CIT 111

Introduction to Information Theory And Applications

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA
CENTRE FOR OPEN DISTANCE AND e-LEARNING

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA
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CENTRE FOR OPEN DISTANCE AND e-LEARNING (CODeL)

B.TECH. COMPUTER SCIENCE PROGRAMME

COURSE TITLE

INTRODUCTION TO INFORMATION THEORY AND APPLICATIONS

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COURSE UNIT

2

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CPT 111 Study Guide

Introduction

CIT 111 Introduction to Information Theory and Applications is a 2- credit unit course for students studying towards acquiring a Bachelor of Science in any field. The course is divided into 5 modules and 15 study units. It will first introduce the Logical and Physical Concepts of Data. Next, History of Computers is discussed in detail. This is followed by an extensive discussion of the Communication System and Transmission Impairments. Subsequently, an overview of Data Encoding and Decoding is presented. Finally, the student is introduced to the Communication Techniques.

The course guide therefore gives you an overview of what CIT 111 is all about, the textbooks and other materials to be referenced, what you expect to know in each unit, and how to work through the course material.

Recommended Study Time

This course is a 2-credit unit course having 15 study units. You are therefore enjoined to spend at least 2 hours in studying the content of each study unit.

What You Are About to Learn in This Course

The overall aim of this course, CIT 111 is to introduce you to the Information Theory and Applications. At the end of this course you will:

i. Know Logical and Physical Concepts of Data.
ii. Discuss in details the History of Computers
iii. Understand Communication System and Transmission Impairments
iv. Know Data Encoding and Decoding
v. Understand Communication Techniques

Course Aims

This course aims to introduce students to Information Theory and Applications. It is expected that the knowledge will enable the reader to understand Information Theory and apply it effectively.

Course Objectives

It is important to note that each unit has specific objectives. Students should study them carefully before proceeding to subsequent units. Therefore, it may be useful to refer to these objectives in the course of your study of the unit to assess your progress. You should always look at the unit objectives after completing a unit. In this way, you can be sure that you have done what is required of you by the end of the unit.

However, below are overall objectives of this course. On completing this course, you should be able to:

1. Define data.
2. Explain what data is.
3. Describe data representation.
4. Covert external data representation to internal data representation and vice versa.
5. Mention data measuring units.
6. Calculate data size in different units.
7. Define information
8. Explain information
9. Itemize forms of information
10. List the characteristics of information
11. Define information processing
12. Explain information processing tasks
13. Describe information interpretation
14. Define computer
15. Explain computer
16. List parts of computer
17. Mention basic operations of computer
18. Explain history of computer
19. List and explain some early computers.
20. Describe all the generations of computers.
21. Mention computers in each generation.
22. List and explain classification of computers.
23. Mention all the units in computer.
24. Explain the units in computer with labeled diagram.
25. Explain instruction cycle.
26. List and describe categories of memory.
27. Describe registers, cache and virtual as special memories.
28. Describe common number systems
29. Covert numbers in one number system to another
30. Perform basic arithmetic operation in binary
31. Represent negative number in binary
32. Explain meaning of computer languages
33. Describe programming language
34. List and explain classification of programming languages
35. Explain computer language translators
36. Describe database management systems
37. Explain basic database concepts.
38. Describe communication system.
39. List and explain components of communication system.
40. Explain transmission impairments

41. Mention common transmission impairments.
42. Describe analog signal
43. List advantages and disadvantages of analog signal
44. Describe digital signal
45. List advantages and disadvantages of digital signal
46. Explain analog to digital signal converters
47. Explain digital to analog converter
48. Define and explain modulation
49. Name types and benefits of modulations
50. Describe signal-to-noise ratio.
51. List three formulas for calculating signal-to-noise ratio
52. Perform calculation using signal-to-noise ratio
53. Write Nyquist and Shannon theorems
54. Calculate data capacity of noiseless and noisy channels
55. Explain data error and data corruption
56. Describe error detection and correction
57. Explain data encoding and decoding
58. Encode and decode data with parity coding
59. Encode and decode data with hamming coding
60. Describe transmission media
61. Explain wired transmission media like with examples.
62. Explain wireless transmission with examples.
63. Explain switch network
64. Describe circuit switching
65. List advantages and disadvantages of circuit switching
66. Describe message switching
67. Mention advantages and disadvantages of message switching
68. Describe packet switching
69. List advantages and disadvantages of packet switching
70. Explain computer network
71. Name and explain computer network by size
72. Describe physical and logical topologies
73. List the seven layers of ISO-OSI model
74. Explain network protocol
75. Describe the history of Internet
76. Explain Internet as a tool
77. State the impacts of Internet in our society
78. Mention uses of Internet
79. Explain how to access Internet
80. Describe some Internet terminologies.

Working Through This Course

In order to have a thorough understanding of the course units, you will need to read and understand the contents, practice the steps by designing and implementing a mini system for your department, and be committed to learning and implementing your knowledge.

This course is designed to cover approximately sixteen weeks, and it will require your devoted attention. You should do the exercises in the Tutor-Marked Assignments and submit to your tutors.

Course Materials

The major components of the course are:

1. Course Guide
2. Study Units
3. Text Books
4. Assignment File
5. Presentation Schedule

Study Units

There are 15 study units and 5 Modules in this course. They are:

Module One	**Introduction to Data and Information**	
	Unit 1	Logical and Physical Concepts of Data
	Unit 2	Concept of Information, Characteristics and Information Processing
Module Two	**Introduction to Computer System**	
	Unit 1	Introduction and History of Computers
	Unit 2	Generations and Classifications of Computers
	Unit 3	Basic Organization of Computer and Memory
	Unit 4	Number Systems and Conversions
	Unit 5	Computer Languages and Basic Concepts of Database
Module Three	**Communication System**	
	Unit 1	Communication System and Transmission Impairments
	Unit 2	Analog and Digital Signals
	Unit 3	Signal Modulation and Signal to Noise Ratio

Module Four	**Communication Signals and Transmission**	
	Unit 1	Data Encoding and Decoding
	Unit 2	Transmission Media
Module Five	**Communication Techniques and Internet**	
	Unit 1	Communication Techniques
	Unit 2	Computer Networks
	Unit 3	The Internet

Recommended Texts

The following texts and Internet resource links will be of enormous benefit to you in learning this course:

1. Yadav, D.S. (2008). *Foundation of Information Technology*. New Delhi: New Age International(P) Ltd.
2. Internet. (2012). Wikipedia. Retrieved on July 24, 2012, from http://en.wikipedia.org/wiki/Internet
3. History of the Internet. (2012). Wikipedia. Retrieved on July 24, 2012, from http://en.wikipedia.org/wiki/History_of_the_Internet.
4. *What is the Internet?* Retrieved on July 26, 2012, from http://www.centerspan.org/tutorial/net.htm

Assignment File

The assignment file will be given to you in due course. In this file, you will find all the details of the work you must submit to your tutor for marking. The marks you obtain for these assignments will count towards the final mark for the course. Altogether, there are tutor marked assignments for this course.

Presentation Schedule

The presentation schedule included in this course guide provides you with important dates for completion of each tutor marked assignment. You should therefore endeavour to meet the deadlines.

Assessment

There are two aspects to the assessment of this course. First, there are tutor marked assignments; and second, the written examination. Therefore, you are expected to take note of the facts, information and problem solving gathered during the course. The tutor marked assignments must be submitted to your tutor for formal assessment, in accordance to the deadline given. The work submitted will count for 40% of your total course mark.

At the end of the course, you will need to sit for a final written examination. This examination will account for 60% of your total score. You will be required to submit some assignments by uploading them to CIT 111 page on the u-learn portal.

Tutor-Marked Assignment (TMA)

There are TMAs in this course. You need to submit all the TMAs. The best 10 will therefore be counted. When you have completed each assignment, send them to your tutor as soon as possible and make certain that it gets to your tutor on or before the stipulated deadline. If for any reason you cannot complete your assignment on time, contact your tutor before the assignment is due to discuss the possibility of extension. Extension will not be granted after the deadline, unless on extraordinary cases.

Final Examination and Grading

The final examination for CIT 111 will last for a period of 2 hours and has a value of 60% of the total course grade. The examination will consist of questions which reflect the Self-Assessment Exercise(s) and tutor marked assignments that you have previously encountered. Furthermore, all areas of the course will be examined. It would be better to use the time between finishing the last unit and sitting for the examination, to revise the entire course. You might find it useful to review your TMAs and comment on them before the examination. The final examination covers information from all parts of the course.

Practical Strategies for Working Through This Course

1. Read the course guide thoroughly
2. Organize a study schedule. Refer to the course overview for more details. Note the time you are expected to spend on each unit and how the assignment relates to the units. Important details, e.g. details of your tutorials and the date of the first day of the semester are available. You need to gather together all this information in one place such as a diary, a wall chart calendar or an organizer. Whatever method you choose, you should decide on and write in your own dates for working on each unit.
3. Once you have created your own study schedule, do everything you can to stick to it. The major reason that students fail is that they get behind with their course works. If you get into difficulties with your schedule, please let your tutor know before it is too late for help.
4. Turn to Unit 1 and read the introduction and the learning outcomes for the unit.
5. Assemble the study materials. Information about what you need for a unit is given in the table of content at the beginning of each unit. You will almost always need

both the study unit you are working on and one of the materials recommended for further readings, on your desk at the same time.

6. Work through the unit, the content of the unit itself has been arranged to provide a sequence for you to follow. As you work through the unit, you will be encouraged to read from your set books

7. Keep in mind that you will learn a lot by doing all your assignments carefully. They have been designed to help you meet the objectives of the course and will help you pass the examination.

8. Review the objectives of each study unit to confirm that you have achieved them.

If you are not certain about any of the objectives, review the study material and consult your tutor.

9. When you are confident that you have achieved a unit's objectives, you can start on the next unit. Proceed unit by unit through the course and try to pace your study so that you can keep yourself on schedule.

10. When you have submitted an assignment to your tutor for marking, do not wait for its return before starting on the next unit. Keep to your schedule. When the assignment is returned, pay particular attention to your tutor's comments, both on the tutor marked assignment form and also written on the assignment. Consult you tutor as soon as possible if you have any questions or problems.

11. After completing the last unit, review the course and prepare yourself for the final examination. Check that you have achieved the unit objectives (listed at the beginning of each unit) and the course objectives (listed in this course guide).

Tutors and Tutorials

There are few hours of tutorial provided in support of this course. You will be notified of the dates, time and location together with the name and phone number of your tutor as soon as you are allocated a tutorial group. Your tutor will mark and comment on your assignments, keep a close watch on your progress and on any difficulties, you might encounter and provide assistance to you during the course. You must mail your tutor marked assignment to your tutor well before the due date. At least two working days are required for this purpose. They will be marked by your tutor and returned to you as soon as possible.

Do not hesitate to contact your tutor by telephone, e-mail or discussion board if you need help. The following might be circumstances in which you would find help necessary: contact your tutor if:

i. You do not understand any part of the study units or the assigned readings.
ii. You have difficulty with the self-test or exercise.
iii. You have questions or problems with an assignment, with your tutor's comments on an assignment or with the grading of an assignment.

You should endeavour to attend the tutorials. This is the only opportunity to have face to face contact with your tutor and ask questions which are answered instantly. You can raise any problem encountered in the course of your study. To gain the maximum benefit from the course tutorials, have some questions handy before attending them. You will learn a lot from participating actively in discussions.

GOODLUCK!

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Module 1

Introduction to Data and Information

Unit 1:	Logical and Physical Concepts of Data
Unit 2:	Concept of Information, Characteristics and Information Processing

Unit 1

Logical and Physical Concepts of Data

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    3.3 Data Representation
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5.0 Summary
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1.0 Introduction

Do you know that as individuals we count objects every day? And we often do so to know their exact numbers or write fresh ideas for use at later time. You will agree with me that occasionally the number becomes so large. Also, the idea turns complex that other tools are employed to keep and process them. Important numbers about objects or ideas are kept as data represented with characters. So many people generate, store and use data in different disciplines, thus read different meanings to what constitutes a data.

We represent data logically by arranging characters and symbols in a certain order to convey a message. Meanwhile, if we want to physically store or process data, we may require another form of data arrangement suitable for storage media or processing activities.

Now what is a computer?

A Computer is an electronic device which is helpful for data generation, processing and storage. Generated logical data which are simple for us to understand are external to computer. And they need to be converted into internal data representation acceptable to many computer manufacturers through agreed sets of coding systems.

Do you also know that data stored in our computers are measured in units just like every other quantity? The units are calibrated in magnitudes ranging from bits which are the least to several Gigabytes with simple conversion procedures among the units.

2.0 Learning Outcomes

After studying this unit, you should be able to:

i. Define data.
ii. Explain what data is.
iii. Describe data representation.
iv. Covert external data representation to internal data representation and vice versa.
v. Mention data measuring units.
vi. Calculate data size in different units.

3.0 Learning Content

3.1 Definitions

A data is a common word that you and I make use of almost on a daily basis. You may have noticed that the word has different meanings at various times to people who are in different fields of human Endeavors.

Below are basic definitions of data:

1. When we compute, data is information that we translate into a form that is more convenient to move or process. Relative to today's computers and transmission media, data is information converted into binary digital form (Margaret R).

2. In computer component interconnection and network communication, we distinguish data from "control information," "control bits," and similar terms to identify the main content of a transmission unit (Margaret R).
3. In telecommunications, we may sometimes say that data means digital-encoded information. We do this to distinguish it from analog-encoded information such as conventional telephone voice calls. In general, you will agree with me that "analog" or voice transmission requires a dedicated continual connection. And this connection should last for the duration of a related series of transmissions (such as in the telephone voice calls earlier mentioned). We can also transmit data with irregular connections in packets that arrive bit by bit (Margaret R).

However, you should know that generally in science, data is a gathered body of facts.

Self-Assessment Exercise(s) 1

1. In science data is regarded as gathered body of ……………..............................
2. The definition for Data varies in different fields. True or False?

3.2 So what is Data?

We can say that the term data (which is plural form of datum) refers to qualitative and quantitative attributes of unprocessed basic facts and figures. We can also say that data is raw material for data processing and it relates to fact, event and transactions. Another way we can define data is by saying that data is unprocessed information. And it is typically the outcome of measurements which can be basis of graphs, images, or observations of a set of variables. Huge volume of data is generated daily by individuals, group of people with common interest and corporate entities.

As individuals, we create data in various forms, such as shopping list, to-do list or mental summary of our needs to guide our decisions from time to time. Also, if you are a research student investigating certain phenomenon in a setting or object, you can generate data from related variables during your period of research.

It may interest you to know that government agencies like National Population Commission (NPC) and National Identity Management Commission (NIMC), regularly conducts census to gather data about people living in locality, region, or the country at large. National Communication Commission (NCC) mandated all telecommunication operators in Nigeria to collect data of their subscribers so as to build a database in the country.

Often, we may choose to regard such data as the lowest level of fact from which information and then knowledge are derived. Raw data as we have used here means collection of numbers, characters, images or outputs from devices that collect information to convert physical quantities into symbols.

Let us look at an example to understand this. D, G and O are raw data. And suppose you receive a letter containing only alphabet D from me it will not convey any meaning to you except if the alphabet is a code with meaning beyond its ordinary use in English alphabet A to Z. Adding extra alphabets to D may form a meaningful word, yet may still not convey a message. Words like DOG and DGO begin with D in addition to other alphabets arranged in specific order. While DOG can be called data, it conveys meaning (information) as well. But you will agree with me that DGO is also data that needs additional data for it to be meaningful.

You may have observed that the term data and information are used interchangeably in everyday speech but note that they are not synonymous. The reason is that information received as output of data processing at one level can easily serve as data at another level.

Self-Assessment Exercise(s) 2

1. Can data and information be used interchangeably? (Yes/No).
2. Which of the followings is lowest level of abstraction?
   a. Knowledge
   b. Information
   c. Data
   d. Quantity
3. The term data refers to….
   a. Qualitative attribute of a quantity
   b. Quantitative attribute of a quantity
   c. All of the above
   d. None of the above.

3.3 What is Data Representation?

After gathering our data, the next step for us to take will be to process it to get information. It is therefore common in present days to see people using different manual or automated method to process data. Since the advent of computer (precisely microcomputers) data processing continues to witness unique tools and conventional methods of gathering, processing and storing data. Computer as we know is an electronic device that operates strictly on distinct binary physical states (off or on, 1 or 0).

Before we feed our data into computer we have to represent it in human readable form (numbers, alphabets, sound, pictures, etc), otherwise called External Data Representation (EDR). To a computer everything is known to be composed of binary digits, also referred to as Internal Data Representation (IDR). So there are needs for standardized conversion from EDR to IDR by all computer manufacturers to make data and information exchange among computers possible. To achieve this some coding systems were developed and adopted by computer manufacturers, the comprehensive list of the coding systems is available at http://www.lookuptables.com/. The three most popular systems developed are:

- **Extended Binary Coded Decimal Interchange Code** (EBCDIC pronounced "EB-si-dic"), developed by International Business Machine (IBM) for its computers.

It consists of 256 symbols and evolved from Binary Coded Decimal (BCD) which was designed for IBM first system. The EBCDIC is still use in IBM mainframe computer but lost its relevance with emergence of microcomputers.

- **American Standard Code for Information Interchange (ASCII)**, developed by American National Standard Institute (ANSI) is the most common IDR found on most microcomputers and hand-held devices like mobile phones and Personal Digital Device (PDA). It has 128 English characters and numbers. ASCII table is included at Appendix A of this course material.

  A quick summary of ASCII table showed that characters 0 to 32 are non-printable characters also called *Control Characters*. Characters from 32 to 34 are called *Special Characters*. The uppercase English alphabets are represented from 65 to 90, while lower case characters occupy positions 97 to 122. Arithmetic characters (0, 1, 2…9) are sequentially arranged from 48 to 57. Extended ASCII code was developed to increase the character of ASCII to 256 characters.

- **Unicode** is by fast replacing ASCII, because it is possible to represent up to 65,535 different characters and symbols with Unicode. It is not restricted to English characters alone and it facilitates localization of computer characters to language of the users without any special program. Unicode makes it possible to search for words in Yoruba, Hausa and Igbo languages on *Google* search engine.

Now that you know what coding system is lets us demonstrate data representation with conversion from EDR and IDR using ASCII code. For example, when you type **A GOOD DAY** which is EDR from your keyboard, your computer will receive IDR which is binary representation of each character of the word including spaces.

Self-Assessment Exercise(s) 3

1. What are the full meanings of following acronyms?

a. ASCII

b. EBCDIC

2. Which of the IDR mentioned in this course guide offers highest number of characters?
3. What is the general name given to characters that are located at positions 0 to 32?
4. Convert **A GOOD DAY** which was typed on a computer (EDR) to its ASCII equivalent (IDR).

3.4 Measuring Data Size

I believe you know that every quantity has unit of measurement. For example, distance, weight and even our currency. Distance is measured in meters or miles, weight is measured in grams or pounds, etc. The unit for measuring data stored digitally of storage device is called byte, which is derived from bits. Storage devices are rated in terms of data capacity they can accommodate in byte. Thus we can say a storage device has storage capacity of 1,024 bytes or 1KB.

Availability of high capacity computer storage media like hard disk, flash drives, zip drives and magnetic tapes called for higher units of measurement such as Gigabyte and Terabyte to reduce number of digits for measuring data. It is convenient to write 120MB than 1,048,696 bytes. A bit is a state that shows if a switch in electronic is *on* or *off* and it is the smallest possible unit of data. A group of 8 bits is called byte. Table 1.2 shows us higher units for measuring data.

Table 1.2 Data Size

8 bits	= 1 byte
1024 bytes	= 1 KB (Kilobyte)
1024 KB	= 1 MB (Megabyte)
1024 MB	= 1 GB (Gigabyte)
1024 GB	= 1 TB (Terabyte)

In computing, the total number of adjacent bits that can be processed together at once is called *word*. Most microcomputers in use today are 32-bit or 64-bit, meaning that a word in 32-bit word system will group 32 adjacent bits to for processing. So we expect a 32-bit word computer to be faster than 16-bits computer in terms of processing speed. Same argument is true for 32-bit word and 64-bit word systems.

Do you observe that conversion from low units to high units or vice versa is simply done by multiplying or dividing by 1024, except for conversion from bits to byte? The examples below will teach you how to easily do the conversion.

Let's take an example

Example 1.1

What is 2Mb of data in Kb and bytes?

Solution 1.1

To convert from Mb to Kb, we simply multiply by 1024 as calculated below,

2Mb is equivalent to 2 x 1024 = **2048 Kb**

Similarly, to covert from Kb to bytes, we multiply again by 1024, as

$$2\ x\ 1024\ x\ 1024\ = \mathbf{2097152}\ \boldsymbol{bytes}$$

Or

$$2048Kb\ x\ 1024\ = \mathbf{2097152}\boldsymbol{bytes}$$

Now let's look at another example 1.2

Covert 12582912 bytes to Kb and Mb.

Solution 1.2

To convert from bytes to Kb we need to divide by 1024, that is,

$$\frac{12582912}{1024} = \mathbf{12288}\boldsymbol{Kb}$$

Again we can divide our last result in Kb by 1024 to get answer in Mb, that is,

$$\frac{12288\ Kb}{1024} = \mathbf{12}\ \boldsymbol{Mb}$$

Or

We can choose to divide 12582912 bytes twice by 1024 to get our answer in Mb, as

$$\frac{12582912}{1024\ x\ 1024} = \mathbf{12}\boldsymbol{Mb}$$

Self-Assessment Exercise(s)4

1. What is a word in computing?
2. How may bits make a byte in computer?
3. Convert 12KB to bits
4. Convert 4KB to bytes.

3.5 Data Processing

As you now know what data is, how it is represented and measured, it equally good you are familiar with how it is processed. Data processing simply means how raw facts are transformed into a meaningful output.

There are four stages of data processing. They are:

1. Input Stage
2. Processing Stage
3. Output Stage
4. Storage Stage

Each of these stages has sub-processes under it. **Input Stage** consists of the following sub-processes – Data Collection, Data Capture, Data Encoding, Data Transmission and Data Communications. **Processing Stage** entails performing instructions and transforming raw data into information. **Output Stage** consists of decoding and presenting data to user. While the last stage, which is the **Storage Stage** involves storing data and retrieving data.

Beyond having the idea of data processing stages, you also need to know the methods of data processing. There are three fundamental method of data processing. They are:

1. Manual Data Processing
2. Mechanical Data Processing
3. Electronic Data Processing

Manual Data Processing: Data is manually processed without the aid of any tool or machine. This method is very slow and attributed with a lot of errors. Examples of this are manual marks sheets, calculations, fee receipts issued by hand.

Mechanical Data Processing: This method involves the use of mechanical devices to process data. Examples of such are – Typewriter, Mechanical Printer, etc. This method is faster than the manual method.

Electronic Data Processing: This is a modern mothed of data processing in which the data is processed through the use of computer. Examples of electronic data processing are – Computerized Student Results, Bank Customers' Accounts processed through computer, etc. This method is very fast and accurate.

Self-Assessment Exercise(s) 5

1. Data Collection and Capture are sub-processes under …………………….stage.
   (a.) Input (b.) Processing (c.) Output (d.) Storage.
2. Data Processing is the transformation of raw facts into a ………………… output.
   (a.) Solid (b.) Useful (c.) meaningful (d.) raw
3. Electronic Data Processing is the modern method of data processing through computer. (True / False)

4.0 Conclusion

In this unit we learnt what data is and how data is represented in computer with different coding systems. We also learnt data conversion using different unit of data size. In unit two we will learn how data is transformed to information.

5.0 Summary

i. Data can be defined in several ways depending on the area discipline of someone giving the definition, but in general, data can be defined as gathered body of facts. It data is often regarded as the lowest level of abstraction from which information and then knowledge are derived.

ii. Individuals and organization need to gather data from which information is later obtained after processing. Examples of organizations that collect data in Nigeria are NIMC, NPC and NCC.

iii. Data generated by human is called EDR and must be converted to format that is suitable for computer called IDR using some coding systems such as ASCII, Unicode or EBCDIC. ASCII is the most popular while EBCDIC contains most characters.

iv. There are many units for measuring data as a quantity when stored in computer. The units are arranged in ascending order of magnitude from bit, bytes, kilobytes, megabytes, gigabytes and terabytes. The higher units the more convenient for representing large data size. Conversion between units is done by multiplying or dividing by 1024.

6.0 Tutor-Marked Assignments

1. Write ASCII representation for sentences given below:
   a. ADEOLU IS A CLEVER STUDENT
   b. codel@futminna.edu.ng
   c. I am going to Kano
2. Mention 3 agencies or commissions charged with responsibility of capturing data about people in Nigeria.
3. Which coding systems will you recommend to a friend who wants to build a website for Yoruba speaking people?
4. Write ASCII number equivalents of the following characters in decimal number system:
   a. @
   b. #
   c. %
   d. &
   e. *
5. A data file consumes 2GB of hard disk space, what is its equivalent in KB and MB?

7.0 References/Further Reading

Deepak, B. (2002). *Fundamentals of Information Technology*. New Delhi: Excel books.

Margaret R. (2012). Definition of Data. Retrieved on July 23, 2012, from http://searchdatamanagement.techtarget.com/definition/data

Unit 2

Concept of Information, Characteristics and Concept of Information Processing

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2.0 Learning Outcomes

3.0 Learning Content

3.1 Concept of Information

3.1.1 Definition of Information

3.1.2 Forms of Information

3.2 Characteristics of Good Information

3.3 Concept of Information Processing

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Reading

1.0 Introduction

Based on our previous unit, we now know that information is the outcome of every data processing activity. And every individual or organization is engaged in information processing in one way or the other. We can give different meaning to what makes up information based on the way we view it. Thus, information exists in various forms to meet our needs.

If we request for important information to solve problems, often we may need to pay to get it. Therefore, information that we receive must be good enough to meet our requirements. Whether information is good or not is left for us to judge. Some characteristics have been identified to describe quality of good information. Similarly, we cannot say that information is good if it cannot solve the problem for which we requested it.

For us to convert data into information, we need to know some sequential tasks (otherwise known as information processing tasks). The information processing tasks define information processing life cycle which shows how information changes from creation to destruction.

Each task takes input from previous task and provides output which again serves as input to next task. Information creation or interpretation task is the actual task where new information is generated during the processing activities.

2.0 Learning Outcomes

After studying this unit, you should be able to:

(i) Define information
(ii) Explain information
(iii) Itemize forms of information
(iv) List the characteristics of information
(v) Define information processing
(vi) Explain information processing tasks
(vii) Describe information interpretation

3.0 Learning Content

3.1 Concept of Information

Information is essentially the output of data processing operation usually carried out under well-defined set of procedures or instructions. Information that affects outcome, decision, or behavior of recipient is considered valuable. Mechanisms to check data accuracy and integrity are additional components added to data processing operations. This is to ensure quality information after processing data.

Haven't you heard that information *is power*? This is because information plays important roles in our daily lives and activities. It is a critical factor for communication within and outside organization and amongst us. In fact, do you know that information is majorly what the entire Information and Communication Technology (ICT) discipline seek to provide and service?

Hope you know that organizations need information to remain in business. And these organizations invest huge sum of money on information processing systems. If we are manufacturers, we may decide to integrate these information processing systems using ICT. By so doing, we make them to be more reliable and timely in information delivery.

3.1.1 Definition of Information

We can define information in several ways, some are given below:

1) We can define information as a processed data or a collection of facts from which we can draw conclusions (Word Web dictionary 5.52).
2) We can also define information as the characteristics of the output of a process, thus being informative about the process and the input. (Robert M. Losee)
3) Lastly, we can say that information is one or more statements or facts that are you and I receive and that have some form of worth to us both.

The definition given by Robert M. Losee is discipline independent, i.e. it is applicable to all domains, from physics to theology. Information, in its most restricted technical sense, is a sequence of symbols that can be interpreted as a message. Information can be recorded as signs, or transmitted as signals.

Information is any kind of event that affects the state of a dynamic system. Conceptually, information is the message (utterance or expression) being conveyed. This concept has numerous other meanings in different contexts.

As we discussed earlier in this course, information generated at a level can partly or wholly constitute a data for other levels. Information is strategic in present generation due to availability of robust computer networks to facilitate information transfer and sharing. For this simple reason, we are said to be living in “information age.”

Self-Assessment Exercise 1

1. Information can be defined as……………………………………………………..

3.1.2 Forms of Information

Once information is generated it can be preserved in various formats in different storage media. The most general formats are: print (books, periodicals and microforms), multimedia (videotapes, audiocassettes, slides, and other image and audio formats) and electronic (CD, DVD, and databases). Information can be presented in forms listed below:

Visual

This form of information involves using items such as pictures, chart or graphs to convey information. We can manipulate digitized form of these to produce synthesize items such as animation or video and then distributed on Compact Disc (CD) and Digital Versatile Disc (DVD). Information presented in this form conveys more meaning and requires less effort to comprehend.

Written

Do you know that majority of information we create are in this form? Whether written as text on paper or prepared with a computer. It may include pictures or charts. There are different styles for generating information with this form. For example, your personal list of activities for a day will have different styles of writing from sales record prepared for your company daily.

Aural

Aural as we all know is the oldest and commonest form of information. It is information presented as sound and examples include conversation during meeting, phone calls, teaching and learning in classroom, and news casting by media houses. Presently, it is possible to convert written information to aural (i.e. text-to-speech) or vice versa (i.e. speech-to-text), with special computer software.

Self-Assessment Exercise 2

1. List 3 forms of information.

3.2 Characteristics of Good Information

As recipients, for us to consider information to be good, it must meet our needs. That is, it should to add value to what we do. Experience and research show numerous qualities a good information should have; we can see some of these qualities below:

Accuracy: information we receive needs to be accurate for us to make the right decision. The degree of information accuracy is determined by recipient. But it will be very difficult if not impossible for us to provide information that is 100% accurate in some circumstances. Suppose you wish to know the future temperature of where you stay, say July 1st of next year. If you consult an expert in meteorology, it will be a good decision. However, an expert can only tell you the temperature range (e.g. 34^{o}C to 37^{o}C), not specific degree like 34^{o}C, 35^{o}C or 36^{o}C.

Completeness: It is important that information should try as much as possible to contain all that we need as recipients to make informed decision. As recipients, a situation when we need to fix information part by part or not having complete information may arise. And this may result to extra cost or waste of time.

Timeliness: Information must arrive on time to serve the purpose for which it was requested. Information received too late can be dangerous in some cases. Consider the arrival of air force jet bomber that receives information about its target few minutes early or late, definitely the chances of bombing friendly force is higher by degree of its wrong timing.

Cost: The cost of producing information should be reasonable to recipient and producer of information. If cost is too unrealistic to producer, low quality information may be produced. Likewise, recipients should not be over billed to avoid seeking information elsewhere. It is obvious that people are willing to pay more to get good information when urgently in need of it.

Reliability: Reliability means how truthful the information is. When recipients begin to doubt information, they will not make good use of it. To some extents, recipients will always question the source of information to determine its reliability. Suppose a popular comedian in your country wearing his stage regalia appears on television station to announce the death of celebrity. Will you believe him? The answer should be no, neither will I. We will like to hear same announcement from another source or someone you consider reliable.

Clarity: This has to do with presentation of information, whether it is legible, audible or have visual components that will make it to be easily understood by recipients. In other to achieve this, unnecessary detail should be omitted from the information. Also, the channel or means of information delivery should be clear as well to avoid noise and other foreign data. Also, the sender of the information should prepare the information not to suit his /her own taste, but to meet requirements of the recipients. For example, if the information being presented is text, you must consider things like font type, font size and print quality.

Availability: Information should be easy for us to obtain or access by users at all times. No matter the amount of efforts and precisions put into preparing information, restricting access to legitimate users will make it unusable. Information in digital forms should be made available online or real time with adequate security. A book such as telephone directory should be placed at conspicuous place in sitting room or leaving room not in car garage, so that people can easily access it.

Relevancy: In order to avoid waster of our precious time and money, information should fit or meet the purpose for which it is required, requested or retrieved. Irrelevant information could mislead and cause wrong or cost by decision making.

Conciseness: Good information should only contain the adequate level of details. It should be straight to the point in order not to cause unnecessary burden on the management or processing.

Self-Assessment Exercise 3

1. List the characteristics of good Information.

3.3 Concept of information Processing

3.3.1 Definitions of Information Processing

Information processing can be defined as follows:

1) We can define information processing as the sciences concerned with gathering, manipulating, storing, retrieving, and classifying recorded information. (word net)

2) We can also define information processing as interpreting incoming information (stimulus) to make a response suitable within the context of an objective, problem, or situation (business dictionary).

3) In cognitive psychology, information processing is the term applied to the human thought process. The brain is considered to be roughly equivalent to a computer, providing the necessary hardware for the computational process to take place. Our thoughts, feelings and emotions are the actual computations (Lisa Fritscher).

We can generalize information processing as conscious efforts of making reasonable response to challenges through organized procedures. Information processing requires human cognitive activities through encoding, organizing, comparing and translating information.

Self-Assessment Exercise 4

1. Define Information Processing.

3.3.2 Information Processing Tasks

Information processing is performed by every entity and ability to process received information determines rate of failure or success individual or organizations. To ensure success in what we do, various technologies are employed in information processing tasks.

Information processing tasks is broadly divided into eight interrelated tasks namely, Searching, Selecting, Capturing, Storing, Creating, Communicating, Implementing and Destroying. All the tasks are sequentially arranged to form information processing cycle or model. Some tasks may be deliberately omitted or performed out of sequence depending on organization structure or form of information concern.

Each task carries out well defined activities on input received from other previous task and provides output that serves as input to other task next in the sequence. Also every unique task has performance metrics to measure its efficiency and effectiveness in terms of processing time, cost and quality of service amongst others. Collectively, individual performances of the tasks will define overall performance of processing by organization or entity. Figure 2.1 shows individual tasks taking part during information processing.

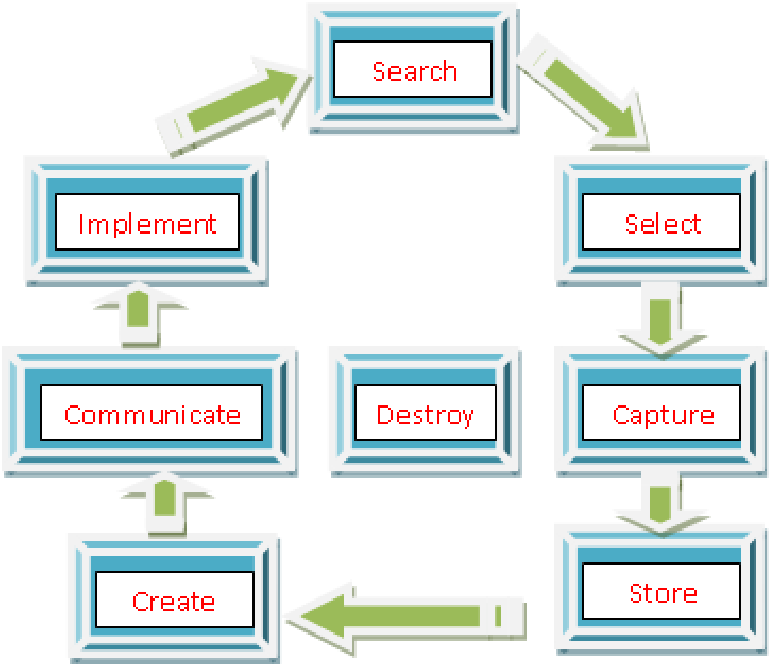

Figure 2.1 Information Processin Tasks

Searching: It involves searching for relevant information from sources within or outside the domain of information seeker. The more information sources consulted the more the quality of information, but it may take more time to fully harmonize and utilize large chunk of information sources identified at this phase of information processing. There are three categories of information sources: primary, secondary and tertiary.

Primary sources are original materials which have not been interpreted or evaluated by second party. They exist as novel idea from research work or careful thought and made public in journals articles, poems, theses, diary, patents and photographs. Secondary sources of information are extracted from primary sources or information about primary sources. Information in secondary sources have been modified, selected, or rearranged from several primary sources to meet the taste of particular group.

Secondary sources of information include bibliographies, textbook, review articles and index. The tertiary sources of information are distillation or collection of primary or secondary sources combined to serve information need of specific audience and they are encyclopedia, fact books and almanacs.

Selecting: The first task will no doubt generate lots of information sources some of which may not be needed. Selecting of relevant information sources comes next in information processing tasks. The task involves removal of unnecessary information sources through simple rules of thumb or thorough study.

Capturing: This task comes next and entails gathering and recording information needed for processing from selected sources. The task can be done manually by reading and writing information on paper or automated with bar code reader, scanner, digital camera and many more.

Storing: Information captured for processing is normally stored for use at later time. Storage media can be human brain, notebook, or computer external storage devices. The storage media should be stored in a safe and information it should protected adequately against corruption. We discussed how computer represent and stored data in unit one of the course guide. Organization that cherishes information may put data/information backup and recovery policies in place to guide against complete information loss.

Creating: This task is otherwise known as information interpretation. This is where new information is generated from those captured and stored in previous tasks. The task is so important that section 3.3.3 is set aside to discuss it.

Communicating: Once new information is created it is disseminated or communicated to those who need it to fulfill one of the conditions of good information. Communicating information can be done via telephone, personal contact, snail post and ICT. The ICT has continued to change and improve how we communicate information since its inception. It offers different ways to send information in different forms from one place another faster than ever before through technologies such as, Internet, Satellite and pagers.

Implementing: This means acting on information received to effect a change. The receiver of good information may not be able to implement it properly to derive optimum benefits from it. Implementing being the last task is so important that it is often used to justify resources committed to other previous tasks.

Destroying: Destroying information does not have link to any of the tasks mentioned earlier because it can happen at any of the previous tasks. It actually terminates information processing due to shortage of funds, lack of management support, insufficient information sources, loss of critical information etc.

Self-Assessment Exercise 5

1. Mention all the tasks in information processing.

3.3.3 Information Interpretation

Definition

Information interpretation is the process through which organization make sense of new information that they have acquired and disseminated.

An important feature of human beings that surpass that of the most intelligent computer is ability to organize and interpret information. Even when information is complex, dynamic, conflicting or incomplete, we are sometimes able to deduce knowledge from such information.

Information interpretation is a stage in information processing where information users apply critical thinking to information gathered from different sources to develop personal meaning to them. Interpretation is required for information to become knowledge through other processes of analyzing, synthesizing and evaluating information to determine its relevancy and usefulness. Information interpretation is very crucial in knowledge management and decision making.

Self-Assessment Exercise 6

1. Information interpretation is defined as……………………………………………..

4.0 Conclusion

In this unit we taught you what the term *information* means and gave its basic definitions. We have also explained good characteristics of information and processing tasks involved when creating new information. This unit prepared you for other subsequent units that concerns information and information processing.

5.0 Summary

i. Information is the end product of any successful data processing activities and is simply defined as a processed data or a collection of facts from which conclusions can be drawn.
ii. Information exists in various forms such as visual, aural, written or combination of these, to suit the need of information seekers.
iii. There are several characteristics used to determine if information is good, amongst characteristics are accuracy, completeness, timeliness, reliability, clarity and availability.
iv. Eight sequential processing tasks were identified for processing data to information, they are, search, select, capture, store, create, communicate, implement and destroy.
v. The first of information processing tasks involves searching for relevant information sources which can be primary, secondary or tertiary information sources. New information is generated during create task otherwise known as information interpretation.

6.0 Tutor-Marked Assignments

1. Give your own definition information.
2. Write short note on information in visual form.
3. Give example of situation when incomplete information has caused financial loss.
4. Mention five reasons why information processing task may head to destruction without completing processing tasks cycle.
5. List five sources for each the following information sources:
   i. Primary
   ii. Secondary

iii. tertiary

6. Define information processing.

7.0 References/Further Reading

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Module 2

Introduction to Computer System

Unit 1:	Introduction and History of Computer
Unit 2:	Generations and Classifications of Computers
Unit 3:	Basic Organization of Computer and Memory
Unit 4:	Number Systems and Conversion
Unit 5:	Computer Languages and Basic Concepts of Database

Unit 1

Introduction and History of Computer

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3.1 Definitions of Computer
3.2 Introduction to Computer
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7.0 References/Further Reading

1.0 Introduction

Do you believe that almost everybody living in urban areas in Nigeria usually have contact with computer in one way or the other? And they do so in their daily activities. When we carry out financial transaction through Automatic Teller Machine (ATM), we are using computer. Even the automatic doors in public places, automobile, Smartphone that you and I see and use are all powered by different types of computer. Our computers as we learnt earlier are electronic device which come in various types, shapes and sizes. All computers irrespective of their type offer four basic operations.

Did you know that the idea to develop computer evolved over a century? The idea actually evolved from early computing devices which are neither mechanical nor electrical in nature. Those who designed the computing devices were only trying to create easy tools that will solve our basic arithmetic problems, just as we use computer to automate our jobs in present days.

Computer as we all know, is a device made up of many parts working together to achieve a common goal. If you can remember, in the previous unit, we emphasized the roles computer plays in information processing. So in this unit we will learn what computer is and its history.

2.0 Learning Outcomes

After studying this unit, you should be able to:

(i) Define computer

(ii) Explain computer

(iii) List parts of computer

(iv) Mention basic operations of computer

(v) Explain history of computer

Do you think they are too much to know in a unit? Don’t worry. It will be easy. Just move at my pace.

3.0 Learning Content

3.1 Definition of Computer

To most people, computer is a machine use for calculation or computation. But actually, it is much more than that. Precisely, we can define computer as follows:

i. You may choose to define computer as an electronic device for performing arithmetic and logical operations (just like Deepak Bharihoke did).
ii. Or, that computer is a device or flexible machine to process data and converts it into information (just like Deepak Bharihoke again).
iii. Another definition known is, computer is an electronic machine that accept data through an input device, process the data and produce information through an output device.

iv. A computer is also known as a device that accepts information (in the form of digitalized data) and manipulates it for some result based on a program or sequence of instructions on how the data is to be processed (SearchWinIt).

You will observe that all the definitions given above point to the fact that computer is machine that requires electricity to work. And it requires data which is processed to produce information. We discussed data, information, and information processing in module one, so refer to appropriate units in module one if you need to refresh your memory on these keywords. Other terms you came across in definitions that need little explanations are:

(i) Logical operations - these are the types of operations in which decisions(s) is/are taken.

(ii) Input device - is use by our computers to get data.

(iii) Output device - is use by our computers to offer information.

We will learn more about these terms as you progress in this course.

Self-Assessment Exercise 1

1. The operations that computer can perform according to one of the definitions above are …………………………………… and …………………………………

3.2 Introduction to Computer

Computer is a wonderful electronic device that evolves over time to transform almost every facet of our lives. When we use computer, processing of data to information is easy, faster and more efficient. Some difficult and repetitive tasks performed when processing data without computer are now automated using computer. And this further reduces human intervention.

Just imagine the time it will take you as an accountant to manually increase salary of one thousand staff in a company by five percent (5%) using calculator, paper and pen. You can do the same task with few key strokes on your computer in less than thirty minutes and high degree of accuracy. For this reason, we commonly refer this generation to a '*computer age*' or 'information age'.

Computer is so important to us that it is often considered a stigma. Most especially if someone cannot use it. And such person is tagged *computer illiterate*. For this reason, the Federal Ministry of Education in Nigeria has made computer science a compulsory subject for all students from primary one to senior secondary schools. And it was done so as to promote its awareness and increase literacy level from childhood. Even testing of the ability to use a computer is now mandatory and included in job recruitment exercises. As computer continues to improve the way we personally do things, it also registers its presence in our government, business, education, legal practice, entertainment, defense etc.

Our computers are broadly made up of ***hardware*** and ***software***. The computer hardware is the physical part of a computer that we can see and touch. Hardware is defined in such a way that it does whatever the software (computer programs) tells it to do. And so we define software as a set of instructions that state how to process data. Also we must consider other things like ***data***, ***users (human and non-human)*** and ***procedures*** for a computer system to be complete and operational. Therefore, our computer systems consist of hardware, software, data, users and procedures. Thus all these together are the five elements of computing process.

There are four basic operations which our computers perform irrespective of the program which is running on it. They are classified as:

1. **Input**: this is inserting or feeding data into the computer by means of input device like keyboard, mouse, light pen, joy stick, and scanner.
2. **Processing**: some kind of processing is done on the computer to take out or transform the data in some way.
3. **Output**: our computers produce outputs via devices, such as printer, speaker or monitor that shows the result of processing operations.
4. **Storage**: our computers store the results of processing operations for future use in some storage device like hard disk, flash drive, magnetic tape, memory card or a floppy disk.

Self-Assessment Exercise(s) 2

1. Computer is broadly divided into two parts. Name them.
2. What are the four basic operations of a computer?

3.3 History of Computers

Although modern electronic computers are very recent (from early 1940's), the idea of computing was conceived far back. So, we can say computing dated back as far as when '***cave man***' needed to count items with his fingers, stones and bones. As the items to be counted becomes larger and ways to represent them increases, man devices compact objects to express numbers and do simple calculations. Below is a summary of early computing devices.

3.3.1 Do you know what Abacus is? You will soon know.

The history of computer started out at the birth of the first pre-mechanical computer called the **Abacus**. Abacus was developed in China in 1450 B.C as a tool used for basic arithmetic computations like addition and subtraction. It consisted of a wooden rack holding two horizontal wires with beads strung on them. Computation is done by moving the beads around according to programming rules memorized by the user, Figure 3.1.

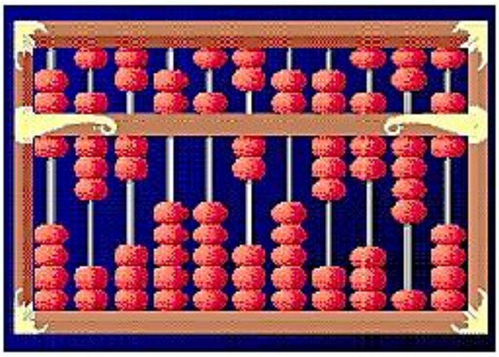

Figure 3.1 Abacus
Source: http://marina-knowledge.blogspot.com/2009/11/heart.html

3.3.2 Do you know who Napier Bones is?

John Napier 1600 A.D was a Scottish mathematician who invented ***Napier Bones*** for counting in 1614. The bones were strips of ivory with numbers written in them. The bones are arranged vertically and the numbers written on them are read horizontally when used for arithmetic operations such as, multiplication, division, and calculation of square and cube roots, Figure 3.2.

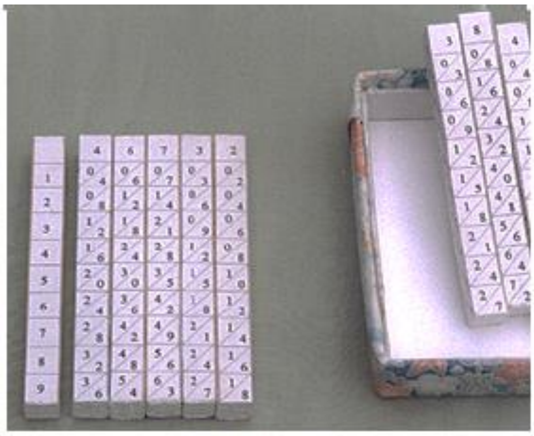

Figure 3.2 Napier Bone
Source: http://www.uwgb.edu/breznayp/cs353/napier.html

Self-Assessment Exercise(s) 3

1. When was Abacus developed?
2. Napier Bones was invented by ………………………. in …………………………..
3. Abacus can be used for ……………………… and ………………………… arithmetic operations while Napier Bones can be used for …………………… and ……………………………

3.3.3 What is Adding Machine

Blaise Pascal 1642 A.D (France), invented the first machine called ***Adding Machine***. It was also referred to as **Pascaline**, which could add, carry digits automatically. The machine is fully mechanical and it operated on gears and levers. It added numbers entered with dials and was made to help his father, a tax collector, Figure 3.3.

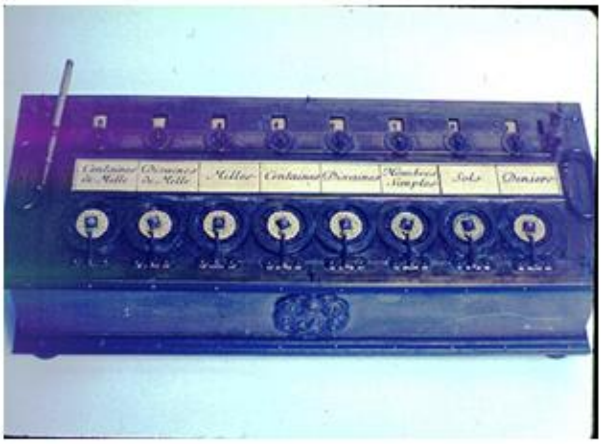

Figure 3.3 Adding Machine
Source: http://www.britannica.com/EBchecked/media/19233/The-Arithmetic-Machine-The-Arithmetic-Machine-or-Pascaline-a-French

3.3.4 Multiplying Machine

Gofffried Leibnitz 1692 A.D (Germany) improved on Pascal machine and introduced a mechanism to carry out all basic arithmetic operations (i.e. addition, subtraction, multiplication and division). The machine was named ***Multiplying Machine***. Multiplying machine is a special stepped gear mechanism for introducing the addend digits, and this is still being used. It was therefore, referred to as Stepped Reckoner.

3.3.5 Difference Engine

Remember Charles Babbage? In 1813 A.D (England) he invented an automatic machine that can perform complex astronomical computations using Newton's method of successive differences and print out the result as well. It was called the first mathematical computer. The machine called ***Difference Engine*** was steam powered. The Difference Engine was never fully completed, but led Babbage to envision a more general calculating machine, Figure 3.4.

Self-Assessment Exercise(s) 4

1. The Adding Machine was invented by ………………... and is fully …………………. in operation
2. …………………………. invented Multiplying machine as an improvement over ………………………. machine.
3. ………………………invented the Difference engine in …….………….. which was ……………………… powered.

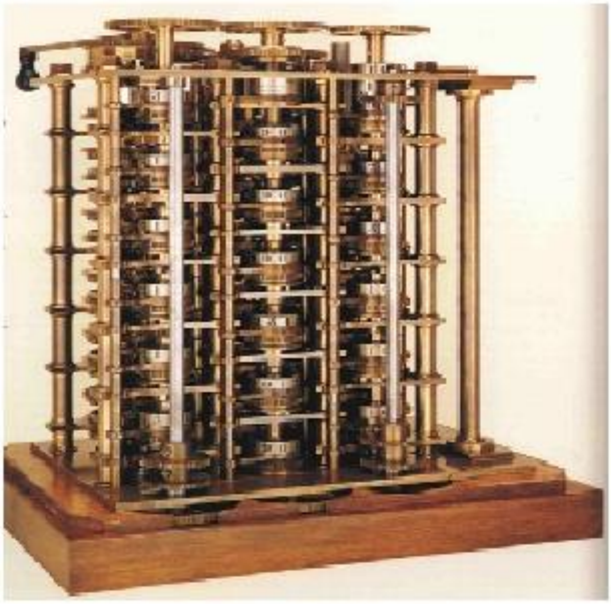

Figure 3.4 Difference Engine
Source:http://people.uncw.edu/tompkinsj/112/texnh/handouts/historyHandout.html

3.3.6 What about this guy Jacquard Loom?

Jacquard Loom 1800 A.D (France) developed Jacquard Loom specifically, in 1881. It was a programmable mechanical loom which used large cards and holes punched in them to control pattern automatically.

3.3.7 Ever heard about Arithrometre?

Charles Xavier Thomas 1862 A.D (France) produces the first calculator known as ***Arithrometre*** with commercial prospects, Figure 3.5. It was the first reliable, useful and commercially successful calculating machine. Arithrometre was capable of performing the four basic mathematical functions.

Self-Assessment Exercise(s) 5

1. The Jacquard Loom was developed in ……………………… and was programmed using …………………………….
2. The first calculator was known as ……………………………………

Figure 3.5 Arithrometer
Source:
http://timerime.com/en/event/323939/Colmars+Arithrometer/

3.3.8 Analytic Engine

Charles Babbage 1863 A.D (England), improved on his earlier work to develop a machine called ***Analytic Engine*** that would have the ability to store 1000, 50- digit numbers in one second and multiply 20-digit numbers in three minutes, Figure 3.6. Babbage used a form of punched cards earlier developed by Jacquard Loom for inputting the data and he was the first person to conceive of the "Stored program concept". A brilliant mathematician called Augusta Ada Bryon assisted Babbage too on the project, though he could not complete the project in his life time. Babbage is recognized as "the father of computer" based on his contribution to computer.

Figure 3.6 Analytic Engine
Source:
http://www.sciencemuseum.org.uk/objects/computing_and_data_processing/1878-3.aspx

3.3.9 Tabulating Machine

Dr. Hermann Hollerith developed a machine called ***Tabulating Machine*** that operated on punch cards to help the US Census Bureau collect census data in 1890, Figure 3.7. The bureau was one of the first organizations to use the mechanical computers which used punch-card equipment designed by Herman Hollerith to tabulate data for the 1890 census.

The tabulating machine was an electrical device designed to assist in summarizing information and, later, accounting. It spawned a larger class of devices known as unit record equipment and the data processing industry. In 1911 Hollerith's company merged with a competitor and founded the corporation which in 1924 became International Business Machines (IBM) Census.

Figure 3.7 Tabulating Machine
Source:
http://www.columbia.edu/cu/computinghistory/census-tabulator.html

Self-Assessment Exercise(s) 6

1. Charles Babbage improved on his earlier Difference Machine to develop the …………………………….
2. The female mathematician who assisted Babbage to invent Analytic engine is called ……………………………
3. ……………………………. developed the Tabulating Machine in…………………
4. The machine operating using ………………………….. to collate data.

4.0 Conclusion

In this unit, we discussed the device called computer by giving its definitions and describing its various parts. We also discussed the history computer by reviewing early computing devices that gave idea to present day computer.

5.0 Summary

(i) Computer as electronic device that accepts input as data from user through input device, process or logical operation on the data and provide information as output to the user through output device.

(ii) Compute comprise of hardware and software. It forms part of computer system in addition to user, procedure and data. It also performs four basic operations which are input, output, processing and storage.

(iii) History of present day computers dated back to over a century ago when old tools such as Abacus, Napier bone, Adding machine, Multiplying machine, Difference engine, Jacquard Loom, Arithrometre, Analytic engine and Tabulating machine were devised for computing basic arithmetic

6.0 Tutor-Marked Assignments

1. Write down all the terms that are common to all the definitions of computer stated in this unit.
2. Describe each of the following in a sentence:
    a. Input device
    b. Out device.
    c. Logical operation
3. Name the five things that make up computer systems.
4. What are the operations a typical computer should perform?
5. Name the early computing machines developed by Charles Babbage
6. Which of the computing machines mentioned in this unit finally lead to today's computer?
7. Write three advantages of Analytic engine over Difference Engine.

7.0 References/Further Reading

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Unit 2

Generations and Classifications of Computers

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7.0 References/Further Reading

1.0 Introduction

We discussed about the early computing tools in unit 1. Tools like abacus, Napier bone, analytic engine, difference engine etc. These lead to developments of electro-mechanical computers in 1940s popularly regarded as first generation computers.

The first generation computers were improved upon for almost ten years (1950s). And we had another set of computers called second generation computers. Since then, computers transitioned to third, fourth and present fifth generation computers. Thus, computers with similar components are normally grouped together to form a generation.

Apart from grouping computers by generations, they are also classified based on size and functionalities into supercomputers, mainframe computers, minicomputers and microcomputers. The classification is not dependent on year or time, so it is possible to classify any computer manufactured this year (2012) as mainframe computer if it possesses features of computers in the class.

So, we will learn generations of computers from 1940s to present. And also, what makes a computer belong to a generation, as well as classification of computers in this unit. This unit is also perquisite to unit five and a very interesting one as well so enjoy!!!

2.0 Learning Outcomes

After completing this unit, you should be able to:

(i) List and explain some early computers.

(ii) Describe all the generations of computers.

(iii) Mention computers in each generation.

(iv) List and explain classification of computers.

3.0 Learning Content

3.1 Early Computers

Before we look into generations of computers in next section, let us take a quick look at some early computers that define computer generations. The computers we will discuss here are cited as examples in this unit.

3.1.1 Mark I -1944

Do you know that Mark I was developed by Dr Howard Aiken? It was a continuation of an uncompleted Analytical Engine started by Babbage and Ada. Mark I also referred to as Automatic Sequence Controlled Calculator (ASCC) was partly electronic and partly mechanical. The Mark I had 60 sets of 24 switches for manual data entry and could store 72 numbers, each 23 decimal digits long. It was bulky-8 feet high and 55 feet long. It could do three additions or subtractions in a second, Figure 4.1. A multiplication took six seconds, a division took 15.3 seconds, and a logarithm or a trigonometric function took over one minute. It uses punch card as tool for data input and weighed about 10,000 pounds (4500 kg)

Figure 4.1 MARK I
Source:
http://www.athsalumni.org/howardaiken.htm

3.1.2 ENIAC – 1943

Closely following on the heels of Mark I, scientist of Havard University brought out *Electronic Numerical Integrator and Calculator (ENIAC).* And this was the first electronic computer, Figure 4.2. It weighed 5 tons and occupied space equivalent to 2 big rooms. It was financed by United State army to help in solving calculations in artillery-firing tables, and settings used for different weapons under varied conditions for target accuracy. The ENIAC contained 17,468 vacuum tubes, along with 70,000 resistors, 10,000 capacitors, 1,500 relays, 6,000 manual switches and 5 million soldered joints and was able to do 300 multiplications per second.

Figure 4.2 ENIAC
Source:
http://www.columbia.edu/cu/computinghistory/eniac.html

3.1.3 EDSAC – 1947

You may have heard about the Electronic Delayed Storage And Calculation (EDSAC). It was a British machine inspired by John von Neumann's seminal EDVAC report. But it was constructed by Professor Sir Maurice Wilkes and his team at the University of

Cambridge Mathematical Laboratory in England, Figure 4.3. It was the first computer to practically implement the ‘stored program concepts’ known later as ‘Von Neumann Concept’. And it proposed the use of binary numbers and internal storage of instructions in digital form. Some of the features of EDSAC we should note are:

1. Its’ input was via 5-hole punched tape and output was via a teleprinter. Its’ registers were only accumulator and multiplier registers
2. Internally, the EDSAC used twos complement to represent negative binary numbers.
3. It has about 87 subroutines as application software arranged into different categories.
4. And it used mercury delay lines for memory, and derated vacuum tubes for logic.
5. Lastly the EDSAC memory had 1024 locations, but only 512 locations were initially implemented.

Figure 4.3 EDISAC
Source:
http://en.wikipedia.org/wiki/Electronic_Delay_Storage_Automatic_Calculator

3.1.4 UNIVAC – 1951

Universal Automatic Computer (UNIVAC) was the first commercial electronic computer to be made available to the public, Figure 4.4. It was designed principally by J. Presper Eckert and John Mauchly, the inventors of the ENIAC UNIVAC I (the first version of UNIVAC) used 5,200 vacuum tubes, weighed 29,000 pounds (13 metric tons), consumed 125 kW, and could perform about 1,905 operations per second running on a 2.25 MHz clock. The Central Complex alone (i.e. the processor and memory unit) was 4.3 m by 2.4 m by 2.6 m high. The complete system occupied more than 35.5 m² of floor space. UNIVAC was the first computer to employ magnetic tape as input device. Its introduction was followed by the entrance of IBM into the computer field with IBM-701 computer.

Figure 4.4 UNIVAC
Source:
http://www.computerhistory.org/timeline/?year=1951

Self-Assessment Exercise(s) 1

1. Mark 1 was developed by ……………………….
2. UNIVAC I was principally developed by ……………………..
3. Which computer was the first biggest in terms of size?
4. ENIAC was developed in ………………..
   a. 1944
   b. 1934
   c. 1943
   d. 1933

3.2 Generations of Computers

The term "***generations***" was initially introduced to distinguish between different hardware technologies. Gradually it shifted to both hardware and software as the complete systems consist of both of them. Computers both past and present can be divided in to five generations, i.e., depending upon the technologies used. The five generations of computer are:

3.2.1 First Generation 1945 - 1955

These computers used vacuum tubes and all the components were joined by copper wires, Figure 4.5. The components of the computers were very large and needed lots of space for airflow and cooling. This made the computers very bulky. And they required high electric power, air conditioners, frequent maintenance and large space for installation.

Some examples we ought to know in this generation are, ENIAC, EDSAC, UNIVAC, IBM 701, IBM 702, and IBM 650. First generation computers were very unreliable, mainly because of vacuum tubes which kept on burning out. And as users we ought to be prepared with extra tubes for standby purposes. Picture of vacuum tube is shown below.

Figure 4.5 Vacuum Tube
Source:
http://www.computermuseum.li/Testpage/UNIVAC-VacuumTube.htm

Some characteristics of this generation that we should know are;

(i) They are quite large as compared to present day computers.
(ii) They generated lots of heat and were not consistent and reliable as the valves tended to fail frequently.
(iii) Low capacity internal storage.
(iv) Individual, non-related models (not user friendly).
(v) Their processors operated in the milliseconds speed range.
(vi) Internal storage consisted of magnetic drum and delay lines.

Self-Assessment Exercise 2

1. List 5 characteristics of a First-Generation Computer

3.2.2 Second Generation 1955 -1965

These computers made use of solid state devices (transistors) instead of vacuum tubes. Circuit that uses transistors were smaller, generated little heat, and were less expensive. They consumed less power than vacuum tube circuits and were much greater in processing capacity.

More efficient programming methods and higher programming languages were deployed on second generation computers due to increase in processing power. It was also possible for computers in this generation to communicate with each other using telephone lines.

Examples of computers in this generation include IBM-1401, IBM-1620 and HONEY-WELL H-400. Many of these computers are used for business application and had the following characteristics:

1. They are smaller than the first-generation computers.
2. They generated lower heat level, as their components were much smaller.
3. They were more reliable because of solid state technology.
4. They had higher capacity of internal storage.
5. And used core storage instead of magnetic drum and delay lines as primary internal storage medium.
6. Their processor operated in the microsecond speed.

Self-Assessment Exercise 3

1. List 5 characteristics of a Second-Generation Computer

3.2.3 Third Generation 1965 - 1975

You may not have known but the third-generation computers were ushered in by the development of Integrated Circuits (IC) on a single silicon chip. IC incorporated number of transistors and electronic circuits on a single wafer or chips of silicon. ICs are also called semiconductors as combining layers of materials that have varying capacity to conduct electricity. The ICs considerably enhanced processing capability and speed of the computer. Figure 4.6 shows us an IC placed on the tip of a knife to confirm how small IC can be.

Figure 4.6 Silicon Chip
Source: chip
http://dev.emcelettronica.com/intel-48-core-cloud-computing-silicon-chip

One driving force in this generation is ability to assemble as many logic gates as possible on silicon chip. Logic gate is a circuit that performs arithmetic operations such as addition, subtraction, multiplication and division. ICs are ranked based on number of logic gates that have as follows:

(i) ***Small Scale Integration*** (***SSI***) - has more than 12 logic gates on a silicon chip.

(ii) ***Middle Scale Integration*** (***MSI***) - has more than one hundred logic gates.
(iii) ***Large Scale Integration*** (***LSI***) - is composed of 1,000 to 10,000 gates per chip.
(iv) ***Very Large-Scale Integration*** (***VLSI***) - consisted of more than 10,000 gates per chip.
(v) ***Ultra-Large-Scale Integration (ULSI)*** – has about one million gate per chip

There are various brands of *minicomputers*. Some of which are System 360 Mainframe from IBM, PDP-8 Mini Computer from Digital Equipment Corporation. All these and others dominated this computer generation. Below are characteristics of third generation computers:

(i) They are smaller than second generation computers.
(ii) They have higher capacity internal storage.
(iii) They also have remote communication facilities.
(iv) And multiprogramming facilities.
(v) They have processors, which operate in nanosecond speed range.
(vi) They have ranges of computers with a common architecture whereby models were upward compactable.
(vii) They also made use of high level languages such as COBOL.
(viii) And have wide range of optional peripherals.

Self-Assessment Exercise 4

1. List 5 characteristics of a Third Generation Computer

3.2.4 Fourth Generation Computers 1975 - 1989

In this era of computers there are different brands of microcomputers. Some of which are Intel's 8088, 80286 and so on, Motorola's 68000, 68030, 68040, Apple II, CRAY I/2/X/MP etc. The achievement made in VLSI was developed upon to produce microprocessor chip. This chip contains an entire central processing unit (CPU) on a single silicon chip. Do you know that the CPUs are not computers themselves? But they can perform all the functions of arithmetic logic unit and control unit to the CPU. And when these microprocessors are connected with memory, input and output devices, they become microcomputers.

The semiconductors we earlier talked about have memories. And they are cheap and fast. The commonly use memories are; Random Access Memory (RAM), Read Only Memory (ROM) and Programmable Read Only Memory (PROM). Thus, the fourth-generation computers are:

(i) very compact
(ii) much less expensive (cheaper than others)
(iii) faster
(iv) more reliable
(v) greater in data processing capability
(vi) Larger in storage capacity

(vii) They also have LAN and WANS which were developed (where desktop work stations interconnected)
(viii) They have introduced C language and Unix OS
(ix) And introduced Graphical User Interface too.

Self-Assessment Exercise 5

1. The introduction of the Fourth Generation Computers was attributed to the achievements recorded in ………………………………….

3.2.5 Fifth Generation Computers 1989 – to present

If you observed well, you will agree that up to fourth generation computer, emphasis had been laid on hardware aspect of computer. And the fifth-generation computers are being designed with highest priority given to making systems that are *easy and natural to use*. This flexibility comes through the concepts of *Artificial Intelligence* (*AI*), which is now a branch in computer science and has more to do with software. Do you know automatic programming, computational logic, pattern recognition and control of robots are examples of AI? Of course, they are.

Most of the sophisticated computers you see nowadays belong to fifth generation computers. Examples of these computers are IBM notebooks, Pentium PCs-Pentium 1/2/3/4/Dual core/Quad corei3. SUN work stations, Origin 2000, PARAM 10000, IBM SP/2 etc. The fifth generation has three functional requirements:

(i) Easy to use computers with high intelligence and natural human input and output mechanism;
(ii) Reliable and efficient software development by new languages, new computer architectures and systems software which overcome previous problems and
(iii) Improved overall functions and performance aimed at making computers smaller, lighter, faster, of greater capacity, more flexible and more reliable.

Self-Assessment Exercise 6

1. What are the functional requirements of fifth generation computers?

3.3 Classification of Computers

In the past, there were various classifications of computer, either by functions, data type (analog or digital), size, speed or cost. But you will agree with me that, there are many more attributes attached to the classifications in recent days. And each computer must fall into one or more of the four categories described in subsequent sections.

3.3.1 Super Computers

Super Computers are highly sophisticated computers used for very special tasks like scientific researches. Many users can access them at the same time. They are used for researches that are mathematically intensive such as aerospace exploration, satellite communications, chemical analysis, electronics research, petroleum exploration and nuclear power plants. The supercomputer shown in Figure: 4.7, is called Blue Gene and it has 250,000 processors.

Figure 4.7 Super Computer
Source:
http://en.wikipedia.org/wiki/Supercomputer

You should know that the main feature of supercomputer is ***multiprocessing.*** And this enables the computer to perform number of operations simultaneously. A super computer can contain hundreds of processors with speed measure in nanoseconds and minimum world length is 64 bits.

3.3.2 Mainframe Computers

Do you know that Mainframe Computers are large, expensive and are designed to meet the needs of a large organization? It is when people in the organization need frequent access to the same information, Figure 4.8. The information is usually organized and stored centrally in datacenter comprising of one or more large database and computer networking facilities. Users like you and I interact with mainframe computers from terminals. They typically contain about 8 processors and are not as fast as super computers.

Figure 4.8: Mainframe Computer
Source:
http://www.computersciencelab.com/ComputerHistory/HistoryPt4.htm

3.3.3 Minicomputers

Minicomputers are smaller than mainframes. They are still big enough to cater for a medium sized organization or a small-scaled business. They lie somewhere in between mainframe and microcomputers and can handle a great amount of data like mainframe. And they also support hundreds of users through terminals.

3.3.4 Microcomputers

Microcomputers or Personal Computer (PC) are solely designed for individuals like you and I. They come in different sizes and shape to meet individual specific needs. Examples include desktop, laptop, notebooks, Personal Digital Assistance (PDA) and embedded computers. Embedded small and specialized set of computers are used in electronics like VCR, TV, ATM machines, robots and cars. So that is why some Plasma or Liquid Cristal Display TV can now be connected to computer terminal for use as monitor.

Microcomputers have all resources they need to perform basic functions they are designed for. Resources such as DVD/CDROM drives, storage devices, input and output devices are attached to them. Microcomputers are sometimes connected to minicomputer or mainframe computer to use abundant resources such as high processors and large storage media available on the bigger computers.

Self-Assessment Exercise(s) 7

1. List all the classification of computers
2. Laptop computer is a minicomputer (Yes/No).
3. The class of computer the lie in between super computer and minicomputer is ……………………………………………..

4.0 Conclusion

This unit described some early computers that were cited as examples when discussing generation of computers from first to fifth generations, we also taught you how computers as classified and features of computers in each classification.

5.0 Summary

(i) Early computers are MarkI (1944), ENIAC (1943), EDSAC (1947), and UNIVAC (1951), all these computers are first generation computers and their circuits are made of vacuum tubes. They are characterized by large size, slow processing power and generate lot of heat. UNIVAC was the first commercial electronic.

(ii) There are five generations of computers namely, first (9145 - 1955), second (1955 - 1965), third (1965 - 1975), fourth (1975 - 1989) and fifth (1989 - present). Computer in each generation are grouped according to component used for processors, storage media, and input/output device.

(iii) Silicon chip contains logic gates and each chip is rated as SSI, MSI, LSI and VLSI depending on number of logic gates it contained. The more the number of logic gates on a chip the faster the computer.

(iv) There are four classifications of computers, which are super computer, mainframe computer, minicomputer and microcomputer. The criteria for the classification are processing speed, number of users that can use it concurrently and size.

6.0 Tutor-Marked Assignments

1. Write the full meaning of the followings:
   a. ENIAC
   b. EDSAC
   c. UNIVAC
2. Write the features of EDSAC and UNIVAC.
3. Which computer was the first to practically implement stored procedure?
4. Write three characteristics for each of the following generations of computers
   a. First
   b. Third
   c. Fifth
5. What do you think actually contributed to progress made for moving from third to fourth generations?
6. In two paragraphs summarize why fifth generation computers are smaller and faster than second generation computers.
7. Which classification of computer will you recommend for each of the scenarios below with wasting computer resources:
   a. A university library that needs to store electronic books centrally.
   b. A new student of CODeL that needs to computer to do her Tutor Marked Assignments.
   c. The Headquarter for a regional bank that wants to service branches in over fifty countries
8. Air conditioners that will auto regulate temperature.
9. Which classifications of computer will allow more than one users from many terminals to connect to concurrently?

7.0 References/Further Reading

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Unit 3

Basic Organization of Computer and Memory

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1.0 Introduction

Do you know that our computers as electronic devices consist of four interrelated units? The units perform same function irrespective of the classification our computers may belong. In addition to the units, computer has many memories for storing data either. And it can do this temporarily when processing data or permanently when computer is not in use. Their memories vary in sizes and purposes

Therefore, basic organization of the units which also shows how data moves from one unit to another, how central processing unit coordinates data and executes instructions, and memories are what you will learn in this unit.

2.0 Learning Outcomes

After completing this unit, you should be able to:

(i) Mention all the units in computer.
(ii) Explain the units in computer with labeled diagram.
(iii) Explain instruction cycle.
(iv) List and describe categories of memory.
(v) Describe registers, cache and virtual as special memories.

1.0 Learning Content

3.1 Basic Organization of Computer

A digital computer is made up of 4 interrelated units. These units are:

(i) Input unit
(ii) Output unit
(iii) Central Processing unit
(iv) Memory unit

Figure 5.1shows these components and their relationship.

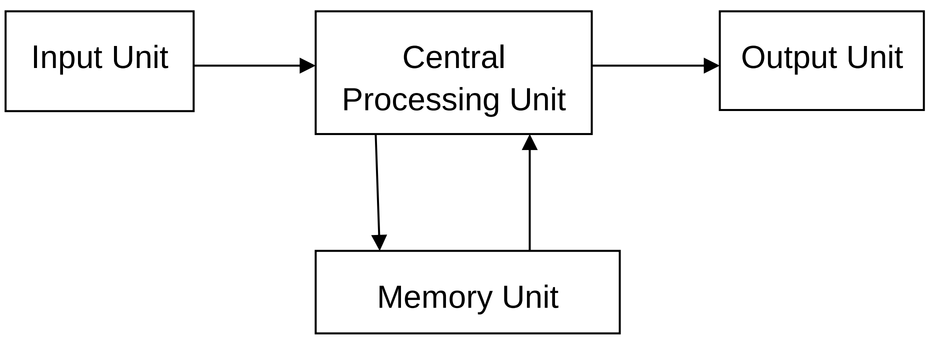

Figure 5.1 Basic Organization of

3.1.1 Input Unit

The input unit provides an interface between the you and I (i.e. users) and the central processing unit of a computer, for entering data and instructions. Data that comes into our computers are in various forms – audio, video, graphical and character texts. And these data in any form is first converted to digital format (i.e. streams of binary number in 0s and 1s) before being processed by CPU. We mentioned some of these input devices in unit 4.

3.1.2 Output Unit

When you hear "output unit" what comes to your mind? It's just the opposite of the input unit. The output unit is also an interface between you and I (users) and computer too. But unlike the input unit, the output unit returns feedback or result (information) of processing activities. Most especially those done by the CPU and conveys it to us. Output unit gets result in form of 0s and 1s from CPU and convert it to appropriate format (audio, video, graphical) as required by you and I. We gave some examples of output devices in unit 4. We will discuss CPU and memory units in detail in section 3.2.

***Note**: the input and output devices are otherwise known as peripherals.*

Self-Assessment Exercise(s) 1

1. How many units form basic computer organization?
2. What is the full meaning of CPU?
3. The CPU takes input from output unit (True/False).

3.2 Central Processing Unit

The Central Processing Units (CPU) in our various computers are the brain of our computers. Although there are differences in functions performed by input and output units, the CPU is mainly responsible for processing data into information. It is the CPU that defines the processing speed, multitasking or multiprocessing characteristics our computers.

Some microcomputers (Intel Pentium core dual and core i3), mainframe, minicomputer and super computers were built with two or more processors for better performances. So, our CPUs are made up of other components as illustrated in Figure 5.2.

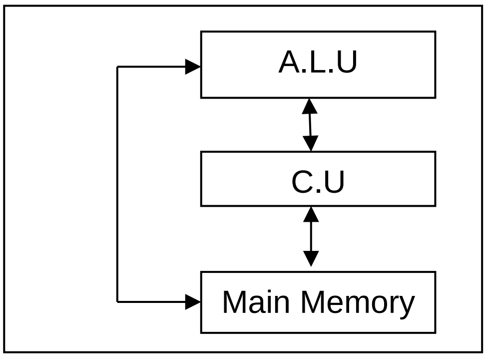

Figure 5.2 Central Processing

As we saw in Figure 5.2, the CPU comprises of **Arithmetic and Logic Unit** (ALU), **Control Unit** (CU), and **Main Memory** (MM). Data and information flow among the components as shown by directions of arrows in the diagram. The CPU receives data in binary digits from input unit then process the data and returns streams of binary digits to output unit. Generally, we can say that CPU performs:

1. Arithmetic calculations.
2. Operations involving logical decisions.
3. Data transmission with help of other devices.
4. Non-arithmetic operations, such as word process, data storage and retrieval.
5. Generates timing signals for synchronizing activities among peripherals attached to it for resource sharing.

3.2.1 The Arithmetic and Logic Unit (ALU)

When you hear the ALU what comes to mind? It's simple. The ALU is responsible for all arithmetic operations such as addition, subtraction, division and multiplication. It also performs logical decisions on data received. Consider the logical statements, D < H which is a logical statement to decide if D is less than H before an action can be carried out. So, if we say D = 9 and H = 7, then the statement D < H will evaluate to *false*. Whereas, the statement D > H, will evaluate to *true* for same values of D and H. So ALU can return 1 and 0 for true and false respectively.

3.2.2 Control Unit

The control unit controls the entire operations of the computer and the CPU. It controls all the other devices connected the CPU, i.e. input devices, output devices, auxiliary memory etc. Hence, the *control unit acts as the nerve centre of computer*.

Do you that the control unit upon receiving an instruction decides what is to be done after interpreting it? That is, whether it is to be sent to the ALU for further processing or to the output devices or to the memory etc. In other words, the control *unit coordinates and controls all hardware operations*.

You may not know this. But the control unit has an *electronic clock* that transmits electronic pulses at equal intervals of time. And it also gives instructions to other devices based upon these pulses. Suppose we have three instructions that we want our computer performed. Let the first instruction take three clock pulses to complete; when the fourth clock pulse is received the control unit would start processing the second instruction and so on.

Suppose another instruction takes three and a half clock pulses to complete. In such a case the control unit could wait for the fourth clock pulse to complete and take up the next instruction with the fifth clock pulse.

The clock pulse basically provides synchronization for every parts of the computer. The control unit generates millions of clock pulses per second. And the speed at which an instruction is executed depends upon the clock speed which is in MHz (10^6 Hz).

Instruction Cycle

It may interest you to know that every instruction before being executed is first interpreted by the control unit. And sequence of operations involved in processing an instruction is known as the *instruction cycle*. The instruction cycle can be divided into two parts:

1. *Fetch Cycle*: the control unit fetches the instruction from the memory data register (MDR) and places it in Current Instruction Register (CIR).
2. *Execution Cycle*: the control unit then decodes this instruction in the current instruction register and sends the appropriate signal to the concerned device for the execution of the instruction.

You can liken this to a relay in which the MDR, the CIR and the concerned device are relay racers. Meanwhile, the instruction is the baton that is being passed around.

3.2.3 Main Memory Unit

The last but not the least is the main memory. It is also known as the primary memory and is a part of the central processing unit. It is a combination of both RAM (Random Access Memory) and ROM (Read Only Memory). The main memory is a fast memory, i.e. it has small access time. In case the CU wants to process some data stored in secondary storage, the data is first transferred to main memory. We shall discuss the RAM and the ROM in section 3.3.

Self-Assessment Exercise(s) 2

1. What units that makes up the CPU?
2. The control unit uses ……………. to schedule time for executing instructions.
3. What is the meaning of RAM.

3.3 Computer Memories

3.3.1 Random Access Memory

The random-access memory is a read write memory i.e. information can be read as well as written into this type of memory. It is volatile in nature, i.e. the information it contains is lost as soon as we shut down our systems unless we save the information for further usage. It is basically used to store programs and data during the computer's operations.

3.3.2 Read Only Memory

The read only memory as the name may suggest contains information that can only be read, i.e. we can't write on this type of memory. It is non-volatile and what that is stored in it is said to be permanent in nature. It is basically to store permanent programs such as computer manufacturer's program for booting computer. ROMs are available in different types as we will see below:

Types of ROM

1. *Programmable Read Only Memory*: is a special type of ROM that allows you and I to write information permanently on ROM chip through a process called "*burning the PROM*".
2. *Erasable Programmable Read Only Memory (EPROM)*: is an erasable PROM. An EPROM can be programmed and reprogrammed using an EPROM programmer. Exposing it to high intensity ultraviolet light for about 30 minutes can erase the content of an EPROM chip. It is not possible to erase particular portion of this chip, we have to erase the entire memory contents.
3. *Electrically Erasable Programmable Read Only Memory (EEPROM)*: EEPROM is like EPROM but with more flexibility. One major advantage of EEPROM over EPROM is that even single memory can be altered electrically, i.e. the entire memory content need not be erased.
4. *Non-Volatile RAM*: a non-volatile RAM combines a static RAM and EEPROM. Such a device operates as normal RAM but in case the power fails the entire contents of the RAM are stored in EEPROM. When the power is restored, the data from EEPROM is transferred back to RAM

3.3.3 Cache Memory

Cache memory is another important memory. It is located in between the CU and main memory. The need for the cache memory is due to the mismatch between the speeds of the main memory and the CPU. The CPU clock as we discussed earlier is very fast, where as the main memory access time is comparatively slower. Hence, no matter how fast the processor is, the processing speed depends more on the speed of the main memory. Therefore, cache memory having ***access time closer*** to the processor speed was introduced to speed up access time.

Cache memory is more expensive and has faster access time than main memory. The data stored in cache memory depends on the algorithm designed for it. These algorithms work out the probability to decide which data would be most frequently needed. Figure 5.3 shows position of cache memory in a typical computer.

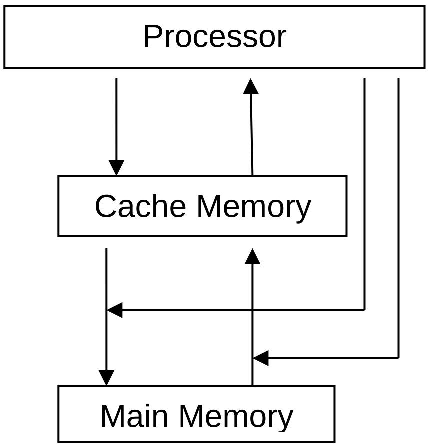

Figure 5.3 Cache Memory

3.3.4 Virtual Memory

The virtual memory is created by using part of the hard disk like RAM. Some operating systems such as Windows will automatically use part of the hard disk to supplement RAM for tasks requiring memory size that cannot be provided by main memory. While other operating systems like UNIX require user to manually set the size of the hard disk for this purpose.

3.3.5 Registers

Note that all data and instructions may not reside in the main memory. Processor contains a number of high-speed storage elements called Registers, which may be used for temporary storage of frequently used data and instructions. Each register can store one word of data. Access times to registers are 5 to 10 times faster than access time to memory. Registers are used in many parts of our computers as described below:

1. ***Accumulator****:* the accumulator is a register that is present within the ALU. It is used to store data which is either the result of an operation or which is to be processed by arithmetic and logical operations.
2. ***Memory Data Register (MDR):*** the MDR is like the accumulator. And it is used by the CU to store all data and instructions temporarily as they pass in and out of the main memory.
3. ***Memory Address Register (MAR):*** the MAR contains the address of the memory location (in main memory) whose data is to be transferred into the MDR.
4. ***Current Instruction Register (CIR):*** is a special purpose register that holds the instruction currently being processed by the control unit.

3.3.6 Auxiliary Storage (Secondary Memory)

The auxiliary storage, also known as the secondary memory is an external (to the CPU) memory. The auxiliary storage devices store large amount of any form of digital information. The auxiliary is permanent in nature, unless we intentionally delete it or roughly handle the storage. It offers convenient way to transfer information between computers and from one location to another.

Auxiliary storage is cheaper than main memory and information from main memory can be transferred to it by the CPU. Data stored in auxiliary storage take more time to process than data in main memory. But it has higher data capacity than main memory. We may also consider it as an input device and it stores the final results as an output device.

Auxiliary Storages are available in different data sizes, from hundreds of megabytes to terabytes. Examples of auxiliary storage are magnetic tape, floppy disk, hard disk, Compact Disc Read Only Memory (CD-ROM), Write Once Read Many Compact Disc (WORM -CD), Digital Versatile Disc (DVD), flash drive and memory card.

Self-Assessment Exercise(s) 3

1. Computer booting program is stored in …………….
2. Write the meaning of these acronyms
   a) EPROM
   b) EEPROM
   c) PROM
   d) CIR
   e) MAR

4.0 Conclusion

In this unit, you learned the four units of computer and diagrams of how the units are related were presented to illustrate how the units fit together. The unit also explained instruction cycle and memories use by computer for storing data either temporarily or permanently. The unit concludes our discussion on computer and the role it plays in data processing.

5.0 Summary

(i) Computer irrespective of its classification has four units which are input, output, central processing unit and memory unit. Input unit is use for data entry, output unit is for displaying information, central processing unit is responsible for actual data processing and control of other units and memory unit is use for data storage.

(ii) Central processing unit comprises ALU, CU, and main memory unit. ALU performs logical and arithmetic operations, CU is the nerve of computer and it is responsible for controlling and coordinating data, instructions and other units, main memory consist of RAM and ROM.

(iii) Instruction cycle defines the fetch and executes cycles to obtain and implement instructions on data respectively.

(iv) Memories are available in many categories for data storage in computer and common categories are register, cache, virtual memory and auxilary (external or secondary) memories.

(v) Cache memory is located in between the CU and main memory to speed up data access, virtual memory is created by using part the hard disk like RAM, register is a special memory is control unit for faster data processing and auxiliary storage devices store large amount data or information outside the computer.

6.0 Tutor-Marked Assignments

1. Draw the diagram of basic computer organization and explain input and output units.
2. What are the operations perform by CPU?
3. In a sentence describe ALU and CU.
4. Write short note on the two phases of instruction cycle.

5. Where is cache located and why is it necessary in computer?
6. List four types register.
7. Explain is auxiliary memory and list 10 types of auxiliary memory.

7.0 References/Further Reading

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Unit 4

Number Systems and Conversion

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1.0 Introduction

Did you know that the number system is a means of representing numbers? We can do this using some characters, digits, English characters or special characters. Common number systems are binary, octal, decimal and hexadecimal with decimal being the most common system we use. But our computers employ binary to represent data and execute instructions. It is also possible to convert number expressed in one number system to another system and represent negative numbers.

In this unit, we will learn the number systems mentioned above and conversion between them. The unit also covers simple arithmetic operations like addition, subtraction, division and multiplication in binary as well as negative number representation in binary. This will help us to understand how computer internally represent and process data, which is important for subsequent units.

2.0 Learning Outcomes

After completing this unit, you should be able to:

(i) Describe common number systems

(ii) Covert numbers in one number system to another

(iii) Perform basic arithmetic operation in binary

(iv) Represent negative number in binary

3.0 Learning Content

3.1 Introduction to Number Systems

Man invented number systems to count objects and communicate information. There are different types of number system and the commonly used are binary, decimal and hexadecimal. We use *radix* or *base* to indicate a particular number system a number represents, except for decimal. For example, 101101_2 means 101101 is binary number system (radix 2 or base 2), and $A12_{16}$ means A12 is hexadecimal (radix16 or base 16).

3.1.1 Binary Number System

The word binary was derived from Latin stem *bi*, meaning two. The number system uses two digits, 0 and 1, for counting. As discussed in unit 5, computer uses binary number system comprising of 0 and 1 for data representation and processing. This is because the computer is made up of electronic circuits which represent data with either ON or OFF (0 or 1).

3.1.2 Decimal Number System

Decimal number system is the one we are most familiar with for counting and representing figures, it consists of digits 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9. Multiple combinations of the digits denote high numeral like tens, hundreds, thousands, millions, billions or trillions. We learned basic arithmetic when growing up with the number system. And we use it in our day-to-day work. The number system also offers flexibility for negative number representation.

3.1.3 Hexadecimal Number System

Hexadecimal was derived from the Greek word *Hexadec*, meaning 16. Hexadecimal number system is used by both humans like us and computers for numbering. It consists of 0,1,2,3,4,5,6,7,8,9, A, B, C, D, E and F. English alphabets A, B, C, D, E and F which can as well be lowercase are included because there are no digits to represent them.

Hexadecimal is not human-friendly and must be converted to decimal before we can understand the figure or number it represents. However, it uses least number of digits to represent large number unlike decimal and binary. For example, to represent number 16 in decimal we use two digits (1 and 6), binary equivalent of 16 is 1111 (four digits), but hexadecimal is F (1 digit).

Table 6.1 below shows binary system, decimal and hexadecimal equivalents for numbers 1 to 16.

Table 6.1 Number System

Binary	Decimal	Hexadecimal
0000	0	0
0001	1	1
0010	2	2
0011	3	3
0100	4	4
0101	5	5
0110	6	6
0111	7	7
1000	8	8
1001	9	9
1010	10	A
1011	11	B
1100	12	C
1101	13	D
1110	14	E
1111	15	F

Self-Assessment Exercise(s) 1

1. List the three commonly used number systems.
2. Which number system do you think 34D2 belong to?

3.2 Number System Conversions

Do you know that all the number systems discussed in section 3.1 can be converted from one number system to another system? We will learn how to do the conversions in subsequent subsections.

3.2.1 Decimal to Other Number Systems

There are two ways we can convert decimal number to other number systems namely, *power method* and *remainder method*. In this section we shall discuss the remainder method because it is more commonly used. The remainder method is done in following order:

(i) Divide the given number (decimal system) by the radix or base of the proposed system and note down the remainder.
(ii) We divide the quotient again by the radix and we will note down the remainder.
(iii) And continue the process until quotient is zero.
(iv) Then we will arrange the remainder from bottom to top to form number for the new radix.

Example 6.1

Convert 153 to binary.

Solution

To covert 153 to binary number system using procedure above, we will divide 153 by 2 since we are converting to radix 2, and write down the remainder, the quotient is 76 and remainder is 1. Again, we divide 76 by 2 and write the new quotient and remainder will continue until the quotient is 0 and arrange the remainders from bottom to top as shown in Figure 5.1. Therefore, converting 153 in decimal to binary is 10011001_2. The subscript 2 called the base or radix is appended to show the digits are in binary number system without which the conversion is incomplete.

Propose radix	Decimal	Remainder
2	153	
2	76	1
2	38	0
2	19	0
2	9	1
2	4	1
2	2	0
2	1	0
	0	1

arrange remainders from bottom to top

Figure 6.1

3.2.2 Convert Decimal with Fraction to Other Number Systems

We have seen how to covert decimal number without fractional or floating point to other number systems. Now we will learn how to convert decimal number with fraction to other number systems by following the steps stated below:

i. We multiply the radix of the proposed system with the fraction to be converted.

ii. Then we write down the resulting integer (if any) otherwise we put down zero in that place.

iii. After which we repeat the multiplication with the resulting fraction.

iv. And keep repeating the procedures till the fraction vanishes or we continue getting repeating fractions.

Now let's take an example.

Example 6.2

Convert 0.30 in decimal to binary

Solution

Suppose we want to convert 0.30 in decimal to binary with steps stated above, Figure 6.2, we first multiply 0.30 by 2 to give us 0.60. We write down integer 0 (the digit before the decimal point) and take the decimal part 60 to next line. We write the decimal part as 0.60 and multiply it by 2 again, this gives us 1.2. We write down integer 1 and take 0.20 to next line and continue until we have same number repeated twice in fraction column or the result is 0.0. In our case we have to stop because 1.2 earlier obtained was repeated again on the last line. Then we arrange all the numbers in integer column from top to bottom. Thus binary equivalent of 0.30 in decimal is 010011_2.

Multipy decima by radix	Fraction	Integer
0.30 x 2	0.6	0
0.60 x 2	1.2	1
0.20 x 2	0.4	0
0.40 x 2	0.8	0
0.80 x 2	1.6	1
0.60 x 2	1.2	1

arrange Integers from top to bottom

Figure 6.2

3.2.3 Convert other Number Systems to Decimal

Do you know that we can convert from other number systems to decimal? We can simply do so by multiplying each digit of the number system with the radix of old number raised to power of its position value and then adding all the results.

Let's consider some examples

Example 6.3

Convert 10010_2 to decimal.

Solution

We arrange all the digits horizontally and assign position values starting from 0 to rightmost digit. Then, we raise the radix which is 2 for binary to power of position values as shown in table below. The first row of the table showed the radix to power of position value and the second row showed the binary digits. The third row displayed each digit multiplied by value in row one. And the last row summed up the total to get the decimal equivalent which is 18. Table 6.2 shows the solution

Table 6.2

2^4	2^3	2^2	2^1	2^0
1	0	0	1	0
1 x 16	0 x 8	0 x 4	1 x 2	0 x 1
16	0	0	2	0
16 + 0 + 0 + 2 + 0 = 18				

Example 6.4

Convert $C14B_{16}$ to decimal.

Solution

Recall that B and C in hexadecimal are equivalent to 11 and 12 respectively. So we will use the decimal equivalent of B and C to compute row three in table below. Following our explanation in last example 6.3 the decimal equivalent of $C14B_{16}$ is 49483.

Table 6.3

16^3	16^2	16^1	16^0
C	1	4	B
12 x 4096	1 x 256	4 x 16	11 x 1
49152	256	64	11
49152 + 256 + 64 +11 = 49483			

3.2.4 Convert other Number Systems with Fraction to Decimal

Conversions from other number systems having fraction (or floating point) to decimal are simply done by multiplying each digit of the number system with the radix raised to *negative* power of its position value and then adding all the results. In addition, the position starts from -1 and decreases rightward.

Let us consider an example.

Example 6.5

Convert 0.10010_2 to decimal.

Solution

Note that we used negative power for the radix and it decreased rightward. The result of converting 0.10010_2 to decimal is therefore 0.5625 as computed in Table 6.4.

Table 6.4

2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}
1	0	0	1	0
1 x 0.5	0 x 0.25	0 x 0.125	1 x 0.0625	0 x 0.03125
0.5	0	0	0.0625	0
0.5 + 0 + 0 + 0.0625 + 0 = 0.5625				

Self-Assessment Exercise(s)

1. How many digits are used for representing binary number?
2. What is radix?
3. When converting decimal to another binary you read the remainder
   a. upward
   b. downward
   c. none of the above

3.3 Binary Arithmetic

The ways we perform basic arithmetic operations (addition, subtraction, multiplication and division) in binary number system are same as the way we do them in decimal number system.

3.3.1 Binary Addition

Table 6.5 shows simple rule for binary digit addition.

Table 6.5

0 + 0 =	0
0 + 1 =	1
1 + 0 =	1
1 + 1 =	10

Note that 1+1 = 10 in fourth row, that the sum is 0 and 1 is carry over to next position value on the left.

Example 6.7
Find the sum of 1001101 and 10011 in binary.
Solution
Use Table 6.5 as guide in this solution and observe that all the digits in first row of the solution had carry over from previous operation added to them.

1 **0 0 1 1 0** 1
+ 1 0 0 1
1

1 1 0 0 0 0 0

It is easy right? Let's consider other operations.

3.3.2 Binary Subtraction

The rule for binary subtraction is shown in Table 6.6.

Table 6.6

0 - 0 =	0
0 - 1 =	1
1 - 0 =	1
1 - 1 =	0

Note that 0 – 1 = 1 in second row, with 1 borrowed from leftmost digit.

Example 6.8
Subtract 10110 from 1001101
Solution

```
 1001101
-  10110
 -------
  110111
```

3.3.3 Binary Multiplication

We obtain multiplication in binary by forming partial products, shifting successive partial products to the left by one space. And adding all the partial products just like multiplication in decimal. The basic rules for multiplication are shown in Table 6.7.

Table 6.7

0 x 0 =	0
0 x 1 =	0
1 x 0 =	0
1 x 1 =	1

Example 6.9
Let us multiply 11101 by 101
Solution

```
    11101
  x   101
    -----
    11101
   00000
  11101
 --------
 10010001
 --------
```

3.3.4 Binary Division

The rule for binary division is same as long division in decimal. We start by selecting the highest number digits from the dividend and divide the by the divisor and write the quotient, when divisor is larger than the digits from dividend we write zero as our quotient. We then multiply the quotient by divisor and subtract the value from the selected digits from the dividend. We will do this operation for all the digits of the divided. All the digits of the quotient will then form the answer.

Example 6.10

Now let us divide 10010001 by 101 in binary

Solution

```
          11101
     ----------
101 | 10010001
      - 101
      ---------
        1000
      - 101
      ---------
          10
          -0
      ---------
          101
         -101
      ---------
          000
```

So, dividing 10010001 by 101 will give 11101_2

Self-Assessment Exercise(s) 3

1. Subtract 101_2 from 110_2.
2. Find the sum of 1101_2 and 1001_2.

3.4 Negative Binary Number

There are two ways to represent negative number in binary number system.

1. Sign binary number
2. 2's complement

3.4.1 Sign Binary Number

To represent positive binary number in binary we set the leftmost digit (most significant digit) to 0 while the leftmost digit will be set to 1 to signify negative number. Number represented using this method is called signed binary number. Suppose 16 is represented in 8 bit systems as 00001111 the -16 will be 10001111 in sign binary.

3.4.2 1's and 2's Complements

We must find 1's complement before we get 2's complement. The 1's complement of a binary number is obtained by changing all 0 to 1 and all 1 to 0 in a given binary number. For example the 1's complement of *11001010* is *00110101*.

The 2's complement is another way to represent negative number in binary. It becomes handy in electronic circuits where binary number system is to represent data and processing logics. To get 2's complement of number we first get its 1's complement and add 1 to it.

Example 6.11

Find the 2's complement of 11001010

Solution

Table 6.8 shows the 2's complement of 11001010 as 00110110. The second row is 1's complement i.e. changing all 1s in row 1 to 0 and all 0s to 1. In row 3 we added 1 to result in row 2 to get the 2's complement in row 4.

Table 6.8

Binary number	11001010
1's complement	00110101
Add 1	+ 1
2's complement	00110110

Self-Assessment Exercise(s) 4

1. Name the two ways of representing negative numbers in binary.
2. You do not need to get 1's complement from 2's complement (True/False).

4.0 Conclusion

In this unit you have learned that number systems are used to represent numbers both by human and computer, while human uses decimal computer works with binary and hexadecimal systems, conversion among the number systems follows simple procedures and computers represent negative number with 2's complement.

5.0 Summary

(i) Common numbers systems are binary using 0 an1 to digits, decimal uses 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9, hexadecimal consisting of 0,1,2,3,4,5,6,7,8,9, A, B, C, D, E and F.

(ii) Conversion of binary to decimal and vice versa is important in data processing because human understands decimal while computer stores data and process data in binary since it is made of circuits that have only two states ON or OFF for 1 or 0 respectively.

(iii) Negative number can be represented in binary with sign number and 2's complement, the latter is use by computer to represent negative number.

(iv) Perform basic arithmetic operations in binary with simple rules of thumb captured in tables below:

Binary Addition

0 + 0 =	0
0 + 1 =	1
1 + 0 =	1
1 + 1 =	10

Binary Subtraction

0 - 0 =	0
0 - 1 =	1
1 - 0 =	1
1 - 1 =	0

Binary Multiplication

0 x 0 =	0
0 x 1 =	0
1 x 0 =	0
1 x 1 =	1

6.0 Tutor-Marked Assignments

1. Write the 16 characters in hexadecimal number system
2. Why do you think decimal and binary number systems are important in data processing?
3. Convert 281 and 456 to binary.
4. Convert 0.110011_2 to decimal.
5. Convert 0.342 to binary.
6. Convert 5EDE1 to decimal.
7. Multiply 1001_2 by 101_2.
8. Change 01110011 to negative number using:
    a. Sign binary number
    b. 2's complement

7.0 References/Further Reading

1. Deepak, B. (2002). *Fundamentals of Information Technology*. New Delhi: Excel books.

Unit 5

Computer Languages and Basic Concepts of Database

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1.0 Introduction

Do you know that communication between us and our computers is possible? This can be achieved through computer languages that must be interpreted from human understandable forms to binary format. You may be wondering how this is done. It's simply through programming. Programming is an act of writing instructions to direct computer operations with programming languages. And these languages are also referred to as computer language.

The data we store in our computers need to be organized to simplify access and conserve space. Database management system is application software designed to achieve efficient data management on our computer systems. This unit will introduce us to computer languages, meaning of programming languages, their classifications and basic concepts of database management system.

2.0 Learning Outcomes

After completing this unit, you should be able to:

i. Explain meaning of computer languages
ii. Describe programming language
iii. List and explain classification of programming languages
iv. Explain computer language translators
v. Describe database management systems
vi. Explain basic database concepts.

3.0 Learning Content

3.1 Introduction to Computer Languages

Do you also know that the term computer language includes wide variety of languages? These are used to ***communicate*** with computers. It is broader than the more commonly-used term ***programming language***. Programming languages are a subset of computer languages. For example, HTML (Hypertext Markup Language), XML (Extensible Markup Language) and SQL (Structured Query Language) are computer languages, but none is traditionally considered a programming language.

Computer languages could also be grouped based on other criteria such as; ***human-readable*** and ***non-human-readable*** languages. Human-readable languages are designed to be used directly by humans to communicate with the computer. Non-human-readable languages, though they can often be partially understandable, are designed to be more compact and easily processed, sacrificing readability for flexibility.

Self-Assessment Exercise(s) 1

1. Computer languages can be divided into two groups: ……………. And ………………
2. XML and HTML are programming language (True/False).

3.2 Programming Languages and Translators

A programming language is an artificial language designed to communicate instructions to a machine, particularly a computer. We can use programming languages to create programs that control the behavior of a machine and/or to express algorithms precisely.
A programming language consists of ***words***, ***symbols*** and ***usage rules*** pertaining to the grammar that permits people to communicate with the computer. It allows programmers and end-users (like you and I) to develop the program that are executed by our computers. The description of a programming language is usually split into the two components of *syntax* (grammar) and *semantics* (meaning).
Computer programming languages can be divided into two groups: ***high-level languages*** and ***low-level languages***. High-level languages are designed to be easier for us to use. It is more abstract, and more portable than low-level languages. Syntactically correct programs (i.e. programs that are grammatically correct) in any high-level languages is compiled to low-level language and executed by our computers. Most modern software are written in a high-level language, compiled into object code, and then translated into machine instructions.

3.2.1 Classification of Programming Languages

Many programming languages are available now unlike some years back. And they are classified by purpose or area of application as described below:
Machine Language: is the lowest form of computer language. Programs are only written in binary based machine found in first generation computers. Our computers understand this language at the lowest level and do not need translator before executing the language. Thus program written in machine language executes faster than other languages. However, it is more difficult to write programs in machine language. The programs in machine language are mostly instructions comprising of two parts called op-code and operand.

1. The ***op-code*** is the first part and is the command or operation. It tells the computer what function to perform.
2. ***Operand*** is the second part of the instruction; it tells the computer where to find or store data or instructions that are to be manipulated.

Assembly Language: this was used for writing programs executed on second generation computers. It is easier for us to write programs in this language than in machine language. Assembly languages permit the use of *mnemonic* or symbols which are two or three English character abbreviations for the function to be performed by the instructions. The mnemonics are then translated by using symbolic equivalence table designed for specific computer on which the program written with assembly language is going to execute.
High Level Languages: this language uses characters and base ten number systems to form English-like instructions and arithmetic expressions. High level languages may be used with different makes of computers with little modifications. High level languages are designed to run on fourth and fifth generation computers. The programs

we write in high level languages executes slower than assembly language counterparts. Examples of high level languages are C, C++, Java, Pascal, dotNet, Scalar, PHP and FORTRAN.

3.2.2 Computer Language Translators

Computer language translators are programs that translate programs in other languages to machine language instruction code which the computer can execute. Below are various kinds of translation programs commonly used:

1. **Assemblers**: Assemblers translates the symbolic instruction code of programs written in assembly language into machine code.
2. **Interpreters**: an interpreter translates and executes each program statement one at a time, instead of producing a complete machine language like assemblers and compilers do. With an interpreter, the source program is not transformed to object program and the result of each executed statement is determined before the next statement is executed.
3. **Compilers**: a compiler is a program which produces a machine level program from the specifications of a high-level language. It generates object program equivalent of source program. The compilation process has several phases including ***Parsing***, ***Mapping*** and ***Generaion of object code***.

Self-Assessment Exercise(s) 2

1. Machine language is divided into two parts called ……………. and …………………
2. A compiler is …………………
3. Assembly language comprises of short character abbreviation known as …………….

3.3 Basic Concepts of Database Management Systems

A ***database*** is a collection of related information stored in a structured format. Most computer users like us or organizations need to store and retrieve data for different purposes and time. Data stored in data base can be in numerous forms like audio, video, pictures, characters and numbers. Several models are employed to efficiently store data in database. And fast retrieval among these are **hierarchical**, **network**, **relational** and **object oriented**. While hierarchical and network databases are no longer common, most database in use today are based on relational database model. Thus, enterprise databases such as Oracle, Microsoft SQL server, MySQL, Informix, and Sybase are popular relation database.

We can say a ***database management system*** (DBMS) is a manager of the database consisting of different types of data organized into several files. The data model used by most available DBMS is one in which information is grouped into files. Each file contains records. Each record contains information about a particular instance of an event or an object. And all the records represent similar events or objects. The terminologies used in DBMS are;

Entity or table: it is a real-world object or event which is of interest to us. For example, if we are interested in creating database for a school some of the entities that will be of interest to us are; students, courses, lecturers and non-teaching staff.

Tuples or Records or Rows: These are rows of a relation apart from the header row containing the attribute names. A Record has one component for each attribute of the relation. For example, a record could have the six components: 2019/I/48576CS, Joseph, Cyber Security Science, Male, 500L and Cyber Security for the Six attributes given or listed above.

Attributes or column: these are the characteristics or properties of the entity. For example, the attributes of student may include; matriculation number, name, department, gender, level and course of study.

Data type: data type of an attribute is a particular data format allowed in that attribute. For example, an attribute defined with number data type will not take any character of English alphabet

Primary Key: is an attribute in a table that uniquely identify each row or record in a table.

Practically speaking, in ***Relational Database Management Systems*** (RDBMS) approach, each entity represents a table and each attribute comprises a field of the table. All fields combined for one particular instance of the entity is called a record or tuple. All records taken together constitute the table.

Most DBMS offer a computer language called Structured Query Language (SQL) to enable database users carry out basic operations such as update, insert, retrieve and delete data from the database. Also, DBMS are built with tools for database maintenance like backup and recovery of database, database performance analyzer, and database advisor.

Self-Assessment Exercise(s) 3

1. The full meaning of DBMS is ……………………
2. Mention the four models design to store data in database.
3. The full meaning of SQL is ………………………

4.0 Conclusion

In this unit you learned how communication between human and computer is normally established with the help of computer languages. DBMS which is application software use for storing data for efficient access was also introduced. Computer languages and RDMS are will b covered in other courses as you progress in you program.

5.0 Summary

1. Computer language includes wide variety of languages for communicating with computers and it can be human-readable and non-human-readable languages.
2. A programming language is an artificial language designed to communicate instructions to a machine, particularly a computer and it can be low-level or high-level language.
3. There three classifications of programming language known as machine language, assembly language and high-level language.
4. Computer language translator is a program that translates program in other languages to machine language instruction code and it can be complier, interpreter or assembler.
5. A is a collection of related information stored in a structured format whereas DBMS is a manager of the database, commonly use database terms are entity, attributes, data type and primary key.

6.0 Tutor-Marked Assignments

1. What is computer language?
2. Explain the meaning of syntax and semantics
3. List two programming languages developed for third and fourth generations computers.
4. Mention three differences between compiler and interpreter.
5. List five maintenance activities perform by most DBMS.
6. What is the difference between database and DBMS?
7. List eight types of DBMS.

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Module 3

Communication System

Unit 1:	Communication System and Transmission Impairments
Unit 2:	Analog and Digital Signals
Unit 3:	Signal Modulation and Signal to Noise Ratio

Unit 1

Communication System and Transmission Impairments

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- 3.2 Element of Communication System
- 3.3 Transmission Impairments

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Reading

1.0 Introduction

You will agree with me that in most cases information or data need to be transmitted for it to be available to esteem users like us. Numerous electronic gadgets have been developed to make data transfer possible. This minimizes data loss during transmission (from source to destination). Data loss occurs due to some identified reasons, most of which are attributed to our gadgets or other environmental factors. The data loss is generally referred to as transmission impairment.

In this unit, we will learn communication systems, its basic components for data transfer and common transmission impairments in electronic data transfer.

2.0 Learning Outcomes

After studying this unit, you should be able to:

i. Describe communication system.

ii. List and explain components of communication system.

iii. Explain transmission impairments

iv. Mention common transmission impairments.

3.0 Learning Content

3.1 Introduction to Communication System

Communication system as we all know is a system or facility for transferring data between us and equipments. The system usually consists of a collection of individual communication networks, transmission systems, relay stations, tributary stations and terminal equipment. And all these are capable of interconnection and interoperation so as to form an integrated whole.

Now, these individual components must serve a common purpose, be technically compatible, employ common procedures, respond to some form of control and generally operate in unison. [" Communications Standard Dictionary", 2nd Edition, Martin H. Weik] (1995-02-06).

Also, a communication system conveys data from its source to a destination. And there are many different applications of communication systems that we cannot attempt to cover every type. Nor can we discuss in detail all the individual parts that make up a specific system. A typical system involves numerous components that run the scope of electrical engineering—circuits, electronics, electromagnetic, signal processing, microprocessors, and communication networks. All communication systems have the same basic function of data transfer.

Information, Messages, and Signals

You should know by now that the concept of **information** is central to communication. But information is a loaded word. It implies semantic and philosophical notions that defy precise definition as we learnt in unit two.

Message is defined as the physical manifestation of information as produced by the source. Whatever form the message takes, the goal of a communication system is *to reproduce at the destination an acceptable replica of the source message*. Messages, as we all know, appear in various forms.

Signal is a physical embodiment of information. Communication systems accept signal as input and release processed signal as output. There are two distinct message categories, **analog** and **digital**.

Self-Assessment Exercise(s) 1

1. Communication system conveys data from ……….. to ……….. some distance away.
2. ………… is physical manifestation of information.

3.2 Elements of a Communication system

Whether analog or digital, few message sources are inherently electrical. Consequently, most communication systems have input and output **transducers**, Figure 8.1**.** The input transducer converts the message to an electrical signal, say a voltage or current, and another transducer at the destination coverts the output signal to the desired message form. For instance, the transducers in a voice communication system could be a microphone at the input and a loudspeaker at the output Figure 8.2.

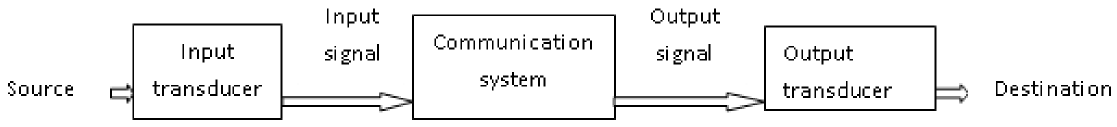

Figure 8.1 Communication system with input and output transducers

There are three essential parts of any communication system, the **transmitter**, **transmission channel**, and **receiver**. Each part plays a particular role in signal transmission as follows:

The **transmitter** processes the input signal to produce a transmitted signal. And the signal should suite the characteristics of the transmission channel. Signal processing for transmission almost always involves **modulation** and may also include **coding**.

The **transmission channel** is the electrical medium that bridges the distance from source to destination. It may be a pair of wires, a coaxial cable, or a radio wave or laser beam. Every channel introduces some amount of transmission loss or attenuation. So the signal power progressively decreases with increasing distance.

The **receiver** operates on the output signal from the channel in preparation for delivery to the transducer at the destination. Receiver operations include amplification to compensate for transmission loss, and **demodulation** and **decoding** to reverse the signal (i.e. processing performed at the transmitter). **Filtering** is another important function at the receiver.

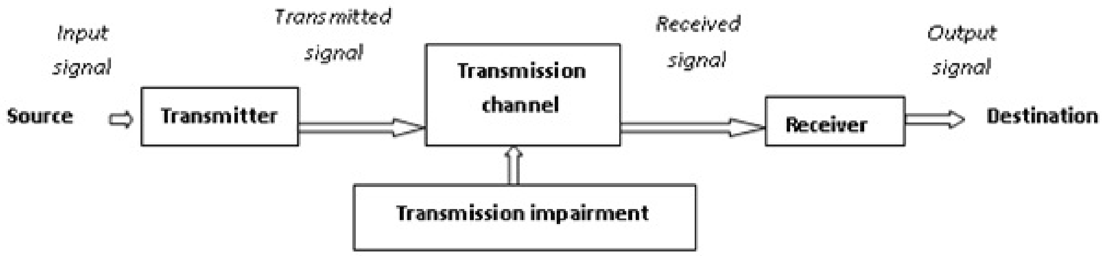

Figure 8.2 Elements of Communication system

Self-Assessment Exercise(s) 2

1. What are the three parts of any communication system?
2. ……………. is a medium that bridges source and destination.

3.3 Transmission Impairments

You may be wondering what transmission impairment actually means. But it's very easy to understand. You will agree to the fact that various unwanted and undesirable effects crop up in the course of signal transmission from transmitter to receiver. Such effects are generally known as transmission impairment. It can either lead to signal corruption or complete loss thereby hampering efficiency of communication system. Noticeable among these are:

1. **Attenuation**: reduces signal strength over time and increases with number of frequencies, thus the signal at the receiver is weak for processing, Figure 8.3. To overcome attenuation signals must be sufficiently strong and maintain sufficient high level. We achieve this by using an amplifier to make them distinguishable from noise so that our receiver will be able to detect and interpret them.

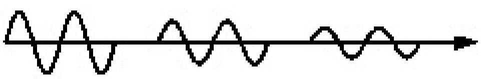

Figure 8.3 Attenuation
Source: http://www.cse.ohio-state.edu/~gurari/course/cis677/cis677Se5.html#QQ1-25-11

2. **Dispersion**: Signals tend to spread as they travel, with the amount of spreading dependent on the frequency Figure 8.4.

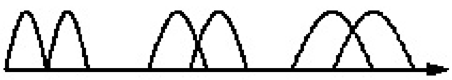

Figure 8.4 Dispersion
Source: http://www.cse.ohio-state.edu/~gurari/course/cis677/cis677Se5.html#QQ1-25-11

3. **Distortion**: Distortion means that the signal changes its form or shape, Figure 8.5. Distortion can occur in a composite signal made of different frequencies. Each signal component has its own propagation speed (see the next section) through a

medium and, therefore, its own delay in arriving at the final destination. Differences in delay may create a difference in phase if the delay is not exactly the same as the period duration. In other words, signal components at the receiver have phases different from what they had at the sender.

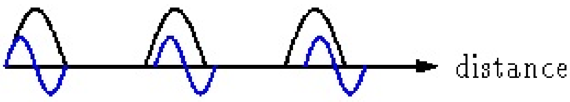

Figure 8.5 Distortion
Source: http://www.cse.ohio-state.edu/~gurari/course/cis677/cis677Se5.html#QQ1-25-11

4. **Noise**: Noise? Yes noise. Although not the normal noise we know. This noise refers to random and unpredictable electrical signals produced by natural processes. These processes can be both internal and external to the system. When such random variations are superimposed on an information-bearing signal, the message may be partially corrupted or totally obliterated, Figure 8.6. Filtering reduces noise contamination, but there inevitably remains some amount of noise that cannot be eliminated.

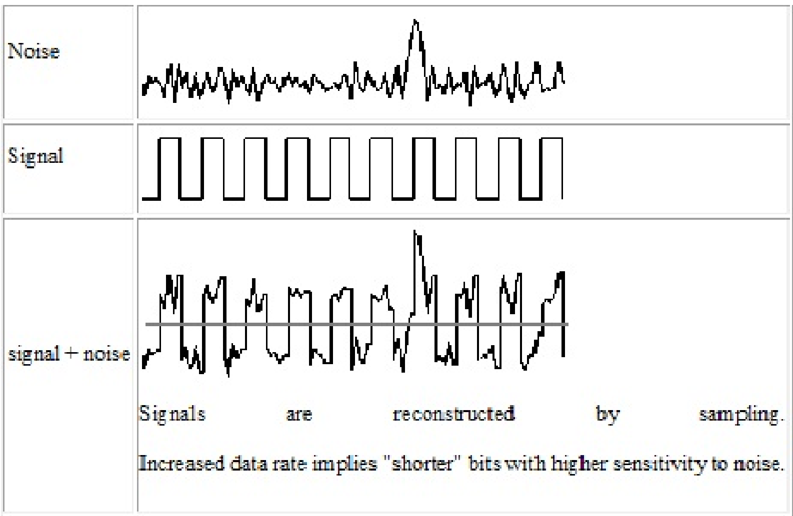

Figure 8.6 Noise

Source: http://www.cse.ohio-state.edu/~gurari/course/cis677/cis677Se5.html#QQ1-25-11

5. **Crosstalk**: Crosstalk occurs when foreign signal enters the path of the transmitted signal.
6. **Impulse**: Irregular disturbances, such as lightning, and flawed communication elements. It is a primary source of error in digital data.

Self-Assessment Exercise(s) 3

1. The general name for data loss in communication system is called ……………………..
2. Noise can occur in communication system due to internal or external factors to the system (True/False).

4.0 Conclusion

Communication system comprises of many components working together to facilitate data transfer from source to destination, but transmission impairments impede the process leading to data corruption or complete loss of data. You will learn how to detect and correct data errors in other unit of this course.

5.0 Summary

(i) Communication system is a system or facility for transferring data between persons and equipment comprising of communication networks, transmission systems, relay stations, tributary stations and terminal equipment.

(ii) Communication system consists of three components namely, transmitter, transmission channel and receiver.

(iii) Transmitter processes input signal to produce a transmitted signal, transmission channel is the electrical medium that bridges the distance from source to destination and receiver operates on the output signal from the channel in preparation for delivery to the transducer.

(iv) Transmission impairments are unwanted and undesirable effects crop up in the course of signal transmission, common examples are attenuation, noise, crosstalk, distortion, dispersion and impulse.

6.0 Tutor-Marked Assignments

1. Mention what a typical communication system would involve.
2. Draw a diagram of communication system showing all its components.
3. What roles does transmission medium play in communication channel?
4. What are the major difference between attenuation and distortion?
5. In two sentences describe communication system.

7.0 References/Further Reading

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Unit 2

Analog and Digital Signals

Contents

1.0 Introduction
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3.0 Learning Content
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1.0 Introduction

Do you know that information or data is transmitted in communication system as signal in analog or digital form? And this is dependent on transducers involved in the transmission process. Some electronic devices are developed to convert analog signal to digital signal, and vice-versa, to ensure interoperability among transducers.

This unit explains analog and digital signals, the advantages and disadvantages of each signal form and how converters convert signal from one form to another. It describes some key terms you will come across in unit 10.

2.0 Learning Outcomes

After completing this unit, you should be able to:

i. Describe analog signal
ii. List advantages and disadvantages of analog signal
iii. Describe digital signal
iv. List advantages and disadvantages of digital signal
v. Explain analog to digital signal converters
vi. Explain digital to analog converter

3.0 Learning Content

3.1 Concepts of Analog and Digital Signals

3.1.1 Analog Signal

An **analog** signal is a physical quantity that varies with time, usually in a smooth and continuous fashion. Example of analog signal is the acoustic pressure produced when you speak. Since the information resides in a time-varying waveform, an analog communication system should deliver this waveform with a specified degree of fidelity (with which an electronic system reproduces the sound or image of its input signal).

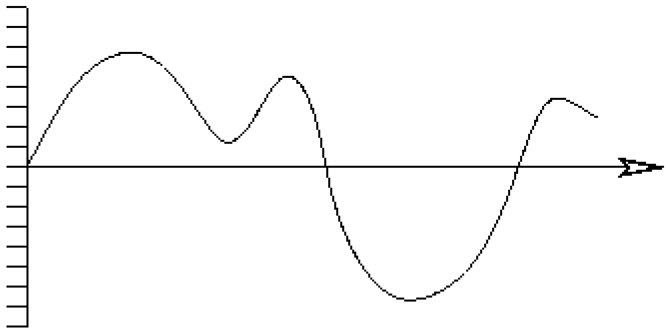

Figure 9.1 Analog Signal

Advantages of Analog Signal

1. The main advantage of analog signal is its fine definition which has the potential for an *infinite amount of signal resolution*. That is any quantity within expected

range of values can easily be represented. Compared to digital signals, analog signals are of higher density.

2. Another advantage of analog signal is *that its processing may be achieved more simply* than with the digital equivalent. An analog signal may be processed directly by analog components, though some processes aren't available except in digital form.

Disadvantages of Analog Signal

The primary disadvantage of analog signaling is that any system has noise – i.e., random unwanted variation. As the signal is copied and re-copied, or transmitted over long distances, these apparently random variations become dominant. Electrically, these losses can be diminished by shielding, good connections, and several cable types such as coaxial or twisted pair. The effects of noise create signal loss and distortion. This is impossible to recover, since amplifying the signal to recover attenuated parts of the signal amplifies the noise (distortion/interference) as well. Even if the resolution of an analog signal is higher than a comparable digital signal, the difference can be overshadowed by the noise in the signal.

3.1.2 Digital Signal

We have just learnt \what an analog signal is, so then what is a digital signal? A digital signal is an ordered sequence of symbols (sets of zero and one) selected from a finite set of discrete elements. A digital signal uses some physical property, such as voltage, to transmit a single bit of information.

Examples of digital signal are the keys you press on a computer keyboard and Digital Audio Broadcast (DAB) radio, like Aljazeera and CNN – it is transmitted as digital signals. Since the information resides in discrete symbols, a digital communication system should deliver these symbols accurately and without delay.

Suppose we want to transmit the number 6. In binary, that number is 110. We first decide that, say, "high" means a **1** or **ON** and "low" means a **0** or **OFF**. Thus, 6 might look like:

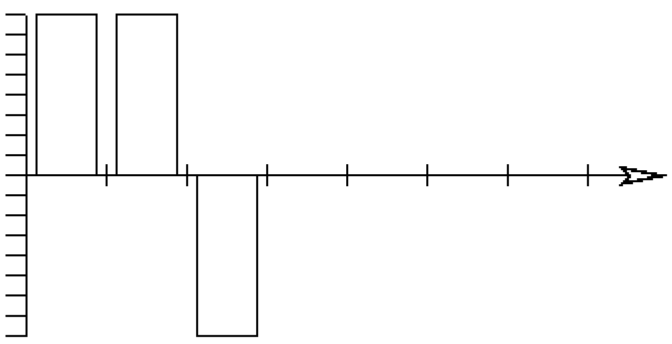

Figure 9.2 Digital Signal

The heavy black line is the signal, which rises to the maximum to indicate a 1 and falls to the minimum to indicate a 0.

Advantages of digital signal

1. Digital signals *carry more information per second* than analogue signals. This is the same whether optical fibers, cables or radio waves are used.
2. Digital signals *maintain their quality over long distances* better than analogue signals. You will notice far less noise and crackle from a DAB radio program than in an ordinary FM or AM radio program.
3. Another advantage of digital signal over analog is *better data compression capability*. Since the digital counterpart of an analog signal is just a bunch of numbers, these numbers can be compressed, just like you would compress a file using WinZip to shrink down the file size.

Disadvantages of digital signal

1. Digital communications *require greater bandwidth* than analogue to transmit the same information.
2. The detection of digital signals *requires the communications system to be synchronized*, whereas generally speaking this is not the case with analogue systems.

Self-Assessment Exercise(s)

1. An analog signal is a ……………. that varies with time, usually in ………….. and ……………. fashion.
2. A digital signal is an ……………….of symbols selected from a ……………….. elements.
3. What is the meaning of DAB?

3.2 Analog to Digital Converter

An analog-to-digital converter (abbreviated ADC, A/D or A to D) is a device that converts a continuous quantity (Analog signal) to a discrete time digital (Digital signal) representation. Typically, an A/D is an electronic device that converts an input analog voltage or current to a digital number proportional to the magnitude of the voltage or current. However, some non-electronic or partially electronic devices, such as rotary encoders, can also be considered A/D.

Conversion of analog signal to digital signal is achieved through a process called **sampling**. Sampling measures the analog signal at different moments in time, recording the physical property of the signal (such as voltage) as a number. It is therefore required to define the rate at which new digital values are sampled from the analog signal. The rate of new values is called the **sampling rate** or **sampling frequency** of the converter.

Here's how we might sample the analog signal we saw earlier:

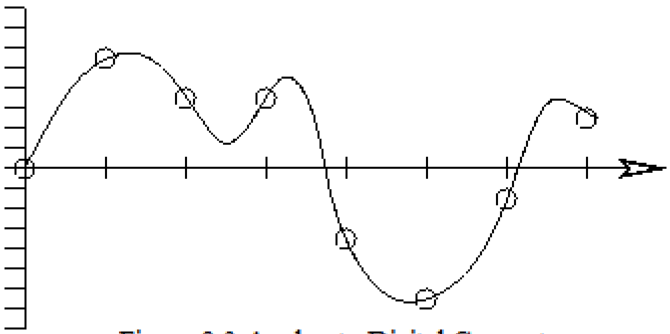

Figure 9.3 Analog to Digital Converter

Reading off the vertical scale on the left, we would transmit the numbers 0, 5, 3, 3, -4, (The number of bits we need to represent these numbers is the so-called *bit-resoluton*. In some sense it is the sound equivalent to images' bit-depth.)

In A/D converters, performance can usually be improved using *dither*. This is a very small amount of random noise (white noise), which is added to the input before conversion. Its effect is to cause the state of the Least Significant Bit (LSB) to randomly oscillate between 0 and 1 in the presence of very low levels of input, rather than sticking at a fixed value.

Rather than the signal simply getting cut off altogether at this low level (which is only being quantized to a resolution of 1 bit), it extends the effective range of signals that the A/D converter can convert. And at the expense of a slight increase in noise - effectively the quantization error is diffused across a series of noise values which is far less objectionable than a hard cutoff. The result is an accurate representation of the signal over time. A suitable filter at the output of the system can thus recover this small signal variation.

A/D has several sources of errors. These errors are measured in a unit called the **least significant bit** (LSB). Common errors in A/D as discussed below:

1. **Quantization error**- Quantization error (or quantization noise) is the difference between the original signal and the digitized signal. This error is either due to rounding or truncation. Hence, the magnitude of the quantization error at the sampling instant is between zero and half of one LSB. Quantization error is due to the finite resolution of the digital representation of the signal and is an unavoidable imperfection in all types of A/DCs.
2. **Non-linearity error**- All A/Ds suffer from non-linearity errors caused by their physical imperfections. This causes their output to deviate from a linear function (or some other function, in the case of a deliberately non-linear ADC) of their input. These errors can sometimes be made less severe by calibration or prevented by testing.
3. **Aperture error** - Aperture error which is due to a clock jitter (caused by phase noise) and is revealed when digitizing a time-variant signal (not a constant value).

Self-Assessment Exercise(s) 2

1. Conversion of analog signal to digital signal is achieved through a process ……………….
2. ADC converters, performance can usually be improved using ……………….

3.3 Digital to Analog Converter

We've discussed what an analog to digital converter is. Now let's discuss what a digital to analog converter is. In electronics, a digital-to-analog converter (D/A, DAC or D-to-A) is a device that converts a digital (usually binary) code to an analog signal (current, voltage, or electric charge). Signals are easily stored and transmitted in digital form, but a D/A is needed for the signal to be recognized by human senses or other non-digital systems.

A common use of digital-to-analog converters is generation of audio signals from digital information in music players. Digital video signals are converted to analog in our televisions and cell phones to display colors and shades. D/A conversion can degrade a signal, so conversion details are normally chosen so that the errors are negligible.

Due to cost and the need for matched components, D/Cs are almost exclusively manufactured on integrated circuits (ICs). There are many D/C architectures which have different advantages and disadvantages. The suitability of a particular D/C for an application is determined by a variety of measurements including *speed* and *resolution*.

DAC is basically done by drawing a curve through the points. In the following picture, the reconstructed curve is dashed, Figure 9.4.

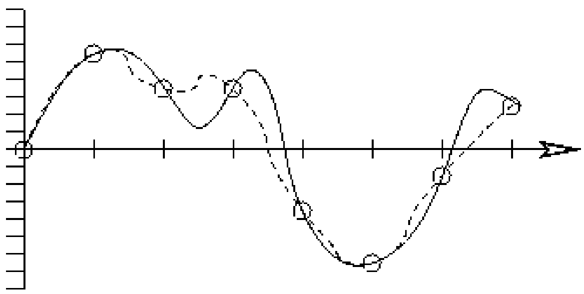

Figure 9.4 Digital to Analog Converter

In the example, you can see that the first part of the curve is fine, but there are some mistakes in the later parts.

The solution to this has two parts:

1. The vertical axis must be fine enough resolution, so that we don't have to round off by too much, and
2. The horizontal axis must be fine enough, so that we sample often enough.

In the example above, it's clear that we didn't sample often enough to get the detail in the intervals. If we double it, we get the following, which is much better Figure 9.5.

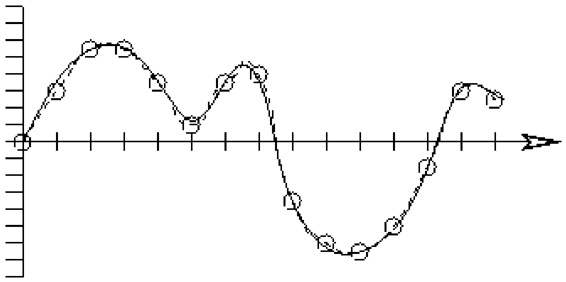

Figure 9.5 Digital to Analog Converter

In general, finer resolution (bits on the vertical axis) and faster sampling gets you better quality (reproduction of the original signal) but the size of the file increases accordingly.

Self-Assessment Exercise(s) 3

1. The suitability of a particular DAC for an application is determined by a variety of measurements including _________ and ____________.
2. A device that converts digital signal to analog signal is called _____________ , __________ .

4.0 Conclusion

In this unit you learned the two forms of signals transmitted in communication system, advantages and disadvantages of each form of signal, the techniques used in ADC or DAC and problems associated with each converter. The topics discussed in this unit will help your understanding of modulation and demodulation in next unit.

5.0 Summary

(i) An analog signal is a physical quantity that varies with time, usually in smooth and continuous fashion.

(ii) Advantages of analog signal are fine definition and processing may be achieved more simply. It only and major disadvantage is electrical noise.

(iii) A digital signal is an ordered sequence of symbols selected from a finite set of discrete elements in only two states. Advantages of digital.

(iv) Advantages of digital signal include ability to carry more information per second, maintain signal quality over long distances and better data compression capability. Known disadvantages of digital signal are greater bandwidths requirement and the communications system need to be synchronized.

(v) An analog-to-digital converter (abbreviated ADC, A/D or A to D) is a device that converts a continuous quantity (Analog signal) to a discrete time digital (Digital signal) representation.

(vi) A digital-to-analog converter (D/A, DAC or D-to-A) is a device that converts a digital (usually binary) code to an analog signal (current, voltage, or electric charge).

6.0 Tutor-Marked Assignments

1. Mention two disadvantages of analog signal.
2. Which signal form carries more information per second?
3. Write four disadvantages of digital signal.
4. Mention three errors associated with ADC.
5. Use graphs to show that finer resolution and faster sampling gets you better quality DAC.

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Unit 3

Signal Modulation and Signal to Noise Ratio

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3.4.3 Using Both Limits

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7.0 References/Further Reading

1.0 Introduction

Signal in communication system exists in analog or digital form as we discussed in unit 9. Therefore, the data to be sent using the signal have to be formatted to suit the signal form before transporting the data. Signals travelling in communication channel are mostly affected by noise. And effects of noise on signal take center stage in the field of telecommunication engineering and other related field. The amount of noise in a channel therefore determines quality and quantity of data delivered through it.

This unit continues our discussion on communication system by looking at how data is formatted by modulation techniques and tools like modem. With the use of existing formula to determine adverse effect of noise on signal with signal-to-noise ratio, determine data capacity of noiseless and noisy channels with Nyquist and Shannon theorems respectively.

2.0 Learning Outcomes

After studying this unit, you should be able to:

i. Define and explain modulation
ii. Name types and benefits of modulations
iii. Describe signal-to-noise ratio.
iv. List three formulas for calculating signal-to-noise ratio
v. Perform calculation using signal-to-noise ratio
vi. Write Nyquist and Shannon theorems
vii. vii) Calculate data capacity of noiseless and noisy channels

3.0 Learning Content

3.1 Definition of Modulation

We can define modulation as:

The process of changing an electrical signal, such as by superimposing the signal's characteristics onto a carrier wave so that it carries the information contained in the signal.

Or,

Modulation is a process of mixing a signal with a sinusoid (sine curve) to produce a new signal. This new signal, conceivably, will have certain benefits of an un-modulated signal, especially during transmission. If we look at a general function for a sinusoid:

$f(t) = A\sin(\omega t + \phi)$

Self-Assessment Exercise(s) 1

1. Modulation is a process of mixing a _______ with a _________ to produce a new signal.
2. Complete the formula below:

$f(t) = A\_\_\_(\omega t + \_\_)$

3.2 Concept of Modulation

The primary purpose of modulation in a communication system is to generate a modulated signal suited to the characteristics of transmission channel.

From above definitions we can deduce that modulation involves two waveforms: a **modulating signal** which typically contains information to be transmitted and a **carrier signal** which is a high-frequency periodic waveform that suits the particular application or transmission medium.

Also, we can see from the second definition that this sinusoid has 3 parameters that can be altered, to affect the shape of the graph. The first term, **A**, is called the magnitude, or amplitude ("volume") of the sinusoid. The next term, **ω** is known as the frequency ("pitch"), and the last term, **ϕ** is known as the phase angle ("timing"). All the three parameters can be altered to transmit data. It is important to notice that a simple sinusoidal carrier contains no information of its own.

3.2.1 Modem

A device that performs modulation is known as a **modulator** and is placed at transmitter. And a device that performs the inverse operation of modulation is known as a **demodulator** (sometimes called **detector** or **demod**) and is located at receiver. A device that can do both operations is a **modem** (from "modulator–demodulator").

A modulator systematically alters the carrier wave in correspondence to variations of the modulating signal. The resulting modulated wave thereby carries the message. We generally require that a modulation be a *reversible* operation, so the message can be retrieved by the complementary process of **demodulation**.

3.2.2 Types of Modulation

There are 3 basic types of modulation: Amplitude modulation, Frequency modulation, and Phase modulation.

1. **Amplitude modulation (AM)** - a type of modulation where the amplitude of the carrier signal is modulated (changed) in proportion to the message signal while the frequency and phase are kept constant.
2. **Frequency modulation (FM)** - a type of modulation where the frequency of the carrier signal is modulated (changed) in proportion to the message signal while the amplitude and phase are kept constant.

3. **Phase modulation (PM)** - a type of modulation where the phase of the carrier signal is modulated (changed) in proportion to the message signal while the amplitude and frequency are kept constant.

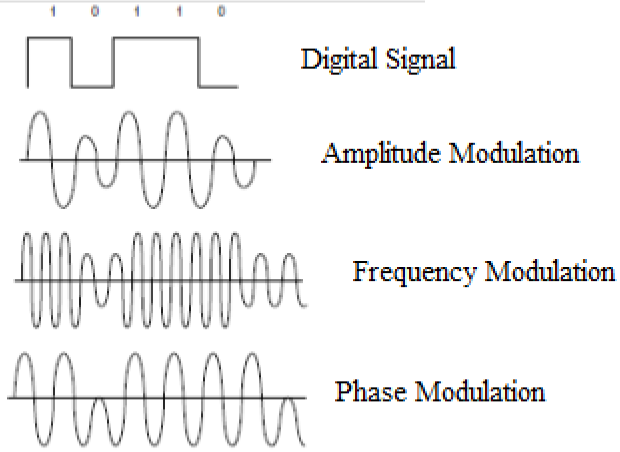

Figure 10.1 Signal Modulation

3.2.3 Benefits of Modulation

1. *Modulation for efficient transmission*: By exploiting the properties of carrier wave, message can be impressed on a carrier whose properties have been selected for the desired transmission method.
2. *Modulation to overcome hardware limitation*: The design of a communication system may be constrained by the cost of availability of hardware, especially hardware whose performance often depends upon the frequencies involved. Modulation permits the designer to place a signal in some frequency range that avoids hardware limitations
3. *Modulation to reduce noise and interference*: Frequency modulation and other types of modulation have valuable property of suppressing both noise and interference. This property is called wideband noise reduction.
4. *Modulation for frequency assignment*: Modulation makes it possible for several radio stations to transmit at different frequencies at same time and allows tuner to select only desired station at a time. If not for modulation only on station could broadcast in a given area, otherwise two or more broadcasting stations would create a hopeless jumble of interference.
5. *Modulation for multiplexing*: multiplexing which outside the scope of this course can only be achieved through modulation, thereby leading to efficient use of transmission medium.

3.2.4 Analog and Digital Signals Modulation

You should note that both analog and digital signals can be modulated. In analog modulation, the modulation is applied continuously in response to the analog information signal. Think about your car radio. There is more than a dozen (or so) channels on the radio at any time, each with a given frequency: 100.1MHz, 102.5MHz etc... Each channel gets a certain range (usually about 0.2MHz), and the entire station gets transmitted over that range.

In digital modulation, an analog carrier signal is modulated by a discrete signal. We can consider digital modulation methods as digital-to-analog conversion, and the corresponding demodulation or detection as analog-to-digital conversion. A telephone line is designed for transferring audible sounds, for example tones, and not digital bits (zeros and ones).

Our computers may however communicate over a telephone line by means of modems, which are representing the digital bits by tones, called symbols. If there are four alternative symbols (corresponding to a musical instrument that can generate four different tones, one at a time), the first symbol may represent the bit sequence 00, the second 01, the third 10 and the fourth 11.

If the modem plays a melody consisting of 1000 tones per second, the symbol rate is 1000 symbols/second, or baud. Since each tone (i.e., symbol) represents a message consisting of two digital bits in this example, the bit rate is twice the symbol rate, i.e. 2000 bits per second. This is similar to the technique used by dialup modems as opposed to DSL modems.

Self-Assessment Exercise(s) 2

1. What is the primary purpose of modulation?
2. The three types of modulations are ……………………, …………………… and ………………………………..

3.3 Signals to Noise Ratio (S/R)

We measure noise relative to an information signal in terms of the signal-to-noise-ratio. Noise reduces the power of signal in analog communication and produces errors in digital communication. These problems become most severe in long distance links when the transmission loss reduces the received signal power down to the noise level It may interest you to know that there are many parameters that are used for specifying the sensitivity performance of radio receivers. And the signal to noise ratio is one of the most basic and easy to comprehend. It is therefore widely used for many radio receivers used in applications ranging from broadcast reception to fixed or mobile radio communications.

Signal to noise ratio formula

The signal to noise ratio is the ratio between the wanted signal and the unwanted background noise and can be expressed in different formulas and units. There are three formulas of expressing signal to noise ratio. And they are;

$$SNR = \frac{\boldsymbol{P}signal}{\boldsymbol{P}noise} \dots\dots\dots formula\ 1$$

Where P_{signal} and P_{noise} are average of wanted signal, and average of unwanted signal (noise) respectively. It is more usual for us to see a signal to noise ratio expressed in a logarithmic basis using decibels:

$$SNR_{db} = 10\ log_{10}\left(\frac{\boldsymbol{P}signal}{\boldsymbol{P}noise}\right) \ldots \ldots \ldots formula\ 2$$

If all levels are expressed in decibels, then the formula can be simplified to:

$$SNR_{db} = \boldsymbol{P}signal_{db} - \boldsymbol{P}noise_{db} \ldots \ldots \ldots formula\ 3$$

The power levels may be expressed in levels such as dBm (decibels relative to a milliwatt) or to some other standard by which the levels can be compared.

Now let's take an example.

Example 10.1

The power of a signal is 10mW and the power of the noise is 1μW; what are the values of SNR and SNR_{db}?

Solution

Recall that 1000 μW = 1 mW.

Thus the values of SNR and SNR_{db} can be calculated as:

$$SNR = \frac{10{,}000\text{mW}}{1\text{mW}} = 10{,}000$$

$SNR_{db} = 10log_{10}\ 10{,}000 = 10log_{10}10^4 = 40$.

It's easy to compute right?

Self-Assessment Exercise(s) 3

1. What is the formula for calculating SNR.
2. What is the value of # in the expression: 1000 μW = # mW?

3.4 Channel Capacity

A very important consideration in data communications is how fast we can send data, in bits per second over a channel. Data rate depends on three factors:

1. The bandwidth available
2. The level of the signals we use
3. The quality of the channel (the level of noise)

Two theoretical formulas were developed to calculate the data rate:

1. Nyquist for a noiseless communication channel
2. Shannon for a noisy communication channel

3.4.1 Noiseless Channel: Nyquist Bit Rate

For a noiseless channel, the Nyquist bit rate formula defines the theoretical maximum bit rate ***Bit Rate = 2 x bandwidth x*** $\boldsymbol{log_2 L}$

In this formula, the bandwidth is the bandwidth of the channel, L is the number of signal levels used to represent data, and bit rate in bits per second. The commonly used signal level is 2 to represent 0 and 1 signals.

Let's take an example to understand this better.

Example 10.2

Consider a noiseless channel with a bandwidth of 3000 Hz transmitting a signal with two signal levels. What is the maximum bit rate for the channel?

Solution

Bit Rate = $2 \times 3000 \times \log_2 2 = 6000$ pbs.

3.4.2 Noisy Channel: Shannon's Theorem

In reality, we cannot have a noiseless channel, the channel is always noisy. In 1944, Claude Shannon introduced a formula, called the Shannon capacity, to determine the theoretical highest data rate for a noisy channel:

Capacity = bandwidth** x **log₂ (1 +SNR)

$$\text{Capacity} = \text{bandwidth} \times \log_2 (1 + SNR)$$

Where bandwidth is the bandwidth of the channel, SNR is the signal-to-noise ratio, and capacity is the capacity of the channel in bits per second. Note that in Shannon formula there is no indication of the signal level, which means that no matter how many levels we have, we cannot achieve a data rate than the capacity of the channel.

For practical purposes, when the SNR is very high, we can assume that SNR + 1 is almost the same as SNR. In these cases, the theoretical channel capacity can be simplified to

$$C = \text{Bandwidth} \times SNR_{db} / 3$$

Let's take another example.

Example 10.3

Calculate the theoretical highest bit rate of a regular telephone line. A telephone line normally has a bandwidth of 3000 Hz (300 to 3300 Hz) assigned for data communications. The signal-to-noise ratio is usually 3162.

Solution

$C = \text{bandwidth} \times \log_2 (1 + SNR) = 3000 \log_2 (1 + 3162) = 3000 \log_2 (3163)$

$= 3000 \times 11.62 = 34{,}860$ bps

This means that the highest bit rate for a telephone line is 34.860 kbps. If we want to send data faster than this, we can either increase the bandwidth of the line or improve the signal-noise ratio.

Let's take another example.

Example 10.4

The signal-noise ratio is often given in decibels. Assume that $SNR_{db} = 36$ and the channel bandwidth is 2 MHz. Let's calculate the channel capacity.

Solution

First we need to express SNR_{db} as simple SNR. Recall that $SNR_{db} = 10\log_{10}SNR$

Therefore $SNR = 10^{SNRdb/10}$

- ⇨ $SNR = 10^{36/10} = 10^{3.6}$
- ⇨ SNR = 3981

$C = \text{bandwidth} \times \log_2 (1 + SNR) = 2 \times 10^6 \times \log_2 3982 = 24$ Mbps

3.4.3 Using Both Limits

In practice, we need to use both Nyquist and Shannon theorems to find the limits and signal levels as demonstrated in next example.

Let's have a look.

Example 10.5

Suppose we have a channel with a 1MHz bandwidth with SNR of 63. What are the appropriate bit rate and signal level?

Solution

First, we use the Shannon formula to find the upper limit.

$C = \text{bandwidth} \times \log_2(1 + SNR) = 1 \times 10^6 \times \log_2 64 = 6$ Mbps

The Shannon formula gives us 6 Mbps, the upper limit. For better performance we choose something lower, 4 Mbps, for example. Then we use the Nyquist formula to find the number of signal levels.

4 Mbps = 2 x 1 MHz x $\log_2 L$ ➔ $L = 2^2 = 4$.

Self-Assessment Exercise(s) 4

1. What are the factors that determine data rate in a channel?
2. The theorem for calculating data rate in noiseless channel is ___________.

4.0 Conclusion

In this unit you learned how data is modulated to match intended transmission channel, different modulation types, various formulas for calculating SNR in a channel, and calculate bit rate with Nyquist and Shannon theorems. The unit wraps up all the topics taught in communication system which is the theme of this module.

5.0 Summary

(i) The primary purpose of modulation in a communication system is to generate a modulated signal suited to the characteristics of transmission channel.

(ii) Modulation is a process of mixing a signal with a sinusoid $f(t) = A\sin(\omega t + \phi)$ to produce a new signal.

(iii) A device that performs modulation is known as a modulator and a device that performs the inverse operation of modulation is known as a demodulator (sometimes called detector or demod), and modem is a device that modulate and demodulate signals.

(iv) The three basic types of modulation are Amplitude modulation, Frequency modulation, and Phase modulation.

(v) Among the benefits of modulation are Modulation for efficient transmission, Modulation to overcome hardware limitation, Modulation to reduce noise and interference, Modulation for frequency assignment and Modulation for multiplexing.

(vi) The formulas for calculating SNR are:

$$SNR = \frac{\boldsymbol{P}signal}{\boldsymbol{P}noise} \ldots\ldots\ldots\ldots formula\ 1$$

$$SNR_{db} = 10\ log_{10}\left(\frac{\boldsymbol{P}signal}{\boldsymbol{P}noise}\right)\ldots\ldots\ldots formula\ 2$$

$$SNR_{db} = \boldsymbol{P}signal_{db} - \boldsymbol{P}noise_{db} \ldots\ldots\ldots formula\ 3$$

(vii) For a noiseless channel, the Nyquist bit rate formula is define as

Rate = 2 x bandwidth x log $_2$ ***L***

(viii) For a noisy channel, the Shannon bit rate formula is define as

Capacity = bandwidth *x* ***log*** $_2$ ***(1 +SNR)***

(ix) For practical purposes, when the SNR is very high, Shannon formula is reduced to

C = Bandwidth x SNR $_{db}$ ***/3***

6.0 Tutor-Marked Assignments

1. Give two definitions of modulation
2. Give seven benefits of modulation
3. The power of a signal is 100mW and the power of the noise is 10µW; what are the values of SNR and SNR_{db}?
4. The SNR of a signal is 50,000, what is the Signal power if power of noise is 2µW?
5. The power of a signal is 1000mW and the power of the noise is 0.5µW; what is the value of SNR_{db}?
6. State the formulas for Nyquist and Shannon theorems.
7. Calculate the theoretical highest bit rate of communication line having bandwidth of 300 Hz assigned for data communications. The signal-to-noise ratio is usually 1023.

7.0 References/Further Reading

1. Bruce, A.C., Paul, B.C., & Janet, C.R. (2002). *Communication systems: An Introduction to Signals and Noise in Electrical Communication, Fourth Edition*. New York: McGraw Hill.

2. Communication Systems/What is Modulation? (2012). In Wikibooks. Retrieved on April 12, 2012, from http://en.wikibooks.org/wiki/Communication_Systems/What_is_Modulation%3F

3. Modulation. (2012). In Wikipedia. Retrieved on April 11, 2012, from http://en.wikipedia.org/wiki/Modulation

Module 4

Communication Signals and Transmission

Unit 1: Data Encoding and Decoding

Unit 2: Transmission Media

Unit 1

Data Encoding and Decoding

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1.0 Introduction

By now we ought to know that errors are bound to occur on data in equipment of the sender, the transmission channel or equipment of the receiver. So mechanisms should be put in place to ensure integrity of data received at destination. The first task to be performed by receiver is to check if received data is corrupt or error free. If data is altered, then a second task should be performed to correct error in the data if possible or notify the sender to retransmit the corrupted data.

In this unit we will learn how to check if data is corrupted and be able to correct such data using basic coding and encoding techniques like parity and hamming coding.

2.0 Learning Outcomes

After completing this unit, you should be able to:

i. Explain data error and data corruption
ii. Describe error detection and correction
iii. Explain data encoding and decoding
iv. Encode and decode data with parity coding
v. Encode and decode data with hamming coding

3.0 Learning Content

3.1 Data Error/Corruption

Whenever bits move from one medium to another, they are subjected to unpredictable changes because of impairments. The impairments can change the shape of the signal and therefore alter the data it carries. Many communication channels are subject to channel noise. And thus errors may be introduced during transmission from the sender to a receiver over communication systems or when data is being written to storage media.

(i) ***Data error*** refers *to corruption during transmission* which has a variety of causes such as interruption of data transmission leading to data loss.

(ii) ***Data corruption*** refers to *errors in computer data* that occur during writing, reading, storage, transmission, or processing, which introduce unintended changes to the original data. Data loss during storage has two broad causes, hardware and software failures.

a. *Hardware failure* -- Background radiation, head crashes, and aging or wear of the storage device fall into the former category.

b. *Software failure* -- typically occurs due to bugs in the code.

In general, when data corruption occurs, the file containing that data may become inaccessible. And the system or the related application will give an error. For example, if a Microsoft Word file is corrupted, when you try to open that file with MS Word, you will get an error message, and the file would not be opened. Some programs can give a suggestion to repair the file automatically (after the error), and some programs cannot repair it. It depends on the level of corruption, and the in-built functionality of the application to handle the error. There are various causes of the corruption.

Types of Errors

Single-Bit Error: Just like the name, it implies the corruption of only one bit. In a single-bit error, a 0 is changed to a 1 or a 1 is changed to a 0. To understand the impact of the change, imagine a change in 00000010 (ASCII STX-start of text) to 00001010 (ASCII LF-line feed).

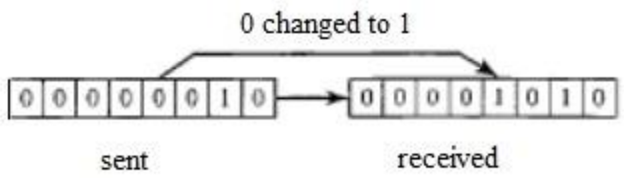

Figure 11.1 Single Bit-Error

Burst Error: In a burst error, multiple bits are changed. A burst error does not necessarily mean that the errors occur in consecutive bits. The length of the burst is measured from the first corrupted to the last corrupted bit. Some bits in between may not have been corrupted. A burst error is more likely to occur in data transmission than a single-bit error. The number of bits affected depends on the data rate and duration of noise. The higher the numbers of bits sent per second the more the likelihood corrupted bits.

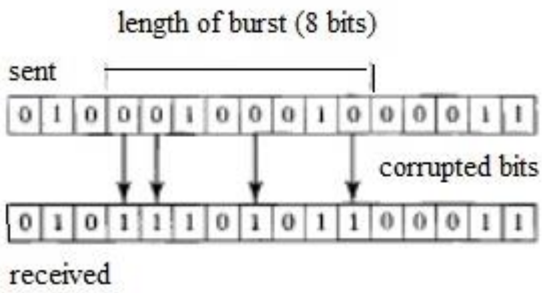

Figure 11.2 Burst Error

Self-Assessment Exercise(s) 1

1. The two types of errors are …………….. and ………………..
2. The two causes of data corruption during data storage are ……………… and …………………

3.2 Error Detection and Correction

The central concept in detecting or correcting errors is redundancy. For us to be able to detect or correct errors, we need to send some extra bits with our data. These redundant bits are added by the sender (Encoding) and removed by the receiver

(Decoding). Their presence allows the receiver to detect or correct corrupted bits. Hence, we can achieve redundancy through various coding schemes.

Error detection

Error detection is the detection of errors caused by noise or other impairments during transmission from the transmitter to the receiver. Error detection techniques are formal and organized procedures for detecting such errors. In error detection, we are looking only to see if any error has occurred. The answer is a simple yes or no. We are not even interested in the number of errors. A single-bit error is the same for us as a burst error.

Error detection

Error correction is post error detection procedures that allow reconstruction of the original and error-free data from corrupted data. Computer storage and transmission systems use a number of measures to provide data integrity, or lack of errors. The correction of errors is more difficult than the detection. In error correction, we need to know the exact number of bits that are corrupted and more importantly, their location in the message.

The number of the errors and the size of the message are important factors. If we need to correct one single error in an 8-bit data unit, we have to consider eight possible error locations and if we need to correct two errors in a data unit of the same size, we need to consider 28 possibilities. You can imagine the receiver's difficulty in finding 10 errors in a data unit of 1000 bits.

Self-Assessment Exercise(s) 2

1. The central concept in detecting or correcting errors is ……………………..
2. You can use error detection to correct error in received data (True/False).

3.3 Concept of Encoding/ Decoding

Coding/decoding as stated above is the main mechanism through which errors can be detected and corrected during data transmission. Coding can be divided into two broad categories known as *block coding* and *convolution coding*. Convolution coding is complex and beyond the scope of this course.

In block coding, we divide our message into blocks, each of ***k*** bits, called ***datawords***. We add ***r*** redundant bits to each block to make new length ***n***, where ***n*** can be defined as ***n= k + r***. The resulting ***n***-bit blocks are called ***codewords***.

How the extra ***r*** bits is chosen or calculated is something we will discuss later. For the moment, it is important for you to know that we have a set of datawords, each of size ***k***, and a set of codewords, each of size of ***n***.

With ***k*** bits, we can create a combination of 2^k datawords; with ***n*** bits, we can create a combination of 2^n codewords.

Example let us assume that k=2 and n=3. This can be denoted as ***C(3,2).***The table below shows the list of datawords and codewords, Table 11.1.

Table 11.1 Dataword and Codeword

Datawords	Codewords
00	000
01	011
10	101
11	110

We can use block coding to detect error if any of the following conditions are met.

1. The receiver has (or can find) a list of valid codewords.
2. The original codewords has changed to an invalid one.

The sender creates codewords out of datawords by using a generator that applies the rules and procedures for encoding. If the received codewords is the same as one of the valid codewords, the word is accepted and corresponding dataword is extracted. If the codeword is not valid it is discarded. However, if the codeword is corrupted during transmission but the received word still matches a valid codeword, the error remains undetected.

Self-Assessment Exercise(s) 3

1. Suppose there are **k** bits each in block of a message, how many dataword can you create from the message?
2. Coding can be divided into two broad categories known as………………and …………………………..

3.4 Parity Coding

Parity check code is one of the error detection and correction encoding mechanisms that uses ***n = k + r*** (i.e. C(n,k)) encoding. There are two types of parity check namely **even** and **odd**. In even parity check we count the number of 1s in datawords and set a parity bit to 0 if there are even numbers of 1s or set the parity bit to 1 if the number of 1s is not even, Table 11.3. The odd parity works like even parity explained above but it ensures there are odd number(s) of 1s in dataword, Table 11. 2.

Table 11.2 Odd Parity

Odd Parity				
Dataword		Codeword		
				Parity
0	0	*0*	*0*	***0***
0	1	*0*	*1*	***0***
1	0	*1*	*0*	***0***
1	1	*1*	*1*	***1***

Table 11.3 Even Parity

Even Parity				
Dataword		Codeword		
				Parity
0	0	*0*	*0*	***0***
0	1	*0*	*1*	***1***
1	0	*1*	*0*	***1***
1	1	*1*	*1*	*0*

Let's take an example.

Example 11.1

This example is to detect error in data. Suppose a dataword consisting of 0110001***1*** originated from a sender and 0111001***1*** was received by the receiver, if both parties agreed to use the last bit as even parity bit then the receiver will know that the data is not correct and will either discard or attempt to correct it. It should be noted that even parity can only detect odd numbers of corrupt bits, i.e. if 1, 3, 5 bits are changed. Also odd parity can only detect even numbers of corrupt bits. How to correct error using 2-dimensional parity check is given Example 11.2.

Let's take another example.

Example 11.2

Suppose the data in the Table 11.4, is to be checked for error by the receiver, the first task is to determine if error actually occurred in the transmitted data. Also assume the last row and last column of the table contain even parity bit. By checking the data with even parity row-wise we can detect error in ***N*** binary digits of the word THA***N***K because the parity bit is 0, whereas the number of 1s is three.

To correct the error, we conduct another even parity check from first column to the last while paying attention to the row containing error. Using this approach, we can see that the digit in column 7 was changed from 1 to 0.

Table 11.4 Error Correction

	1	2	3	4	5	6	7	8	Parity bit
T	0	1	0	1	0	1	0	0	**1**
H	0	1	0	0	1	0	0	0	**0**
A	0	1	0	0	0	0	0	1	**0**
N	0	1	0	0	1	1	0	0	**0**
K	0	1	0	0	1	0	1	1	**0**
	0	0	1	0	0	0	0	0	**1**
G	0	1	0	0	0	1	1	1	**0**
O	0	1	0	0	1	1	1	1	**1**
D	0	1	0	0	0	1	0	0	**0**
Parity bit	**0**	**0**	**1**	**1**	**0**	**1**	**0**	**0**	**0**

Self-Assessment Exercise(s) 4

1. …………….. and …………… are the two types of parity checks.
2. Parity coding is only for error detection (True/False).

3.5 Hamming Code

Hamming code was originally designed to detect up to two errors or correct one single error. Although there are some Hamming codes that can correct multiple errors, our focus is single-bit error for this course. The relationship between ***n*** and ***k*** in Hamming code is given as ***n* = 2**** $n = 2^r - 1$, where ***r*** is chosen such that ***r* >= 3,** and **k = n – r**. Therefore C***(n , k)*** or C$(2^r - 1, k)$.

For example if ***r*= 3** then its Hamming code is denoted as ***C(7,4)***, that is the dataword is four bits three bits, therefore codeword will be seven bits long.

Another point to note is that each parity bit in Hamming code is derived from combination of bits in dataword through algorithm. Also, the parity bits can be based on either even or odd parity and they need to be placed together when generating codeword.

Hamming code can be summarized as follows:

a. Detection of 2-bit errors (assuming no correction is attempted),
b. Correction of single bit error,
c. Cost of 3 bits added to a 4-bit message

Let's try this example.

Example 11.3

Suppose we have a 4-bit dataword (D) to be transmitted as a 7-bit coded word by adding 3 parity bits. Then the Hamming Code is represented as C (7,4) and assume the coding uses *odd parity* and the under listed algorithms are used to generate the parity bits.

$$P1 = d1+d2+d3$$

$$P2 = d1+d2+d4$$

$$P3 = d1+d3+d4$$

Also suppose the bits for codeword is generated from dataword using the arrangement in Table 11.5.

Table 11.5 Codeword Bit Arrangement

d1	d2	d3	p1	d4	p2	p3

Solution

We can consequently use the details given above to obtain the Table 11.6 representing dataword and corresponding codeword.

Table 11.6 Codeword

Dataword					Codeword (Odd parity)						
d1	d2	d3	d4		d1	d2	d3	p1	d4	p2	p3
0	0	0	0		0	0	0	0	0	0	0
0	0	0	1		0	0	0	0	1	0	0
0	0	1	0		0	0	1	0	0	0	0
0	0	1	1		0	0	1	0	1	0	1
0	1	0	0		0	1	0	0	0	0	0
0	1	0	1		0	1	0	0	1	1	0
0	1	1	0		0	1	1	1	0	0	0
0	1	1	1		0	1	1	1	1	1	1
1	0	0	0		1	0	0	0	0	0	0
1	0	0	1		1	0	0	0	1	1	1
1	0	1	0		1	0	1	1	0	0	1
1	0	1	1		1	0	1	1	1	1	0
1	1	0	0		1	1	0	1	0	1	0
1	1	0	1		1	1	0	1	1	0	1
1	1	1	0		1	1	1	0	0	1	1
1	1	1	1		1	1	1	0	1	0	0

Let's look at another example.

Example 11.4

Using the coding system generated in Example 11.3, suppose the message **1101** is coded and sent as **1101101**, but **1001101** was received. The error in d3 (shown in red) can be corrected by examining which of the three parity bits was affected by the bad bit.

Solution

Using the Table 11.7 and the encoding algorithm in Example 11.3, we observed that all the parity checks involving **d2** where the error occurred are "Not Ok". This showed that the bit in **d2** is supposed to be 1 not 0 as received.

Another way to detect and correct the error is to use column labeled **bad parity** containing 110 (from the top to bottom). We assign value of 1 to"Not Ok" and 0 to "Ok". The decimal equivalent of 110 which is 6 (Position Value) points to the bad bit in position 6 by counting received bit from right to left.

Table 11.7 Error Correction

d1	d2	d3	p1	d4	p2	p3	Parity bit	Parity check	Bad parity	Position	Position Value
1	0	0	1	1	0	1					
1	0	0	1	-	-	-	**p1**	**Not Ok**	**1**	2^2	**4**
1	0	-	-	1	0	-	**p2**	**Not Ok**	**1**	2^1	**2**
1	-	0	-	1	-	1	**p3**	**Ok**	**0**	2^0	**0**
7	**6**	**5**	**4**	**3**	**2**	**1**					**6**

Self-Assessment Exercise(s) 5

1. Hamming code was initially designed to detect how many errors in data transmission?
2. You need algorithm to generate codeword with hamming code (True/False).

4.0 Conclusion

In this unit you have learned the basics of detecting and correcting errors in received data using parity and hamming coding techniques. The unit taught you block coding, detection and correction of single error in data, detection and correction techniques for two or more errors in data is beyond the scope of this course.

5.0 Summary

(i) Data error refers *to corruption during transmission* which has a variety of causes such as interruption of data transmission leading to data loss.

(ii) Data corruption refers to *errors in computer data* that occur during writing, reading, storage, transmission, or processing, which introduce unintended changes to the original data. Data loss during storage has two broad causes, hardware and software failures.

(iii) Error detection is to establish if any error has occurred and the answer is a simple yes or no.

(iv) Error correction is post error detection procedures that allow reconstruction of the original and error-free data from corrupted data.

(v) In block coding, we divide our message into blocks, each of ***k*** bits, called ***datawords***. We add ***r*** redundant bits to each block to make new length ***n***, where ***n*** can be defined as ***n= k + r***. The resulting ***n***-bit blocks are called ***codewords***.

(vi) Parity coding is an error detection and correction encoding mechanisms that uses ***n = k + r*** (i.e. C(n,k)) encoding.

(vii) Hamming coding is also for error detection and correction with relationship between ***n*** and ***k*** in given as $n = 2^r - 1$, where ***r*** is chosen such that ***r >= 3,*** and **k = n – r**. Therefore C***(n , k)*** or C$(2^r - 1, k)$.

(viii) The followings can be achieved with Hamming code:

a. Detection of 2 bit errors (assuming no correction is attempted),

b. Correction of single bit error,

c. Cost of 3 bits added to a 4-bit message

6.0 Tutor-Marked Assignments

1. Explain burst error with an example.
2. How many possibilities do we have to consider if we need to correct three errors in a data unit of 8 bits
3. Differentiate between codeword and dataword.
4. Suppose the 0000 1001 was sent by transmitter and 0000 0001 was received, which type of error occurred during transmission?
5. Suppose the **1**000 1001 was sent by transmitter and **1**000 0001 was received. If odd parity coding was used and the leftmost bit (shown in red) is the parity bit, what will be your conclusion on the data?
6. Suppose r= 4 what are the values of n and k in C(n , k) using hamming code?
7. Use the dataword in Table 11.6 to generate codewords using the coding systems below and arrange the generated codewords as indicated Table 11.8.

$$P1 = d1+d2+d4$$

$$P2 = d1+d3+d4$$

$$P3 = d2+d3+d4$$

Table 11.8

d1	d2	p1	d3	p2	d4	p3

7.0 References/Further Reading

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Unit 2

Transmission Media

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1.0 Introduction

Do you know that between the source and destination in communication system is a transmission medium through with signal flows? Transmission medium can be wired or wireless with different degrees of tolerance for noise and other impairments. Factors such as cost, distance and data transmission rate are often considered when selecting particular transmission medium.

As development in computers is a non-stop progress, new grounds are also being broken in producing efficient data transmission media. This is done by telecommunication experts to achieve comprehensive data processing and transmission.

In this unit you will be introduced to transmission media which is broadly divided into wired and wireless media, such as twisted pairs, coaxial cable, fiber optic, radio wave, microwave and satellite communication.

2.0 Learning Outcomes

After studying this unit, you should be able to:

(i) Describe transmission media

(ii) Explain wired transmission media like with examples.

(iii) Explain wireless transmission with examples.

3.0 Learning Content

3.1 Introduction to Transmission Media

A transmission medium can be generally defined as *anything that can carry information from a source to a destination*. It serves as linkage between the sender at the source and receiver at the destination. The use of long distance communication with electric signals began with the invention of telegraph. With advancement in transmission media computers and other telecommunication devices, we use signals to represent data sent via transmission media.

Morse, the inventor of telegraph, in 19th century started the use of electric signal to carry message in a metallic medium which was slow. Telephone was invented in 1869 to widen human voice over a long distance using metallic medium after converting the voice to electric signals. Transmission media can be broadly divided into wired (guided) and wireless (unguided).

Self-Assessment Exercise(s) 1

1. Transmission medium can be broadly divided into …………………… and ……………
2. What serves as linkage between sender and receiver?

3.2 Wired Media

Wired media are those that provide conduit from one device to another. And they include twisted-pair cable, coaxial cable, and fiber optic cable. A signal traveling is directed and contained by the physical limits of the cable. They are laid physically underground or suspended on poles to protect them from vandals.

3.2.1 Twisted pair

A twisted pair consists of two conductors (normally copper), each with its own plastic insulation, twisted together. One of the wires is used to carry signals to the receiver, and the other is used only as a ground reference. The receiver uses the difference between the two.

Twisted pair cables are often shielded in attempt to prevent electromagnetic interference. Because the shielding is made of metal, it may also serve as a ground. However, usually a shielded or a screened twisted pair cable has a special grounding wire added called a *drain wire*. This shielding can be applied to individual pairs, or to the collection of pairs.

When shielding is applied to the collection of pairs, this is referred to as *screening*. The shielding must be grounded for the shielding to work. In contrast to STP (shielded twisted pair) cabling, UTP (unshielded twisted pair) cable is not surrounded by any shielding. UTP is the primary wire type for telephone networks and computer networking, especially as patch cables. UTP comes in several varieties popularly grouped by categories, such as CAT 3 (10Mbps), CAT 4 (16Mbps), CAT 5 (100Mbps) and CAT 6 (1Gbps).

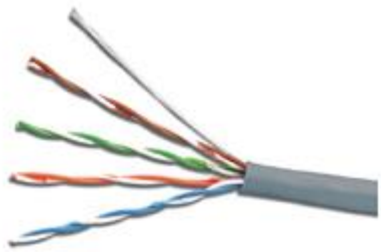

Figure 12. 1 UTP Cable
Source: http://www.siemon.com/e-catalog/ECAT_GI_page.aspx?GI_ID=cable_premium-5e-utp-cable-international

3.2.2 Coaxial Cable

Coaxial cable has a central core conductor which is usually made of copper wire. The core conductor is surrounded by first layer of insulator then followed by a foil made of aluminum sheath. Outside the foil are wire meshes which are sometimes made of copper to serve as shield against noise. The wire meshes are further protected by a plastic cover. Coaxial cable carries more signals and well immune against noise and interference than twisted pair.

Figure 12.2 Coaxial Cable

Source: http://image.made-in-china.com/4f0j00TCQaowmynipq/Coaxial-Cable-RG6-U-Messengered-for-Arial-Use.jpg

3.2.3 Fiber Optic

A fiber optic cable is made up of ultra-thin fiber of glass or plastic and transmits signals in the form of light. It uses a property of light known as *total internal reflection* of light to guide light through the medium when transmitting signal that have been converted to light. Fiber optic consist inner part called the *core* and outer part called *cladding*. The densities of these two parts are selected to enable total internal reflection to occur when critical angle that the ray of light makes with the core is exceeded.

There are two modes that are currently supported by fiber optic technology- *multimode* and *single mode*. The diameter of multimode's core is usually 50 micrometers or 62.5 micrometer and wide enough to allow more than one ray of light to travel through the medium at a time.

On the other hand, the diameter of core of single mode which is normally 8 to 10 micrometers in diameter allows only one ray of light due to the radius of its core. The claddings of both multimode and single mode are usually 125 micrometers in diameter. Single mode fiber is capable of higher bandwidth and runs longer distances than multimode fiber. Single-mode fiber can carry LAN data up to 3 km

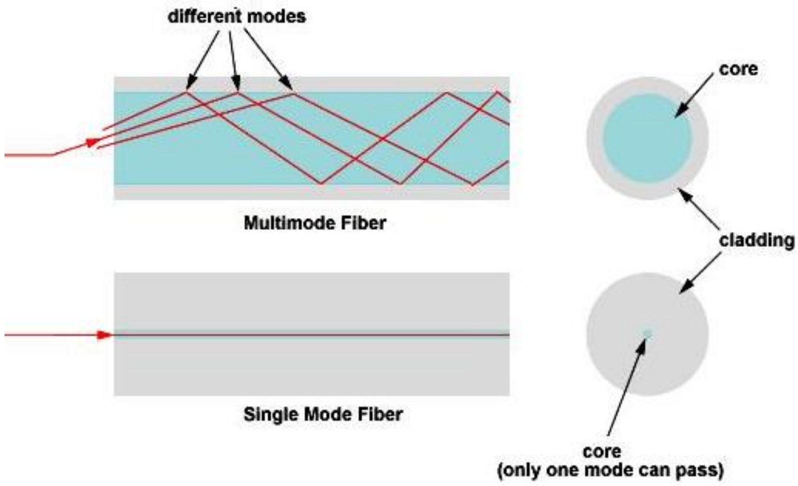

Figure 12.3 Fiber Optic
Source: http://www.cablexpress.com/blog/what-is-the-difference-between-multimode-and-singlemode-fiber-cables

Self-Assessment Exercise(s) 2

1. The two modes that are currently supported by fiber optic technology are ___ and ___.
2. Twisted pair cables are often shielded in attempt to …………………..
3. Fiber optic offers best data transmission (True/False).

3.3 Wireless Media

Wireless media transport *electromagnetic waves* without using a physical conductor. We often refer to this type of communication media as unguided or unwired media. Signals travelling through any of these media are normally broadcasted through free space and are available to anyone who has a device capable of receiving them. Wireless signals can travel from source to destination in several ways: ground propagation, sky propagation and line-of-sight propagation. Examples of these media include radio wave, microwave, Bluetooth, infra-red and satellite.

3.3.1 Radio Wave

Radio wave propagates electromagnetic waves ranging in frequencies between 3kHz and 1GHz in all directions and are called omnidirectional. This means that the sender and receiver do not need to be aligned. The omnidirectional characteristic of radio wave makes them useful for *multicasting*, in which there is one sender but many receivers.

AM and FM radios, television, maritime radio, cordless phone and paging are examples of multicasting. Also due to this characteristic radio waves from different sources are susceptible to *interference*. Another characteristic of radio waves, particularly those with low and medium frequencies is ability to penetrate walls.

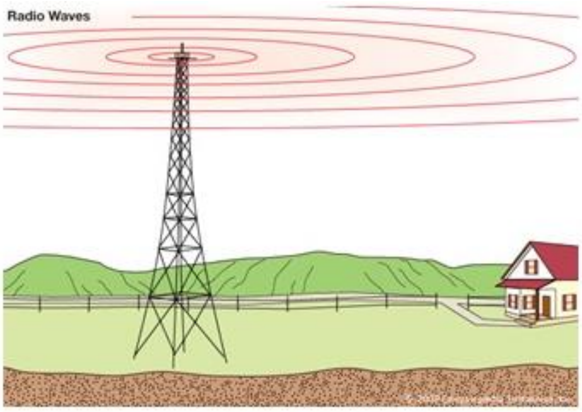

Figure 12.4 Radio Waves
Source: http://kids.britannica.com/comptons/art-53875/Oscillating-electric-current-in-a-transmitting-antenna-sends-radio-waves

3.3.2 Microwave

Electromagnetic wave having frequencies between 1 and 300 GHz are called microwaves. They are unidirectional and narrowly focused; thus, they are referred to as *unicast* (one-to-one). This implies that the sending and receiving antennas need to be aligned. It should be noted that very high frequency microwaves cannot penetrate walls. There are two shapes of antenna use in microwave transmission. A *horn* shape antenna is use for sending signal and a *dish* shape antenna is for receiving.

Figure 12.5 Microwave
Source:
http://www.opticalzonu.com/solutions/uhfandvhf/

3.3.3 Satellite

When we use a satellite for communications, it acts as a repeater. Its height above the Earth means that signals can be transmitted over distances that are very much greater than the line of sight. An earth station transmits the signal up to the satellite. This is called the *up-link* and is transmitted on one frequency. The satellite receives the signal and retransmits it on what is termed the down link which is on another frequency.

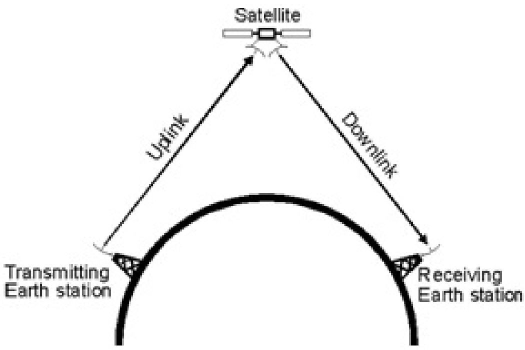

Figure 12.6 Satellite
Source: http://www.radio-electronics.com/info/satellite/communications_satellite/communications-satellite-technology.php

Self-Assessment Exercise(s) 3

1. Wireless media transport ________________without using a ___________ conductor.
2. Unidirectional and narrowly focused microwave are referred to as __________.

4.0 Conclusion

In this unit you have learned transmission media as path through which data travel from sender to receiver. We discussed technologies such as reflection of light, electromagnetic wave and radio waves powering each transmission media and varieties available for each media. This unit introduced you to some concepts you will come across in subsequent units.

5.0 Summary

(i) A transmission medium is anything that can carry information from source to destination and serves as linkage between them. Some media allow data to be sent to multiple receivers at same time, while others are dedicated to single receiver throughout transmission period.

(ii) Transmission medium can be grouped as wired or wireless depending, wired require physical path to be established between sender and receiver, but wireless does not.

(iii) Wired transmission media comprise of like twisted pairs, coaxial cable and fiber optic

(iv) Wireless transmission media include radio wave, microwave and satellite.

6.0 Tutor-Marked Assignments

1. Write three advantages of wired transmission media.
2. Write three disadvantages of fiber optic cable.
3. Describe coaxial cable.
4. Differentiate between multimode and single mode fiber optics.
5. Write short note on FM transmission as radio wave.

7.0 References/Further Reading

1. Behrouz, A.F. (2007). *Data Communications and Networking Fourth Edition*. New York: McGraw-Hill.
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Module 5

Communication Techniques and Internet

Unit 1:	Communication Techniques
Unit 2:	Computer Networks
Unit 3:	The Internet

Unit 1

Communication Techniques

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1.0 Introduction

In large networks there might be multiple paths linking sender and receiver. Data may be switched as it travels through various communication channels to its destination. Many data switching techniques that make best use of limited channel bandwidth and expensive network devices have been developed. The techniques are built into electronic devices that route data in a network.

In this unit you will learn how data is routed through switched network, types of switched networks, their modes of operation with their advantages and disadvantages.

2.0 Learning Outcomes

After completing this unit, you should be able to:

(i) Explain switch network

(ii) Describe circuit switching

(iii) List advantages and disadvantages of circuit switching

(iv) Describe message switching

(v) Mention advantages and disadvantages of message switching

(vi) Describe packet switching

(vii) List advantages and disadvantages of packet switching

(viii) LAN switch simply referred to as *switch* is electronic device that is capable of creating s of message switching

(ix) Describe packet switching

(x) List advantages and disadvantages of packet switching

3.0 Learning Content

3.1 Introduction to Switch Network

What is a switch? We can say that a switch network is a collection of interlinked switches or nodes. Switch networks offer lots of benefits to data travelling in networks as we discussed in other sections of this unit. The major components of switch network are nodes, protocol and intermediate network devices. Depending on the technology we use in the networks and protocols, these intermediate devices may be known as exchanges, bridges, Local Area Network switches (LAN), or routers. Most computer networks use LAN switch or router for network setup and management.

LAN switch simply referred to as *switch* is an electronic device that is capable of creating temporary connections between other devices connected to it. In a typical switch network, switches are directly connected to end systems like our computers or telephones, fax machines and printers. We can also use switch to link networks in different locations together to create larger inter or intra networks. Although, routers play a better role depending on size of the network and financial capabilities of the organization implementing the network.

Many switches today offer high-speed links, like Fast Ethernet or FDDI that can be used to link the switches together or to give added bandwidth to important servers that get a lot of traffic. A network composed of a number of switches linked together via these fast uplinks is called a *collapsed backbone* network.

In large inter-networks there may be several paths joining devices that want to communicate with one another. Therefore, messages may be routed over several different paths within or outside a network. The three methods we use to route messages are circuit switching, message switching and packet switching.

Self-Assessment Exercise(s) 1

1. A switch network is a collection of interlinked _________or _______.
2. What are the three methods of routing message in a network?

3.2 Circuit Switching

Circuit Switching establishes a path for communication that remains fixed for the duration of the connection. Just like a telephone connection, Circuit Switching networks establish a path when the devices initiate a conversation. Basically, all communication is done over the same path and it occurs at *physical layer*. This method of switching ties up a media path until the connection is broken. Therefore, other devices cannot use this path and bandwidth is not used efficiently. Circuit Switching networks are comparatively expensive because more media paths are required.

3.2.1 Advantage of Circuit Switching

1. The major advantage of Circuit Switching is that communication is faster as all needed paths are reserved from beginning to end of communication.
2. Loss of message is reduced to the barest minimum.

3.2.2 Disadvantage of Circuit Switching

1. It wastes communication waste devices.
2. Circuit-switched networks can be relatively inefficient, because bandwidth can be wasted.
3. Another disadvantage to circuit-switched networks is that you have provision for the maximum number of nodes that will be required for peak usage times.

Self-Assessment Exercise(s) 2

1. Circuit Switching establishes a path for communication that …………… for the ……………..
2. All communication is done over the same path circuit switch network and it occurs at what layer?

3.3 Message Switching

In Message Switching, each message is treated as a separate entity. Each message contains addressing information, and at each switch this information is read and the transfer path to the next switch is decided. Depending on network conditions, a conversation of several messages may not be transferred over the same path.

Each message is stored (usually on hard drive due to RAM limitations) before being transmitted to the next switch. Because of this it is also known as a *store-and-forward* network. Email is a common application for Message Switching. A delay in delivering email is allowed unlike real time data transfer between two computers.

3.3.1 Advantages of Message Switching

1. Data channels are shared among communication devices improving the use of bandwidth.
2. Messages can be stored temporarily at message switches, when network congestion becomes a problem.
3. Priorities may be used to manage network traffic.

3.3.2 Disadvantage of Message Switching

1. The only real disadvantage to Message Switching is it's not suitable for real time applications such as data communication, video or audio.
2. Store-and-forward devices are expensive, because they must have large disks to hold potentially long messages

Self-Assessment Exercise(s) 3

1. Message switch network is otherwise known as …………………….
2. In message switch a conversation of several messages may not be transferred over the same path (True/False).

3.4 Packet Switching

Packet Switching is similar to Message Switching. One difference is that the message is divided into *packets*, each containing source and destination information and routed separately. The packets that make up a message may take several different routes to reach their destination.

Also, packet size is restricted enabling the switching devices to manage the packet data entirely in memory without the need to store them on a hard drive. Therefore, this switching is much faster and more efficient than Message Switching. The *Network Layer* is responsible for fragmenting each message as well as reconstructing them at their destination. Here are two different methods of Packet Switching:

3.4.1 Datagram Packet Switching

Datagram services treat *each packet as an independent* message. Each packet is routed separately and each switch decides which network segment should be used for the next step. This allows packets to bypass busy segments and take the fastest route possible. Datagram Packet Switching is frequently used with LANs. And the *Network Layer* protocols are responsible for delivering the packets to the appropriate network where their physical destination is read by devices and processed at the correct device.

3.4.2 Virtual Circuit Packet Switching

Virtual Circuit is similar to Circuit Switching in that the two communicating devices agree on a path to transmit packets. When the devices begin a session, they negotiate maximum message size, network paths and so forth. This establishes a virtual circuit, a well-defined path to communicate. This virtual circuit remains in effect until the devices stop communicating.

However, it is only a logical connection. The devices behave as though a dedicated physical circuit has been established but there isn't, therefore other devices can use the path as well, using bandwidth more efficiently. Virtual circuits are mostly used with connection-oriented services.

3.4.3 Advantages of Packet Switching

1. Bandwidth optimized by enabling many devices to use the same communication channel.
2. Routes may be changed on the fly, achieving the best efficiency possible.
3. Entire messages not stored at switches reducing delays.

3.4.4 Disadvantages of Packet Switching

1. Packet switching requires more main memory.
2. More processing power required due to complex routing protocols. (Like recognizing when a packet has been lost).
3. Protocols for packet switching are typically more complex.
4. It can add some initial costs in implementation.
5. If packet is lost, sender needs to retransmit the data.
6. Another disadvantage is that packet-switched systems still can’t deliver the same quality as dedicated circuits in applications requiring very little delay - like voice conversations or moving images.

Self-Assessment Exercise(s) 4

1. The two types of packet switching are ………………. And ……………..
2. Datagram services treat ……………..message.

4.0 Conclusion

In this unit you have learned that data are routed within internal or external networks using circuit, message and packet switching techniques. Each technique offers some known advantages and disadvantages discussed in the unit. Thorough understanding of topics covered in this unit is essential for next unit, which will introduce you to computer networks.

5.0 Summary

(i) Switch network is a collection of interlinked switches or nodes that allows data to be routed from source to destination with the aid of devices like switches, routers, exchanges and bridges.

(ii) There are three types of switch networks namely, circuit, message and packet switches.

(iii) Circuit Switching establishes a path for communication that remains fixed for the duration of the connection.

(iv) Message Switching treats each message as separate entity containing addressing information use to transfer the message from one switch to another until it gets to the receiver.

(v) Packet switch is available in two varieties: datagram packet switching and virtual circuit switching.

6.0 Tutor-Marked Assignments

1. List five intermediary devices that can be used in switch network.
2. Write short note on collapsed backbone.
3. Why do you think loss of message is reduced to the barest minimum in circuit switch network?
4. Give reason(s) why priorities should be used to manage network traffic.
5. In what way(s) is packet switching similar to message switching?

7.0 References/Further Reading

1. Behrouz, A.F. (2007). *Data Communications and Networking Fourth Edition*. New York: McGraw-Hill.
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Unit 2

Computer Networks

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  - 3.1.2 Local Area Network (LAN)
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1.0 Introduction

Do you know that computers are joined together in a network to share scarce resources and minimize cost of information processing? There are many types of computer network categorized base on size, how the computers are physically joined together and how data moves within network. Movement of data across different networks types follows well defined protocols and models to ensure interoperability among the networks.

In this unit we will be introduced to computer networks, different types of networks, basic model for moving data within and outside a network and some set protocols that specifies how data should be accessed irrespective of the network.

2.0 Learning Outcomes

After completing this unit, you should be able to:

(i) Explain computer network

(ii) Name and explain computer network by size

(iii) Describe physical and logical topologies

(iv) List the seven layers of ISO-OSI model

(v) Explain network protocol

3.0 Learning Content

3.1 Introduction to Computer Networks

A computer network, or simply a network, is a collection of computers and other hardware components interconnected by communication channels that allow sharing of resources and information. Where at least one process in one device is able to send/receive data to/from at least one process residing in a remote device, then the two devices are said to be in a network. Simply, more than one computer interconnected through a communication medium for information interchange is called a computer network.

There are several types or categories of networks and one major reason for classifying network is their scale (physical size). These categories are discussed below:

3.1.1 Personal Area Network (PAN)

A personal area network (PAN) is a computer network that we use for communication among computers and different information technological devices close to us. Some examples of devices that are used in a PAN are personal computers, printers, fax machines, telephones, PDAs, scanners, and even video game consoles.

A PAN may include wired and wireless devices. The reach of a PAN typically extends to 10 meters. A wired PAN is usually constructed with USB and Firewire connections while technologies such as Bluetooth and infrared communication typically form a wireless PAN.

3.1.2 Local Area Network (LAN)

A local area network (LAN) is a network that connects computers and devices in a limited geographical area such as home, school, computer laboratory, office building, or closely positioned group of buildings. Each computer or device on the network is a node.

Current wired LANs are most likely to be based on Ethernet technology, although new standards like *ITU-T G.hn* also provide a way to create a wired LAN using existing home wires (coaxial cables, phone lines and power lines).

3.1.3 Metropolitan Area Network (MAN)

A metropolitan area network (MAN) is a computer network that usually spans a city or a large campus. A MAN usually interconnects a number of local area networks (LANs) using a high-capacity backbone technology, such as fiber-optical links, and provides up-link services to wide area networks (or WAN) and the Internet.

3.1.4 Wide Area Network (WAN)

A wide area network (WAN) is a computer network that covers a large geographic area such as a city, country, or spans even intercontinental distances, using a communications channel that combines many types of media such as telephone lines, cables, and air waves. A WAN often uses transmission facilities provided by common carriers, such as telephone companies.

Self-Assessment Exercise(s) 1

1. Write the meaning of the followings:
   a) WAN
   b) PAN
   c) MAN
2. Which network is smallest in size?

3.2 Network Topology

What is network topology? Network topology is usually a *simplified arrangement of a network*, including its nodes and connecting lines. Essentially, it is the topological structure of a network, and may be depicted physically or logically.

3.2.1 Physical Topology

The shape of the cabling layout used to link devices is called the physical topology of the network. This refers to the layout of cabling, the locations of nodes, and the interconnections between the nodes and the cabling. There are several common physical topologies, as described below:

Bus

In bus topology all nodes are connected to a common medium along this medium. This is the simplest physical topology but very fragile because the entire network can be downed when the main medium is broken.

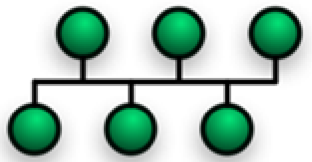

Figure 14.1 Bus Topology

Star

Star topology defines a network where all nodes are connected to a special central node. This is the typical layout found in a Wireless LAN, where each wireless client connects to the central Wireless access point, often called network server.

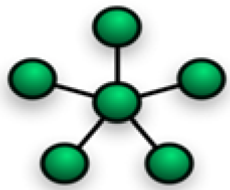

Figure 14.2 Star Topology

Mesh

Mesh topology defines a topology where each node is connected to an arbitrary number of neighbors in such a way that there is at least one traversal from any node to any other.

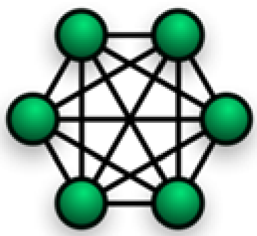

Figure 14.3 Mesh Topology

Ring

In ring topology, each node is connected to its left and right neighbor node, such that all nodes are connected and that each node can reach each other node by traversing nodes left- or rightwards. The Fiber Distributed Data Interface (FDDI) made use of such a topology.

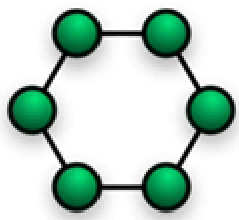

Figure 14.4 Ring Topology

Tree **(or hierarchical)**

The type of network topology in which a central 'root' node (the top level of the hierarchy) is connected to one or more other nodes that are one level lower in the hierarchy (i.e., the second level) with a point-to-point link between each of the second level nodes and the top level central 'root' node, and so on. Each node in the network having a specific fixed number, of nodes connected to it at the next lower level in the hierarchy, the number, being referred to as the 'branching factor' of the hierarchical tree. This tree has individual peripheral nodes.

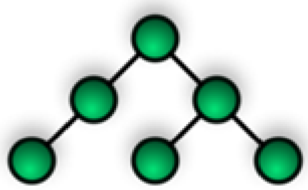

Figure 14.5 Tree Topology

Hybrid

Hybrid networks use a combination of any two or more topologies in such a way that the resulting network does not exhibit one of the standard topologies (e.g., bus, star, ring, etc.). For example, a tree network connected to a tree network is still a tree network topology, but two common examples for Hybrid network are: star-ring (Figure 14.6) network and star-bus network

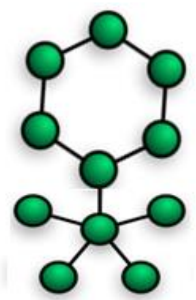

Figure 14.6 Star-Ring
(Hybrid Topology)

3.2.2 Logical Topology

Logical topology is the way that signals act on the network media, or the way that the data passes through the network from one device to the next without regard to the physical interconnection of the devices. A network's logical topology is not necessarily the same as its physical topology. Example of logical topology is Token ring.

The Token Ring network developed by International Business Machine (IBM) is a Local Area Network (LAN) in which all computers are connected in a *ring* or *star* physical topology. And a bit- or token-passing scheme is used in order to prevent the collision of data between two computers that want to send messages at the same time.

The Token Ring protocol is the second most widely-used protocol on local area networks after Ethernet. Both protocols are used and are very similar. The IEEE 802.5 Token Ring technology provides for data transfer rates of either 4 or 16 megabits.

Self-Assessment Exercise(s) 2

1. Tree network is otherwise called …………….
2. What is the name of common network where all the computers connect to single computer?
3. A star network connected to another star network is known as ………………...

3.3 Basic ISO – OSI Model

Do you know that computer networks are created by different companies or vendors? Standards are needed so that these heterogeneous networks can communicate with one another. The International Standards Organization (ISO) is a multinational body established in 1947 to cover worldwide agreement on international standards. Open Systems Interconnection (OSI) was established in 1970 by ISO.

The two best-known standards for computer networks are the *OSI* and *Internet model*. The OSI model defines a *seven-layer* network; the Internet model defines a *five-layer* network. The purpose of the OSI model is to show how to facilitate communication between different systems without requiring changes to the logic of the underlying hardware and software. The seven layers of OSI are presented in Figure 14.7 and described in subsequent sections.

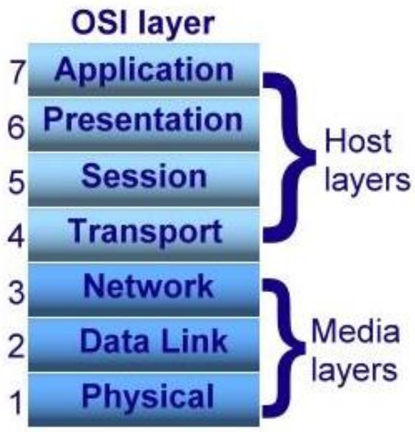

Figure 14.7 ISO OSI Model
source: http://networking.layer-x.com/p030100-1.html

Application layer – This enables users whether humans like you and I or software, to access the network. It provides user interface and support for services such as electronic mail, remote file transfer access and transfer (FTP, HTTP, and TELNET), shared database management, and other types of distributed information services.

Presentation layer – Performs transformations on data to provide a standardized application interface and to provide common communications services. It provides services such as encryption, text compression and reformatting.

Session layer – Provides the control structure for communication between applications. It establishes, manages and terminates connections (sessions) between cooperating applications.

Transport layer – Provides reliable, transparent transfer of data between end points. It provides end-to-end error recovery and flow control.

Network layer – Provides upper layers with independence from the data transmission and switching technologies used to connect systems. It is responsible for establishing, maintaining and terminating connections.

Data Link layer – Provides reliable transfer of data across the physical link. It sends blocks of data (frames) with the necessary synchronization, error control and flow control.

Physical layer – Concerned with transmission of unstructured bit stream over the physical link. It invokes such parameters as signal voltage swing and bit duration. It deals with the mechanical, electrical, procedural characteristics to establish, maintain and deactivate the physical link.

Self-Assessment Exercise(s) 3

1. What is the full meaning of ISO and OSI?
2. When was ISO OSI created?
3. The two best-known standards for computer networks are the ………..and ………...

3.4 Protocols

In computer networks, communication occurs between nodes or entities in the network. An entity is anything capable of sending or receiving information. However, two entities cannot simply send bit streams to each other and expect the bits to be understood. For communication to occur, the entities must agree on a protocol.

So, what is a protocol? A protocol *is a set of rules that govern data communications*. A protocol defines *what* is communicated, *how* it is communicated, and *when* it is communicated. Examples of protocols are File Transfer Protocol (FTP), Transmission Control Protocol (TCP), Internet Protocol (IP), Simple Mail Transfer Protocol (SMTP), Hypertext Transfer Protocol (HTTP). And the key elements of a protocol are syntax, semantics, and timing.

Syntax - The term syntax refers to the *structure or format of the data*, meaning the order in which they are presented. For example, a simple protocol might expect the first 8 bits of data to be the address of the sender, the second 8 bits to be the address of the receiver, and the rest of the stream to be the message itself.

Semantics - The word semantics refers to the *meaning of each section of bits*. How a particular pattern should be interpreted, and what action should be taken based on that interpretation. For example, does an address part of a message identify the route to be taken or the final destination of the message?

Timing - The term timing refers to two characteristics: when data should be sent and how fast they can be sent. For example, if a sender produces data at 100 Mbps but the receiver can process data at only 1 Mbps, the transmission will overload the receiver and some data will be lost.

Self-Assessment Exercise(s) 4

1. A protocol defines ……. is communicated, ……... it is communicated, and ……… it is communicated.
2. What are the three elements of a protocol?

4.0 Conclusion

This unit introduced you to different types of computer network grouped by size, the physical and logical aspects of a typical network, ISO OSI model for data communication in network and network protocols which defines when, what and how data is communicated in a network. The unit serves as introduction some terminologies in unit 15 where Internet is discussed as network of networks.

5.0 Summary

(i) Computer network is a collection of computers and other hardware components interconnected by communication channels that allow sharing of resources and information.

(ii) Computer networks are grouped by physical size into PAN, LAN, MAN and WAN. PAN is the smallest with range of 10meters, LAN is) is a network that connects computers and devices in a limited geographical area such as home, school, computer laboratory, office building, or closely positioned group of buildings. MAN covers entire city or geographical locations. WAN is the biggest network, it can cover entire country, continent or even many continents.

(iii) Physical topology defines the shape of cabling layout used to link devices. Examples are star, bus, ring, tree, mesh and hybrid.

(iv) The logical topology is the way that signals act on the network media, or the way that the data passes through the network from one device to the next without regard to the physical interconnection of the devices.

(v) ISO OSI model is a Standard that allows heterogeneous networks to communicate with one another. It has seven layers which are Physical, Data link, Network, Transport, Session, Presentation and Application.

(vi) Protocol is a set of rules that govern data communications in computer network it defines what is communicated, how it is communicated, and when it is communicated, example of network protocol are FTP, HTTP, IP, TCP and SMTP.

6.0 Tutor-Marked Assignments

1. Write two transmission media that can be used for each of the network.
2. Define computer network.
3. Explain star-bus physical topology with a diagram.
4. Describe token ring network with a diagram.
5. Write short note on physical, network and presentation layers.
6. List and explain ten protocols use in computer network.

7.0 References/Further Reading

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Unit 3

The Internet

Contents

1.0 Introduction
2.0 Learning Outcomes
3.0 Learning Content
    3.1 History
    3.2 Introduction to Internet
        3.2.1 Impacts of Internet
        3.2.2 Internet Uses
        3.2.3 Internet Access
    3.3 Internet Terminologies
4.0 Conclusion
5.0 Summary
6.0 Tutor-Marked Assignment
7.0 References/Further Reading

1.0 Introduction

Information is everywhere!!! And everywhere there is information!!! Computers systems and computer networks brought information explosions and there is need to make information available to people who may require it all over the world.

The best approach is to have a larger network that spans networks in many organizations, geographical locations and individual homes. The network is so big borderless and flexible to extent that nobody can lay claim to it and it is called the Internet.

In this unit we will learn the history and meaning of the Internet, the impact of internet in our society and some Internet terminologies frequently in our day to day activities.

2.0 Learning Outcomes

After completing this unit, you will be able to:

i. Describe the history of Internet
ii. Explain Internet as a tool
iii. State the impacts of Internet in our society
iv. Mention uses of Internet
v. Explain how to access Internet
vi. Describe some Internet terminologies.

3.0 Learning Content

3.1 History

You have heard of internet before, right? It wasn't so-called before. What is now called Internet started in 1950's when idea of connecting terminals to mainframe computer using point-to-point communication and packet switching was conceived. Packet switched networks such as ARPANET, Mark I at NPL in the UK, CYCLADES, Merit Network, Tymnet, and Telenet were developed in the late 1960s and early 1970s using a variety of protocols.

The ARPANET in particular led to the development of protocols for internetworking, where multiple separate networks could be joined together into a network of networks. ARPANET continued to grow in size by connecting research centers and departments of some universities in the United States (US), primarily for information sharing. Thus, as early sign of future growth, there were fifteen sites connected to the young ARPANET by the end of 1971. In December 1974, Vinton Cerf, Yogen Dalal, and Carl Sunshine, used the term internet, as shorthand for internetworking, so the word started out as an adjective rather than the noun it is today.

In 1982, the Internet Protocol Suite (TCP/IP) was standardized and the concept of a world-wide network of fully interconnected TCP/IP networks called the Internet was introduced. In 1986 access to supercomputer sites in research and educational organization in the US was established by National Science Foundation Network (NSFNET) to enable people obtain information at data transfer rate of 45Mbps (45

Megabytes per second). The activities of Internet Service Providers (ISP) emerges in early 1980's and 1990's to give more people access to Internet through analog telephone lines and modem.

The ARPANET was officially decommissioned in 1990. The Internet was commercialized in 1995 when NSFNET was decommissioned, removing the last restrictions on the use of the Internet to carry commercial traffic. Afterwards, the Internet started a rapid expansion to other continents like Australia and Europe in the mid to late 1980s and to Asia in the late 1980s and early 1990s.

Today approximately 20 million computers and over 150 million mobile devices are now connected worldwide to the Internet leading to massive computer networks. Also various wired and wireless media are used to access information any time on the Internet. In addition to TCP/IP, other protocols like SMTP, FTP and HTTP were developed to increase mode of information transfer on the Internet.

Although the Internet is not governed by anybody or organization, there are however some voluntary organization like Internet Society (ISOC), Internet Architecture Board (IAB), and Inter NIC take responsibilities to regulate it.

Self-Assessment Exercise(s) 1

1. The ARPANET was officially decommissioned in …………..
2. What is the full meaning of NSFNET?

3.2 Introduction to Internet

Do you know the Internet is a global system of interconnected computer networks? It uses the standard Internet protocol suite (often called TCP/IP, although not all applications use TCP) to serve billions of users worldwide. It is a network of networks that consists of millions of private, public, academic, business, and government networks, of local to global scope, that are linked by a broad array of electronic, wireless and optical networking technologies.

So, it means all the computers in LAN, MAN and WAN networks collectively form the Internet. The computer in LAN of your school or office is a node when the LANs are connected to form MAN. Similarly, many MANs are connected to create WAN, collectively many WANs are joined together to create Internet. So, our computers or mobile devices form a node on the Internet whenever we use the Internet to access information somewhere. And someone faraway can connect through the Internet to access information from your device as well.

3.2.1 Impacts of Internet

The Internet has reshaped or redefined operations and services traditional information or content delivery media such as telephone, music, film, radio, television, giving birth to new services such as Internet Protocol Television (IPTV) and Voice over Internet Protocol (VoIP). Also, books, newspaper and other print publishing are employing Internet technologies and rebranded their service to blogging and new feeds.

The Internet has also enabled and created new ways of human interactions through Internet forum, instant messaging and social networking. Commercial activities of buying and selling have also taken a new dimension through online shopping which boomed for major retailers and small artisans and traders.

Also, the banking sector takes advantages of Internet to revolutionize its services through various online banking services. It is a common practice nowadays to transfer money across different accounts of different banks from your desktop. The efficiency in banking services therefore improves business-to-business and financial services which consequently boost supply chains across entire industries.

We can say that the major challenges facing Internet users like us are attributed to security. Security issues on Internet are so enormous and devastating that a discipline called cyber security science was carved out of computer science to specifically address the challenges.

Financial frauds or crimes running to millions of naira have been perpetrated in Nigeria alone. Hackers have also continued to exploit vulnerabilities in Internet software and protocols to attack systems and users of Internets through various avenues like malware, spyware, worms, phishing, kiss of death and distributed denial of service.

3.2.2 Internet Uses

Although the list below is not exhaustive, it presents size, scope and design of what users can do with the Internet.

1. Connect easily through ordinary personal computers and local phone numbers.
2. Exchange electronic mail (E-mail) with friends and colleagues with accounts on the Internet.
3. Post information for others to access and update it frequently.
4. Access multimedia information that includes sound, photographic images and even video.
5. Access diverse information from around the world.

3.2.3 Internet Access

Common methods of Internet access or services in homes include dial-up, landline broadband (fiber optic or copper wires), Wi-Fi, satellite and 3G/4G mobile technology cell phones. Internet services are available at public places like libraries, Internet cafes, where computers with Internet connections are available. There are also Internet access points otherwise called hotspots in many public places such as airport halls and coffee shops, in some cases just for brief use while standing.

Many hotels now have public terminals, though these are usually fee-based. Internet services are now available on campuses of many tertiary institutions in Nigerian to facilitate teaching, learning and research. A whole campus or some selected areas within the campus are selected as hotspots where Internet access in free.

Self-Assessment Exercise(s) 2

1. Which of the followings networks does not form part of the Internet?
    a) LAN
    b) WAN
    c) MAN
    d) BAN
2. What is the meaning of IPTV?
3. …………. is the greatest challenges to Internet in the world.

3.3 Internet Terminologies

The Internet as a tool and body of knowledge has some terminologies that we use to represent facilities or service. Unlike many computer networks, the Internet consists of not one but multiple data systems that were developed independently. The most popular and important systems are:

Electronic Mail (E-Mail) -- Electronic mails are another form of communication which nowadays has replaced our traditional hand-written letter. E-mails are letters that can be sent through the internet and can arrive almost instantly and without cost. E-mails are an essential part of every company and every person who needs to communicate with people that live far away from them.

USENET—are newsgroups, for posting and responding to public "bulletin board" messages.

File Transfer Protocol (FTP) -- a system for storing and retrieving data files on large computer systems.

Gopher -- a method of searching for various text-based Internet resources (largely obsolete).

TELNET -- a way of connecting directly to computer systems on the Internet.

Internet Relay Chat (IRC) -- a system for sending public and private messages to other users in "real time"—that is, your message appears on the recipient's screen as soon as you type it.

CU-SeeMe -- a videoconferencing system that allows users to send and receive sound and pictures simultaneously over the Internet.

World Wide Web (WWW) – A multimedia Internet service that allows users to traverse the Internet by moving from one document to another via links that connect them together. WWW can be thought of as a network of millions of host, servers, and users. It is one of the major services of the internet for hosting information of about anything one might like to search for.

Search Engines -- Search engines such as Google, Yahoo, MSN and Lycos are used for searching the internet for information or pictures. For example, you may need to find information about surfing the internet safely. All you need to do is to go to the engine and give a keyword of the topic you are interested in finding information for. In our example you could type in the search bar "internet safety" and the engine would come up with all the information available for this topic.

Hyper Text Markup Language *(HTML)*— it is document that is based upon a script composed of standard tags. Mostly HTML document provides link to other documents via Uniform Resource Locator (URL). Each document is designed to represent a page (called web page) of a book and the URL connects relevant pages together to form website.

Web Browser – Web browser is software designed for viewing web page written in HTML or similar markup language like XML and DHTML. It offers tools for browsing website easily and securely, for example *favorite* for organizing website in a folder and *history* for keeping track of recently visited websites. Examples of web browsers are Google Chrome, Microsoft Internet Explorer, Mozilla and Safari.

Domain Name – website hosted by organizations are grouped by the nature and business activities of the organization. Domain name identifies the general group or country to which a particular website belongs to, it is therefore impossible for two websites to share same domain name. Each domain name ends with top level name that identifies the group as shown below. So www.futhttp://en.wikipedia.org/wiki/Tabulating_machineminna.edu is a domain name that shows that the website belongs to futminna which is educational institution.

(i) .com – commercial

(ii) .edu – education

(iii) .gov – government

(iv) .mil – US military

(v) .net – Network

(vi) .ng – Nigeria

(vii) .in – India

(viii) .uk – United Kingdom

(ix) .us – United States

Self-Assessment Exercise(s) 3

1. Which Internet facility is use for sending and receiving message?
2. Mention 3 Internet browsers.
3. List 3 Internet search engines

4.0 Conclusion

Internet is a large network comprising other networks located all over the world which allows people to access information as at when needed using different communication channels and devices. In has positively transformed most traditional ways of doing business and communication since its inception, but with serious security challenges. This unit concludes module 5 and the entire course.

5.0 Summary

(i) Internet started in 1950's when idea of connecting terminals to mainframe computer using point-to-point communication and packet switching like ARPANET, Mark I at NPL in the UK, was conceived. ARPANET which was officially decommissioned in 1990 played significant roles in setting TCP/IP protocols use in present time Internet.

(ii) Internet has transformed the way business and communication were done before its advent. There is hardly any sector of an economy can survive without Internet nowadays as most businesses are now going electronic.

(iii) Basically, people use Internet for messaging, connect computer, post information, search and share information.

(iv) Internet access are now in homes include dial-up, landline broadband, Wi-Fi, satellite and 3G/4G mobile technology cell phones.

(v) Common Internet terminologies are, email, World Wide Web, domain name, USENET, TELNET, browser, search engine, Cu-SeeMe, Internet Relay Chat, and FTP.

6.0 Tutor-Marked Assignments

1. What is the meaning of ISPs and what roles do they play in providing Internet access to people?
2. Mention five organizations that are voluntarily managing the Internet.
3. Mention the impacts of Internet on agriculture and education sectors of Nigeria.
4. Describe 5 ways on how to enlighten people on Internet security.
5. Describe 3 ways you can get Internet access on campus as a student.

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Appendix A

Dec	Hx	Oct	Char		Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr
0	0	000	NUL	(null)	32	20	040		Space	64	40	100	@	@	96	60	140	`	`
1	1	001	SOH	(start of heading)	33	21	041	!	!	65	41	101	A	A	97	61	141	a	a
2	2	002	STX	(start of text)	34	22	042	"	"	66	42	102	B	B	98	62	142	b	b
3	3	003	ETX	(end of text)	35	23	043	#	#	67	43	103	C	C	99	63	143	c	c
4	4	004	EOT	(end of transmission)	36	24	044	$	$	68	44	104	D	D	100	64	144	d	d
5	5	005	ENQ	(enquiry)	37	25	045	%	%	69	45	105	E	E	101	65	145	e	e
6	6	006	ACK	(acknowledge)	38	26	046	&	&	70	46	106	F	F	102	66	146	f	f
7	7	007	BEL	(bell)	39	27	047	'	'	71	47	107	G	G	103	67	147	g	g
8	8	010	BS	(backspace)	40	28	050	(	(	72	48	110	H	H	104	68	150	h	h
9	9	011	TAB	(horizontal tab)	41	29	051	)	)	73	49	111	I	I	105	69	151	i	i
10	A	012	LF	(NL line feed, new line)	42	2A	052	*	*	74	4A	112	J	J	106	6A	152	j	j
11	B	013	VT	(vertical tab)	43	2B	053	+	+	75	4B	113	K	K	107	6B	153	k	k
12	C	014	FF	(NP form feed, new page)	44	2C	054	,	,	76	4C	114	L	L	108	6C	154	l	l
13	D	015	CR	(carriage return)	45	2D	055	-	-	77	4D	115	M	M	109	6D	155	m	m
14	E	016	SO	(shift out)	46	2E	056	.	.	78	4E	116	N	N	110	6E	156	n	n
15	F	017	SI	(shift in)	47	2F	057	/	/	79	4F	117	O	O	111	6F	157	o	o
16	10	020	DLE	(data link escape)	48	30	060	0	0	80	50	120	P	P	112	70	160	p	p
17	11	021	DC1	(device control 1)	49	31	061	1	1	81	51	121	Q	Q	113	71	161	q	q
18	12	022	DC2	(device control 2)	50	32	062	2	2	82	52	122	R	R	114	72	162	r	r
19	13	023	DC3	(device control 3)	51	33	063	3	3	83	53	123	S	S	115	73	163	s	s
20	14	024	DC4	(device control 4)	52	34	064	4	4	84	54	124	T	T	116	74	164	t	t
21	15	025	NAK	(negative acknowledge)	53	35	065	5	5	85	55	125	U	U	117	75	165	u	u
22	16	026	SYN	(synchronous idle)	54	36	066	6	6	86	56	126	V	V	118	76	166	v	v
23	17	027	ETB	(end of trans. block)	55	37	067	7	7	87	57	127	W	W	119	77	167	w	w
24	18	030	CAN	(cancel)	56	38	070	8	8	88	58	130	X	X	120	78	170	x	x
25	19	031	EM	(end of medium)	57	39	071	9	9	89	59	131	Y	Y	121	79	171	y	y
26	1A	032	SUB	(substitute)	58	3A	072	:	:	90	5A	132	Z	Z	122	7A	172	z	z
27	1B	033	ESC	(escape)	59	3B	073	;	;	91	5B	133	[	[	123	7B	173	{	{
28	1C	034	FS	(file separator)	60	3C	074	<	<	92	5C	134	\	\	124	7C	174			|
29	1D	035	GS	(group separator)	61	3D	075	=	=	93	5D	135	]	]	125	7D	175	}	}
30	1E	036	RS	(record separator)	62	3E	076	>	>	94	5E	136	^	^	126	7E	176	~	~
31	1F	037	US	(unit separator)	63	3F	077	?	?	95	5F	137	_	_	127	7F	177	&#127;	DEL

Source: http://www.asciitable.com/

Answers to Self-Assessment Exercise

MODULE 1: INTRODUCTION TO DATA AND INFORMATION

UNIT 1: LOGICAL AND PHYSICAL CONCEPTS AND DATA

SAE 1

1. Facts.

2. True.

SAE 2

1. No

2. Data

3. C

SAE 3

1. a. American Standard Code for Information Interchange

   b. Extended Binary Coded Decimal Interchange Code

2. Unicode

3. Control Characters

4. Table 1.1 shows the ASCII conversion of **A GOOD DAY** from EDR to IDR. The first upper case character **A** in EDR has ASCII equivalent of 0100 0001, the blank space in between A and G is represented by 0010 0000 and so on. The same conversion is done but in reverse order when computer system displays processing output on monitors or printed on paper.

Table 1.1 EDR to IDR Conversion

EDR	**IDR (ASCII)**
A	0100 0001
	0010 0000
G	0100 0111
O	0100 1111
O	0100 1111
D	0100 0100
	0010 0000
D	0100 0100
A	0100 0001
Y	0101 1001

SAE 4

1. Total number of adjacent bits that can be processed together at once
2. 8 bits make a byte
3. 4 x 1024 = 4096 bytes
4. First Convert 10Kb to bytes

   10 x 1024 = 10240bytes

   Then, Multiply 10240 by 8,

   Since 1 bytes = 8 bits

   10240 x 8 = **81920bits**

SAE 5

1. A – Input
2. C – Meaningful
3. True

UNIT 2: CONCEPTS OF INFORMATION, CHARACTERISTICS AND CONCEPTS OF INFORMATION PROCESSING.

SAE 1

1. Processed Data

SAE 2

Visual, Written and Aural

SAE 3

Accuracy, Completeness, Timeliness, Cost, Reliability, Clarity, Availability, Relevancy, Conciseness

SAE 4

A conscious effort of making reasonable response to challenges through organised procedures.

SAE 5

Search, Select, Capture, Store, create, Communicate, Implement and Destroy

SAE 6

The process through which organizations make sense of new information that they have acquired and disseminated.

MODULE 2: INTRODUCTION TO COMPUTER SYSTEM

UNIT 1: INTRODUCTION AND HISTORY OF COMPUTER

SAE 1

1. Arithmetic and Logical operations

SAEs 2

1. Hardware and Software
2. i. Input ii. Processing, iii. Storage and iv. Output

SAEs 3

1. 1450BCa
2. John Napier in 1600 A.D.
3. Addition and Subtraction, while Multiplication and Division

SAEs 4

1. Blaise Pascal, Mechanical.
2. Goffried Leibnitz, Pascal machine.
3. Charles Babbage, 1813 AD, Steam

SAEs 5

1. 1881, Large Cards and Holes
2. Arithrometre

SAEs 6

1. Analytical Machine
2. Augusta Ada Bryon
3. Dr. Hermann Hollerith, 1890.
4. Punch Cards.

UNIT 2: GENERATIONS AND CLASSIFICATIONS OF COMPUTERS

SAEs 1

1. Dr Howard Aiken
2. J. Presper Eckert and John Mauchly
3. ENIAC
4. 1943

SAE 2

i. Comparatively large in size as compared to present day computers.
ii. Generated lot of heat, they were not consistent and reliable as the valves tended to fail frequently.
iii. Low capacity internal storage.
iv. Individual, non-related models.

v. Processors operated in the milliseconds speed range.
vi. Internal storage consisted of magnetic drum and delay lines.

SAE 3

i. Smaller in size compared to the first-generation computers.
ii. Generated a lower level of heat, as components were much smaller.
iii. Greater degree of reliability because of solid state technology.
iv. Higher capacity of internal storage.
v. Use of core storage instead of magnetic drum and delay lines as primary internal storage medium.
vi. Processor operated in the microsecond speed.

SAE 4

i. Smaller in size as compared to second generation computers.
ii. Higher capacity internal storage.
iii. Remote communication facilities.
iv. Multiprogramming facilities.
v. Processors, which operate in nanosecond speed range.
vi. Ranges of computers with a common architecture whereby models were upward compactable.
vii. Use of high level languages such as COBOL.
viii. Wide range of optional peripherals.

SAE 5

VLSI which brought about the development of microprocessors.

SAE 6

The fifth generation has three functional requirements:

(i) Easy to use computers with high intelligence and natural human input and output mechanism;

(ii) Reliable and efficient software development by new languages, new computer architectures and systems software which overcome previous problems

(iii) Improved overall functions and performance aimed at making computers smaller, lighter, faster, of greater capacity, more flexible and more reliable.

SAEs 7

1. Super Computer, Mainframe, Mini Computer, Micro Computer
2. No
3. Mainframe

UNIT 3: BASIC ORGANIZATION OF COMPUTER AND MEMORY

SAEs 1

1. Four (4) Unit
2. Central Processing Unit

3. False

SAEs 2

1. Arithmetic Logical Unit, Control Unit and Main Memory Unit
2. Electronic clock
3. Random Access Memory

SAE 3

1. Read Only Memory
2. a, Erasable Programmable Read Only Memory

   b, Electrically Erasable Programmable Read Only Memory

   c, Programmable Read Only Memory

   d, Memory Address Register

   e, Current Instruction Register

UNIT 4: NUMBER SYSTEMS AND CONVERSION

SAEs 1

1. Binary, Decimal, and Hexadecimal Number Systems
2. Hexadecimal number system

SAE 2

1. Two digits
2. Number Base or Number System
3. A

SAE 3

1. 001_2
2. 10110_2

SAE 4

1. Sign binary number and 2's complement
2. True

UNIT 5: COMPUTER LANGUAGES AND BASIC CONCEPTS OF DATABASE

SAEs 1

1. Human Readable and non-human readable
2. False

SAEs 2

1. Op-code and Operand
2. Translator
3. Mnemonic

SAEs 3

1. Database Management System
2. Hierarchical, network, relational and object oriented
3. Structured Query Language

MODULE 3: COMMUNICATION SYSTEM

UNIT 1: COMMUNICATION SYSTEM AND TRANSMISSION IMPAIRMENTS

SAEs 1

1. Source, destination
2. Message

SAEs 2

1. Transmitter, transmission channel, and receiver
2. Transmission media

SAEs 3

1. Impairment
2. True

UNIT 2: ANALOG AND DIGITAL SIGNALS

SAEs 1

1. Physical Quantity, Smooth and Continuous
2. Ordered Sequence, Finite
3. Digital Audio Broadcast

SAEs 2

1. Analog to Digital Conversion
2. Dither

SAEs 3

1. D/A, DAC or D-to-A
2. Speed, Resolution

UNIT 3: SIGNAL MODULATION AND SIGNAL TO NOISE RATIO

SAEs 1

1. Signal, Sinusoid
2. Sin, ϕ

SAEs 2

1. Generate a modulated signal suited to the characteristics of transmission channel
2. Amplitude, Phase and Frequency

SAEs 3

1. $SNR = \frac{P_{signal}}{P_{noise}}$

2. 1Mw

SAE 4

1. a, The bandwidth available

   b, The level of the signals we use

   c, The quality of the channel (the level of noise)

2. $datarate = f_{\max} \times 2$

MODULE 4: COMMUNICATION SIGNAL AND TRANSMISSION

UNIT 1: DATA ENCODING AND DECODING

SAEs 1

1. Single Bit error and Burst error
2. Hardware and software failure

SAEs 2

1. Redundancy
2. False

SAEs 3

1. 2^k
2. Block coding and convolution coding

SAEs 4

1. Even and Odd Parity
2. False

SAE 5

1. 2 errors
2. True

UNIT 2: TRANSMISSION MEDIA

SAEs1

1. Wired and Wireless
2. Transmission Media

SAEs 2

1. Single Mode and Multimode Fiber
2. Prevent Interference

3. True

SAEs 3

1. Electromagnetic Waves, Physical Conductor
2. Unicast

MODULE 5: COMMUNICATION TECHNIQUES AND INTERNET

UNIT 1: COMMUNICATION TECHNIQUES

SAEs 1

1. Switches or Nodes
2. Circuit Switching, Message Switching and Packet Switching

SAEs 2

1. Remains Fixed, Duration of the Connection
2. Physical Layer

SAEs 3

1. Store-and-forward
2. True

SAE 4

1. Datagram Packet Switching and Virtual Circuit Packet Switching
2. Each Packet as an Independent Message

UNIT 2: COMPUTER NETWORKS

SAEs 1

a. Wide Area Network,

b. Metropolitan Area Network,

c. Personal Area Network

2. PAN

SAEs 2

1. Hierarchical
2. Star
3. Star

SAEs 3

1. International Standard Organization, Open System Interconnection
2. 1970
3. the OSI and Internet model

SAEs 4

1. What, how and when
2. syntax, semantics, and timing

UNIT 3: THE INTERNET

SAEs 1

1. 1990
2. National Science Foundation Network

SAE 2

1. D
2. Internet Protocol Television
3. Security

SAE 3

1. Electronic Mail
2. Google Chrome, Microsoft Internet Explorer, Mozilla, Safari or any other browser
3. Google, Yahoo, MSN, Lycos or any other search engine