Data Communications

Automatic Repeat Request

Medium Access Control

Handling Error Cases

- **Automatic Repeat reQuest** (**ARQ**), also known as **Automatic Repeat Query**, is an error-control method
- ARQ uses acknowledgements and timeouts to achieve reliable data transmission over an unreliable service.
- Acknowledgements (ACK) : messages sent by the receiver indicating that it has correctly received a data frame
- Timeout: specified periods of time allowed to elapse before an acknowledgment is to be received

Re-transmission

- If the sender does not receive an acknowledgment before the timeout, it usually re-transmits the frame until an acknowledgment is received, or a predefined number of re-transmissions is exceeded.
- A receiver may also send a negative acknowledgement (NAK) to indicate an error

Types of ARQ

- The types of ARQ protocols include
  - Stop-and-wait ARQ
  - Go-Back-N ARQ
  - Selective Repeat ARQ

Stop-and-Wait

- Stop-and-wait ARQ is a method used in telecommunications to send information between two connected devices.
- It is the simplest kind of automatic repeat-request (ARQ) method.
- A stop-and-wait ARQ sender sends one frame at a time. After sending each frame, the sender does NOT send any further frames until it receives an acknowledgement (ACK) signal.
- After receiving a good frame, the receiver sends an ACK. If the ACK does not reach the sender before a certain time, known as the timeout, the sender sends the same frame again.

Sliding Window

- Stop-and-wait does not utilize the bandwidth efficiently.
- The sender does not transmit until it receives an ACK.
- Sliding window methods let a sender to send more frames before receiving an ACK
- The “window” shows the frames waiting for ACK

Go-Back-N

- Sends N frames before receiving an ACK
- N is the window size
- If no ACK is received (timeout), re-transmits all frames in the window (goes back N frames)
- Advantages: Receiver does not need to keep the frames in buffer
- Disadvantage: Even the frames delivered correctly are re-transmitted

Selective Repeat

- Sends N frames before receiving an ACK
- If a frame is in error, the receiver sends NAK for it.
- The sender re-transmits the frame in error.
- The receiver collectively acknowledges the frames (ACK_i means all frames up to and including i have been received)
- Advantages: Sender does not need to re-transmit correctly delivered frames.
- Disadvantage: Receiver has to keep track of the order of the frames. A large buffer is needed.

Sequence Numbers of the Frames

- To distinguish frames and ACK/NAK messages, sequence numbers are used
- Sequence number range should be at least twice the size of the window

Medium Access Control

- In a broadcast network, the medium is shared
- Only one message can be transmitted at any given time.
- If two or more messages are sent, a collision happens
- Medium access control methods try to reduce/eliminate collisions

Pure ALOHA

- If you have any data to send, send immediately
- If the message collides with another transmission, try resending "later"
- On collision, sender waits random time before trying again

Pure ALOHA

- Advantages: Simple, not initial waiting time, best for lightly loaded networks
- Disadvantages: High rate of collisions in heavily loaded networks

Slotted ALOHA

- An improvement to the original ALOHA protocol was "Slotted ALOHA", which introduced discrete timeslots and increased the maximum throughput.
- A station can send only at the beginning of a timeslot, and thus collisions are reduced.

Slotted ALOHA

- Advantages: Lower rate of collisions in heavily loaded networks (compared to pure ALOHA)
- Disadvantages: More complex, time synchronization is required for determining the time slots, includes initial waiting time, nor suitable for lightly loaded networks

Carrier Sensing

- Carrie Sense Multiple Access (CSMA)
  - A carrier sensing scheme is used to avoid transmission when the medium is busy.
  - A transmitting data station that detects another signal while transmitting a frame, stops transmitting that frame, waits [for a random time interval] before trying to resend the frame

Collision Detection

- Transmission in presence of collision is waste of time/bandwidth.
- If sender detects collision, it stops, waits for a random time, re-transmit the frame.
- Collision detection procedure:
  - Continue transmission until minimum packet time is reached to ensure that all receivers detect the collision.
  - Read back the transmitted bits and check.
  - If the transmitted and read back bits are different, then a collision has happened
  - Wait for a random time, retry transmission

Accessing the Medium

- If the medium is busy the transmitter react by:
  - 1-Persistent
  - Non-Persistent
  - P-Persistent

1-Persistent

- When the sender is ready to transmit data, it checks if the transmission medium is busy.
- If busy, it senses the medium continually (Persistently) until it becomes idle, and then it transmits the message (a frame).
- In case of a collision, the sender waits for a random period of time and attempts to transmit again.

Non-Persistent

- The sender senses the medium and if the channel is idle it starts transmitting the data.
- If the medium is busy, the sender does not persistently sense it but instead it waits for a random amount of time and repeats the algorithm.

P-Persistent

- When the sender is ready to send data, it checks continually if the medium is busy.
- When the medium becomes idle, the sender transmits a frame with a probability p at the next time slot.
- If the sender chooses not to transmit (the probability of this event is 1-p), it waits until the next time slot and repeats the process until the frame is sent.