Data Communication

BCE 6th Semester

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Unit 8: Data Link Control and Protocols

- Outline:

- Flow Control

- Data Link Protocols

- A simplex stop and wait protocol

- Sliding window protocols

- One Bit Sliding Window Protocol

- A Protocol Using Go Back N

- A Protocol Using Selective Repeat

- Asynchronous and Synchronous Protocols and their types

Data Link Layer

- The data link layer is responsible for node to node communication of data frames within the same network.

- This layer divides the stream of data received from the network layer into the manageable data units called frames.

- Specific responsibilities of the data link layer include

- framing,

- physical addressing,

- flow control,

- error control and media access control.

Services Provided to Network Layer

- **Services Provided to Network Layer:**

- Data link layer provides several services to the network layer.

- The one of the major services provided is the transferring the data from network layer on the source machine to the network layer on destination machine.

- On source machine data link layer receives the data from network layer and on destination machine pass on this data to the network layer as shown in Figure.

- The path shown in fig (a) is the virtual path. But the actual path is Network layer -> Data link layer -> Physical layer on source machine, then to physical media and thereafter physical layer -> Data link layer -> Network layer on destination machine.

Services Provided to Network Layer

Virtual And Actual Communication
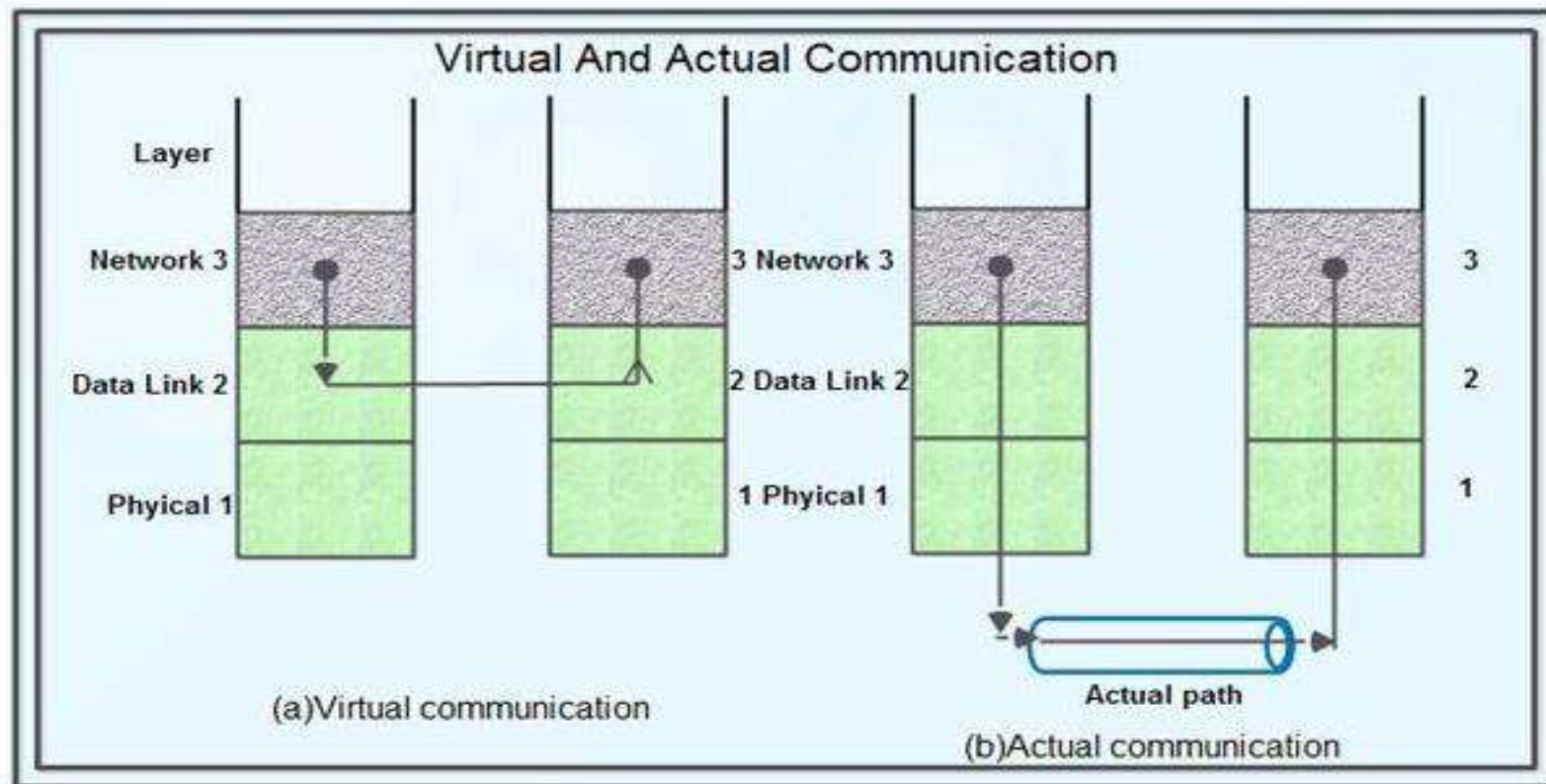
Data Link Protocols

- **Data Link Protocols**

- Data link layer protocols are mainly responsible for flow control.

- When a data frame is sent from one host to another over a single medium, it is required that the sender and receiver should work at the same speed.

- That is, sender sends at a speed on which the receiver can process and accept the data.

- If sender is sending too fast, the receiver may be overloaded and data may be lost.

- Two types of mechanisms can be deployed to control the flow.
  - A simple stop and wait Protocol
  - Sliding Window Protocol

Data Link Protocols

- **Simplex Stop and Wait**

- This flow control mechanism forces the sender after transmitting a data frame to stop and wait until the acknowledgement of the data-frame sent is received.

- The sender sends the next frame only when it has received a positive acknowledgement from the receiver that it is available for further data processing.

- Data transmission is one directional, but must have bidirectional line.
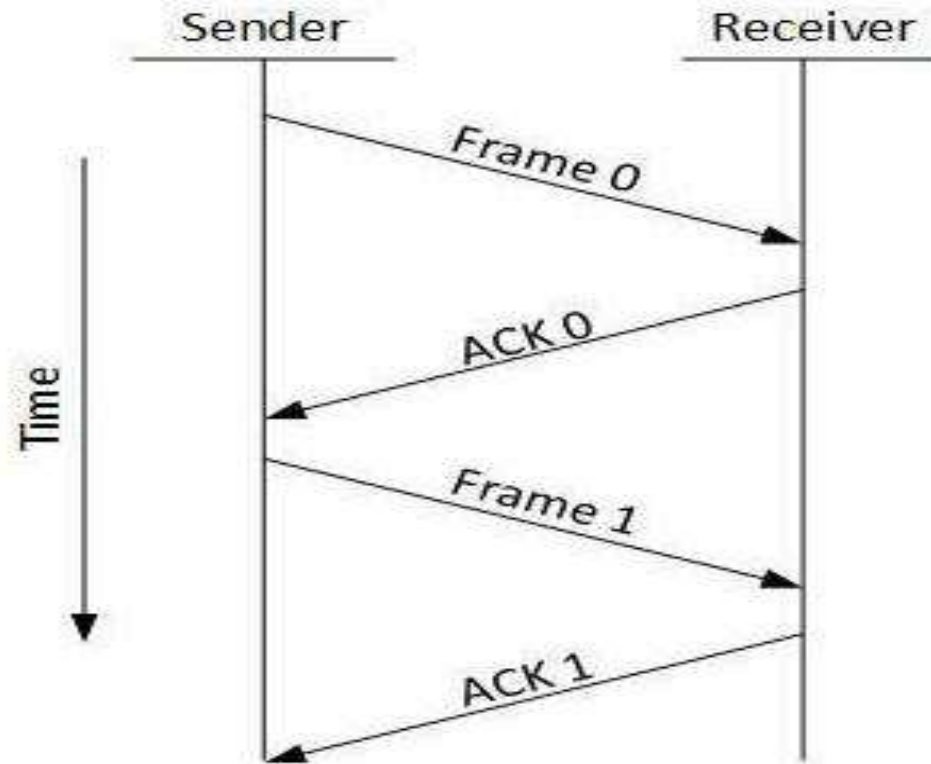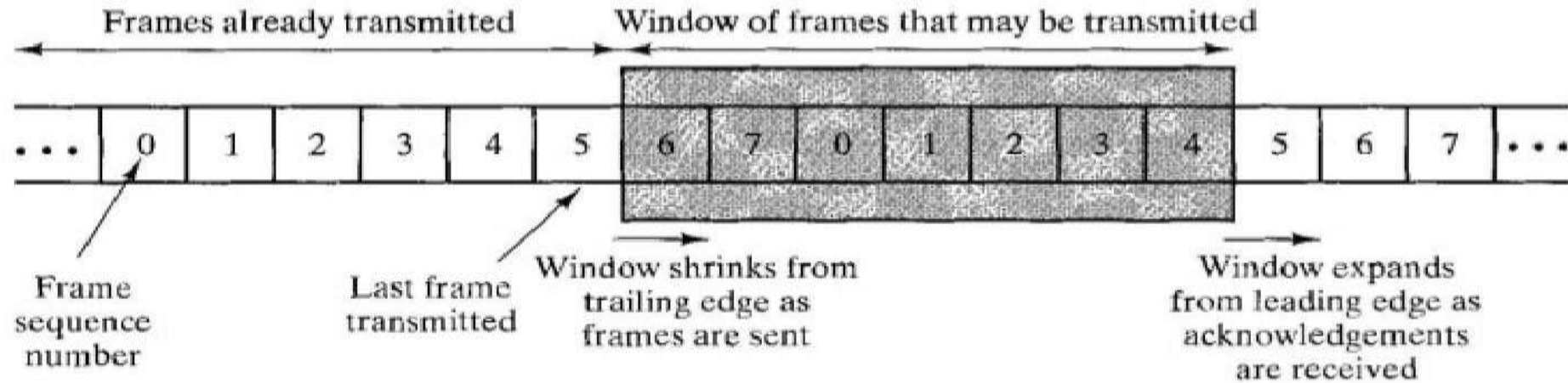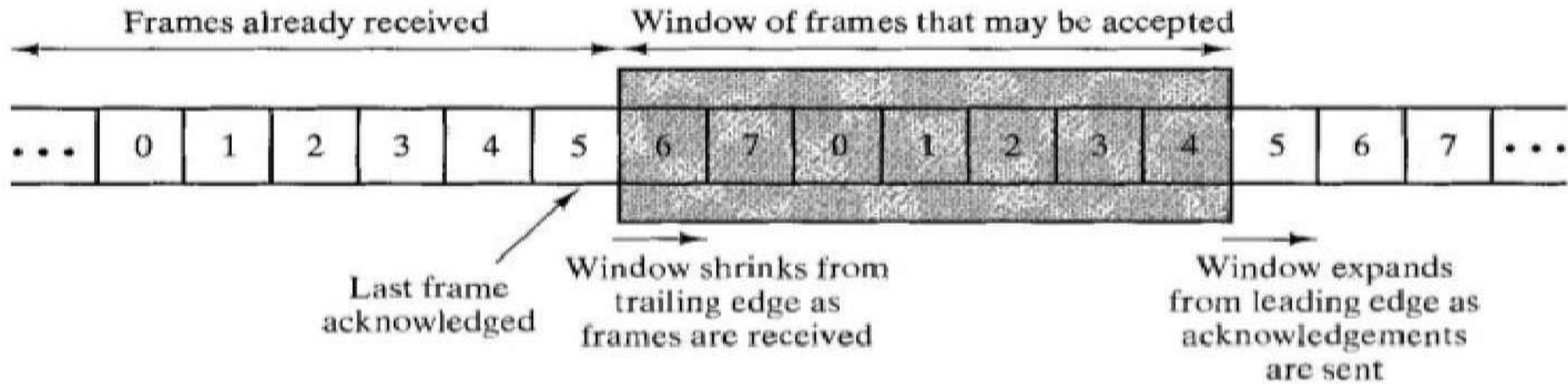
Simplex Stop and Wait

Fig : Simplex Stop and Wait

Sliding Window

Frames already transmitted

Window of frames that may be transmitted

... | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | ...

Frame sequence number

Last frame transmitted

Window shrinks from trailing edge as frames are sent

Window expands from leading edge as acknowledgements are received

(a) Transmitter's perspective

Frames already received

Window of frames that may be accepted

... | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | ...

Last frame acknowledged

Window shrinks from trailing edge as frames are received

Window expands from leading edge as acknowledgements are sent

Stop and Wait ARQ

- **Stop and Wait ARQ**

- The following transition may occur in Stop-and-Wait ARQ:

- The sender maintains a timeout counter.

- When a frame is sent, the sender starts the timeout counter.

- If acknowledgement of frame comes in time, the sender transmits the next frame in queue.

- If acknowledgement does not come in time, the sender assumes that either the frame or its acknowledgement is lost in transit.

- Sender retransmits the frame and starts the timeout counter.

- If a negative acknowledgement is received, the sender retransmits the frame.
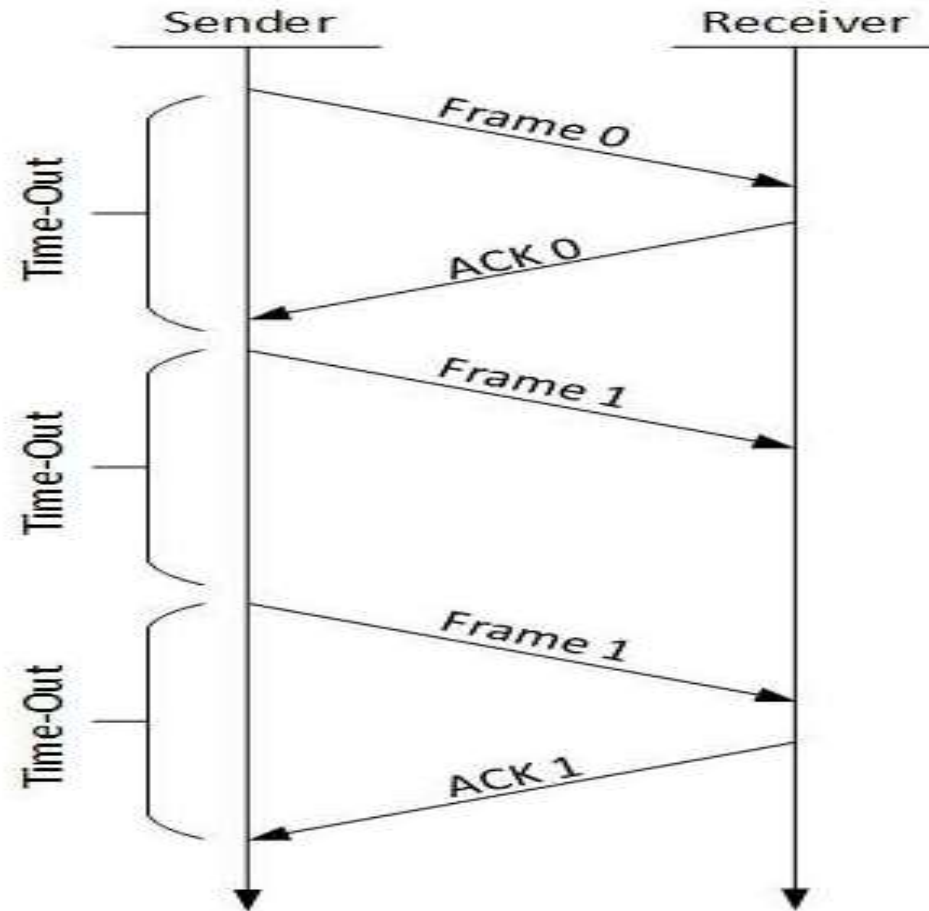
Stop and Wait ARQ

Fig: Stop and Wait ARQ

Sliding Window

- **Sliding Window**

- In this flow control mechanism, both sender and receiver agree on the number of data-frames after which the acknowledgement should be sent.

- As we learnt, stop and wait flow control mechanism wastes resources, this protocol tries to make use of underlying resources as much as possible.

- In this protocol, multiple frames can be sent by a sender at a time before receiving an acknowledgment from the receiver.

- The term sliding window refers to the imaginary boxes to hold frames.

- The size of the receiving window is the maximum number of frames that the receiver can accept at a time.

- It determines the maximum number of frames that the sender can send before receiving acknowledgment.

Sliding Window

- It determines the maximum number of frames that the sender can send before receiving acknowledgment.

- The types of sliding window protocol include:

  - A One Bit Sliding Window Protocol

  - A Protocol Using Go Back N

  - A Protocol Using Selective Repeat

- Note: ARQ (Automatic Repeat Request) is designed for noisy channels.

Sliding Window

- **One Bit sliding window protocol**

- In one – bit sliding window protocol, the size of the window is 1.

- So, the sender transmits a frame, waits for its acknowledgment, then transmits the next frame.

- Thus, it uses the concept of stop and wait protocol.

- This protocol provides for full – duplex communications.

- Hence, the acknowledgment is attached along with the next data frame to be sent called piggybacking.

- So, it is better compared to stop and wait due to full duplex communications.
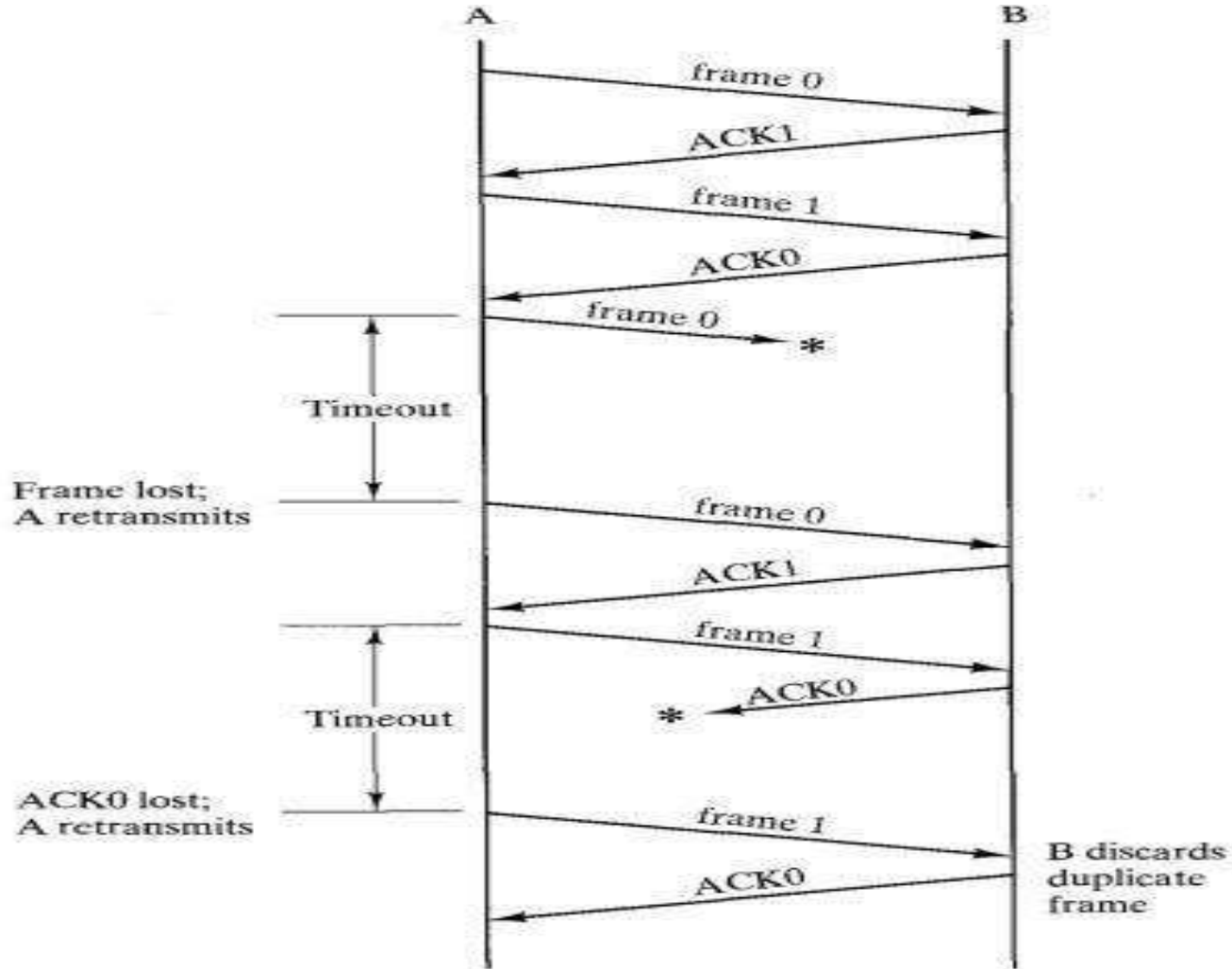
Sliding Window

- **Stop and Wait ARQ**

- The source station transmits a single frame and then must await an acknowledgement (ACK).

- No other data frames can be sent until the destination stations reply arrives at the source station.

- The sending device keeps a copy of the last frame until it receives an acknowledgement for that frame.

- Keeping a copy allows the sender to retransmits lost or damaged frames until they are received correctly.

- For identification purposes, both data frames and acknowledgement frames (ACK) are numbered 0 & 1.

- A data 0 frame is acknowledged by and ACK1 frame, indicating that the receiver has received data frame 0 and is now expecting data frame 1.

Stop and Wait ARQ

- The sender starts a timer when it sends a frame.

- If an acknowledgement is not received within an allotted time period, the sender assumes that the frame was lost or damage and resends it.

- The receiver sends only +ve ACK for frame received safe and sound.

- It is silent about the frames damaged or lost.

- The acknowledgement number always define the number of next expected frame.

- If frame 0 is received, ACK1 is sent; if frame 1 is received ACK 0 is sent.

Stop and Wait ARQ

Sliding Window

- **Go-Back-N ARQ**

- In this protocol, we can send several frames before receiving acknowledgements; we keep a copy of these frames until the acknowledgements arrive.

- Stop and wait mechanism does not utilize the resources at their best.

- When the acknowledgement is received, the sender sits idle and does nothing.

- In Go-Back-N method, both sender and receiver maintain a window.

- The sending-window size enables the sender to send multiple frames without receiving the acknowledgement of the previous ones.

- The receiving-window enables the receiver to receive multiple frames and acknowledge them.

- The receiver keeps track of incoming frame's sequence number.

Go-Back-N ARQ

- When the sender sends all the frames in window, it checks up to what sequence number it has received positive acknowledgement.

- If all frames are positively acknowledged, the sender sends next set of frames.

- If sender finds that it has received NACK or has not receive any ACK for a particular frame, it retransmits all the frames after which it does not receive any positive ACK.
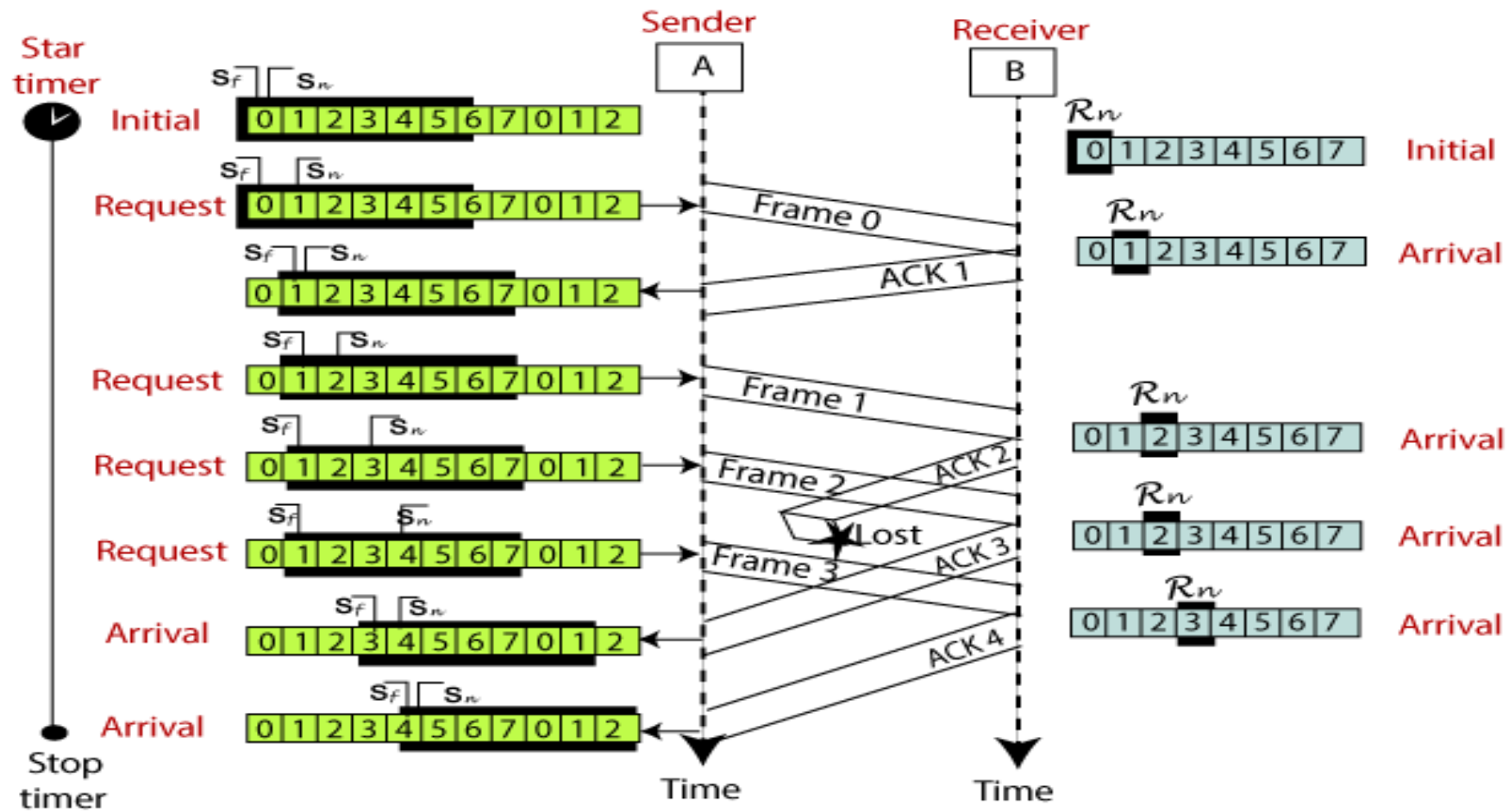
Go-Back-N ARQ

Fig : Go-Back-N ARQ

Sliding Window

- Selective Repeat ARQ

- In Go-back-N ARQ, it is assumed that the receiver does not have any buffer space for its window size and has to process each frame as it comes.

- This enforces the sender to retransmit all the frames which are not acknowledged.

- In Selective-Repeat, the receiver while keeping track of sequence numbers, buffers the frames in memory and sends NACK for only frame which is missing or damaged.

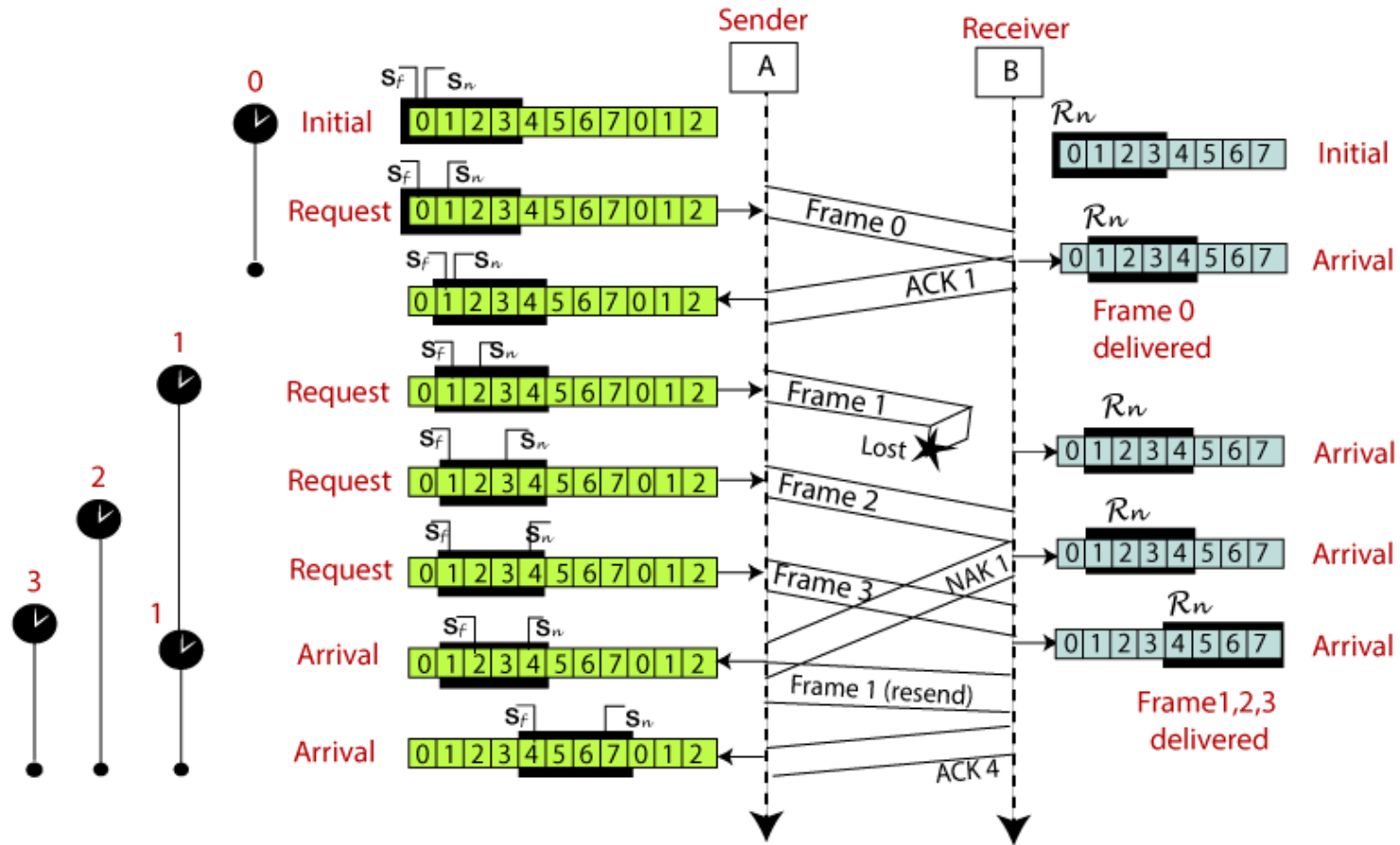- The sender in this case, sends only packet for which NACK is received.

Selective Repeat ARQ

Fig : Selective Repeat ARQ

Asynchronous and Synchronous Protocols

- **Asynchronous Protocols**

- Asynchronous protocols treat each character in a bit stream independently.

- These protocols are used in modems.

- They use start and stop bits, and variable gaps between characters.

- They are slower than synchronous protocols in transmitting data.

- The different asynchronous protocols are:

- XMODEM

- YMODEM

- ZMODEM

- Block Asynchronous Transmission (BLAST)

- Kermit

Asynchronous and Synchronous Protocols

- **XMODEM**
- It is a half duplex stop & wait protocol.
- It is used for telephone line communication between PCs.
- The sender sends a frame to receiver & waits for ACK frame.
- The receiver can send one cancel signal (CAN) to abort the transmission.
- The frame format of XMODEM is:

SOH	Header	Data	CRC
1 Byte	2 Bytes	128 Bytes	
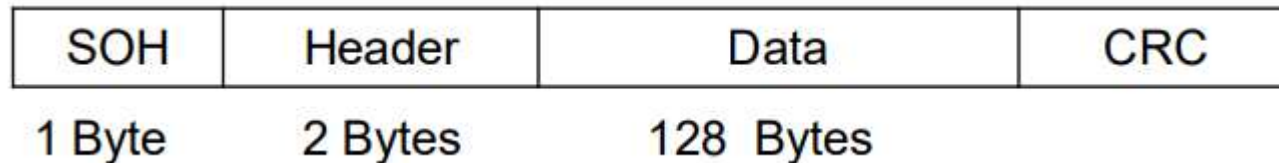
Asynchronous and Synchronous Protocols

- The various fields of the frame are:

- SOH: It is the start of the header. It is a 1-byte field.

- Header: It contains the sequence number. It is 2 bytes in length.

- Data: This field holds 128 bytes of data.

- CRC: It is a Cyclic Redundancy Check. This field checks the errors in the data field.

Asynchronous and Synchronous Protocols

- **YMODEM**
- This protocol is similar to XMODEM with the following major differences:
- Two cancel signals (CAN) are used to abort the transmission.
- The data field is 1024 bytes long.
- ITU-T CRC-16 is used for error checking.
- **ZMODEM**
- It is a combination of XMODEM and YMODEM.

Asynchronous and Synchronous Protocols

- **BLAST**

- BLAST is more powerful than XMODEM.

- It is a full-duplex protocol.

- It uses sliding window flow control.

- **Kermit**

- It is a terminal program as well as a file transfer protocol.

- It is similar in operation to XMODEM, except that sender has to wait for a negative acknowledgment (NAK) before it starts transmission.

Asynchronous and Synchronous Protocols

- **Synchronous Protocols**

- Synchronous Protocols take the whole bit stream and divide it into characters of equal size.

- These protocols have high speed and are used for LAN, WAN and MAN.

- Synchronous protocols are categorized into two groups:

- Character-Oriented Protocol

- Bit-Oriented Protocol

Asynchronous and Synchronous Protocols

- **Character-Oriented Protocol**

- It interprets frame as a series of characters.

- These are also known as Byte-Oriented Protocols.

- Control information is inserted as separate control frames or as an addition to existing data frames.

- The example of a character-oriented protocol is Binary Synchronous Communication (BSC) developed by IBM.

- **Bit-Oriented Protocol**

- It interprets a frame as a series of bits.

- Control information can be inserted as bits depending on the information to be contained in the frame

Asynchronous and Synchronous Protocols

- bit-oriented protocol can pack more information into shorter frames.
- Examples of the bit-oriented protocol are
- Synchronous Data Link Control (SDLC)
- High-Level Data Link Control (HDLC)
- **Synchronous Data Link Control (SDLC)**
- SDLC protocol was developed by IBM in 1975.
- After developing SDLC, IBM submitted it to American National Standard Institute (ANSI) and to International Standard Organization (ISO) for acceptance.
- ANSI modified it to ADCCP (Advanced Data Communication Control Procedure).

Asynchronous and Synchronous Protocols

- ISO modified it to HDLC (High-Level Data Link Control).
- Synchronous Data Link Control (SDLC) Protocol
- The frame format of SDLC is:

01111110					01111110
Flag	Address	Control	User Data	ECF	Flag
	8-Bit	8-Bit		16-Bit	
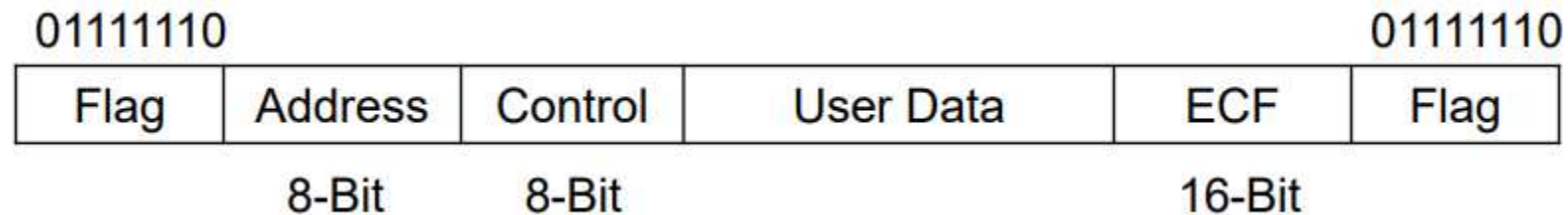
Asynchronous and Synchronous Protocols

- The flag sequence of 8-bits 01111110 marks the beginning and end of the frame.

- Address field contains the address of the receiver.

- Control field carries the sequence number, acknowledgment, requests, and responses.

- The user data field carries the data and is of variable length.

- ECF stands for Error Checking Field and is of 16- bits.

- It is used for error control.

Asynchronous and Synchronous Protocols

- **High Level Data Link Control (HDLC) Protocol**

- HDLC came into existence after ISO modified the SDLC protocol.

- It is a bit-oriented protocol that supports both half and full duplex communication.

- Systems using HDLC are characterized by:

- Station Types

- Configuration.

- Response Modes

Asynchronous and Synchronous Protocols

- **Station Types**

- To make HDLC protocol applicable to various network configurations, three types of stations have been defined:

- Primary Station

- Secondary Station

- Combined Station
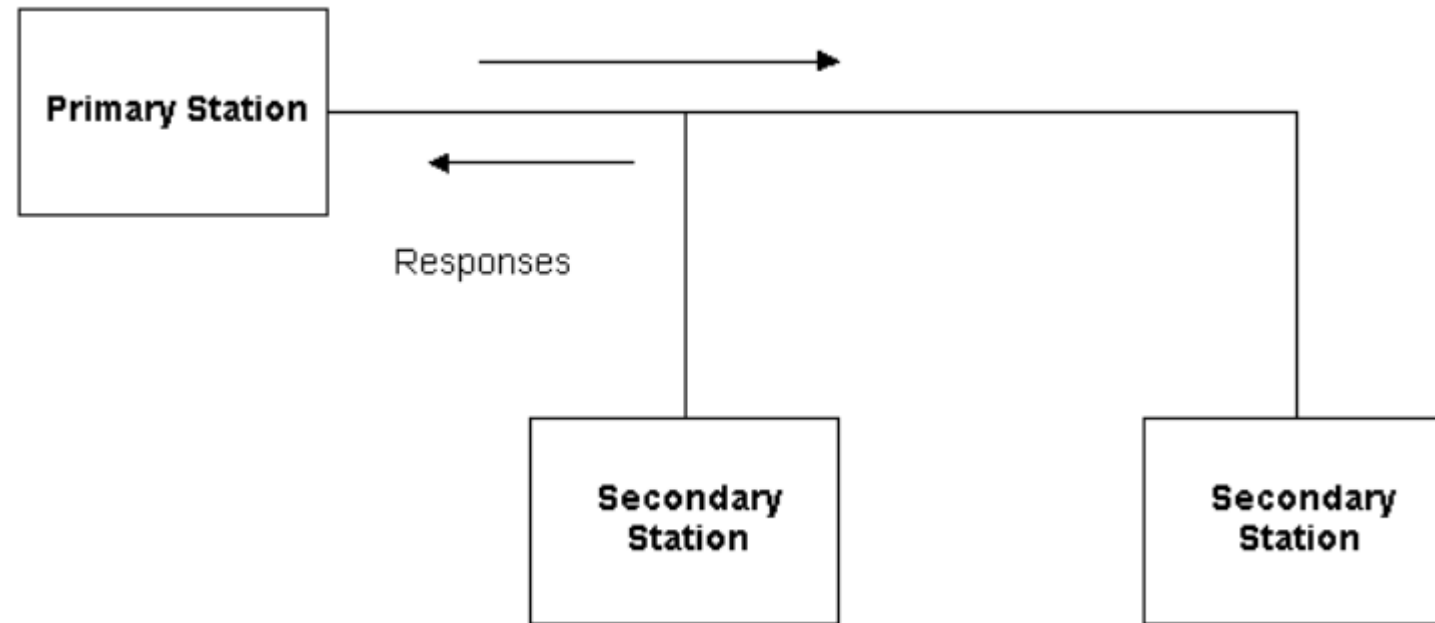
Asynchronous and Synchronous Protocols

- **Primary Station**
- It has complete control over the link at any time.
- It has the responsibility of connecting & disconnecting the link.
- The frames sent by the primary station are called commands.
- **Secondary Station**
- All the secondary stations work under the control of the primary station.
- The frames sent by the secondary station are called responses.
- **Combined Station**
- A combined station can behave either as a primary or as a secondary station.
- It can send commands as well as responses.

Asynchronous and Synchronous Protocols

- **Configuration**

- Configuration defines how the various stations are connected to a link.

- There are three possible configurations:

- Unbalanced Configuration

- Symmetrical Configuration
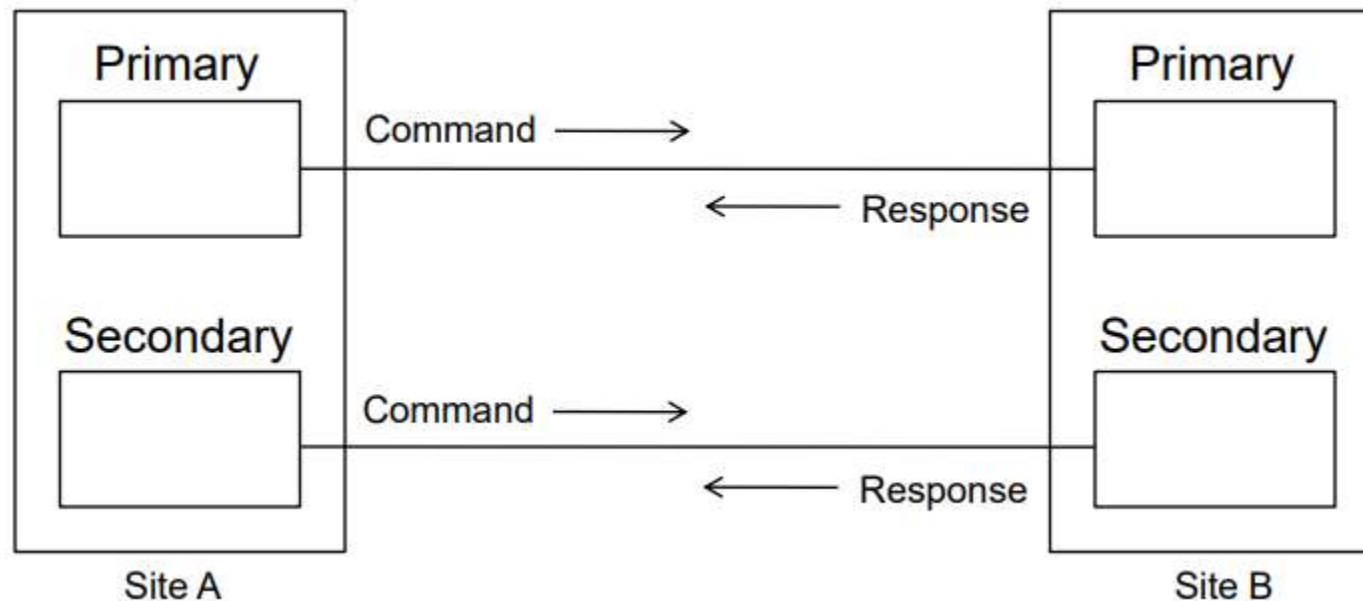
- Balanced Configuration

Asynchronous and Synchronous Protocols

- **Unbalanced Configuration**
- This type of configuration exists if one station is primary and the other is secondary.
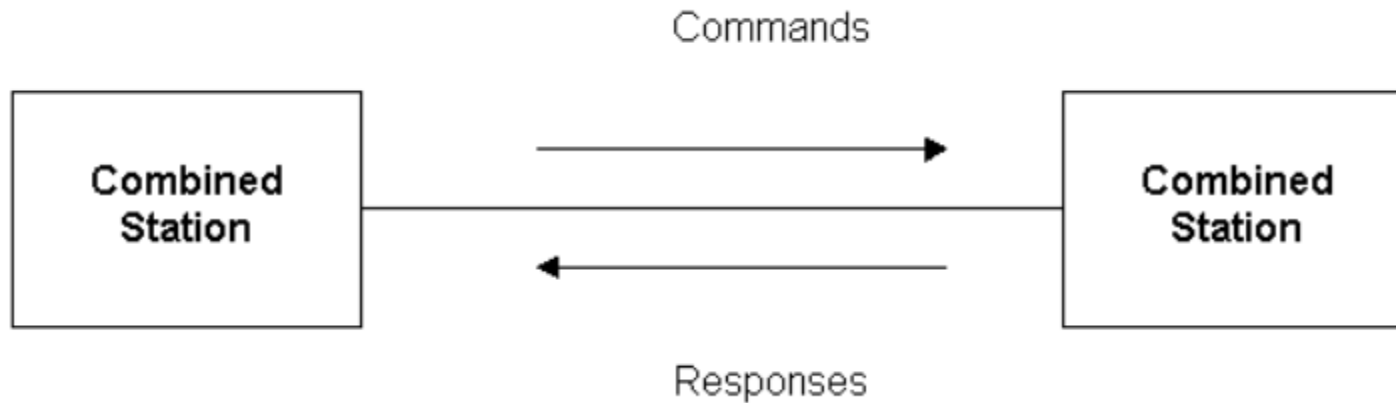
Asynchronous and Synchronous Protocols

- **Symmetrical Configuration**
- In this configuration, both sites contain two stations: one primary and one secondary.
- Primary station of one site is linked with the secondary station of the other and vice versa.

Asynchronous and Synchronous Protocols

- **Balanced Configuration**

- In this configuration, both sites have combined stations.

- These combined stations are connected with a single link.

- This single link can be controlled by either station.

Commands

Responses

Asynchronous and Synchronous Protocols

- **Frame Structure in HDLC**

- Frame in HDLC can have six fields:

Flag	Address	Control	Information	FCS	Flag
8-Bit	8-Bit	8/16-Bit	Variable	16-Bit	8-Bit

01111110 (above Flag on left)   01111110 (above Flag on right)

Asynchronous and Synchronous Protocols

- Flag Field: It is the 8-bit field that contains 01111110.

- It marks the beginning and end of a frame.

- Address Field: This field contains the address of the receiver.

- It is 8-bit long.

- Control Field: It carries the sequence number, acknowledgments, requests, and responses.

- It can be 8-bit or 16-bit.

- Information Field: It contains user data.

- Its length is different for different networks.

Asynchronous and Synchronous Protocols

- FCS Field: FCS stands for Frame Check Sequence.
- It is the error detection field and is 16-bit long.
- It contains either 16-bit CRC or 32-bit CRC.
- **Types of Frames in HDLC**
- HDLC defines three types of frames:
- **Information Frame (I-Frame)**
- I-Frames carry user data, and control information about user's data.
- **Supervisory Frame (S-Frame)**
- S-Frames carry flow & error control information.

Asynchronous and Synchronous Protocols

- **Unnumbered Frame (U-Frame)**

- U-Frames are reserved for system management.

- They are used to exchange session management & control information between the two connected devices.

THANK YOU