Unit - II

Data Link Layer

- Data link layer is the second layer from the bottom in the OSI (Open system interconnection) network architecture model.
- It is responsible for node - to - node delivery of data.
- Also responsible for encoding, decoding and organizing the outgoing and incoming data.

function of Data link layer

Network layer

↓ Packet

Data Link layer
(Divides packet into frames
Add header)

↓ frame

Physical layer

* framing

The packet received from the network layer is known as frame in the Data link layer. At the sender's side DLL receives packet from the network layer and divides them into small frames, then send each frame bit-by-bit to the physical layers.

* Addressing

The data link layer encapsulate the source and destination Mac address in the header of each frame to ensure node - to - node delivery.

Mac address is the unique hardware address that is assigned to the device while manufacturing.

* Error Control

Data can get corrupted due to various reasons like noise, attenuation etc. so it is responsibility of data link layer to detect the error and correct it using error detection and correction technique.

* flow Control

It's responsibility of DLL to synchronize the sender's and receiver's speed and establish flow control between them.

* Access Control

When multiple device share the same communication channel there is a high probability of collision so it's responsibility of DLL to check which device has control over the channel and avoid collision.

Error Detection And Correction

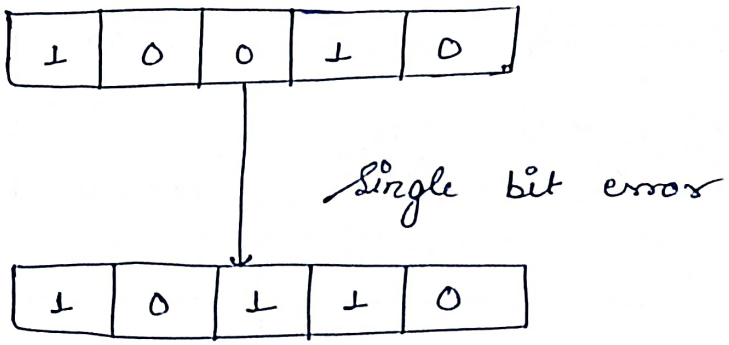
→ Error

When bits are transmitted over the computer network, they are subject to get corrupted due to network problems. This corrupted bits are called errors.

Types of Error

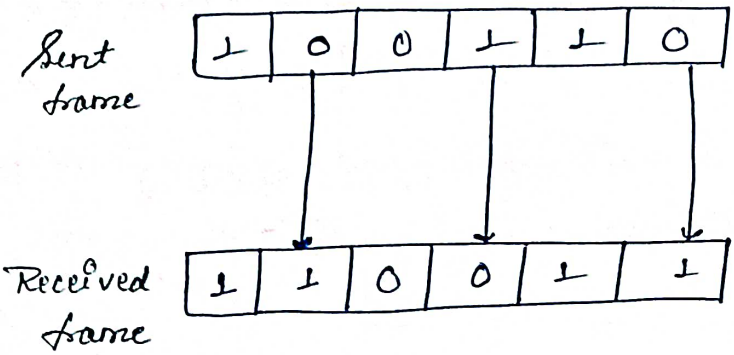
① Single bit Error

In the received frame, only one bit has been corrupted, either changed from 0 to 1 or from 1 to 0



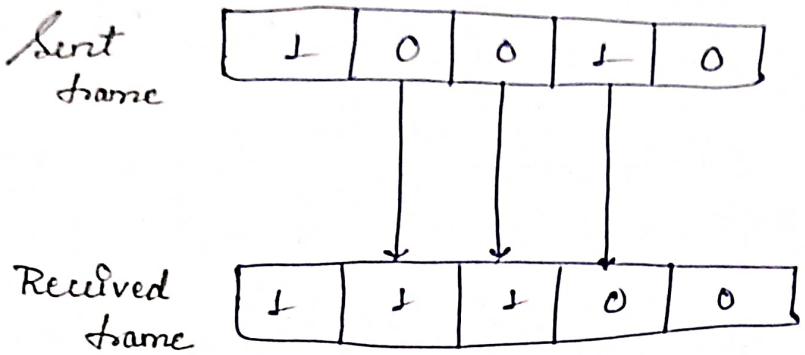
② Multiple bits Error

In the received frame more than one bits are corrupted.



③ Burst Error

In received frame, more than one consecutive bits are corrupted.



* Error Detection Techniques.

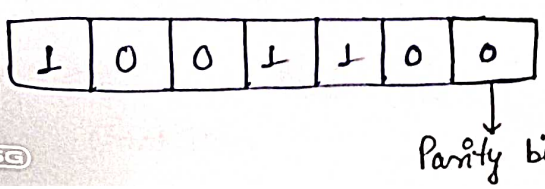
① Parity Check

The parity check is done by adding an extra bit, called parity bit to the data to make a number of 1s either even in case of even or odd in case of odd parity.

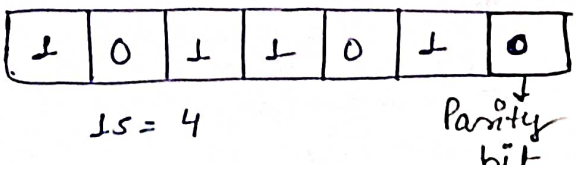
- In case of even parity - If a number of 1s is even then parity bit value is 0. If the number of 1s is odd then parity bit value is 1.
- In case of odd parity - If a number of 1s is odd then parity bit value is 0. If a number of 1s is even then parity bit value is 1.

Ex:-

Odd Parity



Even Parity



(2) Checksum

- Data is divided into fixed sized frames or segment.
- The sendess adds the segment using 1's complement to get sum. Then complement the sum to get the checksum and send it along with data frames.
- The receiver adds the incoming segment along with the checksum using 1's complement to get sum and then complement it.
- If the result is zero, the received frame are accepted, otherwise they are discarded.

Ex:- Original data

10011001	11100010	00100100	10000100

K = 4
m = 8

Sender's

1 → 10011001
2 → 11100010
(1) 01111011
↳ 1
01111100
3 → 00100100
10100000
4 → 10000100
(1) 00100100
↳ 1
00100101 ⇒ Sum
1's Complement → 11011010 → checksum

Receiver

1 → 10011001
2 → 11100010
(1) 01111011
↳ 1
01111100
3 → 00100100
10100000
4 → 10000100
(1) 00100100
↳ 1
00100101 ⇒
checksum

Add the checksum and complement it.

$$\begin{array}{r} 0\ 0\ 1\ 0\ 0\ 1\ 0\ 1 \\ +\ 1\ 1\ 0\ 1\ 1\ 0\ 1\ 0 \\ \hline 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1 \end{array} \Rightarrow \text{Sum}$$

1's Complement $\Rightarrow$ 0 0 0 0 0 0 0 0

So, the received data is accepted.

(3) Cyclic Redundancy Check (CRC)

- The CRC is a network method designed to detect error in the data and information transmitted over the network.
- This is performed by performing a binary solution on the transmitted data at the sender's side and verifying the same at the receiver's side.

Working of CRC

we have given dataword of length 'n' and divisor of length K.

Step 1 :- Append (K-1) zero's to the original message.

Step 2 :- Perform modulo 2 division

Step 3 :- Remainder of division = CRC

Step 4 :- Code word = Data with append (K-1) zero's + CRC

Note :-

* CRC must be K-1 bits
* length of code word = n + K - 1 bits

Ex:-

Let data to be send is 1010000 and divisor in the form of polynomial x^3+1.

- Original message - 1010000
- Generate polynomial - x^3+1

$$(1).x^3 + (0).x^2 + (0).x^1 + (1).x^0$$

CRC generator - 1001 4-bit

Sender

```
1001 ) 1010000000
       1001
       ----
       0011000000
        1001
        ----
        0101000
         1001
         ----
         001100
          1001
          ----
          0101
           1001
           ----
           011
```

Message to be transmitted

```
  1010000000
+        011
------------
  1010000011
------------
```

Receiver

```
1001 ) 1010000011
       1001
       ----
       0011000011
        1001
        ----
        0101001
         1001
         ----
         001101
          1001
          ----
          0100
           1001
           ----
           0000
           ----
```

Zero means data is accepted.

* If CRC generator is of (n) bit then append (n-1) zeros in the end of original message.

Flow Control

- Flow control is design issue at Data link layer. It is a technique that generally observes the proper flow of data from sender to receiver.
- It is very essential because it is possible for sender to transmit data or information at very fast rate and hence receiver and receive this information and process it.

Techniques of Flow Control

① Stop - and - Wait flow Control

This method is the easiest and simplest form of flow control. In this method, basically message or data is broken down into various multiple frame and then receiver indicates its readiness to receive frame of data.

Advantage

- This method is very easiest and simple.
- Each frame is checked and acknowledged well.
- This method is very accurate.

Disadvantage

- This method is fairly slow
- Only one packet can be sent at a time.
- Time taking.

② Sliding Window flow Control

This method is required where reliable in-order delivery of packets or frames is very much needed like in data link layer.

In this method, sender transmits or sends various frames or packets before receiving any acknowledgement. In this method, both the sender and receiver agree upon total number of data frames after which acknowledgement is needed to be transmitted.

Advantages -

- It perform much better than stop-and-wait flow control.
- This method increases efficiency.
- Multiple frames can be sent one after another.

Disadvantages -

- The main issue is complexity at sender and receiver
- The receiver might receive data frame or packet out of sequence.

Data Link Protocol

Data link layer protocol are generally responsible to simply ensure and confirm that the bits and bytes that are received are identical to bits and bytes being transferred.

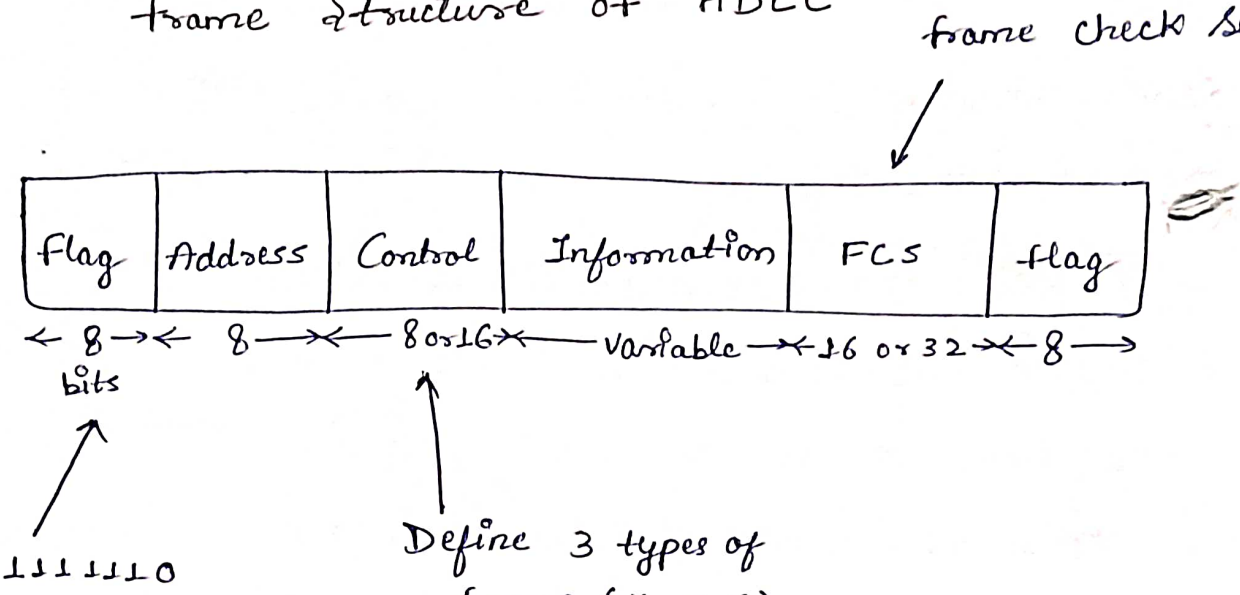
① SDLC

- Synchronous data link protocol.
- SDLC is basically a communication protocol of computer. It supports multipoint links even error recovery or error correction also.
- It is usually used to carry SNA (System network Architecture) traffic.
- It is also designed and developed by IBM in 1975.

② HDLC

- High - level data link protocol.
- It was originally created and developed by ISO in 1979.
- HDLC uses term "frame" to indicate and represent an entity of data or a protocol of data unit often transmitted or transferred from one station to another station.
- Each and every frame on link should begin and end with flag sequence field (F).
- Each of frame in HDLC includes mainly six field.

Frame Structure of HDLC



① Flag field

The flag field is generally responsible for initiation and termination of error checking. The flag field is basically using delimiter 0x7e to simply indicate begining and end of frame

② Address field

The address field generally include HDLC address of secondary station. It helps to identify secondary station will sent or receive data frame. This field generally consist of 8 bit therefore capable of addressing 256 address.

③ Control field

This field is used to determine how to control process of communication. The types of frames can be

- Information frame (I)
- Supervisory frame (S)
- Unnumbered frame (U)

This field basically consist of 8 bit and can be extended upto 16 bit.

④ Information field

This field usually contain data or information of users senders is transmitting to receiver. It also consist of users data is fully transparent.

⑤ Frame check Sequence

FCS is generally used for identification of errors. In FCS CRC is basically used for error detection. FCS is calculated by sender and receiver both of a data frame.

③ PPP

- Point - to - Point Protocol
- It is communication procedure which is utilized for the creation of direct channel between two points of the network.
- PPP is mainly used in WAN and it may offer authentica and encryption and data compression that is required in the transmission of data.

Features of PPP

→ Packet framing
→ Multi protocal
→ Bit transparency
→ Error detection

Component of PPP

- High - level data link Control protocal (HDLC)

  It is a method used to frame data over PPP links

- link Control Protocal (LCP)

  It is liable for formulating, configuring, testing and terminating transmission links.

- Network Control Protocal (NCP)

  NCP frames are used to communicate and customize protocols on network layers that can be used over PPP session.

Advantages

- Support multiple protocol
- Error detection
- Authentication
- Compression

Disadvantages

- Overhead
- Limited to point - to - point
- Complex configuration.

(#) Sublayer of Data Link Layer

- Data link layer is further divided into two - sublayers :-

(1) MAC

- Media Access Control
- MAC sublayer manages the device interaction, responsible for addressing frames, and also control physical media access.
- The data link layer is responsible for node - to - node data transfer and error detection.

* functions

→ It provides an abstraction of the physical layer to the LLC and upper layers of the OSI network.

→ It resolves the addressing of source station as well as the destination station or group of destination station.

→ It performs multiple access resolution when more than one data frame is to be transmitted.

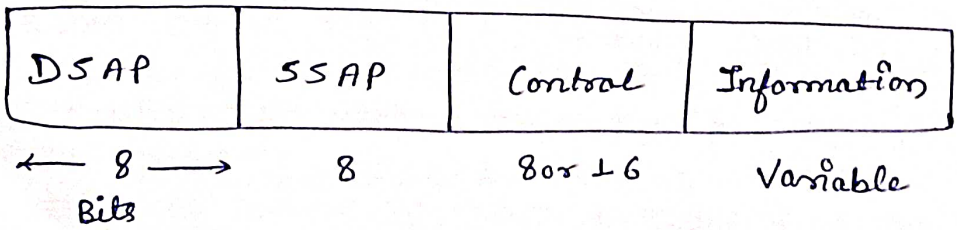
→ It generates the frame check sequence and thus contributes to protection against transmission error.

* MAC Address

- MAC address or media access control address is a unique identifier allotted to a network interface controller (NIC) of a device.
- It is used as a network address for data transmission within a network segment like Ethernet, wifi and bluetooth.

(#) LLC Protocol

- Logical link control (LLC) is a sublayer that generally provide the logic for the data link as it controls the synchronization, multiplexing, flow control and error-checking function of DLL.
- All of these protocol use the same PDU (Protocol data Unit) format.



① DSAP

- Destination Service Access Point
- DSAP is generally 8-bit long field that is used to represent the logical address of the network layer to receive the message.

② SSAP

- Source Service Access Point
- SSAP is also an 8-bit long field that is used to represent the logical address of the network layer to create a message.

③ Control field

- It is an 8 or 16-bit long field, usually depending on identifying the PDU. It is used for flow and error control. There are basically 3-types of control field :-

→ Information

It generally include 7 bit sequence number.

→ Supervisory

It generally include an acknowledgement sequence number.

→ Unnumbered

It generally a 5 bit that is used to indicates the type of PDU.

④ Information field

This field generally indicates data or information.