Unit - 2

Data link layer

The data link layer is a hardware level. Information at this layer is in the form of frames. It takes the services from physical layer and provides the services to network layer. It is divided into 2 sublayers -

1.) Media Access control sublayer (MAC)
2.) Logical link control sublayer (LLC)

imp. Design issues of Data link layer

1.) Data Transfer
2.) Frame synchronization
3.) Error control
4.) Flow control
5.) Addressing
6.) Link management

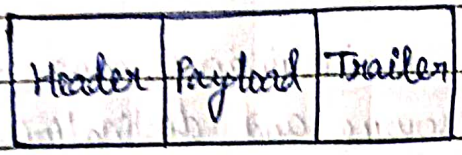
1.) Data Transfer -

The data link layer is responsible to provide defined services to the network layer. The principle of this service is to provide the data from the network layer on the source machine to the destination machine there are 2 types of services -

1.) Connectionless
2.) Connection oriented

2) Frame Synchronization -

The source machine sends data in a block called frames to the destination machine. The starting and ending of each frames must be recognized by the destination machine.



3) Flow control -

The source machine should not send data frame at a faster rate as compared to the destination machine receiving data rate. When a sender sends a data in a high speed, the slow receiver will not be able to handle it and thus, there will be a chance of loosing the data frame.

4) Error control -

The error made in bits during the transmission from the source to destination machine must be detected and corrected. Thus, this layer ensures error free data transmission.

5) Addressing -

Each frame comprises of a header which contains source and destination addresses.

6) Link management -

The initiation, maintainance and termination of a link between the source and destination is required for effective exchange of data.

Framing

Framing in data link layer is a point-to-point connection between the sender and the receiver. The data link layer receives packets from the network layer and converts them into frames. Small frames are more efficient for flow and error control.

Header -
The source and destination address is placed in header part of the frame.

Payload field -
It contains the actual message that the sender wants to transmit to the destination.

Trailer -
It comprises of error detection and error correction bits.

Flag -
It shows the beginning and end of a frame.

Types of Framing

1) Fixed size Framing
2) Variable size Framing

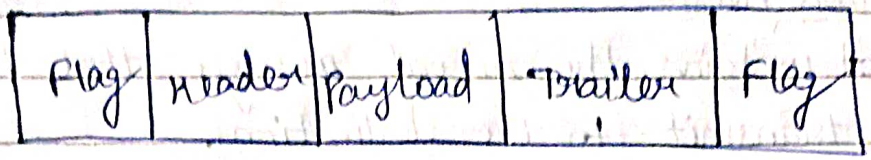
1) Fixed size Framing -

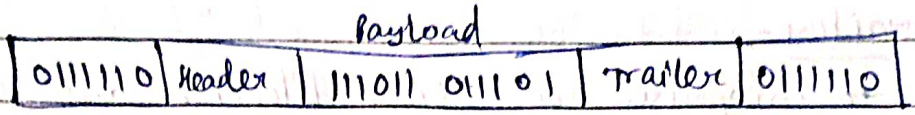
The frame has fixed size. There is no need of defining the boundaries of the frame to mark the beginning and end of the frame.

2) Variable size Framing -

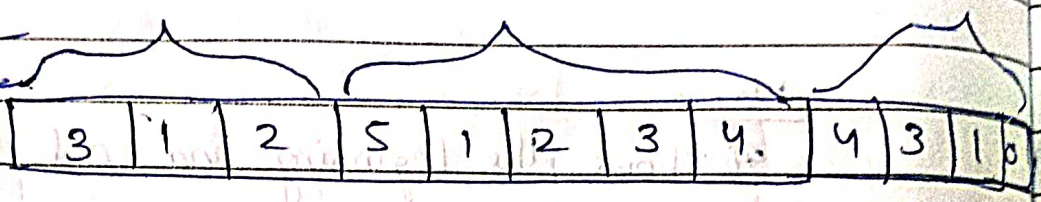
In variable size, we need a way to define the end and start of a frame.

Value of Flag - 01111110





Character count



bit stuffing
byte stuffing

Error

1.) single bit error
2.) multi bit error
3.) burst error → multibit with consequetive error

error detection

1.) Parity check → for single bit error

even parity
(even no. of 1's)
↳ add 0 bit
(odd no. of 1's)
↳ add 1 bit

odd parity
(odd no. of 1's)
↳ add 0 bit
(even no. of 1's)
↳ add 1 bit

Checksum -

10011001	11100010	00100100	10000100

```
    1 1
  10011001
  11100010
  00100100
  10000100
-----------
1 | 00100011
  +
```

```
  00100011
+       1
-----------
  00100101
```

```
  00100101
→ 11011010   → 1's complement
-----------
  11111111
```

sum + checksum

00000000 → 1's complement.

→ This indicates no error.

Q.

10011111	11100010	00100101	10000100

```
    1 1 1 1 1 1
  10011111
  11100010
  00100101
  10000100
-----------
1 | 00100010
  +
```

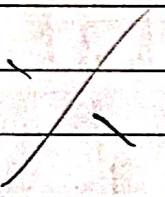
```
  00100010
+       1
-----------
  00100011
```

00101010

10011111

111

$$\begin{array}{r} 1 \\ +\ 0 \\ \hline 1 \end{array} \qquad \begin{array}{r} 1 \\ +\ 1 \\ \hline 10 \end{array} \qquad \begin{array}{r} 1\ 1 \\ +\ 1 \\ \hline 11 \end{array} \qquad \begin{array}{r} 1\ 1\ 1 \\ +\ \ 1 \\ \hline 100 \end{array}$$



Imp CRC

Q. In a CRC (cyclic redundancy check), error detecting scheme the generator polynomial is x^4+x+1. Encode the 11 bit code 100 100 110 11

Soln: x^4+x+1 = 10011

x^4+x^3+x+1 | 10011

sender:-

```
10011 | 100100110 11 0000 | 10001010100
        10011
        ------
        X00010
        00000
        ------
        X 00101
          00000
          -----
        X 01011
          00000
          -----
        X 10110
          10011
          -----
        X 01011
          00000
          -----
        X 10111
          10011
          -----
        X 01000
          00000
          -----
        X 10000
          10011
          -----
        X 00110
          00000
          -----
        X 01100
          00000
          -----
        X 1100  → CRC bit
```

4.

Ans 100100 110 11 1100 Ans

Reason -

Hamming Code (error detection & correction)

$2^n \Rightarrow$ $2^0 = 1$ P_1

$2^1 = 2$ P_2

$2^2 = 4$ P_3

$2^3 = 8$ P_4

Parity bit

Data bit

msg → 1100

4 bit.

3 bit parity to be added.

8	7	6	5	4	3	2	1
P_4	D_4	D_3	D_2	P_3	D_1	P_2	P_1

P_4	1	1	0	P_3	0	P_2	P_1
1	1	0	1	0	0	1	

	7	6	5	4	3	2	1
	111	110	101	100	011	010	001

P_1 = (least sig. bit से 1) 1 3 5 7 = P_1 [1] Even parity

X 0 0 1

odd —

P_2 = (बीच में 1) 2 3 6 7 = P_2 [0]

X 0 1 1

already even

P_3 =	4	5	6	7	P_3
	X	0	1	1	= 0

P_4 = not required.

Q. 100111

1	2	3	4	5	6	7
P_1	P_2	D_1	P_3	D_2	D_3	D_4

$P_1 = 2^0 = 1$

$P_2 = 2^1 = 2$

$P_3 = 2^2 = 4$

$P_4 = 2^3 = 8$

$P_5 = 2^4 = 16$

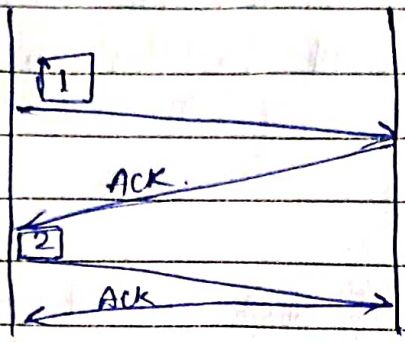
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
P_5						D_6	D_5	P_4	D_4	D_3	P_2	P_3	D_1	P_2	P_1

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
P_5						1	0	P_4	0	0	1	P_3	1	P_2	P_1

Date
Page

Flow control

① Stop & wait



Acknowledgement
- Positive
- Negative

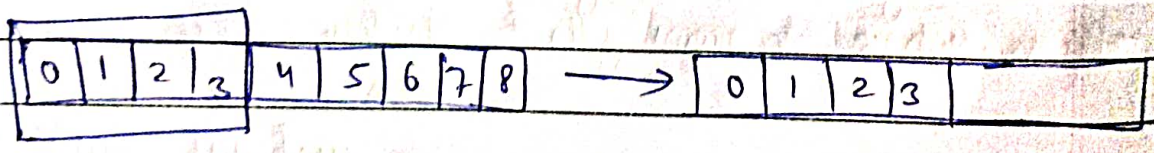
Disadvantages- 1.) wastage of Bandwidth
2.) wait for ack. of one

② Automatic Repeat request

timer

③ sliding window-

K=4 (window size)



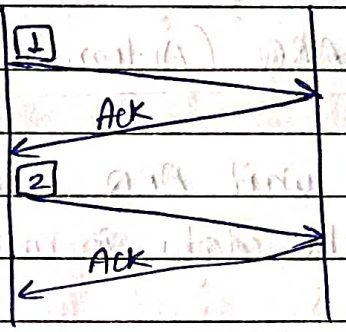
Flow Control

① Stop and wait Protocol -

It is a set of procedure that tells the sender how much data it can transmit to the receiver.

The receiving device has limited speed and memory to store the data. Therefore, the receiving device must be able to inform the sending device to stop the transmission temporarily before the limits has reached.

① Stop and Wait Protocol -



The stop and wait protocol is the most simplest protocol used in flow control.

In this method, the sender waits for an acknowledgement after every frame it sends.

When the acknowledgement is received, then only the next frame is sent.

Advantages -

The stop and wait method is simple as each frame is checked and acknowledged before the next frame is sent

Disadvantages -

It is inefficient as each frame must travel all the way to the receiver and the acknowledgement travels all the way before the next frame is sent. Thus, there is a wastage of bandwidth.

(2.) Stop and wait ARQ (Automatic Repeat Request) -

The stop and wait ARQ is a technique used to re-transmit the data in case of damaged or lost frame.

This technique works on a principle that the sender will not transmit the next frame until it receives the acknowledgement of the last frame. There is a timer after which the frame is re-transmitted.

(3.) Sliding Window -

The sliding window method in flow control is a technique in which the sender can transmit several frame before getting an acknowledgement. Thus, the utilization of

communication channel is very high.

Sliding window refers to imaginary boxes at both the sender and receiver. The frames can be acknowledged even when the window is not completely filled.

When a new frame arrives, the size of the window shrink Once the acknowledgement has been sent, the receiver window expands.

Go Back N -

If one frame is lost or damaged then it re-transmits all the frames after which it does not receive the positive acknowledgement.

Selective Reject -

This technique is more effiuent than Go Back N.

In this technique only those frames are re-transmitted for which negative acknowledgement has received.

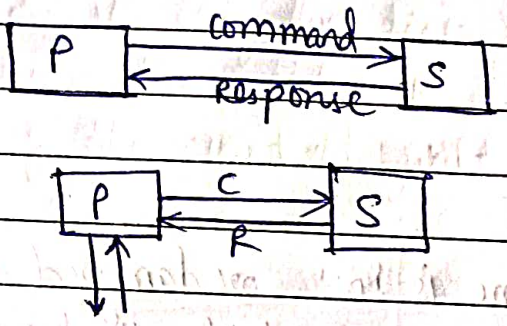
The receiver stores buffer which keeps all the damaged frame on hold until the frame is correctly received.

imp

HDLC (High level Data link Control) –

HDLC is a group of communication protocols of data link layer for transmitting data. It is applicable for point-to-point and point-to-multipoint communication.

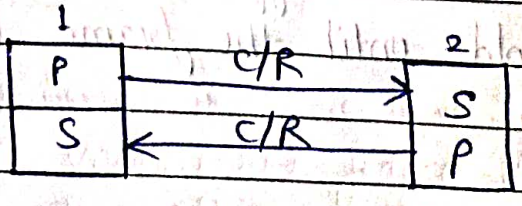
NRM (Normal Response mode) –



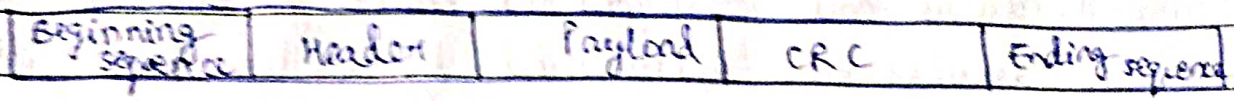
There are two types of stations, the primary station sends the command and the secondary station respon to the received command.

ARM (Asynchronous Response mode) –

Each stations can send the command and respond to the commands.



HDLC Frame -



The Beginning and the ending sequence is a 8-bit sequence that marks the beginning and ending of the frame. It's pattern is 01111110.

Header - It is of 16 bits.
The header is divided into two — address and control.

1) Address - It contains the addresses of primary and secondary stations.

2) Control - It contains the control frames.

Payload -

It carries the data from the network layer. Its length can be vary.

CRC -

It is a 16 bit sequence for error detection.

Types of frames -

There are 3 types of HDLC frames. The type of frame are determined by the control field of the frame.

1) iframe -

The iframe or the information frame carries the user data from the network layer. The 1st bit of the control field is 0.

2) Sframe -

The sframe or the supervisory frame does not contain the information. The 1st two bit of control field is 01.

3) uframe -

The uframe or unnumbered frame is used for link management. The 1st two bit of control field is 11.

Multiple Access Control Protocol (MAC)

The data link layer is separated into two sub-layers. The upper sub layer is responsible for flow control and error control. It is called logical link Control layer. The lower sub layer is responsible for multiple access resolution i.e. called media Access control.
The media Access control protocol is divided into three protocols — 1.) The Random Access
2.) The controlled Access
3.) The channelization protocol.

1.) Random Access Protocol —

In Random access Protocol all the system have equal priority. Noone depends and control the another system. If more than one system attempts to transmit the data, there may be a chance of collision, due to which the frames may either be lost or damaged.

Random Access protocol is divided into —

(i) **ALOHA** — It is used for random access in the network. It was designed for wireless local area network. User transmits the data any time.

Types of ALOHA —

1.) Pure ALOHA
2.) slotted ALOHA

1) Pure ALOHA - • It is the simplest protocol in which whenever the station has data it transm -its the frame continuously, due to which there is high level of risk of collision.

- Each station transmits the data whenever it has a data without checking the system/channel is idle or not.
- Whenever the data frame is sent successfully, the receiver waits for an acknowledgement. If the receiver does not receives an acknowledgement within a specified time, the station waits for a random time called the back off time.

2) Slotted ALOHA - The time of the system is divided into slots so that the system can send only one frame at that slot. It is better than the Pure ALOHA because the chance of collision is low.

Q A bit stream 10011101 is transmitted using CRC method. The generator polynomial is x^3+1. What is the actual bit transmitted? If the 2nd bit is inverted, how will the receiver detect this error?

generator = x^3+x^2+x+1
= 1001

```
1001 ) 10011101000 ( 10001100
       1001
       ----
        0001
        0000
        ----
         0011
         0000
         ----
          0110
          0000
          ----
           1101
           1001
           ----
            1000
            1001
            ----
             0010
             0000
             ----
              0100
              0000
              ----
               100 → CRC bit
```

~~1001110100 Ans~~

1001110 1100 Ans

3rd bit inverted -

100 11101 → 10111101

```
1001 | 10111101000 | 101
       1001
      ------
       X0101
        0000
       -------
       X1011
        1001
       -------
       X0100
```

```
1001 | 10111011100 | 10101000
       1001
      ------
       X0101
        0000
       -------
       X1011
        1001
       -------
       X0100
        0000
       -------
       X1001
        1001
       -------
       X0011
        0000
       -------
       X0110
        0000
       -------
       X1100
```

→ since, bits are not 000 this confirms error.

imp

CSMA (Carrier Sense Multiple Access)

It is a MAC protocol which to sense the traffic on channel before transmitting the data. If the channel is idle, the station can send the data or else wait for the channel to become idle, hence it reduces the chance of collision.

CSMA/CD (Carrier sense multiple access/collision detection)

It is a MAC protocol, it sense the shared channel before broadcasting the frames. If the channel is idle, it transmit the frame and checks whether the transmission was successful. If the frame was successfully received it sends the another frame. If any collision is detected, the station sends a jam signal. The algorithm of CSMA/CD is —

(i) When the frame is ready, the transmitting station checks whether the channel is free or not.

(ii) If the channel is busy, the station waits until the channel becomes idle (iii) If the collision is detected, jam signal is sent.

(iv) The station completes the frame transmission.

CSMA/CA (Collision Avoidance)

It is a MAC protocol for avoidance of collision. When a data frame is sent, the channel receives an acknowledgement to check whether the channel is clear or not. If it receives two signals, a collision is detected.

Algorithm of CSMA/CA is —

(i) If the frame is ready, the transmitting station checks whether channel is ~~ready~~ idle or not. (ii) If channel is busy, it waits for the channel to become idle.

(iii) If the channel is idle, station waits for an interframe gap and then sends the frame.

(iv) After sending the frame, it sets a timer.

(v) The station waits for an acknowledgement before the expiry of timer.