Open system Interconnection (OSI)

DataLink Layer Error Control & Access Control

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Checksum

- Checksum is an error detection method.
- Error detection using checksum method involves the following steps-
- Step 1: At sender side,
  - If m bit checksum is used, the data unit to be transmitted is divided into segments of m bits.
  - All the m bit segments are added.
  - The result of the sum is then complemented using 1s complement arithmetic.
  - The value so obtained is called as checksum.
- Step-02:
  - The data along with the checksum value is transmitted to the receiver.
- Step-03: At the receiver side
  - If m bit checksum is being used, the received data unit is divided into segments of m bits.
  - All the m bit segments are added along with the checksum value.
  - The value so obtained is complemented and the result is checked.

Checksum Cases

- Then, following two cases are possible-
- **Case-01: Result = 0**
  - Receiver assumes that no error occurred in the data during the transmission.
  - Receiver accepts the data.
- **Case-02: Result 0**
  - Receiver assumes that error occurred in the data during the transmission.
  - Receiver discards the data and asks the sender for retransmission.

Checksum Example-

Q1 Consider the data unit to be transmitted is-
10011001111000100010010010000100
Consider 8 bit checksum is used.

- **Step-01:** At sender side, The given data unit is divided into segments of 8 bits as-

10011001	11100010	00100100	10000100

- Now, all the segments are added and the result is obtained as-
10011001 + 11100010 + 00100100 + 10000100 = 1000100011
- Since the result consists of 10 bits, so extra 2 bits are wrapped around.
- 00100011 + 10 = 00100101 (8 bits)
- Now, 1s complement is taken which is 11011010.
- Thus, checksum value = 11011010

- **Step-02:** The data along with the checksum value is transmitted to the receiver.
- **Step-03:** At receiver side,
  - The received data unit is divided into segments of 8 bits.
  - All the segments along with the checksum value are added.
  - Sum of all segments + Checksum value = 00100101 + 11011010 = 11111111
  - Complemented value = 00000000
  - Since the result is 0, receiver assumes no error occurred in the data and therefore accepts it.

Important Notes-

- **Note-01:**
  - Consider while adding the m bit segments, the result obtained consists of more than m bits.
  - Then, wrap around the extra bits and add to the result so that checksum value consists of m bits.
- **Note-02:**
  - While calculating the checksum, if checksum value is needed, then assume it to be zero.
  - After calculating the checksum value, substitute the checksum value in the checksum field.
  - This will be required during checksum calculation of IP Header, TCP Header and UDP Header.
- **Note-03:**
  - The checksum is used in the internet by several protocols although not at the data link layer.

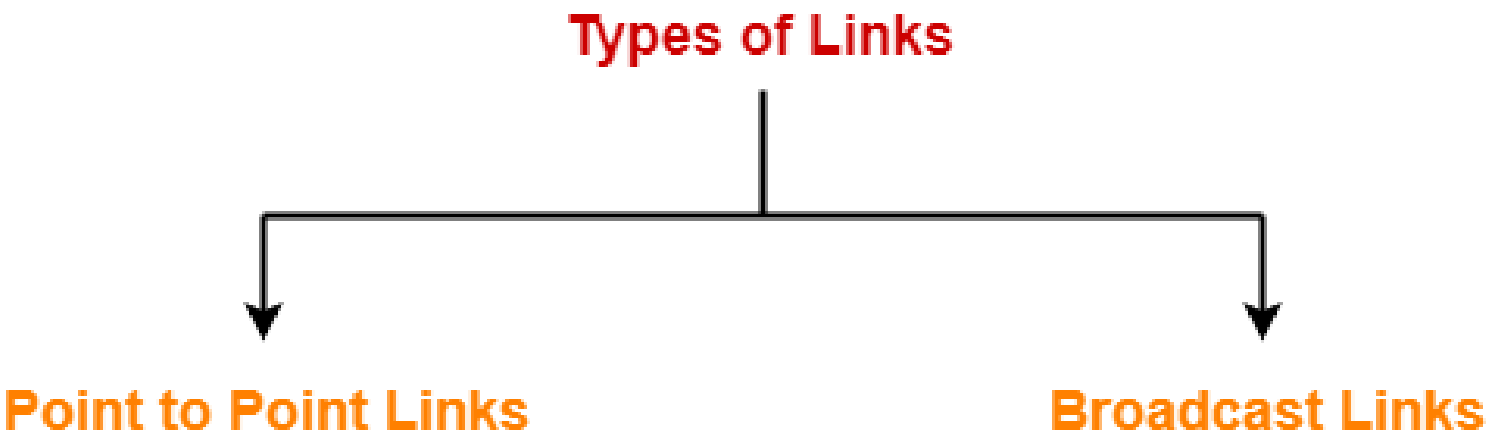
PRACTICE PROBLEM BASED ON CHECKSUM ERROR DETECTION METHOD

Q2 Checksum value of 1001001110010011 and 1001100001001101 of 16 bit segment is-

- **Solution**- We apply the above discussed algorithm to calculate the checksum.
  - $1001001110010011 + 1001100001001101 = 1001010111100000$
  - Since, the result consists of 17 bits, so 1 bit is wrapped around and added to the result.
  - $0010101111100000 + 1 = 0010101111100001$
  - Now, result consists of 16 bits.
  - Now, 1s complement is taken which is 1101010000011110
  - Thus, checksum value = 1101010000011110

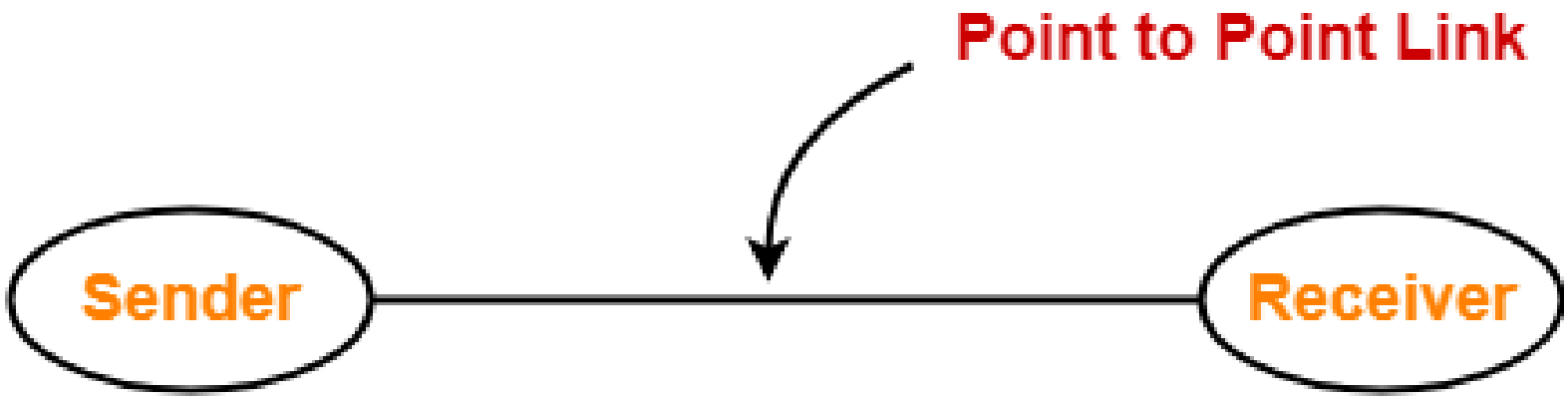
Access Control in Networking

- Types of Communication Link
  - Communication links enable the stations to communicate with each other.
  - Stations may communicate using the following types of links-



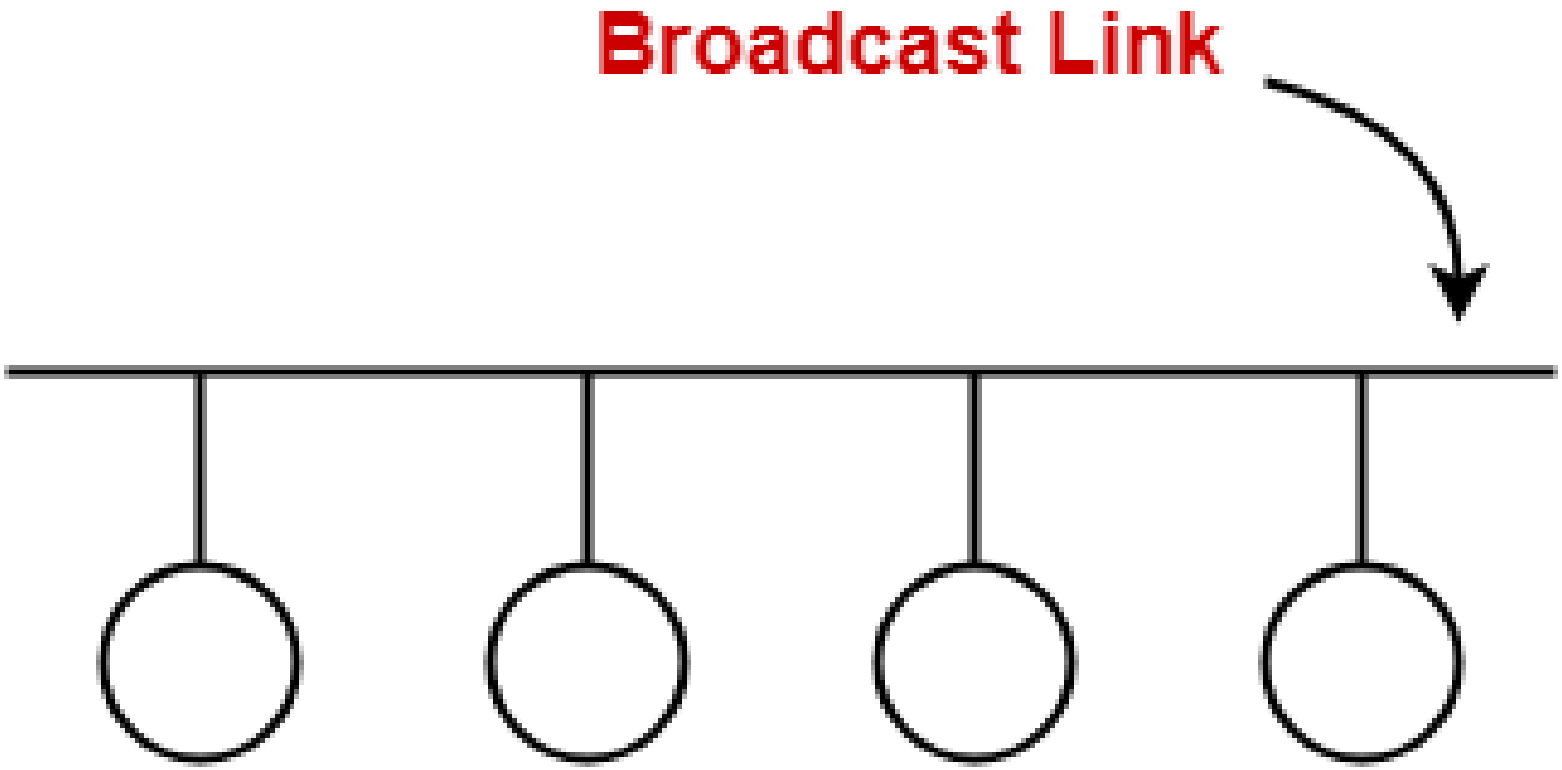
Point to Point Link

- Point to Point Link
  - Point to Point link is a dedicated link that exists between the two stations.
  - The entire capacity of the link is used for transmission between the two connected stations only.
  - Depending upon the Type Of Channel, the data flow takes place between the stations.



Broadcast Link

- Broadcast Link
  - Broadcast link is a common link to which multiple stations are connected.
  - The capacity of the link is shared among the connected stations for transmission.

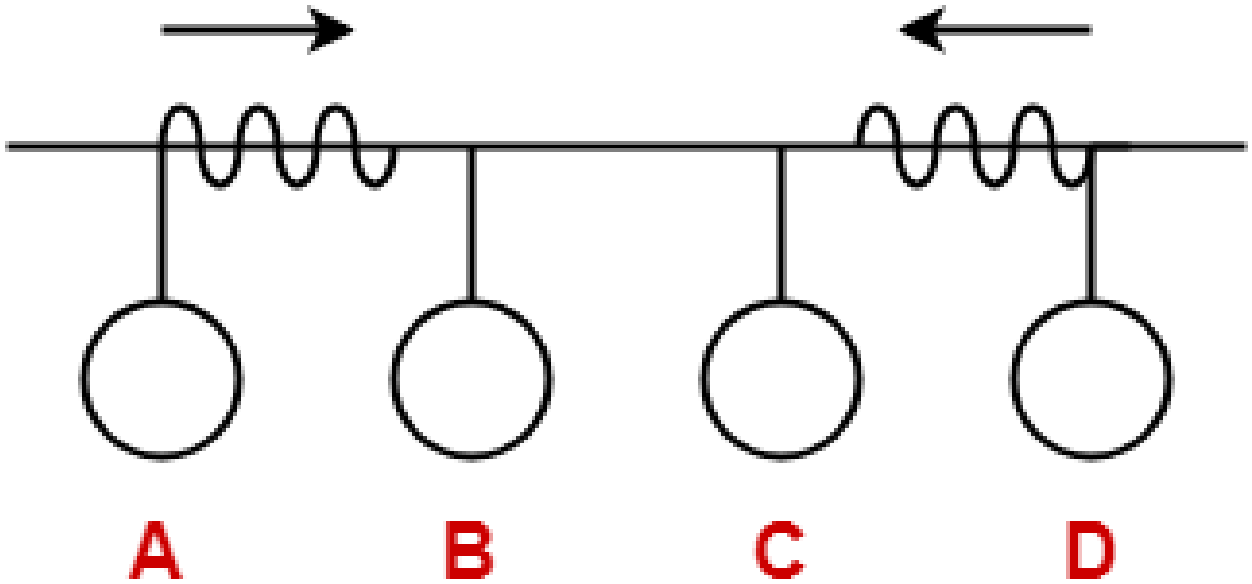


Access Control

- Access Control is a mechanism that controls the access of stations to the transmission link.
  - Broadcast links require the access control.
  - This is because the link is shared among several stations.
- Need of Access Control-
  - To prevent the occurrence of collision or if the collision occurs, to deal with it.
- Consider a situation where-
  - Multiple stations place their data packets on the link and starts transmitting simultaneously.
  - Such a situation gives rise to a collision among the data packets.
  - Collision of data packets causes the data to get corrupt.

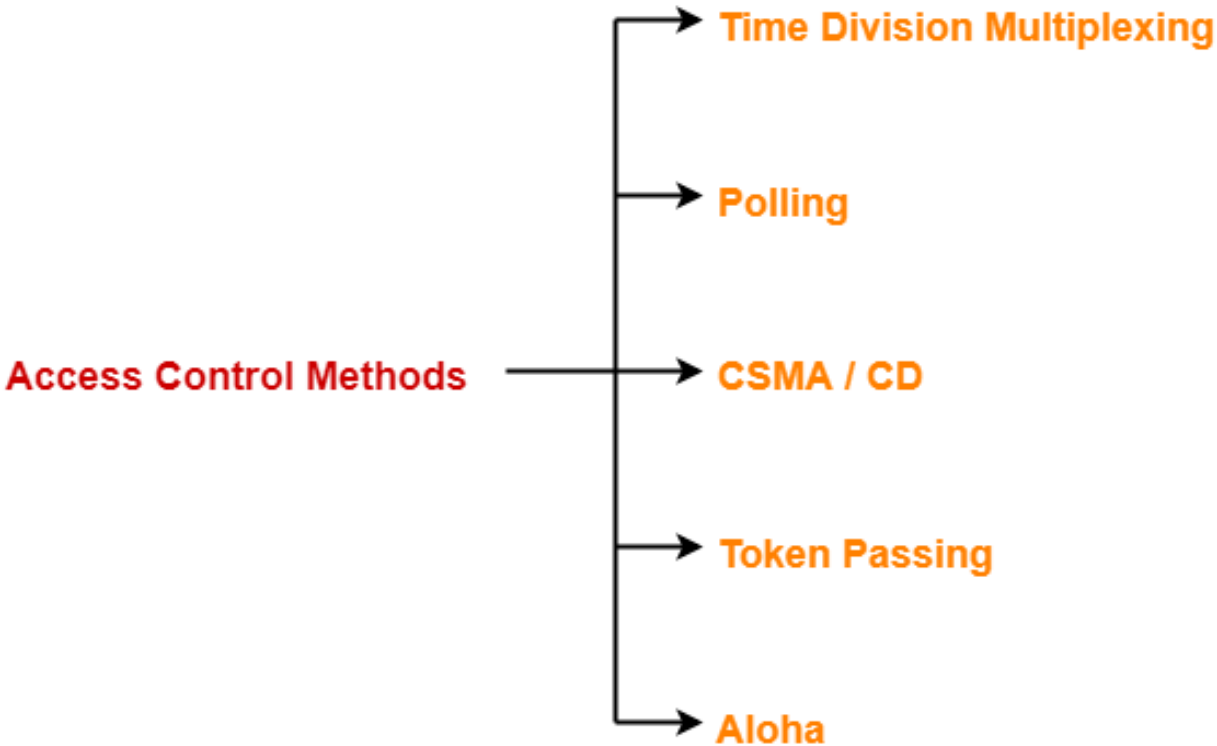
Example

- Consider the following scenario-
  - Two stations A and D starts transmitting their data packets simultaneously.
  - This situation gives rise to a collision between the data packets transmitted by them.
  - Thus, to prevent the collision or to deal with it, access control is needed.



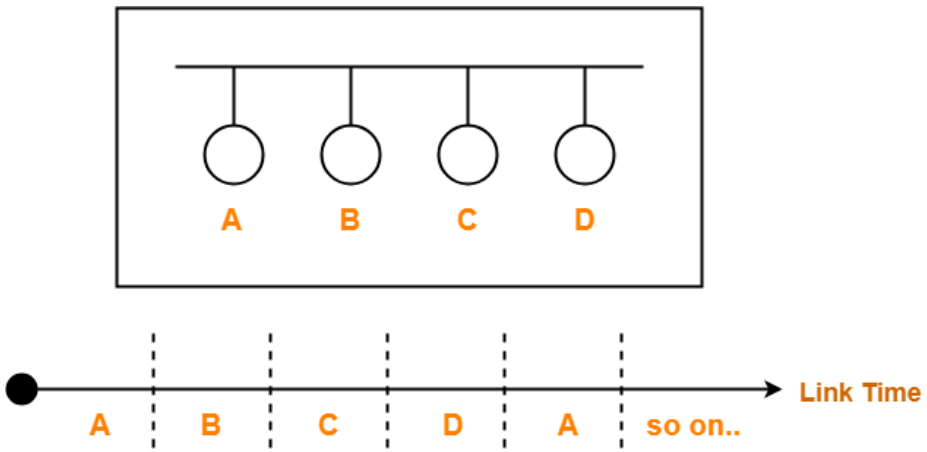
Access Control Methods

- Access control methods are the methods used for providing access control.
  - They prevent the collision or deal with it and ensures smooth flow of traffic on the network.
  - They are implemented at the data link layer of the OSI reference model.
- Various access control methods used are-



Time Division Multiplexing

- Access Control is a mechanism that controls the access of stations to the transmission link.
- Broadcast links require the access control mechanism.
- Time Division Multiplexing-
  - Time of the link is divided into fixed size intervals called as time slots or time slices.
  - Time slots are allocated to the stations in Round Robin manner.
  - Each station transmit its data during the time slot allocated to it.
  - In case, station does not have any data to send, its time slot goes waste.



Time Division Multiplexing

Size Of Time Slots

- The size of each time slot is kept such that each station gets sufficient time for the following tasks-
  - To put its data packet on to the transmission link
  - Last bit of the packet is able to get out of the transmission link
  - **Size of each time slot = Tt + Tp**
- **NOTE**- To keep the size of time slots constant,
  - We have assumed that all the stations want to send the packets of same size.
  - This keeps Tt constant for all the stations.
  - We have considered the worst case when both the stations are present at the two extreme ends.
  - This ensures Tp will be maximum and all the stations will get sufficient time to propagate their data.

Efficiency

- **Efficiency (η) = Useful Time / Total Time**
  - Useful time = Transmission delay of data packet = Tt
  - Useless time = Propagation delay of data packet = Tp

$$\text{Efficiency } (\eta) = \frac{T_t}{T_t + T_p}$$

OR

$$\text{Efficiency } (\eta) = \frac{1}{1 + a} \quad \text{where } a = \frac{T_p}{T_t}$$

Important Formulas

- Size of each time slot in Time Division Multiplexing = Tt + Tp
- Efficiency (η) = 1 / (1+a) where a = Tp / Tt
- Effective Bandwidth / Bandwidth Utilization / Throughput = Efficiency(η) x Bandwidth
- Maximum Available Effective Bandwidth = Total number of stations x Bandwidth requirement of 1 station
- **Disadvantage-**
  - If any station does not have the data to send during its time slot, then its time slot goes waste.
  - This reduces the efficiency.
  - This time slot could have been allotted to some other station willing to send data.

PRACTICE PROBLEM BASED ON TIME DIVISION MULTIPLEXING (TDM)

Q1 If transmission delay and propagation delay of a packet in Time Division Multiplexing is 1 msec each at 4 Mbps bandwidth, then-

- Find the efficiency.
- Find the effective bandwidth.
- How many maximum stations can be connected to the network if each station requires 2 Kbps bandwidth?

- **Solution**- Given- Transmission delay (Tt) = 1msec, Propagation delay (Tp) = 1msec, Bandwidth = 4 Mbps
- **Part-01:**
  - For a TDM Network, Efficiency (η) = 1 / 1+a where a = Tp / Tt, a=1msec/1msec=1
  - **Calculating Efficiency**-
    Efficiency (η)= 1 / (1+a)= 50%

- **Part-02:**
  - Effective Bandwidth = Efficiency (η) x Bandwidth
  - Effective Bandwidth = 0.5 x 4 Mbps = 2 Mbps
- **Part-03:**
  - Maximum Effective Bandwidth = Total number of stations x Bandwidth requirement of 1 station
- Let the total number of stations that can be connected be N.
  - 2 Mbps = N x 2 Kbps
  - N = 1000
  - Thus, maximum 1000 stations can be connected.

Thank You