Unit - 1

Introduction

1.1 Data Communications

* Communication means sharing information.
* Telecommunication means communication at a distance.
* Data refers to information presented in whatever form is agreed upon by the parties creating and using the data.
* Data communications are the exchange of data between two devices via some form of transmission medium such as wire cable.
* To enable data communication, the communicating devices must be a part of the communication system made up of a combination of hardware (physical equipment) and software (programs)

Four fundamental characteristics of data communication

1) Delivery

System must deliver data to the correct destination.
Intended device or user must receive the data.

2) Accuracy

System must deliver the data accurately.
Modified data (altered) during transmission and left uncorrected are unusable.

3) Timeliness

System must deliver data in a timely manner. In case of audio and video, timely delivery means delivering data as they are produced and without significant delay.

↓

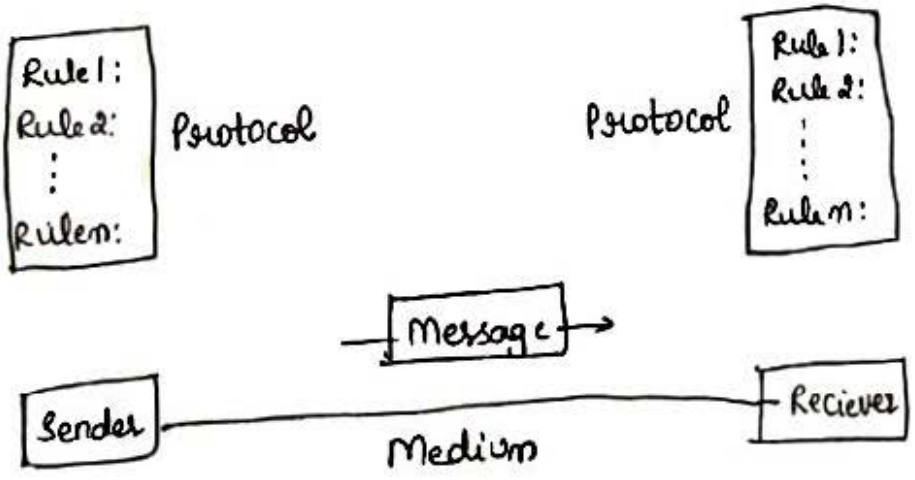
This delivery is called real time transmission.

4) Jitter

Jitter means variation in packet arrival time. It is the uneven delay in the delivery of audio or video packets.

Components

Five Components of data communication



1) Message:

It is the information (data) to be communicated. Different forms of information include text, numbers, pictures, audio and video.

2) Sender:

It is the device that sends the data message.

Example: Computer, workstation, telephone handset etc

3) Receiver:

It is the device that receives the message.

Example: Computer, workstation, television etc.

4) Transmission medium

It is the physical path by which a message travels from sender to receiver.

Example: Twisted pair wire, coaxial cable, radio waves etc.

5) Protocol

It is a set of rules that govern data communications. Without a protocol, two devices may be connected but not communicating.

Example: A person speaking French cannot be understood by a person who only speaks Japanese.

Data Representation

Information can be represented as

1) Text

* Text is represented as a bit pattern, a sequence of bits (0's and 1's)

* Different bit patterns represent text symbols.
* Each set is called a code
* Process of representing symbols is called coding.
* Coding systems:
    a) Unicode - uses 32 bits to represent a symbol / character.
    b) ASCII (American Standard Code for Information Interchange) - Constitutes the first 127 characters in Unicode - also referred as Basic latin.

2) Numbers

* They are represented by bit patterns.

3) Images

* They are also represented by bit patterns.
* An image is composed of a matrix of pixels, where each pixel is a simple dot.
* Size of pixel depends on resolution.
* After each image is divided into pixels, each pixel is assigned a bit pattern

Example: • Images made of only black and white dots, a 1-bit pattern is used to represent a pixel.

• To show four levels of gray scale, 2-bit pattern is used.

Black - 00

Dark Gray - 01

White - 11

* Methods to represent color images are RGB and YCM.

RGB - Red Green Blue

YCM - Yellow Cyan Majenta.

4) Video

* It refers to recording or broadcasting of a picture or movie.
* Video can either be produced as a continuous entity or it can be a combination of images.

5) Audio

* It refers to recording or broadcasting of sound or music.
* It is continuous, not discrete.

Data Flow

Communication between two devices can be simplex, half-duplex and full-duplex.

1) Simplex

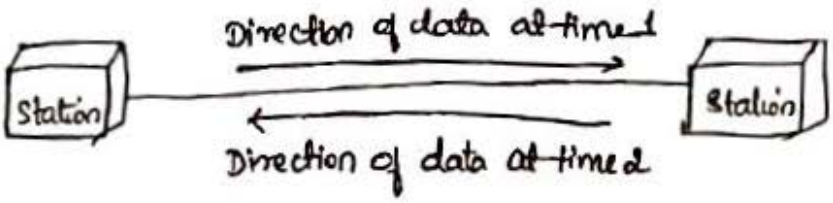
* The communication is unidirectional
* Only one of the two devices on a link can transmit, the other can only receive.

Examples: Keyboards and traditional monitors.

* Simplex mode can use entire capacity of the channel to send data in one direction.

2) Half-duplex

* Here each station can both transmit & receive, but not at the same time.
* When one device is sending, the other can only receive and vice versa.

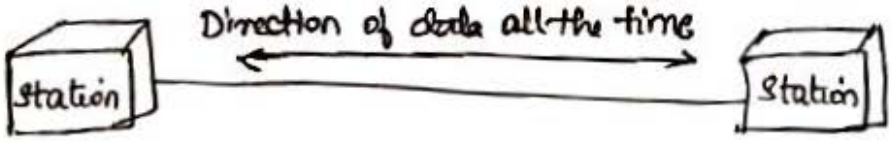


* Here, the entire capacity of the channel is taken over by whichever of the two devices is transmitting at the time.

Examples: Walkie-talkies and CB (citizens band) radios.

3) Full-duplex

* Both stations can transmit and receive simultaneously.



* Full-duplex is like a two-way street with traffic flowing in both directions at the same time.

Here, signals going in one direction share the capacity of the link with signals going in other direction.

Examples: Telephone network.

1.2 Networks

* A network is a set of devices (nodes) connected by communication links.
* Node can be a computer, printer or any other device capable of sending and/or receiving data generated by other nodes on the network.

Distributed Processing

* Here a task is divided among multiple computers.
* Separate computers handle a subset instead of one single large machine being responsible for all aspects of a process.

Network Criteria

a) Performance.

* Performance can be measured by transmit time and response time.
* Transmit time - Amount of time required for a message to travel from one device to another.
  Response time - It is the elapsed time between an inquiry and a response.
* Performance of a network depends on factors such as number of users, type of transmission medium etc.

* Performance is evaluated by two networking metrics
  a) Throughput b) Delay.
* Throughput should be more and delay should be less.

b) Reliability

* Network reliability is measured by the frequency of failure, the time it takes to a link to recover from a failure, and the network's robustness in a catastrophe.

c) Security

* Network security issues include protecting data from unauthorized access, protecting data from damage & development, and implementing policies and procedures from recovery from breaches and data losses.

Network attributes

a) Type of connection

Two possible types of connections are

(i) Point-to-point

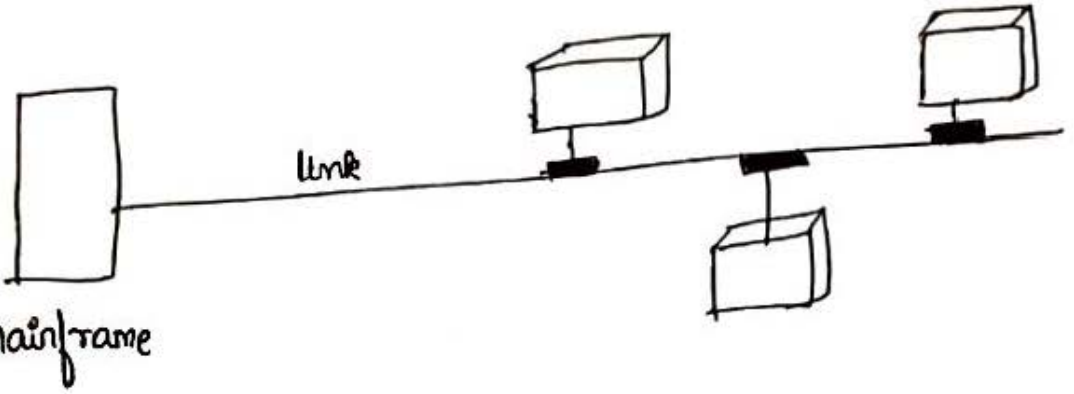
* It provides a dedicated link between two devices.
* Entire capacity of link is reserved for transmission between two devices.

Example: when you change television channels by infrared remote control, you are establishing a point-to-point

Connection between the remote control and the television's control system.

(ii) Multipoint

* It is also called multidrop connection
* Here more than two specific devices share a single link.



* The capacity of the channel is shared, either spatially or temporarily.
* If several devices can use the link simultaneously, it is spatially shared connection. If users must take turns, it is a timeshared connection.

b) Physical topology

* It refers to the way in which a network is laid out physically.
* Two or more devices connect to a link, two or more links form a topology.
* Topology of a network is the geometric representation of the relationship of all the links and linking devices to one another.

Four basic topologies are

(a) Mesh topology

* Here each device has a dedicated point-to-point link to every other device.
* Dedicated means that the link carries traffic only between the two devices it connects.
* $n(n-1)$ physical links are required.

  [To calculate physical links, consider that each node must be connected to every other node. Node 1 should be connected to $n-1$ nodes, node 2 to $n-1$ nodes and final node n to $n-1$ nodes.]

* $n(n-1)/2$ duplex-mode links are required.
* To accomodate these many links, every device on the network must have $n-1$ input/output ports to be conneded to other $n-1$ stations.

Advantages

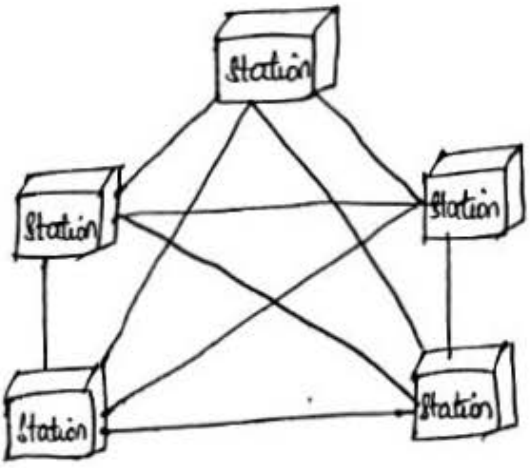
1) Use of dedicated link guarantees that each connection can carry its own data load, thus eliminates traffic problems
2) Mesh topology is robust.
3) Advantage of privacy or security.

Disadvantages

1) Since every device must be connected to every other device, Installation and reconnection are difficult.
2) Shear bulk of the wiring can be greater than the available space.
3) Hardware required to connect each link can be prohibitively expensive.

Example of mesh topology

Connection of telephone regional offices in which each regional office needs to be connected to every other regional office



Fully connected mesh topology

(b) Star topology

* Each devices has a dedicated point-to-point link only to a central controller called hub.
* star topology does not allow direct traffic between devices.

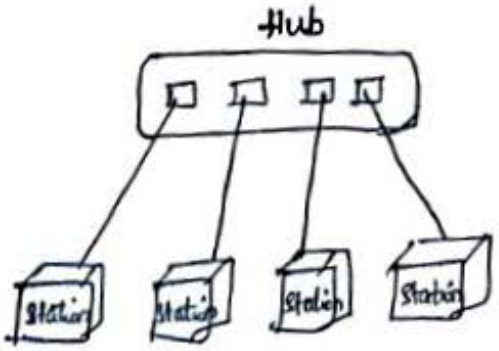
* The controller acts as an exchange. If one device wants to send data to another, it sends the data to the controller, which then relays the data to the other connected device.

Advantages

1) less expensive than mesh topology.
2) Easy to install and reconfigure because each device needs only one link and one I/O port to connect it to any number of others.
3) less cabling is used than mesh.
4) Robustness – If one link fails, only that link is affected.

Disadvantages

1) Dependancy of the whole topology on one single point, the hub. If hub goes down, the whole system is dead.



Star topology

c) Bus topology

* It is multi-point.
* one long cable acts as a backbone to link all the devices in a network.

* Nodes are connected to the bus cable by drop lines and taps.

↓ drop lines: It is a connection running blw device & main cable.

↓ taps: Connector that either splices into main cable or punctures the sheathing of a cable to create a contact with the metallic core.

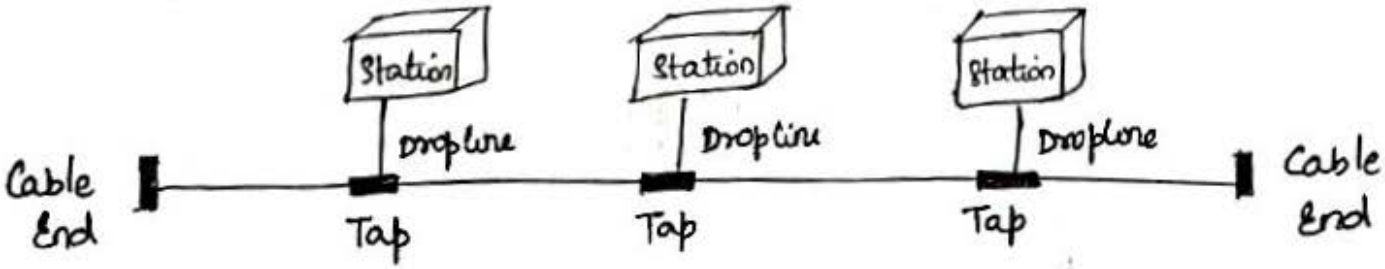
Advantages

1) Ease of installation
2) Use of less cabling than mesh and star topology.

Disadvantages

1) Difficult reconnection and fault isolation
2) A fault or break in the bus cable stops all transmissions.

(c) Ring



d) Ring topology

* Each device has a dedicated point-to-point connection with only the two devices on either side of it.
* A signal is passed along the ring in one direction from device to device, until it reaches its destination.

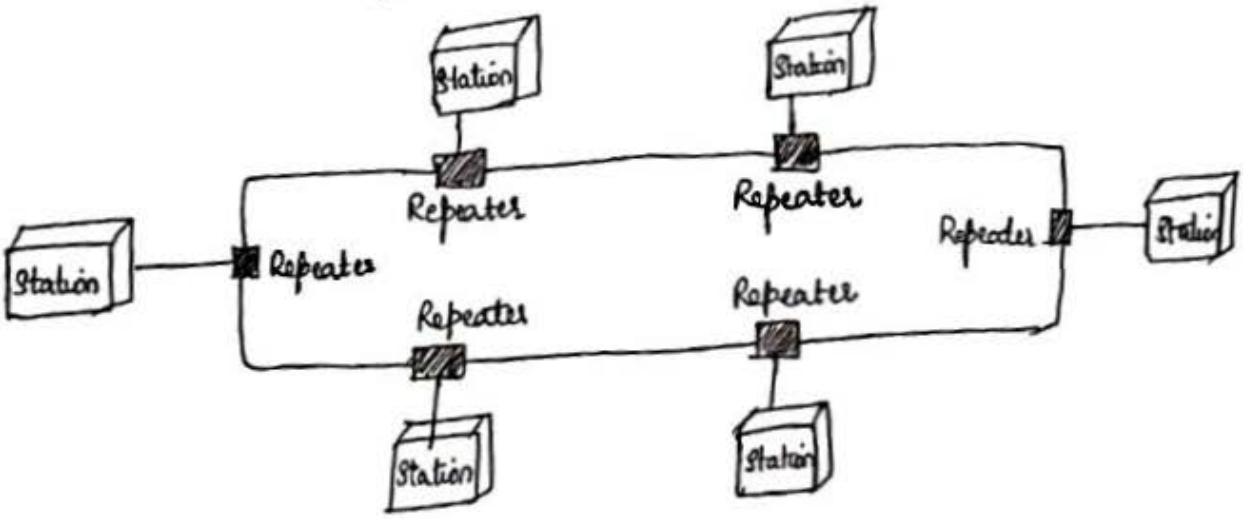
* Each device in the ring incorporates a repeater.
* When a device receives a signal intended for another device, its repeater generates the bits and passes them along.

Advantages

1) Easy to install and reconfigure
2) Fault isolation is simplified.

Disadvantages

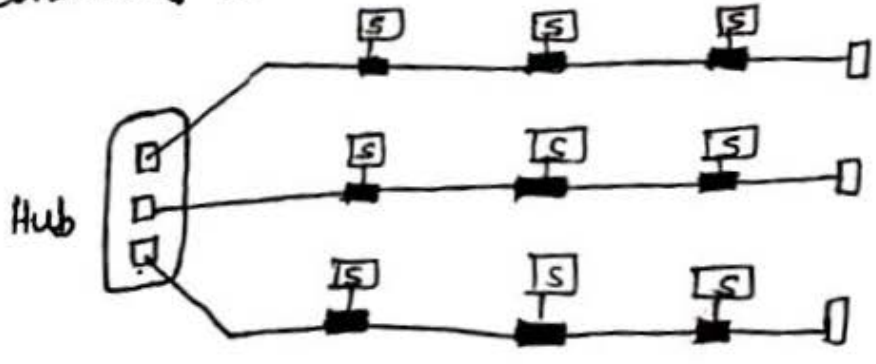
1) Unidirectional traffic



Ring Topology

e) Hybrid Topology

* Network can be hybrid.
* There can be a main star topology with each branch connecting several stations in a bus topology.



Network Models

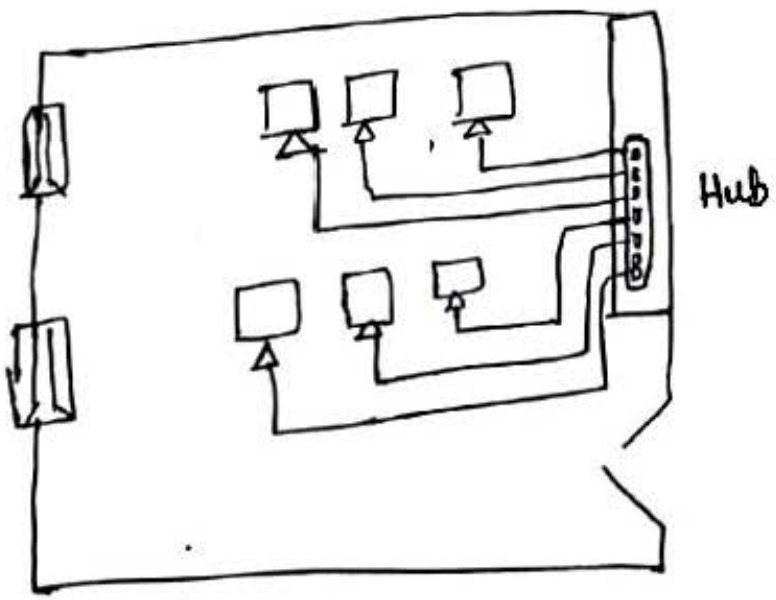
1. OSI model (Open Systems Interconnection) → 7 layer network
2. Internet model → 5 layer network

Categories of Networks

1. LAN (Local Area Networks) → covers area less than 2 mi
2. WAN (Wide Area Networks) → worldwide

local Area Network

* It is usually privately owned and links the devices in a single office, building or campus
* LAN can be as simple as two PC's and a printer in someone's home office or it can extend throughout a company and include audio and video peripherals.

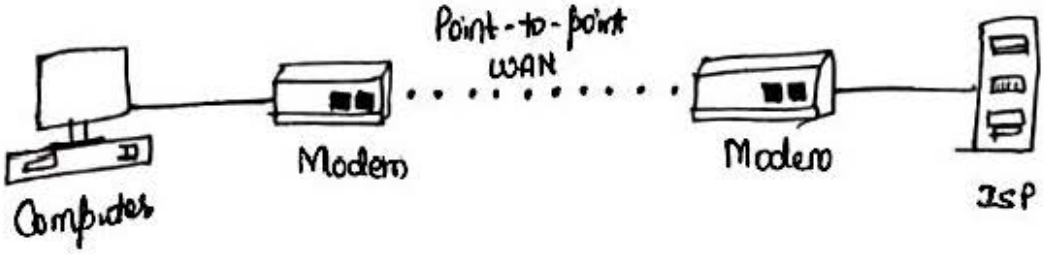


An isolated LAN connecting 6 computer to a hub in a closet.

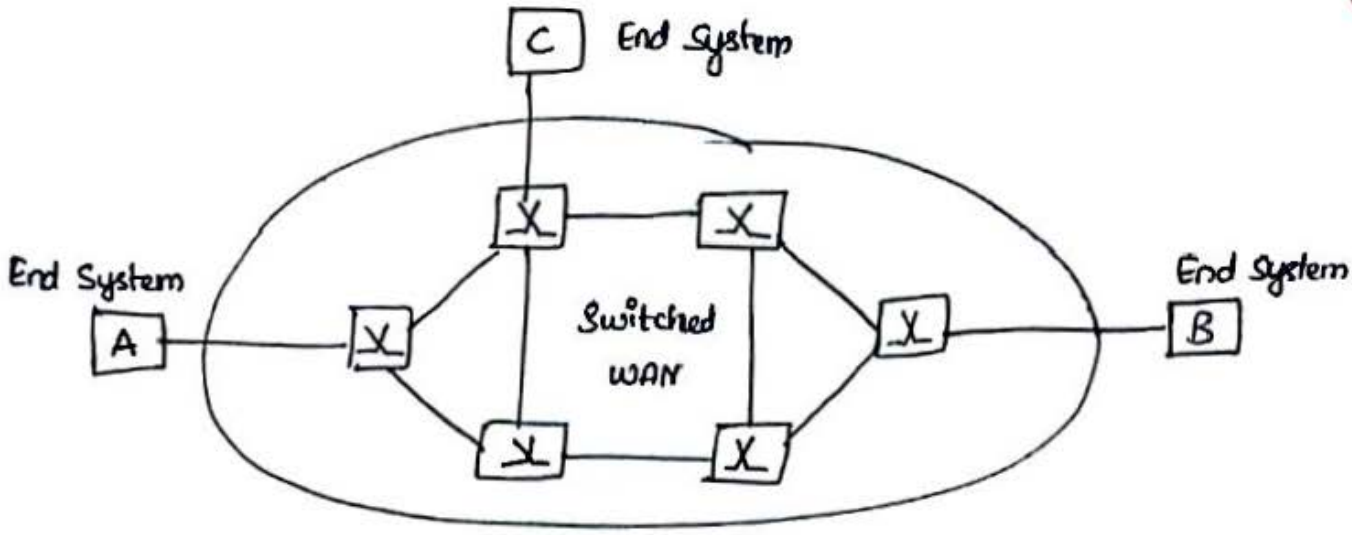
* LANs are designed to allow resources to be shared between personal computers or workstations.
* Resources to be shared can include hardware, software or data. Example: Engineering workstations or accounting PCs.
* LANs are distinguished from other types of networks by their size, transmission media and topology.
* Wireless LANs are the newest evolution in LAN technology.

Wide Area Network

* It provides long-distance transmission of data, image, audio and video information over large geographic areas that may comprise a country, a continent or even the whole world.
* A WAN can be as complex as the backbones that connect the Internet or as simple as a dial-up line that connects a home computer to the Internet.
* Switched WAN connects the end systems, which usually comprise a router that connects to another LAN or WAN.
* Point-to-point WAN is a line leased from a telephone or cable TV provider that connects a home computer or a small LAN to an Internet service provider (ISP)



Point-to-Point WAN



Switched WAN

Metropolitan Area Networks

* It is a network with a size between a LAN and a WAN.
* It normally covers the area inside a town or a city.

Example: A part of the telephone company network that can provide a high speed DSL line to the customer.

Interconnection of Networks : Internetwork.

* When two or more networks are connected they become an internetwork or internet.
* Example:

Assume an organization has 2 offices.
One on east coast & other on west coast.

⇓

West Coast office has a bus topology LAN

+

East Coast office has a star topology LAN

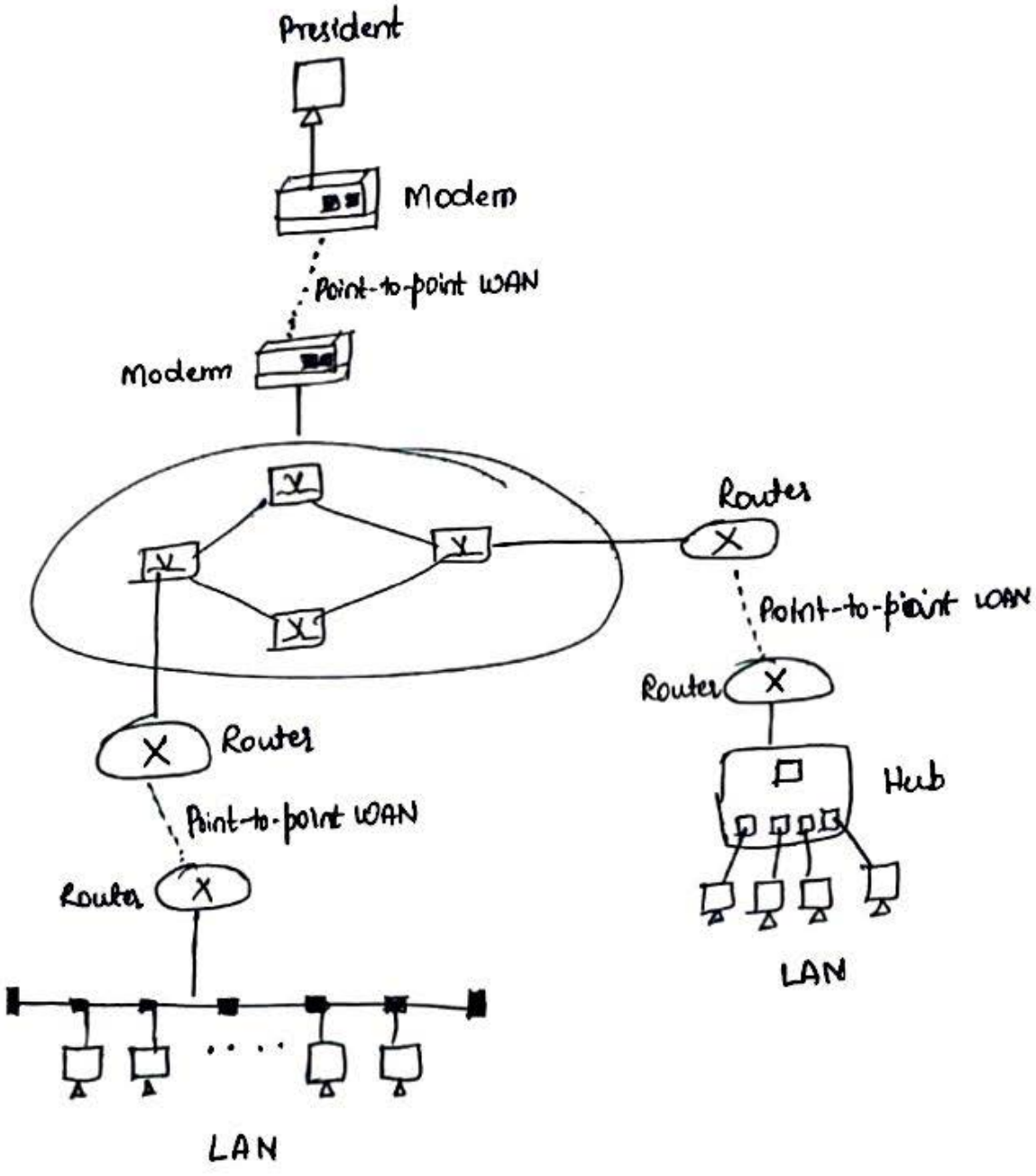
⇓

President of company lives somewhere in middle & needs to have control over the company from her home.

To connected these three entities (2 LANs and president's computer), a switched WAN (operated by a service provider such as telecome company) for WAN, they are been leased.

⇓

TO Connect LANs to WAN, three point-to-point WANs are required.

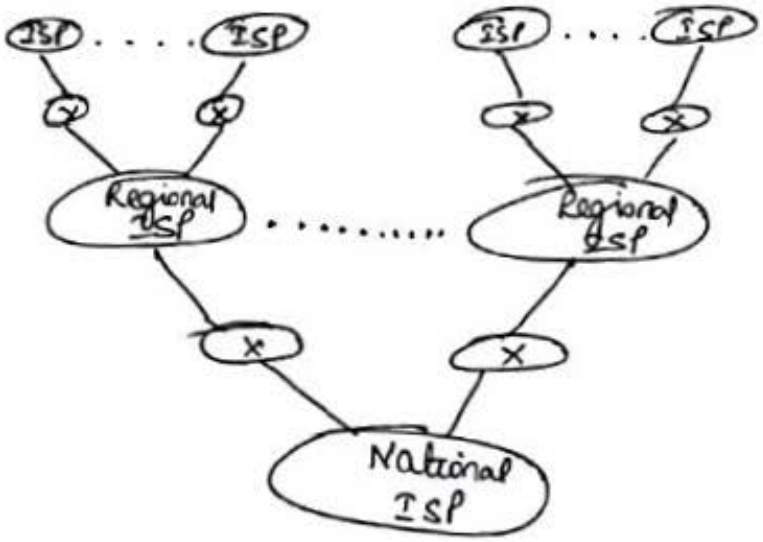


Heterogeneous network made of four WANs and two LANs

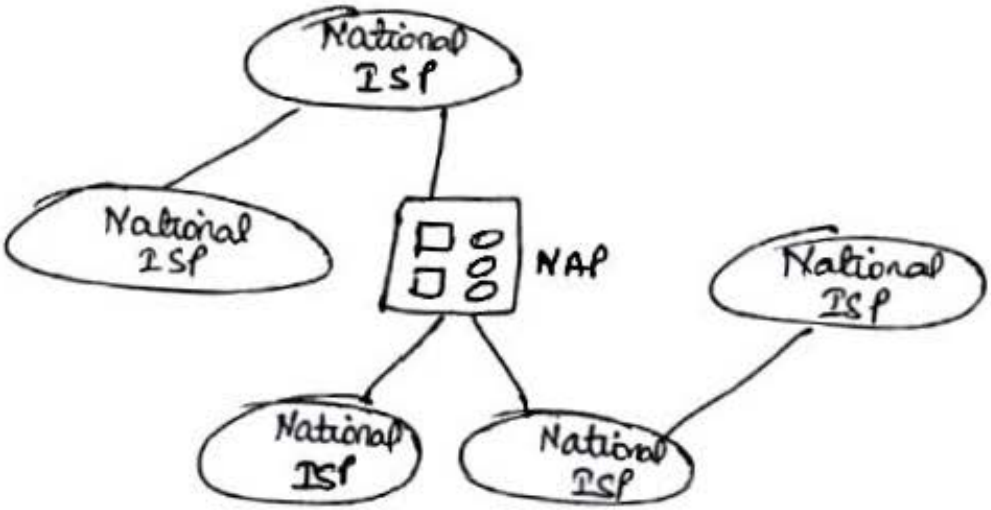
Internet Today

+ It is not just a hierarchical structure, it is made up of many WAN and LAN networks joined by connecting devices and switching stations.

* Internet service providers (ISPs) → These are international service providers, regional service providers, national service providers and local service providers.



Structure of an National ISP



Interconnection of National ISP's

② International Telecommunication Union - Telecommunication Standards Sector (ITU-T)

* Defines national standards for telecommunications.
* ITU with CCITT (Consultative Committee for International Telegraphy and Telephony) devoted to research & establishment of standards for telecommunicaions in general and for phone and data systems in particular.

③ American National Standards Institute (ANSI)

* It is completely private, nonprofit corporation.

④ Institute of Electrical and Electronics Engineers (IEEE)

* It is the largest professional engineering society in the world.
* It aims to advance theory, creativity and product quality in the fields of electrical engineering, electronics and radio as well as in all related branches of engineering.

⑤ Electronic Industries Association (EIA)

* It is a nonprofit organization devoted to the promotion of electronics manufacturing concerns.
* Its activities include public awareness education and lobbying efforts.

1.4 Protocols and standards

Protocols

* An entity is anything capable of sending or receiving information.
* For communication to occur, the entities must agree on a protocol.
* A protocol is a set of rules that govern data communications
* It defines what is communicated, how it is communicated and when it is communicated.
* Key elements of protocol are

a) Syntax → It refers to the structure or format of the data.

Example: A simple protocol might expect the first 8 bits of data to be the address of sender, second 8 bits to be address of receiver and rest to be the message itself.

b) Semantics → It refers to the meaning of each section of bits.

Example: Does an address identify the route to be taken or the final destination of the message?

c) Timing → It refers to two characteristics
① When data should be sent
② How fast they can be sent.

Example: If a sender produces data at 100Mbps but the receiver can process data at only 1 Mbps, the

transmission will overload the receiver and some data will be lost.

Standards

* They provide guidelines to manufacturers, vendors.. government agencies and other service providers to ensure the kind of interconnectivity necessary in today's marketplace and in international communications.
* Two categories of data communication standards are
  1. de facto ("by fact" or "by convention")
  2. de jure ("by law" or "by regulation")
* De facto → standards that have not been approved by an organized body but have been adopted as standards through widespread use
* De jure → Standards that have been legislated by an officially recognized body.

Standards Organizations

* Standards Creation Committees

1. International Organization for Standardization (ISO)
   * It is a multinational body and is active in developing cooperation in realms of scientific, technological and economic activity.

International Internet Service Providers

* They connect nations together.

National Internet Service Providers

* They are backbone networks created and maintained by specialized companies.
* Examples of national ISPs operating in North America are Sprintlink, PSInet, UUNet Technology etc.
* To provide connectivity to end users, these are connected by complex switching stations called Network Access Points (NAPs).
* National ISP n/w's are also connected to one another by private switching stations called peering points.

Regional Internet Service Providers

* They are smaller ISPs that are connected to one or more national ISPs.
* They have smaller data rate.

Local Internet Service Providers

* They provide direct service to end users.
* Local ISPs can be connected to regional ISPs or directly to national ISPs.

Forums

* It is made up of representatives from interested corporations.
* They were formed to accomodate the need for working models and agreements and to facilitate standardization process.
* Forums work with universities and users to test, evaluate and standardize new technologies.

Regulatory Agencies

* All Communications technology is subject to regulation by government agencies such as Federal Communication Commission (FCC) in US.
* Purpose of these agencies is to protect the public interest by regulating radio, television and wire/cable communications.

Internet Standards

* It is a thoroughly tested specification that is useful to and adhered to by those who work with the Internet.
* It is a formalized regulation that must be followed.
* Internet draft is a working document with no official status and a 6-month lifetime.
* A draft may be published as Request for Comment (RFC) upon recommendation from Internet authorities.
* Each RFC is edited, assigned a number and made available to all interest parties.

Chapter 2 - Network Models

2.1 Layered Tasks.

[Refer Text Page no- 28]

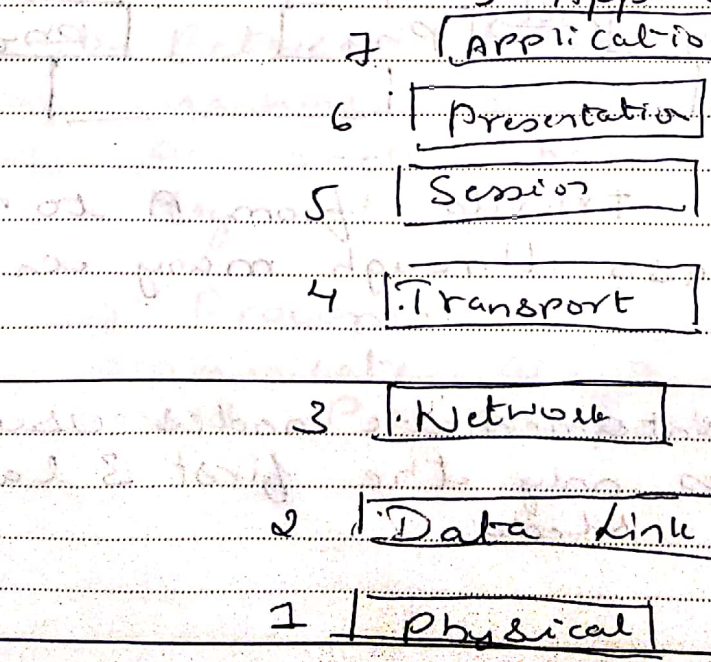
2.2 The OSI Model [Open System Interconnection Model]

→ A model for understanding and designing a network architecture that is flexible, robust and interoperable.

Layered Architecture

→ Layered framework comprising of seven layers

1) Physical
2) Data Link
3) Network
4) Transport
5) Session
6) Presentation
7) Application.



21 April
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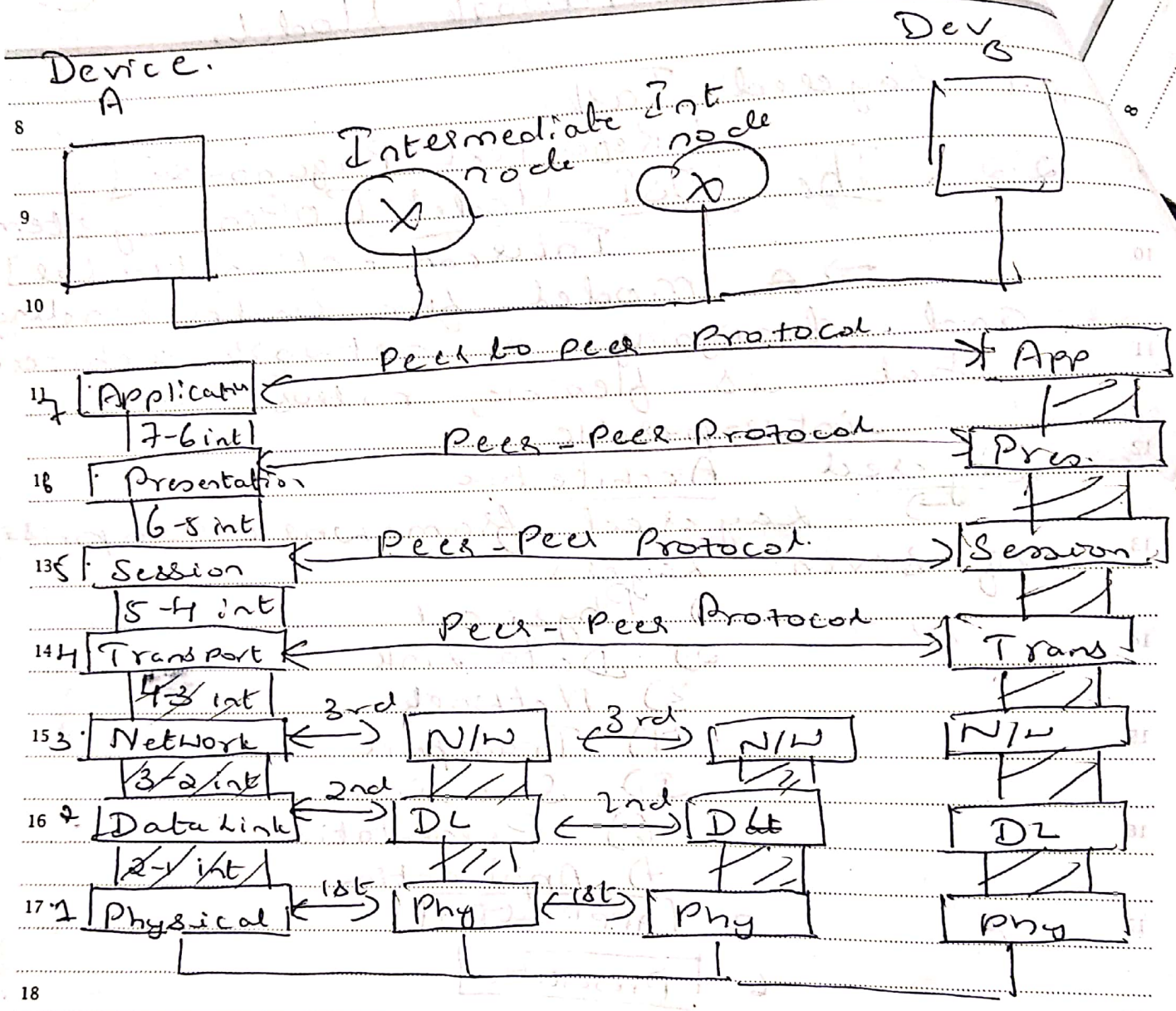

→ The Message travels from A to B, it may pass through many int nodes.

April 2015

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Tue		7	14	21	28
Wed	1	8	15	22	29
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Fri	3	10	17	24	
Sat	4	11	18	25	
Sun	5	12	19	26	

→ The intermediate nodes usually involves only the first 3 layers of OSI Model.

April
Wednesday 22

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→ In developing the model designers identified which networking functions had related uses and collected those functions into discrete groups that became the layers.

→ Thus the architecture created by designer that provided distinct functionality in each layer & is both comprehensive & flexible

→ Within a single machine each layer calls upon the services of the layer just below it.
ex:- Layer 3 uses the services provided by Layer 2, & provides services to Layer 4.

→ Between Machines layer x on one machine communicates with layer x on another machine which is governed by set of rules called protocols.

→ Process on each Machines that communicate at a given layer are called Peer to peer process.

23 April
Thursday

Priority

Peer to Peer Processes

→ At the physical layer communication is direct. Device A in the above fig sends a stream of bits to Device B.

→ At the higher layers, however communication must move down through layers on device A over to device B and then back up through the layers.

→ Each layer in the sending device adds its own info to the msg it receives from the layer just above it & passes the whole package to the layer just below it.

→ At layer 1 the entire package is converted to a form that can be transmitted to the receiving device.

→ At the receiving machine msg is unwrapped layer by layer with each layer removing the data meant for it.

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Friday 24

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Interfaces Between Layers

→ The passing of data & up & down of the layers is possible by interface between each pair of adjacent layers.

→ Each interface defines the info & service a layer must provide for the layer above it.

→ Because of the above characteristic the specific implementation of its function can be modified or replaced without requiring changes to the surrounding layers.

Organization of layers

→ The seven layers can be thought of belonging to three subgroups.

→ Layer 1, 2 & 3 :- Physical, Data link, Network layers are the network support layers; deals with physical aspects of moving data from one another

ex:- electrical specification, physical connections, transmission & reliability.

25 April
Saturday

Priority

→ Layers 5, 6, 7 are user support layers; allow interoperability among unrelated S/W systems.

→ Layer 4 links 2 subgroups and ensures that what lower layers have transmitted is in a form that upper layers can use.

[Refer to diagram figure 2.4 in text page no 32]

→ D7 → Data unit at layer 7

→ 7th by D6, D5 & so on are Data unit at respective layers.

→ Process starts at layer 7 then moves across the descending layers.

→ At each layer headers & trailer is been added.

→ Trailer added at only at layer 2.

→ When it passes through layer 1, it is changed into an electromagnetic signal & transported along physical link.

→ Upon reaching destination, the signal in layer 1 is transformed back into digital form

April 2015

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→ The data unit moves up through the layers at the destination.

→ As each block of data reaches the higher layer headers, trailers are removed respective actions corresponding to the layers are taken.

→ And at layer 7 it is again converted into the form appropriate to the application.

Encapsulation

→ The header and data unit of one layer is encapsulated into the packet at a layer below it.

→ In other words packet at level N-1 carries the whole packet from level N

→ The level N-1 will not be able to make out which part of encapsulated packet is data, & which part is header or trailer.

May 2015

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27 April
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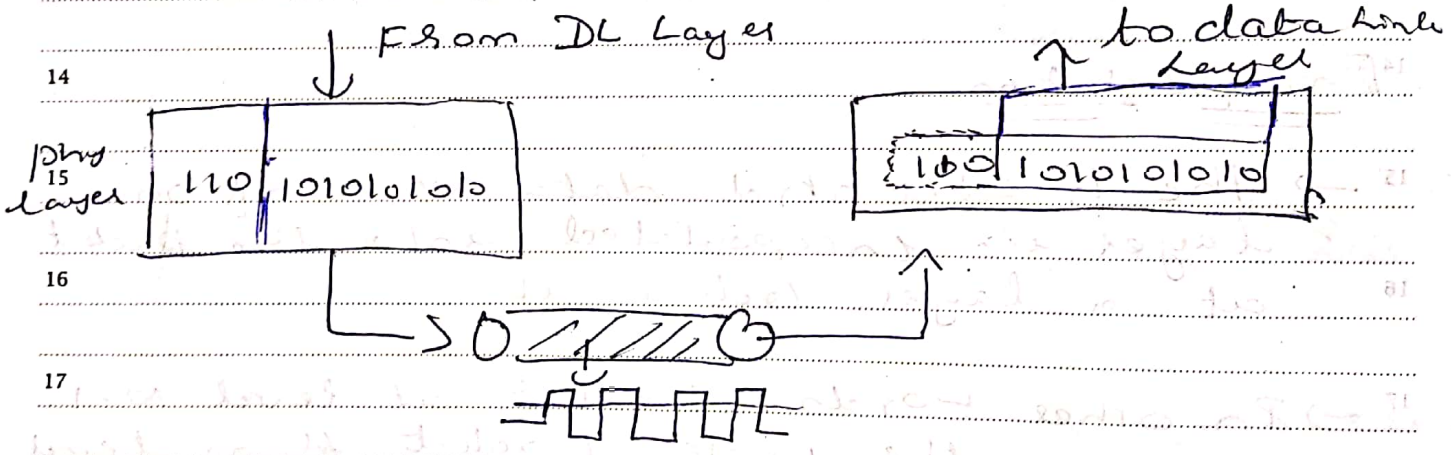
Priority

Layers in the OSI Model

Physical Layer

→ Co-ordinates the functions required to carry a bit stream over physical medium.

→ Deals with mechanical & electrical specifications of the interface & transmission medium.



Physical Layer is concerned with the following

1) Physical Characteristics of the interface & Medium :-

→ Physical layer defines the characteristics of interface between the devices & transmission medium.

→ It also defines the type of transmission medium

April 2015

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Tuesday 28

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Representation of bits

→ The physical layer data consists of stream of bits with no interpretation.

→ It must be encoded into signals. Physical Layers defines the type of encoding.

Data Rate :-

→ Transmission Rate [no of bits sent each second] is defined by the physical layer.

Synchronization of bits :-

→ The sender & receiver must be synchronized at the bit level.

→ The senders & receivers clocks must be synchronized.

Line Configuration.

→ Physical layer is concerned with connection of devices to the media.

May					2015
Wk	18	19	20	21	22
Mon		4	11	18	25
Tue		5	12	19	26
Wed		6	13	20	27
Thu		7	14	21	28
Fri	1	8	15	22	29
Sat	2	9	16	23	30
Sun	3	10	17	24	31

Physical Topology

→ Physical Topology defines h
devices are connected to make a
network

Transmission Mode

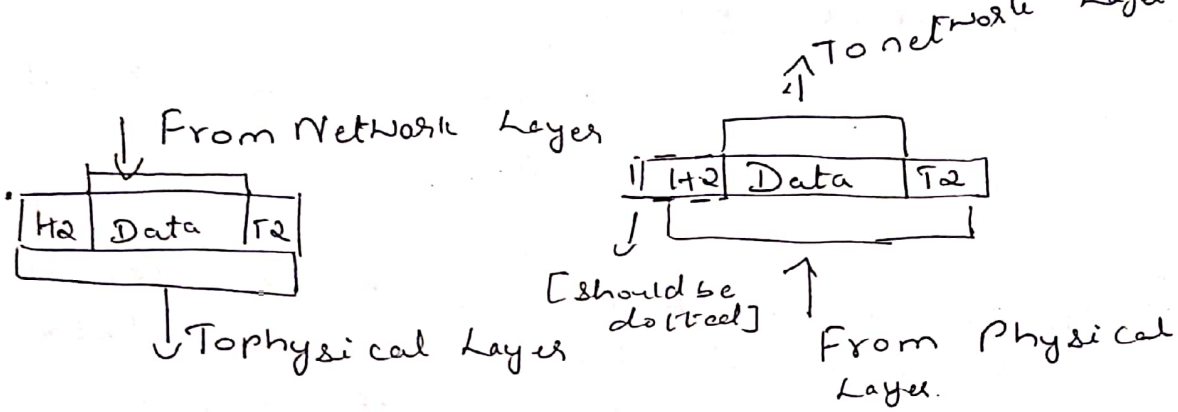
→ Defines direction of tran
between 2 devices

1) simplex
2) halfduplex
3) full duplex

Data link Layer

UNIT I-CONTD

Data Link Layer: Transforms the physical layer to a reliable link. It makes it appear error free to the upper layer.



Data link layer is responsible for ~~moving~~ the following

1) Framing: The data link layer divides the stream of bits received from the network into manageable data units called frames.

2) Physical Addressing:- If frames are to be distributed ~~allowed~~ n/w
→ Data link layer adds header to the frame to define sender/receiver of the frame

→ If the frame is intended for system device outside the senders n/w, the receiver address is the address of the device that connects the networks to the next one.

3) Flow Control :- If the rate at which data are absorbed by the receiver is less than the rate at which data are produced in the sender. The data link layer imposes a flow control mechanism to avoid the overwhelming

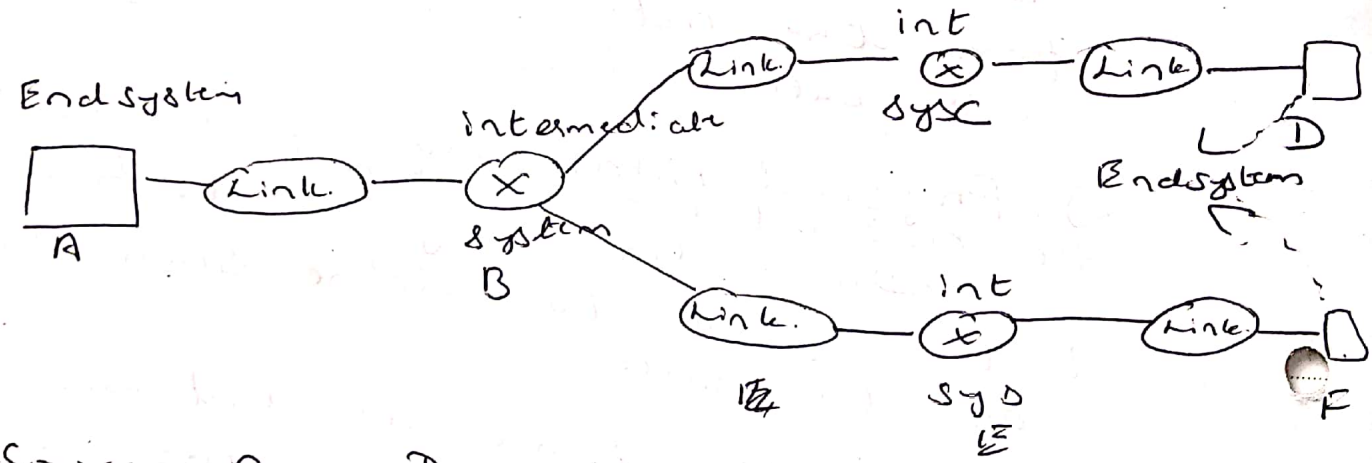
4) Error control:-

→ Adds reliability to the physical layer by adding mechanisms to detect & transmit damaged, lost or duplicate frames.

→ This is added in the trailer at the end of the frame.

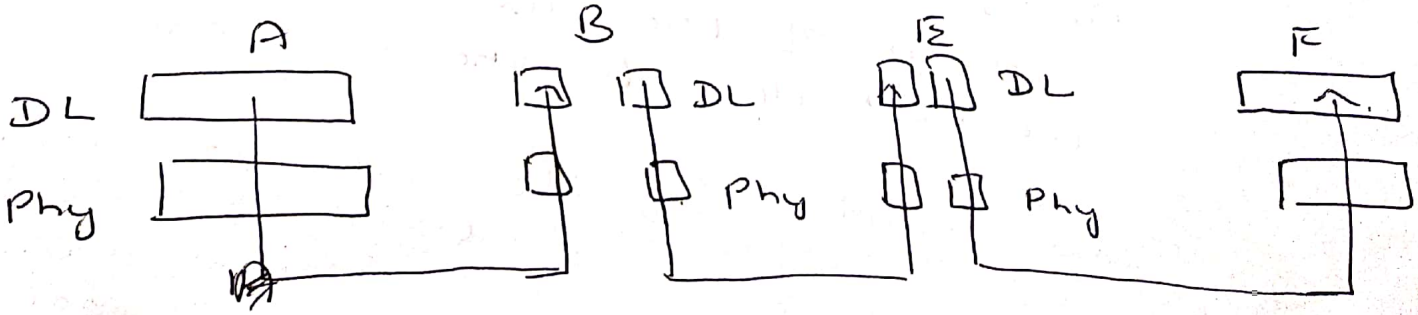
5) Access control:- When 2 or more devices are connected to the same link, data link layer protocols are necessary to determine which device has control over link at a given time.

↳ Hop-to-Hop delivery by data link layer



Source A Destination F

A → B → E → F



in this.

Communication at the data link layer occurs between 2 adjacent nodes

→ Source → A Destination → F

→ 3 partial deliveries made

↓

→ First the DL at A sends frame to DL at B

→ ~~Second~~ Similarly DL at B to DL at E & DL at E to DL at F.

→ 3 frames has different values in its header.

Header Details

→ Frame from A to B has

- A as source addrss
- B as Destination "

→ Frame from B to E has

- B as source add
- E as Destination "

→ Frame from E to F has

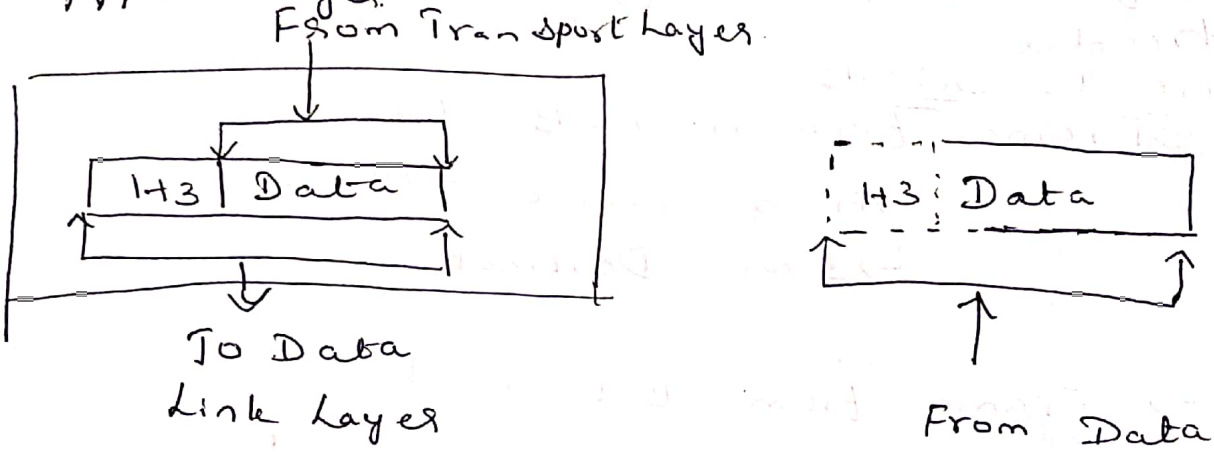
- E as source add
- F as Destination addr

Network Layer :-

→ Responsible for source to destination delivery of a packet possibly across multiple networks (links).

→ Useful when 2 systems are connected over different networks with connecting devices between the n/w.

N/W Layer



Responsibilities of Network Layer

1) Logical Addressing :-

DL → Handles Addressing problem locally.

→ If a packet passes the network boundary, we need another addressing system to help distinguish the source and destination systems.

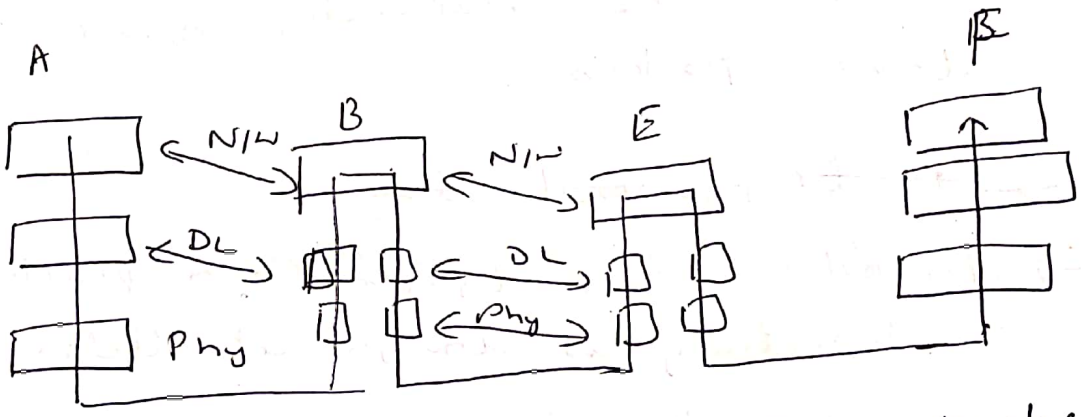
→ So, N/W layer adds the sender & receiver address in the header.

2) Routing:-

1) N/W layer routes the packet obtained from the upper layer in an internetwork using connecting devices such as routers & switches

→ With the same example as given for DL layer

as N/W layer provides source to destination [os end to end delivery of packets]



→ End System A sends the data packet to destination F reaches router B.

→ Router B decides the route to destination F based on its routing table

→ The packet reaches 'E' based on decision made by B.

→ E checks its routing table & sends it to F

Transport Layer

→ Responsible for process to process delivery of the entire message

→ Process is a application program running on a host.

→ Source to Destination delivery service provided by Network layer doesn't recognize the relationship between those packets

~~→ IT for Transport layer~~

→ Network layer treats each packet independently as though it belonged to a seperate Msg

→ Hence Transport layer ensures that the message appears in order & intact.

1) Service Point Addressing :-

→ As transport layer provides process to process delivery

→ Headers should include service point address or port address.

→ N/W layer sends the data to correct comp. → Transport " " " " " process.

Segmentation & Reassembly

→ A message is divided into transmittable segments.

→ Each segment ~~is~~ contains a sequence no which allows to identify the lost frames & to obtain a in-order delivery at the receiver.

3) Connection control

→ Transport layer can be
  - ↳ Connectionless.
  - ↳ Connection-oriented.

→ Connectionless transport layer treats each segment as an independent pkt.

→ Connection-oriented transport layer creates a connection first & then delivers the packet

4) Flow Control

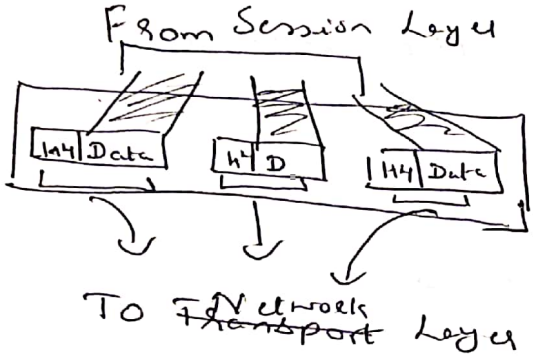
→ Transport layer is responsible for flow control.

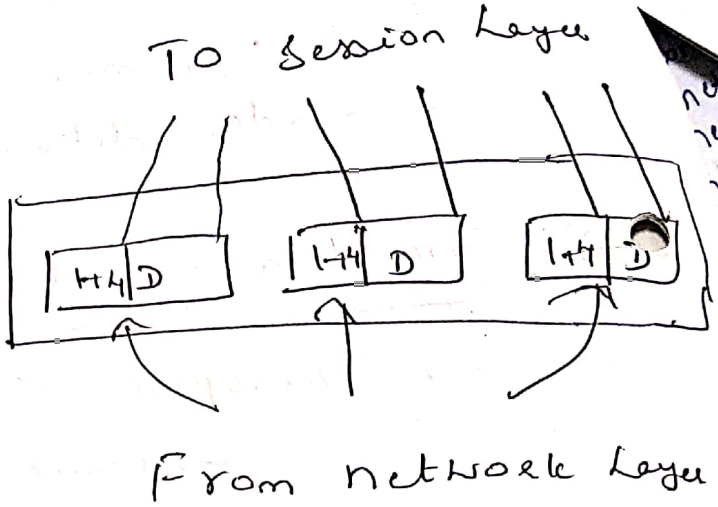
→ It is performed end-to-end.

5) Error Control :-

→ Error control at this layer is performed process to process rather than across a link.

→ Error correction is usually acheived through retransmission.





Session Layer

→ Network Dialog Controller

→ Establishes, maintains, & Synchronizes the interaction among communicating systems

Responsibilities

1) Dialog Control :- a) Two systems enter into a dialog (Request & Response)

b) Communication occurs in half duplex or full duplex manner.

2) Synchronization

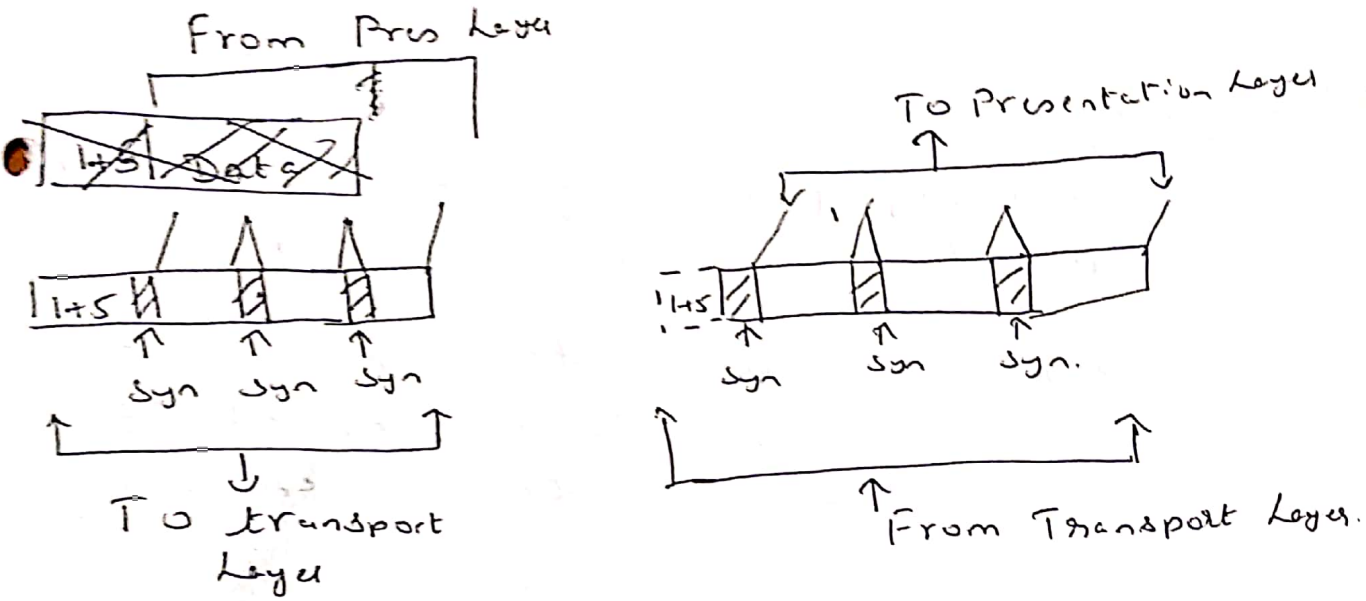
→ Allows a process to add check points to a stream of data.

→ If a system is sending a file of 800 pages. After every 100 pages checkpoints are being added

→ 500 Pages are sent successfully.

→ At 523rd page transmission error occurs.

→ only 501-523 needs to be retransmitted.



Presentation Layer

→ Concerned with the syntax & semantics of the info exchanged between 2 systems.

Responsibilities

1) Translation:- a) Processes exchange info in the form of chars text strings & so on.

b) They needs to be converted into bit stream

c) Different systems follow different encoding systems.

d) Therefore the presentation layer at Sender converts the data in Sender-dependent format to a common format

& AND

At the Receiver converts data in ~~received dependent format to~~ a common format to receiver dependent format.

2) Encryption

→ Security & Privacy is one of the important n/w issues

→ Encryption is a technique where the original message/info is converted to another form & transmitted over n/w

→ Decryption is the reverse process of Encryption

3) Compression

→ Reduces no of bits contained in the info

→ Important in transmission of multimedia such as text, audio & video.

Application Layer

→ Enables users, whether, Human or S/W to access the N/W.

→ It provides user interface and support for such as email, shared db management & other types of distributed info ~~Sys~~ services.

Services / Responsibilities

1) Network Virtual Terminal :-

→ Software version of physical terminal & it allows user to log on to a remote host

2) File Transfer, access, and management

→ Application allows a user to access files in a remote host, to retrieve & manage files.

3) Mail Services

→ Provides the basis for email forwarding & storage.

4) Directory Services

→ Provides distributed db sources & access for global info about various obj & services