HDLC & PPP

1) The High-Level Data Link Control (HDLC) protocol defines a number of types of frames shown in figure 1). Explain I) the general layout of HDLC frames, II) the use of the frame types to implement flow control concepts such as Stop-and-Wait ARQ and Selective Repeat ARQ, and III) the terms piggybacking and bit stuffing.

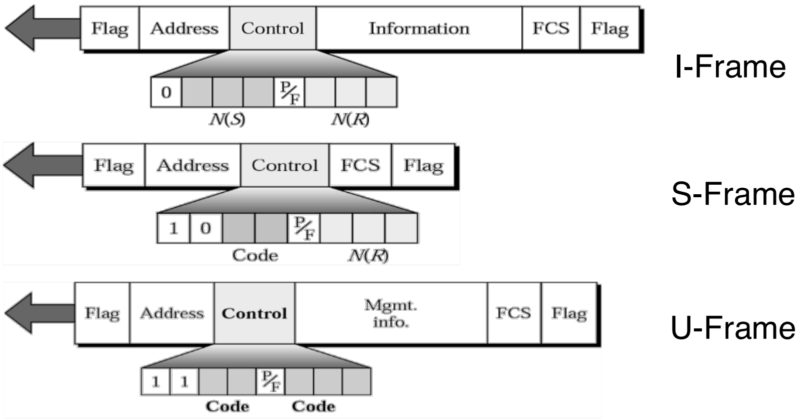
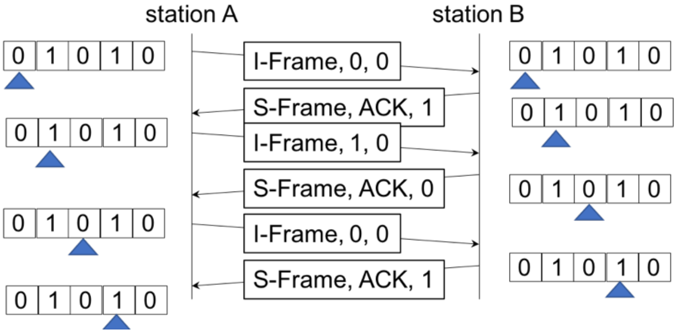


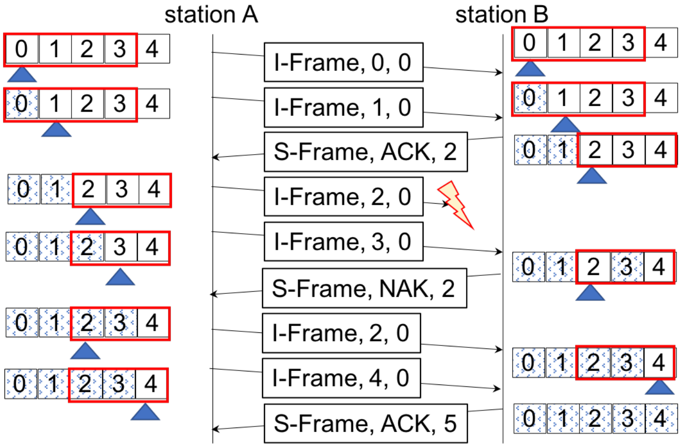
Figure 1: Types of HDLC frames

I) A HDLC frame consist of a flag byte at the beginning and at the end, an address field, a control byte and a CRC – I- and U-frames may carry a payload following the control byte. The first two bits of the control byte decide the type of the frame i.e. if the first bit is 0 the frame is an I-frame, if the first bit is 1 and the second bit 0, the frame is a S-frame and if the two first bits are 1, the frame is an U-frame. The I-frame carries user information and uses 3 bits in the control byte as sequence number for the sender and 3 bits as sequence number for an acknowledgement i.e. to indicate the frames that receiver has received. The S-frame is used to implement acknowledgements (ACKs) and negative acknowledgements (NAKs) by using the last 3 bits of the control byte as sequence number for ACKs and NAKs. The code in the control byte of the S-Frame indicates the type of ACK/NAK. U-Frames are used to handle connection managements i.e. to establish or tear down a connection.
The address field will contain the destination address if the frame transmitted by a primary station or the source address if the frame is transmitted by a slave station.

II) For Stop&Wait, the sender will send I-frames, carrying the sequence number of the frame, and the receiver will respond to this with an S-frame carrying an acknowledgement.



For Selective Repeat, I-frames will carry sequence numbers of the frame and the receiver will reply with S-frames either as acknowledgements or negative acknowledgements. On the transmission and reception of an acknowledgement, the station A and station B will move their windows forward to the sequence number indicated in the acknowledgement.



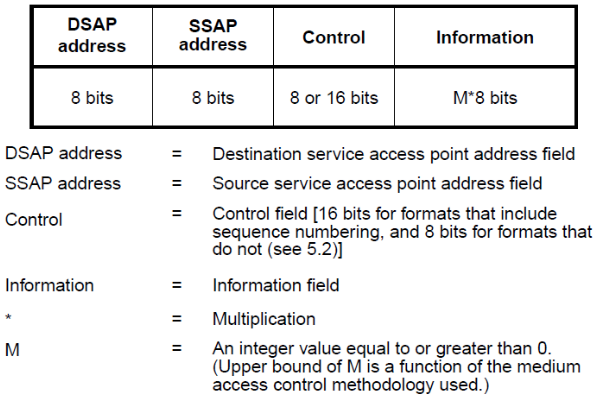
III) Bitstuffing: Process of preventing the sender from transmitting data that are equivalent to the indication of the start of the frame e.g. flag byte. For example if the flag byte consist of 01111110, the transmitter will add a 0 whenever it finds 011111 in the data to be transmitted and the receiver will remove a 0 if it is preceded by 011111.
Piggy-Backing: Frames carrying a sequence number from the sender as well as the next expected sequence number of the receiver as acknowledgement.

2) Assume that station 00001100 will send a 200 byte response using HDLC. Write out the complete frame for HDLC. Where information such as sequence numbers, etc is not given, choose a number and explain your choice.

I assume that the frame will have the sequence number 1 and acknowledge that everything has been received up to sequence number 3.

01111110	00001100	00010011	<200 bytes>	011001110 0110110011	01111110
Flag	Address	Control byte	Payload	Checksum	Flag

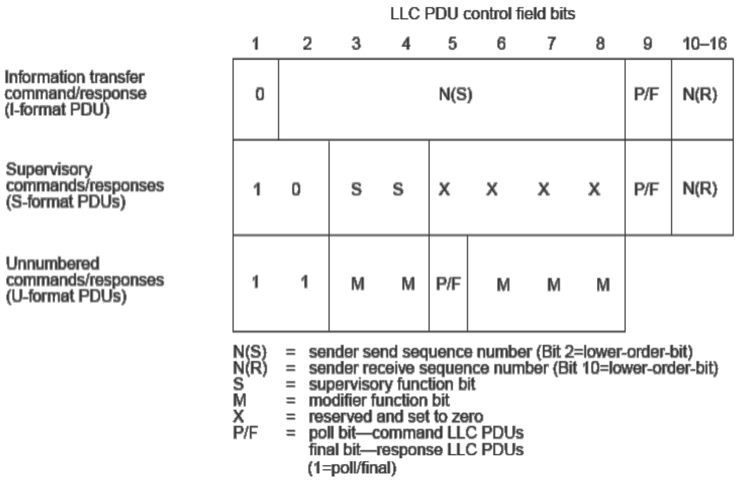
3) The IEEE 802.2 Logical Link Control (LLC) provides a slim layer on top of various IEEE 802 protocols using a similar format for its protocol data unit (PDU) as HDLC. Discuss the difference between the control fields of the two protocols and effect of this difference for LLC.



DSAP address	SSAP address	Control	Information
8 bits	8 bits	8 or 16 bits	M*8 bits

DSAP address	=	Destination service access point address field
SSAP address	=	Source service access point address field
Control	=	Control field [16 bits for formats that include sequence numbering, and 8 bits for formats that do not (see 5.2)]
Information	=	Information field
*	=	Multiplication
M	=	An integer value equal to or greater than 0. (Upper bound of M is a function of the medium access control methodology used.)

Figure 2: LLC PDU format



LLC PDU control field bits

	1	2	3	4	5	6	7	8	9	10–16
Information transfer command/response (I-format PDU)	0	N(S)							P/F	N(R)
Supervisory commands/responses (S-format PDUs)	1	0	S	S	X	X	X	X	P/F	N(R)
Unnumbered commands/responses (U-format PDUs)	1	1	M	M	P/F	M	M	M		

N(S)	=	sender send sequence number (Bit 2=lower-order-bit)
N(R)	=	sender receive sequence number (Bit 10=lower-order-bit)
S	=	supervisory function bit
M	=	modifier function bit
X	=	reserved and set to zero
P/F	=	poll bit—command LLC PDUs final bit—response LLC PDUs (1=poll/final)

Figure 3: Logical Link Control PDU fields

In comparison to HDLC, the control field may consist of 16 bits instead of 8 bits, allowing for sequence numbers of 7 bits for LLC instead of 3 bits for HDLC i.e. LLC allows for sequence numbers from 0 to 127, instead of 0 to 7 for HDLC. As a consequence, 127 frames – in contrast to 7 – may be send using Go-Back-N before a window is exhausted and an acknowledgement is required to move the window forward. Similarly, 64 frames – in contrast to 4 frames – may be send using Selective Repeat before an acknowledgement is required.
So, LLC introduces an additional byte of overhead for every frame but allows to transmit significantly more frames before requiring acknowledgements, making it more suitable for reliable connections where a sender can exploit available bandwidth before having to wait for a reaction from receiver.

4) The Point-to-Point Protocol (PPP) uses a lifecycle shown in the state diagram in figure 2. Draw a diagram that associates the frames exchanged between to endpoints as every step in the state diagram.

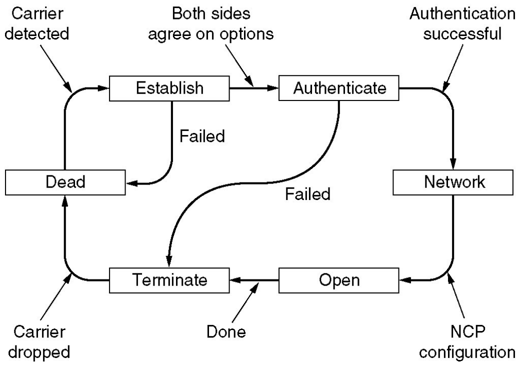


Figure 4: PPP State diagram

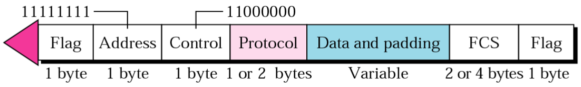


Figure 5: PPP Frame Layout

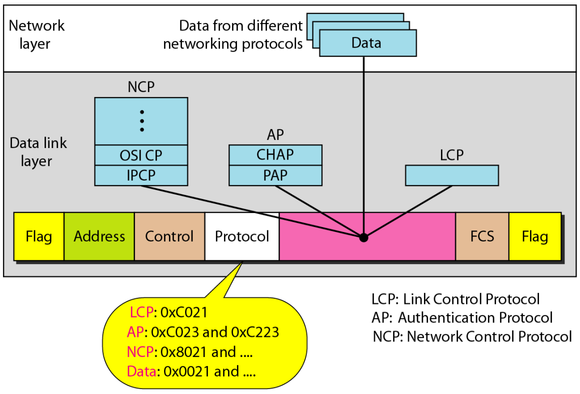
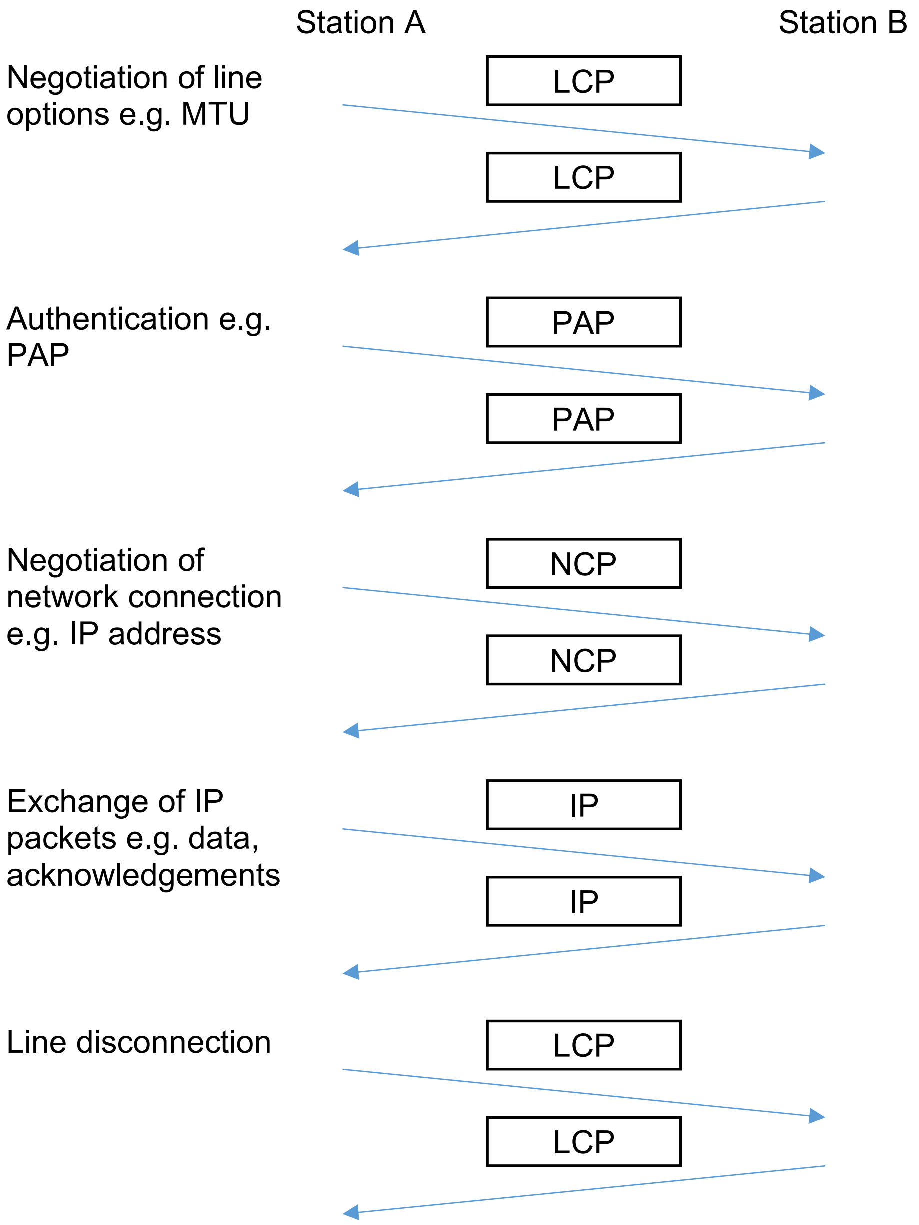


Figure 6: PPP Protocol byte

Every frame in PPP will have the following format:
01111110 11111111 11000000 <Protocol> <Data> <FCS> 01111110

Ignoring Data and FCS checksum fields because they will be specific to every frame and connection, the frames will be

Protocol Field		
0xC021	LCP	01111110 11111111 11000000 11000000 00100001 data fcs 01111110
0xC023	PAP	01111110 11111111 11000000 11000000 00100011 data fcs 01111110
0x8021	NCP	01111110 11111111 10000000 11000000 00100001 data fcs 01111110
0x0021	IP	01111110 11111111 11000000 00000000 00100001 data fcs 01111110



Station A

Station B

Negotiation of line options e.g. MTU

LCP

LCP

Authentication e.g. PAP

PAP

PAP

Negotiation of network connection e.g. IP address

NCP

NCP

Exchange of IP packets e.g. data, acknowledgements

IP

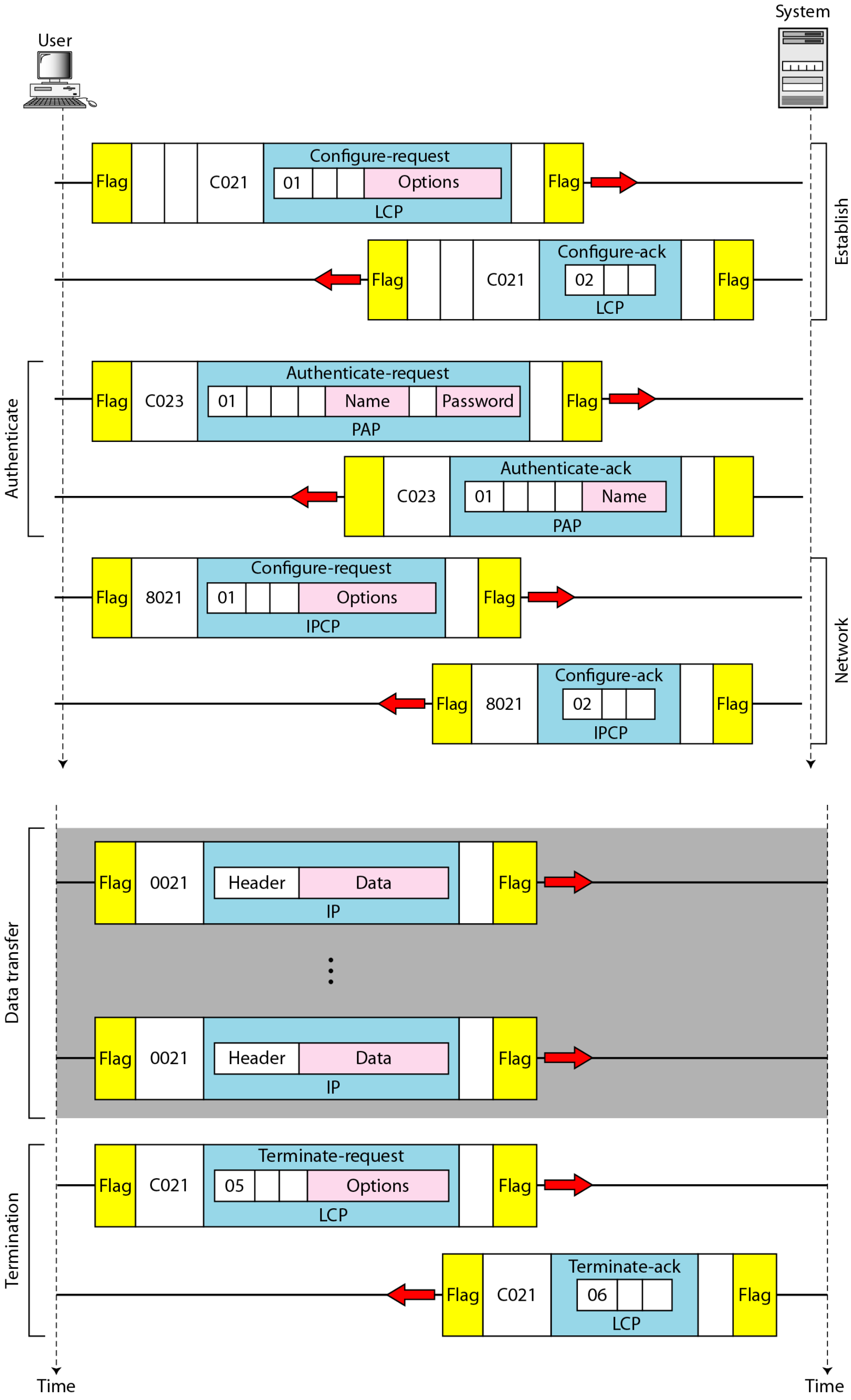
IP

Line disconnection

LCP

LCP

Or from Forouzan:


User
System
Flag
C021
Configure-request
01
Options
LCP
Flag
Flag
C021
Configure-ack
02
LCP
Flag
Establish
Flag
C023
Authenticate-request
01
Name
Password
PAP
Flag
C023
Authenticate-ack
01
Name
PAP
Authenticate
Flag
8021
Configure-request
01
Options
IPCP
Flag
Flag
8021
Configure-ack
02
IPCP
Flag
Network
Flag
0021
Header
Data
IP
Flag
Flag
0021
Header
Data
IP
Flag
Data transfer
Flag
C021
Terminate-request
05
Options
LCP
Flag
Flag
C021
Terminate-ack
06
LCP
Flag
Termination
Time
Time