

ET4254 – Communications and Networking 1

Topic 7

Data Link Control Protocols

Aims:-

- Introduce need for data link protocols
- Flow control
- Error control
- HDLC

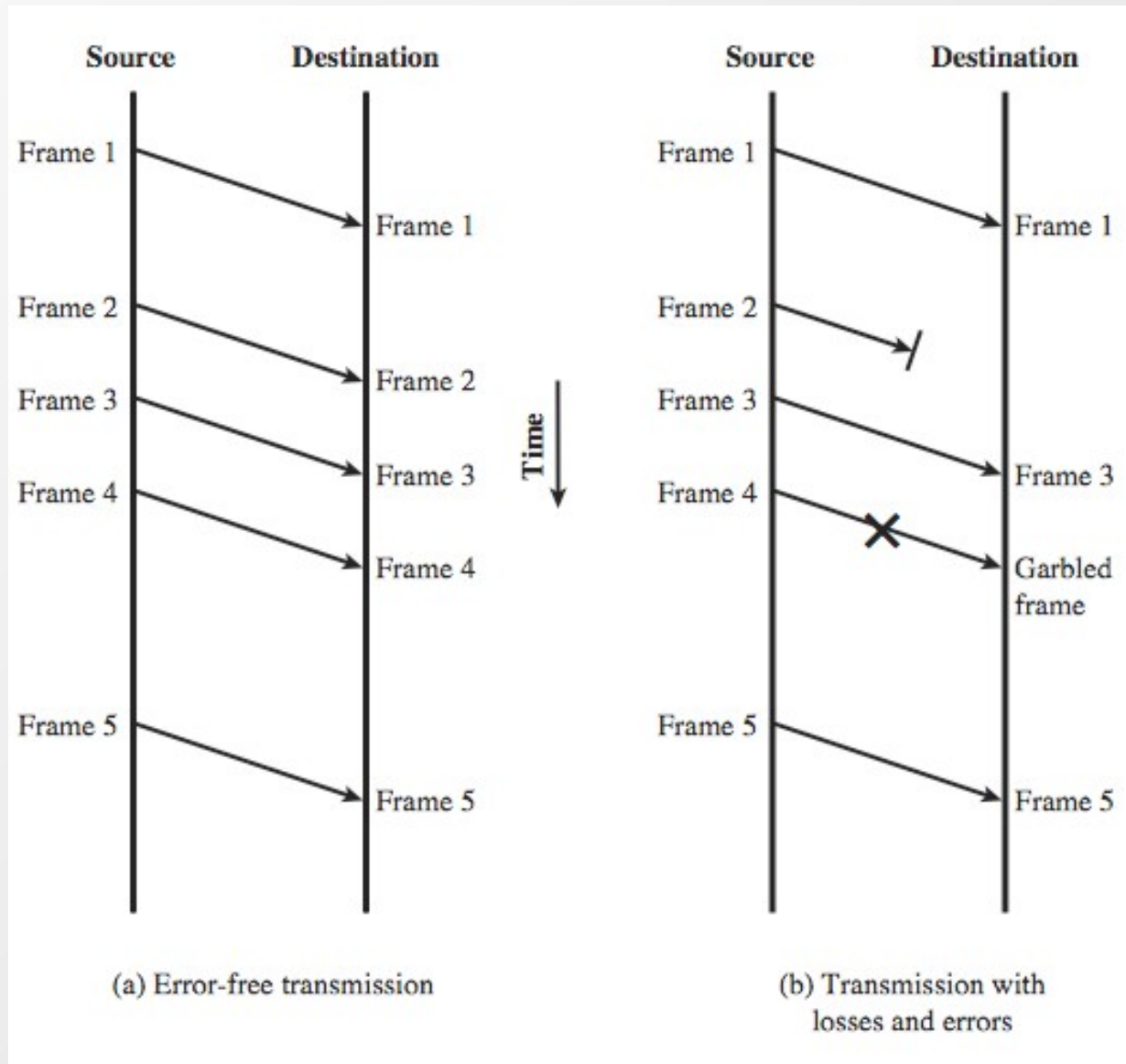
Data Link Control Protocols

- need layer of logic above Physical
- 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
 - 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

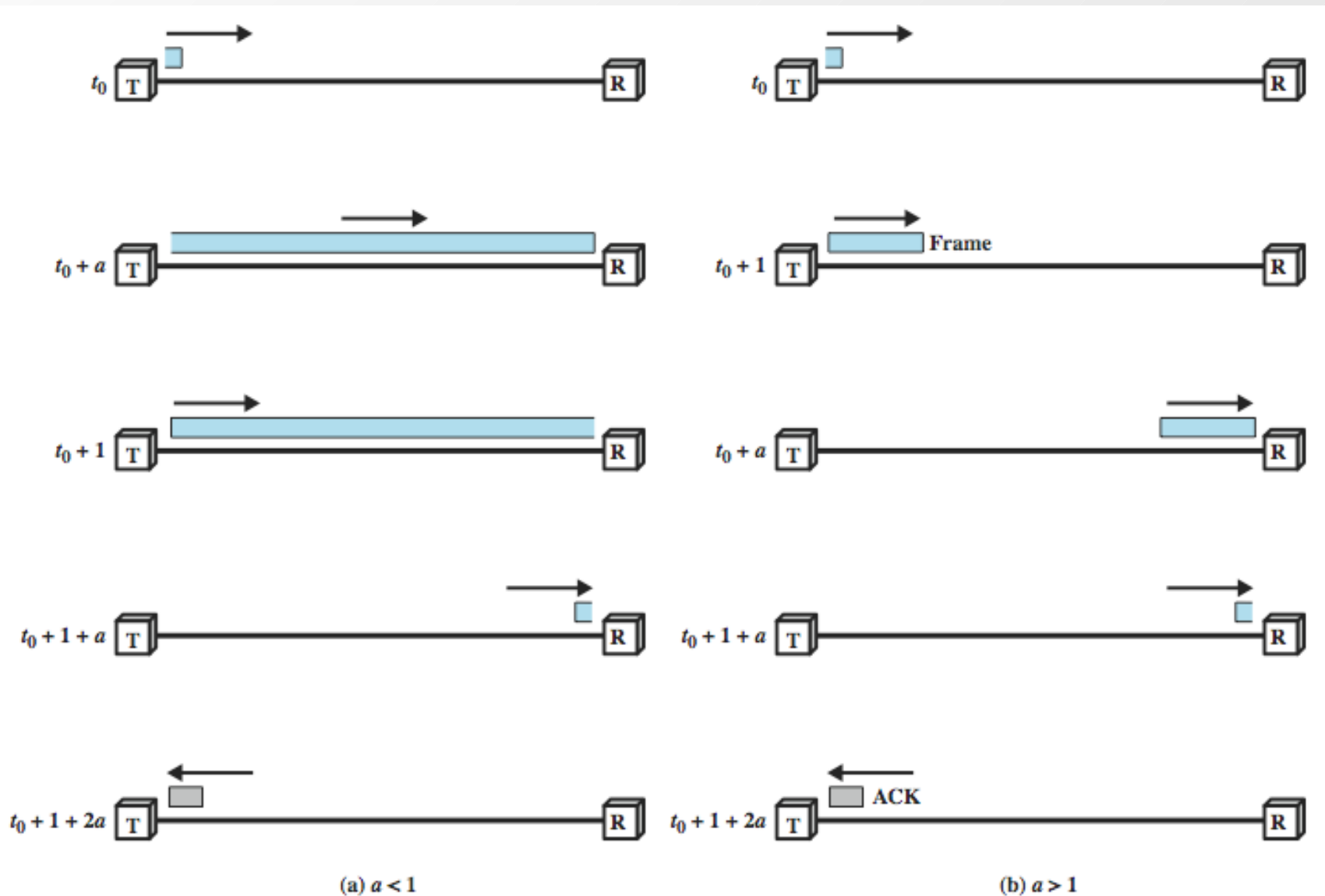
Model of Frame Transmission



Stop and Wait

- 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

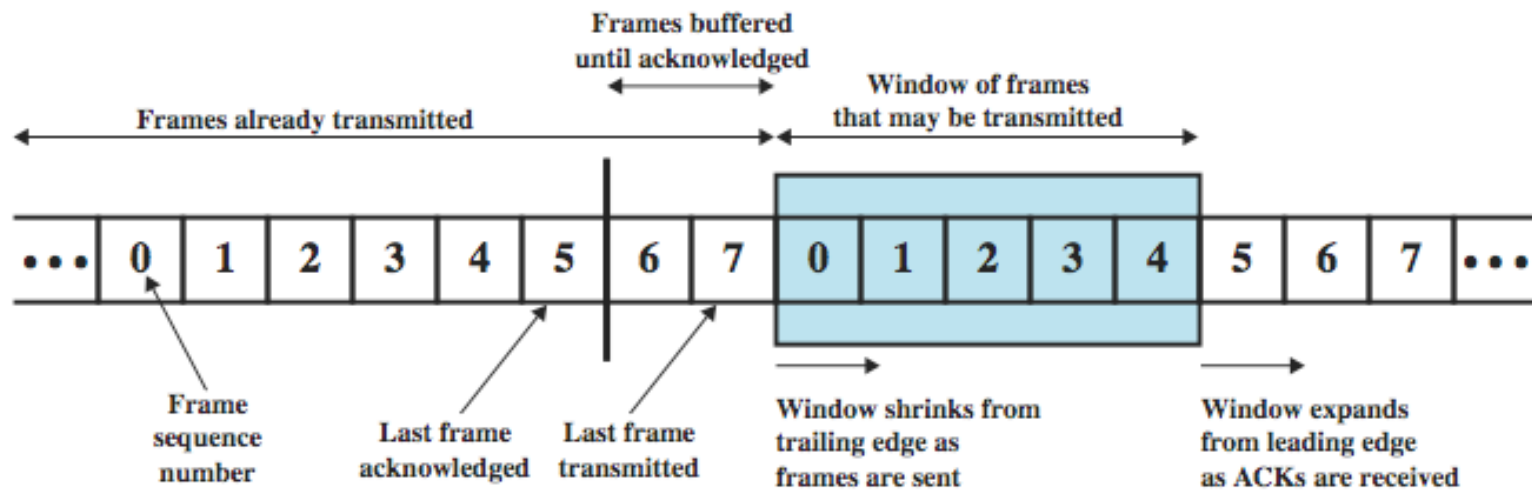
Stop and Wait Link Utilization



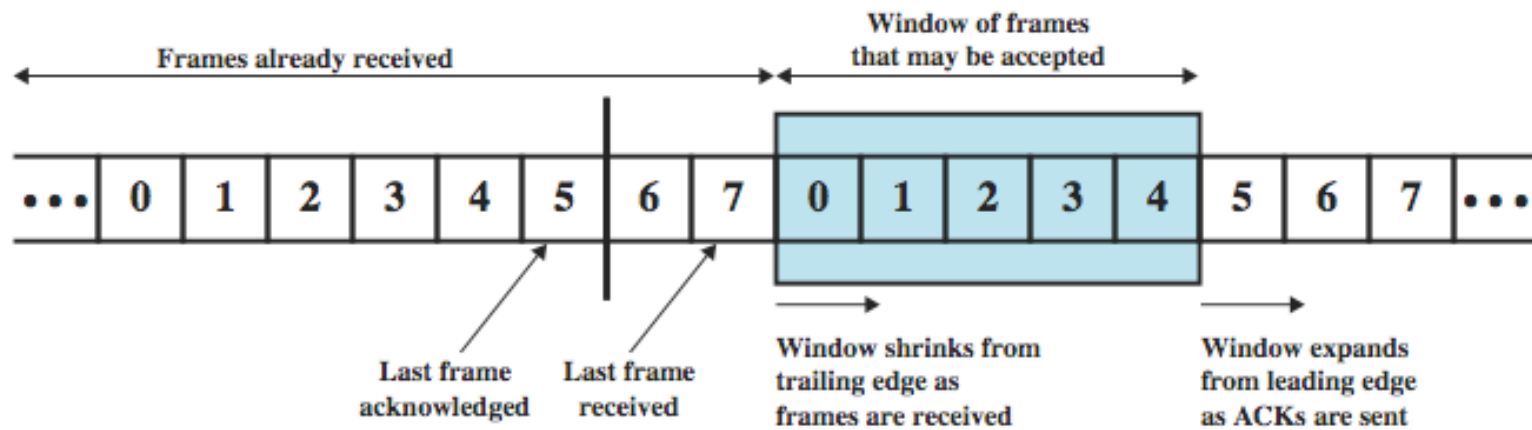
Sliding Windows Flow Control

- 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

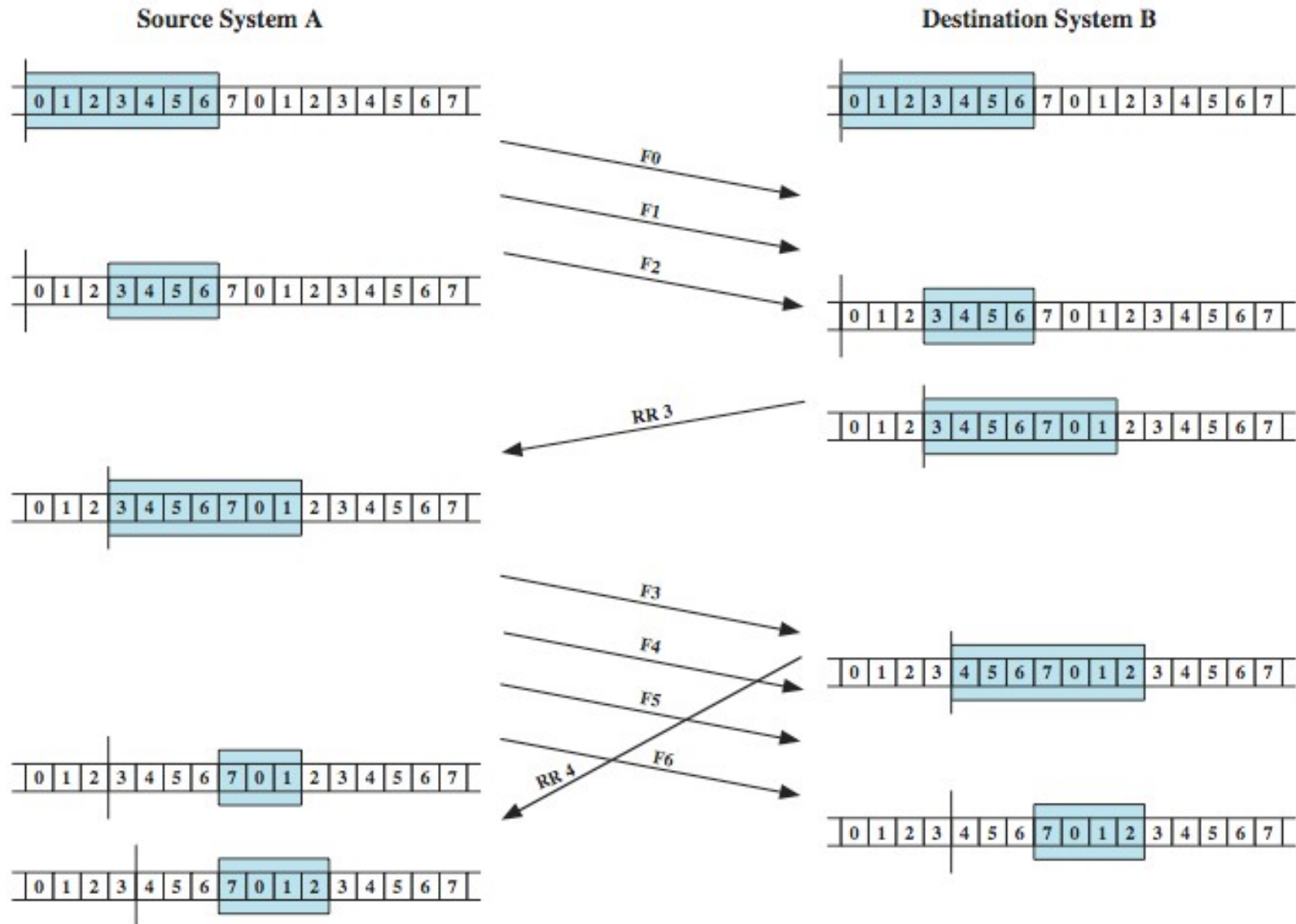


(a) Sender's perspective



(b) Receiver's perspective

Sliding Window Example



Error Control

- detection and correction of errors such as:
 - lost frames
 - damaged frames
- common techniques use:
 - error detection
 - positive acknowledgment
 - retransmission after timeout
 - negative acknowledgement & retransmission

Automatic Repeat Request (ARQ)

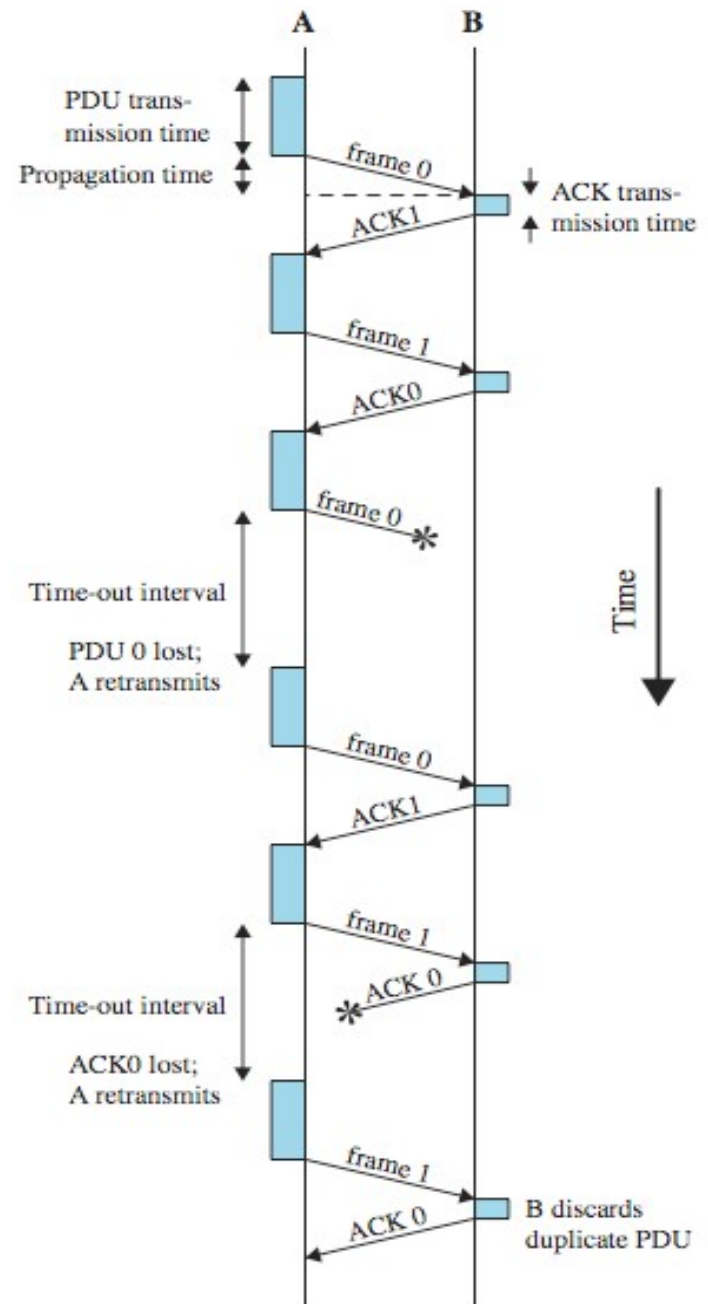
- collective name for such error control mechanisms, including:
- stop and wait
- go back N
- selective reject (selective retransmission)

Stop and Wait

- source transmits single frame
- wait for ACK
- if received frame damaged, discard it
 - transmitter has timeout
 - if no ACK within timeout, retransmit
- if ACK damaged, transmitter will not recognize it
 - transmitter will retransmit
 - receive gets two copies of frame
 - use alternate numbering and ACK0 / ACK1

Stop and Wait

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



Go Back N

- based on sliding window
- if no error, ACK as usual
- use window to control number of outstanding frames
- if error, reply with rejection
 - discard that frame and all future frames until error frame 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 $i+1$ and receiver gets frame $i+1$ out of seq and rejects frame i*
 - *or transmitter times out and send ACK with P bit set which receiver responds to with ACK i*
 - transmitter then retransmits frames from i

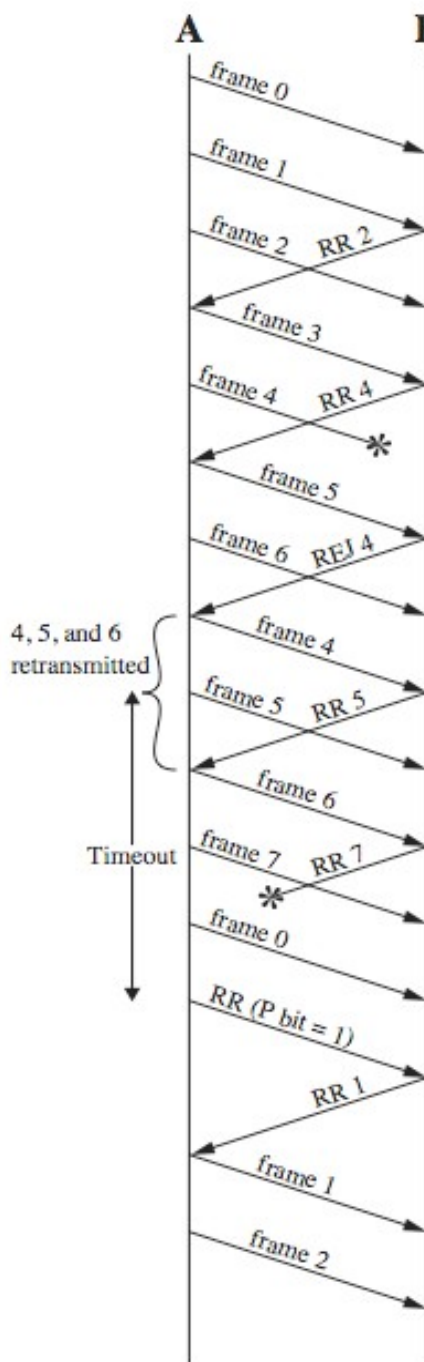
Go Back N - Handling

- 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 for lost frame when transmitter times out

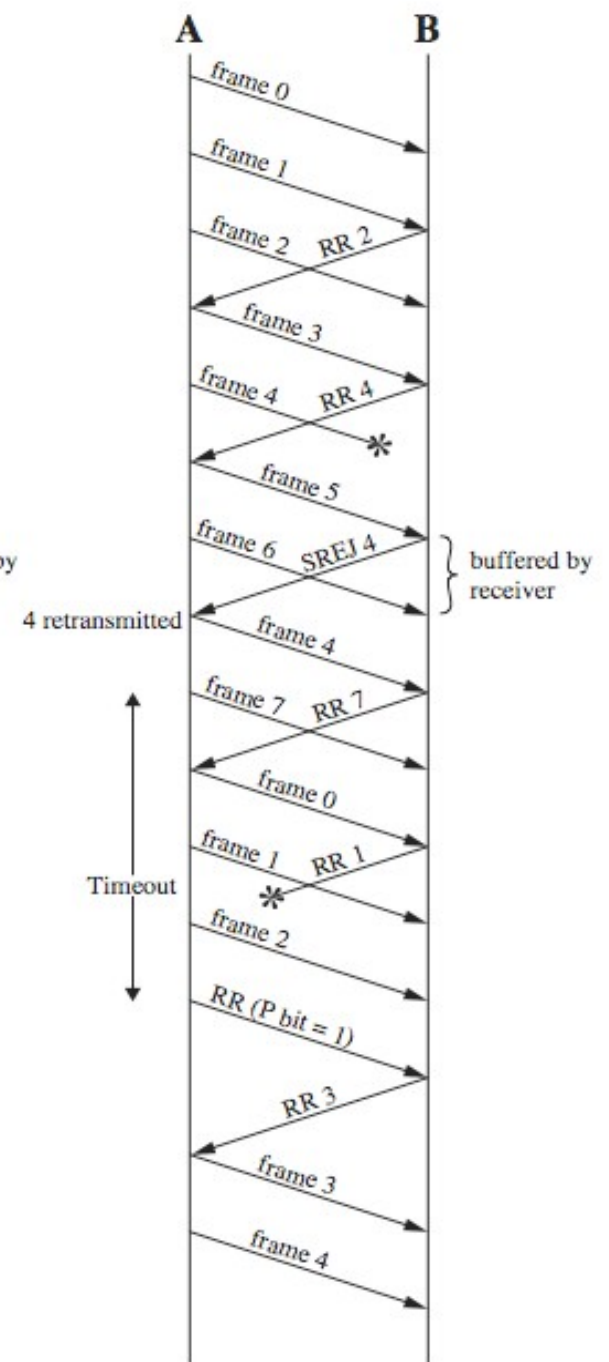
Selective Reject

- 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



(a) Go-back-N ARQ



(b) Selective-reject ARQ

High Level Data Link Control (HDLC)

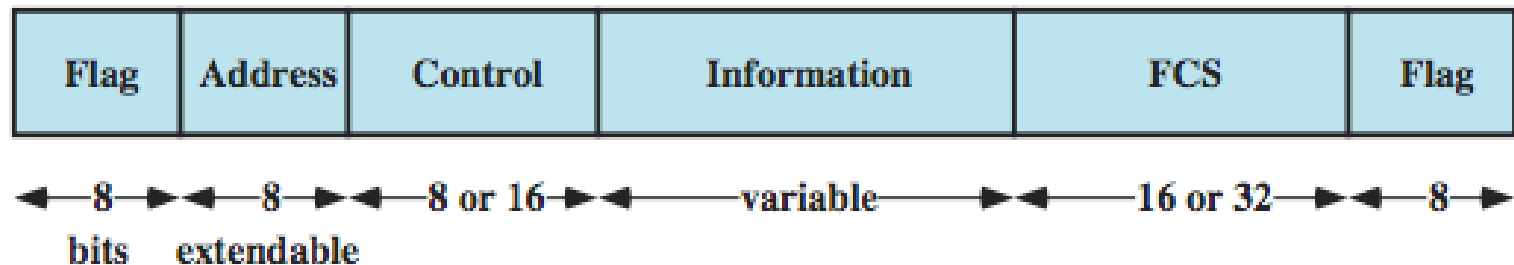
- an important data link control protocol
- specified as ISO 33009, ISO 4335
- station types:
 - Primary - controls operation of link
 - Secondary - under control of primary station
 - Combined - issues commands and responses
- link configurations
 - Unbalanced - 1 primary, multiple secondary
 - Balanced - 2 combined stations

HDLC Transfer Modes

- Normal Response Mode (NRM)
 - unbalanced config, primary initiates transfer
 - used on multi-drop lines, eg host + terminals
- Asynchronous Balanced Mode (ABM)
 - balanced config, either station initiates transmission, has no polling overhead, widely used
- Asynchronous Response Mode (ARM)
 - unbalanced config, secondary may initiate transmit without permission from primary, rarely used

HDLC Frame Structure

- synchronous transmission of frames
- single frame format used



(a) Frame format

Flag Fields and Bit Stuffing

- delimit frame at both ends with 01111110 seq
- receiver hunts for flag sequence to synchronize
- bit stuffing used to avoid confusion with data containing flag seq 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, accept as flag
 - if sixth and seventh bits 1, sender is indicating abort

Original Pattern:

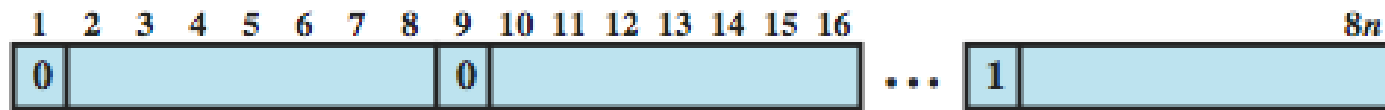
111111111111011111101111110

After bit-stuffing

1111101111101101111101011111010

Address Field

- identifies secondary station that sent or will receive frame
- usually 8 bits long
- may be extended to multiples of 7 bits
 - LSB indicates if is the last octet (1) or not (0)
- all ones address 11111111 is broadcast



(b) Extended Address Field

Control Field

- different for different frame type
 - Information - data transmitted to user (next layer up)
 - *Flow and error control piggybacked on information frames*
 - Supervisory - ARQ when piggyback not used
 - Unnumbered - supplementary link control
- first 1-2 bits of control field identify frame type

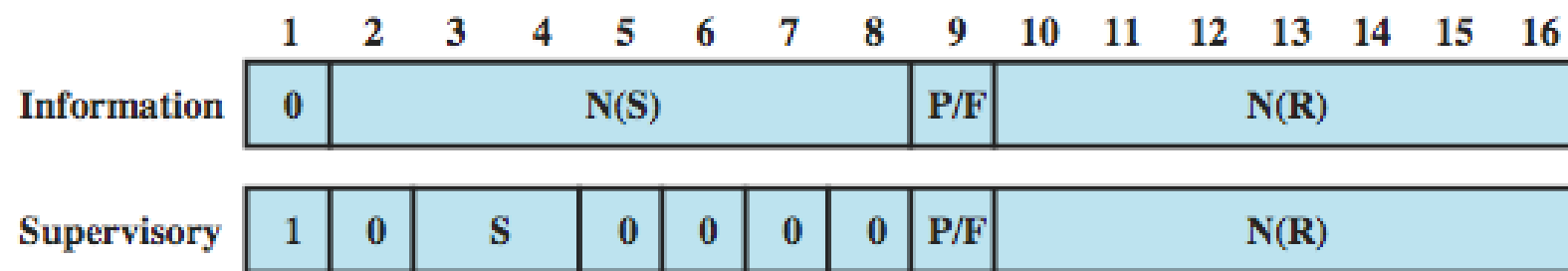
	1	2	3	4	5	6	7	8
I: Information	0	N(S)			P/F	N(R)		
S: Supervisory	1	0	S		P/F	N(R)		
U: Unnumbered	1	1	M		P/F	M		

N(S) = Send sequence number
N(R) = Receive sequence number
S = Supervisory function bits
M = Unnumbered function bits
P/F = Poll/final bit

(c) 8-bit control field format

Control Field

- use of Poll/Final bit depends on context
- in command frame is P bit set to 1 to solicit (poll) response from peer
- in response frame is F bit set to 1 to indicate response to soliciting command
- seq number usually 3 bits
 - can extend to 8 bits as shown below



(d) 16-bit control field format

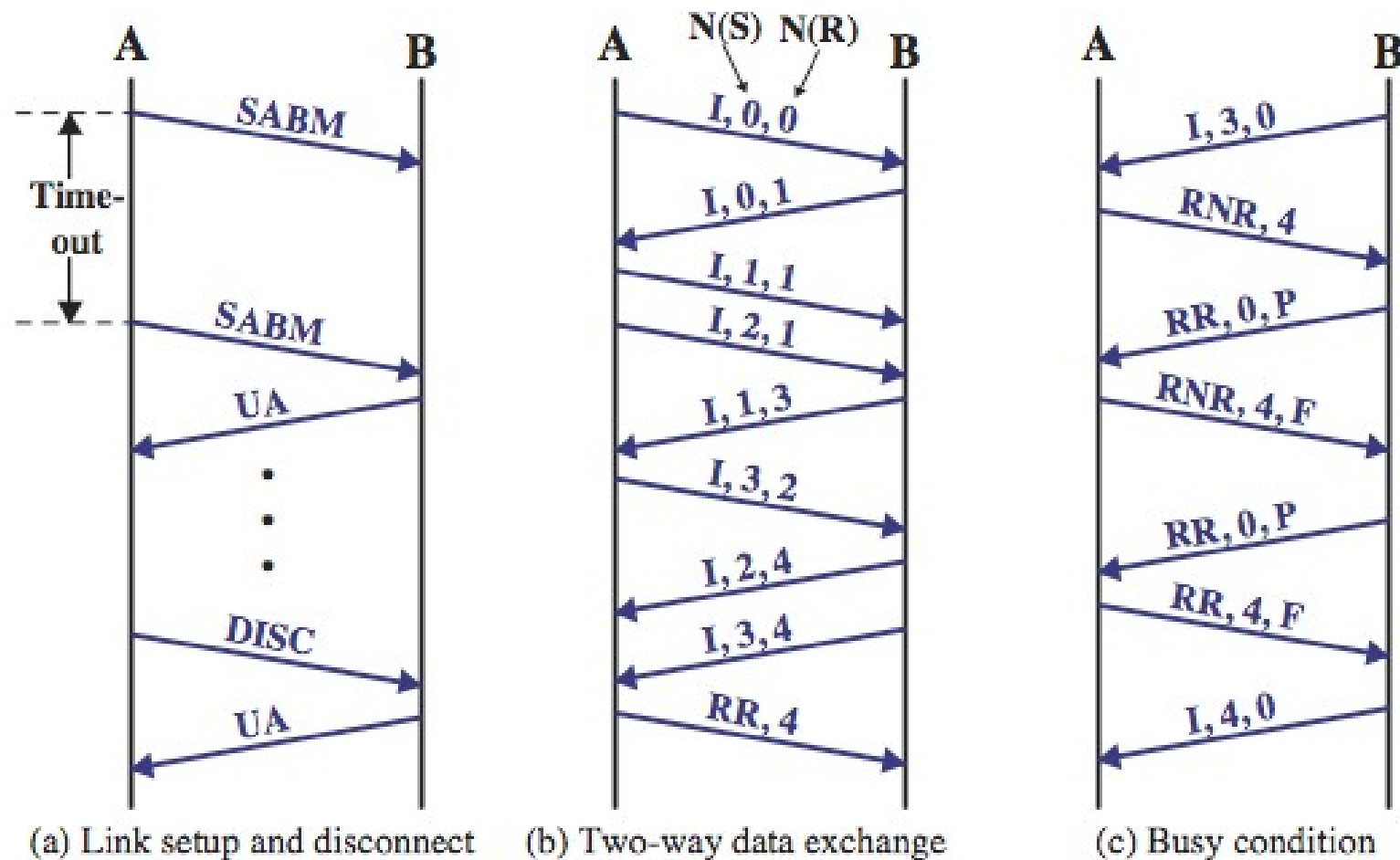
Information & FCS Fields

- Information Field
 - in information and some unnumbered frames
 - must contain integral number of octets
 - variable length
- Frame Check Sequence Field (FCS)
 - used for error detection
 - either 16 bit CRC or 32 bit CRC

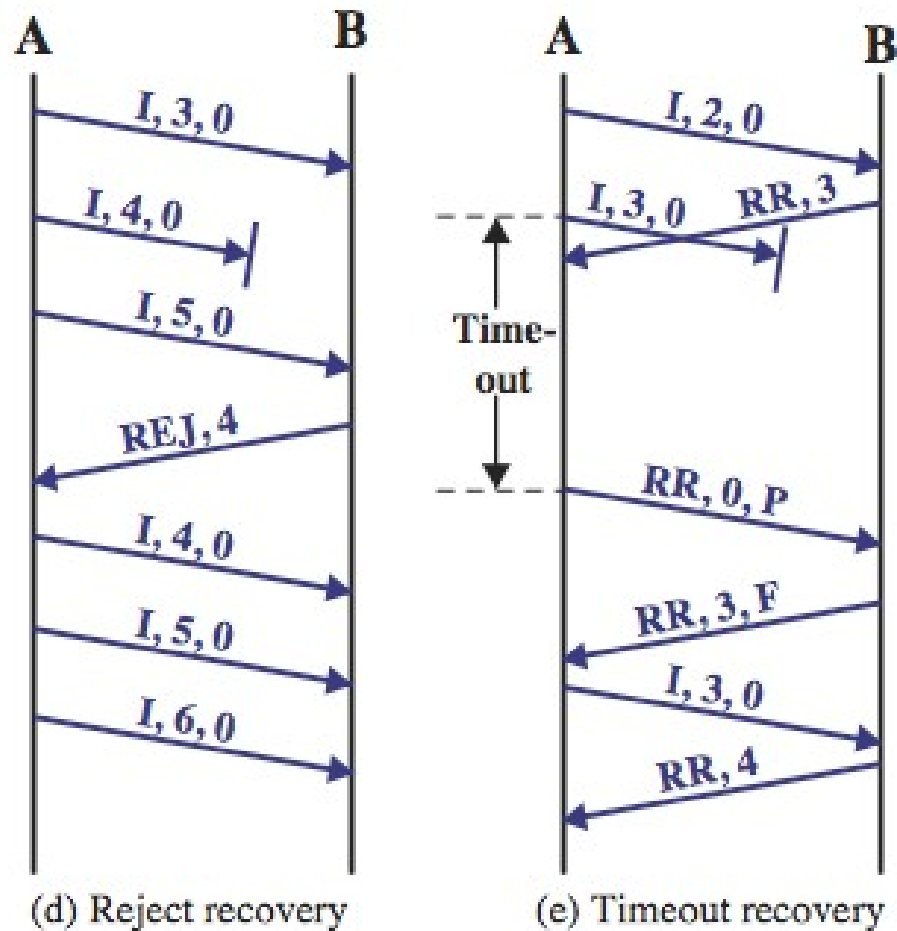
HDLC Operation

- consists of exchange of information, supervisory and unnumbered frames
- have three phases
 - initialization
 - *by either side, set mode & seq*
 - data transfer
 - *with flow and error control*
 - *using both I & S-frames (RR, RNR, REJ, SREJ)*
 - disconnect
 - *when ready or fault noted*

HDLC Operation Example



HDLC Operation Example



Summary

- introduced need for data link protocols
- flow control
- error control
- HDLC