Computer Network

Date - 05/08/19

* 5 Credit cource (3 Theory, 2 Lab)

* Beij's Guide of Socket Programming (Online PDF)

* Larry Peterson & Bruce Davie

* A. S. Tannabuam

* What is Computer Network ?

Ans → It is an interconnection of autonomous device

interconnection → able to exchange data in a meaningful manner.

meaningful → Understandable to indented user.

→ for this protocol is used.

protocol → set of rules

→ is the basis of information exchange.

autonomous → Do not control each-other

device → any computing devices (e.g printer, computer, mobile etc)

* Network Facilitates →

(1) Data Sharing

(2) Hardware sharing

(3) Resource Sharing (Software or Hardware resources)

* Network reduces the cost of deployment also.

* How to visualize a network ?

for this, OSI (Open System Interconnection) model is used which contains seven layers namely Application, presentation, session, transport, Network, Datalink, physical, given by ISO in 1984.

OSI model

Application layer
presentation layer
Session layer
Transport layer
Network layer
Data link layer
Physical Layer

✡ Responsibilites / Services of physical layer ? (802X model

(1) To convert bits into signals. (Digital Encoder / Analog Modulator)

(2) Define the medium of communication.

telephone → twisted pair

Computer → Cat 6 cable

WLAN → 2·4 GHz / 5 GHz band

(3) Interface for connection.

* To fulfill these responsibilities, protocols is used.

Cat 6 → 100 Gbps

Cat 5 → 500 Mbps

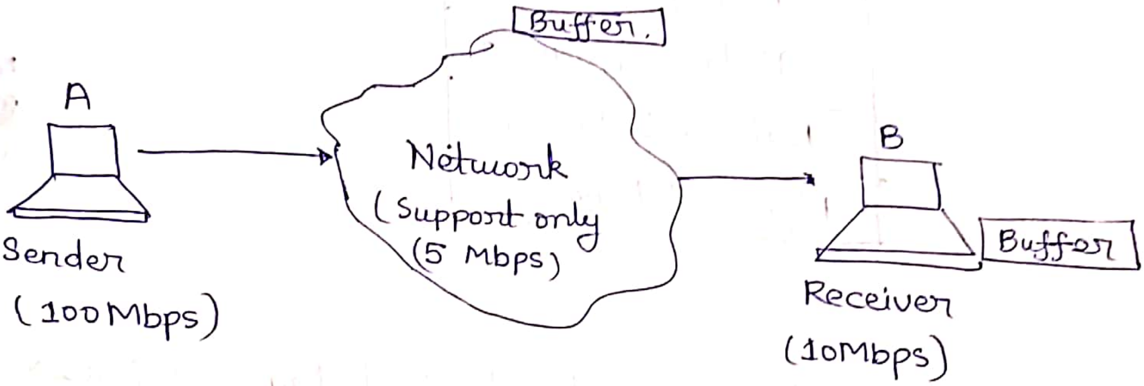
802·3 Lan → Manchaster encoding is used.

✡ Services / Responsibilities of Data Link Layer (DLL)

(1) Framing → To decide boundary of data packets.

(2) Flow control

(3) Error control



* Network has only 5Mbps data speed, so it will accumulate 95Mbps data in its buffer and after some point of time, the network buffer become full and no futher packets will be ~~excee~~ accepted.

* And same thing also happens at receiver end as it also has the capacity of only 10Mbps.

* That's why, flow control protocols are necessary to limit the data rate.

min [Max (Network, Receiver)]

= min (5Mbps, 10Mbps)

= 5 Mbps

* Error control

↓

Error detection and congestion protocols are used at Data Link Layer.

(4) Addressing (48 bits Ethernet address

↓

also known as MAC address/Global address)

DLL

Logical Link Control LLC sublayer	→ points (1, 2, 3) services
MAC (Media Access Control) sublayer.	→ points (1, 4, 5) services.

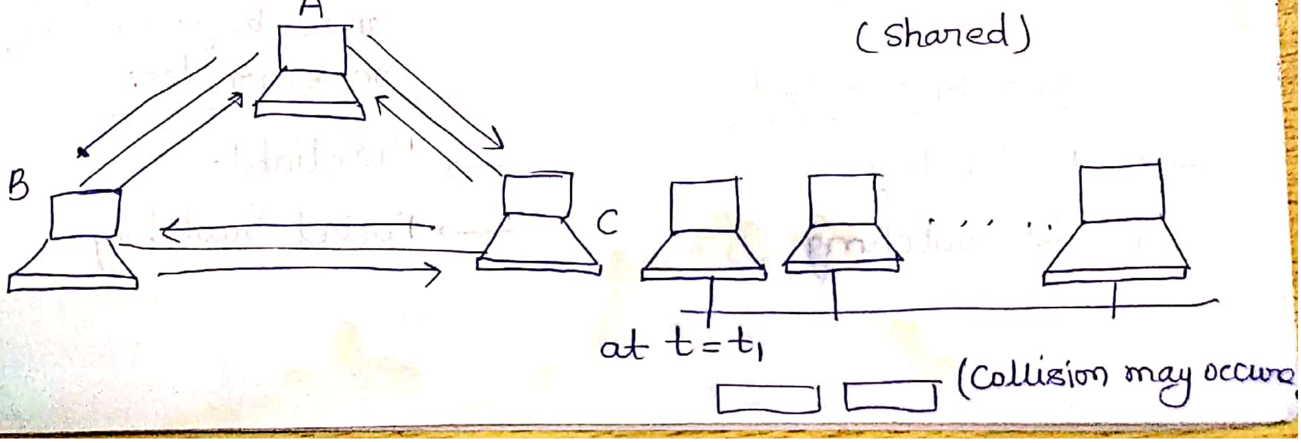
(5) Medium Access Protocals.

✡ Types of Network

Network

point-to-point

point-to-multipoint (Shared)



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* Bluetooth, WiMax etc are wireless sharing medium.

* MAC layer is required only in case of local area network (Sharing Medium)

802.2 ⟶ for LLC.

* For error control, CRC (Cyclic Redundency Check) and checksum is used.

Responsibility/Services of Network layer ⟶

(1) To provide connectionless based effort data delivary services.

based effort ⟶ not gaurenteed to destination

Circuit Switching	Packet Switching
e.g. PSTN → Public Switch Telephone Network (Land line telephone)	e.g. Internet (Postal System)

Packet Switching:
- → delay
- → lost of packets.
- → Packet may follow different routes. ⟶ connection less.
- → fairness.
- → Sequence of data packets can not be gaurenteed.

Connection oriented	Connection less
→ Reliability	→ Unreliable
→ Ckt Switching	→ Packet Switching

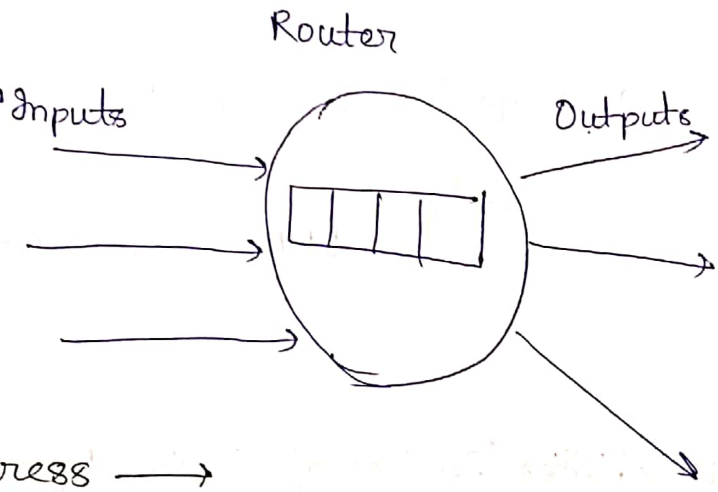
* ~~ckt switching~~

* Connection orientation can be acheived over packet switched networks as well as circuit switched networks.

* Connectionless means always Packet Switching.

(2) Routing

→ RIP }
→ OSPF } Protocols



(3) Logical address →

IPv4 and IPv6

IPv4 → 32-bits address

IPv6 → 128-bits address.

(4) It is also responsible for congestion feedback.

Transport Layer →

→ It provides connection oriented (Reliable) as well as connectionless (Unreliable) services.

→ logical Addressing (Port Number – 16 bits) 0 to 2^{16}

→ Congestion control

TCP → Connection Oriented

UDP → Connectionless

Responsibilities/Services of Session Layer →

(1) Dialog Control

(2) Session Management → Initialization, Maintainance, termination.

(3) Synchronization of the communication.

Respoibilities of presentation layer →

(1) Syntax of data

(2) Semantics of data

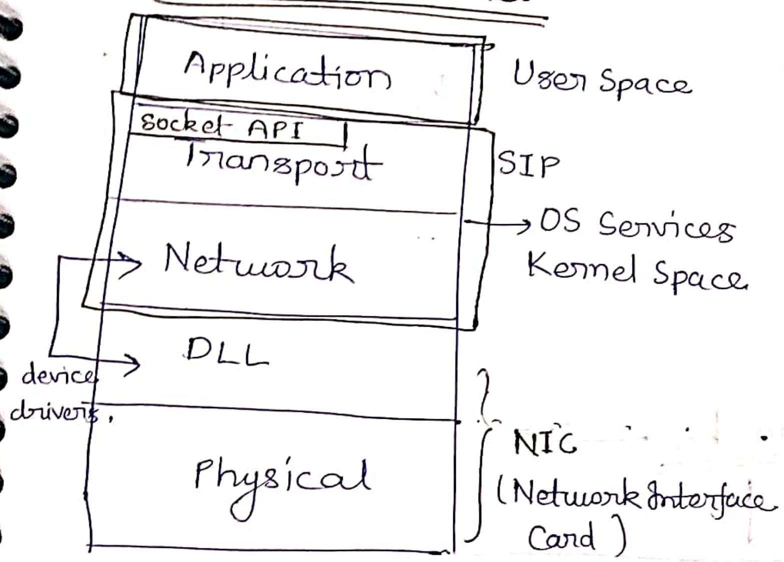
(3) Encoding

✡ Services of application layer →

→ DNS, HTTP, Telnet, FTP all protocols runs on application layer.

Working Model →

TCP/IP Model



OSI model

Application Layer.
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

htons → Host to Network short (16 byte)

htonl → Host to Network long (32 byte)

ntohs → Network to Host short

ntohl → Network to Host long

↓

System calls.

API → Application Program Interface

Socket API
↓
logical entity
└→ IP + Port no.

- STREAM Socket
  ↓
  TCP
- DGRAM socket
  ↓
  UDP
- Raw Socket
  ↓
  any protocol of any layer.

char* tcp1(char *s) ↓

char* tcp2(char *s) ↑

* Classification of Networks →

- point-to-point
- point-to-multipoint

→ PAN
→ LAN
→ MAN
→ WAN

Network Design	Area Network	Network Topology	Network Protocol	Wired or Wireless
↳ Client ↳ Server	→ PAN → CAN → LAN → MAN → WAN	→ Bus → Ring → ~~Car~~ Tree → Star	↳ Proprietary ↳ open (TCP/IP)	

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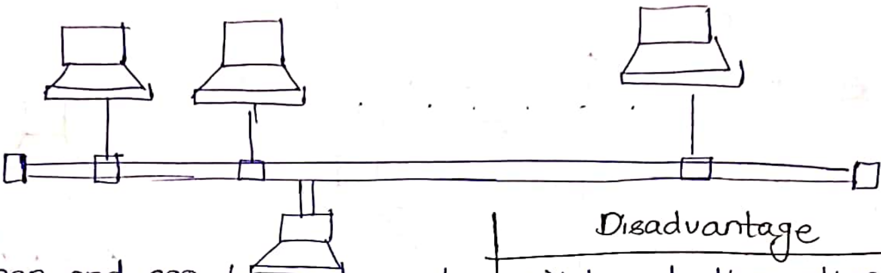
✡ Topologies for Network deployment

(1) BUS topologies



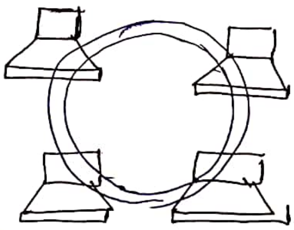
* Cheap and easy to implement.
* Requires less cable.
* Does not use any specialized network equipment.

Disadvantage

* Network disruption when computers are added or removed
* A break in the cable will prevent all systems from accessing the network difficult to troublshoot

(2) RING topologies

* Cable faults are easily located, making troubleshooting easier.



Disadvantage

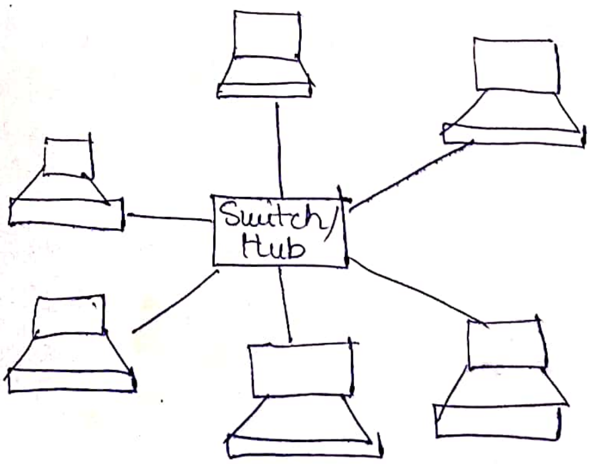
* A single break in the cable can disrupt the entire network.
* Expansion to the network can cause network disruption.

(3) STAR Topologies

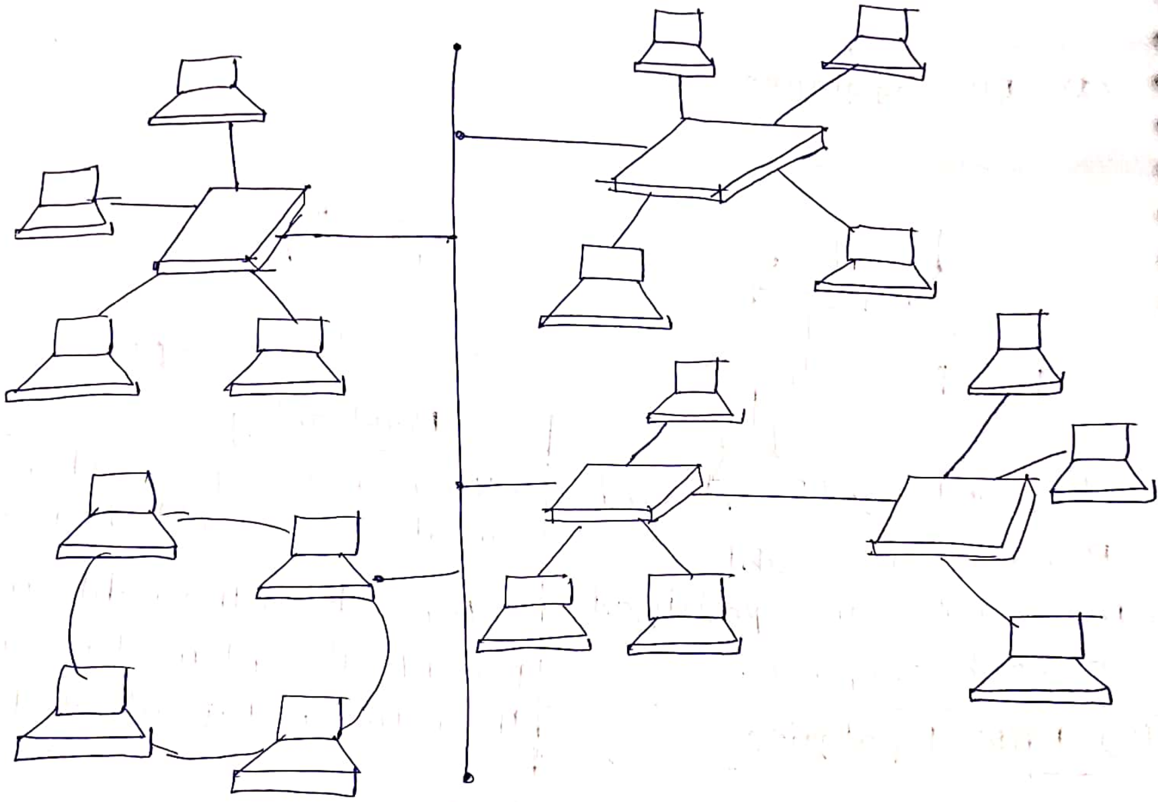
* Most widely implemented.

Disadvantages ⟶

* Requires more cable.
* More difficult to implement.



(4) Hybrid Topology



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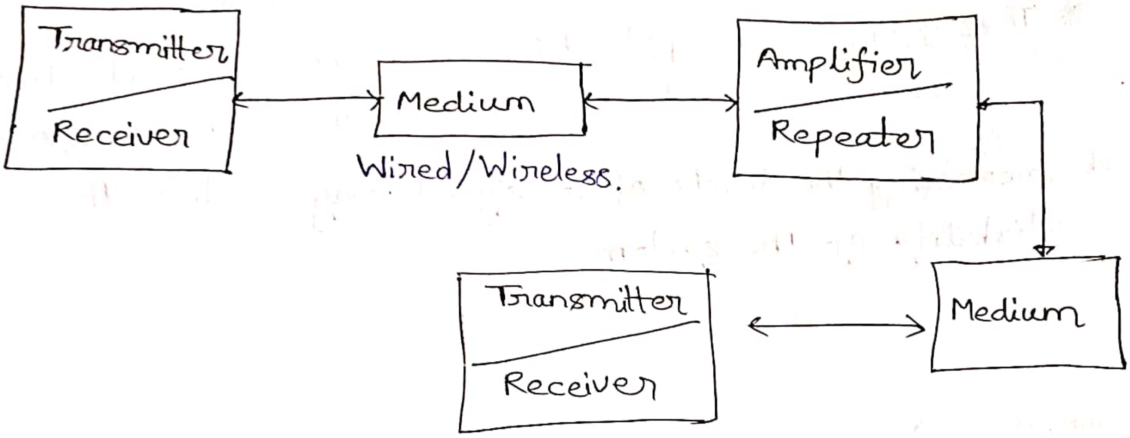
Physical Layer

Abstract Communication Model



Amplifier ⟶ Used for Analog signal

Repeater ⟶ Used for ~~Repeat~~. Digital signal.

Channel ⟶

It is a logical point to point connection between the sender and receiver.

Capacity of the channel ⟶

It is defind in terms of bandwidth / spectrum.

Bandwidth ⟶

$\boxed{BW = f_{max} - f_{min}}$ Hz

Nyquist Theorem →

$$\boxed{C = 2H \log_2 V} \text{ bits/sec}$$

H = Bandwidth of medium.

V = no. of discrete level used in the signal

* This formula is applicable for noiseless channel.

* Increasing the levels of a signal may reduce the reliability of the system.

Signal →

It is electrical or electromagnetic encoding of data.

Que Channel BW = 4000 Hz

Signal level used = 4

How much data rate is acheivable through this channel.

Soln H = 4000Hz

V = 4

$C = 2 \times 4000 \log_2 4$

$= 8000 \times 2$

$$\boxed{C = 16000 \text{ bits/s}}$$

Shann

*

Q

Sol

Shannon Capacity theorem →

$$\boxed{C = H\log_2\left(1+\frac{S}{N}\right)} \quad \text{bit/sec}$$

$\frac{S}{N}$ = Signal to Noise Ratio (SNR)

H = BW (Hz)

* Unit of SNR is dB.

$$\boxed{\left(\frac{S}{N}\right)1\,dB = 10\log_{10}\left(\frac{S}{N}\right)}$$

* Shannon capacity is used to determine the theoretical highest data rate for a noisy channel.

Que Signal is sent over a channel of 3kHz, post signal to noise ratio is 20dB. What is max. acheivable data rate over the channel.

Sol^n

$\frac{S}{N} = 20\,dB$

$\Rightarrow 20 = 10\log_{10}\left(\frac{S}{N}\right)$

$\Rightarrow \boxed{\frac{S}{N} = 100}$

$C = 3\times10^3 \log_2(1+100)$

$= 3\times10^3 \log_2 101$

$$\boxed{C = 3000\log_2 101 \quad \text{bit/sec}}$$

✡ Analog Vs Digital

Analog Data $\xleftrightarrow[\text{QAM-16}]{\text{PSTN Network}}$ Analog Signal

Analog Data $\xleftrightarrow{\text{Mobile Communication}}$ Digital Signal

Digital Data $\xleftrightarrow[\text{dial up internet connection}]{\text{Modem}}$ Analog Signal

Digital Data $\xleftrightarrow[\text{Manchester Encoding}]{\text{802.3}}$ Digital Signal

Advantages of Digital Signal →

Repeater, dsp (Digital Signal Processing)

* The effect of distortion, noise and interference is much less in digital signals as they are less affected.

* The signal is un-altered as the pulse needs a high disturbance to alter its properties, which is very difficult.

* Combining digital signal using TDM is easier than combining analog signal using FDM.

* The configuring process of digital signals is easier than analog signals.

* Digital signals can be saved and retrieved more conveniently than analog signals.

* The capacity of the channel is effectively utilized by digital signals.

Disadvantage of digital Signal

* Generally, more bandwidth is required than that for analog systems.
* Synchronization is required.
* High power consumption (Due to various stages of conversion)
* Introduce sampling error.
* As square wave is more affected by noise, That's why while communicating through channel we send sine waves but while operating on device we use square pulse.

Advantage and disadvantage of Analog Signal

Advantages →

* Major advantages of the analog signal is infinite amount of data.
* Density is much higher.
* Easy processing.

Disadvantages →

* Unwanted noise in recording.
* If we transmit data at long distance then unwanted disturbance is there.
* Generation loss is also a big ~~com~~ cons of analog signal.

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Medium

* Properties of Medium →

Guided Media →

Features →

* High speed
* Secure
* Used for comparatively shorter distances.

(a) Twisted Pair Cable →

(i) UTP →

* Least expensive
* Easy to install
* High speed capacity.

Disadvantages →

* Susceptible to external interference
* Lower capacity and performance in comparison to STP.
* Short distance transmission due to attenuation.

(ii) STP

Advantage →

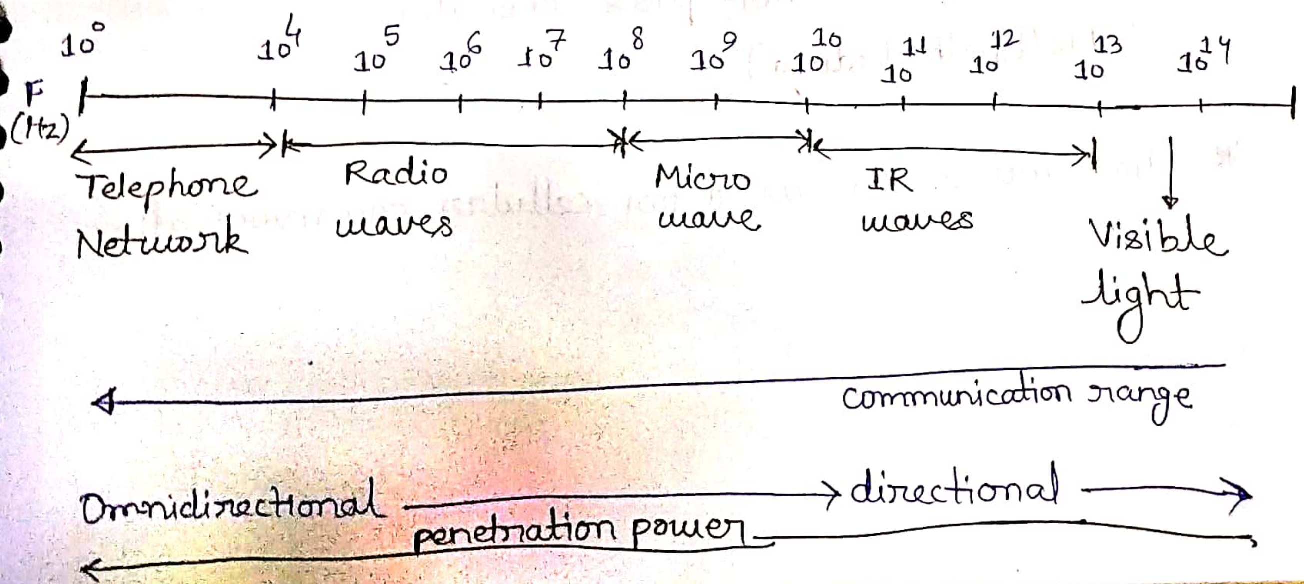
* Better performance at a higher data rate in comparision to UTP.
* Eliminates crosstalk.
* Comparitively faster.

Disadvantages →

* Comparitively difficult to install and manufacture
* More expensive
* Bulky

Medium

- Guided (Wired)
  - Coaxial Cable
    - Thikk (Mbps)
    - Thin
  - Twisted Cable
    - Shilded (STP) (Mbps)
    - Unshilded (UTP)
      - Cat 1
      - Cat 2
      - :
      - Cat 6
  - Fibre Cable
    - Singlemode
    - Multimode (Gbps)
- Unguided. (Wireless)
  - 10^0 Hz — 10^{23} Hz



Radio Wave

It is easy to generate and can travel over long distances.

* It can penetrate obstacles (buildings) easily.
* Widely used for outdoor communication.
* Radio waves are omnidirectional.
* Radio waves are subject to interference from motor and other electrical equipements.

Microwave →

Microwave travels in near straight line path.

* They can use communication over short distances.
* Repeaters are required to increase the communication range.
* Microwaves do not pass obscales. (Multipath fading)
* Microwaves are used for cellular communication.

Infrared (IR) waves →

* It ranges from 700 nm to 1 mm.
* IR waves are longer than those of visible light but shorter than those of radio waves.
* IR light is invisible to the human eye, although longer IR waves can be sensed as heat.

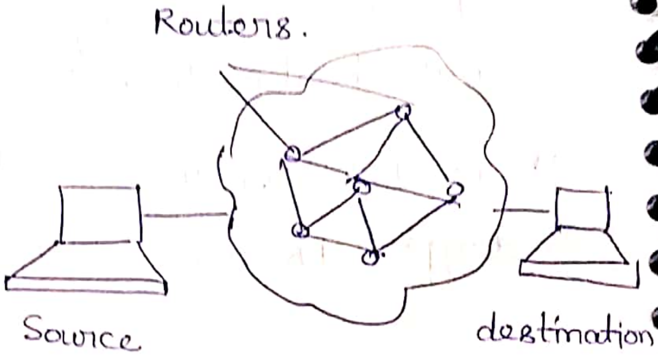
Light waves →

* LEDs are used to generate light waves.
* Visible light is just one particular type of electromagnetic radiation.

Date - 22/08/19

Network Performance →

(1) End to End delay

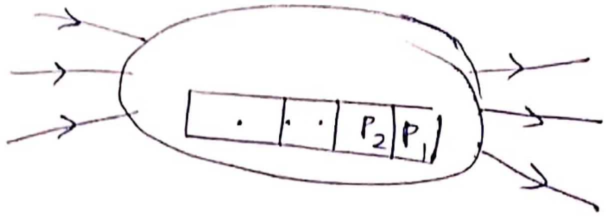


Channel Utilization

It is defind as fraction of time channel occupied.

Throughput →

It is defind as bits per second (successfully received data by receiver)



(1) Transmission delay →

Time elapse between first and last bit of a packet.

(2) Propagation delay →

Time travel to length of link/wire.

(3) Processing delay at each end →

(4) Queuing delay →

① end to end delay (minimum)

$$= \sum_{\text{no. of intermediate nodes}} (\text{Transmission delay} + \text{propagation delay} + \text{Processing delay} + \text{Queuing delay})$$

② Throughput (Maximum)

Physical layer continues.....

* <u>Converting bits into signal</u> →

(1) digital data → digital signal
[Encoding Techniques]

There are four parameters regarding encoding technique

→ Net DC component present in the signal
→ Clock information
→ Error detection

] −ve

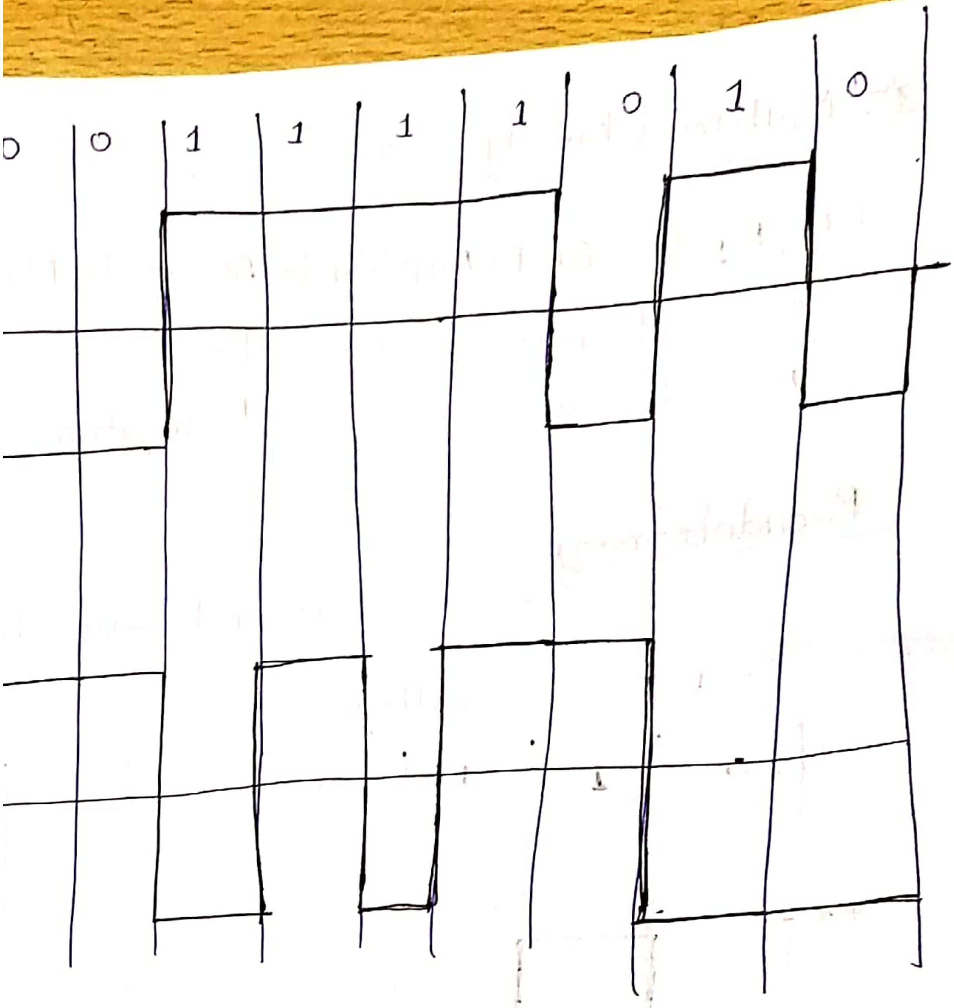
→ cost [bits / signal]
→ Complexity

] +ve

(1) NRZ (Non return to Zero) series of encoding
(2) Multilevel Binary
(3) Biphase Encoding
(4) Encoding for long distance transmission.
(5) Block Encoding

NRZ

- NRZ−I (differential Encoding)
  - 0 : No transition at the begining of bit interval
  - 1 : transition
- NRZ−L
  - 0 : high voltage level
  - 1 : low voltage level



nent undesirable in the signal

ent is not desirable in signal

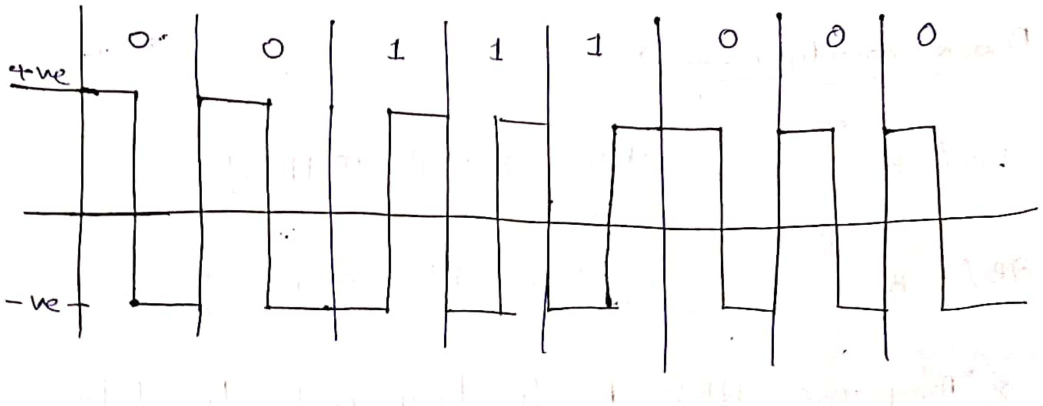
annot pass through some comm.

transformer and also lead to

ent also results loss of compon

l.

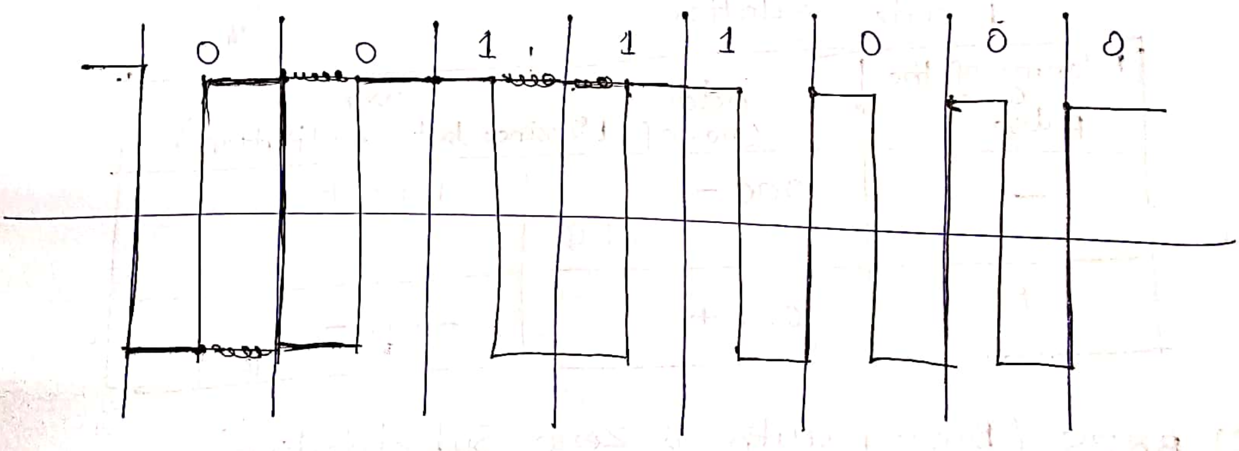
1	0	0	1



(b) Differential Manachester Encoding

0 : Transition at the begining of bit interval

1 : Absense of transition at the begining of bit interval.



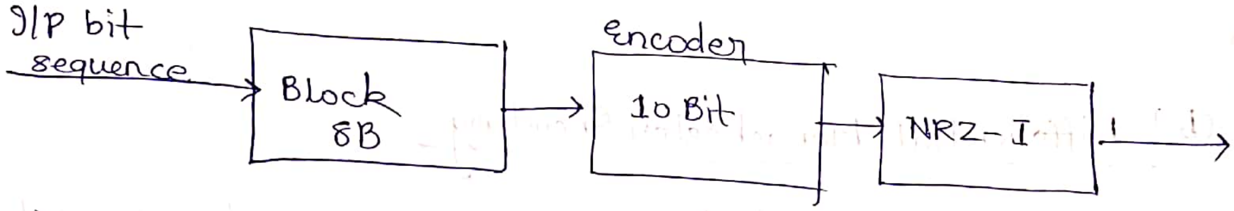
* Manchester technique is used in Ethernet IEEE 802.3
* Differential Manchester technique is used in token ring.

* Block Encoding →

5B/8B — 5 bit − 8 bit mapping

8B/10B — 8 bit − 10 bit mapping

* They use NRZ-I to transmit the data.



✡ Encoding for long distance → (Based on Bipolar AMI)

(1) HDBZ (High Density Binary with 4 Zero Substitution)

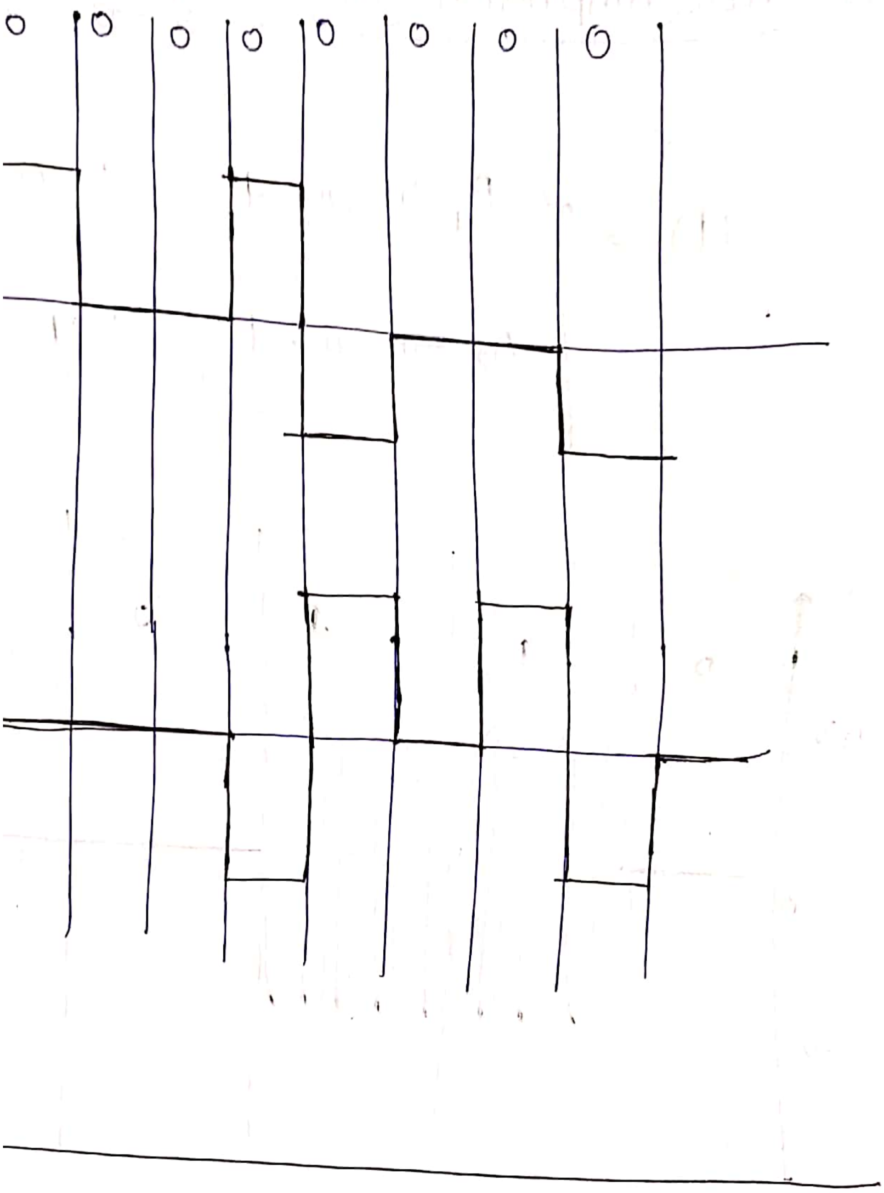
• 1 code voilation

Polarity of the pulse	odd	even
	(no. of 1's since last substitution)	
−	000−	+00+
+	000+	−00−

(2) B8ZS (Binary with 8 zero Substitution)

by substituting 2 code voilation.

Polarity of the pulse	~~odd~~	~~even~~
+	000+	−0+−
−	000−	+0+−



— Analog ~~Encoding~~ Signal

in($\omega t + \phi$)

ude

frequency

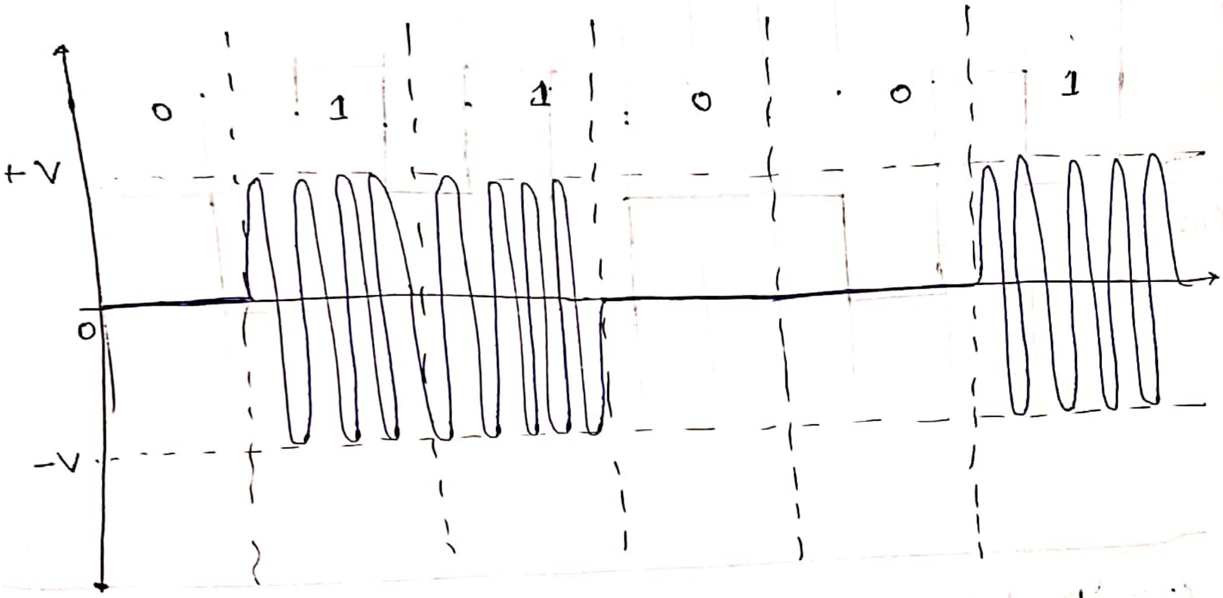
Phase

generation is known as Modulation

(1) ASK (Amplitude Shift Keying)

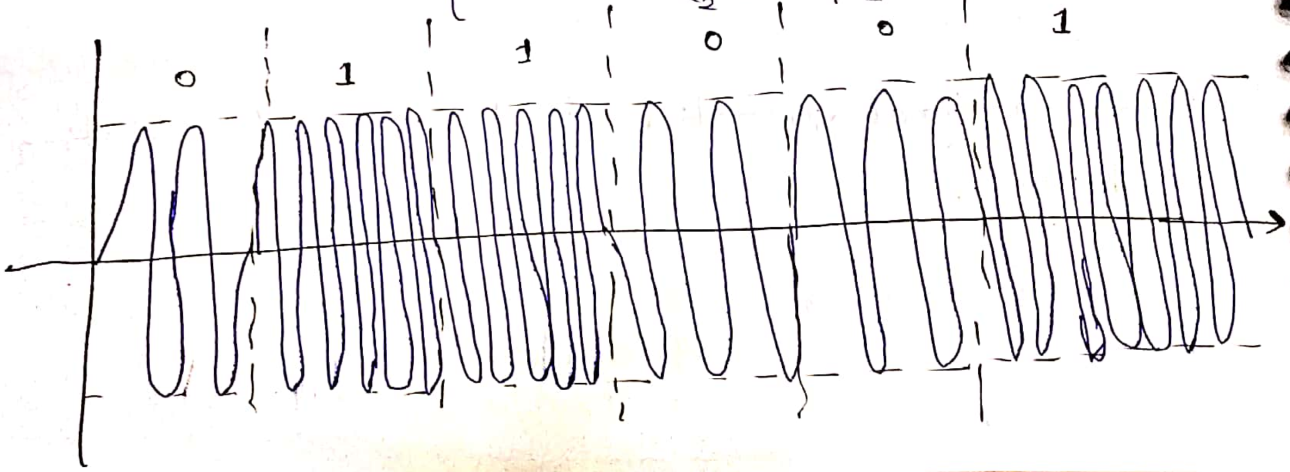
$$s(t) = \begin{cases} A_1 \sin 2\pi f_c t & : 0 \\ A_2 \sin 2\pi f_c t & : 1 \end{cases}$$

$\left.\begin{array}{l}\text{Phase} \\ \text{frequency}\end{array}\right\}$ constant



(2) FSK (Frequency Shift Keying)

$$s(t) = \begin{cases} A \sin 2\pi f_{c_1} t & : 0 \\ A \sin 2\pi f_{c_2} t & : 1 \end{cases}$$



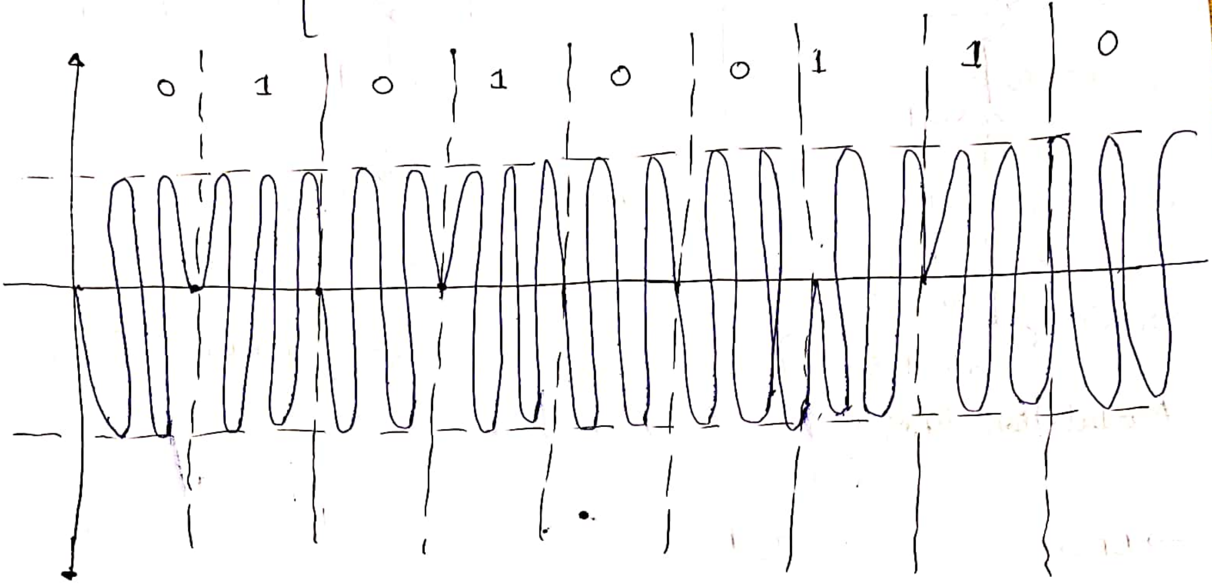
(3) PSK

S(

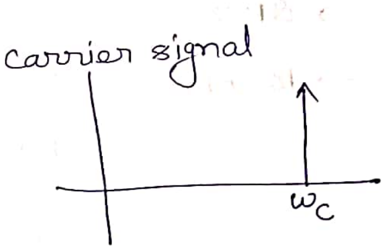
QAM

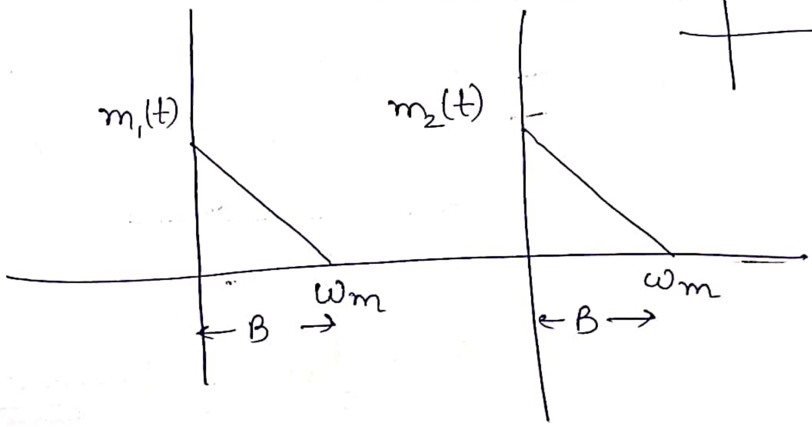
(3) PSK (Phase Shift Keying)

$$s(t) = \begin{cases} A \sin 2\pi f_c t & : 0 \\ A \sin(2\pi f_c t + \pi) & : 1 \end{cases}$$



QAM techniques

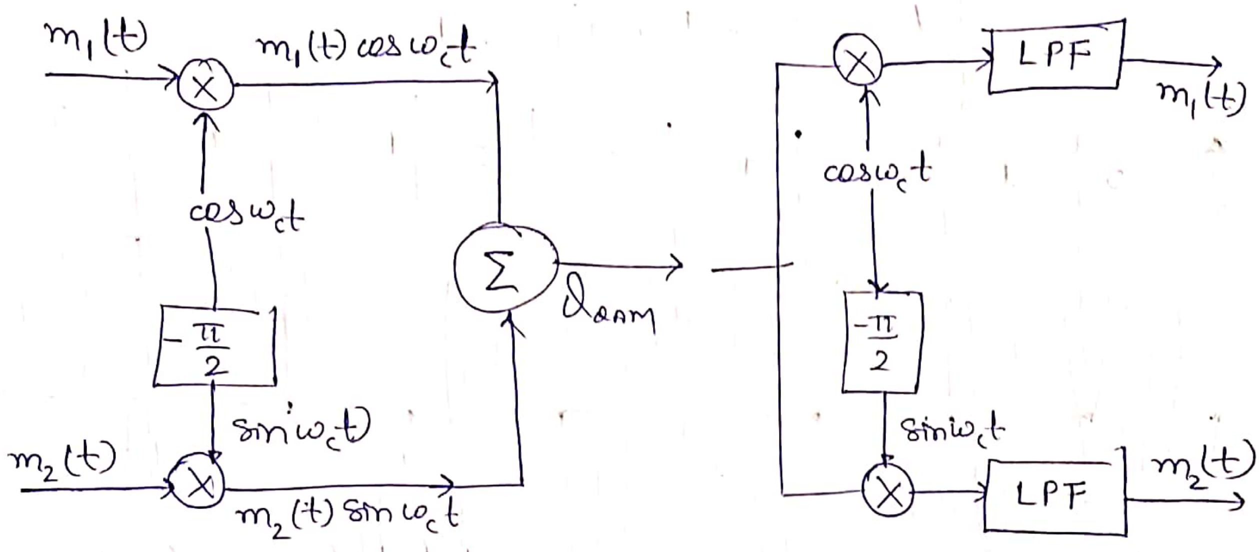




$$Q_{QAM} = m_1 \cos \omega_c t + m_2(t) \sin \omega_c t$$

Block diagram of QAM →

$$q_{QAM} = m_1(t)\cos\omega_c t + m_2(t)\sin\omega_c t$$



Modulation QAM

→ BPSK 0, 1

→ QPSK (00, 01, 10, 11)

→ 16 QAM (0000, 0001, 0010, 0011, 0100, 0101, 0110, 0111, 1000, 1001, 1010, 1011, 1100, 1101, 1110, 1111)

Date- 26/08/19

Data Link Layer

* Framing →

Computer network operates as a packet switched network which means block of data is exchaned between the nodes.

Interfaces are transmitting and receiving stream of bits. Therefore it is required to mark the boundary of frame on the bitstreams, for this framing protocol is used.

Framing
- Byte Oriented
  ASCII character is used.
  - Sentinel
  - byte counting
- Bit Oriented
  - Sentinel
  - Counting

✡ Byte Oriented Protocol →

(BISNYC, DDCMP)

↓ based on

Sentinel approach

BISYNC

8	8	8	16 bits	8	Variable	8	16
SYN	SYN	SOH	Header	STX	IP packets data	ETX	CRC

→ Byte Stuffing

DLE = Data Link Escape character.

SOH = Start Of Header
STX = Start of Transmission
ETX = End of Transmission.

DDCMP (Byte Counting Approach)

8	8	8	14	42 bit	Variable	16
SYN	SYN	Class	Count	Header	data	CRC

Bit Oriented Approach →

HDLC (High Level Data Link Control) protocol

8 bit	16 bit	variable	16	8
Begining bit Sequence	Header	data	CRC	Ending bit Sequence
01111110				01111110

bit stuffing

* Whenever, except starting and ending bit sequence five 1's are encountered, then a zero will be stuffed.

e.g.

0 1 1 1 1 1 | 1 1 0 0 1 0

$\downarrow$

0

* Receiver process will be, whenever five 1's are receiver, it will check next bit, if it is zero, then take out that bit and marks subsequence bit as part of bit.

If the next bit is 1 then there are two possibilities —

* If next bit is zero, then that is boundary of frame.
* If next bit is 1, then ~~data~~ frame received is an error.

* The above protocol discussed works of ISP.

For Ethernet (802.3)

8	16	48	48	Variable		
SOF	length / Control	DA	SA	Data	CRC	EOF

This has also Byte Oriented and Sentinel

✡ Error Control →

1 0 1 1 0 1 0 0 ⟶ 1 1 1 1 0 1 0 0

Single bit error

1 0 1 1 0 1 0 0 ⟶ 1 1 1 1 0 1 1 0

Burst Error

✡ Error Detection Techniques →

(1) Parity Check

→ Scalability

→ No. of extra bits required

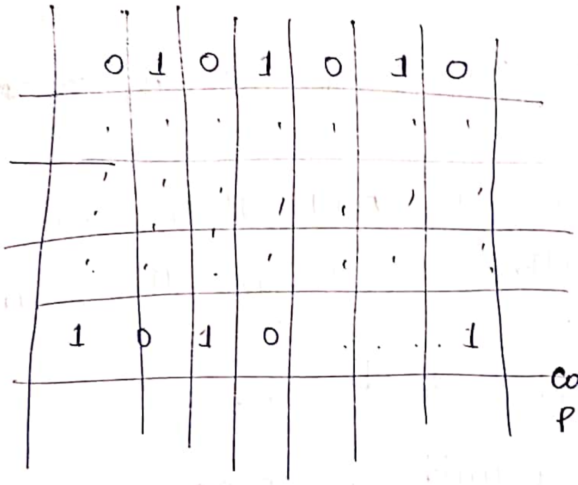
→ power of Error detection.

0 1 0 1 0 1 0	0→odd 1 → even

↑
parity bit

* Enforcement of odd parity means no. of 1's is odd, and for even, 1's should be even.

✡ Two dimensional parity check



even parity

								Row parity
1	0	0	1	1	0	0	1	0
1	1	1	0	0	0	1	0	0
0	0	1	0	0	1	0	0	0
1	0	0	0	0	1	0	0	0
1	1	0	1	1	0	1	1	0

column parity

☆ Checksum

* Checksum use 1's compliment arithmatic for its implementation.

Algorithm

* Consider a message to be made up of bytes or words.

* Divide the message into words. Add all the words using 1's complement arithmatic to get the sum.

* Complement the sum to get checksum.

* Transmit checksum along with the message.

Receiver

* Divide the received message into words. Add all the words including checksum.

* Complement the sum.

* All zeros employees no error, else error.

* power of error detection.

It can detects all error where odd no. of bits are envolved in error. (most of 2 bit or 4 bits error)

Date - 29/08/19

Example

$M = \underbrace{10101001}_{W_1}\underbrace{00111001}_{W_2}$

$$\begin{array}{lr} & 10101001 \\ + & 00111001 \\ \hline \text{Sum} & 11100010 \\ \hline \end{array}$$

Take complement

W_3 $\boxed{00011101}$

Checksum

Transmit massege

$= W_1 + W_2 + W_3$

$$\begin{array}{r} = 11100010 \\ 00011101 \\ \hline 11111111 \\ \hline \end{array}$$

compliment = 00000000

Let the received word is

$$\begin{array}{lr} & 10101111 \\ + & 11111001 \\ \hline & 1\,10101000 \\ \hline \text{Sum} & 10101001 \\ \hline \end{array}$$

$$W_1 + W_2 + W_3 = \begin{array}{r} 10101001 \\ 00011101 \\ \hline 11000110 \\ \hline \end{array}$$

compliment 00111001 [There is an Error]

CRC (Cyclic Redundancy Check) →

* CRC is implemented using special class of polynomial arithmatic known as Polynomial Arithmatic modulo tool.

* For implementation of CRC following properties are important —

(a) Any polynomial B(x) can devide a polynomial C(x) if B(x) is of same or higher degree than C(x).

(b) The remainder obtained when C(x) is divided by B(x) by substracting B(x) from C(x).

(c) To substract B(x) from C(x), we simply perform Ex-OR operation on the ~~pair~~ of matching coefficients of the polynomials and degree of polynomial is defind as —

Let $C(x) = x^3 + 1$

$B(x) = x^3 + x^2 + 1$ degree = 3

Binary Equivalance

$B(x) = 1101$

$C(x) = 1001$

```
         1
1101 ) 1001
       1101
       ⊕⊕⊕⊕
        100
```

CRC at Sender side →

* Let R be the degree of polynomial $C(x)$. [Both Sender and Receiver known that . . . polynomial].

* Append R 0 bits at the end of message bit string and call it $S(x)$.

* Divide $S(x)$ by $C(x)$ to get the remainder $R(x)$.

* Substract $R(x)$ from $S(x)$ and call it $T(x)$

* Transmit $T(x)$.

At Receiver Side

* Let Receiver receive massege and call it $M(x)$.
* Divide $M(x)$ by $C(x)$.

* If remainder is Zero, that accept or otherwise discard.

Example

message = 1011 $\qquad C(x) = x^2 + 1$ (D: 2)

$= 101$

$M(x) = 101100$

```
          1001
101 ) 101100
      101↓
      x001
       000
       x010
        000
        x100
         101
         001
```

$$
\begin{array}{r}
101100 \\
\oplus \quad 001 \\
\hline
\cancel{101011} \\
\hline
101101
\end{array}
$$

At receiver

```
          1001
101 ) 101101
      101↓
      x001
       000
       x010
        000
        x101
         101
         000
```

No error

Let the received bit is 101001

```
          1000
101 ) 101001
      101
      x000
       000
       x000
        000
        x001
         000
         x01
```

Since remainder is not zero hence there is an error in received message.

Standard Port CRC

* CRC-16 = $x^{16} + x^{15} + x^2 + 1$
* CRC-CCITT (telecom) = $x^{16} + x^{12} + x^5 + 1$
* CRC-12 = $x^{12} + x^{11} + x^2 + x + 1$

Power of Error detection

It can detect all errors where odd no. of bits are involved in error, 2 bit, and most of the 4 bit errors and most of burst errors.

---

* Error Correction Techniques

Hamming Code

$m + r + 1 \leq 2^r$

To impliment the algorithm we need to find the no. of r bits required for the implemention which can be obtained by

$$\boxed{(m+r+1) \leq 2^r}$$

where m = no. of message bits

r = no. of redundant bits (parity bits).

Step 1

* bits are numbered from left to right as 1, 2, 3 ..... starting from 1 to $(m+r)$.
* Power of 2 bits positions are reserved for redundant bits.
* Remaining positions are filled with message bits from left to right.

* Each p redundant bit shall enforce parity (even or odd) on the subset of redundant bit.

* Subset of parity bits can be determined as follows —

Example

$M = 1011 = 4$ $\qquad\qquad$ $4 + r + 1 \leq 2^3$

$R = 3$

$\boxed{\text{odd parity}}$

001 1	010 2	011 3	100 4	101 5	110 6	111 7
R_1	R_2	M_3	R_4	M_5	M_6	M_7
		1		0	1	1

$(R_1, 3, 5, 7)$ → 1 0 1 → $\boxed{R_1 = 1}$

$(R_2, 3, 6, 7)$ → 1 1 1 → $\boxed{R_2 = 0}$

$(R_4, 5, 6, 7)$ → 0 1 1 → $\boxed{R_4 = 1}$

$\boxed{\text{Codeword} = 1011011}$

At receiver

odd parity

Received Message is 1011010

(1, 3, 5, 7)
1 1 0 0

(2, 3, 6, 7)
0 1 1 0

(4, 5, 6, 7)
1 0 1 0

P_1	1	1	0	0	1
P_2	0	1	1	0	1
P_4	1	0	1	0	1

111 = 7

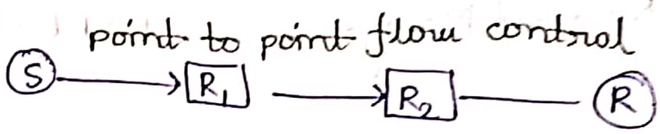
It means there is an error in 7th position.

Hence the correct output will be

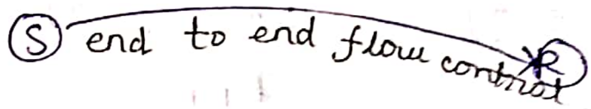
= 1011011

✡ Flow Control ⟶

* Data link layer



* Transport layer



* flow control techniques are required to deal with the problem of fast transmitter and slow receivers

* Flow control techniques are also responsible for order of data packets (Sequence of data packects)

* These techniques also cares of lost data packets.

ARQ

* Automatic Repeate request is implement on all the nodes on network

(1) LLC protocols are required to deliver frames relibly and ~~leaves~~ need some feedback mechanism.

(2) This can be implemented by the use of ACK and timers.

Sender's process

* Sender transmit a frame and keeps a copy of it.

* Associates a timer with copy of frame and wait for ACK.

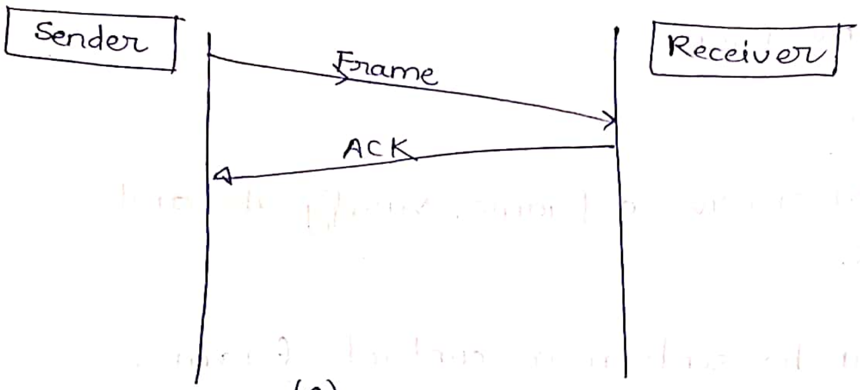
* If ACK is not received before time out then retransmit the frame.

Receiver's process

* Receiver can receive a frame, varify it and send the ACK.

* This ACK can be sent on a control frame (Header without any data or piggyback on the dataframe it is about to sent). This is known as ARQ.

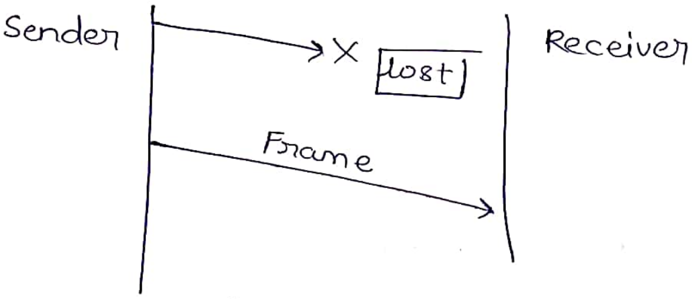
Date 05/09/19



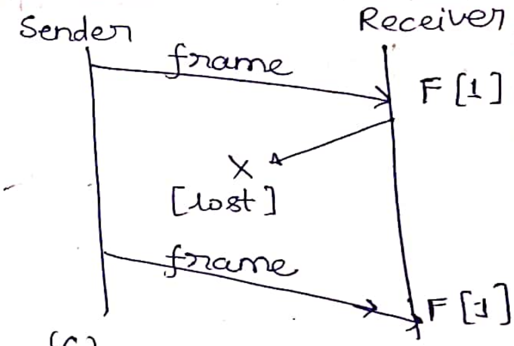
(a)

When frame has lost

When the ACK is lost



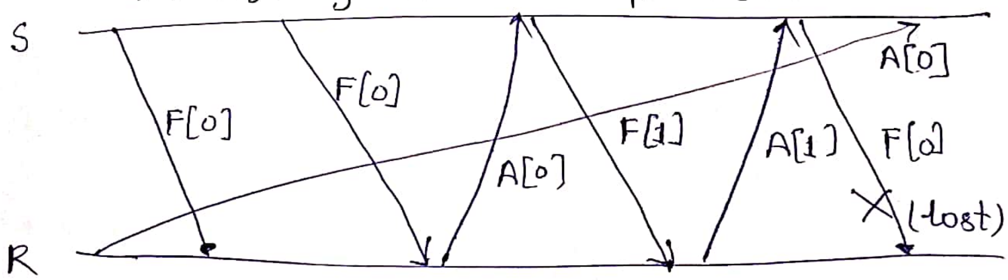
(b)



(c)

* Sequence no. is used to avoid the duplicate copies of frame

In case of one bit sequence no.



(e)

* Stop and Wait protocol can be considered as 1 bit ARQ

Problems

* One bit sequence number is not sufficient for stop and wait protocol as shown in figure (e)

* Only one frame can be transmitted at any point of time, which means link capacity cannot be utilized sufficiently

Que Available link capacity is 1.5 Mbps, timer value = 45 ms and frame size = 1 kB. How many frames can be transmitted to fully utilize link capacity?

Soln

$$\text{no. of frames} = \frac{1.5 \times 10^6 \times 45 \times 10^{-3}}{1 \times 10^3}$$

$\lessdot$ 18.

$\lfloor \ \rfloor$

* To solve the above problems of

(1) N bits sequence no. should be used.

(2) TTL (Time to leave) constrains should be added for frame and ack.

(3) To utilize link capacity, more than one frame should be sent within the timeout ~~an~~. value.

(4) These solution have been encarpted in sliding window protocal.

$$\text{SWS} = \frac{\text{link capacity} \times \text{timeout value}}{\text{frame Size.}}$$

(Sender Window size)

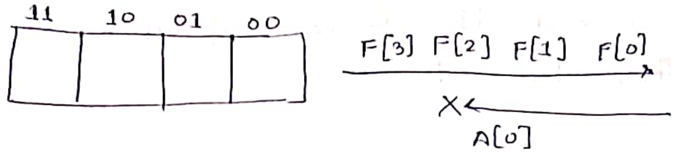
total no. of bits in sequence $= \dfrac{(\text{Max. Sequence No.} + 1)}{2} \geq \text{SWS}$

for SWS = 8

$\Rightarrow \dfrac{\text{Max. Sequence No.} + 1}{2} \geq 8$

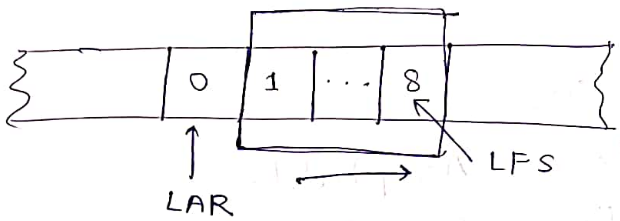
$\Rightarrow$ Max. Sequence No. ≥ 15

no. of bits $= \log_2(15) = \log_2(\text{Max. Sequence No.})$



✡ Sliding Window Protocols →

At Sender



Algorithm

For SWS, sender will maintain following variables –

(a) Sequence No.

(b) SWS → Size of Sender's window (buffer)

(c) LFS (Sequence No. of Last frame Sent)

(d) LAR (Sequence No. of Last ACK received)

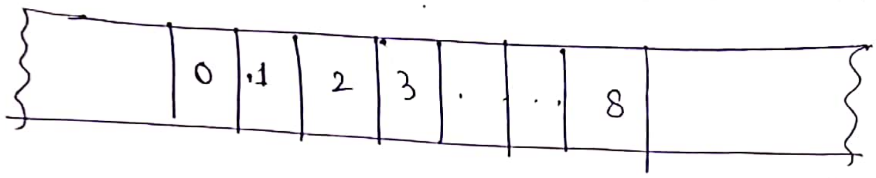
(1) Transmit frames untill (LFS – LAR) ≤ SWS.

~~so sender~~

(2) After each transmission, increament LFS, on receipt of ACK, ~~implement~~ increament LAR.

* Sender will retransmit the frame if ACK is not received within timeout.

At receivers



RWS = Receivers Window Size

LFS = Seq. no. of Last Frame Acceptable

NFE = Seq. no. of Next Frame Expected.

Sequence no. represente

SeqNoToAck ⟶ This variable represents seq. no. of out of order received.

* Receiver can receive

$$\boxed{LFA - NFE + 1 \leq RWS}$$

Algorithm

* Frame arrives with sequence no., if seq. no. is within receiver's window, then accept else discard. (Which means sequence no. is $\leq$ LFA and $\geq$ NFE)

if (SeqNo. $\leq$ LFA && SeqNo. $\geq$ NFE)
then accept else discard.

* If SeqNo. = NFE then send ACK and set NFE = NFE + 1 ;

* If SeqNo != NFE Stop sending ACK.
  then set SeqNo.To Ack = Seq.No.

for e.g. Let NFE = 2 SeqNoTo Ack = 5
then Seq.No = 5

* Once all frame with sequence no.
  SeqNo < SeqNoTo Ack received
  then Send ACK with value
  SeqNoTo Ack (Cummulative ACK)

Set NFE = SeqNoTo Ack + 1

and LFA = SeqNoTo Ack + RWS

Advantages

* Order of data is ensured.
* Loss of data is cared.
* Sliding Window is reliable of communication.
* It will ensure the flow control.

RWS = 1   Stop and Wait Protocol

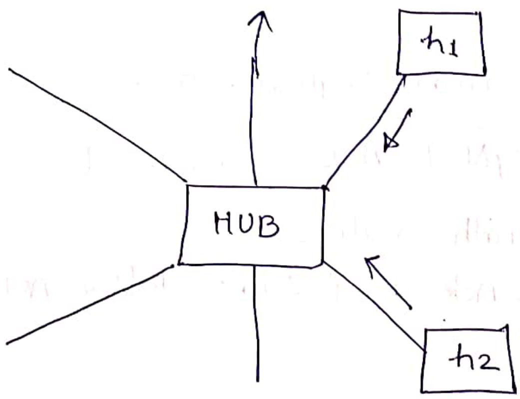
SWS = RWS   In general

SWS < RWS   No meaning.

✡ Medium Access ~~Protocols~~ Control

* Requires in multipoint network. (Shared Network)

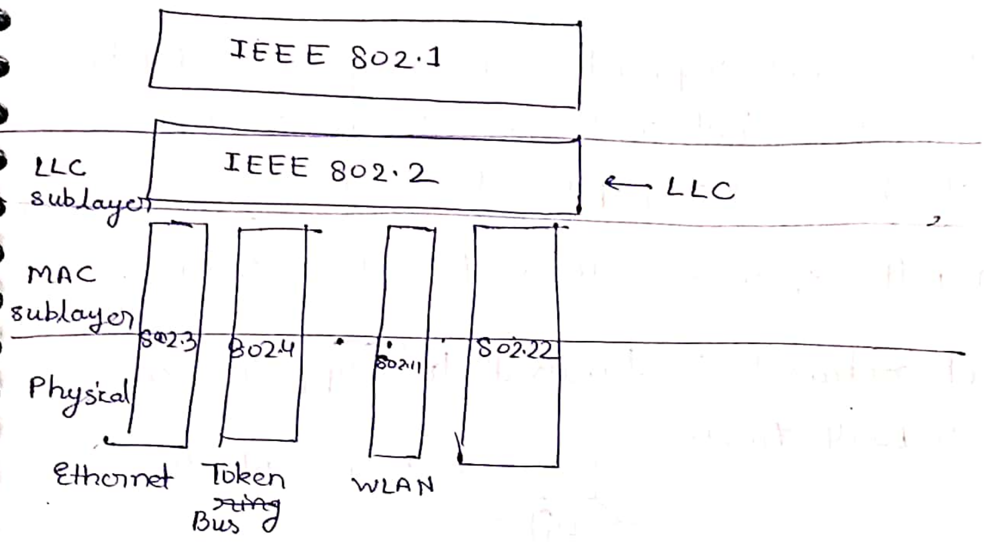
broadcast type



* MAC is nothing but Regulatory Mechanism to use the medium by host.

(1) MAC sublayer is only used in shared network for e.g. Ethernet, WLAN, Cellular System etc.

(2) 802.1X Standard has covered the whole idea of different MAC options.



802.15 → PAN

802.16 → WiMAX

SIG = Special Interest Group.

Ethernet

(1) Physical

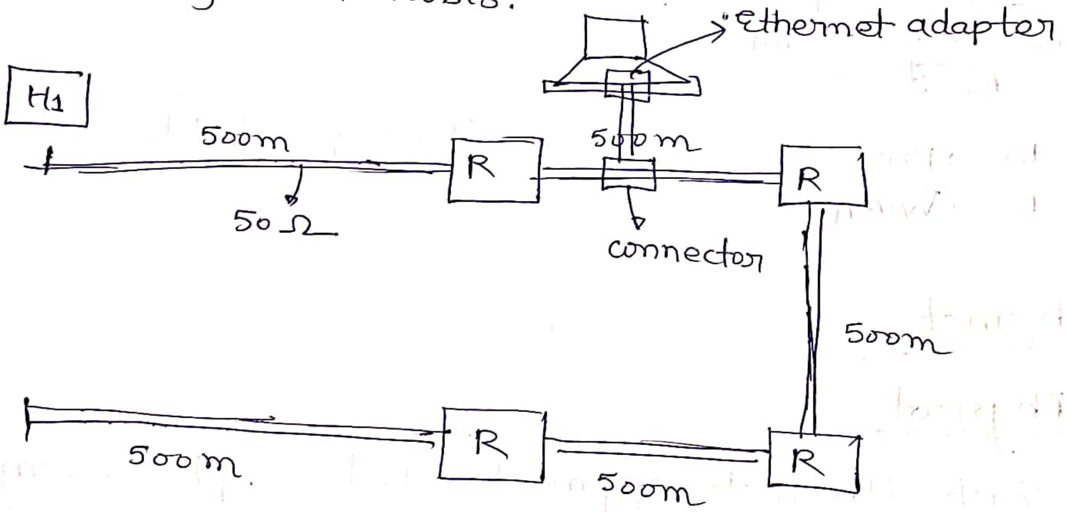
* Each ethernet segment can be upto 500 m long of 50Ω coaxial cable.
* Post tab into cable of connection and should be 2.5 m apart from each other.
* Bus topology ~~is~~ should be used for deployment of network.
* Transceiver should be capable of detecting weather the ~~like~~ link is idle or busy.
* Transceivers are implemented in ethernet.
* Signal placed on the link are broadcast in network.

* Manchester encoding is used.

* Multiple ethernet segments can be joined by the use of repeaters but not more than 4 repeaters can exist between any pair of host.

* Limiting the span of ethernet upto 2.5 km.

* Ethernet network is limited to support a max of 1024 hosts.

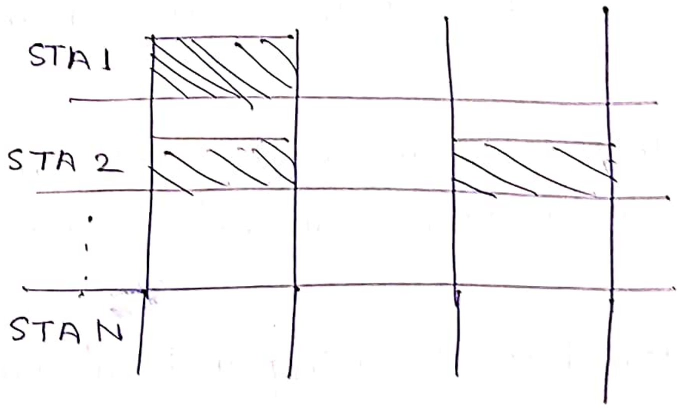


10 Base 5 → 10 Mbps, Baseband, 50Ω

100 Base T → 100 Mbps, Baseband, Twisted pair

✡ Slotted ALOHA ⟶

$\cong$ 33% bandwidth utilized bandwidth is acheived by using Slotted ALOHA.



(1) MAC protocol is known as 1-persitence CSMA/CD with binary exponential backoff.

where 1-persistance means

CSMA/CD

CS ⟶ All nodes are able to determine when the link is idle or busy.

MA ⟶ Multiple access means multiple nodes can transmit their data at any point of time on shared link.

CD ⟶ Collision detection means nodes are able to detect whether the frame transmitted has suffered collision or not.

Date - 12/09/19

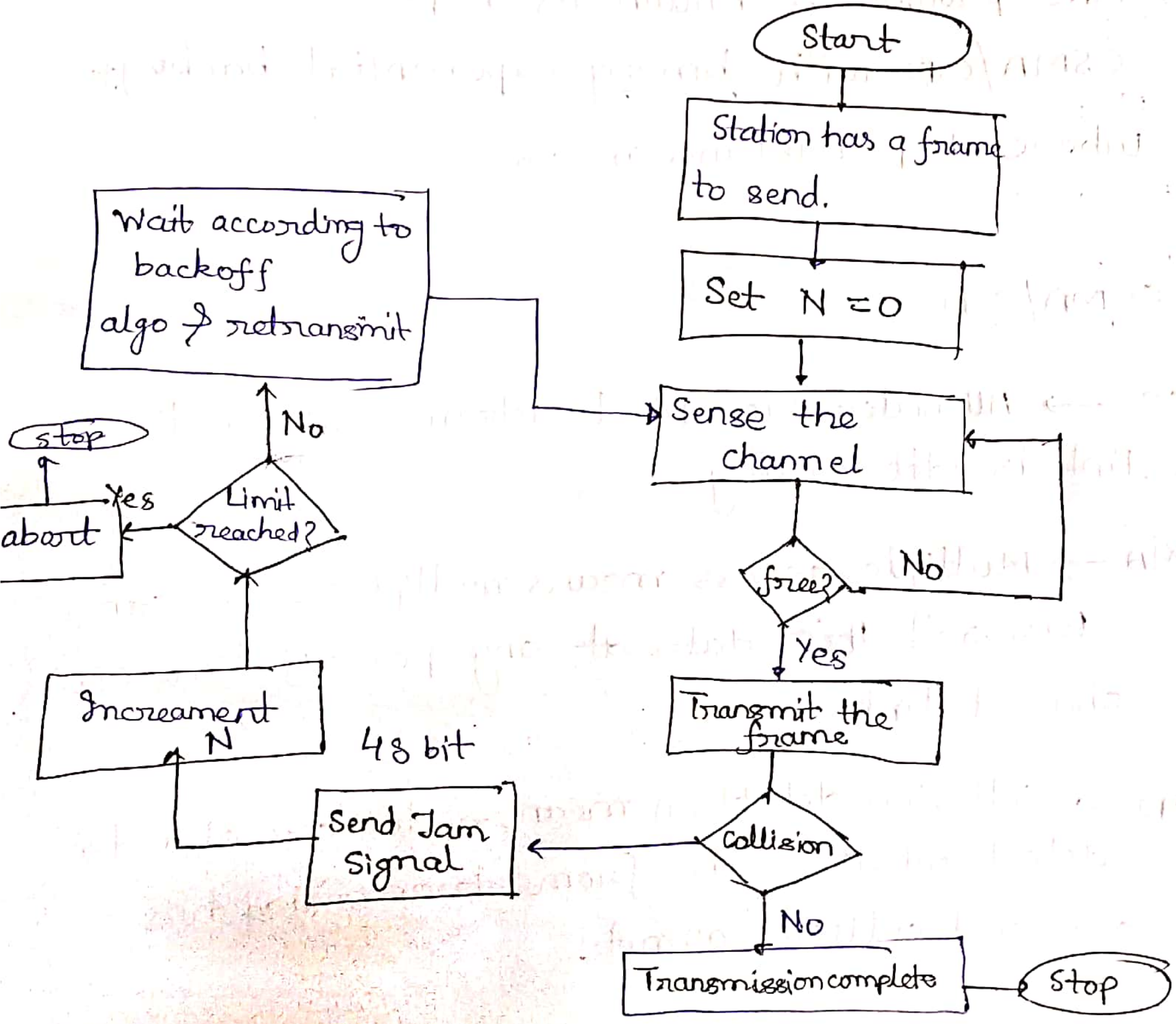
MAC protocol

* Whenever a station has frame to send, it senses the channel.

* If the channel is free, then station will transmits otherwise wait.

* If collision is detected by any station of the network, then it immediately transmit a jam signal.

* On collision station backoff using a local counter and try retransmission accordingly.



N = maximum no. of retransmission.

$\boxed{N_{max} = 16}$

✡ Backoff algorithm

Binary Exponential Back off algorithm

* Upon collision, the sending station increaments local counter Q. The backoff interval is randomly selected using uniform distribution over L where $\boxed{L = 2^K \text{ Slots.}}$

* K is initially set to 0.

✡ Frame Format of Ethernet →

min = 46 byte
max = 1500 byte

7 bytes	1 byte	6 byte	6 byte	2 byte		4 byte
Preamble	S O F	DA	SA	Length	Data / PAD	CRC

SOF = Start of frame.

MTU = Maximum Transfer Unit ≤ 1500 byte

48 bit address (6 bytes) → (Globally Unique Address)

→ Mac MAC address
→ Physical address
→ NIC → Network Interface Card
→ Global address

Scanned by CamScanner

48 bits

24 bit prefix	24 bits
assigned to the companies	⟷ Generate Unique device id

IEEE 802.3

7 bytes	1 byte	6 byte	6 byte	2 byte	min 46, max = 1500	4 byte
Preamble	SOF	DA	SA	Type	data / Pad	CRC

RTT = Round Trip Time

for 10 Mbps Ethernet

RTT = 51.2 μsec

∴ Data = 51.2 X 10 = 512 bits = 64 bytes.

min = 64 − (6+6+2+4)

= 64 − 18

= 46 bytes

MAC address

ipconfig → Windows
ifconfig → Linux

2A : 46 : 3C : 49 : 5E : 6F

Presentation notation.

$\underbrace{0100110 \ldots\ldots 01}_{48\text{ bit}}$ → Network representation

Network Layer

→ IPv4 → 32 bit address
→ IPv6 → 128 bit address } logical address

* IPv4 is used to define the network and to distinguish network.

Header of IP packets →

0	3	15	31
Version	HLEN	TOS	length
Identifier		FLAGS	Offset
TTL	Protocol	Checksum	
Source address			
Destination address			
Option		PAD	
DATA			

Header

Types of services (TOS)
- → min delay
- → max throughput
- → reliability
- → low cost.