Course Plan			
Module	**Contents**	**Hours**	**End Sem. Exam Marks**
II	Data Link layer Design Issues – Flow Control and ARQ techniques. Data link Protocols – HDLC. DLL in Internet. MAC Sub layer – IEEE 802 FOR LANs & MANs, IEEE 802.3, 802.4, 802.5. Bridges - Switches – High Speed LANs - Gigabit Ethernet. Wireless LANs - 802.11 a/b/g/n, 802.15.PPP	**08**	**15%**

Data Link Layer Design Issues

The data link layer has a number of functions to carry out. The functions include providing a well defined service interface to the network layer, determining how the bits of the physical layer are grouped to frames.

The design issues of the data link layer are given below

1. Services provided to the Network Layer: The function of the data link layer is to provide services to the network layer. The principle service is transferring data from the network layer on the source machine to the network layer in the destination machine.
   The actual service offered can vary from system to system. Three reasonable possibilities that commonly provide are :
   1. Unacknowledged Connectionless Service: Source machine send independent frames to the destination machine without expecting any reply from the destination machine.
   2. Acknowledged Connectionless Service: Source machine send independent frames to the destination machine expecting reply from the destination machine. Frames are individually acknowledged. Here reliability is high.
   3. Acknowledged Connection Oriented Services: Here Connection is first established between source and receiver. Source machine send independent frames to the destination machine expecting reply from the destination machine. Frames are individually acknowledged.
2. Framing
   Data link layer groups bits to frames so that each frame is distinguishable from one another. Format is as follows.

Flag	Header	Data	Trailer	Flag

Fig: Frame Format

Here sender address and destination address is also attached. The source address helps the recipient acknowledge the receipt; the destination address defines where the packet is to go.

i) Fixed size framing: boundaries of the frame is already defined here. For eg., the size of the frame is set as delimiter.

ii) Variable size framing:boundaries of the frame is not defined here. Two approaches used here are

   a) Character oriented protocol

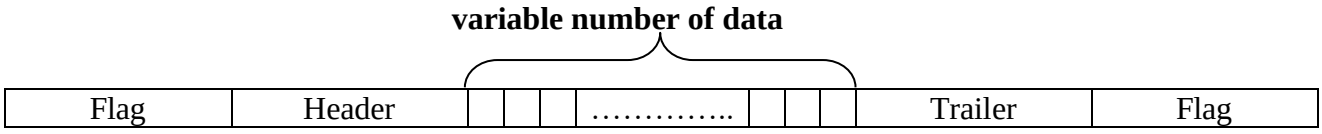

Fig: Frame Format in character oriented protocol

Character oriented protocol carries data as 8-bit ASCII characters. Flags, header,trailer are also carried as 8 bits or its multiples.

b) Bit oriented protocols

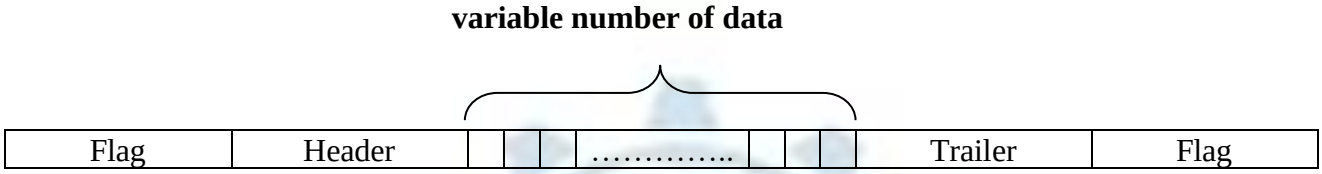

Fig: Frame Format in bit oriented protocol

Bit oriented protocols carries data as a sequence of bits. Flags, header, trailer are also carried as 8 bits or its multiples. Flags use a special pattern like 01111110 which is used as a delimiter to define the beginning and end of frame.

3. Flow Control: flow control is a set of procedures that tells the sender how much data it can transmit before it must wait for an acknowledgment from the receiver. Any receiving device has a limited speed at which it can process incoming data and a limited amount of memory in which it can store incoming data. The receiving device must be able to inform the sending device before those limits are reached and to request that the transmitting device send fewer frames or stop temporarily.

Two approaches used are

i) Feedback based flow control: Receiver send back the sender information regarding permission to send more data.

ii) Rate based flow control: There is a built in mechanism that limits the rate at which the sender may transmit data without any feedback from the receiver.
Two categories of flow control are:
   a. Stop and wait
   b. Sliding window

4. Error control: Error control provides error correction and detection. Some algorithms are implemented such as checksum in error detection and correction.

PROTOCOLS

Different types of protocols are as follows:

PROTOCOLS

1) NOISELESS CHANNEL
   a) Simplest protocol
   b) Stop and wait protocol
2) NOISY CHANNEL
   i) Stop and wait ARQ
   ii) Go-Back-N ARQ
   iii) Selective Repeat ARQ

Simplest Protocol

In simplest protocol sender sends frames and it is received by the receiver.

Stop and wait Protocol

In stop and wait protocol the source sends a frame received by the receiver, which sends an acknowledgment which is received by the sender and then sends the next frame. Sender repeats this process until sender sends an end of transmission frame (EOT). The process is illustrated below

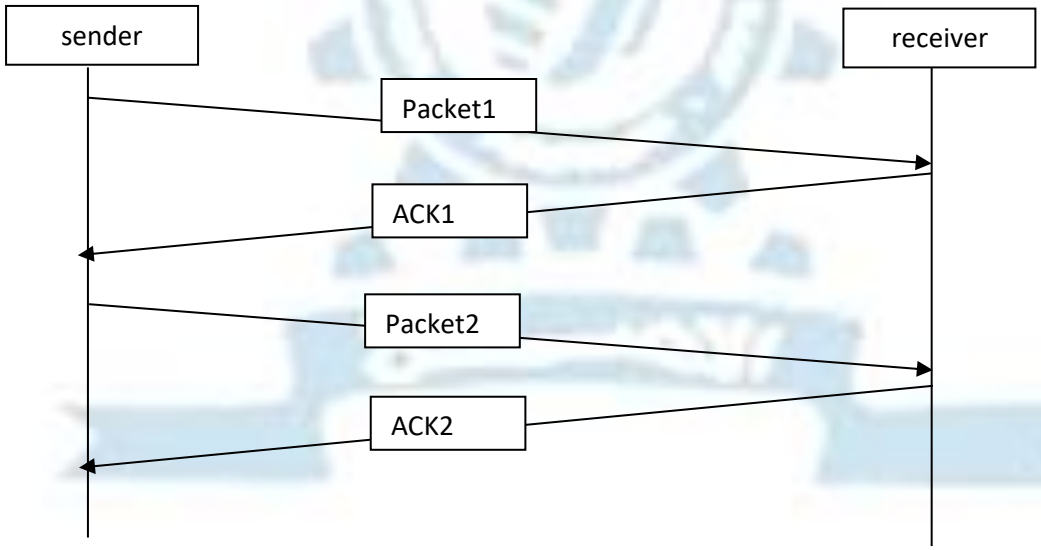

Fig: Stop and Wait Protocol

Advantages of stop and wait protocol

1. Simple
2. Error detection is easy due to its small size of frames

Disadvantages of stop and wait protocol

1. Only single frame is transmitted which wastes the sender time
2. Throughput is very poor and the and the channel is not utilized efficiently.

Stop and Wait ARQ

- Automatic Repeat Request(ARQ) is an error control method for data transmission that uses acknowledgements and timeouts(specified period of time allowed to resend the frame before an acknowledgment is received).
- ARQ maintains reliable data transmission over an unreliable service.
- Stop and wait ARQ is a form of stop and wait protocol which includes retransmission of data in case of lost or damaged frames.
- The sending device keeps a copy of the last frame transmitted until it receives an acknowledgement for that frame. Keeping a copy allows the sender to retransmit lost or damaged frames until they are received correctly.
- If an error is discovered in a data frame indicating that it has been corrupted then NAK frame is returned which tells the sender to retransmit the last frame sent.

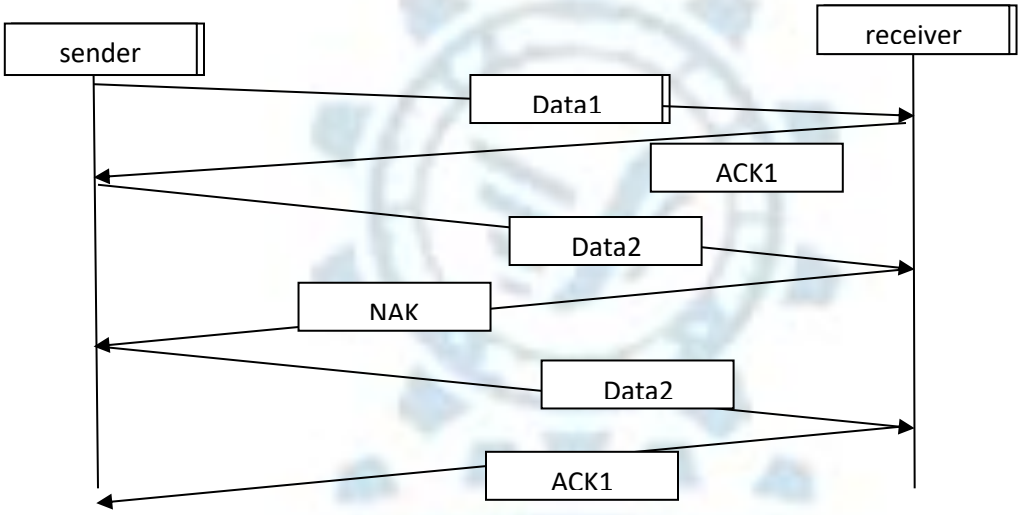

Fig: Stop and wait ARQ, damaged frame

- The sending device is equipped with a timer. If an expected acknowledgement is not received within an allotted time period, the sender assumes that the last data frame was lost in transit and sends it again.

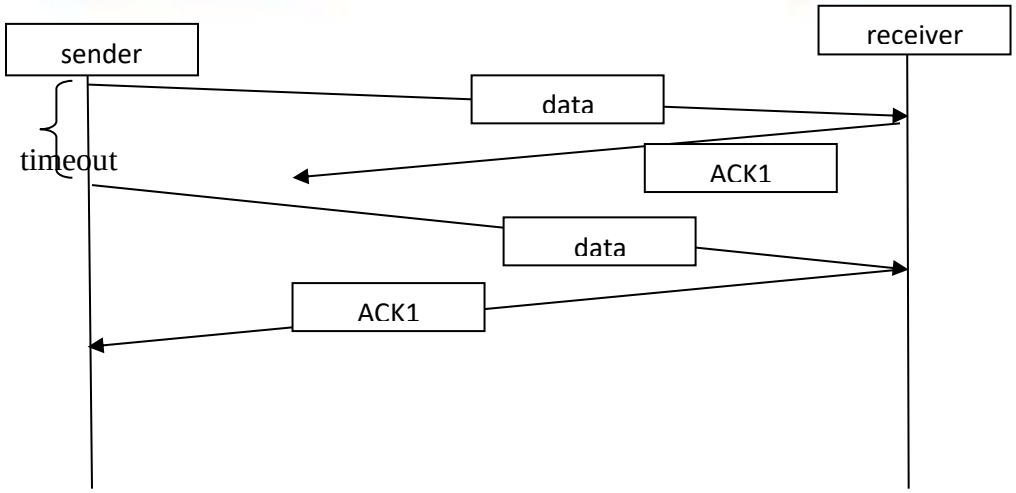

Fig: stop and wait ARQ, lost ACK Frame

Advantages of stop and wait ARQ

1. It can be used for noisy channels
2. It has both flow control and error control
3. It has timer implementation
4. Easy to implement
5. Low processor burden
6. Low buffer requirement

Disadvantages of stop and wait ARQ

1. Efficiency is very less.
2. Timer set for each frame.
3. Sender window size is 1.
4. Receiver window size is 1.

Go back N ARQ

- **Sliding window** method used here where the sender continues to send a number of frames specified by a window size even without receiving an acknowledgement frame from the receiver.
- The sender maintains information about:
  - Size of the sender window
  - Last acknowledgement received
  - Last frame sent
- The receiver holds information about
  - Receiver window size
- The frames are numbered modulo-n which means they are numbered from 0 to n-1. When the receiver sends an ACK, it includes the number of next frame it expects to receive.
- Sender Sliding window can be seen as below

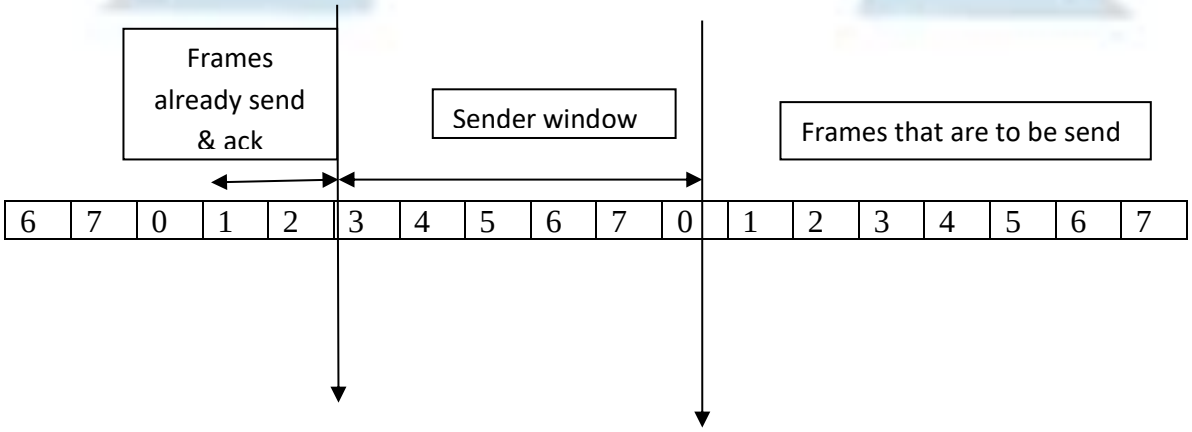

Fig: sender sliding window

- Receiver Sliding window can be seen as follows

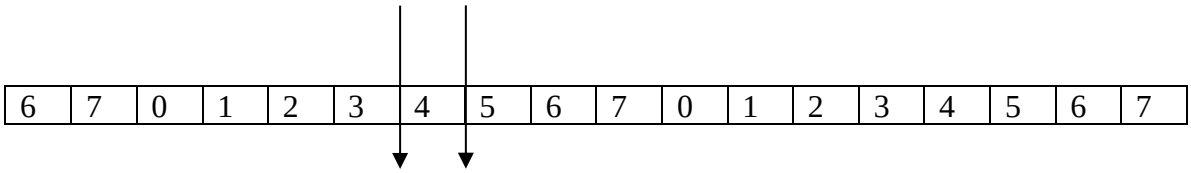

Fig: Receiver sliding window(window size =1)

- When the receiver finds an error in frame, it tells the transmitter to go back , resend that frame and all succeeding frames. This feature guarantees that the frame are received in order, but it also means that some good frames may have to be resent.

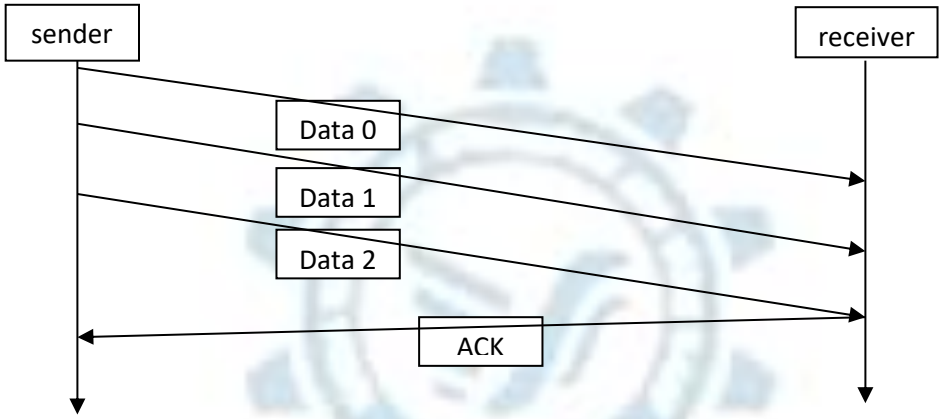

Fig: frames sent and acknowledgement received

Here the frames 0,1,2 sent as a group and the acknowledgment received for the group

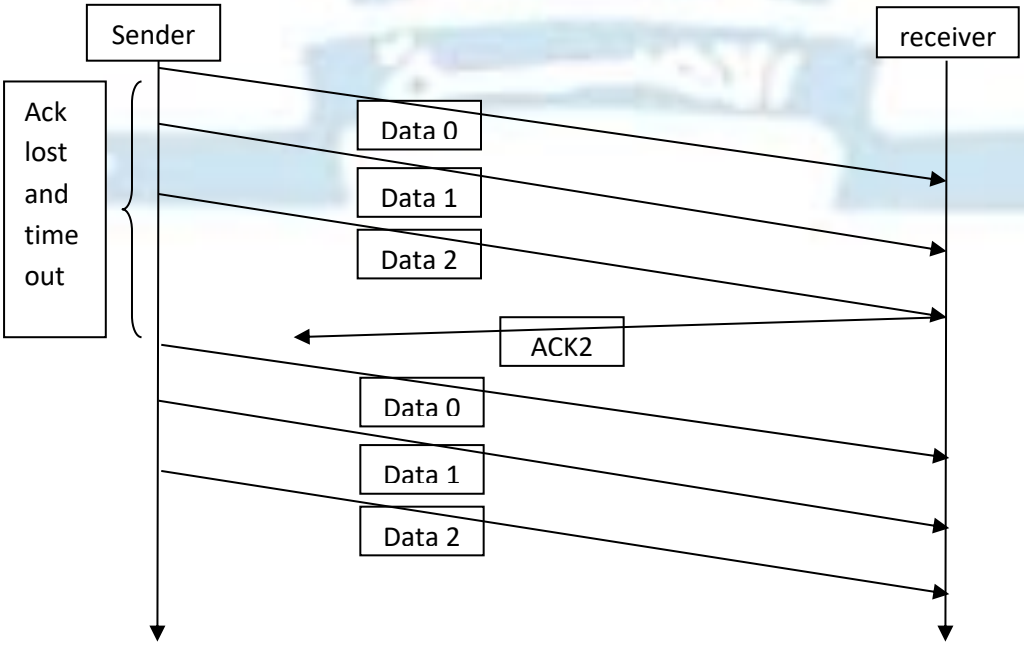

Fig: Go back N, lost ACK

Here the frames are sent as group and the acknowledgement lost and the group is resent.

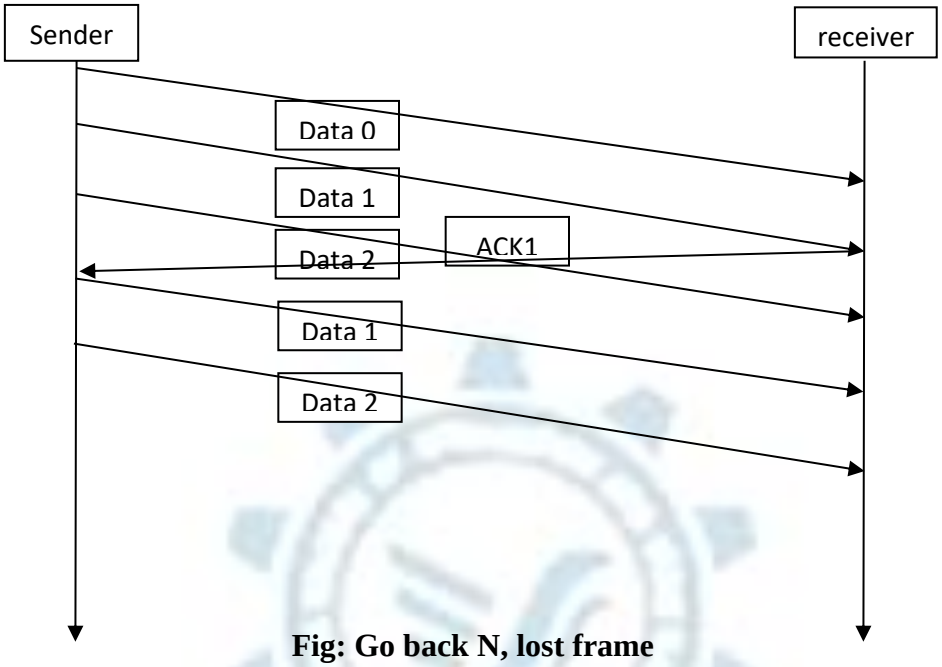

Fig: Go back N, lost frame

Here the frames are sent as group and the frame 1 is damaged, so acknowledgement sent to resend the frame1. Here the frame1 and frame 2 are resend as per the name of Go Back N.

Advantages of Go back N

- The sender can send as many frames at a time
- One ACK can acknowledge one or more frame
- Efficiency is more
- Waiting time is low
- We can alter the size of the sender window

Disadvantages of Go Back N ARQ

- Buffer is required
- Sender needs to duplicate the last send N frames.
- Retransmission of many error free packet because of resending the nth error packet

Selective Repeat ARQ

- With selective repeat ARQ (also known as selective reject ARQ) the receiver sends ACK for each frame individually which is not cumulative ACK as used with Go Back N.
- Here the sender and the receiver has window size N.

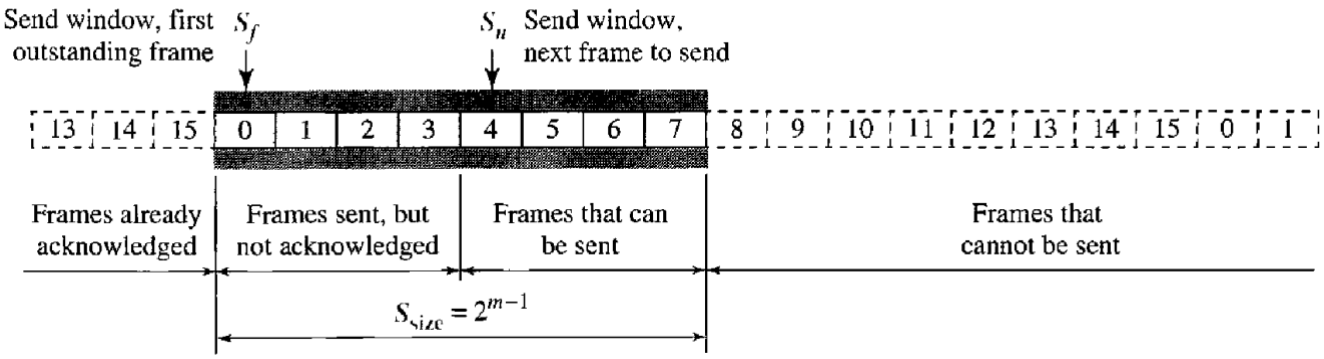

Fig: Send window for Selective repeat request

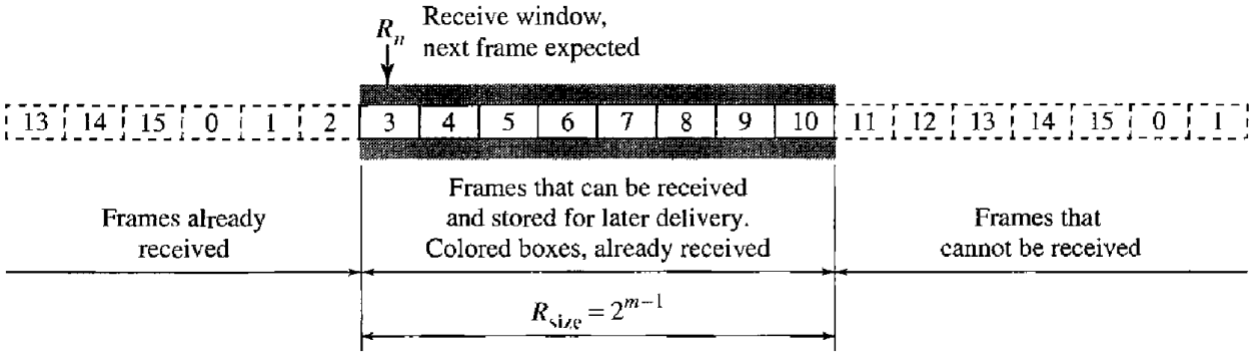

Fig: Receive window for Selective repeat request

- The receiver accepts frames out of order and buffers them. The sender individually retransmits frames that have time out.
- In selective repeat ARQ only the specific damaged or lost frame is retransmitted. If a frame is corrupted in transit an NAK is returned and the frame is resent.
- The receiving device must be able to sort the frames.
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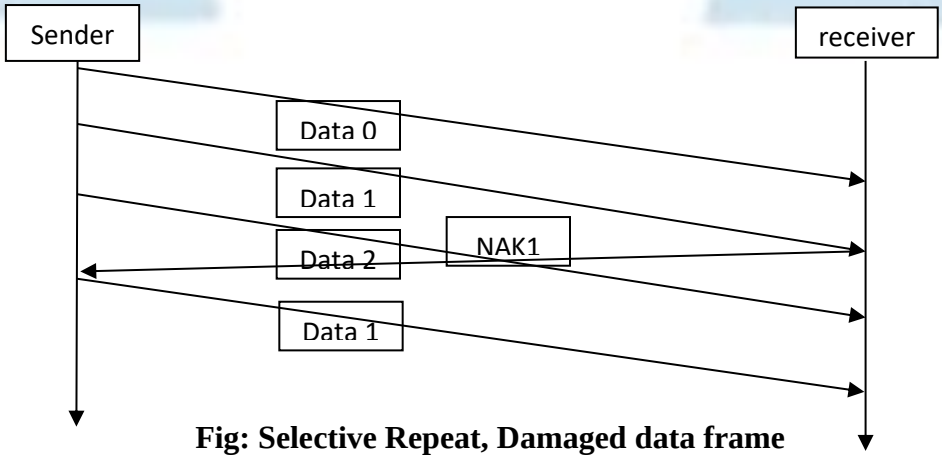


Fig: Selective Repeat, Damaged data frame

Here the data1 is damaged and the acknowledgement for the damaged frame is received and only that data1 is resend.

- Advantages of selective repeat ARQ
  - Similar to Go back N ARQ. Sender only retransmits frames for which a NAK is received.
  - Fewer retransmissions
- Disadvantages of selective repeat ARQ
  - More complex at sender and receiver side
  - Each frame must be individually acknowledged
  - Receiver receives frames out of sequence

HDLC (High Level Data Link Control)

- HDLC is a bit oriented protocol. It works for point to point and multipoint link.
- HDLC defines three types of stations.
  - Primary station: frames are issued by the primary station
  - Secondary station: it operates under the control of primary station. Frames issued by the secondary station are called responses.
  - Combined station: combines the features of both primary and secondary stations.
- HDLC provides two configuration modes
  - Normal Response Mode(NRM): This mode is used in unbalanced configuration(only single primary station). The primary node will initiate the data transfer, but the secondary node can send data only on command from the primary node. NRM is used for communication between a host computer and the terminal connected to it.

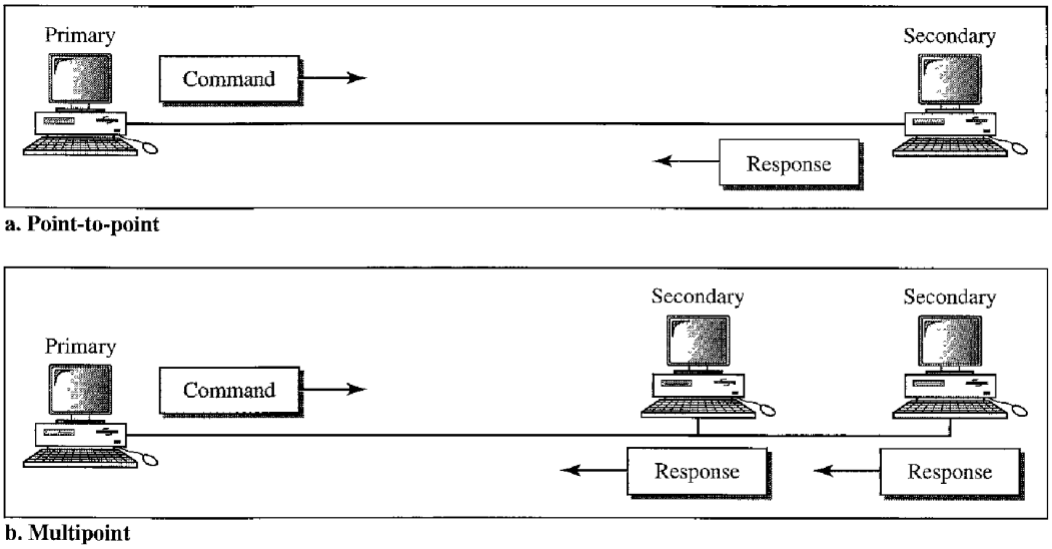


Fig: Normal Response Mode

  - Asynchronous Balanced Mode(ABM): This mode is used with balanced configuration(more than one primary station where each station can act as both primary and secondary station). Here the combined node can initiate the transmission.ABM is used extensively for point-point full-duplex communication.

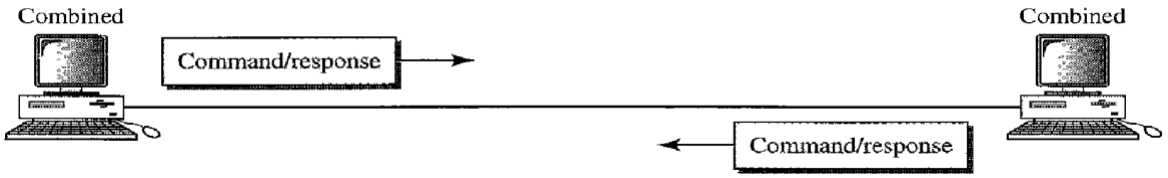
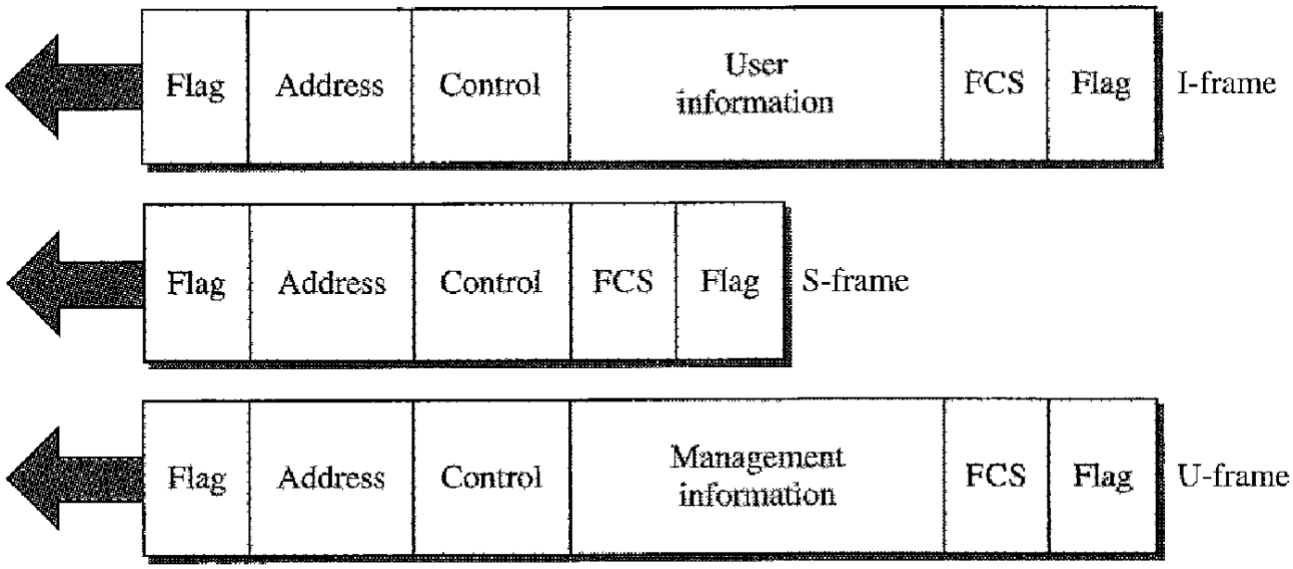


Fig: Asynchronous Balanced Mode

- Aynschronous Response Mode(ARM):this mode is used with unbalanced configuration. The primary node will intiate link,do error recovery and logical disconnection, but the secondary node may intiate data transmission without permission from the primary. ARM is rarely used.

- HDLC support various frame formats for the different modes of operation.
  - Unnumbered Frames(U-Frames): These are used for functions like link set up and disconnection. They do not contain any acknowledgement information.
  - Information Frames(I-Frames): These carry the actual information or data. They can be used to piggy back acknowledgement information along with information.
  - Supervisory Frames(S-Frames): These are used for error control and flow control.



- **Fig: HDLC Frames**

- Frame for the HDLC is as follows

Flag	Address	Control	Information	FCS	Flag

Fig: HDLC Frame format

- The functions of each field are as follows:
  - Flag field: 8-bit sequence with a bit pattern of 01111110. It identifies the beginning and end of frame.
  - Address Field: It contains the address of the secondary station. If frame is created by the primary station the address of the secondary station is stored. If frame is created by the secondary station the from address is stored in it.
  - Control Field: Used for flow control and error control.
  - Information Field: contains user data information

- Frame Check Sequence(FCS): FCS is an error detection field. It contains either 2 or 4 byte.

- Control fields for various HDLC frames are as follows

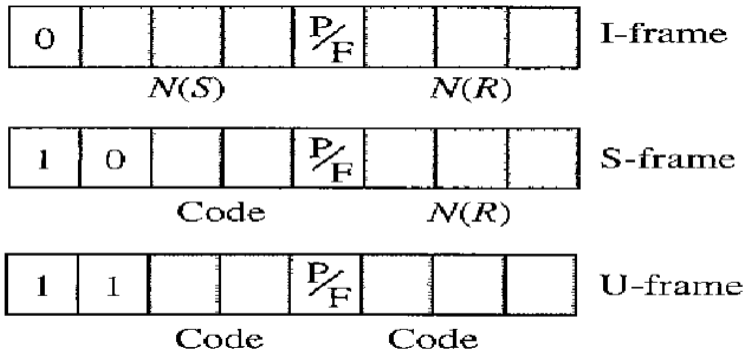


Fig:Control fields for HDLC frames

- Control field for I-frame starts with 0 and N(S) gives the sequence number. N(R) gives the acknowledgement number.P/F gives if its Polling(frame send from primary to secondary) or Final(frame send from secondary to primary).
- Control field for S-frame starts with10. Code are
  - RR(receive ready where frame is received and acknowledged)
  - RNR(receiver not ready where receiver is not ready to receive frame)
  - REJ (reject where Go Back N receives negative acknowledgement)
  - SREJ(reject where Selective Reject ARQ receives negative acknowledgement)
- Control field for U-frame starts with 11.

Code	*Command*	*Response*	*Meaning*
00 001	SNRM		Set normal response mode
11 011	SNRME		Set normal response mode, extended
11 100	SABM	DM	Set asynchronous balanced mode or **disconnect mode**
11 110	SABME		Set asynchronous balanced mode, extended
00 000	UI	UI	Unnumbered information
00 110		UA	**Unnumbered acknowledgment**
00 010	DISC	RD	Disconnect or **request disconnect**
10 000	SIM	RIM	Set initialization mode or **request information mode**
00 100	UP		Unnumbered poll
11 001	RSET		Reset
11 101	XID	XID	Exchange ID
10 001	FRMR	FRMR	Frame reject

Fig:U-Frame Command and Response