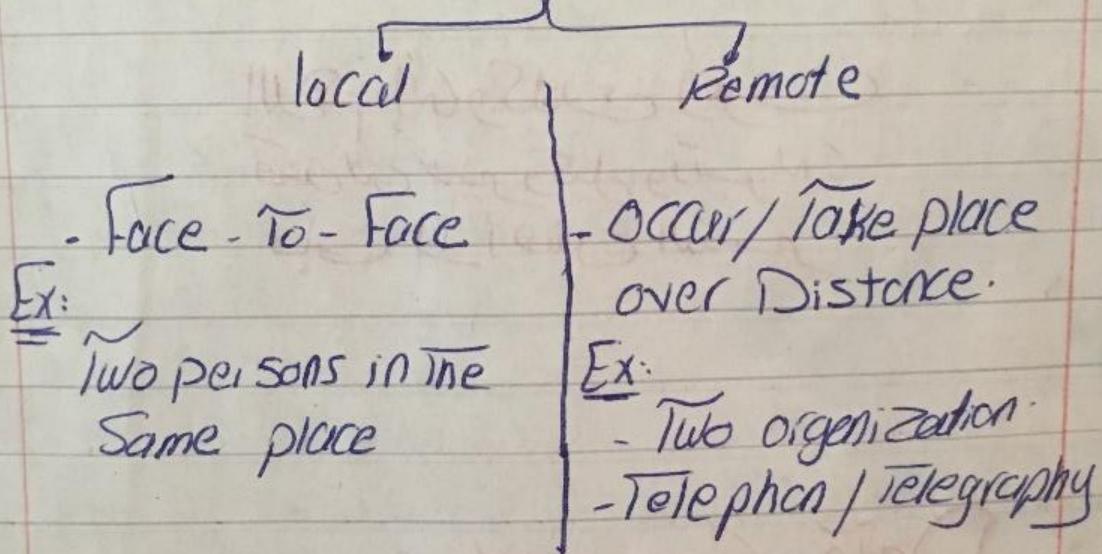


1

Chapter 1 Introduction

is Communication

Communication is The sharing of information.



is Data Communication

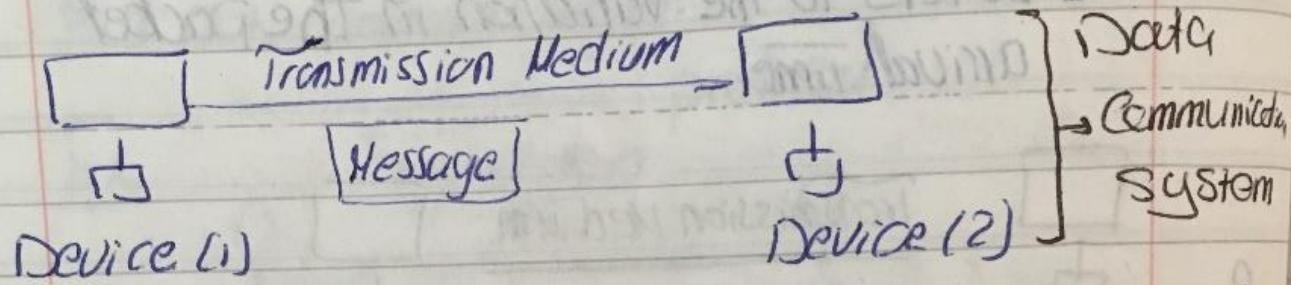
- Sharing/exchange of Data Between Two Devices
- Data (Text/Image/File/Audio/Video)

Communicate ~~Two~~ Two Devices

Transmission Medium
(Wired Cable/Wireless (Bluetooth))

- Send

Data Communication



* Effectiveness of Data Communication System
Depend on: (4 Fundamental characteristics)

① Delivery

- The system must deliver data to the correct destination
- Data received by the correct received device.

② Accuracy

- The system must deliver data accurately
- Data that have been altered in transmission & left uncorrected are unusable.

③ Timeliness

- The system must deliver data in a timely manner
- Data delivered late are useless.

Data ③

↳ frames

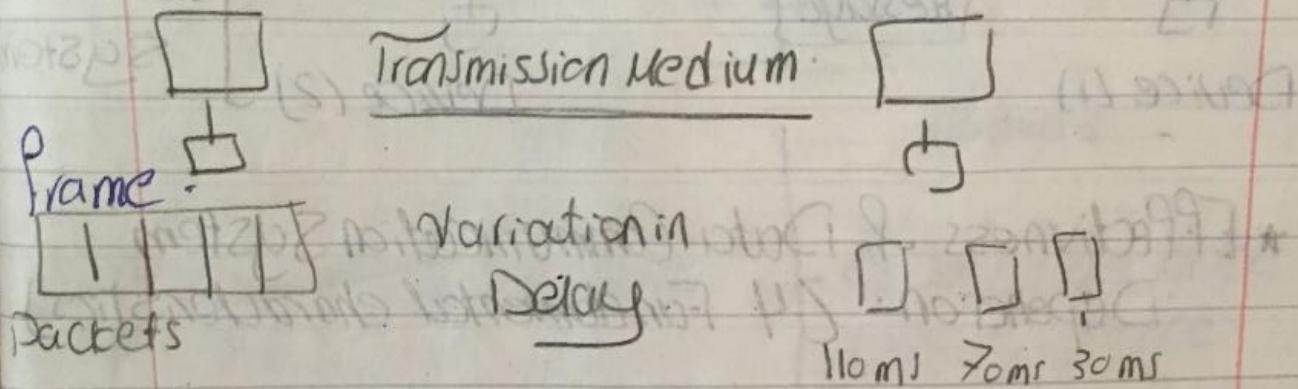
②

↳ packets

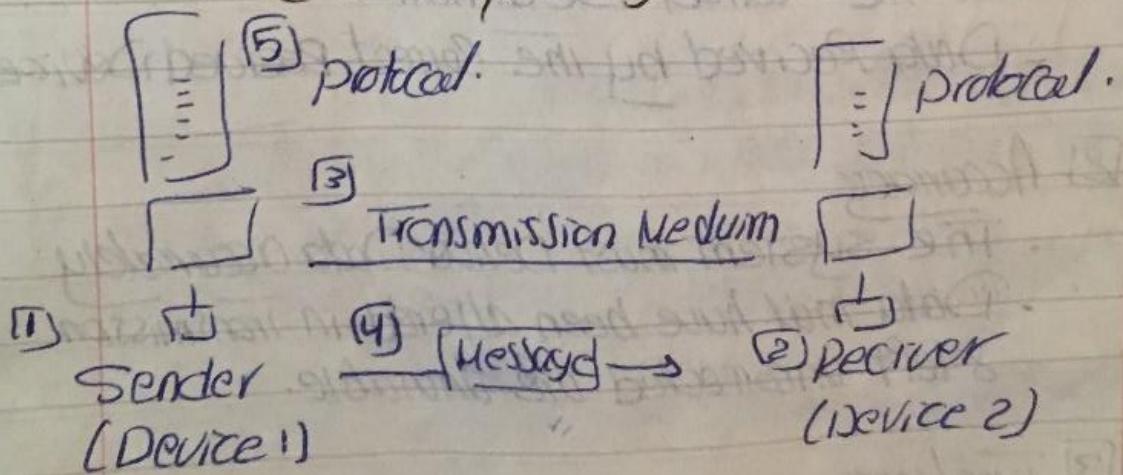
↳ bits

④ Jitter

- Refers to the variation in the packet arrival time.



* 1 Data Communication System Components (5 Components).



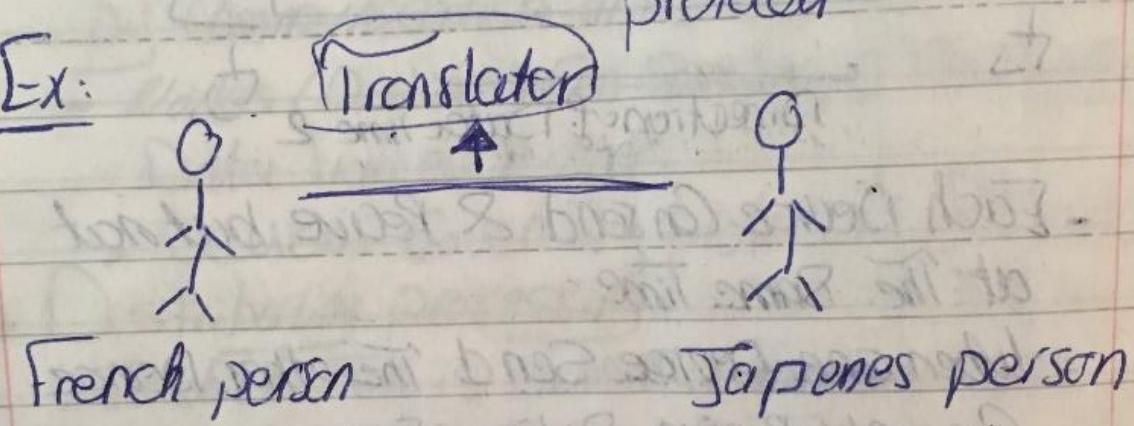
Protocol: Set of Rules that Cover the Data Communication

(4)

Without protocol Two Devices Are Connected
But not Communicated.

protocol.

Ex:



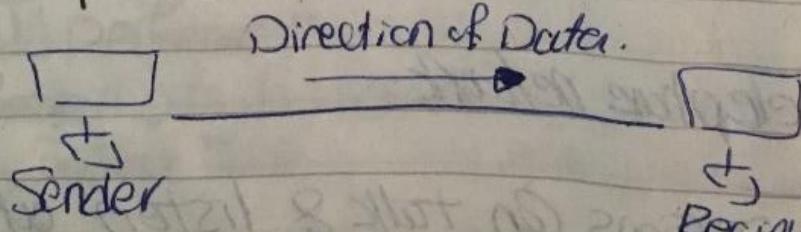
* Data Representation:

Text / Image / numbers / Audio / Video

* Data Flow: (Point to Point, Full Duplex, Half Duplex)

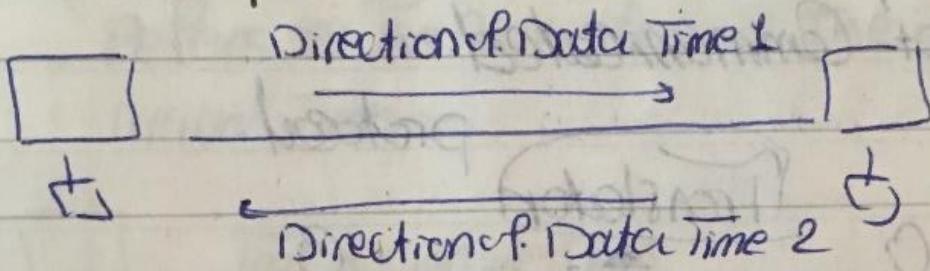
(Three Modes)

① Simplex Mode:



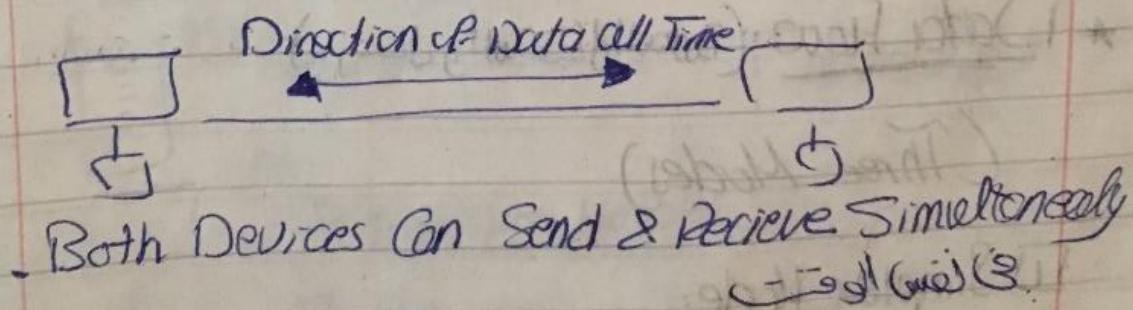
- only one Device can send (transmit) & the other Device receive.

② Half-duplex Mode:



- Each Device Can send & Receive but not at The Same Time -
- When one Device Send The other Device Can only Receive & Vice Versa.

③ Full Duplex Mode:



Both Devices Can Send & Receive Simultaneously

Ex: Telephone network.

- Two persons Can talk & listen at The Same Time.

6:

* Network:

- Set of Devices (Nodes) Connected by Communication links.
- Nodes (Devices) Can sending & Receiving Data From each other.
- = Devices Govern By protocols & standards.

* Distributing processing:

- In which Task is Divided among multiple Nodes (Devices) Instead of one node performing processing

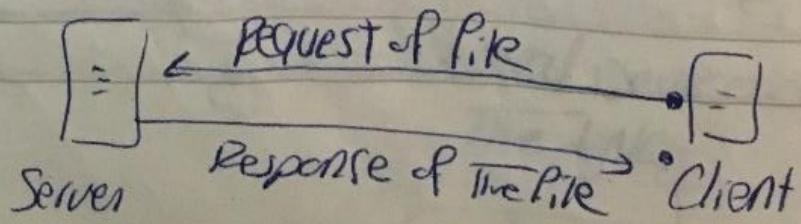
(instead of one Single Machine (Device) node)
being Responsible for all aspects of process
separate (Devices) handle subset of process.

* Network Criteria: (3 Criteria)

اولاً) Performance:

- performance اداء و هو يعتمد على
- 1) Transmit Time
 - 2) Response Time.

Ex:





* Performance Depends on Some Factors:

- ① Number of users in network.
- ② Type of Transmission Medium
- ③ Capabilities of HW
- ④ Efficiency of SW

* Performance Evaluated by Metric:

Throughput (القدرة على نقل)
Delay (throughput / Bandwidth)

To increase performance Increase Throughput
But need to increase Delay. Because of traffic congestion in the network.

② Reliability: (دالة / دالة)

Network Reliability is measured by the Frequency of Failure & The Time it takes a link to recover from failure.
& the network robustness.

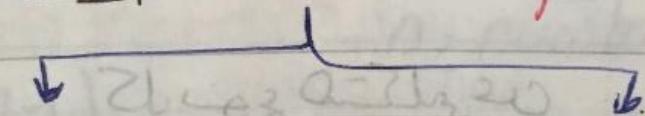
8

③ Security / (protection)

Include protecting Data from Unauthorized Access or Damage & Implementing Policies & procedures for Recovery from Data loss Failure.

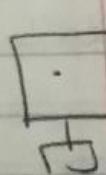
* Physical Structure : (network Attribute)

① Type of Connection / Line Configuration

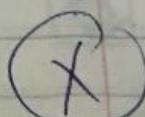
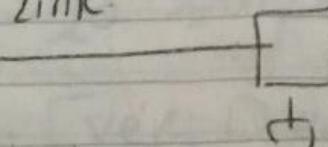


Point to point

Dedicated line Between
Two Devices

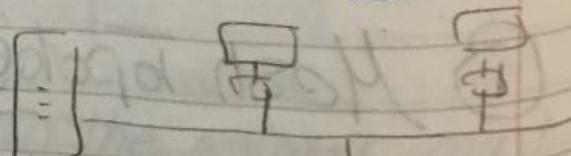


Link



Multipoint

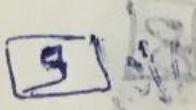
Connection is one in which
more than Two specific
Devices Share Single Link.



Several Devices can share
The Link



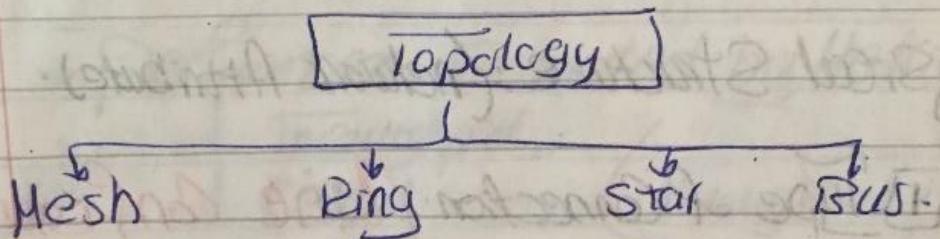
How to design network. 2.



- Number of user
- Type of Transmission Medium.
- Capabilities (HW/SW).

* Physical Topology:

- Topology: Geometric Representation of
The Relationships of all links
& Nodes in the Network.

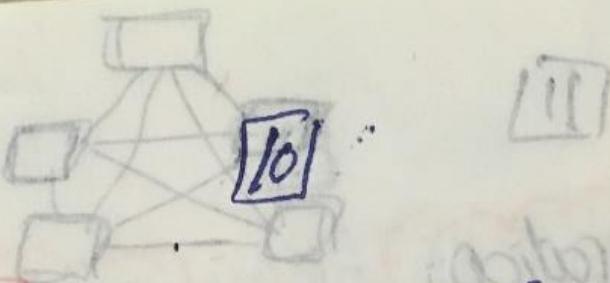


- أمثلة على JS
- ① Line Configuration: (P-to-P / Multi-point)
 - ② Shape
 - ③ number of cables.
 - ④ Operation
 - ⑤ Advantages
 - ⑥ Disadvantages.

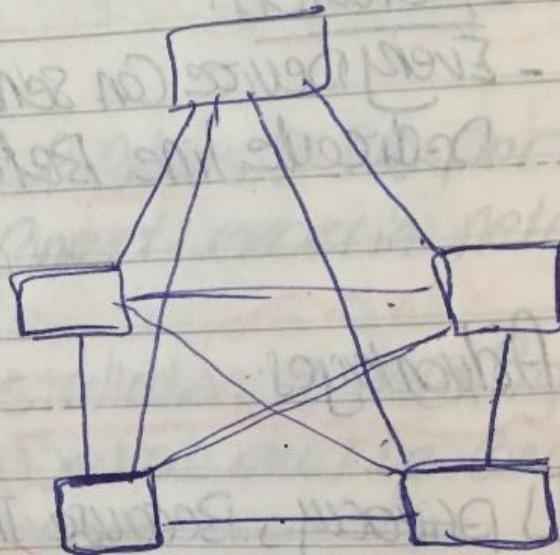
① Mesh Topology:

① Line Configuration

- Every Device has a dedicated point-to-point link to Every other Device.



② Shape:



③ Number of links

$n = \text{number of Nodes}$

$$\frac{n(n-1)}{2}$$

Ex

$$n = 5$$

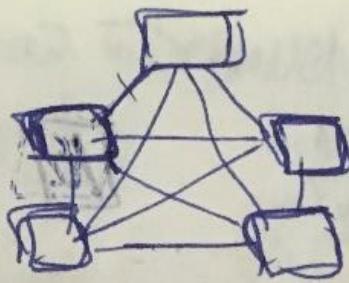
$$\frac{5(5-1)}{2} = \frac{20}{2} = 10 \text{ links}$$

number of I/O ports | Every Device
 = 20 I/O ports. | = $n-1 = 4$



- Every device in the network must have $n-1$ (I/O ports) to be connected to the other $(n-1)$ devices.

III



IV Operation:

- Every device can send Data on The Dedicated line Between The other Device.

V Advantages:

1 Privacy, Because The use of Dedicated links Guarantees that each Connection Can Carry its own Data load so eliminate traffic problems.

2 The Mesh topology is Robust.

- If one link become unusable, it Doesn't Down The all system.

3 Privacy & Security

- Every Message Between Two Devices Transmit along Dedicated line so only Two Devices Can see Message.

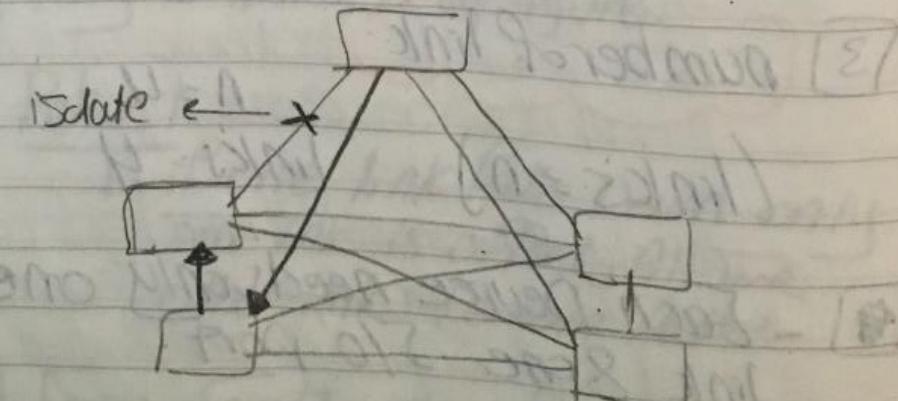
4 Point To point links Make Fault identification & Isolation.

پیشگویی و ایجاد قابلیت از کسر و از بین کردن لینک

12

⑥ Disadvantages:

- 1) large number of cables & I/O ports required to connect devices in network.
- 2) Difficult installation & reconfiguration
- Since every device must be connected to other devices.
- 3) The HW that required to connect I/O ports & cables is expensive.
- 4) Bulk of wiring can be greater than the available space in (walls/floors).



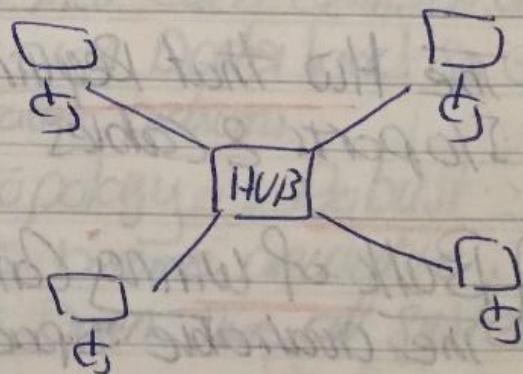
(13)

2] Star Topology:

1] Line Configuration:

- Each Device has a dedicated point-to-point link to the Central Controller (HUB).
- The Devices aren't directly linked to each other.

2] Shape:



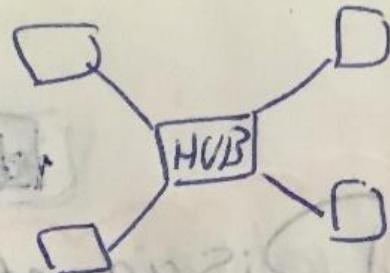
3] number of link

$$(\text{links} = n) \qquad \qquad \qquad n = 4$$

$$\text{links} = 4$$

- Each Device needs only one link & one S/I/O port.

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4 Operation

- ① Devices aren't Directly Connected to each other
- ② The HUB acts as Controller.

If one Device wants to send Data to other Device, First send Data to HUB, HUB then forward Data to other Device.

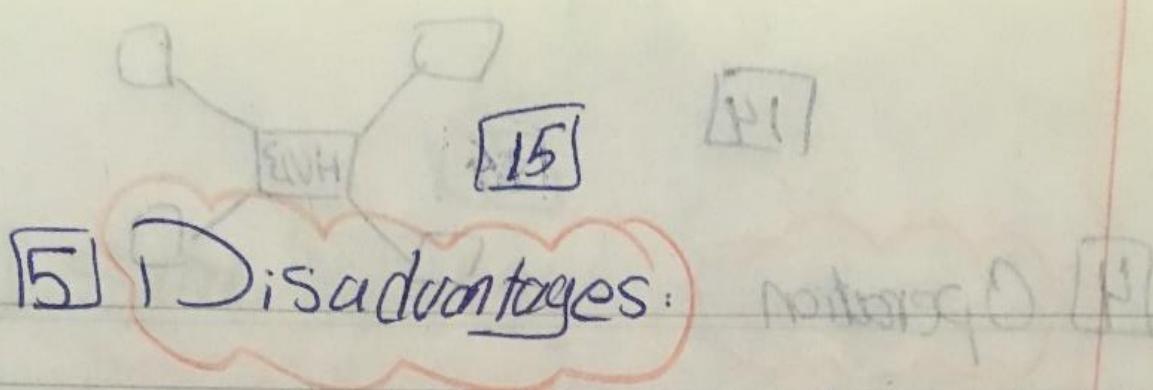
5 Advantages:

- ① less Cables than Mesh Topology.
- ② Easy to install & Configure.

③ Robust

If one link falls Down only that link is affected, All the other links remain active.

④ Easy Fault identification & isolation



5 Disadvantages:

① Dependency of The whole network on one single point
(HUB → central controller)

If HUB Goes Down The whole system Down.

3 Bus Topology:

1 Line Configuration

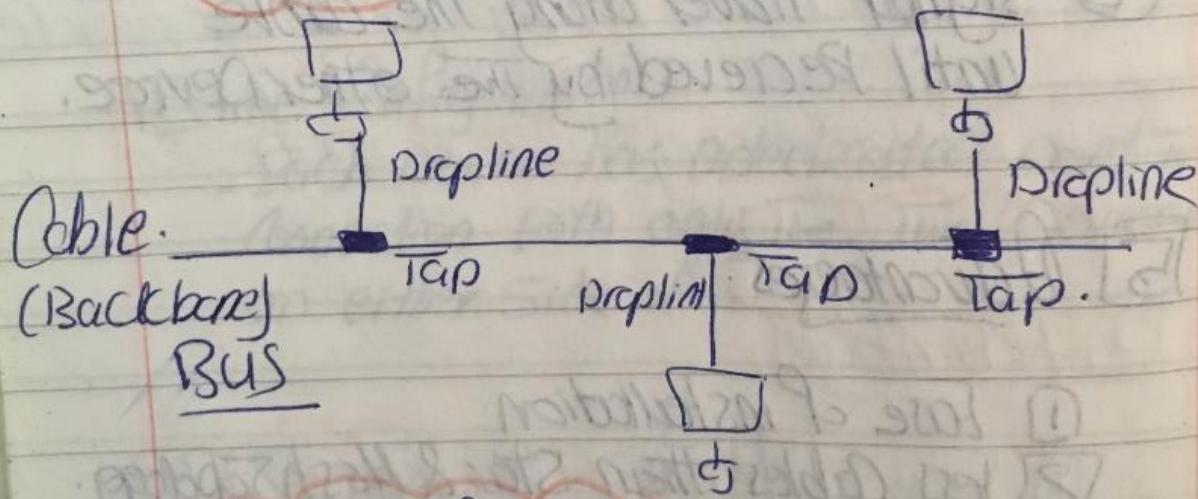
- Multipoint
- ↳ one single Backbone link & all Devices connect to it.
- Nodes (Devices) connected to the Bus By Drop line Connection Between Device & Main cables.
Taps → Connector.

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Taps: Function:

Strength & Support The Signal until
Received by The Device.

② Shape.



③ number of Cable (links)

↳ only one Backbone Cable

2 (n) dropline-

↳ = number of nodes (Devices)

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4 Operation:

- ① When Device need to send Data
To other Device. Send Data (signal)
To The Back Bone Cable.
- ② Signal Travel along the Cable
until Received by the other Device.

5 Advantages:

- ① Ease of installation
- ② less Cables than Star & Mesh Topology.
- ③ Cheap than Star & Mesh

6 Disadvantages:

- ① Difficult Reconnection & Fault Isolation
- ② Difficult To add or Remove A Device.
May be Disrupt The all network.

18

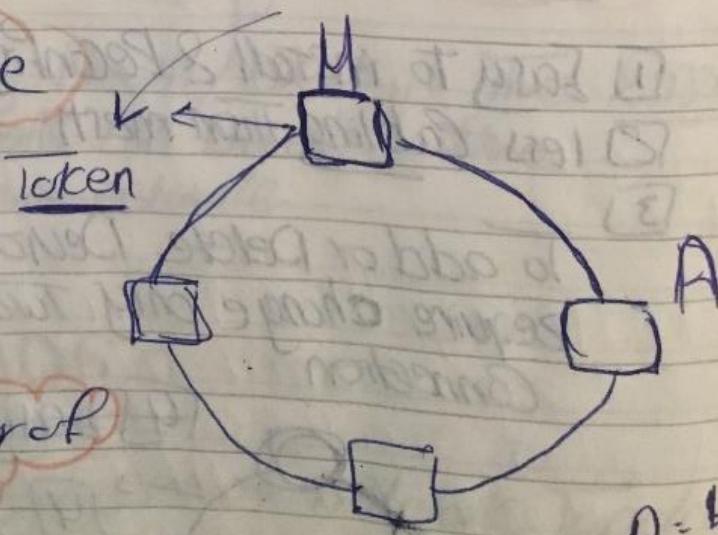
④ Fault in the Bus (Back Bone Cable)
Stop all transmission in the network.
(Down all the network.)

④ Ring Topology:

① Line Configuration:

- Each device has a dedicated point-to-point connection with only the two devices on either side of it.

② Shape



③ number of links

$$n: \text{Devices} \quad \text{links} = n - 1 \quad \text{links} = 4$$

Every Device has Two I/O port.

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4 Operation

- The Signal is passed along the Ring network from the sending Device until Received by the other Device.
- Each Device has Repeater to Regenerate the Signal to send to next Device until receive the Required Device.

5 Advantages

1) Easy to install & ReConfiguration.

2) less Cabling than mesh.

3) To add or Delete Device require change only Two Connection

4) Easy Fault



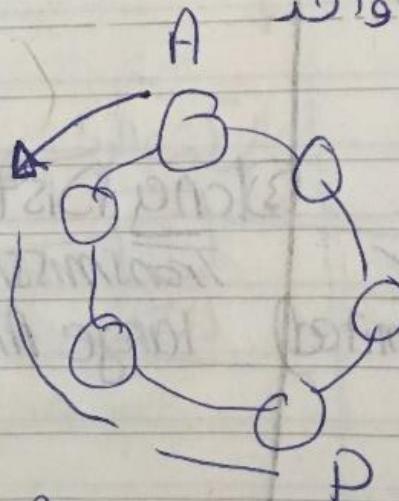
4) Easy Fault Isolation

20

Disadvantages

① Unidirectional Traffic.

arrival (signal) Data 1 Giga



② Any Down/Break in The Ring network Can Disable the Entire network.

⑤ Hybrid

Any Types of network Topology.
Two

21

* Categories of Network.

① LAN

① Local Area Network

② Small area cover.

Such as office,
Building

② WAN

① Wide Area Network

② Large area cover.

③ Short Distance

Transmission over

Small area (limited)

④ Long Distance

Transmission over
large Area.

⑤ MAN

① Metro politan Area network.

② Size Between LAN & WAN.

③ Cover area large than LAN &
small than WAN.

④ Cover area inside

Town & city.

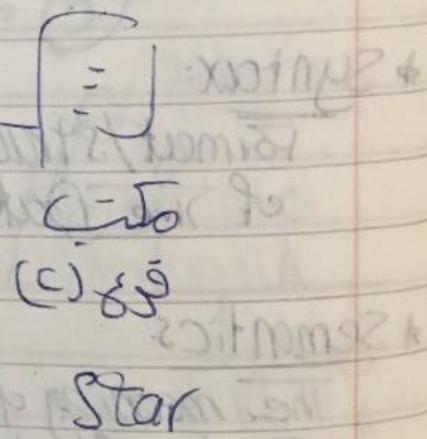
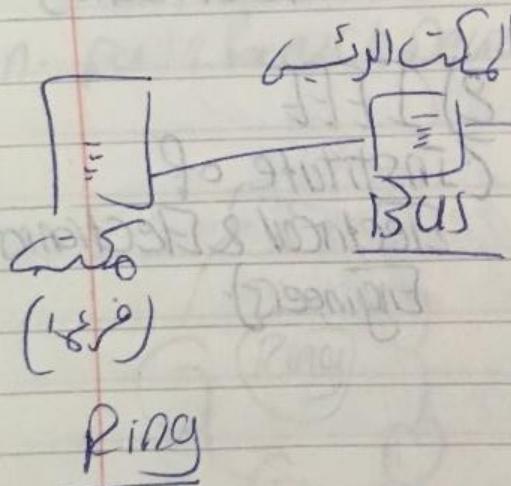
22

* internet

- network of networks

* Internet

- Collection of Many Separate Networks



* Protocol

- set of Rules
The govern
Data Communication

* Standard

- Guidelines to ensure that products from different manufacturers (organisations) can work together as expected.

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* The Key Elements of protocol

- 1) Syntax
- 2) Semantics
- 3) Timing

* Syntax:

Format / Structure
of the Data

* Semantics:

The meaning of each
Section & Bits.

* Timing:

- 1) When Data
Should be sent

- 2) How Fast They
Can be sent -

* Standard Organizations

1) ISO
(International Organization for Standardization)

2) IEEE
(Institute of Electrical & Electronics Engineers)

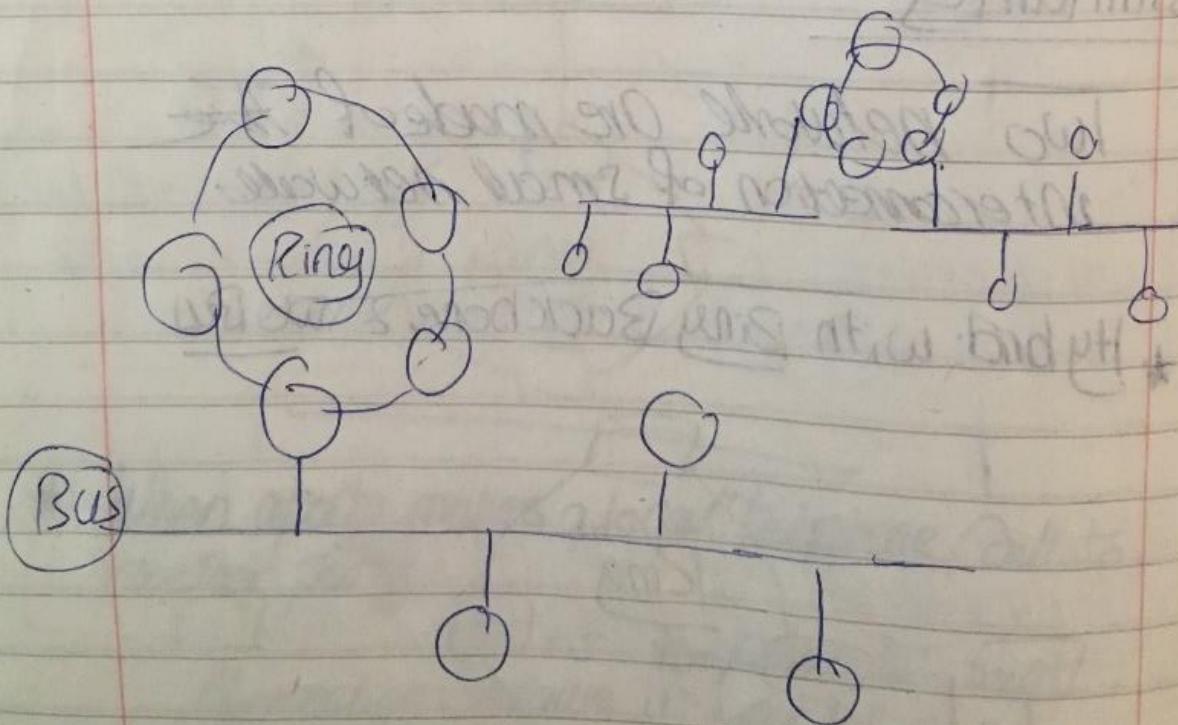
(24)

- * Unicode uses 32 Bit to represent a symbol or character.

$$\text{Max number} = 2^{32} - \boxed{1}$$

$$* n=6 \quad \frac{n(n-1)}{2} = \frac{6 \times 5}{2} = 15$$

$$n \cdot \text{parts for each device} = n-1 = 5$$



125

* Telephone network

- Designed For Voice Communication
- Circuit-switched network

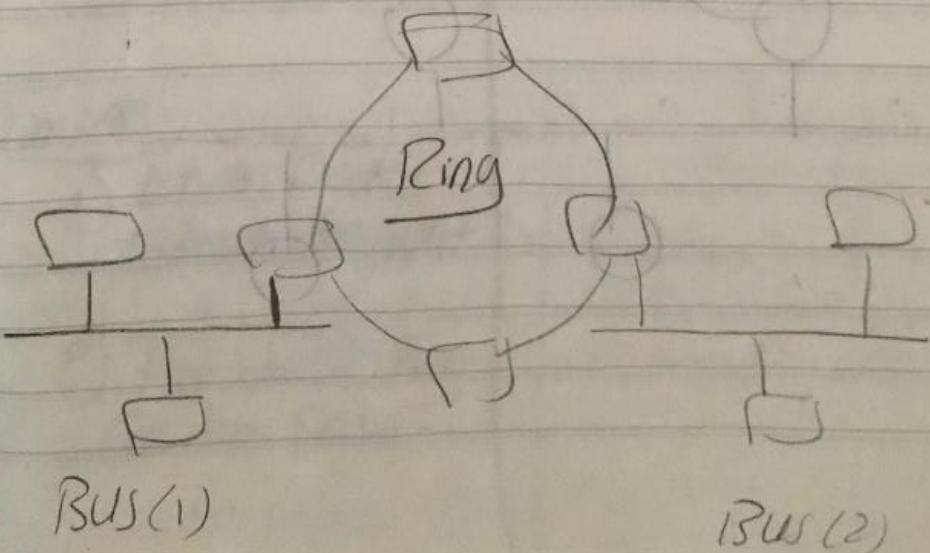
* Internet network

- Designed For Data Communication.
- packet switched network.

Similarities

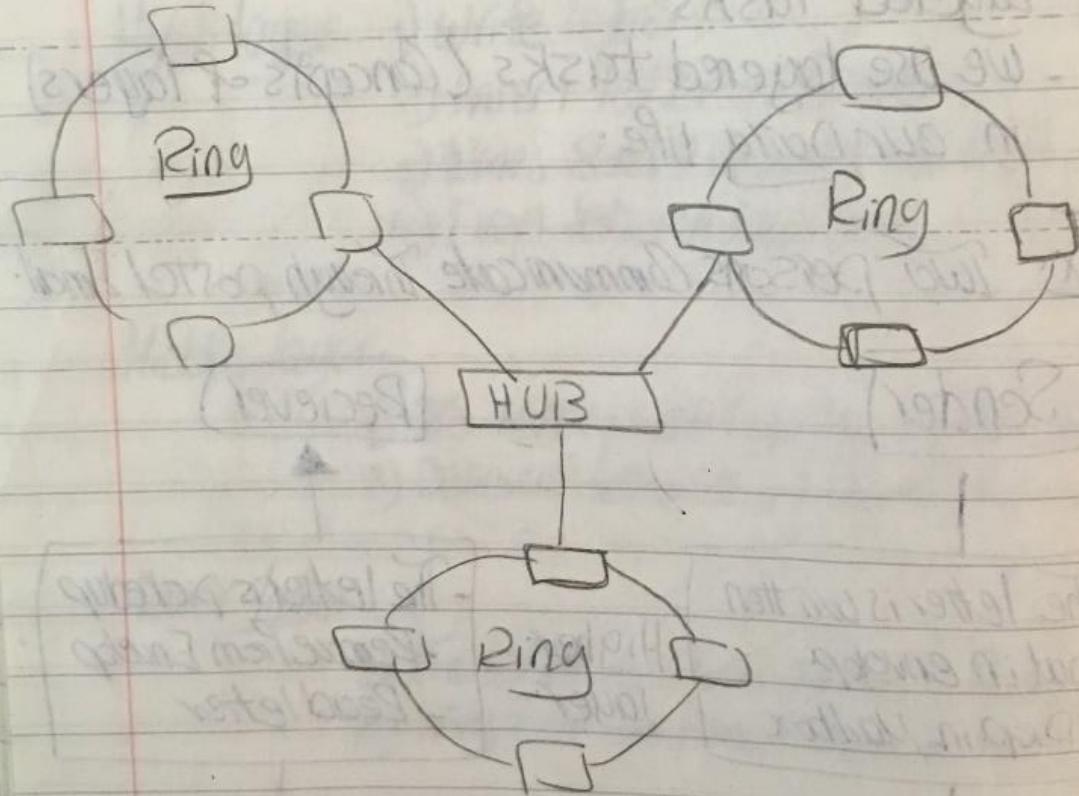
Two networks are made of the interconnection of small networks.

* Hybrid with Ring Backbone & two Bus



26

* Hybrid topology with star backbone & Three Ring



* When a party makes a local Telephone Call to another party

This is ~~one~~ point-to-point Connection Because it's a local Call Between only Two parties.

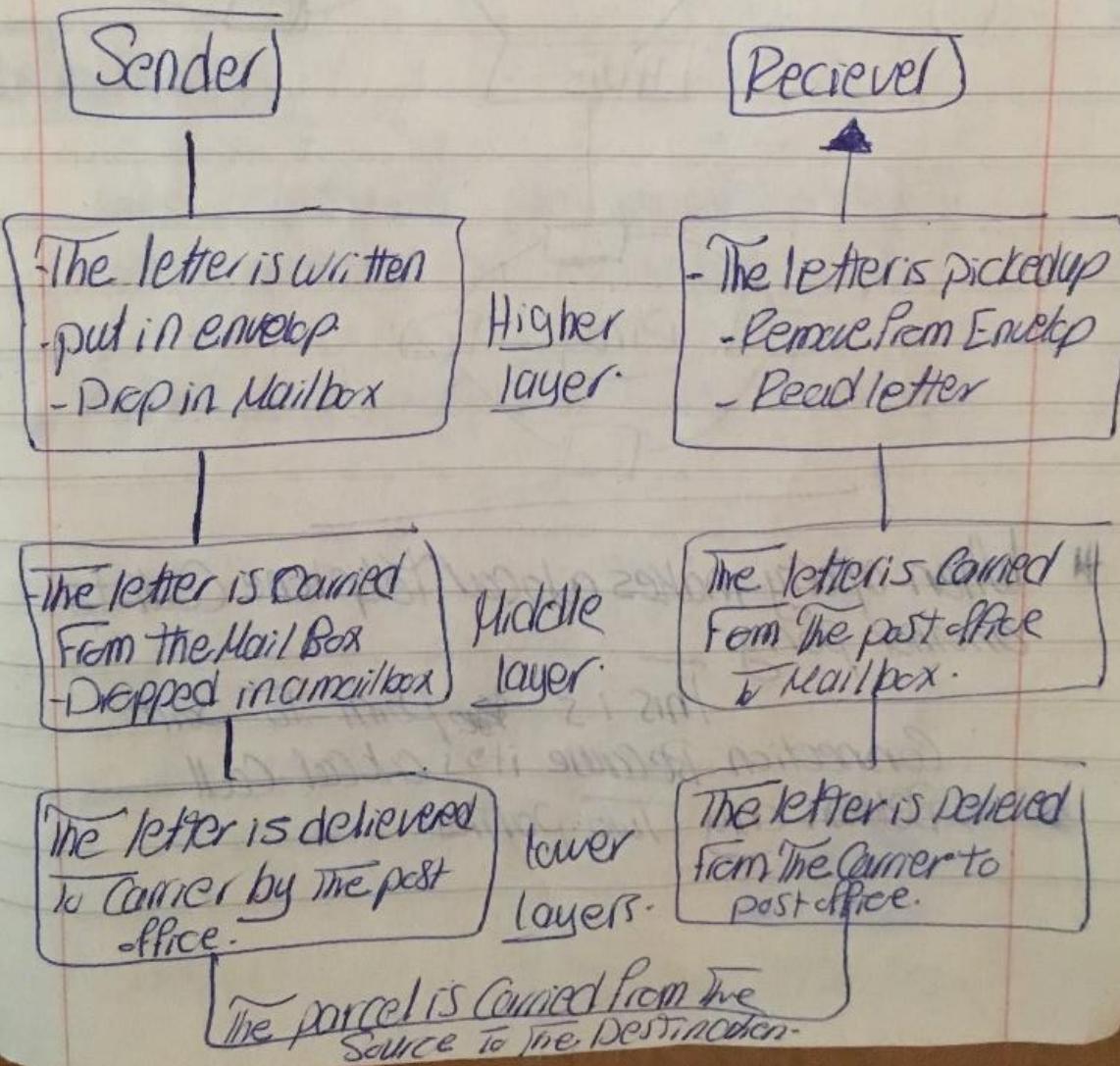
27.

Ch Network Models

* 2.1 Layered Tasks:

- we use layered tasks (concepts of layers) in our daily life.

Ex: Two persons communicate through postal Email.



[28]

Sender.

- High layer.
- 1) Write letter
 - 2) Insert letter in Envelope
 - 3) Writes Send & Receiver address.
 - 4) Drop letter in Mailbox.

Middle layer.

- 1) The letter picked up by letter carrier.
- 2) Delivered letter to post office.

Lower layer.

- 1) The letter is stored at post office.
- 2) Transports the letter by carrier.

Receiver.

Lower layer.

- 1) The carrier transports the letter to post office.

Middle layer.

- 1) The letter is stored & delivered to receiver mailbox.

High layer.

- 1) The Receiver picks up the letter
- 2) Open the Envelope & Read letter.

[29]

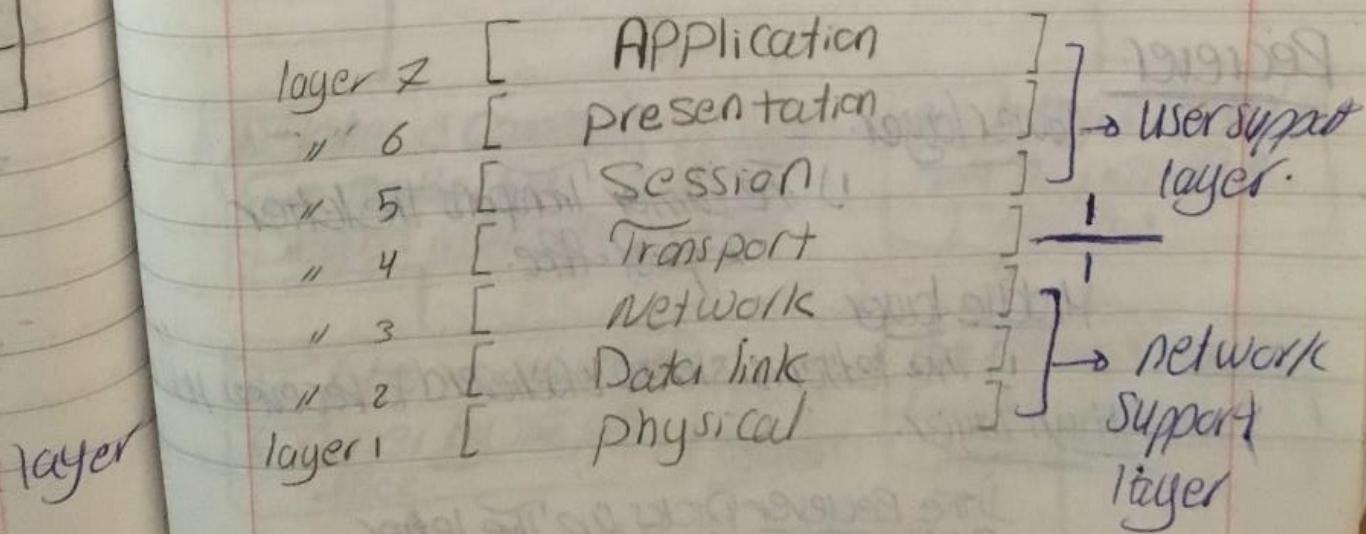
2.2 OSI (Network Model)

* OSI → (Open Systems Interconnection).

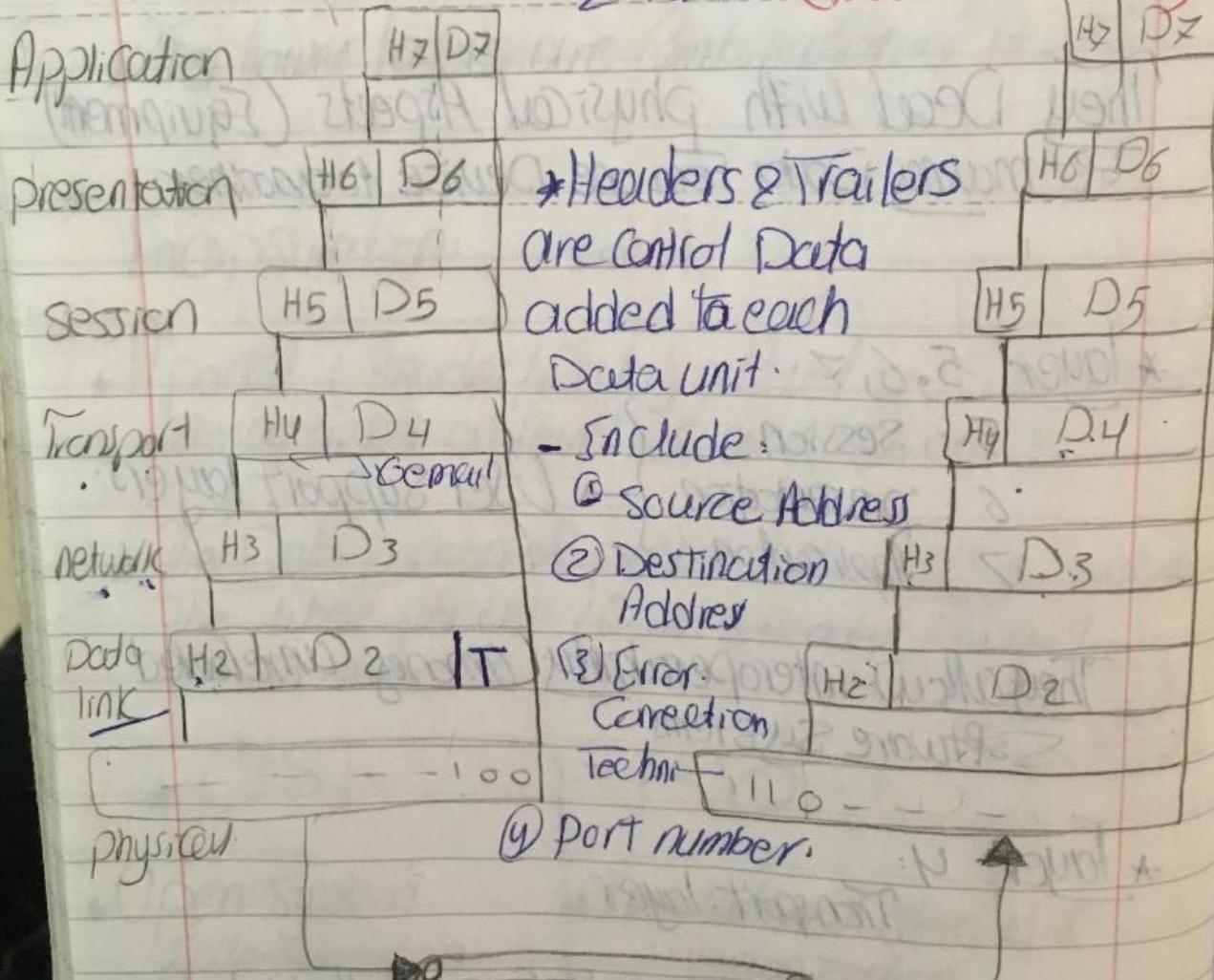
* OSI model is a layered framework for the design of network systems that allow communication between all types of computer systems.

* OSI - consist of 7 layer each layer has a set of protocols that allow any two different systems to communicate.

Each layer defines part of the process of moving information across a network.



- * The physical layer The signal passes into layers is transformed into digital form.
- The Data units moves through 2 layers
 - In Each layer add header & trailer (Data link only)



Trailer → add only at The Data link layer (layer 2).

[SI]

- * layer 1 (Physical)
 - 2 (Data link)
 - 3 (Network)
- } network support layers.

They Deal with physical Aspects (Equipment) of moving Data from one Device to another.

- * layer 5, 6, 7
- 5 : Session
6 : presentation
7 : Application
- } User support layers.

They allow interoperability among unrelated Software Systems.

- * layer 4:
Transport layer

- links the two subgroups & ensures that what the lower layers have transmitted is in a form that the upper layers can use.

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* The upper OSI layers are implemented in Software

* The lower layers are combination of HW & SW.

* Encapsulation:

* A packet (Header/Data) at level i is encapsulated into a packet at level j and so on.

* The Data portion of packet at level $i-1$ carries the whole packet (Data & Header / Tailer) from level i .

* OSI

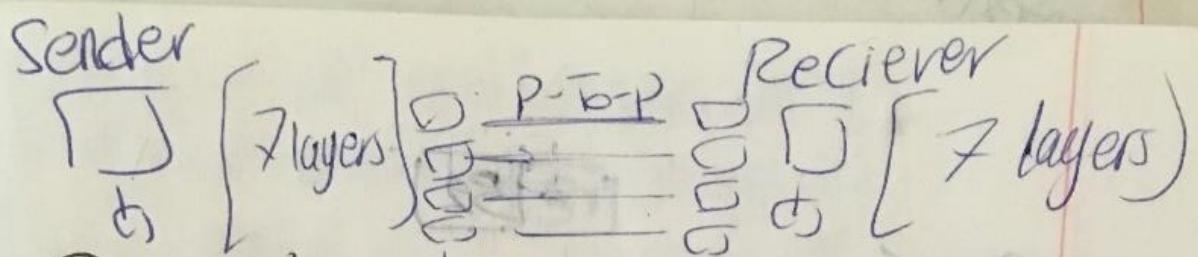
* Open System Interconnection

* Network Model

| ISO

* International Standard Organization

* Organization



* Peer - to - peer processing

- Processes on two or more devices communicating at the same layer.

- |

* OSI layers:

II physical layer

* physical layer is responsible for the movements of individual bits from one node to the next.

(Co 81)

- The physical layer is concerned with:

I physical characteristics of interface & medium.

- It defines the characteristics of the interface between the devices & the type of the transmission medium.

[34]

2] Representation of Bits.

- The physical layer Data Consists of a stream of Bits (0, -1)

- Bits must be Encoded

⇒ Encoding: The process of putting a sequence of Bits in a specific Format

3] Data Rate / Transmission Rate.

- Transmission Rate: The number of Bits sent at each second.

- physical layer Define The Duration of Bit send.

4] Synchronization of Bits. (sequence number.)

- The Sender & Receiver not only must use the Same bit Rate but also must be synchronized at The bit level.

5] Line Configuration.

- The physical layers concerned with The Connection of Devices.

- point-to-point
- Multipoint

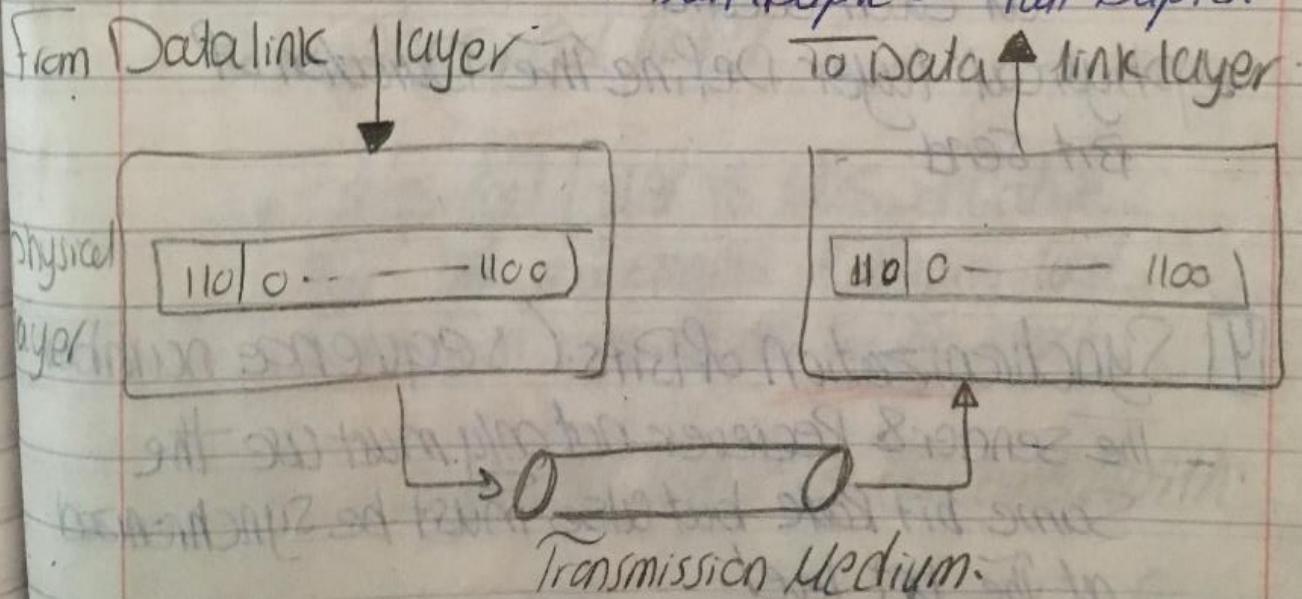
35)

⑥ Physical Topology

- It Defines How Devices are Connected To make network (Mesh/Star/Ring/Bus).

⑦ Transmission Mode:

- The physical layer defines how devices are. The direction of transmission between two devices
 - Simplex
 - Half Duplex
 - Full Duplex



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Frame

0000101

2 Data link layer

- * Data link layer is responsible for moving frames from one node to next.

* Responsibilities of Data link layer.

1 Framing: (Manageable Data units)

The Data link layer divides the stream of bits received from the network layer into manageable data units called frames.

2 Physical Addressing:

Frames are to be distributed to different systems on the network, The Data link layer adds a header to the frame to define the sender and/or receiver of the frame.

3 Flow Control:

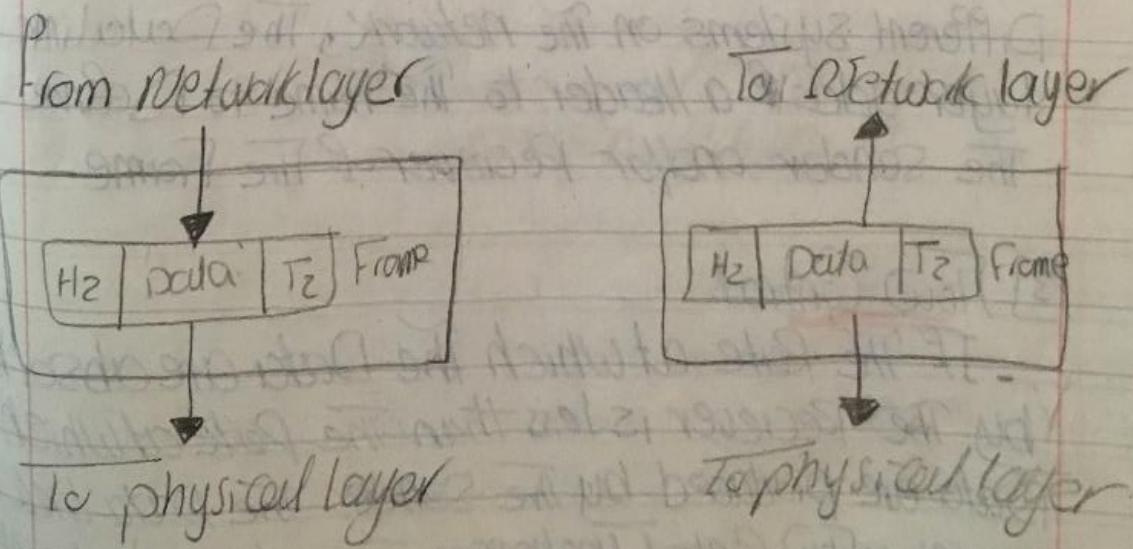
If the rate at which the data are absorbed by the receiver is less than the rate at which data are produced by the sender, the Data link layer imposes a flow control mechanism to avoid overloading the receiver.

4 Error Control:

- The Data link layers adds mechanisms to Detect & Retransmit Damaged or lost frames.
- Use Mechanisms to Recognize Duplicate Frames.
- Error Control is normally achieved through Tailer added to the End of The Frame.

5 Access Control:

- When Two or More Devices are Connected to The Same link, Data link layer protocols are necessary To Determine which Devices has Control over the link at any Given Time.



3 Network Layer (Host-To-Host).

* Network layer is responsible for the delivery of individual packets from the source host to the destination host.

* Responsibilities of Network layer.

IP Address

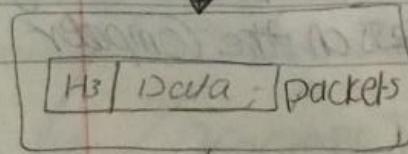
① Logical Addressing

- The network layer adds a header to the packet coming from the upper layer including logical address of the sender & receiver.

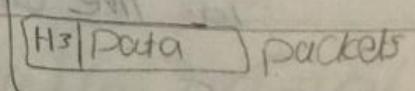
② Routing

- When networks or links are connected to create internetworks (network of networks) or large networks, the connecting devices called (Routers or Switches) route or switch the packets to their destination.

From
Transport layer



To
Transport layer



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4

Transport layer (process-to-process)

* Transport layer is responsible for the Delivery of a message from one process to another.

* Responsibilities of Transport Layer:

① Service point addressing:

- Computer run several programs at the same time.

- Source-to-destination delivery means not only from one computer to another but also from specific process to other process.

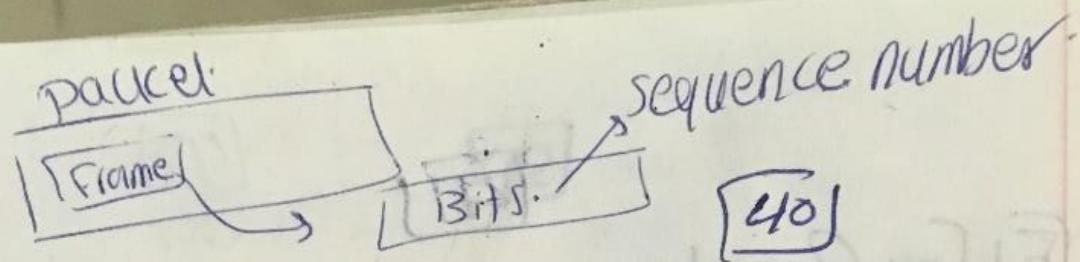
- Transport layer header include service point address (port address).

Port Address

- The network layer gets each packet to the correct computer.

- The Transport layer gets the entire message to the correct process on the computer





2] Segmentation & Reassembly

- A Message is Divided into Segments, with each segment containing a sequence number. This number enable Transport layer to reassemble the message correctly on the Destination.

3] Connection Control:

Connection less

- Connectionless Transport layer treats each segment as an independent packet & delivers it to the Destination.

Ex. UDP

Connection oriented

- Connection oriented Transport layer makes a connection with the Destination first before delivering packets.

After all packets transferred the connection is terminated.

Ex. TCP

4] Flow Control:

- Like the Data link layer, The Transport layer is responsible for flow control. Flow control at this layer is performed end-to-end rather than across single link.

↳ (process-to-process flow control).

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5) Error Control:

- like Data link layer, The Transport layer is responsible for Error Control.
- Error Control at This layer is process-to-process rather than single link.
- Sending process Ensure that Entire Message arrives at The Receiving process without Error.

5) Session layer:

- * Session layer is responsible for Dialog control & Synchronization (connection).
- It Establishes, Maintains & Synchronizes The interaction among Communicating Systems.

* Responsibilities of Session layer:

II) Dialog Control:

- The session layer allows two systems to enter into Dialog. It allows the communication between Two processes to take place.
Half Duplex - Full Duplex.

2] Synchronization

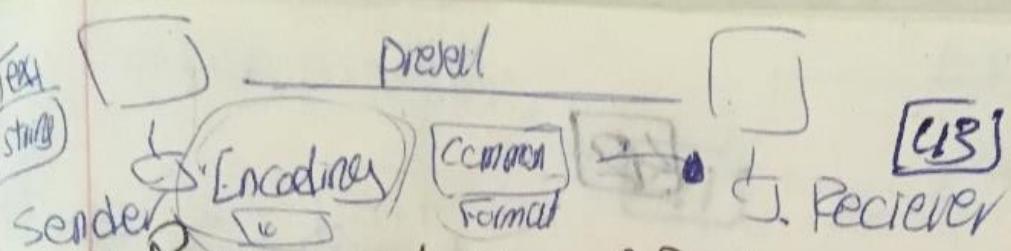
- The session layer allows to add checkpoints or synchronization points to a stream of Data.

Ex File (2000 page) → check point Every 100 page to ensure 100 page received correctly & acknowledged.

6] Presentation layer:

* Presentation layer is concerned with the syntax & semantics of information exchanged between two systems.

- * The presentation layer is responsible for:
 - ① Translation
 - ② Compression
 - ③ & Encryption



* Responsibilities of The presentation layer:

1] Translation:

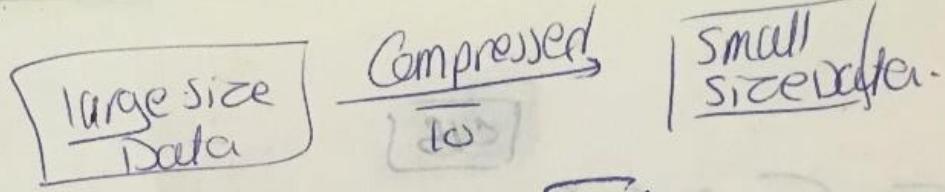
- The processes (Running programs) in two systems are usually exchanging information in the form of strings, numbers & so on.
 - Because computers use different Encoding Systems. The presentation layer at sender change information from sender format to Common format at the Receiver change the Common format to the Receiver format.
- ~~Different Encoding System~~

2] Encryption:

- To carry sensitive information, system must be able to ensure privacy.

- Encryption: Sender transforms the original information to another form & send the result message to the receiver.

- Decryption: Receiver reverse to the transform the encrypted message back to its original data.



3] Compression:

- Data Compression Reduce the number of Bits Contained in The Information.

Q4

7 Application Layer:

* The App layer Responsible for providing services to The Users.

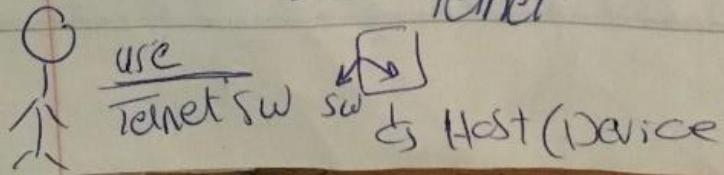
- It provides User interfaces & support For Services Such as Mail, FTP. — —

* Specific Services provided by the App layer:

7) Network Virtual Terminal

- A network Virtual Terminal is a Software allows a user to log on to Remote Host.

Ex: Telnet



CIS

② File Transfer, Access & Management.

- This App Allows user to Access Files in a Remote Host, To Retrieve Files From Remote Computer & manage or Control Files in the Computer.

③ Mail Services:

- provides Emails Forwarding & Storage.

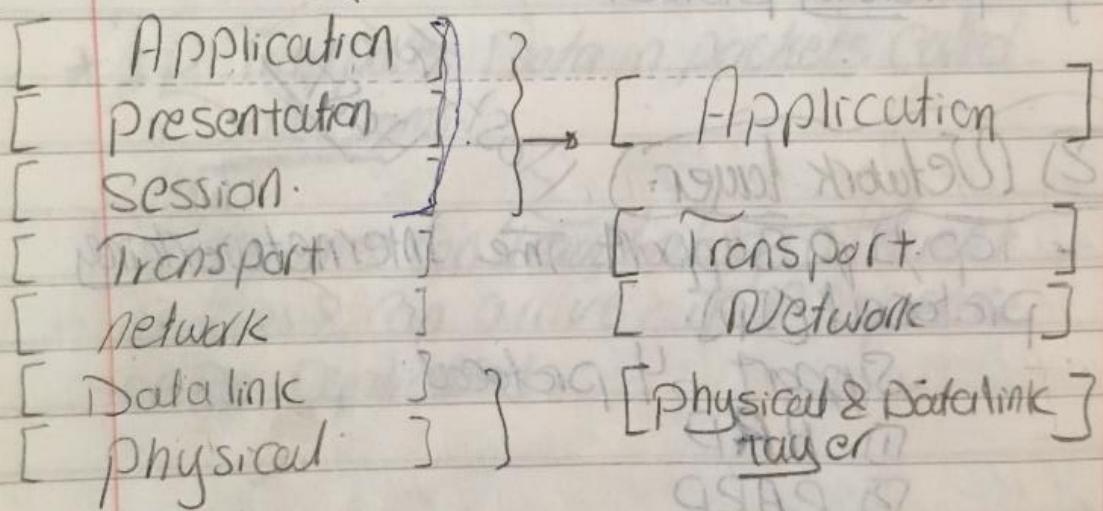
④ Directory Services.

This App provides Distributed Databases Sources & Access For Global Information about Various objects & Services.

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2.4 TCP/IP protocol:

TCP/IP → Transmission Control protocol
/ Internet protocol



OSI Model

7 layers

TCP/IP

4 layers

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① Physical & Data Link layers:

- TCP/IP Doesn't Define any specific protocol, it supports all the standard & proprietary protocols.

② Network layer:

- TCP/IP supports the Internetworking protocol (IP).

- Supports 4 protocols

① ARP

② RARP

③ ICMP

④ IGMP

HOST-TO-HOST

(HOST-TO-HOST protocol).

③ IP (Internetworking protocol)

- IP is the transmission mechanism used by TCP/IP protocols.

- IP is a Best Effort Delivery Service.