05/01/2018

Experiment 1:

Implementation of data link layer framing methods such as character stuffing and bit stuffing in C/C++.

Position of data link layer:

3 [Network layer]

↓ It provides the services to the network layer

2 [data link layer]

↓

1 [Physical layer]

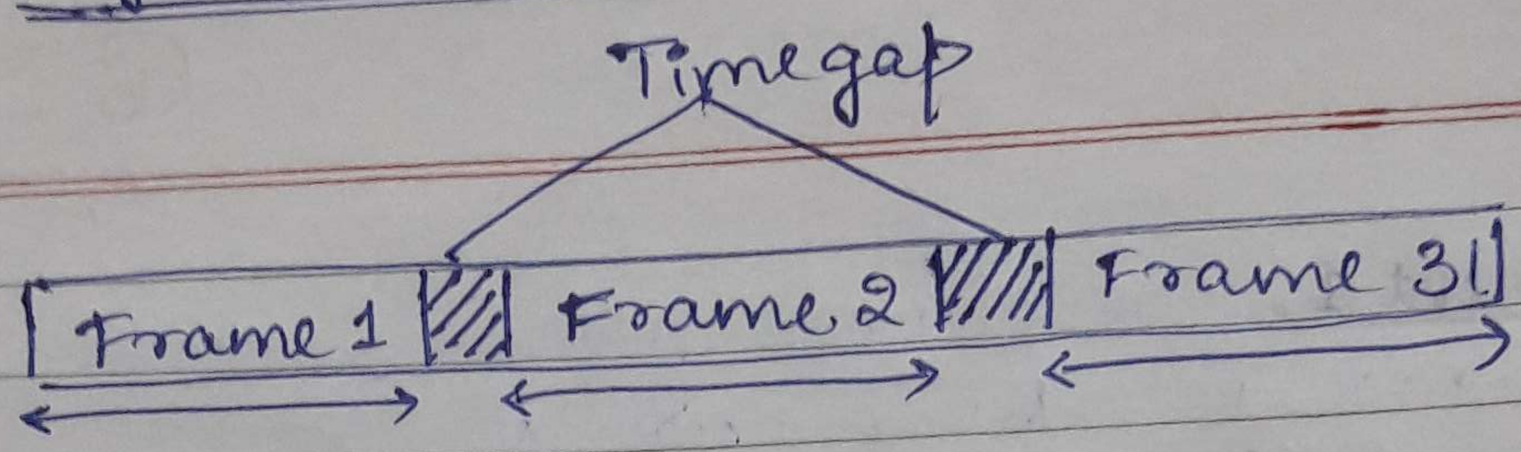
Responsibilities of DLL

- Frame Synchronisation
- Error control
- Flow control
- Data Transfer
- Addressing (Physical)

Unit of data: frame

Framing: frame 1 should not get mixed with frame 2.
There should be a time gap b/w frames otherwise received msg will be meaningless.

logical address : IP address (not same for 2 ~~nodes~~ PC)



Framing: Converting the bit stream into frames

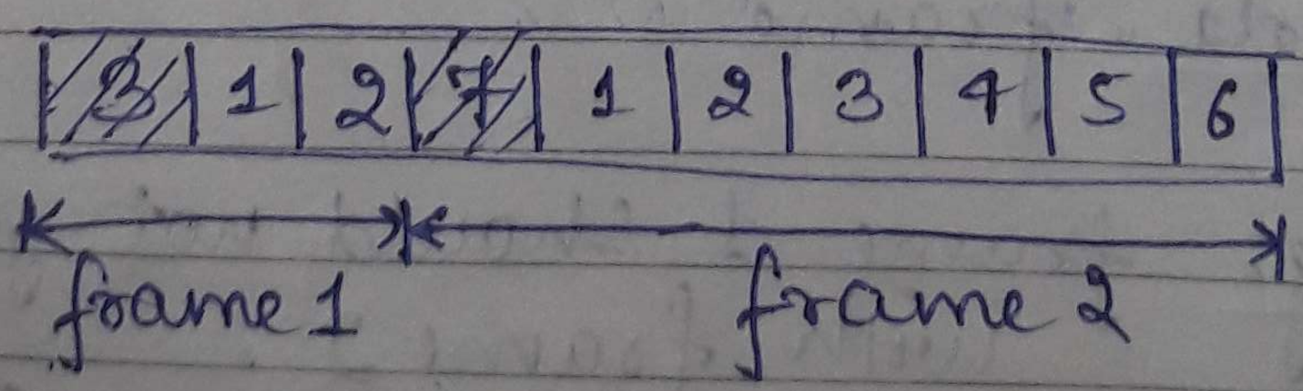
Flow control: The data from the sender should be as fast so ~~As~~ that it can be properly received.

- Network layer provides logical address.
- DLL provides physical address.

FRAMING METHODS:

1. Character Count
2. Character Stuffing
3. Bit Stuffing
4. Manchester Coding or Physical layer coding

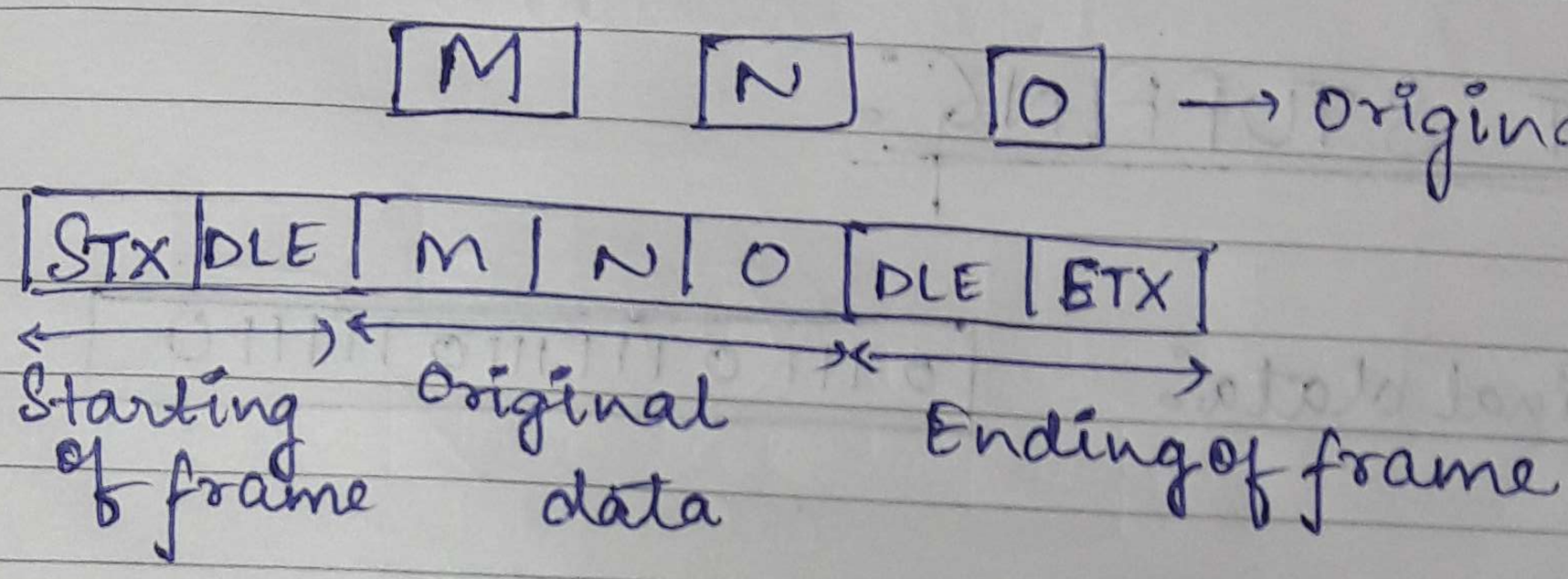
CHARACTER COUNT:



1st position / bit of frame: No. of char in frame.

In data transfer, there can be some error in the data while transfer. Eg: If in case of 1st bits of the 2 frames, some other digit comes, then the 2 frames will get mixed & synchronisation will be lost.

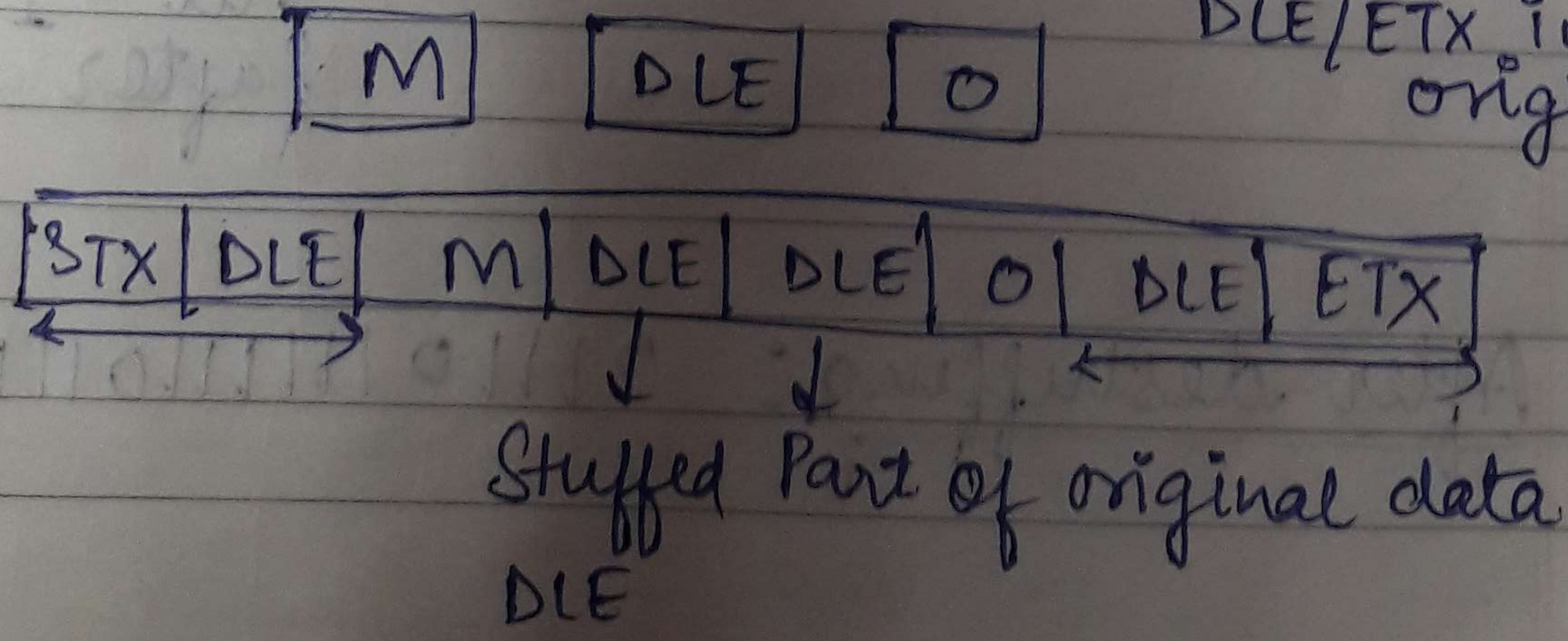
CHARACTER STUFFING:



STX : Starting text
DLE : Data Link Escape → 8 bits (1 byte)
ETX : Ending text

STX : 00000010
DLE : 00000011
ETX : 00100000
} ASCII Codes

If DLE/ETX is present in original data, then there will be problem. RULE: DLE/ETX before DLE/ETX in original data.



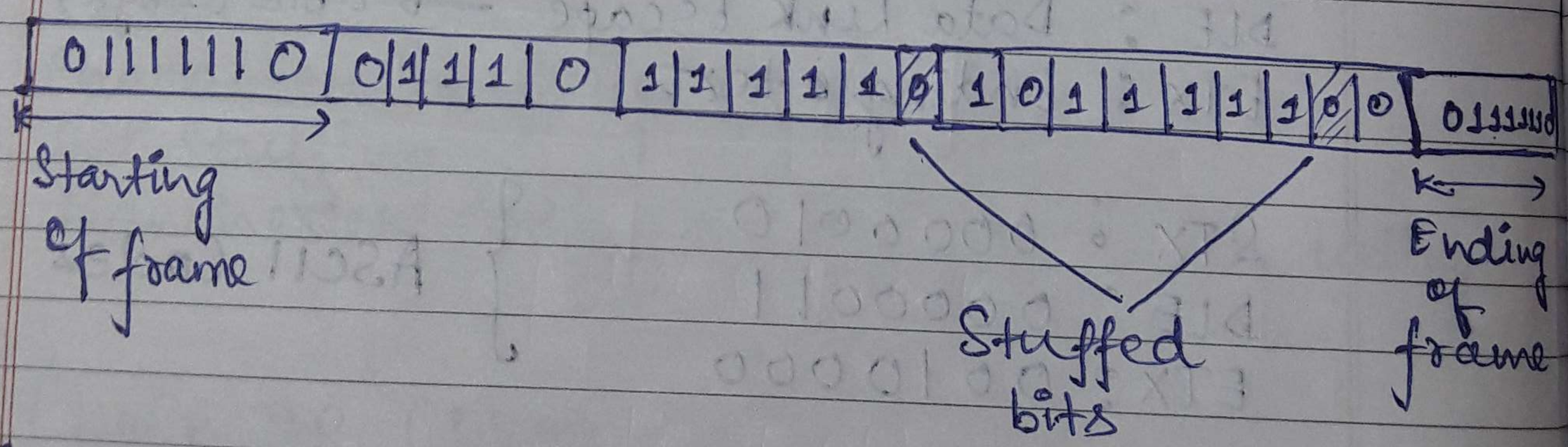
Problem: Msg doubles, bandwidth is consumed, congestion, to increase bandwidth, cost will be more.

4 DLE → 8 DLE

BIT STUFFING:

Original data: 0 1111 0 11111110 111110

After bit stuffing:



Rule:
When 5 times consecutive 1's in original data: Put 1 zero after it.

After destuffing: 01110111111011110

In bit stuffing only 1 bit is stuffed whereas in character stuffing DLE/ETX is stuffed which of 8 bits (1 byte); so bit stuffing is better than character stuffing.

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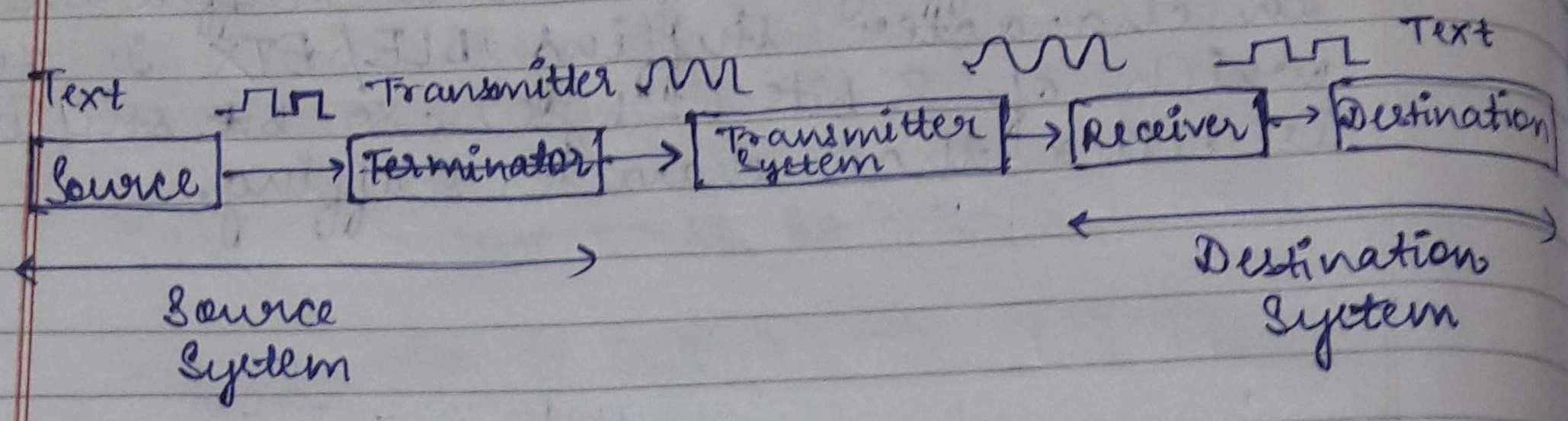
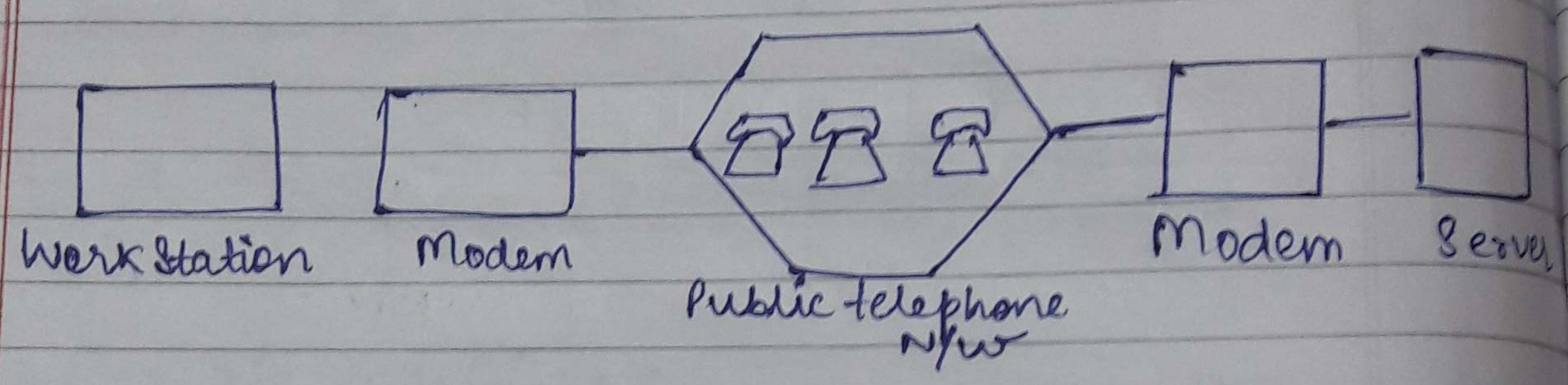
I



(A general communication model)

II



<u>Computer Network</u>: Set of devices connected by <u>media links</u>.
- guided
- unguided

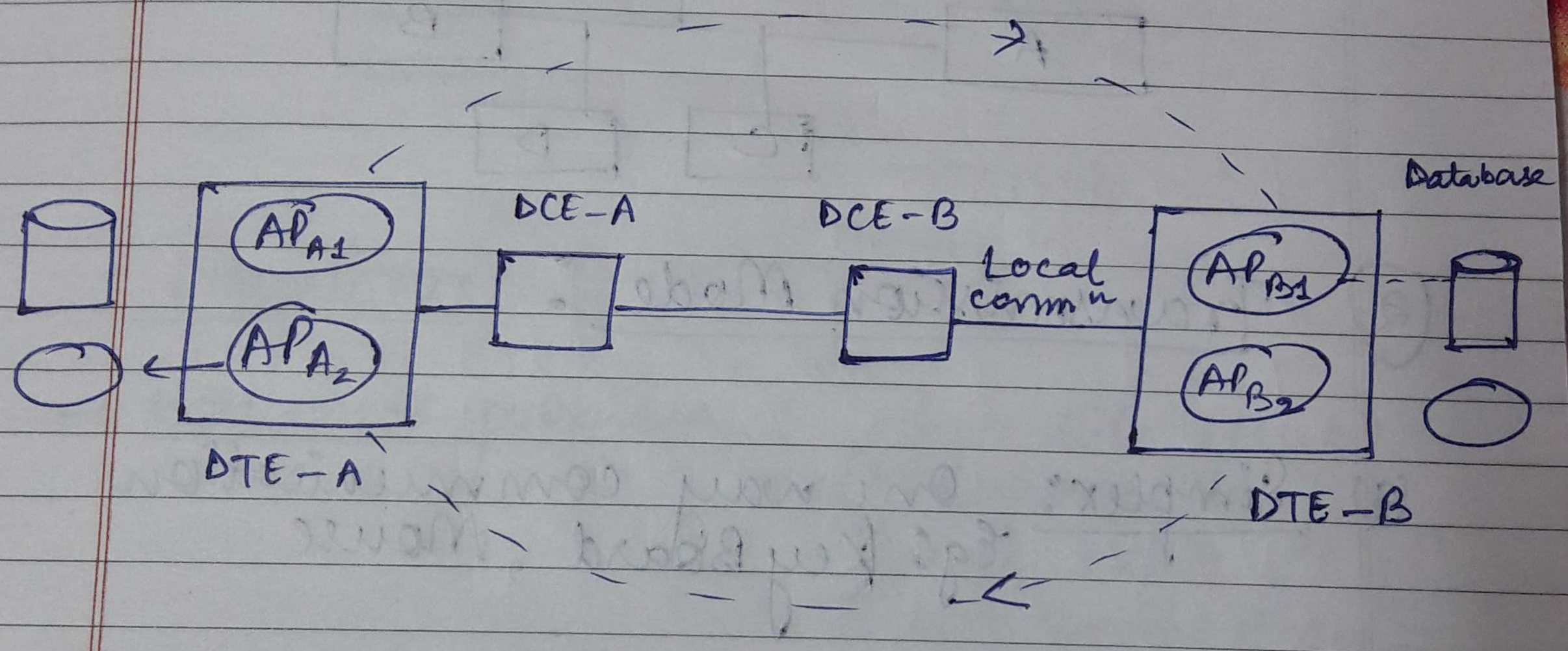
<u>Goals of Computer Network</u>:

Goals of CN

- (Presentation layer) Security Goal
  - viruses, worms
  - unauthorised access)
  - Encryption techniques
  - Login Id & Password
- Performance goall
  - Response time (min)
  - Transit time (min)
  - Hardware speed & capacity
  - Bandwidth
- Reliability Goal
  - failure freq.
  - Avg. downtime min (to download a service
  - Backup
- Network cost
  - Runtime cost (min)
  - Fixed cost (min

Cost
- Runtime Cost (Maintenance)
- Fixed cost

Network Structure and Architecture :



DCE : Data Communication Equipment.
DTE : Data Terminal Equipment.

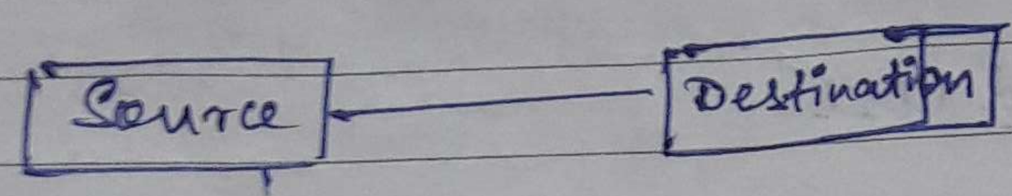
AP : Application Process

(1) Channel configuration
- (a) Point to Point Connection
- (b) Point to Multipoint

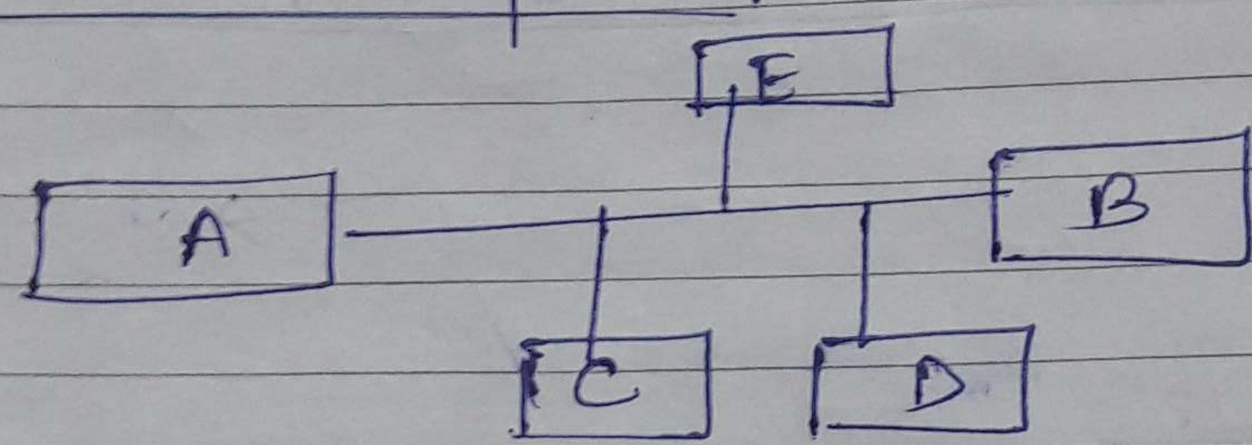
(2) Transmission mode
(3) Topology
(4) Categories of N/w

① Channel Configuration:

(a) Point-to-point:



(b) Point-to-multipoint:



② Transmission Mode:

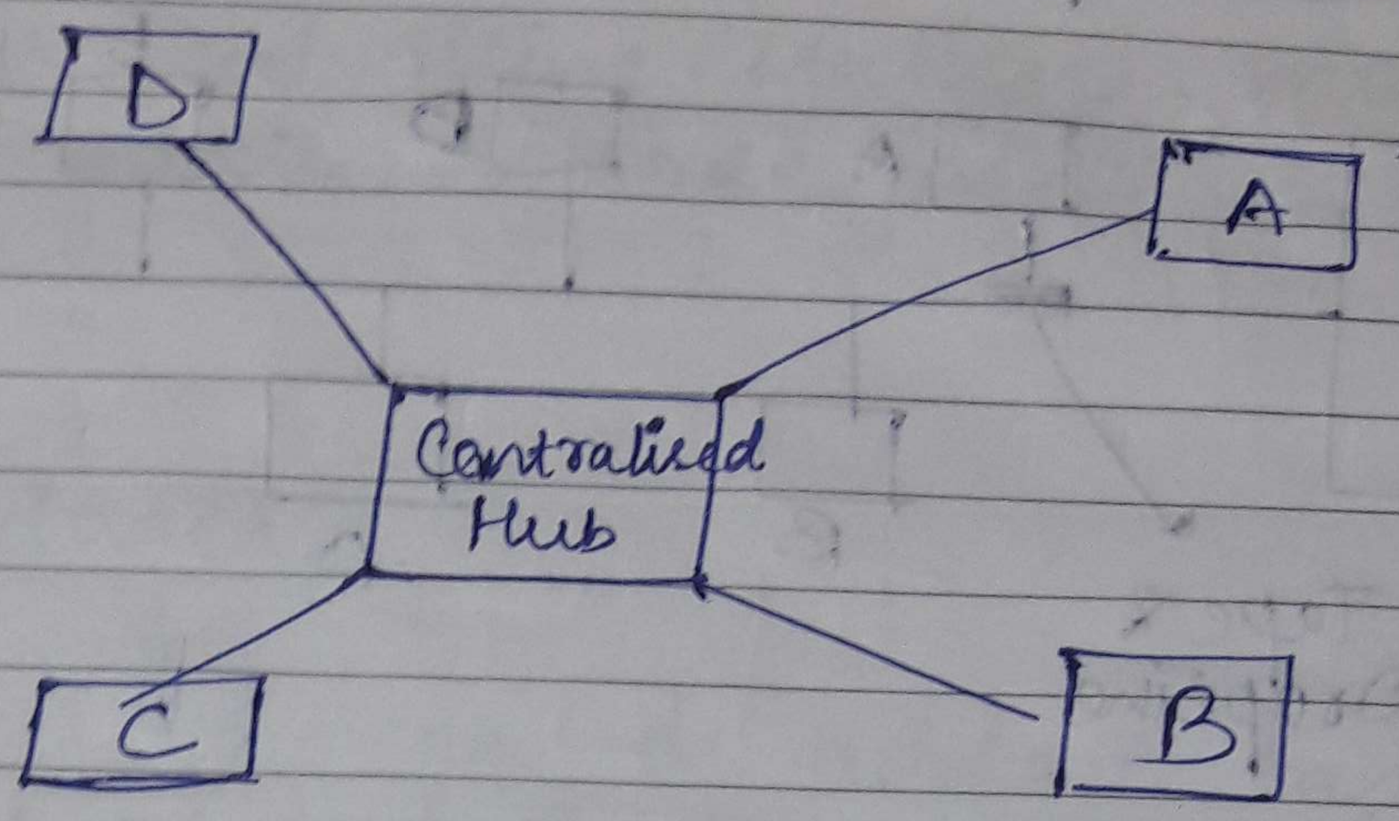
(a) Simplex: One way communication
Eg: Key Board, Mouse

(b) Half duplex: Walkie-talkie
2 way alternate (only 1 at a time)

(c) Full duplex: Telephonic conversation
Bidirectional.

③ Topology: Physical & logical connection b/w the devices.
(Form of something)

(a) Star Topology :



Drawbacks :

→ Bottleneck problem : Single side (Hub) is responsible for routing traffic. Therefore congestion.

→ Hub failure

→ ~~Cost too~~ more cost (~~one~~ separate wire for each device) → more wire length

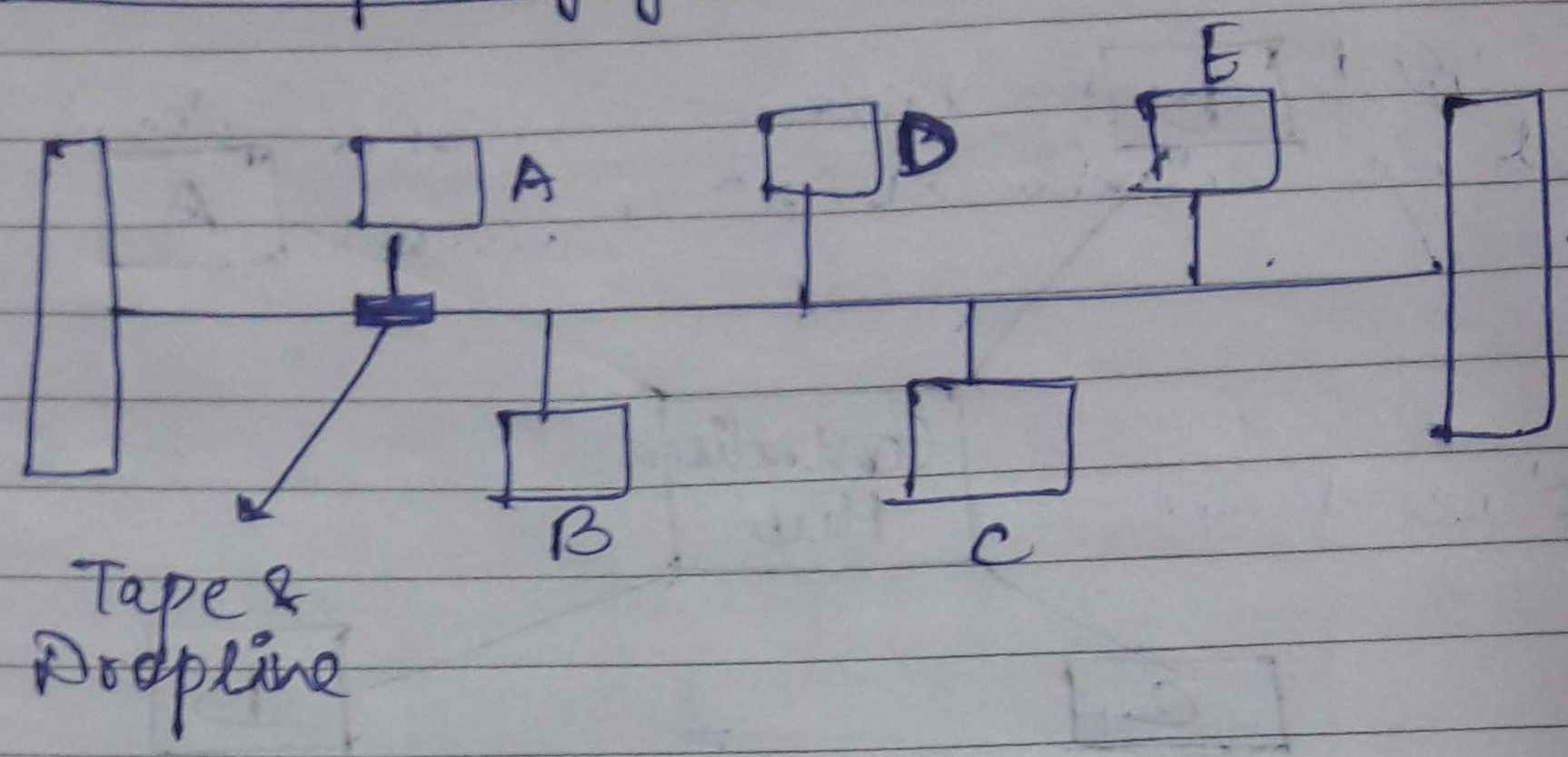
Advantages :

→ Point-to-point connection which is fast.

→ Fault ~~diagonsis~~ diagnosis

→ New device can be added easily.

(b) Bus Topology (Horizontal Topology):



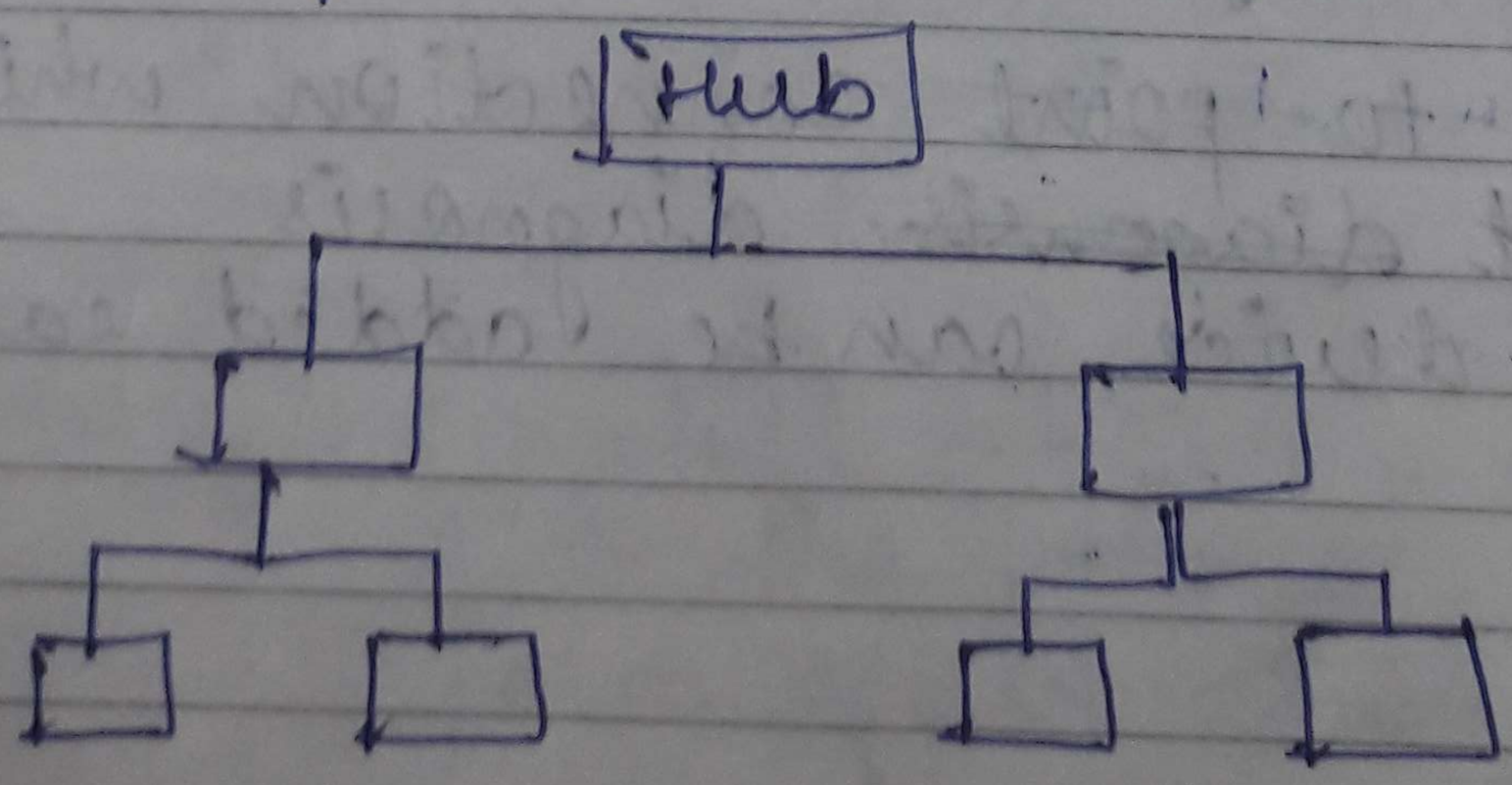
Advantages:

→ Less cost (~~less~~ small length of wire)
→ Any device can be added easily.

Disadvantages:

→ It is broadcast, ∴ security problem (no privacy).

(c) Tree Topology:



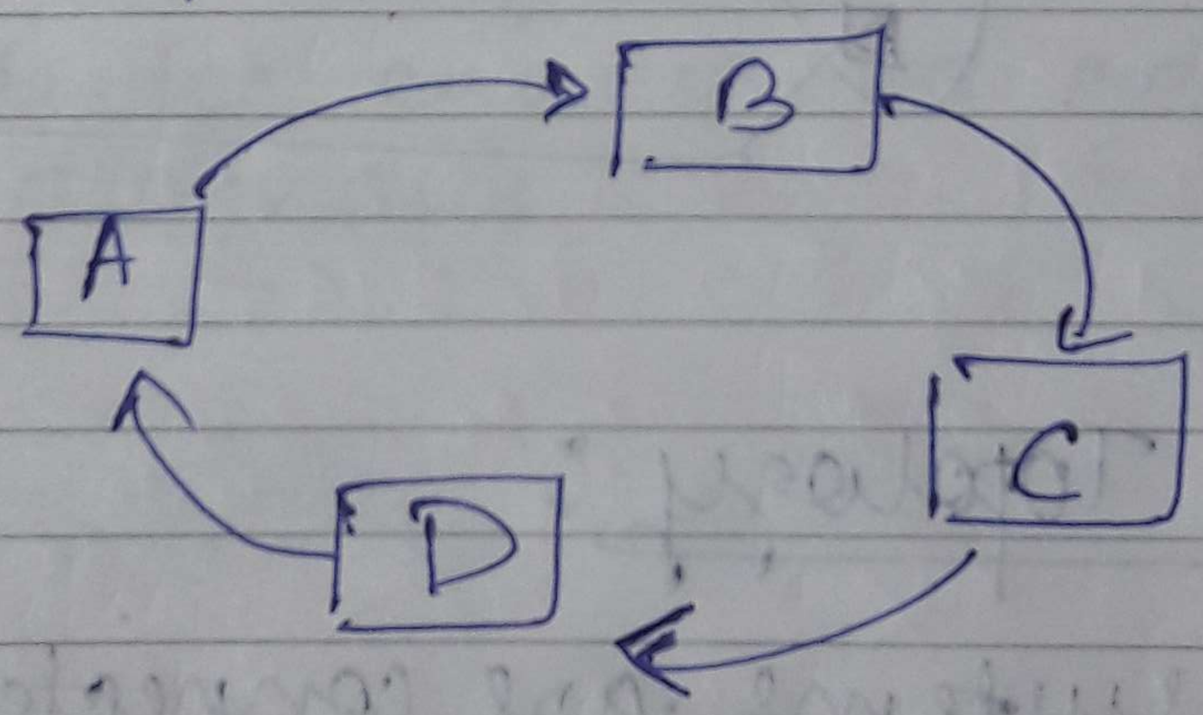
Disadvantages:

→ More controlling stations, more cost.
→ If Root fails, subtree fails.

Advantages:

→ New device can be added easily.
→ Effect of branch is not on other.

(d) Ring Topology:



Unidirectional data flow.

Disadvantages:

→ If one device fails, network fails.
→ Fault diagnosis

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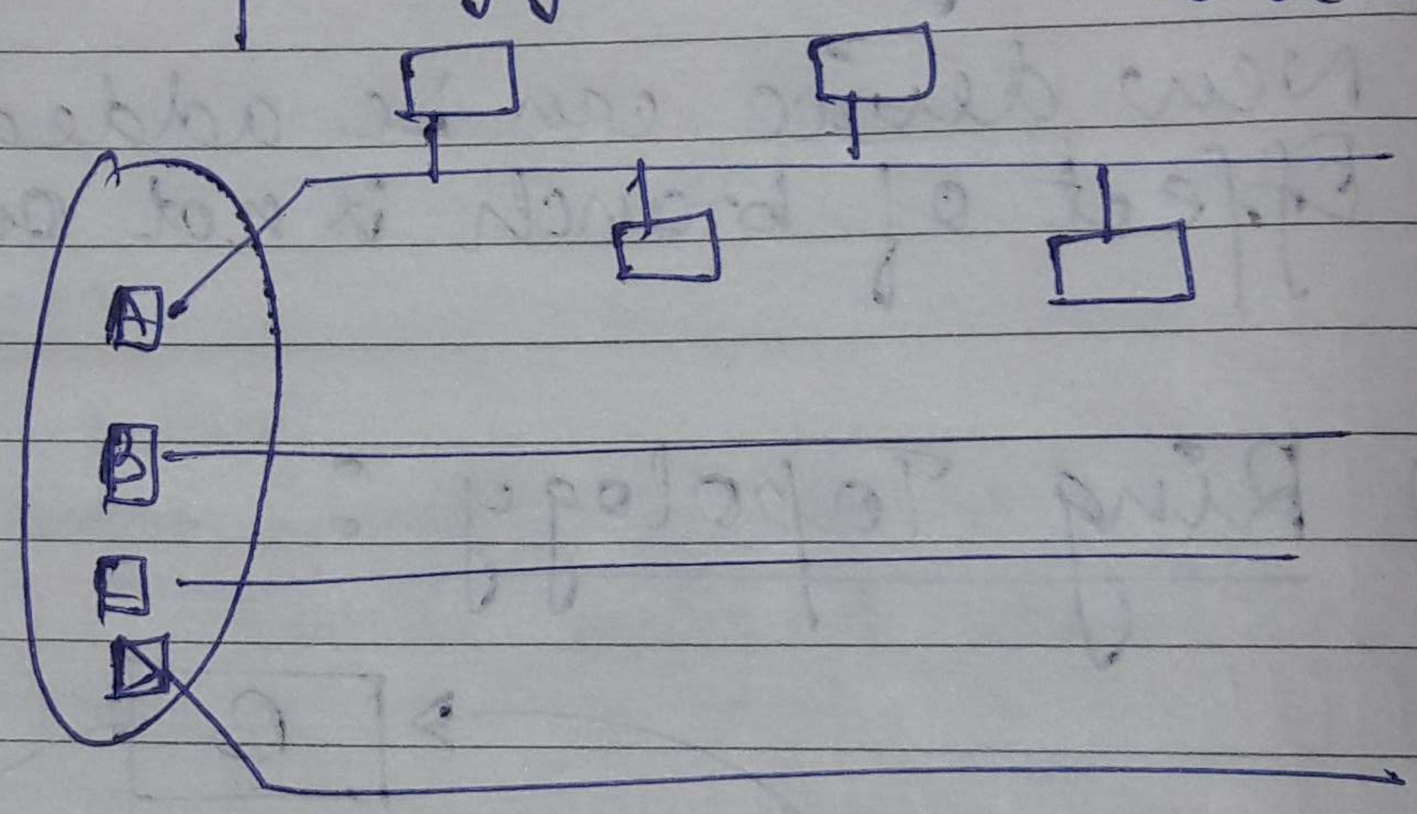
Advantages:

→ Single cable ∴ cost effective
→ Unidirectional data flow, ∴ less traffic (no bottleneck problem)

(e) **Hybrid Topology:** Combination of more than 1.

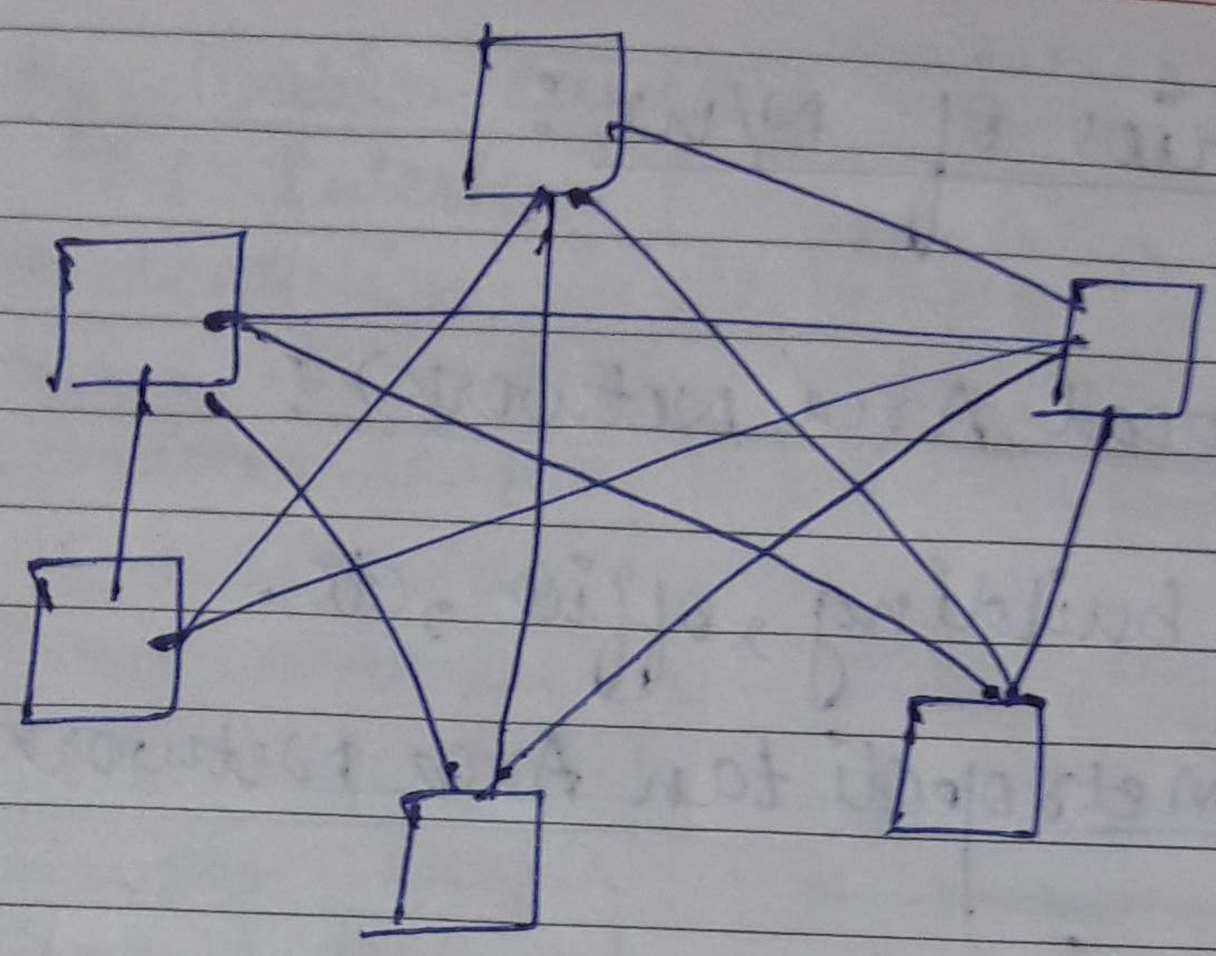


(f) **Mesh Topology:**

Q. If 6 systems are connected in mesh topology, then how many cables are reqd?

$$\frac{n(n-1)}{2} = \frac{6(5)}{2} = \underline{15 \text{ cables}}.$$

No. of devices.



Drawbacks:

→ Wires in bulk, more cost.
→ New device cannot be added easily.
→ Fault diagnosis

12/01/2018

(4) Categories of N/w :

(a) LAN (Local Area Network) :

It covers building, office, etc.

(b) MAN (Metropolitan Area Network) :

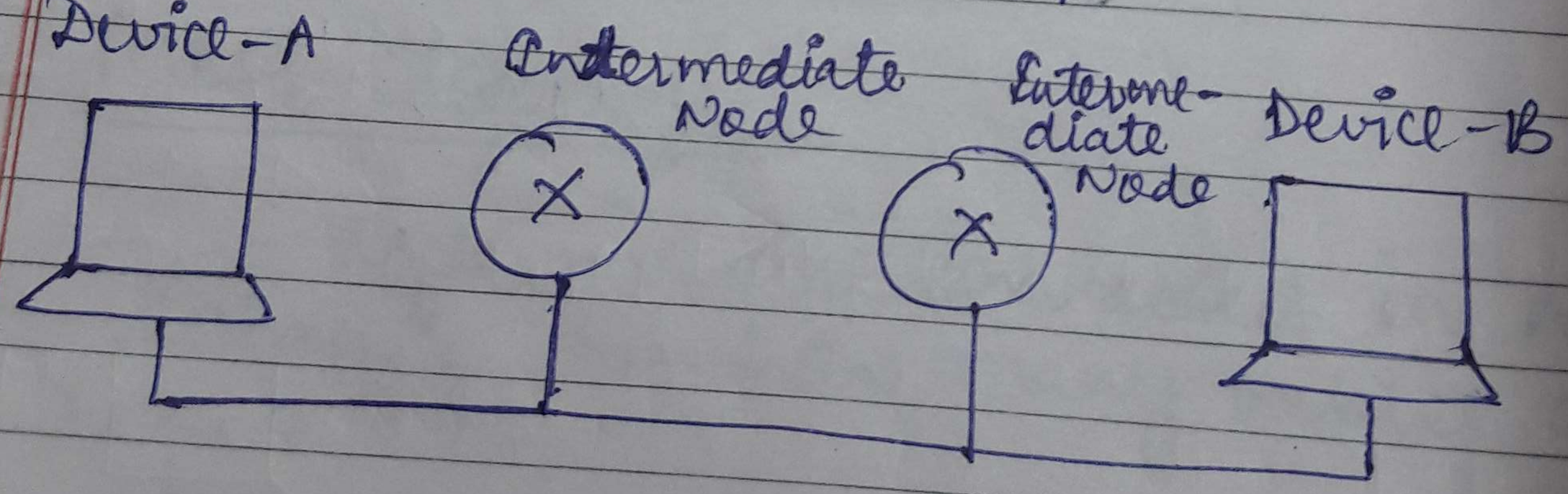
Covers entire city.

(c) WAN (Wide Area Network) :

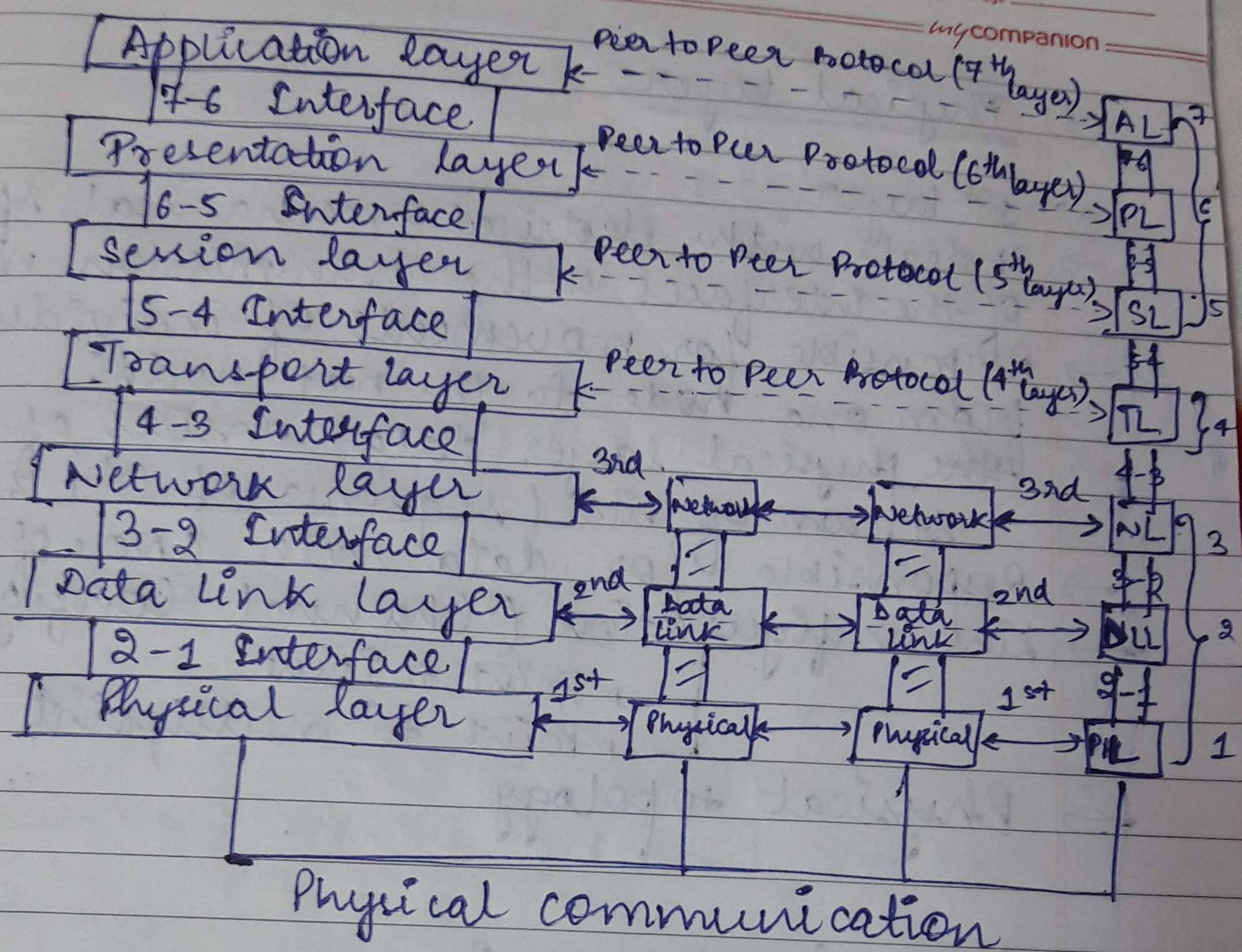
For large geographical area.

OSI Model (Open System Interconnection Model) :

(Developed by ISO in 1947



Interaction b/w devices in the OSI model



7, 6, 5 → User support layer
4 → Reliable delivery of data
3, 2, 1 → Network Support layer

<u>Peer-to-Peer N/w</u>: when all devices share the ~~same~~ link with equal status. (Encryption, Decryption)

Lower layer provides services to the upper layer.
⇓
(data, N/w Info.)

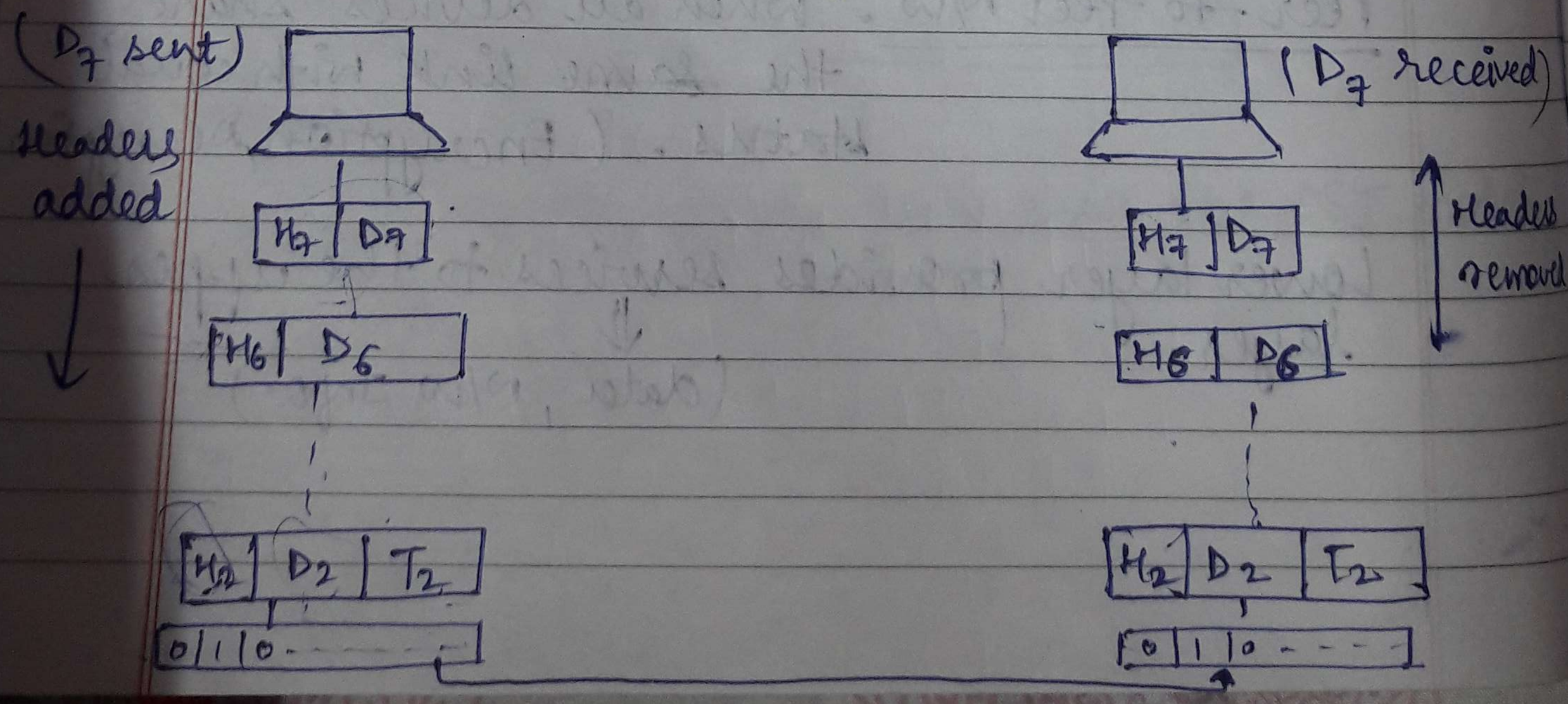
Address → Physical (Device Address (NIC Address))
→ Logical (Internet Address (IP Address))

(1) Physical layer:

→ 1st layer
→ It deals with electrical & mechanical specification of the interfaces & the transmission media.
→ Responsible for movements of individual bits from one node to the next node.
→ ~~The~~ physical layer data consists of ~~bit~~ a stream of bits (sequence of 0's & 1's).
→ Responsible for data rate (No. of bits/sec.)
→ Line configuration (Channel Configuration)
  - → Point to Point
  - → Point to multipoint
→ Physical topology

(2) Data Link Layer:

→ Framing
→ Physical Addressing
  Eg: NIC Address
→ Error Control (Parity Check, Check Sum)



Header → Responsibilities
T (Trailor) → only in DLL

→ Error control is normally achieved through
(cont) a trailer added to the end of the frame.

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Experiment-2:

Implementation of CRC error detection method in C.

CRC → Cyclic Redundancy Check

Error Detection Methods

- Parity check
- CheckSum
- CRC

Data word : Original data
Code word : ~~when~~ Data word + Some bits

$x^3 + x + 1$

→ Divisor/ generator polynomial
→ No. of bits which can be transmitted in 1 time

$1 \times x^3 + 0 \times x^2 + 1 + x + 1$

$\Rightarrow 1011 \ (n+1)$

Eg:

$\underbrace{10101011}_{\text{original data}} \underbrace{000}_{\text{appended}} + 010$ → Remainder

Code word : Data + Remainder
↓
CRC

If remainder on receiving side is 0, data received is error-free.

If non-zero result, then data is retransmitted (request for retransmission)

(i) ~~Thus~~ This is a type of polynomial code in which a bit is represented in the form of polynomial with coefficient 0 and 1 only.

(ii) This technique is more powerful than parity check & check sum.

(iii) CRC is fully based on binary division.

(iv) A sequence of redundant bits called CRC

(v) The resulting data unit after adding CRC remainder becomes exactly divisible by predefined binary no.

<u>Question</u> If the frame is 1101011011 & generator polynomial is $x^4 + x + 1$, then what would be the transmitted frame?

$x^4 + x + 1 = 10011$ (5 bits $\rightarrow n+1$) $\Rightarrow n = 4$

$(1 \times x^4 + 0 \times x^3 + 0 \times x^2 + 1 * x + 1)$

Frame = 1101011011

Appended bits = $n-1$ = 0000

Divisor ~~Remainder~~ = n bits

Max bits in remainder = n-1

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                1011000
10011 ) 11010110000 )
        10011
         00111
          10011
           11100
           10011
           001011
             10011
             001000
              10011
              011010
               10011
               00111
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Codeword = Data word + Remainder
(0111 Here)

Codeword = 11010110110111

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10011 ) 11010110110111 ) 1011000
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         00111111
          10011
           011000
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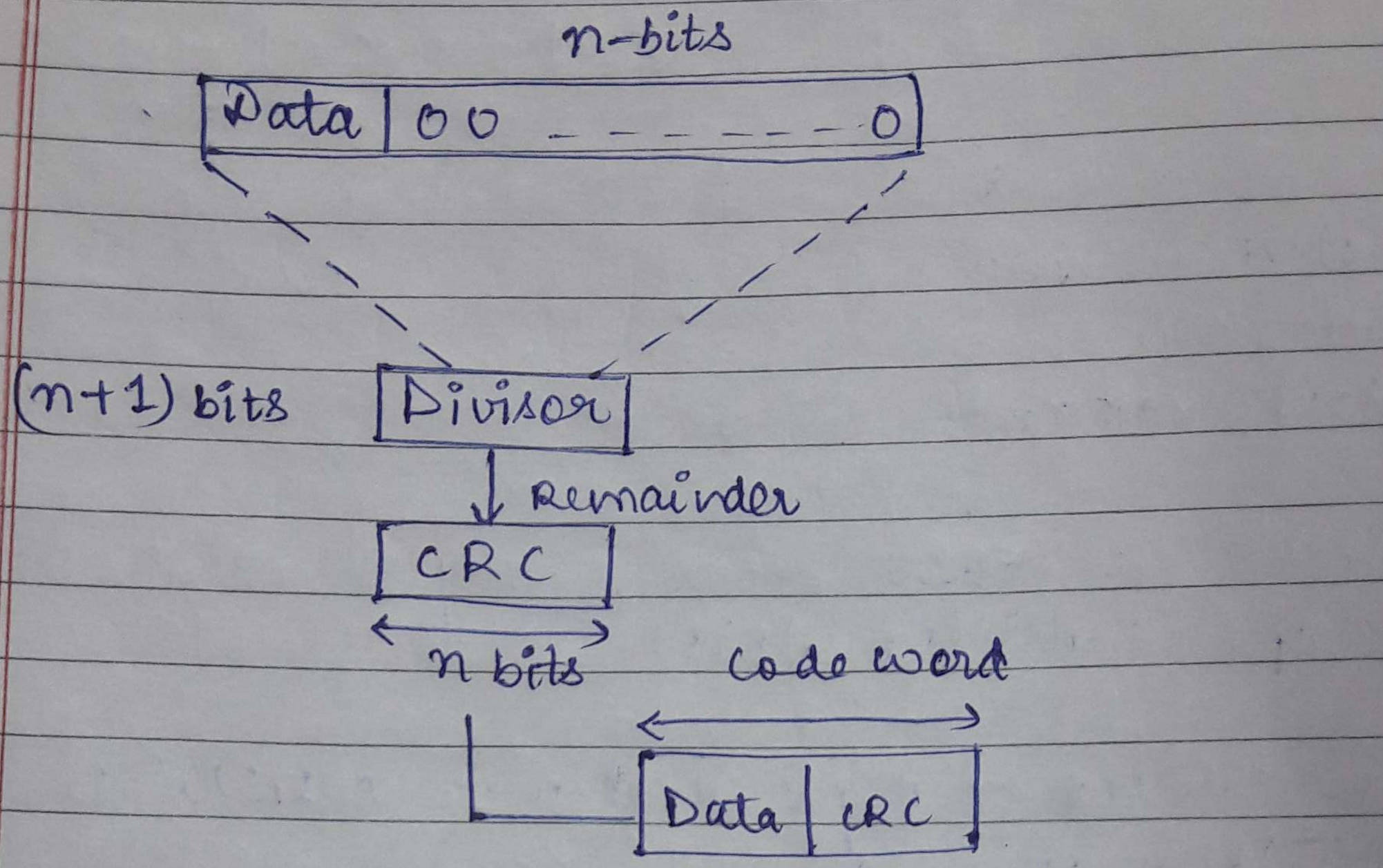
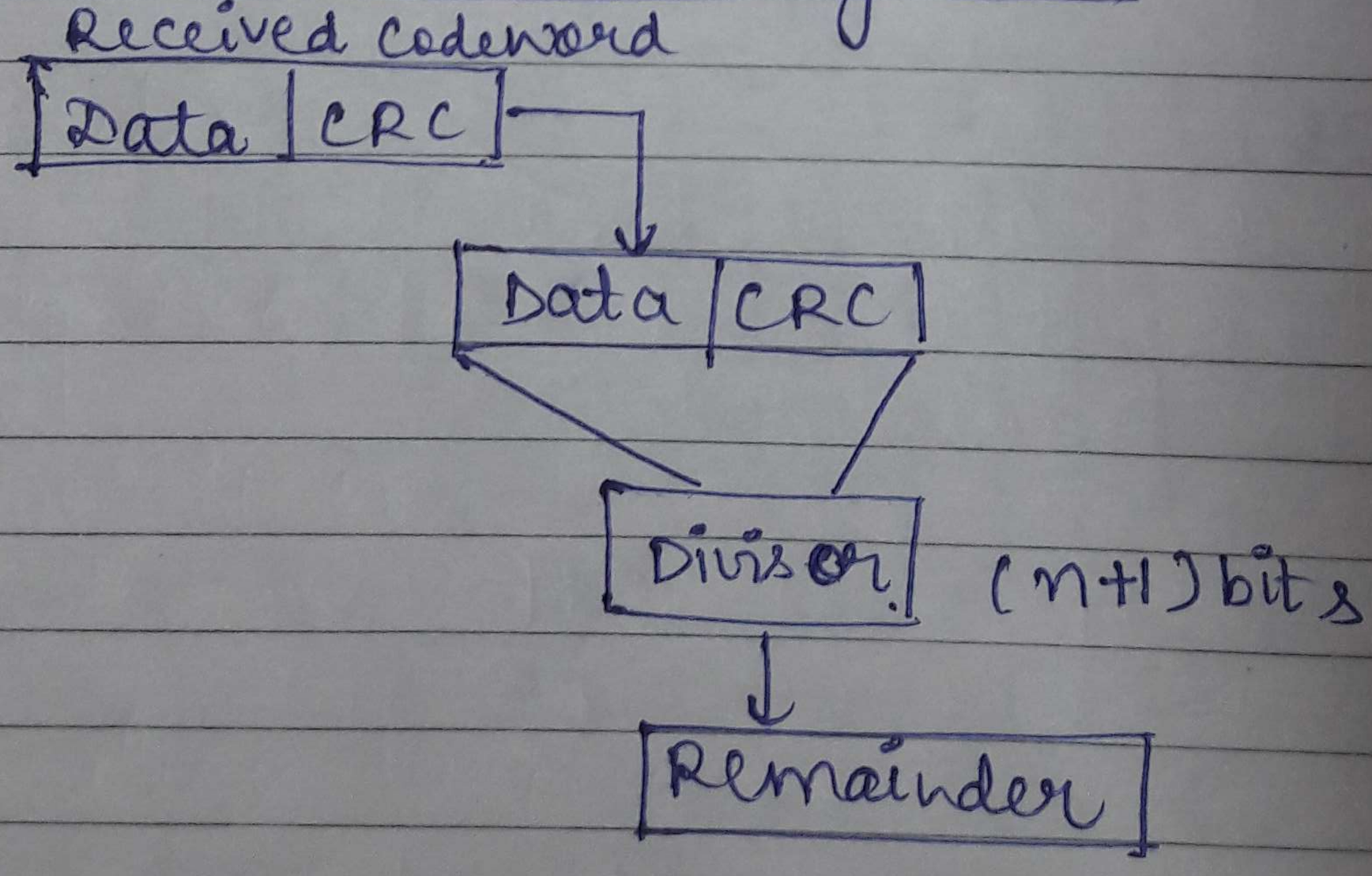
CRC generator (Sending Side):



[CRC generator]

CRC Checker (Receiving Side):



If remainder is 0, then no error.

17/01/2018

OSI Model :

(3) **Network Layer** : Provides logical address.

→ Routing : Provides the least cost path
→ Packetizing
→ Logical Addressing
→ Inter-networking : Two diff n/w connected with router
→ Source to destination delivery

Unit of data : Packets

(4) **Transport Layer** : Provides port address.

→ Flow Control

It provides 2 types of services :

(A) **Connection-Oriented** : Provides the guarantee to delivery of data from source to destination

→ Establish the connection
→ use
→ Release

TCP is used here.

(B) **Connection-less** : Does not provide the guarantee to delivery of data.

Is faster.
Unreliable service
UDP (User datagram protocol)

(5) Session Layer:

→ Synchronisation (checkpoints)

→ Dialogue Control : Means communication mode (Simplex, Half duplex, full duplex)

Session layer allows user on different machines to establish sessions b/w them.

A session might be used to allow a user to login to a time sharing system.

(6) Presentation layer:

→ Translation

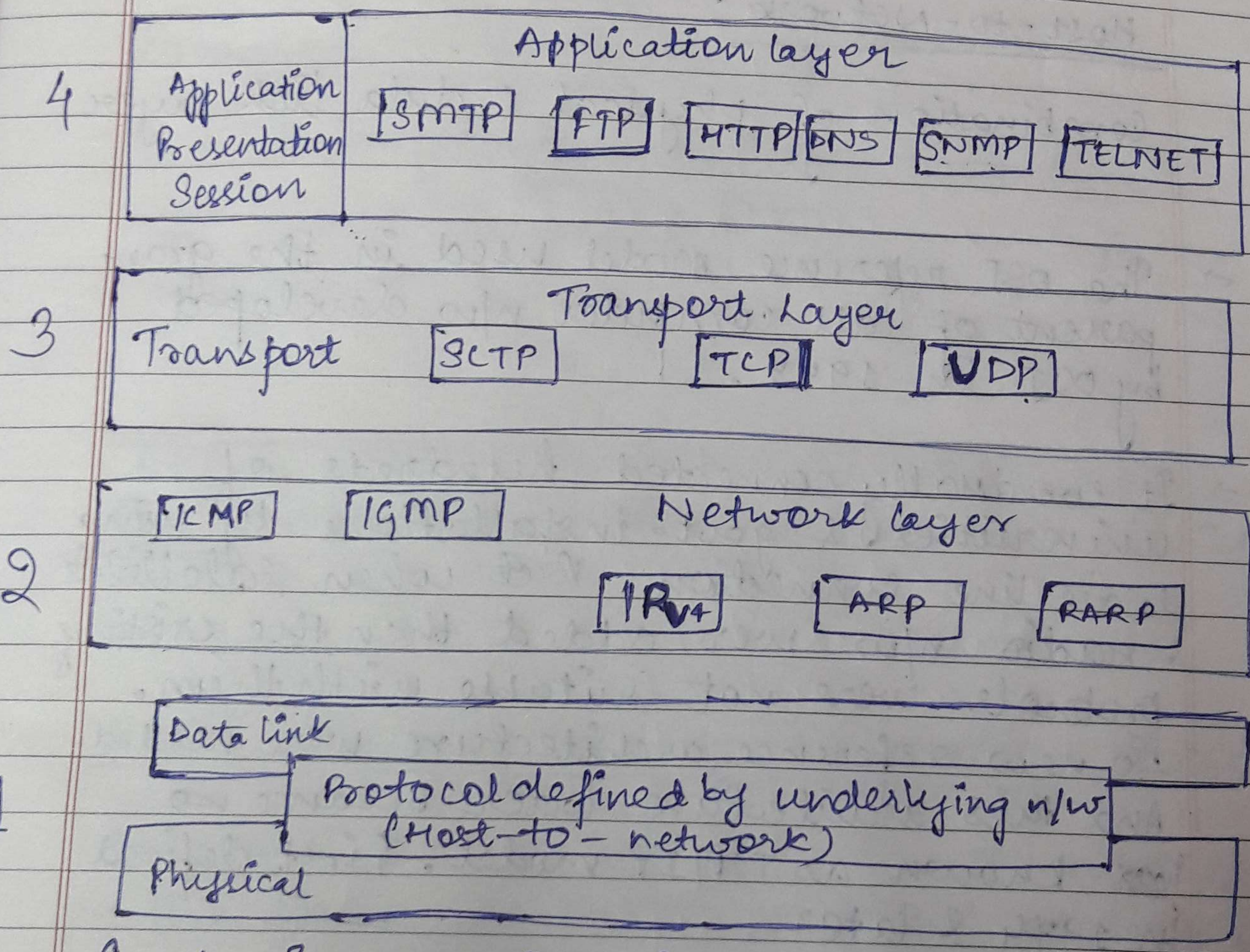
→ Encryption

→ Compression

(7) Application layer:

It provides the services to the user by using SMTP, HTTP, FTP, Telnet, etc.

TCP IP REFERENCE MODEL :



Comparison b/w OSI & TCP/IP Reference Model:

	OSI
7	Application
6	Presentation
5	Session layer
4	Transport layer
3	Network layer
2	Data link layer
1	Physical layer

	TCP/IP
4	Application
	~~Not present in this model~~
3	Transport
2	Internet
1	Host to Network

18/01/2018

TCP/IP REFERENCE MODEL

Host-to-Network:

Combination of physical & data link layer

→ The OSI reference model used in the grand parent of all computer n/w developed by OSI in 1947.

→ It eventually connected hundreds of universities & govt. installations by using leave line connection. But when satellites & radio n/w were added then the existing protocols were not suitable with them. So new reference architecture were needed. And this architecture later became known as TCP/IP model. First defined in 1974 & later

(1) Host-to-Network:

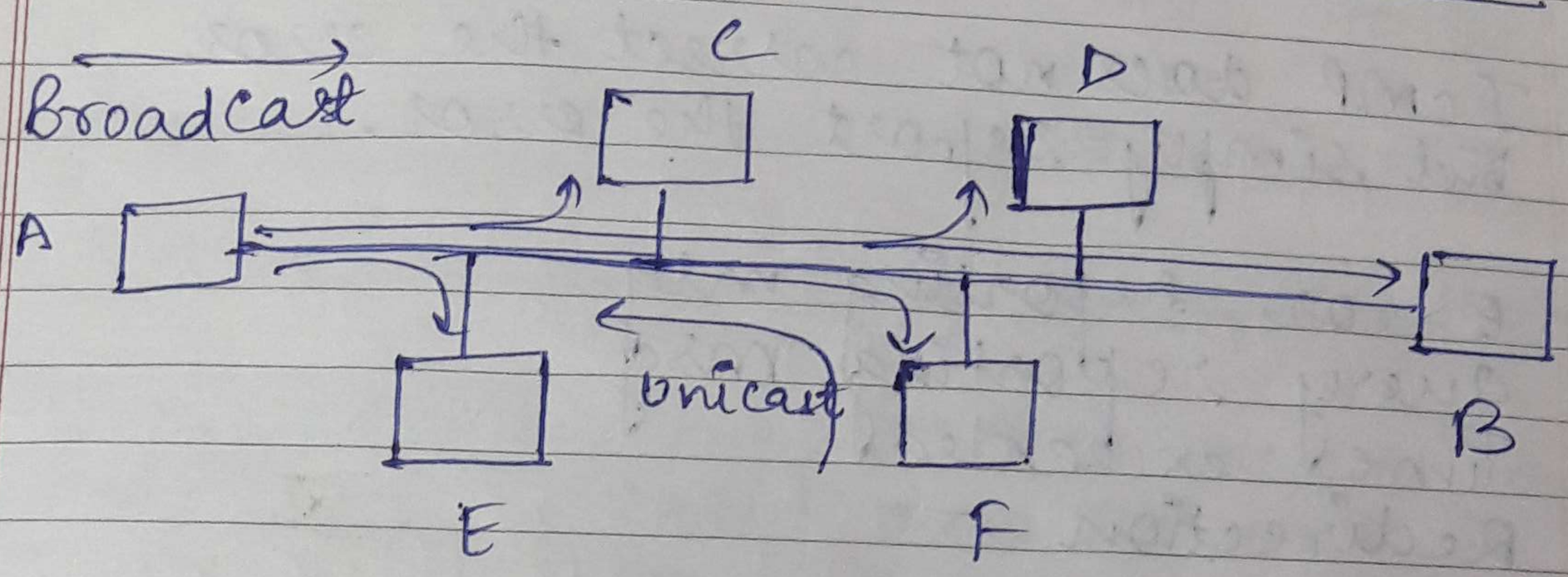
It is equivalent to the combination of physical & data link layer

(2) Network layer:

At this layer, TCP/IP support inter-networking protocols.

IP → Unreliable
TCP → reliable

ARP (Address Resolution Protocol):



ARP is used to find the physical address of the node when its internet address is known.

RARP (Reverse Address Resolution Protocol):

Used to find the logical (internet) address of the node when its physical address is known.

ICMP (Internet Control Message Protocol):

~~prov.~~

Problems with IP:
→ Unreliable service
→ Lack of error control
→ No error reporting
→ Lack of assistance control

To report these types of problem with the IP, we use ICMP.

ICMP does not correct the error but simply report the error.

→ Error reporting msg
→ Query reporting msg
→ Time exceeded
→ Redirection

IGMP (Internet Group Message Protocol):

It is used to facilitate Simultaneous Transmission of a msg to a group of recipients.

(3) Transport Layer:

TCP (Transmission Control Protocol):

→ It provides the guarantee to delivery of data from source to destination
→ Reliable service
→ Connection Oriented
  - → Establish the connection
  - → Use the connection
  - → Release the connection

UDP (User Data Gram Protocol):

→ Provides unreliable service

→ Does not provide guarantee to delivery of data but is faster than TCP because packets move independently

SCTP (Stream Control Transfer Protocol):

It provides the support for newer applications such as voice over Internet.

(4) Application Layer:

FTP (File Transfer Protocol):

Transfers file

SMTP (Simple Mail Transfer Protocol):

Transfer mail

HTTP (Hyper Text Transfer Protocol):

fetches webpages from WWW

DNS (Domain Name Service):

Eg: .com, .edu, .in, etc

~~physical to~~

lease lines : ~~the~~ connection through cable.
(Horizontal connection)

It is used for mapping host name / physical name to their n/w addresses / IP addresses.

TELNET :

It allows user on one machine to login to a distant machine & work there

SNMP (Simple Network Management Protocol):

Provides the systematic way of monitoring & ~~messaging~~ managing a computer n/w.

Comparison b/w OSI & TCP/IP Model:

OSI	TCP/IP
→ It has 7 layers	Has 4 layers
→ Horizontal Approach	Vertical approach
→ Separate session layer	No session layer present
→ separate Presentation layer	No presentation layer present

19/01/2018

SWITCHING METHODS:

→ How the connections are made?

→ How data must move from one node to another?

node is handled

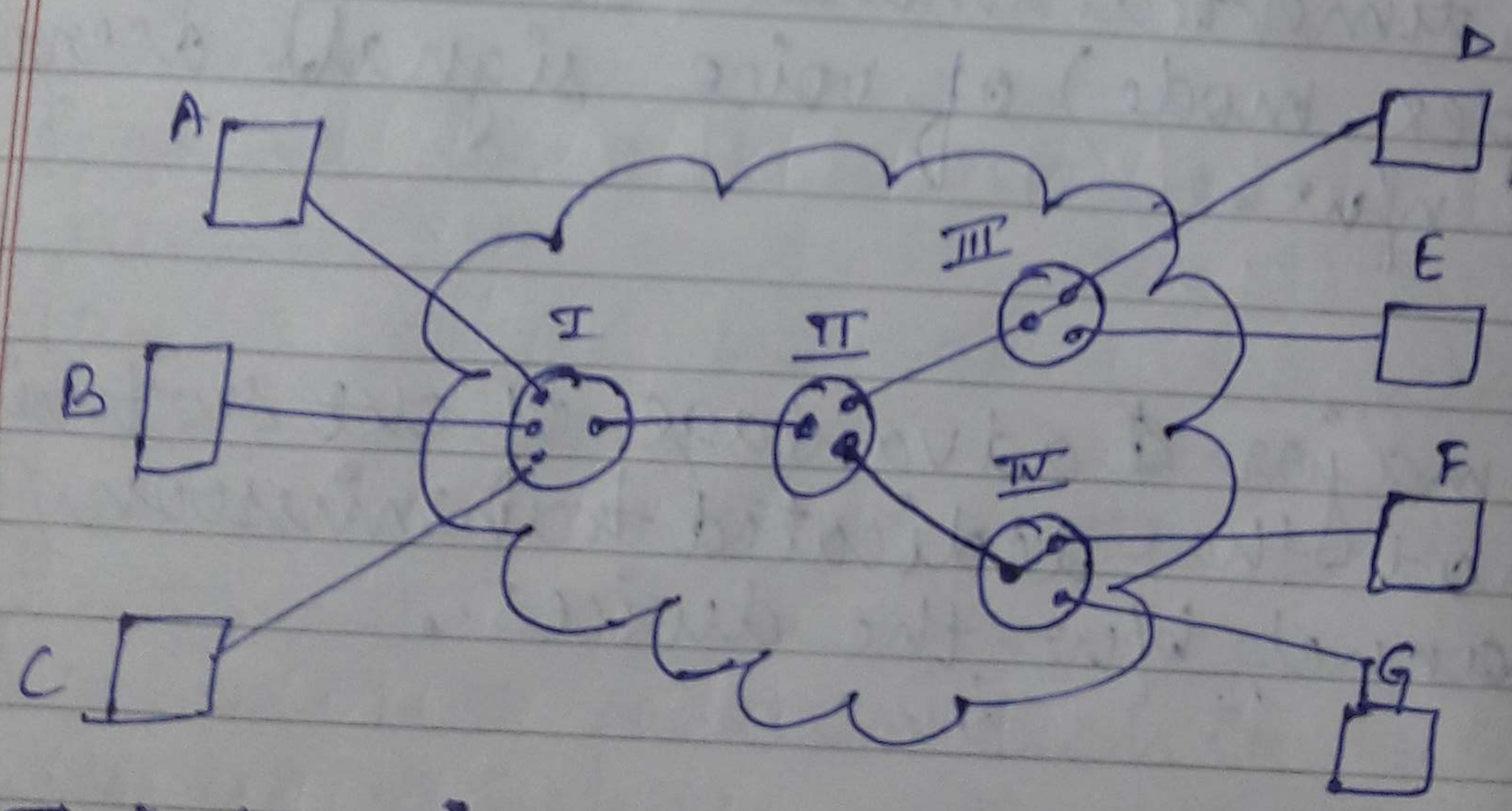
~~(1) Circuit Switching:~~

~~Eg: Telephonic conversation~~

It is an important technique that can determine:

(1) how the connections are made
(2) how the data movement handled in WAN.

(I) CIRCUIT SWITCHING:



A, B, C, D, E, F, G: ~~Nod~~ Devices

II: Routing node

I, III, IV: Connecting nodes

I, II, III, IV: Switching nodes

Date ___/___/___
Page _____
my companion

Advantages:

→ Connection-oriented service
→ Dedicated path b/w sender & receiver, therefore secure.

Disadvantages:

→ Since the connection is dedicated, it cannot be used to transmit any other data even if the channel is free.
→ Third party cannot use the communication channel unless the connection is released.
→ It takes long time to establish the connection
→ Dedicated channels require more bandwidth.

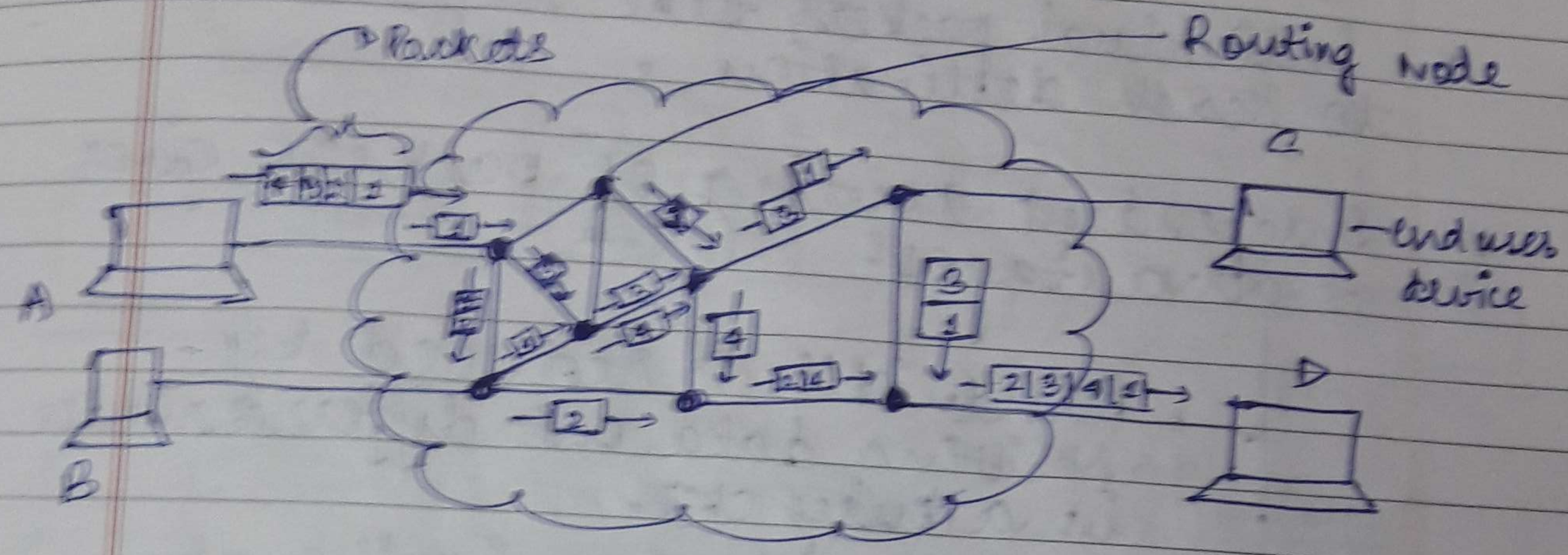
- In telephonic system, ckt switching is used.

- In ckt switching, path is established b/w sender & receiver which is maintained for the entire duration of conversation
- Telephone n/ws are connection-oriented.
- Real time transmission (2-way / full duplex mode) of voice signals accross the n/w.

* The major advantage of ckt switching is that the dedicated transmission channel b/w the devices.

Router → provides shortest path.

(II) PACKET SWITCHING:



[Data Gram Packet Switching]

→ Provides connection-less service.
→ faster than ckt switching
→ Msg is divided into packets
→ Each has a no.
→ Each packet has a header which contain source station address, intermediate nodes address & destination station address.
→ Packets move independently, so bandwidth reqd. is less.
→ can be unreliable at times, that is, ~~[illegible]~~ packets not received in order.
→ Packets can take alternate paths

* In packet switching, messages are broken into packets each of which includes a header with source, destination

& intermediate node address information.

* Individual packets take different routes to reach destination.

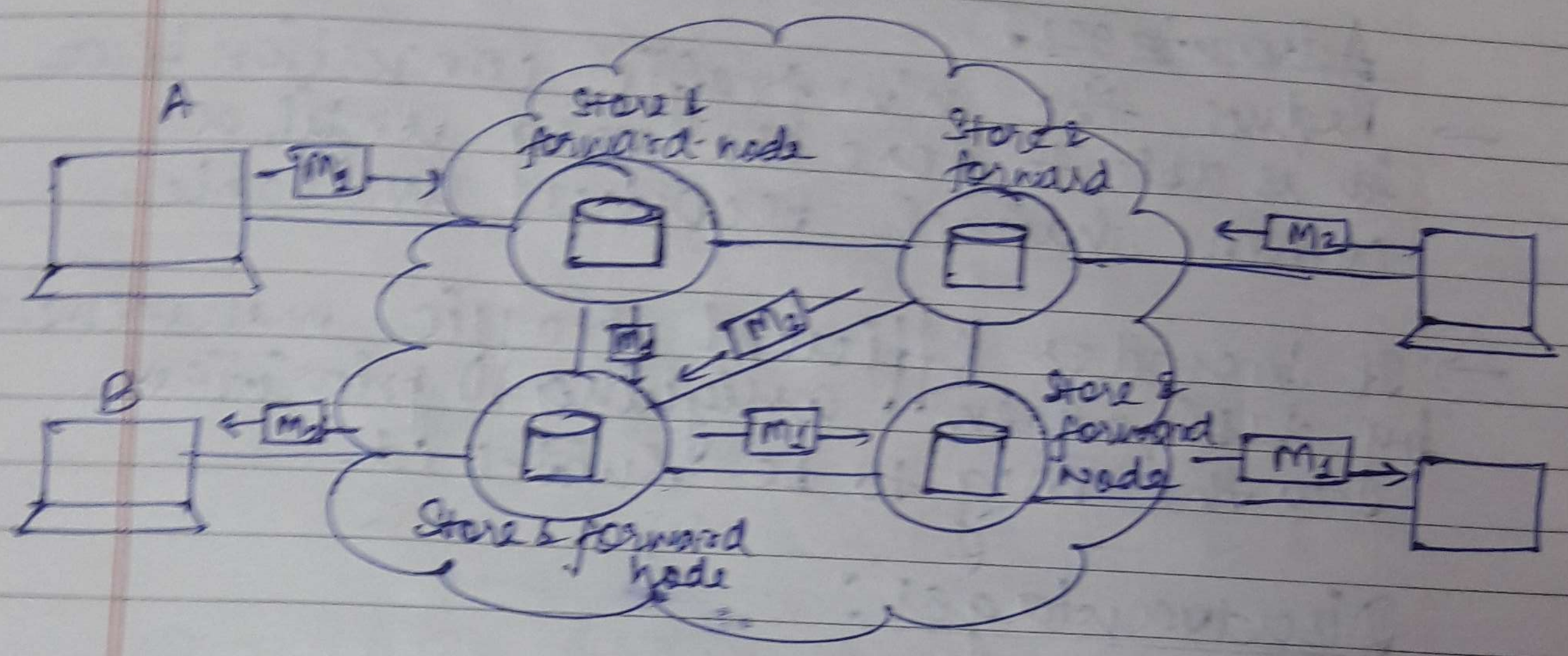
* Independent routing of packets gives 2 advantages:
  - → Bandwidth is reduced by splitting data onto different routes in a busy ckt.
  - → If certain links in the n/w goes down during the transmission, then the remaining packets can be sent through another routes.

Virtual Circuit Packet Switching:

* In this, It establishes logical connection b/w the sending & receiving device called virtual ckt.

* All the packets travel through the logical connection.

(III) MESSAGE SWITCHING :



→ Cannot be used real life application.
→ No congestion.
→ More cost.

* In telegraph n/w, the text msg is transmitted from the source telegraph office to the ~~dest~~ telegraph switching station.

* At this telegraph switching station, an operator takes the decision of routing the msg based on the destination address information.

* The operator will either forward the msg if a communication line to the destination is free or store the msg till the comm. line

becomes free. So msg switching is also known as store & forward n/w.

Advantages:

→ Reduce the n/w traffic congestion becoz it is able to store the msg until a comm. channel becomes available.

→ It provides efficient traffic management by ~~assignmen~~ assigning priorities to the msg to be switched.

Disadvantages:

→ Storing & forwarding delay, hence cannot be used for real time applications like voice & video.

→ Intermediate device require a large storing capacity since it has to store the msg unless a free path is available.

HAMMING CODE (Error correction (7,4) method)

Implementation of a Hamming code to limit the noise in C.

$$\boxed{2^r \geq m + r + 1}$$

m : original data bits
r : redundant bits (Parity bits)

m + r : Transmitted data

$m = 4$

We know that

$2^r >= m + r + 1$

$2^3 \geq 4 + 3 + 1$

$8 \geq 8$

then $\boxed{r = 3}$

$m + r = 4 + 3 = \boxed{7}$.

$2^0 = 1$, $2^1 = 2$, $2^2 = 4$, $2^3 = 8$

8	7	6	5	4	3	2	1
P_4				P_3		P_2	P_1

← Transmitted msg →

Question A bit word 1011 is to be transmitted. Construct the even parity 7-bit hamming code.

8	7	6	5	4	3	2	1
P_4	1	0	1	P_3	1	P_2	P_1

$P_1 \rightarrow 1, 3, 5, 7 \Rightarrow P_1, 1, 1, 1, \Rightarrow P1 \Rightarrow 1$

$P2 \rightarrow 2, 3, 6, 7 \Rightarrow P2, 1, 0, 1 \Rightarrow P2 \Rightarrow 0$

$P3 \rightarrow 4, 5, 6, 7 \Rightarrow P3, 1, 0, 1 \Rightarrow P3 \Rightarrow 0$

7	6	5	4	3	2	1
1	0	1	0	1	0	1

$P_1 (1, 3, 5, 7) = 1, 1, 1, 1 \quad (0)$
$P_2 (2, 3, 6, 7) = 0, 1, 0, 1 \quad (0)$
$P_3 (4, 5, 6, 7) = 0, 1, 0, 1 \quad (0)$

No error

Question A 7-bit hamming code is received as 1110101. What will be the correct code? (Even parity).

7	6	5	4	3	2	1
1	1	1	0	1	0	1

$P1 \Rightarrow 1, 3, 5, 7 \Rightarrow 1, 1, 1, 1 \quad (0)$
$P2 \Rightarrow 2, 3, 6, 7 \Rightarrow 0, 1, 1, 1 \quad (1)$
$P3 \Rightarrow 4, 5, 6, 7 \Rightarrow 0, 1, 1, 1 \quad (1)$

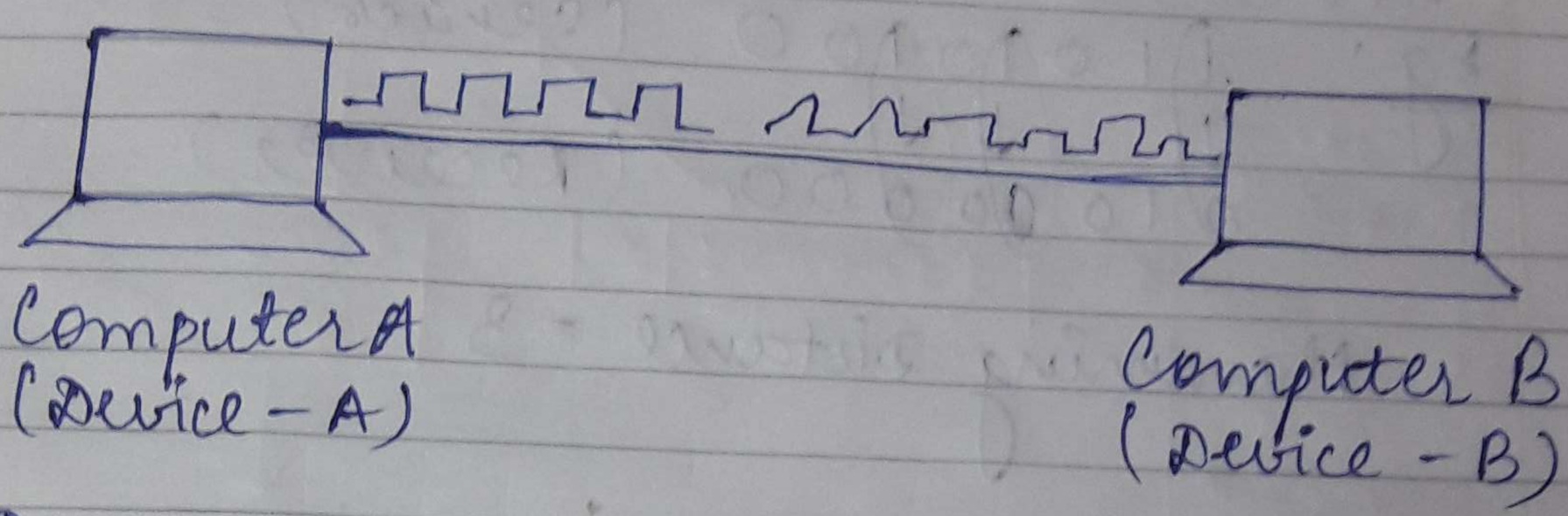
$(110)_2 \Rightarrow (6)_{10}$

Error at 6th position

$\boxed{1010101} \Rightarrow$ corrected code.

24/01/2018

Error Detection and Correction



Types of Error:

(1) Single-Bit Error (Content Error):
Errors in the content of a msg, that is, a 0 may be received as 1 & vice versa.

(2) Flow-Integrity Error:
Missing Blocks of data. Such errors are introduced due to missing blocks of data.

Depending on the no. of bits:

(1) Single-bit error: $0 \rightarrow 1$, $1 \rightarrow 0$

(2) Burst error: Error in more than 1 bits.

* Code Word: Data Bits + Parity / Redundant Bits

* Hamming wt of a codeword is defined as the no. of non-zero elements in the codeword
Eg: $x = 11010100 \Rightarrow (4)$.

Hamming Distance : ~~Change occuring in bits~~ No. of bits changed during transmission.

Eg: 1 1 0 1 0 1 0 0 (sender)

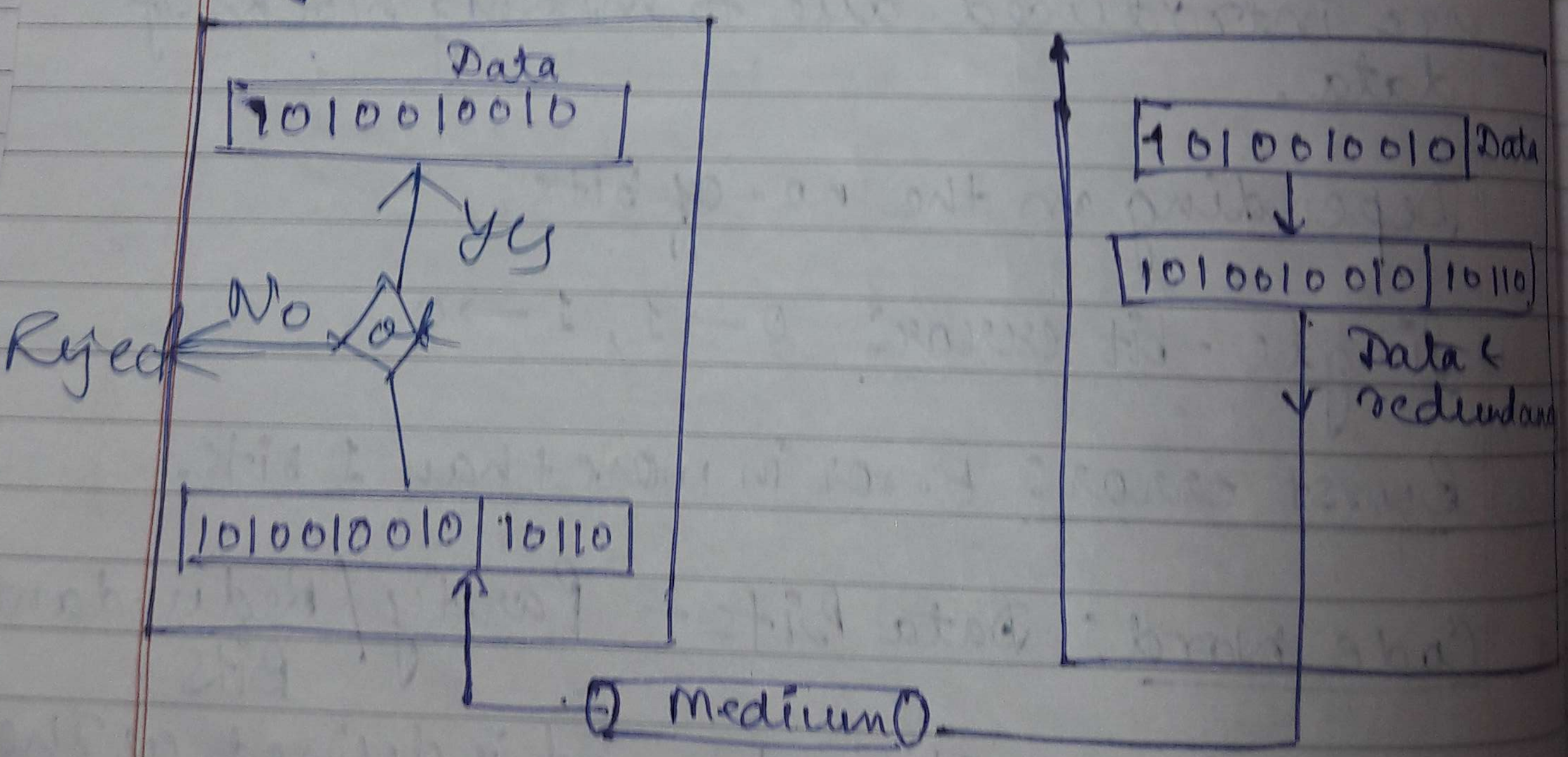
1 1 1 0 1 0 0 0 (Receiver)

Hamming Distance = 3

Redundancy Bits :

The ~~con~~ concept of including extra info. in the transmission for the error detection is known as redundancy.

Eg: CRC bits.



Error - detection Methods

- Parity check
- Checksum
- CRC

(I) PARITY CHECK:

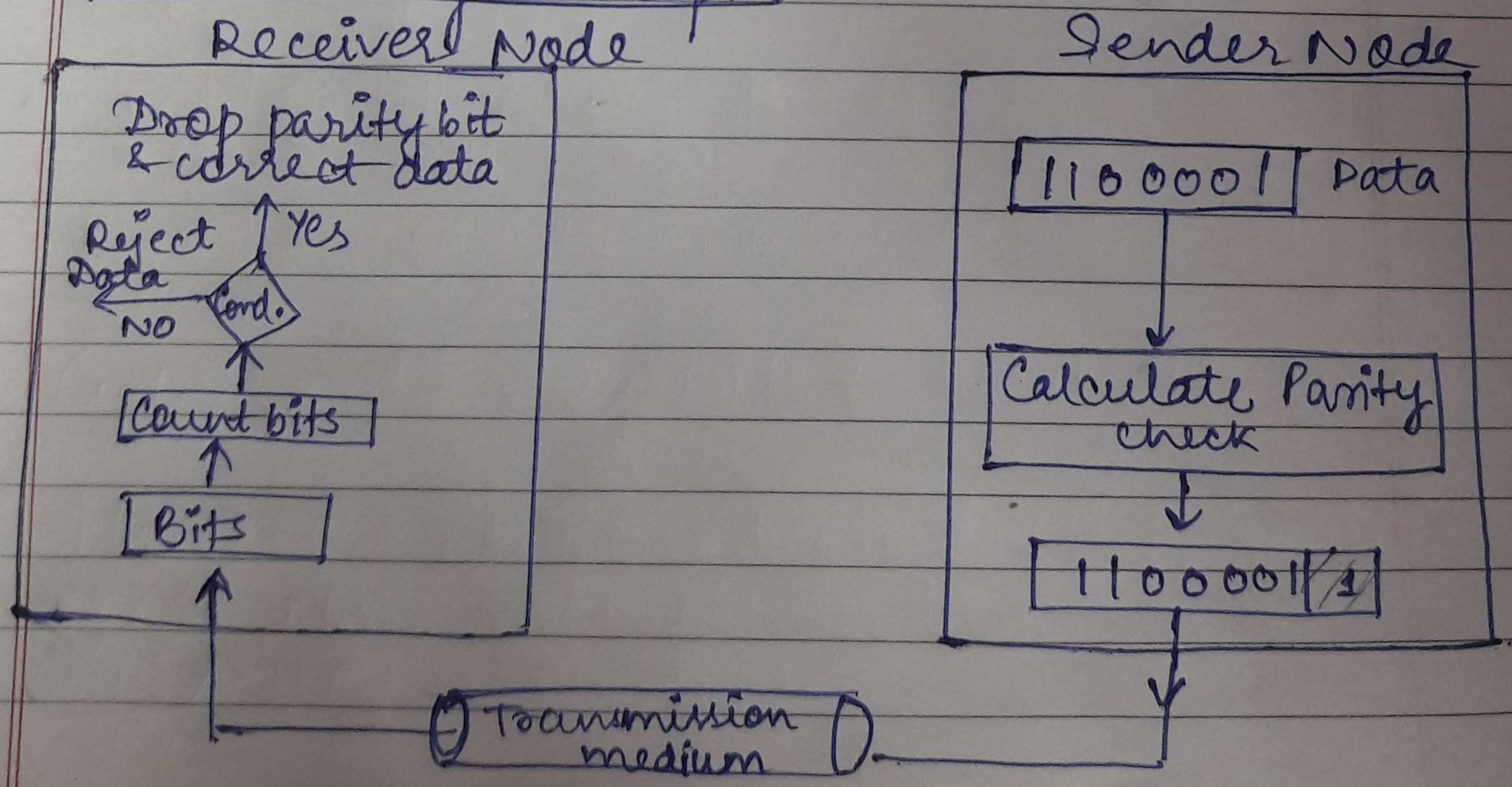
(1) Simple Parity Check:

- VRC (Vertical Redundancy check)
- LRC (Longitudinal Redundancy check)

~~(a) VRC : Vertical Redundancy Check~~

In this technique, a redundant bit called a parity bit is added to every data unit so that the total no. of 1's in the unit (including the parity bit) becomes even or odd.

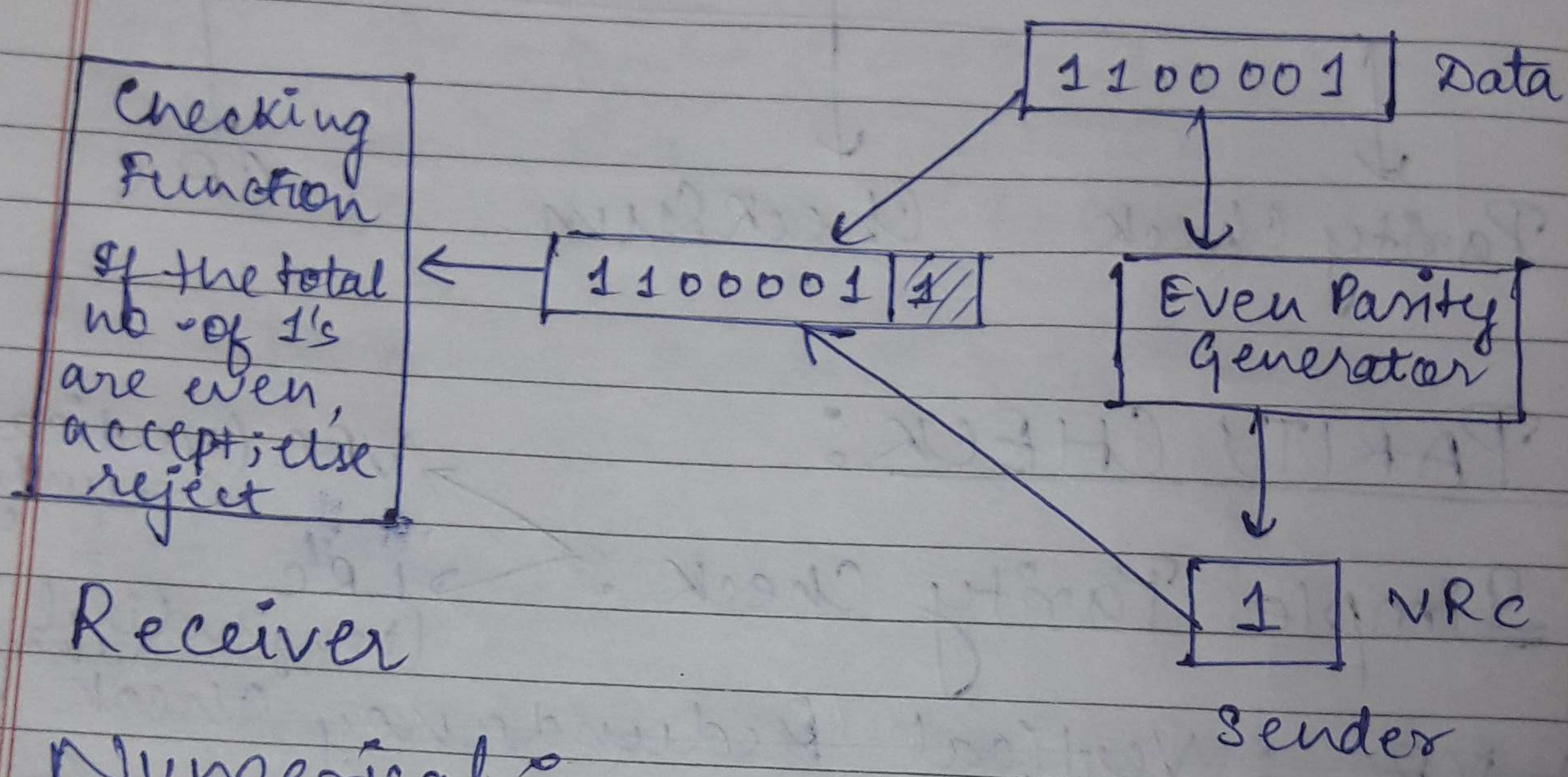
Even Parity Concept:



Drawback: Can only detect single bit

Can detect more than 1 bit if change occurs in 1, 3, 5, 7 bits

Even Parity VRC Concept:



Numerical:

Ascii code

W : 1110111
O : 1101111
R : 1110010
L : 1101100
D : 1100100

Performance:

(1) VRC can detect all single-bit errors.

(2). It can detect burst errors only if the total no. of errors in each data unit is odd