

Data Link Control

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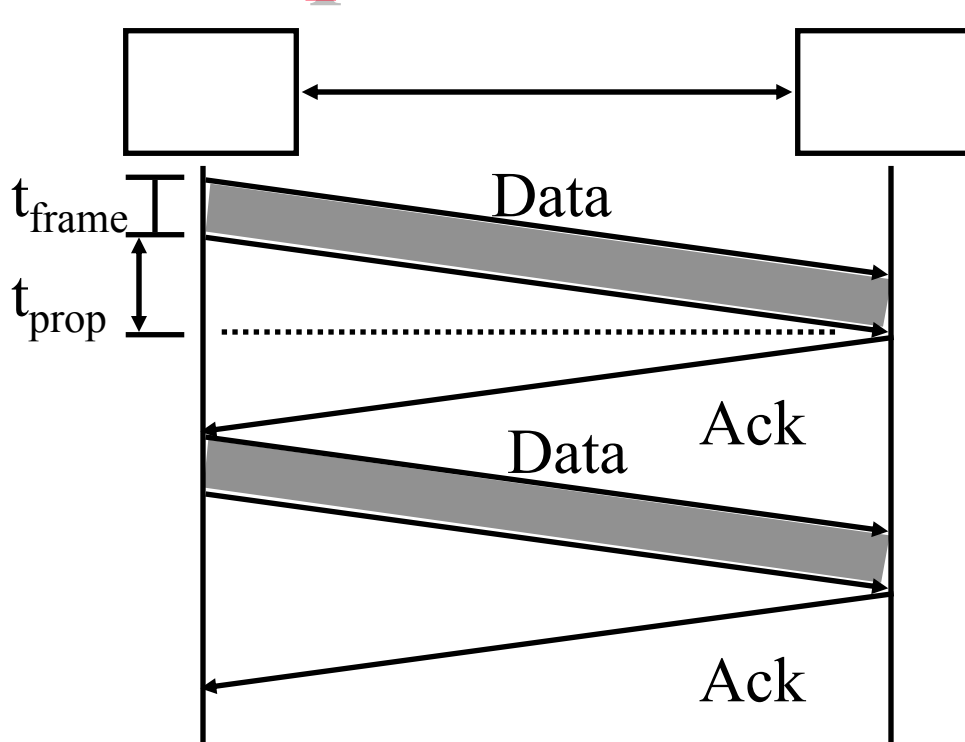


- ❑ Flow Control
- ❑ Effect of propagation delay, speed, frame size
- ❑ Error Control
- ❑ HDLC
- ❑ PPP

Flow Control

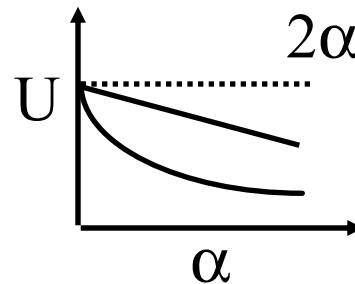
- ❑ Flow Control = Sender does not flood the receiver, but maximizes throughput
- ❑ Sender throttled until receiver grants permission

Stop and Wait Flow Control



$$U = \frac{t_{\text{frame}}}{2t_{\text{prop}} + t_{\text{frame}}}$$

$$= \frac{1}{2\alpha + 1}$$



$$\alpha = \frac{t_{\text{prop}}}{t_{\text{frame}}} = \frac{\text{Distance/Speed of Signal}}{\text{Frame size /Bit rate}}$$

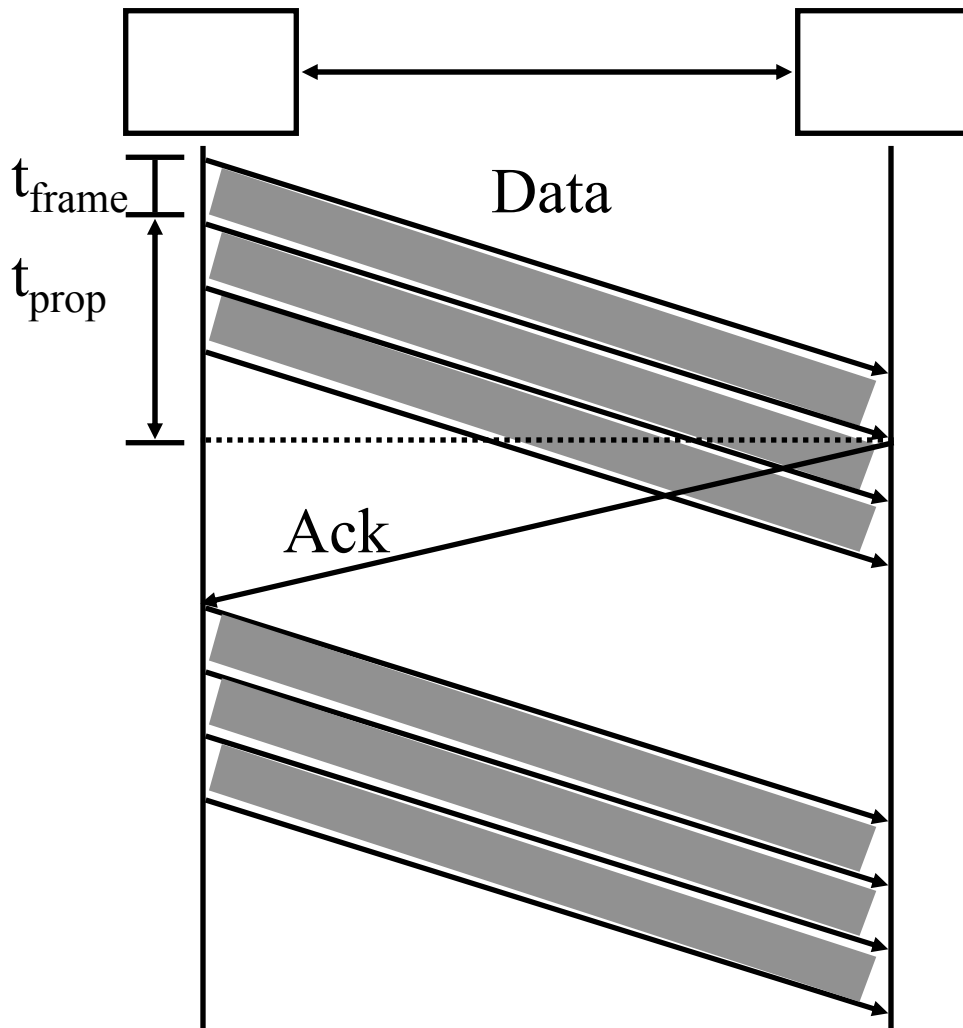
$$= \frac{\text{Distance} \times \text{Bit rate}}{\text{Frame size} \times \text{Speed of Signal}}$$

Light in vacuum
= 300 m/μs
Light in fiber
= 200 m/μs
Electricity
= 250 m/μs

Utilization: Examples

- Satellite Link: Propagation Delay $t_{\text{prop}} = 270$ ms
Frame Size = 4000 bits = 500 bytes
Data rate = 56 kbps $\Rightarrow t_{\text{frame}} = 4/56 = 71$ ms
 $\alpha = t_{\text{prop}}/t_{\text{frame}} = 270/71 = 3.8$
 $U = 1/(2\alpha+1) = 0.12$
- Short Link: 1 km = 5 μ s,
Rate=10 Mbps,
Frame=500 bytes $\Rightarrow t_{\text{frame}} = 4k/10M = 400$ μ s
 $\alpha = t_{\text{prop}}/t_{\text{frame}} = 5/400 = 0.012 \Rightarrow U = 1/(2\alpha+1) = 0.98$

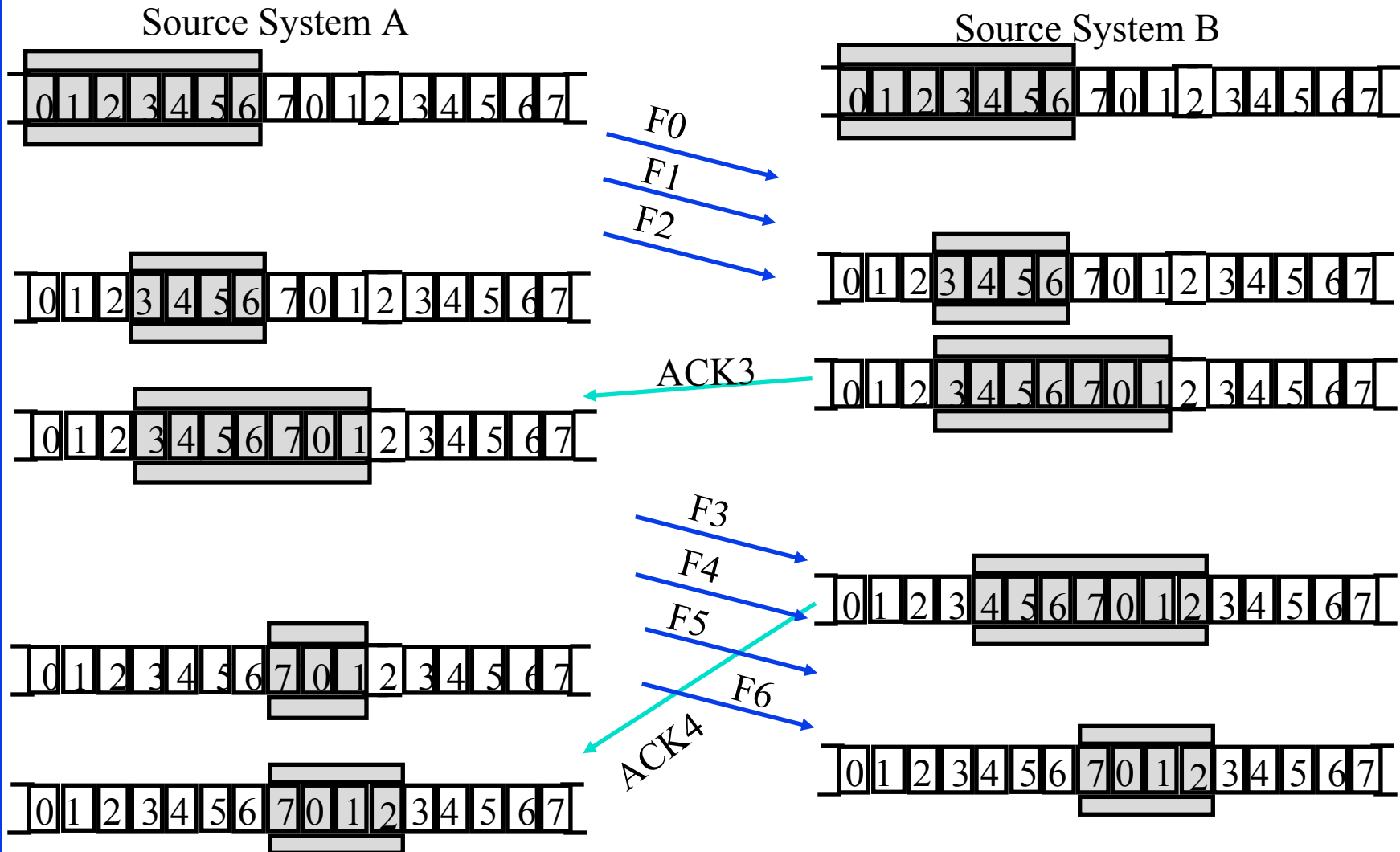
Sliding Window Protocol



$$U = \frac{N t_{\text{frame}}}{2 t_{\text{prop}} + t_{\text{frame}}}$$

$$= \begin{cases} \frac{N}{2\alpha + 1} \\ 1 \text{ if } N > 2\alpha + 1 \end{cases}$$

Sliding Window: Example



Effect of Window Size

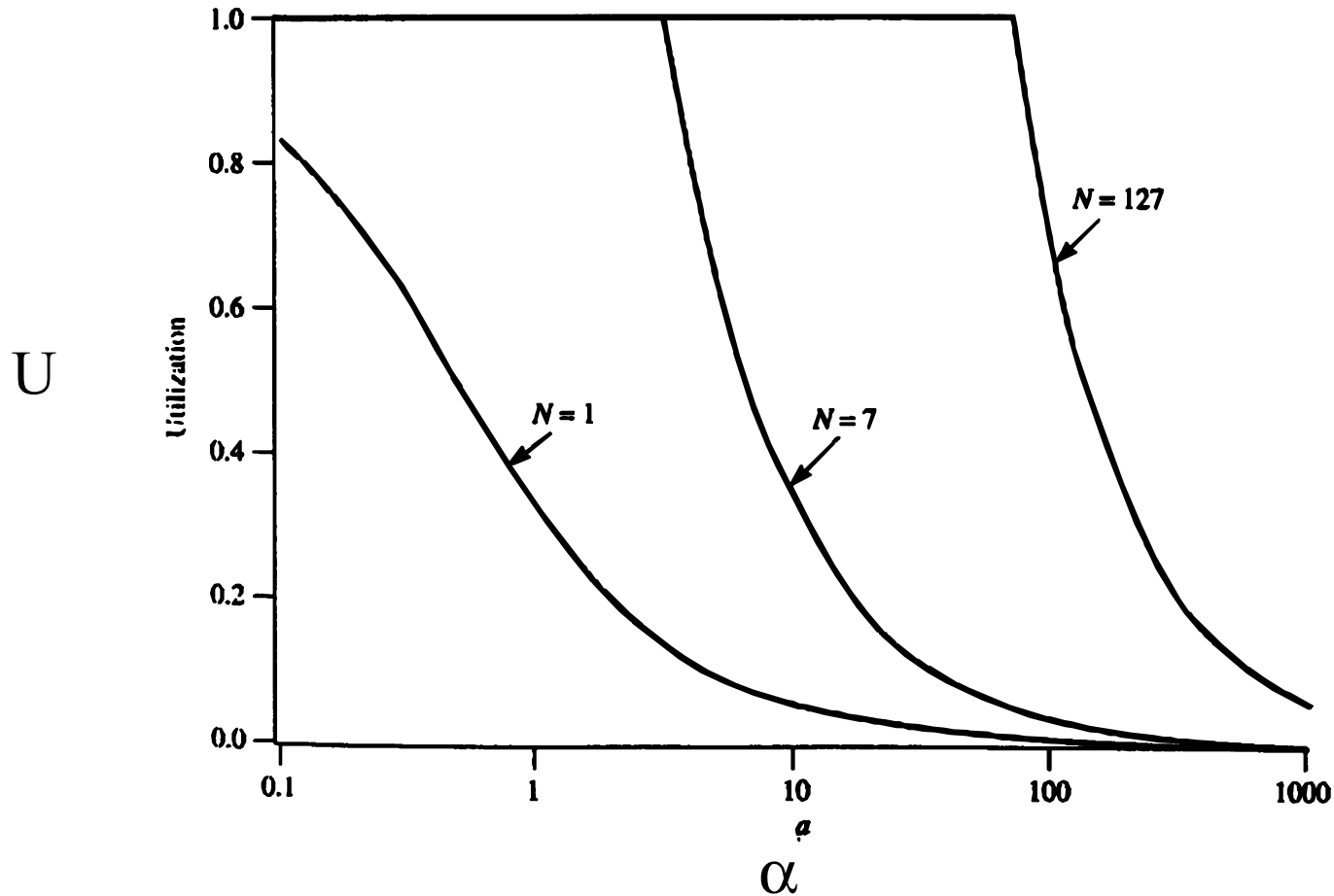
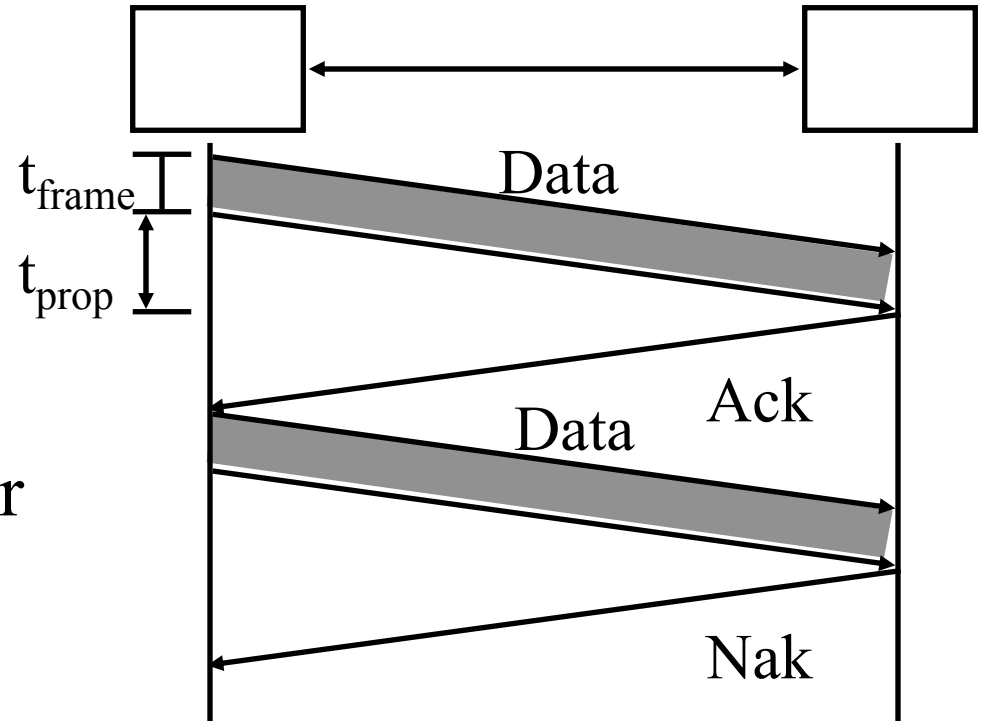


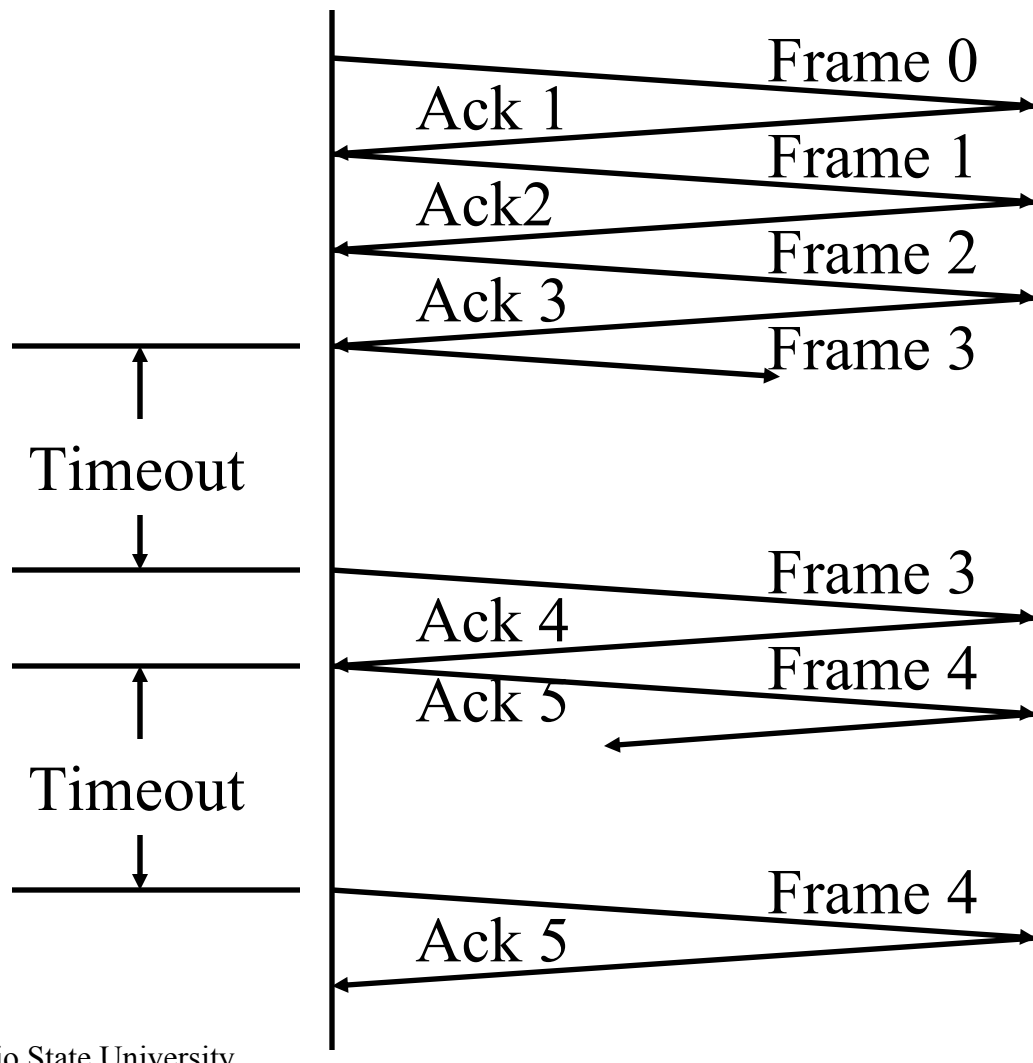
Fig 6.16 Stallings

Error Control

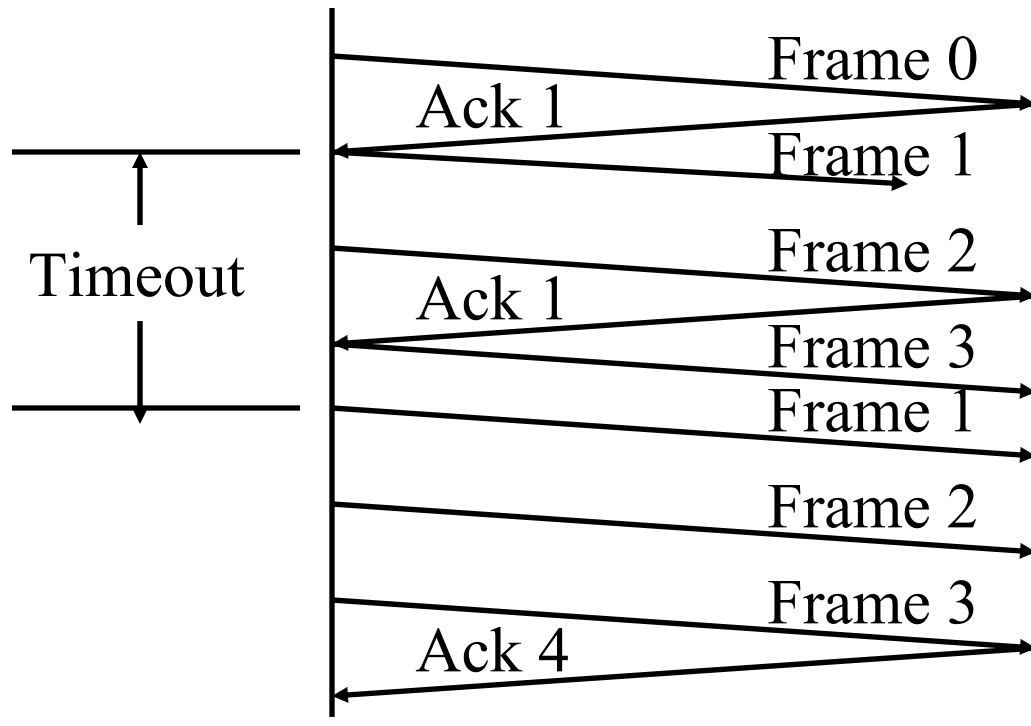
- ❑ Automatic Repeat Request (ARQ)
 - ❑ Error detection
 - ❑ Acknowledgment
 - ❑ Retransmission after timeout
 - ❑ Negative Acknowledgment



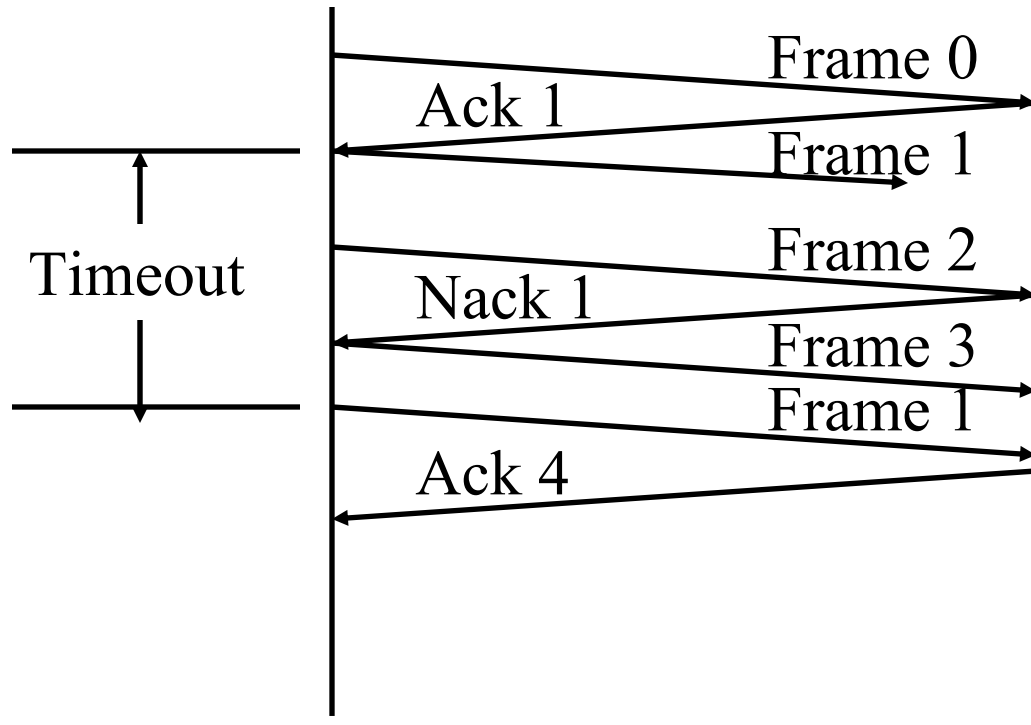
Stop and Wait ARQ



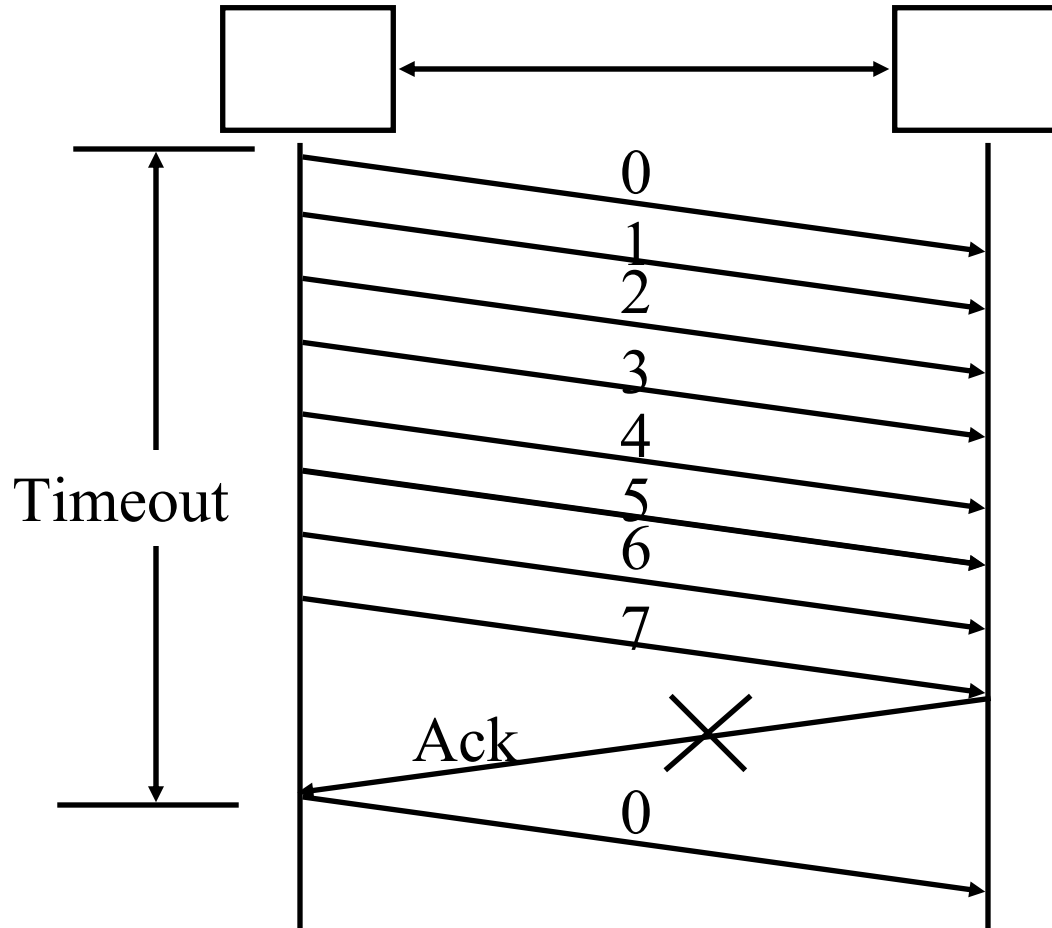
Go-back-n ARQ



Selective Reject ARQ



Selective Reject: Window Size



HDLC Family

- ❑ Synchronous Data Link Control (SDLC): IBM
- ❑ High-Level Data Link Control (HDLC): ISO
- ❑ Link Access Procedure-Balanced (LAPB): X.25
- ❑ Link Access Procedure for the D channel (LAPD): ISDN
- ❑ Link Access Procedure for modems (LAPM): V.42
- ❑ Link Access Procedure for half-duplex links (LAPX): Teletex
- ❑ Point-to-Point Protocol (PPP): Internet
- ❑ Logical Link Control (LLC): IEEE
- ❑ Advanced Data Communications Control Procedures (ADCCP): ANSI
- ❑ V.120 and Frame relay also use HDLC

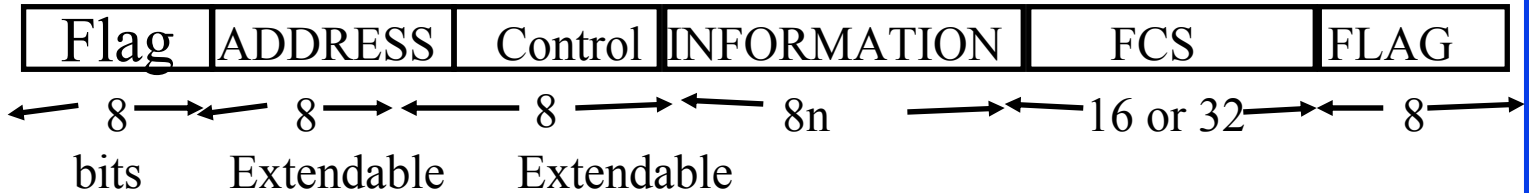
HDLC



- ❑ Primary station: Issue commands
- ❑ Secondary Station: Issue responses
- ❑ Combined Station: Both primary and secondary
- ❑ Unbalanced Configuration: One or more secondary
- ❑ Balanced Configuration: Two combined station
- ❑ Normal Response Mode (NRM): Response from secondary
- ❑ Asynchronous Balanced Mode (ABM): Combined Station
- ❑ Asynchronous Response Mode (ARM): Secondary may respond before command

HDLC Frame Structure

Frame
Format



Control Field Format

	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

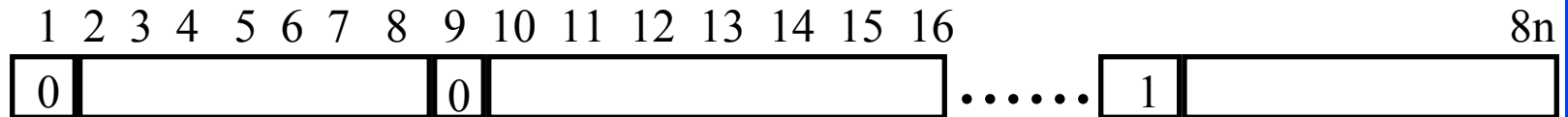
N(R)= Recieve sequence number

S= Supervisory function bits

M= Unnumbered bits

P/F= Poll/final bit

Extended Address Field



Extended Control Field

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Information	0	N(S)						P/F	N(R)							
Supervisory	1	0	S	0	0	0	0	P/F	N(R)							

Fig 6.10 Stallings

Bit Stuffing

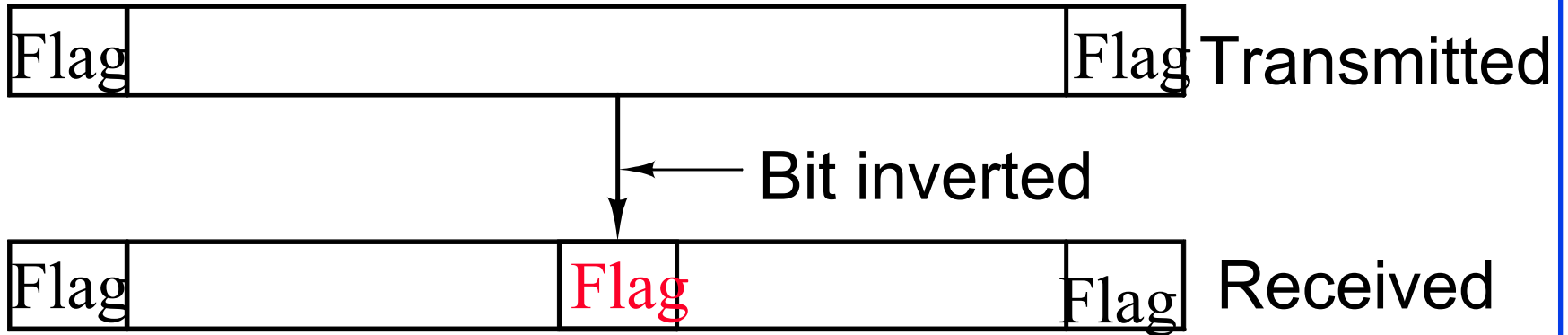
Original Pattern

111111111111011111101111110

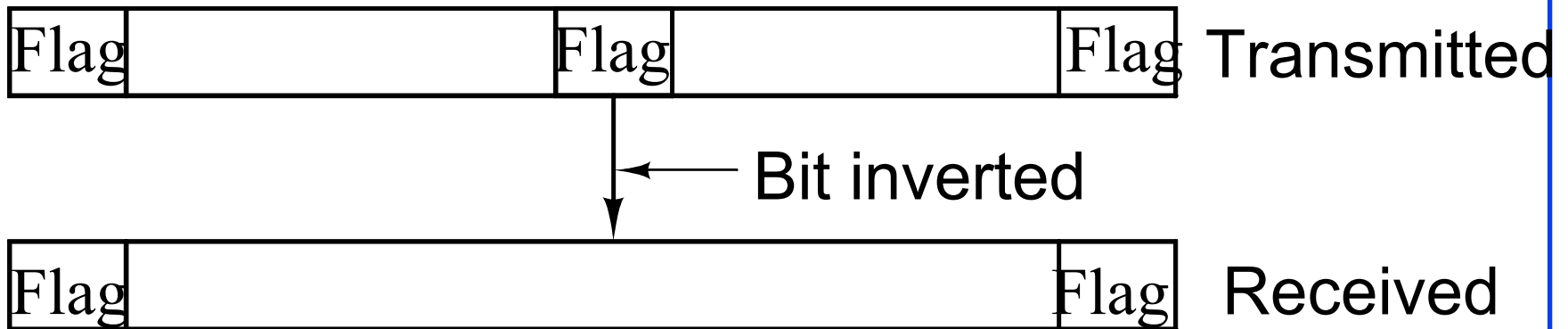
After bit-stuffing

1111101111101101111101011111010
 ↑ ↑ ↑ ↑

Bit Stuffing (Cont)



(b) An inverted bit splits a frame in two



(c) An inverted bit merges two frames

HDLC Frames

- ❑ Information Frames: User data
 - ❑ Piggybacked Acks: Next frame expected
 - ❑ Poll/Final = Command/Response
- ❑ Supervisory Frames: Flow and error control
 - ❑ Go back N and Selective Reject
 - ❑ Final ❑ No more data to send
- ❑ Unnumbered Frames: Control
 - ❑ Mode setting commands and responses
 - ❑ Information transfer commands and responses
 - ❑ Recovery commands and responses
 - ❑ Miscellaneous commands and responses

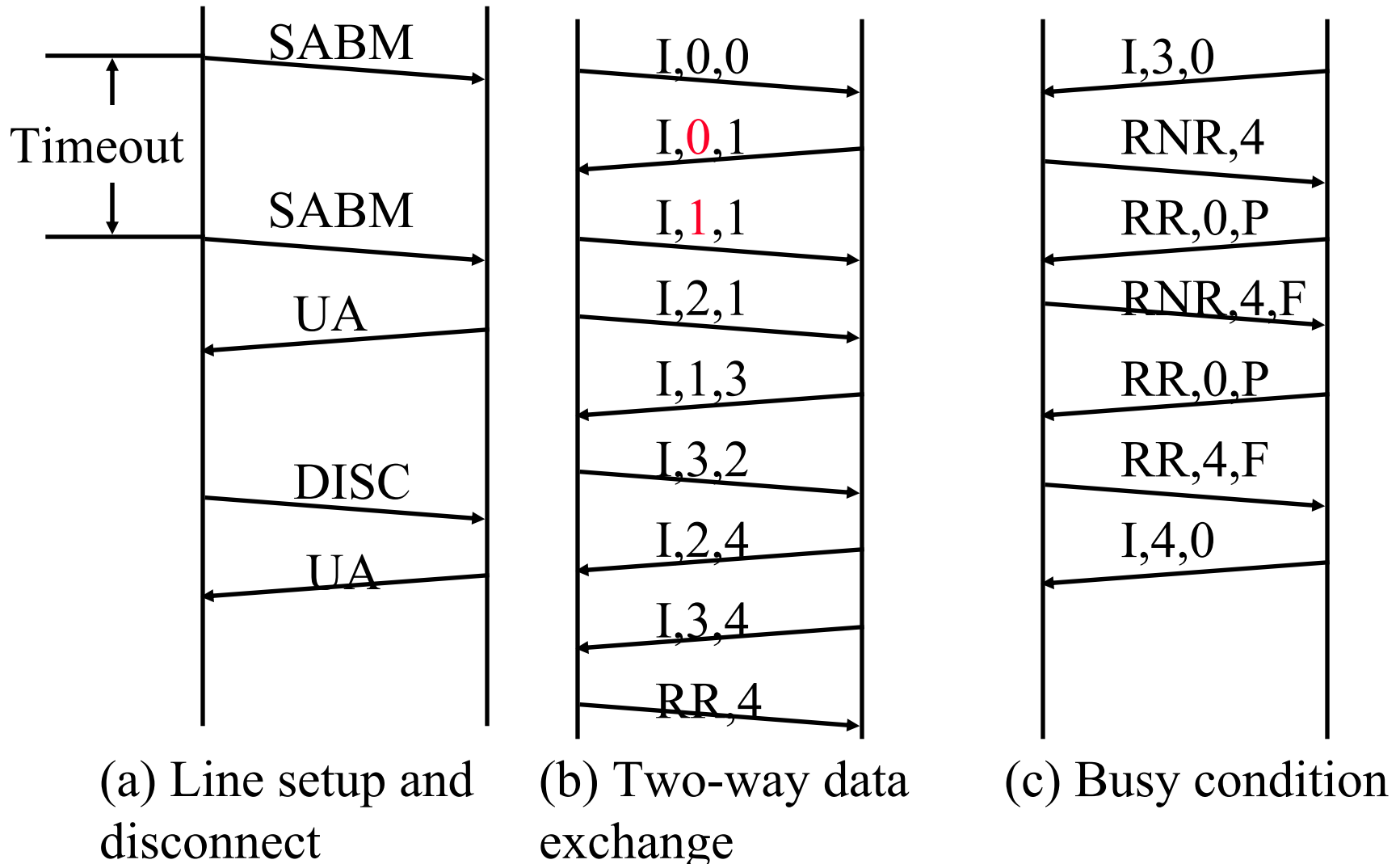
HDLC Commands and Responses

Name	Function	Description
Information (I)	C/R	Exchange user data
Supervisory (S)		
Recieve Ready (RR)	C/R	Positive Acknowledgement; ready to receive I-frame
Recieve Not Ready (RNR)	C/R	Positive acknowledgement; not ready to receive
Reject (REJ)	C/R	Negative acknowledgement; go back N
Selective Reject (SREJ)	C/R	Negative acknowledgement; selective reject
Unnumbered (U)		
Set Normal Response / Extended Mode (SNRM / SNRME)	C	Set mode;extended=two-octet control field
Set Asynchronous Response / Extended Mode (SARM / SARME)	C	Set mode;extended=two-octet control field
Set Asynchronous Balanced / Extended Mode (SABM / SABME)	C	Set mode;extended=two-octet control field
Set Initialization Mode (SIM)	C	Initialize link control functons in addressed station

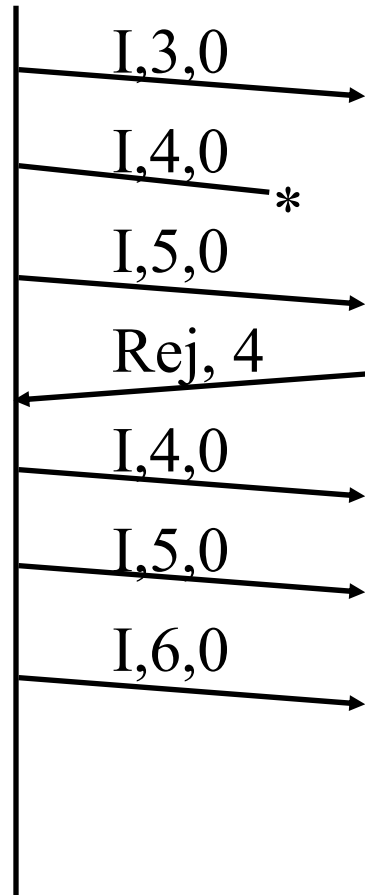
HDLC Commands and Responses (cont)

Name	Function	Description
Disconnect (DISC)	C	Terminate logical link connection
Unnumbered Acknowledgement (UA)	R	Acknowledges acceptance of one of the above set-mode commands
Disconnect Mode (DM)	R	Secondary is logically disconnected
Request Disconnect (RD)	R	Request for DISC command
Request Initialization Mode (RIM)	R	Initialization needed; request for SIM command
Unnumbered Information (UI)	C/R	Used to exchange control information
Unnumbered Poll (UP)	C	Used to solicit control information
Reset (RSET)	C	Used for recovery; resets N(R), N(S)
Exchange Identification (XID)	C/R	Used to request/report identity and status
Test (TEST)	C/R	Exchange identical information fields for testing
Frame Reject (FRMR)	R	Reports receipt of unacceptable frame

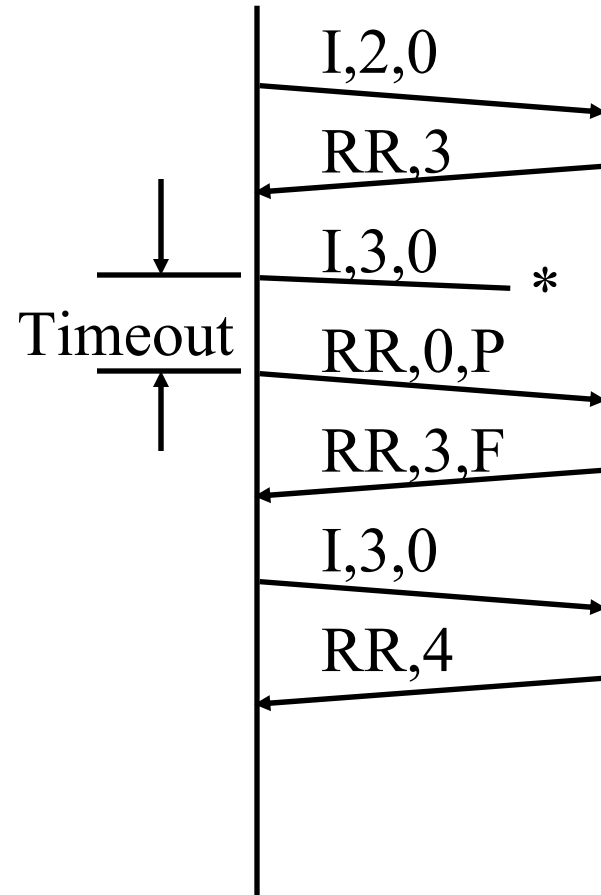
Examples of HDLC Operation



Examples of Operation (Cont)



(d) Reject Recovery

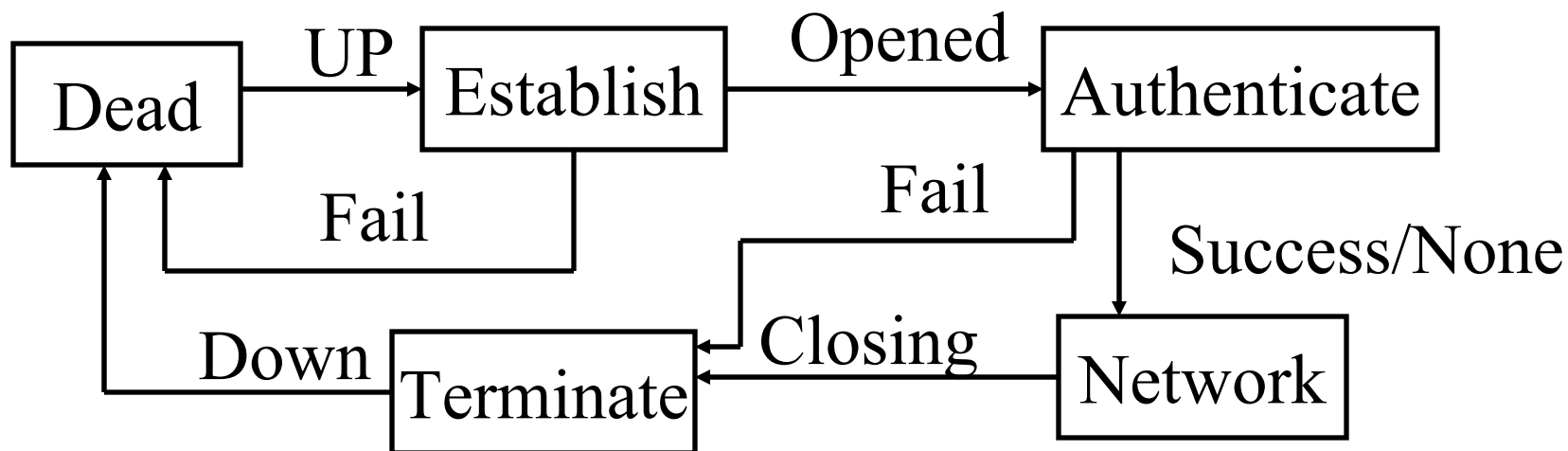


(e) Timeout Recovery

Fig 6.12 Stallings

PPP: Introduction

- ❑ Point-to-point Protocol
- ❑ Originally for User-network connection
- ❑ Now being used for router-router connection
- ❑ Three Components: Data encapsulation, Link Control Protocol (LCP), Network Control Protocols (NCP)



PPP Procedures

- Typical connection setup:
 - Home PC Modem calls Internet
Provider's router: sets up physical link
 - PC sends series of LCP packets
 - + Select PPP (data link) parameters
 - + Authenticate
 - PC sends series of NCP packets
 - + Select network parameters
E.g., Get dynamic IP address
- Transfer IP packets

PPP in HDLC-Like Framing

Flag	Address	Control	Protocol
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01111110 11111111 00000011

Info	Padding	CRC	Flag
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- ❑ Flag = 0111 1110 = 7E
- ❑ Byte Stuffing:
 - 7E \Rightarrow 7D 5E
 - 7D \Rightarrow 7D 5D

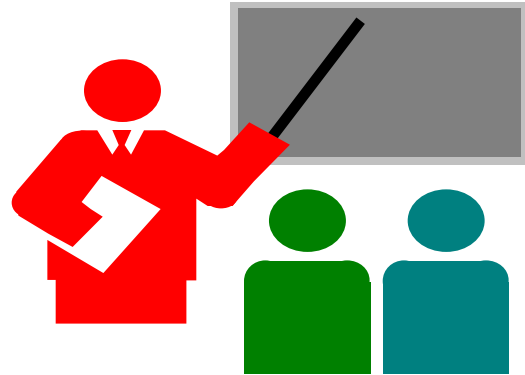
Framing (Cont)

- ❑ Address=FF \Rightarrow All stations
- ❑ Control=03 \Rightarrow Unnumbered
Poll/final = command/response = 0 \Rightarrow Response
- ❑ Protocol = 8/16 bits. lsb=1 of LSB \Rightarrow End of address
All protocols are odd and lsb of MSB = 0
- ❑ Packets may be padded up to MRU.
Maximum receive unit = 1500 default
- ❑ 16-bit FCS default
32-bit FCS can be negotiated using LCP
- ❑ HDLC Shared zero mode:
011111101111110 = Flag-Flag. Not used in PPP

LCP Config Options

- ❑ Maximum Receive Unit
- ❑ Authentication Protocol: C0 23 \Rightarrow Password
C2 23 \Rightarrow Challenge Handshake
- ❑ Quality Protocol: C025 \Rightarrow Will expect link reports
- ❑ Magic Number: To related responses with requests
Randomly number in sequence of the request
Helps detect looped back links
- ❑ Protocol Field Compression:
Only one byte is used even for 2-byte protocols
- ❑ Address and Control Field Compression:
FF03 is not transmitted. CRC is on compressed frame.

Summary



- ❑ Flow Control: Stop and Wait, Sliding window
- ❑ Effect of propagation delay, speed, frame size
- ❑ Error Control: Stop and wait ARQ, Go-back-N, Selective Reject
- ❑ HDLC: Bit stuffing, Flag, I-Frame, RR, RNR