DATA LINK CONTROL PROTOCOLS

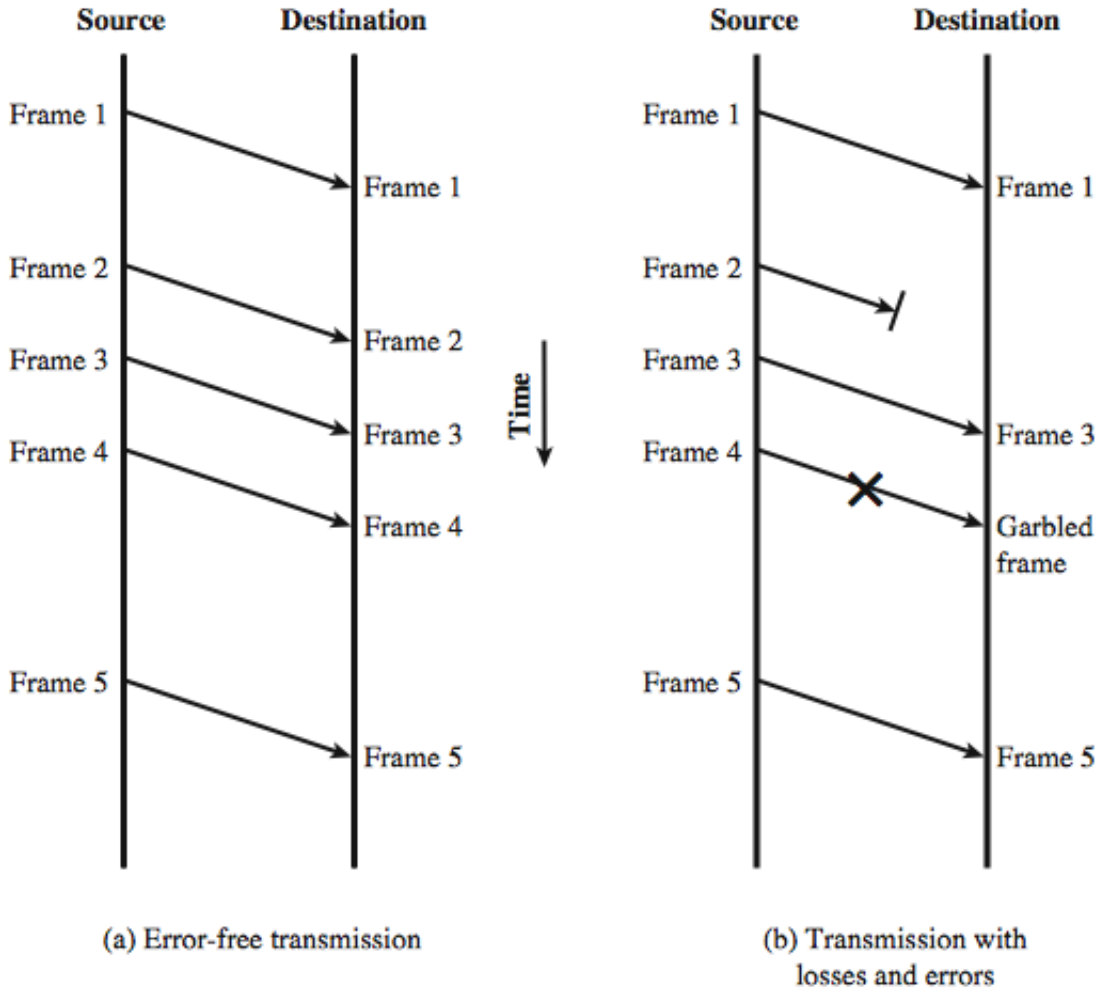
Topics covered

- Data Link Layer Control Protocols
  - Flow control
  - Error control

Flow Control

- ensure sending entity does not overwhelm receiving entity
  - by preventing buffer overflow
- influenced by:
  - transmission time
    - time taken to emit all bits into medium
  - propagation time
    - time for a bit to traverse the link
- assume here no errors but varying delays

Model of Frame Transmission



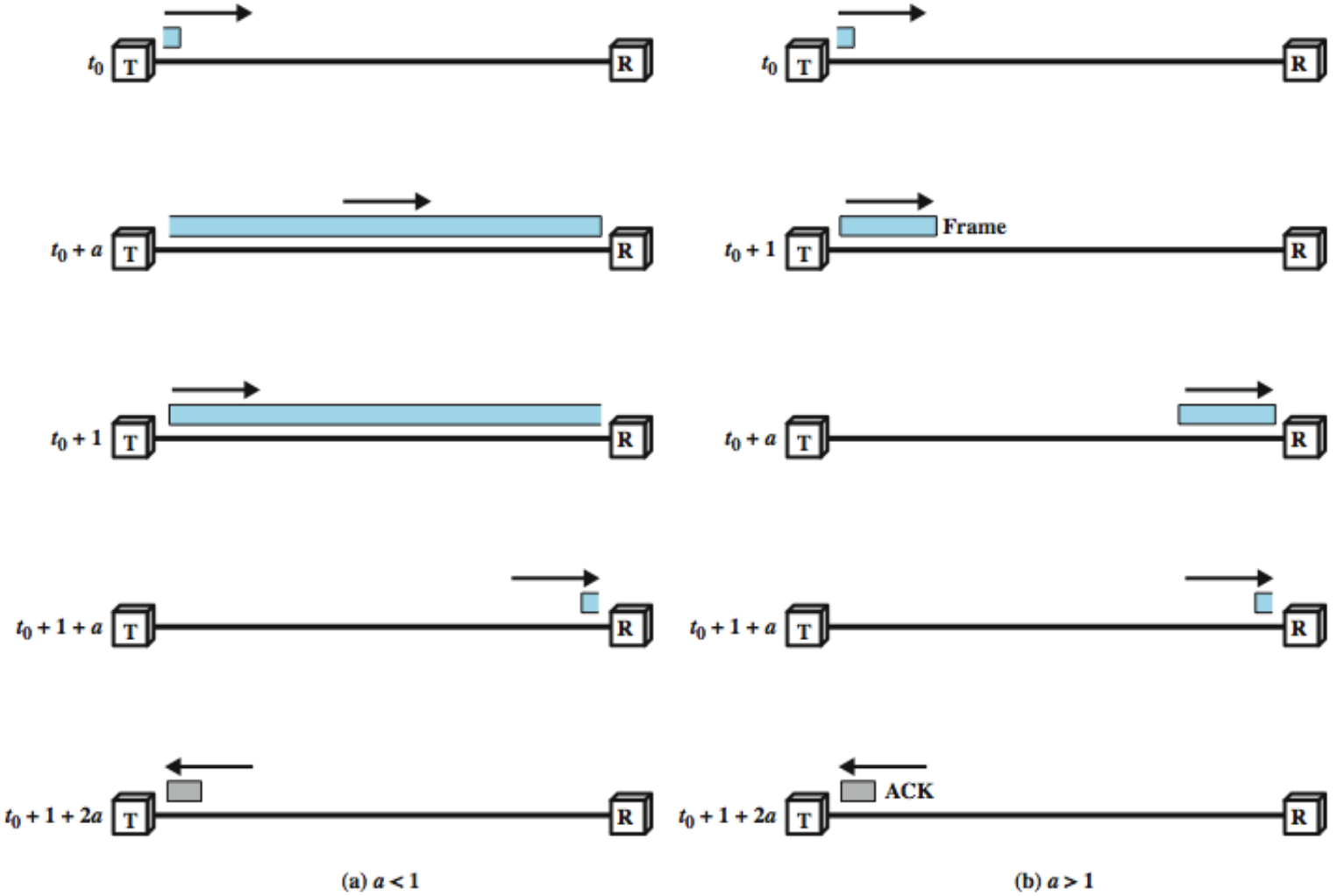
(a) Error-free transmission

(b) Transmission with losses and errors

Stop and Wait Flow Control

- source transmits frame
- destination receives frame and replies with acknowledgement (ACK)
- source waits for ACK before sending next
- destination can stop flow by not send ACK
- works well for a few large frames
- Stop and wait becomes inadequate if large block of data is split into small frames

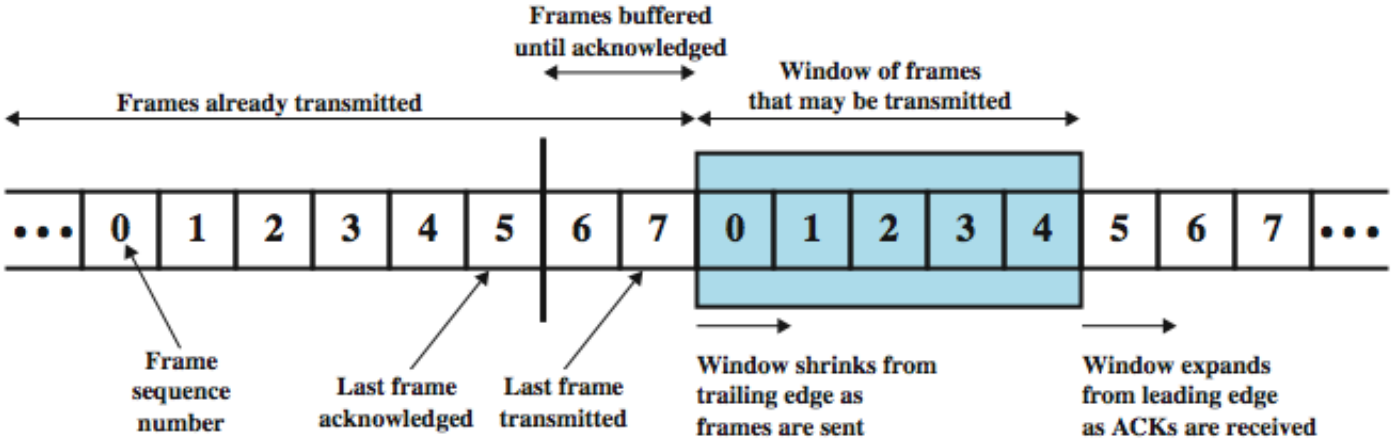
Stop and Wait Link Utilization



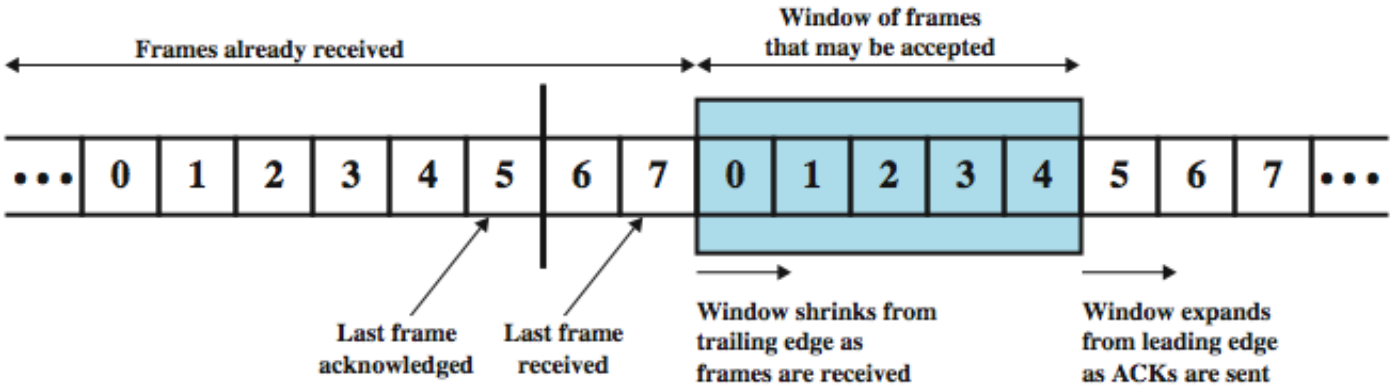
Sliding Windows Flow Control

- 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

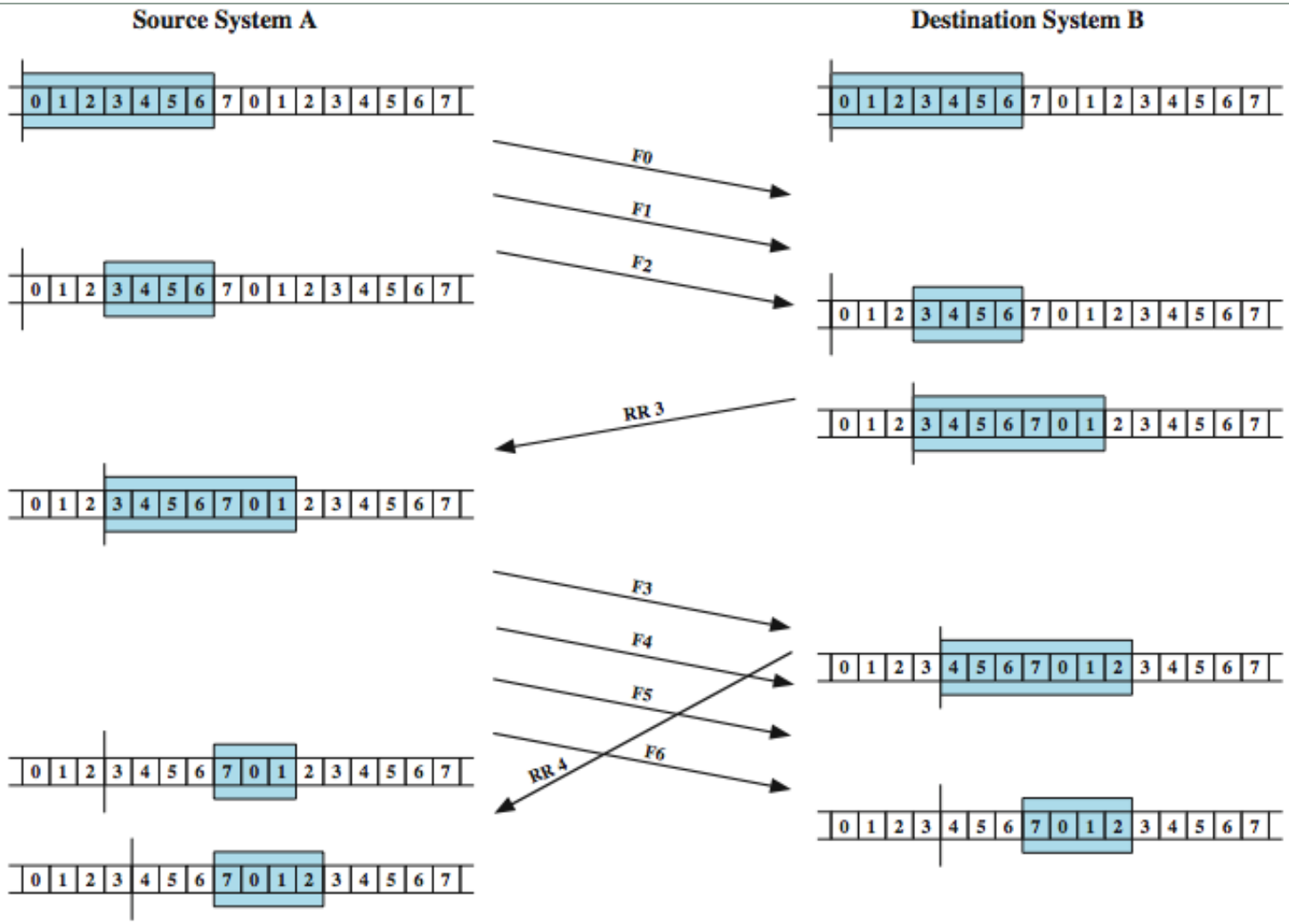


(a) Sender's perspective



(b) Receiver's perspective

Sliding Window Example



2. Error Control - detection and correction of errors

- 2 types of errors are:
  - lost frames : fails to arrive at rxr
  - damaged frames : recognizable frame arrives..but bits damaged

- common techniques for error control are based on :
  - error detection
  - positive acknowledgment : destn returns, if successfully received error free frames
  - retransmission after timeout
  - negative acknowledgement & retransmission

Automatic Repeat Request (ARQ)

collective name for such error control mechanisms.

Most Error Control techniques are based on

(1) Error Detection Scheme (e.g., Parity checks, CRC), and

(2) Retransmission Scheme

Error control schemes that involve error detection and retransmission of lost or corrupted frames are referred to as Automatic Repeat Request (ARQ) error control.

Automatic Repeat Request (ARQ) (2)

3 standardized versions of ARQ retransmission schemes

1. Stop-and-Wait ARQ
2. Go-Back-N ARQ
3. Selective Repeat ARQ

The protocol for sending ACKs in all ARQ protocols are based on the sliding window flow control scheme.

1. Stop and Wait ARQ

- source transmits single frame
- wait for ACK
- if received frame damaged, discard it & no ACK
  - transmitter waits till timeout
  - if no ACK within timeout, retransmit
- if ACK damaged, transmitter will not recognize it
  - transmitter will retransmit
  - receiver gets two copies of frame

1. Stop and Wait ARQ (2)

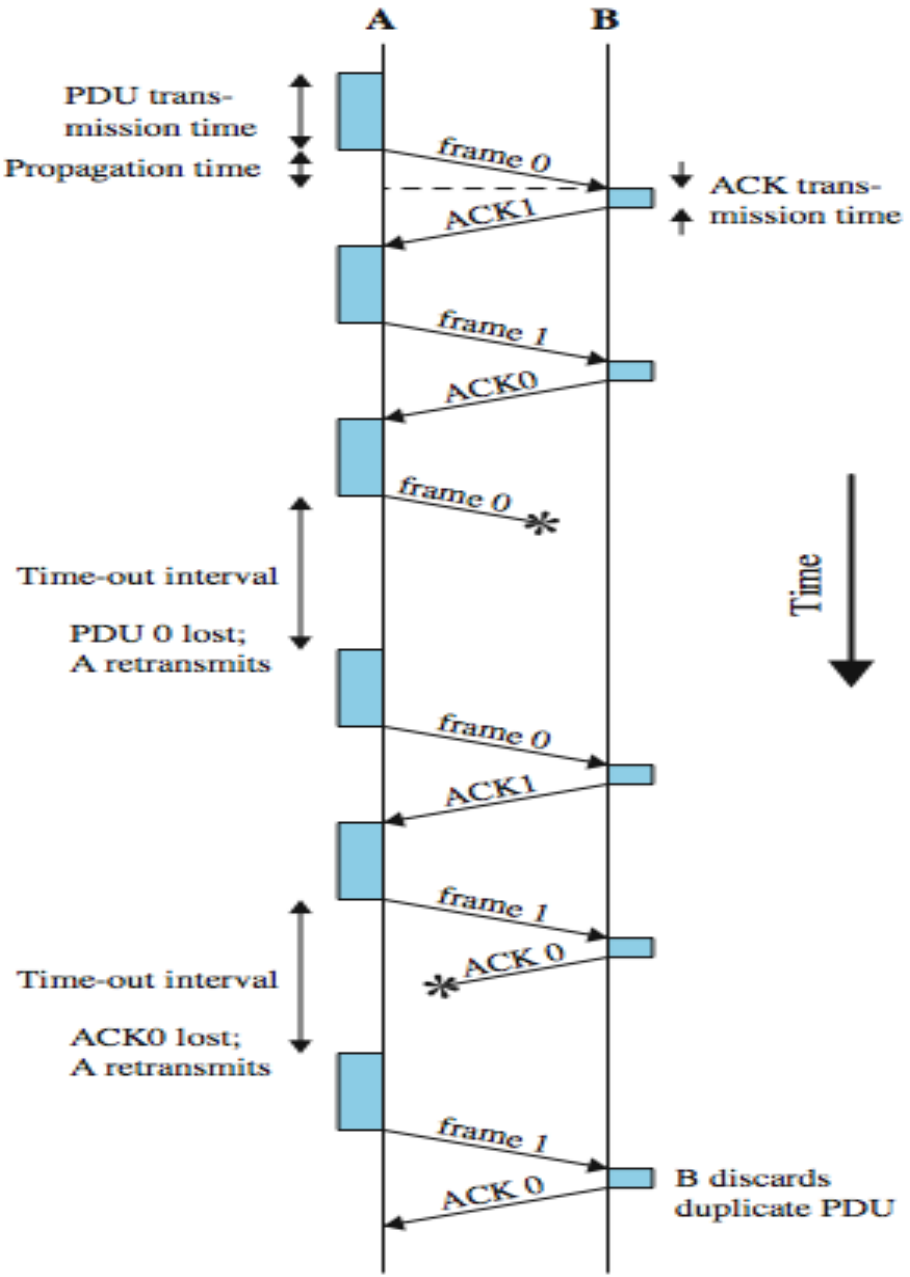
To avoid this problem, frames are alternatively labeled with 0 or 1.

ie. Frames have 1-bit sequence numbers (SN = 0 or 1)

- positive acknowledgment are ACK0 / ACK1
- ACK0 – frame numbered 1……

Stop and Wait

- see example with
  both types of errors
- pros and cons
  - simple
  - inefficient



2. Go Back N ARQ (continuous ARQ)

- based on sliding window
- if no error, the operations are identical to Sliding Window. Use window to control number of outstanding frames

A station may send multiple frames as allowed by the window size

a. Receiver sends a REJ i if frame i is in error. After that, the receiver discards all incoming frames until the frame in error was correctly retransmitted
b. If sender receives a REJ i it will retransmit frame i and all packets i+1, i+2,... which have been sent, but not been acknowledged

Go Back N ARQ (2) - Handling

Ex. Station A sending frames to station B. After each txn, A sets ACK timer. B rxd (i-1), A just txd i. Contingencies (possibilities) are :

1. **Damaged Frame** If rxd **frame i** is invalid, B discards the frame. *2 subcases*

a. Within a time A sends **frame i+1**. B receives it out of order and sends REJ i. A retransmits frame *i* and all subsequent frames.

b. or A times out and send RR frame with P bit set to 1, which B responds by sending RR indicating next frame expected ie. frame *i* transmitter then retransmits frames from *i*

Alternatively just retransmit when timer out.

Go Back N ARQ (3) - Handling

2. **Damaged RR (Acknowledgement)**

   2 subcases

   a. receiver gets frame *i*, sends RR(*i+1*) which is lost. acknowledgments are cumulative, so next RR(*i+n*) may arrive before transmitter times out on frame *I*

   b. if transmitter times out, it sends ack with P bit set. Can be repeated a number of times before a reset procedure is initiated

3. **Damaged REJ (Rejection)**

   - REJ, for a damaged frame, is lost
   - handled as for lost frame when transmitter times out..1b

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
- hence less widely used
- useful for satellite links with long propagation delays

Go Back N vs Selective Reject