# *. Computer Networks

## Unit-5 [ The Link Layer and Local Area Network]

### *. Link Layer Services:

- Framing - it encapsulates the datagrams into frames by adding header and trailer information.

- Link Access - a medium access control (MAC) addresses is used in frame headers to identify source and destination. It's different from IP address.

- Reliable Delivery - this layer protocol provides reliable delivery service i.e it guarantees to move each network-layer datagram across the link without error. ~~It~~ It can be achieved with acknowledgements and retransmissions

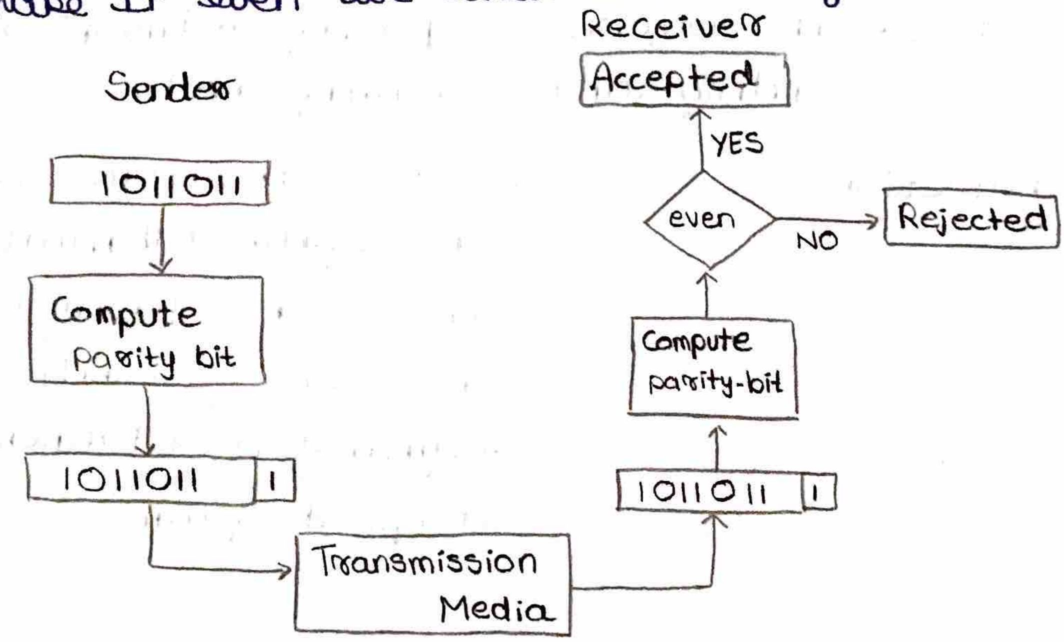
- Flow Control - it requires a pacing between adjacent sending and receiving nodes.

- Error Detection & Correction - here the error are caused by signal attenuation or noise. the receiver detects the error & sender send signal for retransmission or drops the frame.

*. Error ~~Correction~~ Detection & correction technique:

- There are three techniques for error detection,
  - Parity Check.
  - Checksum Method.
  - Cyclic Redundancy Checks [CRC].

- Parity Check:
  - In this, a redundant bit called parity bit is added to every data ~~u~~ so that the no. of 1's in the data becomes even.
  - For example, if even parity is used and no. of 1's is even then one bit of value 0 is added. This way the no. of 1's remains even.
  - ~~For example~~ Similarly, if the no. of 1's is odd, to make it even we add one bit of value 1.




- The receiver counts the no. of 1's in a frame. If the count is even, the frame is considered to be not-corrupted and is accepted and if the count is odd, then the frame is not accepted.

- Checksum:

- Data is divided into k segments each of m bits.
- At senders side, the segments are added using 1's complement to get the sum. This sum is complemented to get the checksum.
- The checksum segment is sent along with the data segments.
- At receiver's side, all received segments are added using 1's complement to get complemented sum.
- If the result is zero, the received data is accepted and if the result is non zero, then the data is corrupted.

```
  10110011
  10101011
 ----------
 1 01011110
          1
 ----------
  01011111
  01011010
 ----------
  10111001
  11010101
 ----------
 101101110
          1
 ----------
  01101111 = Sum
  10010000 =
```

## *. Cyclic Redundancy Checks [CRC]:

- CRC is the most powerful and easy to implement technique.
- CRC is based on binary division.
- In CRC, a sequence of redundant bits are added at the end of the data so that the resulting data unit becomes exactly divisible by a second, predetermined binary no.
- At the destination, the incoming data is divided by the same no.
- If there is no remainder [i.e r=0], the data is assumed to be correct and is accepted.
- A remainder indicates that the data has been damaged in transit & is rejected.

Eg:

**Sender**

```
           111
       ---------
  101 | 11001        <- Data Bit
       -101
       ----
        0110
        -101
        ----
         111
        -101
        ----
          10  -> CRC
```

101 → Divisor

**Receiver.**

```
          111
       ----------
  101 | 1100110      <- Data-Bit + CRC
        101
        ---
        110
       -101
       ----
        111
        101
       ----
        101
        101
       ----
       0000  -> No errors.
```

## *. Multiple Access Links and Protocols:

There are two types of links,

- A point to point link consists of a single sender at one end of the link and a single receiver at the other end of the link
- A broadcast link can have multiple sending and receiving nodes all connected to the same, single shared channel.

### Multiple Access Problem:

- In broadcast link all nodes are capable of transmitting frames, more than two nodes can transmit frames at the same time.
- When this happens, all of the nodes receive multiple frames at the same time; i.e. the transmitted frames collide at all receivers.
- Thus, all the frames involved in the collision are lost.
- Therefore, if many nodes want to transmit frames frequently, thn many transmissions will result in collisions & the broadcast channel is wasted.
- In order to ensure that the broadcast channel performs well, it is necessary to coordinate the transmissions.
- And this coordination job is done by Multiple Access Protocol.

## *. Multiple Access Protocol:

There are 3 categories of multiple access protocol;

- **Channel Partitioning Protocol:**
  - divide channel into smaller parts
  - allocate parts to node for exclusive use
  - Eg:- TDMA - Time division multiple access
    FDMA - Frequency division multiple access
    CDMA - Code division multiple access

- **Random Access Protocol:**
  - channel not divided and allow collisions.
  - "recovers" from collisions.
  - Eg:- MAC - Medium access control
    ALOHA
    Slotted ALOHA
    CSMA, CSMA/CD, CSMA/CA.

- **Taking-Turns Protocols:**
  - nodes take turns but nodes with more to send can take longer turns.
  - Eg:- Polling
    Token passing.

## *. TDMA : Time Division Multiple Access

- Suppose the channel supports N nodes and that the transmission rate of the channel is R bps.
- TDM divides time into time frames and further divides each time frame into N time slots.
- Each time slot is then assigned to one of the N nodes.
- Whenever a node has a packet to send, it transmits the packet's bits during its assigned time slot in the TDM frame.
- TDM is attractive as it eliminates collisions and is perfectly fair.
- But there are two major drawbacks:
  1. A node is limited to an avg. rate of R/N bps. even when it is the only node with packets to send.
  2. A node must always wait for its turn, even when it is the only node with a frame to send.

## *. FDMA: Frequency Division Multiple Access

- FDM divides the channels into different frequencies and assigns each frequency to one of the node.
- FDM thus creates N smaller channels out of the single.
- FDM shares both the advantages & disadvantages of TDM
- It avoids collisions & divides the bandwidth fairly among the nodes.

## *. CDMA : Code Division Multiple Access.

- CDMA assigns a different code to each node. While TDM and FDM assign time and frequencies respectively
- Each node then uses its unique code to encode the data bits it sends
- If the codes are chossen carefully. CDMA networks have the property that different nodes can transmit simultaneously.
- Their respective receivers correctly receive a sender's encoded data bits in spite of interfering transmissions by other nodes.

## *. Pure ALOHA Protocol:

- It allows user to transmit whenever they have data to be sent
- Senders wait to see if a collision occured (after whole message has been sent)
- If collision occurs, each station involved waits a random ~~amo~~ amount of time then tries again.
- Systems in which multiple users share a common channel in a way that can lead to conflicts are known as contention systems.
- whenever two frames try to occupy the channel at the same time, there will be a collision and both will be garbled.
- If the first bit of a new frame overlaps ~~whi~~ with the last bit of the frame, which almost finished, both frames will be totally destroyed and both will have to be retransmitted later.
- The throughput of the Pure ALOHA is max. when the frames are of uniform length.
- The formula to calculate the throughput of the Pure ALOHA is:

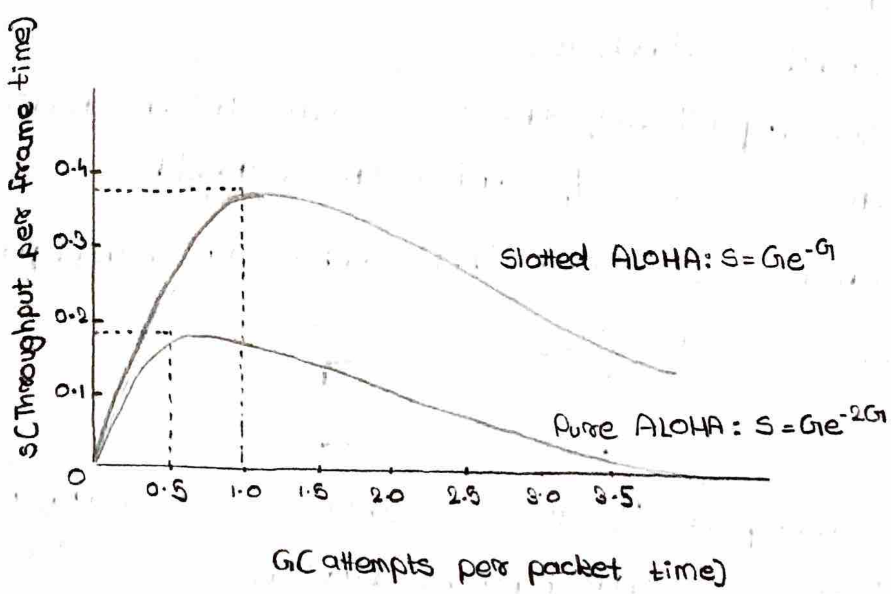
$$\boxed{S = G e^{-2G}.}$$

- The throughput is max when $G = 1/2$ which is 18% of the total transmitted data.

## *. Slotted ALOHA:

- It was invented to improve the efficiency of Pure ALOHA as chances of collision ~~a~~ were high in Pure ALOHA.
- The time of the shared channel is divided into discrete intervals called slots.
- The stations can send ~~frequency~~ a frame only at the beginning of the slot and only one frame is sent in each slot.
- If any station is not able to place the frame onto the channel at the beginning, then the station has to wait until the beginning of next time slot.
- The formula to calculate the throughput of the Slotted ALOHA is:

$$\boxed{S = Ge^{-G}}$$



- Advantages of Slotted ALOHA:
  - A single active node can continuously transmit at full rate of channel.
  - Slotted ALOHA is also highly decentralized.
  - It is also an simple protocol.
- Disadvantages of Slotted ALOHA:
  - when there are multiple active nodes, a fraction of the slot will have collision
  - Idle slots
  - Clock synchronization.

## *. ARP[Address Resolution Protocol]:

- ARP is a protocol for mapping an IP address to a physical machine address [MAC - Media access control] that is recognized in the local network.
- For example, in IP v4 - an address is 32-bit long.
- Whereas the addresses for attached devices are 48-bit long.
- A table called ARP cache, is used to maintain a correlation between each MAC address & its corresponding IP address.
- ARP provides the protocol rules for making this correlation and providing address conversion in both directions.