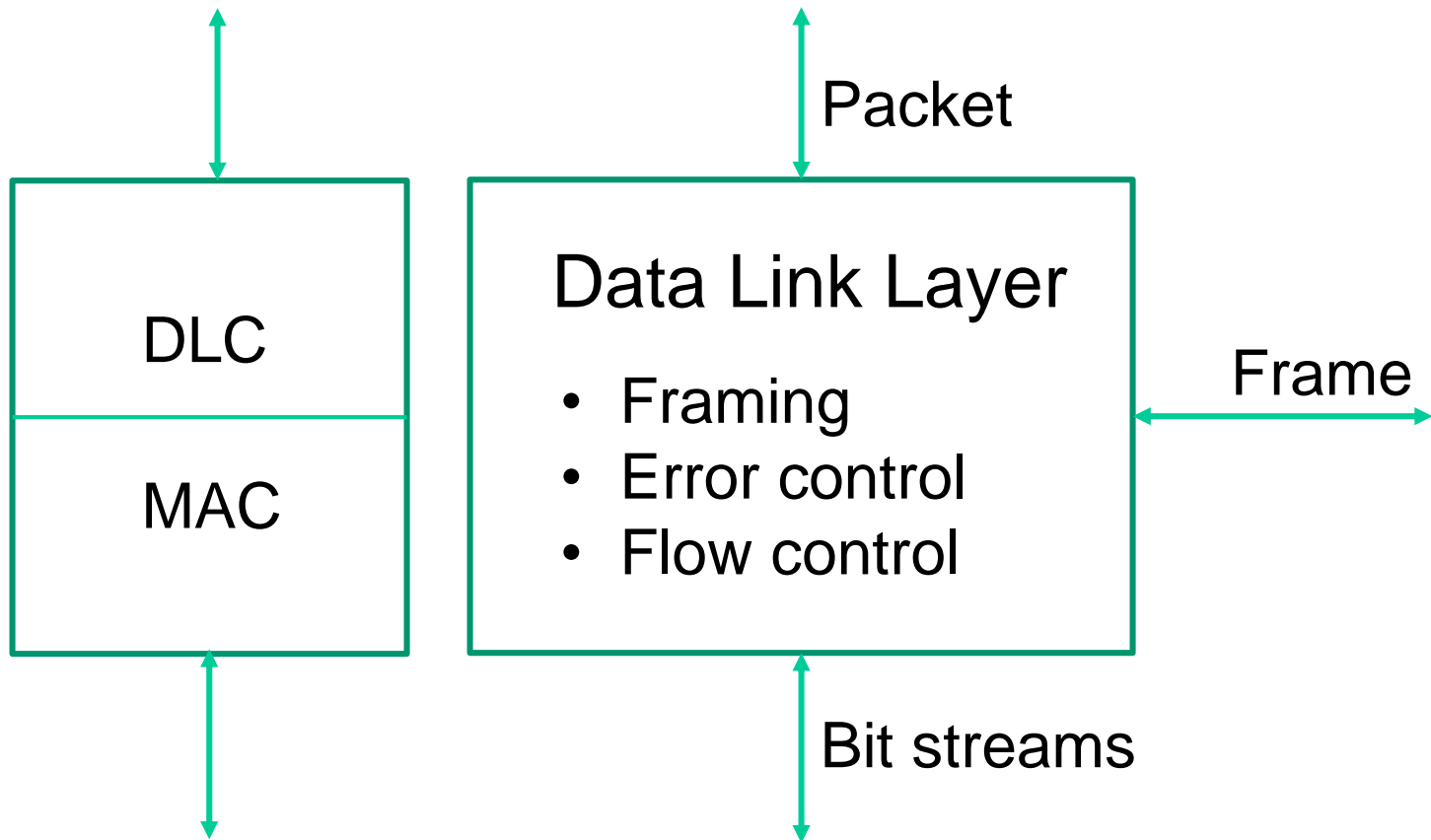


# The Data Link Layer

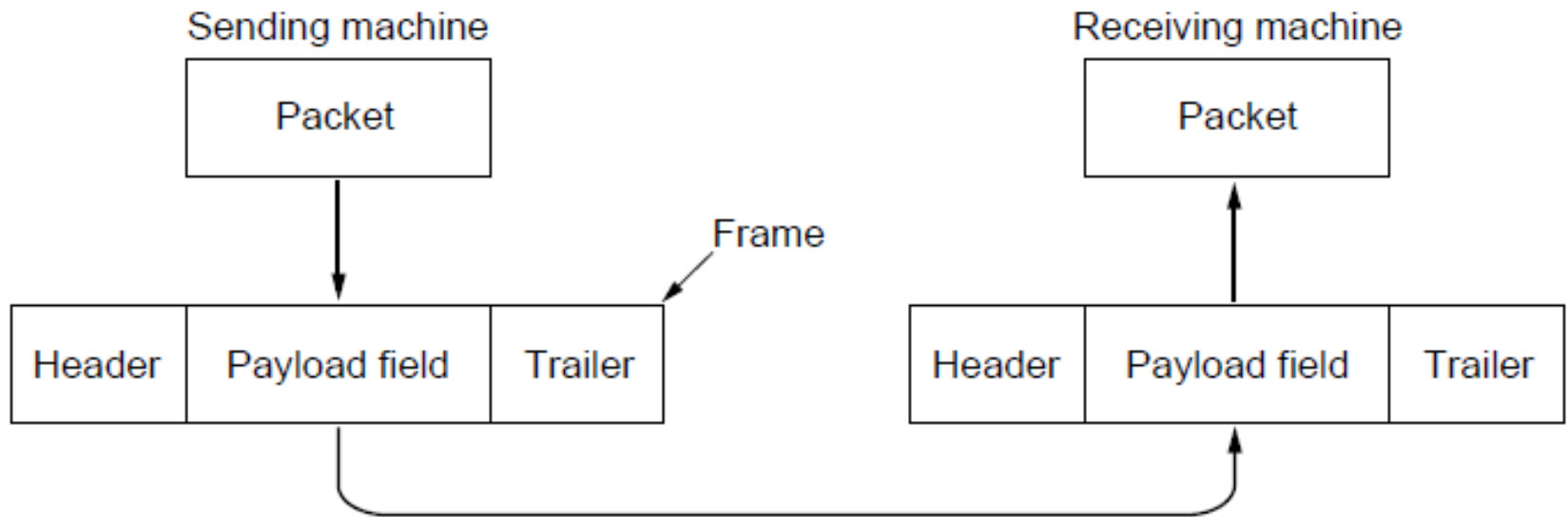
## Chapter 3



# Data Link Layer Design Issues

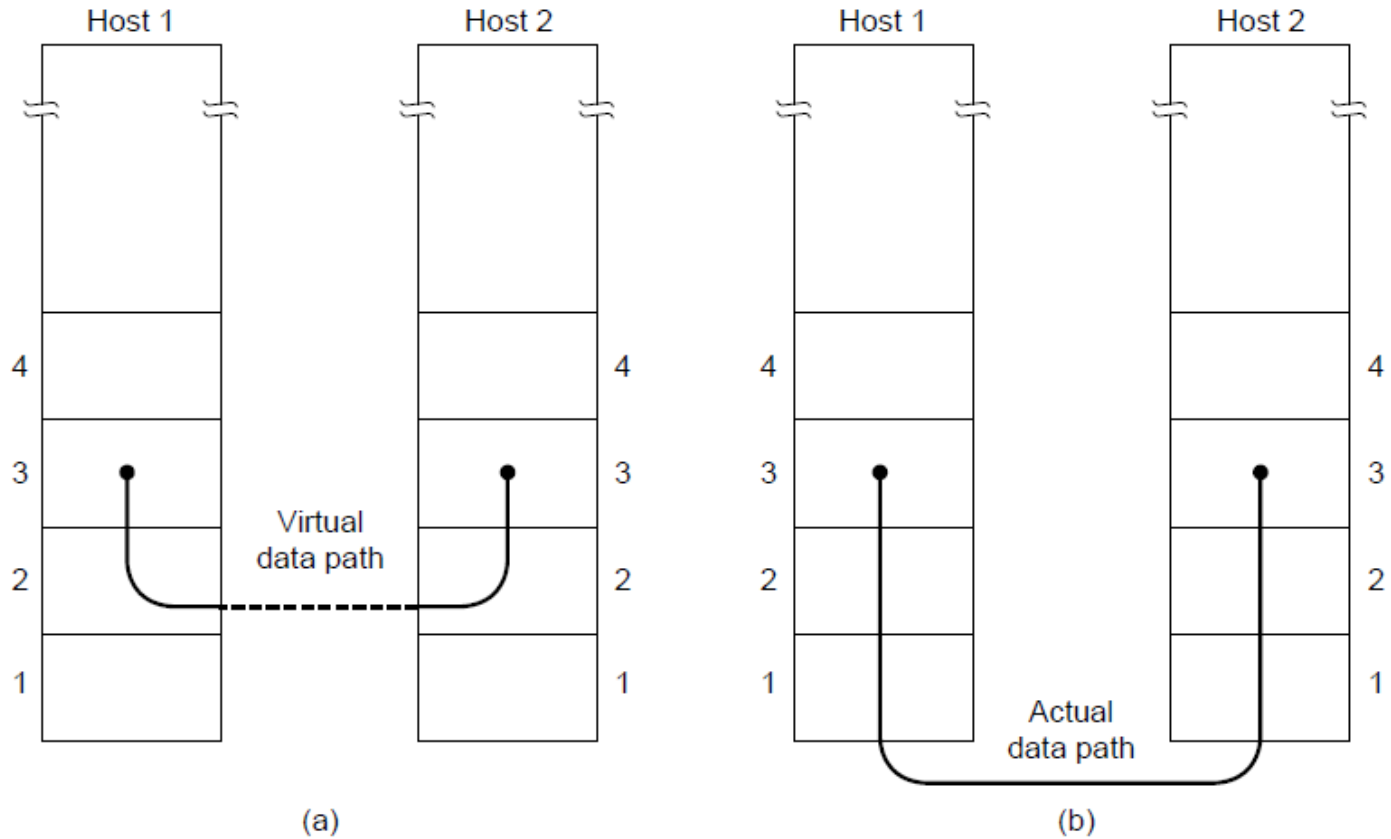
- Network layer services
- Framing
- Error control
- Flow control

# Packets and Frames



Relationship between packets and frames.

# Network Layer Services



(a) Virtual communication. (b) Actual communication.

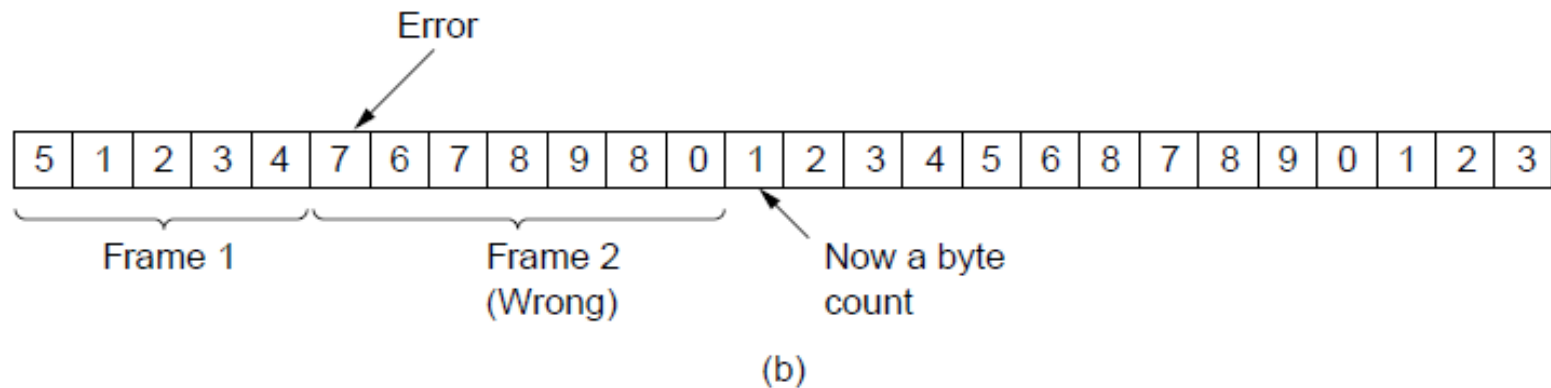
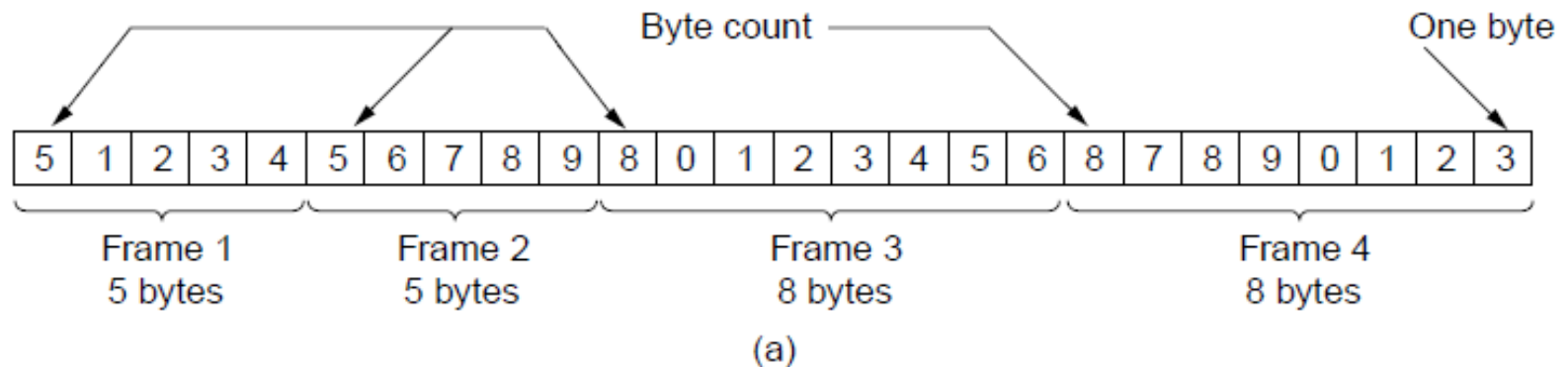
# Possible Services Offered

1. Unacknowledged connectionless service.
  - E.g., Ethernet (IEEE 802.3)
2. Acknowledged connectionless service.
  - WiFi (IEEE 802.11)
3. Acknowledged connection-oriented service.

# Framing Methods

1. Byte count.
  - Rarely used.
2. Flag bytes with byte stuffing.
  - PPP
3. Flag bits with bit stuffing.
  - HDLC, USB
4. Physical layer coding violations.

# Framing (1)



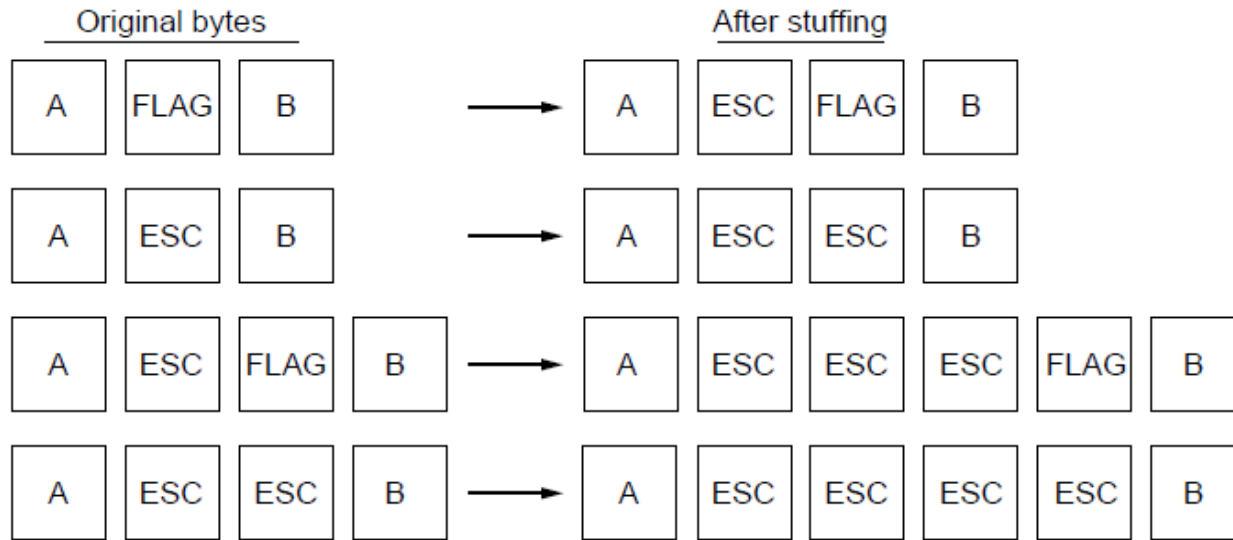
A byte stream. (a) Without errors. (b) With one error.



# Framing (2)



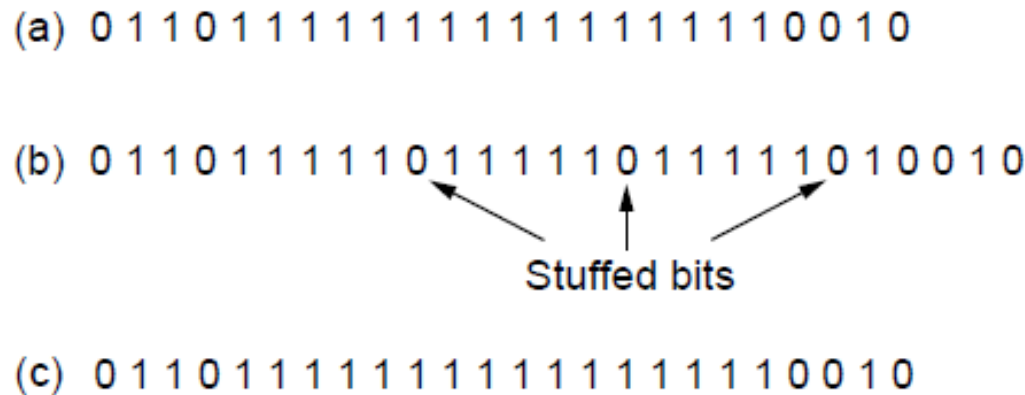
(a)



(b)

- a) A frame delimited by flag bytes.
- b) Four examples of byte sequences before and after byte stuffing.

# Framing (3)



Bit stuffing. (a) The original data. (b) The data as they appear on the line. (c) The data as they are stored in the receiver's memory after destuffing.

# Error control

- a) Positive or negative acknowledgement
- b) Sequence number
- c) Timer
- d) Error control code

# Flow Control

- Closed loop
  - Feedback-based flow control
- Open loop
  - Rate-based flow control

An example of error&flow control:

- Sliding window protocol
  1. Stop-and-wait ARQ
  2. Go-back-N ARQ
  3. Selective-Repeat ARQ

# Error correction and detection

- Error-correction code,
  - often referred to as FEC(Forward Error Correction)
  - Suitable for noisy channels
- Error-detection code
  - Suitable for communication media that are highly reliable, such as fiber.
- Error characteristics:
  - Single-bit errors, burst errors, erasure channel.

# Error Correction Codes (1)

1. Hamming codes.
2. Binary convolutional codes.
3. Reed-Solomon codes.
4. Low-Density Parity Check codes.