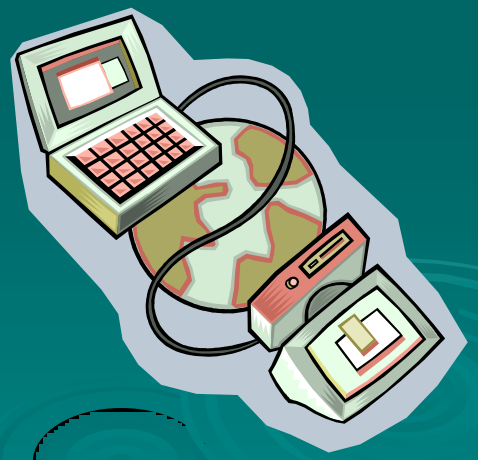
Chapter 7 – Data Link Control Protocols

Data Link Control Protocols

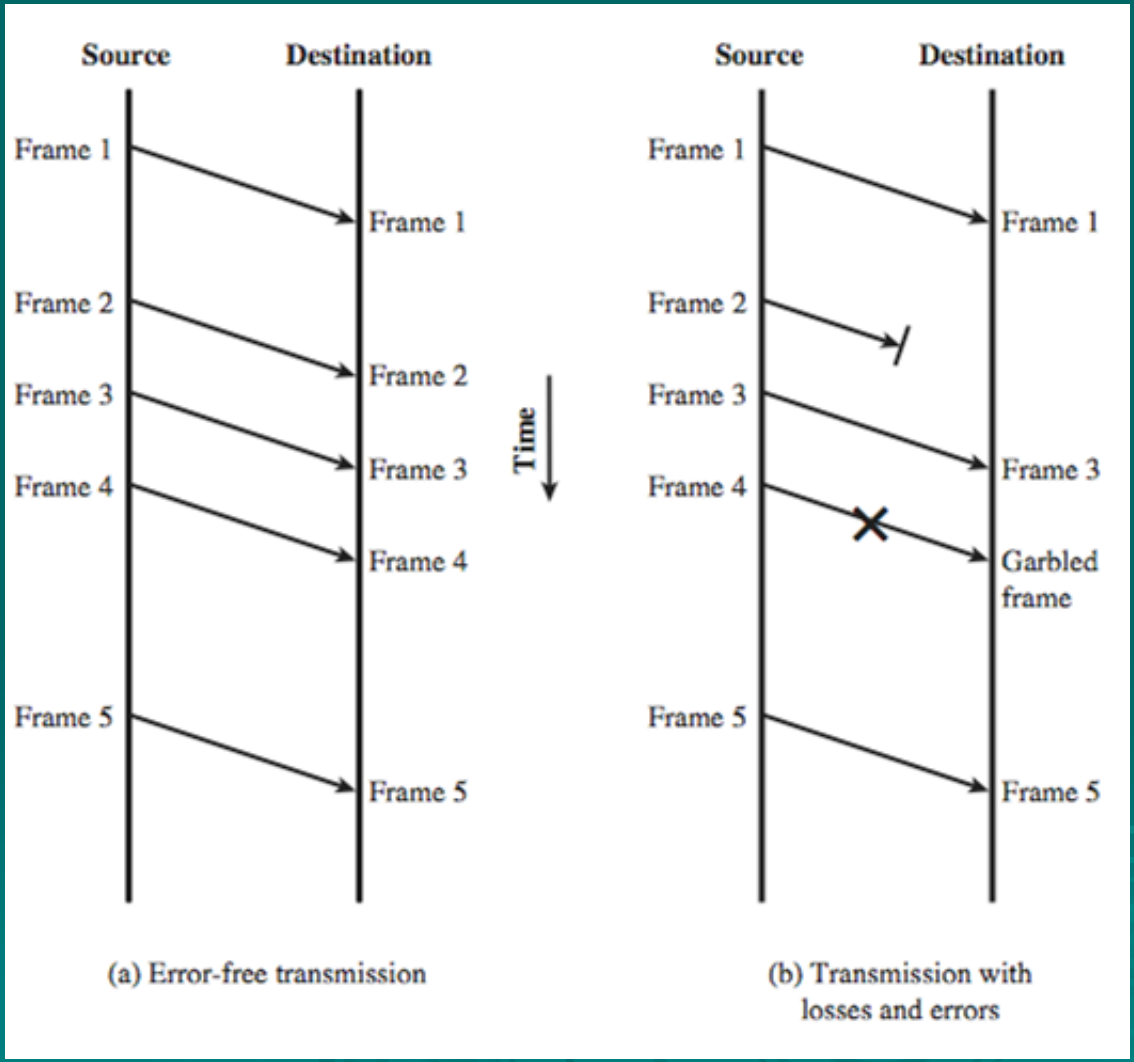
- when sending data, to achieve control, a layer of logic is added above the Physical layer
  - data link control or a data link control protocol
- to manage exchange of data over a link:
  - frame synchronization
  - flow control
  - error control
  - addressing
  - control and data
  - link management



Flow Control

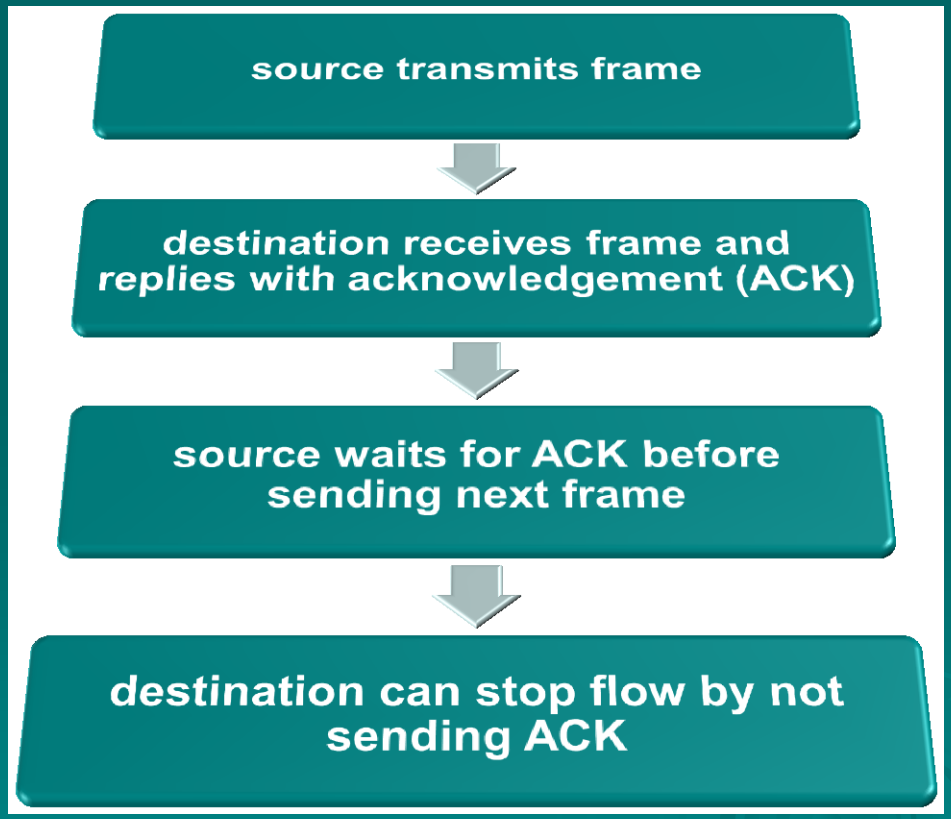
- ensure sending entity does not overwhelm receiving entity
  - prevent buffer overflow
- influenced by:
  - transmission time
    - time taken to emit all bits into medium
  - propagation time
    - time for a bit to traverse the link
- assumption is all frames are successfully received with no frames lost or arriving with errors

Model of Frame Transmission



Stop and Wait

- simplest form of flow control

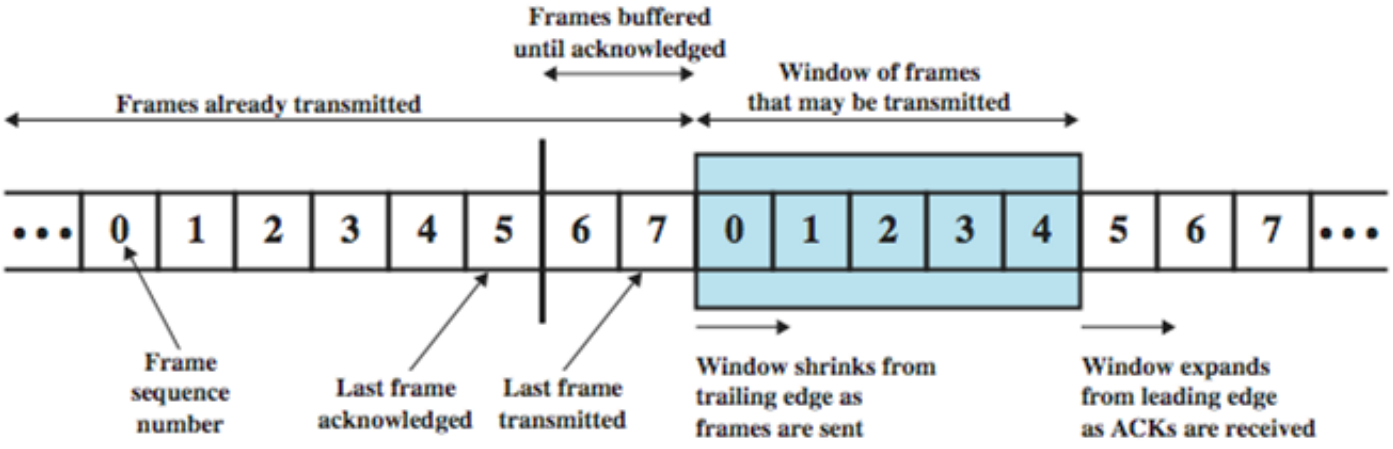


- works well for a message sent in a few large frames
  - stop and wait becomes inadequate if large block of data is split into small frames by source

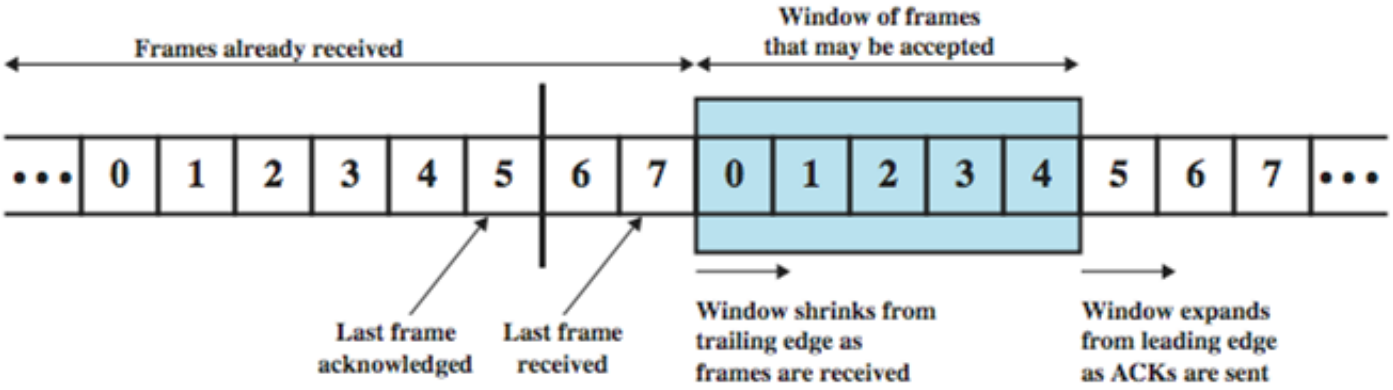
Sliding Windows Flow Control

- allows multiple numbered frames to be in transit
  - receiver has buffer W long
  - transmitter sends up to W frames without ACK
  - ACK includes number of next frame expected
  - sequence number is bounded by size of field (k)
    - frames are numbered modulo 2^k
    - giving max window size of up to $2^k - 1$
  - receiver can ACK frames without permitting further transmission (Receive Not Ready)
  - must send a normal acknowledge to resume
- if have full-duplex link, can piggyback ACKs

Sliding Window Diagram

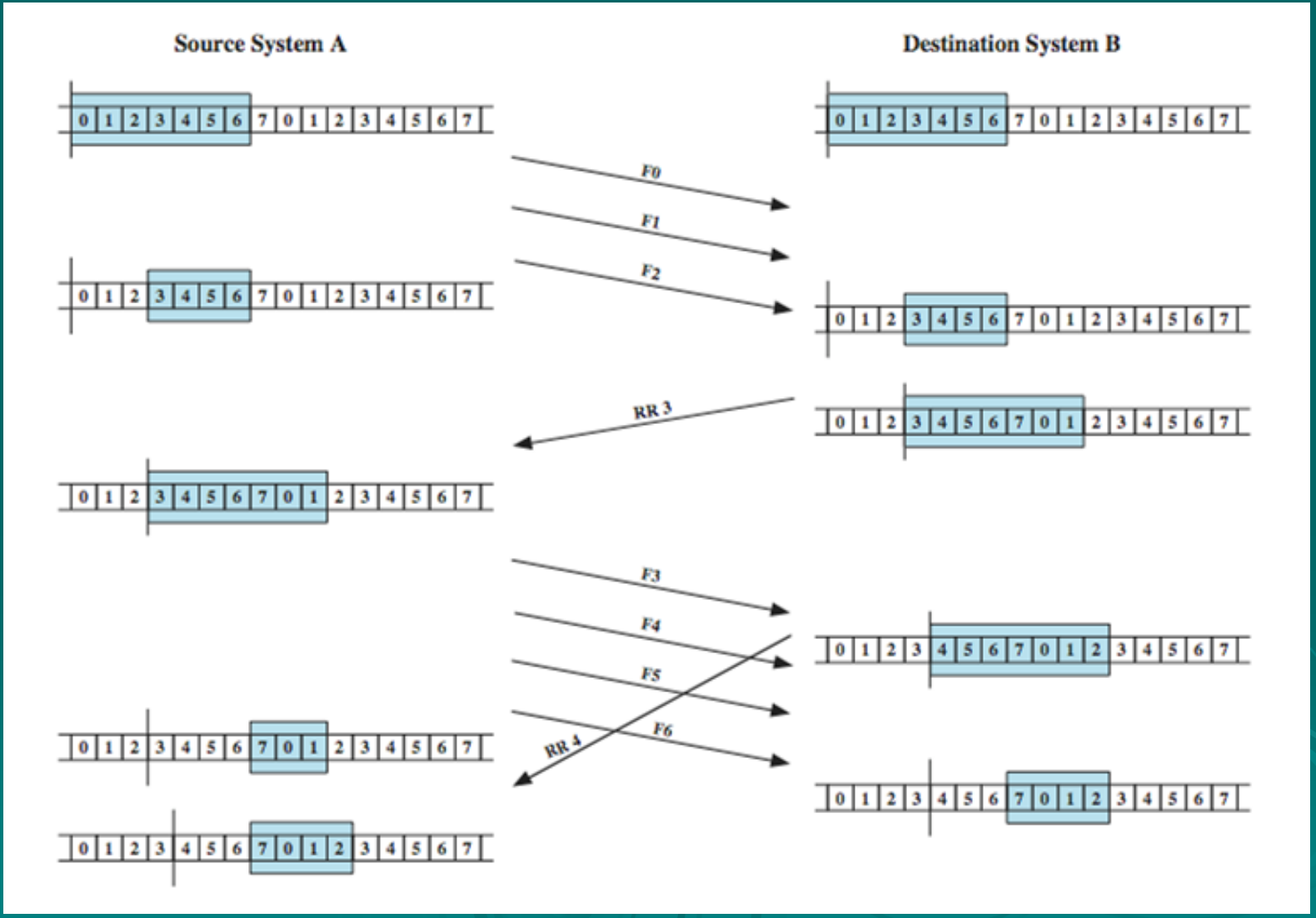


(a) Sender's perspective

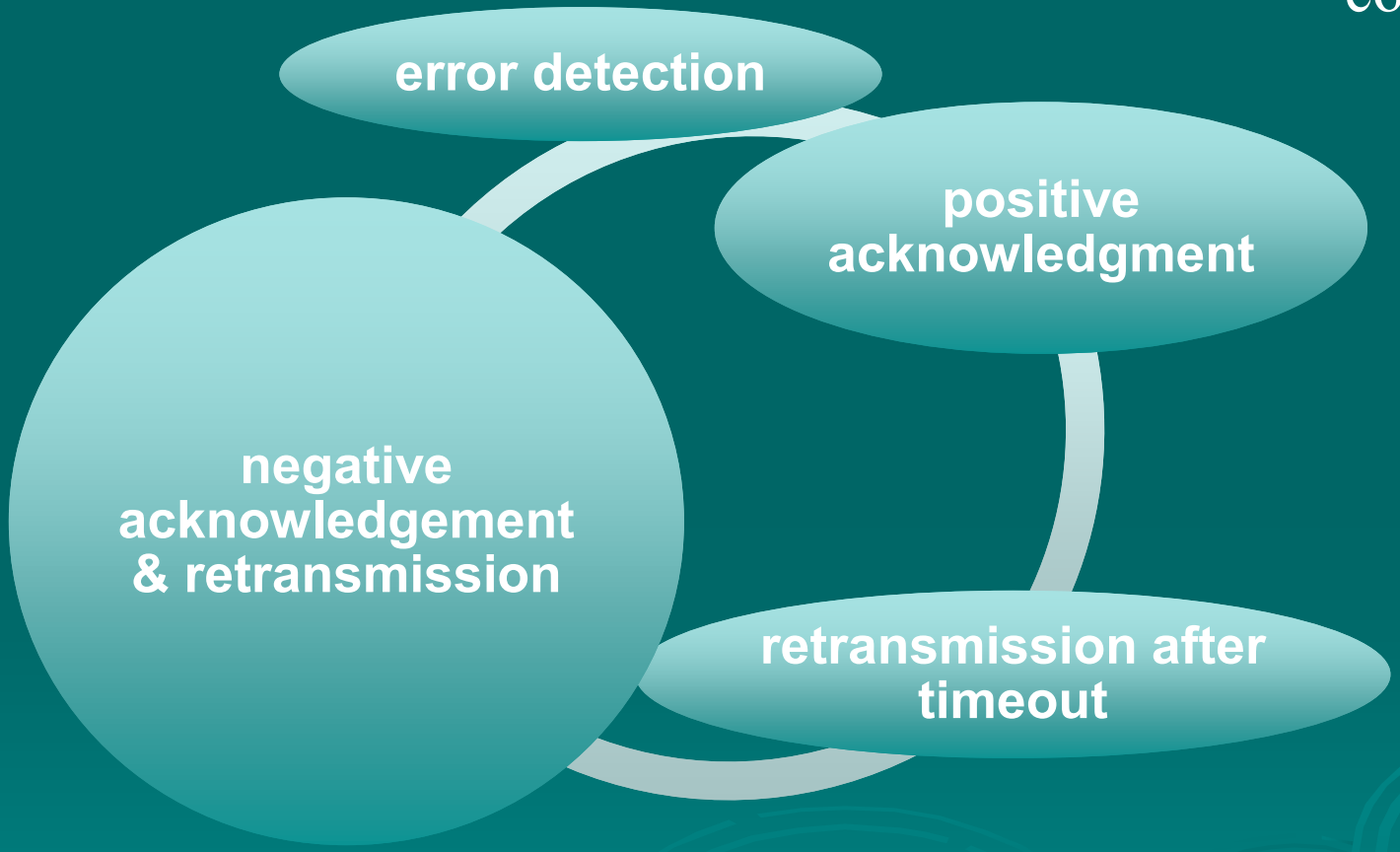


(b) Receiver's perspective

Sliding Window Example



Error Control Techniques



detection and correction of errors such as:

lost frames

-a frame fails to arrive at the other side

damaged frames

-frame arrives but some of the bits are in error

Automatic Repeat Request (ARQ)

- collective name for error control mechanisms
- effect of ARQ is to turn an unreliable data link into a reliable one
- versions of ARQ are:
  - stop-and-wait
  - go-back-N
  - selective-reject

Stop and Wait ARQ

- source transmits single frame
- waits for ACK
  - no other data can be sent until destination's reply arrives
- if frame received is damaged, discard it
  - transmitter has timeout
  - if no ACK within timeout, retransmit
- if ACK is damaged, transmitter will not recognize
  - transmitter will retransmit
  - receiver gets two copies of frame
  - use alternate numbering and ACK0 / ACK1

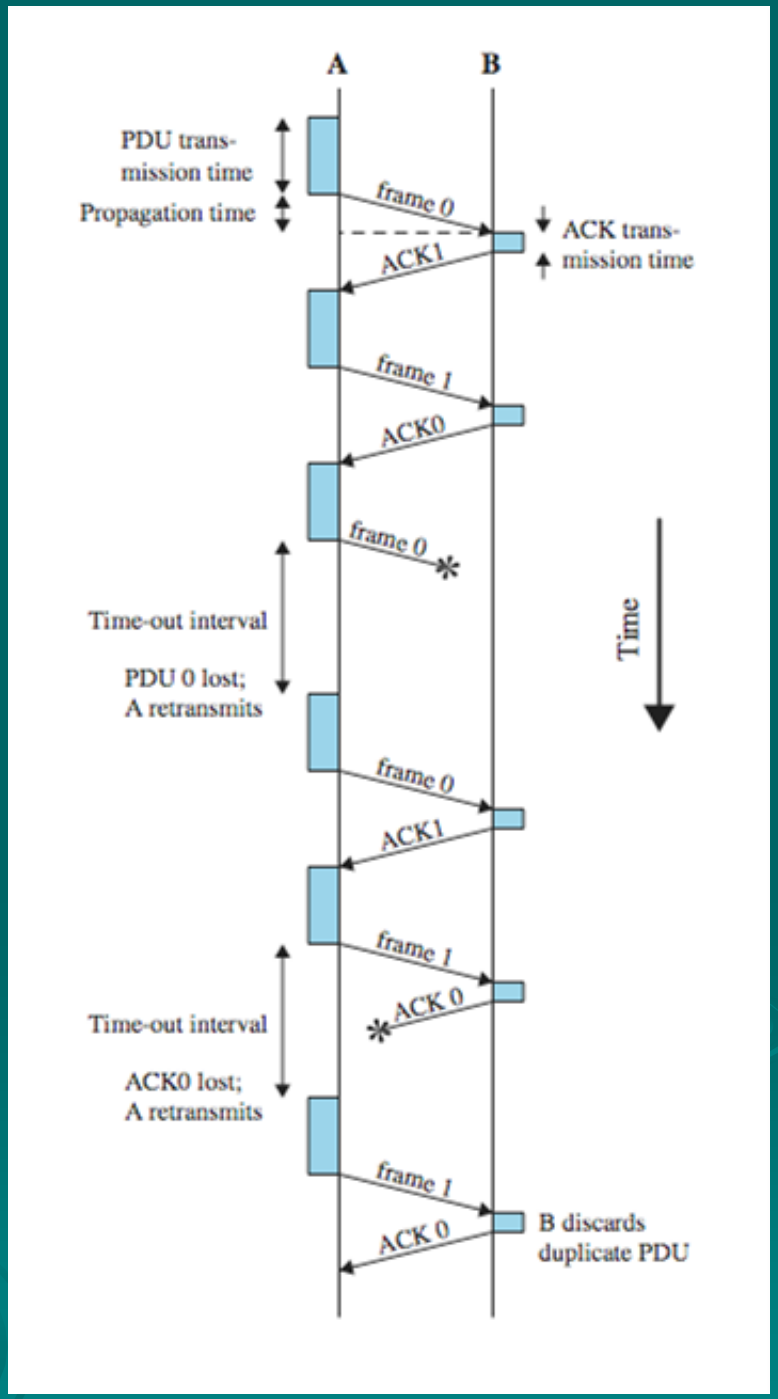
Stop and Wait ARQ

pros

- simplistic

cons

- inefficient



Go-Back-N ARQ

- most commonly used error control
- based on sliding-window
- use window size to control number of outstanding frames
- if no error, ACK as usual
- if error, reply with rejection
  - destination will discard that frame and all future frames until frame in error is received correctly
  - transmitter must go back and retransmit that frame and all subsequent frames

Go Back N - Handling

- Damaged frame
  - error in frame *i* so receiver rejects frame *i*
  - transmitter retransmits frames from *i*
- Lost frame
  - frame *i* lost and either
    - transmitter sends *i+1* andreceiver gets frame *i+1* out of sequence and rejects frame *i*
    - or transmitter times out and sends ACK with P bit set which receiver responds to with ACK *i*
  - transmitter then retransmits frames from *i*

Go Back N - Handling

Damaged Acknowledgement

- receiver gets frame i, sends ACK (i+1) which is lost
- ACKs are cumulative, so next ACK (i+n) may arrive before transmitter times out on frame i
- if transmitter times out, it sends ACK with P bit set
- can be repeated a number of times before a reset procedure is initiated

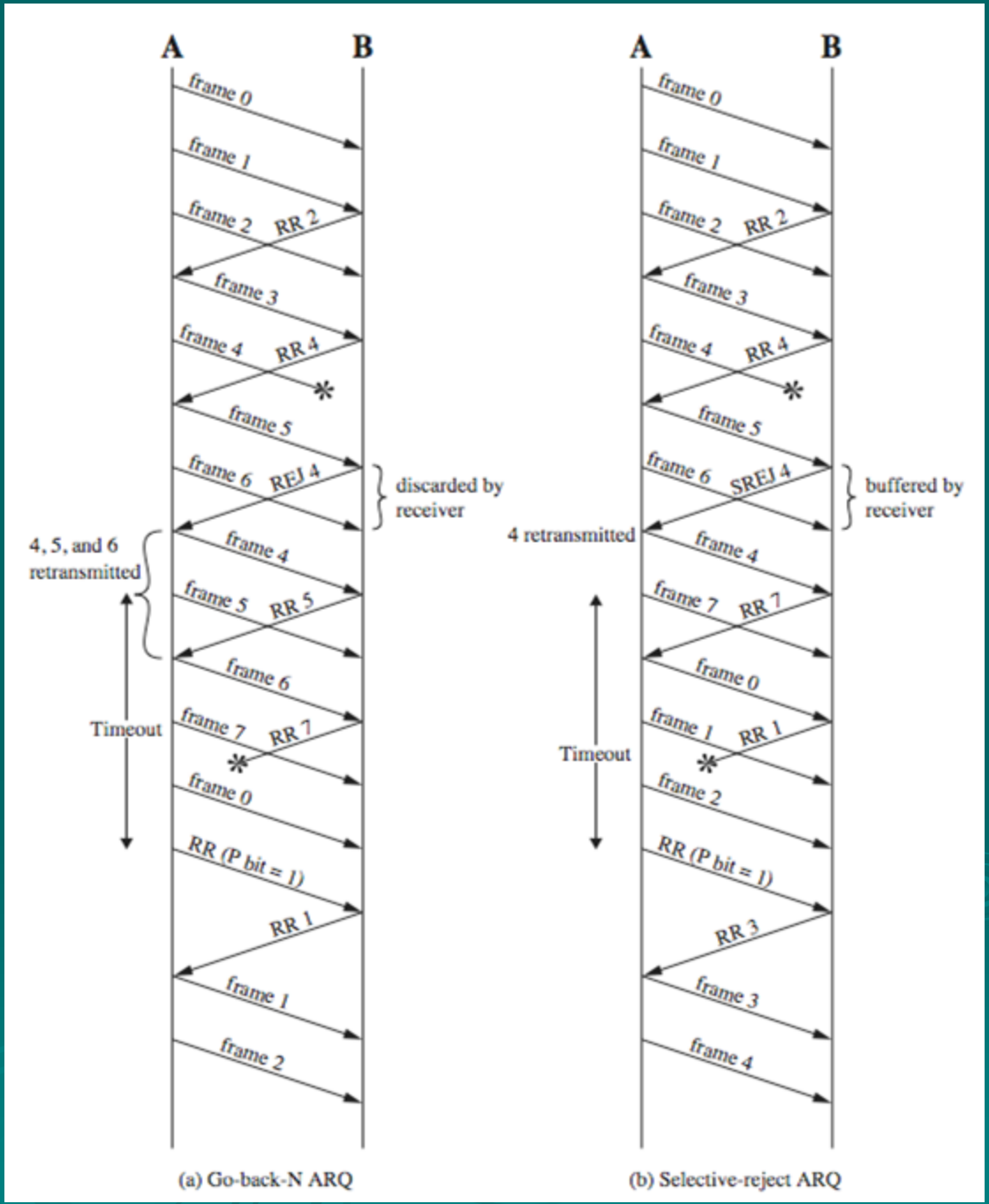
Damaged Rejection

- reject for damaged frame is lost
- handled as lost frame when transmitter times out

Selective-Reject (ARQ)

- also called selective retransmission
- only rejected frames are retransmitted
- subsequent frames are accepted by the receiver and buffered
- minimizes retransmission
- receiver must maintain large enough buffer
- more complex logic in transmitter
  - less widely used
- useful for satellite links with long propagation delays

Go-Back-N vs. Selective Reject



Flag Fields and Bit Stuffing

- delimit frame at both ends with 01111110
- receiver hunts for flag sequence to synchronize
- bit stuffing used to avoid confusion with data containing flag sequence 01111110
  - 0 inserted after every sequence of five 1s
  - if receiver detects five 1s it checks next bit
  - if next bit is 0, it is deleted (was stuffed bit)
  - if next bit is 1 and seventh bit is 0, accepted as flag
  - if sixth and seventh bits 1, sender is indicating abort