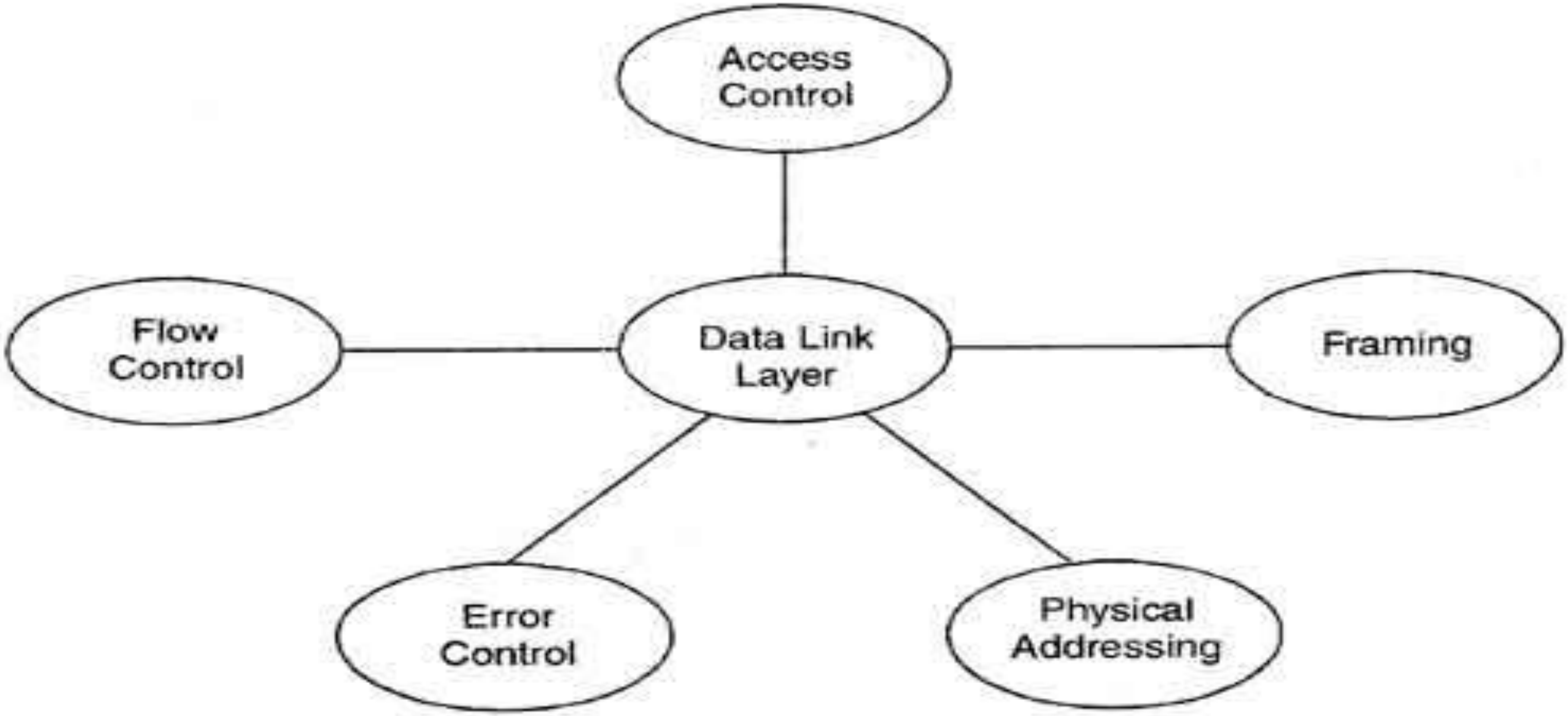
Data Link Layer

Data link layer is the second layer in OSI reference model and lies above the physical layer. The data link layer performs the following functions.



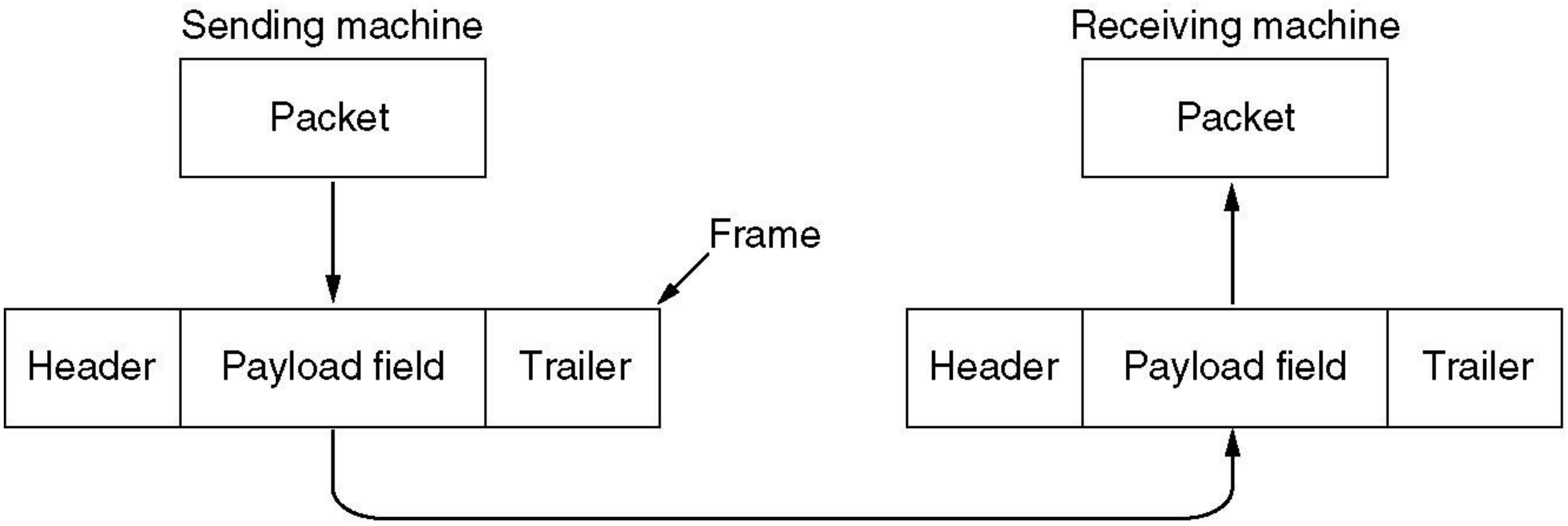
Functions of data link layer

Functions of the Data Link Layer

1. Data link layer divides data into manageable units called frames.
2. It then provides the addressing information by adding header to each frame. **Physical addresses** of source & destination machines are added to each frame.
3. It provides flow control mechanism to ensure that sender is not sending the data at the speed that the receiver cannot process.
4. It also provide error control mechanism to detect & retransmit damaged or lost frame, thus adding reliability.
5. Another function of data link layer is access control. When two or more devices are attached to the same link, data link layer protocols determine which device has control over the link at any given time.

Framing

- The data link layer takes the packets it gets from the network layer and encapsulates them into frames for transmission.
- Each frame contains a frame header, a payload field for holding the packet, and a frame trailer.



Relationship between packets and frames.

Framing Technique

To detect or correct errors, the data link layer breaks the bit stream up into discrete frames and marks the start and end of each frame.

Error Control

- Error control repairs frames that are received in error.
- Error control Mechanisms:
  - ACK/NACK: Provide sender some feedback about other end
  - Time-out: for the case when entire packet or ack is lost
  - Sequence numbers: for distinguishing retransmissions from originals

Flow Control

- Prevents a fast sender from out-pacing a slow receiver.
- Flow control Mechanisms:
  - **Feedback-based flow control:** the receiver sends back information to the sender giving it permission to send more data, or at least telling the sender how the receiver is doing.
  - **Rate-based flow control:** the protocol has a built-in mechanism that limits the rate at which senders may transmit data, without using feedback from the receiver.

Data Link Control

- Data link layer performs
    - Data Link Control
    - Media Access Control

- The data link control deals with the design and procedures for communication between two adjacent nodes.

PROTOCOLS

The protocols are normally implemented in software by using one of the common programming languages.

Types of protocols:

- Protocols used for noiseless channels
- Protocols used for noisy channels

NOISELESS CHANNELS

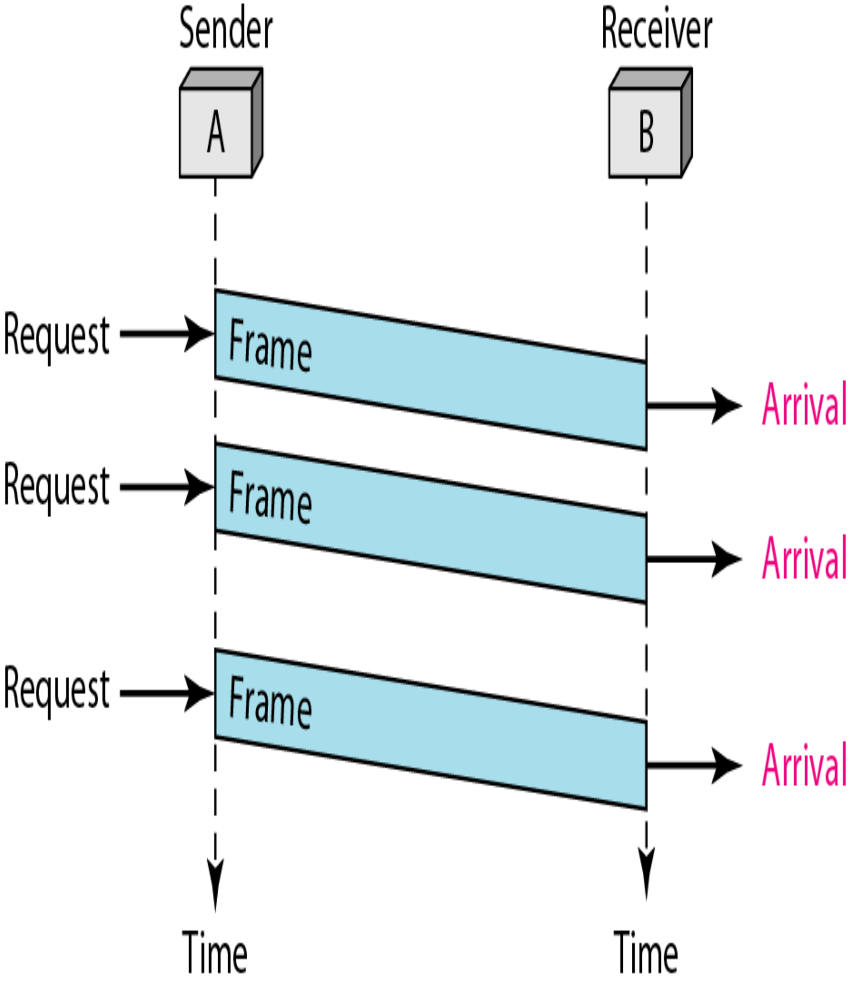
- Noiseless channel is an ideal channel in which no frames are lost, duplicated, or corrupted.
- Two protocols:
  - The first protocol does not use flow control
  - The second uses flow control
- Neither has error control because the channel is a perfect noiseless channel.

Simplest Protocol

- Simplest Protocol, is one that has no flow or error control.
- It is a unidirectional protocol in which data frames are traveling in only one direction- from the sender to receiver.
- The receiver can immediately handle any frame it receives with a processing time that is small enough to be negligible.
- The data link layer of the receiver immediately removes the header from the frame and hands the data packet to network layer, which can also accept the packet immediately.
- The receiver can never be fill out with incoming frames.

Example of Simplest Protocol

- The figure shows an example of communication using this protocol.
- The sender sends a sequence of frames without even thinking about the receiver.
- Note that the data frames are shown by tilted boxes; the height of the box defines the transmission time difference between the first bit and the last bit in the frame.



Stop-and-Wait Protocol

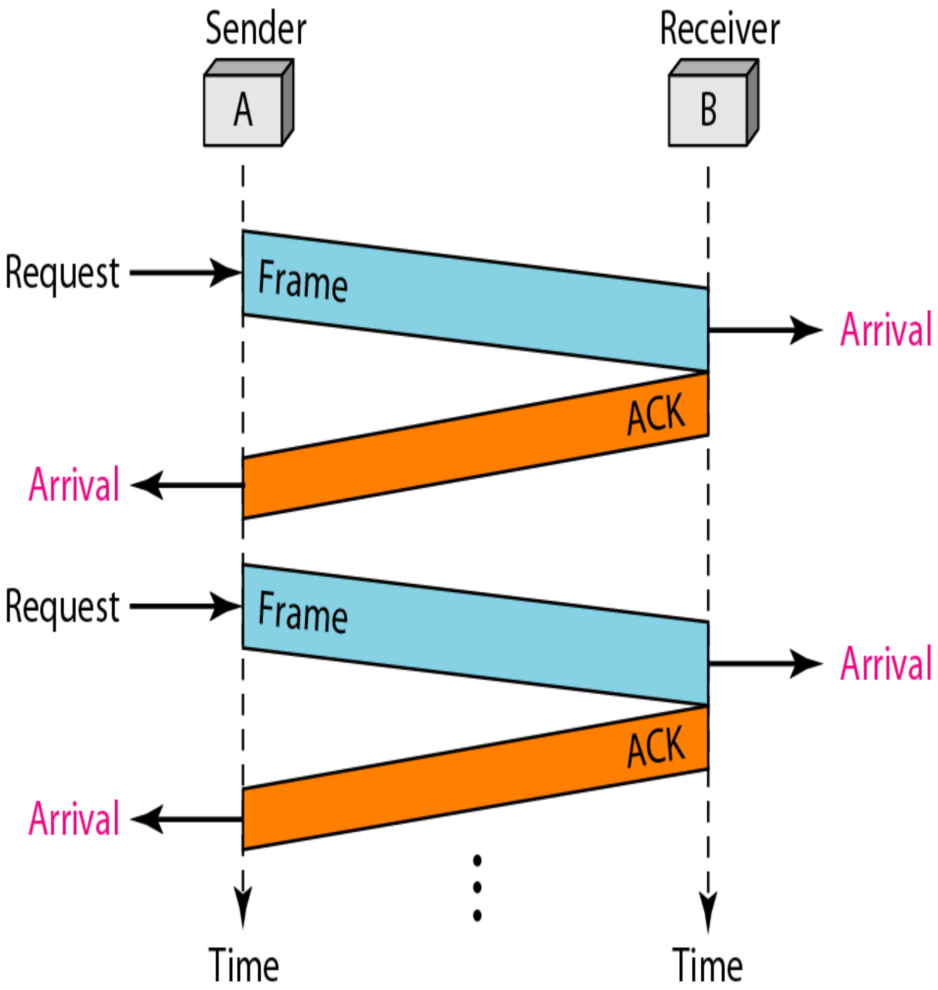
- ➢ If data frames arrive at the receiver site faster than they can be processed, the frames must be stored until their use.
- ➢ Normally, the receiver does not have enough storage space, especially if it is receiving data from many sources.
- ➢ This may result in either the discarding of frames or denial of service.
- ➢ To prevent the receiver from becoming overwhelmed with frames, we somehow need to tell the sender to slow down.
- ➢ There must be feedback from the receiver to the sender.

Stop-and-Wait Protocol (contd.)

- In Stop-and-Wait Protocol, the sender sends one frame, stops until it receives confirmation from the receiver (okay to go ahead), and then sends the next frame.
- It has unidirectional communication for data frames, but ACK frames (simple tokens of acknowledgment) travel from the other direction.
- Add flow control to Simplest protocol.
- At any time, there is either one data frame on the forward channel or one ACK frame on the reverse channel.

Example of Stop-and-Wait Protocol

- ➢ Figure shows an example of communication using this protocol.
- ➢ The sender sends one frame and waits for feedback from the receiver.
- ➢ When the ACK arrives, the sender sends the next frame.



NOISY CHANNELS

- Simplest Protocol (Noiseless channel) has no flow or error control.
- Stop-and-Wait Protocol (Noiseless channel) gives an idea of how to add flow control to Simplest Protocol.
- Both of these protocols do not have a mechanism to control error.
- Noiseless channels are nonexistent.
- We can ignore the error, or we need to add error control to our protocols.
- Noisy Protocols use error control.

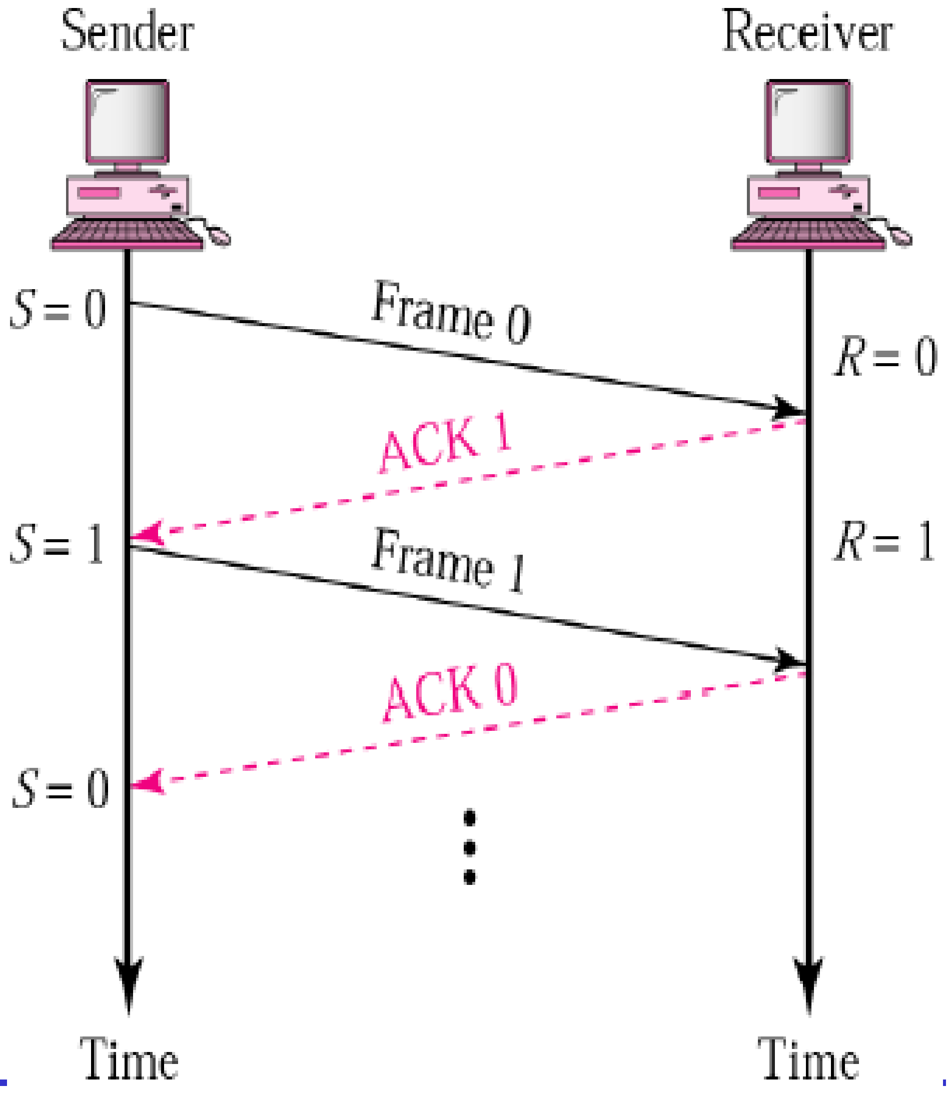
Stop-and-Wait ARQ

- It is the simplest flow and error control mechanism. A transmitter sends a frame then stops and waits for an acknowledgment.
- Stop-and-Wait ARQ has the following features:
  - The sending device keeps a copy of the sent frame transmitted until it receives an acknowledgment(ACK).
  - The sender starts a timer when it sends a frame. If an ACK is not received within an allocated time period, the sender resends it.
  - Both frames and acknowledgment (ACK) are numbered alternately 0 and 1(two sequence number only).

ARQ = Automatic Repeat Request-*

Anytime an error is detected in exchange, specified frames are retransmitted. This process is called Automatic Repeat Request

Stop-and-Wait ARQ



Stop-and-Wait ARQ,

- After each frame sent the host must wait for an ACK
    - inefficient use of bandwidth

- To improve efficiency ACK should be sent after multiple frames

- Alternatives: Sliding Window protocol

Sliding Window

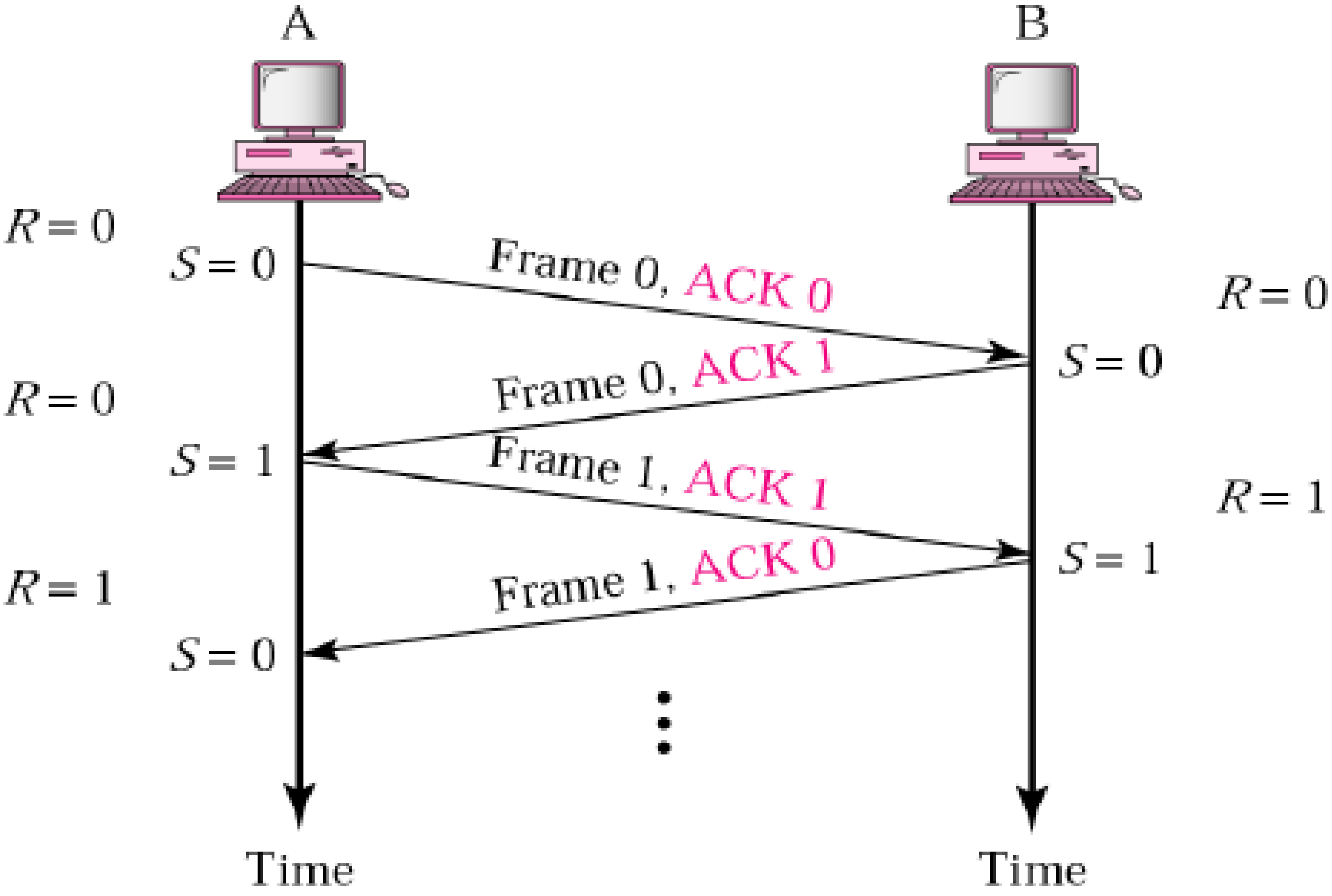
- The sliding window method allows multiple frames to be sent without an acknowledgment, thus eliminating most of the waiting time shown in the stop-and-wait protocol.
- The size of the sliding window is determined by the maximum number of frames, n, that can be sent without an acknowledgment.
- We can send up to n frames and keep a copy of these frames(outstanding) until the ACKs arrive.
- Sliding window protocols improve the efficiency

Piggybacking

- In real life, data frames are normally flowing in both directions: from node A to node B and from node B to node A. This means that the control information also needs to flow in both directions.
- A technique called piggybacking is used to improve the efficiency of the bidirectional protocols.
- When a frame is carrying data from A to B, it can also carry control information about arrived (or lost) frames from B; and verse versa.

Piggybacking (Bidirectional transmission)

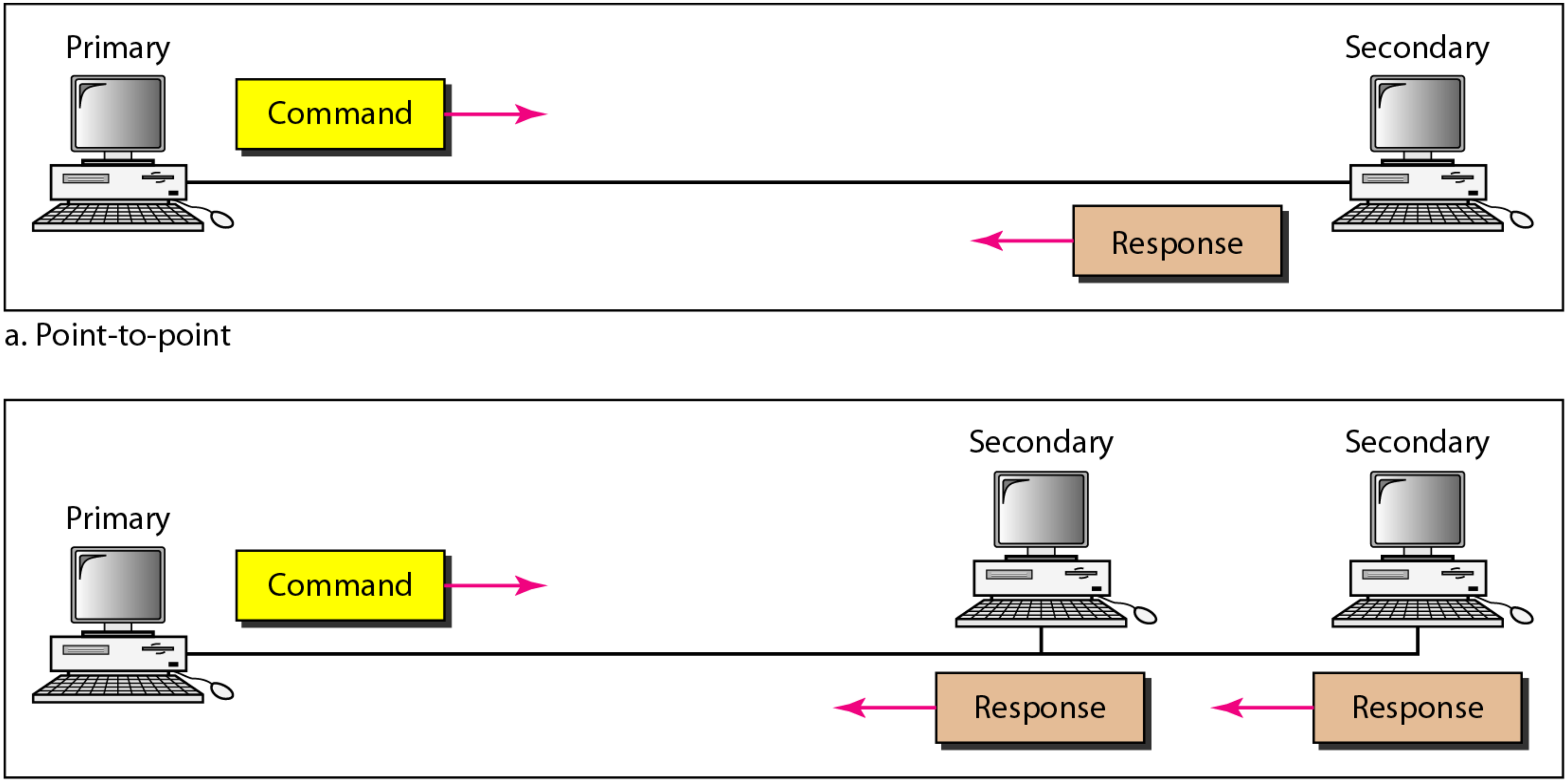
- Is a method to combine a data frame with an acknowledgment.
- It can **save bandwidth** because data frame and an ACK frame can combined into just one frame



HDLC

- High-level Data Link Control (HDLC) is an protocol designed to implement the ARQ mechanisms.
- HDLC provides two common transfer modes that can be used in different configurations:
  - ➢ Normal response mode (NRM)
  - ➢ Asynchronous balanced mode (ABM)

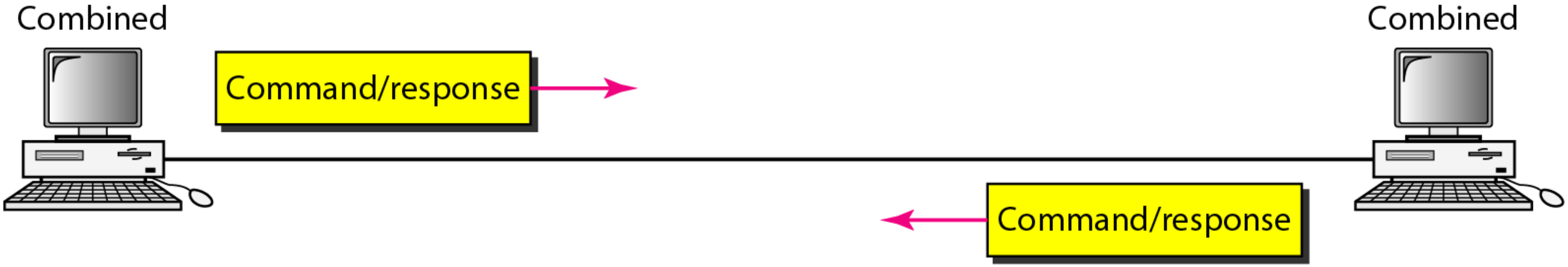
In normal response mode (NRM), the station configuration is unbalanced. One primary station and multiple secondary stations. A primary station can send commands; a secondary station can only respond.



a. Point-to-point

b. Multipoint

In asynchronous balanced mode (ABM), the configuration is balanced. The link is point-to-point, and each station can function as a primary and a secondary (acting as peers) This is the common mode today.


Combined
Combined
Command/response
Command/response