Telecommunication and Networking

LIS 203

University of Ibadan Distance Learning Centre
Open and Distance Learning Course Series Development

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Vice-Chancellor's Message

The Distance Learning Centre is building on a solid tradition of over two decades of service in the provision of External Studies Programme and now Distance Learning Education in Nigeria and beyond. The Distance Learning mode to which we are committed is providing access to many deserving Nigerians in having access to higher education especially those who by the nature of their engagement do not have the luxury of full time education. Recently, it is contributing in no small measure to providing places for teeming Nigerian youths who for one reason or the other could not get admission into the conventional universities.

These course materials have been written by writers specially trained in ODL course delivery. The writers have made great efforts to provide up to date information, knowledge and skills in the different disciplines and ensure that the materials are user-friendly.

In addition to provision of course materials in print and e-format, a lot of Information Technology input has also gone into the deployment of course materials. Most of them can be downloaded from the DLC website and are available in audio format which you can also download into your mobile phones, IPod, MP3 among other devices to allow you listen to the audio study sessions. Some of the study session materials have been scripted and are being broadcast on the university's Diamond Radio FM 101.1, while others have been delivered and captured in audio-visual format in a classroom environment for use by our students. Detailed information on availability and access is available on the website. We will continue in our efforts to provide and review course materials for our courses.

However, for you to take advantage of these formats, you will need to improve on your I.T. skills and develop requisite distance learning Culture. It is well known that, for efficient and effective provision of Distance learning education, availability of appropriate and relevant course materials is a *sine qua non*. So also, is the availability of multiple plat form for the convenience of our students. It is in fulfilment of this, that series of course materials are being written to enable our students study at their own pace and convenience.

It is our hope that you will put these course materials to the best use.

Prof. Abel Idowu Olayinka

Vice-Chancellor

Foreword

As part of its vision of providing education for "Liberty and Development" for Nigerians and the International Community, the University of Ibadan, Distance Learning Centre has recently embarked on a vigorous repositioning agenda which aimed at embracing a holistic and all encompassing approach to the delivery of its Open Distance Learning (ODL) programmes. Thus we are committed to global best practices in distance learning provision. Apart from providing an efficient administrative and academic support for our students, we are committed to providing educational resource materials for the use of our students. We are convinced that, without an up-to-date, learner-friendly and distance learning compliant course materials, there cannot be any basis to lay claim to being a provider of distance learning education. Indeed, availability of appropriate course materials in multiple formats is the hub of any distance learning provision worldwide.

In view of the above, we are vigorously pursuing as a matter of priority, the provision of credible, learner-friendly and interactive course materials for all our courses. We commissioned the authoring of, and review of course materials to teams of experts and their outputs were subjected to rigorous peer review to ensure standard. The approach not only emphasizes cognitive knowledge, but also skills and humane values which are at the core of education, even in an ICT age.

The development of the materials which is on-going also had input from experienced editors and illustrators who have ensured that they are accurate, current and learner-friendly. They are specially written with distance learners in mind. This is very important because, distance learning involves non-residential students who can often feel isolated from the community of learners.

It is important to note that, for a distance learner to excel there is the need to source and read relevant materials apart from this course material. Therefore, adequate supplementary reading materials as well as other information sources are suggested in the course materials.

Apart from the responsibility for you to read this course material with others, you are also advised to seek assistance from your course facilitators especially academic advisors during your study even before the interactive session which is by design for revision. Your academic advisors will assist you using convenient technology including Google Hang Out, You Tube, Talk Fusion, etc. but you have to take advantage of these. It is also going to be of immense advantage if you complete assignments as at when due so as to have necessary feedbacks as a guide.

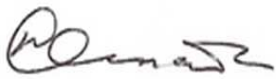
The implication of the above is that, a distance learner has a responsibility to develop requisite distance learning culture which includes diligent and disciplined self-study, seeking available administrative and academic support and acquisition of basic information technology skills. This is why you are encouraged to develop your computer

skills by availing yourself the opportunity of training that the Centre's provide and put these into use.

In conclusion, it is envisaged that the course materials would also be useful for the regular students of tertiary institutions in Nigeria who are faced with a dearth of high quality textbooks. We are therefore, delighted to present these titles to both our distance learning students and the university's regular students. We are confident that the materials will be an invaluable resource to all.

We would like to thank all our authors, reviewers and production staff for the high quality of work.

Best wishes.



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Study Session 1: Concept and Definition of Computer Network

***Source**: https://www.kullabs.com/class-10/computer-science*

Introduction

Telecommunications is the transmission of signals over a distance for the purpose of sharing information. The transmission of signals in telecommunications is done over networks of computers and related devices. Hence, computer network can be regarded as the basis of telecommunications and data transmission.

In this study session you will learn the basic element of telecommunications which is a computer network.

Learning Outcomes for Study Session 1

At the end of this study session, you should be able to:

1.1 Define a Computer Network

1.2 List and discuss the types of Computer Networks

1.1 Computer Networks

A computer network essentially consists of an interconnection of devices (computers, printers, routers and/or other hardware resources) that exchange information with each other. It is an infrastructure that allows two or more computers (called hosts) to communicate with each other by providing a set of rules for communication, called protocols, which should be observed by all participating hosts (**Hekmat**, 2005).

Figure 1.1:*Computer Networks*
Source*:http://www.russbellew.com/siteimages/computernetwork_iStock_000004660040XSmall-2.jpg*

Computer networks can further be described as shared resources used to exchange information between users and involves the movement of data and/or resources from one system to another or movement of information between at least two systems or more.

Figure 1.2 *Printer and CD-ROM*
Source*: https://en.wikipedia.org/wiki/CD-ROM*

Imam et. al. (2008) described a computer network as a system that uses communication equipment to connect two or more computers and their resources. The physically dispersed computers are linked to each other by communication lines to share information resources.

In-Text Question

_____of two or more computers that are linked in order to share resources (such as Printers and CD-ROMs), exchange files, or allow electronic communications.

a. Computer Network
b. Communication
c. Data
d. None of the above

In-Text Answer

a. Computer Network

Benefits of Computer Networking

1. Networking reduces duplication of computer resources thus enabling scarce resources to be shared among the computer systems.
2. Resource sharing: computer network facilitates sharing of peripheral devices such as printers, disk drives, scanners etc
3. Information sharing: computer network facilitates sharing of programs and data
4. Communication: facilitates better communication, e.g through e-mail
5. Security: provides security of information as files and programs on a network can be well secured
6. Access: access to many databases
7. Speed: provides speedy and rapid method for sharing and transferring files
8. Cost: saves cost of sharing and communicating information

Box 1.1: Computer Network

Computer network consists of two or more computers that are linked in order to share resources (such as Printers and CD-ROMs), exchange files, or allow electronic communications. The linking of the computer systems is done with data communication devices.

1.2 Types of Computer Networks

There are several types of computer networks based on size, geographical scope and purpose. The size of a network can be expressed by the geographic area they occupy and the number of computers that are part of the network. Computer networks can cover anything from a handful of devices within a single room to millions of devices spread across the entire globe. The common types of computer networks are discussed below.

1. **Personal Area Network**: This is a type of computer network organised around an individual person within a single building. This could be in a small office or residence. A typical PAN would include one or more computers, telephones, peripheral devices, video game consoles and other personal entertainment devices.

Figure1.3:*Personal AreaNetwork*

Source:*http://www.home-network-help.com/images/bluetooth-network.jpg*

If multiple individuals use the same network within a residence, the network is sometimes referred to as a home area network, or HAN. In a very typical setup, a residence will have a single wired Internet connection connected to a modem. This modem then provides both wired and wireless connections for multiple devices. The network is typically managed from a single computer, but can be accessed from any device. This type of network provides great flexibility.

2. Local Area Networks (LAN): LAN is used to interconnect many computers within a given local area, more often premises of a single or organisational building. The use of

LAN is usually premised on the fact that very high speed of data transmission can be attained within a limited geographic area. LAN is very useful for sharing resources, such as data storage and printers.

LANs can be built with relatively inexpensive hardware, such as hubs, network adapters and Ethernet cables. The smallest LAN may only use two computers, while larger LANs can accommodate thousands of computers. A LAN typically relies mostly on wired connections, for increased speed and security, but wireless connections can also be part of a LAN. High speed and relatively low cost are the defining characteristics of LANs.

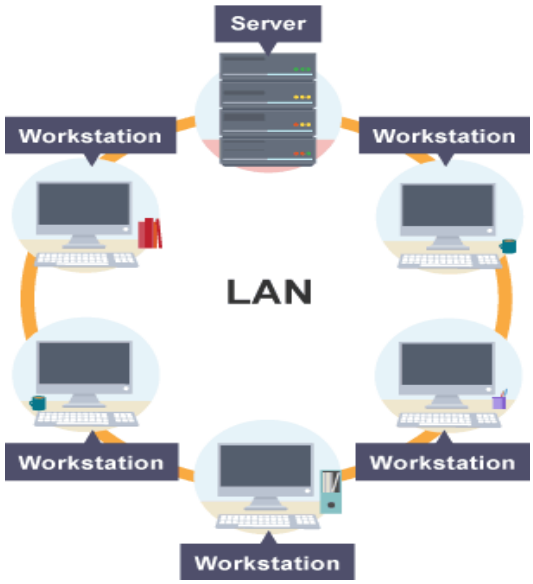

Figure1.4 *Local Area Network*

Source: *http://www.bbc.co.uk/education/guides/z36nb9q/revision*

Local Area Networks are typically used for single sites where people need to share resources among one another, but not with the rest of the outside world. Think of an office building where everybody should be able to access files on a central server or be able to print a document to one or more central printers. Those tasks should be easy for everybody working in the same office, but you would not want anybody just walking outside to be able to send a document to the printer from their cell phone!

If a local area network, or LAN, is entirely wireless, it is referred to as a wireless local area network, or WLAN. The LAN network allows its users to share library programs, databases, languages and specific facilities considered expensive.

3. Wide Area Networks (WAN):WAN is used to interconnect a number of widely dispersed computers in various cities of a country or different countries. WAN use communication media maintained by telephone companies.

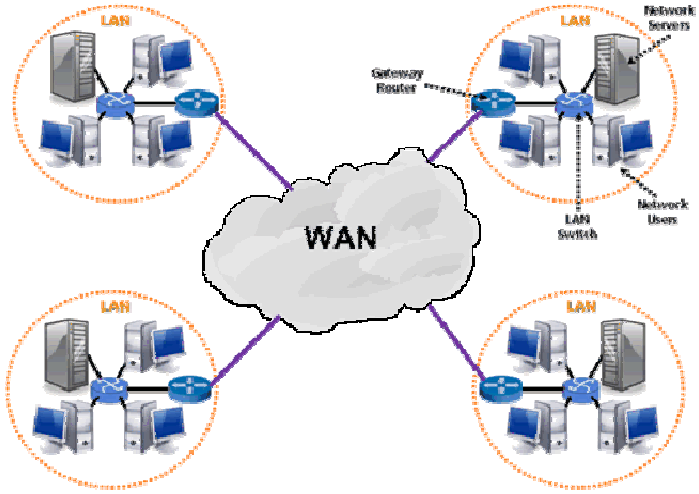

Figure1.5: *Wide Area Network*

Source:*http://www.netprivateer.com/images/lanwan.gif*

A wide area network, or WAN, occupies a very large area, such as an entire country or the entire world and can contain multiple smaller networks, such as LANs or MANs. The Internet is the best-known example of a public WAN. The main objective of a WAN is to allow users to access specialised programs, databases et cetera available at any of the computers in the network.

1. **Metropolitan Area Network (MAN):** This refers to interconnection within geographical limits of a city or a town. It is usually referred to as the last mile problem. A metropolitan area network, or MAN, consists of a computer network across an entire city, college campus or a small region.

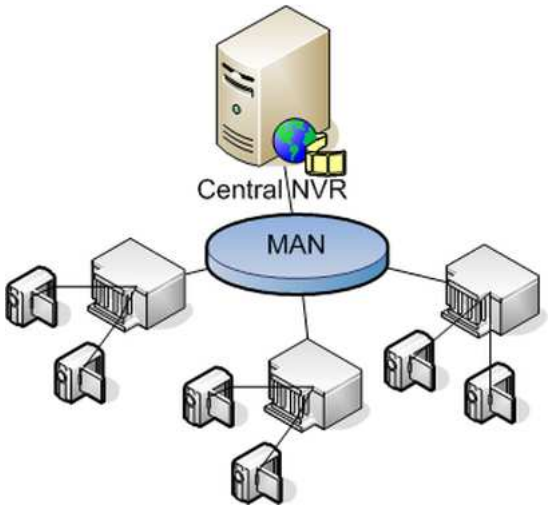

Figure1.6:*Metropolitan Area Network*

Source:*http://computernetworkingtopics.weebly.com/uploads/1/0/2/3/10235412/4647385.png?406*

A MAN is larger than a LAN, which is typically limited to a single building or site. Depending on the configuration, this type of network can cover an area from several miles to tens of miles. A MAN is often used to connect several LANs together to form a bigger network. When this type of network is specifically designed for a college campus, it is sometimes referred to as a campus area network, or CAN.

MAN is used to share problems associated with the poor telephone network infrastructure of local telephone authority and provide excellent communication between remote points irrespective of distance. However, reliability of intra-city communication cannot be guaranteed.

1.2.1 Categorization of Computer Network

Networks may be divided into different categories according to four different criteria:

1. **Geographic spread of nodes and hosts**: When the physical distance between the hosts is within a few kilometres, the network is said to be a Local AreaNetwork (LAN). LANs are typically used to connect a set of hosts within the same building (e.g., an office environment) or a set of closely-located buildings (e.g., a university campus).

2. For larger distances, the network is said to be a Metropolitan Area Network (MAN) or a Wide Area Network (WAN). On the other hand, MANs cover distances of up to a few hundred kilometres and are used for interconnecting hosts spread across a city.
3. Meanwhile, WANs are used to connect hosts spread across a country, a continent, or the globe. However, LANs, MANs, and WANs usually coexist: closely-located hosts are connected by LANs which can access hosts in other remote LANs via MANs and WANs.
4. **Access restrictions***:*Most networks are for the private use of the organisations to which they belong; these are called private networks. Networks maintained by banks, insurance companies, airlines, hospitals, and most other businesses are of this nature.
5. Public networks, on the other hand, are generally accessible to the average user, but may require registration and payment of connection fees. The internet is the most-widely known example of a public network. Technically, both private and public networks may be of LAN, MAN, or WAN type, although public networks, by their size and nature, tend to be WANs.
6. **The communication model employed by the nodes**:The communication between the nodes is either based on a point-to-point model or a broadcast model. In the point-to-point model, a message follows a specific route across the network in order to get from one node to another. In the broadcast model, on the other hand, all nodes share the same communication medium and, as a result, a message transmitted by any node can be received by all other nodes.
7. A part of the message (an address) indicates for which node the message is intended. All nodes look at this address and ignore the message if it does not match their own address.
8. **Switching model employed by the nodes**:In the point-to-point model, nodes either employ circuit switching or packet switching. Suppose that a host A wishes to communicate with another host B. In circuit switching, a dedicated communication path is allocated between A and B, via a set of intermediate nodes.
9. The data is sent along the path as a continuous stream of bits. This path is maintained for the duration of communication between A and B, and is then

released. In packet switching, data is divided into packets (chunks of specific length and characteristics) which are sent from A to B via intermediate nodes.

10. Each intermediate node temporarily stores the packet and waits for the receiving node to become available to receive it. Because data is sent in packets, it is not necessary to reserve a path across the network for the duration of communication between A and B. Different packets can be routed differently in order to spread the load between the nodes and improve performance. However, this requires packets to carry additional addressing information.

Other types of Network include the following

1. Home Area Networks (HAN)
2. Enterprise Private Networks
3. Internetworks
4. Backbone Networks (BBN)
5. Global Area Networks (GAN)
6. The Internet

Uses of Network

Networksare used for the followings:

- Facilitate communication via email, video conferencing, instant messaging, etc.
- Enable multiple users to share a single hardware device like a printer or scanner
- Enable file sharing across the network
- Allow for the sharing of software or operating programs on remote systems
- Make information easier to access and maintain among network users

Summary of Study Session 1

In this study, you have learnt that:

1. Computer network consists of two or more computers that are linked in order to share resources (such as Printers and CD-ROMs), exchange files, or allow electronic communications. The linking of the computer systems is done with data communication devices.
2. The following are types of networks.

a. Local Area Networks (LAN)
b. Personal Area Networks (PAN)
c. Home Area Networks (HAN)
d. Wide Area Networks (WAN)
e. Campus Networks
f. Metropolitan Area Networks (MAN)
g. Enterprise Private Networks
h. Global Area Networks (GAN)
i. The Internet

Self-Assessment Question for Study Session 1

Having studied this session, you can now assess how well you have learnt its learning outcomes by answering the following questions. It is advised that you answer the questions thoroughly and discuss your answers with your tutor in the next Study Support Meeting. Also, brief answers to the Self-Assessment Questions are provided at the end of this module as a guide.

SAQ 1.1 (Test of learning outcome 1.1)

Define a Computer Network

SAQ 1.2 (Test of learning outcome 1.2)

Discuss the various types of Computer Networks

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Study Session 2: Computer Network Topology

Source: *http://www.blog.skytopper.com/computer-network-and-internet/*

Introduction

Computer network topology explains the way in which computers in a network are connected. It addresses issues, like number of network nodes, concentration of terminals and devices to various locations and how effectively they could be interconnected for information transmission and communication.

In this study session you will be introduce to the various physical topologies for computer networks

Learning Outcomes for Study Session 2

At the end of this study session, you should be able to:

2.1 Explain the various physical topologies for computer networks

2.1 Computer Network Topologies

The physical topology of a network refers to the configuration of cables, computers, and other peripherals. Physical topology should not be confused with logical topology which is the method used to pass information between workstations. The types of network topologies that can be used depend on the purpose and available equipment.

Physical topologies: These refer to the configuration of network cables, computers and other peripheral as they link each node. Common types of physical topologies are: Bus-Linear, Star, Ring, Mesh, Tree, Modifies-Ring and Loop topologies among others.

1. **Bus-Linear topology**: A bus topology was common (single) communication line topology connects the various work stations, servicers and other peripheral devices on the network. It consists of a main run of cable with a terminator at each end. With this configuration device can be added or removed easily from the network.

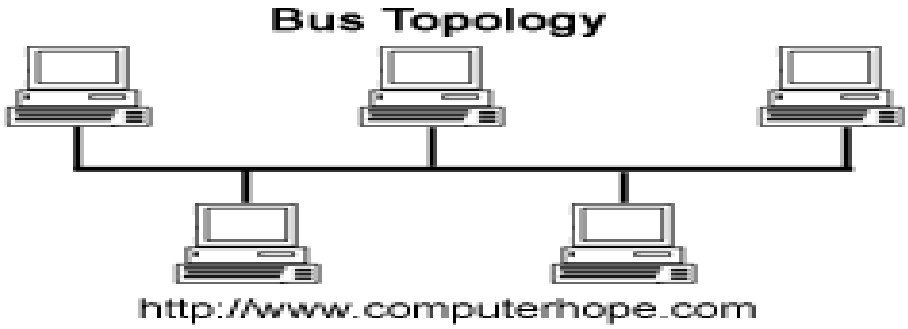

Fig 2.1 *Bus Topology*

Advantages of a Linear Bus Topology

a. Easy to connect a computer or peripheral to a linear bus.
b. Requires less cable length than a star topology.

Disadvantages of a Linear Bus Topology

a. Entire network shuts down if there is a break in the main cable.
b. Terminators are required at both ends of the backbone cable.
c. Difficult to identify the problem if the entire network shuts down.
d. Not meant to be used as a stand-alone solution in a large building.

In-Text Question

Physical topologies refer to the configuration of network cables, computers and other peripheral as they link each node. TRUE or FALSE

In-Text Answer

TRUE

2. Star topology: This topology has a central server to which all workstations are connected. It is designed with each node connected directly to the central network hub or concentrator communication within the network servers that manages and controls all functions of the network. It is the most reliable and usually configured to have dedicated channels between each station and the control hub such that all communication must pass through the hub.

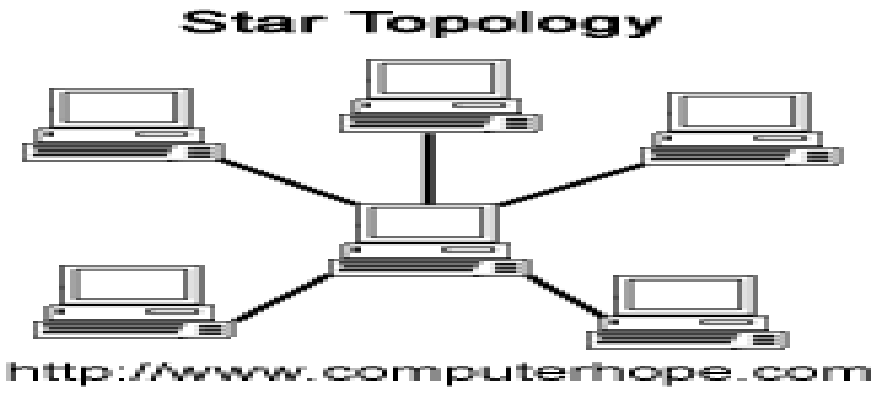

Fig 2.2 *Star Topology*

Advantages of a Star Topology

- Easy to install and wire.
- No disruptions to the network when connecting or removing devices.
- Easy to detect faults and to remove parts.

Disadvantages of a Star Topology

- Requires more cable length than a linear topology.
- If the hub, switch, or concentrator fails, nodes attached are disabled.
- More expensive than linear bus topologies because of the cost of the hubs, etc.

Ring topology: Ring topology consists of interconnected work stations in a continuous ring form. Messages are passed from one work station to another until the destination is reached. The information flow is in one direction. Each node is connected to it. Two adjacent nodes and messages circulate around the closed ring.

If there is a problem with a system at a point the other systems after the problem point will break down. It is a form of network in which each node is connected to its two adjacent nodes and manacles are circulated around the closed ring. It is a variant of ring network in which one master station controls the transmission. The local requirement and computer configurations involved may be considered while choosing a specific topology, (**Satyanarayan**, 2005).

Ring topology has the advantages of:

- Easy installation and reconfiguration
- Simple fault isolation. Generally in a ring, a signal is circulating at all times. Thus, if one device does not receive a signal within a specified period, it can issue an alarm, the alarm alerts the network operator to the problem and its location.

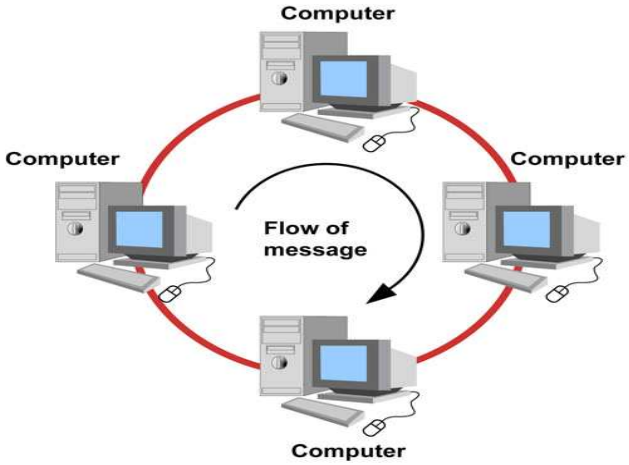

Fig 2.3 *Ring Topology*

3. Mesh Topology: In mesh topology, separated cables are used to connect each drive to every other one on the network, thus providing a district and straight communication line among the various PCs.

It is a fault tolerant network and a prompt trouble shooter. It is commonly employed for long-in trance transmission of data between node packet switches. In mesh network,

computer in different locations are interconnected having multiple message paths between nodes (**Padhu,** 2007).

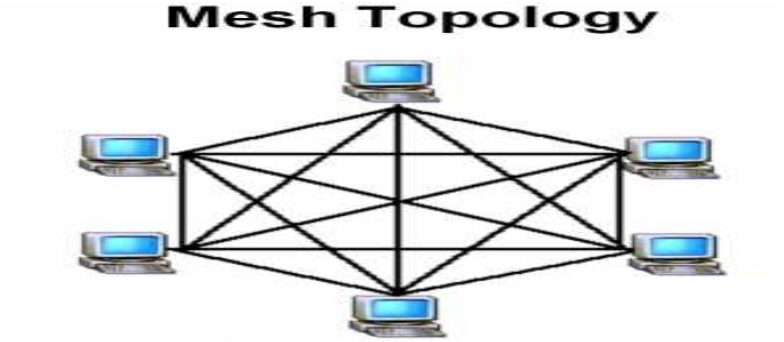

Fig 2.4*Mesh Topology*

Advantages of Mesh Topology:

- ❖ It downplays the traffic problems that may occur when links are jammed by multiple devices.
- ❖ It offers privacy and security since every message travels along a dedicated line to the intended receiver.
- ❖ It is robust in that if one link becomes unusable, it does not incapacitate the whole system
- ❖ Since it involves point – to – point links, it makes fault identification and isolation easier.

Disadvantages of Mesh Topology

- Installation and reconnection could be difficult when many devices are involved.
- The large volume of the wiring can be greater than the available space can accommodate.
- The hardware required for each link can be excessively expensive.

In-Text Question

Topology has a central server to which all workstations are connected. It is designed with each node connected directly to the central network hub or concentrator communication within the network servers that manages and controls all functions of the network.

TRUE or FALSE

In-Text Answer
TRUE

4. Tree topology: Tree topology combines characteristics of linear bus and star topologies. It consists of a group of star-configured workstations connected to a linear bus backbone cable. It allows the expansion of an existing network, and enables schools to configure a network to meet their needs.
It is a complete bus network consisting of a series of branches converging indirectly to a contract network and offering only one transmission path between only 2 stations. It is usually built with the configuration of bus network, but usually consists of a series of branches converging indirectly to a control point and offering only one transmission path between any two stations. (**Satyanarayan,** 2005).

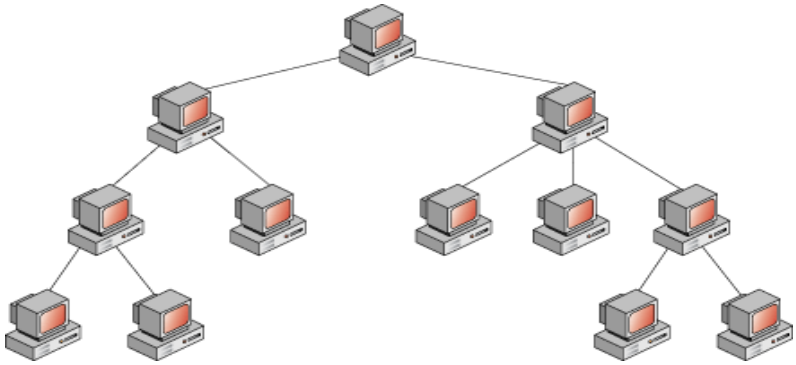

Fig 2.5: *Tree Topology*

Advantages of a Tree Topology
- Point-to-point wiring for individual segments.
- Supported by several hardware and software vendors.

Disadvantages of a Tree Topology
- The overall length of each segment is limited by the type of cabling used.
- If the backbone line breaks, the entire segment goes down.
- It is more difficult to configure and wire than other topologies.

5. Modified ring networks: this is a central ring of wiring hub with stations connected in a star Topology around each hub.

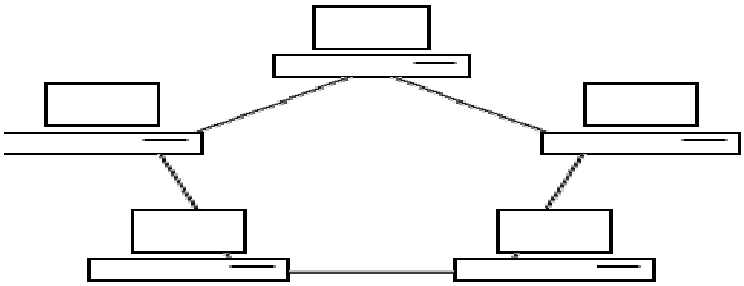

Fig 2.6: *Modified Ring Topology*

6. Loop network: is a ring network in which one master station controls transmission.

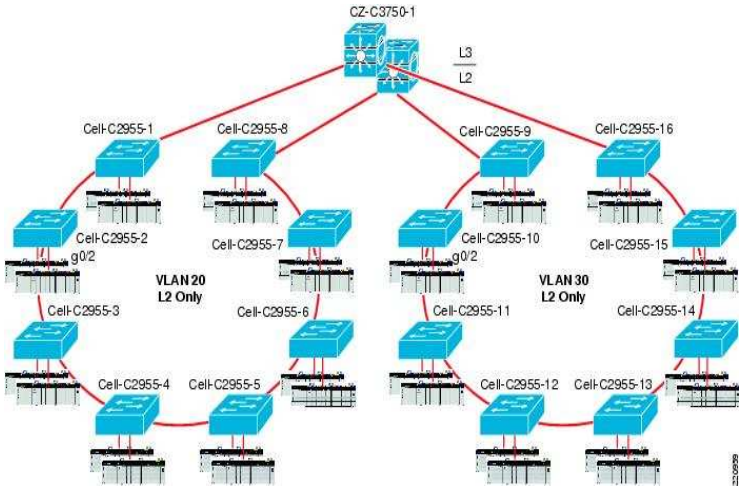

Fig 2.7*: Loop Topology*

7. Logical topologies: Logical topologies refer to how messages flow from one workstation or computer terminal to another. It involves the method used to pass information between workstations and is of two types viz: Peer-to-Peer and Client-Server topologies.

a. Peer-to-Peer It means messages are transmitted from computer-to-computer. This type of network provides a simple and inexpensive way to interconnect computers.(Usually less than ten). It is more common in small offices or department than in a large organisation. It is operated in a peer-to-peer network. Each computer acts as both client and server. A notable feature of this type of network is that each node stores its files and pertinent databases.

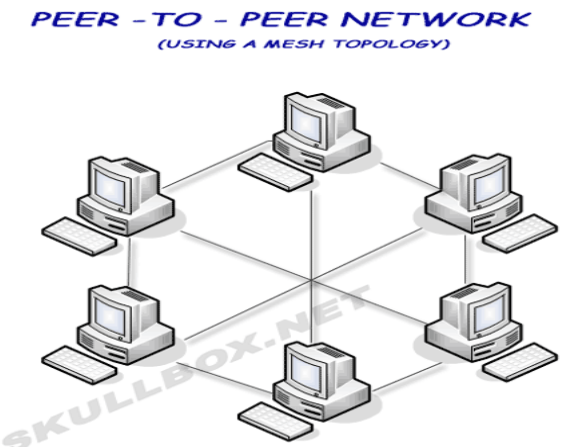

Fig 2.8: *Peer-Peer Logical Topology*

Advantages of Peer-to-Peer Network

- There is no need for a dedicated server.
- It allows for sharing of all resources of the workstations on the network.
- It is easy to install and configure.
- There is no need for a dedicated administrator.

Disadvantages of Peer-to-Peer Network

- There is less security in the network.
- There is less control over the resources.
- Users may have to remember as many passwords as there are resources.
- Data backup has to be done on each computer.

b. The client-server network is a server based network that is effectual for sharing data. A server-based network is such that certain computers called charts request services and other computers called servers respond to their requests.

In a client/server network, there is usually a dedicated central system called server on which the files of users connected to the network are stored. It provides an efficient client ways of connection of computers to share information (10 or more systems).

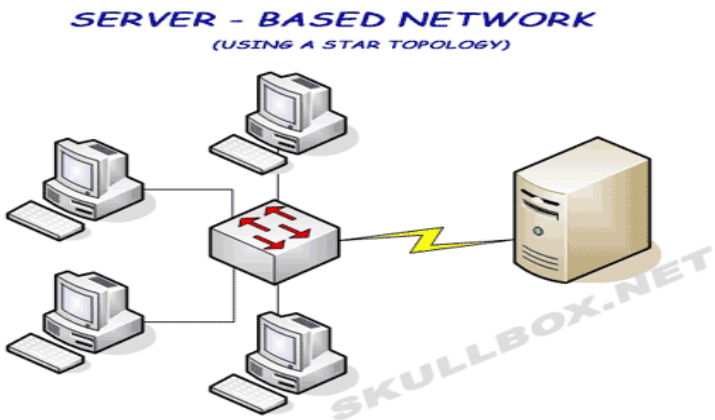

Fig 2.9: *Client-Server Logical Topology*

Advantages of Client/Server Network

- There is proper management as resources are centrally managed.
- There is no duplication of resources.
- Users only have to remember a single password for network login and access to resources.
- The more powerful the equipment, the more efficient its operation.

Disadvantages of Client/Server Network

- It is prone to failure: if the server fails,then the setup automatically fails.
- All messages/requests are routed via the server.
- The overall cost is high because there is a need for the employment of a dedicated administrator.
- The cost of operation also increases due to the requirements of dedicated hardware and specialised software.

Considerations When Choosing a Topology

Funding: A linear bus network may be the least expensive way to install a network; you do not have to purchase concentrators.

Length of cable needed: The linear bus network uses shorter lengths of cable.

Future growth: With a star topology, expanding a network is easily done by adding another concentrator.

c. **Cable Type**: The most common cable in schools is unshielded twisted pair, which is most often used with star topologies.

Summary of Study Session 2

In this study session, you have learnt that:

1. Various physical and logical topologies that can be adopted for computer networks, besides highlighting the areas of strengths and weaknesses of each of the topologies described. Also, basic factors to be considered in choosing a topology for any particular network were discussed.
2. Physical topologies refer to the configuration of network cables, computers and other peripheral as they link each node. Common types of physical topologies are: Bus-Linear, Star, Ring, Mesh, Tree, Modifies-Ring and Loop topologies among others.
3. Star topology has a central server to which all workstations are connected. It is designed with each node connected directly to the central network hub or concentrator communication within the network servers that manages and controls all functions of the

Self-Assessment Question for Study Session 2

Having studied this session, you can now assess how well you have learnt its learning outcomes by answering the following questions. It is advised that you answer the questions thoroughly and discuss your answers with your tutor in the next Study Support Meeting. Also, brief answers to the Self-Assessment Questions are provided at the end of this module as a guide.

SAQ 2.1 (Test of learning outcome 2.1)

1. Describe the various physical topologies for computer networks
2. Explain the difference between physical and logical topology of a computer network

References

Donnet, B. & Friedman, T. (2007). Internet topology discovery: a Survey. *IEEE Communications Surveys and Tutorials*, 9(4): 2-15

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Study Session 3: Data Communication Systems

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***Source**:http://www.intechww.com/products-and-solutions/integrated-control-systems/industrial-data-networks-communication-systems-paga-systems/*

Introduction

For communication of information and messages we use telephone and postal communication systems. Similarly data and information from one computer system can be transmitted to other systems across geographical areas.

Data communications is the exchange of data between two devices via some form of transmission medium such as a wire cable (**Gold**. 2014). This study session you will focus on themajor factor that determine the effectiveness of a data communication system and the basic elements involved in data communication.

Learning Outcomes for Study Session 3

At the end of this study session, you should be able to:

3.1 Explain the major factor that determine the effectiveness of a data communication system.

3.2 Discuss the basic elements involved in data communication.

3.1 Factors Determining the Effectiveness of Data Communication System

Data communications is the exchange of data between two devices via some form of transmission medium such as a wire cable (**Gold**. 2014). For data communications to occur, the communicating devices must be part of a communication system made up of a combination of hardware (physical equipment) and software (programs).

Thus data transmission is the movement of information using some standard methods. These methods include electrical signals carried along a conductor, optical signals along an optical fibers and electromagnetic areas.The effectiveness of data communications system depends on four fundamental characteristics viz: *delivery, accuracy, timeliness, and jitter*.

The following are factor that determines the effectiveness of data communication system:

1. **Delivery**: The system must deliver data to the correct destination and must be received by the intended device or user only, and not any other user or device.
2. **Accuracy**: The system must deliver the data accurately. Data that are transmitted must not be altered in the process of transmission because data that have been altered in transmission and left uncorrected are unusable. Hence, data integrity must be guaranteed.
3. **Timeliness:** Data that are being transmitted must be timely enough to meet the demands of the user or receiver hence the system must deliver data in a timely manner. Data that are delivered late are useless. In the case of video and audio, timely delivery means delivering data as they are produced, in the same order that they are produced, and without significant delay (**Bonaventure**, 2011). This kind of delivery is called real-timetransmission.
4. **Jitter**: Jitter refers to the variation in the packet arrival time and describes the uneven delay in the delivery of audio or video packets. For example, if video packets are sent every 30 ms and some of the packets arrive with 30 ms delay and others with 40 ms delay, a jitter has occurred and an uneven quality in the video would be the result.

In-Text Question

One of the following is not a factors determining the efectiveness of Data Communication System

a. Delivery

b. Accuracy
c. Timeless
d. Speed

In-Text Answer
d. Speed

3.2 Basic Elements of a Communication System

The basic elements for a successful and working communication system are described below:

a. **Message**: The message is the information (data) to be communicated. Popular forms of information include text, numbers, pictures, audio, and video.
b. **Sender**: The sender is the device that sends the data message which can be a computer, workstation, telephone handset, video camera, and any other communication device. The sender creates the messages to be sent.
c. **Receiver:** The receiver is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.
d. **Transmission medium**: The transmission medium is the path by which a message travels from sender to receiver. Some examples of transmission media include twisted-pair wire, coaxial cable, fibre optic cable, and radio waves.
e. **Protocol**: A protocol is a set of rules that govern data communications which is establishes an agreement between the communicating devices. Without a protocol, devices may be connected but not communicating, just as a person speaking French cannot be understood by a person who speaks only Japanese.

The data communication protocol software enables devices and systems to communicate with and understand each other. The data communication software instructs computer systems and devices as to how exactly data is to be transferred from one place to another. The data transmission software or protocols perform the following functions for the efficient and error free transmission of data.

- **Data sequencing**: A long message to be transmitted is broken into smaller packets of fixed size for error free data transmission.
- **Data Routing**: It is the process of finding the most efficient route between source and destination before sending the data.
- **Flow control**: All machines are not equally efficient in terms of speed. Hence the flow control regulates the process of sending data between fast sender and slow receiver.
- **Error Control**: Error detecting and recovering is one of the main functions of communication software. It ensures that data are transmitted without any error.

Terms associated with data communication include:

1. **Data**: Data is a description of a collection of facts in raw forms that become information after processing.
2. **Signals**: It describes electric or electromagnetic encoding of data.
3. **Signaling :**This explains the propagation of signals across a communication medium.
4. **Transmission**: Transmission refers to the communication of data achieved by the processing of signals.

Summary of Study Session 3

In this study session, you have learnt that:

1. 1.The factors determining the dffectiveness of Data Communication System are: Delivery, Accuracy, Timeliness, and Jitter.
2. 2.The basic elements for a successful and working communication system are described below. Message. The message is the information (data) to be communicated. Popular forms of information include text, numbers, pictures, audio, and video.
3. Terms associated with data communication include:

- **Data**: Data is a description of a collection of facts in raw forms that become information after processing.
- **Signals**: It describes electric or electromagnetic encoding of data.
- **Signaling :**This explains the propagation of signals across a communication medium.

- **Transmission**: Transmission

4. The effectiveness of a data communication system depends on some major factors such as delivery, accuracy, timeliness and jitters. Likewise a successful and working data communication system must have a message, sender, receiver, transmission medium and the protocol which is a set of rules governing the data communication process.

Self-Assessment Question for Study Session 3

Having studied this session, you can now assess how well you have learnt its learning outcomes by answering the following questions. It is advised that you answer the questions thoroughly and discuss your answers with your tutor in the next Study Support Meeting. Also, brief answers to the Self-Assessment Questions are provided at the end of this module as a guide.

SAQ 3. 1 (Test of learning outcome 3.1)

Explain the major factor that determine the effectiveness of a data communication system

SAQ 3.2 (Test of learning outcome 3.2)

Discuss the basic elements involved in data communication

References

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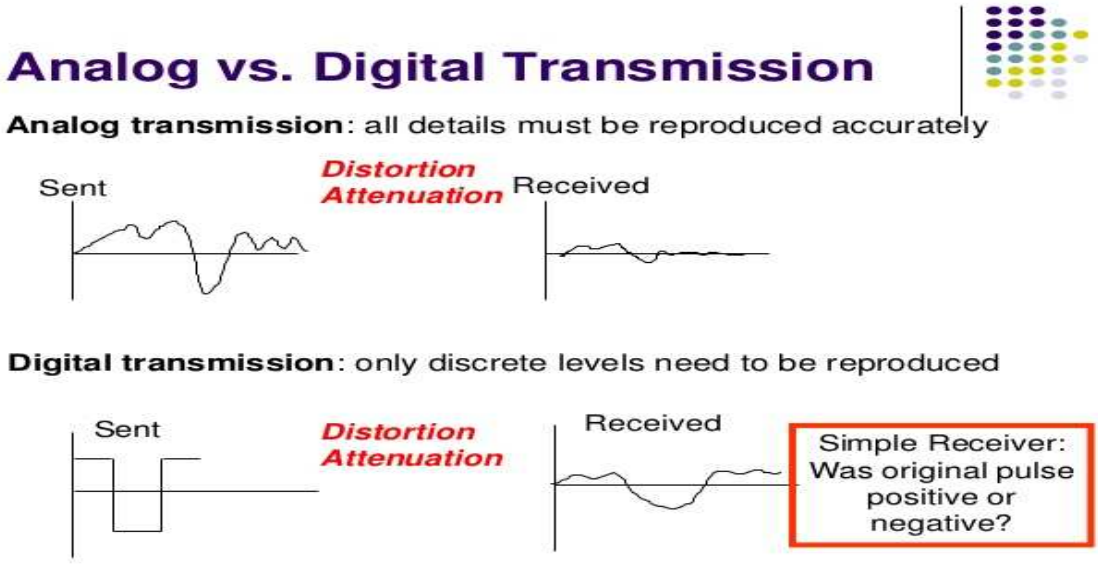
Study Session 4: Digital and Analogue Transmission



***Source**:http://www.slideshare.net/natsirt074311/3-digital-transmission-fundamentals*

Introduction

All forms of data whether text, database files, voice, images, or videos are represented in communicating devices andtransmitted over circuits using two forms of signals viz: Analogue and Digital (Clark, 2000). A signal can be described as the variation of a physical quantity, such as electriccurrent or a light wave.

Data is transmitted from one point to another point by means of electrical signals that may be in digital and analogue form. Then what are digital and analogue signals about?This study session introduces you toanalogue signal transmission and digital signal transmission.

Learning Outcomes for Study Session 4

At the end of this study session, you should be able to:

4.1 Explain analogue signal transmission

4.2 Explain digital signal transmission

4.1 Analogue Signal Transmission

Analogue signals are continuous electrical signals that vary in time. It is a continuously varying signal that has an infinite number of values between some maximum and minimum volts (Ojo, 2012). Analogue signals usually represent some physical quantity in which the transmission power varies over a continuous range with respect to sound, light and radio waves. Analogue signal is measured in Volts and its frequency is in Hertz (Hz). In an analogue audio signal, the instantaneous voltage of the signal varies continuously with the pressure of the sound waves and differs from a digital signal, in which a continuous quantity is represented by a discrete function which can only take on one of a finite number of values from 0 to 1.

The term analogue signal usually refers to electrical signals just as mechanical, pneumatic, hydraulic, human speech, and other systems may also convey or be considered analogue signals. In analogue technology, information is translated into electric pulses of varying amplitude.

It uses some property of the medium to convey the signal's information. For example, an aneroid barometer uses rotary position as the signal to convey pressure information. In an electrical signal, the voltage, current, or frequency of the signal may be varied to represent the information. Diagrammatic representation of analogue signal is shown below.

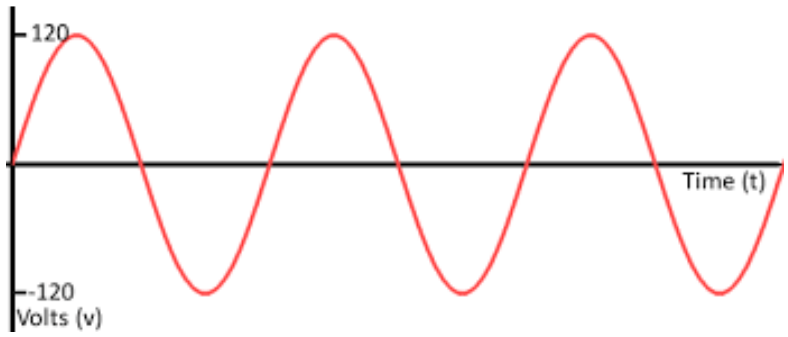


***Fig 4.1**: Analogue Signal*

Merits of Analogue Signal

a. It produces a more faithful reproduction of the physical quantity.
b. It is simple.

Demerits of Analogue Signal

a. It makes a noise and has distortion problems.

In-Text Question

Analogue signals are continuous electrical signals that vary in time. It is a continuously varying signal that has an infinite number of values between some maximum and minimum volts.TRUE or FALSE

In-Text Answer

TRUE

4.2 Digital Signal Transmission

Digital signals are non-continuous and change in individual steps. They have a finite number of steps and consist of pulses or digits with discrete levels or values. The value of each pulse is constant, but there is an abrupt change from one digit to the next. In digital technology, translation of information is in binary format (zero or one) where each bit is representative of two distinct amplitudes.

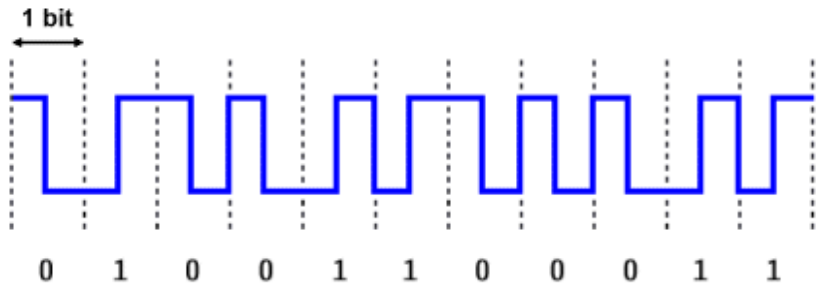


Fig 4.2: *Digital Signal*

A digital signal is a sequence of voltage represented in binary form. When digital data are to be sent over an analogue form the digital signal must be converted to analogue form through a modulation technique. And the reverse process, that is the conversion of analogue signal to its digital form, is known as demodulation.

The device, which converts digital signal into analogue, and the reverse, is known as modem. One can differentiate between analogue and digital signals. For example,

thesound waves generated by speech are converted by the telephone microphone into an analogue electrical signal.

Merits of Digital Signal

- It is immune to noise.
- It can transmit signal over long distances.
- Data integrity is maintained.
- It is better for data integration.
- It can integrate voice, video and digital data.

Demerits

a. It is complex in nature.
b. Its output is subject to quantity errors.

The terms **analogue and digital circuit or network**, and **analogue and digital communication or transmission**, refer to the form of the transmitted signal, which may differ from its original form in the communicating device.

For example, when transmitting an analogue signal over a digital circuit, e.g., voice over long-distance telephone links (today predominantly digital), an analogue-to-digital (A/D) converter is used as a network interface at the source node to transform the analogue voice signal into a digital signal (referred to as digitizing) and a digital to-analogue (D/A)converter at the destination node to reverse this process.

Similarly, when transmitting computer data over analogue circuits, as still prevalent in local telephone networks, a modem (modulator/demodulator) is used as a network interface between the computer and the transmission circuit to convert the digital computer data into an analogue transmission signal and back.

Summary of Study Session 4

In this study session, you have learnt that:

1. Analogue signals are continuous electrical signals that vary in time. It is a continuously varying signal that has an infinite number of values between some maximum and minimum volts

2. Digital signals are non-continuous and change in individual steps. They have a finite number of steps and consist of pulses or digits with discrete levels or values
3. A digital signal is a sequence of voltage represented in binary form. When digital data are to be sent over an analogue form the digital signal must be converted to analogue form through a modulation technique.
4. Merits of Analogue Signal are:
    - It produces a more faithful reproduction of the physical quantity.
    - It is simple
5. Merits of Digital Signal are:
    - It is immune to noise.
    - It can transmit signal over long distances.
    - Data integrity is maintained.
    - It is better for data integration

Self-Assessment Question for Study Session 4

Having studied this session, you can now assess how well you have learnt its learning outcomes by answering the following questions. It is advised that you answer the questions thoroughly and discuss your answers with your tutor in the next Study Support Meeting. Also, brief answers to the Self-Assessment Questions are provided at the end of this module as a guide.

SAQ 4. 1 (Test of learning outcome 4.1)

Explain analogue signal transmission

SAQ 4.2 (Test of learning outcome 4.2)

Explain digital signal transmission

References

Alshanableh, T. (2007). Data communications. Lecture Notes. Available at www.nicosia.com

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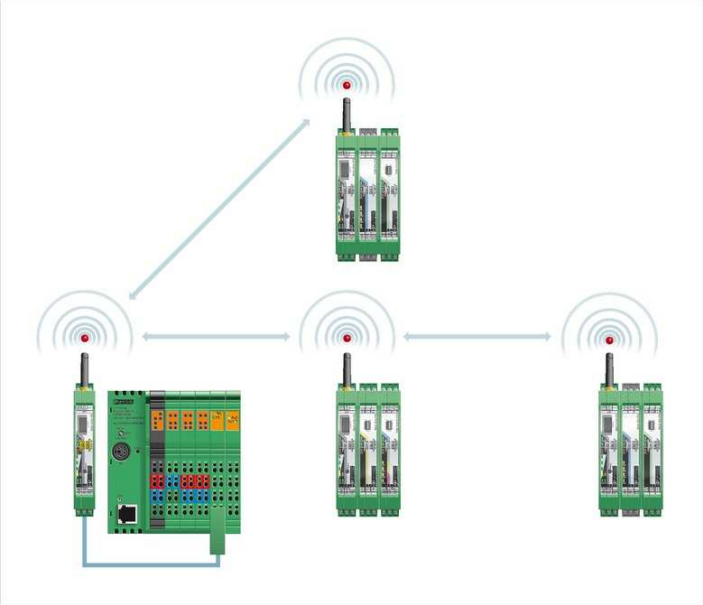
Study Session 5:
Data Transmission Modes



Source:*https://www.phoenixcontact.com/assets/images_ed/global/web_content_graph/pic_con_a_0051650_int.jpg*

Introduction

Data may be transmitted in parallel or serial form, as analogue or digital data; asynchronously and synchronously among others. Data may also be transmitted using one-to-one, one-to-many, many-to-one and many-to-many, synchronous and asynchronous modes of data transmission.

This study session you will learn thevarious modes available for data transmission and the types of communication services.

Learning Outcomes for Study Session 5

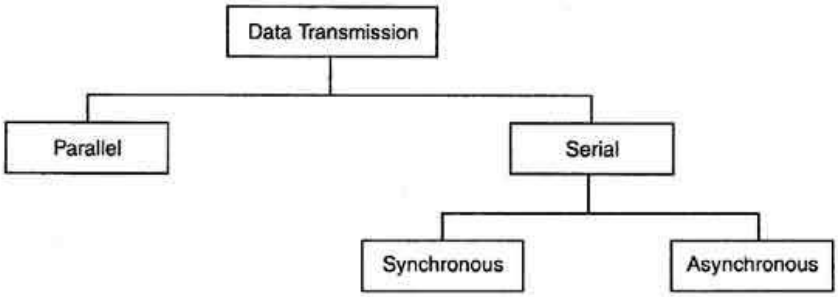
At the end of this study session, you should be able to:

1.1 Discuss the various modes available for data transmission

1.2 Enumerate the Types of Communication Services

5.1 Modes of Data Transmission

Data transmission can occur using several techniques or modes. Communication between two or more computers requires that the computer must work in such a way that the data that are sent can be correctly interpreted and that such data may be transmitted along communication channels in a number of ways each with trade-offs in speed, power requirements data integrity, equipment requirements, cost et cetera (**Imeremba**, 2008).



Source:*http://ecomputernotes.com/images//thumb475-Data-Transmission-Types-eabd448c3a00e7c1d96bb300357fefc7.jpg*

The various modes of data transmission can be categorised into

- Parallel modes of data transmission: **Simplex, half-duplex or full duplex**
- Serialmodes of data transmission: **Synchronous or asynchronous**

In case of serial/parallel data transmission, data is transmitted via parallel mode on buses with the width of the parallel bus matched to the word size of the computer system.Meanwhile for serial transmission, data is usually transmitted in bits of serial mode.

Consequently, it is necessary to make a parallel-to-serial conversion at a computer interface when sending data from a computer system into a network and a serial-to-parallel conversion at a computer interface when receiving information from a network. The type of transmission mode used may also depend upon distance and required data rate.

5.1.1: Parallel Modes of Data Transmission (Simplex, Half-duplex or Full-duplex)

Parallel transmission describes a situation in which multiple bits signals (usually 8 bits or a byte/character) are sent simultaneously on different channels (wires, frequency

channels) within the same cable, or radio path, and synchronized to a clock. Parallel data transmission involves the simultaneous transmission of several bits of data along several transmission lines (**Adeoye**, 2009).

This requires that all the bits to be transmitted should be assembled before transmission can commence; in addition all the bits should arrive at the destination simultaneously so that they can be assembled and interpreted together.

Parallel transmission is used for internal data communication within micro-computer hardware system and from micro-computer hardware systems to any nearby peripherals, e.g. printers. It is also used for data transmission within LANs (Local Area Networks). (All those uses are in view of the expensive cable and high power requirement needed for parallel transmission).

Parallel devices have a wider data bus than serial devices and can therefore transfer data in words of one or more bytes at a time. In a parallel data transmission system, each bit of the binary word to be transmitted must have its own data path. There are a variety of ways to implement this data path. The two basic classifications of transmission line circuits are single-ended and balanced.

There is a speed up in parallel transmission bit rate over serial transmission bit rate. However, this speedup is a trade off versus cost since multiple wires cost more than a single wire, and as a parallel cable gets longer, the synchronization timing between multiple channels becomes more sensitive to distance.

The timing for parallel transmission is provided by a constant clocking signal sent over a separate wire within the parallel cable; thus parallel transmission is considered synchronous.

In-Text Question

_____describes a situation in which multiple bits signals (usually 8 bits or a byte/character) are sent simultaneously on different channels (wires, frequency channels) within the same cable, or radio path, and **s**ynchronized to a clock.

a. Serial transmission
b. Parallel transmission
c. Simultaneous transmission
d. None of the above

In-Text Answer

a. Parallel transmission

1. Simplex: A simplex transmission channel can transmit signals or data in only one direction (e.g. radio and T.V broadcasts). Since this mode of transmission does not enable the receiver to communicate with the sender, simplex transmission channels are rarely used in data communication. In simplex mode, the

Only one of the two devices on a link can transmit and send messages while the other can only receive. Keyboards and traditional monitors are examples of simplex devices. The keyboard can only introduce input while the monitor can only accept output.

The simplex mode can use the entire capacity of the channel to send data in one direction. In simplex mode the communication can take place in onedirection. Since the mode of flow of information is unidirectional, it is rarely used for data communication. See Fig 12.

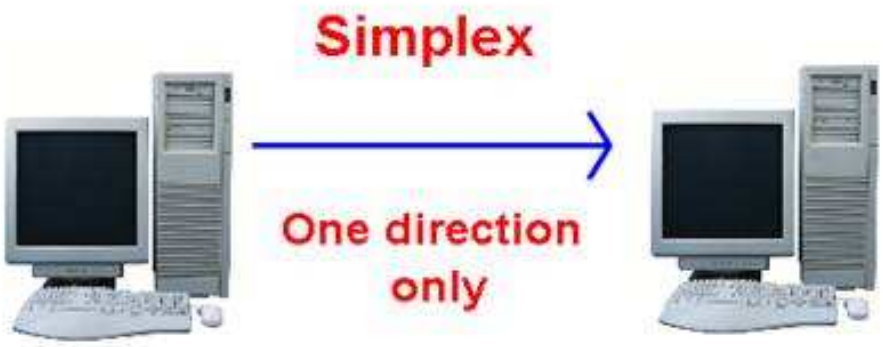


Figure 5.1 *simplex transmission channel*

2. Half-duplex: In half-duplex mode, each station can both transmit and receive, but not at the same time. In other words, when one device is sending, the other can only receive, and vice versa. The half-duplex mode is like a one-lane road with traffic allowed in both directions.

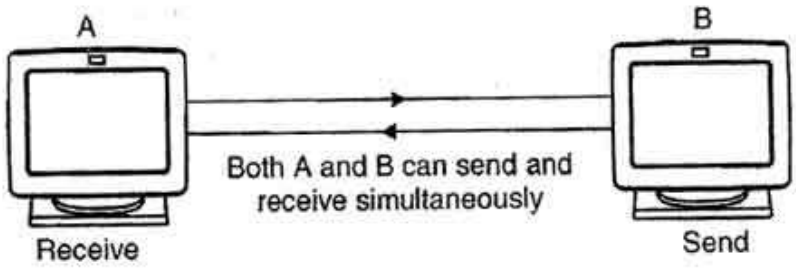
When cars are travelling in one direction, cars going the other way must wait. In half-duplex transmission, the entire capacity of a channel is taken over by whichever of the two devices is transmitting at the time. Example of half duplex device is Walkie-talkies.

In data communication networks, half-duplex channels require two modems between the sender and the receiver. These modems reverse their roles as the sender and the receiver depend on the direction of transfer. The half-duplex mode is used in cases where there is no need for communication in both directions at the same time and as such the entire capacity of the channel can be utilised from each direction. Thus, a half-duplex line can alternately send and receive data. See Fig 13.

Figure 5.2 *half duplex mode*

3. Full-duplex: In full-duplex mode (also called duplex), both stations can transmit and receive simultaneously. The full-duplex mode is like a two-way street with traffic flowing in both directions at the same time. In other words, signal can flow from both stations in both directions at the same time. Signals going in one direction share capacity of the link with signals going in the other direction.

This sharing can occur in two ways: Either the link must contain two physically separate transmission paths, for sending and the other for receiving; or the capacity of the channel is divided between signals travelling in both directions. A full-duplex channel supports simultaneous bi-direction or two-way transmission as in telephone conversation and is usually very fast, hence it is being used mostly in computer-to-computer communication.



Full duplex mode

Figure 5.3 *Full duplex*

One common example of full-duplex communication is the telephone network or mobile telecommunication system. When two people are communicating by a telephone line, both can talk and listen at same time. The full-duplex mode is used when communication in both directions is required all the time.

The capacity of the channel, however, must be divided between the two directions. In full duplex the communication channel is used in bothdirections at the same time. Use of full-duplex line improves theefficiency as the line turnaround time required in half-duplex arrangementis eliminated. Example of this mode of transmission is the telephoneline.

a. One-to-one: This is a mode of communication which takes place between two end points. It is a system in which there is only one sender and one receiver, For instance, in the case of voice communication using telephones, there is one calling party and one called party. Thus it is a point-to-point communication.

Advantages

- Fast connection and low cost of setting up.
- High degree data of privacy and security.
- It allows for active participation of the two involved parties.

Disadvantages

- ❖ It attracts a high overall cost of sharing data in the case the data is meant to be sent to more than one device.
- ❖ It is relatively less effective for disseminating information to the public.

b. One-to-many: This is the type of communication in which there is one sender and multiple recipients. For example, in voice conferencing, one person will be talking and several others can listen. The message from the sender has to be multicast to many others. This type of communication is called point-to-multipoint communication. It is applied in broadcasting as in the case of audio or video broadcasting. In a broadcasting system especially, the listeners are passive and there is no reverse communication path.

Advantages

- It is relatively faster in sending message to more than one receiver.
- It is more effective in terms of the cost of sending message to many.

Disadvantages

- It requires more system sophistication in terms of device software applications.
- It attracts a high cost of sending equipment in the case of broadcasting

c. Many-to-one: This is essentially the reverse of the broadcasting system. It is a communication mode in which there are several senders sending separate messages to a receiver simultaneously. This is the case when we have a giant mainframe computer being accessed uni-directionally by many small workstations or personal computers.

Advantages

- It enables a better and faster processing of data.
- It secures data transmission.

Disadvantages

- It requires a high cost of equipment set up.
- It is essentially a one-way communication.

d. Many-to-many: This is a multiplexing system of communication. In this mode, many senders can send separate messages simultaneously to many receiving devices. It is also a full-duplex system in which the sending and the receiving devices can

communicate simultaneously. This is widely applied today through satellite system communications.

Advantages of Many-to-many

- It is highly effective and very fast dissemination of information to large audience.
- It affords a much easier interaction in a large network of communicating devices.

Disadvantage

It necessitates a high cost of equipment and network setup.

In-Text Question

Half-duplex mode (also called duplex), both stations can transmit and receive simultaneously. It is also a two-way street mode with traffic flowing in both directions at the same time. TRUE or FALSE.

In-Text Answer

FALSE

5.1.2: Serial Modes of Data Transmission (Synchronous or Asynchronous)

In serial transmission data bits are sent and received one at a time in strict sequential order and over a single communication channel. Serial data transmission is used for long data transmission owning to its substantial immunity to noise or interference and low power requirements (**Imeremba**, 2008).

Because bits are sent sequentially in serial order on the same channel (wire), costs for wire are reduced but speed of transmission is slowed down. Therefore, some overhead time is needed since bits must be assembled and sent as a unit and then disassembled at the receiver.Serial transmission can be either synchronous or asynchronous. Since the bits time-share the transmission medium, only one interconnecting lead is required.

Advantages of Serial Data Transmission

- It is much simpler and less expensive because of the use of a single interconnecting line.
- It is useful in systems where high speed is not a requirement.

- Serial data transmission techniques are widely used in transmitting data between a computer and its peripheral units.

Disadvantages of Serial Data Transmission

a. It is a very slow method of data transmission. While the computer operates at very high speeds, most peripheral units are slow because of their electromechanical nature.

1. **Synchronous Transmission**: This is used when high speed transmission is required and when large groups of characters are normally ready for transmission at a time. Synchronous transmission involves transmitting at a time and transmitting characters as one continuous stream of bits (Charles, 2006). There are no 'start' or 'stop' bits or delays, so line capacity is not wasted.

The hardware for synchronous transmission is more expensive because it must have precisely time clocking mechanism that needs to be organised where each character begins and ends as it can carry more bits/characters than the asynchronous transmission. It is good for carrying large volumes of data.

In synchronous transmission, groups of bits are combined into frames. These frames are sent continuously with or without data to be transmitted. In other words, data are sent in packets with end and start frames. The start frame tells the beginning of the packet while the end frame marks the end of the packet.

Features of Synchronous Transmission

- It is very efficient.
- It is suited for high speed data transmission.
- The protocol has error checking capabilities.

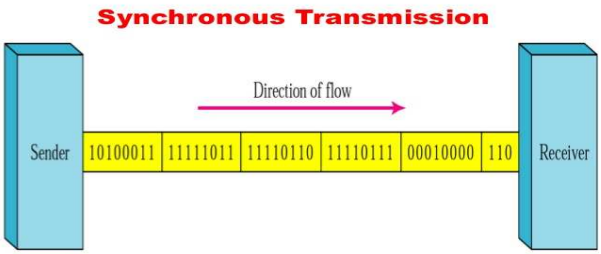


Figure 5.4 *Synchronous transmission*

2. Asynchronous transmission: This is used with relatively slow devices such as terminals. Data is transmitted in short bursts at random intervals of time. The unit of data transmission is usually a character and the bit patterns of the individual characters are enclosed between a `start' bit and a 'stop' bit to mark the beginning and end of each transmission (**Imeremba**, 2008).

The 'start' bit is a logical zero (0) while the 'stop' bit is a logical one (1). After a character is transmitted, there may be a considerable time delay before the `start' bit for the next character is transmitted.

In asynchronous transmission, data is sent one bit at a time with no clock signal transmitted. It has a start and end frame. Even when the receiver and the transmitter use the same frequency, the slightest difference can stop them running synchronously. This can be avoided when the receiver synchronizes with the transmitter frequency in intervals that should be as short as possible.

Asynchronous transmission, groups of bits are sent as independent units with start/stop flags and no data link synchronization, to allow for arbitrary size gaps between frames. However, start/stop bits maintain physical bit level synchronization once detected. In asynchronous transmission data is transmitted character by character as you go on typing on a keyboard. Hence there is an irregular gap between characters. However, it is cheaper to implement, as you do not have to save the data before sending.

Features of Asynchronous Data Transmission

a. It is not efficient because it does not include error checking.
b. It can only be used for low speed data transmission.

5.2 Types of Communication Services

A term used to describe the data-handling capacity of a communication service is bandwidth. Bandwidth is the range of frequencies that is available for the transmission of data. A narrow range bandwidth of frequencies in a communication system is analogous to a garden hose with a small diameter.

The flow of information in such a system is restricted, just as is the flow of water in the narrow hose. Wider bandwidth permits more rapid information flow. The communication data transfer rate is measured in a unit called baud. Baud is identical to bits per second. Therefore, a rate of 300 baud is 300 bits per second.

Communication companies such as American Telephone and Telegraph (AT&T) and Western Union are called common carriers, and they provide three general classes of service for both voice and data communication:

1. Narrow 0tband handles low data volumes. Data transmission rates are from 45 to 300 baud. The low-speed devices might use narrow band communications.
2. Voice-band handles moderate data transmission volumes between 300 and 9600 baud. They are used for applications ranging from operating a CRT to running a line printer. Their major application is for telephone voice communication hence, the term voice-band.
3. Broadband handles very large volumes of data. These systems provide data transmission rates of 1 million baud or more. High-speed data analysis and satellite communications are examples of broadband communication systems.

Summary of Study Session 5

In this study session, you have learnt that:

1. The various modes of data transmission can be categorised into
    - Serial or parallel;
    - Synchronous or asynchronous;
    - Simplex, half-duplex or full duplex
2. In serial transmission data bits are sent and received one at a time in strict sequential order and over a single communication channel. Serial data transmission is used for long data transmission owning to its substantial immunity to noise or interference and low power requirements.
3. Parallel transmission describes a situation in which multiple bits signals (usually 8 bits or a byte/character) are sent simultaneously on different channels (wires, frequency channels) within the same cable, or radio path, and synchronized to a clock.

Self-Assessment Question for Study Session 5

Having studied this session, you can now assess how well you have learnt its learning outcomes by answering the following questions. It is advised that you answer the questions thoroughly and discuss your answers with your tutor in the next Study Support Meeting. Also, brief answers to the Self-Assessment Questions are provided at the end of this module as a guide.

SAQ 5. 1 (Test of learning outcome 5.1)

1. Enumerate the various modes available for data transmission
2. Discuss each of the data communication in detail
3. Discuss in detail one-to-one, one-to-many, many-to-one and many-to-many data transmission modes

SAQ 5.2 (Test of learning outcome 5.2)

Describe synchronous and asynchronous data transmission mode

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Haykin, S. & Barry, V. V. (2003). *Signals and systems*. 2nd ed. Hoboken, NJ: John Wiley and Sons, Inc.

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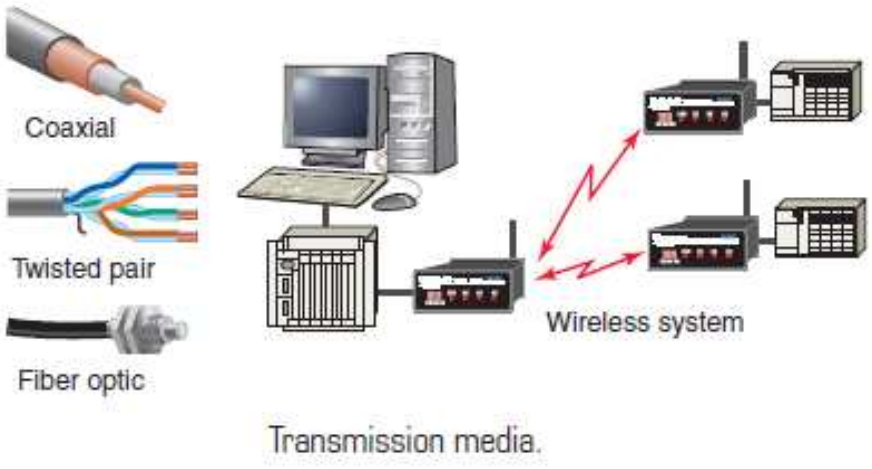
Study Session 6: Data Transmission Media



Source:*http://introautomation.com/wp-content/uploads/2015/12/Transmission-media.png*

Introduction

The transmission media are devices that allow easy transmission of data from one node to another over a distance. There are several devices that can be used in transmission and communication of data from one point to another. These devices include: Bridges, Routers, Repeaters, Gateways, Switches Modem and Multiplexers, among others. This study session you will focus on thethe various hardware media/devices used in data transmission and the types of transmission media.

Learning Outcomes for Study Session 6

At the end of this study session, you should be able to:

6.1 Discus the various hardware media/devices used in data transmission

6.2 Enumerate the types of transmission media.

6.1 Hardware Devices used in Data Transmission

1. Bridges: Bridges are hardware that is used to interconnect two similar (homogenous) networks and also links two dissimilar (heterogeneous) transmission media (fiber optic and coaxial cable).

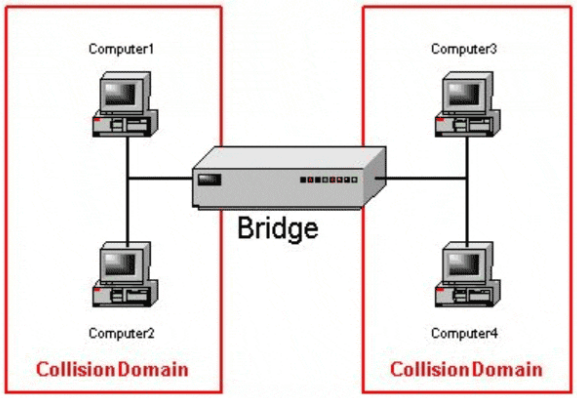


Figure 6.1: *Bridge*

Source:*http://images.ientrymail.com/networknewz/011205figure2.gif*

2. Routers: A router is a system that routes or passes messages from one local area network to another, be it homogenous or heterogeneous. This is usually used to beat the strength of signals.

Figure 6.2: *Routers*

Source:*https://heavyeditorial.files.wordpress.com/2015/08/router.jpg?quality=65&strip=all&w=780&strip=all*

3. Repeaters: These are devices that extend the span of a network by accepting the data packet and regenerate it to restore it to its original format and retransmitted. Repeaters also perform the functions of regenerations, extension of collision fragments and automatic partitioning and reconnections of the network in the event of a segment failure. This is usually used to boost the strength signal.

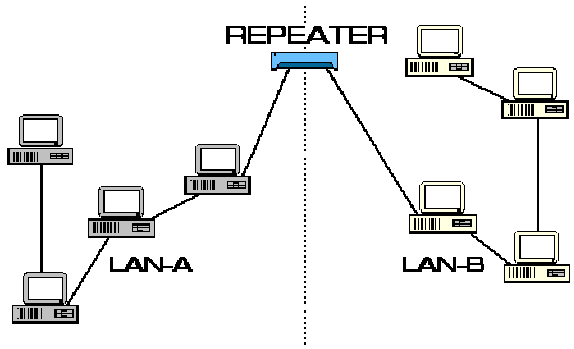


Figure 6.3: *Repeaters*

Source:*http://www.netguru.net/ntc/ntcgrap/Image21.gif*

4. Gateways: This device is used to connect heterogeneous networks with different protocols and architectures. For example, it is used to connect a linear bus network to a ring network.

Figure 6.4: *Gateways*

Source:*http://www.bluelynx.qa/images/gateway/isdn-gateway.png*

5. Switches: This is an electronic message translator between local area networks and applications, running a variety of different protocols.

Figure 6.5: *Switches*

Source:*http://www.netgear.com/images/Products/CBUFamilyPhotos/header-cbu-switches-unmanaged-plus-photo-large.png*

6. Modem

Modulation and demodulation take place in the process of data transmission or communication. Mostly, computers and other terminals are linked together with telephone line which can only carry analogue signal whereas the computers and terminals can only be used to - receive and interpret only digital signals, hence the need for a modulation and demodulation processes.

Modulation is the process by which digital signals sent out from the sending computer are converted to analogue for it to be able to pass through the telephone line to the other computer.

Demodulation is the process by which signals are converted to digital for the receiving computer to understand. The device responsible for the modulation and demodulation process is known as a MODEM i.e modulator-demodulator.

A modem (modulation-demodulator) is a device for achieving digital-analogue digital data conservation (Imeremba, 2008). In essence, modems are devices that provide the translations between the digital signals used by computers and terminals and analogue signal (in binary representation) into the normal carrier wave which is usually in sine wave form.

Figure 6.6: *Modems*
Source*:http://gizmodo.com/tag/cable-modems*

There are three types of modems viz:

- **Internal direct-connect modems** (attached to the computer hardware by a cable),
- **Internal modems** (installed inside the computer), and

- **Acoustic couplers modems** which are usually characterized by the speed at which they can load signals into the communication link as well as the method employed in timing i.e whether they are synchronous or asynchronous.

Asynchronous modems are the least complex technologically and operate at a lower speed than the synchronous modems. In essence, modems can be classified as being high speed (more than 2400 bps) or low speed (24 bps or less).

In general, the major criteria for choosing a modem are transmission rate, turn-around time, error susceptibility, reliability, cost and the basic system data volumes. Modem turn-around time is the length of time required for a modem transmitting in half duplex to shift from sending to receiving signals or vice versa.

7. Multiplexer (MUX)

A multiplexer (MUX) is a device allowing one or more low-speed analogue or digital input signals to be selected, combined and transmitted at a higher speed on a single shared medium or within a single shared device.

Thus, several signals may share a single device or transmission conductor such as a copper wire or fibre optic cable. A MUX functions as a multiple-input, single-output switch. In telecommunications the combined signals, analogue or digital, are considered as a single-output higher-speed signal transmitted on several communication channels by a particular multiplex method or technique.

With two input signals and one output signal, the device is referred to as a 2-to-1 multiplexer; with four input signals it is a 4-to-1 multiplexer et cetera. A multiplexer requires a de-multiplexer to complete the process.

Figure 6.6: *Multiplexer*

Source:*http://starrlifesciences.com/sites/default/files/styles/superhero_portfolio/public/portfolio/multiplexer_1.jpg?itok=PloFT1j6*

Often a multiplexer and a de-multiplexer are combined into a single device (also often just called a multiplexer) allowing the device to process both incoming and outgoing signals. Alternately, a multiplexer's single output may be connected to a de-multiplexer's single input over a single channel.

Either method is often used as a cost-saving measure. Since most communication systems transmit in both directions the single combined device, or two separate devices (in latter example), will be needed at both ends of the transmission line.

In-Text Question

A multiplexer (MUX) is a device allowing one or more low-speed analogue or digital input signals to be selected, combined and transmitted at a higher speed on a single shared medium or within a single shared device. TRUE or FALSE

In-Text Answer

TRUE

There are three basic approaches to multiplexing. These are:

- Time-division multiplexing
- Frequency-division multiplexing, and
- Statistical multiplexing

a. Time-Division Multiplexing (TDM)

In time division multiplexing each user or device is allocated fixed interval of time during which to transmit data. TDM uses time slicing to give each user the full bandwidth, but for only a fraction of a second at a time (analogous to time sharing in operating systems). Again, if the user does not have data to send during his time slice, the bandwidth is not used.

b. Frequency-Division Multiplexing (FDM)

In frequency division multiplexing each sender is allocated a fixed portion of the frequency spectrum of the multiplex or output line so that each sender has a high-speed output line. In FDM the frequency spectrum is divided into smaller sub-channels, giving each user exclusive use of a sub-channel (e.g., radio and TV).

One problem with FDM is that a user is given all of the frequency to use, and if the user has no data to send, bandwidth is wasted since it cannot be used by

another user. Both TDM and FDM work well with continuous transmission, in which data is generated at a constant rate (e.g. voice).

c. **Statistical Multiplexing**: SM allocates bandwidth to arriving packets on demand. This leads to the most efficient use of channel bandwidth because it only carries useful data. That is, channel bandwidth is allocated to packets that are waiting for transmission, and a user generating no packets does not use any of the channel resources.

   Hence, the reason why the phone system limits the bandwidth voice grade lines to 3kHz. This is a means of solving the problem of wastage of transmission line attached to it. A statistical multiplexor gives an unused line capacity to other terminals that are ready to transmit.

Other types of multiplexing technologies and processes include, but are not limited to:

1. Inverse Multiplexing (IMUX)
2. Wavelength Division Multiplexing (WDM)
3. Dense Wavelength Division Multiplexing (DWDM)
4. Conventional Wavelength Division Multiplexing (CWDM)
5. Reconfigurable Optical Add-Drop Multiplexer (ROADM)
6. Frequency Division Multiplexing (FDM)
7. Orthogonal Frequency Division Multiplexing (OFDM)
8. Add/Drop Multiplexing (ADM)

6.2 Types of Transmission Media

The means through which data is transformed from one place to another is called transmission or communication media. There are two categories of transmission media used in computer communications.

- Guided/Bounded media
- Unguided/Unbounded media

A. Guided Media

Guided media are the physical links through which signals are confined to a narrow path. These are also called bounded media. Bounded media are made up of an external conductor (usually Copper) bounded by jacket material.

Bounded media are great for LABS because they offer high speed, good security and low cast. However, some time they cannot be used for distance communication. Three common types of bounded media are used for data transmission. They are

- Coaxial Cable
- Twisted Pairs Cable
- Fiber Optics Cable

a. Coaxial Cable

Coaxial cable is very common & widely used commutation media. For example TV wire is usually coaxial.

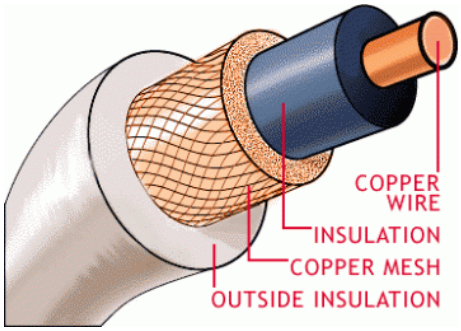


Figure 6.7: *Coaxial cable*

Coaxial cable gets its name because it contains two conductors that are parallel to each other. The center conductor in the cable is usually copper. The copper can be either a solid wire or stranded martial. Outside this central conductor is a non-conductive material.

It is usually white, plastic material used to separate the inner conductor form the outer Conductor. The other conductor is a fine mesh made from copper. It is used to help shield the cable form EMI.

Outside the copper mesh is the final protective cover. The actual data travels through the center conductor in the cable. EMI interference is caught by outer copper mesh. There are different types of coaxial cable vary by gauge & impedance.

Gauge is the measure of the cable thickness. It is measured by the Radio grade measurement, or RG number. The high the RG number, the thinner the central conductor core, the lower the number the thicker the core.

Here the most common coaxial standards.

- 50-Ohm RG-7 or RG-11 : used with thick Ethernet.
- 50-Ohm RG-58 : used with thin Ethernet
- 75-Ohm RG-59 : used with cable television
- 93-Ohm RG-62 : used with ARCNET.

Characteristics of Coaxial Cable

- Low cost
- Easy to install
- Up to 10Mbps capacity
- Medium immunity form EMI
- Medium of attenuation

Advantages of Coaxial Cable

- Inexpensive
- Easy to wire
- Easy to expand
- Moderate level of EMI immunity

Disadvantage of Coaxial Cable

- Single cable failure can take down an entire network

2. Twisted Pair Cable

The most popular network cabling is Twisted pair. It is light weight, easy to install, inexpensive and support many different types of network. It also supports the speed of **100 mbps.** Twisted pair cabling is made of pairs of solid or stranded copper twisted along each other.

The twists are done to reduce vulnerably to EMI and cross talk. The number of pairs in the cable depends on the type. The copper core is usually **22-AWG or 24-AWG, as** measured on the American wire gauge standard. There are two types of twisted pairs cabling namely:

- Unshielded twisted pair (UTP)
- Shielded twisted pair (STP)

i. Unshielded Twisted Pair (UTP)

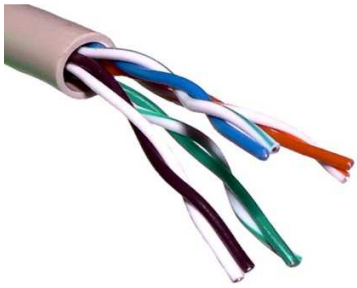


Figure 6.8: *UTP*

UTP is more common. It can be either voice grade or data grade depending on the condition. UTP cable normally has an impedance of 100 ohm. UTP cost less than STP and easily available due to its many use. There are five levels of data cabling.

Characteristics of UTP

- low cost
- easy to install
- High speed capacity
- High attenuation
- Effective to EMI
- 100 meter limit

Advantages of UTP

- Easy installation
- Capable of high speed for LAN
- Low cost

Disadvantages of UTP

- Short distance due to attenuation

ii. Shileded Twisted Pair(STP)

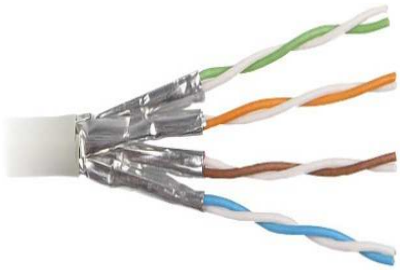


Figure 6.9: *Shielded Twisted Pair*

It is similar to UTP but has a mesh shielding that's protects it from EMI which allows for higher transmission rate.

Characteristics of STP

- Medium cost
- Easy to install
- Higher capacity than UTP
- Higher attenuation, but same as UTP
- Medium immunity from EMI
- 100 meter limit

Advantages of STP

- Shielded
- Faster than UTP and coaxial

Disadvantages of STP

- More expensive than UTP and coaxial
- More difficult installation
- High attenuation rate

3. Fiber Optics

Fiber optic cable uses electrical signals to transmit data. It uses light. In fiber optic cable light only moves in one direction for two way communication to take place a second connection must be made between the two devices. It is actually two stands of cable.

Each stand is responsible for one direction of communication. A laser at one device sends pulse of light through this cable to other device.

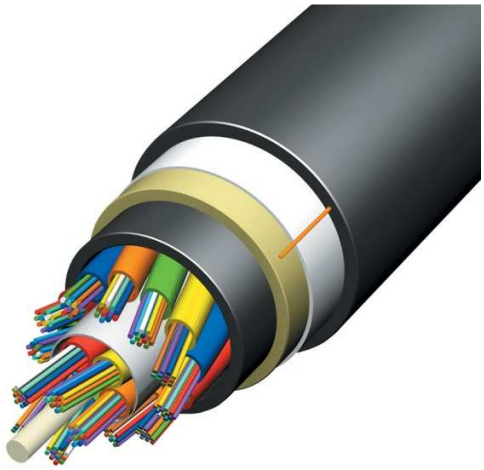


Figure 6.10*Optic fibre*

Source: https://www.aflglobal.com/Products/Fiber-Optic-Cable/ADSS.aspx

These pulses translated into "**1's**" and "**0's**" at the other end. In the center of fiber cable is a glass stand or core. The light from the laser moves through this glass to the other device around the internal core is a reflective material known as **Cladding**. No light escapes the glass core because of this reflective **cladding.**Fiber optic cable has bandwidth more than **2 gbps** (Gigabytes per Second)

Characteristics of Fiber Optic Cable

- Expensive
- Very hard to install
- Capable of extremely high speed
- Extremely low attenuation
- No EMI interference

Advantages of Fiber Optic Cable

- Fast
- Low attenuation
- No EMI interference

Disadvantages od Fiber Optics Cable

- Very costly
- Hard to install

B. Unguided Media

Unbounded /Unguided media **or** wireless media doesn't use any physical connectors between the two devices communicating. Usually the transmission is send through the atmosphere but sometime it can be just across the rule. Wireless media is used when a physical obstruction or distance blocks are used with normal cable media. The three types of wireless media are:

- Radio waves
- Micro waves
- Infrared waves

a. Radio Waves

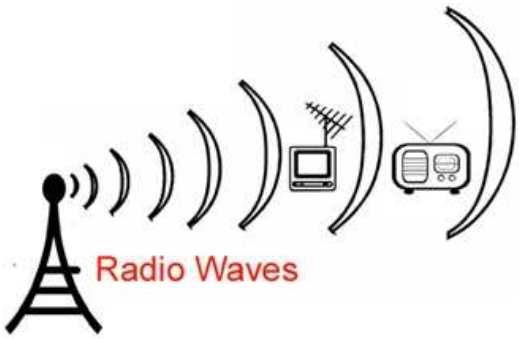


Figure 6.11 *Radio waves*

Source*: http://www.mayankgandhi04.com/2016/01/holographic-universe-and-brain-leela.html*

It has frequency between 10 K Hz to 1 G Hz. Radio waves are of the following types.

- Short waves
- VHF (Very High Frequency)
- UHF (Ultra High Frequency)

There are different types of antennas used for radio waves. Radio waves transmission can be divided into following categories.

- Low Power, Single Frequency
- High Power, Single Frequency

i. Low Power, Single Frequency

As the name shows this system transmits from one frequency and has low power out. The normal operating ranges on these devices are 20 to 25 meter.

Characteristics of Low Power, Single Frequency

- Low cost
- Simple installation with pre-configured settings
- 1 Mbps to 10 Mbps capacity
- Low attenuation
- Low immunity to EMI

ii. High Power, Single Frequency

This is similar to low power single frequency. These devices can communicate over greater distances.

Characteristics of High Power, Single Frequency

- Moderate cost
- Easier to install than Low Power, Single Frequency
- 1 Mbps to 10 Mbps of capacity
- Low attenuation for long distances
- Low immunity to EMI

b. Micro Waves

Micro waves travels at high frequency than radio waves and provide through put as a wireless network media. Micro wave transmission requires the sender to be inside of the receiver.

Following are the types of Micro waves:

- Terrestrial Micro waves
- Satellite Micro waves

i. Terrestrial Micro Waves

Terrestrial Micro waves are used are used to transmit wireless signals across a few miles. Terrestrial system requires that direct parabolic antennas can be pointed to each other. These systems operate in a low Giga Hertz range.

Characteristics of Terrestrial Microwaves

- Moderate to high cost
- Moderately difficult installation
- 1 Mbps to 10 Mbps capacity
- Variable attenuation
- Low immunity to EMI

ii. Satellite Microwaves

The main problem with aero wave communication is the curvature of the earth, mountains, and other structure often block the line of the side. Due to this reason, many repeats are required for long distance which increases the cost of data transmission between the two points. This problem is recommended by using satellites.

Satellite microwave transmission is used to transmit signals throughout the world. These system use satellites in orbit about 50,000 Km above the earth. Satellite dishes are used to send the signals to the satellite where it is again send back down to the receiver satellite. These transmissions also use directional parabolic antenna' with in line of side.

In satellite communication microwave signals at 6 GHz is transmitted from a transmitter on the earth through the satellite position in space. By the time signal reaches the satellites becomes weaker due to 50,000 Km distance. The satellite amplifies week signals and transmits it back to the earth at the frequency less than 6 GHz.

Characteristics Satellite Microwaves:

- High cost
- Extremely difficult and hard installation
- Variable attenuation

- Low immunity to EMI
- High security needed because a signal send to the satellite is broadcast through all receivers within the satellite

c. Infrared

Infrared frequencies are just below visible light. These high frequencies allow high sped data transmission. This technology is similar to the use of a remote control for a TV. Infrared transmission can be affected by objects obstructing sender or receiver. These transmissions fall into two categories:

- Point-to-point
- Broadcast

i. Point-to-point

Point to point infrared transmission signal directly between two systems. Many lap top system use point to pint transmission. These systems require direct alignment between many devices.

Characteristics of Point to point

- Wide range of cost
- Moderately easy installation.
- 100 k bps to 16 Mb of capacity.
- Variable attenuation.
- High immunity to EMI

ii. Broad Cast

These infrared transmission use sprayed signal, one broad cast in all directions instead of direct beam. This help to reduce the problems of proper alignment and abstraction. It also allows multiple receiver of signal

Characteristics of Broad Cast

- In expensive.
- Single installation.
- 1 Mbps capacity.
- Variable attenuation.

Summary of Study Session 6

In this study session, you have learnt that:

1. The Hardware Devices used in Data Transmission are
   - Bridges
   - Routers
   - Repeaters
   - Gateways
   - Switches
   - Modem
   - Multiplexer (MUX)
2. The means through which data is transformed from one place to another is called transmission or communication media. There are two categories of transmission media used in computer communications.
   - Guided/Bounded media
   - Unguided/Unbounded media

. 3. Three common types of bounded media are used for data transmission. They are

- Coaxial Cable
- Twisted Pairs Cable
- Fiber Optics Cable

Self-Assessment Question for Study Session 6

Having studied this session, you can now assess how well you have learnt its learning outcomes by answering the following questions. It is advised that you answer the questions thoroughly and discuss your answers with your tutor in the next Study Support Meeting. Also, brief answers to the Self-Assessment Questions are provided at the end of this module as a guide.

SAQ 6. 1 (Test of learning outcome 6.1)

Describe the various hardware media/devices used in data transmission

SAQ 6.2 (Test of learning outcome 6.2)

Identify the types of transmission media

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Study Session 7: Data Transmission Cables

Source: *http://www.dreamstime.com/stock-image-data-transmission-cables-patch-bay-image18559711*

Introduction

Cable is the medium through which information moves from one network device to another. There are several types of cables which are commonly used within a network. The type of cable chosen for a network is related to the network topology, protocol, and size.

The types of Cables used in a computer network and other ICT installations include: Twisted pair cable, Coaxial cable, Fibre optic cable, Microware link and Satellite link.

In this study session, you will learn the various cables used in data transmission.

Learning Outcomes for Study Session 7

At the end of the study Session, you should be able to:

7.1 Discuss the various cables used in Data Transmission

7.1 Various used in Data Transmission

The following are lists of various cables that are used in data transmission.

7.1.1 Twisted pair cable

The twisted pair cable (TPC) is the familiar wire used for connecting a telephone to the telephone jack. It consists of two insulated copper wires twisted together and is one of the oldest and most widely available cable/medium. The twisted pair cable is prevalent in buildings and for local telephone network links (the local loop), and is inexpensive to install.

However, it can only be used for short links up to about 1km digital transmission because of significant electrical interference (created by the close proximity of the two wires) and rapid signal degradation over long distances. Data transmission speed is normally 9600 bits per second in a distance of 100 meter.

The twisting in TPC reduces electrical interference. The shielded cable has increased amount of insulation hence it is non-immune. The unshielded is used by telephone companies.

In-Text Question

What is the full meaning of TPC?

In-Text Answer

Twisted Pair Cable

Weakness

There is a limit to the speed and distance signals can travel on TPC, e.g. 10 Base T

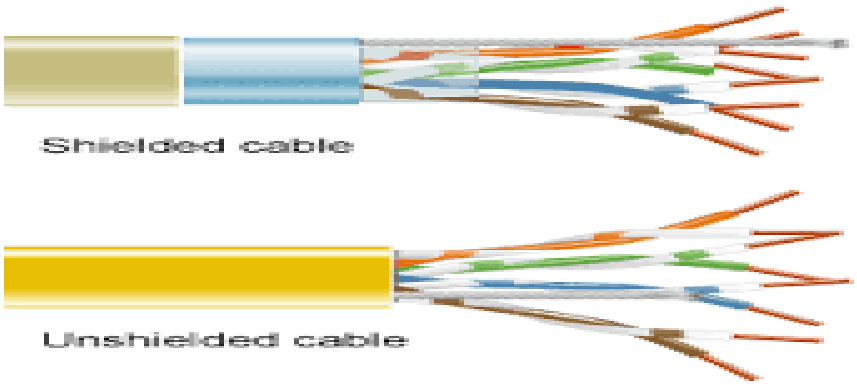


Figure 7.1: Twisted pair cable

7.1.2 Coaxial cable

The coaxial cable is the familiar cable used for connecting a television set to the cable TV jack. It consists of acylindrical copper wire and outer conductor, separated by insulating material and protected by a plastic sheath.It is widely used for local area network, long-distance telephone links, and cable television.

Coaxial cable can carry moredata than twisted pair due to lower electrical interference but it is more expensive. Due to rapid signaldegradation, coaxial links require amplifiers every few hundred feet to maintain high data rates.

Coaxial cable belongs to the groups of specially wrapped andinsulated wires that are able to transfer data at higher rate. They consistof a central copper wire surrounded by an insulation over which coppermesh is placed.

They are used for long distance telephone lines and local area network for their noise immunity and faster data transfer. Specially wrapped and insulated wire lines that are able to transmit data at high rates.

Coaxial cables are of two types viz:

1. ThinNet
2. ThickNet

- ThinNet coaxial cables are single conductor wire within a shielded enclosure. They can be laid underground or undersea and transmit data (10 Base 2) carries signals over short distances.
- ThickNet coaxial cable (10 Base 5) has greater immunity for noise and is more durable.

Figure 7.2: Coaxial cable.

In-Text Question

……..is the cable used for connecting a television set to the cable TV JACK?

In-Text Answer

Coaxial Cable

7.1.3 Fibre-Optic or Optical fibre

It consists of a single bundle of hair-like glass fibre along which signals travel as pulses of light. It uses laser light instead of electricity to carry information for transmission at high speed and is very immune to interference, even though it is expensive.

Data is transmitted by optical signals on fibre optic links, made of very thin glass or plastic fibre, which are progressively replacing coaxial cable for long-distance telephone transmission and are increasingly being used in high speed local area networks.

The optical signals are insensitive to electrical interference and essentially do not degrade, which leads to data rates and ranges that are orders of magnitude higher than those of any other medium. However, using fibre also requires substantial investments for hardware components, e.g., switches handling the optical signals.

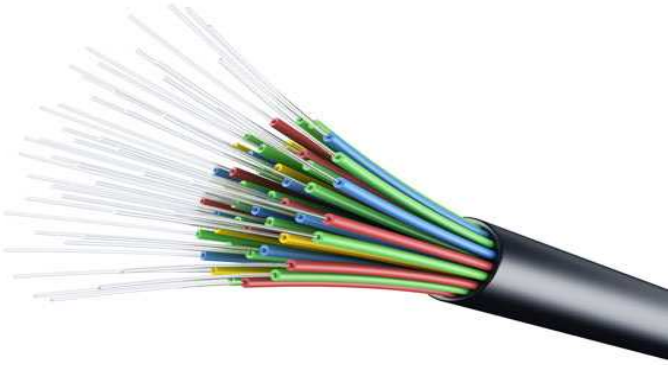


Figure 7.3: Fibre Optic cable

Advantages of Fiber-optic

Fibre optic or Optical fibre cable has several advantages over metallic cable (twisted-pair or coaxial).

- Higher bandwidth: Fibre-optic cable can support dramatically higher bandwidths (and hence data rates) than either twisted-pair or coaxial cable. Currently, data rates

and bandwidth utilisation over fibre-optic cable are limited not by the medium but by the signal generation and reception technology available.

- Less signal attenuation: Fibre-optic transmission distance is significantly greater than that of other guided media. A signal can run for 50 km without requiring regeneration unlike coaxial or twisted-pair cable which requires a repeater for every 5km distance.
- Immunity to electromagnetic interference: Electromagnetic noise cannot affect fibre-optic cables.
- Resistance to corrosive materials: Glass is more resistant to corrosive materials than copper.Light weight. Fibre-optic cables are much lighter than copper cables.
- Greater immunity to tapping: Fibre-optic cables are more immune to tapping than copper cables. Copper cables create antenna effects that can easily be tapped.

Disadvantages of Fibre-Optic

There are some disadvantages in the use of optical fibre which include:

- Installation and maintenance: Fibre-optic cable is a relatively new technology. Its installation and maintenance require expertise that is not yet available everywhere.
- Unidirectional light propagation: Propagation of light is uni-directional, hence if there is need for bidirectional communication, two fibres would be needed.
- Cost: The cable and the interfaces are relatively more expensive than those of other guided media. If the demand for bandwidth is not high, often the use of optical fibre cannot be justified.
- Microware link: Microwaves are electromagnetic waves which travel in a straight line and uses very high frequency radio signals to transmit data through space. The transmitter and receiver of a microwave system should be in line-of-sight because the radio signal cannot bend. With microwave very long distance transmission is not possible.

In-Text Question

Electromagnetic noise cannot affect ……

In-Text Answer

Fibre-Optic Cable

In order to overcome the problems of line of sight and power amplification of weak signal, repeaters are used at intervals of 25 to 30 kilometres between the transmitting and receiving end. The quality of the signals reduces as they move further away from the source.

There are microwave towers serving to the next station. It is used for wireless connection.

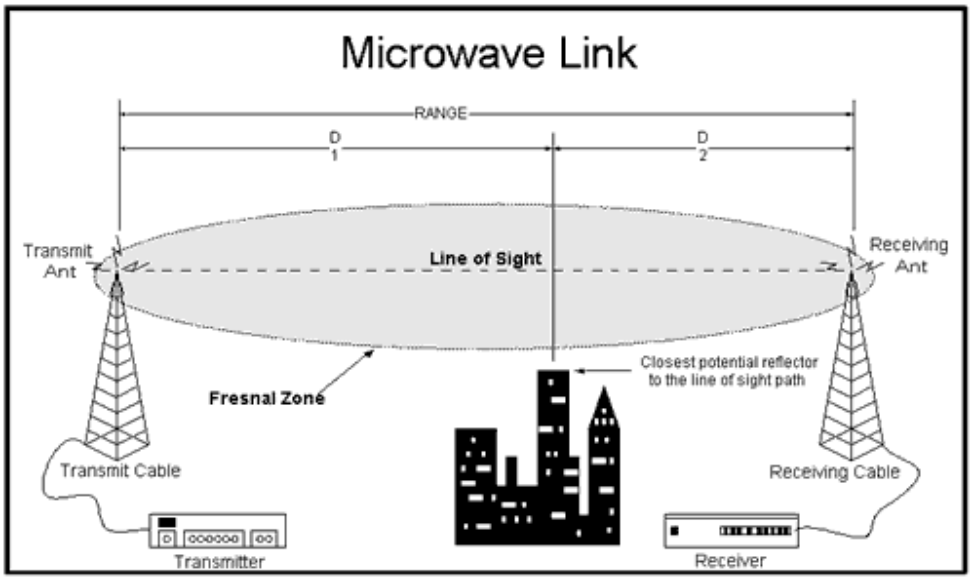


***Figure 7.4**: Microwave link*

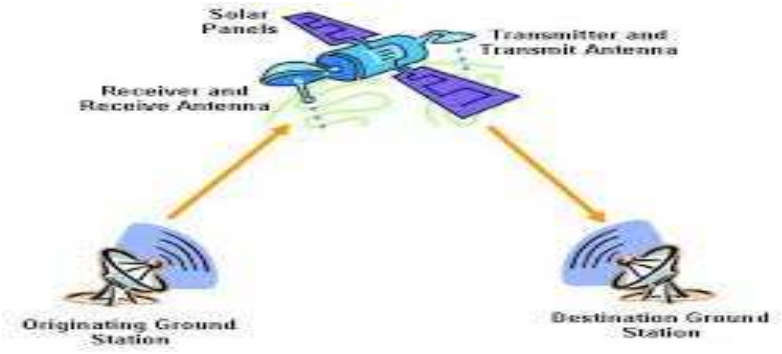
- Satellite link: Communication satellites in the sky above the equator relay signals through free space and air from one ground station to another, thus covering an area hundreds of miles in diameter.

Therefore, satellites are excellent for cost-efficient communication over large areas with little infrastructure. They are used for television networks and by private networks to bypass the telephone system. However, transmission via satellite is subject to a substantial delay due to the long distance being travelled.

The problem of line-sight and repeaters are overcome by using satellites which are the most widely used data transmission media in modern days.

In satellite communication, microwave signal is transmitted from a transmitter on earth to the satellite at space. The satellite amplifies the weak signal and transmits it back to the receiver. The main advantage of satellite communication is that it is a single microwave relay station visible from any point of a very large area.

In microwave the data transmission rate is 16 giga bits per second. They are mostly used to link big metropolitan cities. Satellite is permanently stationed at a point on the planet so that it is continuously available for communication with all the points within its range as it revolves at the same speed of the earth, so that earth-bound microwave is always in-tune with it without continual adjustment. It makes use of wireless connection.



Summary of Study Session 7

Cables are important ingredients of telecommunications system because they are the media through which data are transmitted and communication within a network.

- This study session discussed the various types of cables that can be used in connecting devices in a computer network or telecommunications system, equally highlighting the strengths and weaknesses of each connecting medium.
- The twisted pair cable (TPC) is the familiar wire used for connecting a telephone to the telephone jack.
- The coaxial cable is the familiar cable used for connecting a television set to the cable TV jack.
- It consists of a single bundle of hair-like glass fibre along which signals travel as pulses of light. It uses laser light instead of electricity to carry information for transmission at high speed and is very immune to interference, even though it is expensive.

Self-Assessment Question (SAQs) for Study Session 7

Now that you have completed this study session, you can assess how well you have achieved its Learning outcomes by answering the following questions. Write your answers in your study Diary and discuss them with your Tutor at the next study Support Meeting. You can check your answers with the Notes on the Self-Assessment questions at the end of this Module.

SAQ 7.1 (Tests Learning Outcomes 7.1)

List the data transmission cables you know.

Attempt a recommendation of data transmission cable for a local area network

Discuss vividly the strengths and weaknesses of fibre-optic cable

References

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Study Session 8: Protocols

***Source**: http: //ikkaaarw.blogspot.com.ng/2014/05/ict-and-multimedia-fundamentals.html*

Introduction

In computer networks, communication occurs between entities in different system. Entity is anything capable of sending or receiving information. However, two entities not simply send bit streams to each other and expect to be understood. For communicate to occur, the entities must agree on a protocol. In this study session you will learn about he basics of internet protocols.

Learning Outcomes for Study Session 8

At the end of the study Session, you should be able to:

8.1 Explain the Basics of Internet Protocols

8.1 Internet Protocols

Since data within a network must travel over a variety of channels, such as telephone lines, microwave signals and satellite signals, a standardised set of procedures is required for specifying how electronic component terminals, computers and networks are designed. These standardized sets are called protocols. A protocol is a set of rules that govern communications.

A protocol defines what is communicated, how it is communicated and when it is communicated (Freeman, 1999). A communication protocol is a format set of rules governing the format and relative timing of message exchange between communication devices.

Protocols are standard sets of rules that govern network communication functions by describing both the format that a message must take and the way in which messages are exchanged between computers.

On the other hand, telecommunications protocols are procedures and rules for transferring data across the internet. The original participant of the internet, mostly universities uses TCP/IP which is now the internet protocol (IP).

In-Text Question

What is Protocols?

In-Text Answer

Protocols are standard sets of rules that govern network communication functions by describing both the format that a message must take and the way in which messages are exchanged between computers.

The information that passes through the internet is divided into small portions, called packets, whose creation and transmission are governed by TCP/IP to provide for more consistent delivery and control.

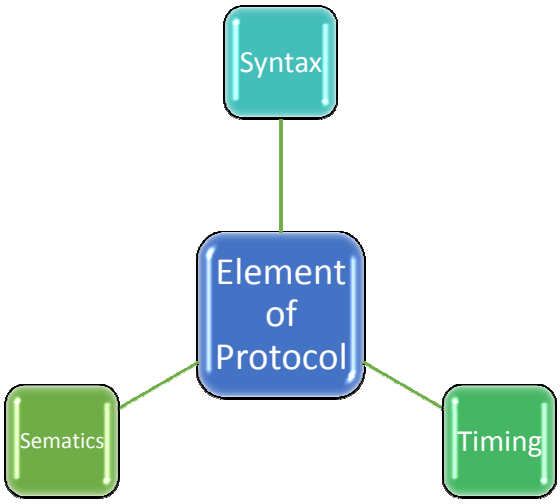

Figure 8.1 *Elements of Protocol*

The key elements of a protocol are syntax, semantics, and timing.

- **Syntax:** The term syntaxrefers to the structure or format of the data, meaning the order in which they are presented. For example, a simple protocol might expect first 8 bits of data to be the address of the sender, the second 8 bits to be at the end of the receiver, and the rest of the stream to be the message itself.
- **Semantics:** The word semanticsrefers to the meaning of each section of the message and describes how a particular pattern is to be interpreted.
- **Standards:** These are a set of rules or specifications for the design or operation of a computing device.

There are proprietary standards, which are those developed and promulgated by companies in the hope of assuring or increasing their market share. There are also open standards, which are published and available for use by anyone.

Either type may become a standard, a set of rules or specifications that comes into widespread use in the market place that it becomes the normative standard given the endorsement of an official standards body such as the International Organization for Standardization (ISO).

In-Text Question

From above passage, …….. structure or format of the data, meaning the order in which they are presented.

In-Text Answer

Syntax.

Quite often the word standard is used to refer to industry standards (i.e. relatively stable principles and practices applied by leading manufacturers). This is a very vague concept. Between official standards and industry standards, there is a wide range of standards that have been agreed on in some form.

Each computer on the Internet has an assigned address, called the IP (Internet Protocol) address that uniquely identifies and distinguishes it from all other computers. The IP numbers have four parts, separated by dots.

For example, the IP address of one computer might be 135.62.128.91.Most computers also have names, which are easier for people to remember than IP addresses.

These names are derived from a naming system called the domain name system (DNS).

1. **Domain names** consist of multiple parts, separated by dots, and are translated from right to left. For example, consider the name ui.edu.ng. The rightmost part of an Internet name, in this case ‘edu.ng’ is its top-level domain or the zone. The abbreviation ‘edu’ indicates that this is an education site based in Nigeria.
2. **Generic top-level domain (TLD**) is a top-level domain used (at least in theory) by a particular class of organization. These are three or more letters long, and are named for the type of organization that they represent.
   For example, .com for commercial organisations. The following TLDs currently exist:

- .aero for the air transport industry
- .biz for business use
- .cat for Catalan language/culture
- .com for commercial organizations but unrestricted
- .coop for cooperatives
- .edu for postsecondary educational establishments
- .gov for government and their agencies in the United States

Summary of Study Session 8

Protocols and standards are keys to effective transmission of messages on the Internet.

- This study gave a vivid description of protocols and standards as well as associated procedures adopted on the Internet.
- Protocols are standard sets of rules that govern network communication functions by describing both the format that a message must take and the way in which messages are exchanged between computers.
- The term syntaxrefers to the structure or format of the data, meaning the order in which they are presented.
- The word semanticsrefers to the meaning of each section of the message and describes how a particular pattern is to be interpreted.
- These are a set of rules or specifications for the design or operation of a computing device.

Self-Assessment Question (SAQs) for Study Session 8

Now that you have completed this study session, you can assess how well you have achieved its Learning outcomes by answering the following questions. Write your

answers in your study Diary and discuss them with your Tutor at the next study Support Meeting. You can check your answers with the Notes on the Self-Assessment questions at the end of this Module.

SAQ 8.1 (Tests Learning Outcomes 8.1)

Describe, protocols, standards, and domain names.

Define Internet Protocol

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Study Session 9: History of Information Network

Source:*http://www.123rf.com/stock-photo/information_system.html*

Introduction

The emergence of information networks can be traced back to the late 1960s and early 1970s in the United States of America at the U.S. Department of Defense (US-DOD). Precisely in 1969, the Advanced Research Project Agency (ARPA) of the United States of America Department of Defence (DOD) initiated a research project to link computers together for resource sharing.

The objective of the whole project was to build a communication system that would withstand catastrophes and still be functional. The history of information network will be the topic of interest you will learn in this session.

Learning Outcomes for Study Session 9

At the end of the study Session, you should be able to:

9.1 Discuss the history of information network

9.1 History of Information Network

ARPANET was designed to prevent nuclear strike of the USSR from disabling all military computers, capability. The 1960's was the period of "armament race" when both the East and West were pursuing researches that would give them military domination of the world. The cold war generated interest in a 'bomb-proof" network in the military bases.

The arrangement was such that the network would be a peer-to peer without a central host. This idea was chosen so that if any part of the network was destroyed by nuclear attack, the remaining would still go on communicating.

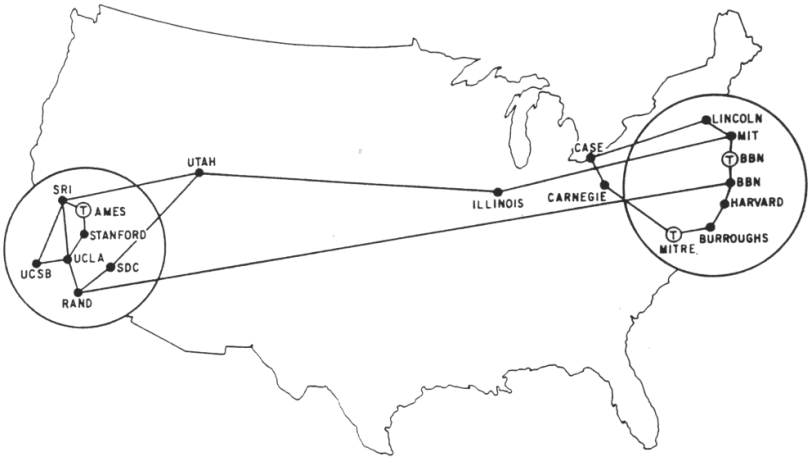

Figure 9.1: *Diagrams of ARPANET*
Source*:*
https://personalpages.manchester.ac.uk/staff/m.dodge/cybergeography/atlas/historical.html

The ARPANET grew to include scientists and researchers across the country and in 1983 APPANET split into two as: MILNET: The Military portion of ARPANET and ARPANET which is purely for research. Other commercial network, cooperative networks and company networks started springing up as a result of the success of ARPANET.

In 1984 JANET (Joint Academic Network) came on board to link all universities and research institutions and also to provide access to the outside world. From this period, the network developed to such a level that it became internationally operational and great numbers of computer networks, which are united by a familiar addressing system were easily connected to aid communication.

In the ARPANET network model, communication will always occur between two computers: a source (the local terminal) and a destination (the remote terminal). It was designed to require minimum information from each end.
To send a message through the network all one had to do was put its data into an envelope called Internet Protocol (IP) packet and switchit over to the destination with the correct "address". With *this packet switching* technique, the source and destination computers were responsible for making sure that the packets get from one end to the other.

In-Text Question
……. was designed to prevent nuclear strike of the USSR
In-Text Answer
ARPANET.

Since the network itself was supposed to be unreliable and any portion of it could disappear without notice, the network was built around the idea that each computer would be able to serve as a pier or levee with any other computer.
If for some reason some part of it were unavailable between the source and destination computers, the machines would automatically trace the next best route among the two and proceed to deliver the message.
This model of networking proved to be very reliable because it not only permitted flawless connections but it also provided the only practical method for computers from different manufacturers to communicate. This was a very attractive idea for universities and other large institutions which did not own one standard set of computers.
Furthermore, as technology evolved and computer prices dropped, manufacturers started to put TCP/IP protocol into their machines. It was not too long before research institutions, libraries and large corporations started adopting the protocol to connect their computers together. This new demand started a communication standard that all institutions took benefit of.

In-Text Question
Sending message of data through the network is called ……
In-Text Answer
Internet Protocol.

Since then, the Internet has not stopped growing. It is the fastest growing system of human communication in history. It has grown faster than telephone, television or fax. It currently connects over 200,000,000 computers, more than 500,000,000 users and grows 25% each month(Tracy, 2006).

Summary of Study Session 9

This lecture traced the historical development of information network from the beginning of the armament war between the US AND USSR between late 1960s and early 1970s.

- The ARPANET grew to include scientists and researchers across the country and in 1983 APPANET split into two as: MILNET: The Military portion of ARPANET and ARPANET which is purely for research. Other commercial network, cooperative networks and company networks started springing up as a result of the success of ARPANET.
- 1984 JANET (Joint Academic Network) came on board to link all universities and research institutions and also to provide access to the outside world.
- In 1984 JANET (Joint Academic Network) came on board to link all universities and research institutions and also to provide access to the outside world.

Self-Assessment Question (SAQs) for Study Session 9

Now that you have completed this study session, you can assess how well you have achieved its Learning outcomes by answering the following questions. Write your answers in your study Diary and discuss them with your Tutor at the next study Support Meeting. You can check your answers with the Notes on the Self-Assessment questions at the end of this Module.

SAQ 9.1 (Tests Learning Outcomes 9.1)

Discuss the role of ARPANET in the development of information network

Trace the history of information network development.

References

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Study Session 10: Historical Development of Telecommunication System

Source:*https://en.wikipedia.org/wiki/Telecommunications_in_China*

Introduction

Telecommunication networks carry information signals among entities, which are geographically far apart (Adewale, 2007). An entity may be a computer or human being, a facsimile machine, a tele-printer, a data terminal and so on.

The entities are involved in the process of information transfer which may be in the form of a telephone conversation (telephony) or a file transfer between two computers or message transfer between two terminals etc.

Learning Outcomes for Study Session 10

At the end of the study Session, you should be able to:

10.1 Discuss the historical development of telecommunications system

10.1 Historical Development of Telecommunications

Telecommunication is a general term for a vast array of technologies that send information over distances. Mobile phones, landlines, satellite phones and voice over internet protocol (VOIP) are all telephony technologies. Radio and television are also examples of telecommunication. Arzika (2000) defines telecommunications as the transmission of signals over a distance for the purpose of sharing information.

Telecommunication process involves the sending of electromagnetic waves by electronic transmitters and has completely changed the rate and manner of information dissemination in the whole world (Okafor, 2012). It is undoubtedly, the greatest facilitator and guarantor of global information flow.

Figure 10.1:*Telecommunication*

Source*: http://binagroup.com.my/telecommunications-services/*

The development of telephone was generally traced to Alexander Graham Bell who was described as the man behind the hello machine" (Bitner as cited in Etukudo, 2009).

After several attempts and research, Bell was granted patent between 1875 and 1877 in Washington DC. It was the efforts of Graham Bell in association with Gardiner Greene Hubbard, Thomas Sanders and Watson that resulted in the first telephone company, Bell Telephone Company in 1877.

In-Text Question

Telephone was originated by ……..

In-Text Answer

Alexander Graham Bell

Today it is almost truism to state that telecommunication systems are the symbol of our information age. With the rapidly growing traffic and untargeted growth of cyberspace, telecommunication becomes a fabric of life. The future challenges are enormous as rapid growth of items of new services and number of users are anticipated.

What comes with the challenge is a genuine need for more advanced methodology supporting analysis and design of telecommunication architectures. Telecommunication

is evolving and growing at an explosive rate in recent years and will undoubtedly continue to do so.

The communication switching system enables the universal connectivity. The universal connectivity is realized when any entity in one part of the world can communicate with any other entity in another part of the world. In many ways telecommunication will acts as a substitute for the increasingly expensive physical transportation.

In-Text Question

Bell Telephone Company in 1877 started by ……..

a. Graham Bell, Gardiner Greene Hubbard, Thomas Sanders, Watson
b. Gardiner Greene Hubbard, Graham, Watson.
c. Thomas Sanders, Graham Bell, Watson,
d. Watson, Thomas Sanders, Bell.
e. None of the above

In-Text Answer

a. Graham Bell, Gardiner Greene Hubbard, Thomas Sanders, Watson

The telecommunication links and switching were mainly designed for voice communication and with the appropriate attachments/equipments they can be used to transmit data. A modern society, therefore needs new facilities including very high bandwidth switched data networks, and large communication satellites with small, cheap earth antennas.

Figure 10.2: *Telephone*

Source:*https://en.wikipedia.org/wiki/Telephone*

The purpose of a telecommunication switching system is to provide the means to pass information from any terminal device to any other terminal device selected by the originator.

Telecommunication system can be divided into four main parts viz:

- End system or Instruments
- Transmission system
- Switching system and
- Signaling

10.1.1 End Systems or Instruments

The end system or instrument are transmitters or receivers that are responsible for sending information or decoding or inverting received information or message into an intelligible message (Freeman, 1999). They have evolved from analogue telephones to digital handsets and cellular phones.

However, endless arrays of other devices are being attached to telephone lines, including computer terminals used for data transmission.

10.1.2 Transmission System

Signals generated by the end system or the instruments are transported to the destination by some means. The transmission links conveys the information and control signals between the terminals and switching centers.

A transmission link can be characterized by its bandwidth, link attenuation and the propagation delay. To maintain signal quality, the signal must be regenerated after a certain distance.

In general a communication path between two distinct points can be setup by connecting a number of transmission lines in tandem. The transmission links may include two-wire lines, coaxial cables, microwave radio, optical fibers and satellites.

10.1.3 Switching System

Functionally, the communication channels between switching system are referred to as trunks. The switching centres receives the control signals, messages or conversations and forwards to the required destination, after necessary modification (link amplifications) if necessary.

A switching system is a collection of switching elements arranged and controlled in such a way as to setup a communication path between any two distant points (Imeremba 2008). A switching center of a telephone network comprising a switching network and its control and support equipment is called a central office.

In computer communication, the switching technique used is known as packet switching or message switch (store and forward switching). In telephone network the switching method used is called circuit switching. Some practical switching systems are step-by-step, cross barred relay system, digital switching systems, electronic switching system etc.

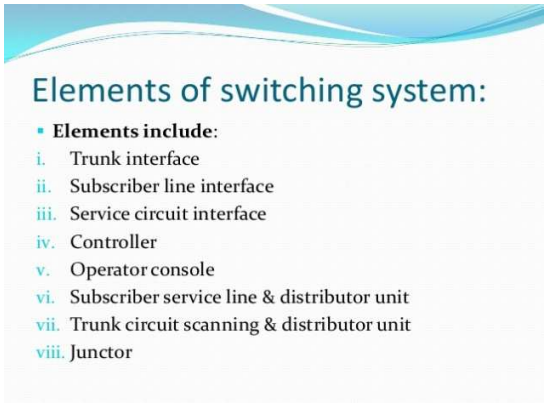

Figure 10.3 *Elements of switching system*

Source: *http://www.slideshare.net/prernasharma10297701/element-of-switching-system*

10.1.4 Signalling Systems

A signaling system in a data communication networks exchanges signalling information effectively between subscribers.

The signaling systems are essential building blocks in providing the ultimate objective of a worldwide automatic telephone services. Traditionally, the design for telephone switching centers or equipment requirements in a telecommunication system is determined on the basis of the traffic intensity of the busy hour.

The traffic intensity is defined as the product of the calling rate and the average holding time. The busy hour is defined as that continuous sixty-minute period during which the traffic intensity is highest. The calling rate is the average number of request for connection that is made per unit time.

If the instant in time that a call request arises is a random variable, the calling rate may be stated as the probability that a call request will occur in a certain short interval of time.

In-Text Question

What is Traffic Intensity?

In-Text Answer

This is the product of the calling rate and the average holding time.

10.1.5 Circuit Switching

The phone system uses a technique called circuit switching.

- Once a call has been completed, the user sees a set of "virtual wires" between communicating endpoints.
- The user sends a continuous stream of data, which the channel guarantees to deliver at a known rate.
- Data transmission handled elegantly using TDM or FDM. Note that TDM/FDM work well because the data rate is predictable while the voice grade signal is sampled using PCM generating a steady stream of bits.
- Call setup required before any data can be sent, allowing network to set up the path, allocate sub-channels, etc. Call setup also used to decide who to charge for the call.
- Call termination required when parties complete call, allowing the network to reclaim resources. At this point, a billing record is saved somewhere that records where the call was made, its duration, etc.

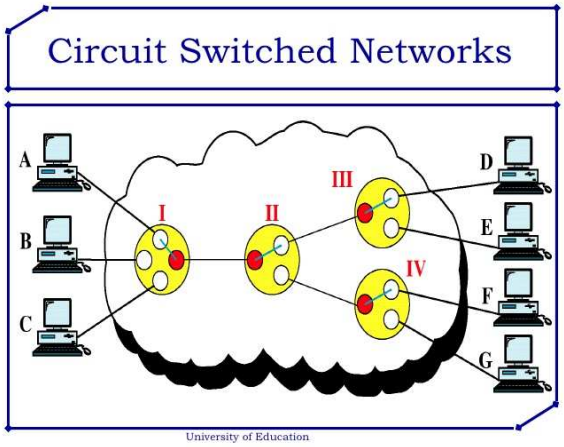

Figure 10.4 *Circuit switching*

Source: *http://www.slideshare.net/tameemyousaf/switching-techniques*

Advantages of circuit switching:

1. Fixed bandwidth, guaranteed capacity (e.g., no congestion).
2. Low-variance end-to-end delay (e.g., delay nearly constant).

Drawbacks:

1. Connection setup introduces delay before communication can begin.
2. User pays for circuit, even when not sending any data.
3. Other users cannot use bandwidth of other circuits that are not actually being used(e.g., in most conversations, only one person speaks at a time. Thus, half the underlying bandwidth is wasted.

Message Switching: Entire message stored at each node. Each message is received in its entirety before forwarding.

Packet Switching: In contrast, packet switching systems use statistical multiplexing to make better use of a channel:

1. Data is sent in individual messages (packets).
2. Each message is forwarded from switch to switch, eventually reaching its destination.
3. Each switch has a small amount of buffer space to temporarily hold messages. If an outgoing line is busy, the packet is queued until the line becomes available.

Packet switching vs circuit switching

1. Packet switching systems do not provide known delay or capacity characteristics. Some applications, like those making use of real-time voice and video, cannot tolerate high variation in delays.
2. If many sites send data at the same time, end-to-end delay increases. That is, per-user response and throughput drops as more users share a channel.
3. Packet switching utilizes resources more efficiently (similar to multiprocessing in operating systems). In particular, with circuit switching, bandwidth can be allocated but unused, as when no one talks.
4. Packet switching systems do not usually require opening a connection before sending data. This is important for applications that send only a single packet of data; the cost of opening and closing a connection may exceed the cost of sending the data.

5. Billing algorithm is more complex in packet switching systems. It is easy to bill for a connection, because one can figure out who to charge during the connection set up. With packet-switching, each packet must be accounted for individually.

Hybrid Switching: Hybrid switching systems attempt to combine the advantages of both approaches. For instance, phone companies have developed fast connect circuit switching systems that establish connections quickly (e.g. on each interactive input line).

However, there is still much debate as to whether these "fast" systems are really fast enough. Another variation, virtual circuits, requires users to open a connection before sending data, but transmits packets.

The call allows the network to establish a path, and once established, all packets follow the same path. Because all packets follow the same path, packets can be delivered in order, and accounting is simplified.

Summary of Study Session 10

This study session described the major parts of a telecommunication system and the major switching system involved.

- Telecommunication process involves the sending of electromagnetic waves by electronic transmitters and has completely changed the rate and manner of information dissemination in the whole world.
- The end system or instrument are transmitters or receivers that are responsible for sending information or decoding or inverting received information or message into an intelligible message.
- The end system or instrument are transmitters or receivers that are responsible for sending information or decoding or inverting received information or message into an intelligible message.
- A signaling system in a data communication networks exchanges signalling information effectively between subscribers.
- Once a call has been completed, the user sees a set of "virtual wires" between communicating endpoints.

Self-Assessment Question (SAQs) for Study Session 10

Now that you have completed this study session, you can assess how well you have achieved its Learning outcomes by answering the following questions. Write your

answers in your study Diary and discuss them with your Tutor at the next study Support Meeting. You can check your answers with the Notes on the Self-Assessment questions at the end of this Module.

SAQ 10.1 (Tests Learning Outcomes 10.1)

Discuss briefly the following:

End system or Instruments

Transmission system

Switching system and

Signaling

Discuss the different types of switching systems in telecommunications

List the various switching systems in telecommunication system

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Study Session 11: Telecommunication System in Nigeria

***Source**: http://healthnewsng.com/telecom-masts-are-not-dangerous-to-human-health-ncc/*

Introduction

Telecommunications is the transmission of signals over a distance for the purpose of sharing information. It is a vital engine of any economy and an essential infrastructure that promotes the development of other sectors such as agriculture, education, industry, health, banking, defense, transportation and tourism (Arzika, 2000).

In this study session you will learn on the development of telecommunication systems in Nigeria.

Learning Outcomes for Study Session 11

At the end of the study Session, you should be able to:

11.1 Discuss the development of telecommunication systems in Nigeria

11.1Telecommunication systems in Nigeria

The availability of an efficient, reliable and affordable telecommunications system is a key ingredient for promoting rapid socio-economic and political development of any nation. Such a system must be universally accessible and cost effective.

Telecommunications is a vital engine of any economy; it is an essential infrastructure that promotes the development of other sectors such as agriculture, education, industry, health, banking, defence, transportation and tourism. It is indispensable in times of national emergency or natural disasters. It considerably reduces the risks and rigours of travel and rural-urban migration.

The journey to success in Nigeria's telecommunication milieu has been long and tortuous. Telecommunication facilities in Nigeria were first established in 1886 by the colonial administration. At independence in 1960, with a population of roughly 40 million people, the country only had about 18,724 phone lines for use.

In-Text Question

What is Telecommunication?

In-Text Answer

Telecommunications is the transmission of signals over a distance for the purpose of sharing information.

This translated to a teledensity of about 0.5 telephone lines per 1,000 people. The telephone network consisted of 121 exchanges of which 116 were of the manual (magneto) type and only 5 were automatic.

Between 1960 and 1985, the telecommunication sector consisted of the Department of Posts and Telecommunications (P&T) in charge of the internal network and a limited liability company, the Nigerian External Telecommunication (NET) Limited, responsible for the external telecommunications services. NET provided the gateway to the outside world.

The installed switching capacity at the end of 1985 was about 200,000 lines as against the planned target of about 460,000. All the exchanges were analogue. Telephone penetration remained poor equaling 1 telephone line to 440 inhabitants, well below the target of 1 telephone line to 100 inhabitants recommended by ITU for developing countries. The quality of service was largely unsatisfactory. The telephone system was unreliable, congested, expensive and customer unfriendly.

Figure 11.1: *NITEL*

Source*: http://nigeriancurrent.com/2015/11/01/nitel-resurrects-as-ntel-plans-to-deploy-4g-network/*

Arising from the foregoing, in January 1985, the erstwhile Posts and Telecommunications Department was split into Postal and Telecommunications Divisions. The latter was merged with NET to form Nigerian Telecommunications Limited (NITEL), a limited liability company.

The main objective of establishing NITEL was to harmonies the planning and co-ordination of the internal and external telecommunications services, rationalize investments in telecommunications development and provide accessible, efficient and affordable services.

Almost 43 years down the line, the Nigerian Telecommunication Plc, NITEL had roughly half a million lines available to over 100 million Nigerians. NITEL the only national carrier had a monopoly on the sector and was synonymous with epileptic services and bad management.

In-Text Question

At independence in 1960, with a population of roughly 40 million people, the country only had about ……..for use.

In-Text Answer

18,724 phone lines

On assumption of office on May 29, 1999 President Olusegun Obasanjo administration swung to gear to make a reality the complete deregulation of the telecom sector, most

especially the much touted granting of licenses to GSM service providers and setting in motion the privatisation of NITEL.

This proactive approach by the government to the telecom sector has made it possible for over 2.5 million Nigerians to clutch GSM phones today.

The Federal Government of Nigeria in the past years has made some commendable policies of which, one is the National Telecommunications Policy with the overriding objective of achieving the modernization and rapid expansion of the telecommunications network and services in Nigeria at large.

The policy was expected not only to enhance socio-economic development in Nigeria but also to be integrated into the telecommunications environment internally as well as globally (Ndukwe, 2004).

Trends in the Nigerian telecommunications industry from 2001 till date

As a result of the implementation of the National Telecommunications Policy, the Nigerian Telecommunications Industry has experienced significant growth in the last 6 years, following the successful take-off of digital mobile telephone services in the country, using the Global System for Mobile communications (GSM) technology.

From 500,000 active fixed telephone lines as at mid-2001, the total number of connected fixed and mobile telephone lines increased to about 190 million lines as at February, 2015 (Subscriber Statistics, February, 2015 available at www.ncc.gov.ng). Up till the year 2001, Nigeria was classified as one of Africa's most under-served telecommunications markets, but today, Nigeria is one of the world's fastest growing telecommunications markets (NCC).

Figure 11.2: *MTN*

Source*: http://www.jazzyfans.net/2015/12/27/mtn-currently-dishing-free-credit-customers-get-now/*

Global System of Mobile Communication

The development of global system of mobile telecommunications (GSM) in the world was prompted by the need to provide seamless telecommunications throughout Europe.

In the early 80's, the analogue mobile telephony was growing rapidly and operators were finding it increasingly difficult to interconnect the various network in Europe and this prevented cell phone use from country to country within Europe. With the emerging European Union and high travel volume between countries in Europe, this was seen as a problem.

In order to remedy the situation, the Conference of European Post and Telegraphs (CEPT) assembled a study group called "Group Special Mobile". This group was formed and tasked to provide a standardized system for mobile telephony.

For years, the GSM group outlined standards, researched technology and designed a way to implement a Pan European mobile phone network. In 1989, work done by the GSM group was transferred to the European Telecommunication Standard Institute (ETSI). The name GSM was transposed to name the type of service invented.

Thus, the acronym GSM was changed from Group Special Mobile to Global Systems Mobile Telecommunications.

Figure 11.3: *Zain*

Source*: http://www.zain.com/media-center/gallery/image/6/*

By April 1991, commercial service of the GSM network began in Finland. Several other countries were on the rise to adopt this new mobile phone network and participate in what was becoming a world-wide standard.

This technological advancement in the Western World has impacted the rest of the world and it is now a global village. The rest of the world can easily reach developing countries now and they are becoming more accessible compared to a couple of years ago. Global System of Mobile Communications (GSM) was recommended to the Military administration of General Abdulsalam Abubakar which made Nigerian Communications Commission (NCC) to grant licenses to Celia Motophone Limited, Mobile Services Limited and United Networks Limited and they were asked to provide GSM network services in Nigeria. However, the Olusegun Obasanjo administration in 1999 saw the exercise as fraudulent, revoked the licenses and introduced the telecommunication policy which empowered the Nigerian Communications Commission (NCC) to re-organize, auction and issue fresh licenses to successful companies who could provide for Nigerians an efficient and cost effective telephone system.

On assumption of office on May 29, 1999, the President Olusegun Obasanjo's administration deregulated the telecom sector, by granting licenses to GSM service providers and setting in motion the privatization of NITEL.
The deregulation policy led to the establishment of National Telecommunication Policy. This proactive approach by the government to the telecom sector has had a positive significant effect on the telecom sector as well as on the citizens' access to telephone.
Presently, MTN, Airtel (then Econet wireless Nigeria and later V-mobile, Celtel and Zain), Glomobile and Etisalat dominate the GSM sector. This approach by the government to the telecom sector has made it possible for there to be over 2.5 million individual GSM telephone subscribers in Nigeria today (Okafor, 2012),

Figure 11.4: Celtel Source:

After rigorous bidding and payments of license fees of $285 million, three companies, Nigeria Telecommunications Plc (Nitel), MTN Nigeria and Econet Wireless were granted Digital Mobile License (DML) on 23rd March 2001 with 90 days deadline to start operation, operating license validity of 15 years, five years exclusivity period, dual band frequency assignment, a waiver of annual 23 operating levy (not more than 25 percent of annual turnover) for the first year of operation, direct international access for own subscribers to facilitate roaming.

Thus, on 7th August, 2001, Econet Wireless (now Airtel) commenced operations of GSM services in Nigeria, followed by MTN, Nitel, Globacom and recently Etisalat.

According to NCC there are over 52 million subscribers as at 30th September, 2008. (www.ncc.gov.com).

***Figure 11.5**: Econet*

***Source**: http://www.thisdaylive.com/index.php/2016/03/31/econet-rivals-dstv-to-air-epl-for-free/*

In August 2001, GSM was launched in Nigeria. Commenting on the advent of GSM in Nigeria, Ajala (2005), a staff member of MTN Nigeria Communication Ltd wrote: August 2001 was a pivotal date in the history of Nigeria. That was when the first Global System of Mobile Communications call was made under a democratic government. This event heralded the dawn of a new era, the era of GSM technology, which completely changed the face of doing business in Nigeria.

***Figure 11.6:** Etisalat*

***Source**: http://oscarmini.com/2015/10/how-to-transfershare-internet-data-bundle-mb-on-etisalat.html*

Also, Wojuade (2006) pointed out that, "GSM mobile communication is one of the most explosive developments ever to have taken place in the telecommunications industry.
It is one of the best things that have happened to Nigeria in terms of technological advancement as people can now reach out to others and be reached, since it is much easier to reach people by dialing their phone number. It has brought positive changes to Nigeria especially in the socio-economic development of the country.

***Figure 11.7:** Globacom*
***Source**: http://theeagleonline.com.ng/globacom-owes-service-providers-over-n2b-defies-nccs-directives-to-pay/*

Since GSM was launched in Nigeria, mobile telephony has rapidly become the most popular method of voice communication in country. In Nigeria, the wide spread of mobile phones has been aided by pre-paid options that allow users to control their spending. Community phone shops also allow many more people to gain access to telecommunication.

In-Text Question
According to report from NCC that we have ……. as at 30th September, 2008.
In-Text Answer
52 million subscribers

Summary of Study Session 11

- This Study session describes the historical development of telecommunication system and global system of telecommunication system (GSM) in Nigeria emphasising the role of NITEL and NCC.
- The journey to success in Nigeria's telecommunication milieu has been long and tortuous. Telecommunication facilities in Nigeria were first established in 1886 by the colonial administration. At independence in 1960, with a population of roughly 40 million people, the country only had about 18,724 phone lines for use.

Self-Assessment Question (SAQs) for Study Session 11

Now that you have completed this study session, you can assess how well you have achieved its Learning outcomes by answering the following questions. Write your answers in your study Diary and discuss them with your Tutor at the next study Support Meeting. You can check your answers with the Notes on the Self-Assessment questions at the end of this Module.

SAQ 11.1 (Tests Learning Outcomes 11.1)

Discuss the development of telecommunication system in Nigeria

Trace the trends in telecommunication system development in Nigeria

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Study Session 12: Nigerian Telecommunication Policy

***Source**: http://businesswire.ng/*

Introduction

For any nation to have an efficient, reliable and affordable telecommunications system there is need for an effective telecommunications policy. A telecommunications policy is concerned with the changing roles of telecommunications on the economy and society. It provides a forum for research and debate amongst academics, policy makers, regulators, industry managers, consultants and other professionals (Pitt, 2006).

The general objectives of the National Telecommunication Policy (NTP) are to achieve the modernization and rapid expansion of the telecommunication network and services as well as enhance national economic and social development and integrate Nigeria internally as well as into the global telecommunications services that should, accordingly, be efficient affordable, reliable and available to all. The rapidly changing nature of technology in telecommunications makes it difficult to set long term policy and medium term policy objectives.

Learning Outcomes for Study Session 12

At the end of the study Session, you should be able to:

12.1 Discuss the Nigeria's National Telecommunication Policy (NTP)

12.2 Explain Private Sector Participation

12.1 National Telecommunication Policy

The maiden edition of the National Policy on Telecommunications was approved in 1995 though not published until 1998 by the ministry of communications. This delay was as a result of the prevailing socio-economic and political environment in the country at the time.

Consequently, at the time of the publication, certain prescriptions contained in the policy were outdated, overtaken by events or required further modification (Arzika, 2000). As a result of this, a new Telecommunications Policy was published in May 2000, which is the policy currently being adopted in the nation today.

The new telecommunication policy was developed in line with new developments and emerging industry trends both locally and internationally.

As a result of the rapidly changing nature of technology in telecommunications, long term policy objectives could be difficult to set; therefore, short to medium term policy objectives were set, with the following time frames: short term (3 years) and medium term (5 years). Both the short term and the medium term objectives of the policy are available at www.ncc.gov.ng.

Figure 12.1: *Nigeria Communications Commission*
Source: *http://guardian.ng/technology/ncc-assures-intl-community-of-nigerias-readiness-for-investments/*

12.1.1 Short-Term Objectives

The short term objectives as set and contained in the Nigeria telecommunication policy are:

To implement network development projects which shall ensure that the country meets and exceeds the ITU recommended minimum teledensity of 1 telephone to 100 inhabitants. This means that a minimum of 2 million fixed lines and 1,200,000 mobile lines should be provided within 2 years;

1. To promote widespread access to advanced communications technologies and services, in particular the Internet and related capabilities;
2. To develop and enhance indigenous capacity in telecommunications technology;
3. To participate effectively in international telecommunications activities in order to promote telecommunications development in Nigeria, meet the country's international obligations and derive maximum benefit from international cooperation in these areas;
4. To establish a National Frequency Management Council (NFMC) within the Ministry of Communications with the responsibility for the planning, coordination and bulk allocation of the radio spectrum in the interest of efficiency, transparency and accountability;
5. To ensure that the government divests its interest in the state owned telecommunications entities;
6. To promote competition to meet growing demand through the full liberalization of the telecommunications market;
7. To review and update telecommunications laws in order to bring all telecommunications operators under the regulatory control of NCC.
8. To resolve with dispatch all licensing problems that are existing in the most equitable and transparent manner.

In-Text Question

What is the full meaning of NFMC?

In-Text Answer

National Frequency Management Council

12.1.2Medium-Term Objectives

The medium term objectives set are as follows:

To provide a new regulatory environment that is sufficiently flexible to take into account new technological development and the international trend towards convergence;

To meet telecommunications service needs of the social, commercial and industrial sectors of the economy;

1. To ensure that public telecommunications facilities are accessible to all communities in the country;
2. To encourage domestic production of telecommunications equipment in Nigeria; and development of related software and services;
3. To establish and meet aggressive targets for the installation of new fixed and mobile lines.
4. To protect the integrity, defense and the security of the state and its citizens.
5. To encourage Nigerian telecommunications operating companies to become global leaders in the industry.
6. To encourage the development of information super-highway that will enable Nigerians enjoy the benefits of globalization and convergence.
7. To create the enabling environment, including the provision of incentives, that will attract investors and resources to achieve the objectives earlier stated.

Developing countries like Nigeria that want to participate effectively and become equal partners in the emerging global market need to put in place a functional and efficient telecommunications system.

In order to be relevant in this new millennium and beyond, Nigeria must join the international telecommunications network as a step towards improving and positioning itself to compete in the economy.

Global telecommunications provides the opportunity for a country to share in the wave of science and technology developments, and the general economy in positive ways that account for the remarkable economic growth in advanced countries and the newly industrialised countries.

Between 1960 and 1985, the telecommunications sector consisted of the Department of Posts and Telecommunications (P&T) in charge of the internal network and a limited liability company, the Nigerian External Telecommunications (NET) Limited, responsible for the external telecommunications services. NET provided the gateway to the outside world.

Telecommunications development during this period was characterized by serious short-falls between planned targets and their realisation, principally because of poor

management, lack of accountability and transparency and low level of executive capacity (Okwor, 2010).

The installed switching capacity at the end of 1985 was about 200,000 lines as against the planned target of about 460,000 while all the exchanges were analogue.

Telephone penetration remained poor at ratio of a line to 440 inhabitants, well below the target of a telephone line to 100 inhabitants recommended by ITU for developing countries just as the quality of service was largely unsatisfactory, unreliable, congested, expensive and customer unfriendly (Obadan, 2000).

In-Text Question

What is the full meaning of NET?

In-Text Answer

Nigerian External Telecommunications (NET) Limited

Arising from the foregoing, in January 1985, the erstwhile Posts and Telecommunications Department was split into Postal and Telecommunications Divisions and the latter was merged with NET to form Nigerian Telecommunications Limited (NITEL), a limited liability company, while the Postal Division was reconstituted into another organisation called the Nigerian Postal Service (NIPOST).

The main objective of establishing NITEL was to harmonise the planning and co-ordination of the internal and external telecommunications services, rationalise investments in telecommunications development and provide accessible, efficient and affordable services.

Even with this slight reform only a modest development in the telecommunications industry was recorded as Nigeria still lags behind comparable and even less endowed African countries, let alone advanced countries.

The process of deregulating the industry was initiated to tackle these observed shortcomings. This began with the establishment of the Nigerian Communications Commission (NCC) by Decree 75 of 1992 whose main objectives include: ·

- Creating a regulatory environment to facilitate the supply of telecommunications services and facilities;
- Facilitating the entry of private entrepreneurs into the telecommunications market
- Promoting fair competition and efficient market conduct among all players in the industry.

Since the inauguration of NCC in July 1993, it has set out guidelines for private sector participation and issued licenses to a number of companies for telecommunications undertakings such as;

- Installation and operation of public switched telephony;
- Installation of terminal or other equipment;
- Provision and operation of public payphones;
- Provision and operation of private network links employing cable, radio communications, or satellite within Nigeria;
- Provision and operation of public mobile communications;
- Provision and operation of telephones;
- Provision and operation of value-added network services; and
- Repair and maintenance of telecommunications facilities.

With the coming of telecommunications companies came a wide range of services which were not available before then such as

- Telephony,
- Telex,
- Cellular Mobile Telephony,
- Facsimile
- Radio/Television Carrier
- Gentex (Extension of Telex Terminals to rural areas)
- Voice Cast/Press Receipt
- Private Leased Circuit
- Alternate Leased Circuit
- Maritime Mobile Service
- INMARSAT
- Ship Shore etc.

And Global Mobile Personal Communications Services [GMPCS]. Other services available include,

- Data Communications
- High Speed Data Transmission
- Telegraphy
- Public Payphones

- Value Added Services
- Business Network Services
- Computer Networking
- Internet Service
- Telecommunications Consultancy Services
- Paging Services
- Mobile Radio Trunking Services (NCC, 1997).

Nigerian Telecommunications Ltd (NITEL) NITEL happened to be the only national operator and monopoly service provider for domestic and international services. This had serious repercussions in terms of inefficiency, high cost of service, and lack of universal access.

NITEL's Public Network The national switching network mainly consists of three parallel networks for telephone, telex switching and cellular services.

Integrated Services Digital Network (ISDN) services have been introduced in the new digital exchanges. The nodal points of such networks are interconnected through a national transmission system comprising terrestrial radio-relay systems (analogue/digital), optical fibre, cable and satellite communication links.

As at 1999, there was only one mobile cellular telephone network, provided by the Nigerian Mobile Telecommunications Ltd. (M-Tel). The cellular mobile network covers three areas of the country with a total capacity of 210,000 lines, out of which 26,500 lines are connected.

There is only one Mobile Switching Center (MSC) in each area except in Area 3 (Abuja) where there are two (2) MSCs. This network is grossly inadequate. A total of twelve other mobile cellular operators have been issued licenses but only a few have commenced limited operations while approvals have also been given for the issuance of licenses to 21 other operators.

12.2 Private Sector Participation

In 1992, Government initiated the liberalisation of the telecommunications industry with the establishment of a regulatory body, the Nigerian Communications Commission (NCC).

The NCC issued various licenses to private telecommunications operators which include 7 fixed telephony providers that have activated 90,000 lines, 35 internet service providers with a customer base of about 17,000.

In-Text Question

In what year did the Government initiated the liberalization of the telecommunication industry?

In-Text Answer

1992

There are also 9 payphone service providers who have installed 600 phones. Several VSAT service providers were in operation, and have improved financial intermediation by providing online banking services to most banks in Nigeria.

Summary of Study Session 12

The overriding objective of the National Telecommunications Policy is to achieve the modernization and rapid expansion of the telecommunications network and services (Ndukwe, 2003).

- This is to enhance national economic and social development, and integrate Nigeria internally as well as into the global telecommunications environment.
- Hence telecommunications services under this arrangement should, accordingly, be efficient, affordable, reliable and available to all.

Self-Assessment Question (SAQs) for Study Session 12

Now that you have completed this study session, you can assess how well you have achieved its Learning outcomes by answering the following questions. Write your answers in your study Diary and discuss them with your Tutor at the next study Support Meeting. You can check your answers with the Notes on the Self-Assessment questions at the end of this Module.

SAQ 12.1 (Tests Learning Outcomes 12.1)

Explain the role of National Telecommunication Policy in the development of telecommunication sector in Nigeria

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Study Session 13: Telecommunication Policy and Liberalisation of Telecommunication Industry

Source:*http://www.ronglian.com/en/industriestelecom/index.jhtml*

Introduction

The general trend worldwide is towards liberalization and privatization in the telecommunications industry and this led Nigeria to take a step in deregulating the industry by establishing the Nigerian Communications Commission (NCC) as the sector regulator Okwor, 2010).

The policy provided for a Nigeria telecommunications industry structure that comprised Government, Ministry of Communications, Nigerian Communications Commission, and Telecommunications Service Providers.

Learning Outcomes for Study Session 13

At the end of the study Session, you should be able to:

13.1 Explain the Government in the Telecommunication sector.

13.2 Highlight the roles of telecommunication service providers

13.2 Discuss the effects of Telecommunication Policy.

13.1 Government in the telecommunications sector

As outlined in the policy, the roles of government are to give overall direction for telecommunications development, ensure policy consistency of telecommunications with other national policies and enact necessary laws and taking other measures promptly in support of the National Telecommunications Policy.

The role of Ministry of Communications in telecommunication sector

The Ministry is saddled with the role of formulating broad telecommunications policy for the sector. Among its specific functions are:

- Proposing policy options and recommending to government such measures as legislation, fiscal incentives, etc;
- Monitoring the implementation of government policy in the industry;
- Establishing policies for promoting universal access to communications in Nigeria as outlined in this policy;
- Representing government on matters pertaining to regional and international organizations;
- Overall monitoring of the radio spectrum allocation in the country, and liaising with National Assembly on telecommunications matters.

The role of Nigerian Communications Commission (NCC) in telecommunication sector

The Nigerian Communications Commission (NCC) is the independent regulator of the telecommunications industry which is empowered to issue licenses, assign frequencies and regulate all telecommunications licensees and service providers.

It has the sole responsibility of designing and maintaining a national numbering plan, and performs such other regulatory functions as may be consistent with its mandate to promote the development of Nigerian communications.

Figure 13.1: *Nigeria Communications Commission*
Source: *http://guardian.ng/technology/ncc-assures-intl-community-of-nigerias-readiness-for-investments/*

The NCC makes its decisions regarding licensing, tariff regulation, interconnection disputes, and any other matters directly affecting industry operators, in an impartial and independent manner and is guided by the overriding objectives of the National Telecommunications Policy, and considerations of fairness, equity, and transparency.
Such rulings shall not be directly influenced by Government or private industry.
The functions of the Nigerian Communications Commission (NCC) include:

- Licensing of telecommunications operators;
- Assignment and registration of frequency to duly licensed operators;
- Administration of national numbering plan;
- Facilitating private sector participation and investment in the telecommunications sector of the Nigerian economy;
- Promoting and enforcing a fair competitive environment for all operators, as outlined in this policy;
- Defining standards for economic regulation of dominant operators, including tariff regulation as outlined in this policy;
- Establishing mechanisms for promoting universal access to telecommunications services in Nigeria, as outlined in this policy;
- Establishing and enforcing technical operational standards and practices for all operators including the imposition of penalties for violations ensuring that the public's interest is protected.

In-Text Question

Which body has the responsibility of promoting and enforcing a fair competitive environment for all operators?

In-Text Answer

Nigerian Communications Commission (NCC)

13.2 Telecommunication Service Providers

The role of telecommunication service providers in the telecommunication sector.

13.2.1 Cellular Mobile Service Providers

The Cellular Mobile Service Provider (CMSP) role includes provision of mobile services including the capability to carry its own long distance traffic within the area it operates. Hence, a CMSP will be required to interconnect with other service providers including other CMSPs.

A CMSP shall be free to provide, in its service area, all types of mobile service including voice and non-voice messages, and using equipment compliant with relevant ITU standards.

13.2.2 Fixed Service Providers

Fixed Service Providers are to establish the “last mile” linkages and switched services to provide end-user access services and carry local and long distance traffic within their service area without additional licensing. The FSP shall be free to provide, in their respective service areas, all types of fixed services including voice and non-voice messages, utilising equipment compliant with relevant ITU standards.

In-Text Question

What is the full meaning of CMSP?

In-Text Answer

Cellular Mobile Service Provider (CMSP)

13.2.3 Cable Service Providers

The Cable Service Providers, under relevant NBC/NCC legislation are to provide cable-related services. CSPs shall be permitted to provide the “last mile” linkages and switched

services within the service areas and shall operate media services, which are essentially one-way entertainment-related services and may also be licensed to provide two way communication services, as local access providers.

Direct interconnectivity between CSPs and other type of service providers in their areas of operation shall be required.

13.2.4 National Long Distance Operators

National Long Distance Operators (NLDOs) are opened up for competition as soon as possible within the provisions of this policy. This is to promote expansion of bandwidth capacity and consumer choice.

All NLDOs should be able to access each other's subscribers. It shall be mandatory for all access providers to provide interconnection to the NLDOs. The consumers therefore, have a choice to make long distance calls through any long distance operator. The terms, conditions and other imperatives decide the number of long distance operators.

13.2.5 International Long Distance Operators

International Long Distance Operators (ILDOs) International long distance services are opened up for competition consistent with the time table for the privatization of NITEL and M-Tel.

The NLDOs, Fixed Service Providers, and Cellular Service Providers, may seek a license to offer international long distance services and provide interconnectivity to access providers. The services shall include voice and non-voice.

This is to promote expansion of international bandwidth, consumer choice and lower the prices of international communications. All ILDOs should be able to access each other's subscribers. It shall be mandatory for all ILDOs to provide access on request, to all access providers.

13.2.6 Multi-Service Access Operators

Multi-Service Access Operators (MSAOs) This other categories of operators are licensed to provide both fixed and mobile services.

This policy envisions that these various types of operators shall operate networks and offer services that will in many instances be in direct competition with each other, and

with the domestic services of the national long distance operators, as well as of the Access Service Providers.

13.2 Effect of Telecommunication Policy on Telecoms Sector

The implementation of telecoms policy led to the adoption of global system of mobile communications (GSM) in Nigeria.

In Nigeria, global system of mobile communications (GSM) means telecom-explosion. The GSM revolution began in August 2001 and changed the face of information and communication in Nigeria. Since the GSM launch, mobile telephony has rapidly become the most popular method of voice communication in Nigeria.

GSM is a digital mobile telephony system which was first launched in Finland in 1991. GSM according to Wikipedia is the most popular standard for mobile phones in the world. GSM is used by over three million people across more than 212 countries and territories.

Its ubiquity makes international roaming very common between mobile phone operators of the world. GSM is a cellular network, which means that mobile phones connect to it by searching for cells in the immediate vicinity. It allows message, sound, video, picture and text to be transmitted simultaneously from one cell phone anywhere in the world to another cell phone.

One of the distinctive features of the GSM system is the use of subscriber identity module (SIM) cards. This card stores all personal data and contacts and once a phone is traded for a new one, transferring the data and activating the phone becomes simply a matter of changing the card.

In-Text Question

What year was GSM first launched in Finland?

a. 1992
b. 1991
c. 1990
d. 1919

In-Text Answer

a. 1991

Another important feature of GSM is that it allows the exchange of Short Message Service (SMS), also called text message. With SMS, one can send messages up to 160 characters to and from GSM mobile handsets.

Another equally important feature of GSM is the ability to connect to the internet with 3G phones such as the Blackberry. The Blackberry gives access to the World Wide Web in any location provided that there is network coverage.

Some GSM handsets are equipped with digital cameras which come handy at occasions where events are recorded for the future. Those who are familiar with computer could easily transfer such pictures to their computer, send them to others through the internet or print them out with the colour printer. Others have in built radio for news, sports, music and entertainment.

The introduction of the global system of mobile communications (GSM) in Nigeria was to expand the teledensity in the country and to make telephone services cheaper and accessible to the common person.

Presently, four competitive GSM service providers have been fully licensed in the country. These are Mobile Telephone Networks Limited

- MTN
- Airtel (formerly Econet Wireless Nigeria Limited, later V-mobile and Celtel, Zain)
- Globacom Nigeria Limited (Glo)
- Etisalat.

Summary of Study Session 13

- These telecommunication networks have created significant effects on the gross domestic product (GDP) of Nigeria in terms of job creation, communication linkages, connectivity, and wealth creation among others with the advent of global system of mobile communication.
- The government of Nigeria was conscious of the role telecommunications especially GSM can play in national development that was why the telecommunications sector was deregulated and liberalized with the establishment of Nigeria Communication Commission (NCC) and specific roles assigned to the various stakeholders in the industry.
- Proposing policy options and recommending to government such measures as legislation, fiscal incentives, etc;

- Monitoring the implementation of government policy in the industry;
- Establishing policies for promoting universal access to communications in Nigeria as outlined in this policy;
- GSM is a digital mobile telephony system which was first launched in Finland in 1991.

Self-Assessment Question (SAQs) for Study Session 13

Now that you have completed this study session, you can assess how well you have achieved its Learning outcomes by answering the following questions. Write your answers in your study Diary and discuss them with your Tutor at the next study Support Meeting. You can check your answers with the Notes on the Self-Assessment questions at the end of this Module.

SAQ 13.1 (Tests Learning Outcomes 13.1)

Describe the roles of the Ministry of Communication in the development of telecommunication industry in Nigeria

Explain the roles of the Nigerian Communications Commission in the development of telecommunication industry in Nigeria.

Enumerate the role of government in the development of telecommunication sector in Nigeria

Enumerate the short-term objectives of the National Telecommunication Policy

List the medium-term objectives of the National Telecommunication Policy

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