The testing in which code is checked

a. Black box testing

b. White box testing

c. Red box testing

d. Green box testing

3. Testing done without planning and Documentation is called

a. Unit testing

b. Regression testing

c. Adhoc testing

d. None of the mentioned

4. Which of the following is non-functional testing?

a. Black box testing

b. Performance testing

c. Unit testing

d. None of the mentioned

5. Software safety is a quality assurance activity that focuses on hazards that may cause an entire system to fall.

a. True

b. False

REVIEW QUESTIONS

1. What is software testing? What are the principles of testing?
2. What are the difference between black-box testing, white-box testing, and grey-box testing?
3. Discuss about the testing documentation.
4. What do you understand by software quality?
5. Discuss about software quality assurance.

Check Your Result

1. (d) 2. (c) 3. (d) 4. (d) 5. (a)

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INDEX

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Level: Beginner to Advanced
Subject: Computer and Information Science

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