Open system Interconnection (OSI)

DataLink Layer

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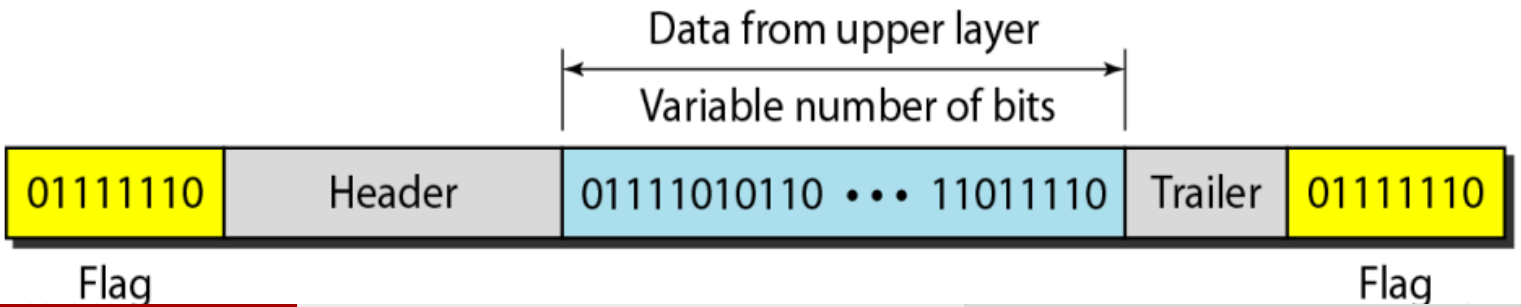
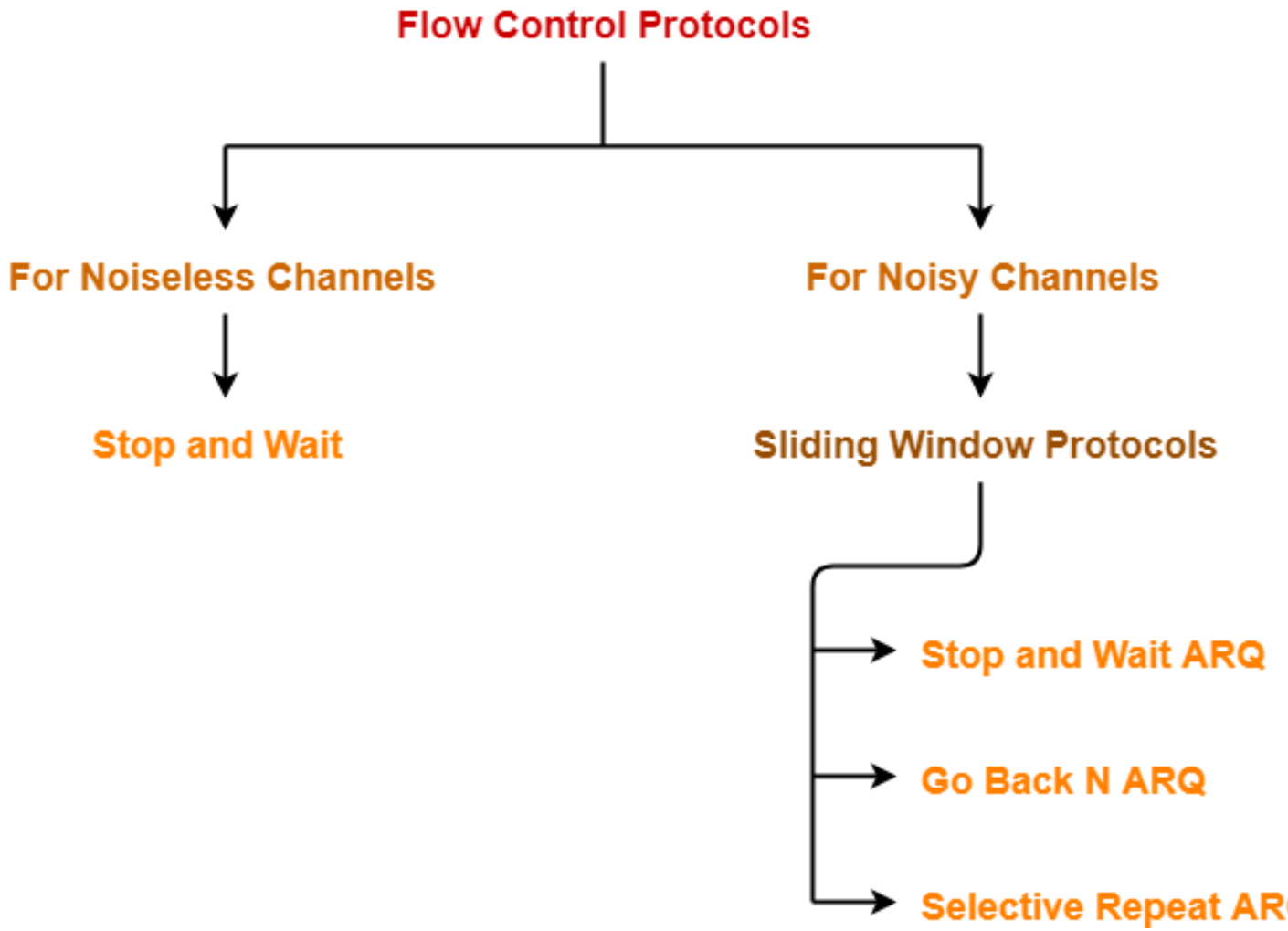
Data link layer

- **Medium Access Control**
  - Access to network
- **Logical Link Control**
  - Node-to-node error and flow control
  - Link layer protocol:
    - **Error detection:** All errors must be detected
    - **Error correction:** Receiver must get correct data
    - **Flow control:** Receiver must not be overloaded
- **Framing**
  - Physical layer- **bitstream**
  - Link layer- **frames**
  - We need logical transmission units
    - Synchronisation points
    - Switching between users
    - Error handling



Flow Control Protocols

- There are various flow control protocols which are classified as-

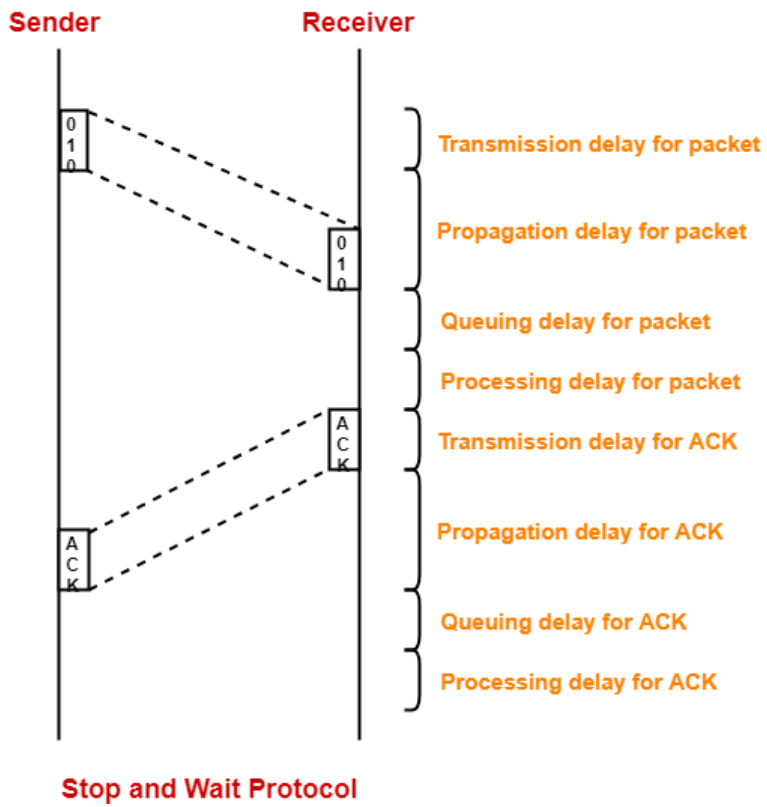


Stop and Wait

- Stop and Wait Protocol is the simplest flow control protocol.
- It works under the following assumptions-
  - Communication channel is perfect.
  - No error occurs during transmission.
- Working: The working of a stop and wait protocol may be explained as-
  - Sender sends a data packet to the receiver.
  - Sender stops and waits for the acknowledgment for the sent packet from the receiver.
  - Receiver receives and processes the data packet.
  - Receiver sends an acknowledgment to the sender.
  - After receiving the acknowledgment, sender sends the next data packet to the receiver.

Stop and Wait Protocol

- Analysis: Now, let us analyze in depth how the transmission is actually carried out-
  - Sender puts the data packet on the transmission link.
  - Data packet propagates towards the receivers end.
  - Data packet reaches the receiver and waits in its buffer.
  - Receiver processes the data packet.
  - Receiver puts the acknowledgment on the transmission link.
  - Acknowledgment propagates towards the senders end.
  - Acknowledgment reaches the sender and waits in its buffer.
  - Sender processes the acknowledgment.



Stop and Wait Protocol

Total Time

- Total time taken in sending one data packet=
  (Transmission delay + Propagation delay + Queuing delay + Processing delay)$_{packet}$
  +
  (Transmission delay + Propagation delay + Queuing delay + Processing delay)$_{ACK}$
- **Assume:**
  - Queuing delay and processing delay to be zero at both sender and receiver side.
  - Transmission time for the acknowledgment to be zero since its size is very small.
- **Under the above assumptions.**
  Total time taken in sending one data packet = (Transmission delay + Propagation delay)$_{packet}$ + (Propagation delay)$_{ACK}$

Total Time & Efficiency

- We know:
  - Propagation delay depends on the distance and speed.
  - So, it would be same for both data packet and acknowledgment.

  Total time taken in sending one data packet = $(\text{Transmission delay})_{packet}$ + 2 x Propagation delay)
- **Efficiency:** Efficiency of any flow control control protocol is given by-

  Efficiency (η) = Useful Time / Total Time

  where-

  -Useful time = Transmission delay of data packet = $(\text{Transmission delay})_{packet}$

  -Useless time = Time for which sender is forced to wait and do nothing = 2 x Propagation delay

  -Total time = Useful time + Useless time

$$\text{Efficiency } (\eta) = \frac{(\text{Transmission delay})_{packet}}{(\text{Transmission delay})_{packet} + 2 \times \text{Propagation delay}}$$

OR

$$\text{Efficiency } (\eta) = \frac{T_t}{T_t + 2T_p}$$

Factors Affecting Efficiency

- Efficiency (η) = $(\text{Transmission delay})_{packet}$ / $(\text{Transmission delay})_{packet}$ + 2 x Propagation delay

$$\text{Efficiency } (\eta) = \frac{1}{1 + 2 \times \left(\frac{\text{Propagation delay}}{(\text{Transmission delay})_{packet}} \right)}$$

$$\text{Efficiency } (\eta) = \frac{1}{1 + 2 \times \left(\frac{\text{Distance}}{\text{speed}} \right) \times \left(\frac{\text{Bandwidth}}{\text{Packet length}} \right)}$$

- From here, we can observe:
  - Efficiency $(\eta) \propto 1$ / Distance between sender and receiver
  - Efficiency $(\eta) \propto 1$ / Bandwidth
  - Efficiency $(\eta) \propto$ Transmission speed
  - Efficiency $(\eta) \propto$ Length of data packet

Throughput

- Number of bits that can be sent through the channel per second is called as its throughput.

$$\text{Throughput} = \text{Efficiency } (\eta) \times \text{Bandwidth}$$

- **Round Trip Time**
  Round Trip Time = 2 x Propagation delay
- **Advantages:** The advantages of stop and wait protocol are-
  - It is very simple to implement.
  - The incoming packet from receiver is always an acknowledgment.
- **Limitation:** It is extremely inefficient because-
  - It makes the transmission process extremely slow.
  - It does not use the bandwidth entirely as each single packet and acknowledgment uses the entire time to traverse the link.

Stop & Wait Protocol Limitations

- If the data packet sent by the sender gets lost, then-
  - Sender will keep waiting for the acknowledgment for infinite time.
  - Receiver will keep waiting for the data packet for infinite time.
- If acknowledgment sent by the receiver gets lost, then-
  - Sender will keep waiting for the acknowledgment for infinite time.
  - Receiver will keep waiting for another data packet for infinite time.
- Efficiency may also be referred by the following names-
  - Line Utilization
  - Link Utilization
  - Sender Utilization
  - Utilization of Sender

Stop & Wait Protocol Limitations

- Throughput may also be referred by the following names-
  - Bandwidth Utilization
  - Effective Bandwidth
  - Maximum data rate possible
  - Maximum achievable throughput
- Stop and Wait protocol performs better for LANs than WANs.
  - Efficiency of the protocol is inversely proportional to the distance between sender and receiver.
  - So, the protocol performs better where the distance between sender and receiver is less.
  - The distance is less in LANs as compared to WANs.

Thank You